CTL Engineering, Inc.
102 Commerce Dr., Wapakoneta, OH 45895
Phone: 419-738-1447 / Fax: 419-738-7670
E-Mail: ctlwapak@ctleng.com

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Established 1927

November 26, 2024

Bockrath & Associates
115 S. Fair Ave., Suite A
Ottawa, OH 45875

Attention: Mr. Greg Bockrath, P.E.

Reference: Structure Foundation Exploration Report - Draft
PAU-TR33-04.75 (Bridge over Flat Rock Creek)
PID No.: 113849; SFN: 6333389
Payne, Paulding County, Ohio
CTL Project No. 24050001WAP

Mr. Bockrath:

CTL Engineering, Inc. (CTL) has completed the draft structure foundation exploration report for the above referenced project. Enclosed is the report in portable document format (.pdf file).

As the design of the project progresses, and if the proposed bridge design is different from the assumptions made in this report, CTL should be provided this information for our review and our report finalized and/or amended, if necessary.

Thank you for the opportunity to be of service to you on this project. If you have any questions, please contact me at our office.

Respectfully Submitted,

CTL ENGINEERING, INC.

Frederick L. Schoen, P.E.
Geotechnical Project Manager

STRUCTURE FOUNDATION EXPLORATION REPORT - DRAFT

PAU-TR33-04.75 (BRIDGE OVER FLAT ROCK CREEK)
PID NO.: 113849; SFN: 6333389
PAYNE, PAULDING COUNTY, OHIO

CTL PROJECT NO. 24050001WAP

PREPARED FOR:

BOCKRATH & ASSOCIATES
115 S. FAIR AVE., SUITE A
OTTAWA, OH 45875

PREPARED BY:

CTL ENGINEERING, INC.
102 COMMERCE DRIVE
P.O. BOX 44
WAPAKONETA, OH 45895
www.ctleng.com

November 26, 2024

RECORD OF REVISIONS

Date of Transmittal	Description	Remarks
11/26/2024	Initial Submittal of Draft Report	--

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I. EXECUTIVE SUMMARY

The overall project, identified as PAU-TR33-04.75, consists of replacing an existing three-span bridge (SFN 6333389) with a new three-span bridge. The bridge will carry Township Road 33 over the Flat Rock Creek in Payne, Paulding County, Ohio. The existing bridge is a non-composite prestressed concrete box beam bridge supported on stone masonry abutments with reinforced concrete cap and column piers. The proposed bridge will be a prestressed composite concrete box beam bridge supported with integral abutments and piers on H-Piles.

Two (2) soil test borings, identified as B-001-0-24 and B-002-0-24, were completed for this subsurface exploration and were drilled within the existing roadway pavement. The test borings were drilled and sampled to depths ranging from 46.8 feet to 48.6 feet below the existing road surface. Both borings encountered asphalt underlain by gravel base at the ground surface.

Beneath the surficial materials, the test borings encountered both fine-grained, cohesive soils and coarse-grained, granular soils before encountering weathered bedrock. The fine-grained, cohesive soils encountered were described as stiff to hard sandy silt (A-4a) and clay (A-7-6). The coarse-grained, granular soils were described as very loose to very dense, gravel and/or stone fragments with sand (A-1-b), gravel and/or stone fragments with sand and silt (A-2-4), and coarse and fine sand (A-3a). Rock fragments and possible boulders were encountered within the encountered subsurface soils. Accordingly, the contractor should be prepared to encounter rock fragments and possible boulders during construction.

Dolomitic bedrock was encountered at depths of 38.0 feet to 35.5 feet below existing surface grades in B-001-0-24 and B-002-0-24, respectively. The bedrock was described as gray, severely to slightly weathered, moderately strong to strong, thin bedded, fine grained, vuggy, and crystalline. Groundwater was encountered in both test borings during drilling and at the completion of drilling at depths ranging from 4.6 feet to 12.0 feet.

Based upon the soil and rock data obtained from the field and laboratory testing the proposed bridge may be supported onto H-Piles (HP 10x42 and HP 12x53) piles driven to refusal into the underlying bedrock. Please refer to the *Analyses and Recommendations* section for additional information.

II. INTRODUCTION

The project involves the replacement of the existing Township Road 33 (PAU-TR33-04.75) bridge over the Flat Rock Creek in Payne, Paulding County, Ohio. The project site is located approximately 820 feet north of the intersection of Township Road 33 and Township Road 72.

Based on the DGL Engineers, LLC (DGL) drawing titled, "Site Plan Bridge No. PAU-TR-04.75 Over Flat Rock Creek" (undated), which was provided to CTL on September 12, 2024, it is understood that the existing three-span non-composite prestressed concrete box beam bridge will be replaced with a three-span prestressed composite concrete box beam bridge supported on integral abutments and piers. It is understood that the proposed bridge will be supported by steel H-Piles (HP 10x42 and HP 12x53) driven to refusal into the underlying bedrock.

The purpose of this geotechnical exploration is to determine the subsurface conditions at the bridge in conjunction with providing recommendations for the design of the bridge foundation. Bockrath & Associates (B&A) requested CTL perform the geotechnical exploration for the bridge replacement in accordance with the State of Ohio's Department of Transportation (ODOT) Specifications of Geotechnical Exploration (SGE), dated July 2024. CTL's initial services were performed in accordance with our proposal number 22050046WAP-PPL, dated May 9, 2022.

III. GEOLOGY AND OBSERVATIONS OF THE PROJECT

A. Geology

According to the Ohio Department of Natural Resources (ODNR) mapping, the project site is located within the Maumee Lake Plains physiographic region. This physiographic region is described as Pleistocene-age silt, clay, and wave-planed clayey till over Silurian- and Devonian-age carbonate rocks and shales.

Geologic mapping (Surficial Geology of the Ohio Portions of the Defiance 30 x 60 Minute Quadrangles, Ohio Division of Geological Survey, 2012) indicates that the overburden soils are mapped to consist of Holocene-age alluvium underlain by Wisconsinan-age glacial till. According to the mapping of bedrock geology in the area, (Reconnaissance bedrock geology of the Payne, Ohio Quadrangle, *Digital Map Series, BG-2, ODNR Geological Survey, 1994*), the surficial soil deposits on the site are underlain by Devonian-age sedimentary bedrock identified as the Dundee Limestone Formation. The Dundee Limestone Formation consists of olive gray to brown fossiliferous limestone and cherty dolomite that is thin to thick bedded.

According to the mapping of karst features (Known and Probable Karst in Ohio, *ODNR Geological Survey Map EG-1, 1999; Revised 2002, 2006*), there are no mapped karst features in the general vicinity of the project area. Additionally, karst features were not observed at the ground surface during our field exploration.

According to the mapping of historic and active mines (ODNR Mines of Ohio), there are no documented mines in the general vicinity of the project area.

B. Observations

The existing Township Road 33 Bridge (SFN 6333389) is a 2-lane, three-span bridge. It is located approximately 820 feet north of the intersection of Township Road 33 and Township Road 72. The existing bridge was constructed in 1980 and has a total length of approximately 132.0 feet with a width of approximately 24.0 feet.

A field reconnaissance was completed by CTL personnel on May 5, 2022, December 19, 2023, and January 11, 2024. Township Road 33 runs generally south to north, and the Flat Rock Creek generally flows west to east beneath Township Road 33. The topography in the surrounding area is relatively flat to gently sloping while the ground surface immediately adjacent to the creek slopes steeply downward in the immediate area of the bridge. The area along the roadway and creek is covered by vegetation consisting of weeds, brush, and trees with the surrounding land usage consists of woodland and a waterway (Flat Rock Creek).

At the bridge, the depth from the road surface to the creek flow line is approximately 10 feet. At the time of the site reconnaissance, the roadway asphalt pavement surface was observed to be in fair to poor condition; roadway pavement cracking was observed on both approaches of the existing bridge and at the abutments. Erosion at the existing bridge abutments was observed.

IV. EXPLORATION

A total of two (2) soil test borings (identified in *Table 1*) were drilled for this project. Each of the test borings were drilled within the existing roadway pavement near the existing abutments. A summary of approximate test boring locations, ground surface elevations and coordinates along with the depths of the two test borings are presented below in *Table 1*.

Table 1. Boring Locations, Depths, Elevations, and Coordinates

Boring No.	Station & Offset	Approximate Ground Surface Elevation (feet)	Approximate Latitude (N-Parallel)	Approximate Longitude (W-Meridian)	Borehole Depth (feet)
B-001-0-24	250+69.5, 0.1’ RT.	748.5	41.056554	84.746131	48.6
B-002-0-24	252+32.5, 10.4’ LT.	748.5	41.057015	84.746170	46.8

The locations of the test borings were determined in the field by CTL using measurements from existing site features. The test boring coordinates and ground surface elevations at the test boring locations were obtained from DGL drawing titled, “Site Plan Bridge No. PAU-TR-04.75 over Flat Rock Creek” (undated), which was provided to CTL on September 12, 2024.

The test borings were drilled by CTL between January 31, 2024 and February 2, 2024, utilizing 3-¼ inch inside diameter hollow-stem augers powered by a track-mounted rotary drill rig. Split-barrel (spoon) samples and Standard Penetration Tests (SPTs) were performed in the test borings using a 140-pound automatic hammer falling 30 inches to drive 2-inch O.D. split barrel samplers for 18 inches. The automatic hammer was calibrated at an energy ratio of 79.3 percent. Rock coring was performed in both structure test borings using wireline casing with an NQ2-size, double tube core barrel with a diamond bit.

The soil materials recovered from the split spoon samples were preserved in glass jars, visually classified in the field, and delivered to CTL's soil laboratory for secondary visual classification, testing and analysis. Samples were also tested for moisture content. Representative samples were subjected to laboratory testing including Atterberg Limits, grain size distribution, and hand penetrometer strength estimates. Rock core samples were subjected to Rock Quality Designation (RQD), rock recovery calculations, and compressive strength testing.

Drilling, sampling, field and laboratory testing were performed according to standard geotechnical engineering practices and current ASTM International and/or AASHTO procedures. Results from field and laboratory tests are shown on the Test Boring Records in *Appendix B* of this report. The results of the laboratory tests are presented in *Appendix C* of this report.

V. FINDINGS

A. Soil Stratigraphy

A general description of the soils encountered during our subsurface exploration is presented below. Further details of the subsurface conditions encountered during CTL's geotechnical exploration are presented in the Test Boring Records in *Appendix B*. Results of the laboratory tests are presented in *Appendix C*.

At the ground surface, the two (2) test borings drilled encountered four (4) inches of asphalt underlain by seven (7) to eight (8) inches of gravel base.

Beneath the surficial materials, the test borings encountered both fine-grained, cohesive soils and coarse-grained, granular soils before encountering weathered bedrock. The fine-grained cohesive soils were described as stiff to hard, brown, grayish brown, and gray sandy silt (A-4a) and clay (A-7-6). SPT N_{60}-values determined within the fine-grained soils ranged from 4 blows per foot (bpf) to 100 bpf with natural moisture content values ranging from 3 percent to 24 percent.

The coarse-grained soils encountered in the test borings were described as very loose to very dense, brown and gray gravel and/or stone fragments with sand (A-1-b), gravel and/or stone fragments with sand and silt (A-2-4), and coarse and fine sand (A-3a). SPT N_{60}-values determined within the coarse-grained soils ranged from 3 bpf to 103 bpf with natural moisture content values ranging from 7 percent to 27 percent.

Beneath the overburden soil materials, test borings B-001-0-24 and B-002-0-24 encountered weathered dolomitic bedrock. The drilling equipment and sampling were able to penetrate into the weathered rock before encountering auger refusal. The transition from the soil overburden to the underlying bedrock stratum is not always distinct and can be gradual depending on the degree of weathering of the rock.

Upon achieving auger refusal, borings B-001-0-24 and B-002-0-24 were rock cored an additional depth of 10.0 feet and 10.5 feet, respectively. The bedrock consisted of dolomite and was described as gray, severely to slightly weathered, moderately strong to strong, thin bedded, fine grained, vuggy, and crystalline. RQD values were determined and ranged from 36 to 89 percent with core loss values of 0 to 27 percent.

B. Results of Laboratory Tests

Selected soil samples were tested in the laboratory for Atterberg Limits and grain size distribution. The results of the soil laboratory tests are presented on the Test Boring Records in *Appendix A* and *Appendix B* and are summarized in *Table 2.*

Table 2. Soil Laboratory Test Results

Boring No.	Sample No.	Depth (feet)	ODOT	Atterberg Limits (%)		Grain-Size Distribution (%)			
				LL	PI	Gr (%)	Sa (%)	Silt (%)	Clay (%)
B-001-0-24	SS-3	6.0 – 7.5	A-7-6	45	20	1	17	40	42
B-001-0-24	SS-5	9.0 – 10.5	A-7-6	44	19	0	9	49	42
B-001-0-24	SS-6	10.5 – 12.0	A-7-6	46	23	0	16	42	42
B-001-0-24	SS-7	12.0 – 13.5	A-3a	Non-Plastic		5	71	13	11
B-001-0-24	SS-8	13.5 – 15.0	A-2-4	21	7	35	37	16	12
B-001-0-24	SS-13	26.0 – 27.5	A-1-b	Non-Plastic		31	57	7	5
B-001-0-24	SS-16	33.5 – 35.0	A-4a	20	7	28	29	24	19
B-002-0-24	SS-3	6.0 – 7.5	A-4a	24	7	1	57	22	20
B-002-0-24	SS-5	9.0 – 10.5	A-3a	Non-Plastic		0	78	11	11
B-002-0-24	SS-6	10.5 – 12.0	A-3a	Non-Plastic		0	80	9	11
B-002-0-24	SS-7	12.0 – 13.5	A-4a	22	8	4	29	43	24
B-002-0-24	SS-8	13.5 – 15.0	A-4a	20	7	10	37	33	20
B-002-0-24	SS-9	16.0 – 17.5	A-4a	20	7	4	27	43	26
B-002-0-24	SS-11	21.0 – 22.5	A-4a	20	8	10	28	37	25

NP = Non-Plastic
LL = Liquid Limit
PI = Plasticity Index

Silt Fraction (particle size < 0.075 mm
Clay Fraction (particle size < 0.005 mm)
Gr = Gravel; Sa = Sand

Samples of the rock cores from borings B-001-0-24 and B-002-0-24 were tested for uniaxial compressive strength utilizing ASTM D7012, Method C. It should be noted that each of the samples tested were comprised of dolomite. The test results are summarized in *Table 3* below.

Table 3. Summary of Rock Compressive Strength Tests

Boring No.	Sample No.	Sample Depth (feet)	Sample Description	Unit Weight (pcf)	Corrected Compressive Strength (psi)(1)
B-001-0-24	NQ2-1	40.9 – 41.5	Dolomite	163.7	6,690
B-001-0-24	NQ2-2	46.2 – 46.7	Dolomite	167.7	7,200
B-002-0-24	NQ2-1	37.8 – 38.1	Dolomite	166.0	5,980
B-002-0-24	NQ2-2	42.6 – 43.0	Dolomite	171.4	10,240

(1) Corrected Compressive Strength Testing conducted in accordance with ASTM D7012, Method C

C. Groundwater

Groundwater was encountered in both test borings during drilling and at the completion of drilling at depths ranging from 4.6 feet to 12.0 feet. It should be noted that the groundwater depths encountered during this subsurface exploration are generally not a reliable indication of long-term groundwater levels. Fluctuations in the level of the groundwater table (or saturated soils/perched water levels) will occur due to seasonal variances in rainfall, drainage, types of soils present and other factors. We caution that groundwater can be perched at various elevations above the general static groundwater level after periods of rainfall, especially in the lower elevations and natural drainage paths of the site.

VI. ANALYSES AND RECOMMENDATIONS

Based upon the preceding considerations as well as the subsurface information obtained from the field and laboratory testing and CTL's experience with these soil/rock types, our recommendations are presented in the following paragraphs.

A. Bridge Scour

Scour parameters were developed in general accordance with ODOT's Geotechnical Design Manual Section 1302. *Table 4* and *Table 5* summarizes the scour parameters.

Table 4. Summary of Scour Parameters – Rear Abutment

Boring No.	Sample No.	Elevation (feet)	Particle Grain Size, D_{50} (mm)	Critical Shear Stress, τ_c (psf)	Equivalent Grain Size, $D_{50,equiv}$ (mm)	Erosion Category (EC)
B-001-0-24	SS-3	742.5 - 741.0	0.0085	0.7934	37.9805	3.72
	SS-5	739.5 - 738.0	0.0076	0.5452	26.1010	3.67
	SS-6	738.0 - 736.5	0.0096	0.5164	24.7194	3.87
	SS-7	736.5 - 735.0	0.2545	0.0053	0.2545	1.49
	SS-8	735.0 - 733.5	0.6114	0.0128	0.6114	1.94
	SS-13	722.5 - 721.0	0.9340	0.0195	0.9340	2.16
	SS-16	715.0 - 713.5	0.1530	0.0996	4.7655	2.63

Table 5. Summary of Scour Parameters – Forward Abutment

Boring No.	Sample No.	Elevation (feet)	Particle Grain Size, D_{50} (mm)	Critical Shear Stress, τ_c (psf)	Equivalent Grain Size, $D_{50,equiv}$ (mm)	Erosion Category (EC)
B-002-0-24	SS-3	742.5 - 741.0	0.0994	0.0240	1.1501	2.63
	SS-5	739.5 - 738.0	0.1482	0.0029	0.1395	2.21
	SS-6	738.0 - 736.5	0.1350	0.0017	0.0837	2.21
	SS-7	736.5 - 735.0	0.0213	0.3802	18.1986	2.75
	SS-8	735.0 - 733.5	0.0558	0.2793	13.3706	2.63
	SS-9	732.5 - 731.0	0.0180	0.7072	33.8532	2.63
	SS-11	727.5 - 726.0	0.0250	1.1228	53.7481	2.75

B. Structure Foundation Support

It is understood that the proposed structure will be a three-span bridge supported on steel HP 10x42 piles (Abutments) and HP 12×53 piles (Piers) driven to refusal in the underlying bedrock.

Top of coreable bedrock was encountered at elevations 709.9 feet and 712.2 feet for B-001-0-24 (Rear Abutment) and B-002-0-24 (Forward Abutment), respectively.

Based on the soil and rock data obtained from the field and laboratory testing, it is CTL's opinion that the proposed bridge may be supported on H-Piles (HP 10x42 and HP 12×53) driven to refusal into the underlying bedrock. Recommendations for driven piles are provided in the following paragraphs.

Maximum factored structural resistance (P_r), estimated pile tip elevations, estimated pile lengths, and pile order length for the proposed structure is shown in *Table 6*. The estimated pile tip elevation at the abutments were estimated as the elevation where rock coring begins in the nearby test borings (B-001-0-24 and B-002-0-24).

The estimated pile tip elevation at the piers were interpolated from the two aforementioned test borings. The estimated pile length includes a 2-foot embedment into the pile cap at the abutments and 1.5-foot embedment into the pile cap at the piers.

Table 6. Recommended H-Pile Design Parameters

Structure Location / Boring No.	**Pile Type**	**Estimated Bottom of Pile Cap Elevation (feet)$^{(1)}$**	**Maximum Factored Structural Resistance (P_r), (kips)$^{(2)}$**	**Estimated Pile Tip Elevation (feet)**	**Estimated Pile Length (feet)$^{(3)}$**	**Order Length (feet)$^{(4)}$**
Rear Abutment B-001-0-24	HP 10x42	741.2	310	709.9	35.0	40.0
Pier 1$^{(5)}$	HP 12x53	744.7	380	710.7	40.0	45.0
Pier 2$^{(6)}$	HP 12x53	744.9	380	711.4	40.0	45.0
Forward Abutment B-002-0-24	HP 10x42	741.6	310	712.2	35.0	40.0

(1) Bottom of pile cap elevations are estimated from DGL Engineers, LLC drawing titled, "Site Plan Bridge No. PAU-TR-04.75 over Flat Rock Creek" (undated), which was provided to CTL on September 12, 2024.
(2) The P_r is based on ODOT Bridge Design Manual Section 305.3.3 and does include the resistance factor, $\phi_c = 0.50$
(3) Estimated Design Pile Length = Estimated Pile Length rounded up to the next 5-foot interval.
(4) Order Length = Estimated Design Pile Length plus 5 feet
(5) Subsurface Model utilizes test boring B-001-0-24 for soil parameters.
(6) Subsurface Model utilizes test boring B-002-0-24 for soil parameters.

A Resistance Factor (ϕ_c) of 0.5 should be used for the piles driven intro bedrock. Pile driving should follow ODOT Construction and Material Specifications Item 507 and 523. Stress applied to the pile from the pile-driving hammer should be monitored during driving so as not to damage the pile. A dynamic load test should be performed to verify that the Ultimate Bearing Value is achieved.

Additionally, please note that the P_r value provided in *Table 6* assumes the following conditions:

- Pile is axially loaded with negligible moment.
- Pile has no appreciable loss of section due to deterioration throughout the life of the structure.
- Pile has a steel yield strength of 50-ksi.
- Pile is fully braced along its length.

In accordance with ODOT BDM Section 305.3.5.6, protection of the pile tips are required during driving due to the presence of encountering rock fragments and potential boulders during the geotechnical exploration. Protection of the pile tips include adding steel points, conical points or cutting shoes.

Drivability Analysis

For point bearing piles on bedrock, select a hammer that is capable of reaching and penetrating bedrock for the specified pile type and size. Driving refusal is defined in ODOT BDM 305.3.1.2. Please refer to *Appendix D* for the wave equation analysis (WEAP) results for the drivability of the piles during construction. The WEAP analysis was performed using a standard Delmag D19-42 hammer rated with an energy of 43.2 kip-ft.

C. General Construction and Earthwork

1. Site preparation, earthwork and installation of structures should be performed in accordance with the ODOT Construction and Material Specifications, and applicable Geotechnical Design Manual.

2. Embankment side slopes should be seeded and vegetation growth permitted to limit sloughing and slope failure.

3. Temporary excavations more than 4.0 feet in depth should be sloped or shored in accordance with OSHA regulations.

VII. CHANGED CONDITIONS

The evaluations, conclusions, and recommendations in this report are based on our interpretation of the field and laboratory data obtained during the exploration, our understanding of the project and our experience with similar sites and subsurface conditions using generally accepted geotechnical engineering practices. Although individual test borings are representative of the subsurface conditions at the boring locations on the dates drilled, they are not necessarily representative of the subsurface conditions between boring locations or subsurface conditions during other seasons of the year.

In the event that changes in the project are proposed, additional information becomes available, or if it is apparent that subsurface conditions are different from those provided in this report, CTL should be notified so that our recommendations can be modified, if required.

VIII. TESTING AND OBSERVATION

During the design process, it is recommended that CTL work with the project designers to confirm that the geotechnical recommendations are properly incorporated into the final plans and specifications, and to assist with establishing criteria for the construction observation and testing.

IX. CLOSING

The report was prepared by CTL Engineering, Inc. (Consultant) solely for the use of Client in accordance with an executed contract. The Client's use of or reliance on this report is limited by the terms and conditions of the contract and by the qualifications and limitations stated in the report. It is also acknowledged that the Client's use of and reliance of this report is limited for reasons which include: actual site conditions that may change with time; hidden conditions, not discoverable within the scope of the assessment, may exist at the site; and the scope of the investigation may have been limited by time, budget and other constraints imposed by the Client.

Neither the report, nor its contents, conclusions or recommendations, are intended for the use of any party other than the Client. Consultant and the Client assume no liability for any reliance placed on this report by such party. The rights of the Client under contract may not be assigned to any person or entity, without the consent of the Consultant which consent shall not be unreasonably withheld. This geotechnical report does not address the environmental conditions of the site. The Consultant is not responsible for consequences or conditions arising from facts that were concealed, withheld, or not fully disclosed at the time the assessment was conducted.

To the fullest extent permitted by law, the Consultant and Client agree to indemnify and hold each other, and their officers and employees harmless from and against claims, damages, losses and expenses arising out of unknown or concealed conditions. Furthermore, neither the Consultant nor its employees shall be liable to the Owner in an amount in excess of the available professional liability insurance coverage of the Consultant. In addition, Client and Consultant agree neither shall be liable for any special, indirect or consequential damages of any kind or nature.

The Consultant's services have been provided consistent with its professional standard of care. No other warranties are made, either expressed or implied.

Thank you for the opportunity to be of service to you on this project. If you have any questions regarding our services, please contact our office.

Respectfully Submitted,
CTL ENGINEERING, INC.

Christopher D. Carey

Christopher D. Carey, E.I.
Geotechnical Engineer

Frederick L. Schoen, P.E.
Project Manager
Licensed Ohio E-66510

CTL
ENGINEERING INC.

APPENDIX A

GEOTECHNICAL PROFILE - BRIDGE

PROJECT DESCRIPTION

THE OVERALL PROJECT, IDENTIFIED AS PAU- TR33- 04.75, CONSISTS OF REPLACING AN EXISTING 132.0-FOOT THREE-SPAN BRIDGE (SFN 6333389) WITH A NEW THREE-SPAN BRIDGE. THE NEW BRIDGE CARRIES TOWNSHIP ROAD 33 OVER THE FLAT ROCK CREEK IN PAYNE, PAULDING COUNTY, OHIO. THE EXISTING BRIDGE IS A NON- COMPOSITE PRESTRESSED CONCRETE BOX BEAM SUPERSTRUCTURE SUPPORTED ON STONE MASONRY ABUTMENTS WITH REINFORCED CONCRETE CAP AND COLUMN PIERS. THE PROPOSED BRIDGE WILL BE A PRESTRESSED COMPOSITE CONCRETE BOX BEAM SUPERSTRUCTURE SUPPORTED ON INTEGRAL ABUTMENTS ON STEEL PILES (HP10X42) AND COLUMN PIERS (HP12X53 PIER PILES WITH ENCASEMENT).

HISTORIC RECORDS

HISTORIC GEOTECHNICAL RECORDS WERE SEARCHED FOR ON THE ODOT TIMS WEBSITE. NO HISTORIC RECORDS WERE FOUND FOR THIS PROJECT.

GEOLOGY

THE PROJECT SITE IS LOCATED WITHIN THE MAUMEE LAKE PLAINS PHYSIOGRAPHIC REGION. THE PROJECT SITE IS COVERED BY HOLOCENE- AGE ALLUVIUM UNDERLAIN BY WISCONSINAN-AGE GLACIAL TILL. THE UNDERLYING BEDROCK CONSISTS OF DEVONIAN-AGE SEDIMENTARY BEDROCK IDENTIFIED AS THE DUNDEE LIMESTONE FORMATION. NO KNOWN KARST OR UNDERGROUND MINE RELATED INCIDENTS EXIST AT THE PROJECT SITE.

RECONNAISSANCE

A FIELD RECONNAISSANCE WAS COMPLETED BY CTL PERSONNEL ON MAY 5, 2022, DECEMBER 19, 2023, AND JANUARY 11, 2024. TOWNSHIP ROAD 33 RUNS GENERALLY SOUTH TO NORTH, AND THE FLAT ROCK CREEK GENERALLY FLOWS WEST TO EAST BENEATH TOWNSHIP ROAD 33. THE TOPOGRAPHY IN THE SURROUNDING AREA IS RELATIVELY FLAT TO GENTLY SLOPING WHILE THE GROUND SURFACE IMMEDIATELY ADJACENT TO THE RIVER SLOPES STEEPLY DOWNWARD IN THE IMMEDIATE AREA OF THE BRIDGE. THE AREA ALONG THE ROADWAY AND CREEK IS COVERED BY VEGETATION CONSISTING OF WEEDS, BRUSH, AND TREES WITH THE SURROUNDING LAND USAGE CONSISTS OF WOODED AND A WATERWAY (FLAT ROCK CREEK).

AT THE BRIDGE, THE DEPTH FROM THE ROAD SURFACE TO THE RIVER FLOW LINE IS APPROXIMATELY 10 FEET. AT THE TIME OF THE SITE RECONNAISSANCE, THE ROADWAY ASPHALT PAVEMENT SURFACE WAS OBSERVED TO BE IN FAIR TO POOR CONDITION; ROADWAY PAVEMENT CRACKING WAS OBSERVED ON BOTH APPROACHES OF THE EXISTING BRIDGE AND AT THE ABUTMENTS. EROSION AT THE EXISTING BRIDGE ABUTMENTS WAS OBSERVED.

SUBSURFACE EXPLORATION

TWO (2) SOIL TEST BORINGS, IDENTIFIED AS B-001-0-24 AND B-002-0-24, WERE COMPLETED FOR THIS SUBSURFACE EXPLORATION AND WERE DRILLED WITHIN THE EXISTING ROADWAY PAVEMENT. THE TEST BORINGS WERE DRILLED AND SAMPLED TO DEPTHS RANGING FROM 46.8 FEET TO 48.6 FEET BELOW THE EXISTING GROUND SURFACE. THE TEST BORINGS WERE DRILLED BETWEEN JANUARY 31, 2024 AND FEBRUARY 2, 2024 UTILIZING 3- 1/4 INCH I.D. HOLLOW-STEM AUGERS POWERED BY A TRACK-MOUNTED ROTARY DRILL RIG. SPLIT-BARREL (SPOON) DISTURBED SOIL SAMPLES AND STANDARD PENETRATION TEST WERE PERFORMED IN ACCORDANCE WITH AASHTO T206 AT 1.5- AND 2.5- FOOT INTERVALS. THE AUTOMATIC HAMMER WAS CALIBRATED ON NOVEMBER 4, 2022 AND HAD AN ENERGY RATIO OF 79.3 PERCENT. ROCK CORING WAS PERFORMED IN BOTH TEST BORINGS USING WIRELINE CASING WITH AN NQ2-SIZE, DOUBLE TUBE CORE BARREL WITH A DIAMOND BIT.

EXPLORATION FINDINGS

AT THE GROUND SURFACE, THE TWO (2) TEST BORINGS ENCOUNTERED FOUR (4) INCHES OF ASPHALT UNDERLAIN BY SEVEN (7) TO EIGHT (8) INCHES OF GRAVEL BASE. BENEATH THE SURFICIAL MATERIALS, THE TEST BORINGS ENCOUNTERED BOTH FINE-GRAINED, COHESIVE SOILS AND COARSE- GRAINED, GRANULAR SOILS BEFORE ENCOUNTERING WEATHERED BEDROCK. THE FINE- GRAINED, COHESIVE SOILS WERE DESCRIBED AS STIFF TO HARD SANDY SILT (A- 4a) AND CLAY (A- 7- 6). THE COARSE- GRAINED, GRANULAR SOILS WERE DESCRIBED AS VERY LOOSE TO VERY DENSE GRAVEL AND/OR STONE FRAGMENTS WITH SAND (A-1-b), GRAVEL AND/OR STONE FRAGMENTS WITH SAND AND SILT (A-2-4), AND COARSE AND FINE SAND (A-3a). IT SHOULD BE NOTED THAT ROCK FRAGMENTS WERE ENCOUNTERED AT VARIOUS DEPTHS IN THESE AFOREMENTIONED NATIVE SOIL MATERIAL.

BELOW THE NATIVE SOIL MATERIAL, THE TEST BORINGS ENCOUNTERED WEATHERED BEDROCK. THE BEDROCK WAS DESCRIBED AS GRAY, SEVERELY TO SLIGHTLY WEATHERED DOLOMITE. GROUNDWATER WAS ENCOUNTERED DURING DRILLING AND AT THE COMPLETION OF DRILLING AT DEPTHS RANGING FROM 4.6 FEET TO 12.0 FEET.

SPECIFICATIONS

THIS GEOTECHNICAL EXPLORATION WAS PERFORMED IN ACCORDANCE WITH THE STATE OF OHIO, DEPARTMENT OF TRANSPORTATION, OFFICE OF GEOTECHNICAL ENGINEERING, SPECIFICATIONS FOR GEOTECHNICAL EXPLORATIONS, DATED JULY 2024.

LEGEND

	DESCRIPTION	ODOT CLASS	CLASSIFIED MECH.	CLASSIFIED VISUAL
▨	GRAVEL AND/OR STONE FRAGMENTS WITH SAND	A-1-b (0)	1	0
▨	GRAVEL AND/OR STONE FRAGMENTS W/SAND AND SILT	A-2-4 (0)	1	1
▨	COARSE AND FINE SAND	A-3a (0)	3	2
▥	SANDY SILT	A-4a (4)	6	14
▦	CLAY	A-7-6 (13)	3	2
		TOTAL	14	19
▤	DOLOMITE	VISUAL		
▨	PAVEMENT OR BASE = X = APPROXIMATE THICKNESS	VISUAL		

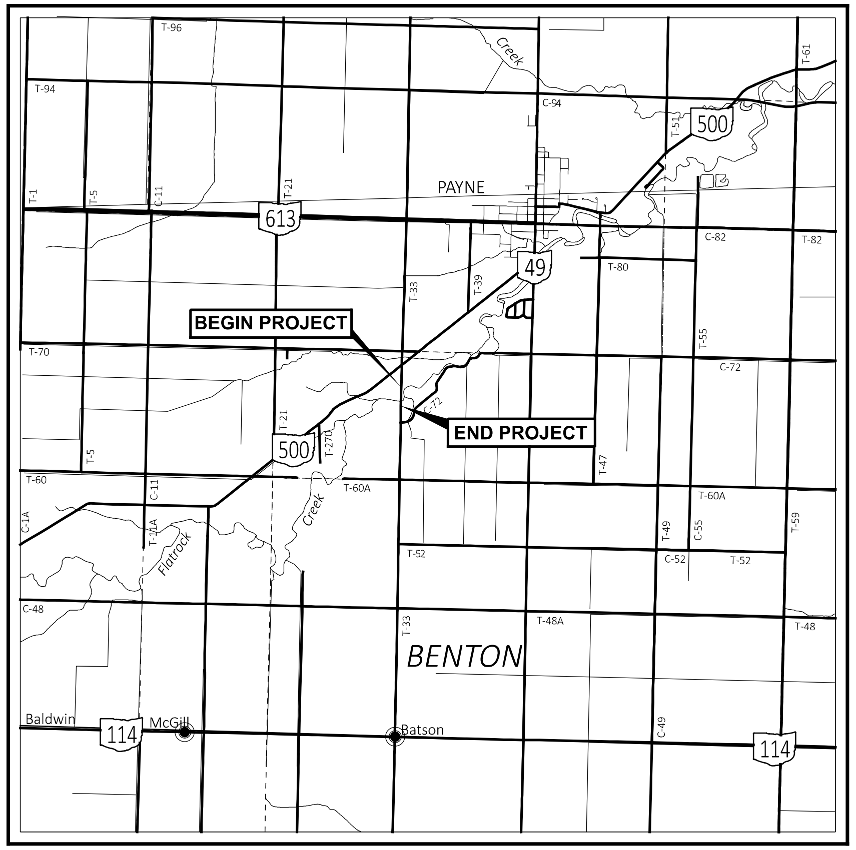
⊕	BORING LOCATION - PLAN VIEW
┼	DRIVE SAMPLE AND/OR TEST BORING PLOTTED TO VERTICAL SCALE ONLY. HORIZONTAL BAR INDICATES A CHANGE IN STRATIGRAPHY.
WC	INDICATES WATER CONTENT IN PERCENT.
N_{60}	INDICATES STANDARD PENETRATION RESISTANCE NORMALIZED TO 60% DRILL ROD ENERGY RATIO.
W—	INDICATES WATER AT COMPLETION.
▼	INDICATES FREE WATER ELEVATION.
TR	INDICATES TOP OF ROCK.
SS	INDICATES A SPLIT-SPOON SAMPLE.
NP	INDICATES A NON-PLASTIC SAMPLE.
NQ2	INDICATES ROCK CORE SAMPLE
X/Y/Z/D"	NUMBER OF BLOWS FOR STANDARD PENETRATION TEST (SPT): X = NUMBER OF BLOWS FOR 6 INCHES (UNCORRECTED). Y = NUMBER OF BLOWS FOR SECOND 6 INCHES (UNCORRECTED). Z/D" = NUMBER OF BLOWS (UNCORRECTED) FOR D" OF PENETRATION AT REFUSAL.
Qu	INDICATES UNCONFINED COMPRESSION TEST, ASTM D7012.
RQD	INDICATES ROCK QUALITY DESIGNATION.
Tc	INDICATES CRITICAL SHEAR STRESS.
D_{50}	INDICATES AVERAGE PARTICLE SIZE OF SOIL.
●	INDICATES A PLASTIC MATERIAL WITH A MOISTURE CONTENT EQUAL TO OR GREATER THAN THE LIQUID LIMIT MINUS 3
⊖	INDICATES A NON-PLASTIC MATERIAL WITH A MOISTURE CONTENT GREATER THAN 25% OR GREATER THAN 19% WITH A WET APPEARANCE.

AVAILABLE INFORMATION

THE SOIL AND GROUNDWATER INFORMATION COLLECTED FOR THIS SUBSURFACE EXPLORATION THAT CAN BE CONVENIENTLY DISPLAYED ON THE GEOTECHNICAL PROFILE SHEETS HAS BEEN PRESENTED. GEOTECHNICAL REPORTS, IF PREPARED, ARE AVAILABLE FOR REVIEW ON THE OFFICE OF CONTRACT SALES WEBSITE.

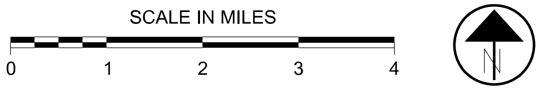
BEDROCK TEST SUMMARY

BORING ID	SAMPLE ELEVATION (FEET)	SAMPLE DEPTH (FEET)	UNIT WEIGHT (PCF)	Qu (PSI)	LITHOLOGY
B-001-0-24	707.6 - 707.0	40.9 - 41.5	163.7	6,690	DOLOMITE
	702.3 - 701.8	46.2 - 46.7	167.7	7,200	DOLOMITE
B-002-0-24	710.7 - 710.4	37.8 - 38.1	166.0	5,980	DOLOMITE
	705.9 - 705.5	42.6 - 43.0	171.4	10,240	DOLOMITE



LOCATION MAP

SCALE IN MILES



PARTICLE SIZE DEFINITIONS

BOULDERS	12"	COBBLES	3"	GRAVEL	2.0 mm	COARSE SAND	0.42 mm	FINE SAND	0.074 mm	SILT	0.005 mm	CLAY
					No. 10 SIEVE		No. 40 SIEVE		No. 200 SIEVE			

RECON. - **FS 05/05/2022, 12/19/2023, 01/11/2024**
DRILLING - **CTL 01/31/2024, 02/01/2024, 02/02/2024**
DRAWN - **N.K.S 03/06/2025**
REVIEWED - **FS 03/06/2025**

GEOTECHNICAL PROFILE - BRIDGE

DESIGN AGENCY
CTL ENGINEERING INC.
102 COMMERCE DRIVE
P.O. BOX 44
WAPAKONETA, OHIO 45895
PHONE: 419-738-1447

DESIGNER
N.K.S
REVIEWER
FS 03-06-25
PROJECT ID
113849
SUBSET 1 TOTAL 6
SHEET P. TOTAL -

PIU-TR33-04.75

MODEL: Sheet PAPERSIZE: 17x11 (in.) DATE: 06-03-2025 TIME: 16:10:37 USER: hp
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BRIDGE SCOUR ANALYSIS

BORING NUMBER	SAMPLE NO.	ELEVATION (FEET)	D_{50} (mm)	T_C (PSF)	D_{50} equi. (mm)	EROSION CATEGORY (EC)
B-001-0-24 (REAR ABUTMENT)	SS-3	742.5 - 741.0	0.0085	0.7934	37.9805	3.72
	SS-5	739.5 - 738.0	0.0076	0.5452	26.1010	3.67
	SS-6	738.0 - 736.5	0.0096	0.5164	24.7194	3.87
	SS-7	736.5 - 735.0	0.2545	0.0053	0.2545	1.49
	SS-8	735.0 - 733.5	0.6114	0.0128	0.6114	1.94
	SS-13	722.5 - 721.0	0.9340	0.0195	0.9340	2.16
	SS-16	715.0 - 713.5	0.1530	0.0996	4.7655	2.63
B-002-0-24 (FORWARD ABUTMENT)	SS-3	742.5 -741.0	0.0994	0.0240	1.1501	2.63
	SS-5	739.5 - 738.0	0.1482	0.0029	0.1395	2.21
	SS-6	738.0 - 736.5	0.1350	0.0017	0.0837	2.21
	SS-7	736.5 - 735.0	0.0213	0.3802	18.1986	2.75
	SS-8	735.0 - 733.5	0.0558	0.2793	13.3706	2.63
	SS-9	732.5 - 731.0	0.0180	0.7072	33.8532	2.63
	SS-11	727.5 - 726.0	0.0250	1.1228	53.7481	2.75

GEOTECHNICAL PROFILE - BRIDGE

DESIGN AGENCY

CTL ENGINEERING INC.
102 COMMERCE DRIVE
P.O. BOX 44
WAPAKONETA, OHIO 45895
PHONE: 419-738-1447

DESIGNER
N.K.S

REVIEWER
FS 03-06-25

PROJECT ID
113849

SUBSET 2 TOTAL 6

SHEET P. TOTAL -

PAU-TR 33-04.75

MODEL: CLX_TR33 - 113849_SP001 PAPERSIZE: 17x11 (in.) DATE: 06-03-2025 TIME: 16:14:08 USER: hp
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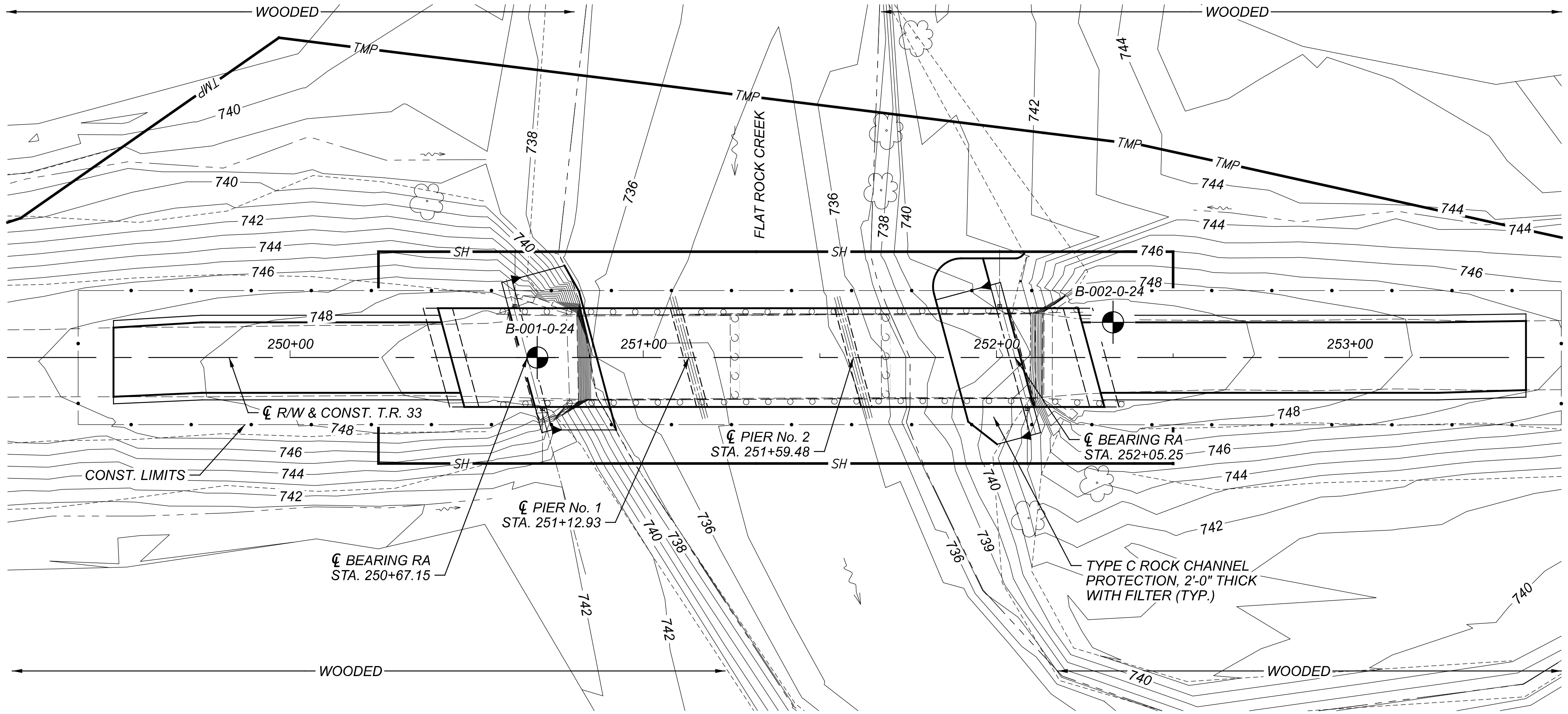

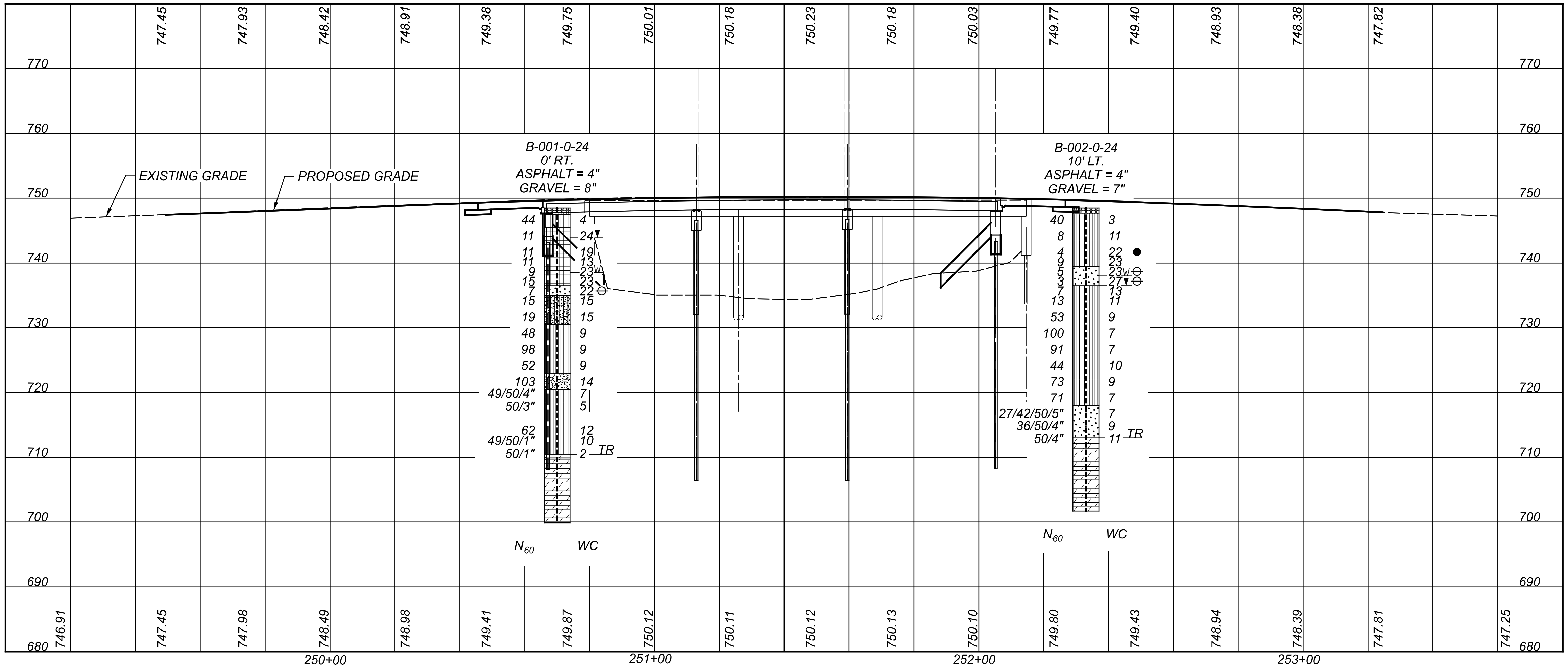

HORIZONTAL
SCALE IN FEET
0 10 20 40

GEOTECHNICAL PROFILE - BRIDGE
BRIDGE NO. PAU-TR33-04.75
OVER FLAT ROCK CREEK

DESIGN AGENCY

CTL ENGINEERING INC.
102 COMMERCE DRIVE
P.O. BOX 44
WAPAKONETA, OHIO 45895
PHONE: 419-738-1447

DESIGNER
N.K.S

REVIEWER
FS 03-06-25

PROJECT ID
113849

SUBSET	TOTAL
3	6

SHEET	TOTAL
P.	-

PAU-TR33-04.75

MODEL: Sheet PAPERSIZE: 17x11 (in.) DATE: 06-03-2025 TIME: 16:15:27 USER: hp
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PROJECT: PAU-TR33-04.75
TYPE: BRIDGE
PID: 113849 SFN: 6333389
START: 1/31/24 END: 2/2/24

DRILLING FIRM / OPERATOR: CTL / T. MILLER
SAMPLING FIRM / LOGGER: CTL / M. HUGHES
DRILLING METHOD: 3.25" HSA / NQ2
SAMPLING METHOD: SPT / NQ2

DRILL RIG: CME 55 TRACK RIG
HAMMER: AUTOMATIC HAMMER
CALIBRATION DATE: 11/4/22
ENERGY RATIO (%): 79.3

STATION / OFFSET: 250+70, 0' RT.
ALIGNMENT: TR 33
ELEVATION: 748.5 (MSL) EOB: 48.6 ft.
LAT / LONG: 41.056554, -84.746131

EXPLORATION ID B-001-0-24
PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 748.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
ASPHALT (4")	748.2																	
GRAVEL (8")	747.5																	
HARD, BROWN, **SANDY SILT**, LITTLE GRAVEL, TRACE CLAY, DRY	745.5		5 18 15	44	100	SS-1	-	-	-	-	-	-	-	-	-	4	A-4a (V)	
VERY STIFF, BROWN, **CLAY**, "AND" SILT, LITTLE SAND, TRACE GRAVEL, CONTAINS ROCK FRAGMENTS, DAMP		▼	7 4 4	11	100	SS-2	2.50	-	-	-	-	-	-	-	-	24	A-7-6 (V)	
			4 4 4	11	100	SS-3	3.50	1	3	14	40	42	45	25	20	19	A-7-6 (13)	
			3 3 5	11	11	SS-4	-	-	-	-	-	-	-	-	-	13	A-7-6 (V)	
@9.0'; GRAYISH BROWN, TRACE SAND		W 738.5	2 3 4	9	100	SS-5	2.50	0	1	8	49	42	44	25	19	23	A-7-6 (12)	
@10.5'; STIFF, BROWN AND GRAY, LITTLE SAND, MOIST	736.5		4 6 5	15	78	SS-6	1.75	0	0	16	42	42	46	23	23	23	A-7-6 (14)	
LOOSE, BROWN AND GRAY, **COARSE AND FINE SAND**, LITTLE SILT, LITTLE CLAY, TRACE GRAVEL, WET	735.0		0 2 3	7	100	SS-7	-	5	34	37	13	11	NP	NP	NP	22	A-3a (0)	
MEDIUM DENSE, BROWN AND GRAY, **GRAVEL AND/OR STONE FRAGMENTS WITH SAND AND SILT**, LITTLE CLAY, MOIST			2 6 5	15	67	SS-8	-	35	19	18	16	12	21	14	7	15	A-2-4 (0)	
	730.5		2 6 8	19	100	SS-9	-	-	-	-	-	-	-	-	-	15	A-2-4 (V)	
HARD, GRAY, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL, CONTAINS ROCK FRAGMENTS, DAMP			12 17 19	48	-	SS-10	4.50	-	-	-	-	-	-	-	-	9	A-4a (V)	
			14 27 47	98	100	SS-11	4.50	-	-	-	-	-	-	-	-	9	A-4a (V)	
	723.0		16 19 20	52	100	SS-12	4.50	-	-	-	-	-	-	-	-	9	A-4a (V)	
VERY DENSE, GRAY, **GRAVEL AND/OR STONE FRAGMENTS WITH SAND**, TRACE SILT, TRACE CLAY, CONTAINS ROCK FRAGMENTS, WET	720.5		14 29 49	103	100	SS-13	-	31	39	18	7	5	NP	NP	NP	14	A-1-b (0)	
HARD, GRAY, **SANDY SILT**, SOME GRAVEL, LITTLE CLAY, CONTAINS ROCK FRAGMENTS, DAMP			49 50/4"	-	100	SS-14	4.50	-	-	-	-	-	-	-	-	7	A-4a (V)	
			50/3"	-	100	SS-15	-	-	-	-	-	-	-	-	-	5	A-4a (V)	
			7 18 29	62	100	SS-16	1.50	28	12	17	24	19	20	13	7	12	A-4a (2)	
	710.5	TR	49 50/1"	-	100	SS-17	-	-	-	-	-	-	-	-	-	10	A-4a (V)	
DOLOMITE, GRAY, SEVERLY WEATHERED, MODERATELY STRONG.	709.9		50/1"	-	100	SS-18	-	-	-	-	-	-	-	-	-	2	Rock (V)	
DOLOMITE, GRAY, MODERATELY TO SLIGHTLY WEATHERED, MODERATELY STRONG, FINE GRAINED, THIN BEDDED, VUGGY, CRYSTALLINE; RQD 81.75%, REC 96.67%. @ 40.9' - 41.5'; γ = 163.7 pcf, **Qu** = 6,690 psi			55		93	NQ2-1											CORE	
@ 46.2' - 46.7'; γ = 167.7 pcf, **Qu** = 7,200 psi	699.9	EOB	89		100	NQ2-2											CORE	

STANDARD ODOT SOIL BORING LOG (11 X 17) - OH DOT.GDT - 11/20/24 09:10 - O:\PROJECT\2024\WAP-05\24050001WAP_BOCKRATH AND ASSOCIATES ENGINEERING AND SURVEYING LLC_PAU-TR33-4-75 BRIDGE OVER FLAT ROCK CREEK- PID 113849\REPORTS\DRAFTING\TO SACHINA 2024.11.20\24050001WAP.GPJ

NOTES: CAVED AT 24.0'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS MIXED WITH CEMENT

DESIGN AGENCY
CTL ENGINEERING INC.
102 COMMERCE DRIVE
P.O. BOX 44
WAPAKONETA, OHIO 45895
PHONE: 419-738-1447

DESIGNER N.K.S
REVIEWER FS 03-06-25
PROJECT ID 113849
SUBSET 4 TOTAL 6
SHEET P. TOTAL -

GEOTECHNICAL PROFILE - BRIDGE
BORING LOG B-001-0-24

PROJECT: PAU-TR33-04.75
TYPE: BRIDGE
PID: 113849 SFN: 6333389
START: 2/1/24 END: 2/1/24

DRILLING FIRM / OPERATOR: CTL / T. MILLER
SAMPLING FIRM / LOGGER: CTL / M. HUGHES
DRILLING METHOD: 3.25" HSA / NQ2
SAMPLING METHOD: SPT / NQ2

DRILL RIG: CME 55 TRACK RIG
HAMMER: AUTOMATIC HAMMER
CALIBRATION DATE: 11/4/22
ENERGY RATIO (%): 79.3

STATION / OFFSET: 252+33, 10' LT.
ALIGNMENT: TR 33
ELEVATION: 748.5 (MSL) EOB: 46.8 ft.
LAT / LONG: 41.057015, -84.746170

EXPLORATION ID B-002-0-24
PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV.
	748.5
ASPHALT (4")	748.2
GRAVEL (7")	747.6
HARD, BROWN AND GRAY, **SANDY SILT**, LITTLE GRAVEL, TRACE CLAY, DRY @3.0'; STIFF, BROWN, LITTLE CLAY, TRACE GRAVEL, DAMP @6.0'; MOIST	739.5
LOOSE, BROWN, **COARSE AND FINE SAND**, LITTLE SILT, LITTLE CLAY, WET @10.5'; VERY LOOSE, TRACE SILT	736.5
HARD, BROWN AND GRAY, **SANDY SILT**, SOME CLAY, TRACE GRAVEL, CONTAINS ROCK FRAGMENTS, DAMP @13.5'; LITTLE CLAY @16.0'; GRAY, SOME CLAY	718.0
VERY DENSE, GRAY, **COARSE AND FINE SAND**, TRACE GRAVEL, TRACE SILT, TRACE CLAY, DAMP	713.0
DOLOMITE, GRAY, SEVERELY WEATHERED, MODERATELY STRONG.	712.2
DOLOMITE, GRAY, MODERATELY TO SLIGHTLY WEATHERED, MODERATELY STRONG TO STRONG, FINE GRAINED, THIN BEDDED, VUGGY, CRYSTALLINE; RQD 51.49%, REC 85.52%. @ 37.8' - 38.1'; **γ** = 166.0 pcf, **Qu** = 5,980 psi @ 42.6' - 43.0'; **γ** = 171.4 pcf, **Qu** = 10,240 psi	701.7

DEPTHS: W 738.0 ▼ TR EOB

SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
10 14 16	40	100	SS-1	-	-	-	-	-	-	-	-	-	3	A-4a (V)	
3 3 3	8	100	SS-2	1.50	-	-	-	-	-	-	-	-	11	A-4a (V)	
2 1 2	4	100	SS-3	1.00	1	7	50	22	20	24	17	7	22	A-4a (1)	
2 3 4	9	100	SS-4	-	-	-	-	-	-	-	-	-	23	A-4a (V)	
2 2 2	5	100	SS-5	-	0	7	71	11	11	NP	NP	NP	23	A-3a (0)	
0 0 2	3	100	SS-6	-	0	17	63	9	11	NP	NP	NP	27	A-3a (0)	
1 3 2	7	100	SS-7	4.50	4	9	20	43	24	22	14	8	13	A-4a (6)	
0 0 10	13	100	SS-8	4.50	10	13	24	33	20	20	13	7	11	A-4a (4)	
4 15 25	53	100	SS-9	4.50	4	9	18	43	26	20	13	7	9	A-4a (7)	
24 31 45	100	100	SS-10	-	-	-	-	-	-	-	-	-	7	A-4a (V)	
20 29 40	91	100	SS-11	4.50	10	10	18	37	25	20	12	8	7	A-4a (5)	
13 17 16	44	100	SS-12	4.50	-	-	-	-	-	-	-	-	10	A-4a (V)	
21 31 24	73	100	SS-13	4.50	-	-	-	-	-	-	-	-	9	A-4a (V)	
15 19 35	71	100	SS-14	4.50	-	-	-	-	-	-	-	-	7	A-4a (V)	
27 42 50/5"	-	100	SS-15	-	-	-	-	-	-	-	-	-	7	A-3a (V)	
36 50/4"	-	100	SS-16	-	-	-	-	-	-	-	-	-	9	A-3a (V)	
50/4"	-	100	SS-17	-	-	-	-	-	-	-	-	-	11	Rock (V)	
36		73	NQ2-1											CORE	
60		87	NQ2-2											CORE	
52		98	NQ2-3											CORE	

NOTES: CAVED AT 21.0'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS MIXED WITH CEMENT

STANDARD ODOT SOIL BORING LOG (11 X 17) - OH DOT.GDT - 11/20/24 09:10 - O:\PROJECT\2024\WAP-05\24050001WAP_BOCKRATH AND ASSOCIATES ENGINEERING AND SURVEYING LLC_PAU-TR33-4-75 BRIDGE OVER FLAT ROCK CREEK- PID 113849\REPORTS\DRAFTING\TO SACHINA 2024.11.20\24050001WAP.GPJ

DESIGN AGENCY
CTL ENGINEERING INC.
102 COMMERCE DRIVE
P.O. BOX 44
WAPAKONETA, OHIO 45895
PHONE: 419-738-1447

DESIGNER N.K.S
REVIEWER FS 03-06-25
PROJECT ID 113849
SUBSET 5 TOTAL 6
SHEET P. TOTAL -

GEOTECHNICAL PROFILE - BRIDGE
BORING LOG B-002-0-24

CTL ENGINEERING, INC.
102 COMMERCE DR. P.O. BOX 44
WAPAKONETA, OHIO 45895
PHONE: (419) 738-1447
FAX: (419) 738-7670

ROCK CORE PHOTOGRAPHS

BR = Beginning of Run
ER = End of Run

B-001-0-24

RUN #	DEPTH (FT.)	RECOVERY		RQD	
NQ2-1	38.6 to 43.6	56"/60"	93%	33"/60"	55%
NQ2-2	43.6 to 48.6	60"/60"	100%	53"/60"	89%

PAU-TR33-04.75; PID No. 113849 (Bridge over Flat Rock Creek)

CTL ENGINEERING, INC.
102 COMMERCE DR. P.O. BOX 44
WAPAKONETA, OHIO 45895
PHONE: (419) 738-1447
FAX: (419) 738-7670

ROCK CORE PHOTOGRAPHS

BR = Beginning of Run
ER = End of Run

B-002-0-24

RUN #	DEPTH (FT.)	RECOVERY		RQD	
NQ2-1	36.3 to 39.3	26"/36"	73%	13"/36"	36%
NQ2-2	39.3 to 44.3	52"/60"	87%	36"/60"	60%
NQ2-3	44.3 to 46.8	29"/30"	98%	16"/30"	52%

PAU-TR33-04.75; PID No. 113849 (Bridge over Flat Rock Creek)

GEOTECHNICAL PROFILE - BRIDGE
ROCK CORE PHOTOS FOR B-001-0-24 & B-002-0-24

DESIGN AGENCY
CTL ENGINEERING INC.
102 COMMERCE DRIVE
P.O. BOX 44
WAPAKONETA, OHIO 45895
PHONE: 419-738-1447

DESIGNER
N.K.S
REVIEWER
FS 03-06-25
PROJECT ID
113849
SUBSET 6 TOTAL 6
SHEET P. TOTAL -

APPENDIX B

TEST BORING RECORDS

CTL ENGINEERING, INC.
102 COMMERCE DRIVE, P.O. BOX 44
WAPAKONETA, OH 45895

KEY TO SYMBOLS

PROJECT PAU-TR33-04.75
PID 113849
CTL PROJECT NUMBER 24050001WAP
PROJECT TYPE STRUCTURE FOUNDATION

LITHOLOGIC SYMBOLS (Unified Soil Classification System)

▨ A-1-B: Ohio DOT: A-1-b, gravel and/or stone fragments with sand

▨ A-2-4: Ohio DOT: A-2-4, gravel and/or stone fragments with sand and silt

▨ A-3A: Ohio DOT: A-3a, coarse and fine sand

▥ A-4A: Ohio DOT: A-4a, sandy silt

▦ A-7-6: Ohio DOT: A-7-6, clay

▤ DOLOMITE: Ohio DOT: Dolomite

▩ PAVEMENT OR BASE: Ohio DOT: Pavement or Aggregate base

SAMPLER SYMBOLS

WELL CONSTRUCTION SYMBOLS

▨ Soil Cuttings Backfill mixed with Bentonite Pellets or Chips

▩ Asphalt or Concrete Pavement Patch

ABBREVIATIONS

LL	- LIQUID LIMIT (%)
PI	- PLASTIC INDEX (%)
W	- MOISTURE CONTENT (%)
DD	- DRY DENSITY (PCF)
NP	- NON PLASTIC
-200	- PERCENT PASSING NO. 200 SIEVE
PP	- POCKET PENETROMETER (TSF)
TV	- TORVANE
PID	- PHOTOIONIZATION DETECTOR
UC	- UNCONFINED COMPRESSION
ppm	- PARTS PER MILLION
▽	Water Level at Time Drilling, or as Shown
▼	Water Level at End of Drilling, or as Shown
▼	Water Level After 24 Hours, or as Shown

EXPLANATION OF TERMS AND SOIL DESCRIPTIONS
(ODOT Specifications of Geotechnical Explorations)

CONSISTENCY AND RELATIVE DENSITY DESCRIPTIONS

Descriptors for soil consistency used in this report are based upon the Standard Penetration Test (SPT), ASTM D 1587, with the penetration (N) values corrected to N_{60}, based upon the efficiency of the SPT Hammer (Energy Ratio) used for the soil sampling.

NON-COHESIVE SOILS

Consistency	SPT-N_{60} (bpf)
Very Loose	< 5
Loose	5 – 10
Medium Dense	11 – 30
Dense	31 - 50
Very Dense	> 50

COHESIVE SOILS

Consistency	SPT-N_{60} (bpf)	Qu (tsf)
Very Soft	< 2	< 0.25
Soft	2 – 4	0.25 – 0.5
Medium Stiff	5 – 8	0.5 – 1.0
Stiff	9 – 15	1.0 – 2.0
Very Stiff	16 – 30	2.0 – 4.0
Hard	> 30	> 4.0

COMPONENT MODIFIERS

SOIL MODIFIERS

Modifier	% by Weight
Trace	0 – 10
Little	10 – 20
Some	20 – 35
"And"	35 – 50

ORGANIC CONTENT

Modifier	% by Weight
Organic	$LL_{oven}/LL_{air} < 0.75$
Slightly	2 – 4
Moderately	4 – 10
Highly	> 10

MOISTURE DESCRIPTIONS

Terms	Non-Cohesive Soils	Cohesive Soils
Dry	Moisture Absent	Powdery
Damp	Some Moisture	Below Plastic Limit
Moist	Damp to the Touch	Between Plastic and Liquid Limits
Wet	Visible Water	Above Liquid Limit

PARTICLE SIZE DESCRIPTIONS

Component	AASHTO Particle Size
Boulders	≥ 12-in. (300 mm)
Cobbles	< 12-in. (300 mm) to 3-in. (75 mm)
Coarse Gravel	< 3-in. (75 mm) to ¾-in. (19 mm)
Fine Gravel	< ¾-in. (19 mm) to #10 Sieve (2.0 mm)
Coarse Sand	< #10 Sieve (2.0 mm) to #40 Sieve (0.42 mm)
Fine Sand	< #40 Sieve (0.42 mm) to #200 Sieve (0.074 mm)
Silt	< #200 Sieve (0.074 mm) to 0.005 mm
Clay	< 0.005 mm

Quick Reference Guide for Rock Description

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

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

3: WEATHERING

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

4: TEXTURE

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

5: RELATIVE STRENGTH

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

6: BEDDING

Description	Thickness
Very Thick	>36”
Thick	18” – 36”
Medium	10” – 18”
Thin	2” – 10”
Very Thin	0.4” – 2”
Laminated	0.1” – 0.4”
Thinly Laminated	<0.1”

7: DESCRIPTORS

Arenaceous – sandy
Calcareous - contains calcium carbonate
Conglomeritic - contains rounded to subrounded gravel
Ferriferous – contains iron
Friable – easily broken down
Siliceous – contains silica

Argillaceous - clayey
Carbonaceous - contains carbon
Crystalline – contains crystalline structure
Fissile – thin planner partings
Micaceous – contains mica
Stylolitic – contain stylotites (suture like structure)

Brecciated – contains angular to subangular gravel
Cherty- contains chert fragments
Dolomitic- contains calcium/magnesium carbonate
Fossiliferous – contains fossils
Pyritic – contains pyrite
Vuggy – contains openings

Quick Reference Guide for Rock Description

8: DISCONTINUITIES

a: Discontinuity Types

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

b: Degree of Fracturing

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

c: Aperture Width

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

d: Surface Roughness

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

11: RECOVERY

$$Run\ \mathrm{Recovery} = \left(\frac{R_R}{L_R}\right) * 100$$

L_R = Run Length
R_R – Run Recovery

$$Unit\ \mathrm{Recovery} = \left(\frac{R_U}{L_U}\right) * 100$$

L_U = Rock Unit Length
R_U – Rock Unit Recovery

9: GSI DESCRIPTION

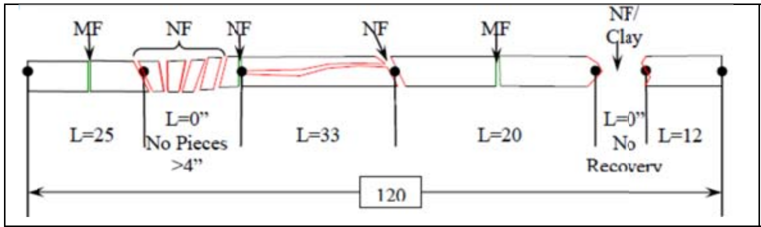
a: Structure

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

b: Surface Condition

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

10: RQD



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

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

PROJECT: PAU-TR33-04.75
TYPE: BRIDGE
PID: 113849 SFN: 6333389
START: 1/31/24 END: 2/2/24

DRILLING FIRM / OPERATOR: CTL / T. MILLER
SAMPLING FIRM / LOGGER: CTL / M. HUGHES
DRILLING METHOD: 3.25" HSA / NQ2
SAMPLING METHOD: SPT / NQ2

DRILL RIG: CME 55 TRACK RIG
HAMMER: AUTOMATIC HAMMER
CALIBRATION DATE: 11/4/22
ENERGY RATIO (%): 79.3

STATION / OFFSET: 250+70, 0' RT.
ALIGNMENT: TR 33
ELEVATION: 748.5 (MSL) EOB: 48.6 ft.
LAT / LONG: 41.056554, -84.746131

EXPLORATION ID
B-001-0-24

PAGE
1 OF 2

MATERIAL DESCRIPTION AND NOTES	ELEV. 748.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
ASPHALT (4")	748.2																	
GRAVEL (8")	747.5																	
HARD, BROWN, **SANDY SILT**, LITTLE GRAVEL, TRACE CLAY, DRY	745.5	1 2	5 18 15	44	100	SS-1	-	-	-	-	-	-	-	-	-	4	A-4a (V)	
VERY STIFF, BROWN, **CLAY**, "AND" SILT, LITTLE SAND, TRACE GRAVEL, CONTAINS ROCK FRAGMENTS, DAMP		3 ▼ 4 5	7 4 4	11	100	SS-2	2.50	-	-	-	-	-	-	-	-	24	A-7-6 (V)	
		6 7	4 4 4	11	100	SS-3	3.50	1	3	14	40	42	45	25	20	19	A-7-6 (13)	
		8	3 3 5	11	11	SS-4	-	-	-	-	-	-	-	-	-	13	A-7-6 (V)	
@9.0'; GRAYISH BROWN, TRACE SAND		9 W 738.5 10	2 3 4	9	100	SS-5	2.50	0	1	8	49	42	44	25	19	23	A-7-6 (12)	
@10.5'; STIFF, BROWN AND GRAY, LITTLE SAND, MOIST	736.5	11	4 6 5	15	78	SS-6	1.75	0	0	16	42	42	46	23	23	23	A-7-6 (14)	
LOOSE, BROWN AND GRAY, **COARSE AND FINE SAND**, LITTLE SILT, LITTLE CLAY, TRACE GRAVEL, WET	735.0	12 13	0 2 3	7	100	SS-7	-	5	34	37	13	11	NP	NP	NP	22	A-3a (0)	
MEDIUM DENSE, BROWN AND GRAY, **GRAVEL AND/OR STONE FRAGMENTS WITH SAND AND SILT**, LITTLE CLAY, MOIST		14 15	2 6 5	15	67	SS-8	-	35	19	18	16	12	21	14	7	15	A-2-4 (0)	
	730.5	16 17	2 6 8	19	100	SS-9	-	-	-	-	-	-	-	-	-	15	A-2-4 (V)	
HARD, GRAY, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL, CONTAINS ROCK FRAGMENTS, DAMP		18 19 20	12 17 19	48	-	SS-10	4.50	-	-	-	-	-	-	-	-	9	A-4a (V)	
		21 22 23	14 27 47	98	100	SS-11	4.50	-	-	-	-	-	-	-	-	9	A-4a (V)	
	723.0	24 25	16 19 20	52	100	SS-12	4.50	-	-	-	-	-	-	-	-	9	A-4a (V)	
VERY DENSE, GRAY, **GRAVEL AND/OR STONE FRAGMENTS WITH SAND**, TRACE SILT, TRACE CLAY, CONTAINS ROCK FRAGMENTS, WET	720.5	26 27	14 29 49	103	100	SS-13	-	31	39	18	7	5	NP	NP	NP	14	A-1-b (0)	
HARD, GRAY, **SANDY SILT**, SOME GRAVEL, LITTLE CLAY, CONTAINS ROCK FRAGMENTS, DAMP		28 29	49 50/4"	-	100	SS-14	4.50	-	-	-	-	-	-	-	-	7	A-4a (V)	

PID: 113849	SFN: 6333389	PROJECT: PAU-TR33-04.75	STATION / OFFSET: 250+70, 0' RT.	START: 1/31/24	END: 2/2/24	PG 2 OF 2	B-001-0-24

MATERIAL DESCRIPTION AND NOTES	ELEV. 718.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
HARD, GRAY, **SANDY SILT**, SOME GRAVEL, LITTLE CLAY, CONTAINS ROCK FRAGMENTS, DAMP *(continued)*		31	50/3"	-	100	SS-15	-	-	-	-	-	-	-	-	-	5	A-4a (V)	
		34	7 18 29	62	100	SS-16	1.50	28	12	17	24	19	20	13	7	12	A-4a (2)	
		36	49 50/1"	-	100	SS-17	-	-	-	-	-	-	-	-	-	10	A-4a (V)	
	710.5	TR 38																
DOLOMITE, GRAY, SEVERLY WEATHERED, MODERATELY STRONG.	709.9	38.5	50/1"	-	100	SS-18	-	-	-	-	-	-	-	-	-	2	Rock (V)	
DOLOMITE, GRAY, MODERATELY TO SLIGHTLY WEATHERED, MODERATELY STRONG, FINE GRAINED, THIN BEDDED, VUGGY, CRYSTALLINE; RQD 81.75%, REC 96.67%. @ 40.9' - 41.5'; γ = 163.7 pcf, **Qu** = 6,690 psi		39-44	55		93	NQ2-1											CORE	
@ 46.2' - 46.7'; γ = 167.7 pcf, **Qu** = 7,200 psi		44-49	89		100	NQ2-2											CORE	
	699.9	EOB																

NOTES: CAVED AT 24.0'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS MIXED WITH CEMENT

PROJECT: PAU-TR33-04.75 TYPE: BRIDGE PID: 113849 SFN: 6333389 START: 2/1/24 END: 2/1/24	DRILLING FIRM / OPERATOR: CTL / T. MILLER SAMPLING FIRM / LOGGER: CTL / M. HUGHES DRILLING METHOD: 3.25" HSA / NQ2 SAMPLING METHOD: SPT / NQ2	DRILL RIG: CME 55 TRACK RIG HAMMER: AUTOMATIC HAMMER CALIBRATION DATE: 11/4/22 ENERGY RATIO (%): 79.3	STATION / OFFSET: 252+33, 10' LT. ALIGNMENT: TR 33 ELEVATION: 748.5 (MSL) EOB: 46.8 ft. LAT / LONG: 41.057015, -84.746170	EXPLORATION ID B-002-0-24 PAGE 1 OF 2

MATERIAL DESCRIPTION AND NOTES	ELEV. 748.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
ASPHALT (4")	748.2																	
GRAVEL (7")	747.6																	
HARD, BROWN AND GRAY, **SANDY SILT**, LITTLE GRAVEL, TRACE CLAY, DRY		1 2	10 14 16	40	100	SS-1	-	-	-	-	-	-	-	-	-	3	A-4a (V)	
@3.0'; STIFF, BROWN, LITTLE CLAY, TRACE GRAVEL, DAMP		3 4 5	3 3 3	8	100	SS-2	1.50	-	-	-	-	-	-	-	-	11	A-4a (V)	
@6.0'; MOIST		6 7	2 1 2	4	100	SS-3	1.00	1	7	50	22	20	24	17	7	22	A-4a (1)	
	739.5	8	2 3 4	9	100	SS-4	-	-	-	-	-	-	-	-	-	23	A-4a (V)	
LOOSE, BROWN, **COARSE AND FINE SAND**, LITTLE SILT, LITTLE CLAY, WET		9 W 738.0 10	2 2 2	5	100	SS-5	-	0	7	71	11	11	NP	NP	NP	23	A-3a (0)	
@10.5'; VERY LOOSE, TRACE SILT	736.5	11 ▼	0 0 2	3	100	SS-6	-	0	17	63	9	11	NP	NP	NP	27	A-3a (0)	
HARD, BROWN AND GRAY, **SANDY SILT**, SOME CLAY, TRACE GRAVEL, CONTAINS ROCK FRAGMENTS, DAMP		12 13	1 3 2	7	100	SS-7	4.50	4	9	20	43	24	22	14	8	13	A-4a (6)	
@13.5'; LITTLE CLAY		14 15	0 0 10	13	100	SS-8	4.50	10	13	24	33	20	20	13	7	11	A-4a (4)	
@16.0'; GRAY, SOME CLAY		16 17	4 15 25	53	100	SS-9	4.50	4	9	18	43	26	20	13	7	9	A-4a (7)	
		18 19 20	24 31 45	100	100	SS-10	-	-	-	-	-	-	-	-	-	7	A-4a (V)	
		21 22	20 29 40	91	100	SS-11	4.50	10	10	18	37	25	20	12	8	7	A-4a (5)	
		23 24 25	13 17 16	44	100	SS-12	4.50	-	-	-	-	-	-	-	-	10	A-4a (V)	
		26 27	21 31 24	73	100	SS-13	4.50	-	-	-	-	-	-	-	-	9	A-4a (V)	
		28 29	15 19 35	71	100	SS-14	4.50	-	-	-	-	-	-	-	-	7	A-4a (V)	

PID: 113849	SFN: 6333389	PROJECT: PAU-TR33-04.75	STATION / OFFSET: 252+33, 10' LT.	START: 2/1/24	END: 2/1/24	PG 2 OF 2	B-002-0-24

MATERIAL DESCRIPTION AND NOTES	ELEV. 718.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
VERY DENSE, GRAY, **COARSE AND FINE SAND**, TRACE GRAVEL, TRACE SILT, TRACE CLAY, DAMP	718.0	31 - 32	27 42 50/5"	-	100	SS-15	-	-	-	-	-	-	-	-	-	7	A-3a (V)	
		33 - 34	36 50/4"	-	100	SS-16	-	-	-	-	-	-	-	-	-	9	A-3a (V)	
	713.0	35 — TR																
DOLOMITE, GRAY, SEVERELY WEATHERED, MODERATELY STRONG.	712.2	36	50/4"	-	100	SS-17	-	-	-	-	-	-	-	-	-	11	Rock (V)	
DOLOMITE, GRAY, MODERATELY TO SLIGHTLY WEATHERED, MODERATELY STRONG TO STRONG, FINE GRAINED, THIN BEDDED, VUGGY, CRYSTALLINE; RQD 51.49%, REC 85.52%. @ 37.8' - 38.1'; γ = 166.0 pcf, **Qu** = 5,980 psi		37 - 39	36		73	NQ2-1											CORE	
@ 42.6' - 43.0'; γ = 171.4 pcf, **Qu** = 10,240 psi		40 - 44	60		87	NQ2-2											CORE	
	701.7	45 - 46 — EOB	52		98	NQ2-3											CORE	

NOTES: CAVED AT 21.0'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS MIXED WITH CEMENT

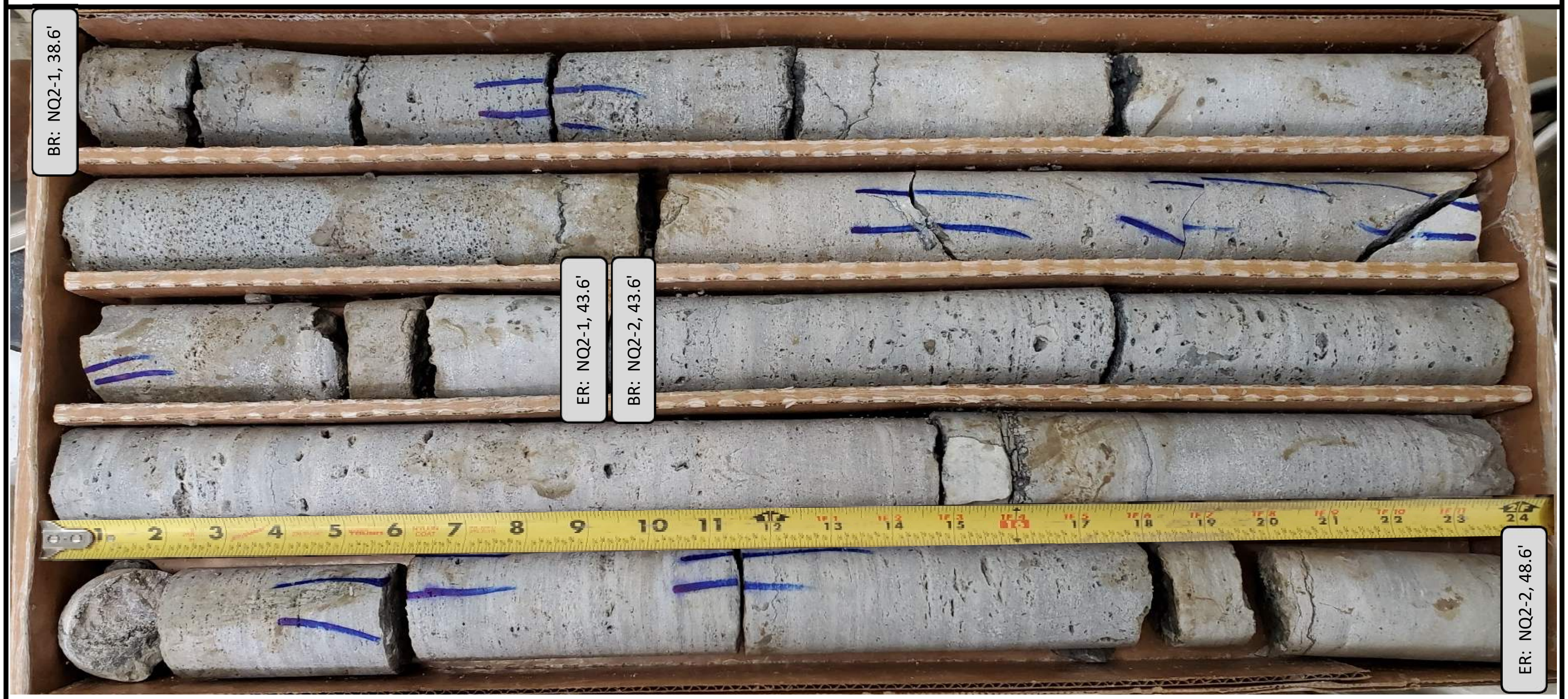
CTL ENGINEERING, INC.
102 COMMERCE DR. P.O. BOX 44
WAPAKONETA, OHIO 45895
PHONE: (419) 738-1447
FAX: (419) 738-7670

ROCK CORE PHOTOGRAPHS

BR = Beginning of Run

ER = End of Run

B-001-0-24



Run #	Depth (ft.)	Recovery		RQD	
NQ2-1	38.6 to 43.6	56"/60"	93%	33"/60"	55%
NQ2-2	43.6 to 48.6	60"/60"	100%	53"/60"	89%

PAU-TR33-04.75; PID No. 113849 (Bridge over Flat Rock Creek)

CTL ENGINEERING, INC.
102 COMMERCE DR. P.O. BOX 44
WAPAKONETA, OHIO 45895
PHONE: (419) 738-1447
FAX: (419) 738-7670

ROCK CORE PHOTOGRAPHS

BR = Beginning of Run
ER = End of Run

B-002-0-24

RUN #	DEPTH (FT.)	RECOVERY		RQD	
NQ2-1	36.3 to 39.3	26"/36"	73%	13"/36"	36%
NQ2-2	39.3 to 44.3	52"/60"	87%	36"/60"	60%
NQ2-3	44.3 to 46.8	29"/30"	98%	16"/30"	52%

PAU-TR33-04.75; PID No. 113849 (Bridge over Flat Rock Creek)

APPENDIX C

LABORATORY TEST RESULTS

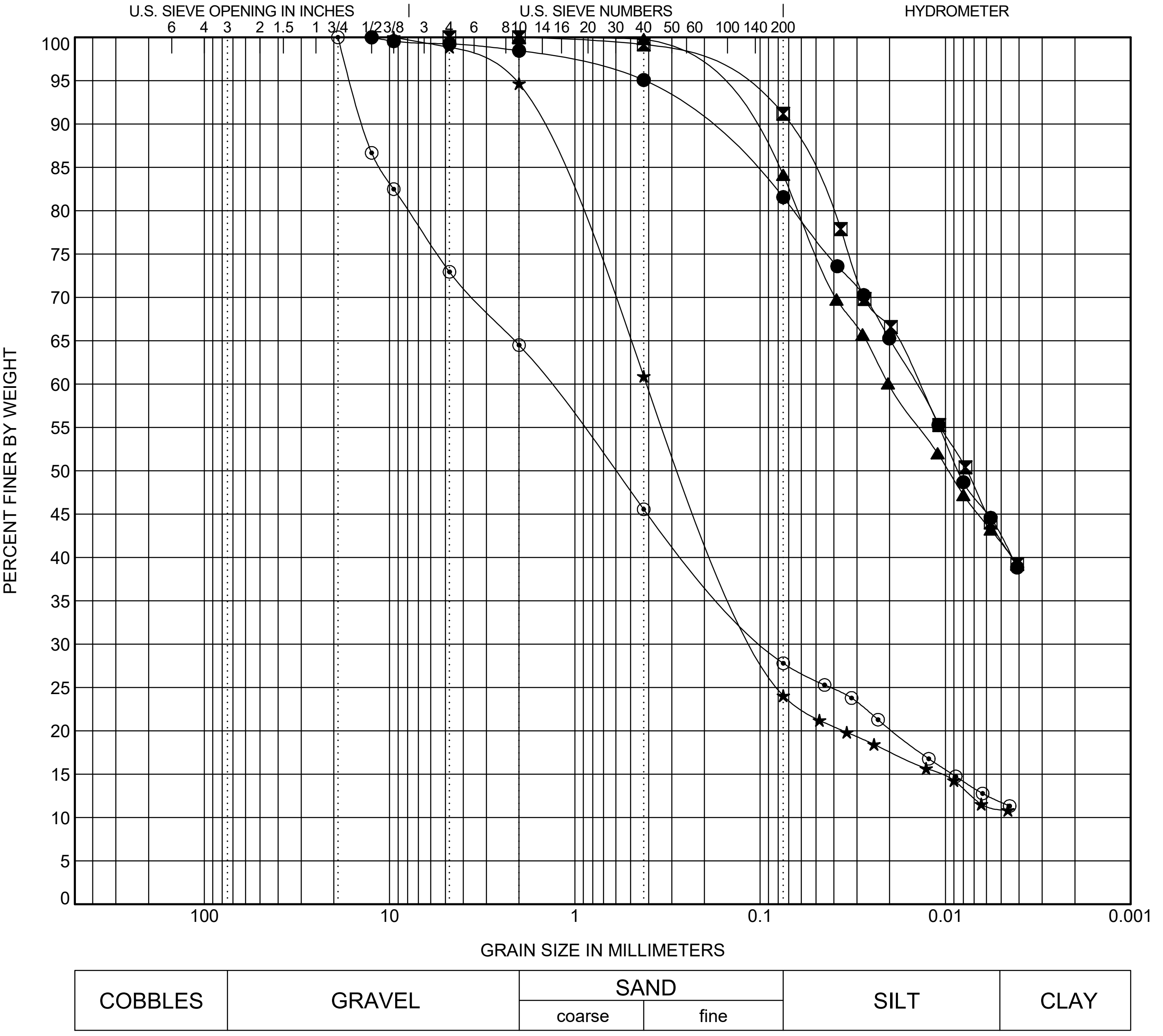
CTL
ENGINEERING INC.

CTL ENGINEERING, INC.
102 COMMERCE DRIVE, P.O. BOX 44
WAPAKONETA, OH 45895

GRAIN SIZE DISTRIBUTION

PROJECT PAU-TR33-04.75 **PID** 113849

CTL PROJECT NUMBER 24050001WAP **PROJECT TYPE** STRUCTURE FOUNDATION



Specimen Identification			ODOT (Modified AASHTO) ~ USCS Classification	LL	PL	PI
●	**B-001-0-24**	**6.0**	**A-7-6 ~ LEAN CLAY with SAND(CL)**	**45**	**25**	**20**
☒	**B-001-0-24**	**9.0**	**A-7-6 ~ LEAN CLAY(CL)**	**44**	**25**	**19**
▲	**B-001-0-24**	**10.5**	**A-7-6 ~ LEAN CLAY with SAND(CL)**	**46**	**23**	**23**
★	**B-001-0-24**	**12.0**	**A-3a ~ SILTY SAND(SM)**	**NP**	**NP**	**NP**
⊙	**B-001-0-24**	**13.5**	**A-2-4 ~ SILTY, CLAYEY SAND with GRAVEL(SC-SM)**	**21**	**14**	**7**

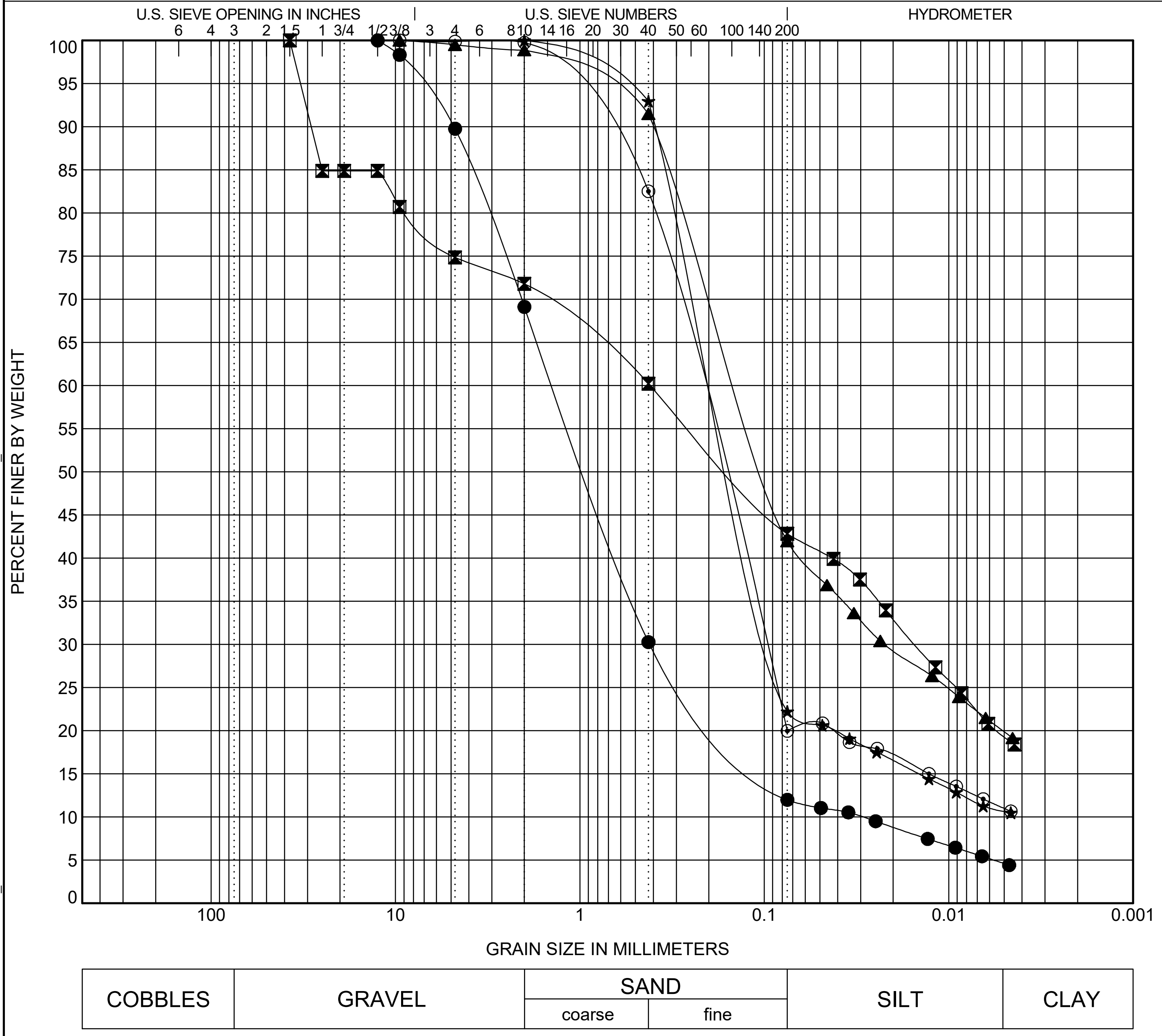
Specimen Identification			D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
●	**B-001-0-24**	**6.0**	**0.222**	**0.009**			**1**	**3**	**14**	**40**	**42**		
☒	**B-001-0-24**	**9.0**	**0.07**	**0.008**			**0**	**1**	**8**	**49**	**42**		
▲	**B-001-0-24**	**10.5**	**0.144**	**0.01**			**0**	**0**	**16**	**42**	**42**		
★	**B-001-0-24**	**12.0**	**1.614**	**0.254**	**0.099**		**5**	**34**	**37**	**13**	**11**		
⊙	**B-001-0-24**	**13.5**	**13.878**	**0.611**	**0.093**		**35**	**19**	**18**	**16**	**12**		

GRAIN SIZE DISTRIBUTION

CTL ENGINEERING, INC.
102 COMMERCE DRIVE, P.O. BOX 44
WAPAKONETA, OH 45895

PROJECT PAU-TR33-04.75 **PID** 113849

CTL PROJECT NUMBER 24050001WAP **PROJECT TYPE** STRUCTURE FOUNDATION



Specimen Identification			ODOT (Modified AASHTO) ~ USCS Classification	LL	PL	PI
●	**B-001-0-24**	**26.0**	**A-1-b ~ WELL-GRADED SAND with SILT(SW-SM)**	**NP**	**NP**	**NP**
⧗	**B-001-0-24**	**33.5**	**A-4a ~ SILTY, CLAYEY SAND with GRAVEL(SC-SM)**	**20**	**13**	**7**
▲	**B-002-0-24**	**6.0**	**A-4a ~ SILTY, CLAYEY SAND(SC-SM)**	**24**	**17**	**7**
★	**B-002-0-24**	**9.0**	**A-3a ~ SILTY SAND(SM)**	**NP**	**NP**	**NP**
⊙	**B-002-0-24**	**10.5**	**A-3a ~ SILTY SAND(SM)**	**NP**	**NP**	**NP**

Specimen Identification			D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
●	**B-001-0-24**	**26.0**	**4.843**	**0.934**	**0.415**	**0.029**	**31**	**39**	**18**	**7**	**5**	**4.20**	**47.28**
⧗	**B-001-0-24**	**33.5**	**28.68**	**0.153**	**0.015**		**28**	**12**	**17**	**24**	**19**		
▲	**B-002-0-24**	**6.0**	**0.403**	**0.099**	**0.022**		**1**	**7**	**50**	**22**	**20**		
★	**B-002-0-24**	**9.0**	**0.395**	**0.148**	**0.091**		**0**	**7**	**71**	**11**	**11**		
⊙	**B-002-0-24**	**10.5**	**0.834**	**0.135**	**0.067**		**0**	**17**	**63**	**9**	**11**		

CTL ENGINEERING, INC.
102 COMMERCE DRIVE, P.O. BOX 44
WAPAKONETA, OH 45895

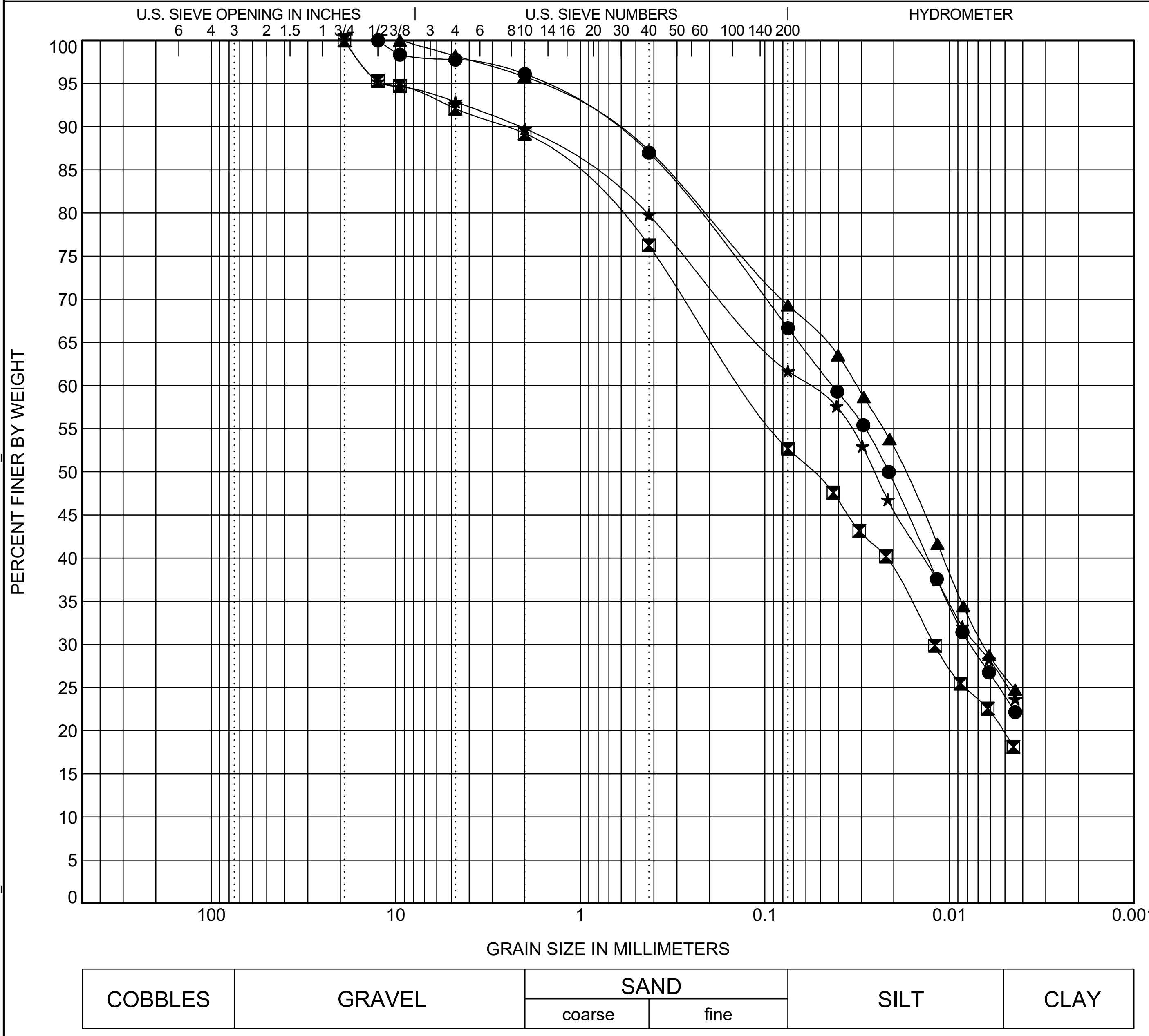
GRAIN SIZE DISTRIBUTION

PROJECT PAU-TR33-04.75

PID 113849

CTL PROJECT NUMBER 24050001WAP

PROJECT TYPE STRUCTURE FOUNDATION



Specimen Identification			ODOT (Modified AASHTO) ~ USCS Classification	LL	PL	PI
●	**B-002-0-24**	**12.0**	**A-4a ~ SANDY LEAN CLAY(CL)**	**22**	**14**	**8**
☒	**B-002-0-24**	**13.5**	**A-4a ~ SANDY SILTY CLAY(CL-ML)**	**20**	**13**	**7**
▲	**B-002-0-24**	**16.0**	**A-4a ~ SANDY SILTY CLAY(CL-ML)**	**20**	**13**	**7**
★	**B-002-0-24**	**21.0**	**A-4a ~ SANDY LEAN CLAY(CL)**	**20**	**12**	**8**

Specimen Identification			D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
●	**B-002-0-24**	**12.0**	**0.708**	**0.021**	**0.008**		**4**	**9**	**20**	**43**	**24**		
☒	**B-002-0-24**	**13.5**	**2.53**	**0.056**	**0.012**		**10**	**13**	**24**	**33**	**20**		
▲	**B-002-0-24**	**16.0**	**0.7**	**0.018**	**0.007**		**4**	**9**	**18**	**43**	**26**		
★	**B-002-0-24**	**21.0**	**2.124**	**0.025**	**0.007**		**10**	**10**	**18**	**37**	**25**		

PROJECT NO:	24050001WAP
DATE:	11/20/2024

UNIAXIAL COMPRESSIVE STRENGTH OF INTACT ROCK CORE - ASTM D 7012

Method C

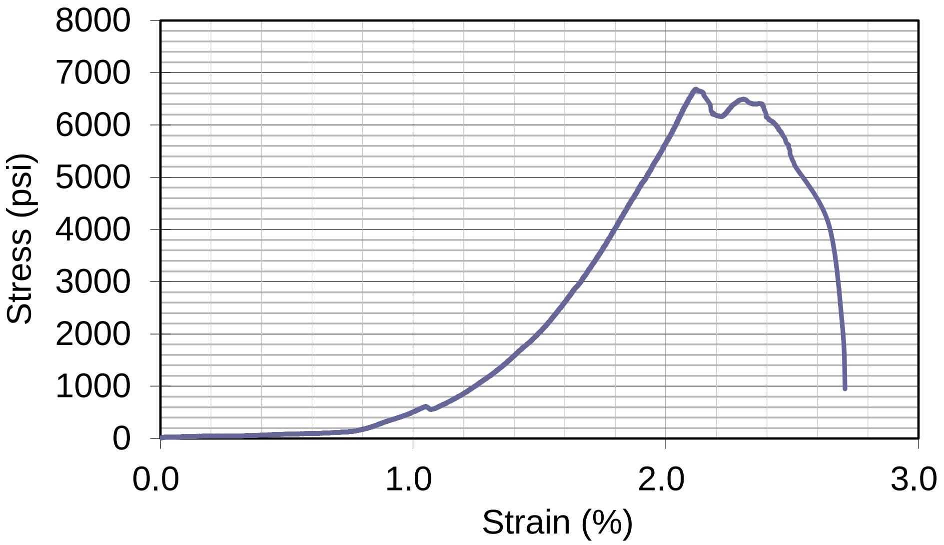
BORING NUMBER	B-001-0-24	TOP DEPTH(FT)	40.9	BOTTOM DEPTH(FT)	41.5
SAMPLE NUMBER	NQ2-1	DISTRICT	1	PID NO.	113849
COUNTY	PAU	ROUTE	TR33	SECTION	4.75

FORMATION	DUNDEE LIMESTONE (Ddd), Devonian Age - Lower Portion of Formation		
DESCRIPTION	Dolomite, Gray, Slightly Weathered, Moderately Strong with possible Chert		
MOISTURE CONDITION	As Received	COMMENTS: Low reaction to HCl	

MEASUREMENT	LENGTH(INCHES)	DIAMETER(INCHES)
1	4.038	1.984
2	4.039	1.987
3	4.037	1.985
AVERAGE	4.038	1.985

LENGTH/DIAMETER	2.03
CORRECTION FACTOR	1.00
AREA(IN^2)	3.10
MASS (GRAMS)	537.2
UNIT WEIGHT(LBS/FT³)	163.7

RATE OF LOADING (in/min)
0.10
COMPRESSIVE STRENGTH (PSI)
6,690
Equip. ID - 68897
NON-CONFORMANCES - None
TIME OF TEST (MINUTES)
1.48
LOADING DIRECTION
PERP. TO BEDDING
TECHNICIAN - MW
TEMPERATURE - Room



BEFORE TESTING

AFTER TESTING

Physical Appearance after Test - Sample sheared through middle portion - No signs of cracking, spalling or shearing at the platen-specimen interface

PROJECT NO:	24050001WAP
DATE:	11/20/2024

UNIAXIAL COMPRESSIVE STRENGTH OF INTACT ROCK CORE - ASTM D 7012

Method C

CTL ENGINEERING INC.

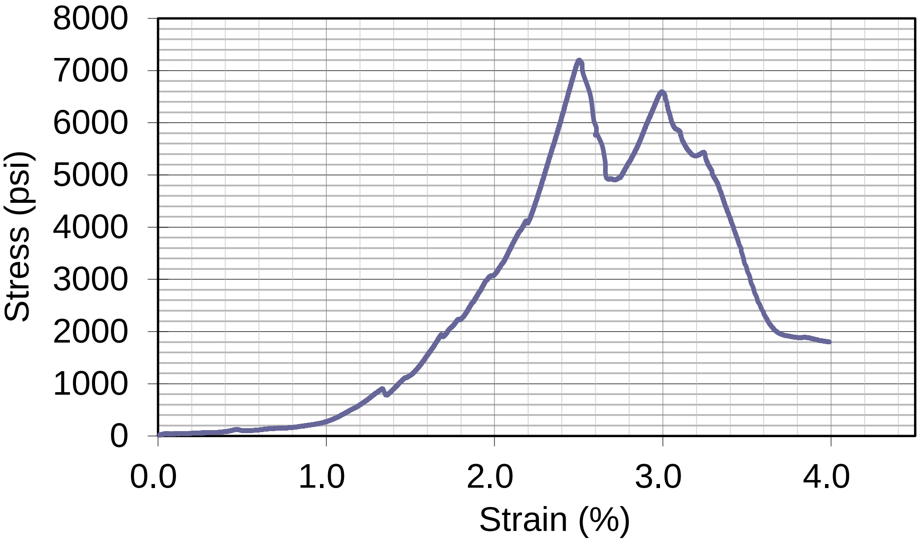
BORING NUMBER	B-001-0-24	TOP DEPTH(FT)	46.2	BOTTOM DEPTH(FT)	46.7
SAMPLE NUMBER	NQ2-2	DISTRICT	1	PID NO.	113849
COUNTY	PAU	ROUTE	TR33	SECTION	4.75

FORMATION	DUNDEE LIMESTONE (Ddd), Devonian Age - Lower Portion of Formation	
DESCRIPTION	Dolomite, Gray, Slightly Weathered, Moderately Strong with possible Chert	
MOISTURE CONDITION	As Received	COMMENTS: Low reaction to HCl

MEASUREMENT	LENGTH(INCHES)	DIAMETER(INCHES)
1	4.031	1.989
2	4.042	1.990
3	4.045	1.989
AVERAGE	4.039	1.989

LENGTH/DIAMETER	2.03
CORRECTION FACTOR	1.00
AREA(IN^2)	3.11
MASS (GRAMS)	552.6
UNIT WEIGHT(LBS/FT³)	167.7

RATE OF LOADING (in/min)
0.09
COMPRESSIVE STRENGTH (PSI)
7,200
Equip. ID - 68897
NON-CONFORMANCES - None
TIME OF TEST (MINUTES)
1.84
LOADING DIRECTION
PERP. TO BEDDING
TECHNICIAN - MW
TEMPERATURE - Room



BEFORE TESTING

AFTER TESTING

Physical Appearance after Test - Sample sheared through middle portion - No signs of cracking, spalling or shearing at the platen-specimen interface

PROJECT NO:	24050001WAP
DATE:	11/20/2024

UNIAXIAL COMPRESSIVE STRENGTH OF INTACT ROCK CORE - ASTM D 7012

Method C

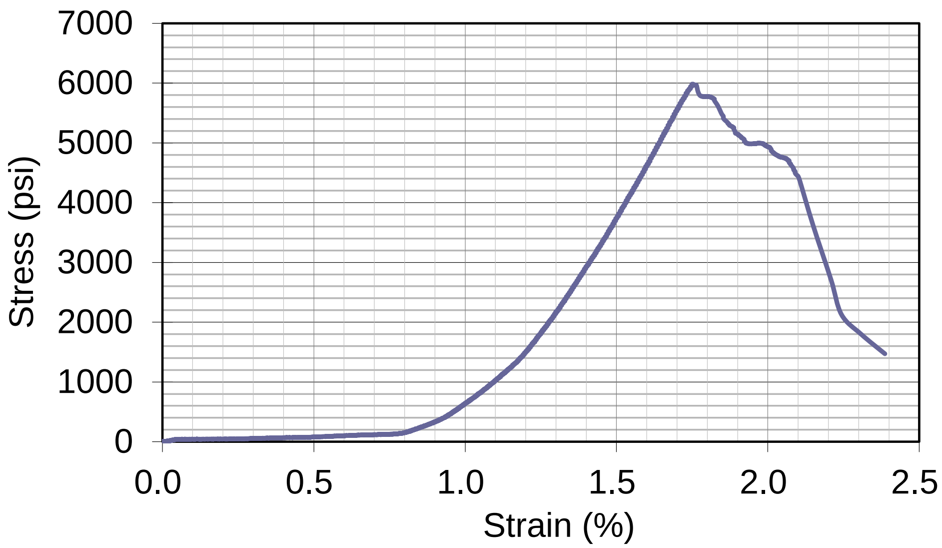
BORING NUMBER	B-002-0-24	TOP DEPTH(FT)	37.8	BOTTOM DEPTH(FT)	38.1
SAMPLE NUMBER	NQ2-1	DISTRICT	1	PID NO.	113849
COUNTY	PAU	ROUTE	TR33	SECTION	4.75

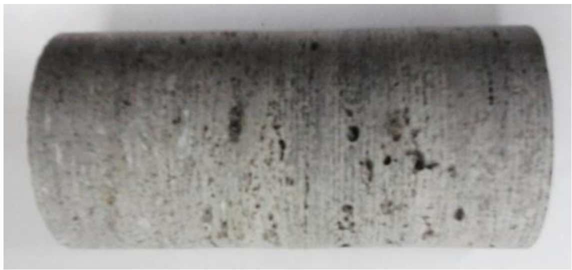
FORMATION	DUNDEE LIMESTONE (Ddd), Devonian Age - Lower Portion of Formation	
DESCRIPTION	Dolomite, Gray, Slightly Weathered, Moderately Strong with possible Chert	
MOISTURE CONDITION	As Received	COMMENTS: Low reaction to HCl

MEASUREMENT	LENGTH(INCHES)	DIAMETER(INCHES)
1	4.042	1.989
2	4.044	1.988
3	4.057	1.986
AVERAGE	4.048	1.988

LENGTH/DIAMETER	2.04
CORRECTION FACTOR	1.00
AREA(IN^2)	3.10
MASS (GRAMS)	547.3
UNIT WEIGHT(LBS/FT³)	166.0

RATE OF LOADING (in/min)
0.08
COMPRESSIVE STRENGTH (PSI)
5,980
Equip. ID - 68897
NON-CONFORMANCES - None
TIME OF TEST (MINUTES)
1.10
LOADING DIRECTION
PERP. TO BEDDING
TECHNICIAN - MW
TEMPERATURE - Room





BEFORE TESTING

AFTER TESTING

Physical Appearance after Test - Sample sheared through middle portion - No signs of cracking, spalling or shearing at the platen-specimen interface

PROJECT NO:	24050001WAP
DATE:	11/20/2024

UNIAXIAL COMPRESSIVE STRENGTH OF INTACT ROCK CORE - ASTM D 7012

Method C

CTL ENGINEERING INC.

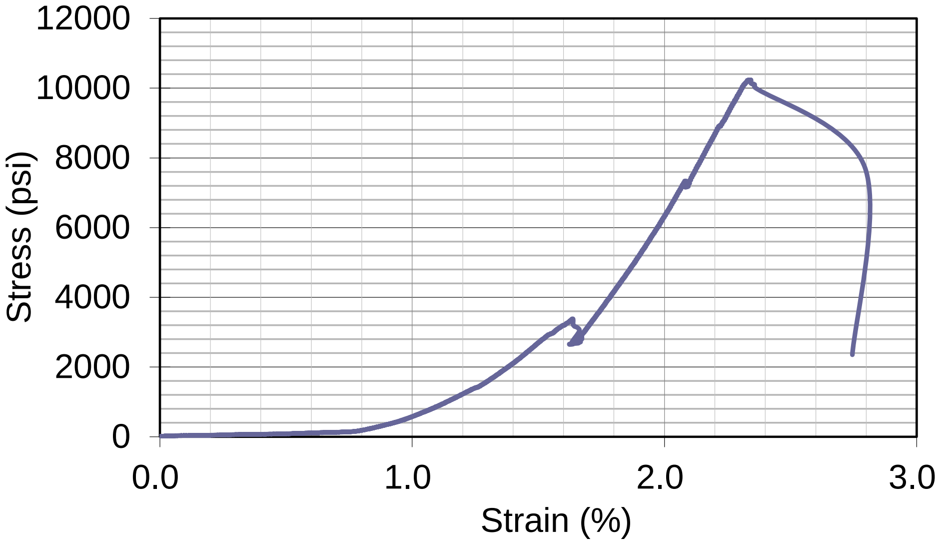
BORING NUMBER	B-002-0-24	TOP DEPTH(FT)	42.6	BOTTOM DEPTH(FT)	43.0
SAMPLE NUMBER	NQ2-2	DISTRICT	1	PID NO.	113849
COUNTY	PAU	ROUTE	TR33	SECTION	4.75

FORMATION	DUNDEE LIMESTONE (Ddd), Devonian Age - Lower Portion of Formation	
DESCRIPTION	Dolomite, Gray, Slightly Weathered, Moderately Strong with possible Chert	
MOISTURE CONDITION	As Received	COMMENTS: Low reaction to HCl

MEASUREMENT	LENGTH(INCHES)	DIAMETER(INCHES)
1	4.025	1.988
2	4.037	1.988
3	4.026	1.989
AVERAGE	4.029	1.988

LENGTH/DIAMETER	2.03
CORRECTION FACTOR	1.00
AREA(IN^2)	3.11
MASS (GRAMS)	562.9
UNIT WEIGHT(LBS/FT³)	171.4

RATE OF LOADING (in/min)
0.07
COMPRESSIVE STRENGTH (PSI)
10,240
Equip. ID - 68897
NON-CONFORMANCES - None
TIME OF TEST (MINUTES)
1.30
LOADING DIRECTION
PERP. TO BEDDING
TECHNICIAN - MW
TEMPERATURE - Room



BEFORE TESTING

AFTER TESTING

Physical Appearance after Test - Sample sheared through middle portion - No signs of cracking, spalling or shearing at the platen-specimen interface

APPENDIX D

CALCULATIONS

Critical Shear Stress Analyses for Scour Evaluation

Bockrath Associates
PAU-TR33-04.75
Payne, Paulding County, OH
CTL Project No.: 24050001WAP

Engineer: F. Schoen
Date: February 25, 2025
Boring/Fnd: Forward & Rear Abutments
Criteria/Details: Scour Samples based on SPT Samples

Sample Data Input				Soil Data Input					Calculated Findings (Imperical Units)		
Boring No.	Sample No.	Sample Elevation (ft.)	Soil/Rock Type	Water Content, *w* (%)	Fraction of Fine Particles, F (%)	Plasticity Index, PI	Unconfined Compressive Str., q_u (tsf)	**Mean Particle Grain Size, D_{50} (mm)**	**Critical Shear Stress, τ_c (psf)**	**Equivalent Particle Grain Size, D_{50eq} (mm)**	**Erosion Category, EC**
B-001-0-24	SS-3	742.5 - 741.0	A-7-6	19	82	20	3.50	0.0085	0.7934	37.9805	3.72
B-001-0-24	SS-5	739.5 - 738.0	A-7-6	23	91	19	2.50	0.0076	0.5452	26.1010	3.67
B-001-0-24	SS-6	738.0 - 736.5	A-7-6	23	84	23	1.75	0.0096	0.5164	24.7194	3.87
B-001-0-24	SS-7	736.5 - 735.0	A-3a	22	24	NP	--	0.2545	0.0053	0.2545	1.49
B-001-0-24	SS-8	735.0 - 733.5	A-2-4	15	28	7	--	0.6114	0.0128	0.6114	1.94
B-001-0-24	SS-13	722.5 - 721.0	A-1-b	14	12	NP	--	0.9340	0.0195	0.9340	2.16
B-001-0-24	SS-16	715.0 - 713.5	A-4a	12	43	7	1.50	0.1530	0.0996	4.7655	2.63
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B-002-0-24	SS-3	742.5 - 741.0	A-4a	22	42	7	1.00	0.0994	0.0240	1.1501	2.63
B-002-0-24	SS-5	739.5 - 738.0	A-3a	23	22	NP	--	0.1482	0.0029	0.1395	2.21
B-002-0-24	SS-6	738.0 - 736.5	A-3a	27	20	NP	--	0.1350	0.0017	0.0837	2.21
B-002-0-24	SS-7	736.5 - 735.0	A-4a	13	67	8	4.50	0.0213	0.3802	18.1986	2.75
B-002-0-24	SS-8	735.0 - 733.5	A-4a	11	53	7	4.50	0.0558	0.2793	13.3706	2.63
B-002-0-24	SS-9	732.5 - 731.0	A-4a	9	69	7	4.50	0.0180	0.7072	33.8532	2.63
B-002-0-24	SS-11	727.5 - 726.0	A-4a	7	62	8	4.50	0.0250	1.1228	53.7481	2.75
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Sample Data Input				Rock Data Input						Calculated Rock Parameters	
Boring No.	Sample No.	Sample Elevation (ft.)	Soil/Rock Type	Rock Quality Designation, RQD (%)	Rock Joint Set No, Jn	Joint Roughness No, Jr	Joint Alteration No, Ja	Relative Joint Orientation Parameter, Js	Intact Rock Mass Strength Parameter, Ms	Block Size Parameter, Kb	Erodibility Index, K
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References: FHWA-HIF-12-003, Hydraulic Engineering Circular 18 (HEC 18), Evaluating Scour at Bridges, 2013
ODOT Geotechnical Design Manual, Jan., 2027

Where D_{50}= Mean Particle Grain Size, mm
w= Water content, percent
F= Fraction of fine particles (< 75μm) by mass, percent
PI= Plasticity index, dimensionless
q_u= Unconfined compressive strength, psf
α= Unit conversion constant, 0.01 in U.S. customary units and 0.1
τ_c = Critical shear stress, psf
EC= Erosion Category
RQD= Rock Quality Designation, percent

Sv= Average Vertical Spacing between Horizontal Discontinuities, m
Jn= Rock Joint Set Number
Jr= Joint Roughness Numer
Ja= Joint Alteration Number
Js= Relative Orientation Number
Ms= Rock Mass Strength Parameter
Kb= Block Size Parameter
Kd= Shear Strength Parameter
K= Erodibility Index

Summary Of Pile Design
PAU-TR33-04.75
Rear Abutment - HP 10x42

Bottom of Pile Cap Elevation =	741.20	ft	(Estimated from Site Plan, Undated)
Resistance Factor for Driven Piles to Bedrock =	0.5		(ODOT BDM C305.3.3)
Maximum Factored Structural Resistance =	310.0	kips/pile	(ODOT BDM C305.3.3)
Scour Depth (from Bottom of Footing El.)=	0.0	ft	(Assumed)
Pile Stick-up Length =	2.0	ft	(ODOT BDM Section 305.3.5.1)
Pile Length =	31.3	ft	(From APile Analysis)
Estimated Pile Length =	35.0	ft	(ODOT BDM 305.3.5.2)
Order Length =	40.0	ft	(ODOT BDM 305.3.5.2)
Pile Tip Elevation =	709.9	ft	(Elevation of Coreable Rock)

Soil Parameters

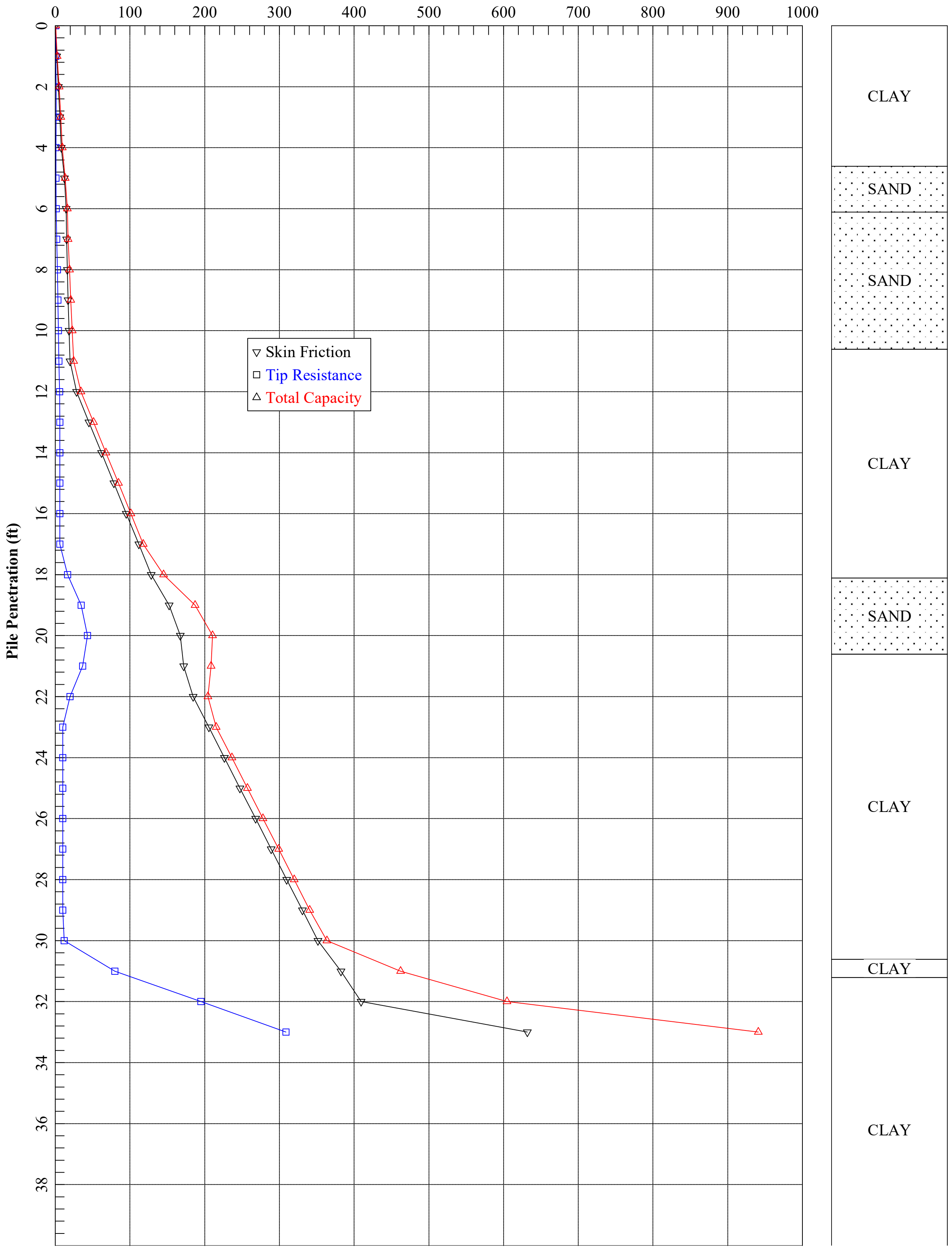
Project: PAU-TR33-04.75
Location: Rear Abutment
Boring No.: B-001-0-24
Date: 3/12/25
Ground Surface Elevation: 748.50
Bottom of Pile Cap Elevation: 741.2

								Total Stress			
Layer No.	Top Elev	Bottom Elev	Thickness (feet)	Type	ODOT	N_{60} value (bpf)	Total Weight (pcf)	Cohesion (psf)	Friction Angle (degrees)	Apile Reduction Factor	Reference
1	741.2	736.5	4.7	Cohesive	A-7-6	11	120				
						9	118				
						15	122				
			Avg			12	120	1500	0	0.50	1, 2
2	736.5	735.0	1.5	Granular	A-3a	7	120				
								LRFD	31		
								ODOT CF	-0.5		
			Avg			7	120	0	30	1.00	3
3	735.0	730.5	4.5	Granular	A-2-4	15	125				
						19	125	LRFD	34.25		
								ODOT CF	0.5		
			Avg			17	125	0	34	0.83	3
4	730.5	723.0	7.5	Cohesive	A-4a	48	135				
						98	140				
						52	140				
			Avg			66	138	7823	0	0.67	2, 4
5	723.0	720.5	2.5	Granular	A-1-b	103	140				
								LRFD	48.45		
								ODOT CF	1.5		
			Avg			103	140	0	49	1	3
6	720.5	710.5	10	Cohesive	A-4a	132	140				
						132	140				
						62	140				
						529	140				
			Avg			109	140	12905	0	0.67	2, 4
7	710.5	709.9	0.6	Rock	Dolomite	529	150	Est. Qu			
								=			
								338 psi			
			Avg			529	150	27991	0	---	4, 5
8	709.9	699.9	10	Rock	Dolomite		163.7	Qu			
							167.7	=			
								6,690 psi			
			Avg				166	481680	0	---	5

Reference Key

1 Cohesive Soils - Total Stress Cohesion estimated as 125 x average N-Value - according to ODOT GDM Section 404.1.
2 Cohesive Soils - Total Stess Friction Angle estimated to be 0.
3 Granular soils - Friction angle estimated using N-value & soil type according ODOT GDM Section 404.2.
4 Total Stress Cohesion estimated as (f_1 x N_{60} x P_a)/100 - according to ODOT GDM Section 404.1.
5 Rock Cohesion equals Undrained Shear Strength, which equals one-half the unconfined compressive strength (Q_u).

24050001WAP Rear Abutment (B-001-0-24) APile Analysis
Axial Capacity (kips)



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     =========================================================================

                      APILE for Windows, Version 2019.9.11

                       Serial Number :  136084177

                       A Program for Analyzing the Axial Capacity
                       and Short-term Settlement of Driven Piles
                                 under Axial Loading.
                     (c) Copyright ENSOFT, Inc., 1987-2019
                           All Rights Reserved

     =========================================================================


     This program is licensed to :

     CTL Engineering, Inc.
     Cincinnati, OH

     Path to file locations      : O:\PROJECT\2024\WAP-05\24050001WAP_Bockrath and
Associates Engineering and Surveying LLC_PAU-TR33-4-75 Bridge over Flat Rock Creek-
PID 113849\Calcs\Pile\Rear Abutment (B-001-0-24)\APile\
     Name of input data file     : 24050001WAP_RA_APile Analysis.ap9d
     Name of output file         : 24050001WAP_RA_APile Analysis.ap9o
     Name of plot output file    : 24050001WAP_RA_APile Analysis.ap9p

     -------------------------------------------------------------------------
                          Time and Date of Analysis
     -------------------------------------------------------------------------

               Date:  October 21, 2024     Time:  13:14:18



1
          *********************
          * INPUT INFORMATION *
          *********************



          PAU-TR33-04.75_Rear Abutment (B-001-0-24)

          DESIGNER   : CTL Engineering, Inc.

          JOB NUMBER : 24050001WAP


          METHOD FOR UNIT LOAD TRANSFERS :
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- FHWA (Federal Highway Administration)
  Unfactored Unit Side Friction and Unit Side Resistance are used.



COMPUTATION METHOD(S) FOR PILE CAPACITY :

- FHWA (Federal Highway Administration)


TYPE OF LOADING :
- COMPRESSION


PILE TYPE :

H-Pile/Steel Pile


DATA FOR AXIAL STIFFNESS :

- MODULUS OF ELASTICITY     = 0.290E+08 PSI
- CROSS SECTION AREA        =     12.40 IN2


NONCIRCULAR PILE PROPERTIES :

- TOTAL PILE LENGTH, TL     =     35.00 FT.
- BATTER ANGLE              =      0.00 DEG
- PILE STICKUP LENGTH, PSL  =      2.00 FT.
- ZERO FRICTION LENGTH, ZFL =      0.00 FT.
- PERIMETER OF PILE         =     39.60 IN.
- TIP AREA OF PILE          =     12.40 IN2
- INCREMENT OF PILE LENGTH
  USED IN COMPUTATION       =      1.00 FT.



SOIL INFORMATIONS :



                  LATERAL    EFFECTIVE    FRICTION      Nq
          SOIL    EARTH      UNIT         ANGLE       FACTOR
 DEPTH    TYPE    PRESSURE   WEIGHT       DEGREES      FHWA
  FT.                        LB/FT^3
   0.00   CLAY      0.80*      120.00         0.00      4.80**
   4.61   CLAY      0.80*      120.00         0.00      4.80**
   4.61   SAND      0.80*      120.00        30.00     30.00**
```

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   6.11   SAND      0.80*      120.00        30.00     30.00**
   6.11   SAND      0.80*      125.00        34.00     55.60**
  10.61   SAND      0.80*      125.00        34.00     55.60**
  10.61   CLAY      0.80*      138.00         0.00      4.80**
  18.11   CLAY      0.80*      138.00         0.00      4.80**
  18.11   SAND      0.80*      140.00        49.00    475.00**
  20.61   SAND      0.80*      140.00        49.00    475.00**
  20.61   CLAY      0.80*      140.00         0.00      4.80**
  30.61   CLAY      0.80*      140.00         0.00      4.80**
  30.61   CLAY      0.80*      150.00         0.00      4.80**
  31.21   CLAY      0.80*    19467.00         0.00      4.80**
  31.21   CLAY      0.80*      166.00         0.00      4.80**
  41.21   CLAY      0.80*      166.00         0.00      4.80**

*  VALUE ASSUMED BY THE PROGRAM
** VALUE ESTIMATED BY THE PROGRAM BASED ON FRICTION ANGLE



MAXIMUM   MAXIMUM   UNDISTURB  REMOLDED
UNIT      UNIT      SHEAR      SHEAR     BLOW   UNIT SKIN  UNIT END
FRICTION  BEARING   STRENGTH   STRENGTH  COUNT  FRICTION   BEARING
  KSF       KSF        KSF       KSF              KSF       KSF
0.10E+08* 0.10E+08*       1.50      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       1.50      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       0.00      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       0.00      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       0.00      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       0.00      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       7.82      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       7.82      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       0.00      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       0.00      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*      12.90      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*      12.90      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*      19.47      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*      27.99      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*     481.68      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*     481.68      0.00   0.00       0.00      0.00

* MAXIMUM UNIT FRICTION AND/OR MAXIMUM UNIT BEARING
  WERE SET TO BE 0.10E+08 BECAUSE THE USER DOES NOT
  PLAN TO LIMIT THE COMPUTED DATA.



         LRFD FACTOR  LRFD FACTOR
          ON UNIT      ON UNIT
 DEPTH    FRICTION     BEARING
  FT.
```

```
             0.00    0.500       1.000
             4.61    0.500       1.000
             4.61    1.000       1.000
             6.11    1.000       1.000
             6.11    0.830       1.000
            10.61    0.830       1.000
            10.61    0.670       1.000
            18.11    0.670       1.000
            18.11    1.000       1.000
            20.61    1.000       1.000
            20.61    0.670       1.000
            30.61    0.670       1.000
            30.61    1.000       1.000
            31.21    1.000       1.000
            31.21    1.000       1.000
            41.21    1.000       1.000



1
          **********************
          * COMPUTATION RESULT *
          **********************



                            **********************
                            *  FED. HWY. METHOD  *
                            **********************

             PILE          SKIN          END       ULTIMATE
          PENETRATION   FRICTION       BEARING     CAPACITY
              FT.          KIP           KIP          KIP
              0.00           0.0           0.6          0.6
              1.00           2.1           0.6          2.6
              2.00           4.1           1.2          5.3
              3.00           6.2           1.2          7.3
              4.00           8.2           1.1          9.3
              5.00          12.3           1.1         13.4
              6.00          14.7           1.4         16.1
              7.00          15.3           2.0         17.3
              8.00          16.2           2.8         19.0
              9.00          17.3           3.5         20.8
             10.00          18.6           4.2         22.7
             11.00          19.7           5.0         24.7
             12.00          28.6           5.7         34.3
             13.00          45.2           6.1         51.3
             14.00          61.9           6.1         67.9
             15.00          78.5           6.1         84.6
             16.00          95.1           6.1        101.2
```

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 17.00         111.8            6.1         117.8
 18.00         128.4           16.6         145.0
 19.00         152.5           34.8         187.3
 20.00         167.4           43.2         210.6
 21.00         171.9           36.8         208.6
 22.00         184.6           19.8         204.4
 23.00         205.5           10.0         215.5
 24.00         226.4           10.0         236.4
 25.00         247.2           10.0         257.2
 26.00         268.1           10.0         278.1
 27.00         289.0           10.0         299.0
 28.00         309.9           10.0         319.9
 29.00         330.7           10.0         340.7
 30.00         351.6           12.0         363.6
 31.00         382.4           79.8         462.3
 32.00         409.5          195.1         604.6
 33.00         632.0          308.9         940.9


NOTES:
- AN ASTERISK IS PLACED IN THE END-BEARING COLUMN
  IF THE TIP RESISTANCE IS CONTROLLED BY THE FRICTION
  OF SOIL PLUG INSIDE AN OPEN-ENDED PIPE PILE.



    *************************************************
    * COMPUTE LOAD-DISTRIBUTION AND LOAD-SETTLEMENT *
    * CURVES FOR AXIAL LOADING                      *
    *************************************************


T-Z CURVE   NO. OF   DEPTH TO CURVE   LOAD TRANSFER   PILE MOVEMENT
   NO.      POINTS        FT.              PSI             IN.

    1         10      0.4167E-01
                                     0.0000E+00      0.0000E+00
                                     0.2591E+01      0.2017E-01
                                     0.4318E+01      0.3908E-01
                                     0.6477E+01      0.7185E-01
                                     0.7772E+01      0.1008E+00
                                     0.8635E+01      0.1261E+00
                                     0.7772E+01      0.2521E+00
                                     0.7772E+01      0.3782E+00
                                     0.7772E+01      0.6303E+00
                                     0.7772E+01      0.2521E+01
    2         10      0.2305E+01
                                     0.0000E+00      0.0000E+00
                                     0.2591E+01      0.2017E-01
                                     0.4318E+01      0.3908E-01
```

```
                                   0.6477E+01      0.7185E-01
                                   0.7772E+01      0.1008E+00
                                   0.8635E+01      0.1261E+00
                                   0.7772E+01      0.2521E+00
                                   0.7772E+01      0.3782E+00
                                   0.7772E+01      0.6303E+00
                                   0.7772E+01      0.2521E+01
3         10      0.4568E+01
                                   0.0000E+00      0.0000E+00
                                   0.2591E+01      0.2017E-01
                                   0.4318E+01      0.3908E-01
                                   0.6477E+01      0.7185E-01
                                   0.7772E+01      0.1008E+00
                                   0.8635E+01      0.1261E+00
                                   0.7772E+01      0.2521E+00
                                   0.7772E+01      0.3782E+00
                                   0.7772E+01      0.6303E+00
                                   0.7772E+01      0.2521E+01
4         10      0.4652E+01
                                   0.0000E+00      0.0000E+00
                                   0.2591E+01      0.2017E-01
                                   0.4318E+01      0.3908E-01
                                   0.6477E+01      0.7185E-01
                                   0.7772E+01      0.1008E+00
                                   0.8635E+01      0.1261E+00
                                   0.8635E+01      0.2521E+00
                                   0.8635E+01      0.3782E+00
                                   0.8635E+01      0.6303E+00
                                   0.8635E+01      0.2521E+01
5         10      0.5360E+01
                                   0.0000E+00      0.0000E+00
                                   0.1813E+01      0.2017E-01
                                   0.3021E+01      0.3908E-01
                                   0.4532E+01      0.7185E-01
                                   0.5438E+01      0.1008E+00
                                   0.6042E+01      0.1261E+00
                                   0.6042E+01      0.2521E+00
                                   0.6042E+01      0.3782E+00
                                   0.6042E+01      0.6303E+00
                                   0.6042E+01      0.2521E+01
6         10      0.6068E+01
                                   0.0000E+00      0.0000E+00
                                   0.4346E+00      0.2017E-01
                                   0.7243E+00      0.3908E-01
                                   0.1086E+01      0.7185E-01
                                   0.1304E+01      0.1008E+00
                                   0.1449E+01      0.1261E+00
                                   0.1449E+01      0.2521E+00
                                   0.1449E+01      0.3782E+00
                                   0.1449E+01      0.6303E+00
```

```
                                       0.1449E+01      0.2521E+01
   7         10       0.6152E+01
                                       0.0000E+00      0.0000E+00
                                       0.4405E+00      0.2017E-01
                                       0.7342E+00      0.3908E-01
                                       0.1101E+01      0.7185E-01
                                       0.1322E+01      0.1008E+00
                                       0.1468E+01      0.1261E+00
                                       0.1468E+01      0.2521E+00
                                       0.1468E+01      0.3782E+00
                                       0.1468E+01      0.6303E+00
                                       0.1468E+01      0.2521E+01
   8         10       0.8360E+01
                                       0.0000E+00      0.0000E+00
                                       0.8408E+00      0.2017E-01
                                       0.1401E+01      0.3908E-01
                                       0.2102E+01      0.7185E-01
                                       0.2522E+01      0.1008E+00
                                       0.2803E+01      0.1261E+00
                                       0.2803E+01      0.2521E+00
                                       0.2803E+01      0.3782E+00
                                       0.2803E+01      0.6303E+00
                                       0.2803E+01      0.2521E+01
   9         10       0.1057E+02
                                       0.0000E+00      0.0000E+00
                                       0.1071E+01      0.2017E-01
                                       0.1784E+01      0.3908E-01
                                       0.2676E+01      0.7185E-01
                                       0.3212E+01      0.1008E+00
                                       0.3569E+01      0.1261E+00
                                       0.3569E+01      0.2521E+00
                                       0.3569E+01      0.3782E+00
                                       0.3569E+01      0.6303E+00
                                       0.3569E+01      0.2521E+01
  10         10       0.1065E+02
                                       0.0000E+00      0.0000E+00
                                       0.1079E+01      0.2017E-01
                                       0.1799E+01      0.3908E-01
                                       0.2698E+01      0.7185E-01
                                       0.3238E+01      0.1008E+00
                                       0.3597E+01      0.1261E+00
                                       0.3238E+01      0.2521E+00
                                       0.3238E+01      0.3782E+00
                                       0.3238E+01      0.6303E+00
                                       0.3238E+01      0.2521E+01
  11         10       0.1436E+02
                                       0.0000E+00      0.0000E+00
                                       0.1568E+02      0.2017E-01
                                       0.2613E+02      0.3908E-01
                                       0.3919E+02      0.7185E-01
```

```
                                    0.4703E+02      0.1008E+00
                                    0.5225E+02      0.1261E+00
                                    0.4703E+02      0.2521E+00
                                    0.4703E+02      0.3782E+00
                                    0.4703E+02      0.6303E+00
                                    0.4703E+02      0.2521E+01
12         10      0.1807E+02
                                    0.0000E+00      0.0000E+00
                                    0.1561E+02      0.2017E-01
                                    0.2601E+02      0.3908E-01
                                    0.3902E+02      0.7185E-01
                                    0.4683E+02      0.1008E+00
                                    0.5203E+02      0.1261E+00
                                    0.4683E+02      0.2521E+00
                                    0.4683E+02      0.3782E+00
                                    0.4683E+02      0.6303E+00
                                    0.4683E+02      0.2521E+01
13         10      0.1815E+02
                                    0.0000E+00      0.0000E+00
                                    0.1553E+02      0.2017E-01
                                    0.2588E+02      0.3908E-01
                                    0.3882E+02      0.7185E-01
                                    0.4658E+02      0.1008E+00
                                    0.5176E+02      0.1261E+00
                                    0.5176E+02      0.2521E+00
                                    0.5176E+02      0.3782E+00
                                    0.5176E+02      0.6303E+00
                                    0.5176E+02      0.2521E+01
14         10      0.1936E+02
                                    0.0000E+00      0.0000E+00
                                    0.1089E+02      0.2017E-01
                                    0.1815E+02      0.3908E-01
                                    0.2723E+02      0.7185E-01
                                    0.3268E+02      0.1008E+00
                                    0.3631E+02      0.1261E+00
                                    0.3631E+02      0.2521E+00
                                    0.3631E+02      0.3782E+00
                                    0.3631E+02      0.6303E+00
                                    0.3631E+02      0.2521E+01
15         10      0.2057E+02
                                    0.0000E+00      0.0000E+00
                                    0.4242E+01      0.2017E-01
                                    0.7070E+01      0.3908E-01
                                    0.1060E+02      0.7185E-01
                                    0.1273E+02      0.1008E+00
                                    0.1414E+02      0.1261E+00
                                    0.1414E+02      0.2521E+00
                                    0.1414E+02      0.3782E+00
                                    0.1414E+02      0.6303E+00
                                    0.1414E+02      0.2521E+01
```

```
16         10      0.2065E+02
                                    0.0000E+00      0.0000E+00
                                    0.4260E+01      0.2017E-01
                                    0.7101E+01      0.3908E-01
                                    0.1065E+02      0.7185E-01
                                    0.1278E+02      0.1008E+00
                                    0.1420E+02      0.1261E+00
                                    0.1278E+02      0.2521E+00
                                    0.1278E+02      0.3782E+00
                                    0.1278E+02      0.6303E+00
                                    0.1278E+02      0.2521E+01
17         10      0.2561E+02
                                    0.0000E+00      0.0000E+00
                                    0.1967E+02      0.2017E-01
                                    0.3278E+02      0.3908E-01
                                    0.4918E+02      0.7185E-01
                                    0.5901E+02      0.1008E+00
                                    0.6557E+02      0.1261E+00
                                    0.5901E+02      0.2521E+00
                                    0.5901E+02      0.3782E+00
                                    0.5901E+02      0.6303E+00
                                    0.5901E+02      0.2521E+01
18         10      0.3057E+02
                                    0.0000E+00      0.0000E+00
                                    0.1942E+02      0.2017E-01
                                    0.3236E+02      0.3908E-01
                                    0.4854E+02      0.7185E-01
                                    0.5825E+02      0.1008E+00
                                    0.6472E+02      0.1261E+00
                                    0.5825E+02      0.2521E+00
                                    0.5825E+02      0.3782E+00
                                    0.5825E+02      0.6303E+00
                                    0.5825E+02      0.2521E+01
19         10      0.3065E+02
                                    0.0000E+00      0.0000E+00
                                    0.1938E+02      0.2017E-01
                                    0.3230E+02      0.3908E-01
                                    0.4845E+02      0.7185E-01
                                    0.5814E+02      0.1008E+00
                                    0.6460E+02      0.1261E+00
                                    0.5814E+02      0.2521E+00
                                    0.5814E+02      0.3782E+00
                                    0.5814E+02      0.6303E+00
                                    0.5814E+02      0.2521E+01
20         10      0.3111E+02
                                    0.0000E+00      0.0000E+00
                                    0.1875E+02      0.2017E-01
                                    0.3125E+02      0.3908E-01
                                    0.4688E+02      0.7185E-01
                                    0.5626E+02      0.1008E+00
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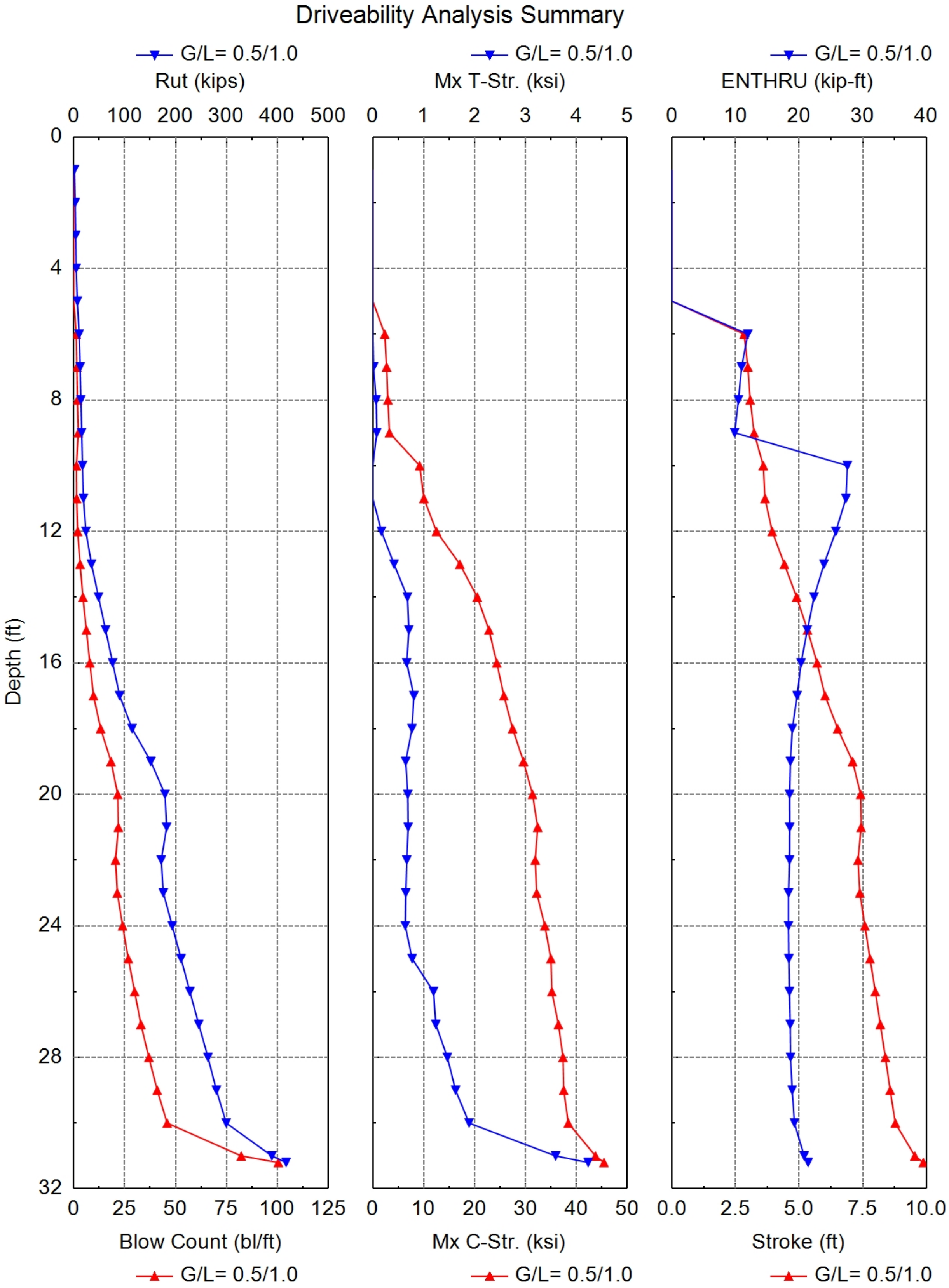
```
                                    0.6251E+02      0.1261E+00
                                    0.5626E+02      0.2521E+00
                                    0.5626E+02      0.3782E+00
                                    0.5626E+02      0.6303E+00
                                    0.5626E+02      0.2521E+01
21         10      0.3157E+02
                                    0.0000E+00      0.0000E+00
                                    0.1679E+02      0.2017E-01
                                    0.2798E+02      0.3908E-01
                                    0.4197E+02      0.7185E-01
                                    0.5037E+02      0.1008E+00
                                    0.5596E+02      0.1261E+00
                                    0.5037E+02      0.2521E+00
                                    0.5037E+02      0.3782E+00
                                    0.5037E+02      0.6303E+00
                                    0.5037E+02      0.2521E+01
22         10      0.3165E+02
                                    0.0000E+00      0.0000E+00
                                    0.1643E+02      0.2017E-01
                                    0.2739E+02      0.3908E-01
                                    0.4108E+02      0.7185E-01
                                    0.4930E+02      0.1008E+00
                                    0.5477E+02      0.1261E+00
                                    0.4930E+02      0.2521E+00
                                    0.4930E+02      0.3782E+00
                                    0.4930E+02      0.6303E+00
                                    0.4930E+02      0.2521E+01
23         10      0.3641E+02
                                    0.0000E+00      0.0000E+00
                                    0.2660E+03      0.2017E-01
                                    0.4434E+03      0.3908E-01
                                    0.6650E+03      0.7185E-01
                                    0.7981E+03      0.1008E+00
                                    0.8867E+03      0.1261E+00
                                    0.7981E+03      0.2521E+00
                                    0.7981E+03      0.3782E+00
                                    0.7981E+03      0.6303E+00
                                    0.7981E+03      0.2521E+01
24         10      0.4117E+02
                                    0.0000E+00      0.0000E+00
                                    0.2660E+03      0.2017E-01
                                    0.4434E+03      0.3908E-01
                                    0.6650E+03      0.7185E-01
                                    0.7981E+03      0.1008E+00
                                    0.8867E+03      0.1261E+00
                                    0.7981E+03      0.2521E+00
                                    0.7981E+03      0.3782E+00
                                    0.7981E+03      0.6303E+00
                                    0.7981E+03      0.2521E+01
```

```
  TIP   LOAD        TIP MOVEMENT
      KIP               IN.

  0.0000E+00          0.0000E+00
  0.1931E+02          0.6303E-02
  0.3862E+02          0.1261E-01
  0.7724E+02          0.2521E-01
  0.1545E+03          0.1639E+00
  0.2317E+03          0.5294E+00
  0.2780E+03          0.9202E+00
  0.3089E+03          0.1261E+01
  0.3089E+03          0.1891E+01
  0.3089E+03          0.2521E+01



                 LOAD VERSUS SETTLEMENT CURVE
                 ****************************



  TOP  LOAD      TOP MOVEMENT       TIP  LOAD      TIP MOVEMENT
     KIP              IN.              KIP             IN.
 0.4092E+01       0.2702E-02      0.3064E+00      0.1000E-03
 0.4365E+02       0.2854E-01      0.3064E+01      0.1000E-02
 0.1887E+03       0.1330E+00      0.1532E+02      0.5000E-02
 0.3088E+03       0.2335E+00      0.3064E+02      0.1000E-01
 0.4565E+03       0.3754E+00      0.6127E+02      0.2000E-01
 0.5887E+03       0.5410E+00      0.9104E+02      0.5000E-01
 0.6481E+03       0.6359E+00      0.1078E+03      0.8000E-01
 0.6711E+03       0.6825E+00      0.1189E+03      0.1000E+00
 0.6969E+03       0.8169E+00      0.1621E+03      0.2000E+00
 0.7561E+03       0.1186E+01      0.2255E+03      0.5000E+00
 0.7944E+03       0.1531E+01      0.2638E+03      0.8000E+00
 0.8159E+03       0.1756E+01      0.2853E+03      0.1000E+01
 0.8396E+03       0.2784E+01      0.3089E+03      0.2000E+01
```


Driveability Analysis Summary
G/L= 0.5/1.0
Rut (kips)
0 100 200 300 400 500
G/L= 0.5/1.0
Mx T-Str. (ksi)
0 1 2 3 4 5
G/L= 0.5/1.0
ENTHRU (kip-ft)
0 10 20 30 40
Depth (ft)
0 4 8 12 16 20 24 28 32
0 25 50 75 100 125
Blow Count (bl/ft)
G/L= 0.5/1.0
0 10 20 30 40 50
Mx C-Str. (ksi)
G/L= 0.5/1.0
0.0 2.5 5.0 7.5 10.0
Stroke (ft)
G/L= 0.5/1.0

Gain/Loss Factor at Shaft/Toe = 0.500/1.000

Depth ft	Rut kips	Rshaft kips	Rtoe kips	Blow Ct bl/ft	Mx C-Str ksi	Mx T-Str. ksi	Stroke ft	ENTHRU kip-ft	Hammer -
1.0	1.1	0.5	0.6	0.3	0.000	0.000	10.81	0.0	D 19-42
2.0	2.7	1.5	1.2	0.3	0.000	0.000	10.81	0.0	D 19-42
3.0	3.8	2.6	1.2	0.3	0.000	0.000	10.81	0.0	D 19-42
4.0	4.7	3.6	1.1	0.0	0.000	0.000	0.00	0.0	D 19-42
5.0	7.0	5.9	1.1	0.0	0.000	0.000	0.00	0.0	D 19-42
6.0	10.5	9.1	1.4	1.2	2.334	0.000	2.84	11.9	D 19-42
7.0	12.5	10.5	2.0	1.5	2.698	0.015	2.98	10.9	D 19-42
8.0	14.0	11.2	2.8	1.8	2.949	0.064	3.08	10.5	D 19-42
9.0	15.5	12.0	3.5	2.2	3.256	0.077	3.23	9.9	D 19-42
10.0	17.2	13.0	4.2	1.3	9.194	0.000	3.59	27.6	D 19-42
11.0	19.0	14.0	5.0	1.4	10.041	0.000	3.66	27.4	D 19-42
12.0	23.8	18.1	5.7	1.9	12.501	0.168	3.94	25.8	D 19-42
13.0	34.8	28.7	6.1	3.1	17.095	0.417	4.42	23.9	D 19-42
14.0	48.7	42.6	6.1	4.5	20.527	0.679	4.90	22.3	D 19-42
15.0	62.5	56.4	6.1	6.2	22.825	0.708	5.33	21.3	D 19-42
16.0	76.4	70.3	6.1	7.9	24.358	0.666	5.71	20.3	D 19-42
17.0	90.2	84.1	6.1	9.7	25.756	0.807	6.02	19.7	D 19-42
18.0	114.6	98.0	16.6	13.2	27.470	0.769	6.51	18.9	D 19-42
19.0	151.4	116.6	34.8	18.3	29.601	0.646	7.10	18.6	D 19-42
20.0	179.3	136.1	43.2	21.6	31.383	0.687	7.42	18.5	D 19-42
21.0	182.6	145.8	36.8	21.9	32.395	0.694	7.44	18.5	D 19-42
22.0	172.0	152.2	19.8	20.5	31.913	0.667	7.31	18.5	D 19-42
23.0	176.1	166.1	10.0	21.4	32.205	0.648	7.38	18.3	D 19-42
24.0	193.6	183.6	10.0	24.0	33.801	0.638	7.58	18.3	D 19-42
25.0	210.9	200.9	10.0	26.8	34.999	0.772	7.79	18.4	D 19-42
26.0	228.2	218.2	10.0	29.9	35.181	1.192	8.00	18.5	D 19-42
27.0	245.7	235.7	10.0	33.0	36.474	1.237	8.19	18.6	D 19-42
28.0	263.8	253.8	10.0	36.9	37.380	1.465	8.39	18.6	D 19-42
29.0	280.4	270.4	10.0	41.0	37.518	1.626	8.58	18.9	D 19-42
30.0	299.7	287.7	12.0	45.9	38.421	1.891	8.78	19.3	D 19-42
31.0	389.4	309.6	79.8	82.3	43.757	3.592	9.55	20.8	D 19-42
31.2	417.4	314.6	102.9	100.5	45.428	4.232	9.88	21.4	D 19-42

Total driving time: 11 minutes; Total Number of Blows: 457 (starting at penetration 1.0 ft)

GRLWEAP: Wave Equation Analysis of Pile Foundations

PAU-TR33-04.75 + HP10x42 RA 11/17/2024
CTL ENGINEERING, INC. GRLWEAP 14.1.20.1

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity-blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of structure and other factors.

PILE INPUT

Uniform Pile		Pile Type:	H Pile
Pile Length: (ft)	40.000	Pile Penetration: (ft)	31.200
Pile Size: (ft)	0.84	Toe Area: (in²)	12.40

Pile Profile

Lb Top	X-Area	E-Modulus	Spec. Wt	Perim.	Crit. Index
ft	in²	ksi	lb/ft³	ft	-
0.0	12.4	30,000.0	492.0	3.3	0
40.0	12.4	30,000.0	492.0	3.3	0

HAMMER INPUT

ID	41	Made By:	DELMAG
Model	D 19-42	Type:	OED

Hammer Data

ID	Ram Wt	Ram L.	Ram Ar.	Rtd. Stk	Effic.	Rtd. Energy
-	kips	in	in²	ft	-	kip-ft
41	4.000	129.1	124.7	10.8	0.80	43.2

DRIVE SYSTEM FOR DELMAG D 19-42-OED

Type	X-Area	E-Modulus	Thickness	COR	Round-out	Stiffness
-	in²	ksi	in	-	in	kips/in
Hammer C.	227.000	530.000	2.000	0.800	0.120	60155.550
Helmet Wt.	1.900	kips				

SOIL RESISTANCE DISTRIBUTION

Depth	Unit Rs	Unit Rt	Qs	Qt	Js	Jt	Set. F.	Limit D.	Set. T.	EB Area
ft	ksf	ksf	in	in	s/ft	s/ft	-	ft	Hours	in²
0.0	0.0	7.0	0.10	0.11	0.20	0.15	2.0	6.0	168.0	12.4
1.0	0.6	7.0	0.10	0.11	0.20	0.15	2.0	6.0	168.0	12.4
2.0	0.6	13.9	0.10	0.11	0.20	0.15	2.0	6.0	168.0	12.4
3.0	0.6	13.9	0.10	0.11	0.20	0.15	2.0	6.0	168.0	12.4
4.0	0.6	12.8	0.10	0.11	0.20	0.15	2.0	6.0	168.0	12.4
5.0	1.2	12.8	0.10	0.16	0.05	0.15	1.0	6.0	1.0	12.4
6.0	0.7	16.3	0.10	0.16	0.05	0.15	1.0	6.0	1.0	12.4
7.0	0.2	23.2	0.10	0.12	0.10	0.15	1.2	6.0	24.0	12.4
8.0	0.3	32.5	0.10	0.12	0.10	0.15	1.2	6.0	24.0	12.4
9.0	0.3	40.6	0.10	0.12	0.10	0.15	1.2	6.0	24.0	12.4
10.0	0.4	48.8	0.10	0.12	0.10	0.15	1.2	6.0	24.0	12.4

11.0	0.3	58.1	0.10	0.08	0.15	0.15	1.2	6.0	168.0	12.4
12.0	2.7	66.2	0.10	0.08	0.15	0.15	1.2	6.0	168.0	12.4
13.0	5.0	70.8	0.10	0.08	0.15	0.15	1.2	6.0	168.0	12.4
14.0	5.1	70.8	0.10	0.08	0.15	0.15	1.2	6.0	168.0	12.4
15.0	5.0	70.8	0.10	0.08	0.15	0.15	1.2	6.0	168.0	12.4
16.0	5.0	70.8	0.10	0.08	0.15	0.15	1.2	6.0	168.0	12.4
17.0	5.1	70.8	0.10	0.08	0.15	0.15	1.2	6.0	168.0	12.4
18.0	5.0	192.8	0.10	0.08	0.15	0.15	1.2	6.0	168.0	12.4
19.0	7.3	404.1	0.10	0.08	0.05	0.15	1.0	6.0	1.0	12.4
20.0	4.5	501.7	0.10	0.08	0.05	0.15	1.0	6.0	1.0	12.4
21.0	1.4	427.4	0.10	0.08	0.15	0.15	1.2	6.0	168.0	12.4
22.0	3.8	229.9	0.10	0.08	0.15	0.15	1.2	6.0	168.0	12.4
23.0	6.3	116.1	0.10	0.08	0.15	0.15	1.2	6.0	168.0	12.4
24.0	6.3	116.1	0.10	0.08	0.15	0.15	1.2	6.0	168.0	12.4
25.0	6.3	116.1	0.10	0.08	0.15	0.15	1.2	6.0	168.0	12.4
26.0	6.3	116.1	0.10	0.08	0.15	0.15	1.2	6.0	168.0	12.4
27.0	6.3	116.1	0.10	0.08	0.15	0.15	1.2	6.0	168.0	12.4
28.0	6.3	116.1	0.10	0.08	0.15	0.15	1.2	6.0	168.0	12.4
29.0	6.3	116.1	0.10	0.08	0.15	0.15	1.2	6.0	168.0	12.4
30.0	6.3	139.4	0.10	0.08	0.15	0.15	1.2	6.0	168.0	12.4
31.0	9.3	926.7	0.10	0.07	0.20	0.15	1.3	6.0	24.0	12.4
32.0	8.2	2265.7	0.10	0.04	0.20	0.15	1.0	6.0	24.0	12.4
33.0	67.4	3587.2	0.10	0.04	0.20	0.15	1.0	6.0	24.0	12.4

Summary Of Pile Design
PAU-TR33-04.75
Pier 1 - HP 12x53

Bottom of Pile Cap Elevation =	744.74	ft	(Estimated from Site Plan, Undated)
Resistance Factor for Driven Piles to Bedrock =	0.5		(ODOT BDM C305.3.3)
Maximum Factored Structural Resistance =	380.0	kips/pile	(ODOT BDM C305.3.3)
Scour Depth (from Bottom of Footing El.)=	0.0	ft	(Assumed)
Pile Stick-up Length =	1.5	ft	(ODOT BDM Section 305.3.5.1)
Pile Length =	34.0	ft	(From APile Analysis)
Estimated Pile Length =	40.0	ft	(ODOT BDM 305.3.5.2)
Order Length =	45.0	ft	(ODOT BDM 305.3.5.2)
Pile Tip Elevation =	710.7	ft	(Estimated Elevation of Coreable Rock)

Soil Parameters

Project: PAU-TR33-04.75
Location: Pier 1
Boring No.: B-001-0-24
Date: 3/12/25
Ground Surface Elevation: 735.00
Bottom of Pile Cap Elevation: 744.74

								Total Stress			
Layer No.	Top Elev	Bottom Elev	Thickness (feet)	Type	ODOT	N_{60} value (bpf)	Total Weight (pcf)	Cohesion (psf)	Friction Angle (degrees)	Apile Reduction Factor	Reference
1	735.0	730.5	4.5	Granular	A-2-4	15	125				
						19	125	LRFD	34.25		
								ODOT CF	0.5		
			Avg			17	125	0	34	0.83	3
2	730.5	723.0	7.5	Cohesive	A-4a	48	135				
						98	140				
						52	140				
			Avg			66	138	7823	0	0.67	2, 4
3	723.0	720.5	2.5	Granular	A-1-b	103	140				
								LRFD	48.45		
								ODOT CF	1.5		
			Avg			103	140	0	49	1	3
4	720.5	711.3	9.2	Cohesive	A-4a	132	140				
						132	140				
						62	140				
						529	140				
			Avg			109	140	12905	0	0.67	2, 4
5	711.3	710.7	0.6	Rock	Dolomite	529	150	Q_u (ksf)			
								=			
								38.9			
			Avg			529	150	27991	0	---	4, 5
6	710.7	700.7	10	Rock	Dolomite		163.7	Qu			
							167.7	=			
								6,690 psi			
			Avg				166	481680	0	---	5

Reference Key

1 Cohesive Soils - Total Stress Cohesion estimated as 125 x average N-Value - according to ODOT GDM Section 404.1.

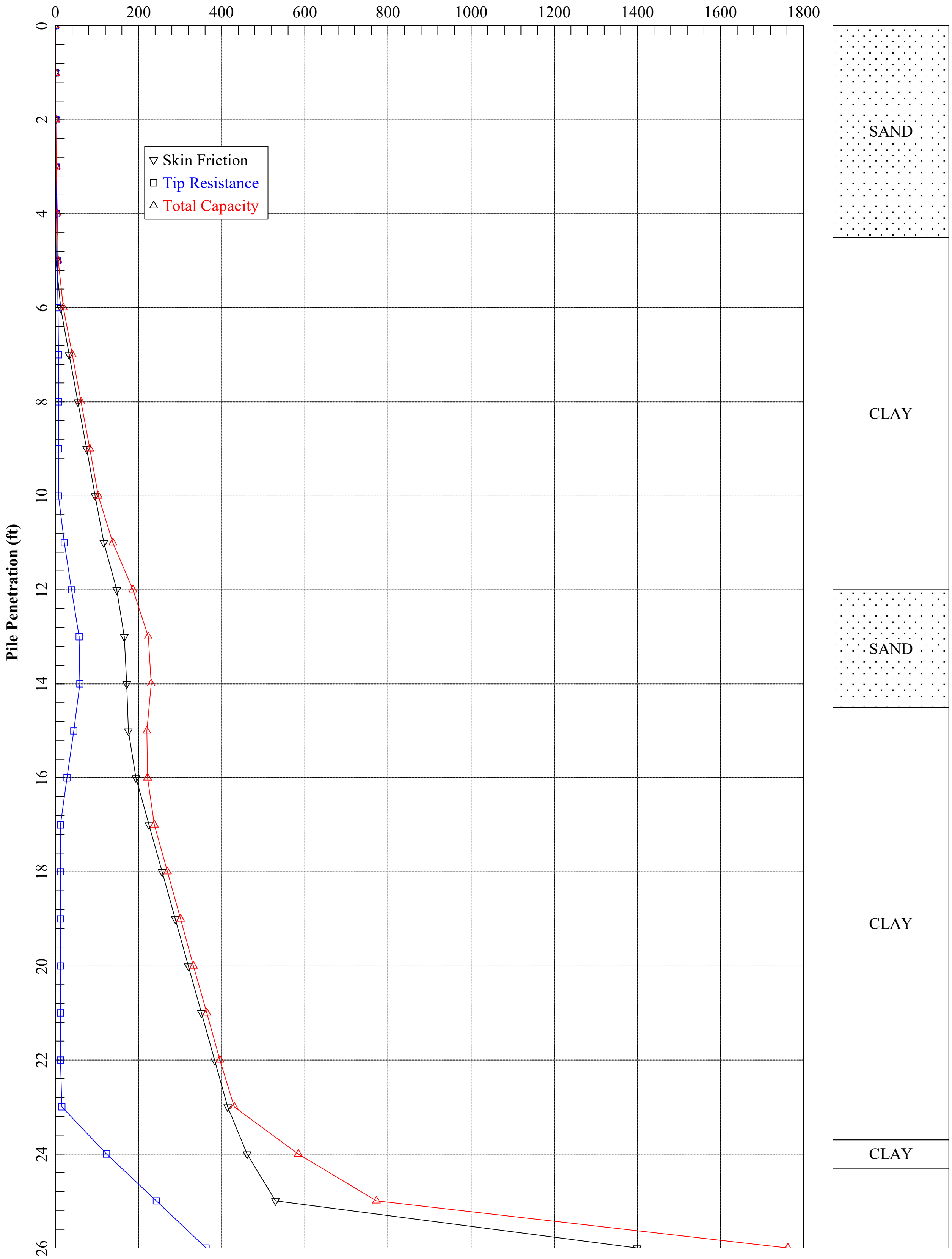
2 Cohesive Soils - Total Stess Friction Angle estimated to be 0.

3 Granular soils - Friction angle estimated using N-value & soil type according ODOT GDM Section 404.2.

4 Total Stress Cohesion estimated as (f_1 x N_{60} x P_a)/100 - according to ODOT GDM Section 404.1.

5 Rock Cohesion equals Undrained Shear Strength, which equals one-half the unconfined compressive strength (Q_u).

24050001WAP Pier 1 (B-001-0-24) APile Analysis
Axial Capacity (kips)



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     =========================================================================

                      APILE for Windows, Version 2019.9.11

                       Serial Number :  136084177

                       A Program for Analyzing the Axial Capacity
                       and Short-term Settlement of Driven Piles
                                 under Axial Loading.
                     (c) Copyright ENSOFT, Inc., 1987-2019
                           All Rights Reserved

     =========================================================================


     This program is licensed to :

     CTL Engineering, Inc.
     Cincinnati, OH

     Path to file locations      : O:\PROJECT\2024\WAP-05\24050001WAP_Bockrath and
Associates Engineering and Surveying LLC_PAU-TR33-4-75 Bridge over Flat Rock Creek-
PID 113849\Calcs\Pile\Pier 1 (B-001-0-24)\APile\
     Name of input data file     : 24050001WAP_Pier 1_APile Analysis.ap9d
     Name of output file         : 24050001WAP_Pier 1_APile Analysis.ap9o
     Name of plot output file    : 24050001WAP_Pier 1_APile Analysis.ap9p

     -------------------------------------------------------------------------
                          Time and Date of Analysis
     -------------------------------------------------------------------------

               Date:  October 21, 2024     Time:  13:34:19



1
          *********************
          * INPUT INFORMATION *
          *********************



          PAU-TR33-04.75_Pier 1 (B-001-0-24)

          DESIGNER   : CTL Engineering, Inc.

          JOB NUMBER : 24050001WAP


          METHOD FOR UNIT LOAD TRANSFERS :
```

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- FHWA (Federal Highway Administration)
  Unfactored Unit Side Friction and Unit Side Resistance are used.



COMPUTATION METHOD(S) FOR PILE CAPACITY :

- FHWA (Federal Highway Administration)


TYPE OF LOADING :
- COMPRESSION


PILE TYPE :

H-Pile/Steel Pile


DATA FOR AXIAL STIFFNESS :

- MODULUS OF ELASTICITY     = 0.290E+08 PSI
- CROSS SECTION AREA        =     15.50 IN2


NONCIRCULAR PILE PROPERTIES :

- TOTAL PILE LENGTH, TL     =     28.00 FT.
- BATTER ANGLE              =      0.00 DEG
- PILE STICKUP LENGTH, PSL  =      1.50 FT.
- ZERO FRICTION LENGTH, ZFL =      0.00 FT.
- PERIMETER OF PILE         =     47.60 IN.
- TIP AREA OF PILE          =     15.50 IN2
- INCREMENT OF PILE LENGTH
  USED IN COMPUTATION       =      1.00 FT.



SOIL INFORMATIONS :



                  LATERAL    EFFECTIVE    FRICTION      Nq
          SOIL    EARTH      UNIT         ANGLE       FACTOR
 DEPTH    TYPE    PRESSURE   WEIGHT       DEGREES      FHWA
  FT.                        LB/FT^3
   0.00   SAND      0.80*      125.00        34.00     55.60**
   4.50   SAND      0.80*      125.00        34.00     55.60**
   4.50   CLAY      0.80*      138.00         0.00      4.80**
```

```
  12.00   CLAY      0.80*      138.00         0.00      4.80**
  12.00   SAND      0.80*      140.00        49.00    475.00**
  14.50   SAND      0.80*      140.00        49.00    475.00**
  14.50   CLAY      0.80*      140.00         0.00      4.80**
  23.70   CLAY      0.80*      140.00         0.00      4.80**
  23.70   CLAY      0.80*      150.00         0.00      4.80**
  24.30   CLAY      0.80*    19467.00         0.00      4.80**
  24.30   CLAY      0.80*      166.00         0.00      4.80**
  34.30   CLAY      0.80*      166.00         0.00      4.80**

*  VALUE ASSUMED BY THE PROGRAM
** VALUE ESTIMATED BY THE PROGRAM BASED ON FRICTION ANGLE



MAXIMUM   MAXIMUM   UNDISTURB  REMOLDED
UNIT      UNIT      SHEAR      SHEAR     BLOW   UNIT SKIN  UNIT END
FRICTION  BEARING   STRENGTH   STRENGTH  COUNT  FRICTION   BEARING
  KSF       KSF        KSF       KSF               KSF        KSF
0.10E+08* 0.10E+08*       0.00      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       0.00      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       7.82      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       7.82      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       0.00      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       0.00      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*      12.90      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*      12.90      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*      19.47      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*      27.99      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*     481.68      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*     481.68      0.00   0.00       0.00      0.00

* MAXIMUM UNIT FRICTION AND/OR MAXIMUM UNIT BEARING
  WERE SET TO BE 0.10E+08 BECAUSE THE USER DOES NOT
  PLAN TO LIMIT THE COMPUTED DATA.



         LRFD FACTOR  LRFD FACTOR
          ON UNIT      ON UNIT
 DEPTH    FRICTION     BEARING
  FT.
   0.00    0.830       1.000
   4.50    0.830       1.000
   4.50    0.670       1.000
  12.00    0.670       1.000
  12.00    1.000       1.000
  14.50    1.000       1.000
  14.50    0.670       1.000
  23.70    0.670       1.000
```

```
            23.70    1.000       1.000
            24.30    1.000       1.000
            24.30    1.000       1.000
            34.30    1.000       1.000


1
          **********************
          * COMPUTATION RESULT *
          **********************


                            **********************
                            *  FED. HWY. METHOD  *
                            **********************

             PILE          SKIN          END       ULTIMATE
          PENETRATION   FRICTION       BEARING     CAPACITY
              FT.          KIP           KIP          KIP
              0.00           0.0           0.2          0.2
              1.00           0.1           0.5          0.6
              2.00           0.3           1.0          1.3
              3.00           0.8           1.5          2.3
              4.00           1.4           3.1          4.5
              5.00           2.0           4.8          6.8
              6.00          12.7           6.3         19.1
              7.00          33.5           7.6         41.1
              8.00          54.3           7.6         61.9
              9.00          75.1           7.6         82.7
             10.00          95.9           7.6        103.5
             11.00         116.7          21.8        138.5
             12.00         147.7          39.0        186.8
             13.00         166.0          57.5        223.6
             14.00         171.8          59.1        230.9
             15.00         176.0          44.3        220.3
             16.00         193.9          28.0        221.9
             17.00         225.5          12.5        238.0
             18.00         257.0          12.5        269.5
             19.00         288.5          12.5        301.0
             20.00         320.0          12.5        332.5
             21.00         351.6          12.5        364.1
             22.00         383.1          12.5        395.6
             23.00         414.6          15.6        430.2
             24.00         461.2         123.1        584.3
             25.00         529.3         243.0        772.2
             26.00        1399.6         362.5       1762.1
```

```
    NOTES:
    - AN ASTERISK IS PLACED IN THE END-BEARING COLUMN
      IF THE TIP RESISTANCE IS CONTROLLED BY THE FRICTION
      OF SOIL PLUG INSIDE AN OPEN-ENDED PIPE PILE.



        *************************************************
        * COMPUTE LOAD-DISTRIBUTION AND LOAD-SETTLEMENT *
        * CURVES FOR AXIAL LOADING                      *
        *************************************************


T-Z CURVE   NO. OF   DEPTH TO CURVE   LOAD TRANSFER   PILE MOVEMENT
   NO.      POINTS        FT.              PSI             IN.

    1         10      0.4167E-01
                                       0.0000E+00      0.0000E+00
                                       0.4542E-02      0.2424E-01
                                       0.7570E-02      0.4697E-01
                                       0.1135E-01      0.8636E-01
                                       0.1363E-01      0.1212E+00
                                       0.1514E-01      0.1515E+00
                                       0.1514E-01      0.3030E+00
                                       0.1514E-01      0.4545E+00
                                       0.1514E-01      0.7576E+00
                                       0.1514E-01      0.3030E+01
    2         10      0.2250E+01
                                       0.0000E+00      0.0000E+00
                                       0.2453E+00      0.2424E-01
                                       0.4088E+00      0.4697E-01
                                       0.6131E+00      0.8636E-01
                                       0.7358E+00      0.1212E+00
                                       0.8175E+00      0.1515E+00
                                       0.8175E+00      0.3030E+00
                                       0.8175E+00      0.4545E+00
                                       0.8175E+00      0.7576E+00
                                       0.8175E+00      0.3030E+01
    3         10      0.4458E+01
                                       0.0000E+00      0.0000E+00
                                       0.4860E+00      0.2424E-01
                                       0.8100E+00      0.4697E-01
                                       0.1215E+01      0.8636E-01
                                       0.1458E+01      0.1212E+00
                                       0.1620E+01      0.1515E+00
                                       0.1620E+01      0.3030E+00
                                       0.1620E+01      0.4545E+00
                                       0.1620E+01      0.7576E+00
                                       0.1620E+01      0.3030E+01
    4         10      0.4542E+01
```

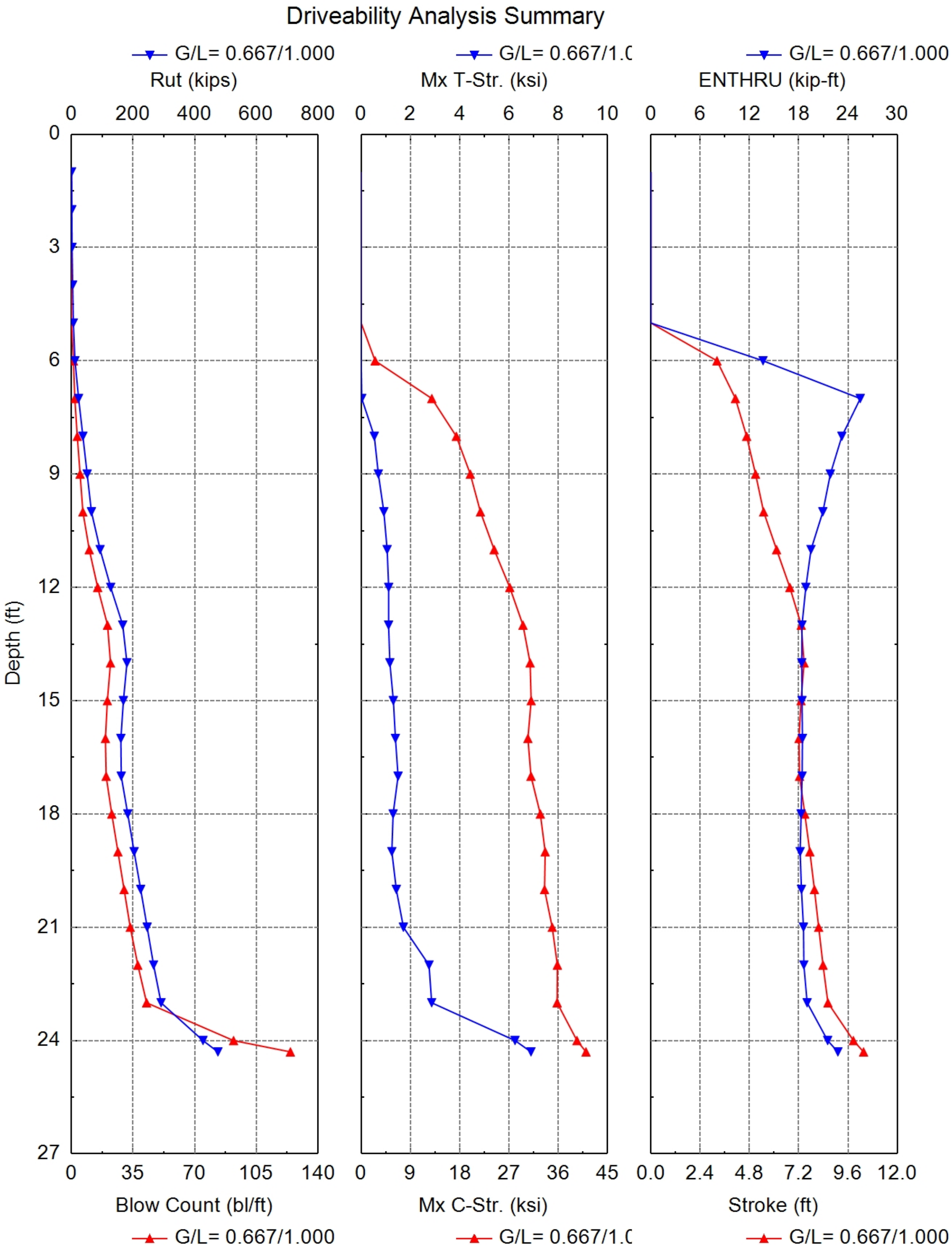
```
                                   0.0000E+00      0.0000E+00
                                   0.4951E+00      0.2424E-01
                                   0.8251E+00      0.4697E-01
                                   0.1238E+01      0.8636E-01
                                   0.1485E+01      0.1212E+00
                                   0.1650E+01      0.1515E+00
                                   0.1485E+01      0.3030E+00
                                   0.1485E+01      0.4545E+00
                                   0.1485E+01      0.7576E+00
                                   0.1485E+01      0.3030E+01
5         10      0.8250E+01
                                   0.0000E+00      0.0000E+00
                                   0.1630E+02      0.2424E-01
                                   0.2716E+02      0.4697E-01
                                   0.4074E+02      0.8636E-01
                                   0.4889E+02      0.1212E+00
                                   0.5433E+02      0.1515E+00
                                   0.4889E+02      0.3030E+00
                                   0.4889E+02      0.4545E+00
                                   0.4889E+02      0.7576E+00
                                   0.4889E+02      0.3030E+01
6         10      0.1196E+02
                                   0.0000E+00      0.0000E+00
                                   0.1630E+02      0.2424E-01
                                   0.2716E+02      0.4697E-01
                                   0.4074E+02      0.8636E-01
                                   0.4889E+02      0.1212E+00
                                   0.5433E+02      0.1515E+00
                                   0.4889E+02      0.3030E+00
                                   0.4889E+02      0.4545E+00
                                   0.4889E+02      0.7576E+00
                                   0.4889E+02      0.3030E+01
7         10      0.1204E+02
                                   0.0000E+00      0.0000E+00
                                   0.1574E+02      0.2424E-01
                                   0.2623E+02      0.4697E-01
                                   0.3935E+02      0.8636E-01
                                   0.4722E+02      0.1212E+00
                                   0.5247E+02      0.1515E+00
                                   0.5247E+02      0.3030E+00
                                   0.5247E+02      0.4545E+00
                                   0.5247E+02      0.7576E+00
                                   0.5247E+02      0.3030E+01
8         10      0.1325E+02
                                   0.0000E+00      0.0000E+00
                                   0.2980E+01      0.2424E-01
                                   0.4967E+01      0.4697E-01
                                   0.7451E+01      0.8636E-01
                                   0.8941E+01      0.1212E+00
                                   0.9934E+01      0.1515E+00
```

```
                                   0.9934E+01      0.3030E+00
                                   0.9934E+01      0.4545E+00
                                   0.9934E+01      0.7576E+00
                                   0.9934E+01      0.3030E+01
 9          10      0.1446E+02
                                   0.0000E+00      0.0000E+00
                                   0.3266E+01      0.2424E-01
                                   0.5443E+01      0.4697E-01
                                   0.8164E+01      0.8636E-01
                                   0.9797E+01      0.1212E+00
                                   0.1089E+02      0.1515E+00
                                   0.1089E+02      0.3030E+00
                                   0.1089E+02      0.4545E+00
                                   0.1089E+02      0.7576E+00
                                   0.1089E+02      0.3030E+01
10          10      0.1454E+02
                                   0.0000E+00      0.0000E+00
                                   0.3285E+01      0.2424E-01
                                   0.5476E+01      0.4697E-01
                                   0.8213E+01      0.8636E-01
                                   0.9856E+01      0.1212E+00
                                   0.1095E+02      0.1515E+00
                                   0.9856E+01      0.3030E+00
                                   0.9856E+01      0.4545E+00
                                   0.9856E+01      0.7576E+00
                                   0.9856E+01      0.3030E+01
11          10      0.1910E+02
                                   0.0000E+00      0.0000E+00
                                   0.2472E+02      0.2424E-01
                                   0.4119E+02      0.4697E-01
                                   0.6179E+02      0.8636E-01
                                   0.7415E+02      0.1212E+00
                                   0.8239E+02      0.1515E+00
                                   0.7415E+02      0.3030E+00
                                   0.7415E+02      0.4545E+00
                                   0.7415E+02      0.7576E+00
                                   0.7415E+02      0.3030E+01
12          10      0.2366E+02
                                   0.0000E+00      0.0000E+00
                                   0.2437E+02      0.2424E-01
                                   0.4061E+02      0.4697E-01
                                   0.6092E+02      0.8636E-01
                                   0.7310E+02      0.1212E+00
                                   0.8122E+02      0.1515E+00
                                   0.7310E+02      0.3030E+00
                                   0.7310E+02      0.4545E+00
                                   0.7310E+02      0.7576E+00
                                   0.7310E+02      0.3030E+01
13          10      0.2374E+02
                                   0.0000E+00      0.0000E+00
```

```
                                    0.2432E+02      0.2424E-01
                                    0.4054E+02      0.4697E-01
                                    0.6081E+02      0.8636E-01
                                    0.7297E+02      0.1212E+00
                                    0.8107E+02      0.1515E+00
                                    0.7297E+02      0.3030E+00
                                    0.7297E+02      0.4545E+00
                                    0.7297E+02      0.7576E+00
                                    0.7297E+02      0.3030E+01
14         10      0.2420E+02
                                    0.0000E+00      0.0000E+00
                                    0.2881E+02      0.2424E-01
                                    0.4802E+02      0.4697E-01
                                    0.7202E+02      0.8636E-01
                                    0.8643E+02      0.1212E+00
                                    0.9603E+02      0.1515E+00
                                    0.8643E+02      0.3030E+00
                                    0.8643E+02      0.4545E+00
                                    0.8643E+02      0.7576E+00
                                    0.8643E+02      0.3030E+01
15         10      0.2466E+02
                                    0.0000E+00      0.0000E+00
                                    0.3941E+02      0.2424E-01
                                    0.6568E+02      0.4697E-01
                                    0.9852E+02      0.8636E-01
                                    0.1182E+03      0.1212E+00
                                    0.1314E+03      0.1515E+00
                                    0.1182E+03      0.3030E+00
                                    0.1182E+03      0.4545E+00
                                    0.1182E+03      0.7576E+00
                                    0.1182E+03      0.3030E+01
16         10      0.2474E+02
                                    0.0000E+00      0.0000E+00
                                    0.4134E+02      0.2424E-01
                                    0.6889E+02      0.4697E-01
                                    0.1033E+03      0.8636E-01
                                    0.1240E+03      0.1212E+00
                                    0.1378E+03      0.1515E+00
                                    0.1240E+03      0.3030E+00
                                    0.1240E+03      0.4545E+00
                                    0.1240E+03      0.7576E+00
                                    0.1240E+03      0.3030E+01
17         10      0.2950E+02
                                    0.0000E+00      0.0000E+00
                                    0.8669E+03      0.2424E-01
                                    0.1445E+04      0.4697E-01
                                    0.2167E+04      0.8636E-01
                                    0.2601E+04      0.1212E+00
                                    0.2890E+04      0.1515E+00
                                    0.2601E+04      0.3030E+00
```

```
                                         0.2601E+04      0.4545E+00
                                         0.2601E+04      0.7576E+00
                                         0.2601E+04      0.3030E+01
    18          10      0.3426E+02
                                         0.0000E+00      0.0000E+00
                                         0.8669E+03      0.2424E-01
                                         0.1445E+04      0.4697E-01
                                         0.2167E+04      0.8636E-01
                                         0.2601E+04      0.1212E+00
                                         0.2890E+04      0.1515E+00
                                         0.2601E+04      0.3030E+00
                                         0.2601E+04      0.4545E+00
                                         0.2601E+04      0.7576E+00
                                         0.2601E+04      0.3030E+01



 TIP   LOAD         TIP MOVEMENT
     KIP                 IN.

 0.0000E+00          0.0000E+00
 0.2266E+02          0.7576E-02
 0.4531E+02          0.1515E-01
 0.9063E+02          0.3030E-01
 0.1813E+03          0.1970E+00
 0.2719E+03          0.6364E+00
 0.3263E+03          0.1106E+01
 0.3625E+03          0.1515E+01
 0.3625E+03          0.2273E+01
 0.3625E+03          0.3030E+01



              LOAD VERSUS SETTLEMENT CURVE
              ****************************



 TOP  LOAD     TOP MOVEMENT       TIP  LOAD      TIP MOVEMENT
    KIP             IN.              KIP              IN.
0.9297E+01      0.4187E-02      0.2991E+00      0.1000E-03
0.1035E+03      0.4627E-01      0.2991E+01      0.1000E-02
0.4246E+03      0.2088E+00      0.1495E+02      0.5000E-02
0.6723E+03      0.3602E+00      0.2991E+02      0.1000E-01
0.9921E+03      0.5899E+00      0.5981E+02      0.2000E-01
0.1466E+04      0.9587E+00      0.1013E+03      0.5000E-01
0.1745E+04      0.1192E+01      0.1177E+03      0.8000E-01
0.1877E+04      0.1309E+01      0.1285E+03      0.1000E+00
0.2053E+04      0.1539E+01      0.1819E+03      0.2000E+00
0.2036E+04      0.1828E+01      0.2438E+03      0.5000E+00
```

```
0.2083E+04       0.2163E+01       0.2908E+03       0.8000E+00
0.2106E+04       0.2380E+01       0.3140E+03       0.1000E+01
0.2155E+04       0.3417E+01       0.3625E+03       0.2000E+01
```


Driveability Analysis Summary
G/L= 0.667/1.000
Rut (kips)
0 200 400 600 800
G/L= 0.667/1.(
Mx T-Str. (ksi)
0 2 4 6 8 10
G/L= 0.667/1.000
ENTHRU (kip-ft)
0 6 12 18 24 30
Depth (ft)
0 3 6 9 12 15 18 21 24 27
0 35 70 105 140
Blow Count (bl/ft)
G/L= 0.667/1.000
0 9 18 27 36 45
Mx C-Str. (ksi)
G/L= 0.667/1.(
0.0 2.4 4.8 7.2 9.6 12.0
Stroke (ft)
G/L= 0.667/1.000

Gain/Loss Factor at Shaft/Toe = 0.667/1.000

Depth ft	Rut kips	Rshaft kips	Rtoe kips	Blow Ct bl/ft	Mx C-Str ksi	Mx T-Str. ksi	Stroke ft	ENTHRU kip-ft	Hammer -
1.0	0.5	0.0	0.5	0.3	0.000	0.000	10.81	0.0	D 19-42
2.0	1.2	0.2	1.0	0.3	0.000	0.000	10.81	0.0	D 19-42
3.0	2.0	0.5	1.5	0.3	0.000	0.000	10.81	0.0	D 19-42
4.0	4.0	0.9	3.1	0.3	0.000	0.000	10.81	0.0	D 19-42
5.0	6.2	1.4	4.8	0.0	0.000	0.000	0.00	0.0	D 19-42
6.0	11.4	5.1	6.3	1.1	2.542	0.000	3.22	13.7	D 19-42
7.0	23.2	15.6	7.6	1.9	12.909	0.024	4.12	25.5	D 19-42
8.0	37.1	29.5	7.6	3.3	17.376	0.532	4.66	23.3	D 19-42
9.0	51.0	43.4	7.6	4.9	19.931	0.697	5.10	21.8	D 19-42
10.0	64.9	57.3	7.6	6.5	21.783	0.920	5.49	20.9	D 19-42
11.0	93.0	71.2	21.8	10.1	24.286	1.053	6.12	19.5	D 19-42
12.0	127.5	88.5	39.0	14.9	27.139	1.117	6.77	18.9	D 19-42
13.0	166.5	109.0	57.5	20.5	29.551	1.112	7.32	18.4	D 19-42
14.0	180.2	121.1	59.1	22.2	30.856	1.165	7.46	18.4	D 19-42
15.0	168.6	124.3	44.3	20.4	31.047	1.306	7.31	18.4	D 19-42
16.0	160.5	132.5	28.0	19.3	30.447	1.390	7.21	18.5	D 19-42
17.0	161.6	149.1	12.5	19.7	31.014	1.497	7.24	18.4	D 19-42
18.0	182.7	170.2	12.5	22.9	32.718	1.296	7.50	18.3	D 19-42
19.0	203.5	191.0	12.5	26.4	33.603	1.245	7.74	18.2	D 19-42
20.0	224.7	212.2	12.5	29.9	33.488	1.426	7.96	18.3	D 19-42
21.0	245.8	233.3	12.5	33.4	34.891	1.714	8.17	18.6	D 19-42
22.0	266.6	254.1	12.5	37.7	35.836	2.754	8.38	18.6	D 19-42
23.0	291.0	275.4	15.6	42.7	35.786	2.861	8.62	19.0	D 19-42
24.0	427.2	304.1	123.1	92.1	39.413	6.244	9.86	21.5	D 19-42
24.3	475.6	316.5	159.1	124.4	41.059	6.891	10.36	22.8	D 19-42

Total driving time: 10 minutes; Total Number of Blows: 417 (starting at penetration 1.0 ft)

GRLWEAP: Wave Equation Analysis of Pile Foundations

PAU-TR33-04.75 + HP12x53 Pier 2 11/17/2024
CTL ENGINEERING, INC. GRLWEAP 14.1.20.1

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity-blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of structure and other factors.

PILE INPUT

Uniform Pile		Pile Type:	H Pile
Pile Length: (ft)	45.000	Pile Penetration: (ft)	24.300
Pile Size: (ft)	1.00	Toe Area: (in²)	15.50

Pile Profile

Lb Top ft	X-Area in²	E-Modulus ksi	Spec. Wt lb/ft³	Perim. ft	Crit. Index -
0.0	15.5	30,000.0	492.0	4.0	0
45.0	15.5	30,000.0	492.0	4.0	0

HAMMER INPUT

ID	41	Made By:	DELMAG
Model	D 19-42	Type:	OED

Hammer Data

ID -	Ram Wt kips	Ram L. in	Ram Ar. in²	Rtd. Stk ft	Effic. -	Rtd. Energy kip-ft
41	4.000	129.1	124.7	10.8	0.80	43.2

DRIVE SYSTEM FOR DELMAG D 19-42-OED

Type -	X-Area in²	E-Modulus ksi	Thickness in	COR -	Round-out in	Stiffness kips/in
Hammer C.	227.000	530.000	2.000	0.800	0.120	60155.555
Helmet Wt.	1.900	kips				

SOIL RESISTANCE DISTRIBUTION

Depth ft	Unit Rs ksf	Unit Rt ksf	Qs in	Qt in	Js s/ft	Jt s/ft	Set. F. -	Limit D. ft	Set. T. Hours	EB Area in²
0.0	0.0	1.9	0.10	0.12	0.10	0.15	1.2	6.0	24.0	15.5
1.0	0.0	4.6	0.10	0.12	0.10	0.15	1.2	6.0	24.0	15.5
2.0	0.1	9.3	0.10	0.12	0.10	0.15	1.2	6.0	24.0	15.5
3.0	0.1	13.9	0.10	0.12	0.10	0.15	1.2	6.0	24.0	15.5
4.0	0.2	28.8	0.10	0.12	0.10	0.15	1.2	6.0	24.0	15.5
5.0	0.2	44.6	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
6.0	2.7	58.5	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
7.0	5.2	70.6	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
8.0	5.2	70.6	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
9.0	5.2	70.6	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
10.0	5.2	70.6	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5

11.0	5.2	202.5	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
12.0	7.8	362.3	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
13.0	4.6	534.2	0.10	0.08	0.05	0.15	1.0	6.0	1.0	15.5
14.0	1.5	549.1	0.10	0.08	0.05	0.15	1.0	6.0	1.0	15.5
15.0	1.1	411.6	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
16.0	4.5	260.1	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
17.0	8.0	116.1	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
18.0	7.9	116.1	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
19.0	7.9	116.1	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
20.0	7.9	116.1	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
21.0	8.0	116.1	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
22.0	7.9	116.1	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
23.0	7.9	144.9	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
24.0	11.7	1143.6	0.10	0.08	0.20	0.15	1.3	6.0	24.0	15.5
25.0	17.2	2257.5	0.10	0.04	0.20	0.15	1.0	6.0	0.0	15.5
26.0	219.4	3367.7	0.10	0.04	0.20	0.15	1.0	6.0	0.0	15.5

Summary Of Pile Design
PAU-TR33-04.75
Pier 2 - HP 12x53

Bottom of Pile Cap Elevation =	744.87	ft	(Estimated from Site Plan, Undated)
Resistance Factor for Driven Piles to Bedrock =	0.5		(ODOT BDM C305.3.3)
Maximum Factored Structural Resistance =	380.0	kips/pile	(ODOT BDM C305.3.3)
Scour Depth (from Bottom of Footing El.)=	0.0	ft	(Assumed)
Pile Stick-up Length =	1.5	ft	(ODOT BDM Section 305.3.5.1)
Pile Length =	33.5	ft	(From APile Analysis)
Estimated Pile Length =	40.0	ft	(ODOT BDM 305.3.5.2)
Order Length =	45.0	ft	(ODOT BDM 305.3.5.2)
Pile Tip Elevation =	711.4	ft	(Estimated Elevation of Coreable Rock)

Soil Parameters

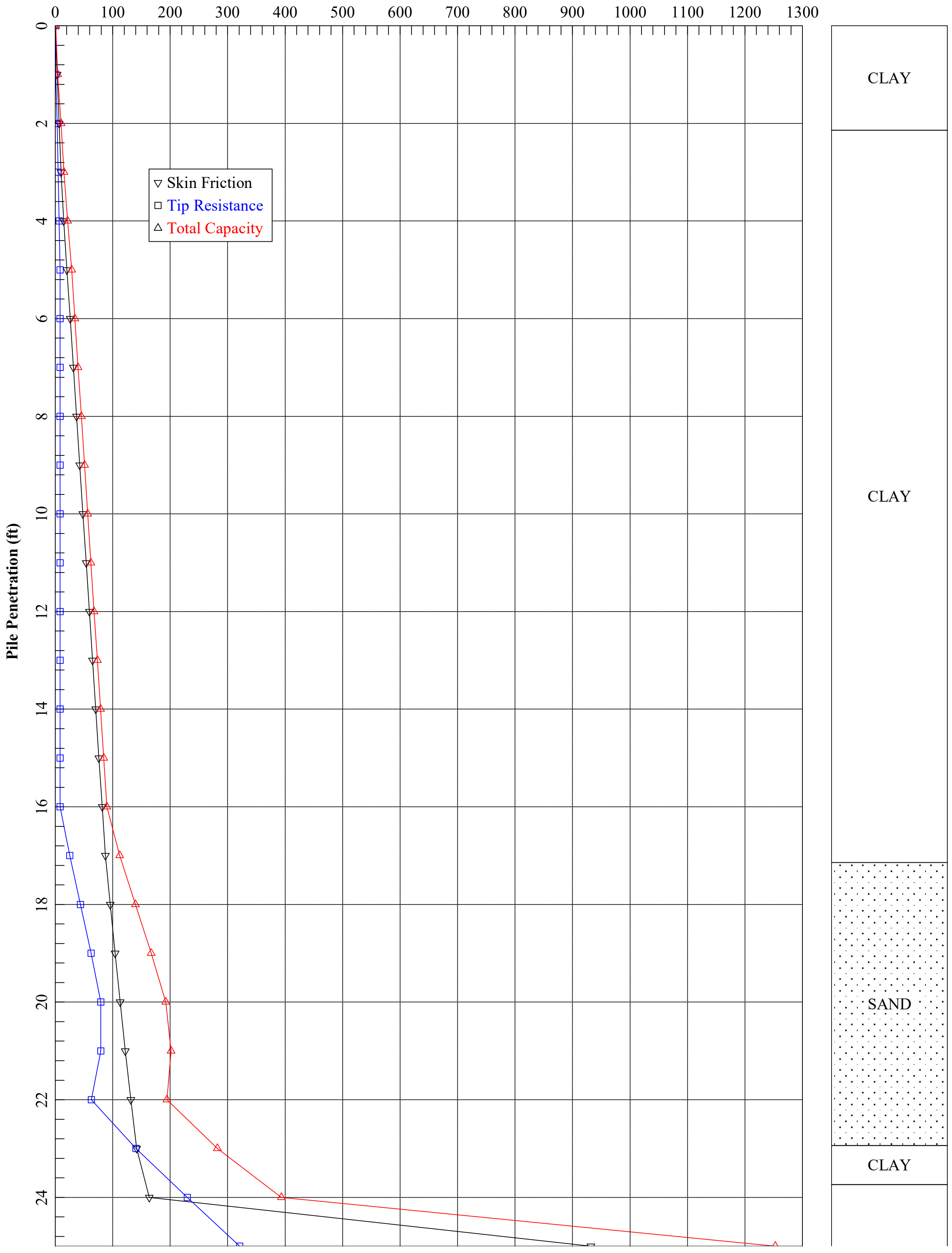
Project: PAU-TR33-04.75
Location: Pier 2
Boring No.: B-002-0-24
Date: 10/21/24
Ground Surface Elevation: 744.87
Bottom of Pile Cap Elevation: 744.87

								Total Stress			
Layer No.	Top Elev	Bottom Elev	Thickness (feet)	Type	ODOT	N_{60} value (bpf)	Total Weight (pcf)	Cohesion (psf)	Friction Angle (degrees)	Apile Reduction Factor	Reference
1	735.1	733.0	2.14	Cohesive	A-4a	13	120				
			Avg			13	120	1625	0	0.67	1, 2
2	733.0	718.0	15	Cohesive	A-4a	53	140				
						100	140				
						91	140				
						44	135				
						73	140				
						71	140				
			Avg			72	139	8534	0	0.67	2, 4
3	718.0	712.2	5.8	Granular	A-3a	106	140				
						132	140	LRFD	50.85		
								ODOT CF	-0.5		
			Avg			119	140	0	50	1.00	3
4	712.2	711.4	0.8	Rock	Dolomite	264	150	Qu (ksf) = 19.4			
			Avg			264	150	9715	0	---	4, 5
5	711.4	701.4	10	Rock	Dolomite		166	Qu			
							171	=			
								5,980 psi			
			Avg				169	430560	0	---	5

Reference Key

1 Cohesive Soils - Total Stress Cohesion estimated as 125 x average N-Value - according to ODOT GDM Section 404.1.
2 Cohesive Soils - Total Stess Friction Angle estimated to be 0.
3 Granular soils - Friction angle estimated using N-value & soil type according ODOT GDM Section 404.2.
4 Total Stress Cohesion estimated as (f_1 x N_{60} x P_a)/100 - according to ODOT GDM Section 404.1.
5 Rock Cohesion equals Undrained Shear Strength, which equals one-half the unconfined compressive strength (Q_u).

24050001WAP Pier 2 (B-002-0-24) APile Analysis
Axial Capacity (kips)



```
     ==========================================================================

                      APILE for Windows, Version 2019.9.11

                       Serial Number :  136084177

                       A Program for Analyzing the Axial Capacity
                       and Short-term Settlement of Driven Piles
                                 under Axial Loading.
                     (c) Copyright ENSOFT, Inc., 1987-2019
                           All Rights Reserved

     ==========================================================================


     This program is licensed to :

     CTL Engineering, Inc.
     Cincinnati, OH

     Path to file locations      : O:\PROJECT\2024\WAP-05\24050001WAP_Bockrath and
Associates Engineering and Surveying LLC_PAU-TR33-4-75 Bridge over Flat Rock Creek-
PID 113849\Calcs\Pile\Pier 2 (B-002-0-24)\APile\
     Name of input data file     : 24050001WAP_Pier 2_APile Analysis.ap9d
     Name of output file         : 24050001WAP_Pier 2_APile Analysis.ap9o
     Name of plot output file    : 24050001WAP_Pier 2_APile Analysis.ap9p

     --------------------------------------------------------------------------
                         Time and Date of Analysis
     --------------------------------------------------------------------------

               Date:  October 21, 2024     Time:  14:15:43



1
          *********************
          * INPUT INFORMATION *
          *********************




          PAU-TR33-04.75_Forward Abutment (B-002-0-24)

          DESIGNER   : CTL Engineering, Inc.

          JOB NUMBER : 24050001WAP


          METHOD FOR UNIT LOAD TRANSFERS :
```

```
- FHWA (Federal Highway Administration)
  Unfactored Unit Side Friction and Unit Side Resistance are used.



COMPUTATION METHOD(S) FOR PILE CAPACITY :

- FHWA (Federal Highway Administration)


TYPE OF LOADING :
- COMPRESSION


PILE TYPE :

H-Pile/Steel Pile


DATA FOR AXIAL STIFFNESS :

- MODULUS OF ELASTICITY     = 0.290E+08 PSI
- CROSS SECTION AREA        =     15.50 IN2


NONCIRCULAR PILE PROPERTIES :

- TOTAL PILE LENGTH, TL     =     27.00 FT.
- BATTER ANGLE              =      0.00 DEG
- PILE STICKUP LENGTH, PSL  =      1.50 FT.
- ZERO FRICTION LENGTH, ZFL =      0.00 FT.
- PERIMETER OF PILE         =     47.60 IN.
- TIP AREA OF PILE          =     15.50 IN2
- INCREMENT OF PILE LENGTH
  USED IN COMPUTATION       =      1.00 FT.



SOIL INFORMATIONS :



                  LATERAL    EFFECTIVE    FRICTION      Nq
          SOIL    EARTH      UNIT         ANGLE       FACTOR
 DEPTH    TYPE    PRESSURE   WEIGHT       DEGREES      FHWA
  FT.                        LB/FT^3
   0.00   CLAY      0.80*      120.00         0.00      4.80**
   2.14   CLAY      0.80*      120.00         0.00      4.80**
   2.14   CLAY      0.80*      139.00         0.00      4.80**
```

```
  17.14   CLAY      0.80*      139.00         0.00      4.80**
  17.14   SAND      0.80*      140.00        50.00    475.00**
  22.94   SAND      0.80*      140.00        50.00    475.00**
  22.94   CLAY      0.80*      150.00         0.00      4.80**
  23.74   CLAY      0.80*      150.00         0.00      4.80**
  23.74   CLAY      0.80*      169.00         0.00      4.80**
  33.74   CLAY      0.80*      169.00         0.00      4.80**

*  VALUE ASSUMED BY THE PROGRAM
** VALUE ESTIMATED BY THE PROGRAM BASED ON FRICTION ANGLE



MAXIMUM   MAXIMUM   UNDISTURB  REMOLDED
UNIT      UNIT      SHEAR      SHEAR     BLOW   UNIT SKIN  UNIT END
FRICTION  BEARING   STRENGTH   STRENGTH  COUNT  FRICTION   BEARING
  KSF       KSF        KSF       KSF                KSF       KSF
0.10E+08* 0.10E+08*       1.62      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       1.62      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       8.53      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       8.53      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       0.00      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       0.00      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       9.71      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       9.71      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*     430.56      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*     430.56      0.00   0.00       0.00      0.00

* MAXIMUM UNIT FRICTION AND/OR MAXIMUM UNIT BEARING
  WERE SET TO BE 0.10E+08 BECAUSE THE USER DOES NOT
  PLAN TO LIMIT THE COMPUTED DATA.



         LRFD FACTOR  LRFD FACTOR
          ON UNIT      ON UNIT
 DEPTH    FRICTION     BEARING
  FT.
   0.00    0.670       1.000
   2.14    0.670       1.000
   2.14    0.670       1.000
  17.14    0.670       1.000
  17.14    1.000       1.000
  22.94    1.000       1.000
  22.94    1.000       1.000
  23.74    1.000       1.000
  23.74    1.000       1.000
  33.74    1.000       1.000
```

```
1
          **********************
          * COMPUTATION RESULT *
          **********************



                            **********************
                            *  FED. HWY. METHOD  *
                            **********************

             PILE          SKIN          END       ULTIMATE
          PENETRATION   FRICTION       BEARING     CAPACITY
              FT.          KIP           KIP          KIP
              0.00           0.0           0.8           0.8
              1.00           3.4           0.8           4.2
              2.00           6.9           3.2          10.0
              3.00          10.3           4.9          15.3
              4.00          14.9           6.7          21.6
              5.00          20.4           8.3          28.7
              6.00          26.0           8.3          34.3
              7.00          31.6           8.3          39.8
              8.00          37.1           8.3          45.4
              9.00          42.7           8.3          51.0
             10.00          48.2           8.3          56.5
             11.00          53.8           8.3          62.1
             12.00          59.4           8.3          67.6
             13.00          64.9           8.3          73.2
             14.00          70.5           8.3          78.8
             15.00          76.1           8.3          84.3
             16.00          81.6           8.3          89.9
             17.00          87.2          25.1         112.2
             18.00          95.6          43.8         139.5
             19.00         104.2          62.6         166.8
             20.00         112.9          79.4         192.3
             21.00         122.0          79.4         201.4
             22.00         131.6          62.9         194.5
             23.00         141.6         140.6         282.3
             24.00         163.7         229.8         393.5
             25.00         931.9         320.9        1252.8


            NOTES:
            - AN ASTERISK IS PLACED IN THE END-BEARING COLUMN
              IF THE TIP RESISTANCE IS CONTROLLED BY THE FRICTION
              OF SOIL PLUG INSIDE AN OPEN-ENDED PIPE PILE.
```

```
                 ************************************************
                 * COMPUTE LOAD-DISTRIBUTION AND LOAD-SETTLEMENT *
                 * CURVES FOR AXIAL LOADING                      *
                 ************************************************


          T-Z CURVE   NO. OF   DEPTH TO CURVE   LOAD TRANSFER   PILE MOVEMENT
             NO.      POINTS        FT.              PSI              IN.

              1         10     0.4167E-01
                                                0.0000E+00      0.0000E+00
                                                0.2687E+01      0.2424E-01
                                                0.4479E+01      0.4697E-01
                                                0.6718E+01      0.8636E-01
                                                0.8062E+01      0.1212E+00
                                                0.8957E+01      0.1515E+00
                                                0.8062E+01      0.3030E+00
                                                0.8062E+01      0.4545E+00
                                                0.8062E+01      0.7576E+00
                                                0.8062E+01      0.3030E+01
              2         10     0.1070E+01
                                                0.0000E+00      0.0000E+00
                                                0.2687E+01      0.2424E-01
                                                0.4479E+01      0.4697E-01
                                                0.6718E+01      0.8636E-01
                                                0.8062E+01      0.1212E+00
                                                0.8957E+01      0.1515E+00
                                                0.8062E+01      0.3030E+00
                                                0.8062E+01      0.4545E+00
                                                0.8062E+01      0.7576E+00
                                                0.8062E+01      0.3030E+01
              3         10     0.2098E+01
                                                0.0000E+00      0.0000E+00
                                                0.2694E+01      0.2424E-01
                                                0.4491E+01      0.4697E-01
                                                0.6736E+01      0.8636E-01
                                                0.8083E+01      0.1212E+00
                                                0.8981E+01      0.1515E+00
                                                0.8083E+01      0.3030E+00
                                                0.8083E+01      0.4545E+00
                                                0.8083E+01      0.7576E+00
                                                0.8083E+01      0.3030E+01
              4         10     0.2182E+01
                                                0.0000E+00      0.0000E+00
                                                0.2700E+01      0.2424E-01
                                                0.4501E+01      0.4697E-01
                                                0.6751E+01      0.8636E-01
                                                0.8101E+01      0.1212E+00
                                                0.9002E+01      0.1515E+00
                                                0.8101E+01      0.3030E+00
```

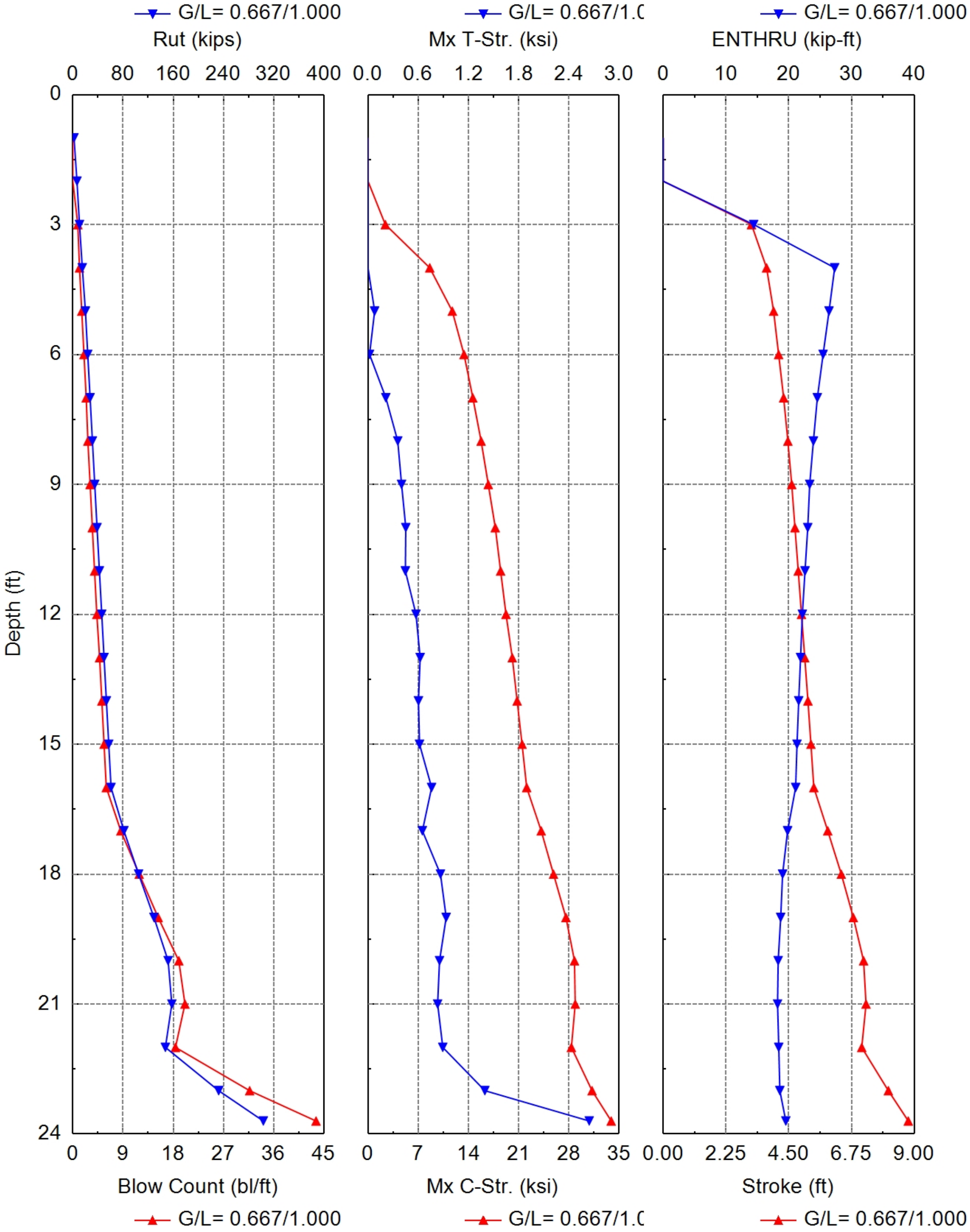
```
                                   0.8101E+01      0.4545E+00
                                   0.8101E+01      0.7576E+00
                                   0.8101E+01      0.3030E+01
5         10      0.9640E+01
                                   0.0000E+00      0.0000E+00
                                   0.4361E+01      0.2424E-01
                                   0.7268E+01      0.4697E-01
                                   0.1090E+02      0.8636E-01
                                   0.1308E+02      0.1212E+00
                                   0.1454E+02      0.1515E+00
                                   0.1308E+02      0.3030E+00
                                   0.1308E+02      0.4545E+00
                                   0.1308E+02      0.7576E+00
                                   0.1308E+02      0.3030E+01
6         10      0.1710E+02
                                   0.0000E+00      0.0000E+00
                                   0.4377E+01      0.2424E-01
                                   0.7295E+01      0.4697E-01
                                   0.1094E+02      0.8636E-01
                                   0.1313E+02      0.1212E+00
                                   0.1459E+02      0.1515E+00
                                   0.1313E+02      0.3030E+00
                                   0.1313E+02      0.4545E+00
                                   0.1313E+02      0.7576E+00
                                   0.1313E+02      0.3030E+01
7         10      0.1718E+02
                                   0.0000E+00      0.0000E+00
                                   0.4391E+01      0.2424E-01
                                   0.7318E+01      0.4697E-01
                                   0.1098E+02      0.8636E-01
                                   0.1317E+02      0.1212E+00
                                   0.1464E+02      0.1515E+00
                                   0.1464E+02      0.3030E+00
                                   0.1464E+02      0.4545E+00
                                   0.1464E+02      0.7576E+00
                                   0.1464E+02      0.3030E+01
8         10      0.2004E+02
                                   0.0000E+00      0.0000E+00
                                   0.4688E+01      0.2424E-01
                                   0.7814E+01      0.4697E-01
                                   0.1172E+02      0.8636E-01
                                   0.1406E+02      0.1212E+00
                                   0.1563E+02      0.1515E+00
                                   0.1563E+02      0.3030E+00
                                   0.1563E+02      0.4545E+00
                                   0.1563E+02      0.7576E+00
                                   0.1563E+02      0.3030E+01
9         10      0.2290E+02
                                   0.0000E+00      0.0000E+00
                                   0.5375E+01      0.2424E-01
```

```
                                    0.8959E+01      0.4697E-01
                                    0.1344E+02      0.8636E-01
                                    0.1613E+02      0.1212E+00
                                    0.1792E+02      0.1515E+00
                                    0.1792E+02      0.3030E+00
                                    0.1792E+02      0.4545E+00
                                    0.1792E+02      0.7576E+00
                                    0.1792E+02      0.3030E+01
10         10      0.2298E+02
                                    0.0000E+00      0.0000E+00
                                    0.5395E+01      0.2424E-01
                                    0.8992E+01      0.4697E-01
                                    0.1349E+02      0.8636E-01
                                    0.1619E+02      0.1212E+00
                                    0.1798E+02      0.1515E+00
                                    0.1619E+02      0.3030E+00
                                    0.1619E+02      0.4545E+00
                                    0.1619E+02      0.7576E+00
                                    0.1619E+02      0.3030E+01
11         10      0.2344E+02
                                    0.0000E+00      0.0000E+00
                                    0.1086E+02      0.2424E-01
                                    0.1810E+02      0.4697E-01
                                    0.2715E+02      0.8636E-01
                                    0.3257E+02      0.1212E+00
                                    0.3619E+02      0.1515E+00
                                    0.3257E+02      0.3030E+00
                                    0.3257E+02      0.4545E+00
                                    0.3257E+02      0.7576E+00
                                    0.3257E+02      0.3030E+01
12         10      0.2390E+02
                                    0.0000E+00      0.0000E+00
                                    0.1654E+02      0.2424E-01
                                    0.2757E+02      0.4697E-01
                                    0.4136E+02      0.8636E-01
                                    0.4963E+02      0.1212E+00
                                    0.5515E+02      0.1515E+00
                                    0.4963E+02      0.3030E+00
                                    0.4963E+02      0.4545E+00
                                    0.4963E+02      0.7576E+00
                                    0.4963E+02      0.3030E+01
13         10      0.2398E+02
                                    0.0000E+00      0.0000E+00
                                    0.1758E+02      0.2424E-01
                                    0.2930E+02      0.4697E-01
                                    0.4395E+02      0.8636E-01
                                    0.5273E+02      0.1212E+00
                                    0.5859E+02      0.1515E+00
                                    0.5273E+02      0.3030E+00
                                    0.5273E+02      0.4545E+00
```

```
                                    0.5273E+02      0.7576E+00
                                    0.5273E+02      0.3030E+01
   14         10      0.2884E+02
                                    0.0000E+00      0.0000E+00
                                    0.7891E+03      0.2424E-01
                                    0.1315E+04      0.4697E-01
                                    0.1973E+04      0.8636E-01
                                    0.2367E+04      0.1212E+00
                                    0.2630E+04      0.1515E+00
                                    0.2367E+04      0.3030E+00
                                    0.2367E+04      0.4545E+00
                                    0.2367E+04      0.7576E+00
                                    0.2367E+04      0.3030E+01
   15         10      0.3370E+02
                                    0.0000E+00      0.0000E+00
                                    0.7891E+03      0.2424E-01
                                    0.1315E+04      0.4697E-01
                                    0.1973E+04      0.8636E-01
                                    0.2367E+04      0.1212E+00
                                    0.2630E+04      0.1515E+00
                                    0.2367E+04      0.3030E+00
                                    0.2367E+04      0.4545E+00
                                    0.2367E+04      0.7576E+00
                                    0.2367E+04      0.3030E+01


TIP   LOAD        TIP MOVEMENT
    KIP               IN.

0.0000E+00         0.0000E+00
0.2006E+02         0.7576E-02
0.4011E+02         0.1515E-01
0.8022E+02         0.3030E-01
0.1604E+03         0.1970E+00
0.2407E+03         0.6364E+00
0.2888E+03         0.1106E+01
0.3209E+03         0.1515E+01
0.3209E+03         0.2273E+01
0.3209E+03         0.3030E+01


              LOAD VERSUS SETTLEMENT CURVE
              ****************************



TOP   LOAD     TOP MOVEMENT       TIP   LOAD      TIP MOVEMENT
   KIP              IN.              KIP             IN.
```

```
0.3465E+01      0.1831E-02      0.2647E+00      0.1000E-03
0.3713E+02      0.1939E-01      0.2647E+01      0.1000E-02
0.1759E+03      0.9713E-01      0.1324E+02      0.5000E-02
0.3182E+03      0.1856E+00      0.2647E+02      0.1000E-01
0.5396E+03      0.3434E+00      0.5295E+02      0.2000E-01
0.9063E+03      0.6299E+00      0.8970E+02      0.5000E-01
0.1146E+04      0.8278E+00      0.1041E+03      0.8000E-01
0.1265E+04      0.9306E+00      0.1138E+03      0.1000E+00
0.1435E+04      0.1151E+01      0.1610E+03      0.2000E+00
0.1421E+04      0.1442E+01      0.2158E+03      0.5000E+00
0.1463E+04      0.1773E+01      0.2574E+03      0.8000E+00
0.1483E+04      0.1987E+01      0.2779E+03      0.1000E+01
0.1526E+04      0.3018E+01      0.3209E+03      0.2000E+01
```

Driveability Analysis Summary



Gain/Loss Factor at Shaft/Toe = 0.667/1.000

Depth	Rut	Rshaft	Rtoe	Blow Ct	Mx C-Str	Mx T-Str.	Stroke	ENTHRU	Hammer
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft	-
1.0	1.9	1.1	0.8	0.3	0.000	0.000	10.81	0.0	D 19-42
2.0	6.6	3.4	3.2	0.0	0.000	0.000	0.00	0.0	D 19-42
3.0	10.6	5.7	4.9	0.9	2.412	0.000	3.16	14.4	D 19-42
4.0	15.1	8.4	6.7	1.2	8.612	0.000	3.71	27.3	D 19-42
5.0	20.1	11.8	8.3	1.6	11.750	0.079	3.96	26.4	D 19-42
6.0	23.8	15.5	8.3	2.0	13.382	0.018	4.14	25.5	D 19-42
7.0	27.5	19.2	8.3	2.4	14.614	0.213	4.32	24.6	D 19-42
8.0	31.2	22.9	8.3	2.7	15.770	0.355	4.47	23.9	D 19-42
9.0	34.9	26.6	8.3	3.1	16.766	0.401	4.61	23.3	D 19-42
10.0	38.6	30.3	8.3	3.5	17.750	0.451	4.72	23.0	D 19-42
11.0	42.3	34.0	8.3	3.9	18.486	0.447	4.84	22.6	D 19-42
12.0	46.1	37.8	8.3	4.3	19.240	0.573	4.96	22.2	D 19-42
13.0	49.8	41.5	8.3	4.8	20.115	0.623	5.08	21.9	D 19-42
14.0	53.5	45.2	8.3	5.2	20.789	0.603	5.19	21.6	D 19-42
15.0	57.2	48.9	8.3	5.6	21.478	0.615	5.30	21.3	D 19-42
16.0	60.9	52.6	8.3	6.0	22.121	0.760	5.40	21.1	D 19-42
17.0	81.4	56.3	25.1	8.6	24.147	0.650	5.90	19.8	D 19-42
18.0	104.8	61.0	43.8	11.9	25.864	0.866	6.38	19.0	D 19-42
19.0	129.3	66.7	62.6	15.3	27.593	0.934	6.82	18.7	D 19-42
20.0	151.8	72.4	79.4	19.0	28.787	0.855	7.18	18.3	D 19-42
21.0	157.8	78.4	79.4	20.1	28.890	0.832	7.27	18.2	D 19-42
22.0	147.5	84.6	62.9	18.4	28.355	0.894	7.12	18.4	D 19-42
23.0	232.4	91.8	140.6	31.7	31.236	1.396	8.07	18.6	D 19-42
23.7	303.5	100.5	203.0	43.6	33.912	2.644	8.79	19.5	D 19-42

Total driving time: 4 minutes; Total Number of Blows: 183 (starting at penetration 1.0 ft)

GRLWEAP: Wave Equation Analysis of Pile Foundations

PAU-TR33-04.75 + HP12x53 Pier 2 11/17/2024
CTL ENGINEERING, INC. GRLWEAP 14.1.20.1

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity-blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of structure and other factors.

PILE INPUT

Uniform Pile		Pile Type:	H Pile
Pile Length: (ft)	45.000	Pile Penetration: (ft)	23.700
Pile Size: (ft)	1.00	Toe Area: (in²)	15.50

Pile Profile

Lb Top ft	X-Area in²	E-Modulus ksi	Spec. Wt lb/ft³	Perim. ft	Crit. Index -
0.0	15.5	30,000.0	492.0	4.0	0
45.0	15.5	30,000.0	492.0	4.0	0

HAMMER INPUT

ID	41	Made By:	DELMAG
Model	D 19-42	Type:	OED

Hammer Data

ID -	Ram Wt kips	Ram L. in	Ram Ar. in²	Rtd. Stk ft	Effic. -	Rtd. Energy kip-ft
41	4.000	129.1	124.7	10.8	0.80	43.2

DRIVE SYSTEM FOR DELMAG D 19-42-OED

Type -	X-Area in²	E-Modulus ksi	Thickness in	COR -	Round-out in	Stiffness kips/in
Hammer C.	227.000	530.000	2.000	0.800	0.120	60155.555
Helmet Wt.	1.900	kips				

SOIL RESISTANCE DISTRIBUTION

Depth ft	Unit Rs ksf	Unit Rt ksf	Qs in	Qt in	Js s/ft	Jt s/ft	Set. F. -	Limit D. ft	Set. T. Hours	EB Area in²
0.0	0.0	7.4	0.10	0.11	0.15	0.15	1.5	6.0	168.0	15.5
1.0	0.9	7.4	0.10	0.11	0.15	0.15	1.5	6.0	168.0	15.5
2.0	0.9	29.7	0.10	0.11	0.15	0.15	1.5	6.0	168.0	15.5
3.0	0.9	45.5	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
4.0	1.2	62.2	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
5.0	1.4	77.1	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
6.0	1.4	77.1	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
7.0	1.4	77.1	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
8.0	1.4	77.1	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
9.0	1.4	77.1	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
10.0	1.4	77.1	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5

11.0	1.4	77.1	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
12.0	1.4	77.1	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
13.0	1.4	77.1	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
14.0	1.4	77.1	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
15.0	1.4	77.1	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
16.0	1.4	77.1	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
17.0	1.4	233.2	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
18.0	2.1	406.9	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
19.0	2.2	581.6	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
20.0	2.2	737.7	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
21.0	2.3	737.7	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
22.0	2.4	584.4	0.10	0.08	0.15	0.15	1.5	6.0	168.0	15.5
23.0	2.5	1306.2	0.10	0.09	0.20	0.15	1.3	6.0	24.0	15.5
24.0	5.6	2134.9	0.10	0.04	0.20	0.15	1.0	6.0	0.0	15.5
25.0	193.7	2981.3	0.10	0.04	0.20	0.15	1.0	6.0	0.0	15.5

Summary Of Pile Design
PAU-TR33-04.75
Forward Abutment - HP 10x42

Bottom of Pile Cap Elevation =	741.20	ft	(Estimated from Site Plan, Undated)
Resistance Factor for Driven Piles to Bedrock =	0.5		(ODOT BDM C305.3.3)
Maximum Factored Structural Resistance =	310.0	kips/pile	(ODOT BDM C305.3.3)
Scour Depth (from Bottom of Footing El.)=	0.0	ft	(Assumed)
Pile Stick-up Length =	2.0	ft	(ODOT BDM Section 305.3.5.1)
Pile Length =	29.0	ft	(From APile Analysis)
Estimated Pile Length =	35.0	ft	(ODOT BDM 305.3.5.2)
Order Length =	40.0	ft	(ODOT BDM 305.3.5.2)
Pile Tip Elevation =	712.2	ft	(Elevation of Coreable Rock)

Soil Parameters

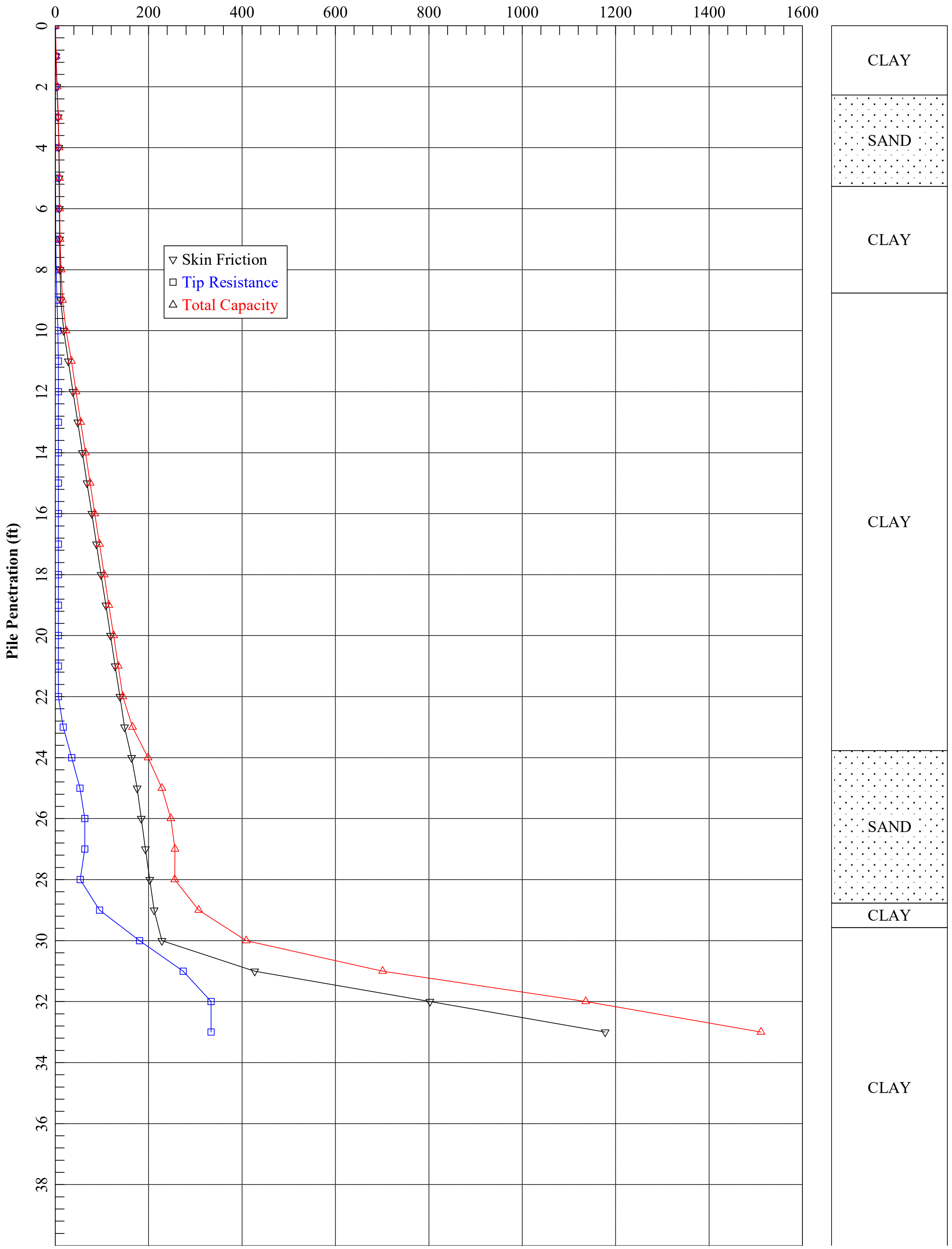
Project: PAU-TR33-04.75
Location: Forward Abutment
Boring No.: B-002-0-24
Date: 3/12/25
Ground Surface Elevation: 748.50
Bottom of Pile Cap Elevation: 741.2

								Total Stress			
Layer No.	Top Elev	Bottom Elev	Thickness (feet)	Type	ODOT	N_{60} value (bpf)	Total Weight (pcf)	Cohesion (psf)	Friction Angle (degrees)	Apile Reduction Factor	Reference
1	741.2	739.5	1.7	Cohesive	A-4a	8	118				
						4	112				
						9	118				
			Avg			7	116	875	0	0.67	1, 2
2	739.5	736.5	3	Granular	A-3a	5	118				
						3	118	LRFD	29.5		
								ODOT CF	-0.5		
			Avg			4	118	0	29	1.00	3
3	736.5	733.0	3.5	Cohesive	A-4a	7	118				
						13	120				
			Avg			10	119	1250	0	0.67	1, 2
4	733.0	718.0	15	Cohesive	A-4a	53	140				
						100	140				
						91	140				
						44	135				
						73	140				
						71	140				
			Avg			72	139	8534	0	0.67	2, 4
5	718.0	713.0	5	Granular	A-3a	106	140				
						132	140	LRFD	50.85		
								ODOT CF	-0.5		
			Avg			119	140	0	50	1.00	3
6	713.0	712.2	0.8	Rock	Dolomite	264	150	Qu (ksf)			
								=			
								19.4			
			Avg			264	150	9715	0	---	4, 5
7	712.2	701.7	10.5	Rock	Dolomite		166	Qu			
							171	=			
								5,980 psi			
			Avg				169	430560	0	---	5

Reference Key

1 Cohesive Soils - Total Stress Cohesion estimated as 125 x average N-Value - according to ODOT GDM Section 404.1.
2 Cohesive Soils - Total Stess Friction Angle estimated to be 0.
3 Granular soils - Friction angle estimated using N-value & soil type according ODOT GDM Section 404.2.
4 Total Stress Cohesion estimated as (f_1 x N_{60} x P_a)/100 - according to ODOT GDM Section 404.1.
5 Rock Cohesion equals Undrained Shear Strength, which equals one-half the unconfined compressive strength (Q_u).

24050001WAP Forward Abutment (B-002-0-24) APile Analysis
Axial Capacity (kips)



```
     =========================================================================

                      APILE for Windows, Version 2019.9.11

                       Serial Number :  136084177

                       A Program for Analyzing the Axial Capacity
                       and Short-term Settlement of Driven Piles
                                 under Axial Loading.
                     (c) Copyright ENSOFT, Inc., 1987-2019
                           All Rights Reserved

     =========================================================================


     This program is licensed to :

     CTL Engineering, Inc.
     Cincinnati, OH

     Path to file locations      : O:\PROJECT\2024\WAP-05\24050001WAP_Bockrath and
Associates Engineering and Surveying LLC_PAU-TR33-4-75 Bridge over Flat Rock Creek-
PID 113849\Calcs\Pile\Forward Abutment (B-002-0-24)\APile\
     Name of input data file     : 24050001WAP_FA_APile Analysis.ap9d
     Name of output file         : 24050001WAP_FA_APile Analysis.ap9o
     Name of plot output file    : 24050001WAP_FA_APile Analysis.ap9p

     -------------------------------------------------------------------------
                         Time and Date of Analysis
     -------------------------------------------------------------------------

               Date:  October 21, 2024     Time:  13:45:42



1
          *********************
          * INPUT INFORMATION *
          *********************




          PAU-TR33-04.75_Forward Abutment (B-002-0-24)

          DESIGNER   : CTL Engineering, Inc.

          JOB NUMBER : 24050001WAP


          METHOD FOR UNIT LOAD TRANSFERS :
```

```
- FHWA (Federal Highway Administration)
  Unfactored Unit Side Friction and Unit Side Resistance are used.



COMPUTATION METHOD(S) FOR PILE CAPACITY :

- FHWA (Federal Highway Administration)


TYPE OF LOADING :
- COMPRESSION


PILE TYPE :

H-Pile/Steel Pile


DATA FOR AXIAL STIFFNESS :

- MODULUS OF ELASTICITY     = 0.290E+08 PSI
- CROSS SECTION AREA        =     12.40 IN2


NONCIRCULAR PILE PROPERTIES :

- TOTAL PILE LENGTH, TL     =     35.00 FT.
- BATTER ANGLE              =      0.00 DEG
- PILE STICKUP LENGTH, PSL  =      2.00 FT.
- ZERO FRICTION LENGTH, ZFL =      0.00 FT.
- PERIMETER OF PILE         =     39.60 IN.
- TIP AREA OF PILE          =     12.40 IN2
- INCREMENT OF PILE LENGTH
  USED IN COMPUTATION       =      1.00 FT.



SOIL INFORMATIONS :



                  LATERAL    EFFECTIVE    FRICTION      Nq
          SOIL    EARTH      UNIT         ANGLE       FACTOR
 DEPTH    TYPE    PRESSURE   WEIGHT       DEGREES      FHWA
  FT.                        LB/FT^3
   0.00   CLAY      0.80*      116.00         0.00      4.80**
   2.27   CLAY      0.80*      116.00         0.00      4.80**
   2.27   SAND      0.80*      118.00        29.00     26.40**
```

```
   5.27   SAND      0.80*      118.00        29.00     26.40**
   5.27   CLAY      0.80*      119.00         0.00      4.80**
   8.77   CLAY      0.80*      119.00         0.00      4.80**
   8.77   CLAY      0.80*      139.00         0.00      4.80**
  23.77   CLAY      0.80*      139.00         0.00      4.80**
  23.77   SAND      0.80*      140.00        50.00    475.00**
  28.77   SAND      0.80*      140.00        50.00    475.00**
  28.77   CLAY      0.80*      150.00         0.00      4.80**
  29.57   CLAY      0.80*      150.00         0.00      4.80**
  29.57   CLAY      0.80*      169.00         0.00      4.80**
  40.07   CLAY      0.80*      169.00         0.00      4.80**

*  VALUE ASSUMED BY THE PROGRAM
** VALUE ESTIMATED BY THE PROGRAM BASED ON FRICTION ANGLE



MAXIMUM   MAXIMUM   UNDISTURB  REMOLDED
UNIT      UNIT      SHEAR      SHEAR     BLOW   UNIT SKIN  UNIT END
FRICTION  BEARING   STRENGTH   STRENGTH  COUNT  FRICTION   BEARING
  KSF       KSF        KSF       KSF              KSF        KSF
0.10E+08* 0.10E+08*       0.88      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       0.88      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       0.00      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       0.00      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       1.25      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       1.25      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       8.53      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       8.53      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       0.00      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       0.00      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       9.71      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*       9.71      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*     430.56      0.00   0.00       0.00      0.00
0.10E+08* 0.10E+08*     430.56      0.00   0.00       0.00      0.00

* MAXIMUM UNIT FRICTION AND/OR MAXIMUM UNIT BEARING
  WERE SET TO BE 0.10E+08 BECAUSE THE USER DOES NOT
  PLAN TO LIMIT THE COMPUTED DATA.



         LRFD FACTOR  LRFD FACTOR
          ON UNIT      ON UNIT
 DEPTH    FRICTION     BEARING
  FT.
   0.00    0.670       1.000
   2.27    0.670       1.000
   2.27    1.000       1.000
   5.27    1.000       1.000
```

```
        5.27    0.670       1.000
        8.77    0.670       1.000
        8.77    0.670       1.000
       23.77    0.670       1.000
       23.77    1.000       1.000
       28.77    1.000       1.000
       28.77    1.000       1.000
       29.57    1.000       1.000
       29.57    1.000       1.000
       40.07    1.000       1.000



1
          **********************
          * COMPUTATION RESULT *
          **********************



                            **********************
                            *  FED. HWY. METHOD  *
                            **********************

             PILE          SKIN          END       ULTIMATE
          PENETRATION   FRICTION       BEARING     CAPACITY
              FT.          KIP           KIP          KIP
              0.00           0.0           0.3          0.3
              1.00           1.8           0.3          2.2
              2.00           3.6           0.6          4.3
              3.00           6.3           0.6          7.0
              4.00           7.9           0.6          8.5
              5.00           8.4           0.7          9.1
              6.00           8.7           0.9          9.6
              7.00           9.5           0.9         10.4
              8.00          10.5           2.0         12.5
              9.00          12.0           3.8         15.8
             10.00          18.0           5.6         23.5
             11.00          28.0           6.6         34.6
             12.00          38.0           6.6         44.7
             13.00          48.1           6.6         54.7
             14.00          58.1           6.6         64.7
             15.00          68.2           6.6         74.8
             16.00          78.2           6.6         84.8
             17.00          88.2           6.6         94.8
             18.00          98.3           6.6        104.9
             19.00         108.3           6.6        114.9
             20.00         118.3           6.6        125.0
             21.00         128.4           6.6        135.0
             22.00         138.4           6.6        145.0
```

```
  23.00         148.5          17.0        165.5
  24.00         163.5          35.1        198.6
  25.00         175.4          53.1        228.5
  26.00         184.0          63.5        247.5
  27.00         192.9          63.5        256.5
  28.00         202.3          53.3        255.6
  29.00         212.0          95.1        307.1
  30.00         228.1         180.8        409.0
  31.00         427.0         274.1        701.1
  32.00         802.3         333.7       1135.9
  33.00        1177.5         333.7       1511.2


 NOTES:
 - AN ASTERISK IS PLACED IN THE END-BEARING COLUMN
   IF THE TIP RESISTANCE IS CONTROLLED BY THE FRICTION
   OF SOIL PLUG INSIDE AN OPEN-ENDED PIPE PILE.



     *************************************************
     * COMPUTE LOAD-DISTRIBUTION AND LOAD-SETTLEMENT *
     * CURVES FOR AXIAL LOADING                      *
     *************************************************


T-Z CURVE   NO. OF   DEPTH TO CURVE   LOAD TRANSFER   PILE MOVEMENT
   NO.      POINTS        FT.              PSI              IN.

    1         10      0.4167E-01
                                     0.0000E+00      0.0000E+00
                                     0.1710E+01      0.2017E-01
                                     0.2851E+01      0.3908E-01
                                     0.4276E+01      0.7185E-01
                                     0.5131E+01      0.1008E+00
                                     0.5701E+01      0.1261E+00
                                     0.5131E+01      0.2521E+00
                                     0.5131E+01      0.3782E+00
                                     0.5131E+01      0.6303E+00
                                     0.5131E+01      0.2521E+01
    2         10      0.1135E+01
                                     0.0000E+00      0.0000E+00
                                     0.1710E+01      0.2017E-01
                                     0.2851E+01      0.3908E-01
                                     0.4276E+01      0.7185E-01
                                     0.5131E+01      0.1008E+00
                                     0.5701E+01      0.1261E+00
                                     0.5131E+01      0.2521E+00
                                     0.5131E+01      0.3782E+00
                                     0.5131E+01      0.6303E+00
```

```
                                   0.5131E+01      0.2521E+01
3         10      0.2228E+01
                                   0.0000E+00      0.0000E+00
                                   0.1710E+01      0.2017E-01
                                   0.2851E+01      0.3908E-01
                                   0.4276E+01      0.7185E-01
                                   0.5131E+01      0.1008E+00
                                   0.5701E+01      0.1261E+00
                                   0.5131E+01      0.2521E+00
                                   0.5131E+01      0.3782E+00
                                   0.5131E+01      0.6303E+00
                                   0.5131E+01      0.2521E+01
4         10      0.2312E+01
                                   0.0000E+00      0.0000E+00
                                   0.1710E+01      0.2017E-01
                                   0.2851E+01      0.3908E-01
                                   0.4276E+01      0.7185E-01
                                   0.5131E+01      0.1008E+00
                                   0.5701E+01      0.1261E+00
                                   0.5701E+01      0.2521E+00
                                   0.5701E+01      0.3782E+00
                                   0.5701E+01      0.6303E+00
                                   0.5701E+01      0.2521E+01
5         10      0.3770E+01
                                   0.0000E+00      0.0000E+00
                                   0.5943E+00      0.2017E-01
                                   0.9905E+00      0.3908E-01
                                   0.1486E+01      0.7185E-01
                                   0.1783E+01      0.1008E+00
                                   0.1981E+01      0.1261E+00
                                   0.1981E+01      0.2521E+00
                                   0.1981E+01      0.3782E+00
                                   0.1981E+01      0.6303E+00
                                   0.1981E+01      0.2521E+01
6         10      0.5228E+01
                                   0.0000E+00      0.0000E+00
                                   0.3421E+00      0.2017E-01
                                   0.5702E+00      0.3908E-01
                                   0.8553E+00      0.7185E-01
                                   0.1026E+01      0.1008E+00
                                   0.1140E+01      0.1261E+00
                                   0.1140E+01      0.2521E+00
                                   0.1140E+01      0.3782E+00
                                   0.1140E+01      0.6303E+00
                                   0.1140E+01      0.2521E+01
7         10      0.5312E+01
                                   0.0000E+00      0.0000E+00
                                   0.3476E+00      0.2017E-01
                                   0.5794E+00      0.3908E-01
                                   0.8691E+00      0.7185E-01
```

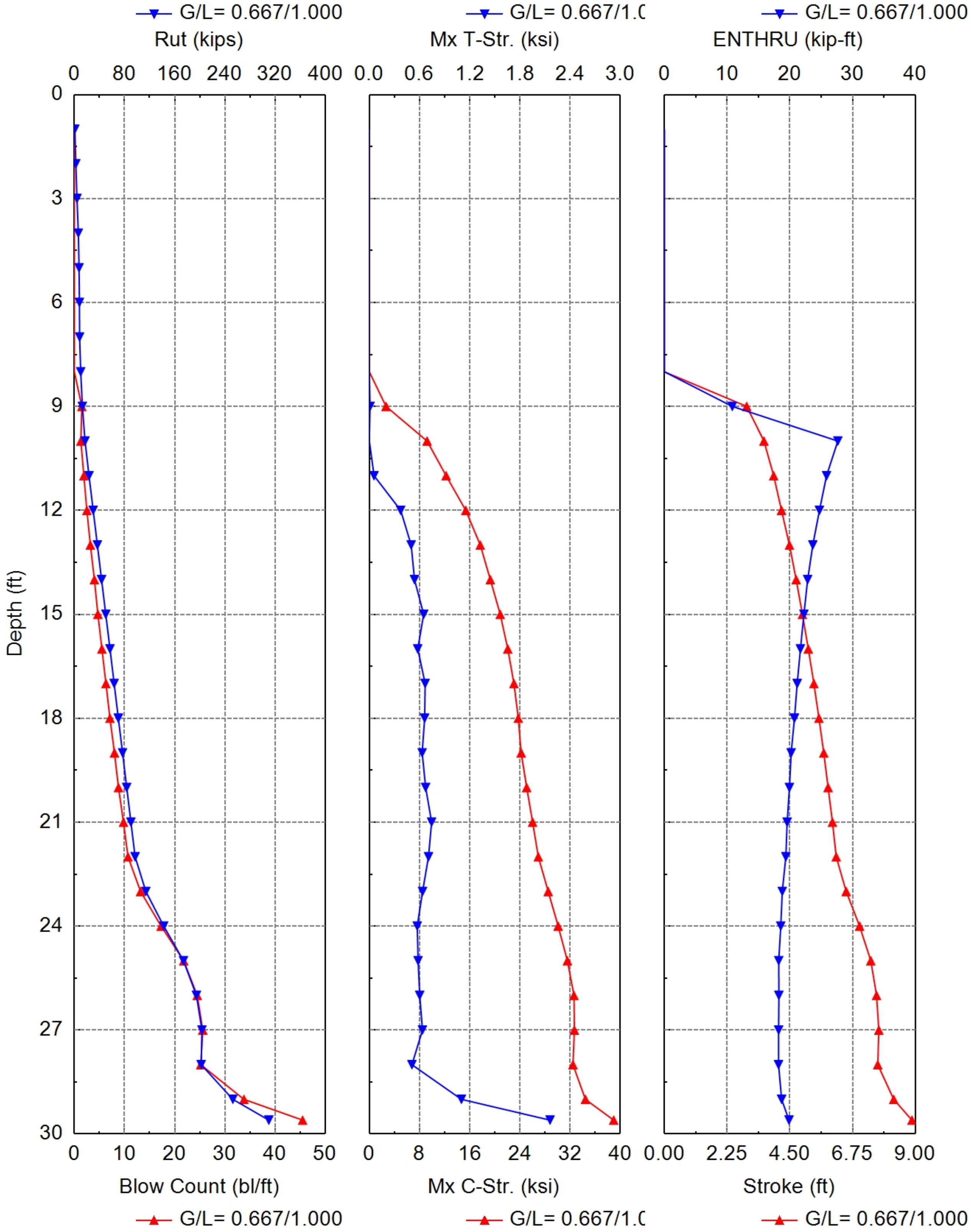
```
                                      0.1043E+01      0.1008E+00
                                      0.1159E+01      0.1261E+00
                                      0.1043E+01      0.2521E+00
                                      0.1043E+01      0.3782E+00
                                      0.1043E+01      0.6303E+00
                                      0.1043E+01      0.2521E+01
   8         10      0.7020E+01
                                      0.0000E+00      0.0000E+00
                                      0.9531E+00      0.2017E-01
                                      0.1589E+01      0.3908E-01
                                      0.2383E+01      0.7185E-01
                                      0.2859E+01      0.1008E+00
                                      0.3177E+01      0.1261E+00
                                      0.2859E+01      0.2521E+00
                                      0.2859E+01      0.3782E+00
                                      0.2859E+01      0.6303E+00
                                      0.2859E+01      0.2521E+01
   9         10      0.8728E+01
                                      0.0000E+00      0.0000E+00
                                      0.1609E+01      0.2017E-01
                                      0.2682E+01      0.3908E-01
                                      0.4023E+01      0.7185E-01
                                      0.4828E+01      0.1008E+00
                                      0.5364E+01      0.1261E+00
                                      0.4828E+01      0.2521E+00
                                      0.4828E+01      0.3782E+00
                                      0.4828E+01      0.6303E+00
                                      0.4828E+01      0.2521E+01
  10         10      0.8812E+01
                                      0.0000E+00      0.0000E+00
                                      0.1684E+01      0.2017E-01
                                      0.2807E+01      0.3908E-01
                                      0.4211E+01      0.7185E-01
                                      0.5053E+01      0.1008E+00
                                      0.5615E+01      0.1261E+00
                                      0.5053E+01      0.2521E+00
                                      0.5053E+01      0.3782E+00
                                      0.5053E+01      0.6303E+00
                                      0.5053E+01      0.2521E+01
  11         10      0.1627E+02
                                      0.0000E+00      0.0000E+00
                                      0.9458E+01      0.2017E-01
                                      0.1576E+02      0.3908E-01
                                      0.2364E+02      0.7185E-01
                                      0.2837E+02      0.1008E+00
                                      0.3153E+02      0.1261E+00
                                      0.2837E+02      0.2521E+00
                                      0.2837E+02      0.3782E+00
                                      0.2837E+02      0.6303E+00
                                      0.2837E+02      0.2521E+01
```

```
12         10      0.2373E+02
                                    0.0000E+00      0.0000E+00
                                    0.9562E+01      0.2017E-01
                                    0.1594E+02      0.3908E-01
                                    0.2390E+02      0.7185E-01
                                    0.2869E+02      0.1008E+00
                                    0.3187E+02      0.1261E+00
                                    0.2869E+02      0.2521E+00
                                    0.2869E+02      0.3782E+00
                                    0.2869E+02      0.6303E+00
                                    0.2869E+02      0.2521E+01
13         10      0.2381E+02
                                    0.0000E+00      0.0000E+00
                                    0.9574E+01      0.2017E-01
                                    0.1596E+02      0.3908E-01
                                    0.2393E+02      0.7185E-01
                                    0.2872E+02      0.1008E+00
                                    0.3191E+02      0.1261E+00
                                    0.3191E+02      0.2521E+00
                                    0.3191E+02      0.3782E+00
                                    0.3191E+02      0.6303E+00
                                    0.3191E+02      0.2521E+01
14         10      0.2627E+02
                                    0.0000E+00      0.0000E+00
                                    0.5610E+01      0.2017E-01
                                    0.9350E+01      0.3908E-01
                                    0.1402E+02      0.7185E-01
                                    0.1683E+02      0.1008E+00
                                    0.1870E+02      0.1261E+00
                                    0.1870E+02      0.2521E+00
                                    0.1870E+02      0.3782E+00
                                    0.1870E+02      0.6303E+00
                                    0.1870E+02      0.2521E+01
15         10      0.2873E+02
                                    0.0000E+00      0.0000E+00
                                    0.6168E+01      0.2017E-01
                                    0.1028E+02      0.3908E-01
                                    0.1542E+02      0.7185E-01
                                    0.1850E+02      0.1008E+00
                                    0.2056E+02      0.1261E+00
                                    0.2056E+02      0.2521E+00
                                    0.2056E+02      0.3782E+00
                                    0.2056E+02      0.6303E+00
                                    0.2056E+02      0.2521E+01
16         10      0.2881E+02
                                    0.0000E+00      0.0000E+00
                                    0.6187E+01      0.2017E-01
                                    0.1031E+02      0.3908E-01
                                    0.1547E+02      0.7185E-01
                                    0.1856E+02      0.1008E+00
```

```
                                    0.2062E+02      0.1261E+00
                                    0.1856E+02      0.2521E+00
                                    0.1856E+02      0.3782E+00
                                    0.1856E+02      0.6303E+00
                                    0.1856E+02      0.2521E+01
17         10      0.2927E+02
                                    0.0000E+00      0.0000E+00
                                    0.8374E+01      0.2017E-01
                                    0.1396E+02      0.3908E-01
                                    0.2093E+02      0.7185E-01
                                    0.2512E+02      0.1008E+00
                                    0.2791E+02      0.1261E+00
                                    0.2512E+02      0.2521E+00
                                    0.2512E+02      0.3782E+00
                                    0.2512E+02      0.6303E+00
                                    0.2512E+02      0.2521E+01
18         10      0.2973E+02
                                    0.0000E+00      0.0000E+00
                                    0.1201E+02      0.2017E-01
                                    0.2002E+02      0.3908E-01
                                    0.3003E+02      0.7185E-01
                                    0.3604E+02      0.1008E+00
                                    0.4004E+02      0.1261E+00
                                    0.3604E+02      0.2521E+00
                                    0.3604E+02      0.3782E+00
                                    0.3604E+02      0.6303E+00
                                    0.3604E+02      0.2521E+01
19         10      0.2981E+02
                                    0.0000E+00      0.0000E+00
                                    0.1268E+02      0.2017E-01
                                    0.2113E+02      0.3908E-01
                                    0.3169E+02      0.7185E-01
                                    0.3803E+02      0.1008E+00
                                    0.4225E+02      0.1261E+00
                                    0.3803E+02      0.2521E+00
                                    0.3803E+02      0.3782E+00
                                    0.3803E+02      0.6303E+00
                                    0.3803E+02      0.2521E+01
20         10      0.3492E+02
                                    0.0000E+00      0.0000E+00
                                    0.2369E+03      0.2017E-01
                                    0.3949E+03      0.3908E-01
                                    0.5923E+03      0.7185E-01
                                    0.7108E+03      0.1008E+00
                                    0.7897E+03      0.1261E+00
                                    0.7108E+03      0.2521E+00
                                    0.7108E+03      0.3782E+00
                                    0.7108E+03      0.6303E+00
                                    0.7108E+03      0.2521E+01
21         10      0.4003E+02
```

```
                                                     0.0000E+00      0.0000E+00
                                                     0.2369E+03      0.2017E-01
                                                     0.3949E+03      0.3908E-01
                                                     0.5923E+03      0.7185E-01
                                                     0.7108E+03      0.1008E+00
                                                     0.7897E+03      0.1261E+00
                                                     0.7108E+03      0.2521E+00
                                                     0.7108E+03      0.3782E+00
                                                     0.7108E+03      0.6303E+00
                                                     0.7108E+03      0.2521E+01


 TIP   LOAD        TIP MOVEMENT
     KIP                IN.

 0.0000E+00         0.0000E+00
 0.2086E+02         0.6303E-02
 0.4171E+02         0.1261E-01
 0.8342E+02         0.2521E-01
 0.1668E+03         0.1639E+00
 0.2503E+03         0.5294E+00
 0.3003E+03         0.9202E+00
 0.3337E+03         0.1261E+01
 0.3337E+03         0.1891E+01
 0.3337E+03         0.2521E+01


               LOAD VERSUS SETTLEMENT CURVE
               ****************************



 TOP  LOAD     TOP MOVEMENT      TIP  LOAD      TIP MOVEMENT
    KIP             IN.             KIP              IN.
0.7943E+01      0.5571E-02      0.3309E+00      0.1000E-03
0.8652E+02      0.6159E-01      0.3309E+01      0.1000E-02
0.3162E+03      0.2559E+00      0.1655E+02      0.5000E-02
0.4797E+03      0.4295E+00      0.3309E+02      0.1000E-01
0.6921E+03      0.6787E+00      0.6618E+02      0.2000E-01
0.1016E+04      0.1074E+01      0.9834E+02      0.5000E-01
0.1221E+04      0.1335E+01      0.1164E+03      0.8000E-01
0.1305E+04      0.1452E+01      0.1284E+03      0.1000E+00
0.1326E+04      0.1578E+01      0.1751E+03      0.2000E+00
0.1371E+04      0.1931E+01      0.2436E+03      0.5000E+00
0.1412E+04      0.2279E+01      0.2849E+03      0.8000E+00
0.1435E+04      0.2507E+01      0.3081E+03      0.1000E+01
0.1461E+04      0.3536E+01      0.3337E+03      0.2000E+01
```

Driveability Analysis Summary



Gain/Loss Factor at Shaft/Toe = 0.667/1.000

Depth	Rut	Rshaft	Rtoe	Blow Ct	Mx C-Str	Mx T-Str.	Stroke	ENTHRU	Hammer
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft	-
1.0	0.9	0.6	0.3	0.3	0.000	0.000	10.81	0.0	D 19-42
2.0	2.4	1.8	0.6	0.3	0.000	0.000	10.81	0.0	D 19-42
3.0	4.3	3.7	0.6	0.3	0.000	0.000	10.81	0.0	D 19-42
4.0	6.4	5.8	0.6	0.0	0.000	0.000	0.00	0.0	D 19-42
5.0	7.6	6.9	0.7	0.0	0.000	0.000	0.00	0.0	D 19-42
6.0	8.1	7.2	0.9	0.0	0.000	0.000	0.00	0.0	D 19-42
7.0	8.5	7.6	0.9	0.0	0.000	0.000	0.00	0.0	D 19-42
8.0	10.2	8.2	2.0	0.0	0.000	0.000	0.00	0.0	D 19-42
9.0	12.8	9.0	3.8	1.5	2.657	0.008	2.95	10.8	D 19-42
10.0	17.1	11.5	5.6	1.3	9.205	0.000	3.57	27.7	D 19-42
11.0	23.4	16.8	6.6	1.9	12.238	0.056	3.92	25.9	D 19-42
12.0	30.1	23.5	6.6	2.5	15.370	0.374	4.20	24.7	D 19-42
13.0	36.8	30.2	6.6	3.2	17.686	0.500	4.49	23.7	D 19-42
14.0	43.5	36.9	6.6	4.0	19.290	0.540	4.73	22.8	D 19-42
15.0	50.2	43.6	6.6	4.7	20.867	0.650	4.95	22.2	D 19-42
16.0	56.9	50.3	6.6	5.5	22.072	0.579	5.16	21.7	D 19-42
17.0	63.5	56.9	6.6	6.3	23.050	0.667	5.36	21.2	D 19-42
18.0	70.2	63.6	6.6	7.1	23.750	0.661	5.54	20.7	D 19-42
19.0	76.9	70.3	6.6	8.0	24.205	0.631	5.72	20.2	D 19-42
20.0	83.5	76.9	6.6	8.8	25.086	0.673	5.87	19.9	D 19-42
21.0	90.2	83.6	6.6	9.8	26.029	0.745	6.03	19.6	D 19-42
22.0	96.9	90.3	6.6	10.7	26.939	0.707	6.16	19.4	D 19-42
23.0	114.0	97.0	17.0	13.2	28.510	0.636	6.52	18.8	D 19-42
24.0	142.6	107.5	35.1	17.3	30.104	0.573	7.00	18.6	D 19-42
25.0	174.0	120.9	53.1	21.8	31.573	0.583	7.40	18.2	D 19-42
26.0	194.7	131.2	63.5	24.5	32.623	0.602	7.61	18.3	D 19-42
27.0	203.5	140.0	63.5	25.6	32.686	0.635	7.69	18.2	D 19-42
28.0	202.3	149.0	53.3	25.2	32.463	0.509	7.65	18.2	D 19-42
29.0	252.7	157.6	95.1	33.8	34.444	1.101	8.23	18.7	D 19-42
29.6	310.1	163.6	146.5	45.5	38.951	2.161	8.88	19.9	D 19-42

Total driving time: 6 minutes; Total Number of Blows: 244 (starting at penetration 1.0 ft)

GRLWEAP: Wave Equation Analysis of Pile Foundations

PAU-TR33-04.75 + HP10x42 FA 11/17/2024
CTL ENGINEERING, INC. GRLWEAP 14.1.20.1

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity-blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of structure and other factors.

PILE INPUT

Uniform Pile		Pile Type:	H Pile
Pile Length: (ft)	40.000	Pile Penetration: (ft)	29.600
Pile Size: (ft)	0.84	Toe Area: (in²)	12.40

Pile Profile

Lb Top ft	X-Area in²	E-Modulus ksi	Spec. Wt lb/ft³	Perim. ft	Crit. Index -
0.0	12.4	30,000.0	492.0	3.3	0
40.0	12.4	30,000.0	492.0	3.3	0

HAMMER INPUT

ID	41	Made By:	DELMAG
Model	D 19-42	Type:	OED

Hammer Data

ID -	Ram Wt kips	Ram L. in	Ram Ar. in²	Rtd. Stk ft	Effic. -	Rtd. Energy kip-ft
41	4.000	129.1	124.7	10.8	0.80	43.2

DRIVE SYSTEM FOR DELMAG D 19-42-OED

Type -	X-Area in²	E-Modulus ksi	Thickness in	COR -	Round-out in	Stiffness kips/in
Hammer C.	227.000	530.000	2.000	0.800	0.120	60155.550
Helmet Wt.	1.900	kips				

SOIL RESISTANCE DISTRIBUTION

Depth ft	Unit Rs ksf	Unit Rt ksf	Qs in	Qt in	Js s/ft	Jt s/ft	Set. F. -	Limit D. ft	Set. T. Hours	EB Area in²
0.0	0.0	3.5	0.10	0.12	0.15	0.15	1.5	6.0	168.0	12.4
1.0	0.5	3.5	0.10	0.12	0.15	0.15	1.5	6.0	168.0	12.4
2.0	0.5	7.0	0.10	0.12	0.15	0.15	1.5	6.0	168.0	12.4
3.0	0.8	7.0	0.10	0.19	0.05	0.15	1.0	6.0	1.0	12.4
4.0	0.5	7.0	0.10	0.19	0.05	0.15	1.0	6.0	1.0	12.4
5.0	0.2	8.1	0.10	0.19	0.05	0.15	1.0	6.0	1.0	12.4
6.0	0.1	10.5	0.10	0.11	0.15	0.15	1.5	6.0	168.0	12.4
7.0	0.2	10.5	0.10	0.11	0.15	0.15	1.5	6.0	168.0	12.4
8.0	0.3	23.2	0.10	0.11	0.15	0.15	1.5	6.0	168.0	12.4
9.0	0.5	44.1	0.10	0.08	0.15	0.15	1.5	6.0	168.0	12.4
10.0	1.8	65.0	0.10	0.08	0.15	0.15	1.5	6.0	168.0	12.4

11.0	3.0	76.6	0.10	0.08	0.15	0.15	1.5	6.0	168.0	12.4
12.0	3.0	76.6	0.10	0.08	0.15	0.15	1.5	6.0	168.0	12.4
13.0	3.1	76.6	0.10	0.08	0.15	0.15	1.5	6.0	168.0	12.4
14.0	3.0	76.6	0.10	0.08	0.15	0.15	1.5	6.0	168.0	12.4
15.0	3.1	76.6	0.10	0.08	0.15	0.15	1.5	6.0	168.0	12.4
16.0	3.0	76.6	0.10	0.08	0.15	0.15	1.5	6.0	168.0	12.4
17.0	3.0	76.6	0.10	0.08	0.15	0.15	1.5	6.0	168.0	12.4
18.0	3.1	76.6	0.10	0.08	0.15	0.15	1.5	6.0	168.0	12.4
19.0	3.0	76.6	0.10	0.08	0.15	0.15	1.5	6.0	168.0	12.4
20.0	3.0	76.6	0.10	0.08	0.15	0.15	1.5	6.0	168.0	12.4
21.0	3.1	76.6	0.10	0.08	0.15	0.15	1.5	6.0	168.0	12.4
22.0	3.0	76.6	0.10	0.08	0.15	0.15	1.5	6.0	168.0	12.4
23.0	3.1	197.4	0.10	0.08	0.15	0.15	1.5	6.0	168.0	12.4
24.0	4.5	407.6	0.10	0.08	0.05	0.15	1.0	6.0	1.0	12.4
25.0	3.6	616.6	0.10	0.08	0.05	0.15	1.0	6.0	1.0	12.4
26.0	2.6	737.4	0.10	0.08	0.05	0.15	1.0	6.0	1.0	12.4
27.0	2.7	737.4	0.10	0.08	0.05	0.15	1.0	6.0	1.0	12.4
28.0	2.8	619.0	0.10	0.08	0.05	0.15	1.0	6.0	1.0	12.4
29.0	2.9	1104.4	0.10	0.08	0.20	0.15	1.3	6.0	24.0	12.4
30.0	4.9	2099.6	0.10	0.04	0.20	0.15	1.0	6.0	0.0	12.4
31.0	60.3	3183.1	0.10	0.04	0.20	0.15	1.0	6.0	0.0	12.4
32.0	113.7	3875.2	0.10	0.04	0.20	0.15	1.0	6.0	0.0	12.4
33.0	113.7	3875.2	0.10	0.04	0.20	0.15	1.0	6.0	0.0	12.4

APPENDIX E

GEOTECHNICAL DESIGN CHECKLIST

Ohio Department of Transportation
Geotechnical Engineering
Design Checklists

Version 6.0
January 20, 2023

Preface

Geotechnical design features that arise in the development of roadway projects vary both in type and complexity. Cuts, embankments, wetlands, mine issues, and rock slopes are just some geotechnical issues encountered on transportation projects. Consistent and comprehensive reconnaissance, analysis, and plan preparation are necessary to ensure that all possible geotechnical issues that may occur on a project will be adequately identified and accounted for on the final plans.

A set of topical review checklists, a reference list, and a technical publications list have been developed to aid the project development personnel in their production of geotechnically sound project plans. All projects that contain geotechnical related issues will benefit from the use of this document. Although it is expected that the District Geotechnical Engineer will be one of the main users of these checklists, any personnel responsible for a geotechnical aspect of the project plan development will use this document. Possible users of this checklist include, but are not limited to, design and geotechnical Consultants and District and Central Office reviewers and project engineers.

The design checklists are provided to assist the project development personnel in:

- Developing a comprehensive geotechnical scope of services
- Developing and reviewing geotechnical reports and assimilating information
- Analyzing, designing, and reviewing geotechnical related aspects of a transportation project, including needs assessment, plans, and specifications
- Recognizing cost-saving opportunities
- Identifying deficiencies due to inadequate geotechnical exploration, analysis, or design
- Recognizing when to request additional technical assistance from a geotechnical specialist
- Defining areas of needed training

At first glance, the design checklist will seem to be inordinately lengthy. One, however, should not avoid using the checklist because of this. Only on major and complex projects will it be necessary to complete most of the checklist. Just those checklists that pertain to a specific geotechnical feature encountered on the project should be completed. Therefore, for most projects, only a small portion of the checklist will need to be completed.

Since several entities may be involved in the geotechnical development of a transportation project, it is possible that there may be more than one set of checklists completed for a specific project, or different entities may fill out different sections of the checklist. It is anticipated that all completed checklists will be included with the project file in District or Central Office.

<u>To utilize the checklists,</u>

- First fill out the project information on the Checklist Cover tab. The project information in the headings of the rest of the checklists will autopopulate. Also indicate which checklists will be utilized.
- Complete only the checklists that apply to the project by using the dropdown boxes.
- Submit the checklist cover along with all completed checklists with the report and plan submission

Additional topics and questions may be added as the development of these checklists continues and input is received from the users. All additional updates and design guidance will be issued from the Office of Geotechnical Engineering (OGE) and available on the internet at the Design Reference Resource Center and the OGE website. The OGE Administrator will be the point of contact regarding the checklist, and any questions, recommendations, and training requests should be directed to the Office Administrator.

Table of Contents

Symbols and Abbreviations

Y	Yes
N	No
X	Not Applicable (Reason should be explained in the “Notes” area of the checklist)
✓	Selected item utilized

AASHTO	American Association of State Highway and Transportation Officials
AML	Abandoned Mine Land Reclamation Program, DMRM, ODNR
AUMIRA	Manual for Abandoned Underground Mine Inventory and Risk Assessment, ODOT
BDM	Bridge Design Manual, ODOT
CBR	California Bearing Ratio
C&MS	Construction and Material Specifications, ODOT
DGE	District Geotechnical Engineer, ODOT District
DGS	Division of Geological Survey, ODNR
DMRM	Division of Mineral Resources Management, ODNR
DSWC	Division of Soil and Water Conservation, ODA
EPA	Ohio Environmental Protection Agency
FHWA	Federal Highway Administration
F.S.	Factor of Safety
GDM	Geotechnical Design Manual, ODOT
L&D1	Location & Design Manual, Volume 1, ODOT
L&D3	Location & Design Manual, Volume 3, ODOT
LRFD	Load and Resistance Factor Design
N_{60}	Standard Penetration Value, normalized to 60 percent of drill rod energy ratio
ODNR	Ohio Department of Natural Resources
ODOT	Ohio Department of Transportation
OGE	Office of Geotechnical Engineering, ODOT
OSMRE	Office of Surface Mining Reclaimation and Enforcement, U.S. Dept. of the Interior
ROW	Right of Way
RQD	Rock Quality Designation
SDI	Slake Durability Index
SGE	Specifications for Geotechnical Explorations, ODOT
SPT	Standard Penetration Test
TIMS	Transportation Information Mapping System
UBV	Ultimate Bearing Value
	Standard Penetration Test
USGS	U.S. Geological Survey
WEAP	Wave Equation Analysis of Pile Driving (Software)

I. Geotechnical Design Checklists

Project: PAU-TR33-04.75 **PDP Path:**

PID: 113849 **Review Stage:**

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. Geotechnical Profile	✓
VI. D. Geotechnical Reports	✓

II. Reconnaissance and Planning Checklist

C-R-S: PAU-TR33-04.75	**PID:** 113849	**Reviewer:**	**Date:**

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:	Y	
	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	
	The schedule of borings should present the following information for each boring:		
a.	exploration identification number	Y	
b.	location by station and offset	Y	
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, soundings, 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)		
	Rock Slope (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 and b)		
	Noise Barrier (Type E4)		
	CCTV & High Mast Lighting Towers (Type E5)		
	Buildings and Salt Domes (Type E6)		

IV.A Foundations of Structures Checklist

C-R-S:	PAU-TR33-04.75	**PID:**	113849	**Reviewer:**		**Date:**

Use this Checklist in conjunction with the bridge foundation design guidance in GDM Section 1300
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:		
	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	N	
5	Have the recommended bottom of footing elevation and reason for this recommendation been provided?		
a.	Has the recommended bottom of footing elevation taken scour from streams or other water flow into account?		
6	Were representative sections analyzed for the entire length of the structure for the following:		
a.	factored bearing resistance?		
b.	factored sliding resistance?		
c.	eccentric load limitations (overturning)?		
d.	predicted settlement?		
e.	overall (global) stability?		
7	Has the need for a shear key been evaluated?		
a.	If needed, have the details been included in the plans?		
8	If special conditions exist (e.g. geometry, sloping rock, varying soil conditions), was the bottom of footing "stepped" to accommodate them?		
9	Have the Service I and Maximum Strength Limit States for bearing pressure on soil or rock been provided?		

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?		
a. Have the procedure and quantities related to this removal / treatment been included in the plans?		
Pile Structures	(Y/N/X)	Notes:
11 Are there piles on the project? If no, go to Question 17	Y	
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.	Y	HP 10x42 & HP 12x53 Piles driven to Bedrock
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 305.3.1.2 to determine whether the pile can be driven to either the UBV, the pile tip elevation, or refusal on bedrock without overstressing the pile?	Y	
16 If required for design, have sufficient soil parameters been provided and calculations performed to evaluate the:	Y	
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 305.3.2.2?		
d. Potential for and impact of lateral squeeze from soft foundation soils?	Y	

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 305.3.5.6?	Y	
18	If subsurface obstacles exist, has preboring been recommended to avoid these obstructions?	X	
19	If piles will be driven through 15 feet or more of new embankment, has preboring been specified as per BDM 305.3.5.7?	X	

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 305.4.2?		
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?		
a.	If needed, have details and plan notes for load testing been included in the plans?		

VI.A. Geotechnical Profile Checklist

C-R-S: PAU-TR33-04.75	**PID:** 113849	**Reviewer:**	**Date:**

General Presentation		(Y/N/X)	Notes:
1	Has an electronic copy of all geotechnical submissions been provided to the District Geotechnical Engineer (DGE)?	Y	
2	Have the cadd files been prepared using the appropriate version of the ODOT CADD standards?	Y	
3	Has the geotechnical specification (title and date) under which the work was performed been clearly identified on every submission (reports, plans, etc.)?	Y	
4	Has the first complete version of all documents being submitted been labeled as 'Draft'?	Y	
5	Subsequent to ODOT's review and approval, has the complete version of the revised documents being submitted been labeled as 'Final'?	X	
a.	Have the C-R-S, PID number, and product title been included in the folder name?	X	
6	If the project includes structures, have all structure explorations been presented together under the same cover sheet? (Do not create separate Geotechnical Profile - Bridge Sheets)	Y	
7	Has a scale of 1"=1' been used for cover sheets, laboratory test data sheets, and boring log sheets, if applicable?	Y	
8	Based on the project length, has the correct horizontal scale been used to plot the project data?	Y	
	Check scale used:		
	1" = 5', 10', 20', 25', 40', or 50' for projects 1500' or less (use largest scale appropriate to present entire plan on one sheet)	✓	
	1" = 50' projects greater than 1500'		
9	Has a scale of 1" = 10' been utilized for the vertical scale of the project data?	Y	
10	If the project includes structures, has the plan and profile view been shown at the same scale as the Site Plan for the proposed structure(s), when possible?	Y	

VI.A. Geotechnical Profile Checklist

General Presentation		(Y/N/X)	Notes:
11	If the project includes culverts, have the plan and profile been presented along the flowline of the culvert?	X	
12	Have the cross-sections been plotted at a scale of 1” = 10’ (preferred) or 1” = 20’ (for higher or wider slopes)?	X	
Cover Sheet		(Y/N/X)	Notes:
13	Has the following general information been provided on the cover sheet:	Y	
a.	Brief description of the project, including the bridge number of each bridge involved in the plan set, if any?	Y	
b.	Brief description of historic geotechnical explorations referenced in this exploration? State if no historic records are available.	Y	
c.	Generalized information about the geology of the project area, including terrain, soil origin, bedrock types, and age?	Y	
d.	Brief presentation of geological and topographical information derived from the field reconnaissance? Include comments on structure and pavement conditions.	Y	
e.	Brief presentation of test boring and sampling methods? Include date of last calibration and drill rod energy ratio as a percent for the hammer systems used.	Y	
f.	Summary of general soil, bedrock, and groundwater conditions, including a generalized interpretation of findings?	Y	
g.	A statement of which version (date) of the SGE specification the exploration was performed in accordance with?	Y	
h.	Statement of where geotechnical reports are available for review?	Y	
i.	Initials of personnel and dates they performed field reconnaissance, subsurface exploration and preparation of the geotechnical profile?	Y	

VI.A. Geotechnical Profile Checklist

Cover Sheet		(Y/N/X)	Notes:
14	Has a Legend been provided?	Y	
15	Have the following items been included in the Legend:	Y	
a.	Symbols and usual descriptions for only the soil and bedrock types presented in the Geotechnical Profile, as per the Soil and Rock Symbology Chart in Appendix D of the SGE?	Y	
b.	All miscellaneous symbols and acronyms, used on any of the sheets, defined?	Y	
c.	The number of soil samples for each classification that were mechanically classified and visually described in the current exploration?	Y	
16	Has a Location Map, showing the beginning and end stations for the project, been shown on the cover sheet, sized per the L&D3 Manual?	Y	
17	Have the station limits for each plan and profile sheet for projects with multiple alignments, or greater than 1500’, been identified in a table?	X	
18	Have the station limits for any cross section sheets been identified in the same table?	X	
19	Has a list of any structures for which structure foundation explorations been performed been identified in the same table?	Y	
20	If sampling and testing for a scour analysis was performed, has this data been shown in tabular form?	Y	
21	Has a summary table of test data for all roadway and subgrade boring samples been shown?	X	
22	If borings from previous subsurface explorations are being used, has that data been shown in a separate table?	X	
23	In the summary table, has the data been displayed by roadway and subgrade boring in ascending stationing order for each roadway?	X	
24	Have the centerline or baseline station, offset, and exploration identification number been provided for each boring presented in the table?	X	

VI.A. Geotechnical Profile Checklist

Cover Sheet		(Y/N/X)	Notes:
25	For each sample, has the following information been provided in the summary table:	Y	
a.	Sample depth interval?	Y	
b.	Sample number and type?	Y	
c.	N_{60}?	Y	
d.	Percent recovery?	Y	
e.	Hand Penetrometer?	Y	
f.	Percentage of aggregate, coarse sand, fine sand, silt, and clay size particles?	Y	
g.	Liquid limit, plastic limit, plasticity index, and water content, all rounded to the nearest percent or whole number?	Y	
h.	ODOT classification and Group Index?	Y	
i.	Visual description of samples not mechanically classified, including water content, and estimated ODOT classification with 'Visual' in parentheses?	Y	
j.	Sulfate Content test results?	X	
26	Have all undisturbed test results been displayed in graphical format on the sheet prior to the plan and profile sheets?	X	
Surface Data		(Y/N/X)	Notes:
27	Has the following information been shown on each roadway plan drawing:	Y	
a.	Existing surface features described in Section 702.5.1?	Y	
b.	Proposed construction items, as described in Section 702.5.2?	Y	
c.	Project and historic boring locations, with appropriate exploration targets and exploration identification numbers?	Y	
d.	Notes regarding observations not readily shown by drawings?	X	
28	Have the existing ground surface contours been presented?	Y	
29	If cross sections are to be developed for stationing covered on a plan sheet, has an index for the appropriate cross section sheets been included on the plan sheet?	X	

VI.A. Geotechnical Profile Checklist

Subsurface Data		(Y/N/X)	Notes:
30	Has all the subsurface data been presented in the form of a profile along the centerline or baseline, and on cross sections where applicable?	Y	
31	Have the graphical boring logs been correctly shown, as follows:	Y	
a.	Location and depth of boring indicated by a heavy dashed vertical line?	Y	
b.	Exploration identification number above the boring?	Y	
c.	Logs indicate soil and bedrock layers with symbols 0.4” wide and centered on the heavy dashed vertical line where possible?	Y	
d.	Bedrock exposures with 0.4” wide symbols, but without a heavy dashed vertical line?	X	
e.	Soil and bedrock symbols as per ODOT Soil and Rock Symbology chart (SGE - Appendix D)?	Y	
f.	Historical borings shown in same manner with the exploration identification number above the boring?	X	
32	Have the proposed groundline and existing groundline been shown on the profile view, according to ODOT CADD standards?	Y	
33	Have the locations of the proposed structure foundation elements been shown on the profile view?	Y	
34	Have the offsets from centerline or baseline been indicated above the borings in the profile view?	Y	
35	Have borings located immediately adjacent to the centerline or baseline and considered representative of centerline or baseline subsurface conditions been referenced directly to the centerline or baseline?	Y	
36	Have offset borings in or near the same elevation interval of a centerline or baseline boring been plotted either on a cross section or immediately above or below the centerline boring in a box containing an elevation scale?	Y	
37	Have cross-sections been developed to show subsurface conditions disclosed by a series of borings drilled transverse to centerline or baseline?	Y	

VI.A. Geotechnical Profile Checklist

Subsurface Data		(Y/N/X)	Notes:
38	Have the existing and proposed groundlines been displayed on cross section sheets according to ODOT CADD standards?	Y	
39	Have bedrock exposures shown on the cross sections been plotted along the contour of the cross section?	X	
40	Has the following information been provided adjacent to the graphical logs or bedrock exposure:	Y	
a.	Thickness, to the nearest inch, of sod/topsoil or other shallow surface material written above the boring (with corresponding symbology at top of log)?	Y	
b.	Moisture content, to nearest whole percent, with the bottom of the text aligned with the bottom of the sample? Label this column as ‘WC’ at bottom of the boring.	Y	
c.	N_{60}, aligned with the bottom of sample? Label column as ‘N_{60}’ at bottom of boring.	Y	
d.	Free water indicated by a horizontal line with a ‘w’ attached, and water level at the end of drilling indicated by an open equilateral triangle, point down?	Y	
e.	Complete geologic description of each bedrock unit, including unit core loss, unit RQD, SDI, and compressive strength test results? (Do not present geologic descriptions for structure borings for which this information is presented on the boring logs as described in 703.3)	Y	
f.	Visual description of any uncontrolled fill or interval not adequately defined by a graphical symbol?	X	
g.	Organic content with modifiers, per 603.5?	X	
h.	Designate a plastic soil with moisture content equal to or greater than the liquid limit minus three with a 1/8” solid black circle adjacent to the moisture content?	X	
i.	Designate a non-plastic soil with moisture content exceeding 25% or exceeding 19% but appearing wet initially, with a 1/8” open circle with a horizontal line through it adjacent to the moisture content?	Y	
j.	The reason for discontinuing a boring prior to reaching the planned depth indicated immediately below the boring?	Y	

VI.A. Geotechnical Profile Checklist

Boring Logs	(Y/N/X)	Notes:
41 Have the boring logs of all structure borings, all geohazard borings, and any roadway borings drilled in the vicinity of the structures or geohazard been shown on the boring log sheets following the plan and profile sheets? (Create the logs in accordance with 703.3)	Y	
42 Have the boring logs been developed by integrating the driller’s field logs, laboratory test data, and visual descriptions?	Y	
43 Has the following boring information been included in the heading of each boring log:	Y	
a. Exploration identification number?	Y	
b. Project designation (C-R-S) and PID?	Y	
c. Structure File Number (if applicable) and project type?	Y	
d. Centerline or baseline name, station, offset, and surface elevation?	Y	
e. Coordinates?	Y	
f. Method of drilling?	Y	
g. Date started and date completed?	Y	
h. Method and material (including quantity) used for backfilling or sealing, including type of instrumentation, if any (reported in the footer)?	Y	
i. Date of last calibration and drill rod energy ratio (ER) in percent for the hammer system(s) used, not to exceed 90%?	Y	
44 Has the following boring information been included in each boring log:	Y	
a. A depth and elevation scale?	Y	
b. Indication of stratum change?	Y	
c. Description of material in each stratum?	Y	
d. Depth of bottom of boring?	Y	
e. Depth of boulders or cobbles, if encountered?	Y	
f. Caving depth?	Y	
g. Water level observations?	Y	
h. Artesian water level and height of rise?	X	
i. Heaving sand?	X	
j. Cavities or other unusual conditions?	X	
k. Depth interval represented by sample?	Y	
l. Sample number and type?	Y	
m. Percent recovery for each sample?	Y	
n. Measured blow counts for each 6 inches of drive for split spoon samples, not to exceed 18 inches total?	Y	
o. N_{60} to the nearest whole number?	Y	

VI.A. Geotechnical Profile Checklist

p. Hand penetrometer?	Y	

VI.A. Geotechnical Profile Checklist

Boring Logs		(Y/N/X)	Notes:
q.	Particle-size analysis?	Y	
r.	Liquid limit, plastic limit, plasticity index?	Y	
s.	Water content?	Y	
t.	ODOT soil classifications, with "V" in parentheses for those samples that are not mechanically classified?	Y	
u.	Top of bedrock and bedrock descriptions?	Y	
v.	Rock core run percent recovery?	Y	
w.	Run RQD?	Y	
x.	Unit rock core percent recovery?	Y	
y.	Unit RQD?	Y	
z.	SDI, if applicable?	X	
aa.	Rock compressive strength test results, if applicable?	Y	

VI.B. Geotechnical Reports

C-R-S:	PAU-TR33-04.75	**PID:**	113849	**Reviewer:**	**Date:**

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'?	X	
4	Has the boring data been submitted in a native format that is DIGGS (Data Interchange for Geotechnical and Geoenvironmental) compatable? gINT files meet this demand?	N	
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 706.1 of the SGE?	Y	
Report Body		(Y/N/X)	Notes:
7	Do all geotechnical reports being submitted contain the following:	Y	
a.	an Executive Summary as described in Section 706.2 of the SGE?	Y	
b.	an Introduction as described in Section 706.3 of the SGE?	Y	
c.	a section titled "Geology and Observations of the Project," as described in Section 706.4 of the SGE?	Y	
d.	a section titled "Exploration," as described in Section 706.5 of the SGE?	Y	
e.	a section titled "Findings," as described in Section 706.6 of the SGE?	Y	
f.	a section titled "Analyses and Recommendations," as described in Section 706.7 of the SGE?	Y	
Appendices		(Y/N/X)	Notes:
8	Do all geotechnical reports being submitted contain all applicable Appendices as described in Section 706.8 of the SGE?	Y	
9	Do the Appendices present a site Boring Plan showing all boring locations as described in Section 706.8.1 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 706.8.2 of the SGE?	Y	
11	Do the Appendices include reports of undisturbed test data as described in Section 706.8.3 of the SGE?	Y	
12	Do the Appendices include calculations in a logical format to support recommendations as described in Section 706.8.4 of the SGE?	Y	

VII. References

Publications - FHWA

Advanced Course on Slope Stability, Volume 1 and 2, Abramson, Lee, Boyce, Glenn, et al., Publication No. FHWA-SA-94-005 and 006

Corrosion/Degradation of Soil Reinforcement for Mechanically Stabilized Earth Walls and Reinforced Soil Slopes, Elias, Publication No. FHWA-NHI-09-087

Geotechnical Engineering Circular No. 2 - Earth Retaining Systems, Sabitini, Elias, et al., Publication No. FHWA-SA-96-038

Geotechnical Engineering Circular No. 3 - LRFD Seismic Analysis and Design of Transportation Geotechnical Features and Structural Foundations, Kavazanjian, Publication No. FHWA-NHI-11-032

Geotechnical Engineering Circular No. 4 - Ground Anchors and Anchor Systems, Sabitini, Pass and Bachus, Publication No. FHWA-IF-99-015

Geotechnical Engineering Circular No. 5 – Geotechnical Site Characterization, Loehr, et. al., Publication No. FHWA-NHI-16-072

Geotechnical Engineering Circular No. 6 – Shallow Foundations, Kimmerling, Publication No. FHWA-IF-02-054

Geotechnical Engineering Circular No. 7 – Soil Nail Walls Reference Manual, Lazarte, et. al., Publication No. FHWA-NHI-14-007

Geotechnical Engineering Circular No. 8 – Design and Construction of Continuous Flight Auger Piles, Brown, et. al., Publication No. FHWA-HIF-07-039

Geotechnical Engineering Circular No. 9 – Design and Analysis of Laterally Loaded Deep Foundations, Parkes, et. al., Publication No. FHWA-HIF-18-031

Geotechnical Engineering Circular No. 10 - Drilled Shafts: Construction Procedures and Design Methods, Brown, et. al., Publication No. FHWA-NHI-18-024

Geotechnical Engineering Circular No. 11 - Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes, Volume I and II, Berg, Christopher, and Samtani, Publication No. FHWA-NHI-10-024 and 025

Geotechnical Engineering Circular No. 12 - Design and Construction of Driven Pile Foundations, Volume I and II, Hannigan, Rausche, Likins, Robinson, and Becker, Publication No. FHWA-NHI-16-009 and 010

Geotechnical Engineering Circular No. 13 – Ground Modification Methods Reference Manual, Volume I and II, Schaefer, et. al., Publication No. FHWA-NHI-16-027 and 028

Geotechnical Engineering Circular No. 15 – Acceptance Procedures for Structural Foundations, Loehr, et. al., Publication No. FHWA-HIF-22-024

Geotechnical Instrumentation Reference Manual, Dunnicliff, NHI Course No. 13241 - Module 11

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