



ECS Southeast, LLP

Report of Bridge Foundation Design Recommendations (REV)

Bridge No. 271 on SR 1818 (Neils Eddy Road) over Mill Creek

Riegelwood, Columbus County, North Carolina

WBS No.: BP6.R008

TIP No: SF-230271

ECS Project No. 33:6005

May 11, 2023





ECS SOUTHEAST, LLP

"Setting the Standard for Service"

Geotechnical • Construction Materials • Environmental • Facilities

May 11, 2023

Mr. Bryan Hough, P.E.
KCI Associates of North Carolina, PA
4505 Falls of Neuse Road, Suite 400
Raleigh, North Carolina 27609

ECS Project No. 33:6005

Reference: Bridge Foundation Design Recommendations (REV)
Bridge No. 271 on SR 1818 (Neils Eddy Road) over Mill Creek
WBS No: BP6.R008
TIP No: SF-230271
County: Columbus

Dear Mr. Hough:

ECS Southeast, LLP (ECS) is pleased to submit the revised Bridge Foundation Design Recommendations for Bridge No. 271 on SR 1818 (Neils Eddy Road) over Mill Creek in Riegelwood, Columbus County, North Carolina. This revised report incorporates recent NCDOT review comments. This work was performed in general accordance with our "Subconsultant Professional Services Agreement" between KCI Associates of North Carolina, PA and ECS Southeast, LLP dated December 22, 2022.

Our design is based on project information provided to us by KCI. This report contains the foundation recommendations, a Structure Subsurface Investigation report prepared by ECS, and supporting calculations.

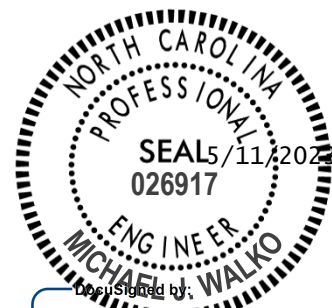
ECS Southeast, LLP appreciates the opportunity to assist you during this phase of the project. If you have questions concerning this report, please contact our office at 704-525-5152.

Respectfully submitted,

ECS Southeast, LLP

DocuSigned by:

7BDD9975E22C480...
Kelly N. de Montbrun, P.E.
Senior Project Engineer
KdeMontbrun@ecslimited.com



DocuSigned by:

78222AC7F82F4D7
Michael J. Walko, P.E.
Principal Engineer
MWalko@ecslimited.com
NC Registered No. 026917

FOUNDATION RECOMMENDATIONS

Prepared for NCDOT by: ECS Southeast, LLP

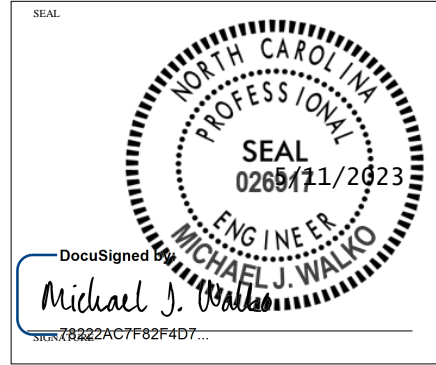
WBS NO. BP6.R008 DESCRIPTION Bridge No. 271 on SR 1818 (Neils Eddy Road) over
Mill Creek

T.I.P. NO. SF-230271

COUNTY Columbus

STATION 13+47.0 -L-

	INITIALS	DATE
DESIGN	MJW	05/03/23
CHECK	KND	05/04/23
REVISED	MJW	05/11/23



	STATION	FOUNDATION TYPE	FACTORED LOAD	MISCELLANEOUS DETAILS
END BENT NO. 1	13+10.84 -L-	Cap on HP 12X53 Steel Piles	85 Tons/Pile	Average Bottom of Cap Elevation = 12.1 +/- Average Pile Length = 60 ft 7 Vertical Piles @ 6'-0" Spacing
END BENT NO. 2	13+83.16 -L-	Cap on HP 12X53 Steel Piles	85 Tons/Pile	Average Bottom of Cap Elevation = 10.5 ft +/- Average Pile Length = 50 ft 7 Vertical Piles @ 6'-0" Spacing

(SEE NOTES ON PLANS AND COMMENTS ON FOLLOWING PAGES)

WBS No: BP6.R008

County: Columbus

FOUNDATION RECOMMENDATION COMMENTS

- 1) 1.5:1 (H:V) END SLOPES WITH RIP RAP PROTECTION ARE RECOMMENDED AS SHOWN ON THE APPROVED BSR.
- 2) NO WAITING PERIOD IS REQUIRED AT EITHER END BENT PRIOR TO CONSTRUCTION.
- 3) AVERAGE PILE LENGTHS ARE BASED ON PLUMB PILES FROM THE PILE CUT-OFF ELEVATION TO THE ANTICIPATED TIP ELEVATION, ROUNDED UP TO THE NEAREST 5 FEET.
- 4) SINCE THESE ARE BEING DESIGNED AS FRICTION PILES, RESTRIKES SHOULD BE ANTICIPATED IF PILES DO NOT ACHIEVE CAPACITY DURING INITIAL DRIVE.
- 5) USE TYPE II MODIFIED BRIDGE APPROACH FILL DETAILS AT EACH END BENT.

SUMMARY OF PILE INFORMATION/INSTALLATION
(Blank entries indicate item is not applicable to structure)

End Bent/ Bent No, Pile(s) #:# (e.g., "Bent 1, Piles 1-5")	Factored Resistance per Pile TONS	Pile Cut-Off (Top of Pile) Elevation FT	Estimated Pile Lenth per Pile FT	Scour Critical Elevation FT	Driven Piles			Predrilling for Piles*			Drilled-In Piles		
					Min Pile Tip (Tip No Higher Than) Elev FT	Required Driving Resistance (RDR)** per Pile TONS	Total Pile Redrives Quantity EACH	Predrilling Length per Pile Lin FT	Predrilling Elevation (Elev Not To Predrill Below) FT	Maximum Predrilling Dia INCHES	Pile Excavation (Bottom of Hole) Elev FT	Pile Exc Not In Soil per Pile Lin FT	Pile Exc In Soil per Pile Lin FT
End Bent No 1, Piles 1-7	85	See Substructure	60			145							
End Bent No 2, Piles 1-7	85	Plans	50			145	8						

*Predrilling for Piles is required for end bents/bents with a predrilling length and at the Contractor's option for end bents/bents with predrilling information but no predrilling length.

$$**RDR = \frac{\text{Factored Resistance} + \text{Factored Downdrag Load} + \text{Factored Dead Load}}{\text{Dynamic Resistance Factor}} + \text{Nominal Downdrag Resistance} + \frac{\text{Nominal Scour Resistance}}{\text{Scour Resistance Factor}}$$

SUMMARY OF PDA/PILE ORDER LENGTHS
(Blank entries indicate item is not applicable to structure)

Pile Driving Analyzer (PDA)				Pile Order Lengths	
End Bent/ Bent No	PDA Testing Required? YES or MAYBE	PDA Test Pile Length FT	Total PDA Testing Quantity EACH	End Bent/ Bent No(s)	Pile Order Length Basis* EST or PDA
End Bent No 1	MAYBE	65	1		
End Bent No 2	MAYBE	55			

*EST = Pile order lengths from estimated pile lengths; PDA = Pile order lengths based on PDA testing. For groups of end bents/bents with pile order lengths based on PDA testing, the first end bent/bent no. listed for each group is the representative end bent/bent with the PDA.

PILE DESIGN INFORMATION
(Blank entries indicate item is not applicable to structure)


End Bent/ Bent No, Pile(s) #:# (e.g., "Bent 1, Piles 1-5")	Factored Axial Load per Pile TONS	Factored Downdrag Load per Pile TONS	Factored Dead Load* per Pile TONS	Dynamic Resistance Factor	Nominal Downdrag Resistance per Pile TONS	Nominal Scour Resistance per Pile TONS	Scour Resistance Factor (Default = 1.00)
End Bent No 1, Piles 1-7	81			0.60			
End Bent No 2, Piles 1-7	81			0.60			

*Factored Dead Load is factored weight of pile above the ground line.

PROJECT NO. BP6.R008
COLUMBUS COUNTY
 STATION: 13+47.0 -L-

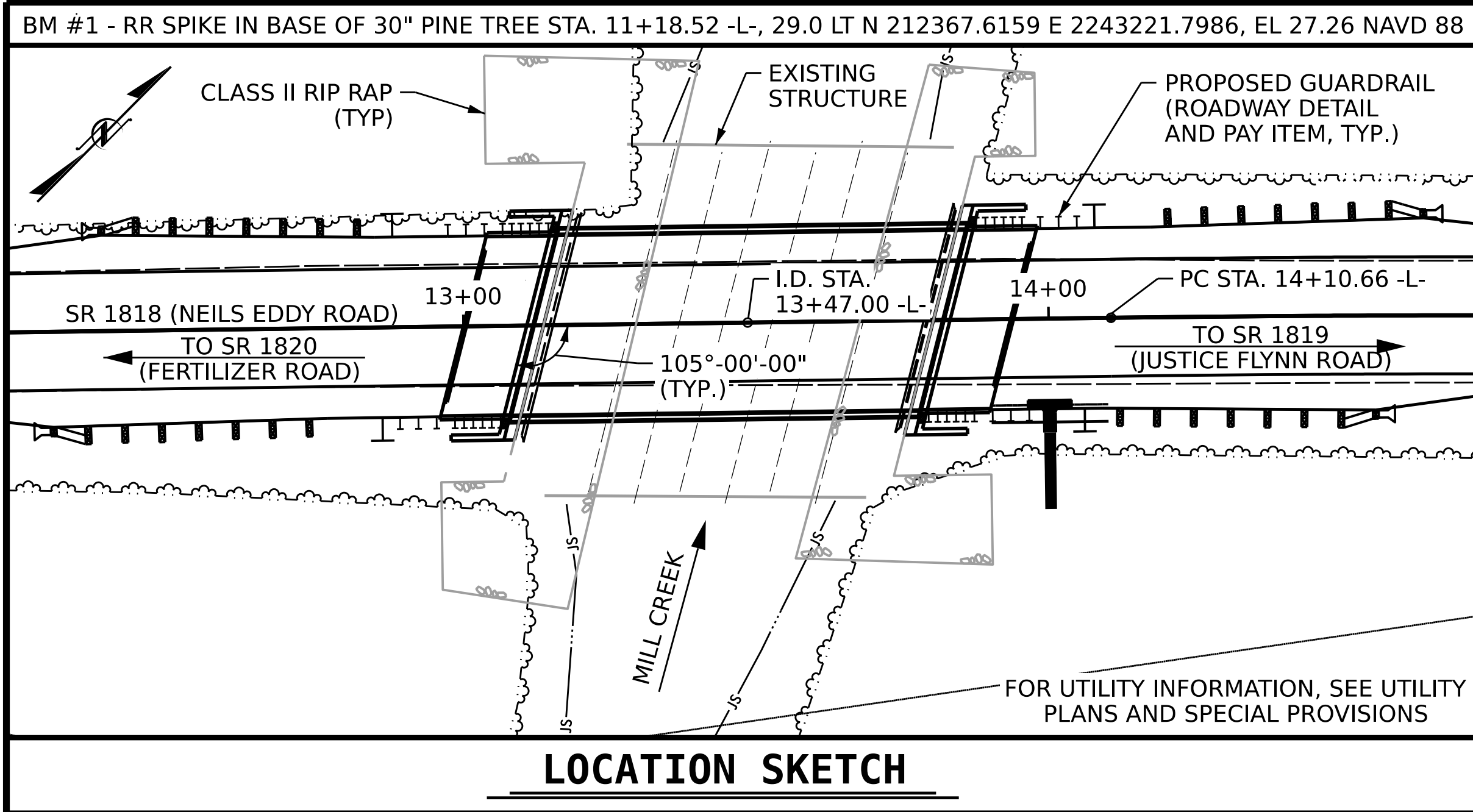
NOTES:

- The Pile Foundation Tables are based on the bridge substructure design and foundation recommendations sealed by a North Carolina Professional Engineer (Michael J. Walko, #026917) on 05-11-2023.
- Total Pile Driving Equipment Setup quantity (not shown in Pile Foundation Tables) equals the number of driven piles, i.e., the number of piles with a Required Driving Resistance.
- The Engineer will determine the need for PDA Testing when PDAs may be required.
- For Piles, See Piles Provision and Section 450 of the Standard Sprcifications.

	STATE OF NORTH CAROLINA DEPARTMENT OF TRANSPORTATION RALEIGH		PILE FOUNDATION TABLES																		
	SIGNATURE _____ DATE _____		REVISIONS <table border="1"> <tr> <th>NO.</th> <th>BY:</th> <th>DATE:</th> <th>NO.</th> <th>BY:</th> <th>DATE:</th> </tr> <tr> <td align="center">1</td> <td></td> <td></td> <td align="center">3</td> <td></td> <td></td> </tr> <tr> <td align="center">2</td> <td></td> <td></td> <td align="center">4</td> <td></td> <td></td> </tr> </table>	NO.	BY:	DATE:	NO.	BY:	DATE:	1			3			2			4		
NO.	BY:	DATE:	NO.	BY:	DATE:																
1			3																		
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BRIDGE No. 271 ON SR 1818 (NEILS EDDY ROAD) OVER MILL CREEK

SUPPORTING DOCUMENTATION



NOTES:

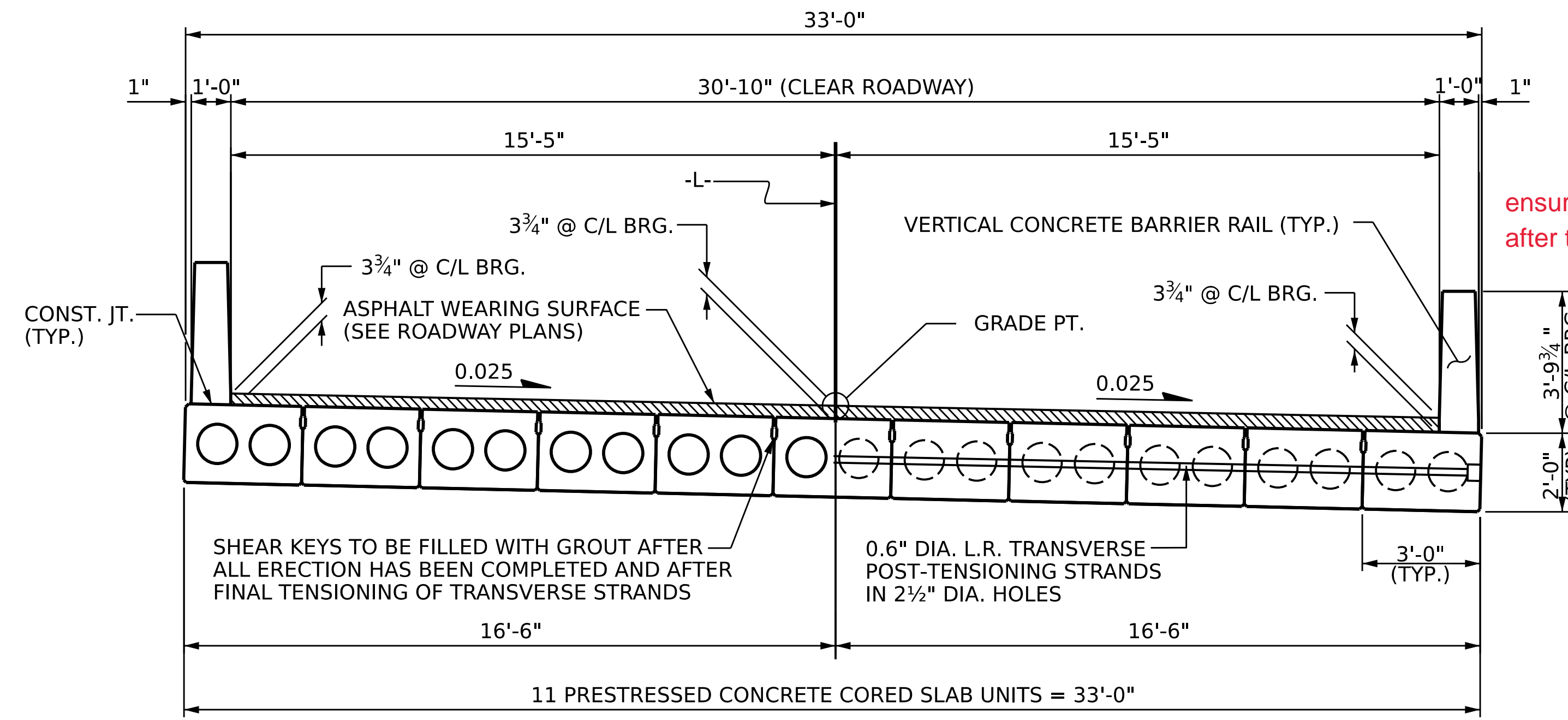
ASSUMED LIVE LOAD = HL-93 OR ALTERNATE LOADING.
 THIS BRIDGE HAS BEEN DESIGNED IN ACCORDANCE WITH THE AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS.
 THIS BRIDGE IS LOCATED IN SEISMIC ZONE 1.

HYDRAULIC DATA:

DESIGN DISCHARGE: = 720 CFS
 FREQUENCY OF DESIGN FLOOD: = 25 YRS
 DESIGN HIGH WATER ELEVATION: = 10.2 FT
 DRAINAGE AREA: = 5.9 SQ. MI.
 BASE DISCHARGE (Q100): = 1282 (FEMA) CFS
 BASE HIGH WATER ELEVATION: = 11.58 FT

OVERTOPPING FLOOD DATA:

OVERTOPPING DISCHARGE: = 3600 CFS
 FREQUENCY OF OVERTOPPING: = >500 YRS
 OVERTOPPING FLOOD ELEVATION: = 16.5 FT
 SAG @ 14+85.70 -L-



ensure for final plans that 3.75" of asphalt at bearing is thick enough to have a minimum of 1.5" at mid-span, after taking sag curve into account.

HALF SECTION
THROUGH VOIDS

HALF SECTION
AT INTERMEDIATE DIAPHRAGMS

TYPICAL SECTION

PROJECT NO. **BP6.R008.1**
COLUMBUS COUNTY
 STATION: **13+47.00 -L-**

SHEET 2 OF 2

STATE OF NORTH CAROLINA
 DEPARTMENT OF TRANSPORTATION
 RALEIGH
PRELIMINARY
GENERAL DRAWING
 FOR BRIDGE ON SR 1818 (NEILS EDDY RD) OVER MILL CREEK 2
 BETWEEN SR 1820 (FERTILIZER RD)
 AND SR 1819 (JUSTICE FLYNN RD)

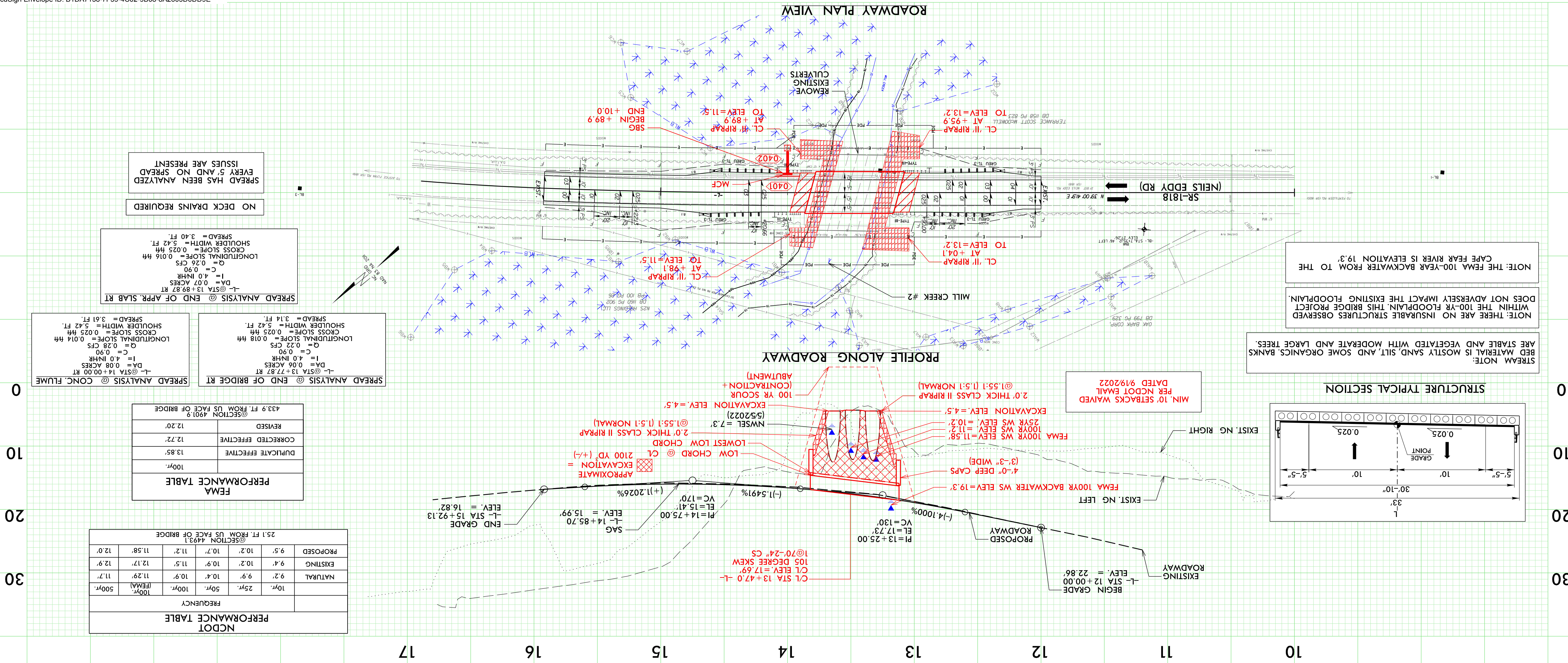
DRAWN BY: M.G. Armstrong DATE: 1/27/23
 CHECKED BY: R.F. DeCola DATE: 2/10/23
 DESIGN ENGINEER OF RECORD: R.F. DeCola DATE:



DOCUMENT NOT CONSIDERED FINAL UNLESS ALL SIGNATURES COMPLETED

REVISIONS				SHEET NO.
NO.	BY:	DATE:	NO.	DATE:
1			3	
2			4	

TOTAL SHEETS: 2



SPREAD ANALYSIS @ END OF APPR. SLAB RT
 LONGITUDINAL SLOPE = 0.016 FH
 CROSS SLOPE = 0.025 FH
 SHOULDER WIDTH = 5.42 FT
 SPREAD = 3.40 FT

NO DECK DRAINS REQUIRED
 EVERY 5' AND NO SPREAD
 ISSUES ARE PRESENT

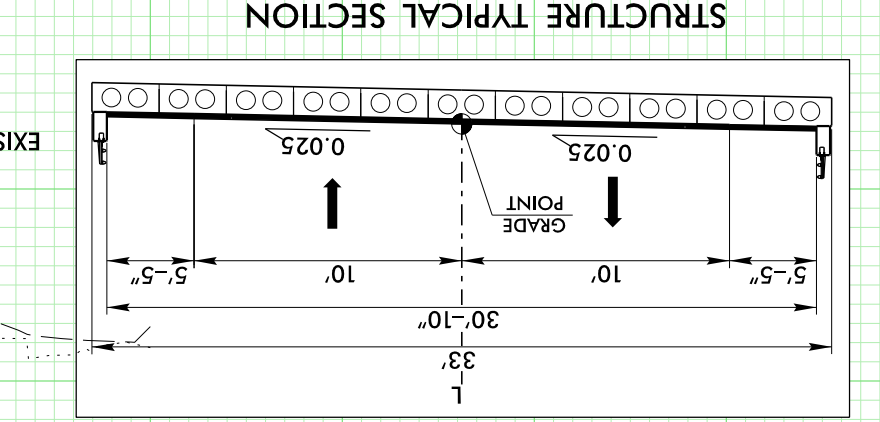
SPREAD ANALYSIS @ CONC. FLUME
 LONGITUDINAL SLOPE = 0.014 FH
 CROSS SLOPE = 0.025 FH
 SHOULDER WIDTH = 5.42 FT
 SPREAD = 3.61 FT

SPREAD ANALYSIS @ END OF BRIDGE RT
 LONGITUDINAL SLOPE = 0.018 FH
 CROSS SLOPE = 0.025 FH
 SHOULDER WIDTH = 5.42 FT
 SPREAD = 3.14 FT

PERFORMANCE TABLE	
100yr.	13.85'
Duplicate Effective	12.72'
Corrected Effective	12.20'
Revised	12.20'

NCDOT PERFORMANCE TABLE	
Frequency	500yr.
Natural	10yr. 11.7'
Existing	10yr. 12.9'
Proposed	10yr. 11.58'

NOTE: THERE ARE NO INSURABLE STRUCTURES OBSERVED WITHIN THE 100-YR FLOODPLAIN. THIS BRIDGE PROJECT DOES NOT ADVERSELY IMPACT THE EXISTING FLOODPLAIN.
 NOTE: THE FEMA 100-YEAR BACKWATER FROM THE CAPE FEAR RIVER IS ELEVATION 19.3'



INFORMATION TO BE SHOWN ON PLANS
 WS EL. Taken @ River Station 4493.1

Design:	Discharge	Frequency	Elev.
720	c.f.s.	25 yr.	10.2 ft.
1282 (FEMA)	c.f.s.	100 (FEMA) yr.	11.58 ft.
3600	c.f.s.	> 500 yr.	16.5 ft.

ADDITIONAL INFORMATION AND COMPUTATIONS

DA = 5.90 SQMI.

RURAL COASTAL PLAIN	FLOWS USED FOR MODEL	FEMA FLOWS (USED FOR COMPLIANCE)
Q ₁₀ = 174 (5.9) = 520 CFS	Q ₁₀ = 520 CFS	
Q ₂₅ = 245 (5.9) = 718 CFS	Q ₂₅ = 720 CFS	
Q ₅₀ = 309 (5.9) = 896 CFS	Q ₅₀ = 900 CFS	
Q ₁₀₀ = 380 (5.9) = 1090 CFS	Q ₁₀₀ = 1100 CFS	Q ₁₀₀ = 1282 CFS
Q ₅₀₀ = 550 (5.9) = 1548 CFS	Q ₅₀₀ = 1500 CFS	

SCOUR COMPUTATIONS (HEC-18, APRIL 2012)

$Y_2 = Y_1 [Q_2/Q_1]^{0.67} [W_1/W_2]^{K1} Y_5 = Y_2 - Y_0$

100_YR NCDOT CONTRACTION SCOUR
 $Y_2 = 7.31 [973.66/449.60]^{0.67} [19.60/37.47]^{0.69} = 9.07$ FT $Y_5 = 9.07 - 6.67 = 2.4$ FT

APPROACH XS = 4901.9

100-YR ABUTMENT SCOUR

ABUTMENT AND CONTRACTION SCOUR (NCHRP 24-20)
 $Y_C = Y_1 [q_2/q_1]^{0.67} q_1 = Q_1/W_1 = 449.60/19.60 = 22.94$ $q_2 = Q_2/W_2 = 973.66/37.47 = 25.99$

$Y_C = 7.31 [25.99/22.94]^{0.67} = 8.13$ FT

$Y_{max} = \alpha_A Y_C$ (α_A DETERMINED FROM FIGURE 8.9 IN HEC-18 MANUAL)
 $Y_{max} = 1.65 * 8.13 = 13.42$ FT

$Y_5 = Y_{max} - Y_0 = 13.42 - 6.67 = 6.8$ FT

APPROACH XS = 4901.9

DESIGN FOLLOWS SUB-REGIONAL TIER GUIDELINES. OT DISCHARGE IS > 500YR STORM.
 WATERSHED IS RURAL AND IS NOT ANTICIPATED TO CHANGE.
 LONG TERM SCOUR EFFECTS ARE ASSUMED TO BE NEGLIGIBLE

SITE DATA

Drainage Area	5.9 SQMI.	Source	FEMA FIS /STREAM STATS
River Basin	CAPE FEAR	Character	RURAL
Stream Classification	(Such as Trout, High Quality Water, etc.)		C,Sw
Data on Existing Structure	3@12'x7.8' CORRUGATED METAL ARCH CULVERTS		
	Total Waterway Opening	213	s.f.
	Waterway Opening Below 100yr. WS EL.	172	s.f.
Debris Potential:	Low X Moderate High		
Data on Structures Up and Down Stream	DS NA; CONFLUENCE WITH LIVINGSTON CREEK		
	US: NA; CONFLUENCE WITH FOX MAPLE BRANCH		

Design Control Elev.	10.2 (EX NCDOT 25YR)	ft.	(MAINTAIN OR IMPROVE EXISTING LEVEL OF SERVICE - 25YR WS) @ XS 4493.1
Gage Station No.	N/A	Period of Records	N/A
Max. Discharge	N/A	c.f.s.	Date N/A Frequency N/A
Historical Flood Information:	RESIDENT - FLOW FROM HURRICANE ANA OF BRIDGE AND BANKS	Period of Knowledge	~ 30 yrs.
Date 9/6/2018	Elev. ft. Est. Freq. 500+ yr. Source	Period of Knowledge	~ 30 yrs.
Date	Elev. ft. Est. Freq. yr. Source	Period of Knowledge	~ 30 yrs.
Date	Elev. ft. Est. Freq. yr. Source	Period of Knowledge	~ 30 yrs.
Historical Scour Info.:	General N/A	ft. Contraction	NA
Channel Slope	0.002	ft/ft Source	SURVEY
Manning's n:	Left O.B. 0.15 Channel 0.045 Right O.B. 0.15	Source	FEMA /FIELD SURVEY
Flood Study /Status	REVISD 06/202018, FIRM #3720224000L	Non-Encroachment Established?	YES
Flood Study 100yr. Discharge	1282 c.f.s. WS Elev.:	With Non-Encroachment	14.5 ft. Non-Encroachment 13.9 ft.
	@ River Station 4901.9 (DUPLICATE EFFECTIVE)		

DESIGN DATA

USGS FACT SHEET SIR 2009-5158 RURAL REGRESSION EQUATIONS FOR DESIGN (100YR FEMA USED FOR COMPLIANCE)					
HEC-RAS 6.2; FILE NAME: MILL CREEK 2 ADJ.PRJ					
PLAN NAME: REVISED /REVISED - NCDOT					
Hydrological Method					
Hydraulic Design Method					
Floods Evaluated:	Freq. (yr.)	Q (c.f.s.)	Elev. (ft.)	Backwater (ft.)	Bridge Opening Velocity (f.p.s.)
@ River Station 4493.1	10	520	9.5	0.3	2.5
	25	720	10.2	0.3	3.0
	50	900	10.7	0.3	3.4
	100	1100	11.2	0.3	3.9
	100 (FEMA)	1282 (FEMA)	11.58 (FEMA)	0.3	4.2
	500	1500	12.0	0.3	4.6

Waterway Opening Provided Below Design W.S. Elev. 254 s.f., 100yr W.S. Elev. 310 s.f., Total 570 s.f., Average Channel Velocity (Design) 3.0 f.p.s. Average Overbank Velocity (Design) 0.3 f.p.s.
 Computed Scour: CONTR. ONLY 2.4 ft. ABUTMENT & CONSTRUCTION 6.8 ft. Local NA ft.
 Is a Floodway Revision Required? NO; MOA TYPE B

BRIDGE SURVEY & HYDRAULIC DESIGN REPORT

N. C. DEPARTMENT OF TRANSPORTATION
 DIVISION OF HIGHWAYS
 HYDRAULICS UNIT
 RALEIGH, N. C.

I.D. No.	BP6.R008.1	Project No.	BP6.R008.1	Proj. Station	13 + 47.0 -L-	
County	COLUMBUS	Bridge Over	MILL CREEK 2	Bridge Inv. No.	0271	
On Highway	(NEILS EDDY RD) SR 1818	Between	(SR 1820) (JUSTICE FLYNN RD)			
Recommended Structure	1@70'-24" CORED SLAB - 4'-0" DEEP CAPS					
Recommended Width of Roadway	30'-10" CLEAR ROADWAY (33' OTO)				Skew	105°
Recommended Location is (Up/At/Down) Stream from Existing Crossing	AT EXISTING					
Latitude	34.3312	Longitude	-78.1938			
Statewide Tier	<input type="checkbox"/>	Regional Tier	<input type="checkbox"/>	Sub-Regional Tier	<input checked="" type="checkbox"/>	
Bench Mark is	BM1: RR SPIKE IN. BASE OF 30" PINE TREE; -L- STA. 11+18.52, OFFSET 29.0 LT					
Northing	212367.6159	Easting	2243221.7986	Elev.	27.26 ft. Datum: NAVD 88	
Temporary Crossing	NA - OFFSITE DETOUR					



Stream MILL CREEK 2 - Struc. Inv. No. 0271.I.D. No. BP6.R008.1 - Project No. BP6.R008.1 - Proj. Station 13 + 47.0 -L-

Designed by: LEAH YOUNG, PE
 Assisted by: PUSHPAL REGMI
 Project Engineer: LEAH YOUNG, PE
 Reviewed by:

Date: 11/22/2022

Seal: KCI ASSOCIATES OF NC, PA
 SEAL 033860
 LEAH YOUNG, PE

STATE	STATE PROJECT REFERENCE NO.	SHEET NO.	TOTAL SHEETS
N.C.	SF-230271	1	11

REFERENCE: SF-230271

PROJECT: BP6.R008

**STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
GEOTECHNICAL ENGINEERING UNIT**

**STRUCTURE
SUBSURFACE INVESTIGATION**

COUNTY COLUMBUS
PROJECT DESCRIPTION BRIDGE NO. 271 OVER
MILL CREEK ON SR 1818 (NEILS EDDY ROAD)
SITE DESCRIPTION -L- STA. 13 + 47

CONTENTS

<u>SHEET NO.</u>	<u>DESCRIPTION</u>
1	TITLE SHEET
2, 2A	LEGEND (SOIL & ROCK)
3	SITE PLAN
4-7	BORE LOG(S)
8	LABRATORY TEST RESULTS
9-10	SITE PHOTOGRAPH(S)

PERSONNEL

A. SUTTLE, P.G.
BRIDGER DRILLING

INVESTIGATED BY ECS SOUTHEAST, LLP
DRAWN BY A. SUTTLE, P.G.
CHECKED BY M. WALKO, P.E.
SUBMITTED BY ECS SOUTHEAST, LLP
DATE MAY 2023

CAUTION NOTICE

THE SUBSURFACE INFORMATION AND THE SUBSURFACE INVESTIGATION ON WHICH IT IS BASED WERE MADE FOR THE PURPOSE OF STUDY, PLANNING AND DESIGN, AND NOT FOR CONSTRUCTION OR PAY PURPOSES. THE VARIOUS FIELD BORING LOGS, ROCK CORES AND SOIL TEST DATA AVAILABLE MAY BE REVIEWED OR INSPECTED IN RALEIGH BY CONTACTING THE N. C. DEPARTMENT OF TRANSPORTATION, GEOTECHNICAL ENGINEERING UNIT AT (919) 707-6850. THE SUBSURFACE PLANS AND REPORTS, FIELD BORING LOGS, ROCK CORES AND SOIL TEST DATA ARE NOT PART OF THE CONTRACT.

GENERAL SOIL AND ROCK STRATA DESCRIPTIONS AND INDICATED BOUNDARIES ARE BASED ON A GEOTECHNICAL INTERPRETATION OF ALL AVAILABLE SUBSURFACE DATA AND MAY NOT NECESSARILY REFLECT THE ACTUAL SUBSURFACE CONDITIONS BETWEEN BORINGS OR BETWEEN SAMPLED STRATA WITHIN THE BOREHOLE. THE LABORATORY SAMPLE DATA AND THE IN SITU (IN-PLACE) TEST DATA CAN BE RELIED ON ONLY TO THE DEGREE OF RELIABILITY INHERENT IN THE STANDARD TEST METHOD. THE OBSERVED WATER LEVELS OR SOIL MOISTURE CONDITIONS INDICATED IN THE SUBSURFACE INVESTIGATIONS ARE AS RECORDED AT THE TIME OF THE INVESTIGATION. THESE WATER LEVELS OR SOIL MOISTURE CONDITIONS MAY VARY CONSIDERABLY WITH TIME ACCORDING TO CLIMATIC CONDITIONS INCLUDING TEMPERATURES, PRECIPITATION AND WIND, AS WELL AS OTHER NON-CLIMATIC FACTORS.

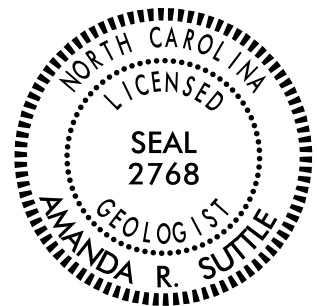
THE BIDDER OR CONTRACTOR IS CAUTIONED THAT DETAILS SHOWN ON THE SUBSURFACE PLANS ARE PRELIMINARY ONLY AND IN MANY CASES THE FINAL DESIGN DETAILS ARE DIFFERENT. FOR BIDDING AND CONSTRUCTION PURPOSES, REFER TO THE CONSTRUCTION PLANS AND DOCUMENTS FOR FINAL DESIGN INFORMATION ON THIS PROJECT. THE DEPARTMENT DOES NOT WARRANT OR GUARANTEE THE SUFFICIENCY OR ACCURACY OF THE INVESTIGATION MADE, NOR THE INTERPRETATIONS MADE, OR OPINION OF THE DEPARTMENT AS TO THE TYPE OF MATERIALS AND CONDITIONS TO BE ENCOUNTERED. THE BIDDER OR CONTRACTOR IS CAUTIONED TO PERFORM INDEPENDENT SUBSURFACE INVESTIGATIONS AND MAKE INTERPRETATIONS AS NECESSARY TO CONFIRM CONDITIONS ENCOUNTERED ON THE PROJECT. THE CONTRACTOR SHALL HAVE NO CLAIM FOR ADDITIONAL COMPENSATION OR FOR AN EXTENSION OF TIME FOR ANY REASON RESULTING FROM THE ACTUAL CONDITIONS ENCOUNTERED AT THE SITE DIFFERING FROM THOSE INDICATED IN THE SUBSURFACE INFORMATION.

NOTES:

- THE INFORMATION CONTAINED HEREIN IS NOT IMPLIED OR GUARANTEED BY THE N. C. DEPARTMENT OF TRANSPORTATION AS ACCURATE NOR IS IT CONSIDERED PART OF THE PLANS, SPECIFICATIONS OR CONTRACT FOR THE PROJECT.
- BY HAVING REQUESTED THIS INFORMATION, THE CONTRACTOR SPECIFICALLY WAIVES ANY CLAIMS FOR INCREASED COMPENSATION OR EXTENSION OF TIME BASED ON DIFFERENCES BETWEEN THE CONDITIONS INDICATED HEREIN AND THE ACTUAL CONDITIONS AT THE PROJECT SITE.

Prepared in the Office of:

ECS SOUTHEAST, LLP
1812 CENTER PARK DRIVE, SUITE D
CHARLOTTE, NC 28217
(704) 525-5152 [PHONE]
(704) 357-0023 [FAX]
NC REGISTERED
ENGINEERING
FIRM # F-1078



DocuSigned by:

Amanda R. Suttle

5/1/2023

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SIGNATURE

DATE

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NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
GEOTECHNICAL ENGINEERING UNIT

SUBSURFACE INVESTIGATION

SOIL AND ROCK LEGEND, TERMS, SYMBOLS, AND ABBREVIATIONS
(PAGE 1 OF 2)

Table with columns: SOIL DESCRIPTION, SOIL LEGEND AND AASHTO CLASSIFICATION, GROUP CLASS., SYMBOL, % PASSING, MATERIAL PASSING, GROUP INDEX, USUAL TYPES OF MAJOR MATERIALS, GEN. RATING AS SUBGRADE.

Table with columns: GRADATION, ANGULARITY OF GRAINS, MINERALOGICAL COMPOSITION, COMPRESSIBILITY, PERCENTAGE OF MATERIAL, GROUND WATER, MISCELLANEOUS SYMBOLS.

Table with columns: CONSISTENCY OR DENSENESS, PRIMARY SOIL TYPE, COMPACTNESS OR CONSISTENCY, RANGE OF STANDARD PENETRATION RESISTANCE, RANGE OF UNCONFINED COMPRESSIVE STRENGTH.

Table with columns: TEXTURE OR GRAIN SIZE, U.S. STD. SIEVE SIZE OPENING (MM), BOULDER (BLDR.), COBBLE (COB.), GRAVEL (GR.), COARSE SAND (CSE, SD.), FINE SAND (F SD.), SILT (SL.), CLAY (CL.).

Table with columns: SOIL MOISTURE - CORRELATION OF TERMS, SOIL MOISTURE SCALE (ATTERBERG LIMITS), FIELD MOISTURE DESCRIPTION, GUIDE FOR FIELD MOISTURE DESCRIPTION.

Table with columns: PLASTICITY, PLASTICITY INDEX (PI), DRY STRENGTH, NON PLASTIC, SLIGHTLY PLASTIC, MODERATELY PLASTIC, HIGHLY PLASTIC.

COLOR
DESCRIPTIONS MAY INCLUDE COLOR OR COLOR COMBINATIONS (TAN, RED, YELLOW-BROWN, BLUE-GRAY). MODIFIERS SUCH AS LIGHT, DARK, STREAKED, ETC. ARE USED TO DESCRIBE APPEARANCE.

Table with columns: RECOMMENDATION SYMBOLS, UNDERCUT, UNCLASSIFIED EXCAVATION - UNSUITABLE WASTE, UNCLASSIFIED EXCAVATION - ACCEPTABLE, BUT NOT TO BE USED IN THE TOP 3 FEET OF EMBANKMENT OR BACKFILL, UNCLASSIFIED EXCAVATION - ACCEPTABLE DEGRADABLE ROCK.





Table with columns: ABBREVIATIONS, AR - AUGER REFUSAL, BT - BORING TERMINATED, CL - CLAY, CPT - CONE PENETRATION TEST, CSE. - COARSE, DMT - DILATOMETER TEST, DPT - DYNAMIC PENETRATION TEST, e - VOID RATIO, F - FINE, FOSS. - FOSSILIFEROUS, FRAC. - FRACTURED, FRACTURES, FRAGS. - FRAGMENTS, HI. - HIGHLY, MED. - MEDIUM, MICA. - MICACEOUS, MOD. - MODERATELY, NP - NON PLASTIC, ORG. - ORGANIC, PMT - PRESSUREMETER TEST, SAP. - SAPROLITIC, SD. - SAND, SANDY, SL. - SILT, SILTY, SLI. - SLIGHTLY, TCR - TRICONE REFUSAL, w - MOISTURE CONTENT, V - VERY, VST - VANE SHEAR TEST, WE. - WEATHERED, U - UNIT WEIGHT, U - DRY UNIT WEIGHT.

Table with columns: EQUIPMENT USED ON SUBJECT PROJECT, DRILL UNITS, ADVANCING TOOLS, HAMMER TYPE, CORE SIZE, HAND TOOLS.

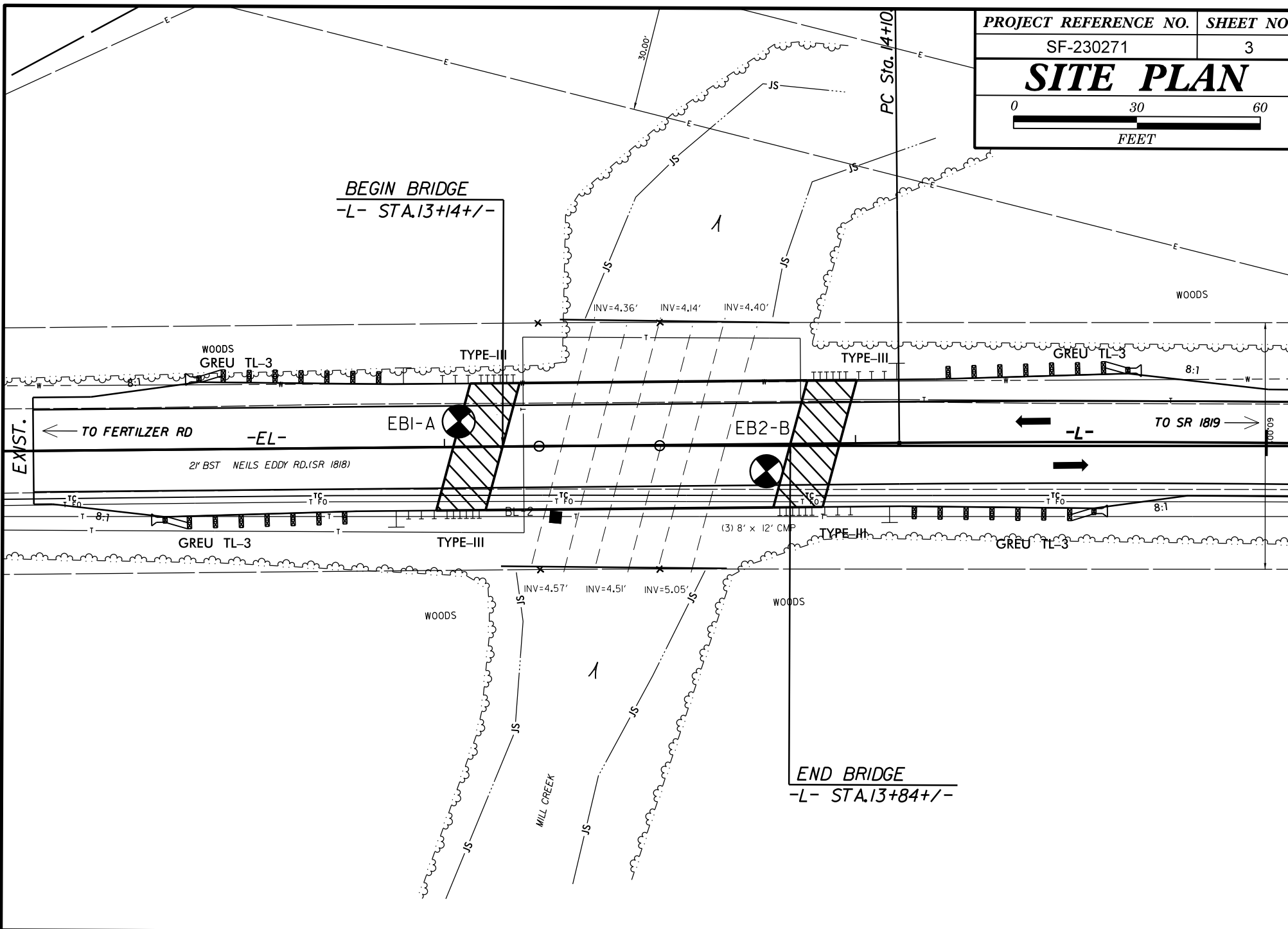
**NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
GEOTECHNICAL ENGINEERING UNIT**

SUBSURFACE INVESTIGATION

SOIL AND ROCK LEGEND, TERMS, SYMBOLS, AND ABBREVIATIONS
(PAGE 2 OF 2)

ROCK DESCRIPTION		TERMS AND DEFINITIONS	
<p>HARD ROCK IS NON-COASTAL PLAIN MATERIAL THAT WOULD YIELD SPT REFUSAL IF TESTED. AN INFERRED ROCK LINE INDICATES THE LEVEL AT WHICH NON-COASTAL PLAIN MATERIAL WOULD YIELD SPT REFUSAL. SPT REFUSAL IS PENETRATION BY A SPLIT SPOON SAMPLER EQUAL TO OR LESS THAN 0.1 FOOT PER 60 BLOWS IN NON-COASTAL PLAIN MATERIAL. THE TRANSITION BETWEEN SOIL AND ROCK IS OFTEN REPRESENTED BY A ZONE OF WEATHERED ROCK. ROCK MATERIALS ARE TYPICALLY DIVIDED AS FOLLOWS:</p>		<p>ALLUVIUM (ALLUV.) - SOILS THAT HAVE BEEN TRANSPORTED BY WATER. AQUIFER - A WATER BEARING FORMATION OR STRATA. ARENACEOUS - APPLIED TO ROCKS THAT HAVE BEEN DERIVED FROM SAND OR THAT CONTAIN SAND. ARGILLACEOUS - APPLIED TO ALL ROCKS OR SUBSTANCES COMPOSED OF CLAY MINERALS, OR HAVING A NOTABLE PROPORTION OF CLAY IN THEIR COMPOSITION, SUCH AS SHALE, SLATE, ETC. ARTESIAN - GROUND WATER THAT IS UNDER SUFFICIENT PRESSURE TO RISE ABOVE THE LEVEL AT WHICH IT IS ENCOUNTERED, BUT WHICH DOES NOT NECESSARILY RISE TO OR ABOVE THE GROUND SURFACE. CALCAREOUS (CALC.) - SOILS THAT CONTAIN APPRECIABLE AMOUNTS OF CALCIUM CARBONATE. COLLUVIUM - ROCK FRAGMENTS MIXED WITH SOIL DEPOSITED BY GRAVITY ON SLOPE OR AT BOTTOM OF SLOPE. CORE RECOVERY (REC.) - TOTAL LENGTH OF ALL MATERIAL RECOVERED IN THE CORE BARREL DIVIDED BY TOTAL LENGTH OF CORE RUN AND EXPRESSED AS A PERCENTAGE. DIKE - A TABULAR BODY OF IGNEOUS ROCK THAT CUTS ACROSS THE STRUCTURE OF ADJACENT ROCKS OR CUTS MASSIVE ROCK. DIP - THE ANGLE AT WHICH A STRATUM OR ANY PLANAR FEATURE IS INCLINED FROM THE HORIZONTAL. DIP DIRECTION (DIP AZIMUTH) - THE DIRECTION OR BEARING OF THE HORIZONTAL TRACE OF THE LINE OF DIP, MEASURED CLOCKWISE FROM NORTH. FAULT - A FRACTURE OR FRACTURE ZONE ALONG WHICH THERE HAS BEEN DISPLACEMENT OF THE SIDES RELATIVE TO ONE ANOTHER PARALLEL TO THE FRACTURE. FISSILE - A PROPERTY OF SPLITTING ALONG CLOSELY SPACED PARALLEL PLANES. FLOAT - ROCK FRAGMENTS ON SURFACE NEAR THEIR ORIGINAL POSITION AND DISLODGED FROM PARENT MATERIAL. FLOOD PLAIN (FP) - LAND BORDERING A STREAM, BUILT OF SEDIMENTS DEPOSITED BY THE STREAM. FORMATION (FM) - A MAPPABLE GEOLOGIC UNIT THAT CAN BE RECOGNIZED AND TRACED IN THE FIELD. JOINT - FRACTURE IN ROCK ALONG WHICH NO APPRECIABLE MOVEMENT HAS OCCURRED. LEDGE - A SHELF-LIKE RIDGE OR PROJECTION OF ROCK WHOSE THICKNESS IS SMALL COMPARED TO ITS LATERAL EXTENT. LENS - A BODY OF SOIL OR ROCK THAT THINS OUT IN ONE OR MORE DIRECTIONS. MOTTLED (MOT.) - IRREGULARLY MARKED WITH SPOTS OF DIFFERENT COLORS, MOTTLING IN SOILS USUALLY INDICATES POOR AERATION AND LACK OF GOOD DRAINAGE. PERCHED WATER - WATER MAINTAINED ABOVE THE NORMAL GROUND WATER LEVEL BY THE PRESENCE OF AN INTERVENING IMPERVIOUS STRATUM. RESIDUAL (RES.) SOIL - SOIL FORMED IN PLACE BY THE WEATHERING OF ROCK. ROCK QUALITY DESIGNATION (ROD) - A MEASURE OF ROCK QUALITY DESCRIBED BY TOTAL LENGTH OF ROCK SEGMENTS EQUAL TO OR GREATER THAN 4 INCHES DIVIDED BY THE TOTAL LENGTH OF CORE RUN AND EXPRESSED AS A PERCENTAGE. SAPROLITE (SAP.) - RESIDUAL SOIL THAT RETAINS THE RELIC STRUCTURE OR FABRIC OF THE PARENT ROCK. SILL - AN INTRUSIVE BODY OF IGNEOUS ROCK OF APPROXIMATELY UNIFORM THICKNESS AND RELATIVELY THIN COMPARED WITH ITS LATERAL EXTENT, THAT HAS BEEN EMPLACED PARALLEL TO THE BEDDING OR SCHISTOSITY OF THE INTRUDED ROCKS. SLICKENSIDE - POLISHED AND STRIATED SURFACE THAT RESULTS FROM FRICTION ALONG A FAULT OR SLIP PLANE. STANDARD PENETRATION TEST (PENETRATION RESISTANCE) (SPT) - NUMBER OF BLOWS (IN OR BPF) OF A 140 LB. HAMMER FALLING 30 INCHES REQUIRED TO PRODUCE A PENETRATION OF 1 FOOT INTO SOIL WITH A 2 INCH OUTSIDE DIAMETER SPLIT SPOON SAMPLER. SPT REFUSAL IS PENETRATION EQUAL TO OR LESS THAN 0.1 FOOT PER 60 BLOWS. STRATA CORE RECOVERY (SREC.) - TOTAL LENGTH OF STRATA MATERIAL RECOVERED DIVIDED BY TOTAL LENGTH OF STRATUM AND EXPRESSED AS A PERCENTAGE. STRATA ROCK QUALITY DESIGNATION (SROD) - A MEASURE OF ROCK QUALITY DESCRIBED BY TOTAL LENGTH OF ROCK SEGMENTS WITHIN A STRATUM EQUAL TO OR GREATER THAN 4 INCHES DIVIDED BY THE TOTAL LENGTH OF STRATA AND EXPRESSED AS A PERCENTAGE. TOPSOIL (TS.) - SURFACE SOILS USUALLY CONTAINING ORGANIC MATTER.</p>	
<p>WEATHERED ROCK (WR)  NON-COASTAL PLAIN MATERIAL THAT WOULD YIELD SPT N VALUES > 100 BLOWS PER FOOT IF TESTED.</p>			
<p>CRYSTALLINE ROCK (CR)  FINE TO COARSE GRAIN IGNEOUS AND METAMORPHIC ROCK THAT WOULD YIELD SPT REFUSAL IF TESTED. ROCK TYPE INCLUDES GRANITE, GNEISS, GABBRO, SCHIST, ETC.</p>			
<p>NON-CRYSTALLINE ROCK (NCR)  FINE TO COARSE GRAIN METAMORPHIC AND NON-COASTAL PLAIN SEDIMENTARY ROCK THAT WOULD YIELD SPT REFUSAL IF TESTED. ROCK TYPE INCLUDES PHYLLITE, SLATE, SANDSTONE, ETC.</p>			
<p>COASTAL PLAIN SEDIMENTARY ROCK (CP)  COASTAL PLAIN SEDIMENTS CEMENTED INTO ROCK, BUT MAY NOT YIELD SPT REFUSAL. ROCK TYPE INCLUDES LIMESTONE, SANDSTONE, CEMENTED SHELL BEDS, ETC.</p>			
WEATHERING			
FRESH	ROCK FRESH, CRYSTALS BRIGHT, FEW JOINTS MAY SHOW SLIGHT STAINING. ROCK RINGS UNDER HAMMER IF CRYSTALLINE.		
VERY SLIGHT (V SL.)	ROCK GENERALLY FRESH, JOINTS STAINED, SOME JOINTS MAY SHOW THIN CLAY COATINGS IF OPEN. CRYSTALS ON A BROKEN SPECIMEN FACE SHINE BRIGHTLY. ROCK RINGS UNDER HAMMER BLOWS IF OF A CRYSTALLINE NATURE.		
SLIGHT (SL.)	ROCK GENERALLY FRESH, JOINTS STAINED AND DISCOLORATION EXTENDS INTO ROCK UP TO 1 INCH. OPEN JOINTS MAY CONTAIN CLAY. IN GRANITOID ROCKS SOME OCCASIONAL FELDSPAR CRYSTALS ARE DULL AND DISCOLORED. CRYSTALLINE ROCKS RING UNDER HAMMER BLOWS.		
MODERATE (MOD.)	SIGNIFICANT PORTIONS OF ROCK SHOW DISCOLORATION AND WEATHERING EFFECTS. IN GRANITOID ROCKS, MOST FELDSPARS ARE DULL AND DISCOLORED, SOME SHOW CLAY. ROCK HAS DULL SOUND UNDER HAMMER BLOWS AND SHOWS SIGNIFICANT LOSS OF STRENGTH AS COMPARED WITH FRESH ROCK.		
MODERATELY SEVERE (MOD. SEV.)	ALL ROCK EXCEPT QUARTZ DISCOLORED OR STAINED. IN GRANITOID ROCKS, ALL FELDSPARS DULL AND DISCOLORED AND A MAJORITY SHOW KAOLINIZATION. ROCK SHOWS SEVERE LOSS OF STRENGTH AND CAN BE EXCAVATED WITH A GEOLOGIST'S PICK. ROCK GIVES "CLUNK" SOUND WHEN STRUCK. <u>IF TESTED, WOULD YIELD SPT REFUSAL</u>		
SEVERE (SEV.)	ALL ROCK EXCEPT QUARTZ DISCOLORED OR STAINED. ROCK FABRIC CLEAR AND EVIDENT BUT REDUCED IN STRENGTH TO STRONG SOIL. IN GRANITOID ROCKS ALL FELDSPARS ARE KAOLINIZED TO SOME EXTENT. SOME FRAGMENTS OF STRONG ROCK USUALLY REMAIN. <u>IF TESTED, WOULD YIELD SPT N VALUES > 100 BPF</u>		
VERY SEVERE (V SEV.)	ALL ROCK EXCEPT QUARTZ DISCOLORED OR STAINED. ROCK FABRIC ELEMENTS ARE DISCERNIBLE BUT MASS IS EFFECTIVELY REDUCED TO SOIL STATUS, WITH ONLY FRAGMENTS OF STRONG ROCK REMAINING. SAPROLITE IS AN EXAMPLE OF ROCK WEATHERED TO A DEGREE THAT ONLY MINOR VESTIGES OF ORIGINAL ROCK FABRIC REMAIN. <u>IF TESTED, WOULD YIELD SPT N VALUES < 100 BPF</u>		
COMPLETE	ROCK REDUCED TO SOIL. ROCK FABRIC NOT DISCERNIBLE, OR DISCERNIBLE ONLY IN SMALL AND SCATTERED CONCENTRATIONS. QUARTZ MAY BE PRESENT AS DIKES OR STRINGERS. SAPROLITE IS ALSO AN EXAMPLE.		
ROCK HARDNESS			
VERY HARD	CANNOT BE SCRATCHED BY KNIFE OR SHARP PICK. BREAKING OF HAND SPECIMENS REQUIRES SEVERAL HARD BLOWS OF THE GEOLOGIST'S PICK.		
HARD	CAN BE SCRATCHED BY KNIFE OR PICK ONLY WITH DIFFICULTY. HARD HAMMER BLOWS REQUIRED TO DETACH HAND SPECIMEN.		
MODERATELY HARD	CAN BE SCRATCHED BY KNIFE OR PICK. GOUGES OR GROOVES TO 0.25 INCHES DEEP CAN BE EXCAVATED BY HARD BLOW OF A GEOLOGIST'S PICK. HAND SPECIMENS CAN BE DETACHED BY MODERATE BLOWS.		
MEDIUM HARD	CAN BE GROOVED OR GOUGED 0.05 INCHES DEEP BY FIRM PRESSURE OF KNIFE OR PICK POINT. CAN BE EXCAVATED IN SMALL CHIPS TO PIECES 1 INCH MAXIMUM SIZE BY HARD BLOWS OF THE POINT OF A GEOLOGIST'S PICK.		
SOFT	CAN BE GROOVED OR GOUGED READILY BY KNIFE OR PICK. CAN BE EXCAVATED IN FRAGMENTS FROM CHIPS TO SEVERAL INCHES IN SIZE BY MODERATE BLOWS OF A PICK POINT. SMALL, THIN PIECES CAN BE BROKEN BY FINGER PRESSURE.		
VERY SOFT	CAN BE CARVED WITH KNIFE. CAN BE EXCAVATED READILY WITH POINT OF PICK. PIECES 1 INCH OR MORE IN THICKNESS CAN BE BROKEN BY FINGER PRESSURE. CAN BE SCRATCHED READILY BY FINGERNAIL.		
FRACTURE SPACING		BEDDING	
TERM	SPACING	TERM	THICKNESS
VERY WIDE	MORE THAN 10 FEET	VERY THICKLY BEDDED	4 FEET
WIDE	3 TO 10 FEET	THICKLY BEDDED	1.5 - 4 FEET
MODERATELY CLOSE	1 TO 3 FEET	THINLY BEDDED	0.16 - 1.5 FEET
CLOSE	0.16 TO 1 FOOT	VERY THINLY BEDDED	0.03 - 0.16 FEET
VERY CLOSE	LESS THAN 0.16 FEET	THICKLY LAMINATED	0.008 - 0.03 FEET
		THINLY LAMINATED	< 0.008 FEET
INDURATION			
FOR SEDIMENTARY ROCKS, INDURATION IS THE HARDENING OF MATERIAL BY CEMENTING, HEAT, PRESSURE, ETC.			
FRIABLE	RUBBING WITH FINGER FREES NUMEROUS GRAINS; GENTLE BLOW BY HAMMER DISINTEGRATES SAMPLE.		
MODERATELY INDURATED	GRAINS CAN BE SEPARATED FROM SAMPLE WITH STEEL PROBE; BREAKS EASILY WHEN HIT WITH HAMMER.		
INDURATED	GRAINS ARE DIFFICULT TO SEPARATE WITH STEEL PROBE; DIFFICULT TO BREAK WITH HAMMER.		
EXTREMELY INDURATED	SHARP HAMMER BLOWS REQUIRED TO BREAK SAMPLE; SAMPLE BREAKS ACROSS GRAINS.		
		BENCH MARK:	
		ELEVATION: FEET	
NOTES:			
DESIGN FILES, .TIN AND .GPK FILE PROVIDED BY KCI			
NORTHING AND EASTINGS OBTAINED USING A TRIMBLE GEO7X			
ELEVATIONS FOR BRIDGE BORINGS OBTAINED USING BENCHMARK BM-1 (N21368 E2243222)			
FIAD = FILLED IN AFTER DRILLING			

PROJECT REFERENCE NO.	SHEET NO.
SF-230271	3
SITE PLAN	
FEET	



EXIST.

BEGIN BRIDGE
-L- STA.13+14+/-

PC Sta. 14+10

PROJECT REFERENCE NO.	SHEET NO.
SF-230271	3
SITE PLAN	
FEET	

END BRIDGE
-L- STA.13+84+/-

GEOTECHNICAL BORING REPORT

BORE LOG

WBS BP6.R008.1	TIP SF-230271	COUNTY COLUMBUS	GEOLOGIST A. Suttle
SITE DESCRIPTION Bridge No. 271 over Mill Creek on SR 1818 (Neils Eddy Road)			GROUND WTR (ft)
BORING NO. EB1-A	STATION 13+04	OFFSET 6 ft LT	ALIGNMENT -L-
COLLAR ELEV. 18.4 ft	TOTAL DEPTH 80.0 ft	NORTHING 212,497	EASTING 2,243,356
DRILL RIG/HAMMER EFF./DATE BR12425 CME-45D 84% 004/12/2022		DRILL METHOD Mud Rotary	HAMMER TYPE Automatic
DRILLER N. Bigley	START DATE 01/26/23	COMP. DATE 01/26/23	SURFACE WATER DEPTH N/A

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT			BLOWS PER FOOT					SAMP. NO.	LOG MOI	SOIL AND ROCK DESCRIPTION	DEPTH (ft)	
			0.5ft	0.5ft	0.5ft	0	25	50	75	100					ELEV. (ft)
20															
	17.4	1.0	14	11	7									18.4	0.0
	14.9	3.5	2	2	2									17.7	0.7
15															
	12.4	6.0	1	2	2									12.9	5.5
	9.9	8.5	WOH	WOH	WOH									10.4	8.0
10															
	4.9	13.5	WOH	WOH	WOH									5.4	13.0
5															
	-0.1	18.5	3	2	5									0.4	18.0
0															
	-5.1	23.5	19	39	19									-4.6	23.0
-5															
	-10.1	28.5	4	4	6										
-10															
	-15.1	33.5	4	5	7									-14.6	33.0
-15															
	-20.1	38.5	4	5	6										
-20															
	-25.1	43.5	12	8	9										
-25															
	-30.1	48.5	5	6	10										
-30															
	-35.1	53.5	5	7	8									-34.6	53.0
-35															
	-40.1	58.5	9	19	23										
-40															
	-45.1	63.5	6	7	10										
-45															
	-50.1	68.5	7	9	13										
-50															
	-55.1	73.5	9	9	14										
-55															
-60															

NCDOT BORE SINGLE R008_GEO_GTM.GPJ NC_DOT.GDT 4/6/23

GEOTECHNICAL BORING REPORT

BORE LOG

WBS BP6.R008.1			TIP SF-230271			COUNTY COLUMBUS			GEOLOGIST A. Suttle						
SITE DESCRIPTION Bridge No. 271 over Mill Creek on SR 1818 (Neils Eddy Road)									GROUND WTR (ft)						
BORING NO. EB1-A			STATION 13+04			OFFSET 6 ft LT			ALIGNMENT -L-						
COLLAR ELEV. 18.4 ft			TOTAL DEPTH 80.0 ft			NORTHING 212,497			EASTING 2,243,356						
DRILL RIG/HAMMER EFF./DATE BR12425 CME-45D 84% 004/12/2022						DRILL METHOD Mud Rotary			HAMMER TYPE Automatic						
DRILLER N. Bigley			START DATE 01/26/23			COMP. DATE 01/26/23			SURFACE WATER DEPTH N/A						
ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT			BLOWS PER FOOT					SAMP. NO.	LOG MOI	L O G	SOIL AND ROCK DESCRIPTION	DEPTH (ft)
			0.5ft	0.5ft	0.5ft	0	25	50	75	100					
-60	-60.1	78.5	8	10	17	Match Line					M			-61.6	80.0
														Boring Terminated at Elevation -61.6 ft In Coastal Plain Silty CLAY (A-7-6)	

NCDOT BORE SINGLE R008_GEO_GTM.GPJ NC_DOT.GDT 4/6/23

GEOTECHNICAL BORING REPORT

BORE LOG

WBS BP6.R008.1	TIP SF-230271	COUNTY COLUMBUS	GEOLOGIST A. Suttle
SITE DESCRIPTION Bridge No. 271 over Mill Creek on SR 1818 (Neils Eddy Road)			GROUND WTR (ft)
BORING NO. EB2-B	STATION 13+78	OFFSET 6 ft RT	ALIGNMENT -L-
COLLAR ELEV. 16.6 ft	TOTAL DEPTH 85.0 ft	NORTHING 212,547	EASTING 2,243,413
DRILL RIG/HAMMER EFF./DATE BR12425 CME-45D 84% 004/12/2022		DRILL METHOD Mud Rotary	HAMMER TYPE Automatic
DRILLER N. Bigley	START DATE 01/26/23	COMP. DATE 01/26/23	SURFACE WATER DEPTH N/A

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT			BLOWS PER FOOT					SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION	DEPTH (ft)		
			0.5ft	0.5ft	0.5ft	0	25	50	75	100							
20																	
15	15.6	1.0	10	9	8										16.6	GROUND SURFACE	0.0
															15.9	ROADWAY EMBANKMENT	0.7
	13.1	3.5	2	1	3											Asphalt (0.7')	
	10.6	6.0	2	1	2											Very Loose to Medium Dense, Orange-Brown-Gray, Silty Fine to Coarse SAND (A-2-4)	
	8.1	8.5	1	WOH	WOH										8.6	ALLUVIAL	8.0
																Very Loose, Brown-Gray, Silty Fine to Coarse SAND (A-2-4), little organic matter	
	3.1	13.5	4	3	1												
	-1.9	18.5	4	4	12												
	-6.9	23.5	3	4	5												
	-11.9	28.5	26	25	18												
	-16.9	33.5	4	5	7												
	-21.9	38.5	4	5	9												
	-26.9	43.5	4	8	11												
	-31.9	48.5	4	6	8												
	-36.9	53.5	6	7	10												
	-41.9	58.5	7	8	9												
	-46.9	63.5	7	8	12												
	-51.9	68.5	7	7	11												
	-56.9	73.5	9	9	12												

NCDOT BORE SINGLE R008_GEO_GTM.GPJ NC_DOT.GDT 4/6/23

GEOTECHNICAL BORING REPORT

BORE LOG

WBS BP6.R008.1			TIP SF-230271			COUNTY COLUMBUS			GEOLOGIST A. Suttle							
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DRILL RIG/HAMMER EFF./DATE BR12425 CME-45D 84% 004/12/2022						DRILL METHOD Mud Rotary			HAMMER TYPE Automatic							
DRILLER N. Bigley			START DATE 01/26/23			COMP. DATE 01/26/23			SURFACE WATER DEPTH N/A							
ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT			BLOWS PER FOOT					SAMP. NO.	LOG MOI	LOG G	SOIL AND ROCK DESCRIPTION	DEPTH (ft)	
			0.5ft	0.5ft	0.5ft	0	25	50	75	100						ELEV. (ft)
-60						Match Line										
	-61.9	78.5	8	9	13							M		Very Stiff, Gray, Silty CLAY (A-7-6) (continued)		
-65												M		Boring Terminated at Elevation -68.4 ft In Coastal Plain Silty CLAY (A-7-6)	85.0	
	-66.9	83.5	8	9	12											

NCDOT BORE SINGLE R008_GEO_GTM.GPJ NC_DOT.GDT 4/6/23

PROJECT REFERENCE NO.

SHEET NO.

SF-230271

8

SOIL TEST RESULTS

BORING NO.	SAMPLE NO.	OFFSET	STATION	DEPTH INTERVAL	AASHTO CLASS.	L.L.	P.I.	% BY WEIGHT			% PASSING (SIEVES)			% MOISTURE	% ORGANIC	
								C. SAND	F. SAND	SILT	CLAY	10	40			200
EB1-A	SS-4	6' LT	13+04 -L-	8.5-10.0	A-6(14)	40	22	0.5	44.9	32.8	21.8	99.8	99.6	71.6	19.1	-
EB1-A	SS-5	6' LT	13+04 -L-	13.5-15.0	A-4(0)	34	5	7.8	51.6	11.0	29.6	99.6	97.8	46.9	65.9	-
EB1-A	SS-10	6' LT	13+04 -L-	38.5-40.0	A-6(6)	33	14	0.2	55.6	30.1	14.1	100.0	99.9	60.3	28.6	-
EB1-A	SS-13	6' LT	13+04 -L-	53.5-55.0	A-7-6(8)	41	24	22.4	29.3	9.4	38.9	100.0	95.1	50.0	26.0	-
EB2-B	SS-10	6' RT	13+78 -L-	38.5-40.0	A-6(7)	33	14	3.2	55.2	29.4	12.2	100.0	99.8	64.3	25.0	-
EB2-B	SS-13	6' RT	13+78 -L-	53.5-55.0	A-6(14)	39	22	0.3	45.1	31.9	22.7	100.0	99.8	71.2	26.4	-

LAB TECHNICIAN: AMANDA SUTTLE, P.G.

NCDOT CERTIFICATION NO. 112-09-1003



PHOTO 1 - VIEW DOWNSTATION FROM END BENT 2.



PHOTO 2 - VIEW FACING DOWNSTREAM FROM THE STRUCTURE.



PHOTO 3 - VIEW UPSTATION FROM END BENT I.



PHOTO 4 - VIEW FACING UPSTREAM FROM THE STRUCTURE.

End Bent Geometry and Loads (Cored Slabs)

Columbus 271

1 @ 70', 33' out to out
105° Skew

Bridge Width	CS Unit Length	Factored Pile Reaction (kips)	Factored Pile Reaction (tons)
27'	25'-0"	106	53
	30'-0"	118	59
	35'-0"	126	63
	40'-0"	132	66
	45'-0"	140	70
	50'-0"	154	77
	55'-0"	162	81
	60'-0"	170	85
30'	25'-0"	110	55
	30'-0"	122	61
	35'-0"	132	66
	40'-0"	140	70
	45'-0"	148	74
	50'-0"	162	81
	55'-0"	170	85
	60'-0"	180	90
33'	25'-0"	92	46
	30'-0"	102	51
	35'-0"	110	55
	40'-0"	118	59
	45'-0"	122	61
	50'-0"	134	67
	55'-0"	142	71
	60'-0"	148	74
36'	25'-0"	96	48
	30'-0"	108	54
	35'-0"	116	58
	40'-0"	122	61
	45'-0"	130	65
	50'-0"	142	71
	55'-0"	148	74
	60'-0"	156	78
39'	25'-0"	100	50
	30'-0"	112	56
	35'-0"	120	60
	40'-0"	126	63
	45'-0"	136	68
	50'-0"	146	73
	55'-0"	154	77
	60'-0"	162	81

USE 85 tons/pile for
EB-1 & EB-2

Bridge Width	Skew	Cap Length	No. of Vertical Piles	Pile Spacing
27'	60/120	38'-2"	5	8'-6"
	75/105	34'-3"	5	7'-6"
	90	33'-0"	5	7'-6"
30'	60/120	41'-8"	5	9'-6"
	75/105	37'-4"	5	8'-3"
	90	36'-0"	5	8'-3"
33'	60/120	45'-2"	7	7'-0"
	75/105	40'-6"	7	6'-0"
	90	39'-0"	7	6'-0"
36'	60/120	48'-7"	7	7'-6"
	75/105	43'-7"	7	6'-6"
	90	42'-0"	7	6'-6"
39'	60/120	52'-0"	7	8'-0"
	75/105	46'-8"	7	7'-0"
	90	45'-0"	7	7'-0"

7 Vertical piles @ 6'-0" Spacing

GEOTECHNICAL BORING REPORT BORE LOG

WBS BP6.R008.1	TIP SF-230271	COUNTY COLUMBUS	GEOLOGIST A. Suttle
SITE DESCRIPTION Bridge No. 271 over Mill Creek on SR 1818 (Neils Eddy Road)			GROUND WTR (ft)
BORING NO. EB1-A	STATION 13+04	OFFSET 6 ft LT	ALIGNMENT -L-
COLLAR ELEV. 18.4 ft	TOTAL DEPTH 80.0 ft	NORTHING 212,497	EASTING 2,243,356
DRILL RIG/HAMMER EFF./DATE BRI2425 CME-45D 84% 004/12/2022		DRILL METHOD Mud Rotary	HAMMER TYPE Automatic
DRILLER N. Bigley	START DATE 01/26/23	COMP. DATE 01/26/23	SURFACE WATER DEPTH N/A

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT			BLOWS PER FOOT					SAMP. NO.	LOG	SOIL AND ROCK DESCRIPTION	DEPTH (ft)			
			0.5ft	0.5ft	0.5ft	0	25	50	75	100							
20						Boc = 12.1											
17.4	17.4	1.0	14	11	7									GROUND SURFACE 0.0			
15	14.9	3.5	2	2	2									ROADWAY EMBANKMENT 0.7			
	12.4	6.0	1	2	2									Asphalt (0.7)			
10	9.9	8.5	WOH	WOH	WOH									Very Loose to Medium Dense, Orange-Gray-Brown, Silty Fine to Coarse SAND (A-2-4)	5.5		
						Boc = 12.1 γ = 105 (42.6)								Very Loose, Brown-Gray, Clayey Fine to Coarse SAND (A-2-6)	8.0		
						N = 2 C = 200					SS-4	19%		ALLUVIAL			
5	4.9	13.5	WOH	WOH	WOH									Very Soft, Gray-Orange, Moderately Plastic Fine Sandy CLAY (A-6(14))	6.7		
						N _{corr} = 9 γ = 115 (52.6)					SS-5	66%		Very Soft, Gray, Fine to Coarse Sandy SILT (A-4(D)), little organic matter	13.0		
0	-0.1	18.5	3	2	5									Loose, Brown-Gray, Silty Fine to Coarse SAND (A-2-4), moderately organic	18.0		
						φ = 30											
-5	-5.1	23.5	19	39	19									COASTAL PLAIN (WACCAMAW FORMATION)			
						N = 13 γ = 120 (57.6) C = 1250								Stiff to Hard, Gray, Fine Sandy SILT (A-4)			
-10	-10.1	28.5	4	4	6												
						N = 13 γ = 120 (57.6) C = 1250					SS-10	29%		Stiff to Very Stiff, Gray, Slightly Plastic Fine Sandy CLAY (A-6(6))	33.0		
-15	-15.1	33.5	4	5	7												
						N = 22 γ = 120 (57.6) C = 2000											
-20	-20.1	38.5	4	5	6												
						N = 22 γ = 120 (57.6) C = 2000											
-25	-25.1	43.5	12	8	9												
						N = 24 γ = 120 (57.6) C = 2500											
-30	-30.1	48.5	5	6	10												
						N = 24 γ = 120 (57.6) C = 2500					SS-13	26%		Very Stiff to Hard, Gray, Moderately Plastic Silty CLAY (A-7-6(8))	53.0		
-35	-35.1	53.5	5	7	8												
						N = 24 γ = 120 (57.6) C = 2500											
-40	-40.1	58.5	9	19	23												
						N = 24 γ = 120 (57.6) C = 2500											
-45	-45.1	63.5	6	7	10												
						N = 24 γ = 120 (57.6) C = 2500											
-50	-50.1	68.5	7	9	13												
						N = 24 γ = 120 (57.6) C = 2500											
-55	-55.1	73.5	9	9	14												
						N = 24 γ = 120 (57.6) C = 2500											
-60																	

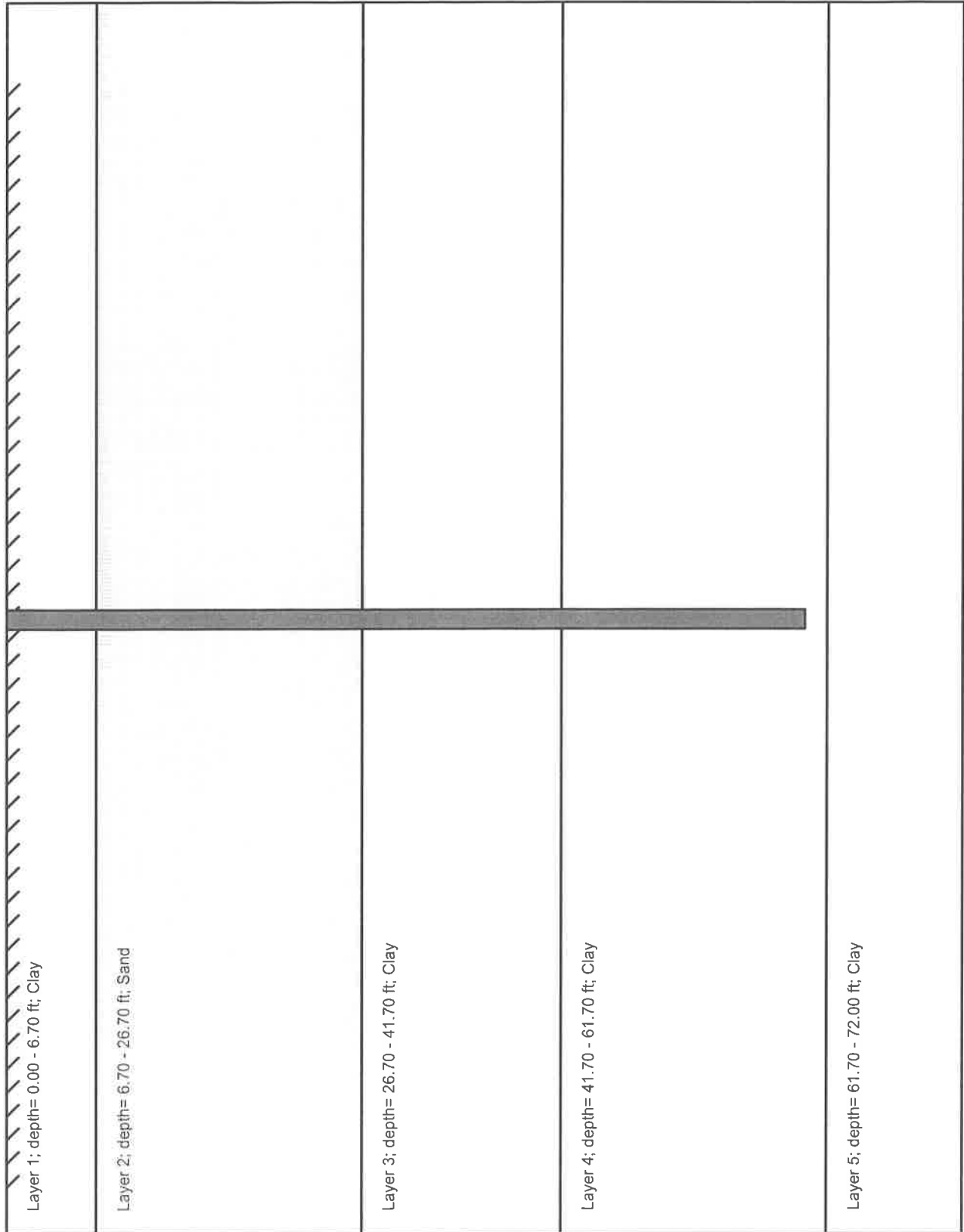
NCDOT BORE SINGLE R008_GEO_GTM:GPIJ_NC_DOT_GDT 4/6/23

GEOTECHNICAL BORING REPORT BORE LOG

WBS BP6.R008.1			TIP SF-230271			COUNTY COLUMBUS			GEOLOGIST A. Suttle						
SITE DESCRIPTION Bridge No. 271 over Mill Creek on SR 1818 (Neils Eddy Road)										GROUND WTR (ft)					
BORING NO. EB1-A			STATION 13+04			OFFSET 6 ft LT			ALIGNMENT -L-		0 HR. 10.5				
COLLAR ELEV. 18.4 ft			TOTAL DEPTH 80.0 ft			NORTHING 212,497			EASTING 2,243,356		24 HR. FIAD				
DRILL RIG/HAMMER EFF./DATE BRI2425 CME-45D 84% 004/12/2022						DRILL METHOD Mud Rotary			HAMMER TYPE Automatic						
DRILLER N. Bigley			START DATE 01/26/23			COMP. DATE 01/26/23			SURFACE WATER DEPTH N/A						
ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT			BLOWS PER FOOT					SAMP. NO.	L O G	SOIL AND ROCK DESCRIPTION	DEPTH (ft)	
			0.5ft	0.5ft	0.5ft	0	25	50	75	100					ELEV. (ft)
-60	-60.1	78.5	8	10	17	Match Line					M			-61.6	80.0
														Boring Terminated at Elevation -61.6 ft In Coastal Plain Silty CLAY (A-7-6)	

NCDOT BORE SINGLE #088_GEO_GTM.GPJ NC_DOT.GDT 4/6/23

Bridge 271
End Bent 1



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APILE for Windows, Version 2019.9.6

Serial Number : 562476398

A Program for Analyzing the Axial Capacity
and Short-term Settlement of Driven Piles
under Axial Loading.

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Path to file locations : C:\Users\mwalko\OneDrive - ECS Corporate Services\Home Dir\Working Files to Move to Sharepoint\Fayetteville
Projects\33-6005 Columbus Bridge 271 - KCI\Axial Capacity Analysis\

Name of input data file : Columbus 271 - EB-1.ap9d

Name of output file : Columbus 271 - EB-1.ap9o

Name of plot output file : Columbus 271 - EB-1.ap9p

Time and Date of Analysis

Date: May 03, 2023 Time: 13:43:38

1

* INPUT INFORMATION *

Columbus 271 - EB-1

DESIGNER : ECS

JOB NUMBER : 33:6005

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 = 60.00 FT.
 - BATTER ANGLE = 0.00 DEG
 - PILE STICKUP LENGTH, PSL = 0.00 FT.
 - ZERO FRICTION LENGTH, ZFL = 0.00 FT.
 - PERIMETER OF PILE = 70.87 IN.
 - TIP AREA OF PILE = 15.50 IN2
 - INCREMENT OF PILE LENGTH
 USED IN COMPUTATION = 1.00 FT.

SOIL INFORMATIONS :

DEPTH FT.	SOIL TYPE	LATERAL EFFECTIVE		ANGLE DEGREES	FRICTION CAPACITY	BEARING FACTOR
		UNIT PRESSURE LB/FT^3	UNIT WEIGHT			
0.00	CLAY	0.80*	42.60	0.00	8.00**	
6.70	CLAY	0.80*	42.60	0.00	8.00**	
6.70	SAND	0.80*	52.60	30.00	20.00**	
26.70	SAND	0.80*	52.60	30.00	20.00**	
26.70	CLAY	0.80*	57.60	0.00	8.00**	
41.70	CLAY	0.80*	57.60	0.00	8.00**	
41.70	CLAY	0.80*	57.60	0.00	8.00**	
61.70	CLAY	0.80*	57.60	0.00	8.00**	
61.70	CLAY	0.80*	57.60	0.00	8.00**	
72.00	CLAY	0.80*	57.60	0.00	8.00**	

* VALUE ASSUMED BY THE PROGRAM

** VALUE ESTIMATED BY THE PROGRAM BASED ON FRICTION ANGLE

MAXIMUM UNIT FRICTION KSF	MAXIMUM UNIT BEARING KSF	UNDISTURB SHEAR STRENGTH KSF	REMOVED SHEAR STRENGTH KSF	BLOW COUNT KSF	UNIT SKIN FRICTION KSF	UNIT END BEARING KSF
0.10E+08*	0.10E+08*	0.20	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.20	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*	2.00	0.00	0.00	0.00	0.00
0.10E+08* 0.10E+08*	2.00	0.00	0.00	0.00	0.00
0.10E+08* 0.10E+08*	2.50	0.00	0.00	0.00	0.00
0.10E+08* 0.10E+08*	2.50	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.

DEPTH FT.	LRFD FACTOR ON UNIT FRICTION	LRFD FACTOR ON UNIT BEARING
0.00	1.000	1.000
6.70	1.000	1.000
6.70	1.000	1.000
26.70	1.000	1.000
26.70	1.000	1.000
41.70	1.000	1.000
41.70	1.000	1.000
61.70	1.000	1.000
61.70	1.000	1.000
72.00	1.000	1.000

1

* COMPUTATION RESULT *

* FED. HWY. METHOD *

PILE PENETRATION FT.	SKIN FRICTION KIP	END FRICTION KIP	ULTIMATE BEARING KIP	CAPACITY
0.00	0.0	0.1	0.1	
1.00	0.0	0.1	0.1	
2.00	0.4	0.1	0.5	
3.00	1.1	0.2	1.3	
4.00	1.9	0.2	2.0	
5.00	2.6	0.3	2.8	
6.00	3.3	0.3	3.7	
7.00	4.1	0.4	4.6	
8.00	4.9	0.6	5.5	
9.00	5.6	0.7	6.3	
10.00	6.3	0.9	7.2	
11.00	7.2	1.0	8.1	
12.00	8.1	1.1	9.2	
13.00	9.2	1.1	10.3	
14.00	10.3	1.2	11.5	
15.00	11.5	1.3	12.8	
16.00	12.8	1.4	14.2	
17.00	14.2	1.4	15.6	
18.00	15.7	1.4	17.2	

19.00	17.3	1.4	18.8
20.00	19.0	1.4	20.4
21.00	20.8	1.4	22.2
22.00	22.7	1.4	24.1
23.00	24.6	1.4	26.1
24.00	26.7	1.4	28.1
25.00	28.8	1.4	30.2
26.00	31.1	1.4	32.4
27.00	33.4	1.3	34.7
28.00	38.3	1.3	39.6
29.00	45.7	1.2	46.9
30.00	53.1	1.2	54.3
31.00	60.4	1.2	61.6
32.00	67.8	1.2	69.0
33.00	75.2	1.2	76.4
34.00	82.6	1.2	83.8
35.00	90.0	1.2	91.2
36.00	97.3	1.2	98.6
37.00	104.7	1.2	105.9
38.00	112.1	1.2	113.3
39.00	119.5	1.2	120.7
40.00	126.9	1.3	128.2
41.00	134.3	1.4	135.7
42.00	141.6	1.6	143.2
43.00	150.8	1.7	152.5
44.00	161.8	1.8	163.6
45.00	172.8	1.9	174.7
46.00	183.8	1.9	185.8
47.00	194.8	1.9	196.8
48.00	205.9	1.9	207.8
49.00	216.9	1.9	218.8
50.00	227.9	1.9	229.8
51.00	238.9	1.9	240.8
52.00	249.9	1.9	251.9
53.00	260.9	1.9	262.9
54.00	272.0	1.9	273.9
55.00	283.0	1.9	284.9
56.00	294.0	1.9	295.9
57.00	305.0	1.9	307.0
58.00	316.0	1.9	318.0
59.00	327.0	1.9	329.0
60.00	338.1	2.0	340.1

Factored Load = 85 tons/pile
 Static Analysis $\frac{85 \text{ ton}}{0.7} = 121.4 \text{ tons/pile}$

Round up to 125 tons/pile (250 k)

Est Tip EL = 12.1 - 53.0 = -40.9'

$L = \text{Box-Tip EL} + 2.0 \text{ Embed into Cap}$
 $= 12.1 - (-40.9) + 2.0 = 55.0'$

Pile Pen = 53.0'

Say Ave Pile Length = 60 FE

DRIVE Piles to: $\frac{85 \text{ ton}}{0.6} = 141.7 \text{ tons}$

Say 145 ton (290 k) = RDR

For WEAP, use 95% skin friction

Est
Tip

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.	NO. OF POINTS	DEPTH TO CURVE FT.	LOAD TRANSFER PSI	PILE MOVEMENT IN.
1	10	0.0000E+00		

			0.0000E+00	0.0000E+00
			0.0000E+00	0.3609E-01
			0.0000E+00	0.6993E-01
			0.0000E+00	0.1286E+00
			0.0000E+00	0.1805E+00
			0.0000E+00	0.2256E+00
			0.0000E+00	0.4512E+00
			0.0000E+00	0.6768E+00
			0.0000E+00	0.1128E+01
			0.0000E+00	0.4512E+01
2	10	0.3375E+01		
			0.0000E+00	0.0000E+00
			0.2615E+00	0.3609E-01
			0.4358E+00	0.6993E-01
			0.6537E+00	0.1286E+00
			0.7845E+00	0.1805E+00
			0.8717E+00	0.2256E+00
			0.7845E+00	0.4512E+00
			0.7845E+00	0.6768E+00
			0.7845E+00	0.1128E+01
			0.7845E+00	0.4512E+01
3	10	0.6658E+01		
			0.0000E+00	0.0000E+00
			0.2950E+00	0.3609E-01
			0.4916E+00	0.6993E-01
			0.7375E+00	0.1286E+00
			0.8849E+00	0.1805E+00
			0.9833E+00	0.2256E+00
			0.8849E+00	0.4512E+00
			0.8849E+00	0.6768E+00
			0.8849E+00	0.1128E+01
			0.8849E+00	0.4512E+01
4	10	0.6700E+01		
			0.0000E+00	0.0000E+00
			0.2971E+00	0.3609E-01
			0.4952E+00	0.6993E-01
			0.7427E+00	0.1286E+00
			0.8913E+00	0.1805E+00
			0.9903E+00	0.2256E+00
			0.9903E+00	0.4512E+00
			0.9903E+00	0.6768E+00
			0.9903E+00	0.1128E+01
			0.9903E+00	0.4512E+01
5	10	0.1673E+02		
			0.0000E+00	0.0000E+00
			0.5038E+00	0.3609E-01
			0.8397E+00	0.6993E-01
			0.1260E+01	0.1286E+00
			0.1512E+01	0.1805E+00
			0.1679E+01	0.2256E+00
			0.1679E+01	0.4512E+00
			0.1679E+01	0.6768E+00
			0.1679E+01	0.1128E+01
			0.1679E+01	0.4512E+01
6	10	0.2666E+02		
			0.0000E+00	0.0000E+00
			0.8290E+00	0.3609E-01
			0.1382E+01	0.6993E-01
			0.2072E+01	0.1286E+00
			0.2487E+01	0.1805E+00
			0.2763E+01	0.2256E+00

		0.2763E+01	0.4512E+00
		0.2763E+01	0.6768E+00
		0.2763E+01	0.1128E+01
		0.2763E+01	0.4512E+01
7	10	0.2670E+02	
		0.0000E+00	0.0000E+00
		0.8303E+00	0.3609E-01
		0.1384E+01	0.6993E-01
		0.2076E+01	0.1286E+00
		0.2491E+01	0.1805E+00
		0.2768E+01	0.2256E+00
		0.2491E+01	0.4512E+00
		0.2491E+01	0.6768E+00
		0.2491E+01	0.1128E+01
		0.2491E+01	0.4512E+01
8	10	0.3423E+02	
		0.0000E+00	0.0000E+00
		0.2604E+01	0.3609E-01
		0.4340E+01	0.6993E-01
		0.6510E+01	0.1286E+00
		0.7812E+01	0.1805E+00
		0.8681E+01	0.2256E+00
		0.7812E+01	0.4512E+00
		0.7812E+01	0.6768E+00
		0.7812E+01	0.1128E+01
		0.7812E+01	0.4512E+01
9	10	0.4166E+02	
		0.0000E+00	0.0000E+00
		0.2589E+01	0.3609E-01
		0.4314E+01	0.6993E-01
		0.6471E+01	0.1286E+00
		0.7766E+01	0.1805E+00
		0.8629E+01	0.2256E+00
		0.7766E+01	0.4512E+00
		0.7766E+01	0.6768E+00
		0.7766E+01	0.1128E+01
		0.7766E+01	0.4512E+01
10	10	0.4170E+02	
		0.0000E+00	0.0000E+00
		0.2588E+01	0.3609E-01
		0.4313E+01	0.6993E-01
		0.6469E+01	0.1286E+00
		0.7763E+01	0.1805E+00
		0.8625E+01	0.2256E+00
		0.7763E+01	0.4512E+00
		0.7763E+01	0.6768E+00
		0.7763E+01	0.1128E+01
		0.7763E+01	0.4512E+01
11	10	0.5173E+02	
		0.0000E+00	0.0000E+00
		0.3886E+01	0.3609E-01
		0.6477E+01	0.6993E-01
		0.9716E+01	0.1286E+00
		0.1166E+02	0.1805E+00
		0.1295E+02	0.2256E+00
		0.1166E+02	0.4512E+00
		0.1166E+02	0.6768E+00
		0.1166E+02	0.1128E+01
		0.1166E+02	0.4512E+01
12	10	0.6166E+02	
		0.0000E+00	0.0000E+00

			0.3886E+01	0.3609E-01
			0.6477E+01	0.6993E-01
			0.9716E+01	0.1286E+00
			0.1166E+02	0.1805E+00
			0.1295E+02	0.2256E+00
			0.1166E+02	0.4512E+00
			0.1166E+02	0.6768E+00
			0.1166E+02	0.1128E+01
			0.1166E+02	0.4512E+01
13	10	0.6170E+02		
			0.0000E+00	0.0000E+00
			0.3886E+01	0.3609E-01
			0.6477E+01	0.6993E-01
			0.9716E+01	0.1286E+00
			0.1166E+02	0.1805E+00
			0.1295E+02	0.2256E+00
			0.1166E+02	0.4512E+00
			0.1166E+02	0.6768E+00
			0.1166E+02	0.1128E+01
			0.1166E+02	0.4512E+01
14	10	0.6688E+02		
			0.0000E+00	0.0000E+00
			0.3886E+01	0.3609E-01
			0.6477E+01	0.6993E-01
			0.9716E+01	0.1286E+00
			0.1166E+02	0.1805E+00
			0.1295E+02	0.2256E+00
			0.1166E+02	0.4512E+00
			0.1166E+02	0.6768E+00
			0.1166E+02	0.1128E+01
			0.1166E+02	0.4512E+01
15	10	0.7196E+02		
			0.0000E+00	0.0000E+00
			0.3886E+01	0.3609E-01
			0.6477E+01	0.6993E-01
			0.9716E+01	0.1286E+00
			0.1166E+02	0.1805E+00
			0.1295E+02	0.2256E+00
			0.1166E+02	0.4512E+00
			0.1166E+02	0.6768E+00
			0.1166E+02	0.1128E+01
			0.1166E+02	0.4512E+01

TIP LOAD KIP	TIP MOVEMENT IN.
0.0000E+00	0.0000E+00
0.1255E+00	0.1128E-01
0.2510E+00	0.2256E-01
0.5020E+00	0.4512E-01
0.1004E+01	0.2933E+00
0.1506E+01	0.9475E+00
0.1807E+01	0.1647E+01
0.2008E+01	0.2256E+01
0.2008E+01	0.3384E+01
0.2008E+01	0.4512E+01

LOAD VERSUS SETTLEMENT CURVE

TOP LOAD	TOP MOVEMENT	TIP LOAD	TIP MOVEMENT
KIP	IN.	KIP	IN.
0.4464E+00	0.5407E-03	0.1113E-02	0.1000E-03
0.4464E+01	0.5407E-02	0.1113E-01	0.1000E-02
0.2261E+02	0.2725E-01	0.5563E-01	0.5000E-02
0.4516E+02	0.5464E-01	0.1113E+00	0.1000E-01
0.8679E+02	0.1076E+00	0.2225E+00	0.2000E-01
0.1734E+03	0.2320E+00	0.5119E+00	0.5000E-01
0.2288E+03	0.3254E+00	0.5725E+00	0.8000E-01
0.2572E+03	0.3792E+00	0.6130E+00	0.1000E+00
0.3296E+03	0.5735E+00	0.8153E+00	0.2000E+00
0.3083E+03	0.8483E+00	0.1163E+01	0.5000E+00
0.3085E+03	0.1149E+01	0.1393E+01	0.8000E+00
0.3087E+03	0.1349E+01	0.1529E+01	0.1000E+01
0.3091E+03	0.2350E+01	0.1924E+01	0.2000E+01

WEAP Parameter Calculation

Bent #: EB-1

	Toe Quake	Shaft Quake
Pile Type: HP 12X53	0.10	0.10

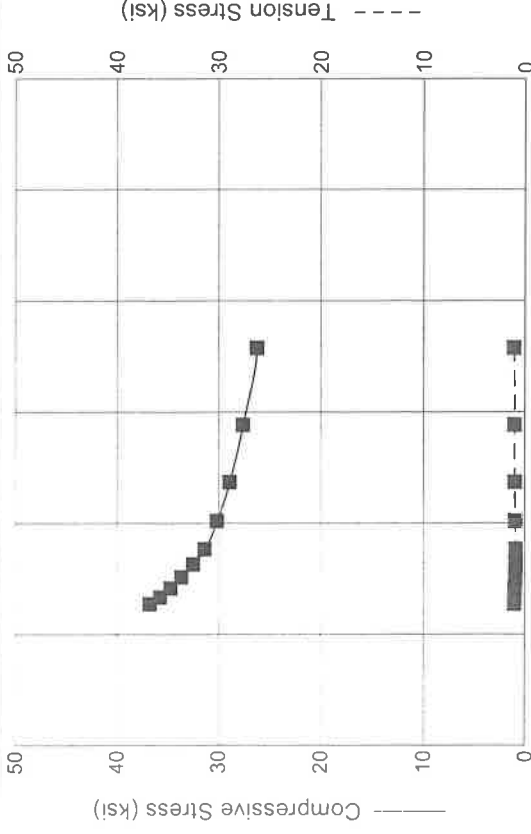
Subsurface Conditions: Loose/Soft or Submerged

Layer #	Top	Bottom	Navg	Soil Type	Shaft Damping	
1	12.1	0.4	1	Clay	0.30	
2	0.4	-14.6	9	Sand	0.20	
3	-14.6	-29.6	13	Clay	0.25	
4	-29.6	-40.9	22	Clay	0.20	
5						
6						
7						
8						
9						
10						
11						
12						
13						
					Toe Damping	
					0.24	0.10

Length of Pile: 53.0

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Columbus 271 - End Bent 1

20-Feb-2023
GRLWEAP Version 2010



DELMAG D 19-32

- Capacity 290.0 kips
- Ram Weight 4.00 kips
- Efficiency 0.800
- Pressure 1580 (100%) psi
- Helmet Weight 1.90 kips
- Hammer Cushion 60155 kips/in
- COR of H.C. 0.800
- Skin Quake 0.100 in
- Toe Quake 0.100 in
- Skin Damping 0.240 sec/ft
- Toe Damping 0.100 sec/ft
- Pile Length 60.00 ft
- Pile Penetration 53.00 ft
- Pile Top Area 15.50 in²

Skin Friction Distribution

Res. Shaft = 95 % (Proportional)

Pile Model

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Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
290.0	26.29	1.09	143.1	6.50	12.83
290.0	27.64	1.03	115.4	7.00	14.26
290.0	28.95	1.00	94.8	7.50	15.85
290.0	30.18	0.94	80.9	8.00	17.40
290.0	31.39	0.92	70.7	8.50	19.01
290.0	32.54	0.91	65.3	9.00	20.23
290.0	33.67	0.94	60.7	9.50	21.51
290.0	34.75	0.99	56.7	10.00	22.82
290.0	35.80	1.02	53.5	10.50	24.05
290.0	36.81	1.03	51.0	11.00	25.22

A Delmag D19-32 is suitable to drive piles at EB-1.

GRLWEAP - Version 2010
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins and Associates, Inc.) with cooperation from Pile Dynamics, Inc.
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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 building and other factors.

Input File: C:\USERS\MWALKO\ONEDRIVE - ECS CORPORATE SERVICES\HOME DIR\WORKING FILES TO MOVE TO SHAREPOINT\FAYETTEVILLE PROJECTS\33-6005 COLUMBUS BRIDGE 271 - KCI\WEAP\EB-1 DELMAG D19-32.GWW

Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW

Hammer File Version: 2003 (12/4/2015)

Input File Contents

Columbus 271 - End Bent 1

OUT	OSG	HAM	STR	FUL	PEL	N	SPL	N-U	P-D	%SK	ISM	0	PHI	RSA	ITR	H-D	MXT	DEx
6	0	40	-2	1	0	0	0	0	0	95	1	0	0	0	0	0	0	0.000

Pile g Hammer g Toe Area Pile Size Pile Type

32.170	32.170	141.890	12.040	H Pile			
W Cp	A Cp	E Cp	T Cp	CoR	ROut	StCp	
1.900	227.000	530.0	2.000	0.800	0.010	0.0	
A Cu	E Cu	T Cu	CoR	ROut	StCu		
0.000	0.0	0.000	0.000	0.000	0.0		
LPl	APle	EPle	WPle	Peri	CI	CoR	ROut
60.000	15.50	30000.0	492.000	3.970	0	0.850	0.010
FFatigue	F0	0-Bottom					
0	0.000	0.000					

Manufac Hmr Name HmrType No Seg-s

DELMAG	D 19-32	1	5				
Ram Wt	Ram L	Ram Dia	MaxStrk	RtdStrk	Efficy		
4.00	129.10	12.60	11.76	10.61	0.80		
IB. Wt	IB. L	IB. Dia	IB CoR	IB RO			
0.75	25.30	12.60	0.900	0.010			
CompStrk	A Chamber	V Chamber	C Delay	C Duratn	Exp Coeff	VolCStart	Vol CEnd
15.50	124.70	157.70	0.0020	0.0020	1.250	0.00	0.00
P atm	P1	P2	P3	P4	P5		
14.70	1580.00	1420.00	1280.00	1150.00	0.00		
Stroke	Effic.	Pressure	R-Weight	T-Delay	Exp-Coeff	Eps-Str	Total-AW
6.5000	0.8000	1580.0000	0.0000	0.0000	0.0000	0.0100	0.0000
Qs	Qt	Js	Jt	Qx	Jx	Rati	Dept
0.100	0.100	0.240	0.100	0.000	0.000	0.000	0.000
Research	Soil Model:	Atoe, Plug,	Gap,	Q-fac			
0.000	0.000	0.000	0.000	0.000			
Research	Soil Model:	RD-skn: m,	d, toe: m,	d			
0.000	0.000	0.000	0.000	0.000			

Res. Distribution

Dpth	Rskn	Dpth	Dpth						
0.00	0.08	53.00	53.00	0.00	0.00	0.00	0.00	0.00	0.0
11.70	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11.70	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
26.70	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
26.70	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
41.70	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
41.70	1.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
53.00	1.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
53.00	1.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
60.00	1.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Rult									
290.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS
Version 2010
English Units

Columbus 271 = End Bent 1

Hammer Model:	D 19-32	Made by:	DELMAG		
No.	Weight kips	Stiffn k/inch	CoR	C-Slk ft	Dampg k/ft/s
1	0.800				
2	0.800	140046.6	1.000	0.0100	
3	0.800	140046.6	1.000	0.0100	
4	0.800	140046.6	1.000	0.0100	
5	0.800	140046.6	1.000	0.0100	
Imp Block	0.753	70735.6	0.900	0.0100	
Helmet	1.900	60155.0	0.800	0.0100	5.8
Combined Pile Top		11625.0			

HAMMER OPTIONS:

Hammer File ID No.	40	Hammer Type	OE Diesel
Stroke Option	Var.P-IC	Stroke Convergence Crit.	0.010
Fuel Pump Setting	Maximum		

HAMMER DATA:

Ram Weight	(kips)	4.00	Ram Length	(inch)	129.10
Maximum Stroke	(ft)	11.76			
Rated Stroke	(ft)	10.61	Efficiency		0.800
Maximum Pressure	(psi)	1580.00	Actual Pressure	(psi)	1580.00
Compression Exponent		1.350	Expansion Exponent		1.250
Ram Diameter	(inch)	12.60			
Combustion Delay	(s)	0.00200	Ignition Duration	(s)	0.00200

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION

Cross Sect. Area	(in2)	227.00	PILE CUSHION	Cross Sect. Area	(in2)	0.00
Elastic-Modulus	(ksi)	530.0	Elastic-Modulus	(ksi)		0.0
Thickness	(inch)	2.00	Thickness	(inch)		0.00
Coeff of Restitution		0.8	Coeff of Restitution			0.0
RoundOut	(ft)	0.0	RoundOut	(ft)		0.0
Stiffness	(kips/in)	60155.0	Stiffness	(kips/in)		0.0

Columbus 271 - End Bent 1
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04/20/2023
 GRLWEAP Version 2010

PILE PROFILE:

Toe Area (in2) 141.890 Pile Type H Pile
 Pile Size (inch) 12.040

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	30000.	492.0	4.0	0	16807.	27.7
60.0	15.50	30000.	492.0	4.0	0	16807.	27.7

Wave Travel Time 2L/c (ms) 7.140

Pile and Soil Model						Total Capacity Rut (kips)				290.0	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.177	11625	0.010	0.000	0.85	0.0	0.240	0.100	3.33	4.0	15.5
2	0.177	11625	0.000	0.000	1.00	0.0	0.240	0.100	6.67	4.0	15.5
3	0.177	11625	0.000	0.000	1.00	2.2	0.240	0.100	10.00	4.0	15.5
4	0.177	11625	0.000	0.000	1.00	2.5	0.240	0.100	13.33	4.0	15.5
6	0.177	11625	0.000	0.000	1.00	3.1	0.240	0.100	20.00	4.0	15.5
7	0.177	11625	0.000	0.000	1.00	4.9	0.240	0.100	23.33	4.0	15.5
8	0.177	11625	0.000	0.000	1.00	5.8	0.240	0.100	26.67	4.0	15.5
9	0.177	11625	0.000	0.000	1.00	6.7	0.240	0.100	30.00	4.0	15.5
10	0.177	11625	0.000	0.000	1.00	7.7	0.240	0.100	33.33	4.0	15.5
11	0.177	11625	0.000	0.000	1.00	22.1	0.240	0.100	36.67	4.0	15.5
12	0.177	11625	0.000	0.000	1.00	23.8	0.240	0.100	40.00	4.0	15.5
15	0.177	11625	0.000	0.000	1.00	29.7	0.240	0.100	50.00	4.0	15.5
16	0.177	11625	0.000	0.000	1.00	39.0	0.240	0.100	53.33	4.0	15.5
18	0.177	11625	0.000	0.000	1.00	39.0	0.240	0.100	60.00	4.0	15.5
Toe						14.5	0.100	0.100			

3.178 kips total unreduced pile weight (g= 32.17 ft/s2)
 3.178 kips total reduced pile weight (g= 32.17 ft/s2)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile
 No. of Slacks/Splices 0 Pile Segments: Automatic
 Pile Penetration (ft) 53.00 Pile Damping (%) 1
 % Shaft Resistance 95 Pile Damping Fact. (k/ft/s) 0.553
 Inspection Chart
 Soil Damping Option Smith
 Max No Analysis Iterations 0 Time Increment/Critical 160
 Output Time Interval 1 Analysis Time-Input (ms) 0
 Output Level: Variable vs Time
 Gravity Mass, Pile, Hammer: 32.170 32.170 32.170
 Output Segment Generation: Automatic

Columbus 271 - End Bent 1
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No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	399.8	0.00	25.80	13.04	0.543	12.83
2	-5.6	402.3	-0.36	25.95	12.90	0.515	12.47
3	-10.7	407.5	-0.69	26.29	12.78	0.488	12.00
4	-12.9	404.9	-0.83	26.13	12.62	0.461	11.43
5	-14.7	402.1	-0.95	25.94	12.45	0.435	10.86
6	-16.3	400.9	-1.05	25.86	12.19	0.407	10.25
7	-16.8	399.5	-1.09	25.78	11.84	0.379	9.56
8	-15.0	392.9	-0.97	25.35	11.44	0.352	8.84
9	-12.0	385.2	-0.78	24.85	10.93	0.326	8.12
10	-7.8	382.7	-0.50	24.69	10.23	0.301	7.43
11	-3.5	389.3	-0.23	25.12	9.20	0.277	6.50
12	0.0	351.2	0.00	22.66	8.29	0.256	5.39
13	0.0	312.8	0.00	20.18	7.54	0.237	4.44
14	0.0	278.2	0.00	17.95	6.85	0.220	3.64
15	0.0	241.6	0.00	15.59	6.19	0.206	2.90
16	0.0	208.5	0.00	13.45	5.85	0.196	2.11
17	0.0	155.4	0.00	10.03	6.43	0.188	1.31
18	0.0	88.5	0.00	5.71	7.12	0.184	0.93

(Eq) Return Strokes and Stroke Analyzed (ft):
8.55 6.55 6.50

Max. Combustion Pressure 1185.0 psi

Columbus 271 - End Bent 1
ECS Carolinas LLP

04/20/2023
GRLWEAP Version 2010

Rut= 290.0, Rtoe = 14.5 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	420.7	0.00	27.14	13.83	0.571	14.26
2	-5.5	423.1	-0.35	27.30	13.69	0.542	13.86
3	-10.5	428.5	-0.68	27.64	13.57	0.514	13.35
4	-12.5	426.0	-0.81	27.48	13.41	0.486	12.74
5	-14.1	423.0	-0.91	27.29	13.24	0.459	12.11
6	-15.6	422.0	-1.01	27.23	12.96	0.430	11.44
7	-16.0	420.7	-1.03	27.14	12.60	0.401	10.71
8	-14.1	413.8	-0.91	26.70	12.18	0.374	9.93
9	-10.9	405.8	-0.70	26.18	11.64	0.347	9.15
10	-6.6	403.0	-0.43	26.00	10.88	0.321	8.40
11	-2.3	410.5	-0.15	26.48	9.77	0.297	7.38
12	0.0	370.9	0.00	23.93	8.80	0.276	6.16
13	0.0	330.4	0.00	21.32	7.99	0.256	5.10
14	0.0	295.2	0.00	19.04	7.25	0.240	4.21
15	0.0	254.0	0.00	16.39	6.54	0.227	3.38
16	0.0	219.2	0.00	14.14	6.17	0.216	2.47
17	0.0	163.4	0.00	10.54	6.75	0.208	1.54
18	0.0	93.2	0.00	6.01	7.49	0.204	1.09

(Eq) Return Strokes and Stroke Analyzed (ft):
8.55 6.80 6.99 7.00

Max. Combustion Pressure 1264.8 psi

Columbus 271 - End Bent 1
ECS Carolinas LLP

04/20/2023
GRLWEAP Version 2010

Rut= 290.0, Rtoe = 14.5 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	440.8	0.00	28.44	14.61	0.602	15.85
2	-5.4	443.1	-0.35	28.59	14.46	0.572	15.42
3	-10.4	448.8	-0.67	28.95	14.34	0.542	14.88
4	-12.3	446.3	-0.79	28.80	14.18	0.514	14.20
5	-13.8	443.5	-0.89	28.61	14.00	0.485	13.51
6	-15.3	442.3	-0.99	28.54	13.73	0.455	12.78
7	-15.6	441.2	-1.00	28.46	13.33	0.426	11.99
8	-13.5	434.1	-0.87	28.01	12.90	0.398	11.15
9	-10.3	425.9	-0.66	27.48	12.33	0.370	10.30
10	-6.0	422.8	-0.39	27.28	11.53	0.344	9.50
11	-1.7	431.0	-0.11	27.81	10.32	0.320	8.39
12	0.0	389.7	0.00	25.15	9.30	0.298	7.03
13	0.0	347.6	0.00	22.42	8.42	0.279	5.86
14	0.0	311.5	0.00	20.10	7.63	0.263	4.87
15	0.0	269.1	0.00	17.36	6.86	0.249	3.93
16	0.0	229.6	0.00	14.81	6.45	0.238	2.88
17	0.0	171.4	0.00	11.06	7.04	0.231	1.80
18	0.0	97.5	0.00	6.29	7.81	0.227	1.27

(Eq) Return Strokes and Stroke Analyzed (ft):
8.55 7.46 7.50

Max. Combustion Pressure 1358.9 psi

Columbus 271 - End Bent 1
ECS Carolinas LLP

04/20/2023
GRLWEAP Version 2010

Rut= 290.0, Rtoe = 14.5 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	460.2	0.00	29.69	15.32	0.630	17.40
2	-5.2	462.1	-0.34	29.81	15.18	0.599	16.94
3	-10.1	467.8	-0.65	30.18	15.05	0.570	16.37
4	-11.9	465.2	-0.77	30.01	14.92	0.540	15.63
5	-13.3	462.8	-0.86	29.86	14.72	0.509	14.87
6	-14.5	461.8	-0.94	29.79	14.44	0.479	14.10
7	-14.6	460.4	-0.94	29.70	14.06	0.449	13.26
8	-12.4	452.9	-0.80	29.22	13.57	0.420	12.35
9	-9.0	444.4	-0.58	28.67	13.00	0.392	11.45
10	-4.7	441.3	-0.30	28.47	12.15	0.367	10.60
11	-0.4	450.0	-0.02	29.03	10.86	0.342	9.39
12	0.0	407.7	0.00	26.30	9.75	0.319	7.91
13	0.0	363.9	0.00	23.47	8.80	0.300	6.62
14	0.0	326.7	0.00	21.08	7.98	0.284	5.53
15	0.0	284.1	0.00	18.33	7.19	0.271	4.48
16	0.0	238.7	0.00	15.40	6.73	0.260	3.29
17	0.0	178.8	0.00	11.53	7.34	0.252	2.06
18	0.0	101.7	0.00	6.56	8.14	0.248	1.46

(Eq) Return Strokes and Stroke Analyzed (ft):
8.57 8.02 8.00

Max. Combustion Pressure 1466.8 psi

Columbus 271 - End Bent 1
ECS Carolinas LLP

04/20/2023
GRLWEAP Version 2010

Rut= 290.0, Rtoe = 14.5 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	478.8	0.00	30.89	16.02	0.658	19.01
2	-5.2	480.7	-0.33	31.01	15.88	0.627	18.55
3	-10.0	486.5	-0.65	31.39	15.75	0.597	17.93
4	-11.7	484.2	-0.75	31.24	15.61	0.565	17.12
5	-13.0	481.6	-0.84	31.07	15.42	0.534	16.30
6	-14.2	480.8	-0.92	31.02	15.12	0.503	15.49
7	-14.1	479.4	-0.91	30.93	14.74	0.473	14.60
8	-11.8	471.7	-0.76	30.43	14.25	0.443	13.63
9	-8.4	462.8	-0.54	29.86	13.64	0.415	12.67
10	-4.1	459.3	-0.26	29.63	12.74	0.389	11.76
11	0.0	468.6	0.00	30.24	11.37	0.364	10.45
12	0.0	424.9	0.00	27.42	10.19	0.341	8.83
13	0.0	379.4	0.00	24.48	9.21	0.322	7.42
14	0.0	341.4	0.00	22.03	8.34	0.305	6.21
15	0.0	298.7	0.00	19.27	7.50	0.292	5.04
16	0.0	248.3	0.00	16.02	7.00	0.281	3.72
17	0.0	185.5	0.00	11.97	7.62	0.274	2.33
18	0.0	105.8	0.00	6.83	8.45	0.270	1.66

(Eq) Return Strokes and Stroke Analyzed (ft):
8.60 8.50 8.50

Max. Combustion Pressure 1561.8 psi

Columbus 271 - End Bent 1
ECS Carolinas LLP

04/20/2023
GRLWEAP Version 2010

Rut= 290.0, Rtoe = 14.5 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	496.5	0.00	32.03	16.69	0.677	20.23
2	-5.2	498.3	-0.34	32.15	16.55	0.645	19.74
3	-10.0	504.3	-0.65	32.54	16.42	0.613	19.09
4	-11.6	502.1	-0.75	32.39	16.28	0.581	18.24
5	-12.9	499.6	-0.84	32.23	16.09	0.549	17.38
6	-14.1	498.8	-0.91	32.18	15.77	0.518	16.55
7	-14.0	497.5	-0.90	32.10	15.38	0.488	15.61
8	-11.6	489.7	-0.75	31.59	14.88	0.458	14.59
9	-8.2	480.6	-0.53	31.00	14.25	0.430	13.59
10	-3.8	476.7	-0.25	30.76	13.30	0.403	12.63
11	0.0	486.7	0.00	31.40	11.85	0.378	11.24
12	0.0	441.5	0.00	28.48	10.62	0.355	9.52
13	0.0	394.7	0.00	25.46	9.59	0.335	8.01
14	0.0	355.3	0.00	22.92	8.68	0.319	6.72
15	0.0	312.4	0.00	20.16	7.79	0.306	5.47
16	0.0	257.4	0.00	16.61	7.25	0.295	4.04
17	0.0	191.8	0.00	12.38	7.88	0.288	2.53
18	0.0	109.6	0.00	7.07	8.74	0.284	1.80

(Eq) Return Strokes and Stroke Analyzed (ft):
8.63 9.00

Max. Combustion Pressure 1580.0 psi

Columbus 271 - End Bent 1
ECS Carolinas LLP

04/20/2023
GRLWEAP Version 2010

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
		Rut= 290.0,	Rtoe = 14.5	kips,	Time Inc. =0.076 ms		
1	0.0	514.1	0.00	33.17	17.34	0.695	21.51
2	-5.4	515.7	-0.35	33.27	17.20	0.662	20.98
3	-10.3	521.9	-0.66	33.67	17.07	0.630	20.30
4	-12.0	519.7	-0.77	33.53	16.95	0.598	19.41
5	-13.3	517.4	-0.86	33.38	16.75	0.565	18.51
6	-14.5	516.6	-0.94	33.33	16.43	0.534	17.64
7	-14.5	515.3	-0.94	33.24	16.02	0.503	16.66
8	-12.2	507.2	-0.79	32.72	15.51	0.473	15.59
9	-8.9	497.8	-0.57	32.12	14.85	0.444	14.54
10	-4.5	494.0	-0.29	31.87	13.86	0.418	13.53
11	0.0	504.7	0.00	32.56	12.34	0.392	12.07
12	0.0	457.8	0.00	29.53	11.04	0.369	10.24
13	0.0	409.9	0.00	26.44	9.96	0.349	8.63
14	0.0	369.1	0.00	23.81	9.00	0.333	7.26
15	0.0	326.2	0.00	21.05	8.06	0.319	5.91
16	0.0	266.3	0.00	17.18	7.50	0.309	4.37
17	0.0	198.3	0.00	12.79	8.13	0.302	2.74
18	0.0	113.4	0.00	7.31	9.02	0.298	1.95

(Eq) Return Strokes and Stroke Analyzed (ft):
8.65 9.50

Max. Combustion Pressure 1580.0 psi

Columbus 271 - End Bent 1
ECS Carolinas LLP

04/20/2023
GRLWEAP Version 2010

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
		Rut= 290.0,	Rtoe = 14.5	kips,	Time Inc. =0.076 ms		
1	0.0	531.2	0.00	34.27	17.96	0.714	22.82
2	-5.5	532.2	-0.36	34.34	17.82	0.680	22.25
3	-10.7	538.6	-0.69	34.75	17.71	0.647	21.54
4	-12.4	536.8	-0.80	34.63	17.56	0.614	20.60
5	-13.8	534.1	-0.89	34.46	17.38	0.581	19.66
6	-15.2	533.6	-0.98	34.43	17.06	0.549	18.76
7	-15.3	532.5	-0.99	34.35	16.62	0.518	17.73
8	-13.2	524.4	-0.85	33.83	16.11	0.487	16.61
9	-9.9	514.7	-0.64	33.21	15.44	0.459	15.52
10	-5.5	510.2	-0.36	32.92	14.43	0.432	14.46
11	-1.0	521.3	-0.07	33.63	12.83	0.406	12.91
12	0.0	473.6	0.00	30.55	11.45	0.383	10.97
13	0.0	424.2	0.00	27.37	10.31	0.363	9.27
14	0.0	382.5	0.00	24.67	9.29	0.347	7.80
15	0.0	339.2	0.00	21.89	8.30	0.333	6.36
16	0.0	274.6	0.00	17.71	7.71	0.323	4.71
17	0.0	205.0	0.00	13.22	8.34	0.315	2.96
18	0.0	116.6	0.00	7.52	9.26	0.312	2.10

(Eq) Return Strokes and Stroke Analyzed (ft):
8.67 10.00

Max. Combustion Pressure 1580.0 psi

Columbus 271 - End Bent 1
ECS Carolinas LLP

04/20/2023
GRLWEAP Version 2010

Rut= 290.0, Rtoe = 14.5 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	547.4	0.00	35.31	18.56	0.731	24.05
2	-5.7	548.1	-0.37	35.36	18.42	0.696	23.46
3	-10.9	554.9	-0.70	35.80	18.31	0.662	22.70
4	-12.8	552.9	-0.82	35.67	18.18	0.629	21.73
5	-14.2	550.7	-0.92	35.53	17.99	0.595	20.75
6	-15.6	550.1	-1.01	35.49	17.65	0.563	19.81
7	-15.8	548.9	-1.02	35.41	17.22	0.531	18.74
8	-13.7	540.5	-0.89	34.87	16.68	0.501	17.58
9	-10.5	530.5	-0.68	34.23	15.98	0.472	16.43
10	-6.2	526.3	-0.40	33.95	14.94	0.445	15.33
11	-1.6	538.1	-0.11	34.72	13.27	0.418	13.71
12	0.0	488.4	0.00	31.51	11.83	0.395	11.66
13	0.0	437.9	0.00	28.25	10.65	0.376	9.87
14	0.0	394.9	0.00	25.48	9.59	0.359	8.32
15	0.0	351.7	0.00	22.69	8.57	0.346	6.79
16	0.0	282.6	0.00	18.23	7.94	0.335	5.03
17	0.0	210.5	0.00	13.58	8.57	0.328	3.16
18	0.0	120.1	0.00	7.75	9.51	0.324	2.24

(Eq) Return Strokes and Stroke Analyzed (ft):
8.69 10.50

Max. Combustion Pressure 1580.0 psi

Columbus 271 - End Bent 1
ECS Carolinas LLP

04/20/2023
GRLWEAP Version 2010

Rut= 290.0, Rtoe = 14.5 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	563.4	0.00	36.35	19.15	0.746	25.22
2	-5.8	564.0	-0.37	36.39	19.00	0.710	24.60
3	-11.1	570.6	-0.71	36.81	18.91	0.676	23.80
4	-12.9	569.2	-0.83	36.72	18.75	0.642	22.80
5	-14.4	566.3	-0.93	36.54	18.58	0.608	21.79
6	-15.7	566.0	-1.02	36.52	18.26	0.575	20.81
7	-16.0	565.0	-1.03	36.45	17.78	0.544	19.71
8	-13.9	556.7	-0.90	35.91	17.24	0.512	18.50
9	-10.8	546.5	-0.69	35.26	16.55	0.483	17.31
10	-6.4	541.5	-0.42	34.93	15.46	0.456	16.16
11	-1.8	553.6	-0.12	35.71	13.73	0.430	14.46
12	0.0	503.4	0.00	32.48	12.21	0.407	12.32
13	0.0	451.3	0.00	29.12	10.96	0.387	10.43
14	0.0	407.3	0.00	26.28	9.86	0.371	8.80
15	0.0	363.7	0.00	23.46	8.82	0.357	7.20
16	0.0	290.5	0.00	18.74	8.14	0.346	5.33
17	0.0	216.6	0.00	13.98	8.79	0.339	3.35
18	0.0	123.0	0.00	7.94	9.72	0.335	2.38

(Eq) Return Strokes and Stroke Analyzed (ft):
8.73 11.00

Max. Combustion Pressure 1580.0 psi

Columbus 271 - End Bent 1
ECS Carolinas LLP

04/20/2023
GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Stroke (ft) up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
290.0	143.1	6.50	6.55	-1.09	7	38	26.29	3	2	12.8	46.1
290.0	115.4	7.00	6.99	-1.03	7	38	27.64	3	2	14.3	44.6
290.0	94.8	7.50	7.46	-1.00	7	38	28.95	3	2	15.8	43.1
290.0	80.9	8.00	8.02	-0.94	7	38	30.18	3	2	17.4	41.7
290.0	70.7	8.50	8.50	-0.92	6	38	31.39	3	2	19.0	40.5
290.0	65.3	9.00	8.63	-0.91	6	38	32.54	3	2	20.2	39.8
290.0	60.7	9.50	8.65	-0.94	6	38	33.67	3	2	21.5	39.3
290.0	56.7	10.00	8.67	-0.99	7	38	34.75	3	2	22.8	38.7
290.0	53.5	10.50	8.69	-1.02	7	38	35.80	3	2	24.1	38.2
290.0	51.0	11.00	8.73	-1.03	7	37	36.81	3	2	25.2	37.7

GEOTECHNICAL BORING REPORT BORE LOG

WBS BP6.R008.1		TIP SF-230271		COUNTY COLUMBUS		GEOLOGIST A. Suttle											
SITE DESCRIPTION Bridge No. 271 over Mill Creek on SR 1818 (Neils Eddy Road)							GROUND WTR (ft)										
BORING NO. EB2-B		STATION 13+78		OFFSET 6 ft RT		ALIGNMENT -L-	0 HR. 10.9										
COLLAR ELEV. 16.6 ft		TOTAL DEPTH 85.0 ft		NORTHING 212,547		EASTING 2,243,413	24 HR. FIAD										
DRILL RIG/HAMMER EFF./DATE BRI2425 CME-45D 84% 004/12/2022				DRILL METHOD Mud Rotary		HAMMER TYPE Automatic											
DRILLER N. Bigley		START DATE 01/26/23		COMP. DATE 01/26/23		SURFACE WATER DEPTH N/A											
ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT			BLOWS PER FOOT					SAMP. NO.	LOG	SOIL AND ROCK DESCRIPTION				
			0.5ft	0.5ft	0.5ft	0	25	50	75	100			ELEV. (ft)	DEPTH (ft)			
20						BOC = 10.5'											
15	15.6	1.0	10	9	8												
	13.1	3.5	2	1	3												
-10	10.6	6.0	2	1	2												
	8.1	8.5	1	WOH	WOH												
5	3.1	13.5	4	3	1												
0																	
	-1.9	18.5	4	4	12												
-5	-6.9	23.5	3	4	5												
-10	-11.9	28.5	26	25	18												
-15	-16.9	33.5	4	5	7												
-20	-21.9	38.5	4	5	9												
-25	-26.9	43.5	4	8	11												
-30	-31.9	48.5	4	6	8												
-35	-36.9	53.5	6	7	10												
-40	-41.9	58.5	7	8	9												
-45	-46.9	63.5	7	8	12												
-50	-51.9	68.5	7	7	11												
-55	-56.9	73.5	9	9	12												
-60																	

NCDOT BORE SINGLE #008_BEO_GTM.GPJ NC_DOT_GDT_4/6/23

BOC = 10.5'

BOC = 10.5

N_{corr} = 5 γ = 105 (42.6)

φ = 29

N_{corr} = 19 γ = 120 (57.6)

φ = 30

γ = 120 (57.6)

C = 3000

N = 16 γ = 120 (57.6)

C = 1500

N = 20 γ = 120 (57.6)

C = 2000

GROUND SURFACE 0.0

ROADWAY EMBANKMENT 0.7

Asphalt (0.7)

Very Loose to Medium Dense, Orange-Brown-Gray, Silty Fine to Coarse SAND (A-2-4)

ALLUVIAL 8.0

Very Loose, Brown-Gray, Silty Fine to Coarse SAND (A-2-4), little organic matter

COASTAL PLAIN (WACCAMAW FORMATION) 18.0

Stiff to Very Stiff, Gray, Fine Sandy SILT (A-4)

Hard, Gray, Clayey SILT (A-5) 28.0

Stiff to Very Stiff, Gray, Slightly to Moderately Plastic Fine Sandy CLAY (A-6(7)/A-6(14)) 33.0

SS-10 25%

SS-13 26%

Very Stiff, Gray, Silty CLAY (A-7-6) 58.0

11.9

21.9

26.9

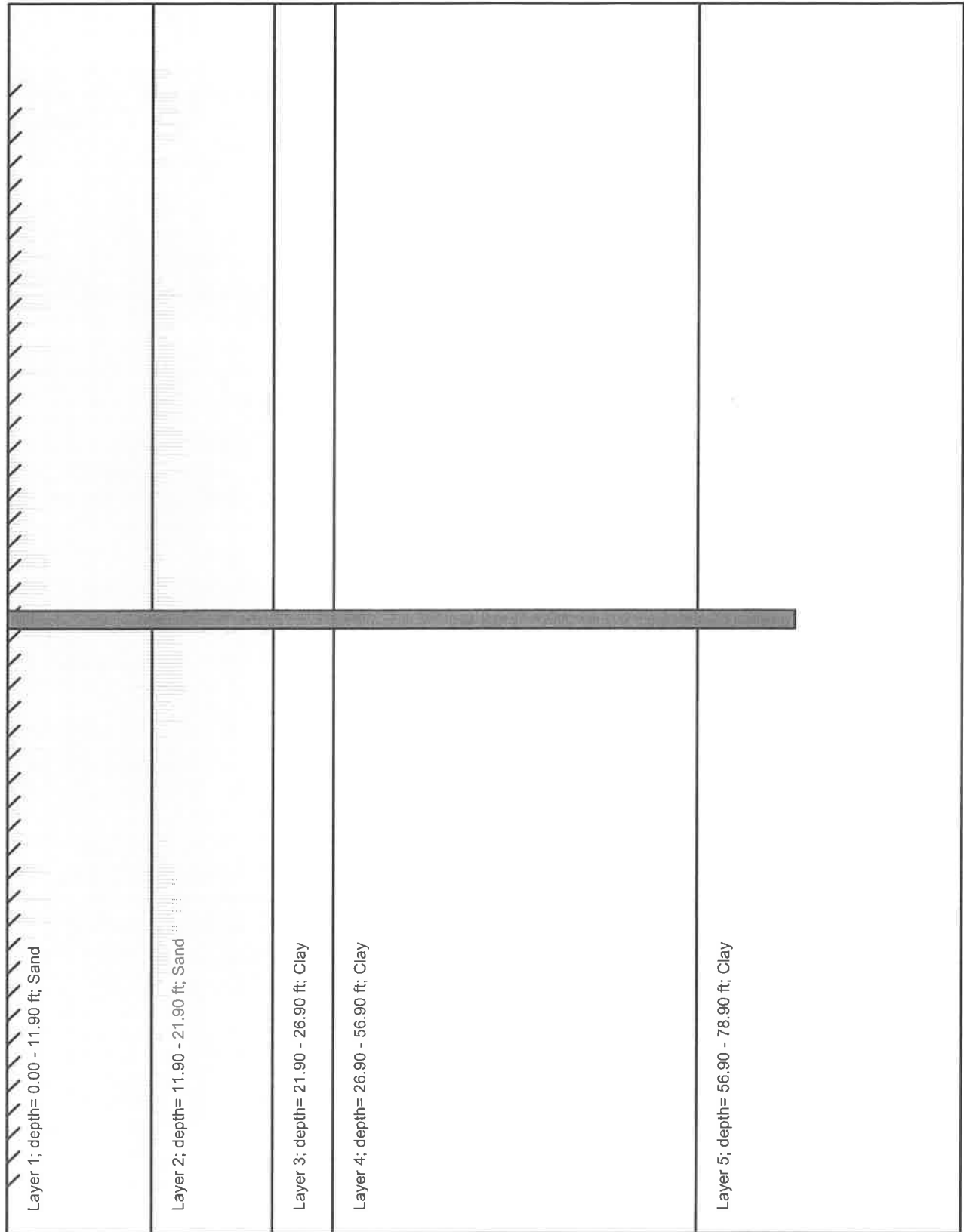
56.9

GEOTECHNICAL BORING REPORT BORE LOG

WBS BP6.R008.1			TIP SF-230271			COUNTY COLUMBUS			GEOLOGIST A. Suttle					
SITE DESCRIPTION Bridge No. 271 over Mill Creek on SR 1818 (Neils Eddy Road)								GROUND WTR (ft)						
BORING NO. EB2-B			STATION 13+78			OFFSET 6 ft RT			ALIGNMENT -L-					
COLLAR ELEV. 16.6 ft			TOTAL DEPTH 85.0 ft			NORTHING 212,547			EASTING 2,243,413					
DRILL RIG/HAMMER EFF./DATE BRI2425 CME-45D 84% 004/12/2022			DRILL METHOD Mud Rotary			HAMMER TYPE Automatic			0 HR. 10.9					
DRILLER N. Bigley			START DATE 01/26/23			COMP. DATE 01/26/23			24 HR. FIAD					
DRILLER N. Bigley			START DATE 01/26/23			COMP. DATE 01/26/23			SURFACE WATER DEPTH N/A					
ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT			BLOWS PER FOOT					SAMP. NO.	LOG	SOIL AND ROCK DESCRIPTION	
			0.5ft	0.5ft	0.5ft	0	25	50	75	100				ELEV. (ft)
-60						Match Line								
	-61.9	78.5	8	9	13							M	Very Stiff, Gray, Silty CLAY (A-7-6) (continued)	
-65														
	-66.9	83.5	8	9	12							M		
														-68.4 85.0
														Boring Terminated at Elevation -68.4 ft In Coastal Plain Silty CLAY (A-7-6)

NCDOT BORE SINGLE R008_GEO_GTM.GPJ NC_DOT_GDT 4/19/23

Bridge 271
End Bent 2



APILE for Windows, Version 2019.9.6

Serial Number : 562476398

A Program for Analyzing the Axial Capacity
and Short-term Settlement of Driven Piles
under Axial Loading.

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ECS Carolinas, LLP
Charlotte, NC, USA

Path to file locations : C:\Users\mwalko\OneDrive - ECS Corporate Services\Home Dir\Working Files to Move to Sharepoint\Fayetteville
Projects\33-6005 Columbus Bridge 271 - KCI\Axial Capacity Analysis\
Name of input data file : Columbus 271 - EB-2.ap9d
Name of output file : Columbus 271 - EB-2.ap9o
Name of plot output file : Columbus 271 - EB-2.ap9p

Time and Date of Analysis

Date: May 03, 2023 Time: 13:50:51

1

* INPUT INFORMATION *

Columbus 271 - EB-2

DESIGNER : ECS

JOB NUMBER : 33:6005

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 = 65.00 FT.
 - BATTER ANGLE = 0.00 DEG
 - PILE STICKUP LENGTH, PSL = 0.00 FT.
 - ZERO FRICTION LENGTH, ZFL = 0.00 FT.
 - PERIMETER OF PILE = 70.87 IN.
 - TIP AREA OF PILE = 15.50 IN2
 - INCREMENT OF PILE LENGTH
 USED IN COMPUTATION = 1.00 FT.

SOIL INFORMATIONS :

LATERAL EFFECTIVE FRICTION BEARING					
DEPTH	SOIL TYPE	EARTH PRESSURE	UNIT WEIGHT	ANGLE	FRICTION CAPACITY
FT.		LB/FT^3		DEGREES	FACTOR
0.00	SAND	0.80*	42.60	29.00	18.40**
11.90	SAND	0.80*	42.60	29.00	18.40**
11.90	SAND	0.80*	57.60	30.00	20.00**
21.90	SAND	0.80*	57.60	30.00	20.00**
21.90	CLAY	0.80*	57.60	0.00	8.00**
26.90	CLAY	0.80*	57.60	0.00	8.00**
26.90	CLAY	0.80*	57.60	0.00	8.00**
56.90	CLAY	0.80*	57.60	0.00	8.00**
56.90	CLAY	0.80*	57.60	0.00	8.00**
78.90	CLAY	0.80*	57.60	0.00	8.00**

* VALUE ASSUMED BY THE PROGRAM

** VALUE ESTIMATED BY THE PROGRAM BASED ON FRICTION ANGLE

MAXIMUM MAXIMUM UNDISTURB REMOLDED							
UNIT FRICTION	UNIT BEARING	UNIT SHEAR	UNIT SHEAR	UNIT BLOW	UNIT SKIN	UNIT END	UNIT END
KSF	KSF	KSF	KSF	KSF	KSF	KSF	KSF
0.10E+08*	0.10E+08*	0.00	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	0.00
0.10E+08*	0.10E+08*	0.00	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	0.00
0.10E+08*	0.10E+08*	3.00	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	3.00	0.00	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*	1.50	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	2.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	2.00	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.

DEPTH FT.	LRFD FACTOR ON UNIT FRICTION	LRFD FACTOR ON UNIT BEARING
0.00	1.000	1.000
11.90	1.000	1.000
11.90	1.000	1.000
21.90	1.000	1.000
21.90	1.000	1.000
26.90	1.000	1.000
26.90	1.000	1.000
56.90	1.000	1.000
56.90	1.000	1.000
78.90	1.000	1.000

1

* COMPUTATION RESULT *

* FED. HWY. METHOD *

PILE PENETRATION FT.	SKIN FRICTION KIP	END FRICTION KIP	ULTIMATE BEARING CAPACITY KIP
0.00	0.0	0.0	0.0
1.00	0.0	0.1	0.1
2.00	0.1	0.1	0.3
3.00	0.3	0.2	0.5
4.00	0.6	0.3	0.8
5.00	0.9	0.3	1.2
6.00	1.3	0.4	1.7
7.00	1.7	0.5	2.2
8.00	2.3	0.5	2.8
9.00	2.9	0.6	3.5
10.00	3.5	0.7	4.2
11.00	4.3	0.8	5.1
12.00	5.1	0.9	6.0
13.00	6.0	1.0	7.0
14.00	7.1	1.2	8.2
15.00	8.2	1.3	9.5
16.00	9.5	1.3	10.8
17.00	10.8	1.4	12.2
18.00	12.3	1.4	13.7

19.00	13.8	1.4	15.3
20.00	15.5	1.6	17.2
21.00	17.3	1.9	19.2
22.00	19.1	2.2	21.3
23.00	29.0	2.4	31.4
24.00	46.7	2.7	49.4
25.00	64.4	2.7	67.1
26.00	82.1	2.4	84.5
27.00	97.9	2.2	100.1
28.00	109.3	1.9	111.2
29.00	118.2	1.7	119.8
30.00	127.0	1.5	128.5
31.00	135.9	1.5	137.3
32.00	144.7	1.5	146.2
33.00	153.6	1.5	155.0
34.00	162.5	1.5	163.9
35.00	171.3	1.5	172.8
36.00	180.2	1.5	181.6
37.00	189.0	1.5	190.5
38.00	197.9	1.5	199.3
39.00	206.7	1.5	208.2
40.00	215.6	1.5	217.1
41.00	224.5	1.5	225.9
42.00	233.3	1.5	234.8
43.00	242.2	1.5	243.6
44.00	251.0	1.5	252.5
45.00	259.9	1.5	261.4
46.00	268.8	1.5	270.2
47.00	277.6	1.5	279.1
48.00	286.5	1.5	287.9
49.00	295.3	1.5	296.8
50.00	304.2	1.5	305.6
51.00	313.1	1.5	314.5
52.00	321.9	1.5	323.4
53.00	330.8	1.5	332.2
54.00	339.6	1.5	341.1
55.00	348.5	1.5	350.0
56.00	356.7	1.6	358.4
57.00	364.9	1.7	366.6
58.00	374.6	1.8	376.4
59.00	385.3	1.9	387.2
60.00	396.1	1.9	398.0
61.00	406.8	1.9	408.8
62.00	417.6	1.9	419.5
63.00	428.3	1.9	430.3
64.00	439.1	1.9	441.0
65.00	449.9	1.9	451.8

EST TIP

Factored Load = 85 tons/pile
 STATIC ANALYSIS = $\frac{85 \text{ ton}}{0.7} = 121.4 \text{ tons}$

Round up to 125 tons (250k)

EST TIP EL = $10.5 - 44.0 = -33.5'$

$L = \text{BOC} - \text{TIP EL} + 2.0 \text{ Embed into Cap}$
 $= 10.5 - (-33.5) + 2.0 = 46.0'$

Pile Pen = 44.0'

Say Ave Pile Length = 50 ft

DRIVE PILES to: $\frac{85 \text{ ton}}{0.6} = 141.7 \text{ tons}$

Say 145 ton (290k) = RDR

For WEAP, USE 95% SKIN FRICTION

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.	NO. OF POINTS	DEPTH TO CURVE FT.	LOAD TRANSFER PSI	PILE MOVEMENT IN.
1	10	0.0000E+00	0.0000E+00	0.0000E+00
			0.0000E+00	0.3609E-01
			0.0000E+00	0.6993E-01
			0.0000E+00	0.1286E+00
			0.0000E+00	0.1805E+00
			0.0000E+00	0.2256E+00
			0.0000E+00	0.4512E+00
			0.0000E+00	0.6768E+00
			0.0000E+00	0.1128E+01
			0.0000E+00	0.4512E+01
2	10	0.5975E+01	0.0000E+00	0.0000E+00
			0.1485E+00	0.3609E-01
			0.2475E+00	0.6993E-01
			0.3713E+00	0.1286E+00
			0.4455E+00	0.1805E+00
			0.4951E+00	0.2256E+00
			0.4951E+00	0.4512E+00
			0.4951E+00	0.6768E+00
			0.4951E+00	0.1128E+01
			0.4951E+00	0.4512E+01
3	10	0.1186E+02	0.0000E+00	0.0000E+00
			0.2948E+00	0.3609E-01
			0.4913E+00	0.6993E-01
			0.7369E+00	0.1286E+00
			0.8843E+00	0.1805E+00
			0.9825E+00	0.2256E+00
			0.9825E+00	0.4512E+00
			0.9825E+00	0.6768E+00
			0.9825E+00	0.1128E+01
			0.9825E+00	0.4512E+01
4	10	0.1190E+02	0.0000E+00	0.0000E+00
			0.2958E+00	0.3609E-01
			0.4930E+00	0.6993E-01
			0.7395E+00	0.1286E+00
			0.8874E+00	0.1805E+00
			0.9860E+00	0.2256E+00
			0.9860E+00	0.4512E+00
			0.9860E+00	0.6768E+00
			0.9860E+00	0.1128E+01
			0.9860E+00	0.4512E+01
5	10	0.1693E+02	0.0000E+00	0.0000E+00
			0.4946E+00	0.3609E-01
			0.8243E+00	0.6993E-01
			0.1236E+01	0.1286E+00
			0.1484E+01	0.1805E+00
			0.1649E+01	0.2256E+00
			0.1649E+01	0.4512E+00
			0.1649E+01	0.6768E+00
			0.1649E+01	0.1128E+01
			0.1649E+01	0.4512E+01
6	10	0.2186E+02	0.0000E+00	0.0000E+00
			0.0000E+00	0.0000E+00

			0.6714E+00	0.3609E-01
			0.1119E+01	0.6993E-01
			0.1679E+01	0.1286E+00
			0.2014E+01	0.1805E+00
			0.2238E+01	0.2256E+00
			0.2238E+01	0.4512E+00
			0.2238E+01	0.6768E+00
			0.2238E+01	0.1128E+01
			0.2238E+01	0.4512E+01
7	10	0.2190E+02		
			0.0000E+00	0.0000E+00
			0.6729E+00	0.3609E-01
			0.1122E+01	0.6993E-01
			0.1682E+01	0.1286E+00
			0.2019E+01	0.1805E+00
			0.2243E+01	0.2256E+00
			0.2019E+01	0.4512E+00
			0.2019E+01	0.6768E+00
			0.2019E+01	0.1128E+01
			0.2019E+01	0.4512E+01
8	10	0.2443E+02		
			0.0000E+00	0.0000E+00
			0.6250E+01	0.3609E-01
			0.1042E+02	0.6993E-01
			0.1562E+02	0.1286E+00
			0.1875E+02	0.1805E+00
			0.2083E+02	0.2256E+00
			0.1875E+02	0.4512E+00
			0.1875E+02	0.6768E+00
			0.1875E+02	0.1128E+01
			0.1875E+02	0.4512E+01
9	10	0.2686E+02		
			0.0000E+00	0.0000E+00
			0.5094E+01	0.3609E-01
			0.8490E+01	0.6993E-01
			0.1274E+02	0.1286E+00
			0.1528E+02	0.1805E+00
			0.1698E+02	0.2256E+00
			0.1528E+02	0.4512E+00
			0.1528E+02	0.6768E+00
			0.1528E+02	0.1128E+01
			0.1528E+02	0.4512E+01
10	10	0.2690E+02		
			0.0000E+00	0.0000E+00
			0.5038E+01	0.3609E-01
			0.8397E+01	0.6993E-01
			0.1260E+02	0.1286E+00
			0.1511E+02	0.1805E+00
			0.1679E+02	0.2256E+00
			0.1511E+02	0.4512E+00
			0.1511E+02	0.6768E+00
			0.1511E+02	0.1128E+01
			0.1511E+02	0.4512E+01
11	10	0.4193E+02		
			0.0000E+00	0.0000E+00
			0.3125E+01	0.3609E-01
			0.5208E+01	0.6993E-01
			0.7812E+01	0.1286E+00
			0.9375E+01	0.1805E+00
			0.1042E+02	0.2256E+00
			0.9375E+01	0.4512E+00

			0.9375E+01	0.6768E+00
			0.9375E+01	0.1128E+01
			0.9375E+01	0.4512E+01
12	10	0.5686E+02		
			0.0000E+00	0.0000E+00
			0.2993E+01	0.3609E-01
			0.4988E+01	0.6993E-01
			0.7482E+01	0.1286E+00
			0.8978E+01	0.1805E+00
			0.9976E+01	0.2256E+00
			0.8978E+01	0.4512E+00
			0.8978E+01	0.6768E+00
			0.8978E+01	0.1128E+01
			0.8978E+01	0.4512E+01
13	10	0.5690E+02		
			0.0000E+00	0.0000E+00
			0.3007E+01	0.3609E-01
			0.5011E+01	0.6993E-01
			0.7517E+01	0.1286E+00
			0.9020E+01	0.1805E+00
			0.1002E+02	0.2256E+00
			0.9020E+01	0.4512E+00
			0.9020E+01	0.6768E+00
			0.9020E+01	0.1128E+01
			0.9020E+01	0.4512E+01
14	10	0.6793E+02		
			0.0000E+00	0.0000E+00
			0.3794E+01	0.3609E-01
			0.6323E+01	0.6993E-01
			0.9484E+01	0.1286E+00
			0.1138E+02	0.1805E+00
			0.1265E+02	0.2256E+00
			0.1138E+02	0.4512E+00
			0.1138E+02	0.6768E+00
			0.1138E+02	0.1128E+01
			0.1138E+02	0.4512E+01
15	10	0.7886E+02		
			0.0000E+00	0.0000E+00
			0.3794E+01	0.3609E-01
			0.6323E+01	0.6993E-01
			0.9484E+01	0.1286E+00
			0.1138E+02	0.1805E+00
			0.1265E+02	0.2256E+00
			0.1138E+02	0.4512E+00
			0.1138E+02	0.6768E+00
			0.1138E+02	0.1128E+01
			0.1138E+02	0.4512E+01

TIP LOAD KIP	TIP MOVEMENT IN.
0.0000E+00	0.0000E+00
0.1211E+00	0.1128E-01
0.2422E+00	0.2256E-01
0.4844E+00	0.4512E-01
0.9688E+00	0.2933E+00
0.1453E+01	0.9475E+00
0.1744E+01	0.1647E+01
0.1938E+01	0.2256E+01

0.1938E+01 0.3384E+01
0.1938E+01 0.4512E+01

LOAD VERSUS SETTLEMENT CURVE

TOP LOAD KIP	TOP MOVEMENT IN.	TIP LOAD KIP	TIP MOVEMENT IN.
0.7450E+00	0.7893E-03	0.1074E-02	0.1000E-03
0.7450E+01	0.7893E-02	0.1074E-01	0.1000E-02
0.3797E+02	0.3999E-01	0.5368E-01	0.5000E-02
0.7552E+02	0.8002E-01	0.1074E+00	0.1000E-01
0.1396E+03	0.1530E+00	0.2147E+00	0.2000E-01
0.2624E+03	0.3118E+00	0.4939E+00	0.5000E-01
0.3359E+03	0.4239E+00	0.5525E+00	0.8000E-01
0.3690E+03	0.4841E+00	0.5915E+00	0.1000E+00
0.4329E+03	0.6790E+00	0.7867E+00	0.2000E+00
0.4078E+03	0.9490E+00	0.1122E+01	0.5000E+00
0.4081E+03	0.1249E+01	0.1344E+01	0.8000E+00
0.4082E+03	0.1450E+01	0.1475E+01	0.1000E+01
0.4086E+03	0.2450E+01	0.1856E+01	0.2000E+01

WEAP Parameter Calculation

Bent #:

	Toe Quake	Shaft Quake
Pile Type: <input type="text" value="HP 12X53"/>	<input type="text" value="0.10"/>	<input type="text" value="0.10"/>

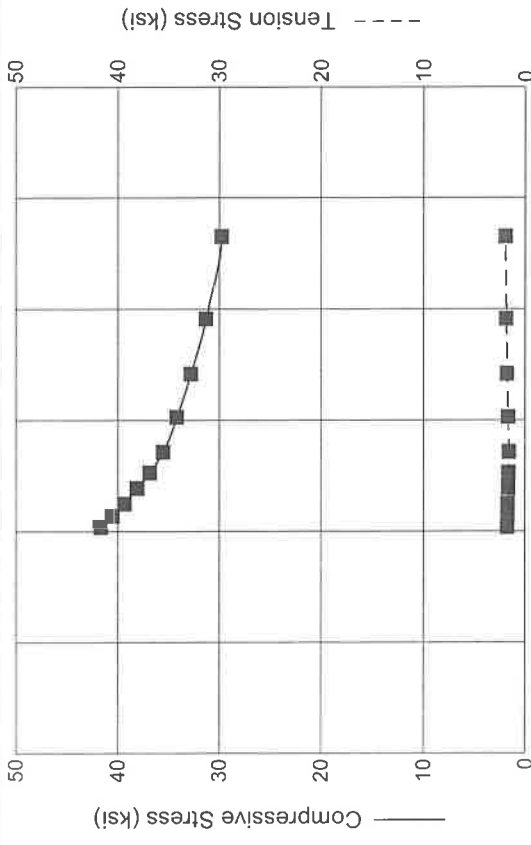
Subsurface Conditions:

Layer #	Top	Bottom	Navg	Soil Type	Shaft Damping	
1	10.5	-1.4	2	Sand	0.20	
2	-1.4	-11.4	12	Sand	0.18	
3	-11.4	-16.4	43	Clay	0.10	
4	-16.4	-31.4	15	Clay	0.25	
5	-31.4	-33.5	16	Clay	0.25	
6						
7						
8						
9						
10						
11						
12						
13						
					Toe Damping	
					0.20	0.10

Length of Pile

ECS Carolinas LLP
Columbus 271 - End Bent 2

20-Apr-2023
GRLWEAP Version 2010



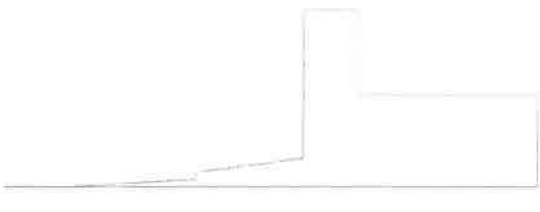
DEL MAG D 19-32

Capacity 290.0 kips
 Ram Weight 4.00 kips
 Efficiency 0.800
 Pressure 1580 (100%) psi
 Helmet Weight 1.90 kips
 Hammer Cushion 60155 kips/in
 COR of H.C. 0.800
 Skin Quake 0.100 in
 Toe Quake 0.100 in
 Skin Damping 0.200 sec/ft
 Toe Damping 0.100 sec/ft
 Pile Length 50.00 ft
 Pile Penetration 44.00 ft
 Pile Top Area 15.50 in²

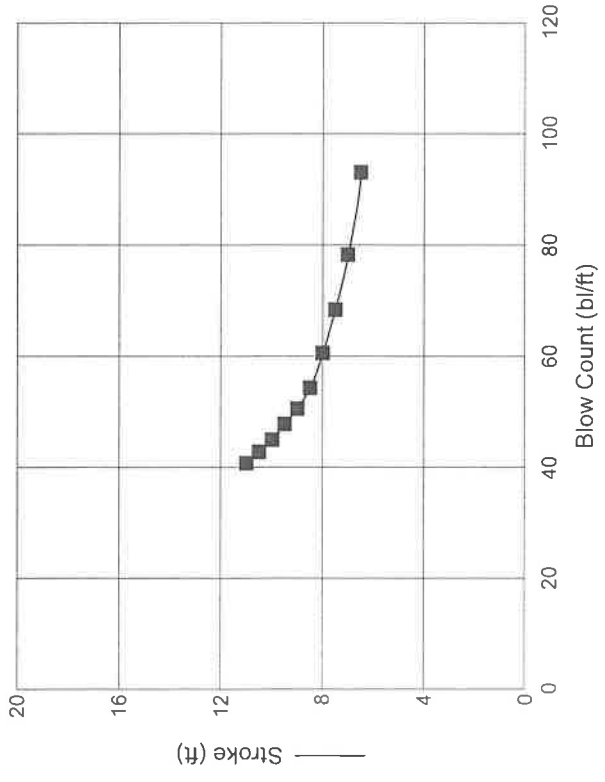
Pile Model



Skin Friction Distribution



Res. Shaft = 95 %
(Proportional)



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Columbus 271 - End Bent 2

20-Apr-2023
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Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
290.0	29.77	1.95	93.1	6.50	12.49
290.0	31.32	1.88	78.3	7.00	14.02
290.0	32.82	1.79	68.4	7.50	15.48
290.0	34.20	1.68	60.6	8.00	17.03
290.0	35.58	1.59	54.3	8.50	18.65
290.0	36.88	1.65	50.6	9.00	19.92
290.0	38.13	1.67	47.8	9.50	21.07
290.0	39.36	1.72	45.0	10.00	22.35
290.0	40.52	1.74	42.8	10.50	23.56
290.0	41.68	1.76	40.8	11.00	24.75

A Delmag D19-32 is suitable to drive piles at
EB-2.

GRLWEAP - Version 2010
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins and Associates, Inc.) with cooperation from Pile Dynamics, Inc.
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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 building and other factors.

Input File: C:\USERS\MWALKO\ONEDRIVE - ECS CORPORATE SERVICES\HOME DIR\WORKING FILES TO MOVE TO SHAREPOINT\FAYETTEVILLE PROJECTS\33-6005 COLUMBUS BRIDGE 271 - KCI\WEAP\EB-2 DELMAG D19-32.GWW
 Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW
 Hammer File Version: 2003 (12/4/2015)

Input File Contents

Columbus 271 - End Bent 2

OUT	OSG	HAM	STR	FUL	PEL	N	SPL	N-U	P-D	%SK	ISM	0	PHI	RSA	ITR	H-D	MXT	DEX
6	0	40	-2	1	0	0	0	0	0	95	1	0	0	0	0	0	0	0.000

File g Hammer g Toe Area File Size File Type

32.170	32.170	141.890	12.040	H File
W Cp	A Cp	E Cp	T Cp	CoR
1.900	227.000	530.0	2.000	0.800
A Cu	E Cu	T Cu	CoR	Rout
0.000	0.0	0.000	0.000	0.000
LPle	APle	EPle	WPle	Peri
50.000	15.50	30000.0	492.000	3.970
FFatigue	F0	0-Bottom		
0	0.000	0.000		

Manufac Hmr Name HmrType No Seg-s

DELMAG	D	19-32	1	5
Ram Wt	Ram L	Ram Dia	MaxStrk	RtdStrk
4.00	129.10	12.60	11.76	10.61
IB. Wt	IB. L	IB. Dia	IB CoR	IB RO
0.75	25.30	12.60	0.900	0.010
CompStrk	A Chamber	V Chamber	C Delay	C Duratn
15.50	124.70	157.70	0.0020	0.0020
P atm	P1	P2	P3	P4
14.70	1580.00	1420.00	1280.00	1150.00
Stroke	Effic.	Pressure	R-Weight	T-Delay
6.5000	0.8000	1580.0000	0.0000	0.0000
Qs	Qt	Js	Jt	Qx
0.100	0.100	0.200	0.100	0.000
Research	Soil Model:	Atoe, Plug,	Gap,	Q-fac
0.000	0.000	0.000	0.000	
Research	Soil Model:	RD-skn: m, d,	toe: m, d	
0.000	0.000	0.000	0.000	

Res. Distribution

Dpth	Rskn	Dpth	Dpth						
0.00	0.00	44.00	44.00	0.00	0.00	0.00	0.00	0.00	0.0
11.90	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11.90	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
21.90	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
21.90	1.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
26.90	1.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
26.90	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
41.90	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
41.90	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
44.00	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
44.00	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
50.00	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Rult									
290.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS
 Version 2010
 English Units

Columbus 271 - End Bent 2

Hammer Model:		D 19-32		Made by:		DELMAG	
No.	Weight kips	Stiffn k/inch	CoR	C-Slk ft	Dampg k/ft/s		
1	0.800						
2	0.800	140046.6	1.000	0.0100			
3	0.800	140046.6	1.000	0.0100			
4	0.800	140046.6	1.000	0.0100			
5	0.800	140046.6	1.000	0.0100			
Imp Block	0.753	70735.6	0.900	0.0100			
Helmet	1.900	60155.0	0.800	0.0100	5.8		
Combined Pile Top		11625.0					

HAMMER OPTIONS:

Hammer File ID No.	40	Hammer Type	OE Diesel
Stroke Option	Var.P-IC	Stroke Convergence Crit.	0.010
Fuel Pump Setting	Maximum		

HAMMER DATA:

Ram Weight	(kips)	4.00	Ram Length	(inch)	129.10
Maximum Stroke	(ft)	11.76			
Rated Stroke	(ft)	10.61	Efficiency		0.800
Maximum Pressure	(psi)	1580.00	Actual Pressure	(psi)	1580.00
Compression Exponent		1.350	Expansion Exponent		1.250
Ram Diameter	(inch)	12.60			
Combustion Delay	(s)	0.00200	Ignition Duration	(s)	0.00200

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION

Cross Sect. Area	(in ²)	227.00	PILE CUSHION		
Elastic-Modulus	(ksi)	530.0	Cross Sect. Area	(in ²)	0.00
Thickness	(inch)	2.00	Elastic-Modulus	(ksi)	0.0
Coeff of Restitution		0.8	Thickness	(inch)	0.00
RoundOut	(ft)	0.0	Coeff of Restitution		0.0
Stiffness	(kips/in)	60155.0	RoundOut	(ft)	0.0
			Stiffness	(kips/in)	0.0

Columbus 271 - End Bent 2
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PILE PROFILE:

Toe Area (in2) 141.890 Pile Type H Pile
 Pile Size (inch) 12.040

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	30000.	492.0	4.0	0	16807.	27.7
50.0	15.50	30000.	492.0	4.0	0	16807.	27.7

Wave Travel Time 2L/c (ms) 5.950

No.	Pile and Soil Model					Total Capacity Rut (kips)				290.0	
	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.177	11625	0.010	0.000	0.85	0.0	0.200	0.100	3.33	4.0	15.5
2	0.177	11625	0.000	0.000	1.00	0.0	0.200	0.100	6.67	4.0	15.5
3	0.177	11625	0.000	0.000	1.00	0.5	0.200	0.100	10.00	4.0	15.5
4	0.177	11625	0.000	0.000	1.00	1.2	0.200	0.100	13.33	4.0	15.5
5	0.177	11625	0.000	0.000	1.00	1.9	0.200	0.100	16.67	4.0	15.5
6	0.177	11625	0.000	0.000	1.00	3.7	0.200	0.100	20.00	4.0	15.5
7	0.177	11625	0.000	0.000	1.00	6.4	0.200	0.100	23.33	4.0	15.5
8	0.177	11625	0.000	0.000	1.00	8.7	0.200	0.100	26.67	4.0	15.5
9	0.177	11625	0.000	0.000	1.00	42.1	0.200	0.100	30.00	4.0	15.5
10	0.177	11625	0.000	0.000	1.00	56.9	0.200	0.100	33.33	4.0	15.5
11	0.177	11625	0.000	0.000	1.00	30.8	0.200	0.100	36.67	4.0	15.5
15	0.177	11625	0.000	0.000	1.00	30.8	0.200	0.100	50.00	4.0	15.5
Toe						14.5	0.100	0.100			

2.648 kips total unreduced pile weight (g= 32.17 ft/s2)
 2.648 kips total reduced pile weight (g= 32.17 ft/s2)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile		File Segments: Automatic	
No. of Slacks/Splices	0	File Damping (%)	1
Pile Penetration (ft)	44.00	Pile Damping Fact. (k/ft/s)	0.553
% Shaft Resistance	95		
Inspection Chart			
Soil Damping Option	Smith		
Max No Analysis Iterations	0	Time Increment/Critical	160
Output Time Interval	1	Analysis Time-Input (ms)	0
Output Level: Variable vs Time			
Gravity Mass, Pile, Hammer:	32.170	32.170	32.170
Output Segment Generation: Automatic			

Columbus 271 - End Bent 2
ECS Carolinas LLP

04/20/2023
GRLWEAP Version 2010

Rut= 290.0, Rtoe = 14.5 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	410.3	0.00	26.47	13.04	0.510	12.49
2	-6.9	412.0	-0.45	26.58	12.98	0.484	12.18
3	-13.8	405.5	-0.89	26.16	12.93	0.457	11.82
4	-19.9	408.7	-1.28	26.37	12.83	0.429	11.37
5	-24.8	411.0	-1.60	26.52	12.66	0.401	10.87
6	-28.8	414.3	-1.85	26.73	12.35	0.372	10.30
7	-30.2	416.8	-1.95	26.89	11.81	0.344	9.61
8	-28.0	445.3	-1.80	28.73	10.83	0.316	8.84
9	-24.8	461.4	-1.60	29.77	9.17	0.289	7.49
10	-6.3	391.9	-0.40	25.28	7.79	0.268	5.54
11	0.0	285.2	0.00	18.40	7.06	0.254	4.05
12	0.0	238.2	0.00	15.37	6.50	0.243	3.12
13	0.0	205.3	0.00	13.25	6.34	0.236	2.27
14	0.0	161.0	0.00	10.38	7.32	0.232	1.47
15	0.0	94.4	0.00	6.09	8.32	0.229	1.07

(Eq) Return Strokes and Stroke Analyzed (ft):
8.50 6.48 6.50

Max. Combustion Pressure 1185.0 psi

Columbus 271 - End Bent 2
ECS Carolinas LLP

04/20/2023
GRLWEAP Version 2010

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	434.2	0.00	28.01	13.84	0.539	14.02
2	-6.8	436.1	-0.44	28.14	13.77	0.513	13.69
3	-13.4	428.5	-0.87	27.64	13.72	0.485	13.30
4	-19.5	429.8	-1.26	27.73	13.64	0.456	12.81
5	-24.2	432.9	-1.56	27.93	13.46	0.427	12.28
6	-27.9	436.0	-1.80	28.13	13.14	0.398	11.67
7	-29.1	438.4	-1.88	28.29	12.57	0.368	10.91
8	-26.7	468.5	-1.72	30.23	11.52	0.340	10.08
9	-23.5	485.5	-1.52	31.32	9.73	0.313	8.58
10	-5.4	413.8	-0.35	26.69	8.24	0.292	6.38
11	0.0	303.0	0.00	19.55	7.46	0.277	4.69
12	0.0	250.2	0.00	16.14	6.86	0.267	3.63
13	0.0	215.9	0.00	13.93	6.66	0.260	2.66
14	0.0	169.6	0.00	10.94	7.68	0.256	1.72
15	0.0	99.6	0.00	6.43	8.74	0.253	1.25

Rut= 290.0, Rtoe = 14.5 kips, Time Inc. =0.076 ms

(Eq) Return Strokes and Stroke Analyzed (ft):
8.51 6.78 6.98 7.00

Max. Combustion Pressure 1279.4 psi

Columbus 271 - End Bent 2
ECS Carolinas LLP

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GRLWEAP Version 2010

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	455.6	0.00	29.40	14.62	0.566	15.48
2	-6.5	457.5	-0.42	29.51	14.55	0.539	15.13
3	-13.1	449.5	-0.84	29.00	14.51	0.510	14.71
4	-18.8	450.1	-1.21	29.04	14.42	0.480	14.20
5	-23.3	453.1	-1.50	29.23	14.25	0.451	13.64
6	-26.8	456.8	-1.73	29.47	13.91	0.421	12.98
7	-27.8	459.2	-1.79	29.63	13.33	0.391	12.17
8	-25.3	490.5	-1.63	31.65	12.21	0.361	11.27
9	-22.0	508.7	-1.42	32.82	10.27	0.334	9.63
10	-4.4	434.8	-0.28	28.05	8.67	0.313	7.19
11	0.0	320.2	0.00	20.66	7.85	0.298	5.31
12	0.0	261.9	0.00	16.90	7.20	0.289	4.13
13	0.0	226.0	0.00	14.58	6.98	0.282	3.03
14	0.0	177.7	0.00	11.46	8.04	0.278	1.95
15	0.0	104.7	0.00	6.75	9.16	0.275	1.42

(Eq) Return Strokes and Stroke Analyzed (ft):
8.52 7.43 7.50

Max. Combustion Pressure 1364.1 psi

Columbus 271 - End Bent 2
ECS Carolinas LLP

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GRLWEAP Version 2010

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	478.1	0.00	30.85	15.33	0.593	17.03
2	-6.3	479.8	-0.41	30.95	15.26	0.565	16.65
3	-12.5	471.9	-0.80	30.44	15.23	0.536	16.21
4	-17.9	469.5	-1.15	30.29	15.15	0.505	15.67
5	-22.0	472.6	-1.42	30.49	14.97	0.475	15.08
6	-25.3	476.3	-1.63	30.73	14.64	0.444	14.37
7	-26.1	479.0	-1.68	30.91	14.03	0.413	13.50
8	-23.3	510.8	-1.50	32.95	12.87	0.383	12.53
9	-19.9	530.2	-1.29	34.20	10.81	0.356	10.74
10	-2.9	454.6	-0.18	29.33	9.10	0.334	8.06
11	0.0	335.6	0.00	21.65	8.23	0.320	5.98
12	0.0	275.8	0.00	17.79	7.53	0.311	4.66
13	0.0	235.1	0.00	15.17	7.28	0.305	3.42
14	0.0	185.4	0.00	11.96	8.35	0.301	2.21
15	0.0	109.0	0.00	7.03	9.57	0.298	1.61

Rut= 290.0, Rtoe = 14.5 kips, Time Inc. =0.076 ms

(Eq) Return Strokes and Stroke Analyzed (ft):
8.54 8.01 8.00

Max. Combustion Pressure 1474.3 psi

Columbus 271 - End Bent 2
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No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	501.0	0.00	32.32	16.04	0.621	18.65
2	-6.1	502.8	-0.39	32.44	15.97	0.592	18.26
3	-11.8	494.7	-0.76	31.92	15.94	0.562	17.78
4	-17.0	488.2	-1.10	31.50	15.87	0.530	17.21
5	-21.1	491.7	-1.36	31.72	15.68	0.499	16.59
6	-24.2	495.5	-1.56	31.97	15.36	0.468	15.83
7	-24.7	498.3	-1.59	32.15	14.71	0.436	14.90
8	-21.7	531.0	-1.40	34.26	13.49	0.405	13.85
9	-18.3	551.4	-1.18	35.58	11.31	0.377	11.91
10	-1.8	474.1	-0.12	30.59	9.50	0.356	8.97
11	0.0	351.1	0.00	22.65	8.57	0.343	6.69
12	0.0	290.6	0.00	18.75	7.85	0.335	5.23
13	0.0	244.7	0.00	15.79	7.58	0.328	3.84
14	0.0	193.2	0.00	12.46	8.68	0.324	2.48
15	0.0	113.9	0.00	7.35	9.94	0.321	1.81

Rut= 290.0, Rtoe = 14.5 kips, Time Inc. = 0.076 ms

(Eq) Return Strokes and Stroke Analyzed (ft):
8.54 8.50

Max. Combustion Pressure 1580.0 psi

Columbus 271 - End Bent 2
ECS Carolinas LLP

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GRLWEAP Version 2010

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	514.6	0.00	33.20	16.71	0.639	19.92
2	-6.2	516.5	-0.40	33.32	16.63	0.610	19.51
3	-12.1	508.2	-0.78	32.79	16.61	0.579	19.02
4	-17.4	506.2	-1.12	32.66	16.55	0.548	18.42
5	-21.6	509.7	-1.39	32.89	16.36	0.516	17.78
6	-24.9	513.9	-1.60	33.15	16.03	0.485	16.99
7	-25.6	516.7	-1.65	33.33	15.37	0.452	16.01
8	-22.8	550.0	-1.47	35.48	14.09	0.421	14.91
9	-19.4	571.6	-1.25	36.88	11.78	0.393	12.85
10	-2.9	492.0	-0.19	31.74	9.88	0.372	9.70
11	0.0	365.9	0.00	23.61	8.89	0.359	7.25
12	0.0	304.5	0.00	19.65	8.14	0.351	5.67
13	0.0	253.4	0.00	16.35	7.94	0.345	4.17
14	0.0	200.2	0.00	12.92	8.98	0.340	2.69
15	0.0	118.2	0.00	7.63	10.28	0.337	1.96

(Eq) Return Strokes and Stroke Analyzed (ft):
8.55 9.00

Max. Combustion Pressure 1580.0 psi

Columbus 271 - End Bent 2
ECS Carolinas LLP

04/20/2023
GRLWEAP Version 2010

Rut= 290.0, Rtoe = 14.5 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	526.3	0.00	33.96	17.35	0.655	21.07
2	-6.1	528.1	-0.40	34.07	17.27	0.626	20.65
3	-12.2	519.2	-0.79	33.49	17.26	0.595	20.14
4	-17.5	523.3	-1.13	33.76	17.21	0.563	19.53
5	-21.7	527.2	-1.40	34.02	17.04	0.531	18.87
6	-25.0	531.7	-1.61	34.30	16.67	0.499	18.06
7	-25.9	534.4	-1.67	34.48	16.02	0.467	17.03
8	-23.2	568.4	-1.50	36.67	14.70	0.435	15.89
9	-19.8	591.0	-1.28	38.13	12.21	0.407	13.71
10	-3.3	509.9	-0.21	32.89	10.21	0.385	10.36
11	0.0	379.8	0.00	24.50	9.23	0.373	7.76
12	0.0	317.9	0.00	20.51	8.43	0.365	6.08
13	0.0	261.6	0.00	16.88	8.31	0.358	4.47
14	0.0	206.5	0.00	13.32	9.28	0.354	2.89
15	0.0	122.3	0.00	7.89	10.59	0.351	2.10

(Eq) Return Strokes and Stroke Analyzed (ft):
8.57 9.50

Max. Combustion Pressure 1580.0 psi

Columbus 271 - End Bent 2
ECS Carolinas LLP

04/20/2023
GRLWEAP Version 2010

Rut= 290.0, Rtoe = 14.5 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	539.2	0.00	34.78	17.97	0.673	22.35
2	-6.2	540.9	-0.40	34.90	17.90	0.643	21.90
3	-12.3	535.5	-0.80	34.55	17.91	0.611	21.38
4	-17.8	540.5	-1.15	34.87	17.86	0.579	20.76
5	-22.1	544.6	-1.42	35.14	17.69	0.547	20.07
6	-25.5	549.1	-1.65	35.43	17.31	0.515	19.22
7	-26.6	551.9	-1.72	35.60	16.66	0.482	18.16
8	-24.1	586.5	-1.55	37.84	15.29	0.450	16.96
9	-20.8	610.1	-1.34	39.36	12.66	0.422	14.66
10	-4.3	527.0	-0.28	34.00	10.58	0.400	11.10
11	0.0	393.8	0.00	25.41	9.56	0.388	8.32
12	0.0	330.9	0.00	21.35	8.71	0.380	6.52
13	0.0	269.8	0.00	17.41	8.68	0.374	4.80
14	0.0	213.0	0.00	13.74	9.56	0.369	3.10
15	0.0	126.3	0.00	8.15	10.93	0.366	2.26

(Eq) Return Strokes and Stroke Analyzed (ft):
8.58 10.00

Max. Combustion Pressure 1580.0 psi

Columbus 271 - End Bent 2
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GRLWEAP Version 2010

Rut= 290.0, Rtoe = 14.5 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	550.9	0.00	35.54	18.58	0.689	23.56
2	-6.3	552.2	-0.41	35.62	18.50	0.659	23.10
3	-12.5	551.5	-0.81	35.58	18.51	0.627	22.57
4	-18.0	557.1	-1.16	35.94	18.48	0.594	21.92
5	-22.3	561.2	-1.44	36.21	18.29	0.562	21.21
6	-25.8	565.8	-1.66	36.50	17.93	0.529	20.34
7	-27.0	568.6	-1.74	36.69	17.24	0.496	19.23
8	-24.7	603.1	-1.59	38.91	15.83	0.464	17.98
9	-21.5	628.0	-1.39	40.52	13.10	0.435	15.57
10	-5.0	543.8	-0.32	35.08	10.93	0.414	11.80
11	0.0	406.9	0.00	26.25	9.85	0.402	8.86
12	0.0	342.7	0.00	22.11	8.99	0.394	6.95
13	0.0	277.9	0.00	17.93	9.01	0.388	5.12
14	0.0	219.7	0.00	14.17	9.83	0.383	3.31
15	0.0	130.3	0.00	8.40	11.21	0.381	2.41

(Eq) Return Strokes and Stroke Analyzed (ft):
8.59 10.50

Max. Combustion Pressure 1580.0 psi

Columbus 271 - End Bent 2
 ECS Carolinas LLP

04/20/2023
 GRLWEAP Version 2010

Rut= 290.0, Rtoe = 14.5 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	564.7	0.00	36.43	19.16	0.705	24.75
2	-6.4	562.8	-0.42	36.31	19.08	0.673	24.27
3	-12.7	567.1	-0.82	36.59	19.12	0.641	23.72
4	-18.1	572.7	-1.17	36.95	19.05	0.608	23.06
5	-22.4	577.0	-1.45	37.23	18.90	0.576	22.33
6	-25.9	582.1	-1.67	37.56	18.52	0.543	21.43
7	-27.3	584.8	-1.76	37.73	17.81	0.510	20.28
8	-25.1	620.4	-1.62	40.03	16.35	0.477	18.98
9	-22.0	646.1	-1.42	41.68	13.53	0.448	16.45
10	-5.5	560.0	-0.36	36.13	11.27	0.427	12.49
11	0.0	419.5	0.00	27.07	10.14	0.415	9.39
12	0.0	355.3	0.00	22.93	9.23	0.407	7.37
13	0.0	285.7	0.00	18.43	9.35	0.401	5.43
14	0.0	226.2	0.00	14.59	10.08	0.397	3.51
15	0.0	133.6	0.00	8.62	11.56	0.394	2.55

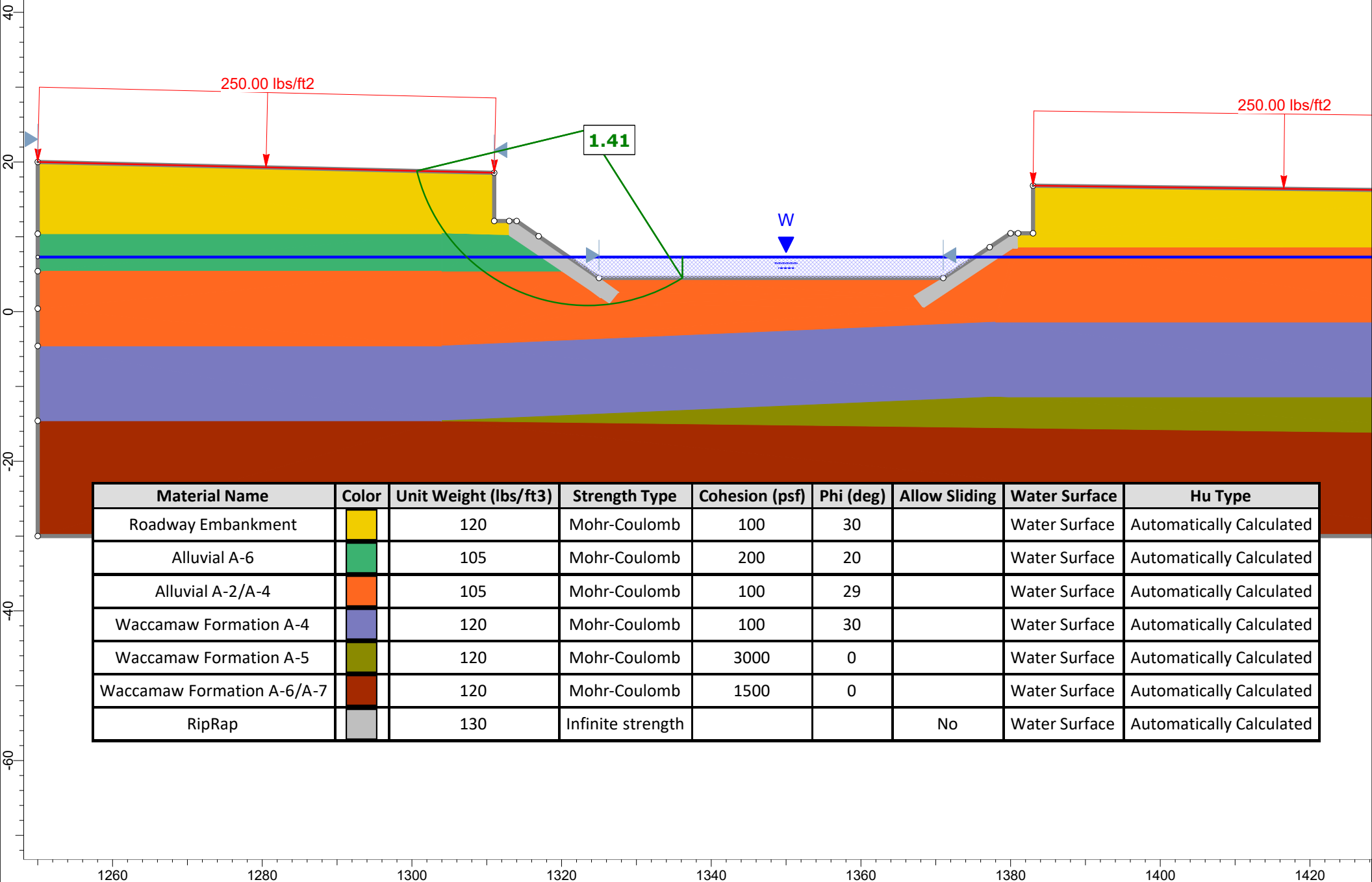
(Eq) Return Strokes and Stroke Analyzed (ft):
 8.61 11.00








Max. Combustion Pressure 1580.0 psi

Columbus 271 - End Bent 2
ECS Carolinas LLP

04/20/2023
GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Stroke (ft) up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
290.0	93.1	6.50	6.48	-1.95	7	35	29.77	9	4	12.5	46.2
290.0	78.3	7.00	6.98	-1.88	7	35	31.32	9	4	14.0	44.6
290.0	68.4	7.50	7.43	-1.79	7	35	32.82	9	4	15.5	43.2
290.0	60.6	8.00	8.01	-1.68	7	35	34.20	9	4	17.0	41.8
290.0	54.3	8.50	8.54	-1.59	7	36	35.58	9	4	18.7	40.5
290.0	50.6	9.00	8.55	-1.65	7	35	36.88	9	4	19.9	40.0
290.0	47.8	9.50	8.57	-1.67	7	35	38.13	9	4	21.1	39.4
290.0	45.0	10.00	8.58	-1.72	7	35	39.36	9	4	22.3	38.9
290.0	42.8	10.50	8.59	-1.74	7	35	40.52	9	4	23.6	38.4
290.0	40.8	11.00	8.61	-1.76	7	35	41.68	9	3	24.7	37.9

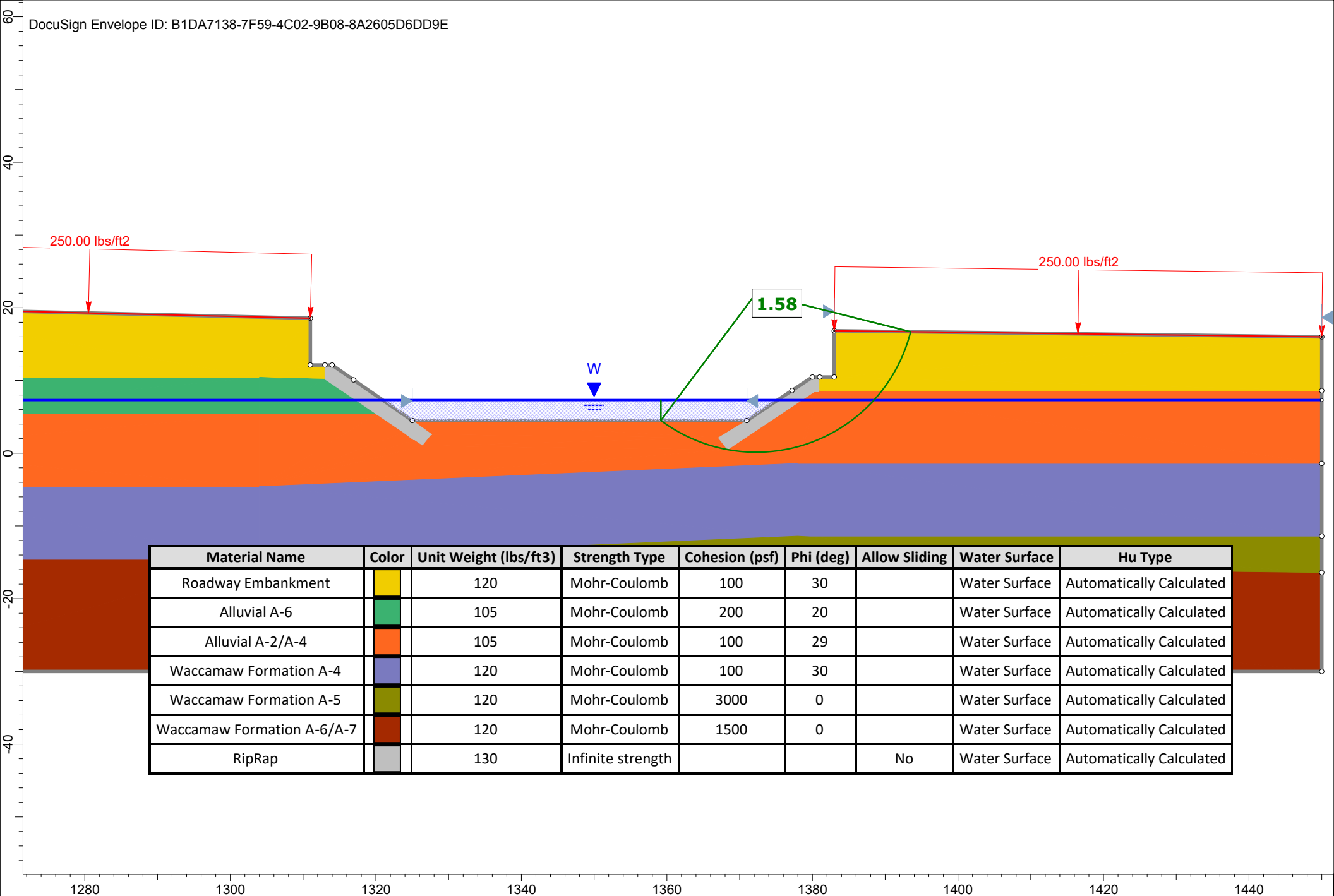


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Allow Sliding	Water Surface	Hu Type
Roadway Embankment		120	Mohr-Coulomb	100	30		Water Surface	Automatically Calculated
Alluvial A-6		105	Mohr-Coulomb	200	20		Water Surface	Automatically Calculated
Alluvial A-2/A-4		105	Mohr-Coulomb	100	29		Water Surface	Automatically Calculated
Waccamaw Formation A-4		120	Mohr-Coulomb	100	30		Water Surface	Automatically Calculated
Waccamaw Formation A-5		120	Mohr-Coulomb	3000	0		Water Surface	Automatically Calculated
Waccamaw Formation A-6/A-7		120	Mohr-Coulomb	1500	0		Water Surface	Automatically Calculated
RipRap		130	Infinite strength			No	Water Surface	Automatically Calculated

1260 1280 1300 1320 1340 1360 1380 1400 1420



<i>Project</i>		BP6.R008.1 - Columbus Bridge 271	
<i>Group</i>	End Bent No. 1	<i>Scenario</i>	Master Scenario
<i>Drawn By</i>	KND	<i>Company</i>	ECS Southeast, LLP
<i>Date</i>	5/1/2023, 9:20:18 AM	<i>File Name</i>	Bridge271.slmd



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Allow Sliding	Water Surface	Hu Type
Roadway Embankment		120	Mohr-Coulomb	100	30		Water Surface	Automatically Calculated
Alluvial A-6		105	Mohr-Coulomb	200	20		Water Surface	Automatically Calculated
Alluvial A-2/A-4		105	Mohr-Coulomb	100	29		Water Surface	Automatically Calculated
Waccamaw Formation A-4		120	Mohr-Coulomb	100	30		Water Surface	Automatically Calculated
Waccamaw Formation A-5		120	Mohr-Coulomb	3000	0		Water Surface	Automatically Calculated
Waccamaw Formation A-6/A-7		120	Mohr-Coulomb	1500	0		Water Surface	Automatically Calculated
RipRap		130	Infinite strength			No	Water Surface	Automatically Calculated



Project	BP6.R008.1 - Columbus Bridge 271		
Group	End Bent No. 2	Scenario	Master Scenario
Drawn By	KND	Company	ECS Southeast, LLP
Date	5/1/2023, 9:20:18 AM	File Name	Bridge271.slmd