# Revised

# Geotechnical Engineering Report

**ATH – Chauncey Bikeway Extension**

**PID 106647**

**Athens County, Ohio**

July 12, 2021

Terracon Project No. N4205071

**Prepared for:**

Pennoni Partners
Columbus, Ohio

**Prepared by:**

Terracon Consultants, Inc.
Columbus, Ohio

July 12, 2021

Terracon

Pennoni Partners
5202 Bethel Road Park, Suite 200
Columbus, Ohio 43235

Attn: Mr. David Jones, P.E.
P: [614] 335 9601
E-mail: DJones@Pennoni.com

Re: Revised Geotechnical Engineering Report
ATH – Chauncey Bikeway Extension
PID 106647
Athens County, Ohio
Terracon Project No.: N4205071

Dear Mr. Jones:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the above referenced project. This study was performed in general accordance with our proposal number PN4205071 dated February 12, 2020 and your authorization to proceed on April 30, 2020.

This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning the construction of the proposed bikeway pavement and embankment foundation design of the bikeway bridge. We submitted our revised geotechnical engineering report originally on February 10, 2021.

We appreciate the opportunity to work with you on this project. Please contact us concerning any questions that may arise during review of the report, or if you require additional information as you proceed into the final design and construction stage of this project.

Sincerely,
**Terracon Consultants, Inc.**

Rohit Singh
Senior Staff Engineer

Kevin M. Ernst, P.E.
Regional Manager | Principal

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# EXECUTIVE SUMMARY

A geotechnical exploration has been performed for a bikeway between Main Street and River Road, that will cross over Hocking River, located in Dover Township, Athens County, Ohio. The proposed bikeway will include embankment sections and a single span bridge. Five (5) borings were advanced to depths of approximately 10 to 45 feet below the existing ground surface at the locations indicated in the "Appendix" section of this report.

Based on the information obtained from our subsurface exploration, the following geotechnical considerations have been identified:

- Recently performed soil borings encountered topsoil underlain by very loose and medium stiff to stiff native fine-grained soils and loose to medium dense native course-grained soils which were in-turn underlain by shale and limestone bedrock. The soils at proposed subgrade elevations for embankment fill and pavement include weak, high moisture content cohesive soils and fine textured granular soils. Bedrock was encountered in the borings B-002-0-20 and B-003-0-20 at depths of 33.5 and 26.0 feet, respectively.

- Recommendations have been provided in this report for supporting the proposed bridge abutments, culverts and retaining walls on steel H-piles bearing in bedrock upon encountering refusal.

- A significant geotechnical issue related to earthwork for the proposed construction at this site will be stabilizing subgrade soils in areas to receive embankment fill and pavements. Chemical stabilization or undercutting and replacement of exposed weak or wet cohesive and fine textured granular soils, should be anticipated.

- The analysis of scour depth is not within the scope of services for this project. We recommend that a scour analysis be undertaken by the designer as part of the bridge design process. Design of shallow foundations should consider scour so as to mitigate the potential for undermining of the bridge foundations.

- In our opinion, a soldier pile and lagging wall system should be selected for retaining the elevated bikeway sections. Terracon assisted Pennoni in designing the described soldier pile and lagging wall system. We submitted our design inputs for the retaining wall sections to Pennoni on June 25, 2021.

- In order to minimize the deflections associated with the soldier pile and lagging retaining wall sections, along the bikeway sections approximately between STA 101+70 to STA 102+00 and, STA 104+50 to STA 106+00, 3 feet deep undercuts should be made that extend for at least 10

feet beyond the center of the piles and the undercut soils should be replaced with engineered fill in accordance with ODOT CMS Item 203.02R and 203.3. Please note that weak, soft, high moisture soils are anticipated at the bottom of the 3 feet deep undercuts and will likely require further stabilization with stone; or geogrid and stone as further described in Section 5.7.2.

This geotechnical executive summary should be used in conjunction with the entire report for design and/or construction purposes. It should be recognized that specific details were not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. The section titled **General Comments** should be read for an understanding of the report limitations.

**REVISED GEOTECHNICAL ENGINEERING REPORT**
**ATH – CHAUNCEY BIKEWAY EXTENSION**
**PID 106647**
**DOVER TOWNSHIP, ATHENS COUNTY, OHIO**
**Terracon Project No. N4205071**
**July 12, 2021**

# 1.0 INTRODUCTION

A geotechnical exploration has been completed for the bikeway extension constituting of a new bridge and embankment construction planned between Main Street and River Road in Dover Township, Athens County, Ohio. A total of five (5) test borings were completed for the along the alignment of the proposed bikeway. Borings were drilled to depths ranging from approximately 10 to 45 feet below ground surface. Logs of the borings along with boring location plans are included in Appendix A of this report.

The purpose of the geotechnical exploration services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil and groundwater conditions
- Soil gradation tests for scour analysis
- Earthwork
- Foundation design
- Lateral earth pressure recommendations

# 2.0 PROJECT INFORMATION

## 2.1 Project Description

| ITEM | DESCRIPTION |
|---|---|
| **Site Layouts** | See Appendix A, Exhibit A-2, Boring Location Plan |
| **Project Information** | The project includes a construction of a new bikeway between Main Street and River Road including new embankment sections and a bridge over the Hocking River. |
| **Proposed Bridge** | The proposed bridge is anticipated to be a prefabricated, single span bridge. The bridge will be located between STA 102+34.96 and STA 104+18.96. The proposed bridge abutments will be about 13 feet in height. Based on the |

| ITEM | DESCRIPTION |
|---|---|
| | recently provided information, the proposed development will also include two twin culverts behind each of the bridge abutments. The culverts will be approximately, 9 feet in height, 17 feet in length and 11 feet in width. |
| **Site Grading** | Based on the provided information, between STA 100+08.88 and STA 102+39.77 fill up to about 12 feet fill will be utilized for establishing the proposed design grades. Between STA 104+10.77 and STA 108+44.31, up to about 12 feet of fill will be required to establish the proposed design grades. Between STA 108+44.31 and STA 111+23.91, nominal amount of fill will be required to establish the proposed site grades and between STA 111+23.91 and STA 116+91 up to about up to about 5 feet of fill and up to about 4 feet of cut will be required for establishing the required grades. |

## 2.2 Site Location and Description

| ITEM | DESCRIPTION |
|---|---|
| **Site location** | The project site is located between Main Street and River Road in Dover Township, Athens County, Ohio.<br>Approximate Site Coordinates: 39°23'39.4"N, 82°07'57.9"W<br>See **Exhibit A-1** |
| **Existing conditions and topography** | The existing conditions approximately between STA 100+08.88 to STA 102+39.77 and STA 104+10.77 to 116+90.70 consist of undeveloped areas including natural vegetation, some trees and grass. The bikeway alignment approximately between STA 102+39.77 and STA 104+10.77 passes over the Hocking River. The general site topography is relatively level except at the river banks, the ground surface elevations range from 646 to 659 feet. The elevation of the bottom of the river bed approximately ranges from 634 to 636 feet.<br>Based on the provided information, the ordinary high-water mark (OHWM) of the river is 640 feet and the 10-year high water level is 654.09 feet. A stream known as Coal run flows south into the Hocking river on the west side of the proposed bikeway. |
| **Current ground cover** | The current ground cover along the bikeway alignment consists of natural vegetation, some trees and grass. |
| **Geologic Setting** | The project site is located within the Muskingum-Pittsburg plateau physiographic region and unglaciated area of Ohio.<br>Based on our review of Ohio Department of Natural Resources Quaternary Geology Map of Ohio, the surficial geology at the project site consists of Alluvium and Alluvial |

| ITEM | DESCRIPTION |
|---|---|
| | terrace deposits which were deposited in present and former floodplains and range from silty clay in areas of fine-grained deposits to coarse sand, gravel, or cobbles in areas of shallow bedrock.<br>Based on our review of Ohio Department of Natural Resources Bedrock Geology Map of Ohio, the bedrock geology along the bikeway alignment consists of Allegheny and Pottsville groups, and Conemaugh group formations. The Allegheny and Pottsville groups lithology comprises of Shale, siltstone, sandstone, conglomerate, and subordinate amounts of limestone, clay and flint. The Allegheny and Pottsville groups unit features include economic beds of coal and clay, marine limestone, flint, and shale beds, local development of thick quartzose sandstone and conglomerate in lower ¼ of unit, predominant gray color of unweathered rock, and rapid horizontal and vertical changes of rock types. The Conemaugh group lithology comprises of shale, siltstone, sandstone, mudstone, and lesser amounts of limestone and coal. The Conemaugh group unit features include multicolored mudstones, rare coal beds, thin to thick marine shale and limestone in lower 2/3 of unit, and rapid vertical and horizontal changes of rock types. |

# 3.0 EXPLORATION

## 3.1 Field Exploration

A total of five (5) borings were performed on May 26 and May 27, 2020 designated as B-002-0-20 through B-006-0-20. The boring locations were located in the field using a hand-held GPS unit.

The borings were performed in general accordance with the most recent Ohio Department of Transportation (ODOT) Specifications for Geotechnical Explorations (SGE) Type E1 bridge borings. The approximate locations of the borings are illustrated on the attached Boring Location Plan (Exhibit A-2) and summarized in the following table.

| Boring Number | Surface Elevation (Feet) | Latitude | Longitude | Boring Depth (feet) |
|---|---|---|---|---|
| B-002-0-20 | 653.0 | 39.39283° | -82.13264° | 45.0 |
| B-003-0-20 | 646.0 | 39.393395° | -82.132961° | 39.5 |
| B-004-0-20 | 648.5 | 39.393963° | -82.133706° | 10.0 |

| Boring Number | Surface Elevation (Feet) | Latitude | Longitude | Boring Depth (feet) |
|---|---|---|---|---|
| B-005-0-20 | 647.0 | 39.39464° | -82.13469° | 10.0 |
| B-006-0-20 | 650.5 | 39.395439° | -82.135295° | 10.0 |

The boring locations were located in the field prior to drilling operations by Terracon personnel using a survey grade GPS unit in consultation with the client.

We advanced the borings with a truck-mounted drill rig using continuous flight hollow stem augers through overburden materials and a NQ-size core barrel through bedrock. Soil samples were generally obtained in the borings at 2.5 feet intervals to the termination depths of the borings or auger refusal, with exception of samples taken from depths ranging from 13.5 to 25.5 in boring B-002-0-20; and depths ranging from 8.5 to 20.5 in boring B-003-0-20, where sampling was performed continuously.

The soil samples were obtained using the split-barrel sampling procedure. In the split-barrel sampling procedure, a standard 2-inch O.D. sampling spoon is driven into the boring with a 140-pound automatic SPT (Standard Penetration Test) hammer falling 30 inches. We recorded the number of blows required to advance the sampling spoon the last 12 inches of an 18-inch sampling interval as the standard penetration resistance value (N-value). This value is corrected to an equivalent (60 percent) energy ratio ($N_{60}$) utilizing the hammer efficiency energy ratio.

Rock coring in borings B-002-0-20 and B-003-0-20 was performed using a NQ-size double tube-swivel core barrel. Percentage of recovery and rock quality designation (RQD) were calculated for the core samples and are noted at their depths of occurrence on the boring logs.

In addition, we observed and recorded groundwater levels during drilling. The samples were placed in appropriate containers and taken to our soil laboratory for testing.

Our exploration team prepared field boring logs as part of standard drilling operations that include sampling depths, penetration distances, and other relevant sampling information. Field logs include visual classifications of materials encountered during drilling, and our interpretation of subsurface conditions between samples. Final boring logs represent the geotechnical engineer's interpretation of field logs, and include modifications based on visual classification and laboratory tests. Following the completion of drilling, the boreholes were sealed with a cement-bentonite grout.

### 3.2 Laboratory Testing Program

As part of the testing program, all samples were examined in the laboratory by a geologist and a geotechnical engineer. Soil samples were classified in general accordance with ODOT SGE Section 600 Laboratory Testing based on the texture and plasticity of the soils.

Visual classification was performed on all recovered soil samples and rock cores. Atterberg limits, moisture content, and grain size analysis testing were performed on selected soil samples to obtain accurate information. In addition, in accordance with ODOT specifications, grain size analysis testing was performed on selected samples obtained from the zone below the approximate river bed elevation for scour analysis purposes. The results of lab testing are shown on the boring logs and presented in the appendix of this report.

## 4.0 FINDINGS

Boring logs have been prepared based on the field logs prepared at the time of drilling, and the visual examination performed in the laboratory, with soils classified and described in general accordance with the current ODOT SGE. The logs have also been modified as necessary based on the results of the laboratory testing program. Borings B-002-0-20 and B-003-0-20 were drilled in the vicinity of the proposed bridge structure near the banks of Hocking River. Borings B-004-0-20 through B-006-0-20 were performed between the Hocking River and Main Street. The following sections summarize the conditions encountered at the boring locations.

### 4.1 Surface Materials

At the existing ground surface, borings B-002-0-20 and B-003-0-20 encountered 3 and 5 inches of topsoil, respectively whereas borings B-004-0-20 through B-006-0-20 encountered approximately 3 to 4 inches of topsoil, as identified by the significant presence of organic material and its friable nature.

### 4.2 Soil Conditions

Underlaying the topsoil, soil borings B-002-0-20 and B-003-0-20 generally encountered native fine-grained soils underlain by native course grained soils (granular), which were in-turn underlain by shale and limestone bedrock to the termination depths of the borings at 39.5 to 45 feet. Native find-grained soils encountered in these borings extended to 14.5 to 15 feet below ground surface. Bedrock was encountered in borings B-002-0-20 and B-003-0-20 at 33.5 and 26 feet below ground surface. Native fine-grained soils encountered in the borings consisted of Sandy Silt (A-4a) with very loose relative density, and Silt and Clay (A-6a) with consistencies ranging from medium stiff to stiff. Native course grained soils (granular) encountered in the borings consisted of Fine Sand (A-3), Coarse and Fine Sand (A-3a), and gravel and/or stone fragments with sand (A-1-b) with relative densities ranging from loose to medium dense.

Underlaying the topsoil, soil borings B-004-0-20 through B-006-0-20 generally encountered native fine-grained soils. The native fine-grained soils encountered in the borings consisted of Silt and Clay (A-6a) and Clay (A-7-6) with consistencies ranging from medium stiff to stiff and Sandy Silt (A-4) with very loose relative density.

## 4.3 Bedrock

Bedrock encountered in borings B-002-0-20 consisted of severely to highly weathered shale bedrock and bedrock encountered in boring B-003-0-20 consisted of severely to highly weathered shale underlain by highly weathered limestone.

## 4.4 Groundwater Conditions

The borings were observed during drilling and at completion for the presence and level of groundwater. Groundwater was encountered in the borings B-002-0-20, B-003-0-20 and B-005-0-20 at about 3.5 to 15 feet below ground surface while drilling.

Groundwater was not encountered in borings B-004-0-20 and B-006-0-20 while drilling or for the relatively short period of time the borings were allowed to remain open. However, this does not necessarily mean these borings terminated above groundwater, or that the water levels summarized above are stable groundwater levels. Due to the low permeability of the soils encountered in the borings, a relatively long period of time may be necessary for a groundwater level to develop and stabilize in a borehole in these materials. Long term observations in piezometers or observation wells sealed from the influence of surface water are often required to define groundwater levels in materials of this type.

Fluctuations of groundwater levels will likely occur due to seasonal variations in the amount of rainfall, runoff, the level of water in Hocking River and other factors not evident at the time the boring was performed. Also, trapped or “perched” water could be present in the sand or silt seams and layers underlain by cohesive soil deposits. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

# 5.0 ANALYSIS AND RECOMMENDATIONS

It is understood that the proposed Hocking River bikeway bridge is a single span structure. Based on an evaluation of the conditions encountered at the site, it is recommended that a deep foundation system consisting of driven piles be employed for support of the proposed bridges. Recommendations for steel H-piles are presented in the following sections.

Additionally, due to relatively deep unsuitable soils encountered in borings B-002-0-20 and B-003-0-20, we recommend that the proposed culverts and associated retaining walls also be supported on steel H-piles driven to refusal.

## 5.1 Driven Pile Recommendations

We understand that Pennoni Partners' preferred bridge abutment foundation system for this project is steel H-piles driven to refusal on the bedrock. We recommend that the proposed culverts and retaining walls also should be supported on steel H-piles driven to refusal on the bedrock. The findings of our subsurface exploration showed that highly weathered to severely weathered shale was encountered in borings B-002-0-20 and B-003-0-20 at elevations approximately 619.4, and 621.8 feet, respectively. As outlined in Section 202.2.3 of ODOT (BDM), H-piles should be used when piles are driven to refusal. Refusal is met during driving when the pile penetration is an inch or less after receiving at least 20 blows from the pile hammer. An appropriate hammer should be selected by the contractor based on the selected pile size and required driving energy. The recommended pile capacities for H piles driven to refusal are presented in the following table.

| H Pile Size | Maximum Factored Load [1] (kips) |
|---|---|
| HP 10X42 | 310 |
| HP 12X53 | 380 |
| HP 14X73 | 530 |

1. Maximum pile factored loads are defined based on the maximum structural resistance $R_{R\ max}$.
2. The maximum factored loads listed above assume an axially loaded pile with negligible moment, no appreciable loss of section due to erosion or deterioration throughout the life of the structure, a steel yield strength of 50 ksi, a structural resistance factor due to severe driving conditions of $\phi_C = 0.5$ (LRFD 6.5.4.2), and a pile fully braced along its length.

Settlement of individual piles is estimated to be less than 1 inch considering that the piles are designed and installed in accordance with ODOT specifications and the recommendations presented in this report.

Due to the presence of limestone bedrock as encountered in the soil boring B-003-0-20, we recommend that steel points be utilized to protect the tips of the steel H-piles.

Lateral loads can be resisted by appropriately designed battered H-piles. In general, battered piles are used to support structures subjected to large lateral loads, or if the upper foundation soils will not adequately resist lateral movement of vertical piles. Piles may be battered in opposite directions or used in combination with vertical piles. The axial load of a battered pile should not exceed the allowable load for a vertical pile. It is very difficult to drive piles with a batter greater than 1H:2V. The driving efficiency of the hammer decreases as the batter increases. Lateral analysis of piles was not included in our scope. However, we can provide these recommendations in an addendum to this report upon request.

A pre-construction wave equation analysis such as GRLWEAP analysis should be performed by the contractor to assess the ability of the proposed driving system to develop a point resistance of at least 80% of the pile yield stress without damaging the pile. The results of the wave equation should be submitted to the Engineer of Record for review and approval of the proposed pile driving system prior to construction. Piles should be installed according to Item 507 of the most recent ODOT Construction and Material Specifications (CMS). In addition, field dynamic testing with a pile driving analyzer per ODOT CMS Item 523 is recommended to confirm that the contractor's equipment is imparting the required energy to the piles without causing damage to the piles.

## 5.2 Soldier Pile Wall

Based on our conference call dated April 21, 2021 with the representatives of Pennoni, ODOT and Athens County, it was concluded that the geogrid reinforced bikeway embankment slopes extending will not be feasible and instead a retaining wall system such as mechanically stabilized walls or soldier pile and lagging retaining walls be considered for constructing the elevated bikeway sections.

In our opinion, due to the relatively lower subgrade remediation and maintenance costs, we recommend that a soldier pile and lagging wall system should be selected for retaining the elevated bikeway sections over an MSE wall system. Terracon assisted Pennoni in designing the soldier pile and lagging wall system The wall system extended approximately between STA 104+50 to STA 106+30, Left and Right, and STA 101+70 to STA 102+00, Left and Right. We submitted our design inputs for the retaining wall sections to Pennoni on June 25, 2021.

## 5.3 Embankment Settlement

The settlement calculations were performed at each of the proposed approach embankments for the proposed bikeway bridge. It is understood that the embankment is being built on the alluvium.

From the settlement calculations, we anticipate that the proposed embankment could experience between approximately 8 and 9 inches of settlement, requiring about 4 to 6 months for approximately 90 percent of the settlement to occur.

We anticipate that fill for the bridge approaches will need to be placed well before the bridge substructure foundations are installed so as to allow time for settlement associated with the fill loading to occur.

Settlement due to placement of new embankment fill should be allowed to occur prior to driving piles and constructions, the new bridge structure and associated pavements. To assure that settlement has occurred, we recommend that a settlement monitoring program be established for the embankment fill approach of the bridge. This program should consist of installing settlement platforms on the subgrade prior to fill placement consistent with ODOT Geotechnical Bulletin 4; as well as establishing a series of settlement pins at various points along the finished subgrade at the top of the embankment once fill has reached design grade. We recommend settlement platforms be installed at STA 101+79 and STA 104+72, one at each side of the bridge, at least 20 feet horizontal distance should be maintained between the culverts and the settlement platforms. Consideration could be given to constructing the embankment to heights above the design grades to account for the predicted settlement. The pins should consist of steel pins at least 4 feet long so as to not be influenced by near surface soil movements from shrink/swell or frost action. The settlement monitoring should be performed by a professional surveyor over a minimum 4-month period with readings provided to the engineer of record for evaluation. Once the settlement is within the acceptable tolerance, installation of the pins and bridge construction can proceed.

The excessive settlements of subgrade soils could create excessive negative downdrag forces on the piles supporting the abutments, culverts and retaining walls as an additional load. Therefore, consolidation settlement of the soils should be allowed to occur prior to installation of driven piles. Consideration should be given to installation of friction reduction pile sleeves to reduce any remaining downdrag forces on the piles.

## 5.4 Lateral Earth Pressures

Subsurface walls, abutment walls, culverts, wing walls, and excavation support systems must be designed to withstand lateral earth pressures, as well as hydrostatic pressure, that may develop behind the structures. The magnitude of lateral earth pressure varies on the basis of soil type, permissible wall movement, and configuration of the backfill. It should be noted that the recommendations pertaining to the lateral earth pressures presented in this section are not applicable to the soldier pile and lagging retaining walls.

In order to minimize lateral earth pressures, the zone behind the proposed abutments, culverts and retaining walls should be effectively drained. For effective drainage, a zone of porous backfill (ODOT CMS Item 518.03) should be used directly behind the structures for a minimum thickness of 2 feet in accordance with ODOT CMS Item 518.05. The granular zone should be designed to drain to either weep holes or a pipe, to alleviate the build-up of hydrostatic pressures against the walls.

The type of backfill beyond the free-draining granular zone will govern the pressure to be used for structural design. Pressures of a relatively low magnitude will be generated by granular backfill materials, whereas cohesive backfill materials will result in the development of higher lateral pressures. Therefore, it is recommended that granular backfill be utilized whenever possible. Granular backfill behind structures should be placed and compacted in accordance with ODOT CMS Item 203.

Retaining walls that are fixed and unable to rotate or deflect will be subjected to at-rest earth pressure conditions. Earth pressure distributions should be based on the mobilization of active earth pressure conditions for retaining walls that are free to deflect or rotate. Retaining walls exerting a force on the soil (such as soil in front of the footing on the face side of the wall) are subject to a passive resistance. However, due to the potential for erosion, this passive resistance is typically ignored.

The tables presented below include the recommended unfactored and factored equivalent fluid unit weights for walls subject to the mobilization of both at-rest and active earth pressure conditions as described above. A load factor of 1.5 has been used for the determination of the factored equivalent fluid unit weights. The values presented in the following table assume a flat backslope behind the walls, and that the backfill material will not be subject to any additional load (such as uniformly distributed soil surcharge near the top and immediately behind the face of the wall). Two cases have been considered for backfill behind the wall: a two-foot wide zone of granular porous backfill with filter fabric, and backfilling with a wedge of granular material.

For a two-foot wide zone of granular porous backfill, the earth pressure was calculated assuming an angle of internal friction of 28 degrees, a moist soil unit weight of 115 pcf, and a soil/concrete interface friction angle of 19 degrees.

| Wall Type | Pressure Distribution | Unfactored Equivalent Fluid Weight (pcf) | Factored Equivalent Fluid Weight (pcf) | Earth Pressure Coefficient |
|---|---|---|---|---|
| Cantilever Retaining Wall – Free Head | Active | 41 | 62 | $K_a = 0.36$ |
| Rigid Retaining Wall – Fixed Head | At-rest[1] | 61 | 91 | $K_o = 0.53$ |

1. Due to the fixity condition at the top of the wall, it is recommended that the triangular pressure distribution should be converted into a uniform or rectangular pressure distribution along the height of the wall.

For a wedge of granular material, the earth pressure was computed assuming an angle of internal friction of 34 degrees, a moist soil unit weight of 120 pcf, and a soil/concrete interface friction angle of 24 degrees.

| Wall Type | Pressure Distribution | Unfactored Equivalent Fluid Weight (pcf) | Factored Equivalent Fluid Weight (pcf) | Earth Pressure Coefficient |
|---|---|---|---|---|
| Cantilever Retaining Wall Free Head | Active | 34 | 50 | $K_a = 0.28$ |
| Rigid Retaining Wall Fixed Head | At-rest[1] | 53 | 79 | $K_o = 0.44$ |

1. Due to the fixity condition at the top of the wall, it is recommended that the triangular pressure distribution should be converted into a uniform or rectangular pressure distribution along the height of the wall.

The earth pressure values presented in the preceding tables assume that provisions for positive gravity drainage will be provided, and that the abutments, culverts and walls will be backfilled with free-draining coarse aggregate, such as ODOT No. 57 stone.

We do not recommend using passive earth pressures in design of permanent retaining walls, culverts and/or bridge abutments due to the potential for erosion, scour, or possibility of removal of the soils in front of the wall in the future.

## 5.5 Scour Data

The table below provides $D_{50}$ values for use in scour analysis at the foundations for the proposed bridge locations. $D_{50}$ is defined as the particle size diameter corresponding to 50 percent finer by dry weight of the soil on the grain size distribution curve.

| Bridge/ Boring Number | Sample Number | Approximate Depth Range (feet) | $D_{50}$ Value (millimeter) |
|---|---|---|---|
| B-002-0-20 | S-9 | 18.0-19.5 | 0.274 |
| | S-12 | 22.5-24.0 | 0.553 |
| B-003-0-20 | S-6 | 13.0-14.5 | 0.051 |
| | S-9 | 16.0-17.5 | 0.778 |
| | S-13 | 23.5-25.0 | 0.784 |

Scour of soil is an important consideration with respect to the design of bridge foundations at stream and river crossings. We recommend that the designer evaluate the scour potential of the sub-structure units as part of the bridge design process.

## 5.6 Construction Considerations

All site work should conform to local codes and to the latest ODOT Construction and Material Specifications (CMS), including that all excavation and embankment preparation and construction should follow ODOT CMS Item 200 (Earthwork).

The geotechnical engineer 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, and backfilling of any excavations into the completed subgrade.

## 5.7 Earthwork Considerations

Earthwork, including subgrade preparation should be performed in accordance with respective items in Section 200 of the current ODOT CMS.

Based on the plan and profile drawings available at the time of this report, it is anticipated that up to 12 feet of fill will be required along the proposed alignment. It is recommended that subgrade preparation for the bikeway pavement and embankments should be performed in accordance with ODOT CMS Items 203 and 204. If applicable, it is recommended that any benching required for embankment construction for the project be performed in accordance with "A. General Case: Special Benched Embankment Construction" of ODOT Geotechnical Bulletin 2 (GB-2).

Prior to subgrade preparation, perform clearing and grubbing, including removal of stumps and roots, in accordance with ODOT CMS Item 201. The subgrade should be stripped of any topsoil, organics, or other deleterious or unsuitable materials. Based on the conditions encountered in the soil borings along the bikeway alignment, unstable subgrade conditions consisting of soft native cohesive soils and loose native granular soils are anticipated. Therefore, subgrade stabilization measures will be required to provide for suitable conditions for embankment and pavement construction. Additional subgrade stabilization recommendations are provided in Section 5.7.2.

In order to minimize the deflections associated with the soldier pile and lagging retaining wall sections, along the bikeway sections approximately between STA 101+70 to STA 102+00 and, STA 104+50 to STA 106+30, 3 feet deep undercuts should be made that extend for at least 10 feet beyond the center of the piles and the undercut soils should be replaced with engineered fill in accordance with ODOT CMS Item 203.02R and 203.3. Please note that weak, soft, high moisture soils are anticipated at the bottom of the 3 feet deep undercuts and will likely require further stabilization with stone; or geogrid and stone as further described in Section 5.7.2.

Consideration may be given to using the in-situ soils or soils from the local borrow sources. However, the material will likely require moisture adjustments to achieve proper compaction. Potentially, chemical treatment may be used to condition borrow materials and existing embankment soil with high moisture contents. Due to high moisture contents of the soils indicated in the test borings, chemically treating soils with lime or lime kiln dust could be considered as an additive to expedite drying of high moisture content soils and to facilitate workability for placement as embankment fill chemical treatment should be performed in accordance with ODOT Item 205.

### 5.7.1 Embankment / Structural Fill

All embankment materials should be spread and compacted in accordance with Items 203.06 and 203.07 and subgrade materials should be spread and compacted in accordance with Items 204.07 and 204.03. Frozen materials should not be incorporated into any new fill nor should new fill, pavement materials, or structures be placed on top of frozen materials. Material to be utilized as borrow should be restricted to conform to Item 203.02R and 203.3 for embankment construction and Item 204.2 for subgrade. Clay with high plasticity should not be used for the embankment.

If applicable, it is recommended that any benching required for embankment construction for the project be performed in accordance with "A. General Case: Special Benched Embankment Construction" of ODOT Geotechnical Bulletin 2 (GB-2).

Stabilization of the existing subgrade will be required to provide for a stable subgrade / working platform for subsequent embankment fill placement. Please refer to Section 5.7 and Section 5.7.2 for additional recommendations for subgrade stabilization.

All material types to be used as embankment fill must be tested in the laboratory to determine their compaction characteristics and their suitability for project use.

The loading of the new embankment fill will cause the underlying soil to consolidate and settle. Thus, depending on the rate of construction, residual settlement might occur after the construction period. To allow time for settlements to occur, any new embankment fill at the bridge abutments should be constructed as early as possible, and time allowed for settlement to occur before the final grading and construction of the bike path pavement.

The excessive settlements of subgrade soils could create excessive negative downdrag forces on the piles supporting the abutments, culverts and retaining walls as an additional load. Therefore, consolidation settlement of the soils should be allowed to occur prior to installation of driven piles. Consideration should be given to installation of friction reduction pile sleeves to reduce any remaining downdrag forces on the piles.

Due to the presence of highly erodible soils encountered in the soil borings, slope measure protections such as crushed aggregate material (ODOT CMS Item 601.06) consistent of ODOT BDM Item 209.4 should be implemented. The size of the aggregate material to be used should be determined by the designer based on anticipated flow velocity of the river at the crossing.

### 5.7.2 Subgrade Stabilization

Based on information from the borings, we anticipate that stabilization of subgrades to receive embankment fill; and pavement subgrades in areas where proposed grades are situated near existing grades, will required stabilization on order to to provide for stable conditions for placement of embankment fill; or for pavement construction, as applicable.

To identify subgrade areas that require stabilization, we recommend that the exposed at subgrades be thoroughly proofrolled to identify unstable areas consistent with ODOT CMS 204.06 in the presence of experienced geotechnical personnel. Proofrolling of cohesive soils may be accomplished with suitable pneumatic tired equipment. Granular soils, if encountered, can be proof-rolled with several passes of a heavy vibratory roller to help densify those soils.

We recommend that any soft or yielding areas encountered during proofrolling operations should be undercut or reworked in place to a suitable acceptable condition or stabilized by other means.

As described in section **5.7 Earthwork Considerations**, the existing subgrade between STA 101+70 to STA 102+00 and, STA 104+50 to STA 106+30, 3 feet deep undercuts should be made that extend for at least 10 feet beyond the center of the piles of the soldier pile and lagging retaining wall and the undercut soils should be replaced with engineered fill in accordance with ODOT CMS Item 203.02R and 203.3. Please note that weak, soft, high moisture soils are anticipated at the bottom of the 3 feet deep undercuts and will likely require further stabilization with stone; or geogrid and stone as further described in Section 5.7.2.

In the bikeway embankment sections outside of the extents of the soldier pile and lagging retaining wall described above, the construction expedient approach for the remediation of the unstable subgrade soils anticipated at this site should consist of chemical stabilization of the subgrade soils in areas to receive embankment fill and pavement subgrade areas at or near existing grades. This chemical stabilization should be performed in accordance with ODOT CMS Item 206 up to a minimum depth of about 18 inches below exposed subgrade surface. Alternatively, provided that conditions are conducive to drying and reworking soils, stabilization could be performed by scarifying, discing, drying and recompacting the subgrade soils, or by "punching" No. 2 stone into the subgrade.

If chemical stabilization is not used, undercutting and replacement may also be extended to improve the stability of subgrades. Depending on the instability of the of subgrade at the time of construction, durable rock/stone may be considered for use as a replacement backfill material. The gradation/ type of rock/stone to be used will depend on the severity of the instability encountered at the time of construction. The use of No. 1 and No. 2 size stone may be suitable for stabilizing areas of minor to moderate instability by "punching" the stone into the subgrade soils. In areas of more significant instability, "Dumped Rock Fill" as outlined under ODOT CMS Section 601.08 could be used to create an initial stabilizing lift. All lifts of rock fill should be suitably "choked off" at the top with finer grained granular materials. Where No. 1 and No. 2 stone are used, this choking material should consist of crushed No. 57 stone and/ or ODOT 304 aggregate base. Areas of dumped rock should be choked off using No. 1 and No. 2 stone, as appropriate, with the No. 1 and No. 2 stone choked with crushed No. 57 stone and/ or ODOT 304 aggregate base. These stabilizing materials should be thoroughly densified using heavy vibratory compaction equipment.

Undercut excavations containing granular backfill materials should be drained to a suitable outlet, such as an underdrain, catch basin or pipe, or daylighted if grades permit. According to ODOT's Geotechnical Bulletin 1 (GB1), ODOT CMS 712.09, Geotextile Fabric should be used in the bottom of the undercut. In the case of deeper undercuts, multiple layers of geotextile can be used, if needed, at a minimum 12-inch vertical spacing. It should be noted that underdrains cannot be placed through Types C, D, or E material, or the geotextile without difficulty. Therefore, GB1 allows the use of Type B material, with no geotextile, in the areas of the underdrains.

Undercuts in areas of soft soils could be limited to a maximum depth of 3 feet below design subgrade elevation by bridging over deeper soft soils using Tensar BX-1300 geogrid (or equivalent) and No. 2 stone. In most cases, Tensar BX-1300 geogrid and 1± foot of No. 2 stone, choked off with ODOT 304 crushed limestone at top of No. 2's can be used to create a bridging lift. Following densification of the bridging lift with suitable vibratory compaction equipment, the design subgrade elevation should be reestablished using ODOT CMS 703.16.C, Type B or C granular material.

### 5.7.3 Grading and Drainage

During construction, site grading should be developed to direct surface water flow away from, or around, the site. Exposed subgrades should be sloped to provide positive drainage so that saturation of subgrades is avoided. Surface water should not be permitted to accumulate on the site.

Final surrounding grades should be sloped away from the proposed embankments on all sides to prevent ponding of water. Due to the nature of the soil profile, trapped water infiltration or groundwater seepage may be encountered, particularly after periods of precipitation. In such an event, sump and pumping methods may be used for temporary dewatering.

Due to relatively high flood levels anticipated at the site, there are issues related to erosion of the coal run stream bank that are present. Erosion is affected by the stream cross section, stream bed gradient, bank cover, depth of flow and degree of meander. Therefore, we recommend placement of dump rock fill (riprap) along the slope for protection of the slope surface. The dump rock fill typically consists of limestone or dolomite. The variance in size and the rough angular surfaces of the rock allow the revetment to absorb the impact of the flowing water instead of deflecting the flow which could cause erosion to an adjacent streambank area. The rough angular surfaces of the broken rocks also allow them to fit together to form a dense layer of protection over the eroding bank.

### 5.7.4 Excavation Considerations

As a minimum, all excavations should be sloped or braced as required by Occupational Health and Safety Administration (OSHA) regulations to provide stability and safe working conditions. Reference to OSHA 29CFR, Part 1926, Subpart P should be included in the job specifications. current OSHA excavation and trench safety standards.

The grading contractor, by his contract, is usually responsible for designing and constructing stable, temporary excavations and should shore, slope or bench the sides of the excavations as required, to maintain stability of both the excavation sides and bottom. Slope heights, slope inclinations and/or excavation depths should in no case exceed those specified in local, state or federal safety regulations, including the current OSHA Excavation and Trench Safety Standards.

Under no circumstances should the information provided in this report be interpreted to mean that Terracon is responsible for construction site safety or the contractor's activities. Construction site safety is the sole responsibility of the contractor, who shall also be solely responsible for the means, methods, and sequencing of the construction operations.

### 5.7.5 Groundwater Considerations

Groundwater is anticipated during construction at the normal water elevation of Hocking River. Where encountered during construction, proper groundwater control should be employed and maintained to prevent disturbance to excavation bottoms consisting of cohesive soil, and to prevent the possible development of a quick or "boiling" condition where soft silts and/or fine sands are encountered. It is preferable that the groundwater level, if encountered, be maintained at least 5 feet below the deepest excavation. Any seepage or groundwater encountered during foundation excavation should be able to be controlled by pumping from temporary sumps. However, additional measures may be required depending on seasonal fluctuations of the river/groundwater level. Note that determining and maintaining actual groundwater levels during construction is the responsibility of the contractor

## 6.0 GENERAL COMMENTS

Terracon should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon also should be retained to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project.

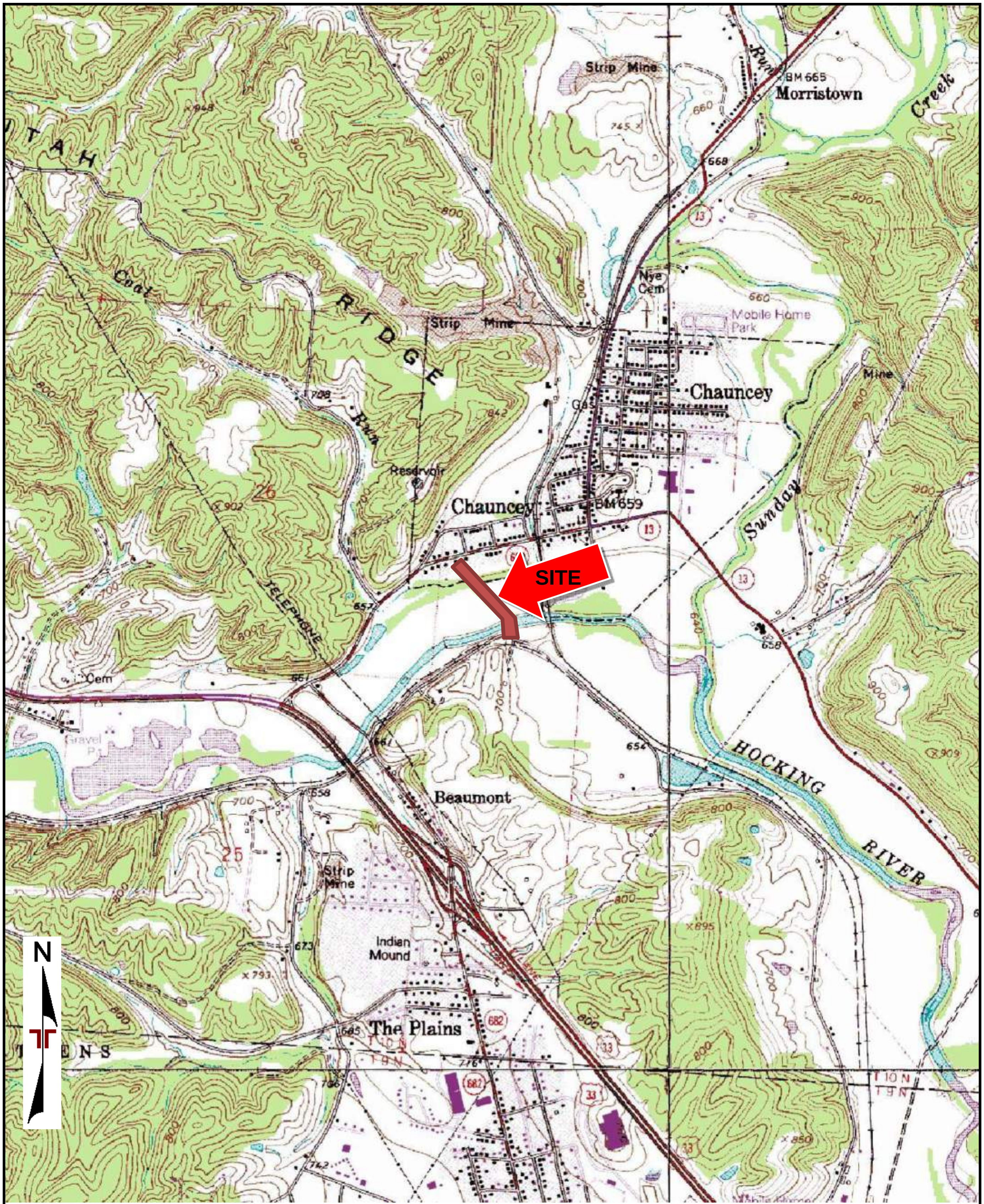
The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The scope of services for this project does not include either specifically or by implication any environmental or biological (*e.g.*, mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

# APPENDIX A

# FIELD EXPLORATION




TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY
QUADRANGLES INCLUDE: NELSONVILLE, OH (1/1/2002), JACKSONVILLE, OH (1/1/2002), THE PLAINS, OH (1/1/1995) and ATHENS, OH (1/1/2002).

| | | | | |
|---|---|---|---|---|
| Project Manager: RS | Project No. N4205071 | Terracon | SITE LOCATION | Exhibit |
| Drawn by: RS | Scale: 1"=2,000' | 800 Morrison Rd | ATH-Chauncey Bikeway Extension | A-1 |
| Checked by: KME | File Name: SLP and BLP | Gahanna, OH 43230-6643 | **River Road Main Street** | |
| Approved by: KMF | Date: 7-16-2020 | | **Chauncey, OH** | |

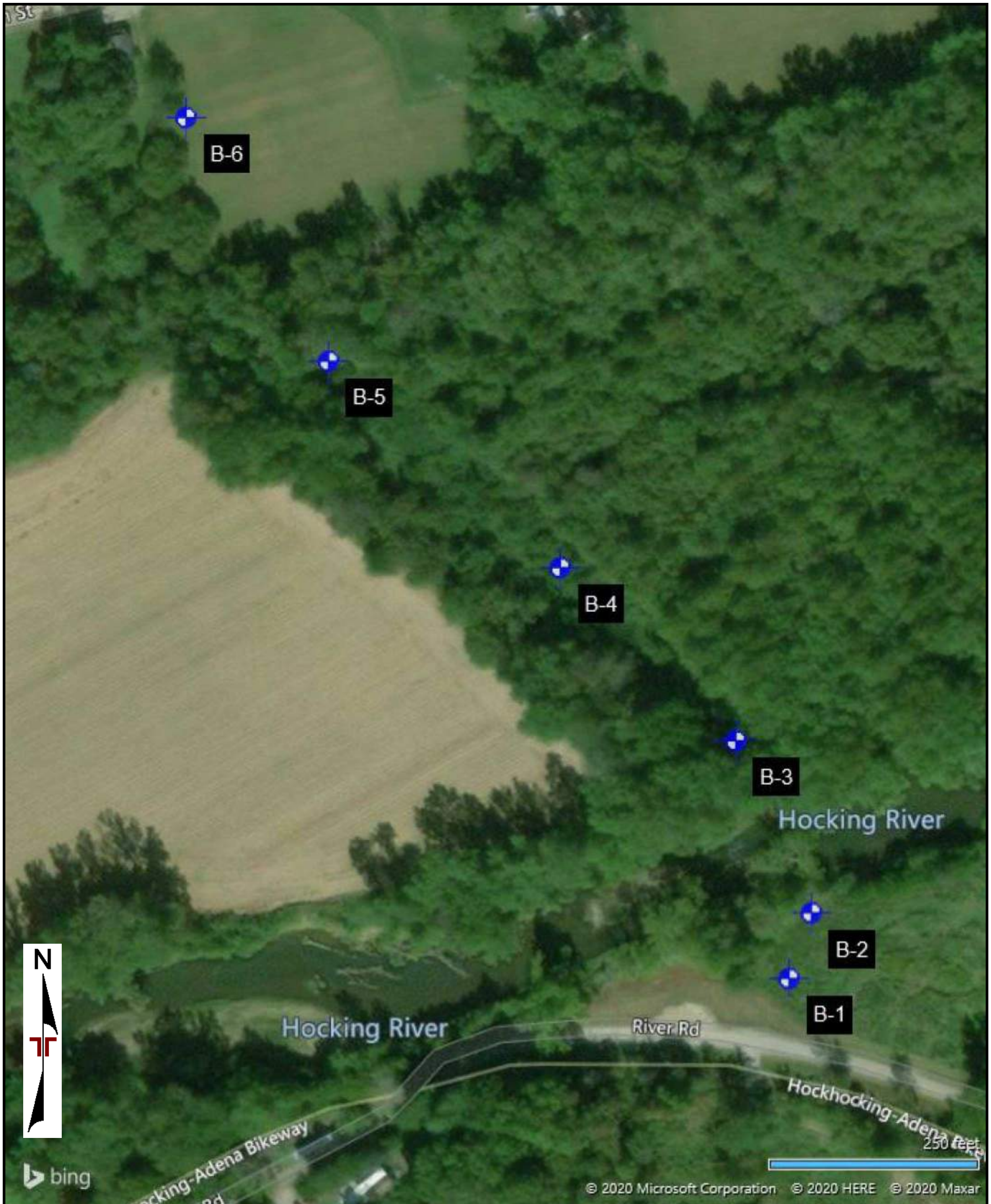



DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

| | | | | |
|---|---|---|---|---|
| Project Manager: RS | Project No. N4205071 | Terracon | BORING LOCATION PLAN | Exhibit |
| Drawn by: RS | Scale: AS SHOWN | 800 Morrison Rd | ATH-Chauncey Bikeway Extension | A-2 |
| Checked by: KME | File Name: SLP and BLP | Gahanna, OH 43230-6643 | **River Road Main Street** | |
| Approved by: KME | Date: 7-16-2020 | | **Chauncey, OH** | |

# APPENDIX B

# LABORATORY INFORMATION

| | | | | |
|---|---|---|---|---|
| PROJECT: ATH-CHAUNCEY BIKEWAY- | DRILLING FIRM / OPERATOR: TERRACON / TJG | DRILL RIG: MOBILE B-57 #613 | STATION / OFFSET: | EXPLORATION ID B-002-0-20 |
| TYPE: ROADWAY | SAMPLING FIRM / LOGGER: TERRACON / MAE | HAMMER: MOBILE AUTOMATIC | ALIGNMENT: | |
| PID: 106647 SFN: | DRILLING METHOD: 3.25" HSA / NQ2 | CALIBRATION DATE: 8/20/19 | ELEVATION: 653.0 (MSL) EOB: 45.0 ft. | PAGE 1 OF 2 |
| START: 5/26/20 END: 5/26/20 | SAMPLING METHOD: SPT / NQ2 | ENERGY RATIO (%): 88.9 | LAT / LONG: 39.392830, -82.132640 | |

| MATERIAL DESCRIPTION AND NOTES | ELEV. 653.0 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOPSOIL [5"] | 652.6 | | | | | | | | | | | | | | | | | |
| VERY LOOSE, BROWN, **SANDY SILT**, SOME FINE TO COARSE SAND, SOME CLAY, MOIST | | 1–2 | 2 2 2 | 6 | 89 | SS-1 | 2.00 | - | - | - | - | - | - | - | - | - | A-4a (V) | |
| | | 3–5 | 1 1 1 | 3 | 100 | SS-2 | 0.50 | - | - | - | - | - | - | - | - | - | A-4a (V) | |
| | | 6–7 | 1 1 1 | 3 | 100 | SS-3 | 0.25 | - | - | - | - | - | - | - | - | - | A-4a (V) | |
| | 642.0 | 8–10 | WOH WOH 2 | 3 | 100 | SS-4 | - | - | - | - | - | - | - | - | - | - | A-4a (V) | |
| VERY LOOSE, GRAY, **SANDY SILT**, LITTLE TO SOME FINE TO COARSE SAND, SOME TO "AND" CLAY, TRACE ORGANICS, MOIST | | 11–12 | WOH WOH WOH | 0 | 100 | SS-5 | 0.25 | - | - | - | - | - | - | - | - | - | A-4a (V) | |
| | 638.0 | 13–15 W 638.0 | WOH WOH WOH | 0 | 100 | SS-6 | 0.75 | - | - | - | - | - | - | - | - | - | A-4a (V) | |
| VERY LOOSE TO LOOSE, GRAY, **FINE SAND**, TRACE SILT, TRACE CLAY, TRACE ORGANICS, WET | | 15–16 | 2 2 3 | 7 | 100 | SS-7 | - | - | - | - | - | - | - | - | - | - | A-3a (V) | |
| | | 17 | WOH WOH 2 | 3 | 100 | SS-8 | - | - | - | - | - | - | - | - | - | - | A-3a (V) | |
| | 633.5 | 18–19 | 2 2 3 | 7 | 100 | SS-9 | - | 5 | 32 | 54 | 4 | 5 | NP | NP | NP | 52 | A-3 (0) | |
| LOOSE, BROWN, **GRAVEL AND/OR STONE FRAGMENTS WITH SAND**, TRACE SILT, TRACE CLAY, WET | | 20–21 | WOH 2 3 | 7 | 100 | SS-10 | - | - | - | - | - | - | - | - | - | 23 | A-3a (V) | |
| | | 21–22 | 2 2 3 | 7 | 100 | SS-11 | - | - | - | - | - | - | - | - | - | - | A-3a (V) | |
| | | 23 | 2 2 3 | 7 | 100 | SS-12 | - | 10 | 48 | 35 | 3 | 4 | NP | NP | NP | 22 | A-1-b (0) | |
| | | 24–25 | 3 3 3 | 9 | 100 | SS-13 | - | - | - | - | - | - | - | - | - | - | A-3a (V) | |
| | 624.5 | 26–28 | 2 3 3 | 9 | 100 | SS-14 | - | - | - | - | - | - | - | - | - | - | A-3a (V) | |
| | | 29 | 7 7 7 | 21 | 78 | SS-15 | - | - | - | - | - | - | - | - | - | - | A-4a (V) | |

| PID: 106647 | SFN: | PROJECT: ATH-CHAUNCEY BIKEWAY- | STATION / OFFSET: | START: 5/26/20 | END: 5/26/20 | PG 2 OF 2 | B-002-0-20 |
|---|---|---|---|---|---|---|---|

| MATERIAL DESCRIPTION AND NOTES | ELEV. 623.0 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MEDIUM DENSE, BROWN TO GRAY, **SANDY SILT**, SOME TO "AND" FINE TO COARSE SAND, TRACE FINE GRAVEL, WET *(continued)* | 619.5 | 31–33 | 9 9 9 | 27 | 100 | SS-16 | - | - | - | - | - | - | - | - | - | - | A-4a (V) | |
| **SHALE**, BROWN TO GRAY, SEVERELY WEATHERED, VERY WEAK. | 618.0 | TR 34 | 50/2" | - | 100 | SS-17 | - | - | - | - | - | - | - | - | - | - | Rock (V) | |
| **SHALE**, GRAY, SEVERELY TO HIGHLY WEATHERED, VERY WEAK, THINLY LAMINATED, ARGILLACEOUS, FRACTURED TO HIGHLY FRACTURED WITH NARROW TO TIGHT, SLIGHTLY ROUGH, CLAY-FILLED JOINTS, CONTAINS CALCAREOUS NODULES<br><br>-LOST RECOVERY @ 35.8-38.8', WASHED OUT SEVERELY WEATHERED SHALE | | 35–40 | 0 | | 40 | NQ2-R-1 | | | | | | | | | | | CORE | |
| -MODERATELY WEAHERED, SLIGHTLY STRONG CALCAREOUS ZONES @ 39.7-46.0', 49.0-49.6'; RQD 7%, REC 69%. | 608.0 | 40–45 EOB | 13 | | 98 | NQ2-R-2 | | | | | | | | | | | CORE | |

NOTES: BORING BACKFILLED WITH CEMENT-BENTONITE GROUT UPON COMPLETION

ABANDONMENT METHODS, MATERIALS, QUANTITIES: TREMIED 0.33 BAG BENTONITE POWDER; TREMIED 1 BAG CEMENT; TREMIED 70 GAL. WATER

| | | | | |
|---|---|---|---|---|
| PROJECT: ATH-CHAUNCEY BIKEWAY- | DRILLING FIRM / OPERATOR: TERRACON / TJG | DRILL RIG: MOBILE B-57 #613 | STATION / OFFSET: | EXPLORATION ID B-003-0-20 |
| TYPE: ROADWAY | SAMPLING FIRM / LOGGER: TERRACON / MAE | HAMMER: MOBILE AUTOMATIC | ALIGNMENT: | |
| PID: 106647 SFN: | DRILLING METHOD: 3.25" HSA / NQ2 | CALIBRATION DATE: 8/20/19 | ELEVATION: 646.0 (MSL) EOB: 39.5 ft. | PAGE 1 OF 2 |
| START: 5/27/20 END: 5/27/20 | SAMPLING METHOD: SPT / NQ2 | ENERGY RATIO (%): 88.9 | LAT / LONG: 39.393395, -82.132961 | |

| MATERIAL DESCRIPTION AND NOTES | ELEV. 646.0 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GR | CS | FS | SI | CL | LL | PL | PI | WC | ODOT CLASS (GI) | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOPSOIL [3"] | 645.8 | | | | | | | | | | | | | | | | | |
| MEDIUM STIFF TO STIFF, BROWN, **SILT AND CLAY**, TRACE FINE TO COARSE SAND, MOIST | | 1–2 | WOH 1 1 | 3 | 100 | SS-1 | 1.25 | - | - | - | - | - | - | - | - | - | A-6a (V) | |
| | 640.0 | 4–5 | 1 1 1 | 3 | 100 | SS-2 | 0.75 | - | - | - | - | - | - | - | - | - | A-6a (V) | |
| VERY LOOSE, BROWN, **SANDY SILT**, SOME CLAY, MOIST | | 6–7 | WOH WOH WOH | 0 | 100 | SS-3 | - | - | - | - | - | - | - | - | - | - | A-4a (V) | |
| | | 9 | WOH WOH WOH | 0 | 100 | SS-4 | 1.25 | - | - | - | - | - | - | - | - | - | A-4a (V) | |
| | | 10–11 (W 635.0) | 2 1 1 | 3 | 100 | SS-5 | - | - | - | - | - | - | - | - | - | - | A-4a (V) | |
| | 633.0 | 12 | WOH WOH WOH | 0 | 100 | SS-6 | 0.50 | - | - | - | - | - | - | - | - | - | A-4a (V) | |
| VERY LOOSE, GRAY, **SANDY SILT**, LITTLE CLAY, TRACE ORGANICS, MOIST | 631.5 | 13–14 | WOH WOH WOH | 0 | 100 | SS-7 | 0.50 | 0 | 1 | 42 | 39 | 18 | 25 | 18 | 7 | 33 | A-4a (4) | |
| LOOSE TO MEDIUM DENSE, GRAY, **GRAVEL AND/OR STONE FRAGMENTS WITH SAND**, LITTLE SILT, TRACE CLAY, WET | | 15 | WOH 2 4 | 9 | 89 | SS-8 | - | - | - | - | - | - | - | - | - | - | A-3a (V) | |
| | | 16–17 | 4 7 10 | 25 | 100 | SS-9 | - | 38 | 19 | 26 | 11 | 6 | NP | NP | NP | 23 | A-1-b (0) | |
| | 627.0 | 18 | 4 8 9 | 25 | 100 | SS-10 | - | - | - | - | - | - | - | - | - | - | A-3a (V) | |
| LOOSE TO MEDIUM DENSE, BROWN TO GRAY, **GRAVEL AND/OR STONE FRAGMENTS WITH SAND**, TRACE SILT, TRACE CLAY, WET | | 19–20 | 11 11 8 | 28 | 89 | SS-11 | - | - | - | - | - | - | - | - | - | - | A-3a (V) | |
| | | 21–22 | 5 4 6 | 15 | 0 | SS-12 | - | - | - | - | - | - | - | - | - | - | A-3a (V) | |
| | 620.0 | 24–25 (TR at 26) | 5 6 6 | 18 | 89 | SS-13 | - | 28 | 37 | 24 | 7 | 4 | NP | NP | NP | 14 | A-1-b (0) | |
| **SHALE**, GRAY, SEVERELY WEATHERED, VERY WEAK. | | 26 | 50/4" | - | 100 | SS-14 | - | - | - | - | - | - | - | - | - | - | Rock (V) | |
| | 616.5 | 29 | 35 50/4" | - | 100 | SS-15 | - | - | - | - | - | - | - | - | - | - | Rock (V) | |

| PID: 106647 | SFN: | PROJECT: ATH-CHAUNCEY BIKEWAY- | STATION / OFFSET: | START: 5/27/20 | END: 5/27/20 | PG 2 OF 2 | B-003-0-20 |
|---|---|---|---|---|---|---|---|

| MATERIAL DESCRIPTION AND NOTES | ELEV. 616.0 | DEPTHS | SPT/RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | HOLE SEALED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SHALE**, GRAY, SEVERELY TO HIGHLY WEATHERED, VERY WEAK, THINLY LAMINATED, ARGILLACEOUS, FRACTURED TO HIGHLY FRACTURED WITH LOW ANGLE, NARROW TO TIGHT, SLIGHTLY ROUGH JOINTS<br>-LOST RECOVERY @ 33.1-33.8', WASHED OUT PROBABLE SEVERELY WEATHERED SHALE<br>-CALCAREOUS ZONES @ 29.5-29.7', 30.4-30.7', 32.9-33.1'; RQD 0%, REC 88%. *(continued)* | 612.0 | 31 – 34 | 0 | | 87 | NQ2-R-1 | | | | | | | | | | | CORE | |
| **LIMESTONE**, LIGHT GRAY, HIGHLY WEATHERED, WEAK TO SLIGHTLY STRONG, THIN BEDDED, ARGILLACEOUS, FRACTURED TO MODERATELY FRACTURED, WITH NARROW, SLIGHTLY ROUGH JOINTS<br>- LOST RECOVERY @ 37.9-39.4', WASHED OUT PROBABLE SEVERELY WEATHERED SHALE; RQD 10%, REC 76%. | 606.5 | 35 – 39, EOB | 10 | | 73 | NQ2-R-2 | | | | | | | | | | | CORE | |

NOTES: BORING BACKFILLED WITH CEMENT-BENTONITE GROUT UPON COMPLETION

ABANDONMENT METHODS, MATERIALS, QUANTITIES: TREMIED 0.33 BAG BENTONITE POWDER; TREMIED 1 BAG CEMENT; TREMIED 70 GAL. WATER

| PROJECT: ATH-CHAUNCEY BIKEWAY- | DRILLING FIRM / OPERATOR: TERRACON / TJG | DRILL RIG: MOBILE B-57 #613 | STATION / OFFSET: | EXPLORATION ID B-004-0-20 |
|---|---|---|---|---|
| TYPE: ROADWAY | SAMPLING FIRM / LOGGER: TERRACON / MAE | HAMMER: MOBILE AUTOMATIC | ALIGNMENT: | |
| PID: 106647 SFN: | DRILLING METHOD: 3.25" HSA | CALIBRATION DATE: 8/20/19 | ELEVATION: 648.5 (MSL) EOB: 10.0 ft. | PAGE 1 OF 1 |
| START: 5/27/20 END: 5/27/20 | SAMPLING METHOD: SPT | ENERGY RATIO (%): 88.9 | LAT / LONG: 39.393963, -82.133706 | |

| ***MATERIAL DESCRIPTION AND NOTES*** | ELEV. 648.5 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOPSOIL [3"] | 648.3 | | | | | | | | | | | | | | | | | |
| MEDIUM STIFF TO STIFF, BROWN, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST | | 1–2 | 1 1 2 | 4 | 89 | SS-1 | 2.00 | - | - | - | - | - | - | - | - | 25 | A-6a (V) | |
| | | 4–5 | 1 1 1 | 3 | 100 | SS-2 | 0.50 | - | - | - | - | - | - | - | - | - | A-6a (V) | |
| | | 6–7 | 1 1 2 | 4 | 100 | SS-3 | 0.75 | 2 | 0 | 18 | - 80 - | | 30 | 18 | 12 | 27 | A-6a (9) | |
| | 638.5 | 9–10 EOB | 1 1 1 | 3 | 100 | SS-4 | 1.50 | - | - | - | - | - | - | - | - | - | A-6a (V) | |

NOTES: BORING BACKFILLED WITH AUGER CUTTINGS UPON COMPLETION

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH AUGER CUTTINGS

| | | | | |
|---|---|---|---|---|
| PROJECT: ATH-CHAUNCEY BIKEWAY- | DRILLING FIRM / OPERATOR: TERRACON / TJG | DRILL RIG: MOBILE B-57 #613 | STATION / OFFSET: | EXPLORATION ID B-005-0-20 |
| TYPE: ROADWAY | SAMPLING FIRM / LOGGER: TERRACON / MAE | HAMMER: MOBILE AUTOMATIC | ALIGNMENT: | |
| PID: 106647 SFN: | DRILLING METHOD: 3.25" HSA | CALIBRATION DATE: 8/20/19 | ELEVATION: 647.0 (MSL) EOB: 10.0 ft. | PAGE 1 OF 1 |
| START: 5/27/20 END: 5/27/20 | SAMPLING METHOD: SPT | ENERGY RATIO (%): 88.9 | LAT / LONG: 39.394640, -82.134690 | |

**MATERIAL DESCRIPTION AND NOTES** (ELEV. 647.0)

- TOPSOIL [3"] — 646.8
- STIFF, BROWN, **SILT AND CLAY**, TRACE FINE TO COARSE SAND, MOIST — 643.5 (W 643.5)
- VERY LOOSE, BROWN, **SANDY SILT**, WET — 637.0 (EOB at 10)

| Depths | SPT/RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GR | CS | FS | SI | CL | LL | PL | PI | WC | ODOT CLASS (GI) | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1–2.5 | 1 1 2 | 4 | 100 | SS-1 | 1.50 | - | - | - | - | - | - | - | - | 21 | A-6a (V) | |
| 3.5–5 | 1 2 2 | 6 | 100 | SS-2 | - | 0 | 12 | 14 | - 74 - | | NP | NP | NP | 18 | A-4 (8) | |
| 6–7.5 | 1 1 2 | 4 | 100 | SS-3 | - | - | - | - | - | - | - | - | - | - | A-3a (V) | |
| 8.5–10 | 1 1 1 | 3 | 100 | SS-4 | - | - | - | - | - | - | - | - | - | - | A-3a (V) | |

NOTES: BORING BACKFILLED WITH AUGER CUTTINGS UPON COMPLETION

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH AUGER CUTTINGS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 7/21/20 12:33 - C:\USERS\RSINGH\ONEDRIVE - TERRACON CONSULTANTS INC\DESKTOP\JUNK\N4205071\N4205071 ODOT FORMAT

| | | | | |
|---|---|---|---|---|
| PROJECT: ATH-CHAUNCEY BIKEWAY-<br>TYPE: ROADWAY<br>PID: 106647 SFN:<br>START: 5/27/20 END: 5/27/20 | DRILLING FIRM / OPERATOR: TERRACON / TJG<br>SAMPLING FIRM / LOGGER: TERRACON / MAE<br>DRILLING METHOD: 3.25" HSA<br>SAMPLING METHOD: SPT | DRILL RIG: MOBILE B-57 #613<br>HAMMER: MOBILE AUTOMATIC<br>CALIBRATION DATE: 8/20/19<br>ENERGY RATIO (%): 88.9 | STATION / OFFSET:<br>ALIGNMENT:<br>ELEVATION: 650.5 (MSL) EOB: 10.0 ft.<br>LAT / LONG: 39.395439, -82.135295 | EXPLORATION ID<br>B-006-0-20<br>PAGE<br>1 OF 1 |

| ***MATERIAL DESCRIPTION AND NOTES*** | ELEV. 650.5 | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOPSOIL [4"] | 650.2 | | | | | | | | | | | | | | | | | |
| MEDIUM STIFF TO STIFF, BROWN, **CLAY**, LITTLE SAND, MOIST | | 1–2 | 1 2 3 | 7 | 89 | SS-1 | 1.50 | 0 | 2 | 17 | 81 | | 43 | 21 | 22 | 26 | A-7-6 (13) | |
| | | 4–5 | 2 2 3 | 7 | 89 | SS-2 | 1.50 | - | - | - | - | - | - | - | - | 24 | A-6a (V) | |
| | | 6–7 | 3 3 5 | 12 | 100 | SS-3 | 1.75 | - | - | - | - | - | - | - | - | 21 | A-6a (V) | |
| | 640.5 | 9–10 EOB | 2 3 3 | 9 | 100 | SS-4 | 0.50 | - | - | - | - | - | - | - | - | 22 | A-6a (V) | |

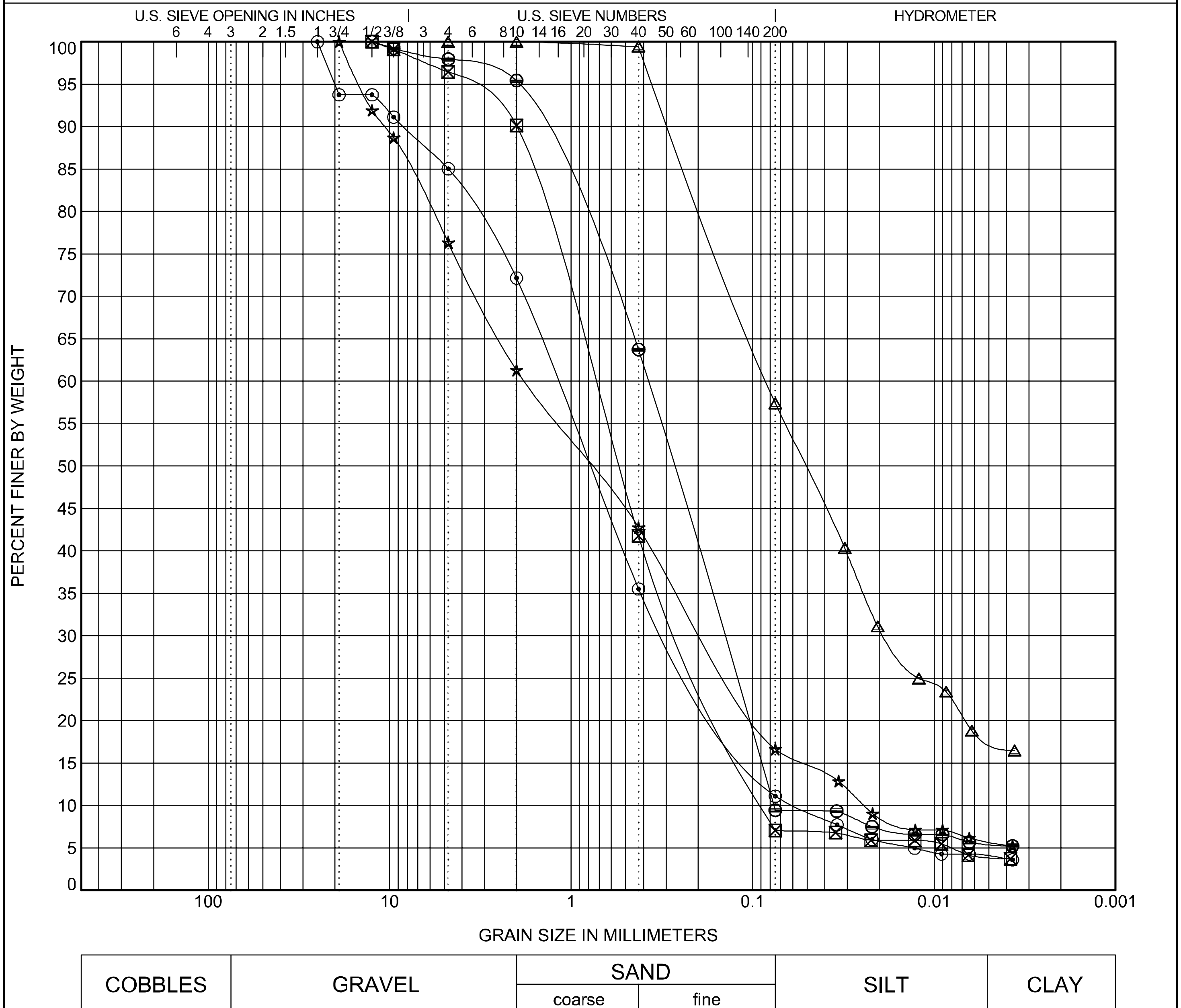
NOTES: BORING BACKFILLED WITH AUGER CUTTINGS UPON COMPLETION

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH AUGER CUTTINGS

# GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

**PROJECT** ATH-CHAUNCEY BIKEWAY- **PID** 106647
**OGE NUMBER** NA **PROJECT TYPE** ROADWAY




| Specimen Identification | | | ODOT (Modified AASHTO) ~ USCS Classification | LL | PL | PI |
|---|---|---|---|---|---|---|
| ⊖ | B-2 | 18.0 | A-3 ~ POORLY GRADED SAND with SILT(SP-SM) | NP | NP | NP |
| ⊠ | B-2 | 22.5 | A-1-b ~ POORLY GRADED SAND with SILT(SP-SM) | NP | NP | NP |
| △ | B-3 | 13.0 | A-4a ~ SANDY SILTY CLAY(CL-ML) | 25 | 18 | 7 |
| ★ | B-3 | 16.0 | A-1-b ~ SILTY SAND with GRAVEL(SM) | NP | NP | NP |
| ⊙ | B-3 | 23.5 | A-1-b ~ POORLY GRADED SAND with SILT(SP-SM) | NP | NP | NP |

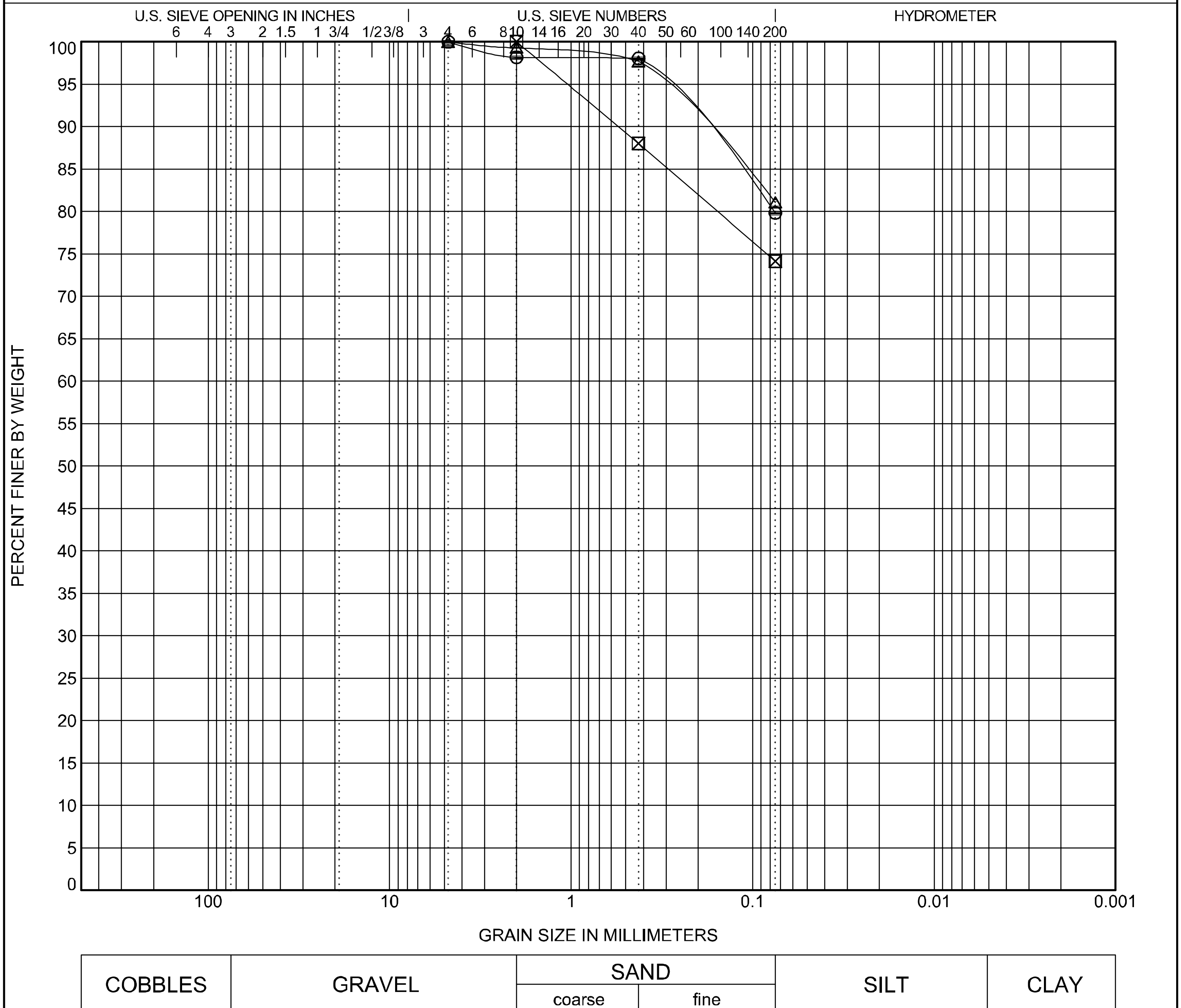
| Specimen Identification | | | D90 | D50 | D30 | D10 | %G | %CS | %FS | %M | %C | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ⊖ | B-2 | 18.0 | 1.534 | 0.274 | 0.145 | 0.076 | 5 | 32 | 54 | 4 | 5 | 0.73 | 4.94 |
| ⊠ | B-2 | 22.5 | 1.99 | 0.553 | 0.236 | 0.087 | 10 | 48 | 35 | 3 | 4 | 0.84 | 8.76 |
| △ | B-3 | 13.0 | 0.288 | 0.051 | 0.019 | | 0 | 1 | 42 | 39 | 18 | | |
| ★ | B-3 | 16.0 | 10.616 | 0.778 | 0.182 | 0.024 | 38 | 19 | 26 | 11 | 6 | 0.76 | 73.78 |
| ⊙ | B-3 | 23.5 | 8.364 | 0.784 | 0.287 | 0.058 | 28 | 37 | 24 | 7 | 4 | 1.18 | 20.54 |

# GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

**PROJECT** ATH-CHAUNCEY BIKEWAY- **PID** 106647

**OGE NUMBER** NA **PROJECT TYPE** ROADWAY




| Specimen Identification | | | ODOT (Modified AASHTO) ~ USCS Classification | LL | PL | PI |
|---|---|---|---|---|---|---|
| ⊖ | B-4 | 6.0 | **A-6a ~ LEAN CLAY with SAND(CL)** | 30 | 18 | 12 |
| ⊠ | B-5 | 3.5 | **A-4 ~ SILT with SAND(ML)** | NP | NP | NP |
| △ | B-6 | 1.0 | **A-7-6 ~ LEAN CLAY with SAND(CL)** | 43 | 21 | 22 |

| Specimen Identification | | | D90 | D50 | D30 | D10 | %G | %CS | %FS | %M %C | Cc | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ⊖ | B-4 | 6.0 | 0.198 | | | | 2 | 0 | 18 | 80 | | |
| ⊠ | B-5 | 3.5 | 0.551 | | | | 0 | 12 | 14 | 74 | | |
| △ | B-6 | 1.0 | 0.19 | | | | 0 | 2 | 17 | 81 | | |

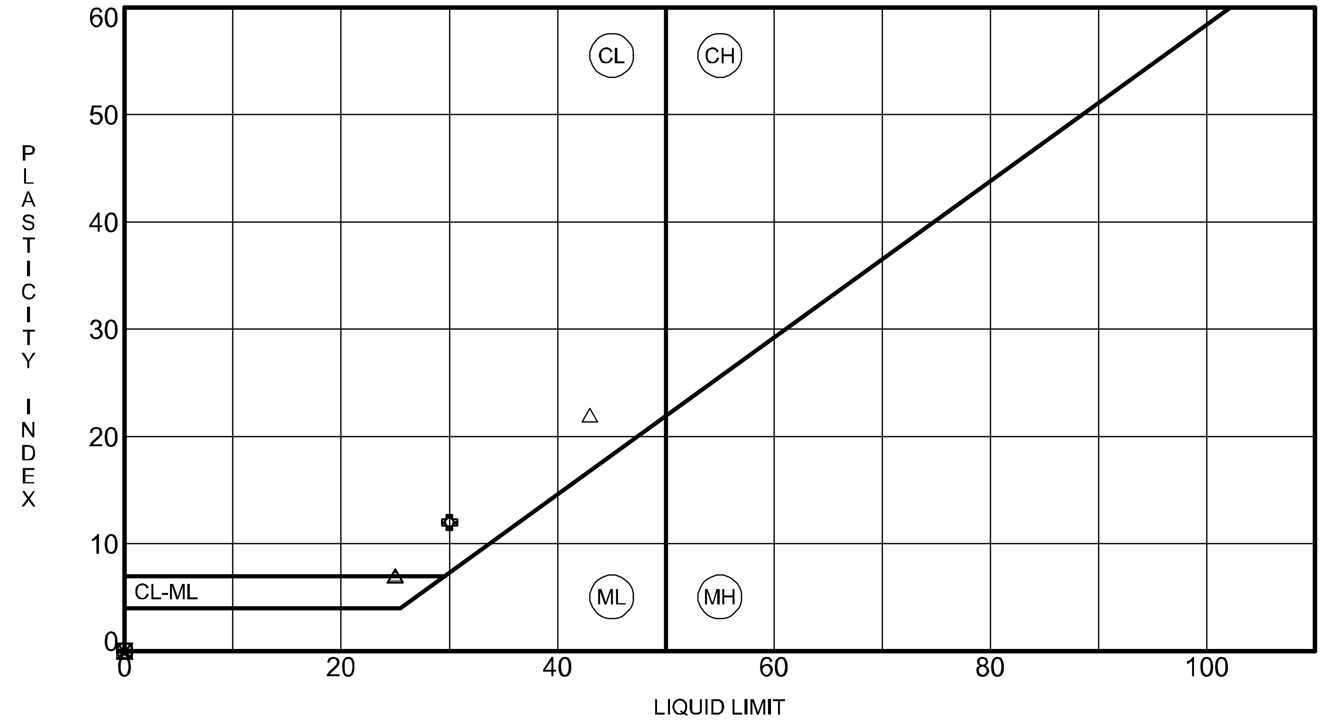
GRAIN SIZE - OH DOT.GDT - 7/9/20 10:46 - C:\USERS\RSINGH\DESKTOP\JUNK\N4205071\N4205071 ODOT FORMAT.GPJ

# ATTERBERG LIMITS' RESULTS

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

**PROJECT** ATH-CHAUNCEY BIKEWAY- **PID** 106647

**OGE NUMBER** NA **PROJECT TYPE** ROADWAY




| | Specimen Identification | | LL | PL | PI | Fines | Classification |
|---|---|---|---|---|---|---|---|
| ⊖ | **B-2** | **18.0** | **NP** | **NP** | **NP** | **9** | **POORLY GRADED SAND with SILT(SP-SM)** |
| ⊠ | **B-2** | **22.5** | **NP** | **NP** | **NP** | **7** | **POORLY GRADED SAND with SILT(SP-SM)** |
| ▲ | **B-3** | **13.0** | **25** | **18** | **7** | **57** | **SANDY SILTY CLAY(CL-ML)** |
| ★ | **B-3** | **16.0** | **NP** | **NP** | **NP** | **17** | **SILTY SAND with GRAVEL(SM)** |
| ⊙ | **B-3** | **23.5** | **NP** | **NP** | **NP** | **11** | **POORLY GRADED SAND with SILT(SP-SM)** |
| ✪ | **B-4** | **6.0** | **30** | **18** | **12** | **80** | **LEAN CLAY with SAND(CL)** |
| ○ | **B-5** | **3.5** | **NP** | **NP** | **NP** | **74** | **SILT with SAND(ML)** |
| △ | **B-6** | **1.0** | **43** | **21** | **22** | **81** | **LEAN CLAY with SAND(CL)** |
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ATTERBERG LIMITS - OH DOT.GDT - 7/9/20 10:44 - C:\USERS\RSINGH\DESKTOP\JUNK\N4205071\N4205071 ODOT FORMAT.GPJ

# APPENDIX C
# SUPPORTING DOCUMENTS

# CLASSIFICATION OF SOILS

Ohio Department of Transportation

(The classification of a soil is found by proceeding from top to bottom of the chart. The first classification that the test data fits is the correct classification.)

| SYMBOL | DESCRIPTION | Classifcation AASHTO | Classifcation OHIO | $LL_O/LL \times 100$* | % Pass #40 | % Pass #200 | Liquid Limit (LL) | Plastic Index (PI) | Group Index Max. | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gravel and/or Stone Fragments | A-1-a | | | 30 Max. | 15 Max. | | 6 Max. | 0 | Min. of 50% combined gravel, cobble and boulder sizes |
| | Gravel and/or Stone Fragments with Sand | A-1-b | | | 50 Max. | 25 Max. | | 6 Max. | 0 | |
| F S | Fine Sand | A-3 | | | 51 Min. | 10 Max. | NON-PLASTIC | | 0 | |
| | Coarse and Fine Sand | -- | A-3a | | | 35 Max. | | 6 Max. | 0 | Min. of 50% combined coarse and fine sand sizes |
| | Gravel and/or Stone Fragments with Sand and Silt | A-2-4 | | | | 35 Max. | 40 Max. | 10 Max. | 0 | |
| | | A-2-5 | | | | | 41 Min. | | | |
| | Gravel and/or Stone Fragments with Sand, Silt and Clay | A-2-6 | | | | 35 Max. | 40 Max. | 11 Min. | 4 | |
| | | A-2-7 | | | | | 41 Min. | | | |
| | Sandy Silt | A-4 | A-4a | 75 Min. | | 36 Min. | 40 Max. | 10 Max. | 8 | Less than 50% silt sizes |
| | Silt | A-4 | A-4b | 75 Min. | | 50 Min. | 40 Max. | 10 Max. | 8 | 50% or more silt sizes |
| | Elastic Silt and Clay | A-5 | | 75 Min. | | 36 Min. | 41 Min. | 10 Max. | 12 | |
| | Silt and Clay | A-6 | A-6a | 75 Min. | | 36 Min. | 40 Max. | 11 - 15 | 10 | |
| | Silty Clay | A-6 | A-6b | 75 Min. | | 36 Min. | 40 Max. | 16 Min. | 16 | |
| | Elastic Clay | A-7-5 | | 75 Min. | | 36 Min. | 41 Min. | ≤LL-30 | 20 | |
| | Clay | A-7-6 | | 75 Min. | | 36 Min. | 41 Min. | >LL-30 | 20 | |
| | Organic Silt | A-8 | A-8a | 74 Max. | | 36 Min. | | | | W/o organics would classify as A-4a or A-4b |
| | Organic Clay | A-8 | A-8b | 74 Max. | | 36 Min. | | | | W/o organics would classify as A-5, A-6a, A-6b, A-7-5 or A-7-6 |

MATERIAL CLASSIFIED BY VISUAL INSPECTION

- Sod and Topsoil
- Pavement or Base
- Uncontrolled Fill (Describe)
- Bouldery Zone
- P Peat

* Only perform the oven-dried liquid limit test and this calculation if organic material is present in the sample.

# APPENDIX A.2 – ODOT Quick Reference Guide for Rock Description

**1: ROCK TYPE**: Common rock types are: Claystone; Coal; Dolomite; Limestone; Sandstone; Siltstone; & Shale.

**2: COLOR**: To be determined when rock is wet. When using the GSA Color charts use only Name, not code.

**3: WEATHERING**

| Description | Field Parameter |
|---|---|
| **Unweathered** | No evidence of any chemical or mechanical alternation of the rock mass. Mineral crystals have a bright appearance with no discoloration. Fractures show little or no staining on surfaces. |
| **Slightly weathered** | Slight discoloration of the rock surface with minor alterations along discontinuities. Less than 10% of the rock volume presents alteration. |
| **Moderately weathered** | Portions of the rock mass are discolored as evident by a dull appearance. Surfaces may have a pitted appearance with weathering "halos" evident. Isolated zones of varying rock strengths due to alteration may be present. 10 to 15% of the rock volume presents alterations. |
| **Highly weathered** | Entire rock mass appears discolored and dull. Some pockets of slightly too moderately weathered rock may be present and some areas of severely weathered materials may be present. |
| **Severely weathered** | Majority of the rock mass reduced to a soil-like state with relic rock structure discernable. Zones of more resistant rock may be present, but the material can generally be molded and crumbled by hand pressures. |

**4: TEXTURE**

| Component | | Grain Diameter |
|---|---|---|
| Boulder | | >12" |
| Cobble | | 3"-12" |
| Gravel | | 0.08"-3" |
| Sand | Coarse | 0.02"-0.08" |
| | Medium | 0.01"-0.02" |
| | Fine | 0.005"-0.01" |
| | Very Fine | 0.003"-0.005" |

**5: RELATIVE STRENGTH**

| Description | Field Parameter |
|---|---|
| **Very Weak** | Core can be carved with a knife and scratched by fingernail. Can be excavated readily with a point of a pick. Pieces 1 inch or more in thickness can be broken by finger pressure. |
| **Weak** | Core can be grooved or gouged readily by a knife or pick. Can be excavated in small fragments by moderate blows of a pick point. Small, thin pieces can be broken by finger pressure. |
| **Slightly Strong** | Core can be grooved or gouged 0.05 inch deep by firm pressure of a knife or pick point. Can be excavated in small chips to pieces about 1-inch maximum size by hard blows of the point of a geologist's pick. |
| **Moderately Strong** | Core can be scratched with a knife or pick. Grooves or gouges to ¼" deep can be excavated by hand blows of a geologist's pick. Requires moderate hammer blows to detach hand specimen. |
| **Strong** | Core can be scratched with a knife or pick only with difficulty. Requires hard hammer blows to detach hand specimen. Sharp and resistant edges are present on hand specimen. |
| **Very Strong** | Core cannot be scratched by a knife or sharp pick. Breaking of hand specimens requires hard repeated blows of the geologist hammer. |
| **Extremely strong** | Core cannot be scratched by a knife or sharp pick. Chipping of hand specimens requires hard repeated blows of the geologist hammer. |

**6: BEDDING**

| Description | Thickness |
|---|---|
| **Very Thick** | >36" |
| **Thick** | 18" – 36" |
| **Medium** | 10" – 18" |
| **Thin** | 2" – 10" |
| **Very Thin** | 0.4" – 2" |
| **Laminated** | 0.1" – 0.4" |
| **Thinly Laminated** | <0.1" |

**7: DESCRIPTORS**

| | | |
|---|---|---|
| Arenaceous – sandy | Argillaceous - clayey | Brecciated – contains angular to subangular gravel |
| Calcareous - contains calcium carbonate | Carbonaceous - contains carbon | Cherty- contains chert fragments |
| Conglomeritic - contains rounded to subrounded gravel | Crystalline – contains crystalline structure | Dolomitic- contains calcium/magnesium carbonate |
| Ferriferous – contains iron | Fissile – thin planner partings | Fossiliferous – contains fossils |
| Friable – easily broken down | Micaceous – contains mica | Pyritic – contains pyrite |
| Siliceous – contains silica | Stylolitic – contain stylotites (suture like structure) | Vuggy – contains openings |

# APPENDIX A.2 – ODOT Quick Reference Guide for Rock Description

## 8: Discontinuities

### a: Discontinuity Types

| Type | Parameters |
|---|---|
| ***Fault*** | Fracture which expresses displacement parallel to the surface that does not result in a polished surface. |
| ***Joint*** | Planar fracture that does not express displacement. Generally occurs at regularly spaced intervals. |
| ***Shear*** | Fracture which expresses displacement parallel to the surface that results in polished surfaces or slickensides. |
| ***Bedding*** | A surface produced along a bedding plane. |
| ***Contact*** | A surface produced along a contact plane. (generally not seen in Ohio) |

### b: Degree of Fracturing

| Description | Spacing |
|---|---|
| **Unfractured** | > 10 ft. |
| **Intact** | 3 ft. – 10 ft. |
| **Slightly fractured** | 1 ft. – 3 ft. |
| **Moderately fractured** | 4 in. – 12 in. |
| **Fractured** | 2 in. – 4 in. |
| **Highly fractured** | < 2 in. |

### c: Aperture Width

| Description | Spacing |
|---|---|
| **Open** | > 0.2 in. |
| **Narrow** | 0.05 in. - 0.2 in. |
| **Tight** | <0.05 in. |

### d: Surface Roughness

| Description | Criteria |
|---|---|
| Very Rough | Near vertical steps and ridges occur on the discontinuity surface. |
| Slightly Rough | Asperities on the discontinuity surface are distinguishable and can be felt. |
| Slickensided | Surface has a smooth, glassy finish with visual evidence of striation. |

## 11: Recovery

$$Run\ Recovery = \left(\frac{R_R}{L_R}\right) * 100 \qquad Unit\ Recovery = \left(\frac{R_U}{L_U}\right) * 100$$

| | |
|---|---|
| $L_R$ = Run Length<br>$R_R$ – Run Recovery | $L_U$ = Rock Unit Length<br>$R_U$ – Rock Unit Recovery |

## 9: GSI Description

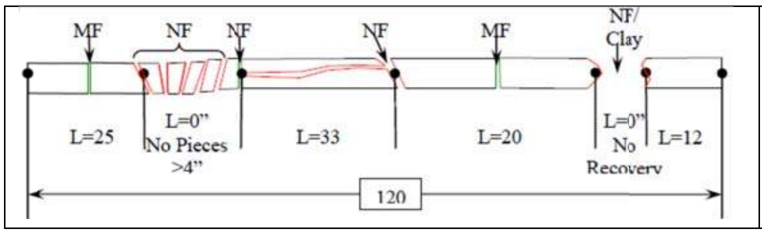
### a: Structure

| Description | Parameters |
|---|---|
| **Intact or Massive** | Intact rock with few widely spaced discontinuities |
| **Blocky** | Well interlocked undisturbed rock mass consisting of cubical blocks formed by three interesting discontinuity sets |
| **Very Blocky** | Interlocked, partially disturbed mass with multi-faceted angular blocks formed by 4 or more joint sets |
| **Blocky/Disturbed/ Seamy** | Angular blocks formed by many intersecting discontinuity sets, Persistence of bedding planes |
| **Disintegrated** | Poorly interlocked, heavily broken rock mass with mixture of angular and rounded rock pieces |
| **Laminated/Sheared** | Lack of blockiness due to close spacing of weak shear planes |

### b: Surface Condition

| Description | Parameters |
|---|---|
| Very Good | Very rough, fresh unweathered surfaces |
| Good | Rough, slightly weathered, iron stained surface |
| Fair | Smooth, moderately weathered and altered surfaces |
| Poor | Slickensided, highly weathered surface with compact coatings or fillings or angular fragments |
| Very Poor | Slickensided, highly weathered surfaces with soft clay coating or fillings |

## 10: RQD




$$RQD = \left(\frac{\sum Length\ \ of\ \ Pieces > 4inches}{Total\ Length\ of\ Core}\right) * 100$$

$$RQD = \left(\frac{25+33+20+12}{120}\right) * 100 = 75\%$$