STRUCTURE FOUNDATION EXPLORATION

Proposed Culvert Replacement

WOO 64-5.78, PID 107711

SR 64 over Tributary of Haskins Creek

Plain Township, Wood County, Ohio

Submitted to Tetra Tech, Inc.
Date April *2025*

Prepared by

Ohio Department of Transportation

1915 North 12th Street
Toledo, OH 43604-5305
T 419-324-2222
F 419-241-1808
www.ttlassoc.com

April 2, 2025

TTL Project No. 2130501

Mr. David T. Charville, PE
Tetra Tech, Inc.
420 Madison Avenue, Suite 1001
Toledo, Ohio 43604

Final Report
Structure Foundation Exploration
Proposed Culvert Replacement
WOO-64-5.78, PID 107711
SR 64 over Tributary of Haskins Creek
Plain Township, Wood County, Ohio

Dear Mr. Charville:

Following is the final report of our structure foundation exploration performed by TTL Associates, Inc. (TTL) for the referenced site. This study was performed in accordance with TTL Proposal No. 2130501R, dated August 22, 2021, and was authorized with a Tetra Tech, Inc. Subconsultant agreement signed by you on September 22, 2021, for which you referenced Tetra Tech Project No. 200-12914-21002, Task 003.A.

A "draft" version of this report was provided on May 25, 2022. This report contains the results of our study, our engineering interpretation of the results with respect to the project characteristics, as well as our design and construction recommendations for the replacement culvert and associated pavements. We were notified in March 2025 that no changes to the report were requested after review of the draft submittal. Therefore, this submittal is considered final.

Should you have any questions regarding this report or require additional information, please contact our office.

Sincerely,

TTL Associates, Inc.

STATE OF OHIO
CHRISTOPHER P IOTT
E-69734
REGISTERED
PROFESSIONAL ENGINEER

Imad El Hajjar, EI
Geotechnical Project Manager

Christopher P. Iott, P.E.
Chief Geotechnical Engineer

H:\2022\229121\PHASE\Reports and Other Deliverables\64-05.78\2130501 TTL FINAL Geotech Report WOO 64-5.78 Culvert Replacement.docx

FINAL REPORT
STRUCTURE FOUNDATION EXPLORATION
PROPOSED CULVERT REPLACEMENT
WOO-64-5.78, PID 107711
SR 64 OVER TRIBUTARY OF HASKINS CREEK
PLAIN TOWNSHIP, WOOD COUNTY, OHIO

FOR

TETRA TECH, INC.
420 MADISON AVENUE, SUITE 1001
TOLEDO, OHIO 43604

SUBMITTED

APRIL 2, 2025
TTL PROJECT NO. 2130501

TTL ASSOCIATES, INC.
1915 NORTH 12TH STREET
TOLEDO, OHIO 43604
(419) 324-2222
(419) 321-6257 FAX

EXECUTIVE SUMMARY

This structure foundation exploration report has been prepared for the proposed replacement of the culvert along State Route 64 (SR 64), in Plain Township, Wood County, Ohio, designated as WOO-64-5.78, PID No. 107711. This exploration included two test borings and one pavement core. A summary of the conclusions and recommendations of this study are as follows:

1. The pavement section encountered in Borings B-001 and B-002 consisted of approximately 10 inches and 11 inches of asphalt, respectively, underlain by approximately 14 inches and 8 inches of aggregate base, respectively. The surface materials encountered in Corehole X-001 consisted of approximately 7½ inches asphalt, underlain by approximately 7 inches of aggregate base.

2. The subsoils encountered underlying the pavement materials can be generally described as predominantly cohesive soils overlying bedrock. The encountered subsoils consisted of predominantly native cohesive soils encountered underlying the pavement materials to depths of 33 to 34 feet. These soils consisted of sandy silt (A-4a), silt and clay (A-6a) and silty clay (A-6b). The upper portion of the cohesive soils exhibited generally stiff to very stiff consistency. This layer extended to a depth of 11 feet (Elev. 663±) in Boring B-001 and to a depth of 7½ feet (Elev. 666±) in Boring B-002. The lower portion of the cohesive soil profile exhibited generally very stiff to hard consistency. A zone of very dense granular soils was encountered underlying the predominantly very stiff to hard cohesive soils to depths of 34½ feet in Boring B-001 and to auger refusal at a depth of 35 feet in Boring B-002. These soils consisted of coarse and fine sand with some silt and varying amounts of gravel and rock fragments (A-3a). **Weathered dolomite** that was able to be penetrated with augers was encountered underlying the zone of granular soils to auger refusal at a depth of approximately 35½ feet in Boring B-001. Upon encountering auger refusal in Borings B-001 and B-002, the rock was cored for a total length of 5 feet. The cored bedrock consisted of highly to slightly weathered dolomite.

3. During our site reconnaissance on October 19, 2021, water levels in the creek tributary were approximately 1 to 1½ feet deep. The creek tributary bottom was approximately 9 to 11 feet below the road surface. Hence, based on our field observations, water was approximately 8 to 9½ feet below the road surface (Elevs. 666± to 664±) during the more normal/non-rain-influenced observation date of October 19, 2021. Apart from streamflow influences in the creek tributary, it is our opinion that the "normal" groundwater level can generally be expected at depths below pavement surface on the order of 12 to 16 feet (Elevs. 662± to 657±).

4. Based on the conditions encountered in the borings, the soils at the anticipated culvert bearing elevation are expected to consist of very stiff to hard cohesive soils. These soils are considered suitable for support of the proposed culvert. However, with any installation within a creek area, there may be areas of encountered sediment at bearing elevations, which would require over-excavation.

5. We understand that the culvert will be designed using LRFD specifications. At the **service** limit state, the factored bearing resistance was determined to be 8 ksf based on the very stiff to hard cohesive bearing soils. Settlement associated with this bearing resistance was calculated to be on the order of 1¾ to 2¼ inches. To limit total calculated settlement to the typical maximum magnitude of 1 inch, we recommend a service limit state bearing resistance of 2.5 ksf be utilized for design. At the **strength** limit state, the factored bearing resistance was calculated to be 9.7 ksf based on the very stiff to hard cohesive bearing soils. The bearing soils should be confirmed as being native cohesive soils with an unconfined compressive strength of at least 7,000 pounds per square foot (hand penetrometer reading of 3.5 or greater).

6. Based on the GB-1 analysis, a design CBR value of 6 percent was determined for the project. It should be noted that the CBR determination by the GB-1 spreadsheet is based on the **average** Group Index of all the evaluated samples, which was 11. Group indices for the tested samples ranged from 0 to 16, which would correlate with a CBR value of 4 to 12 percent. Cohesive subgrade soils classified as A-6b were present within the upper 6 feet of the subgrade in both borings. The average group index for the tested A-6b samples was also 11. Based on the average design value calculations from GB-1, it does not appear to be unconservative to use the GB-1 design CBR value of 6 percent for new pavement sections throughout the project area.

7. The GB-1 analysis indicates options for global chemical stabilization using cement or lime to a depth of 14 inches, or planned over-excavation of unsuitable subgrade soils to a depth of 12 inches and replacement with new granular engineered fill from the southern extent of the culvert to the southern project extent (based on the conditions encountered in Boring B-001). Due to the relatively small project areas, global chemical stabilization is not anticipated to be economical compared to over-excavation and replacement with granular engineered fill. The GB-1 analysis spreadsheet indicates that rubblize and roll is not an option for this project.

This executive summary highlights our evaluations and recommendations and should only be utilized in conjunction with the accompanying report, including the detailed findings, analysis and recommendations, and qualifications presented herein.

TABLE OF CONTENTS

Page No.

TABLE OF CONTENTS (CONT.)

1.0 INTRODUCTION

This structure foundation exploration report has been prepared for the proposed replacement of the culvert along State Route 64 (SR 64) in Plain Township, Wood County, Ohio, designated as WOO-64-5.78 PID No. 107711. The project is located northwest of Bowling Green, Ohio, at the intersection of SR 64 and Mitchell Road (AKA County Road 81), as shown on the attached Site Location Map (Plate 1.0).

This study was performed in accordance with TTL Proposal No. 2130501R, dated August 22, 2021, and was authorized with a Tetra Tech, Inc. Subconsultant agreement signed by Mr. David Charville, PE on September 22, 2021. The subconsultant agreement referenced Tetra Tech Project No. 200-12914-21002, Task 003.A.

1.1 Purpose and Scope of Exploration

The purpose of this exploration was to evaluate the subsurface conditions relative to installation and support of a culvert and associated pavement reconstruction at the referenced location. To accomplish this, TTL performed two test borings, one pavement core, field and laboratory soil testing, a geotechnical engineering evaluation of the test results, as well as review of available geologic and soils data for the project area.

This report summarizes our understanding of the proposed construction, describes the investigative and testing procedures utilized to evaluate the subsurface conditions at the site, and presents our findings from the field and laboratory testing. This report also presents our design and construction recommendations for culvert support, our evaluations and conclusions with respect to pavement subgrade conditions in accordance with ODOT GB-1 "Plan Subgrades" (January 15, 2021), as well as our design and construction recommendations for pavements.

This report includes:

- A description of the existing surface cover, subsurface soils, and groundwater conditions encountered in the borings.
- Design recommendations for culvert support and pavements.
- Recommendations concerning soil- and groundwater-related construction procedures such as site preparation, subgrade preparation in accordance with ODOT GB-1 criteria, earthwork, pavement construction, culvert installation, as well as related field testing.

Appendix B includes pertinent ODOT Geotechnical Engineering Design Checklists that apply to the scope of this report.

The scope of this study did not include an environmental assessment of the surface or subsurface materials at this site.

1.2 Proposed Construction

It is our understanding that the existing bridge/culvert will be replaced with a new precast concrete box culvert. It is assumed that the roadway grade and width will remain approximately the same as the current structure. The bottom of the box culvert was indicated at Elev. 660.00 at the inlet and outlet, roughly corresponding to 5 feet below the existing creek bottom elevation. Based on this information, the bearing depth will be approximately 13 to 13½ feet below existing roadway grades. The box base was indicated to be on the order of 13 feet in width (11 feet span plus 1-foot-thick walls on each side), and the box length is anticipated to be on the order of 40 feet.

It was indicated that ODOT standard concrete headwalls for precast box culverts (Sheet HWDD-1) will be utilized for this project. The headwalls are indicated to be 11'-6" high, Type A or B structures. The inlet and outlet structures are anticipated to include a 7½ feet and 9 feet wide footings, respectively. The footings are anticipated to bear 2 feet below bottom of box culvert base/box culvert bearing elevation (approximately 15 to 15½ feet below roadway grades at the site), and the cutoff walls are expected to extend 2 feet below the bottom of headwall footing.

2.0 GEOLOGY AND OBSERVATIONS OF THE PROJECT

2.1 General Geology and Hydrogeology

Published geologic maps from the Ohio Department of Natural Resources (ODNR) indicate that the project site is located near the borderline of the Maumee Lake Plains Physiographic Region and the Maumee Sand Plains District within that region. With the lack of encountered sand in the upper profile of the borings performed for this exploration, it is interpreted that the site is located within the Maumee Lake Plains Region. Within this region, the geologic deposits consist of Pleistocene-age silt, clay, and wave-planed clayey till overlying Silurian- and Devonian-age carbonate rocks and shales.

The lacustrine soils are generally characterized as mostly soft to medium stiff clays, often with a desiccated stiffer layer within the upper portion of the profile. The lacustrine deposits generally do not exhibit significant overconsolidation, although the desiccation effects induce some apparent overconsolidation within the near-surface soils. In addition to the clayey lake bottom deposits, alluvial deposits may be encountered overlying the till.

The glacial till, also referred to as moraine, was deposited by the advance and retreat of glacial ice. Due to the weight of the ice mass, the till deposits are moderately to highly over-consolidated, that is, the existing soil deposits have experienced a previous vertical stress significantly higher than the present effective vertical stress due to the remaining overlying soil strata in the profile. The till may contain cobbles and/or boulders left in the till soil matrix. Additionally, seams of granular soils may also be encountered within glacial tills. These granular seams may or may not be water bearing. In the Maumee Lake Plains Physiographic Region, the surface of the glacial till has generally experienced some reworking from wave action of the historic lake.

Bedrock in the project area is broadly mapped on the “Geologic Map of Ohio” as upper and lower Silurian-age Lockport dolomite limestone. Top of bedrock was encountered at depths of 34½ feet and 35 feet below existing grades (Elevs. 640± and 639±) in Borings B-001 and B-002, respectively.

Review of the ODNR “Ohio Karst Areas” map indicated that the site is not in an area of probable karst. A Review of the Ohio Department of Natural Resources (ODNR) Map of Mines indicated no historic mining activity in the vicinity of the site area.

The USDA Soil Conservation Service (SCS) “Soil Survey of Sandusky County, Ohio” indicates that the near-surface soils in the project area are mapped as Hoytville clay loam (HoA). These soils are comprised of clayey lodgment till formed on wave-worked till plains.

Lodgment till consists of material eroded and entrained by glacial ice that is moved by the ice and deposited elsewhere. HoA soils are considered very poorly drained with a very low permeability.

2.2 Site Reconnaissance

TTL performed site reconnaissance on October 19 and 28, 2021. The site is located in a predominantly rural/agricultural area.

In the immediate area of the culvert, the pavement along both SR 64 and Mitchell Road was observed to generally be in fair condition, albeit heavily weathered. The pavements were observed to have occasional transverse, longitudinal, and fatigue cracks that were generally not sealed, with the exception of a continuous longitudinal crack along the center of SR 64, which was sealed. Along the northeast edge of the SR 64 pavement, larger and more frequent longitudinal and fatigue cracks, as well as some undulations/rutting in pavement surface, were noted, particularly just above the culvert. In that same area above the culvert, several of the wooden guardrail posts appeared to be out of plumb, towards the creek tributary. Several deep 6 to 10-inch diameter horizontal holes were observed near the pavement edge along the top of the northeast creek tributary slope, presumably animal burrows. Increased pavement distresses were generally noted where these holes appeared.

The existing culvert appeared to be made of corrugated metal sheets bolted together and was an arch in cross-sectional shape. The culvert dimensions are approximately 8.5 feet tall from the top most part of the culvert to creek tributary bottom, approximately 15 feet wide at the bottom, and is approximately 100 feet in length. The culvert appeared to have rust along some of the edges of the corrugated metal sections and along the waterline extending about a foot from the water level encountered. The remanence of a stone block wall was noted along the slope, above the north end of the culvert. The block wall was generally in poor condition with many blocks that apparently moved/fell out of place. The creek tributary to the south, along Mitchell Road, was generally well maintained and free of debris. The creek tributary to the northwest, along SR 64, was generally not maintained to the same degree, with numerous small to medium trees/brush along the slopes and areas of excess sediment along the creek tributary bottom.

Within the site area, grades along SR 64 and Mitchell Road were generally flat. Grades of the agricultural fields were also generally flat but on the order of 1 to 2 feet below the road surface. The creek tributary bottom was approximately 9 to 11 feet below the road surface with relatively steep slopes.

Overhead utility lines were observed along the southwest side of SR 64 and the west side of Mitchell Road.

At the time of this the October 19 reconnaissance, water levels in the creek tributary were approximately 1 to 1½ feet deep. October 28, shortly after significant rain in the area, the water levels rose by approximately 1½ to 2 feet.

3.0 EXPLORATION

3.1 Historic Borings

Review of ODOT records indicated that no historic test borings have been drilled within the project area.

3.2 Project Exploration Program

Two test borings, designated as Borings B-001-0-21 and B-002-0-21, and a Pavement Core X-001-0-21, were drilled/obtained by TTL on October 18 and 19, 2021. Pavement cores were also obtained at the boring locations. These borings and pavement cores are fully designated as Borings B-001-0-21 and B-002-0-21, and Pavement Core X-001-0-21 in accordance with ODOT protocol, but the -0-21 portion of the nomenclature is generally omitted in the discussions within this report. Borings B-001 and B-002 were located in the southbound and northbound lanes of SR 64, respectively, drilled near the inlet and outlet sides of the culvert, respectively. Pavement Core X-001 was obtained within Mitchell Road near the intersection with SR 64. The existing site features and approximate locations of the borings are presented on the Test Boring Location Plan (Plate 2.0).

Stationing and offsets at the boring locations were provided by Tetra Tech, Inc. Latitude, Longitude, and ground surface elevations were surveyed by TTL via a hand-held GPS device. The accuracy from the handheld GPS device was generally found to be approximately 2 to 6 inches horizontal, and approximately 4 to 12 inches vertical. These data are presented on the logs of test borings as well as in the following table.

Table 3.2 General Boring Location Information

Boring Number	Centerline SR 64 Station (feet)	Offset (feet)	Ground Surface Elevation (feet)	Latitude (Degrees)	Longitude (Degrees)
B-001-0-21	Sta. 304+64	6 Left	674.3	41.414139	- 83.688798
B-002-0-21	Sta. 305+79	8 Right	673.5	41.414435	-83.688956
X-001-0-21	Mitchell Road		675.0	41.414271	-83.689024

The two culvert borings (B-001 and B-002) were planned as Type E2a box culvert with a diameter/span of greater than 10 feet and sampled to 6 feet as a ODOT type A Borings per geotechnical investigative procedures outlined in Ohio Department of Transportation (ODOT) “Specifications for Geotechnical Explorations” (SGE).

Borings B-001 and B-002 were terminated after encountering auger refusal at a depth of 35.5 and 35 feet below existing grade, respectively, then coring 5 feet of rock.

Experience indicates that the actual subsoil conditions at a site could vary from those generalized on the basis of test borings made at specific locations. Therefore, it is essential that a geotechnical engineer be retained to provide soil engineering services during the site preparation, excavation, and foundation phases of the proposed project. This is to observe compliance with the design concepts, specifications, and recommendations, and to allow design changes in the event subsurface conditions differ from those anticipated prior to the start of construction.

3.3 Boring Methods

The test borings performed during this exploration were drilled with a CME 75 truck-mounted drilling rig utilizing 3¼-inch inside diameter hollow-stem augers. During auger advancement, split-spoon drive samples were generally taken continuously to 6 feet, at 2½-foot intervals to a depth of 30 feet and at 5-foot intervals thereafter. The samples were sealed in jars and transported to our laboratory for further classification and testing.

In addition to the two (2) pavement cores obtained in Borings B-001 and B-002, one pavement core identified as X-001 was obtained within Mitchell Road near the intersection with SR 64. The cores were obtained using a 4-inch diameter single-wall, diamond-tipped core barrel. After pavement coring was completed, a determination was made of the underlying aggregate base thickness. The recovered cores were photographed and retained by TTL.

Split-spoon (SS) soil samples were obtained by the Standard Penetration Test Method (ASTM D 1586). The Standard Penetration Test (SPT) consists of driving a 2-inch outside diameter split-spoon sampler into the soil with a 140-pound weight falling freely through a distance of 30 inches. The sampler was driven in three successive 6-inch increments, with the number of blows per increment being recorded. The number of blows per increment was recorded at each depth interval, and these data are presented under the "SPT" column on the Logs of Test Borings attached to this report. The sum of the number of blows required to advance the sampler the second and third 6-inch increments is termed the Standard Penetration Resistance, or N_m-value, and is typically reported in blows per foot (bpf). The N_m-values were corrected to an equivalent rod energy ratio of 60 percent, N_{60}. The calibrated hammer/rod energy ratio for the CME 75 truck-mounted drill rig utilized in this project was 66.0 percent, based on calibration on March 15, 2021. The N_{60}-values are presented on the attached Logs of Test Borings.

A Shelby tube sample, designated ST on the Log of Test Boring, was obtained from Boring B-001 (11 to 13 feet). The Shelby tube sample was obtained by hydraulically advancing a 3-inch diameter, thin-walled sampler approximately 24 inches beyond the hollow-stem auger into undisturbed soil, in accordance with ASTM D 1587. The Shelby tube was then extracted from the subsoils, and the ends were capped and sealed. The sample was transported to our laboratory where it was extruded, classified, and tested.

Core samples of the bedrock were obtained from Borings B-001 and B-002, using an NQ2 diamond-bit core barrel and coring techniques in general accordance with ASTM D 2113. In each boring, one core run of five feet was completed immediately following auger refusal. Recovery of the core is expressed as the percentage ratio of the recovered rock length to the total length of the core run. The Rock Quality Designation (RQD) is the percentage ratio of the summed length of rock pieces 4 inches long and greater to the total length of the run. The rock core samples are designated as "NQ2" on the Logs of Test Borings. The recovered rock cores were visually classified using the ODOT Rock Classification System. The rock cores were also documented in a photographic core log, which is attached to this report.

Soil and rock conditions encountered in the test borings are presented in the Logs of Test Borings, along with information related to sample data, SPT results, water conditions observed in the borings, and laboratory test data. In conjunction with published data and typical correlations, the N_{60}-values can be evaluated as a measure of soil compactness/consistency as well as shear strength.

Field and laboratory data were incorporated into gINT™ software for presentation purposes. It should be noted that these logs have been prepared on the basis of laboratory classification and testing as well as field logs of the encountered soils and rock.

3.4 Laboratory Testing Program

All samples were visually or manually classified in accordance with the ODOT Soil Classification System. All samples of the subsoils were also tested in our laboratory for moisture content (ASTM D 2216). A dry density determination and an unconfined compressive strength test by the constant rate of strain method (ASTM D 2166) were performed on the recovered Shelby tube sample. Unconfined compressive strength estimates were obtained for the remaining intact cohesive samples using a calibrated hand penetrometer. Atterberg limits tests (ASTM D 4318) and particle size analyses (ASTM D 6913 & D 7928) were performed on selected samples to determine soil classification and index properties. These test results are presented on the Logs of Test Borings, Grain Size Distribution sheets, and Unconfined Compression Test sheet.

Compressive strength tests (ASTM D 7012, Method C) were performed for selected rock core specimens. The results of these tests are presented on the Logs of Test Borings and Compressive Strength of Rock sheets attached to this report.

4.0 FINDINGS

4.1 General Site Conditions

The site is located along SR 64, northwest of Bowling Green, Ohio, at the intersection with Mitchell Road. In the project area, grades along SR 64 were on the order of Elevs. 674.5 to 673.5. The creek bottom is on the order of 9 to 11 feet below the top of pavement, roughly on the order of Elev. 665.

The surface materials encountered in Borings B-001 and B-002 consisted of approximately 10 inches and 11 inches of asphalt, respectively, underlain by approximately 14 inches and 8 inches of aggregate base, respectively. The surface materials encountered in Corehole X-001 consisted of approximately 7½ inches asphalt, underlain by approximately 7 inches of aggregate base.

Granular **fill** materials were encountered underlying the pavement materials in Boring B-001 to a depth of approximately 2½ feet below existing grades. The granular fill materials consisted of predominantly concrete fragments (ODOT A-2-4) mixed with sand and silt. Within the granular fill materials an SPT N_{60}-value of 14 blows per foot (bpf) was recorded, indicating medium dense compactness. A moisture content of 4 percent was recorded.

4.2 General Soil Conditions

Based on the results of our field and laboratory tests, the subsoils encountered underlying the pavement materials can be generally described as predominantly cohesive soils overlying bedrock. However, a zone of granular soils was encountered in the lower-soil profile just before encountering the bedrock in both borings.

The encountered subsoils consisted of predominantly native cohesive soils encountered underlying the pavement materials in Boring B-002 and the granular fill in Boring B-001 to depths of 33 feet below existing grade and 34 feet (Elevs. 641± and 639±) , respectively. These soils consisted of sandy silt (A-4a) with little to trace amounts of gravel and clay, silt and clay (A-6a) with little sand and varying amounts of gravel, as well as silty clay (A-6b) with varying amounts of sand and gravel.

The upper portion of the cohesive soils exhibited generally stiff to very stiff consistency. This layer extended to a depth of 11 feet (Elev. 663±) in Boring B-001 and to a depth of 7½ feet (Elev. 666±) in Boring B-002. SPT N_{60}-values ranged from 9 to 15 bpf. Unconfined compressive strengths generally ranged from 3,000 to 7,500 psf. Moisture contents generally ranged from 17 to 23 percent.

The lower portion of the cohesive soil profile exhibited generally very stiff to hard consistency. Within this layer, SPT N_{60}-values generally varied from 18 to 40 bpf. Unconfined compressive strengths generally ranged from 6,500 pounds per square foot (psf) to greater than 9,000 psf (the highest obtainable strength using a hand penetrometer). Moisture contents ranged from 11 to 17 percent.

A zone of very dense granular soils was encountered underlying the very stiff to hard cohesive soils in Boring B-001 to a depth of 34½ feet (Elev. 640±) and in Boring B-002 to auger refusal at a depth of 35 feet (Elev. 639±). These soils consisted of coarse and fine sand (A-3a) mixed with some silt and varying amounts of gravel and dolomite fragments. An SPT N_{60}-value of 79 bpf was determined for the sample obtained in this zone from Boring B-002. Moisture contents were on the order of 8 to 9 percent.

Weathered shale that was able to be penetrated with augers was encountered underlying the zone of granular soil in Boring B-001 to auger refusal at a depth of approximately 35½ feet (Elev. 638±).

Upon encountering auger refusal in Borings B-001 and B-002, the rock was cored using a 5-foot rock core run. The cored bedrock consisted of slightly to highly weathered dolomite. The recovered material represented 98 percent and 83 percent of the core runs in Borings B-001 and B-002, respectively. RQD values of 95 percent and 48 percent were determined for the cores recovered from Borings B-001 and B-002, respectively. A photographic log of the recovered rock from each core is attached to this report. Compressive strengths for intact specimens of the cores ranged from 12,350 to 15,270 pounds per square inch (psi).

Additional descriptions of the stratigraphy encountered in the borings are presented on the Logs of Test Borings.

4.3 Groundwater Conditions

During our site reconnaissance on October 19, 2021, water levels in the creek tributary were approximately 1 to 1½ feet deep. During our site reconnaissance on October 28, 2021, shortly after a significant rain in the area, the water levels rose by approximately 1½ to 2 feet. The creek tributary bottom was approximately 9 to 11 feet below the road surface. Hence, based on our field observations, water was approximately 8 to 9½ feet below the road surface (Elevs. 666± to 664±) during the more normal/non-rain-influenced observation date of October 19, 2021.

Groundwater was initially encountered during drilling at a depth of 33 feet (Elev. 641±) in Boring B-001 and at a depth of 34 feet (Elev. 639±) in Boring B-002. Water was noted upon completion of drilling and rock coring operations at a depth of 21½ feet (Elev. 652±) in Boring B-001 and at a depth of 23 feet (Elev. 650±) in Boring B-002. However, these water levels were affected by water introduced during rock coring. It should be noted that the boreholes were drilled and sealed within the same day, and stabilized water levels may not have occurred over this limited time period.

Apart from streamflow influences in the creek tributary, it is our opinion that the "normal" groundwater level can generally be expected at depths on the order of 12 to 16 feet below roadway grades (Elevs. 662± to 657±). However, groundwater elevations can fluctuate with seasonal and climatic influences, will also be particularly affected locally by water levels in the creek tributary. Therefore, groundwater conditions may vary at different times of the year from those encountered during this exploration.

4.4 Remedial Measures

Based on the conditions encountered in the borings, the soils at the anticipated culvert invert are expected to generally consist of very stiff to hard cohesive soils. These soils are considered suitable for support of the proposed culvert. However, with any installation within a creek area, there may be areas of encountered sediment at bearing elevations, which would require over-excavation.

The GB-1 "Subgrade Analysis" worksheet (V14.5, 01/18/19) indicates that over-excavation of unsuitable subgrade soils and replacement with new granular engineered fill are anticipated south of the culvert based on the conditions encountered in Boring B-001. Due to the limited extent of the required remediation, global stabilization is not anticipated to be economical.

5.0 ANALYSES AND RECOMMENDATIONS

The following analysis and recommendations are based on our understanding of the proposed construction and upon the data obtained during our field exploration. If the project information or location as outlined is incorrect or should change significantly, a review of these recommendations should be made by TTL.

5.1 Culvert and Headwall Support

5.1.1 Culvert Foundations

For the culvert replacement WOO-64-5.78, it is planned to use a precast concrete box culvert. The bottom of the box culvert was indicated at Elev. 660.00 at the inlet and outlet, roughly corresponding to 5 feet below the existing creek bottom elevation. Based on this information, the bearing depth will be approximately 13 to 13½ feet below existing roadway grades. The box base was indicated to be on the order of 13 feet in width (11 feet span plus 1-foot-thick walls on each side), and the box length is anticipated to be on the order of 40 feet.

Based on the conditions encountered in the borings, the soils at the anticipated culvert bearing elevation are expected to consist of very stiff to hard native cohesive soils. These soils are considered generally suitable for support of the proposed culvert. However, with any installation within a creek area, there may be areas of encountered sediment at bearing elevations, which would require over-excavation. The bearing soils should be confirmed as being native cohesive soils with an unconfined compressive strength of at least 7,000 pounds per square foot (hand penetrometer reading of 3.5 or greater).

We understand that the culvert bearing slab will be designed using LRFD specifications. At the **service** limit state, a nominal (unfactored) bearing resistance (q_n) of 8 kips per square foot (ksf) was determined for the culvert base bearing on very stiff to hard native cohesive soils. At the service limit state, the resistance factor (ϕ_b) is 1.0. Therefore, the factored bearing resistance (q_r) is 8 ksf. From a conventional allowable stress design comparison, this is roughly akin to using an allowable bearing pressure. **A reduced service limit state factored bearing resistance would need to be utilized for design, to maintain calculated settlement of 1 inch or less, if required for the structure. Discussion regarding this reduced value is discussed below.**

At the **strength** limit state, we recommend a nominal bearing resistance (q_n) of 19.5 ksf for the culvert base bearing on very stiff to hard native cohesive soils. At the strength limit state, the resistance factor (ϕ_b) is 0.5. Therefore, the factored bearing resistance (q_r) is 9.7 ksf. From a conventional allowable stress design comparison, this is roughly akin to calculating an ultimate bearing capacity and applying a factor of safety.

Settlement of the culvert was calculated by conventional consolidation theory utilizing recompression indices for the over-consolidated soils, based on empirical relations using moisture content. Based on a bearing pressure of 8 ksf, using the service limit state bearing resistance indicated above, total settlement was calculated to be on the order of 1¾ to 2¼ inches, well above the maximum magnitude of 1 inch that is typically considered. To reduce total calculated settlement to 1 inch or less, we recommend a service limit state factored bearing resistance (q_r) of 2.5 ksf.

Although not anticipated to be prevalent, if unsuitable bearing soils are encountered during culvert installation, over-excavation should extend through these materials to suitable bearing soils. The base of the over-excavation should be widened 6 inches for every foot of depth extending beyond the edge of the culvert. For the relatively high strength limit state factored bearing resistance of 9.7 ksf and service limit state factored bearing resistance of 8 ksf (if utilized) indicated above, the over-excavated areas should be backfilled with lean concrete having a minimum compressive strength of 1,500 pounds per square inch (psi) or other flowable controlled-density fill having a minimum compressive strength of 300 psi. If design incorporates a strength limit state and service limit state factored bearing resistance of 4.0 ksf or less, then dense-graded aggregate may be utilized for backfill. The aggregate should be placed and compacted as described in our forthcoming report. If foundations will be placed at the base of the over-excavation or the lean concrete fill option will be utilized, widening the footing over-excavation will not be required. If the controlled-density fill or aggregate fill option is utilized, the footing over-excavation shall be widened as discussed above.

For culvert walls that are restrained at the top of the wall, lateral earth pressures should be assumed for “at-rest” conditions. It is anticipated that excavated on-site cohesive soils will comprise the majority of the backfill behind the new culvert walls. For the cohesive soils, an active earth pressure coefficient (k_a) of 0.5 should be used in determining the lateral pressure acting on the walls, along with a total (moist) soil unit weight of 130 pounds per cubic foot (pcf). Alternatively, an equivalent fluid weight of 65 pcf may be used for the “at-rest” case design.

If lower at-rest earth pressures are preferred for structural reasons, we recommend that a select, free-draining granular fill (such as No. 57 or 67 stone) be utilized for the entire culvert backfill zone extending to the surface from the base of the wall at 45 degrees. For these granular fill types, k_o may be taken as 0.4, and the soil unit weight may be assumed as 120 pcf. Alternatively, an equivalent fluid weight of 50 pcf may be used for these granular fills.

Lateral load due to hydrostatic pressures below the design groundwater depth should be included in design of below-grade walls. Additionally, the earth pressures indicated above are based on a level backfill condition behind the culvert wall. If there are areas beyond the horizontal roadway portion of the backfill area that include sloping backfill behind the top of the wall, surcharge loading or equivalent higher earth pressure coefficients should be evaluated, based on backfill material, backfill slope, and proximity to the wall. In general, 50 percent of the vertical surcharge load may be assumed for lateral loading in the design of the wall.

Backfill for the culvert should be placed concurrently on both sides to avoid unbalanced forces that could cause sliding. If this method of backfilling is not possible and one side will be backfilled prior than the other, sliding can be evaluated as presented below.

We recommend that passive pressure be considered negligible at the toe of the wall due to the potential for erosion and/or freeze-thaw behavior that would significantly reduce reliance on passive earth pressure. As such, the LRFD nominal sliding resistance (R_R) is determined by $\phi_T R_T$, where R_T is the nominal sliding resistance on the base of the footing.

For cohesive soils, nominal sliding resistance R_T is the lesser of the following:

- The cohesion (c) of the clay, for which we recommend c be taken as 3,500 psf, or
- Although not anticipated to be the case, where footings are supported on at least 6 inches of compacted granular material, one-half the normal stress on the interface between the footing and soil.

For sliding resistance on clays, the resistance factor ϕ_T should be taken as 0.85.

5.1.2 Headwall Foundations

It was indicated that ODOT standard concrete headwalls for precast box culverts (Sheet HWDD-1) will be utilized for this project. The headwalls are indicated to be 11'-6" high, Type A or B structures. This inlet and outlet structures are anticipated to include a 7½ and 9 feet wide footings, respectively. The footings are anticipated to bear 2 feet below bottom of box culvert base/box culvert bearing elevation (approximately 15 to 15½ feet below roadway grades at the site), and the cutoff walls are expected to extend 2 feet below the bottom of headwall footing.

Based on the conditions encountered in the borings, the soils at the anticipated headwall foundation bearing elevation are expected to consist of very stiff to hard native cohesive soils. These soils are considered generally suitable for support of the proposed headwall foundations.

The standard concrete headwalls are indicated to be based on design using a minimum undrained shear strength (su), or cohesion (c), of 1,500 pounds per square foot (psf) when the walls are bearing on cohesive soils. The design s_u or c value for the very stiff to hard cohesive bearing soils is 3,500 psf, which meets the minimum design requirement.

It should be noted that the standard headwall design values are based on backfill with a slope not exceeding 2 horizontal to 1 vertical (2H:1V) consisting of soil with an internal angle of friction (ϕ) of at least 30 degrees and a total soil unit weight of 120 pounds per cubic foot (pcf) or less. As such, the backfill behind headwalls should <u>not</u> consist of on-site excavated cohesive soils, since they do not meet these criteria. Rather, a select, free-draining granular fill (such as No. 57 or 67 stone) could be utilized. For these granular fill types, ϕ may be taken as 37 degrees, and the soil unit weight may be assumed as 120 pcf. This material should be placed for the entire headwall backfill zone extending to the surface from the base of the wall at 63 degrees from the horizontal [Slip Line/Failure Envelope of 45 + (ϕ/2) degrees for active earth pressure condition].

Settlement of the wingwall was calculated by conventional consolidation theory utilizing recompression indices for the over-consolidated soils, based on empirical relations using moisture content. Based on the indicated bearing pressure of 3.0 ksf, settlement was calculated to be less than 1 inch.

We recommend all slopes on the toe side of the wall have erosion protection, such as vegetated topsoil, riprap, and/or man-made materials. Seeding of the exterior slopes should be completed as soon as possible after construction is complete.

5.2 Subgrades and Pavements

5.2.1 GB-1 "Plan Subgrades" Evaluation

An evaluation of the subgrade soils was completed in general accordance with ODOT Geotechnical Bulletin GB-1 "Plan Subgrades" (January 15, 2021). As part of this evaluation, the ODOT "Subgrade Analysis" worksheet (V14.5, 01/18/19) was completed and is attached to this report.

Final pavement grades are assumed to approximate existing grades. Based on the existing pavement cross-sections encountered in the borings, the proposed subgrade is presumed to be

18 to 24 inches below the existing top of pavement grades (represented as a 1.5 to 2 feet cut in the ODOT "Subgrade Analysis" worksheet).

Based on GB-1, soils classified as ODOT A-4b, A-2-5, A-5, A-7-5, A-8a, A-8b, or rock have been designated as being problematic with respect to pavement subgrade support. None of these soil types were encountered at planned subgrade elevations in the borings performed for this exploration.

Based on GB-1 criteria, subgrade soils with moisture contents greater than 3 percent above optimum likely indicate the presence of unstable subgrade that may require some form of subgrade modification. Approximately 50 percent of the tested subgrade soil samples were greater than 3 percent above the optimum as determined using GB-1 criteria. Approximately 50 percent of the samples with moisture contents greater than 3 percent above optimum had moisture contents greater than or equal to 5 percent above optimum. Thus, where moisture contents were wet of optimum, they were appreciably wet of optimum. These data indicate that scarification and aeration methods may not be feasible to achieve satisfactory proof rolling and stabilization of the predominantly cohesive subgrades. However, scarification and aeration methods may be utilized if construction schedule will allow such soil modification.

The type and thickness of subgrade modification is determined by GB-1 criteria based on the average, low SPT N_{60}-value (N_{60L}) of the subgrade soils in a particular portion of the project area, hand penetrometer value, soil type, and moisture content. Based on these criteria, 1 of the 2 borings (Boring B-001) contained subgrade soils which indicated subgrade modification is likely to be required. Subgrade modification for this boring was indicated by ODOT GB-1 to include planned undercutting of 12 inches of the existing subgrade and replacement with granular engineered fill. The modification area should be prescribed as the extents from south of the new culvert installation to the southern project limit, since Boring B-001 was performed south of the proposed new culvert.

Although ODOT GB-1 indicates that global cement or lime stabilization to a depth of 14 inches could be considered, due to the relatively small project areas, global chemical stabilization is not anticipated to be economical compared to over-excavation and replacement with granular engineered fill. In any case, sulfate content tests for tested subgrade samples were on the order of 310 parts per million (ppm) and 340 ppm, which would not preclude the use of global chemical stabilization. The GB-1 analysis spreadsheet indicates that rubblize and roll is not an option for this project.

It should be noted that GB-1 analyses are used as a pre-construction tool to plan subgrade modification alternatives. Actual subgrade modification will depend on field observations of proof-rolling conditions at the time of construction. Changes in soil moisture content could create more or less favorable subgrade conditions that may result in adjustments to subgrade modification or soil stabilization requirements at the time of construction.

5.2.2 Flexible (Asphalt) Pavement Design

Based on the GB-1 analysis, a design CBR value of 6 percent was determined for the project. It should be noted that the CBR determination by the GB-1 spreadsheet is based on the **average** Group Index of all the evaluated samples, which was 11. Group indices for the tested samples ranged from 0 to 16, which would correlate with a CBR value of 4 to 12 percent. Cohesive subgrade soils classified as ODOT A-6b were predominantly present within the upper 6 feet of the subgrade elevation in both borings. The average group index for the tested A-6b samples was also 11. Based on the average design value calculations from GB-1, it does not appear to be unconservative to use the GB-1 design CBR value of 6 percent for new pavement sections throughout the project area.

It should also be noted that the design CBR value is based on subgrades compacted to at least 100 percent of the maximum dry density as determined by ASTM D 698 (Standard Proctor) or verified as stable through proof-rolling in accordance with Section 5.3.2 of this report.

All pavement design and paving operations should conform to ODOT specifications. The pavement and subgrade preparation procedures outlined in this report should result in a reasonably workable and satisfactory pavement. It should be recognized, however, that all pavements need repairs or overlays over time as a result of progressive yielding under repeated loading for a prolonged period.

It is recommended that proof rolling, placement of aggregate base, and placement of asphalt be performed within as short a time period as possible. Exposure of the aggregate base to rain, snow, or freezing conditions may lead to deterioration of the subgrade and/or base materials due to excessive moisture conditions and to difficulties in achieving the required compaction.

5.3 Construction

5.3.1 Sedimentation and Erosion Control

In planning the implementation of earthwork operations, special consideration should be given to provide measures to prevent or reduce soil erosion and the subsequent sedimentation into nearby waterways. These measures may include some or all of the following:

1. Scheduling of earthwork operations such that erodible areas are kept as small as possible and are exposed for the shortest possible time.
2. Using special grading practices, along with diversion or interceptor structures, to reduce the amount of run-off water from an erodible area.
3. Providing vegetative buffer zones, filter berms, or sedimentation basins to trap sediment from surface run-off water.

A specific and detailed soil erosion and sedimentation control program and permits may be required by local, state, or federal regulatory agencies.

5.3.2 Site and subgrade Preparation

Site and subgrade preparation activities should conform to ODOT Construction and Materials Specifications (CMS) Item 204 specifications. Site preparation activities should include the removal of vegetation, topsoil, root mats, pavements, structures, and other deleterious non-soil materials from all proposed culvert and roadway replacement areas. The actual amount of required stripping should be determined in the field by a geotechnical engineer or qualified representative.

Upon completion of the clearing and undercutting activities, all areas that are to receive fill, or that have been excavated to proposed final subgrade elevation, should be inspected by a geotechnical engineer. Pavement subgrades should be proof rolled in accordance with ODOT CMS 204.06.

Any unsuitable materials observed during the inspection and proof-rolling operations should be undercut and replaced with compacted fill, or stabilized in place utilizing conventional remedial measures such as discing, aeration, and recompaction. As stated previously, based on the conditions encountered during our exploration, where subgrade soil moisture contents were wet of optimum, they were significantly wet of optimum. As such, scarification and aeration methods may not be feasible to achieve satisfactory proof rolling and stabilization of the predominantly cohesive subgrades. However, scarification and aeration methods may be utilized if areas where granular subgrades wet of optimum are present, provided weather conditions and construction schedule will allow such soil modification.

The GB-1 analysis indicates options for global chemical stabilization using cement or lime to a depth of 14 inches, or planned over-excavation of unsuitable subgrade soils to a depth of 12 inches and replacement with new granular engineered fill from the southern extent of the culvert to the southern project extent (based on the conditions encountered in Boring B-001).

Due to the relatively small project areas, global chemical stabilization is not anticipated to be economical compared to over-excavation and replacement with granular engineered fill.

5.3.3 Temporary Excavations and Permanent Slopes

The sides of the temporary excavations for culvert installation should be adequately sloped to provide stable sides and safe working conditions. Otherwise, the excavation must be properly braced against lateral movements. In any case, applicable Occupational Safety and Health Administration (OSHA) standards must be followed. It is the responsibility of the installation contractor to develop appropriate installation methods and specify pertinent equipment prior to commencement of work, and to obtain the services of a geotechnical engineer to design or approve sloped or benched excavations and/or lateral bracing systems as required by OSHA criteria.

Although the encountered cohesive soils and anticipated “normal” groundwater level below the culvert invert should be generally conducive to stable excavation slopes, provisions should be made for the culvert installation to proceed as a sloped-bank excavation, or as a steeper trench-type cut with properly designed and installed lateral bracing. The latter system may include the use of a portable trench box or a sliding trench shield.

If the excavation is to be performed with sloped banks, adequate stable slopes must be provided in accordance with OSHA criteria. Based on the test borings, it is likely that excavations will encounter a range of soil conditions that include the following OSHA designations:

- Type A soils (cohesive soils with unconfined compressive strengths of 3,000 pounds per square foot (psf) or greater) and
- Type C soils (existing granular fill material).

For temporary excavations in Type A and C soils, side slopes must be no steeper than ¾ horizontal to 1 vertical (¾H:1V) and 1½H:1V, respectively. For situations where a higher strength soil is underlain by a lower strength soil and the excavation extends into the lower strength soil, the slope of the entire excavation is governed by that required for the lower strength soil. In all cases, flatter slopes may be required if lower strength soils or adverse seepage conditions are encountered during construction.

For permanent excavations and slopes, we recommend that grades generally be no steeper than 3H:1V. It should be noted that ODOT routinely uses 2H:1V slopes for roadway embankments. These steeper slopes could be used, with recognition that the embankment faces are more prone to erosion and sloughing.

5.3.4 Construction Dewatering and Groundwater Control

Groundwater conditions encountered during our exploration are summarized in Section 4.3.

During construction, methods should be taken to divert the creek tributary flow around the construction area.

Based on the soil characteristics and groundwater conditions encountered in the borings and apart from streamflow influences in the creek tributary, it is our opinion that the “normal” groundwater level can generally be expected at depths on the order of 12 to 16 feet below roadway grades (Elevs. 662± to 657±).

If construction does not occur during a particularly wet period, adequate control of groundwater seepage into excavations should be achievable by minor dewatering systems, such as pumping from prepared sumps. Even at depths a few feet below the “normal” groundwater level, control of groundwater using sumps should be feasible due to the predominantly cohesive nature of the encountered soils and their associated low permeability, but will require due diligence by the contractor to maintain a stable subgrade condition at the bottom of the excavation.

Based on the location of the proposed excavation relative to the creek, it is likely that the headwall foundation excavations will encounter saturated subgrade conditions including groundwater seepage. In addition to dewatering measures, the contractor may need to incorporate a thin mat of lean concrete over the bottom of the excavation to avoid loss of subgrade strength and excessive undercutting of the bearing soils from groundwater seepage or surface run off.

5.3.5 Fill

Material for engineered fill or backfill required to achieve design grades should meet ODOT Item 203 “Embankment Fill” placement and compaction requirements.

The upper profile on-site soils consist of predominantly native cohesive soils, with some near-surface granular existing fill materials. For the cohesive soils, a sheepsfoot roller should provide the most effective soil compaction. Where existing pavement base materials remain or new dense-graded aggregate pavement base materials are placed, a vibratory smooth-drum roller would be required to provide effective compaction.

6.0 QUALIFICATION OF RECOMMENDATIONS

Our evaluation of design and construction conditions for the proposed culvert replacement and pavement reconstruction has been based on our understanding of the site and project information and the data obtained during our field exploration. The general subsurface conditions were based on interpretation of the data obtained at specific boring locations. Regardless of the thoroughness of a subsurface exploration, there is the possibility that conditions between borings will differ from those at the boring locations, that conditions are not as anticipated by the designers, or that the construction process has altered the soil conditions. This is especially true for previously developed sites. Therefore, experienced geotechnical engineers should observe earthwork and foundation construction to confirm that the conditions anticipated in design are noted. Otherwise, TTL assumes no responsibility for construction compliance with the design concepts, specifications, or recommendations.

The design recommendations in this report have been developed on the basis of the previously described project characteristics and subsurface conditions. If project criteria or locations change, a qualified geotechnical engineer should be permitted to determine whether the recommendations must be modified. The findings of such a review will be presented in a supplemental report.

The nature and extent of variations between the borings may not become evident until the course of construction. If such variations are encountered, it will be necessary to reevaluate the recommendations of this report after on-site observations of the conditions.

Our professional services have been performed, our findings derived, and our recommendations prepared in accordance with generally accepted geotechnical engineering principles and practices. This warranty is in lieu of all other warranties either expressed or implied. TTL is not responsible for the conclusions, opinions, or recommendations of others based on this data.

Plates

Site Location Map

WOO 64-5.78 – PID 107711

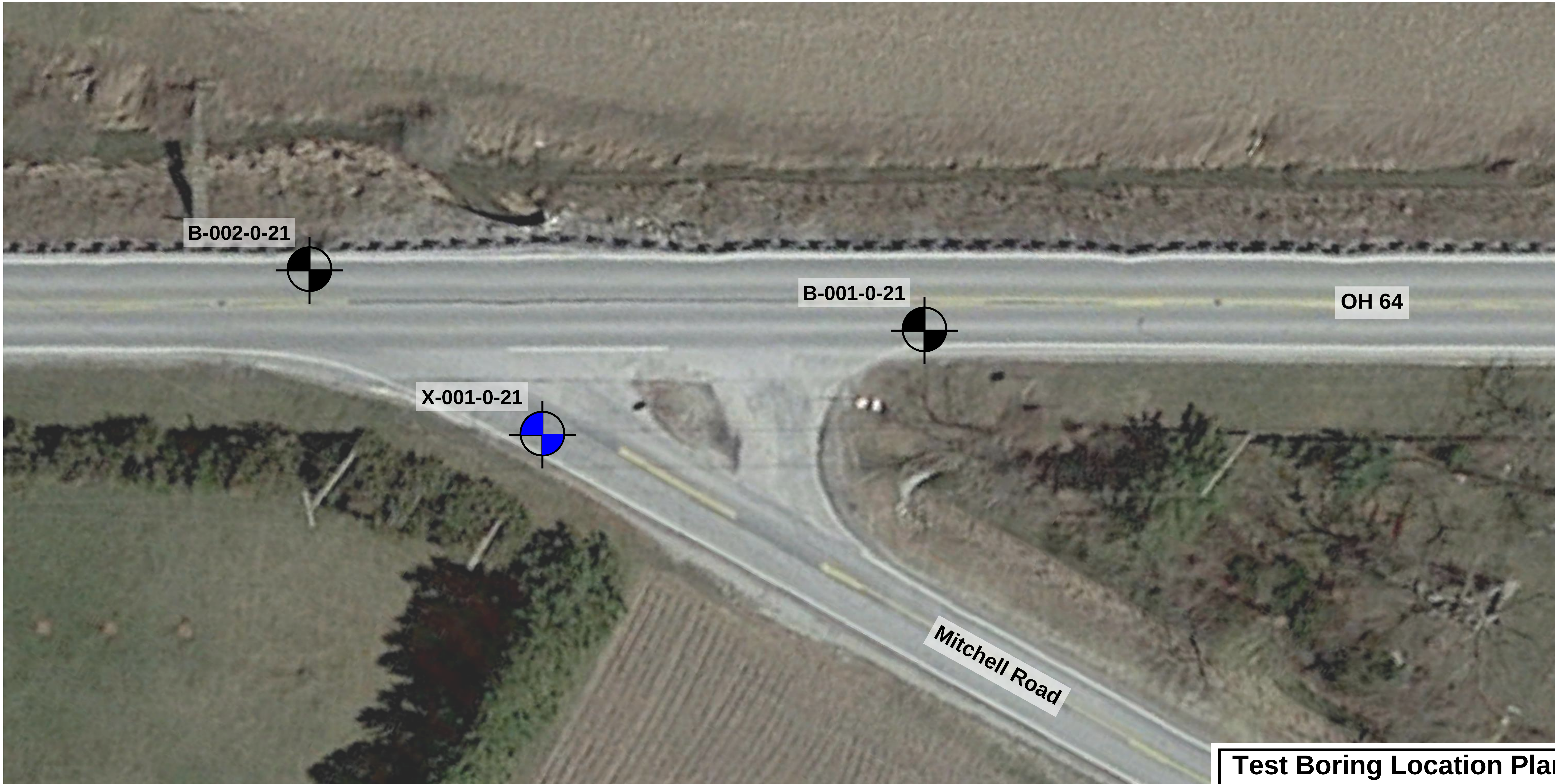
Plain Township, Ohio

Tetra Tech, Inc.

DRAWN:	IJH 05/20/22
REVISED:	---
Project No.: 2130501	
Drawing No.: Plate 1.0	

TTL associates inc
Environmental, Geotechnical Engineering & Testing

Notes: Aerial Basemap obtained From Google Earth and dated 03/20/2021.



Legend:

B-001-0-21	Approximate Pavement Core/ Test Boring Location
X-001-0-21	Approximate Pavement Core Location

Notes: Aerial Basemap obtained From Google Earth and dated 03/20/2021.

0' 25' 50'

Test Boring Location Plan

WOO 64-5.78 – PID 107711

Plain Township, Ohio

Tetra Tech, Inc.

DRAWN: IJH 05/20/22
REVISED: ---
Project No.: 2130501
Drawing No.: Plate 2.0

associates inc
Environmental, Geotechnical Engineering & Testing

Figures

Logs of Test Borings
Legend Key
Grain Size Distribution Curves
Undisturbed Sample Unconfined Compressive Strength Test Results
Pavement Core Photographic Logs
Rock Core Photographic Logs
Rock Core Unconfined Compressive Strength Test Results

PROJECT: WOO-64-05.78	DRILLING FIRM / OPERATOR: TTL / TB	DRILL RIG: CME 75 TRUCK 844	STATION / OFFSET: 304+64, 6' LT.	EXPLORATION ID B-001-0-21
TYPE: CULVERT	SAMPLING FIRM / LOGGER: TTL / KKC	HAMMER: CME AUTOMATIC	ALIGNMENT: CL R/W & CONST. SR 64	
PID: 107711 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 3/15/21	ELEVATION: 674.3 (NAVD88) EOB: 40.5 ft.	PAGE 1 OF 2
START: 10/19/21 END: 10/19/21	SAMPLING METHOD: SPT / ST / NQ2	ENERGY RATIO (%): 66	LAT / LONG: 41.414139, -83.688798	

MATERIAL DESCRIPTION AND NOTES	ELEV. 674.3	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	HOLE SEALED
ASPHALT - 10 INCHES	673.5																		
AGGREGATE BASE - 14 INCHES	672.3	1-2	14 9 4	14	78	SS-1	-	-	-	-	-	-	-	-	-	4	A-2-4 (V)	310	
MEDIUM DENSE, GRAY, **CONCRETE FRAGMENTS WITH SAND AND SILT**, MOIST FILL	671.8																		
STIFF TO VERY STIFF, GRAY, **SILTY CLAY**, SOME SAND, TRACE GRAVEL, TRACE ORGANICS, MOIST		3	4 5 6	12	89	SS-2	1.50	1	4	24	28	43	34	18	16	23	A-6b (10)	-	
		4-5	3 4 5	10	100	SS-3	2.50	3	5	20	25	47	39	18	21	20	A-6b (12)	-	
@5.5': BROWN/GRAY		6	6 6 6	13	100	SS-4	2.00	-	-	-	-	-	-	-	-	21	A-6b (V)	-	
@8': BROWN		7-8																	
		9	5 4 8	13	100	SS-5	2.00	-	-	-	-	-	-	-	-	19	A-6b (V)	-	
	663.3	10																	
VERY STIFF TO HARD, GRAY, **SILTY CLAY**, LITTLE SAND, DAMP Qu = 25 PSI = 3600 PSF @12': GRAY		11-13			63	ST-6	4.50	8	6	13	26	47	31	13	18	14	A-6b (11)	-	
		14	9 12 14	29	100	SS-7	4.50	-	-	-	-	-	-	-	-	13	A-6b (V)	-	
	658.3	15																	
VERY STIFF TO HARD, GRAY, **SILT AND CLAY**, LITTLE SAND, LITTLE GRAVEL, DAMP		16-17	4 9 12	23	100	SS-8	4.50	-	-	-	-	-	-	-	-	14	A-6a (V)	-	
@18.5': SOME SAND, TRACE GRAVEL		18-19	4 9 9	20	100	SS-9	4.25	6	7	14	25	48	25	13	12	13	A-6a (8)	-	
		20																	

STANDARD ODOT LOG W/ SULFATES (8.5 X 11) - OH DOT.GDT - 5/25/22 11:12 - S:\PROJECTS\2130501SR64-5.78.GPJ

PID: 107711	SFN:	PROJECT: WOO-64-05.78	STATION / OFFSET: 304+64, 6' LT.	START: 10/19/21	END: 10/19/21	PG 2 OF 2	B-001-0-21

MATERIAL DESCRIPTION AND NOTES	ELEV. 653.3	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	HOLE SEALED
VERY STIFF TO HARD, GRAY, **SILT AND CLAY**, LITTLE SAND, LITTLE GRAVEL, DAMP *(continued)* @21': LITTLE SAND	650.8	22, 23	4 9 11	22	100	SS-10	3.25	-	-	-	-	-	-	-	-	14	A-6a (V)	-	
HARD, GRAY, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL, DAMP		24, 25	6 11 16	30	100	SS-11	4.50	-	-	-	-	-	-	-	-	14	A-4a (V)	-	
@26': MOIST	645.8	26, 27, 28	4 12 15	30	100	SS-12	4.50	-	-	-	-	-	-	-	-	15	A-4a (V)	-	
HARD, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST	641.3	29, 30, 31, 32; W 641.3	5 10 12	24	100	SS-13	4.50	-	-	-	-	-	-	-	-	16	A-6a (V)	-	
VERY DENSE, GRAY, **COARSE AND FINE SAND**, SOME SILT, LITTLE GRAVEL, MOIST	640.0	33, 34; TR	5 9 50/2"	-	86	SS-14	-	-	-	-	-	-	-	-	-	8	A-3a (V)	-	
WEATHERED DOLOMITE	638.8	35																	
DOLOMITE, LIGHT GRAY, SLIGHTLY TO MODERATELY WEATHERED, STRONG, VERY FINE GRAINED, VERY THIN TO THIN BEDDED, JOINTED - SLIGHTLY TO MODERATELY FRACTURED, TIGHT. @ 36.7': 1 TO 2 INCH HIGHLY FRACTURED SEAM, Qu = 15270 PSI @ 38.9': SLIGHTLY VUGGY & PYRITIC @ 39.9': 1 TO 2 INCH HIGHLY FRACTURED SEAM	633.8	36, 37, 38, 39, 40; EOB	95		98	NQ2-1											CORE		

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; PUMPED 11 CF CEMENT-BENTONITE GROUT

STANDARD ODOT LOG W/ SULFATES (8.5 X 11) - OH DOT.GDT - 5/25/22 11:12 - S:\PROJECTS\2130501SR64-5.78.GPJ

PROJECT: WOO-64-05.78	DRILLING FIRM / OPERATOR: TTL / TB	DRILL RIG: CME 75 TRUCK 844	STATION / OFFSET: 305+79, 8' RT.
TYPE: CULVERT	SAMPLING FIRM / LOGGER: TTL / KKC	HAMMER: CME AUTOMATIC	ALIGNMENT: CL R/W & CONST. SR 64
PID: 107711 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 3/15/21	ELEVATION: 673.5 (NAVD88) EOB: 40.0 ft.
START: 10/18/21 END: 10/18/21	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 66	LAT / LONG: 41.414435, -83.688956

EXPLORATION ID B-002-0-21

MATERIAL DESCRIPTION AND NOTES	ELEV. 673.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	HOLE SEALED
ASPHALT - 11 INCHES	672.6																		
AGGREGATE BASE - 8 INCHES	671.8																		
HARD, BLACK/BROWN, **SILTY CLAY**, SOME SAND, LITTLE CRUSHED STONE, MOIST FILL		1 – 2	15 8 8	18	78	SS-1	4.50	17	6	20	19	38	33	13	20	13	A-6b (8)	340	
@2.5': STIFF TO VERY STIFF, LITTLE SAND, TRACE ASPHALT CEMENT, TRACE ORGANICS	668.7	3 – 4	5 7 7	15	89	SS-2	2.50	-	-	-	-	-	-	-	-	20	A-6b (V)	-	
VERY STIFF, BROWN, **SILTY CLAY**, SOME SAND, TRACE GRAVEL, MOIST		4 – 5	3 4 4	9	100	SS-3	3.25	-	-	-	-	-	-	-	-	17	A-6b (V)	-	
@5.5': GRAY/BROWN	666.0	6 – 7	3 6 6	13	100	SS-4	3.75	3	6	15	21	55	34	15	19	18	A-6b (12)	-	
HARD, BROWN, **SANDY SILT**, LITTLE GRAVEL, TRACE CLAY, MOIST		9 – 10	7 15 17	35	100	SS-5	4.50	-	-	-	-	-	-	-	-	11	A-4a (V)	-	
@11.5': DARK BROWN, TRACE GRAVEL		11 – 12	15 25 25	55	100	SS-6	4.50	-	-	-	-	-	-	-	-	12	A-4a (V)	-	
	657.5	14 – 15	15 15 21	40	100	SS-7	4.50	-	-	-	-	-	-	-	-	13	A-4a (V)	-	
VERY STIFF TO HARD, GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST		16 – 17	6 9 12	23	100	SS-8	4.50	4	5	13	21	57	30	13	17	15	A-6b (11)	-	
@18.5': LITTLE GRAVEL, DAMP		19 – 20	5 6 10	18	100	SS-9	3.75	-	-	-	-	-	-	-	-	13	A-6b (V)	-	

PID: 107711 | SFN: | PROJECT: WOO-64-05.78 | STATION / OFFSET: 305+79, 8' RT. | START: 10/18/21 | END: 10/18/21 | PG 2 OF 2 | B-002-0-21

MATERIAL DESCRIPTION AND NOTES	ELEV. 652.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	HOLE SEALED
VERY STIFF TO HARD, GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST *(continued)* @21': SOME GRAVEL	650.0	22–23	3 6 8	15	100	SS-10	3.00	-	-	-	-	-	-	-	-	11	A-6b (V)	-	
HARD, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST		24–25	8 16 16	35	100	SS-11	4.50	-	-	-	-	-	-	-	-	15	A-6a (V)	-	
		26–27	5 11 15	29	100	SS-12	4.50	-	-	-	-	-	-	-	-	16	A-6a (V)	-	
		29–30	6 7 10	19	100	SS-13	4.25	2	5	9	21	63	31	16	15	17	A-6a (10)	-	
@31.5': POSSIBLE BOULDER	639.5	W 639.5																	
VERY DENSE, GRAY, **COARSE AND FINE SAND**, SOME SILT, LITTLE DOLOMITE FRAGMENTS, MOIST	638.5	34–35 TR	20 22 50	79	67	SS-14	-	-	-	-	-	-	-	-	-	9	A-3a (V)	-	
DOLOMITE, BLACK/GRAY, HIGHLY WEATHERED, STRONG, VERY FINE GRAINED, LAMINATED, JOINTED - FRACTURED, TIGHT; RQD 6%.	637.7																		
DOLOMITE, BLACK/GRAY, HIGHLY WEATHERED, STRONG, VERY FINE GRAINED, LAMINATED, JOINTED - HIGHLY FRACTURED, TIGHT; RQD 0%.	636.6																		
DOLOMITE, LIGHT GRAY, MODERATELY WEATHERED, STRONG, VERY FINE GRAINED, THIN BEDDED, VUGGY, JOINTED - SLIGHTLY TO MODERATELY FRACTURED, TIGHT; RQD 23%. @37.3': Qu = 12350 PSI	633.5	35–40 EOB	48		83	NQ2-1											CORE		

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; PUMPED 11 CF CEMENT-BENTONITE GROUT

LEGEND KEY

Ohio Department of Transportation Soil Symbols

- A-1-a - Gravel and/or Stone Fragments
- A-1-b - Gravel and/or Stone Fragments with Sand
- A-2-4,A-2-5 - Gravel and/or Stone Fragments with Sand and Silt
- A-2-6,A-2-7 - Gravel and/or Stone Fragments with Sand, Silt and Clay
- A-3 - Fine Sand
- A-3a - Coarse and Fine Sand
- A-4a - Sandy Silt
- A-4b - Silt
- A-5 - Elastic Silt and Clay
- A-6a - Silt and Clay
- A-6b - Silty Clay
- A-7-5 - Elastic Clay
- A-7-6 - Clay
- A-8a - Organic Silt
- A-8b - Organic Clay
- Asphalt
- Sod and/or Topsoil
- Concrete
- Random Fill
- Peat
- Dolomite
- Weathered Dolomite
- Limestone
- Weathered Limestone
- Sandstone
- Weathered Sandstone
- Shale
- Weathered Shale

Sample Symbols

- SS - Split Spoon
- ST - Shelby Tube
- RC - Rock Core
- GS - Geoprobe Sleeve
- AU - Auger Cuttings
- GB - Grab

Notes:

1. Exploratory borings B-001-0-21 and B-002-0-21 were drilled on October 18 and 19, 2021, using 3¼-inch diameter hollow-stem augers. Pavement cores were obtained using a 4-inch inside diameter thin-wall core bit. Upon encountering auger refusal, a rock core run was performed using an NQ2 diamond-bit core barrel.

2. These logs are subject to the limitations, conclusions, and recommendations in the report and should not be interpreted separate from the report.

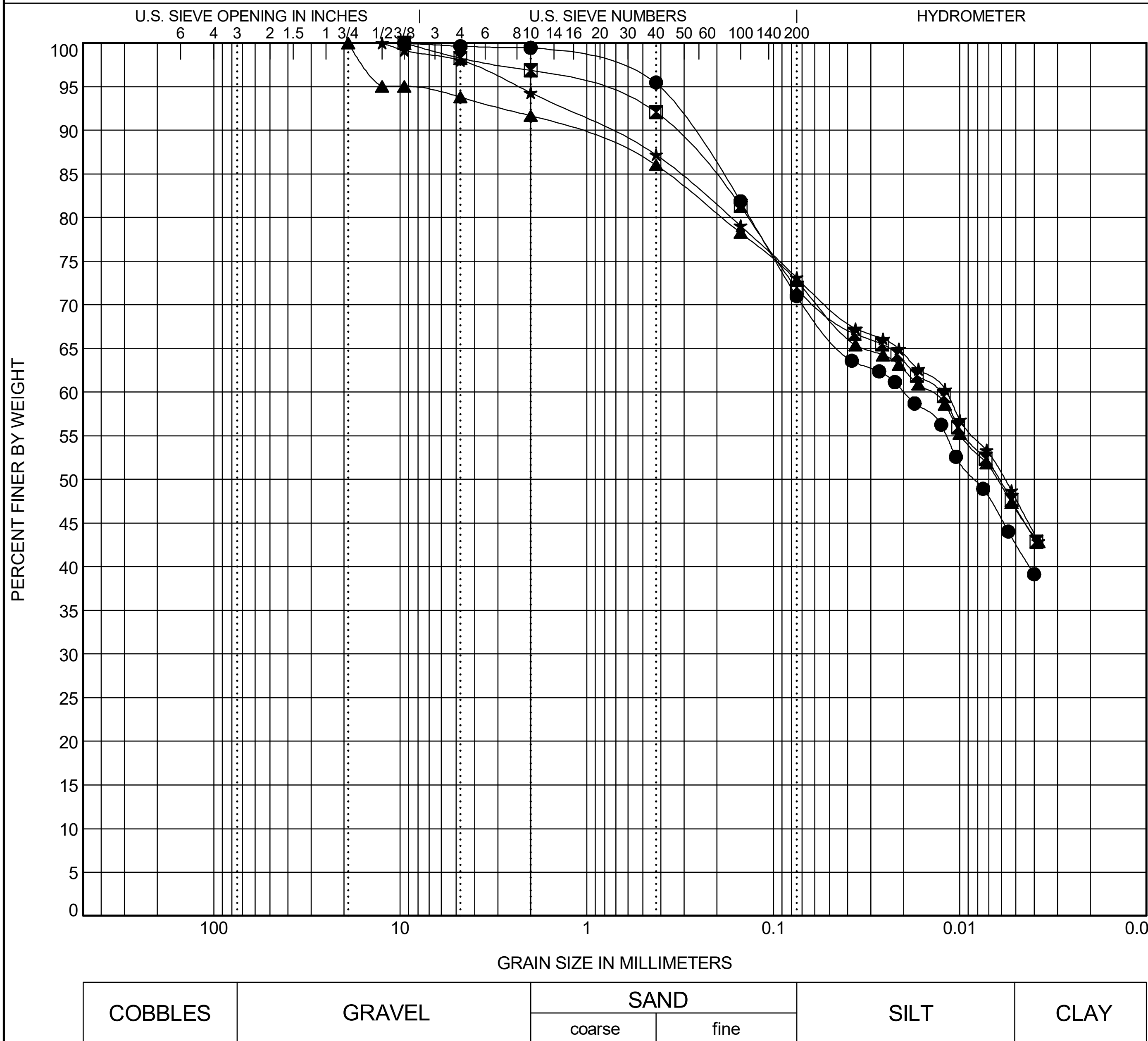
3. The borings were located in the field by TTL in accordance with the Proposed Boring Location Plan, attached to the proposal via a hand-held GPS device. Stationing and offsets were provided by Tera Tech, Inc. Latitude, Longitude, and ground surface elevations were surveyed by TTL via a hand-held GPS device. The accuracy from the handheld GPS device was generally found to be approximately 2 to 6 inches horizontal, and approximately 4 to 12 inches vertical.

GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT WOO-64-05.78 **PID** 107711

OGE NUMBER N/A **PROJECT TYPE** STRUCTURE FOUNDATION



Specimen Identification			ODOT (Modified AASHTO) ~ USCS Classification	LL	PL	PI
●	**B-001-0-21**	**2.5**	**A-6b ~ LEAN CLAY with SAND(CL)**	**34**	**18**	**16**
⧗	**B-001-0-21**	**4.0**	**A-6b ~ LEAN CLAY with SAND(CL)**	**39**	**18**	**21**
▲	**B-001-0-21**	**11.0**	**A-6b ~ LEAN CLAY with SAND(CL)**	**31**	**13**	**18**
★	**B-001-0-21**	**18.5**	**A-6a ~ LEAN CLAY with SAND(CL)**	**25**	**13**	**12**

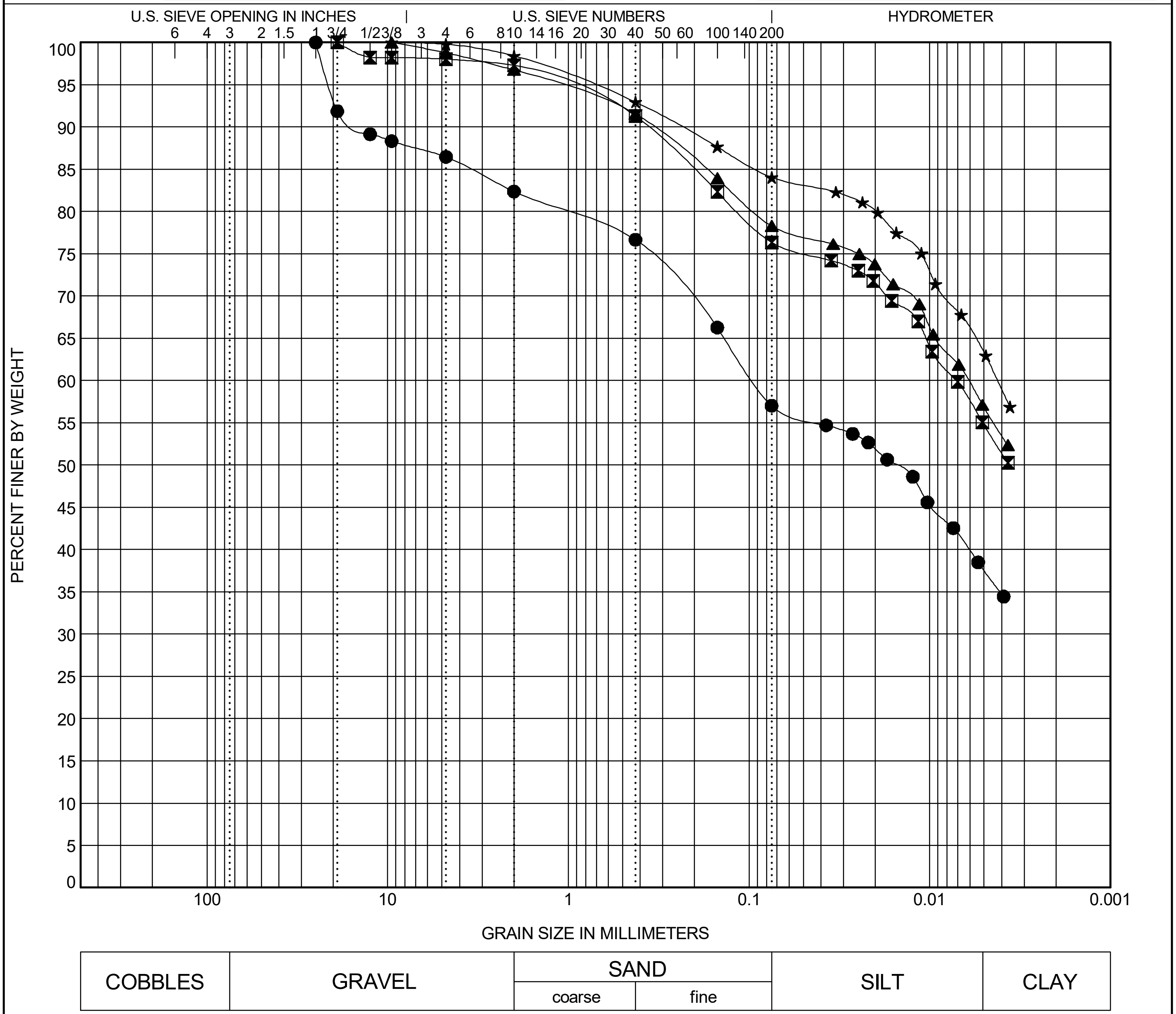
Specimen Identification			D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
●	**B-001-0-21**	**2.5**	**0.279**	**0.008**			**1**	**4**	**24**	**28**	**43**		
⧗	**B-001-0-21**	**4.0**	**0.347**	**0.006**			**3**	**5**	**20**	**25**	**47**		
▲	**B-001-0-21**	**11.0**	**1.263**	**0.006**			**8**	**6**	**13**	**26**	**47**		
★	**B-001-0-21**	**18.5**	**0.782**	**0.006**			**6**	**7**	**14**	**25**	**48**		

GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT WOO-64-05.78 **PID** 107711

OGE NUMBER N/A **PROJECT TYPE** STRUCTURE FOUNDATION



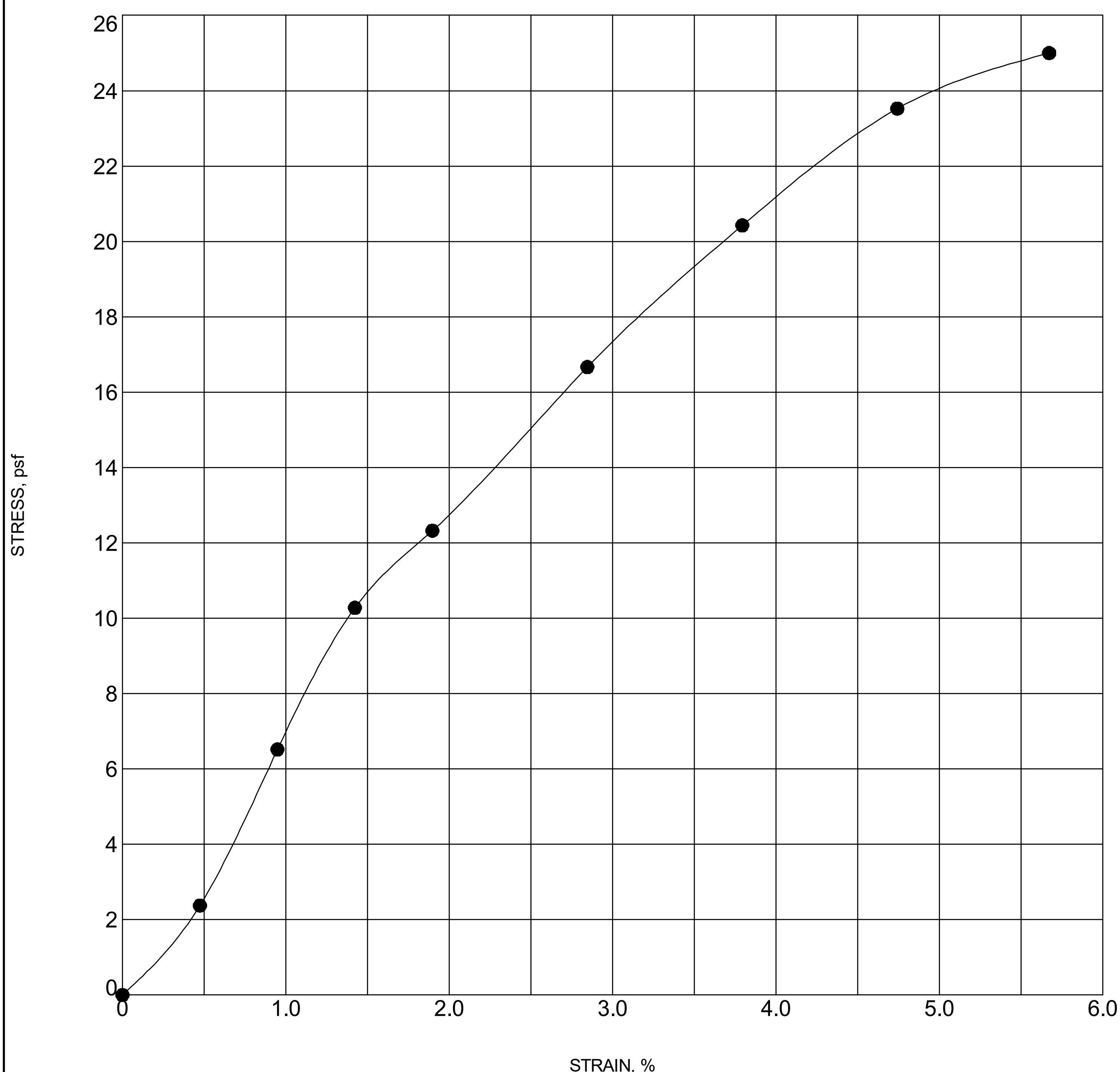
Specimen Identification		ODOT (Modified AASHTO) ~ USCS Classification	LL	PL	PI
● B-002-0-21	1.0	**A-6b ~ SANDY LEAN CLAY(CL)**	33	13	20
⧗ B-002-0-21	5.5	**A-6b ~ LEAN CLAY with SAND(CL)**	34	15	19
▲ B-002-0-21	16.0	**A-6b ~ LEAN CLAY with SAND(CL)**	30	13	17
★ B-002-0-21	28.5	**A-6a ~ LEAN CLAY with SAND(CL)**	31	16	15

Specimen Identification		D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
● B-002-0-21	1.0	14.246	0.015			17	6	20	19	38		
⧗ B-002-0-21	5.5	0.365				3	6	15	21	55		
▲ B-002-0-21	16.0	0.344				4	5	13	21	57		
★ B-002-0-21	28.5	0.237				2	5	9	21	63		

UNCONFINED COMPRESSION TEST

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT WOO-64-05.78 **PID** 107711
OGE NUMBER N/A **PROJECT TYPE** STRUCTURE FOUNDATION



	Specimen Identification		Classification	γ_d	MC%
●	B-001-0-21	11.0	A-6b	118	14

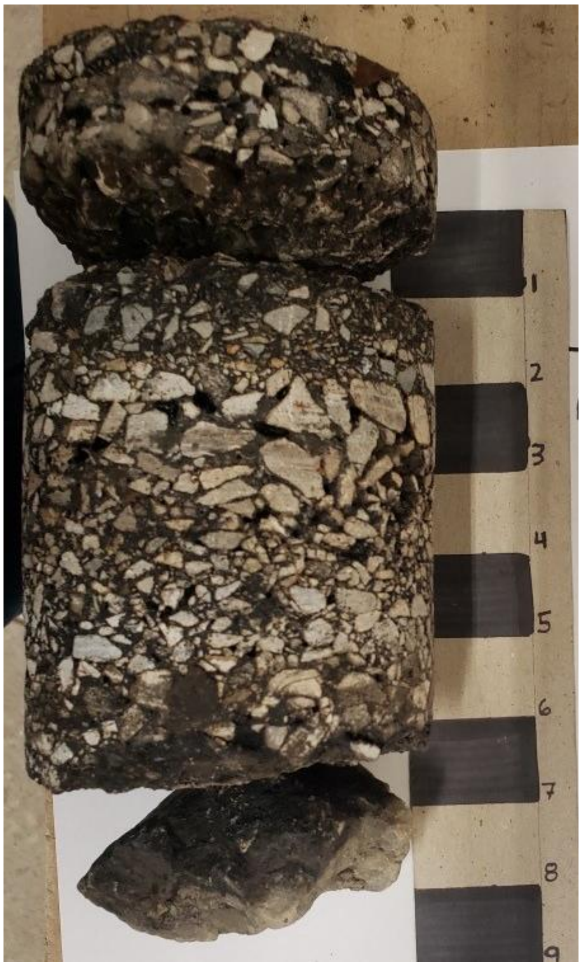
CORE LOG for X-001-0-21

Project: WOO 64-05.78 – PID 107711

Project Location: Plain Township, Ohio

TTL Project No. 2130501

Core Date: October 19, 2022



ASPHALT THICKNESS (in)	=	7.5
STONE THICKNESS (in)	=	7.0
CORE BARREL DIAMETER (in)	=	4.0

VISUAL DESCRIPTION:

Apparent delamination at approximately 2 Inches below top of pavement.

CORE LOG for B-001-0-21

Project: WOO 64-05.78 – PID 107711

Project Location: Plain Township, Ohio

TTL Project No. 2130501

Core Date: October 19, 2021

ASPHALT THICKNESS (in)	=	10.0
STONE THICKNESS (in)	=	14.0
CORE BARREL DIAMETER (in)	=	4.0

VISUAL DESCRIPTION:

Apparent delamination at approximately 2 Inches below top of pavement.

CORE LOG for B-002-0-21

Project: WOO 64-05.78 – PID 107711

Project Location: Plain Township, Ohio

TTL Project No. 2130501

Core Date: October 18, 2021

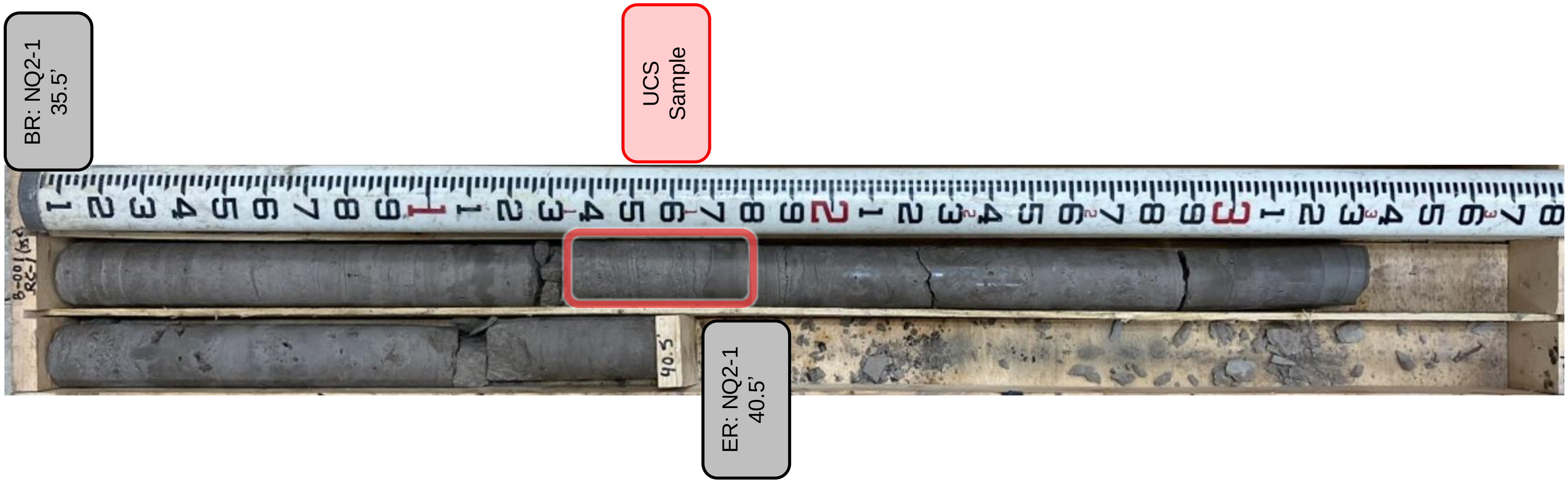
ASPHALT THICKNESS (in)	=	11.0
STONE THICKNESS (in)	=	8.0
CORE BARREL DIAMETER (in)	=	4.0

VISUAL DESCRIPTION:

Ohio Department of Transportation
Division of Engineering

Office of Geotechnical Engineering

B-001-0-21

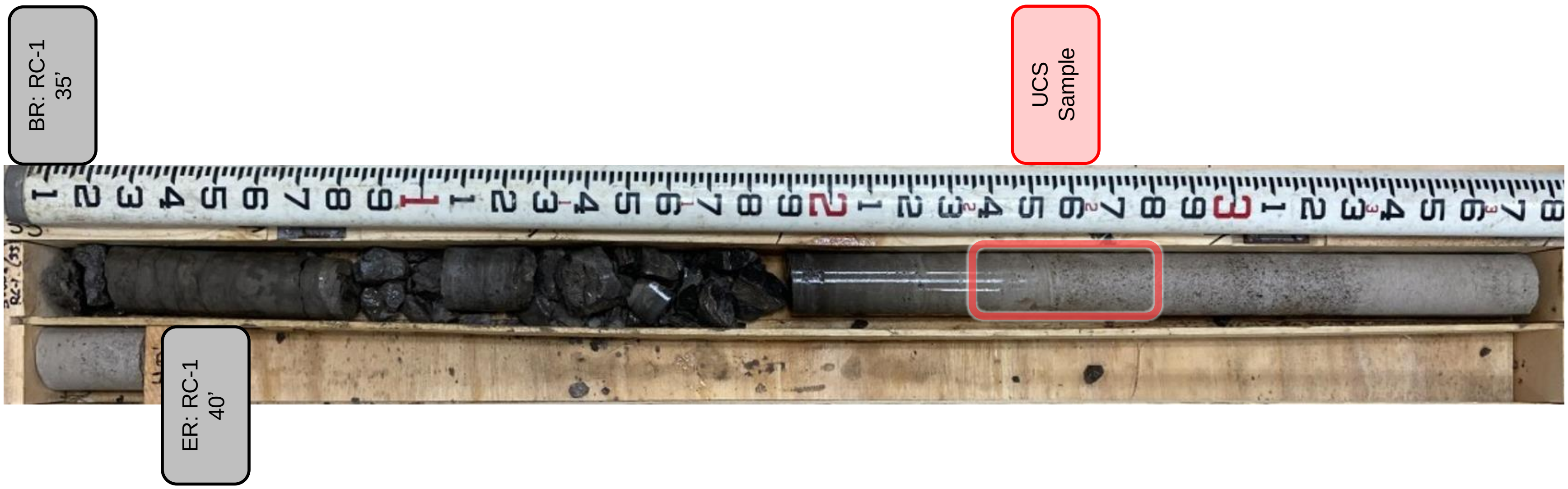


Core Date:	October 19, 2021				Ground Surface Elevation:	674.3 feet (NAVD88)		
Run #:	Depth		Elevation		Recovery		RQD	
RC-1	35.5'	40.5'	638.8	633.8	59/60	98%	57/60	95%
WOO-64-5.78, PID 107711								

Prepared by TTL associates inc
Environmental, Geotechnical Engineering & Testing

TTL Project No.: 2130501

B-002-0-21



Core Date: October 18, 2021					Ground Surface Elevation: 673.5 feet (NAVD88)			
Run #:	Depth		Elevation		Recovery		RQD	
RC-1	35'	40'	638.5	633.5	50/60	83%	29/60	48%
WOO-64-5.78, PID 107711								

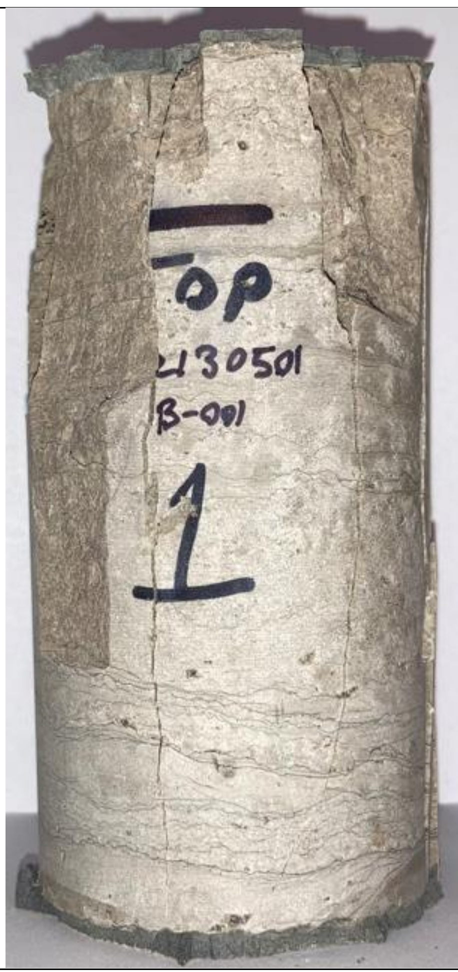
Compressive Strength of Rock
ASTM D 7012, Method C

PROJECT	WOO-64-5.78, PID 107711	TTL PROJECT NUMBER	2130501
LOCATION	Plain Township, Ohio		
CLIENT	Tetra Tech		
BORING NUMBER	B-001-0-21	SAMPLE NUMBER	1 (RC-1)
SAMPLE DEPTH (FEET)	35.5 – 40.5	SPECIMEN DEPTH (FEET)	36.7

ROCK DESCRIPTION	Dolomite, Light Gray, Slightly to Moderately Weathered, Strong, Very Fine Grained, Very Thin to Thin Bedded, Jointed - Slightly to Moderately Fractured, Tight.

LENGTH (INCHES)	4.04
DIAMETER (INCHES)	1.99
LENGTH / DIAMETER	2.03
CORRECTION FACTOR	1.0
AREA (SQ. IN.)	3.11

MASS (GRAMS)	529.2
UNIT WEIGHT (LBS/CU. FT.)	160.5
MAXIMUM LOAD (LBS)	47,500
COMPRESSIVE STRENGTH (PSI)	15,270



TEST SPECIMEN PHOTO

TEST SPECIMEN PHOTO

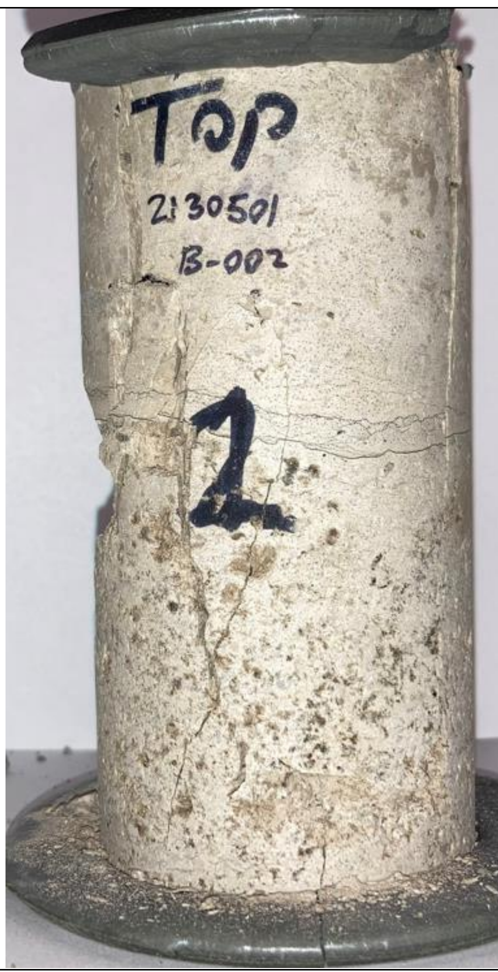
Compressive Strength of Rock
ASTM D 7012, Method C

Project	WOO-64-5.78, PID 107711	TTL Project Number	2130501
Location	Plain Township, Ohio		
Client	Tetra Tech		
Boring Number	B-002-0-21	Sample Number	2 (RC-1)
Sample Depth (feet)	35 - 40	Specimen Depth (feet)	37.3

Rock Description	Dolomite, Light Gray, Moderately Weathered, Strong, Very Fine Grained, Thin Bedded, Vuggy, Jointed - Slightly to Moderately Fractured, Tight.

Length (inches)	4.08
Diameter (inches)	1.99
Length / Diameter	2.05
Correction Factor	1.0
Area (sq. in.)	3.11

Mass (grams)	501.9
Unit Weight (lbs/cu. ft.)	150.7
Maximum Load (lbs)	38,420
Compressive Strength (psi)	12,350



Test Specimen Photo


Test Specimen Photo

APPENDIX A

Engineering Calculations

TTL Project No. 2130501				
WOO-64-5.78, PID 107711				
Calculation By: IJH 04-07-22		Checked:	CPI 04-07-22	
Soil Strength Evaluations				
Predominantly Very stiff to hard Cohesive Bearing Soils				
From 14 feet bearing depth down to thin zone of very dense granular				
at 33 to 34 feet, underlain by weathered rock at 34 to 35 feet.				
	N60	**HP (tsf)**	**UCS (psf)**	
	23	4.5		
	20	4.25		
	22	3.25		
	30	4.5		
	30	4.5		
	24	4.5		
	23	4.5		
	18	3.75		
	15	3		
	35	4.5		
	29	4.5		
	19	4.25		
Average:	**24.0**	**4.2**		
c (psf): N60x250/2=	3000	psf		
c (psf)=		4167	0	
Average of N60 and HP	3583	psf		
Conservatively, say su = c =		**3500**	**psf**	

By: IJH Date: 4/7/2022 Checked: CPI Date: 4/7/2022

GENERAL FOUNDATION INFORMATION:

Box culvert 13 feet wide (11' span +2 x 1’ wall thicknesses), but approxiamtely 40 feet long.
Bearing at approxiamtely 13 to 13.5 feet below road grades.

GENERAL SOIL INFORMATION:

Anticipated Bearing Conditions:

Predominantly Very Stiff to Hard Cohesive Soils underlain by 1' zone very dense sand, and then weathered bedrock.

Based on Soil Strength Evaluation Spreadsheet,

USE c =	3.5	ksf for these soils

Groundwater

Model groundwater in creek above foundation bearing elevation.

STRENTH LIMIT STATE:

$q_R = \varphi_b * q_n$ (AASTHO LRFD 10.6.3.1.1-1)

q_R = factored resistance at strength limit state (ksf)

φ_b = resistance factor (Article 10.5.5.2.2)

q_n = nominal bearing resistance (ksf)

$q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + 0.5\gamma B N_{\gamma m} C_{w\gamma}$ (AASTHO LRFD 10.6.3.1.2a-1)

$N_{cm} = N_c s_c i_c$ (AASTHO LRFD 10.6.3.1.2a-2)

$N_{qm} = N_q s_q d_q i_q$ (AASTHO LRFD 10.6.3.1.2a-3)

$N_{\gamma m} = N_\gamma s_\gamma i_\gamma$ (AASTHO LRFD 10.6.3.1.2a-4)

c = cohesion, undrained shear strength (ksf)

N_c = cohesion term (Table 10.6.3.1.2a-1)

N_q = surcharge term (Table 10.6.3.1.2a-1)

N_γ = unit weight term (Table 10.6.3.1.2a-1)

γ = total (moist) unit weight (kcf)

D_f = footing embedment depth (ft)

B = footing width (ft)

C_{wq} , $C_{w\gamma}$ = groundwater correction factors (Table 10.6.3.1.2a-2)

s_c , s_γ , s_q = shape correction factors (Table 10.6.3.1.2a-3)

d_q = shear resistance thought cohesionless material correction factor (Table 10.6.3.1.2a-4)

i_c , i_γ , i_q = inclination correction factors

By:	IJH	Date:	4/7/2022	Checked:	CPI	Date:	4/7/2022

Setup	$c =$	3.5	ksf			
	$\phi_f =$	0	degrees	assumed zero in cohesive soil		
	$N_c =$	5.14	*unitless*			
	$N_q =$	1.0	*unitless*	for soil with a $\phi_f =$ 0 Degrees		
	$N_\gamma =$	0.0	*unitless*			
	$\gamma =$	0.125	kcf	(assumed in upper 1.5 feet above bearing)		
	$D_f =$	5	ft	(Depth below creek bottom)		
	$B =$	13	ft	Width		
	$L =$	40	ft	Length (measured on Google Earth)		
	$D_w =$	0	ft	highest anticipated groundwater depth		
	$C_{wq} =$	0.5	*unitless*	where $D_w = 0.0$	$1.5B + D_f =$ 24.5	
	$C_{w\gamma} =$	0.5	*unitless*	(above D_f)		
	$s_c =$	1.065	*unitless*	$s_c = 1 + (B/(5L))$		$s_c = 1 + (B/(5L))(Nq/Nc)$
	$s_\gamma =$	1.0	*unitless*	for $\phi_f = 0$ $s_\gamma = 1$	for $\phi_f > 0$	$s_\gamma = 1 - 0.4(B/L)$
	$s_q =$	1.0	*unitless*	$s_q = 1$		$s_q = 1 + ((B/L)\tan(\phi_f))$
	$d_q =$	1.0	*unitless*	taken as 1 since cohesive soil	$D_f / B =$ 0.384615	
	$i_c, i_\gamma, i_q =$	1.0	*unitless*	Assumed loaded without inclination		

calculation	$N_{cm} = N_c s_c i_c$	$= 5.14 * 1.065 * 1 =$	5.474
	$N_{qm} = N_q s_q d_q i_q$	$= 1 * 1 * 1 * 1 =$	1
	$N_{\gamma m} = N_\gamma s_\gamma i_\gamma$	$= 0 * 1 * 1 =$	0

$q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + 0.5\gamma B N_{\gamma m} C_{w\gamma}$ $\qquad cN_{cm} =$ 19.159

$= (3.5*5.474) + (0.125*5*1*0.5) + (0.5*13*0*0.5) =$ $\qquad \gamma D_f N_{qm} C_{wq} =$ 0.313

$= (19.159) + (0.313) + (0) =$ $\qquad 0.5\gamma B N_{\gamma m} C_{w\gamma} =$ 0

$q_n =$ 19.47 ksf

$\varphi_b =$ 0.5 $\qquad$ based on theoretical method (Munfakh et al., 2001), in clay

$q_R = \varphi_b * q_n$ $\qquad = 0.5 * 19.472 =$ 9.74 ksf

Factored resistance at the strength limit state for the culvert bearing in the very stiff to hard cohesive soils is equal to 9.7 ksf

SERVICE LIMIT STATE:

Based on : (Table C10.6.2.6.1-1)

"Presumptive Bearing Resistance for Spread Footing Foundations at the Service Limit State" Table

Predominantly Very Stiff to Hard cohesive soils

Consistency	Soil Type	Bearing Resistance (ksf)	
		Ordinary Range	Recommended Value to use
Very Stiff	CL	6 to 12	8

$\varphi_b =$ 1

Factored bearing resistance = 8 ksf

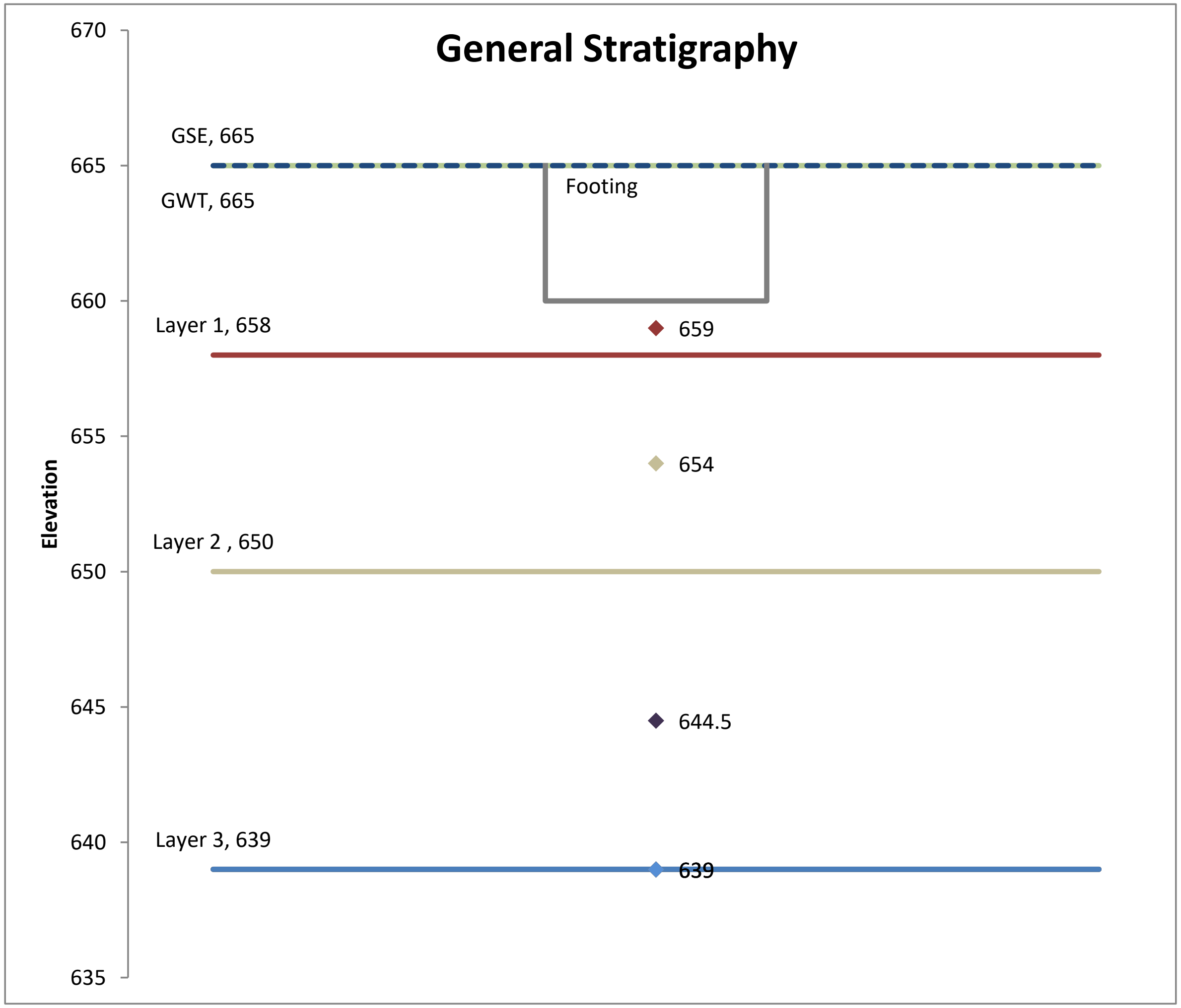
Reduce to 2.5 ksf based on settlement <1"	

(see attached *Settlement Calculation*)

Project Name:	WOO-64-5.78	Boring Number	B-002-0-21
Project Number:	2130501	Analysis Type	Boussinesq Continuous
Calculated by:	IJH 04-07-22		**Culvert Calculated Service Limit State Factored Bearing Resistance**

Layer	H (feet)	C_r	e_o	sigma v (psf)	z (feet)	b (feet)	(z-Df) / b	I_z	delta p@	7662 psf	(check) sigma v+ΔP	delta H (inches)
Layer 1	2	0.013	0.47	406	1	13	0.1	1.0	7662		8068	0.28
Layer 2	8	0.013	0.47	744	6	13	0.5	0.8	6129.6		6873	0.82
Layer 3	11	0.016	0.50	1386	15.5	13	1.2	0.5	3831		5217	0.81
Layer 4	0	0	0.30	1758	21	13	1.6	0.4	3064.8		4822	0.00
Layer 5	0	0	0.30	1758	21	13	1.6	0.4	3064.8		4822	0.00
Layer 6	0	0	0.30	1758	21	13	1.6	0.4	3064.8		4822	0.00

Total delta H (in.)	1.91
+15%	2.19
-15%	1.62



pc = su/(0.11+0.0037(PI))
su (psf)= 3500
Max PI = 17
pc (psf)= 20243
All sigma + delta P < pc, so all Cr

Project Name:	WOO-64-5.78	Boring Number	B-002-0-21
Project Number:	2130501	Analysis Type	Boussinesq Continuous (Homogeneous)
Calculated by:	IJH 04-07-22		
	Checked CPI 04-07-22		

MC higher compared to B-001 so B-002 Governs

Culvert Calculated Service Limit State Factored Bearing Resistance

G (assumed)	2.7		
GSE	665		Approximate Creek Bottom
GWT	665		At or above Creek Bottom
Bearing Elev	660		Provided by Tetra Tech
D_f	5	ft	
Footing Width, B	13	ft	
Bearing Pressure	7662	psf	Settlement based on increase in pressure so back out overburden pressure from Service Limit State Factored Bearing Resistance:

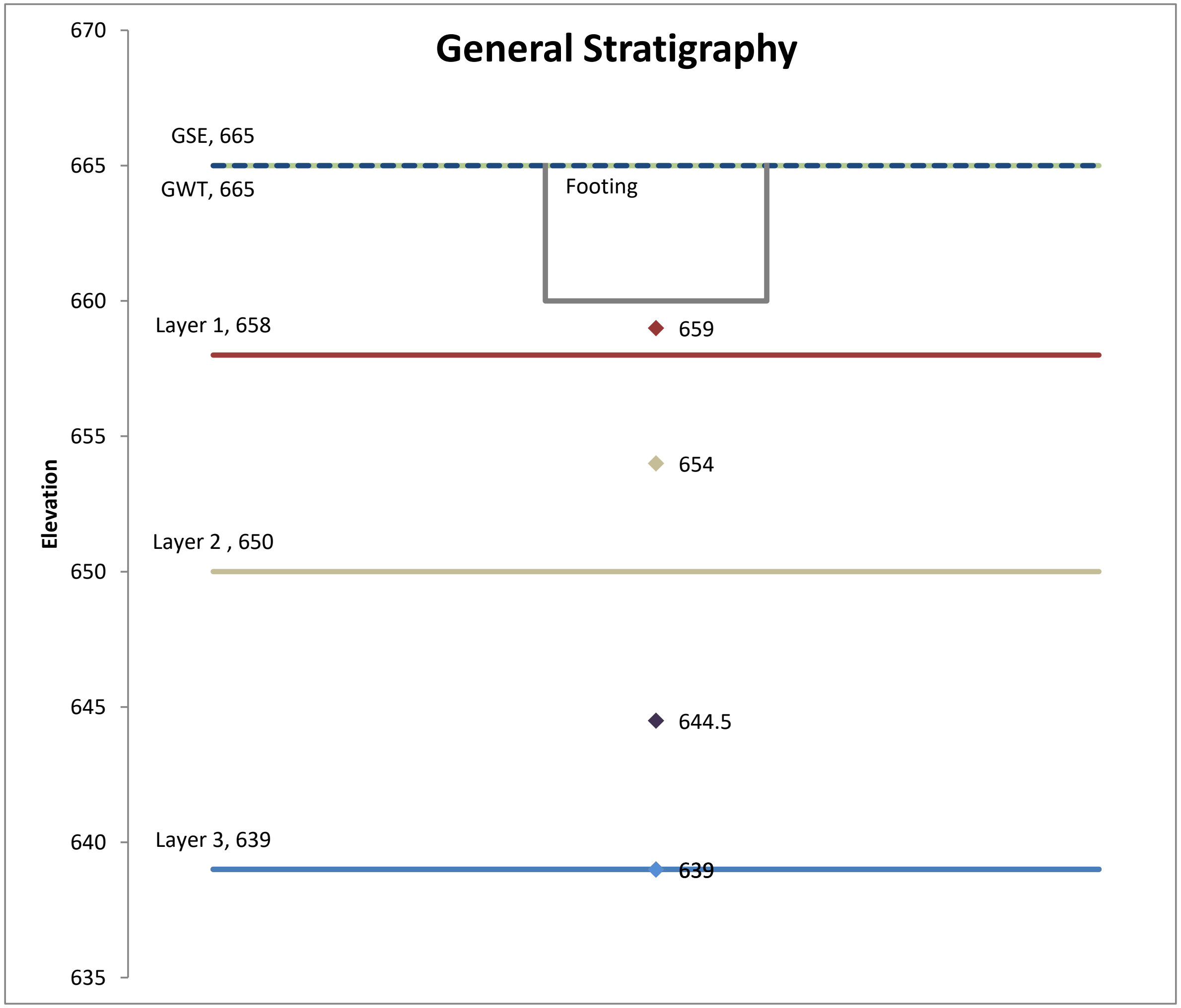
8000 - 338 = **7662** **psf** Change in pressure causing settlement

	Bot. Elev.	Centroid (C) Elev.	H (ft)	z below footing	z below GSE	γ_T (pcf)	γ_d (pcf)	H_{GWT-C}	w at C (%) (or C_rx1000)	e_o	Depth of Influence = $(z-D_f)/B$	I_z	σ_v' (psf)
Layer 1	658.00	659	2	1	6	130	115	6	13	0.47	0.08	1.0	406
Layer 2	650.00	654	8	6	11	130	115	11	13	0.47	0.5	0.8	744
Layer 3	639.00	644.5	11	15.5	20.5	130	112	20.5	16	0.50	1.2	0.5	1386
Layer 4	639.00	639	0	21	26	130	130	26	0	0.30	1.6	0.4	1758
Layer 5	639.00	639	0	21	26	130	130	26	0	0.30	1.6	0.4	1758
Layer 6	639.00	639	0	21	26	130	130	26	0	0.30	1.6	0.4	1758

Project Name:	WOO-64-5.78	Boring Number B-002-0-21
Project Number:	2130501	Analysis Type Boussinesq Continuous
Calculated by:	IJH 04-07-22	**Culvert bearing pressure for less than 1 inch settlement**

Layer	H (feet)	C_r	e_o	sigma v (psf)	z (feet)	b (feet)	(z-Df) / b	I_z	delta p@	2250 psf	(check) sigma v+ΔP	delta H (inches)
Layer 1	2	0.013	0.47	406	1	13	0.1	1.0	2250		2656	0.17
Layer 2	8	0.013	0.47	744	6	13	0.5	0.8	1800		2544	0.45
Layer 3	11	0.016	0.50	1386	15.5	13	1.2	0.5	1125		2511	0.36
Layer 4	0	0	0.30	1758	21	13	1.6	0.4	900		2658	0.00
Layer 5	0	0	0.30	1758	21	13	1.6	0.4	900		2658	0.00
Layer 6	0	0	0.30	1758	21	13	1.6	0.4	900		2658	0.00

Total delta H (in.)	0.99
+15%	1.14
-15%	0.84



pc = su/(0.11+0.0037(PI))
su (psf)= 3500
Max PI = 17
pc (psf)= 20243
All sigma + delta P < pc, so all Cr

Project Name:	WOO-64-5.78	Boring Number	B-002-0-21
Project Number:	2130501	Analysis Type	Boussinesq Continuous (Homogeneous)
Calculated by:	IJH 04-07-22		
	Checked CPI 04-07-22		

MC higher compared to B-001 so B-002 Governs

Culvert bearing pressure for less than 1 inch settlement

G (assumed)	2.7		
GSE	665		Approximate Creek Bottom
GWT	665		At or above Creek Bottom
Bearing Elev	660		Provided by Tetra Tech
D_f	5	ft	
Footing Width, B	13	ft	
Bearing Pressure	2250	psf	Max change in pressure for 1" or less settlement.

Service Limit State Factored Bearing Resistance:

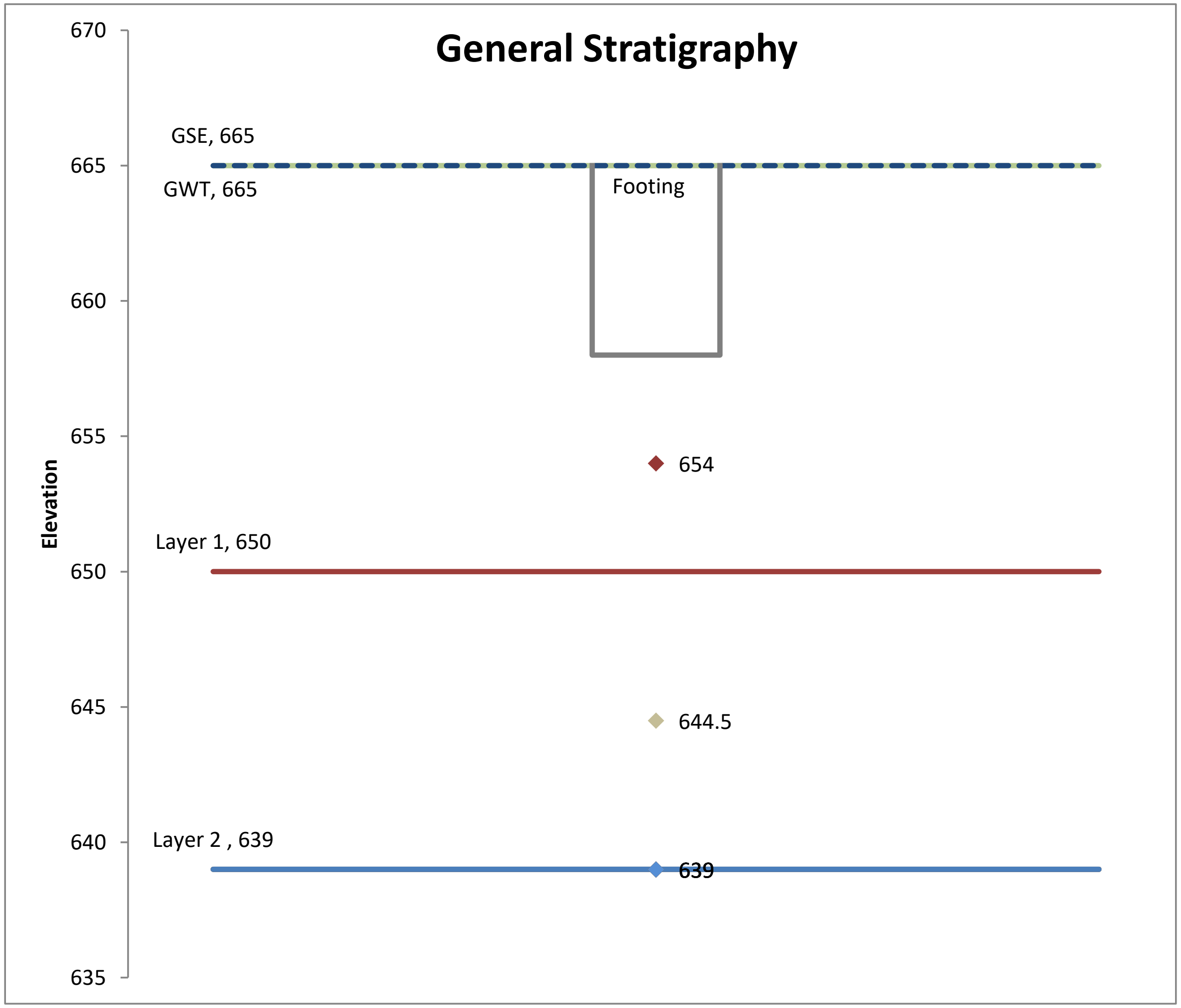
2250 + 338 = **2588** **psf** Change in pressure causing settlement

	Bot. Elev.	Centroid (C) Elev.	H (ft)	z below footing	z below GSE	γ_T (pcf)	γ_d (pcf)	H_{GWT-C}	w at C (%) (or C_rx1000)	e_o	Depth of Influence = $(z-D_f)/B$	I_z	σ_v' (psf)
Layer 1	658.00	659	2	1	6	130	115	6	13	0.47	0.08	1.0	406
Layer 2	650.00	654	8	6	11	130	115	11	13	0.47	0.5	0.8	744
Layer 3	639.00	644.5	11	15.5	20.5	130	112	20.5	16	0.50	1.2	0.5	1386
Layer 4	639.00	639	0	21	26	130	130	26	0	0.30	1.6	0.4	1758
Layer 5	639.00	639	0	21	26	130	130	26	0	0.30	1.6	0.4	1758
Layer 6	639.00	639	0	21	26	130	130	26	0	0.30	1.6	0.4	1758

Project Name:	WOO-64-5.78	Boring Number	B-002-0-21
Project Number:	2130501	Analysis Type	Boussinesq Continuous
Calculated by:	IJH 04-07-22		**Wingwall - Indicated 3 ksf bearing pressure.**

Layer	H (feet)	C_r	e_o	sigma v (psf)	z (feet)	b (feet)	(z-Df) / b	I_z	delta p@	2527 psf	(check) sigma v+ΔP	delta H (inches)
Layer 1	8	0.013	0.47	744	4	7.5	0.5	0.8	2021.44		2765	0.49
Layer 2	11	0.016	0.50	1386	13.5	7.5	1.8	0.3	758.04		2144	0.27
Layer 3	0	0	0.30	1758	19	7.5	2.5	0.2	505.36		2263	0.00
Layer 4	0	0	0.30	1758	19	7.5	2.5	0.2	505.36		2263	0.00
Layer 5	0	0	0.30	1758	19	7.5	2.5	0.2	505.36		2263	0.00
Layer 6	0	0	0.30	1758	19	7.5	2.5	0.2	505.36		2263	0.00

Total delta H (in.)	0.75
+15%	0.86
-15%	0.64



pc = su/(0.11+0.0037(PI))
su (psf)= 3500
Max PI = 17
pc (psf)= 20243
All sigma + delta P < pc, so all Cr

Project Name:	WOO-64-5.78	Boring Number	B-002-0-21	
Project Number:	2130501	Analysis Type	Boussinesq Continuous	MC higher compared to B-001 so B-002 Governs
Calculated by:	IJH 04-07-22		(Homogeneous)	
	Checked CPI 04-07-22	**Wingwall - Indicated 3 ksf bearing pressure.**		

G (assumed)	2.7		
GSE	665		Approximate Creek Bottom
GWT	665		At or above Creek Bottom
Bearing Elev	658		2 feet below base of culvert
D_f	7	ft	
Footing Width, B	7.5	ft	
Bearing Pressure	2527	psf	Max change in pressure for 1" or less settlement.

Service Limit State Factored Bearing Resistance:

2527 + 473.2 = **3000** **psf** Change in pressure causing settlement

	Bot. Elev.	Centroid (C) Elev.	H (ft)	z below footing	z below GSE	γ_T (pcf)	γ_d (pcf)	H_{GWT-C}	w at C (%) (or C_rx1000)	e_o	Depth of Influence = $(z-D_f)/B$	I_z	σ_v' (psf)
Layer 1	650.00	654	8	4	11	130	115	11	13	0.47	0.53	0.8	744
Layer 2	639.00	644.5	11	13.5	20.5	130	112	20.5	16	0.50	1.8	0.3	1386
Layer 3	639.00	639	0	19	26	130	130	26	0	0.30	2.5	0.2	1758
Layer 4	639.00	639	0	19	26	130	130	26	0	0.30	2.5	0.2	1758
Layer 5	639.00	639	0	19	26	130	130	26	0	0.30	2.5	0.2	1758
Layer 6	639.00	639	0	19	26	130	130	26	0	0.30	2.5	0.2	1758

OHIO DEPARTMENT OF TRANSPORTATION

OFFICE OF GEOTECHNICAL ENGINEERING

PLAN SUBGRADES
Geotechnical Bulletin GB1

WOO 64-5.78
107711
SR 64 over Tributary of Haskins Creek
Proposed Culvert Replacement

TTL Associates, Inc

Prepared By: Imad El Hajjar, EI
Date prepared: Monday, May 23, 2022

Imad El Hajjar, EI
TTL Associates, Inc.
1915 North 12 Street
Toledo, Ohio 43604
216-217-5449
ihajjar@ttlassoc.com

NO. OF BORINGS: **2**

#	Boring ID	Alignment	Station	Offset	Dir	Drill Rig	ER	Boring EL.	Proposed Subgrade EL	Cut Fill
1	B-001-0-21	SR-64	304+64	6	Left	CME 75 Truck Mounted	66	674.3	672.3	2.0 C
2	B-002-0-21	SR-64	305+79	8	Right	CME 75 Truck Mounted	66	673.5	672.0	1.5 C

OHIO DEPARTMENT OF TRANSPORTATION

Subgrade Analysis

V. 14.5 1/18/2019

#	Boring	Sample	Sample Depth		Subgrade Depth		Standard Penetration		HP (tsf)	Physical Characteristics						Moisture		Ohio DOT		Sulfate Content (ppm)	Problem		Excavate and Replace (Item 204)		Recommendation (Enter depth in inches)
			From	To	From	To	N_{60}	N_{60L}		LL	PL	PI	% Silt	% Clay	P200	M_C	M_{OPT}	Class	GI		Unsuitable	Unstable	Unsuitable	Unstable	
1	B	SS-1	1.0	2.5	-1.0	0.5	14		NP							4	10	A-2-4	0	310					**12"**
	001-0	SS-2	2.5	4.0	0.5	2.0	12		1.5	34	18	16	28	43	71	23	16	A-6b	10			HP & Mc		**12"**	**204 Geotextile**
	21	SS-3	4.0	5.5	2.0	3.5	10		2.5	39	18	21	25	47	72	20	16	A-6b	12			N_{60} & Mc			
		SS-4	5.5	7.0	3.5	5.0	13	10	2							21	16	A-6b	16						
2	B	SS-1	1.0	2.5	-0.5	1.0	18		4.5	33	13	20	19	38	57	13	16	A-6b	8	340					
	002-0	SS-2	2.5	4.0	1.0	2.5	15		2.5							20	16	A-6b	16			Mc			
	21	SS-3	4.0	5.5	2.5	4.0	9		3.25							17	16	A-6b	16						
		SS-4	5.5	7.0	4.0	5.5	13	9	3.75	34	15	19	21	55	76	18	16	A-6b	12						

PID: 107711

County-Route-Section: WOO 64-5.78
No. of Borings: 2

Geotechnical Consultant: TTL Associates, Inc
Prepared By: Imad El Hajjar, EI
Date prepared: 5/23/2022

Chemical Stabilization Options		
320	Rubblize & Roll	No
206	Cement Stabilization	Option
	Lime Stabilization	Option
206	Depth	14"

Excavate and Replace Stabilization Options	
Global Geotextile Average(N60L): Average(HP):	 12" 0"
Global Geogrid Average(N60L): Average(HP):	 0" 0"

Design CBR	6

% Samples within 6 feet of subgrade			
$N_{60} \leq 5$	0%	$HP \leq 0.5$	0%
$N_{60} < 12$	25%	$0.5 < HP \leq 1$	0%
$12 \leq N_{60} < 15$	50%	$1 < HP \leq 2$	25%
$N_{60} \geq 20$	0%	$HP > 2$	63%
M+	38%		
Rock	0%		
Unsuitable	0%		

Excavate and Replace at Surface	
Average	6"
Maximum	12"
Minimum	0"

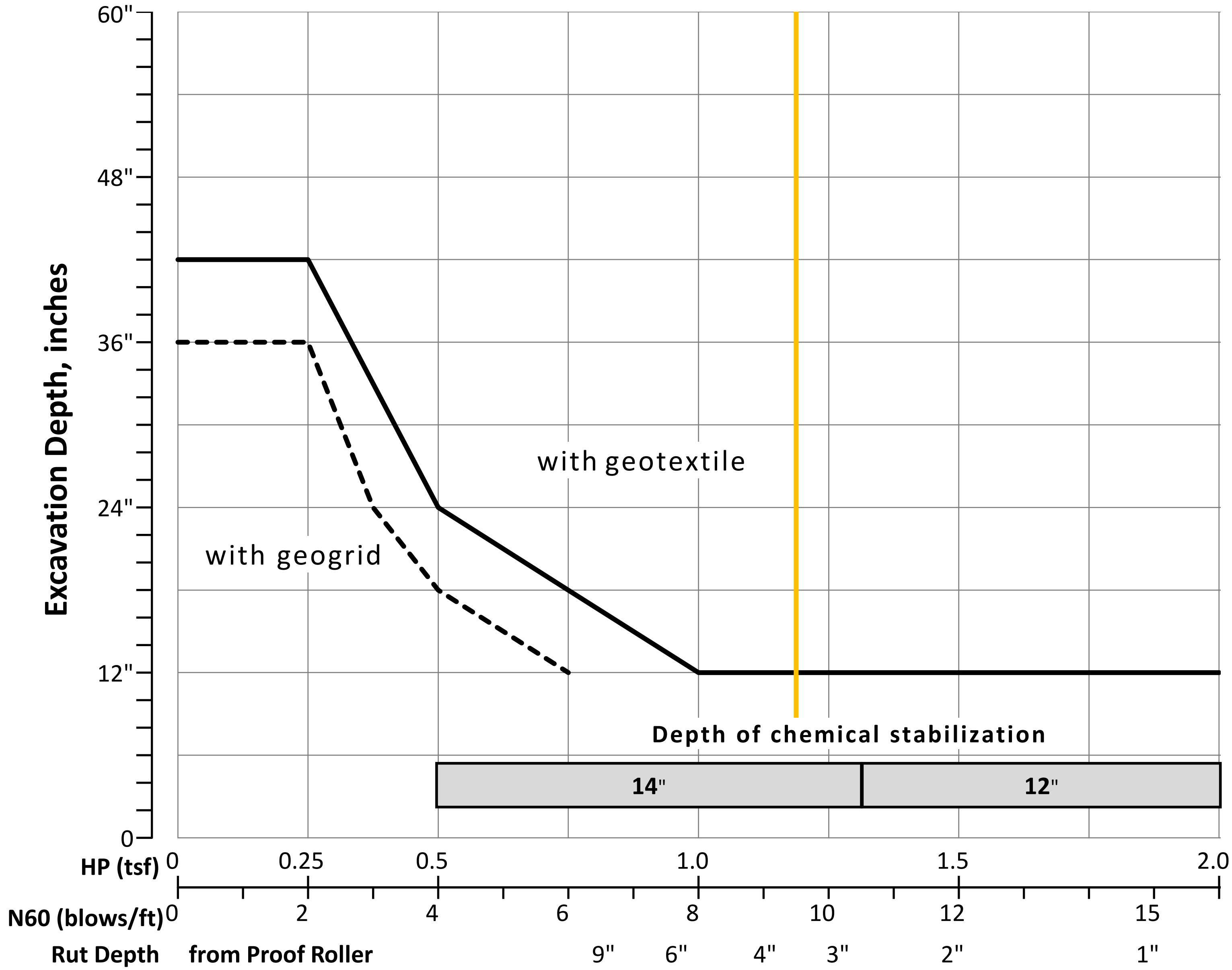
% Proposed Subgrade Surface	
Unstable & Unsuitable	50%
Unstable	50%
Unsuitable	0%

	N_{60}	N_{60L}	HP	LL	PL	PI	Silt	Clay	P 200	M_C	M_{OPT}	GI
Average	13	10	2.86	35	16	19	23	46	69	17	15	11
Maximum	18	10	4.50	39	18	21	28	55	76	23	16	16
Minimum	9	9	1.50	33	13	16	19	38	57	4	10	0

Classification Counts by Sample

ODOT Class	Rock	A-1-a	A-1-b	A-2-4	A-2-5	A-2-6	A-2-7	A-3	A-3a	A-4a	A-4b	A-5	A-6a	A-6b	A-7-5	A-7-6	A-8a	A-8b	Totals
Count	0	0	0	1	0	0	0	0	0	0	0	0	0	7	0	0	0	0	8
Percent	0%	0%	0%	13%	0%	0%	0%	0%	0%	0%	0%	0%	0%	88%	0%	0%	0%	0%	100%
% Rock|Granular|Cohesive	0%	13%								88%									100%
Surface Class Count	0	0	0	1	0	0	0	0	0	0	0	0	0	5	0	0	0	0	6
Surface Class Percent	0%	0%	0%	17%	0%	0%	0%	0%	0%	0%	0%	0%	0%	83%	0%	0%	0%	0%	100%

GB1 Figure B – Subgrade Stabilization



OVERRIDE TABLE

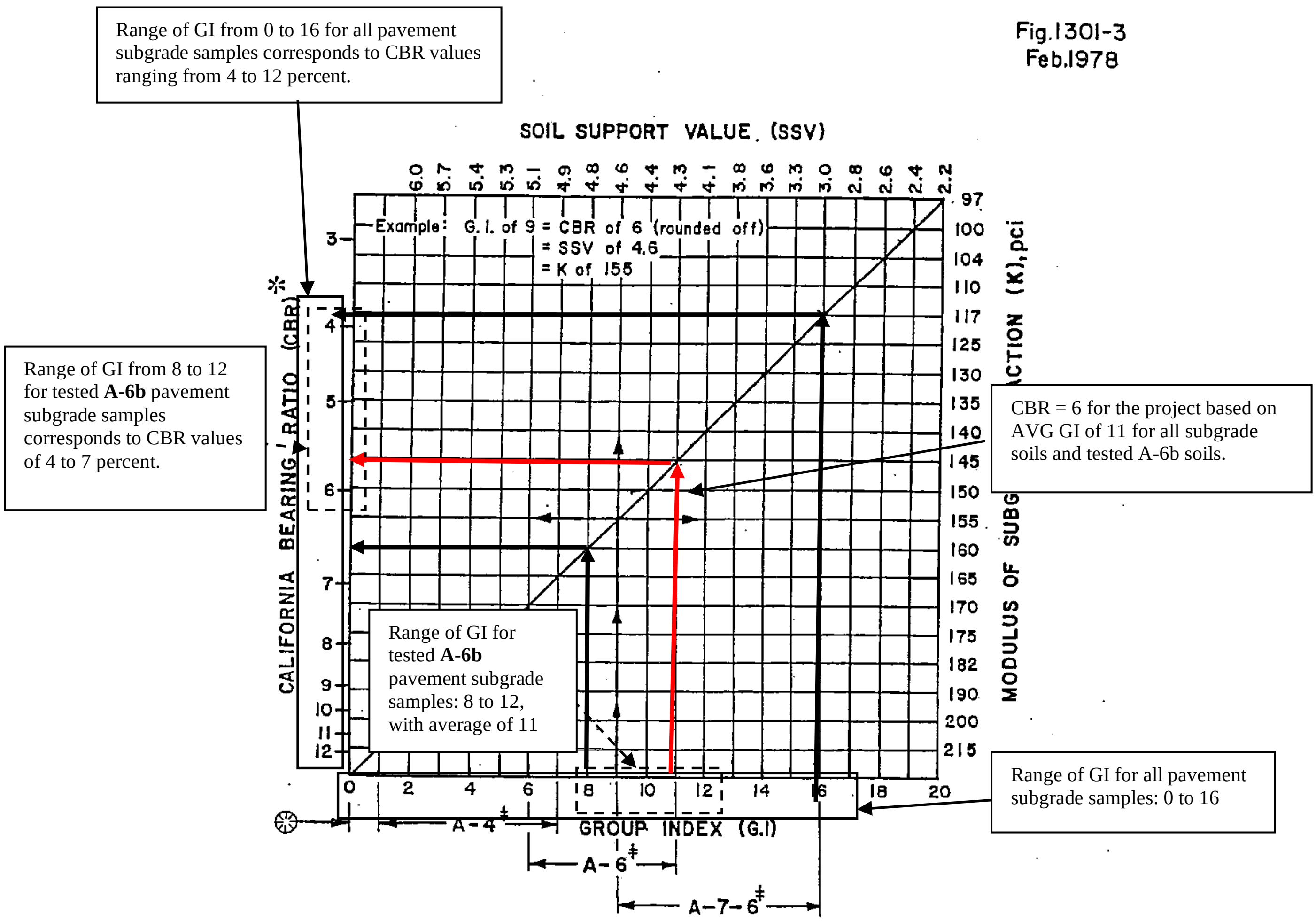
Calculated Average	New Values	Check to Override
2.86		☐ HP
9.50		☐ N60L

Average HP

Average N_{60L}

WOO 64-5.78

Fig.1301-3
Feb.1978



⊛ AASHTO Classes A-1, A-2 & A-3 lie below 0. SSV=6-10; K=200+.

‡ Usual range of AASHTO Classes.

⁂ 5-1/2 Lb. hammer, 12" drop, 4 layers, 45 blows per layer, compacted at optimum moisture as determined by AASHTO T-99.

CORRELATION CHART FOR
SUBGRADE STRENGTHS

APPENDIX B

Geotechnical Engineering Design Checklists

I. Geotechnical Design Checklists	
Project: WOO-64-5.78	PDP Path:
PID: 107711	Review Stage: 1

Checklist	Included in This Submission
II. Reconnaissance and Planning	✓
III. A. Centerline Cuts	
III. B. Embankments	
III. C. Subgrade	✓
IV. A. Foundations of Structures	✓
IV. B. Retaining Wall	
V. A. Landslide Remediation	
V. B. Rockfall Remediation	
V. C. Wetland or Peat Remediation	
V. D. Underground Mine Remediation	
V. E. Surface Mine Remediation	
V. F. Karst Remediation	
VI. A. Soil Profile	
VI. D. Geotechnical Reports	✓

II. Reconnaissance and Planning Checklist

C-R-S: WOO-64-5.78	PID: 107711	Reviewer: IJH	Date: 5/23/2022

Reconnaissance		(Y/N/X)	Notes:
1	Based on Section 302.1 in the SGE, have the necessary plans been developed in the following areas prior to the commencement of the subsurface exploration reconnaissance:	X	Plans to be prepared by others.
	Roadway plans		
	Structures plans		
	Geohazards plans		
2	Have the resources listed in Section 302.2.1 of the SGE been reviewed as part of the office reconnaissance?	Y	
3	Have all the features listed in Section 302.3 of the SGE been observed and evaluated during the field reconnaissance?	Y	
4	If notable features were discovered in the field reconnaissance, were the GPS coordinates of these features recorded?	X	

Planning - General		(Y/N/X)	Notes:
5	In planning the geotechnical exploration program for the project, have the specific geologic conditions, the proposed work, and historic subsurface exploration work been considered?	Y	
6	Has the ODOT Transportation Information Mapping System (TIMS) been accessed to find all available historic boring information and inventoried geohazards?	Y	
7	Have the borings been located to develop the maximum subsurface information while using a minimum number of borings, utilizing historic geotechnical explorations to the fullest extent possible?	Y	
8	Have the topography, geologic origin of materials, surface manifestation of soil conditions, and any other special design considerations been utilized in determining the spacing and depth of borings?	Y	
9	Have the borings been located so as to provide adequate overhead clearance for the equipment, clearance of underground utilities, minimize damage to private property, and minimize disruption of traffic, without compromising the quality of the exploration?	Y	

II. Reconnaissance and Planning Checklist

Planning - General		(Y/N/X)	Notes:
10	Have the scaled boring plans, showing all project and historic borings, and a schedule of borings in tabular format, been submitted to the District Geotechnical Engineer?	Y	Included with proposal.
	The schedule of borings should present the following information for each boring:		
a.	exploration identification number	Y	
b.	location by station and offset	X	Station and offset were not available during planning.
c.	estimated amount of rock and soil, including the total for each for the entire program.	Y	
Planning – Exploration Number		(Y/N/X)	Notes:
11	Have the coordinates, stations and offsets of all explorations (borings, probes, test pits, etc.) been identified?	y	
12	Has each exploration been assigned a unique identification number, in the following format X-ZZZ-W-YY, as per Section 303.2 of the SGE?	Y	
13	When referring to historic explorations that did not use the identification scheme in 12 above, have the historic explorations been assigned identification numbers according to Section 303.2 of the SGE?	X	

II. Reconnaissance and Planning Checklist

Planning – Boring Types		(Y/N/X)	Notes:
14	Based on Sections 303.3 to 303.7.6 of the SGE, have the location, depth, and sampling requirements for the following boring types been determined for the project?	Y	
	Check all boring types utilized for this project:		
	Existing Subgrades (Type A)	✓	
	Roadway Borings (Type B)		
	Embankment Foundations (Type B1)		
	Cut Sections (Type B2)		
	Sidehill Cut Sections (Type B3)		
	Sidehill Cut-Fill Sections (Type B4)		
	Sidehill Fill Sections on Unstable Slopes (Type B5)		
	Geohazard Borings (Type C)		
	Lakes, Ponds, and Low-Lying Areas (Type C1)		
	Peat Deposits, Compressible Soils, and Low Strength Soils (Type C2)		
	Uncontrolled Fills, Waste Pits, and Reclaimed Surface Mines (Type C3)		
	Underground Mines (C4)		
	Landslides (Type C5)		
	Rockfall (Type C6)		
	Karst (Type C7)		
	Proposed Underground Utilities (Type D)		
	Structure Borings (Type E)		
	Bridges (Type E1)		
	Culverts (Type E2 a,b,c)	✓	
	Retaining Walls (Type E3 a,b,c)		
	Noise Barrier (Type E4)		
	CCTV & High Mast Lighting Towers (Type E5)		
	Buildings and Salt Domes (Type E6)		

III.C. Subgrade Checklist

C-R-S: WOO-64-5.78	PID: 107711	Reviewer: IJH	Date: 5/23/2022

If you do not have any subgrade work on the project, you do not have to fill out this checklist.

Subgrade		(Y/N/X)	Notes:
1	Has the subsurface exploration adequately characterized the soil or rock according to Geotechnical Bulletin 1: Plan Subgrades (GB1)?	Y	
a.	Has each sample been visually classified and inspected for the presence of gypsum? Has a moisture content been performed on each sample?	Y	This is the final Submital
b.	Has mechanical classification (Plastic Limit (PL), Liquid Limit (LL), and gradation testing) been done on at least two samples from each boring within six feet of the proposed subgrade?	Y	gINT project file is being provided with this final Submittal report
c.	Has the sulfate content of at least one sample from each boring within 3 feet of the proposed subgrade been determined, per Supplement 1122, Determining Sulfate Content in Soils?	Y	
d.	Has the sulfate content of all samples that exhibit gypsum crystals been determined?	X	No gypsum observed in samples.
e.	Have A-2-5, A-4b, A-5, A-7-5, A-8a, or A-8b soils within the top 3 feet of the proposed subgrade been mechanically classified?	X	None present.
2	If soils classified as A-2-5, A-4b, A-5, A-7-5, A-8a, or A-8b, or having a LL>65, are present at the proposed subgrade (soil profile), do the plans specify that these materials need to be removed and replaced or chemically stabilized?	X	None present.
a.	If these materials are to be removed and replaced, have the station limits, depth, and lateral limits for the planned removal been provided?	X	
3	If there is any rock, shale, or coal present at the proposed subgrade (C&MS 204.05), do the plans specify the removal of the material?	X	Rock deeper than 24 inches below anticipated subgrade elevation so removal not required.
a.	If removal of any rock, shale, or coal is required, have the station limits, depth, and lateral limits for the planned removal of the material at proposed subgrade been provided?		

III.C. Subgrade Checklist

Subgrade		(Y/N/X)	Notes:
4	In accordance with GB1, do the SPT (N_{60})/HP values and existing moisture contents for the proposed subgrade soils indicate the need for subgrade stabilization?	N	
a.	If removal and replacement is applicable, has the detail of subgrade removal been shown on the plans, including depth of removal, station limits, lateral extent, replacement material, and plan notes (Item 204 - Subgrade Compaction and Proof Rolling)?	Y	Removal and replacement is anticipated. Extent of Removal and replacement is shown in the report. Plans to be prepared by others.
b.	If chemical stabilization is applicable, has the detail of this treatment been shown on the plans, including depth, percentage of chemical, station limits, lateral extent, and plan notes?	X	Chemical stabilization not anticipated to be economical. Plans to be prepared by others.
	Indicate type of chemical stabilization specified:		
	cement stabilization		
	lime stabilization		
5	If removal and replacement has been specified, do the plans include Plan Note G121 from L&D3?	X	Plans to be prepared by others.
6	If drainage or groundwater is an issue with the proposed subgrade, has an appropriate drainage system (e.g., pipe, underdrains) been provided?	X	Plans to be prepared by others.
7	Has an appropriate quantity of Proof Rolling (C&MS 204.06) and has Plan Note G111 from L&D3 been included in the plans?	X	Plans to be prepared by others.
8	Has a design CBR value been provided?	Y	

IV.A Foundations of Structures Checklist

C-R-S: WOO-64-5.78	PID: 107711	Reviewer: IJH	Date: 5/23/2022

If you do not have such a foundation or structure on the project, you do not have to fill out this checklist.

Soil and Bedrock Strength Data		(Y/N/X)	Notes:
1	Has the shear strength of the foundation soils been determined?	Y	
	Check method used:		
	laboratory shear tests	✓	
	estimation from SPT or field tests	✓	
2	Have sufficient soil shear strength, consolidation, and other parameters been determined so that the required allowable loads for the foundation/structure can be designed?	Y	
3	Has the shear strength of the foundation bedrock been determined?	Y	
	Check method used:	UCS	
	laboratory shear tests	✓	
	other (describe other methods)		
Spread Footings		(Y/N/X)	Notes:
4	Are there spread footings on the project? If no, go to Question 11	Y	
5	Have the recommended bottom of footing elevation and reason for this recommendation been provided?	Y	
a.	Has the recommended bottom of footing elevation taken scour from streams or other water flow into account?	N	
6	Were representative sections analyzed for the entire length of the structure for the following:	Y	
a.	factored bearing resistance?	Y	
b.	factored sliding resistance?	N	Recommended soil parameters provided
c.	eccentric load limitations (overturning)?	N	
d.	predicted settlement?	Y	
e.	overall (global) stability?	N	
7	Has the need for a shear key been evaluated?	N	
a.	If needed, have the details been included in the plans?	X	Plans to be prepared by others.
8	If special conditions exist (e.g. geometry, sloping rock, varying soil conditions), was the bottom of footing “stepped” to accommodate them?	X	Conditions not present.
9	Have the Service I and Maximum Strength Limit States for bearing pressure on soil or rock been provided?	Y	

IV.A Foundations of Structures Checklist

Spread Footings		(Y/N/X)	Notes:
10	If weak soil is present at the proposed foundation level, has the removal / treatment of this soil been developed and included in the plans?	X	Conditions not present.
a.	Have the procedure and quantities related to this removal / treatment been included in the plans?	X	See response for Item 10, above.
Pile Structures		**(Y/N/X)**	**Notes:**
11	Are there piles on the project? If no, go to Question 17	N	
12	Has an appropriate pile type been selected?		
	Check the type selected:		
	H-pile (driven)		
	H-pile (prebored)		
	Cast In-place Reinforced Concrete Pipe		
	Micropile		
	Continuous Flight Auger (CFA)		
	other (describe other types)		
13	Have the estimated pile length or tip elevation and section (diameter) based on either the Ultimate Bearing Value (UBV) or the depth to top of bedrock been specified? Indicate method used.		
14	If scour is predicted, has pile resistance in the scour zone been neglected?		
15	Has a wave equation drivability analysis been performed as per BDM 305.4.1.2 to determine whether the pile can be driven to either the UBV, the pile tip elevation, or refusal on bedrock without overstressing the pile?		
16	If required for design, have sufficient soil parameters been provided and calculations performed to evaluate the:		
a.	Nominal unit tip resistance and maximum settlement of the piles?		
b.	Nominal unit side resistance for each contributing soil layer and maximum deflection of the piles?		
c.	Downdrag load on piles driven through new embankment or compressible soil layers, as per BDM 305.4.2.2?		
d.	Potential for and impact of lateral squeeze from soft foundation soils?		

IV.A Foundations of Structures Checklist

Pile Structures		(Y/N/X)	Notes:
17	If piles are to be driven to strong bedrock (Q_u >7.5 ksi) or through very dense granular soils or overburden containing boulders, have “pile points” been recommended in order to protect the tips of the steel piling, as per BDM 305.4.5.6?		
18	If subsurface obstacles exist, has preboring been recommended to avoid these obstructions?		
19	If piles will be driven through 15 feet or more of new embankment, has preboring been specified as per BDM 305.4.5.7?		

IV.A Foundations of Structures Checklist

Drilled Shafts		(Y/N/X)	Notes:
20	Are there drilled shafts on the project? If no, go to the next checklist.	N	
21	Have the drilled shaft diameter and embedment length been specified?		
22	Have the recommended drilled shaft diameter and embedment been developed based on the nominal unit side resistance and nominal unit tip resistance for vertical loading situations?		
23	For shafts undergoing lateral loading, have the following been determined:		
a.	total factored lateral shear?		
b.	total factored bending moment?		
c.	maximum deflection?		
d.	reinforcement design?		
24	If a bedrock socket is required, has a minimum rock socket length equal to 1.5 times the rock socket diameter been used, as per BDM 305.5.2?		
25	Generally, bedrock sockets are 6" smaller in diameter than the soil embedment section of the drilled shaft. Has this factor been accounted for in the drilled shaft design?		
26	If scour is predicted, has shaft resistance in the scour zone been neglected?		
27	Has the site been assessed for groundwater influence?		
a.	If yes, and if artesian flow is a potential concern, does the design address control of groundwater flow during construction?		
28	Have all the proper items been included in the plans for integrity testing?		
29	If special construction features (e.g., slurry, casing, load tests) are required, have all the proper items been included in the plans?		
30	If necessary, have wet construction methods been specified?		

General		(Y/N/X)	Notes:
31	Has the need for load testing of the foundations been evaluated?	N	
a.	If needed, have details and plan notes for load testing been included in the plans?		

VI.B. Geotechnical Reports

C-R-S: WOO-64-5.78	PID: 107711	Reviewer: CPI	Date: 4/2/2025

General		(Y/N/X)	Notes:
1	Has an electronic copy of all geotechnical submissions been provided to the District Geotechnical Engineer (DGE)?	Y	
2	Has the first complete version of a geotechnical report being submitted been labeled as 'Draft'?	Y	
3	Subsequent to ODOT's review and approval, has the complete version of the revised geotechnical report being submitted been labeled 'Final'?	Y	This is the final Submital
4	Has the boring data been submitted in a native format that is DIGGS (Data Interchange for Geotechnical and Geoenvironmental) compatable? gINT files may be used for this.	Y	gINT project file is being provided with this final report submittal
5	Does the report cover format follow ODOT's Brand and Identity Guidelines Report Standards found at http://www.dot.state.oh.us/brand/Pages/default.aspx ?	Y	
6	Have all geotechnical reports being submitted been titled correctly as prescribed in Section 705.1 of the SGE?	Y	
Report Body		**(Y/N/X)**	**Notes:**
7	Do all geotechnical reports being submitted contain the following:		
a.	an Executive Summary as described in Section 705.2 of the SGE?	Y	
b.	an Introduction as described in Section 705.3 of the SGE?	Y	
c.	a section titled "Geology and Observations of the Project," as described in Section 705.4 of the SGE?	Y	
d.	a section titled "Exploration," as described in Section 705.5 of the SGE?	Y	
e.	a section titled "Findings," as described in Section 705.6 of the SGE?	Y	
f.	a section titled "Analyses and Recommendations," as described in Section 705.7 of the SGE?	Y	
Appendices		**(Y/N/X)**	**Notes:**
8	Do all geotechnical reports being submitted contain all applicable Appendices as described in Section 705.8 of the SGE?	Y	
9	Do the Appendices present a site Boring Plan showing all boring locations as described in Section 705.8.1 of the SGE?	Y	

VI.B. Geotechnical Reports

Appendices		(Y/N/X)	Notes:
10	Do the Appendices include boring logs and color pictures of rock, if applicable, as described in Section 705.8.2 of the SGE?	Y	
11	Do the Appendices include reports of undisturbed test data as described in Section 705.8.3 of the SGE?	Y	
12	Do the Appendices include calculations in a logical format to support recommendations as described in Section 705.8.4 of the SGE?	Y	