Terracon GeoReport

Geotechnical Engineering Report

Walworth Avenue Development
Cincinnati, Hamilton County, Ohio
May 23, 2019
Terracon Project No. N1195144

Prepared for:
East End Developers LLC
Cincinnati, Ohio

Prepared by:
Terracon Consultants, Inc.
Cincinnati, Ohio

May 23, 2019

East End Developers LLC
4010 N. Bend Road Suite 301
Cincinnati, Ohio 45211

Attn: Mr. Ralph Meierjohan
P: (513) 662-3111
E: ralphm@meierjohanbuildinggroup.com

Re: Geotechnical Engineering Report
Walworth Avenue Development
3100 Walworth Avenue
Cincinnati, Hamilton County, Ohio
Terracon Project No. N1195144

Dear Mr. Meierjohan:

We have completed the Geotechnical Engineering services for proposed development of Walworth Avenue. This study was performed in general accordance with Terracon Proposal No. PN1195144 dated February 7, 2019. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork, pavements and other site development elements for the proposed development.

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

Sincerely,
Terracon Consultants, Inc.

Anurupa S. Kumar, EIT
Staff Geotechnical Engineer

Craig M. Davis, PE, CPSCE
Senior Engineer

Ronald S. Lech, PE
Senior Principal

REPORT TOPICS

INTRODUCTION 1
SITE CONDITIONS 1
PROJECT DESCRIPTION 2
GEOTECHNICAL CHARACTERIZATION 3
GEOTECHNICAL OVERVIEW 5
EARTHWORK 6
STORMWATER MANAGEMENT 13
PAVEMENTS 13
SLOPE STABILITY 15
LATERAL EARTH PRESSURES 17
GENERAL COMMENTS 18
FIGURES 20

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

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES
SITE LOCATION AND EXPLORATION PLANS
EXPLORATION RESULTS
SLOPE STABILITY ANALYSES
SUPPORTING INFORMATION

Note: Refer to each individual Attachment for a listing of contents.

Geotechnical Engineering Report
Walworth Avenue Development
3100 Walworth Avenue
Cincinnati, Hamilton County, Ohio
Terracon Project No. N1195144
May 23, 2019

INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed development to be located west of 3100 Walworth Avenue in Cincinnati, Hamilton County, Ohio. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil and rock conditions
- Short-term groundwater conditions
- Site preparation and earthwork
- Seismic site classification per IBC
- Pavement design and construction
- Stormwater control considerations

The geotechnical engineering Scope of Services for this project included the advancement of eleven (11) test borings to depths ranging from approximately 16.5 to 45.5 feet below existing site grades.

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

SITE CONDITIONS

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

Item	Description
Parcel Information	The project properties (parcels) extend up to about 1,600-feet west of the current terminus of Walworth Avenue, at 3100 Walworth Avenue in Cincinnati, Hamilton County, Ohio. Latitude, Longitude: 39.120957, -84.447031 (approximate) See Site Location

Item	Description
Existing Conditions	Site consists of a wooded hillside, downslope of Columbia Parkway, and the former Pendleton Railroad Yard. The remnants of several former structures and the associated pavements are located throughout the property. The site also contains remnants of a storm sewer system and an active overhead utility line on wood poles. The flat/bottom area of the site was previously covered with brush (primarily honeysuckle), which has since been cleared. The slope to the north of the property, downslope of Columbia Parkway, is owned by the Cincinnati Parks Department, and will remain so. A retaining wall was constructed in 1976 along Columbia Parkway (at the top of the hillside). The south side of the western end of Walworth Ave. is supported by a concrete retaining wall.
Existing Topography	Based off the Preliminary Site Plan by Abercrombie Associates, Inc. (3/28/18), the slope north of the proposed new roadway is at an inclination of about 2.5 to 4 Horizontal to 1 Vertical. The bottom area is relatively flat. Ground surface ranges in elevation from 518 feet along the railroad tracks to 594 feet along Columbia Parkway.

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 Available	■ Preliminary Site Plan by Abercrombie & Associates, Inc. dated 3/28/18 ■ Preliminary Grading Plan by Abercrombie & Associates, Inc. dated 2/5/19 ■ Archive Terracon (H. C. Nutting Company) Geotechnical Borings (1967) ■ Terracon Environmental Soil Borings (SB-1 through SB-35) performed in September 2018 ■ Proposed Remediation/ Cut & Fill Plan prepared by Abercrombie & Associates, Inc. dated 2/20/19

Item	Description
Project Description	The project includes the extension of Walworth Ave. and utility services about 1600 feet west from the current terminus. The new street will facilitate the redevelopment of the former Pendleton Railroad Yard into single and multi-story building development. Two retaining walls will be required on the north (upslope) side of new Walworth Ave. to facilitate the grading of the cul-de-sac and intermediate firetruck turn-around. The development of the site will be split into two phases. Phase 1 will consist of the removal of existing contaminated soils and their replacement with clean fill. This will be completed to depths ranging from about 2 to 30 below the current ground surface. Contaminated soils will be hauled off site and disposed of. The site will be restored to its prior grading at the completion of Phase 1. Environmental reports have been submitted separately from this geotechnical report. Phase 2 will consist of the earthwork required to achieve the grading plan for the development and the installation of utilities, retaining walls, and pavements.
Grading/Slopes	After completion of the Phase 1 temporary excavations and backfilling, Phase 2 will generally include fill placement (up to about 10 feet) to develop final grades based on the preliminary grading plan provided. Existing slopes will remain at their existing inclination of 2.5H to 4H:1V. Locally, excavation of up to 15 feet deep will be required at the two proposed retaining walls. These, and any other excavations into the existing slopes require review by the Geotechnical Engineer.
Free-Standing Retaining Walls	Two retaining walls have been proposed to achieve final grades along the upslope edge of new Walworth Ave. Wall heights of up to 15 feet are anticipated. These retaining walls have not been designed at this time but are planned to have a decorative concrete facing. Retaining wall designs are beyond the scope of these geotechnical exploration services.
Estimated Start of Construction	Spring/Summer 2019

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 site preparation and foundation options. Conditions encountered at each exploration point are indicated on the individual logs. The individual logs can be found in the Exploration Results section and the GeoModel can be found in the Figures section 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	FILL	gravel and lean to fat clay, with cinders, brick and rock fragments, concrete and coal
2	LEAN TO FAT CLAY	trace limestone fragments and sand, olive brown/brown, medium stiff to hard
3	SILTY CLAY	brown and gray, medium stiff to stiff
4	LEAN CLAY (Colluvium)	with shale and limestone fragments, olive gray/brown, medium stiff to hard
5	LEAN CLAY (Residuum)	with limestone fragments, olive gray/brown, hard
6	SHALE AND LIMESTONE	Shale: brown/ brown with gray, highly weathered, extremely weak Limestone: gray, strong
7	SHALE AND LIMESTONE	Shale: gray, very weak to weak Limestone: gray, strong

Colluvial soils are derivative of the weathering of the bedrock surface and the gradual downslope creep of the overburden soils. Colluvial soils are identified by shale and limestone fragments derived from the parent bedrock yet in a random orientation. Colluvial soils have a relatively high internal shear strength. However, the shear strength at the contact with the underlying bedrock is considerably lower and subject to pore pressures caused by water permeating along the contact surface.

Residual soils are derived from weathering of the parent bedrock to a cohesive soil and are characterized by a soil-like consistency with trace bedding planes and horizontally-aligned limestone fragments indicative of the parent material.

Approximately 15-feet of rock coring was performed at Test Boring B-6, with recovery ranging from about 25 to 100% and Rock Quality Designation (RQD) ranging from about 0 to 50%. Bedrock consisted of interbedded shale and limestone, with shale comprising about 61% of the rock matrix. Shale bedrock encountered was gray, slightly weathered and weak. Limestone bedrock encountered was light gray, unweathered and strong.

The boreholes were observed while drilling and after completion for the presence and level of groundwater. The water levels observed in the boreholes can be found on the boring logs in Exploration Results. However, groundwater levels during construction or at other times in the life of the structure may be higher or lower than the levels indicated on the boring logs. Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Perched groundwater is often encountered at the existing fill/natural soil interface, within existing fill, at the overburden soil/bedrock interface or within seams, bedding planes or fractures within the bedrock. As a result, perched water

could be encountered during construction. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

GEOTECHNICAL OVERVIEW

The test borings located to the south of the site (Borings B-2, B-3, B-5, B-7, B-8 and B-10) encountered about 5 to 15 feet of fill overlying native cohesive soils underlain by bedrock encountered at depths ranging from about 30 to 40 feet below existing site grades. The test borings located along the north slope of the site (Borings B-1, B-4, B-6 and B-9) encountered about 3.5 to 6 feet of fill, underlain by native cohesive soils and colluvium and then bedrock at depths ranging from 6 to 33.5 feet below existing site grades. The shallow bedrock was observed to consist primarily of extremely weak to weak shale with moderately strong to strong limestone interbeds.

The development of the site will be split into two phases. Phase 1 will consist of the removal of existing contaminated soils and their replacement with clean fill. This will be completed to depths ranging from about 2 to 30 below the current ground surface. Contaminated soils will be hauled off site and disposed of. The site will be restored to its prior grading at the completion of Phase 1. Environmental reports have been submitted separately from this geotechnical report. Phase 2 will consist of the earthwork required to achieve the grading plan for the development and the installation of utilities, retaining walls, and pavements.

Upon removal of the proposed overburden soil, structural fill (meeting material property requirements described in the Earthwork section of this report) must be placed to achieve final site grades. The newly-placed fill will experience consolidation settlement and has been discussed in this report. Temporary excavations will be required during grading operations. All excavations should, at a minimum, comply with applicable local, state and federal safety regulations, including the current Occupational Safety and Health Administration (OSHA) Excavation and Trench Safety Standards. Excavations should be planned to prevent destabilization of the north hillside and the adjacent railroad property that borders the development to the south. Where temporary excavation slopes cannot be established, other support systems such as shoring or shielding may be required.

The near-surface low to medium plasticity clay could become unstable with typical earthwork and construction traffic, especially after precipitation events. Effective drainage systems 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. If grading is performed during the winter months, an increased risk for possible undercutting and replacement of unstable subgrade will persist. The near-surface soils encountered in the borings, are not expected to pass proofroll in their current condition. In areas of fills and shallow cuts, these soils will require undercutting and replacement or stabilization prior to paving. Additional site preparation recommendations, including subgrade improvement and fill placement, are provided in the Earthwork section.

The fill soils encountered in the test borings consisted of uncontrolled fill consisting of concrete, brick and rock fragments, coal and other inclusions. Due to the variability in the consistency of fill material the existing fill should be considered unsuitable for building support. Based on the proposed remediation plan, a portion of the existing fill areas will be undercut and backfilled with structural fill. If existing fill is encountered at the pavement subgrade level, following proposed remediation, the existing fill should be undercut such that the subgrade consists of a minimum 2-feet of new engineered fill. Besides the existing fill, some of the native soils were identified in a medium stiff condition. These soils should also be undercut and replaced with structural fill to provide building support. In lieu of removing and replacing these soils, bearing elements of foundations may be designed to penetrate into the underlying at-least-stiff native soils or bedrock.

The proposed buildings on the individual lots within the development have not yet been prepared. It is anticipated that these structures will be unique to each lot/builder. Specific recommendations for the design of building foundations will likely be required by the individual builders on each lot. The builders will need to abide by Ohio Building Code or engage a firm, other than Terracon, for any services related to the proposed building structures.

To create a model and determine soil properties for the design of the 2 retaining walls planned for the development, slope stability analyses of the north slope were performed. The parameters used in these analyses were based upon new borings performed toward the bottom of the slope and historical borings performed by HC Nutting (now Terracon) in the upper slope. Copies of the relevant historical boring logs are included in the Appendix. Any excavations into the existing slope at this site must be reviewed by the Geotechnical Engineer. Retaining walls should be designed such that an open-cut is not required. Typical wall types may include a drilled shaft and lagging wall that may be faced with decorative concrete. See Slope Stability for additional discussion.

The Pavements section addresses the subgrade parameters to be used in the design of pavement systems.

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

EARTHWORK

The following sections provide recommendations for use in the preparation of specifications for the earthwork. These recommendations include critical quality criteria that are necessary to render the site in the state considered in our geotechnical engineering evaluation for support of pavements, infrastructure, and general building development.

Site Preparation

Clearing and grubbing has already been carried out on most of the property to be developed. The development of the site will be split into two phases. Phase 1 will consist of the removal of existing contaminated soils and their replacement with clean fill. This will be completed to depths ranging from about 2 to 30 below the current ground surface. Contaminated soils will be hauled off site and disposed of. The site will be restored to its prior grading at the completion of Phase 1. Environmental reports have been submitted separately from this geotechnical report. Phase 2 will consist of the earthwork required to achieve the grading plan for the development and the installation of utilities, retaining walls, and pavements.

Prior to placing fill, any remaining existing vegetation and root mat/root bulbs should be removed. Complete stripping of the topsoil should be performed within the grading limits. Following stripping of site, specific evaluation should be performed to determine whether remnants of the former structures (e.g. below-grade walls, slabs and foundations, underground utilities) can be left in place or removed. In general, these items should be removed in their entirety and replaced with engineered fill. These items should be evaluated on a case-by-case basis by Terracon in consideration of proposed structures which may conflict with the presence of existing structural remnants.

Any existing utilities should be clearly marked in the field prior to construction and specific information regarding existing utilities (including accurate locations and depths) is very important to identify potential conflicts with new utilities, future building development, and roadways. Site preparation should include the relocation of any existing utilities outside of proposed building footprints. If any existing utilities are to be abandoned in-place, it is recommended that the utilities be grouted solid. Any existing catch basins, underdrains and septic systems should be completely removed.

The fill soils encountered in the test borings consisted of uncontrolled fill consisting of concrete, brick and rock fragments, coal and other inclusions. Due to the variability in the consistency of fill material the existing fill should be considered unsuitable for building support. Besides the existing fill, some of the native soils were identified in a medium stiff condition. Based on the proposed environmental remediation plan, a portion of the existing fill and medium stiff native soils will be undercut and backfilled with structural fill.

In building areas, plus a 10-feet perimeter, any existing fill or medium stiff native soils should be undercut and replaced with structural fill to provide building support. In lieu of removing and replacing these soils, bearing elements of foundations may be designed to penetrate to bear in the underlying at-least-stiff native soils or bedrock. Typical methods for this purpose include trenched footings or a foundation system of drilled shafts and grade beams.

The following table indicates the depths of the fill and medium stiff native soil zones.

Boring ID	Depth of Fill/Medium Stiff Zone (feet)
B-2	10
B-3	10
B-5	15
B-7	5
B-8	7.5
B-10	15
B-11	7.5

If encountered, any existing fill in proposed pavement areas should be undercut to provide a minimum 2-feet engineered fill thickness. The bottom of the undercut areas and other subgrade areas to receive engineered should be proof rolled with multiple passes of a loaded dump truck (minimum total weight of 20-tons) under the observation of Terracon. Soft, yielding areas should be isolated and remediated prior to placement of engineered fill. Undercutting in areas that fail a proofroll may require undercutting to depths greater than the 2 feet mentioned above. Possible remediation methods could include in-place stabilization with gravel and a geogrid/geotextile, undercutting and replacement with engineered fill, or chemical stabilization. The appropriate remediation method will depend on the conditions encountered at that time and location and should be determined in the field during construction.

Fill Material Types

It is our understanding that the fill materials for both phases of the development will be obtained from an approved borrow site. Terracon has evaluated and reported on one identified potential borrow site located near the intersection of Interstate 74 and Ohio State Route 128 in Hamilton County, Ohio. A copy of this report is included in the Appendix.

Fill required to achieve design grade should be consist of "structural" fill since it will be relied upon for support of infrastructure and future building development. Structural fill is generally described as material used below, or within 10 feet of structures, pavements or constructed slopes. We recommend the use of a uniform compaction specification due to the scale of the development. Earthen materials used for structural fill should meet the following material property requirements:

Soil Type [1]	USCS Classification	Acceptable Parameters
Lean clay	CL (LL<40)	All locations and elevations
Moderately plastic clay	CL (40<LL<50)	> 3 feet below pavement subgrade

Soil Type [1]	USCS Classification	Acceptable Parameters
Well graded granular	GW [2]	All locations and elevations
On-site soils and weathered bedrock	Varies	The existing on-site soils, typically described as lean clay, are suitable for use as engineered fill. Medium plasticity clay should not be used within 3 feet of subgrade beneath building/pavement areas. Moisture conditioning and some culling of excavated soils should be anticipated. The suitability of all excavated soils should be evaluated in the field during construction.

1. New engineered fill should consist of approved materials that are free of organic matter and debris and have a maximum particle size of 6 inches. Frozen material should not be used. Fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to Terracon for evaluation.
2. Similar to ODOT Item 304 stone or crushed limestone aggregate or granular material such as sand, gravel or crushed stone containing no more than 10% low plasticity fines (passing #200 sieve).

Shale and limestone materials can be used as structural fill. However, the following special measures should be implemented:

- Brown and gray shale should not be intermixed.
- Soil should not be mixed with gray shale but can be mixed with brown shale.
- Large rock fragments or limestone slabs having a thickness greater than 6 inches in any dimension, should be removed from the layer to be compacted, or broken down in-place before being incorporated in to the compacted lift. No solid fragment greater than 6 inches in any dimension should be placed in the fill. All rock pieces should be well distributed in the mass and "nesting" should be avoided. Stones or rock fragments larger than 4 inches in their greatest dimension should be prohibited in the top 6 inches of the final subgrade.
- Water should be added to each layer as required to obtain a moisture content of the soil or shale portion of the fill to within a range of optimum moisture content to +4% for any shale fill (and +/-2% for soils). The addition of water is necessary to facilitate compaction, but also accelerate the slaking and breakdown in the case of shales. Water should be added utilizing a spray bar on a truck or other approved method to produce uniform application. The water should be uniformly incorporated throughout the entire layer's thickness. Note that it has been our experience to observe that gray shale will require comparatively more water to condition the lift than brown weathered shale.
- All structural fill, including soil and shale materials, should be placed in loose lifts not exceeding 8 inches in thickness. Compaction should be accomplished as outlined in this report.
- Where shale materials are included in the structural fill, both vibratory and static tamping foot rollers having a minimum weight of 50,000 lbs. should be utilized.

- Due to occasional difficulty in performing field density tests due to limestone fragment influences, proof-rolling the compacted lifts may be necessary in some cases to observe stability and confirm compaction, in lieu of moisture-density testing.

Fill Compaction Requirements

Structural and general fill should meet the following compaction requirements.

Item	Structural Fill
Maximum Lift Thickness	▫ 8-inches or less in loose thickness when heavy, self-propelled compaction equipment is used ▫ 6-inches in loose thickness when hand-guided equipment (i.e. jumping jack or plate compactor) is used
Minimum Compaction Requirements [1, 2]	▫ 98% of max. below foundations and within 2-feet of finished pavement subgrade
Water Content Range [1]	▫ Low plasticity cohesive: -2% to +3% of optimum ▫ Granular: -3% to +3% of optimum / workable moisture levels

1. Maximum density and optimum water content as determined by the standard Proctor test (ASTM D 698).
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 D 4253 and D 4254).

All materials to be used as engineered fill should be tested in the laboratory to determine their suitability and compaction characteristics.

Grading and Drainage

Effective site drainage is important to satisfactory long-term performance of buildings and pavements. Final surrounding grades should be sloped away from these items to prevent the ponding of water and should be maintained throughout its lifespan. Water retained next to buildings 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. Effective site drainage is also important during construction to reduce the potential for undercuts associated with ponding of water in excavations and on approved subgrades.

Where the bedrock surface is exposed in cut subgrade areas, it should be examined for drainage characteristics and careful crowning of the subgrade is important to avoid low spots that can trap water and soften the subgrade. Fill placed on benches that intercept the overburden soil/bedrock interface, and those that extend into the bedrock, should be evaluated to determine if ground water

seepage exists. Where ground water is encountered in fill areas, temporary drainage will be required. Depending upon the depth and location of the groundwater, permanent drainage may be required to prevent the build-up of groundwater pressures.

Earthwork Construction Considerations

It is anticipated that variable excavation depths are planned across the site to establish the design subgrades. The feasibility of performing open-cut excavations with laid-back slopes will depend on several factors and requires specific evaluation. Excavations/trenches deeper than 20 feet should be designed by a registered engineer. Temporary excavation support systems, where required, should be installed prior to making excavations. Trenches at the base of and parallel to slopes should limited to sections of 30 feet or less and backfilled prior to excavating the adjacent sections. All backfill should be compacted to specifications.

All trench excavations should be made with sufficient working space to permit construction including backfill placement and compaction. If utility trenches are backfilled with relatively clean granular material, they should be capped with at least 18 inches of cohesive fill in non-pavement areas to reduce the infiltration and conveyance of surface water through the trench backfill.

Temporary excavations will be required during grading operations. The excavation/site contractor is responsible for designing and constructing stable, temporary excavations and should shore, slope or bench the sides of the excavations as required, to maintain stability of both the excavation sides and bottom. The design of the excavation support system should not only take into account the forces, but also tolerable displacement as specified in the project documents. All excavations should, at a minimum, comply with applicable local, state and federal safety regulations, including the current Occupational Safety and Health Administration (OSHA) Excavation and Trench Safety Standards. The soils encountered in the test borings generally appear to classify as OSHA Type B. However, OSHA Type C are also likely to be present due to the presence of uncontrolled fill and the groundwater table. The final determination of the soil type should be made by the contractor's competent person and be based upon the conditions that exist at that time and location.

Any subgrades to receive fill and which are steeper than 5H:1V should be benched to allow for placement of the fill on relatively horizontal surfaces and to key in the new fill into existing soils. The minimum width of the bench, typically 4 to 8-feet, should be sufficient to accommodate construction equipment.

Placement of new embankment fill will cause settlement. These settlements will occur as a result of consolidation of bearing materials upon which the fill is placed, as well as compression of the embankment material. The degree of fill-induced settlement will vary depending on existing overburden thickness and characteristics, new fill type and thickness, moisture content, etc. Fill-induced settlements are estimated to be about ¾ to 1 inch per 10 feet of fill placed. Some of this settlement should occur during fill placement, but additional settlement will likely occur after

topping out the fill. It is recommended that some form(s) of instrumentation monitoring be performed to observe total and time-rate of fill-induced settlement.

A permanent slope of 3H:1V or flatter is recommended within the stiff overburden and engineered-fill soils at the site. This will also allow the areas to be mowed/maintained.

Upon completion of filling and grading, care should be taken to maintain the subgrade moisture content prior to construction of buildings and pavements. Although the exposed subgrade may be relatively stable upon initial exposure, unstable subgrade conditions could develop during general construction operations, particularly if the soils are wetted and/or subjected to repetitive construction traffic. The use of light construction equipment would aid in reducing subgrade disturbance. Should unstable subgrade conditions develop, stabilization measures will be required. The appropriate remediation measure(s) will depend on conditions exposed during construction and requires field evaluation.

It is recommended that all exposed earth slopes be immediately seeded upon the completion of earthwork in the area to provide protection against erosion. Seeded slopes should be protected with erosion control mats until the vegetation is established.

Terracon should be retained during the construction phase of the project to observe earthwork and to perform necessary tests and observations during subgrade preparation; proof-rolling; placement and compaction of controlled compacted fills; backfilling of excavations into the completed subgrade, and just prior to construction of pavements.

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.

Construction Observation and Testing

The earthwork efforts should be monitored under the direction of the Geotechnical Engineer. Monitoring should include documentation of adequate removal of vegetation and topsoil, proof-rolling and mitigation of areas delineated by the proof-roll to require mitigation.

Each lift of compacted fill should be tested, evaluated, and reworked as necessary until approved 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 5,000 square feet in pavement areas and 2,500 feet in building areas. One density and water content test for every 50 linear feet of compacted utility trench backfill.

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.

STORMWATER MANAGEMENT

Based on the provided site plan, one new detention basin, up to 6 feet deep, is planned at the east end of the site. It is anticipated that clay soils will be encountered at the proposed detention basin bottom elevation. Based on the short-term groundwater observations made during the drilling of our test borings, we do not anticipate significant seepage within the detention basin excavation. However, seepage could vary seasonally. The civil engineer should determine the dimensions, bearing level, and composition of the retaining wall for correlate to the proposed grading of the detention basin such that the retaining wall is not impacted. We recommend an inclination of no steeper than 5H:1V between the grade at the base of the wall to the bottom of the detention basin. Any fill placed to build the detention basin should consist of cohesive soils and comply with the Compaction Requirements recommendations specified in section Site Preparation.

Ground water springs were observed on the slope above the site. These springs may produce continual water seepage or may be seasonal. A collection system should be established at the toe of the slope to reduce the potential for sheet flow of water over the roadway and/or the saturation of the subgrade.

PAVEMENTS

Subgrade Preparation

The subgrade for the pavements will consist of imported fill material as well as native cohesive soils. On most project sites, site grading is accomplished relatively early in the construction phase. Excavations are made to subgrade elevations and fill (as needed) is placed and compacted in a uniform manner. However, as construction proceeds, excavations for utilities and other purposes are made into these areas, rainfall and surface water saturates some areas, heavy traffic from concrete trucks and other delivery vehicles disturbs the subgrade and many surface irregularities are filled in with loose, uncompacted soils to prevent ponding. As a result, the pavement subgrades, initially prepared early in the project, may be unsuitable and should be carefully evaluated as the time for pavement construction approaches.

The native soils include low to high plasticity soils. Where exposed at subgrade level, these soil types are easily disturbed/softened by very few traffic loadings and/or by precipitation and groundwater seepage. These soils may require undercutting and replacement or stabilization prior to paving. We recommend the moisture content and density of the top 8 inches of the subgrade be evaluated and the pavement subgrades (in soil areas) be proof-rolled prior to commencement of paving operations. Areas not in compliance with the required ranges of moisture or density should

be moisture conditioned and recompacted. Areas where unsuitable conditions are located should be repaired by removing and replacing the materials with properly-compacted fill.

After proof-rolling and repairing subgrade deficiencies, the entire subgrade should be scarified and developed as recommended in Earthwork section of this report to provide a uniform subgrade for pavement construction. If a significant precipitation event occurs after the evaluation or if the surface becomes disturbed, the subgrade should be reviewed by qualified geotechnical personnel immediately prior to paving. The subgrade should be in its finished form at the time of the final review.

Design Considerations

We anticipate that traffic loads will be produced primarily by automobile traffic and some delivery and trash removal trucks. The thickness of pavements subjected to heavy truck traffic should be determined using expected traffic volumes, vehicle types, and vehicle loads and should be in accordance with local, city or county ordinances.

For pavement subgrades prepared in accordance with our recommendations in this report, we recommend a California Bearing Ratio (CBR) value of 3 be used for design of flexible asphalt concrete pavements at the site. CBR testing is recommended during construction to confirm the design value. A modulus of subgrade reaction value of 100 pounds per cubic inch (pci) is recommended for design of rigid concrete pavement sections, if any.

Pavement design methods are intended to provide structural sections with adequate thickness over a particular subgrade such that wheel loads are reduced to a level the subgrade can support. The support characteristics of the subgrade for pavement design do not account for shrink/swell movements of subgrade soils or long-term settlement of undocumented fills left in-place. Thus, the pavement section may be adequate from a structural standpoint, yet still experience cracking and deformation due to shrink/swell/settlement related movement of the subgrade.

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

- Final grade adjacent to roadways should slope down from pavement edges at a minimum 2%.
- The subgrade and the pavement surface should have a minimum ¼ inch per foot slope to promote proper surface drainage.
- Install pavement drainage surrounding areas anticipated for frequent wetting.
- Install joint sealant and seal cracks immediately.
- Seal all landscaped areas in, or adjacent to pavements to reduce moisture migration to subgrade soils.
- Place compacted, low permeability backfill against the exterior side of curb and gutter.

- Place curb/gutter directly on clay subgrade soils rather than on unbound granular base course materials.

Pavement Drainage

Effective pavement drainage is important to satisfactory long-term performance of pavements. 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. Appropriate sub-drainage or connection to a suitable daylight outlet should be provided to remove water from the granular subbase. In our experience, pavement failures are more often caused by poor drainage than inadequate section thickness.

Pavement Maintenance

Periodic preventive maintenance should be planned and provided for through an on-going pavement management program. Preventive maintenance activities are intended to slow the rate of pavement deterioration, and to preserve the pavement investment. Preventive maintenance consists of both localized maintenance (e.g., crack and joint sealing and patching) and global maintenance (e.g., surface sealing). Preventive maintenance is usually the first priority when implementing a planned pavement maintenance program and provides the highest return on investment for pavements. Prior to implementing any maintenance, additional engineering observation is recommended to determine the type and extent of preventive maintenance. Even with periodic maintenance, some movements and related cracking may still occur and repairs may be required.

SLOPE STABILITY

Mechanics of Stability

Slope stability analyses take into consideration material strength, the orientation of layers, water (piezometric) pressures, surcharge loads, and the slope geometry. Mathematical computations are performed using computer-assisted simulations to calculate a Factor of Safety (FS). Minor changes to slope geometry, surface water flow and/or groundwater levels could result in slope instability. Reasonable FS values are dependent upon the confidence in the parameters utilized in the analyses performed, among other factors related to the project.

Geometric Analysis Results

Slope stability analyses were performed for an upslope-downslope cross-section through Borings B-9 and B-10 (west end of site) and Borings B-1 and B-2 (east end of site). These locations were

selected due to their proximity to the proposed retaining walls. Historical borings performed by HC Nutting (now Terracon) that were performed in 1967 were also used to determine stratigraphy. Copies of the historical logs are included in the Exploration Results. Surface topography was obtained from the Preliminary Grading Plan (by Abercrombie). Parameters for the analyses were derived from our exploratory borings, experience, and laboratory tests. Stability analyses were conducted using the computer program Slope/W Version 8.16 developed by Geo-Slope International.

Our stability analyses presume that the retaining wall that exists along the south edge of Columbia Parkway has been designed to fully retain the upslope soils and will continue to do so for the life of the project. Analysis of this existing wall is beyond our scope of services.

Unstable or Potentially Unstable Slopes

Based on the results of our field investigation, laboratory testing program, and geotechnical analysis, development of the site is considered feasible from a geotechnical viewpoint provided the conclusions and considerations provided herein are incorporated into the design and construction of the project.

The stability of the slopes at the cross-section locations were analyzed based on the provided topography, proposed grading, soil properties derived from our geotechnical exploration, laboratory test results and our experience with similar soil conditions. Soil and bedrock properties used in the analyses are shown below:

Material	Moist Unit Weight (pcf)	Drained Cohesion (psf)	Drained Friction Angle (degrees)
Fill	120	50	18
Upper Lean Clay	125	50	18
Lower Lean Clay 1	130	200	22
Lower Lean Clay 2	125	100	20
Gray Shale (Bedrock)	Impenetrable by failure surface		

The slope stability results are included in the Slope Stability Analyses section of this report. Based on the analyses, the calculated FS for the critical surfaces identified in each section is shown below. These factors of safety indicate a marginally-stable slope which is common for the slopes along Columbia Parkway. The installation of properly designed retaining walls and the placement of fill at the toe of the slope will not negatively impact the stability of the slope. However, the stability of the undisturbed existing slope, upslope of the wall, will continue to have a low FS. At the west end of the site, where the factor of safety is marginal, site grades will be raised, thus providing a buttress to the slope. We recommend that the existing slope not be disturbed, denuded or otherwise manipulated beyond the grading limits as this may create a condition of instability.

Cross-Section	Minimum Calculated Factor-of-Safety for Slopes
	Circular Failure Surface
Boring B-9 and B-10	1.01
Boring B-1 and B-2	1.14

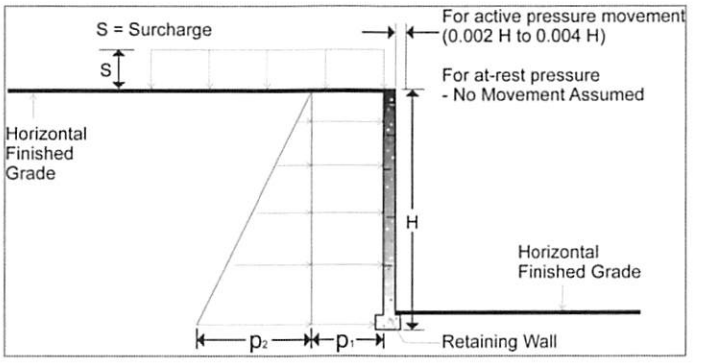
Surficial Slope Stability

Surface instability was observed on the slopes to the north of the proposed improvements during our site visits. These consisted of shallow surface sloughing and groundwater seepage. Minor areas of erosion by surface runoff were observed. Surficial slope instability typically impacts the upper 2 to3 feet +/- of the subsurface profile, predominantly during extended wet periods. Regular maintenance should be anticipated to identify and address changes in natural drainage patterns, creating potential for soil creep or erosion near the project. No new source of water onto the slope, such as irrigation of lawns or landscaping, should be created by the new development.

LATERAL EARTH PRESSURES

Design Parameters

Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the materials being restrained. For preliminary retaining wall designs, the following table of parameters has been provided. Final design values will depend upon the wall system to be used. The final design parameters will be established by the design engineer in consultation with Terracon. Two wall restraint conditions are shown in the diagram below. Active earth pressure is commonly used for design of free-standing cantilever retaining walls and assumes wall movement. The "at-rest" condition assumes no wall movement and is commonly used walls restrained at the top. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls (unless stated).



Lateral Earth Pressure Design Parameters				
Earth Pressure Condition [1]	Coefficient for Backfill Type [2]	Surcharge Pressure [3, 4] p_1 (psf)	Effective Fluid Pressures (psf) [2, 4]	
			Unsaturated [5]	Submerged [5]
Active (Ka)	0.41	(0.41)S	(50)H	(85)H
At-Rest (Ko)	0.58	(0.58)S	(70)H	(95)H
Passive (Kp)	2.46	---	(295)H	(205)H

1. For active earth pressure, wall must rotate about base, with top lateral movements 0.002 H to 0.004 H, where H is wall height. For passive earth pressure, wall must move horizontally to mobilize resistance.
2. Uniform, horizontal backfill, rendering a maximum unit weight of 120 pcf.
3. Uniform surcharge, where S is surcharge pressure.
4. No safety factor is included in these values.
5. "Submerged" conditions are recommended when drainage behind walls is not incorporated into the design.

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. Natural 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 services and any correspondence or collaboration through this system 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 impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

FIGURES

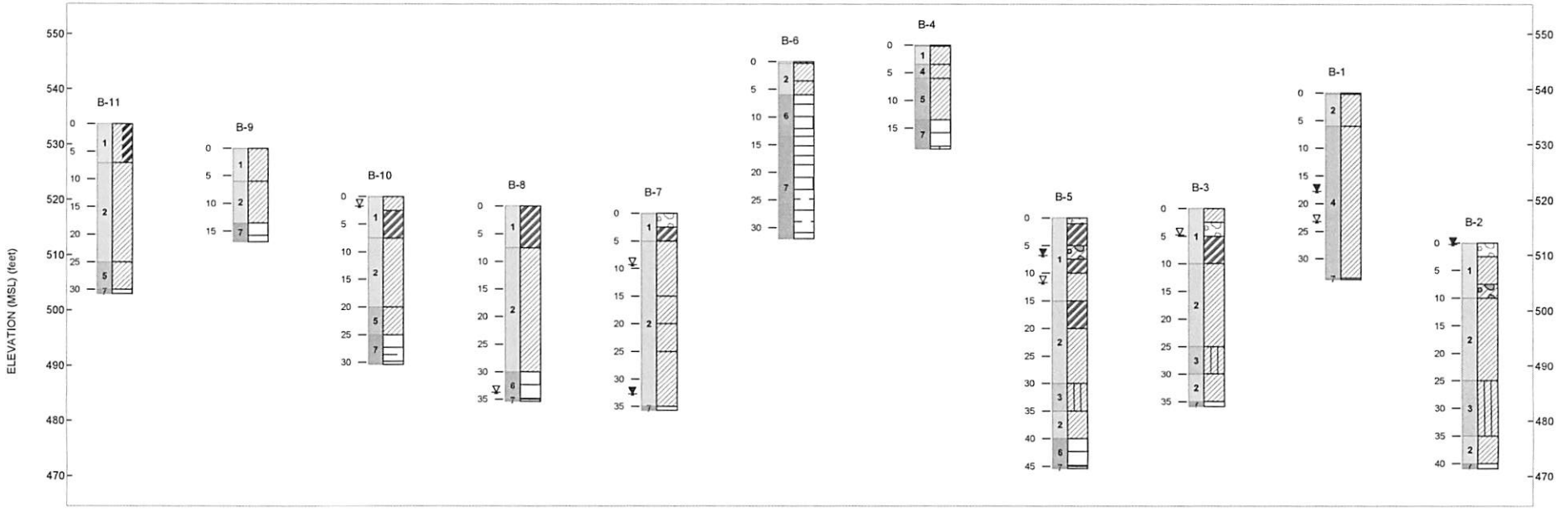
Contents:

GeoModel
Longitudinal & Cross Section Fences (6 pages)

GEOTECHNICAL MODEL

Walworth Avenue Development ■ Cincinnati, OH
5/23/2019 ■ Terracon Project No. N1185144

Terracon GeoReport



Topsoil | Lean Clay | Interbedded Limestone and Shale | Aggregate Base Course | Clayey Gravel | Silty Clay | Interbedded Limestone and Shale 1 | Fat Clay | Interbedded Shale or Limestone 1 | Concrete | Lean Clay/Fat Clay

Model Layer	Termed	General Description
1	**FILL**	gravel/ lean to fat clay, with cinders, brick and rock fragements, concrete and coal
2	**LEAN TO FAT CLAY**	trace limestone fragments and sand, olive brown/brown, medium stiff to hard
3	**SILTY CLAY**	brown and gray, medium stiff to stiff
4	**LEAN CLAY (Colluvium)**	with shale and limestone fragments, olive gray/brown, medium stiff to hard
5	**LEAN CLAY (Residuum)**	with limestone fragments, olive gray/brown, hard

Model Layer	Termed	General Description
6	**SHALE AND LIMESTONE**	Shale: brown/ brown with gray, highly weathered, extremely weak Limestone: gray, strong
7	**SHALE AND LIMESTONE**	Shale: gray, very weak to weak Limestone: gray, strong

NOTES:
See boring logs for more detailed conditions specific to each boring.
GeoModel provided for illustration purposes only. Actual subsurface conditions between borings will vary.

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.

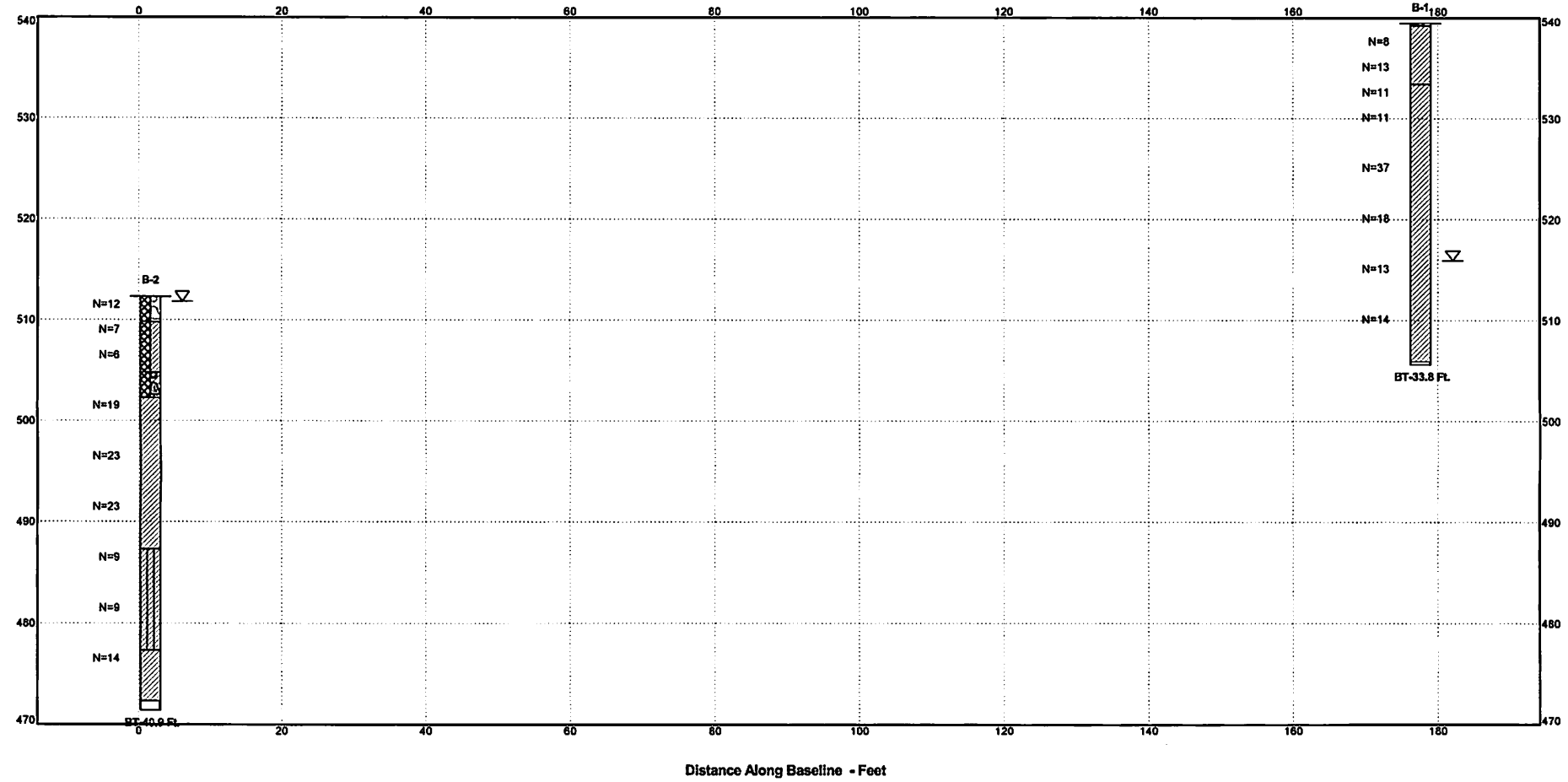
LEGEND
▽ First Water Observation
▼ Second Water Observation
▼ Final Water Observation

Groundwater levels are temporal. The levels shown are representative of the date and time of our exploration. Significant changes are possible over time.

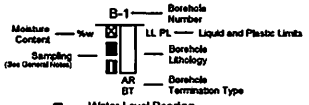
Water levels shown are as measured during and/or after drilling. In some cases, boring advancement methods mask the presence/absence of groundwater. See individual logs for details.

S

N



Explanation



Water Level Reading at time of drilling.

Water Level Reading after drilling.

Topsoil | Lean Clay | Interbedded Limestone and Shale | Aggregate Base Course | Clayey Gravel

Silty Clay | Interbedded Limestone and Shale 1

NOTES:

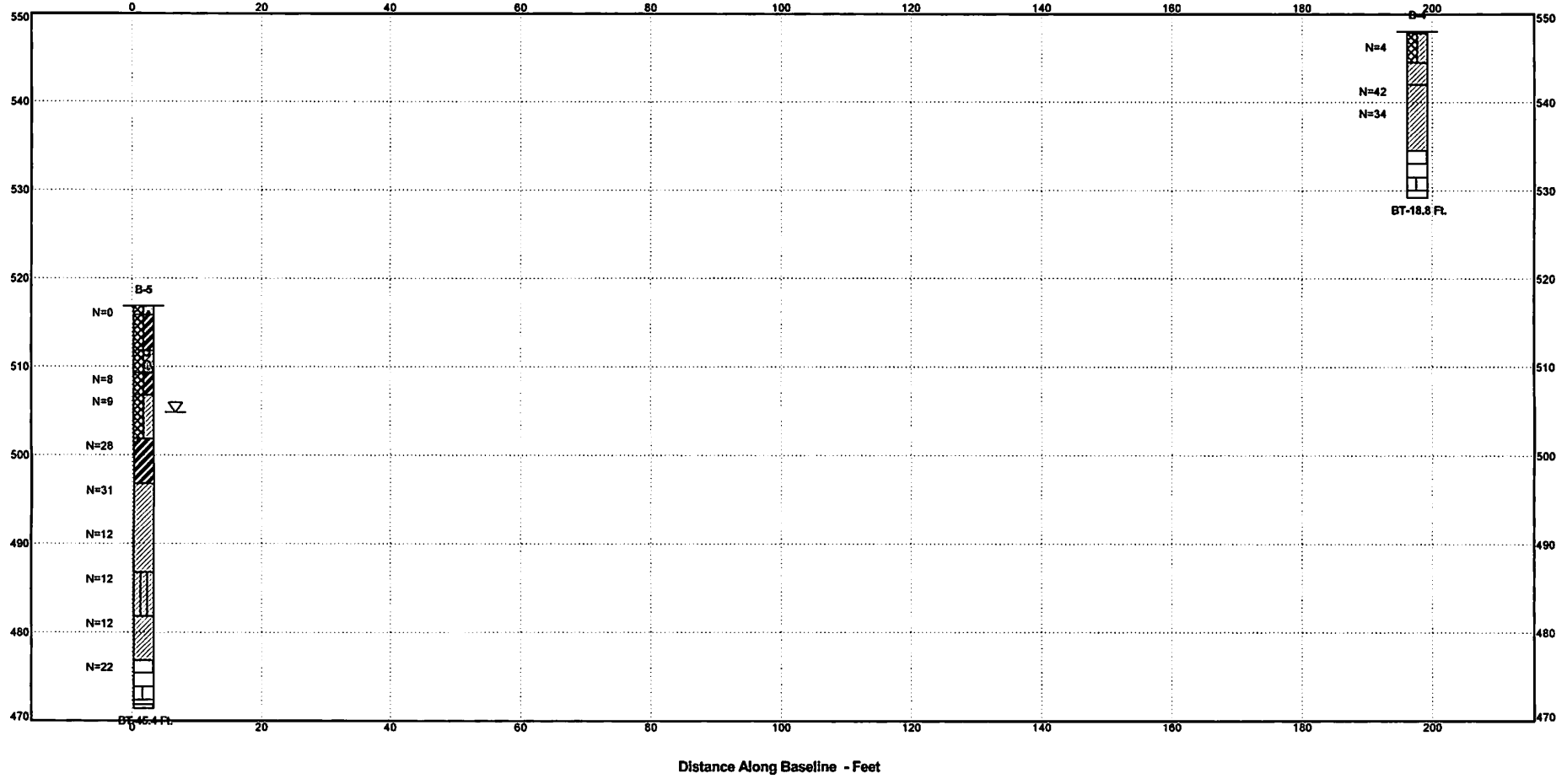
See Exploration Plan for orientation of soil profile.
See General Notes in Supporting Information for symbols and soil classifications.
Soils profile provided for illustration purposes only.
Soils between borings may differ
AR - Auger Refusal
BT - Boring Termination

Project No.: N1185144	Terracon	SUBSURFACE PROFILE
Date: 5/20/2019	611 Lunken Park Dr Cincinnati, OH	N-S FENCE (EAST) WALWORTH AVENUE DEVELOPMENT WALWORTH AVENUE CINCINNATI, OH
Scale: NTS		

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. SMART FENCE N1185144 WALWORTH AVENUE D.GPJ TERRACON_DATATEMPLATE.GDT 5/29/19

S

N



Explanation

B-4 — Borehole Number

Moisture Content — %w

LL PL — Liquid and Plastic Limits

Sampling (See General Notes) — Borehole Lithology

AR / BT — Borehole Termination Type

Water Level Reading at time of drilling.

Water Level Reading after drilling.

Topsoil | Lean Clay | Interbedded Limestone and Shale | Concrete | Fat Clay

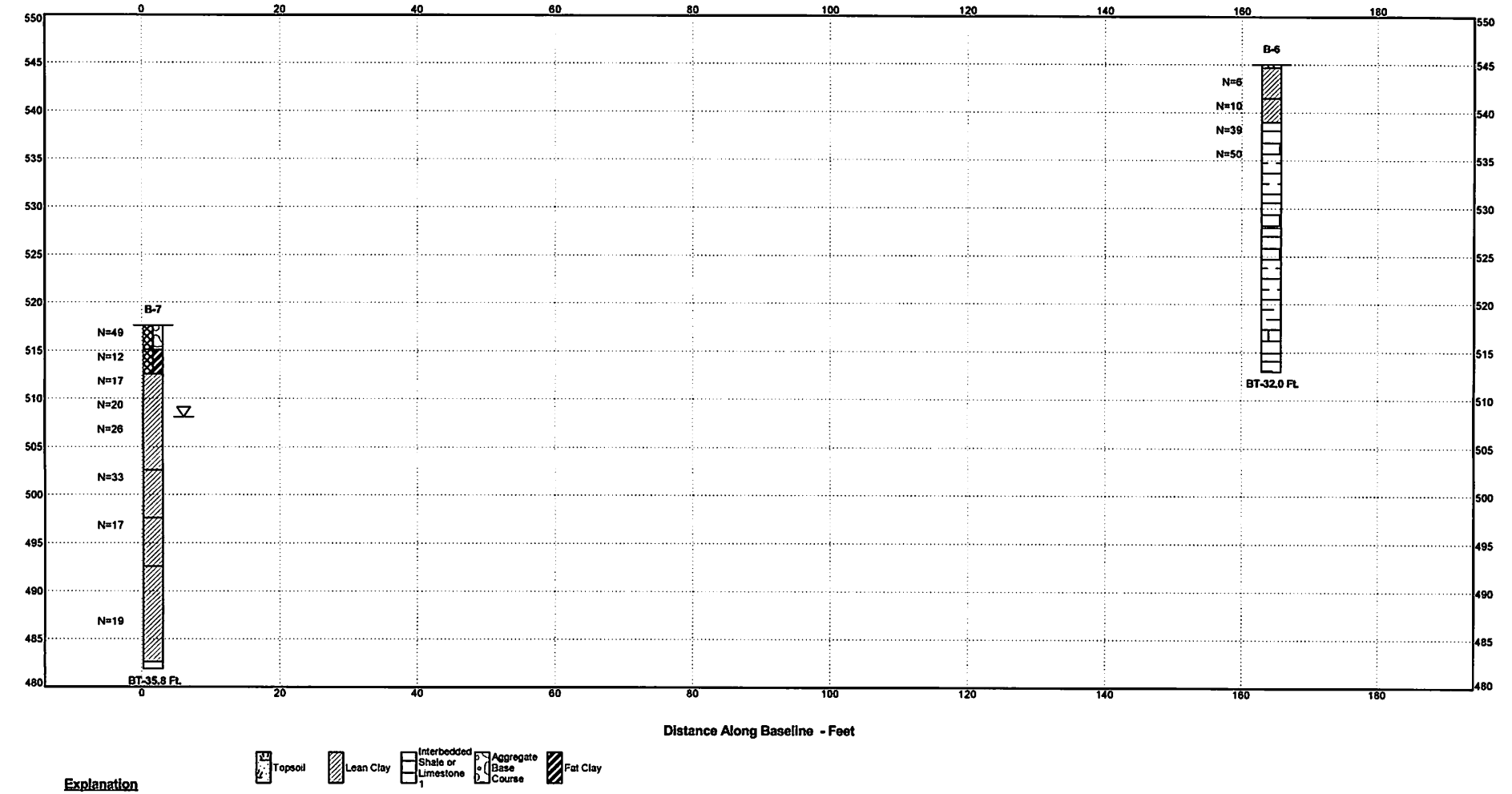
Clayey Gravel | Silty Clay

NOTES:

See Exploration Plan for orientation of soil profile.
See General Notes in Supporting Information for symbols and soil classifications.
Soils profile provided for illustration purposes only.
Soils between borings may differ
AR - Auger Refusal
BT - Boring Termination

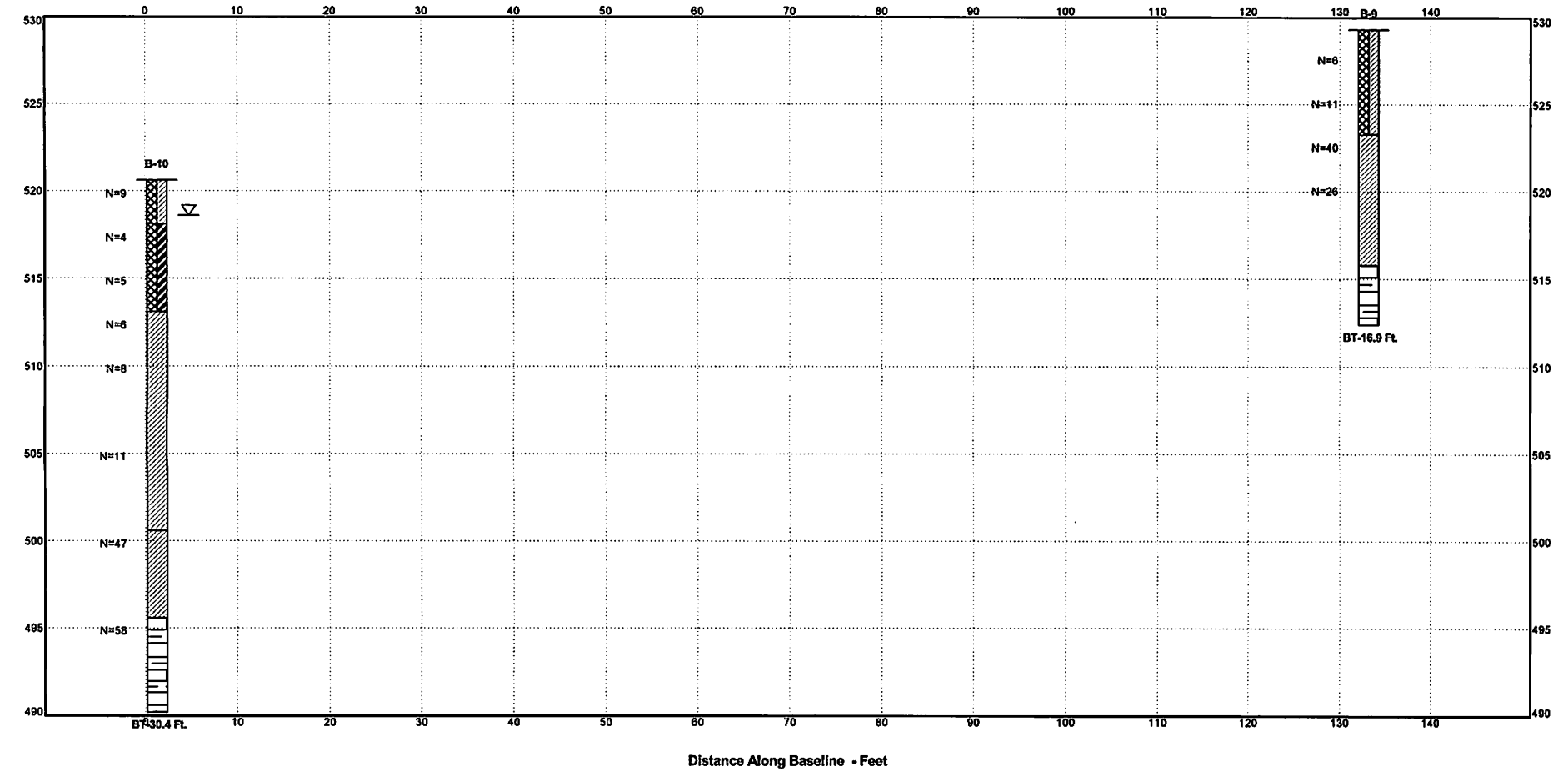
Project No.: N1185144	Terracon	SUBSURFACE PROFILE
Date: 5/20/2019	611 Lunken Park Dr Cincinnati, OH	N-S FENCE (CENTER-EAST) WALWORTH AVENUE DEVELOPMENT WALWORTH AVENUE CINCINNATI, OH
Scale: NTS		

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. SMART FENCE N1185144 WALWORTH AVENUE D.GPJ TERRACON_DATATEMPLATE.GDT 5/20/19



THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. SMART FENCE N1185144 WALWORTH AVENUE D.GPJ TERRACON_DATATEMPLATE.GDT 5/20/19

Project No.: N1185144	Terracon	SUBSURFACE PROFILE
Date: 5/20/2019	611 Lunken Park Dr Cincinnati, OH	N-S FENCE (CENTER-WEST) WALWORTH AVENUE DEVELOPMENT WALWORTH AVENUE CINCINNATI, OH
Scale: NTS		



Explanation

B-9 — Borehole Number

Moisture Content — %w — LL PL — Liquid and Plastic Limits

Sampling (See General Notes) — Borehole Lithology

AR / BT — Borehole Termination Type

Water Level Reading at time of drilling.

Water Level Reading after drilling.

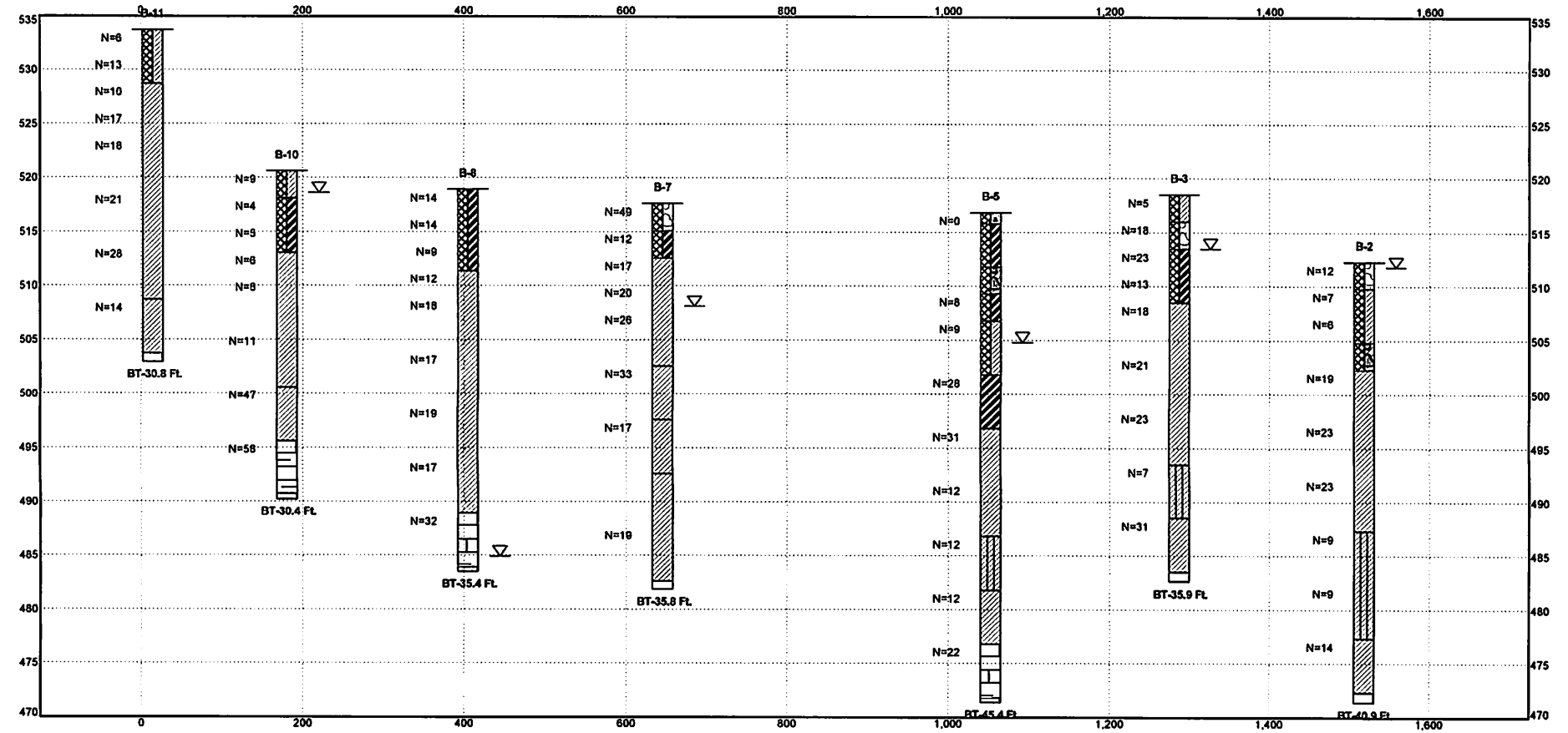
NOTES:

See Exploration Plan for orientation of soil profile.
See General Notes in Supporting Information for symbols and soil classifications.
Soils profile provided for illustration purposes only.
Soils between borings may differ
AR - Auger Refusal
BT - Boring Termination

Project No.: N1185144	Terracon 611 Lunken Park Dr Cincinnati, OH	SUBSURFACE PROFILE N-S FENCE (WEST) WALWORTH AVENUE DEVELOPMENT WALWORTH AVENUE CINCINNATI, OH
Date: 5/20/2019		
Scale: NTS		

W

E



THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. SMART FENCE N1185144 WALWORTH AVENUE D.GPJ TERRACON_DATATEMPLATE.GDT 5/20/19

Explanation

B-2 — Borehole Number

Moisture Content — %w — LL PL — Liquid and Plastic Limits

Sampling (See General Notes) — Borehole Lithology

AR / BT — Borehole Termination Type

Water Level Reading at time of drilling.

Water Level Reading after drilling.

Aggregate Base Course; Lean Clay; Clayey Gravel; Silty Clay; Interbedded Limestone and Shale 1

Fat Clay; Interbedded Shale or Limestone 1; Concrete; Interbedded Limestone and Shale

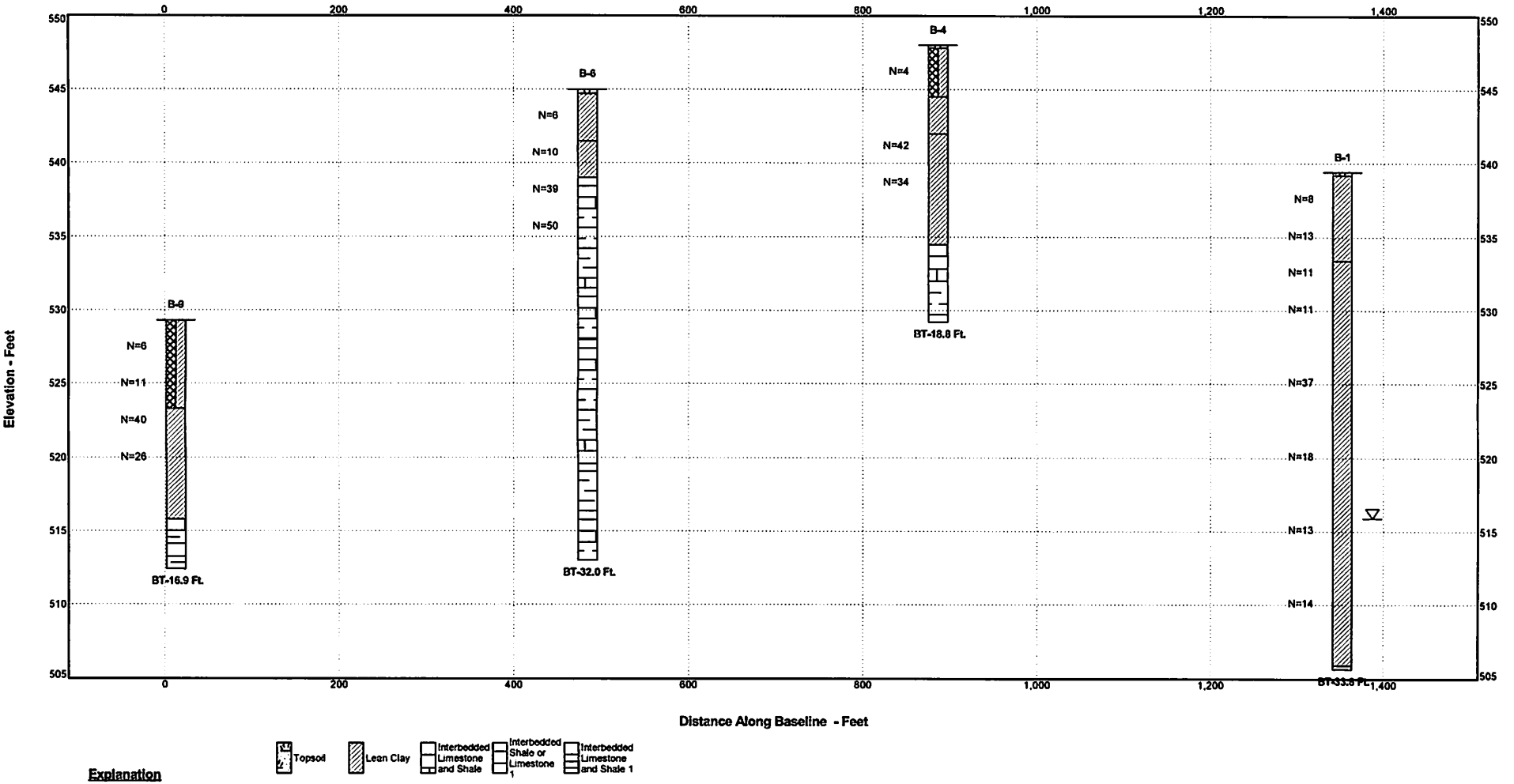
NOTES

See Exploration Plan for orientation of soil profile.
See General Notes in Supporting Information for symbols and soil classifications.
Soils profile provided for illustration purposes only.
Soils between borings may differ
AR - Auger Refusal
BT - Boring Termination

Project No.: N1185144	Terracon	SUBSURFACE PROFILE
Date: 5/20/2019	611 Lunken Park Dr Cincinnati, OH	W-E FENCE (DOWNHILL) WALWORTH AVENUE DEVELOPMENT WALWORTH AVENUE CINCINNATI, OH
Scale: NTS		

◄ W

E ►



Topsoil | Lean Clay | Interbedded Limestone and Shale | Interbedded Shale or Limestone 1 | Interbedded Limestone and Shale 1

Explanation

B-1 — Borehole Number
Moisture Content — %w — LL PL — Liquid and Plastic Limits
Sampling (See General Notes) — Borehole Lithology
AR / BT — Borehole Termination Type
Water Level Reading at time of drilling.
Water Level Reading after drilling.

NOTES:
See Exploration Plan for orientation of soil profile.
See General Notes in Supporting Information for symbols and soil classifications.
Soils profile provided for illustration purposes only.
Soils between borings may differ
AR - Auger Refusal
BT - Boring Termination

Project No.: N1185144	Terracon	SUBSURFACE PROFILE
Date: 5/20/2019	611 Lunken Park Dr Cincinnati, OH	W-E FENCE (UPHILL) WALWORTH AVENUE DEVELOPMENT WALWORTH AVENUE CINCINNATI, OH
Scale: NTS		

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. SMART FENCE N1185144 WALWORTH AVENUE D.GPJ TERRACON_DATATEMPLATE.GDT 5/20/19

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Number of Borings	Boring Depth (feet)	Planned Location
3	16.9 to 33.8	Northern slope (Cincinnati Parks Property)
6	30.4 to 45.4	Within limits of development area
1	16.9	Cul-de-sac
1	30.8	Western detention basin

Boring Layout and Elevations: Terracon personnel provided the boring layout. Coordinates were obtained with a handheld GPS unit (estimated horizontal and vertical accuracy of about ±1 feet).

Subsurface Exploration Procedures: We advanced the borings with a track-mounted rotary drill rig using continuous hollow-stem flight augers. Generally, four samples were obtained in the upper 10 feet of each boring and at intervals of 5 feet thereafter. 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 normal 18-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 depths. We observed and recorded groundwater levels during drilling and sampling. All borings were backfilled with auger cuttings after their completion. Upon encountering bedrock, a sample was typically collected by over-driving the split-spoon sampler. At Boring B-6, about 15-feet of rock coring using a NQ rock core barrel was performed.

The sampling depths, penetration distances, and other sampling information was 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. Our exploration team prepared field boring logs as part of the drilling operations. These field logs included visual classifications of the materials encountered during drilling and our interpretation of the subsurface conditions between samples. Final boring logs were prepared from the field logs. The final boring 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 to understand the engineering properties of the various soil and rock strata, as necessary, for this project.

Procedural standards noted below are for reference to methodology in general. In some cases, variations to methods were applied because of local practice or professional judgment. Standards noted below include reference to other, related standards. Such references are not necessarily applicable to describe the specific test performed.

- ASTM D2216 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- ASTM D4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- ASTM D7263 Standard Test Methods for laboratory Determination of Density (Unit Weight) of Soil Specimens

The laboratory testing program included examination of soil samples by an engineer. Based on the material's texture and plasticity, we described and classified the soil samples in accordance with the Unified Soil Classification System. Rock classification was conducted using locally-accepted practices for engineering purposes. Boring log rock classification was determined using the attached Description of Rock Properties.

SITE LOCATION AND EXPLORATION PLANS

Contents:

Site Location Plan
Exploration Plan

Note: All attachments are one page unless noted above.

SITE LOCATION

Walworth Avenue Development ■ Cincinnati, Hamilton County, Ohio

May 23, 2019 ■ Terracon Project No. N1195144

Terracon GeoReport

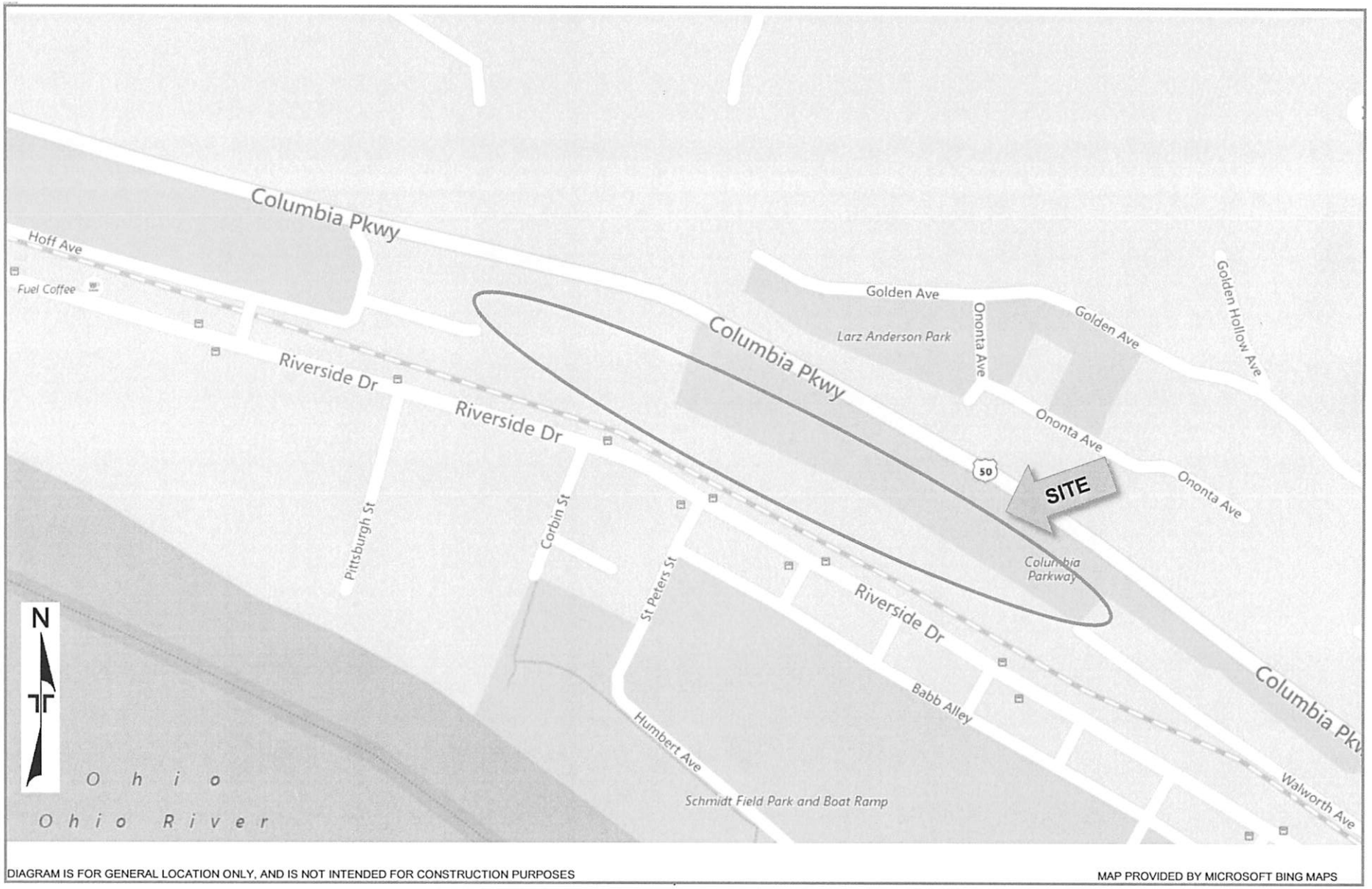


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION PLAN

Walworth Avenue Development ■ Cincinnati, Hamilton County, Ohio

May 23, 2019 ■ Terracon Project No. N1195144

Terracon GeoReport

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

EXPLORATION RESULTS

Contents:

Boring Logs (B-1 through B-11)
Historical Boring Logs (6 pages)

Note: All attachments are one page unless noted above.

BORING LOG NO. B-1

PROJECT: Walworth Avenue Development

CLIENT: East End Developers LLC
Cincinnati, OH

SITE: Walworth Avenue
Cincinnati, OH

LOCATION See Exploration Plan

Latitude: 39.120519° Longitude: -84.445853°

Surface Elev.: 539.4 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	ROD%	LABORATORY HP (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
		0.2	539											
			TOPSOIL (2 INCHES)											
2			**LEAN CLAY (CL)**, trace gravel, root hairs and limestone fragments, olive brown, medium stiff to very stiff											
							11	4-4-4 N=8		3.5 (HP)				
							39	11-7-6 N=13				27		
		6.0	533.5	5										
			LEAN CLAY (CL), trace root hairs and limestone fragments, olive brown with light gray mottling, very stiff to hard (Colluvium)											
							53	3-5-6 N=11		4.5+ (HP)		17		
							100	4-6-5 N=11		4.5+ (HP)		18		
				10										
4							100	9-14-23 N=37		4.5+ (HP)				
				15										
					▽									
							100	5-7-11 N=18		4.5+ (HP)		21	108	
				20										
					▽									
							100	3-5-8 N=13		3.5 (HP)		23		
				25										

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

Hammer Type: Automatic

Advancement Method:
3.25-inch Continuous-Flight Hollow-Stem Augers
2-inch Split-Barrel Sampler

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *Water observed at 23.5' during drilling*

▽ *Water observed at 18' after drilling*

Terracon
611 Lunken Park Dr
Cincinnati, OH

Boring Started: 04-29-2019 | Boring Completed: 04-29-2019

Drill Rig: Geoprobe | Driller: P. Pattison

Project No.: N1185144

BORING LOG NO. B-1

PROJECT: Walworth Avenue Development

CLIENT: East End Developers LLC
Cincinnati, OH

SITE: Walworth Avenue
Cincinnati, OH

LOCATION See Exploration Plan

Latitude: 39.120519° Longitude: -84.445853°

Surface Elev.: 539.4 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (")	FIELD TEST RESULTS	RQD%	LABORATORY HP (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
4														
							0	1-3-11 N=14						
				30										
		33.5	506											
		33.8	505.5				100	50/3"				15		

LEAN CLAY (CL), trace root hairs and limestone fragments, olive brown with light gray mottling, hard (Colluvium) *(continued)*

INTERBEDDED SHALE AND LIMESTONE
Shale: gray, very weak
Limestone: gray, strong

Boring Terminated at 33.75 Feet

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

Hammer Type: Automatic

Advancement Method:
3.25-inch Continuous-Flight Hollow-Stem Augers
2-inch Split-Barrel Sampler

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *Water observed at 23.5' during drilling*

▽ *Water observed at 18' after drilling*

Terracon
611 Lunken Park Dr
Cincinnati, OH

Boring Started: 04-29-2019 | Boring Completed: 04-29-2019

Drill Rig: Geoprobe | Driller: P. Pattison

Project No.: N1185144

BORING LOG NO. B-2

PROJECT: Walworth Avenue Development

CLIENT: East End Developers LLC
Cincinnati, OH

SITE: Walworth Avenue
Cincinnati, OH

LOCATION See Exploration Plan
Latitude: 39.120084° Longitude: -84.446125°
Surface Elev.: 512.3 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (%)	FIELD TEST RESULTS	RQD%	LABORATORY HP (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
					▽									
			FILL - GRAVEL, black and gray			X	67	4-6-6 N=12						
		2.5	510											
1			**FILL - LEAN CLAY**, trace sand, petroleum odor and bedding planes, brown with dark brown			X	67	3-3-4 N=7						
				5		X	100	3-2-4 N=6						
		7.5	505											
			FILL - CLAYEY GRAVEL, black and gray			X	11	7-10-50/3"						
		10.0	502.5	10										
2			**LEAN CLAY (CL)**, trace iron oxide stains, with shale and limestone fragments, brown and gray, very stiff to hard			X	100	7-8-11 N=19		4.5+ (HP)				
				15		X	100	13-10-13 N=23		4.5+ (HP)				
				20		X	100	8-10-13 N=23						
		25.0	487.5	25										

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

Hammer Type: Automatic

Advancement Method:
3.25-inch Continuous-Flight Hollow-Stem Augers
2-inch Split-Barrel Sampler

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *Water observed at 0.5' during drilling*

▽ *Water observed at 0.5' after drilling*

Terracon
611 Lunken Park Dr
Cincinnati, OH

Boring Started: 03-26-2019 | Boring Completed: 03-26-2019

Drill Rig: D-90 | Driller: A. Moore

Project No.: N1185144

BORING LOG NO. B-2

PROJECT: Walworth Avenue Development

CLIENT: East End Developers LLC
Cincinnati, OH

SITE: Walworth Avenue
Cincinnati, OH

LOCATION See Exploration Plan

Latitude: 39.120084° Longitude: -84.446125°

Surface Elev.: 512.3 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	RQD%	LABORATORY HP (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
3			**SILTY CLAY (CL)**, trace gravel, brown to gray, medium stiff to stiff				100	3-4-5 N=9		1.25 (HP)		24		
				30			100	3-4-5 N=9		1.0 (HP)		23		
		35.0	477.5											
2			**LEAN CLAY (CL)**, with limestone fragments, brown with gray, stiff	35			100	5-7-7 N=14		1.5 (HP)		26		
		40.0	472.5											
7		40.9	**INTERBEDDED SHALE AND LIMESTONE** 471.5 Shale: gray, very weak Limestone: gray, strong ***Boring Terminated at 40.9 Feet***	40			56	22-50/5"						

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

Hammer Type: Automatic

Advancement Method:
3.25-inch Continuous-Flight Hollow-Stem Augers
2-inch Split-Barrel Sampler

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Water observed at 0.5' during drilling

Water observed at 0.5' after drilling

Terracon
611 Lunken Park Dr
Cincinnati, OH

Boring Started: 03-26-2019	Boring Completed: 03-26-2019
Drill Rig: D-90	Driller: A. Moore
Project No.: N1185144	

BORING LOG NO. B-3

PROJECT: Walworth Avenue Development

CLIENT: East End Developers LLC
Cincinnati, OH

SITE: Walworth Avenue
Cincinnati, OH

LOCATION See Exploration Plan
Latitude: 39.120455° Longitude: -84.446795°
Surface Elev.: 518.5 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (%)	FIELD TEST RESULTS	RQD%	LABORATORY HP (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
			FILL - LEAN CLAY, with root hairs and coal, brown with gray				67	2-2-3 N=5						
		2.5	516											
			FILL - GRAVEL, with coal, black				100	7-9-9 N=18						
		5.0	513.5											
1			**FILL - FAT CLAY**, with black sand veins and limestone fragments, brown and gray	5	▽		67	19-18-5 N=23						52-24-28
							100	16-6-7 N=13						
		10.0	508.5											
			LEAN CLAY (CL), with shale and limestone fragments, trace fossils, brown with gray, very stiff to hard	10			100	7-9-9 N=18		4.0 (HP)		19		
			- with iron oxide concretions @ 15' to 25'	15			100	6-9-12 N=21		4.5+ (HP)		17	98	
2				20			100	6-9-14 N=23		4.5+ (HP)				
		25.0	493.5	25										

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

Hammer Type: Automatic

Advancement Method:
3.25-inch Continuous-Flight Hollow-Stem Augers
2-inch Split-Barrel Sampler

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *Water observed at 5' during drilling*

No water observed after drilling

Terracon
611 Lunken Park Dr
Cincinnati, OH

Boring Started: 03-26-2019 | Boring Completed: 03-27-2019

Drill Rig: D-90 | Driller: A. Moore

Project No.: N1185144

BORING LOG NO. B-3

PROJECT: Walworth Avenue Development

CLIENT: East End Developers LLC
Cincinnati, OH

SITE: Walworth Avenue
Cincinnati, OH

LOCATION See Exploration Plan

Latitude: 39.120455° Longitude: -84.446795°

Surface Elev.: 518.5 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (%)	FIELD TEST RESULTS	ROD%	LABORATORY HP (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
3			**SILTY CLAY (CL-ML)**, with iron oxide concretions, reddish brown, medium stiff to stiff			X	100	3-4-3 N=7		1.5 (HP)		20		
		30.0		30										
2			**LEAN CLAY (CL)**, with limestone fragments, gray trace brown, hard			X	100	4-17-14 N=31				10		
		35.0												
7		35.9	**INTERBEDDED SHALE AND LIMESTONE**	35		X	67	35-50/5"						
			Shale: gray, very weak											
			Limestone: gray, strong											
			Boring Terminated at 35.9 Feet											

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

Hammer Type: Automatic

Advancement Method:
3.25-inch Continuous-Flight Hollow-Stem Augers
2-inch Split-Barrel Sampler

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *Water observed at 5' during drilling*

No water observed after drilling

Terracon
611 Lunken Park Dr
Cincinnati, OH

Boring Started: 03-26-2019 | Boring Completed: 03-27-2019

Drill Rig: D-90 | Driller: A. Moore

Project No.: N1185144

BORING LOG NO. B-4

PROJECT: Walworth Avenue Development

CLIENT: East End Developers LLC
Cincinnati, OH

SITE: Walworth Avenue
Cincinnati, OH

LOCATION See Exploration Plan
Latitude: 39.12122° Longitude: -84.447241°
Approximate Surface Elev.: 548 (Ft.) +/-

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	RQD%	LABORATORY HP (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
		0.2	548+/-											
			TOPSOIL (2 INCHES)											
1			**FILL - LEAN CLAY**, trace root hairs, limestone fragments and silt lenses, olive brown			X	53	0-1-3 N=4		4.0 (HP)				
		3.5	544.5+/-											
4			**LEAN CLAY (CL)**, with limestone fragments and silt lenses, olive brown, very stiff to hard (Colluvium)	5		X	100	10-50/2"		4.0 (HP)		19		
		6.0	542+/-											
5			**LEAN CLAY**, with limestone fragments, brown, hard (Residuum)			X	100	13-16-26 N=42				14		
				10		X	100	10-14-20 N=34				15		
		13.5	534.5+/-											
7			**INTERBEDDED SHALE AND LIMESTONE** Shale: gray, very weak Limestone: gray, strong	15		X	33	50/3"				8		
		18.8	529+/-			X	100	50/4"				7		
			Boring Terminated at 18.8 Feet											

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

Hammer Type: Automatic

Advancement Method:
3.25-inch Continuous-Flight Hollow-Stem Augers
2-inch Split-Barrel Sampler

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No water observed during drilling

No water observed after drilling

Terracon
611 Lunken Park Dr
Cincinnati, OH

Boring Started: 05-01-2019	Boring Completed: 05-01-2019
Drill Rig: Geoprobe	Driller: P. Pattison
Project No.: N1185144	

BORING LOG NO. B-5

PROJECT: Walworth Avenue Development

CLIENT: East End Developers LLC
Cincinnati, OH

SITE: Walworth Avenue
Cincinnati, OH

LOCATION See Exploration Plan

Latitude: 39.120735° Longitude: -84.447539°

Surface Elev.: 516.8 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (%)	FIELD TEST RESULTS	RQD%	LABORATORY HP (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
		0.0	516.8											
		1.0	516											
			FILL - CONCRETE											
			FILL - FAT CLAY, with limestone fragments, trace roots, black and brown				56	0-0-0 N=0						
							33	3-50/2"						
		5.0	512	5										
			FILL - CLAYEY GRAVEL, with limestone fragments, gray and black				6	50/1"						
1		7.5	509.5		▽									
			FILL - FAT CLAY, with roots, limestone fragments, petroleum odor and wood chips, black and brown				100	5-4-4 N=8						
		10.0	507	10										
			FILL - LEAN CLAY, with petroleum odor, dark gray with black		▽		100	3-3-6 N=9				46		
		15.0	502	15										
			FAT CLAY (CH), with shale and limestone fragments, brown with gray, very stiff				100	10-11-17 N=28		4.25 (HP)				63-25-38
2		20.0	497	20										
			LEAN CLAY (CL), with iron oxide concretions, reddish brown with gray, stiff to very stiff				100	8-14-17 N=31		3.5 (HP)				
				25										

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

Hammer Type: Automatic

Advancement Method:
3.25-inch Continuous-Flight Hollow-Stem Augers
2-inch Split-Barrel Sampler

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *Water observed at 12' during drilling*

▽ *Water observed at 7' after drilling*

Terracon
611 Lunken Park Dr
Cincinnati, OH

Boring Started: 03-26-2019 | Boring Completed: 03-26-2019

Drill Rig: D-90 | Driller: A. Moore

Project No.: N1185144

BORING LOG NO. B-5

PROJECT: Walworth Avenue Development

CLIENT: East End Developers LLC
Cincinnati, OH

SITE: Walworth Avenue
Cincinnati, OH

LOCATION See Exploration Plan
Latitude: 39.120735° Longitude: -84.447539°
Surface Elev.: 516.8 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (%)	FIELD TEST RESULTS	RQD%	LABORATORY HP (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
2			**LEAN CLAY (CL)**, with iron oxide concretions, reddish brown with gray, stiff to very stiff *(continued)*				100	4-4-8 N=12		1.75 (HP)				
		30.0		487										
3			**SILTY CLAY (CL-ML)**, with limestone fragments, brown, medium stiff	30			100	6-5-7 N=12		0.5 (HP)				
		35.0		482										
2			**LEAN CLAY**, with silt lenses, limestone fragments and iron oxide stains, brown, very stiff	35			100	5-4-8 N=12						
		40.0		477										
6			**INTERBEDDED SHALE AND LIMESTONE** Shale: brown and gray, very weak Limestone: gray, strong	40			100	6-6-16 N=22						
		45.0		472										
7		45.4	**INTERBEDDED SHALE AND LIMESTONE** Shale: gray, very weak Limestone: gray, strong ***Boring Terminated at 45.4 Feet***	471.5 45			28	50/5"						

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

Hammer Type: Automatic

Advancement Method:
3.25-inch Continuous-Flight Hollow-Stem Augers
2-inch Split-Barrel Sampler

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *Water observed at 12' during drilling*

▽ *Water observed at 7' after drilling*

Terracon
611 Lunken Park Dr
Cincinnati, OH

Boring Started: 03-26-2019 | Boring Completed: 03-26-2019

Drill Rig: D-90 | Driller: A. Moore

Project No.: N1185144

BORING LOG NO. B-6

PROJECT: Walworth Avenue Development

CLIENT: East End Developers LLC
Cincinnati, OH

SITE: Walworth Avenue
Cincinnati, OH

LOCATION See Exploration Plan

Latitude: 39.121678° Longitude: -84.448529°

Approximate Surface Elev.: 545 (Ft.) +/-

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DESCRIPTION
		0.3	544.5+/-	**TOPSOIL (4 INCHES)**
2		3.5	541.5+/-	**LEAN CLAY (CL)**, trace root hairs and limestone fragments, olive brown with light gray mottling, medium stiff
		6.0	539+/-	**LEAN CLAY (CL)**, trace root hairs, olive brown with light gray mottling, very stiff
6		13.5	531.5+/-	**INTERBEDDED SHALE AND LIMESTONE** Shale: brown with gray, highly weathered, extremely weak Limestone: gray, strong
7		17.0	528+/-	**INTERBEDDED SHALE AND LIMESTONE** Shale: gray, very weak Limestone: gray, strong
				INTERBEDDED SHALE AND LIMESTONE Shale (61%): gray, slightly weathered, laminated, weak Limestone (39%): gray, slightly weathered, fossiliferous with iron staining, strong - vertical fracture in limestone layer at 17.7'

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (%)	FIELD TEST RESULTS	ROD%	LABORATORY HP (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
			89	1-2-4 N=6		1.0 (HP)				
5			100	5-4-6 N=10		3.75 (HP)				
			53	12-16-23 N=39				11		
10			100	11-18-32 N=50				12		
			90	22-50/3"				6		
15										
			90	30-43-50/3"				14		
			83		43					
20										
			25		0					
25										

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

Hammer Type: Automatic

Advancement Method:
3.25-inch Continuous-Flight Hollow-Stem Augers
2-inch Split-Barrel Sampler

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No water observed during drilling

No water observed after drilling

Terracon
611 Lunken Park Dr
Cincinnati, OH

Boring Started: 04-30-2019 | Boring Completed: 04-30-2019

Drill Rig: Geoprobe | Driller: P. Pattison

Project No.: N1185144

BORING LOG NO. B-6

PROJECT: Walworth Avenue Development

CLIENT: East End Developers LLC
Cincinnati, OH

SITE: Walworth Avenue
Cincinnati, OH

LOCATION See Exploration Plan

Latitude: 39.121678° Longitude: -84.448529°

Approximate Surface Elev.: 545 (Ft.) +/-

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	RQD%	LABORATORY HP (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
7				30			100		50					

INTERBEDDED SHALE AND LIMESTONE
Shale (61%): gray, slightly weathered, laminated, weak
Limestone (39%): gray, slightly weathered, fossiliferous with iron staining, strong
(continued)
- extremely weak shale at 27.8'

32.0 513+/-

Boring Terminated at 32 Feet

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

Hammer Type: Automatic

Advancement Method:
3.25-inch Continuous-Flight Hollow-Stem Augers
2-inch Split-Barrel Sampler

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No water observed during drilling

No water observed after drilling

Terracon
611 Lunken Park Dr
Cincinnati, OH

Boring Started: 04-30-2019 | Boring Completed: 04-30-2019

Drill Rig: Geoprobe | Driller: P. Pattison

Project No.: N1185144

BORING LOG NO. B-7

PROJECT: Walworth Avenue Development

CLIENT: East End Developers LLC
Cincinnati, OH

SITE: Walworth Avenue
Cincinnati, OH

LOCATION See Exploration Plan

Latitude: 39.121281° Longitude: -84.448792°

Surface Elev.: 517.6 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (")	FIELD TEST RESULTS	RQD%	LABORATORY HP (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
			FILL - SANDY GRAVEL, with cinders and coal, black to dark gray			X	100	4-4-45 N=49						
1		2.5	515											
1			**FILL - FAT CLAY**, with cinders, coal and limestone fragments, brown and gray			X	100	5-7-5 N=12				29		
1		5.0	512.5											
			LEAN CLAY (CL), silt lenses, shale/limestone fragments and iron oxide concretions, brown, very stiff to hard	5		X	100	5-7-10 N=17				24		
						X	100	7-10-10 N=20				23		
				10	▽	X	100	8-11-15 N=26				21		49-22-27
2		15.0	502.5	15		X	100	14-14-19 N=33						
2			**LEAN CLAY (CL)**, with shale and limestone fragments, trace fossils and iron oxide stains, brown with gray, very stiff to hard											
2		20.0	497.5	20		X	100	10-7-10 N=17						
2			**LEAN CLAY (CL)**, trace iron oxide concretions, dark brown with gray, very stiff to hard											
2		25.0	492.5	25										

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

Hammer Type: Automatic

Advancement Method:
3.25-inch Continuous-Flight Hollow-Stem Augers
2-inch Split-Barrel Sampler

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *Water observed at 9.5' during drilling*

▽ *Water observed at 33' after drilling*

Terracon
611 Lunken Park Dr
Cincinnati, OH

Boring Started: 03-27-2019 | Boring Completed: 03-27-2019

Drill Rig: D-90 | Driller: A. Moore

Project No.: N1185144

BORING LOG NO. B-7

PROJECT: Walworth Avenue Development

CLIENT: East End Developers LLC
Cincinnati, OH

SITE: Walworth Avenue
Cincinnati, OH

LOCATION See Exploration Plan

Latitude: 39.121281° Longitude: -84.448792°

Surface Elev.: 517.6 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	ROD%	LABORATORY HP (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
2						X	67	7-7-50/5"						
				30		X	100	7-9-10 N=19						
		35.0	482.5		▽									
7		35.8	482	35		X	67	32-50/3"						

INTERBEDDED SHALE AND LIMESTONE
Shale: gray, very weak
Limestone: gray, strong

Boring Terminated at 35.75 Feet

LEAN CLAY (CL), with fossils and limestone fragments, brown with gray, hard

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

Hammer Type: Automatic

Advancement Method:
3.25-inch Continuous-Flight Hollow-Stem Augers
2-inch Split-Barrel Sampler

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *Water observed at 9.5' during drilling*

▽ *Water observed at 33' after drilling*

Terracon
611 Lunken Park Dr
Cincinnati, OH

Boring Started: 03-27-2019 | Boring Completed: 03-27-2019

Drill Rig: D-90 | Driller: A. Moore

Project No.: N1185144

BORING LOG NO. B-8

PROJECT: Walworth Avenue Development

CLIENT: East End Developers LLC
Cincinnati, OH

SITE: Walworth Avenue
Cincinnati, OH

LOCATION See Exploration Plan

Latitude: 39.12161° Longitude: -84.449527°

Surface Elev.: 518.9 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (")	FIELD TEST RESULTS	RQD%	LABORATORY HP (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
1			**FILL - FAT CLAY**, with cinders, brick fragments, asphalt fragments, mortar and coal, brown and black			X	100	10-8-6 N=14						
						X	56	10-8-6 N=14						
				5										
						X	100	6-5-4 N=9						
		7.5	511.5											
2			**LEAN CLAY (CL)**, with limestone fragments, trace iron oxide stains and silt lenses, brown to reddish brown, very stiff to hard			X	100	4-6-6 N=12		4.5 (HP)		23	104	
				10		X	100	4-8-10 N=18		4.25 (HP)		20		
				15		X	100	6-7-10 N=17		4.5+ (HP)				
				20		X	100	7-9-10 N=19		4.5+ (HP)				
				25										

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

Hammer Type: Automatic

Advancement Method:
3.25-inch Continuous-Flight Hollow-Stem Augers
2-inch Split-Barrel Sampler

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *Water observed at 34' during drilling*

No water observed after drilling

Terracon
611 Lunken Park Dr
Cincinnati, OH

Boring Started: 03-27-2019 | Boring Completed: 03-28-2019

Drill Rig: D-90 | Driller: A. Moore

Project No.: N1185144

BORING LOG NO. B-8

PROJECT: Walworth Avenue Development

CLIENT: East End Developers LLC
Cincinnati, OH

SITE: Walworth Avenue
Cincinnati, OH

LOCATION See Exploration Plan
Latitude: 39.12161° Longitude: -84.449527°
Surface Elev.: 518.9 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	ROD%	LABORATORY HP (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
2			**LEAN CLAY (CL)**, with limestone fragments, trace iron oxide stains and silt lenses, brown to reddish brown, very stiff to hard *(continued)*			X	100	6-9-8 N=17		4.5+ (HP)				
		30.0		489										
6			**INTERBEDDED SHALE AND LIMESTONE** Shale: gray with brown, very weak Limestone: gray, strong	30		X	100	12-12-20 N=32						
		35.0		484	▽									
7		35.4	**INTERBEDDED SHALE AND LIMESTONE** Shale: gray, very weak Limestone: gray, strong ***Boring Terminated at 35.4 Feet***	483.5	35	X	28	50/5"						

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

Hammer Type: Automatic

Advancement Method:
3.25-inch Continuous-Flight Hollow-Stem Augers
2-inch Split-Barrel Sampler

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *Water observed at 34' during drilling*

No water observed after drilling

Terracon
611 Lunken Park Dr
Cincinnati, OH

Boring Started: 03-27-2019 | Boring Completed: 03-28-2019

Drill Rig: D-90 | Driller: A. Moore

Project No.: N1185144

BORING LOG NO. B-9

PROJECT: Walworth Avenue Development

CLIENT: East End Developers LLC
Cincinnati, OH

SITE: Walworth Avenue
Cincinnati, OH

LOCATION See Exploration Plan
Latitude: 39.122191° Longitude: -84.45006°
Surface Elev.: 529.3 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	RQD%	LABORATORY HP (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
1			**FILL - LEAN CLAY**, trace limestone fragments, gray			X	100	2-3-3 N=6		2.25 (HP)				
						X	100	3-5-6 N=11						
		6.0	523.5	5										
2			**LEAN CLAY (CL)**, trace limestone fragments, brown, hard			X	53	5-8-32 N=40				17		
						X	33	10-11-15 N=26				20		
		13.5	516	10										
7			**INTERBEDDED SHALE AND LIMESTONE** Shale: gray, very weak Limestone: gray, strong			X	100	25-50/3"				16		
				15										
		16.9	512.5			X	100	17-50/5"				10		
			Boring Terminated at 16.9 Feet											

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

Hammer Type: Automatic

Advancement Method:
3.25-inch Continuous-Flight Hollow-Stem Augers
2-inch Split-Barrel Sampler

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No water observed during drilling

No water observed after drilling

Terracon
611 Lunken Park Dr
Cincinnati, OH

Boring Started: 04-29-2019 | Boring Completed: 04-30-2019

Drill Rig: Geoprobe | Driller: P. Pattison

Project No.: N1185144

BORING LOG NO. B-10

PROJECT: Walworth Avenue Development

CLIENT: East End Developers LLC
Cincinnati, OH

SITE: Walworth Avenue
Cincinnati, OH

LOCATION See Exploration Plan

Latitude: 39.121861° Longitude: -84.450252°

Surface Elev.: 520.6 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DESCRIPTION
1		0.0	520.6	
		2.5	518	**FILL - LEAN CLAY**, with cinder and bricks, black to brown
		7.5	513	**FILL - FAT CLAY**, with cinders, roots and bricks, gray and brown
2		20.0	500.5	**LEAN CLAY (CL)**, with limestone fragments, iron oxide stains and silt lenses, brown and gray, medium stiff to very stiff
5		25.0	495.5	**LEAN CLAY (CL)**, with limestone fragments, light brown, hard (Residuum)

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (%)	FIELD TEST RESULTS	ROD%	LABORATORY HP (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	▽		67	2-6-3 N=9						
			67	1-1-3 N=4						
5			100	3-2-3 N=5						
			100	2-3-3 N=6		1.75 (HP)		18		
10			100	2-5-3 N=8		2.0 (HP)		27		
15			100	4-5-6 N=11		2.75 (HP)		24		
20			100	11-19-28 N=47				12		
25										

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

Hammer Type: Automatic

Advancement Method:
3.25-inch Continuous-Flight Hollow-Stem Augers
2-inch Split-Barrel Sampler

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *Water observed at 2' during drilling*

No water observed after drilling

Terracon
611 Lunken Park Dr
Cincinnati, OH

Boring Started: 03-28-2019	Boring Completed: 03-28-2019
Drill Rig: D-90	Driller: A. Moore
Project No.: N1185144	

BORING LOG NO. B-10

PROJECT: Walworth Avenue Development

CLIENT: East End Developers LLC
Cincinnati, OH

SITE: Walworth Avenue
Cincinnati, OH

MODEL LAYER	GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 39.121861° Longitude: -84.450252° Surface Elev.: 520.6 (Ft.) DEPTH / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	ROD%	LABORATORY HP (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
7		**INTERBEDDED SHALE AND LIMESTONE** Shale: gray, very weak Limestone: gray, strong				33	19-33-25 N=58						
		30.4 490	30			28	50/5"						
		Boring Terminated at 30.4 Feet											

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

Hammer Type: Automatic

Advancement Method:
3.25-inch Continuous-Flight Hollow-Stem Augers
2-inch Split-Barrel Sampler

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *Water observed at 2' during drilling*

No water observed after drilling

Terracon
611 Lunken Park Dr
Cincinnati, OH

Boring Started: 03-28-2019 | Boring Completed: 03-28-2019

Drill Rig: D-90 | Driller: A. Moore

Project No.: N1185144

BORING LOG NO. B-11

PROJECT: Walworth Avenue Development

CLIENT: East End Developers LLC
Cincinnati, OH

SITE: Walworth Avenue
Cincinnati, OH

LOCATION See Exploration Plan

Latitude: 39.122158° Longitude: -84.450709°

Surface Elev.: 533.7 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	ROD%	LABORATORY HP (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
1		0.0	533.7			X	56	3-3-3 N=6						
						X	100	5-6-7 N=13						
				5		X	100	5-5-5 N=10		4.25 (HP)		25		62-27-35
						X	100	9-7-10 N=17		4.5+ (HP)		20		
				10		X	100	5-10-8 N=18		4.5+ (HP)		17		
2								- rock fragments encountered @ 15'						
				15		X	100	7-12-9 N=21		4.5+ (HP)				
				20		X	100	4-16-12 N=28		4.5+ (HP)				
		25.0	508.5	25										

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

Hammer Type: Automatic

Advancement Method:
3.25-inch Continuous-Flight Hollow-Stem Augers
2-inch Split-Barrel Sampler

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No water observed during drilling

No water observed after drilling

Terracon
611 Lunken Park Dr
Cincinnati, OH

Boring Started: 03-28-2019 | Boring Completed: 03-28-2019

Drill Rig: D-90 | Driller: A. Moore

Project No.: N1185144

BORING LOG NO. B-11

PROJECT: Walworth Avenue Development

CLIENT: East End Developers LLC
Cincinnati, OH

SITE: Walworth Avenue
Cincinnati, OH

MODEL LAYER	GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 39.122158° Longitude: -84.450709° Surface Elev.: 533.7 (Ft.) DEPTH / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	RQD%	LABORATORY HP (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
5		**LEAN CLAY (CL)**, with limestone fragments, light brown, hard (Residuum) 30.0 / 503.5			X	67	3-5-9 N=14		4.5+ (HP)				
7		**INTERBEDDED SHALE AND LIMESTONE** 30.8 / 503 Shale: gray, very weak Limestone: gray, strong ***Boring Terminated at 30.75 Feet***	30		X	67	35-50/3"						

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

Hammer Type: Automatic

Advancement Method:
3.25-inch Continuous-Flight Hollow-Stem Augers
2-inch Split-Barrel Sampler

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No water observed during drilling

No water observed after drilling

Terracon
611 Lunken Park Dr
Cincinnati, OH

Boring Started: 03-28-2019	Boring Completed: 03-28-2019
Drill Rig: D-90	Driller: A. Moore
Project No.: N1185144	

Form No. 630—16-59

THE H. C. NUTTING COMPANY

4120 AIRPORT ROAD
CINCINNATI 26, OHIO

TESTING ENGINEERS AND SOILS CONSULTANTS

12-4-67 jh
Order No. 99.998

LOG OF BORING

DATE STARTED 8-6-67 SAMPLER: TYPE S.S. DIA. 2"O.D. WATER ELEV. IMMEDIATE None CLIENT: City of Cincinnati, Ohio
DATE COMPLETED 8-6-67 CASING: LENGTH HSA DIA. 2.25"I.D. AFTER 1 HOURS Backfilled PROJECT: Columbia Parkway, Proj.#2138
HAM 50-24.91 Collins Avenue to Aspasia Street
BORING No. H-60 STATION AND OFFSET 150+25, 50'Rt. of Baseline SURFACE ELEV. 592.8'

ELEV.	DEPTH	SAMPLE No.	STD. PEN. (N)	% REC.	DESCRIPTION	Physical Characteristics: % AGG.	% C.S.	% F.S.	% SILT	% CLAY	L.L.	P.I.	W.C.	SHTL CLASS
592.8	0				Concrete	Visual								
592.3														
	2	1	2-1-1	3"	Brown sand and gravel,(FILL) dry -very loose	Visual								
	4	2	2-2-2	4"	do do do	49	25	8	-13-				4	A-1-b
587.8														
	6	3	2-6-4	8"	Brown silty clay and limestone fragments (FILL) moist - medium stiff	51	9	4	16	20	36	16	16	A-6b
	8	4	8-12-10	10"	do do do	Visual								
582.8	10													
	12	5	4-6-6	8"	Brown clay and limestone fragments, (FILL) moist - very stiff	53	6	3	14	24	43	20	16	A-7-6
		6	10-10	8"	do do do	Visual								
577.8	14													
	16	7	5-6-7	15"	Brown and gray CLAY,trace limestone fragments, moist - stiff	2	4	3	32	59	42	20	19	A-7-6
	18	8	7-5-6	8"	do do do	Visual								
	20													
571.3		9	6-7-8	14"	do do do	2	4	2	33	59	43	20	15	A-7-6
	22													
	24													
	26	10	12-16-14	14"	Brown silty CLAY and limestone fragments moist - very stiff	43	10	4	17	26	39	19	21	A-6b
	28													
564.0		11	22-34-34	12"	do do do	Visual								
	30				Boring Completed									
	32													
	34													

Form No. 630—1659

THE H. C. NUTTING COMPANY

4120 AIRPORT ROAD
CINCINNATI 26, OHIO

TESTING ENGINEERS AND SOILS CONSULTANTS

12-7-67 jh
Order No.99.998 Page 1 o 2

LOG OF BORING

DATE STARTED 8-24-67 SAMPLER: TYPE S.S. DIA. 2"O.D. WATER ELEV. IMMEDIATE None CLIENT: City of Cincinnati, Ohio

DATE COMPLETED 8-24-67 CASING: LENGTH HSA DIA. 2.25"I.D. AFTER ____ HOURS Backfilled PROJECT: Columbia Parkway, Proj.#2138 HAM 50-24.91, Collins Avenue to Aspasia Street

BORING No. 61 STATION AND OFFSET 150+09, 135'Rt. of Baseline SURFACE ELEV. 506.3

ELEV.	DEPTH	SAMPLE No.	STD. PEN. 00	% REC.	DESCRIPTION	Physical Characteristics								
						% AGG.	% C.S.	% F.S.	% SILT	% CLAY	L.L.	P.I.	W.C.	SHTT. CLASS
560.3	0													
	2	1	8-6-7	12"	Topsoil, brown clay with rock, (FILL) moist - stiff	Visual								
557.8														
	4	2	9-9-6	14"	Brown and gray clay, trace limestone fragments, (FILL) moist - stiff	7	4	3	32	54	45	22	15	A-7-6
555.3														
	6	3	10-9-7	8"	Brown and gray clay with limestone fragments, ashes and cinders, (FILL) moist - stiff	22	2	2	21	53	50	26	16	A-7-6
	8	4	24-14-16	14"	do do do	Visual								
550.3	10													
	12	5	14-14-14	12"	Brown CLAY and limestone fragments, moist - very stiff	64	10	5	7	14	33	16	15	A-2-6
	14	6	14-12-16	8"	do do do	Visual								
545.3														
	16	7	12-16-22	8"	Brown CLAY with limestone fragments, moist - very stiff	14	7	3	26	50	46	24	16	A-7-6
542.8	18													
	20	8	20-30-42	12"	Brown highly weathered SHALE with limestone fragments, moist - hard	28	6	3	25	38	41	20	15	A-7-6
540.3														
	22	9	40-60	12"	Brown and gray weathered SHALE	Visual								
	24													
535.3														
	26	10	60-66	12"	Gray SHALE with thin layers of limestone	Visual								
	28													
	30													
	32	11	80-106	10"	do do do	Visual								
	34													

Form No. 630—10-59

THE H. C. NUTTING COMPANY

4120 AIRPORT ROAD
CINCINNATI 26, OHIO

TESTING ENGINEERS AND SOILS CONSULTANTS

12-7-67 jh
Order No.99.998, Page 2 of 2

LOG OF BORING

DATE STARTED 8-24-67 SAMPLER: TYPE S.S. DIA. 2"O.D. WATER ELEV. IMMEDIATE None CLIENT: City of Cincinnati, Ohio

DATE COMPLETED 8-24-67 CASING: LENGTH HSA DIA 2.25"I.D. AFTER ____ HOURS Backfilled PROJECT: Columbia Parkway, Proj.#2138 RAM 50-24.91, Collins Avenue to Aspasia Street

BORING No. 61 STATION AND OFFSET 150+09, 135'Rt. of Baseline SURFACE ELEV. 506.3

ELEV.	DEPTH	SAMPLE No.	STD. PEN. (N)	% REC.	DESCRIPTION	Physical Characteristics: % AGG.	% C.S.	% F.S.	% SILT	% CLAY	L.L.	P.I.	W.C.	SMTL CLASS
	34													
	36	12	125	5"	Gray SHALE with thin layers of limestone	Visual								
	38													
	40													
	42	13	120-132	9"	do do do	Visual								
	44													
514.0	46	14	130-138	12"	do do do	Visual								
	48				Boring Completed									
	50													
	52													
	54													
	56													
	58													
	60													
	62													
	64													
	66													
	68													

Form No. 636—16-59

THE H. C. NUTTING COMPANY

4120 AIRPORT ROAD
CINCINNATI 26, OHIO

TESTING ENGINEERS AND SOILS CONSULTANTS

12-7-67 jh
Order No.99.998

LOG OF BORING

DATE STARTED 8-25-67 SAMPLER: TYPE S.S. DIA. 2"O.D. WATER ELEV. IMMEDIATE None CLIENT: City of Cincinnati, Ohio

DATE COMPLETED 8-25-67 CASING: LENGTH HSA. DIA. 2.25"I.D. AFTER Backfilled-Upon Completion HOURS PROJECT: Columbia Parkway, Proj.#2138 HAM 50-24.91, Collins Avenue to Aspasia Street

BORING No. 62 STATION AND OFFSET 153+50, 45'Rt. of Baseline SURFACE ELEV. 596.5'

ELEV.	DEPTH	SAMPLE No.	STD. PEN. (#)	% REC.	DESCRIPTION	Physical Characteristics								
						% AGG.	% C.S.	% F.S.	% SILT	% CLAY	L.L.	P.I.	W.C.	SHTL CLASS
596.5	0				Concrete	Visual								
596.0														
	2	1	4-4-6	10"	Brown and gray clay, trace of limestone fragments, (FILL) moist - stiff	14	7	5	28	46	42	20	19	A-7-6
594.0														
	4	2	6-4-6	10"	Mottled brown and gray CLAY, moist - stiff	Visual								
	6	3	6-7-10	9"	do do do	2	3	3	33	59	45	22	18	A-7-6
589.0	8													
		4	12-17-20	10"	Brown and gray highly weathered SHALE, moist - hard	2	0	1	34	63	46	23	11	A-7-6
586.5	10													
	12	5	16-18-26	12"	Brown and gray weathered SHALE with thin layers of limestone	Visual								
	14	6	18-20-27	14"	do do do	Visual								
	16	7	20-37-50	10"	do do do	Visual								
	18	8	25-43-62	12"	do do do	Visual								
576.5	20													
	22	9	30-35-43	12"	Gray and brown SHALE with thin layers of limestone	Visual								
	24													
571.0		10	40-80-120	16"	do do do	Visual								
	26													
	28				Boring Completed									
	30													
	32													
	34													

Form No. 830—16-59

THE H. C. NUTTING COMPANY

4120 AIRPORT ROAD
CINCINNATI 26, OHIO

TESTING ENGINEERS AND SOILS CONSULTANTS

12-7-67 jh
Order No. 99.998

LOG OF BORING

DATE STARTED 8-28-67 SAMPLER: TYPE S.S. DIA. 2"O.D. WATER ELEV. IMMEDIATE None CLIENT: City of Cincinnati, Ohio

DATE COMPLETED 8-28-67 CASING: LENGTH BSA. DIA. 2.25"I.D. AFTER ____ HOURS Backfilled PROJECT: Columbia Parkway, Proj.#2138 HAM 50-24.91 Collins Avenue to Aspasia Street

BORING No. 63 STATION AND OFFSET 153+50, 145'Rt. of Baseline SURFACE ELEV. 566.5'

ELEV.	DEPTH	SAMPLE No.	STD. PEN. ON	% REC.	DESCRIPTION	Physical Characteristics								
						% AGG.	% C.S.	% F.S.	% SILT	% CLAY	L.L.	P.I.	W.C.	SHTL CLASS
566.5	0													
	2	1	3-3-3	6"	Topsoil and clay (FILL) dry - medium stiff	Visual								
564.0														
	4	2	8-7-8	10"	Brown clay with limestone fragments, (FILL) dry - very stiff	15	4	3	24	54	48	24	14	A-7-6
561.5														
	6	3	8-9-12	6"	Brown and gray highly weathered SHALE, dry- hard	23	1	2	23	51	49	26	13	A-7-6
559.0	8													
		4	8-12-16	8"	Brown weathered SHALE with thin layers of limestone	Visual								
	10													
	12	5	22-20-24	14"	do do do	Visual								
		6	38-42	10"	do do do	Visual								
	14													
	16	7	28-31-41	16"	do do do	Visual								
	18	8	28-28-36	7"	do do do	Visual								
546.5	20													
		9	14-24-46	12"	Gray and brown SHALE with thin layers of limestone	Visual								
	22													
	24													
541.0		10	40-48-60	12"	do do do	Visual								
	26													
					Boring Completed									
	28													
	30													
	32													
	34													

Form No. 530—16-59

THE H. C. NUTTING COMPANY

4120 AIRPORT ROAD
CINCINNATI 26, OHIO

TESTING ENGINEERS AND SOILS CONSULTANTS

8-1-67 jh

LOG OF BORING

DATE STARTED 5-25-67 SAMPLER: TYPE NXM SS DIA. 2-1/8"I.D. 2"O.D. WATER ELEV. IMMEDIATE None CLIENT: City of Cincinnati, Ohio

DATE COMPLETED 5-25-67 CASING: LENGTH HSA DIA. 3.5"I.D. AFTER ____ HOURS Backfilled PROJECT: Columbia Parkway, Proj.#2138 HAM 50-24.91, Collins Ave.to Aspasia St.

BORING No. H-65 STATION AND OFFSET 161+25, 50'Rt.of Baseline SURFACE ELEV. 579.1

ELEV.	DEPTH	SAMPLE No.	STD. PEN. (N)	% REC.	DESCRIPTION	Physical Characteristics % AGG.	% C.S.	% F.S.	% SILT	% CLAY	L.L.	P.I.	W.C.	SHTL CLASS
579.1	0													
	2	1	6-8-10	10"	Cinders and Clay, (FILL)	Visual								
576.6														
	4	2	6-8-11	15"	Dark brown clay, trace cinders,(FILL) moist - medium stiff	2	2	5	35	56	52	24	28	A-7-6
574.1														
	6	3	7-9-14	16"	Brown CLAY, moist - stiff	0	6	7	41	46	49	24	26	A-7-6
	8	4	8-8-12	18"	do do	Visual								
569.1	10													
	12	5	13-18-22	10"	Brown highly weathered SHALE, moist - very stiff	36	8	6	16	34	35	15	18	A-6a
566.6														
	14	6	17-19-33	8"	Brown highly weathered SHALE and LIMESTONE, moist - very stiff	Visual								
	16	7	19-31-41	10"	do do do	35	6	3	21	35	36	14	15	A-6a
561.6	18													
		8	27-35-30	16"	Brown and gray weathered SHALE	Visual								
559.1	20													
557.6		R-1		81%	Layered gray SHALE, medium tough & gray fossiliferous limestone, jointed approx. 25 to 30% limestone in ½"to 4"pieces.									
	22													
	24	R-2		71%	Layered gray SHALE,medium tough to tough and gray fossiliferous limestone, 2 pieces 1" and 2½"									
554.1														
	26				Boring Completed									
	28													
	30													
	32													
	34													

Form No. 530—16-59

THE H. C. NUTTING COMPANY

4120 AIRPORT ROAD
CINCINNATI 26, OHIO

TESTING ENGINEERS AND SOILS CONSULTANTS 8-1-67 jh

LOG OF BORING

DATE STARTED 5-31-67 SAMPLER: TYPE NXM 2-1/8"ID DIA. SS 2"O.D. WATER ELEV. IMMEDIATE None CLIENT: City of Cincinnati, Ohio

DATE COMPLETED 5-31-67 CASING: LENGTH HSA DIA. 2.25"I.D. 3.5"I.D. AFTER Backfilled HOURS PROJECT: Columbia Parkway, Proj.#2138 HAM 50-24.91, Collins Ave.to Aspasia Street

BORING No. 66 STATION AND OFFSET 161+25, 145'Rt.of Baseline SURFACE ELEV. 546.6

ELEV.	DEPTH	SAMPLE No.	STD. PEN. (N)	% REC.	DESCRIPTION	Physical Characteristics: % AGG.	% C.S.	% F.S.	% SILT	% CLAY	L.L.	P.I.	W.C.	SHTL CLASS
546.6	0													
545.6		1A	2-2	14"	Black clay, some cinders, (FILL) moist-med. stiff	Visual								
	2	1B	2		Brown clay with limestone fragments, (FILL) moist - medium stiff	9	3	3	30	55	45	22	20	A-7-6
544.1														
	4	2	4-5-6	*	Brown CLAY with limestone fragments, moist - stiff	24	6	4	17	49	49	26	22	A-7-6
542.1														
	6	3	8-13-50	15"	Brown highly weathered SHALE and limestone fragments, moist - very stiff	13	5	2	28	52	41	20	16	A-7-6
539.6														
	8	4	13-30	12"	Brown weathered SHALE with limestone fragments, moist- hard	Visual								
	10	5	27-33-30	18"	do do do	Visual								
534.6	12													
	14	R-1		70%	Layered brown weathered SHALE, jointed, soft and gray fossiliferous limestone jointed, iron oxide stained, two 1" pieces									
530.6	16													
	18				Layered brown weathered SHALE, trace of gray shale in the bottom 3", jointed, soft to medium tough and gray fossiliferous limestone, jointed in the lower half, approx.15 to 20% limestone in ½" to 7½" pieces.									
	20	R-2		85%										
525.6														
	22				Layered gray SHALE, medium tough to tough and gray fossiliferous limestone, jointed and iron oxide stained, approx.15% limestone in ½" to 5" pieces.									
	24	R-3		100%										
520.6	26													
	28				Boring Completed									
	30	* Auger Sample												
	32													
	34													

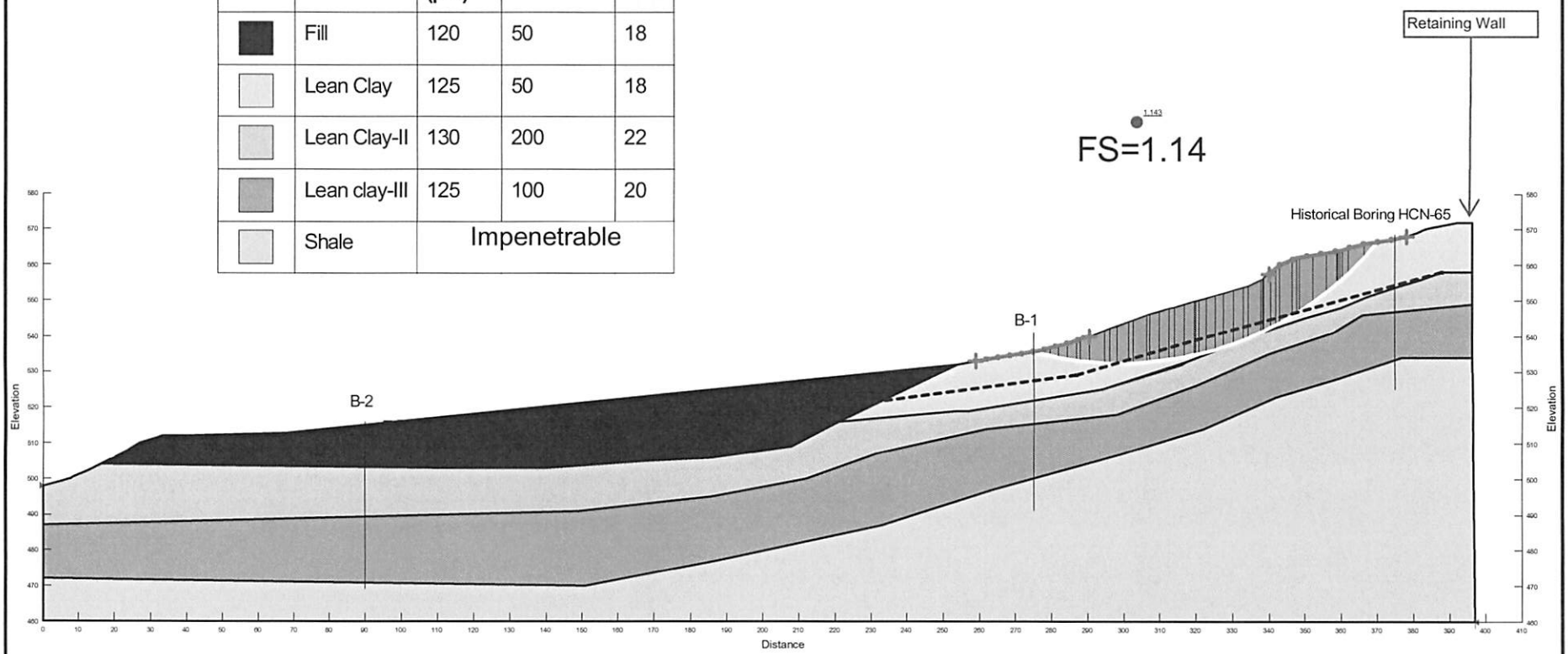
SLOPE STABILITY ANALYSES

Contents:

Results of Slope Stability Analyses (2 pages)

Note: All attachments are one page unless noted above.

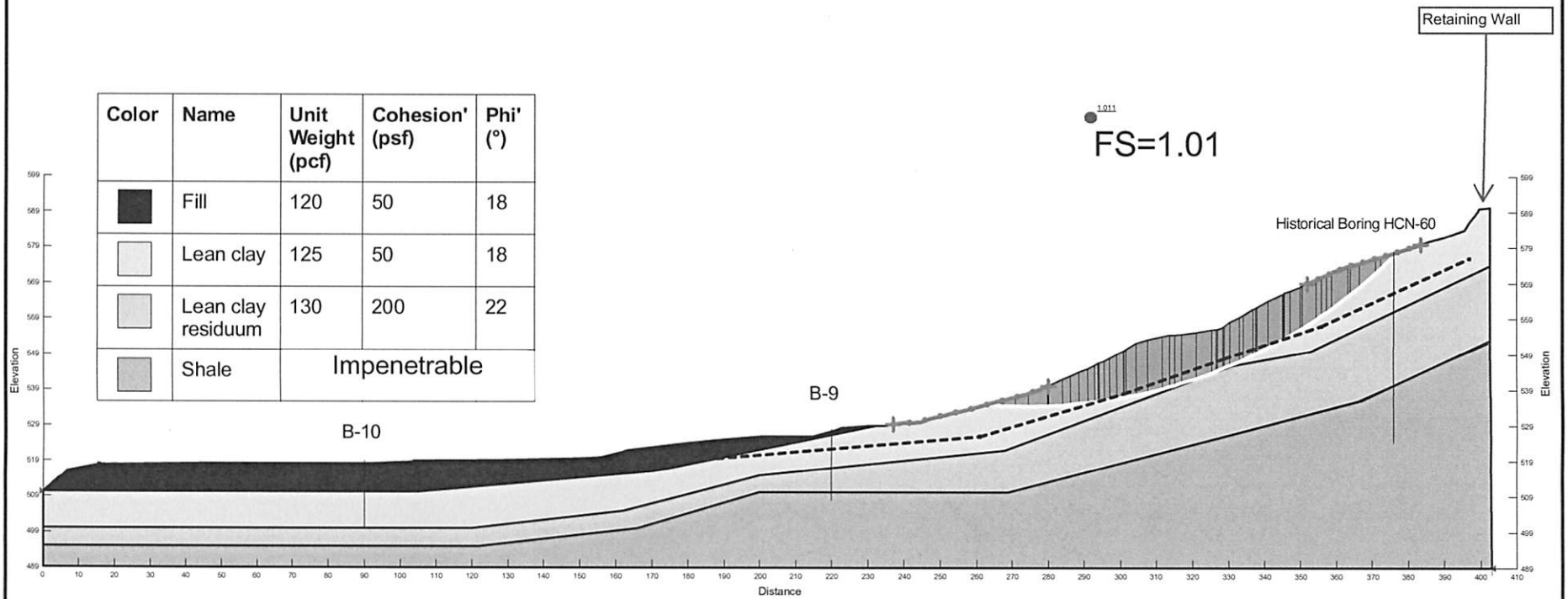
Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Fill	120	50	18
	Lean Clay	125	50	18
	Lean Clay-II	130	200	22
	Lean clay-III	125	100	20
	Shale	Impenetrable		



Cross Section with Borings B-1 and B-2

Terracon Project Number : N1185144
Project Name : Walworth Avenue Development
Cross Section with Borings B-1 and B-2

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Fill	120	50	18
	Lean clay	125	50	18
	Lean clay residuum	130	200	22
	Shale	Impenetrable		



Cross Section with Borings B-9 and B-10

Terracon Project Number: N1185144
Project Name: Walworth Avenue Development
Cross Section with Borings B-9 and B-10

SUPPORTING INFORMATION

Contents:

General Notes
Unified Soil Classification System
Description of Rock Properties
Geotechnical Engineering Report for Walworth Development – Borrow Sites (25 pages)

Note: All attachments are one page unless noted above.

GENERAL NOTES
DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

Terracon GeoReport

SAMPLING	WATER LEVEL	FIELD TESTS
Rock Core Standard Penetration Test Split Spoon	Water Initially Encountered Water Level After a Specified Period of Time Water Level After a Specified Period of Time Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.	N Standard Penetration Test Resistance (Blows/Ft.) (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 is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no 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		
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength Qu, (tsf)**	**Standard Penetration or N-Value Blows/Ft.**
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

RELATIVE PROPORTIONS OF SAND AND GRAVEL		RELATIVE PROPORTIONS OF FINES	
Descriptive Term(s) of other constituents	Percent of Dry Weight	**Descriptive Term(s) of other constituents**	**Percent of Dry Weight**
Trace	<15	Trace	<5
With	15-29	With	5-12
Modifier	>30	Modifier	>12
GRAIN SIZE TERMINOLOGY		**PLASTICITY DESCRIPTION**	
Major Component of Sample	**Particle Size**	**Term**	**Plasticity Index**
Boulders	Over 12 in. (300 mm)	Non-plastic	0
Cobbles	12 in. to 3 in. (300mm to 75mm)	Low	1 - 10
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)	Medium	11 - 30
Sand	#4 to #200 sieve (4.75mm to 0.075mm	High	> 30
Silt or Clay	Passing #200 sieve (0.075mm)		

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	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]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [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]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [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 on or above "A"		CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]		ML	Silt [K, L, M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried	< 0.75	OL	Organic clay [K, L, M, N] / Organic silt [K, L, M, O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line		CH	Fat clay [K, L, M]
			PI plots below "A" line		MH	Elastic Silt [K, L, M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried	< 0.75	OH	Organic clay [K, L, M, P] / Organic silt [K, L, M, Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

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

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

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

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

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

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

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

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

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

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

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

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

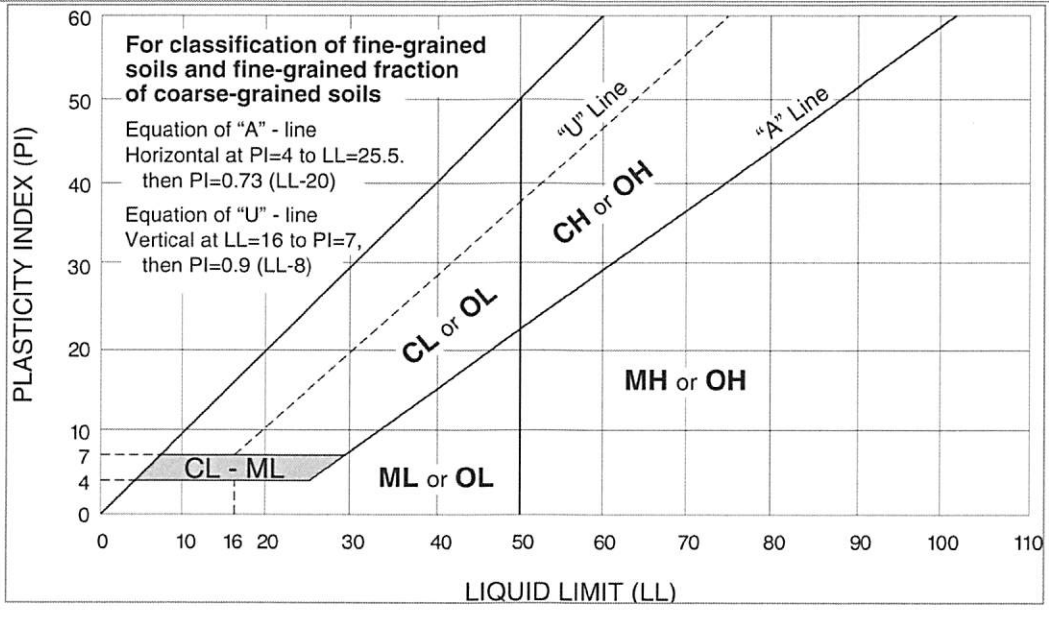
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

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

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

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

[Q] PI plots below "A" line.



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

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

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

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

ROCK QUALITY DESIGNATION (RQD) [1]	
Description	**RQD Value (%)**
Very Poor	0 - 25
Poor	25 – 50
Fair	50 – 75
Good	75 – 90
Excellent	90 - 100

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

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

Terracon GeoReport

Geotechnical Engineering Report

Walworth Development - Borrow Sites
Cincinnati, Hamilton County, Ohio
April 25, 2019
Terracon Project No. N1195144

Prepared for:
East End Developers LLC
Cincinnati, Ohio

Prepared by:
Terracon Consultants, Inc.
Cincinnati, Ohio

April 25, 2019

East End Developers LLC
4010 N. Bend Road Suite 301
Cincinnati, Ohio 45211

Attn: Mr. Ralph Meierjohan
P: (513) 662-3111
E: ralphm@meierjohanbuildinggroup.com

Re: Geotechnical Engineering Report
Walworth Development - Borrow Sites
6896 Harrison Avenue & 6025 Ohio SR-128
Cincinnati, Hamilton County, Ohio
Terracon Project No. N1195144

Dear Mr. Meierjohan:

We have completed the Geotechnical Engineering services for the two borrow sites considered for the proposed earthwork at the Walworth Avenue development. This study was performed in general accordance with Terracon Proposal No. PN1195144. This report presents the findings of the test pit explorations at the borrow sites and provides geotechnical recommendations concerning the proposed excavations and the suitability of the use of the cut-soils for the proposed earthwork as part of the development.

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

Sincerely,
Terracon Consultants, Inc.

Craig M. Davis, PE, CPSCE
Senior Engineer

Ronald S. Lech, PE
Geotechnical Department Manager

REPORT TOPICS

INTRODUCTION 1
SITE CONDITIONS 1
PROJECT DESCRIPTION 2
GEOTECHNICAL CHARACTERIZATION 3
EARTHWORK 3
GENERAL COMMENTS 5

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

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES
SITE LOCATION AND EXPLORATION PLANS
EXPLORATION RESULTS
SUPPORTING INFORMATION

Note: Refer to each individual Attachment for a listing of contents.

Geotechnical Engineering Report
Walworth Development - Borrow Sites
6896 Harrison Avenue & 6025 Ohio SR-128
Cincinnati, Hamilton County, Ohio
Terracon Project No. N1195144
April 25, 2019

INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed Walworth Development borrow sites to be located at 6896 Harrison Avenue & 6025 Ohio SR-128 in Cincinnati, Hamilton County, Ohio. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil and rock conditions
- Site preparation and earthwork
- Suitability for the reuse of the cut-soils as fill

The geotechnical engineering Scope of Services for this project included the observation of test pits excavated at each site, laboratory testing of the recovered samples and engineering analyses.

Maps showing the site and test pit locations are shown in the Site Location and Exploration Plan sections, respectively. The results of the laboratory testing performed on the soil samples obtained from the site during the field exploration as separate tables/graphs in the Exploration Results section.

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 borrow site properties (parcels) are located at 6896 Harrison Avenue & 6025 Ohio SR-128 in the vicinity of Miamitown, Cincinnati, Hamilton County, Ohio. The OH-128 site is proposed to be graded into 2 primary terraces. Our study was limited to the proposed upper terrace. See Site Location

Item	Description
Existing Conditions	▫ **Harrison Avenue Site**: Consists of a partly-wooded hillside with the remnants of several building structures and the associated pavements. ▫ **OH-128 Site**: Consists of an agricultural field with a grass/weed cover and perimeter fence. Site appears to have been subject to past cutting/earthwork.
Existing Topography (from site plans provided)	▫ **Harrison Ave. Site**: Site grades are at elevations ranging from about 566 feet to 610 feet above mean sea level. Slopes are at inclinations that are locally as steep as 2.7 horizontal to 1 vertical (2.7H:1V), but generally flatter than about 4H:1V. ▫ **OH-128 Site**: Site grades are at elevations ranging from about 540 feet to 700 feet above mean sea level. The grades of the upper terrace (to which this study was limited) range from about El. 620 to 690. Slopes are at inclinations that are locally as steep as about 2.4H:1V, but generally flatter than about 3H:1V.

PROJECT DESCRIPTION

Our initial understanding of this portion of the Walworth Development project was based upon conversations with our client and the project civil engineer, Abercrombie & Associates, Inc. (Abercrombie). We were provided with the Grading Plans for the Harrison Ave. site, dated 4/22/19 and the OH-128 site, dated 3/29/19. The project, as it pertains to the aforementioned sites, consists of performing excavations for the purposes of developing suitable borrow materials for use as fill at the Walworth Development project site located at the eastern terminus of Walworth Avenue in the East End, Cincinnati, Ohio.

Test pits at each site were completed on April 14, 2019 by the property owner, Mr. Dave House, and/or his contractor. Test pit locations were established prior to the field work to provide uniform coverage of proposed cut areas, as depicted on the Grading Plans. The test pits were relatively logged by Terracon's field geologist, then backfilled. Grab samples were obtained from each test pit for further evaluation, classification and laboratory testing to determine the compaction properties of the soils and/or bedrock. These tests were performed on representative samples to determine natural moisture content, Atterberg limits, and standard Proctor moisture-density relationships.

Our services were limited to the assessment of the suitability of the soils encountered in the test pits for use as fill at the Walworth Development. Erosion and sediment control measures have been designed by Abercrombie and depicted on the Grading Plan sets. Our services did not include the evaluation of the global stability of the subject properties and adjacent properties or evaluation/recommendations for redevelopment of the sites or building construction. Additional geotechnical exploration and engineering analyses would be required for those purposes.

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

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. Conditions encountered at each test pit and lab test results can be found in the Exploration Results section. Groundwater was not encountered in any of the test pits during the short duration that they were left exposed.

Harrison Ave. Site: The soil profile consists of overburden soils consisting of topsoil and lean clay underlain bedrock, an interbedded system of Ordovician Age shale and limestone. Comparisons of bedrock elevation in the test pits to the geologic column of the Cincinnati area indicate the bedrock categorizes as the Southgate and McMicken Members of the Kope Formation. See Test Pit Observations - Harrison Ave. Site in Exploration Results section for conditions encountered at each test pit.

OH-128 Site: The soil profile consists of overburden soils consisting of topsoil and lean clay underlain by bedrock, an interbedded system of Ordovician Age shale and limestone. Comparisons of bedrock elevation in the test pits to the geologic column of the Cincinnati area indicate the bedrock categorizes as the McMicken Member of the Kope Formation (lower zone) to the Mt. Hope Member of the Fairview Formation (upper zone). The contact between these formations is generally assumed at around El. 660. See Test Pit Observations - OH-128. Site in Exploration Results section for conditions encountered at each test pit.

EARTHWORK

Earthwork at the borrow sites is anticipated to include clearing and grubbing and excavations to proposed grades. The placement of fill is not proposed at either borrow site. Prior to excavating soils for borrow and transport to the Walworth Development, existing vegetation and root mat should be removed. The topsoil identified in the test pits is based upon coloration of soil observed in test pits. In general, the upper 4-inches of the topsoil in lawn/grass areas is not suitable as a borrow material and should be removed from the site. This depth may be deeper in wooded areas due to the more pervasive roots of trees and brush. Beneath the organic-laden zone, the dark brown soils can be excavated and mixed with other soils for use as borrow.

Excessively wet or dry material should either be moisture conditioned or mixed with other drier soils on site prior to transport to the Walworth Development. The on-site clay soils and the weathered zones of the bedrock (brown to olive brown in color) can generally be directly excavated and used as fill/borrow.

Past experience has shown that the interbedded shale and limestone bedrock on-site can typically be excavated by conventional means. Successful excavation procedures on past projects have included the use of large track-mounted hydraulic backhoe equipment with occasional use of a dozer equipped with a single-tooth ripper. A "hoe ram" and rock saws can also be utilized for penetrating larger limestone layers and to assist in shaping the side walls. The thickness and distribution of hard limestone layers can impact the level of difficulty in excavation.

The composite fill material obtained from cuts at the borrow sites should have a liquid limit less than 50% and a plasticity index less than 24 (typical for USCS Soil Class of CL). Based upon the laboratory test results, some mixing of the borrow soils will be required. This commonly occurs as part of most top-down excavation procedures. The moisture content should be adjusted to within +/-2% of its optimum moisture content, as determined by the standard Proctor method, ASTM D 698. This may be done at either the borrow site or when the fill is placed at the Walworth Development. Rock fragments larger than 6 inches in their greatest dimension should be prohibited from the borrow material since it would impede placement and compaction at the Walworth Development. Some shale or shale/soil mixtures will likely occur.

Brown and gray shale should not be intermixed. Soil should not be mixed with gray shale but can be mixed with brown shale. All rock pieces should be well distributed in the mass and "nesting" should be avoided. Water should be added to each layer as required to obtain a moisture content of the soil or shale portion of the fill to within a range of optimum moisture content to +4% for any shale fill and +/-2% for soil fill. The addition of water is necessary to facilitate compaction, but also accelerate the slaking and breakdown in the case of shales. The water should be uniformly incorporated throughout the entire layer's thickness. Note that it has been our experience to observe that gray shale will require comparatively more water to condition the lift than brown weathered shale. Wherever gray shale is used for structural fill, it should be confined to levels at least 4-feet below final grade.

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.

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.

Surface instability was not observed on the slopes adjacent to the proposed borrow areas during our site visit on April 14, 2019. Minor areas of erosion were observed. Surficial slope instability typically impacts the upper 3 to 5 feet of the subsurface profile, predominantly during extended

wet periods. Regular maintenance should be anticipated to identify and address changes in natural drainage creating potential for soil creep or erosion near the grading limits. This includes replacing or replanting trees and grasses, as necessary, and grading the slope to reduce soil creep and erosion. If future surficial slope erosion occurs near the crest of slopes, we recommend the slope face be restored as soon as practical.

Slopes should be re-vegetated as soon as possible after grading and protected from erosion until vegetation is established. Slope planting should consist of ground cover, shrubs, and trees possessing deep, dense root structures that require minimum irrigation. It is the responsibility of the property owner to maintain such planting.

The proposed finished slopes at both borrow sites are planned at 3H:1V or flatter. Slopes of this inclination are deemed stable for the cohesive soil profile encountered by the test pits. It was beyond the scope of our services at the borrow sites to evaluate the global stability of the borrow sites or adjacent properties. Even minor changes to slope geometry, surface water flow and/or groundwater levels could result in slope instability, particularly if preordained/historical failure surfaces exist. Therefore, the borrow sites should be monitored for signs of instability during and after the proposed earthwork, particularly until the erosion protection measures are in place and vegetation is established. Any indications of slope instability, such as tension cracks, sloughing, or toe bulges will require additional geotechnical investigation and analyses. In most cases, slope instability is corrected by means of a retaining wall.

Construction Observation and Testing

The earthwork efforts should be monitored under the direction of the Geotechnical Engineer. Monitoring should include documentation of adequate removal of vegetation and topsoil and the condition and/or preparation of borrow materials.

The borrow site excavations should be evaluated under the direction of the Geotechnical Engineer. If unanticipated conditions are encountered, 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.

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. Natural 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 Geotechnical Scope of Services does not include either specifically or by implication any environmental, ecological or biological assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. Other studies may be performed alongside the geotechnical study and will be issued under sperate cover.

Our services and any correspondence or collaboration through this system 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 impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

ATTACHMENTS

SITE LOCATION AND EXPLORATION PLANS

Contents:

Site Location Plans (2 pages)
Exploration Plans (2 pages)

Note: All attachments are one page unless noted above.

SITE LOCATION – OH-128 SITE
Walworth Development – Borrow Sites ■ Cincinnati, OH
April 25, 2019 ■ Terracon Project No. N1185144

Terracon GeoReport

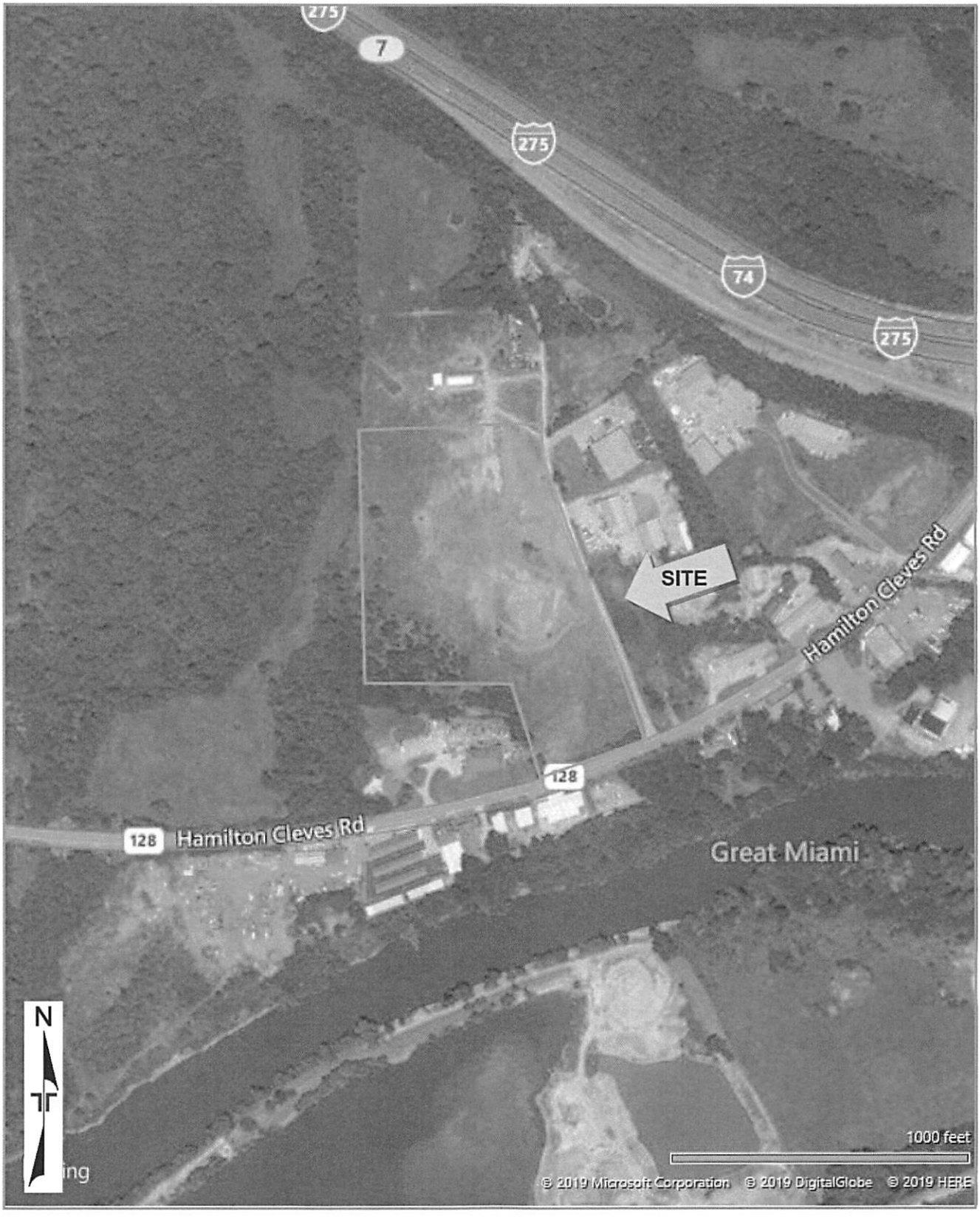
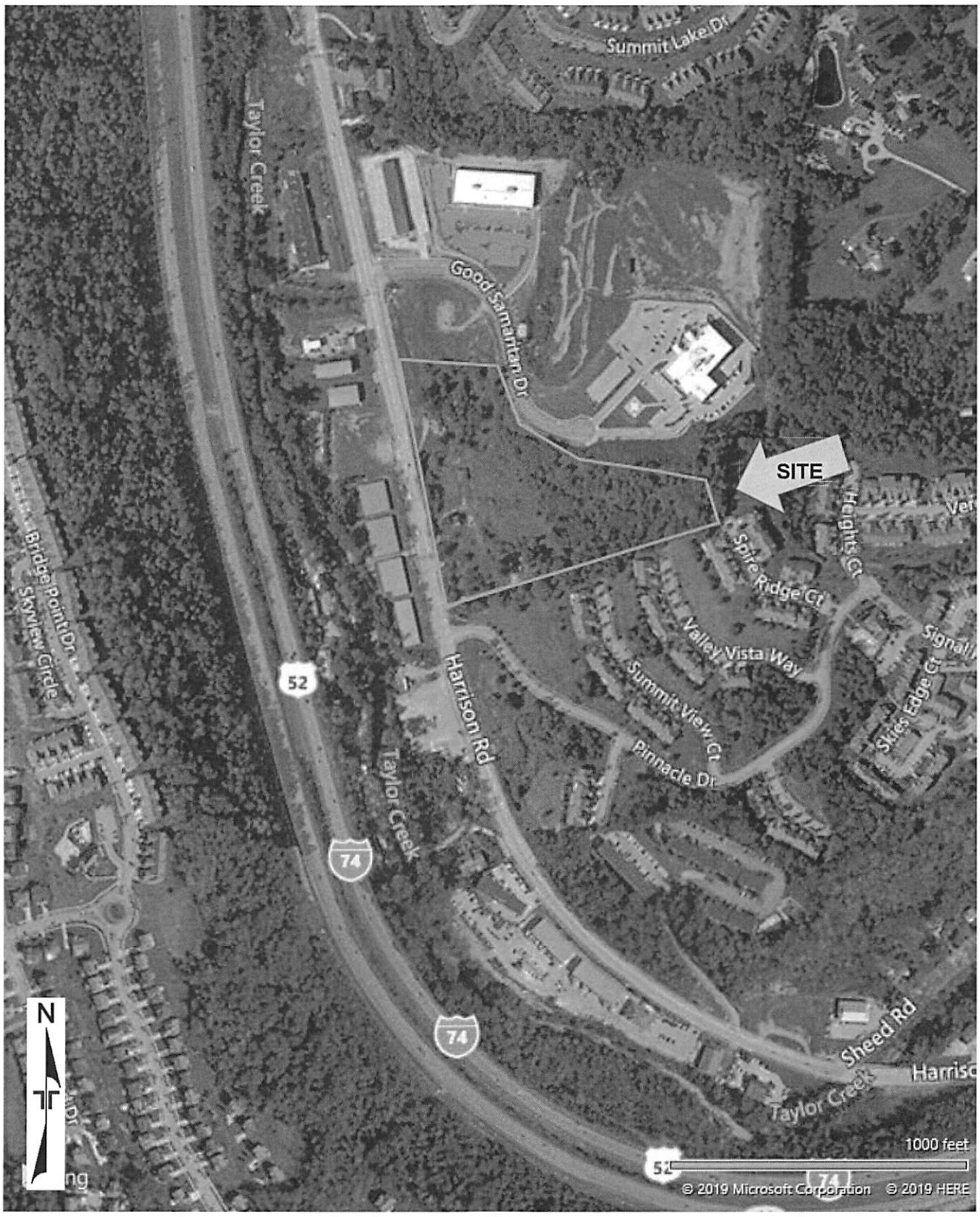


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

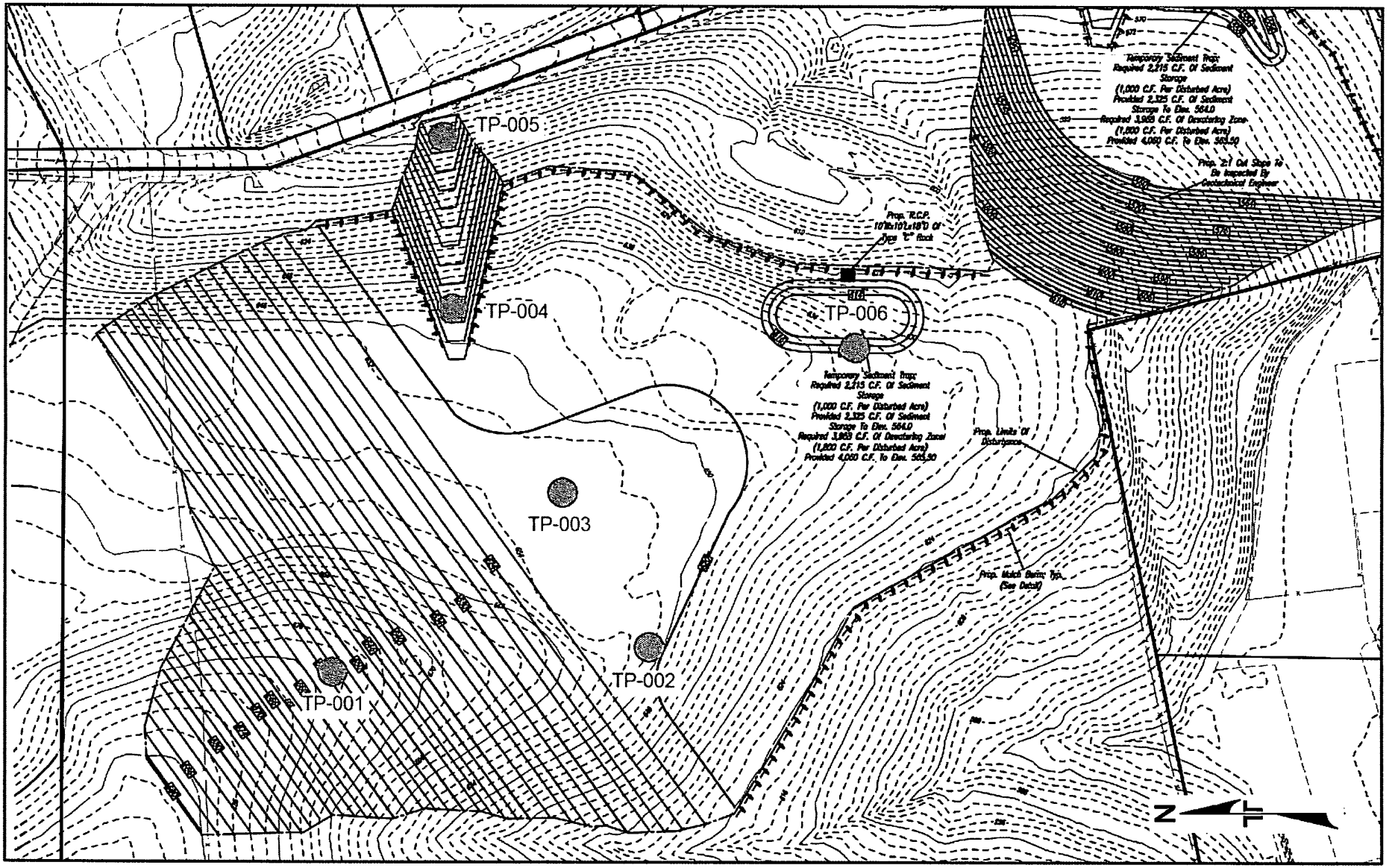
SITE LOCATION – HARRISON AVENUE SITE
Walworth Development – Borrow Sites ■ Cincinnati, OH
April 25, 2019 ■ Terracon Project No. N1185144

Terracon GeoReport



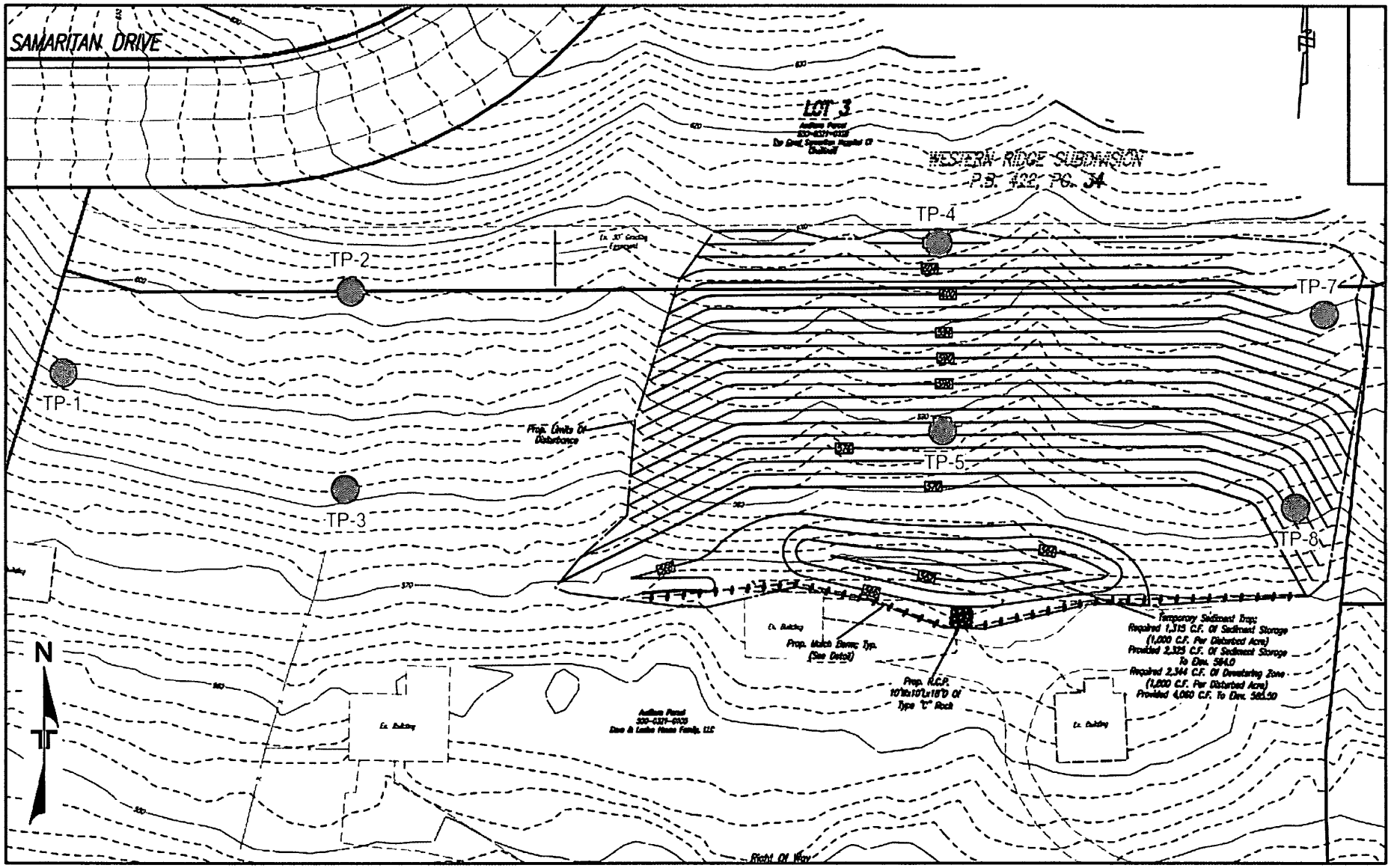
EXPLORATION PLAN - OH-128 SITE
Walworth Development – Borrow Sites ▫ Cincinnati, Hamilton County, Ohio
April 25, 2019 ▫ Terracon Project No. N1185144

Terracon GeoReport



EXPLORATION PLAN - HARRISON AVENUE SITE
Walworth Development – Borrow Sites ▫ Cincinnati, Hamilton County, Ohio
April 25, 2019 ▫ Terracon Project No. N1185144

Terracon GeoReport



EXPLORATION RESULTS

Contents:

Test Pit Observations (2 pages)
Test Pit Lab Results
Moisture Density Relationship (2 pages)

Note: All attachments are one page unless noted above.

TEST PIT OBSERVATIONS - HARRISON AVENUE SITE
Walworth Development – Borrow Sites ▫ Cincinnati, Hamilton County, Ohio
April 25, 2019 ▫ Terracon Project No. N1185144

Terracon GeoReport

TEST PIT ID	LATITUDE (Est.)	LONGITUDE (Est.)	SAMPLE TYPE	DEPTH	DESCRIPTION	MODIFIERS	CONSISTENCY
TP-1	39.12' 11.93" N	84.40' 20.23" W	Jar Only	0'-1'	Topsoil		
				1'-8'	Brown Lean Clay	With Limestone Fragments and Some Sand	Stiff to Very Stiff
				8'	Gray Shale	With Limestone Layers	Very Weak
TP-2	39.12' 9.40" N	84.40' 19.34" W	Jar & Bucket	0'-1'	Topsoil		N/A
				1'-6'	Brown to Gray Lean Clay	With Limestone Fragments	Stiff
				6'	Gray Shale	With Limestone Layers	Very Weak
TP-3	39.12' 10.93" N	84.40' 21.30" W	N/A	0'-1.5'	Topsoil		
				1.5'-8'	Brown Lean Clay	With Limestone Fragments and Some Sand	Stiff to Very Stiff
				8'	Brown Shale	With Limestone Layers	Very Weak
TP-4	39.12' 8.49" N	84.40' 18.91" W	N/A	0'-1'	Topsoil		N/A
				1'-8'	Brown Lean Clay	With Limestone Fragments	Stiff to Very Stiff
				8'	Brown Shale	With Limestone Layers	Very Weak
TP-5	39.12' 7.68" N	84.40' 20.25" W	Jar & Bucket	0'-1	Topsoil		N/A
				1'-7'	Brown Lean Clay	With Limestone Fragments and Some Sand	Stiff to Very Stiff
				7'-8'	Gray Shale	With Limestone Layers	Very Weak
TP-6	N/A	N/A	N/A	N/A	Not performed at the request of property owner		
TP-7	39.12' 7.0" N	84.40' 18.47" W	N/A	0'-1'	Topsoil		N/A
				1'-6'	Brown Lean Clay	With Limestone Fragments and Some Sand	Stiff to Very Stiff
				6'	Gray Shale	With Limestone Layers	Very Weak
TP-8	39.12' 5.91" N	84.40' 20.63" W	Jar Only	0-1'	Topsoil		N/A
				1'-7'	Brown to Gray Lean Clay	With Limestone Fragments	Stiff to Very Stiff
				7'	Gray Shale	With Limestone Layers	Very Weak

TEST PIT OBSERVATIONS - OH-128 SITE
Walworth Development – Borrow Sites ▫ Cincinnati, Hamilton County, Ohio
April 25, 2019 ▫ Terracon Project No. N1185144

Terracon GeoReport

TEST PIT ID	LATITUDE (Est.)	LONGITUDE (Est.)	SAMPLE TYPE	DEPTH	DESCRIPTION	MODIFIERS	CONSISTENCY
TP-001	39.12' 18.66" N	84.42' 58.26" W	Jar Only	0-1'	Topsoil		N/A
				1'-8'	Brown Lean Clay	With Limestone Fragments and Some Sand	Stiff
				8'	Brown & Gray Shale	With Limestone Layers	Very Weak
TP-002	39.12' 17.02" N	84.42' 58.09" W	Jar Only	0-1'	Topsoil		N/A
				1'-7'	Brown Lean Clay	With Limestone Fragments	Stiff to Very Stiff
				7'-8.5'	Brown Shale	With Limestone Layers	Very Weak
TP-003	39.12' 16.68" N	84.42' 55.22" W	Jar & Bucket	0'-0.5'	Topsoil		N/A
				0.5'-1.5'	Brown Lean Clay		Stiff
				1.5'-4'	Brown Lean to Fat Clay	With Limestone Fragments	Medium Stiff
				4'-8'	Brown Shale	With Limestone Layers	Very Weak
TP-004	39.12' 17.78" N	84.42' 53.94" W	N/A	0-1'	Topsoil		N/A
				1'-7.5'	FILL- Brown/Gray Lean Clay	With Gravel and Cobbles	
				7.5'-9	Brown Lean to Fat Clay	With Limestone Fragments and Some Sand	Medium Stiff
				9'-10'	Brown Lean Clay	With Limestone Fragments	Medium Stiff to Stiff
				10'	Brown Shale	With Limestone Layers	Very Weak
TP-005	N/A	N/A	N/A	N/A	Not performed at the request of property owner		
TP-006	39.12' 14.43" N	84.42' 54.85" W	Jar & Bucket	0'-1	Topsoil		N/A
				1'-5.5'	FILL-Brown/Gray Lean to Fat Clay		Medium Stiff
				5.5'-10'	Brown with Gray Lean Clay		Stiff to Very Stiff
				10'	Gray Shale		Very Weak

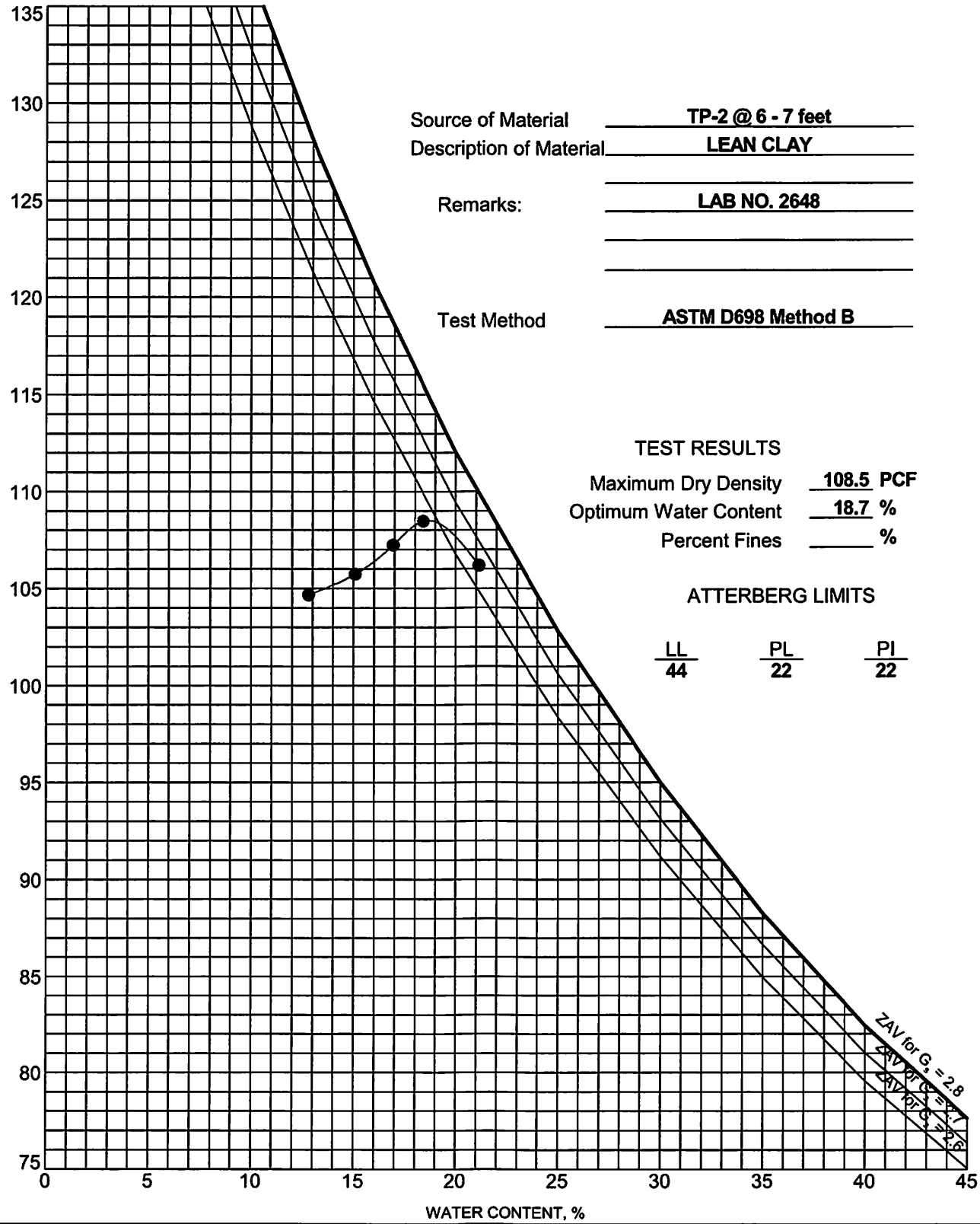
TEST PIT LAB RESULTS
Walworth Development – Borrow Sites▫ Cincinnati, Hamilton County, Ohio
April 25, 2019 ▫ Terracon Project No. N1185144

Terracon GeoReport

	TEST PIT ID	SAMPLE TYPE	DEPTH	WATER CONTENT (%)	MAXIMUM DRY DENSITY (pcf)	OPTIMUM WATER CONTENT (%)
SR 128 SITE	TP-001	JAR	5'	29		
	TP-002	JAR	1'	29		
	TP-003	JAR	1'	23		
	TP-003	BULK	0'-2'		106.4	17
	TP-006	JAR	6'	25		
HARRSION SITE	**TEST PIT ID**	**SAMPLE TYPE**	**DEPTH**	**WATER CONTENT (%)**	**MAXIMUM DRY DENSITY (pcf)**	**OPTIMUM WATER CONTENT (%)**
	TP-1	JAR	3.5'	26		
	TP-2	JAR	6'	21		
	TP-2	BULK	6'-7'		108.5	18.7
	TP-5	JAR	5'	20		
	TP-8	JAR	5'	23		

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557



Source of Material: TP-2 @ 6 - 7 feet

Description of Material: LEAN CLAY

Remarks: LAB NO. 2648

Test Method: ASTM D698 Method B

TEST RESULTS

Maximum Dry Density	108.5 PCF
Optimum Water Content	18.7 %
Percent Fines	%

ATTERBERG LIMITS

LL	PL	PI
44	22	22

PROJECT: Walworth Avenue Development

SITE: Walworth Avenue
Cincinnati, OH

Terracon
611 Lunken Park Dr
Cincinnati, OH

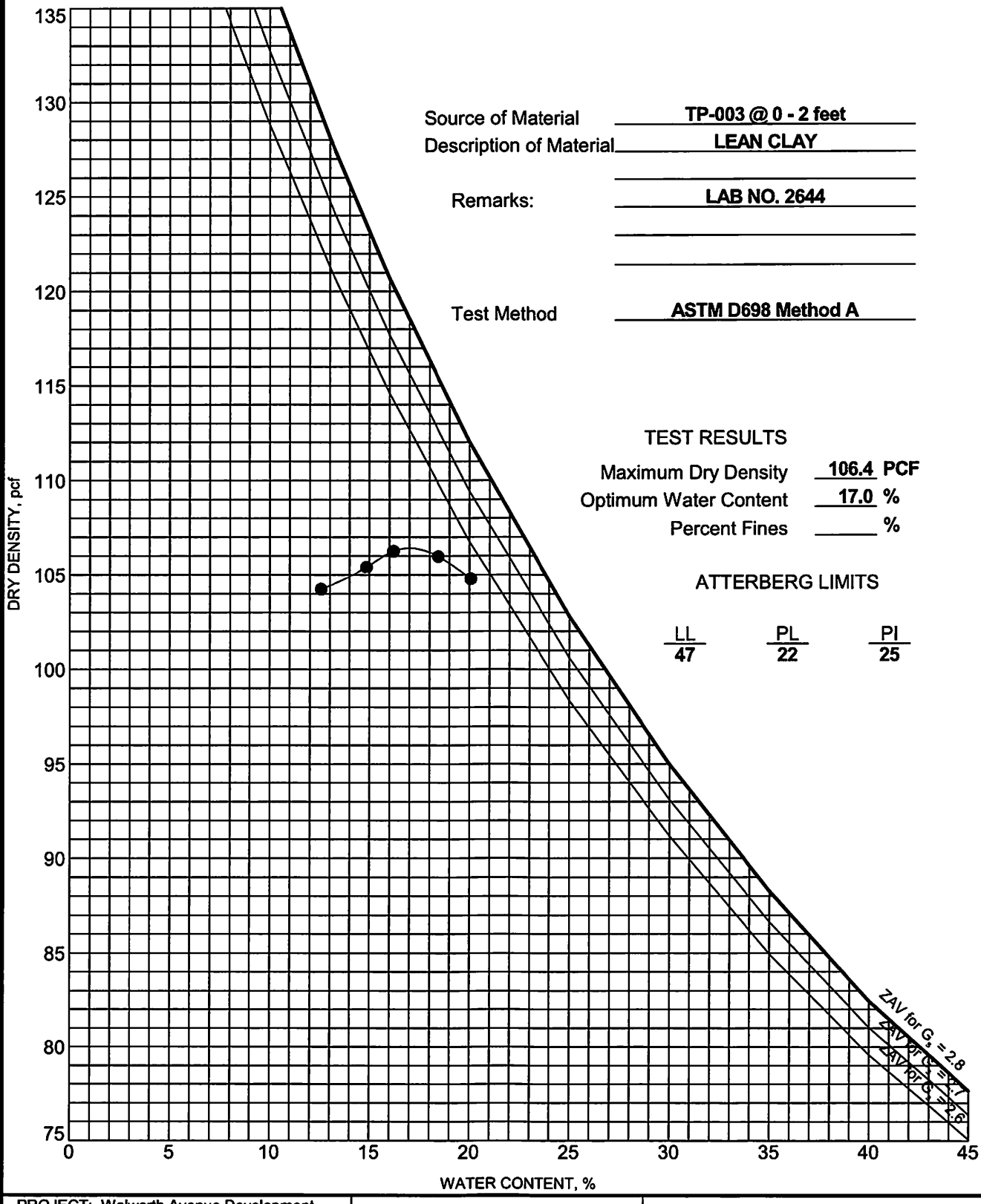
PROJECT NUMBER: N1185144

CLIENT: East End Developers LLC
Cincinnati, OH

EXHIBIT: B-1

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557



Source of Material: TP-003 @ 0 - 2 feet

Description of Material: LEAN CLAY

Remarks: LAB NO. 2644

Test Method: ASTM D698 Method A

TEST RESULTS

Maximum Dry Density	106.4	PCF
Optimum Water Content	17.0	%
Percent Fines		%

ATTERBERG LIMITS

LL	PL	PI
47	22	25

PROJECT: Walworth Avenue Development

SITE: Walworth Avenue
Cincinnati, OH

Terracon
611 Lunken Park Dr
Cincinnati, OH

PROJECT NUMBER: N1185144

CLIENT: East End Developers LLC
Cincinnati, OH

EXHIBIT: B-1

SUPPORTING INFORMATION

Contents:

General Notes
Unified Soil Classification System
Description of Rock Properties

Note: All attachments are one page unless noted above.

GENERAL NOTES
DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

Terracon GeoReport

SAMPLING	WATER LEVEL	FIELD TESTS
Rock Core Standard Penetration Test Split Spoon	Water Initially Encountered Water Level After a Specified Period of Time Water Level After a Specified Period of Time Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.	N Standard Penetration Test Resistance (Blows/Ft.) (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 is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no 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		
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength Qu, (tsf)**	**Standard Penetration or N-Value Blows/Ft.**
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

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

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

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	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]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [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]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [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 on or above "A"		CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]		ML	Silt [K, L, M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K, L, M, N]
			Liquid limit - not dried			Organic silt [K, L, M, O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line		CH	Fat clay [K, L, M]
			PI plots below "A" line		MH	Elastic Silt [K, L, M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K, L, M, P]
			Liquid limit - not dried			Organic silt [K, L, M, Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

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

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

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

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

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

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

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

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

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

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

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

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

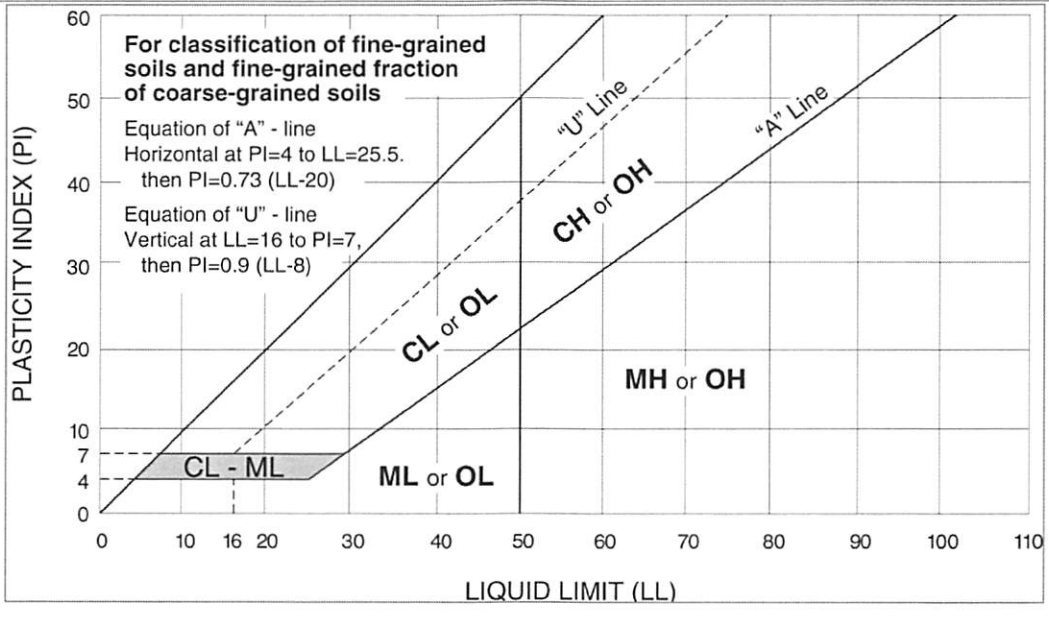
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

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

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

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

[Q] PI plots below "A" line.



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

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

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

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

ROCK QUALITY DESIGNATION (RQD) [1]	
Description	**RQD Value (%)**
Very Poor	0 - 25
Poor	25 – 50
Fair	50 – 75
Good	75 – 90
Excellent	90 - 100

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

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