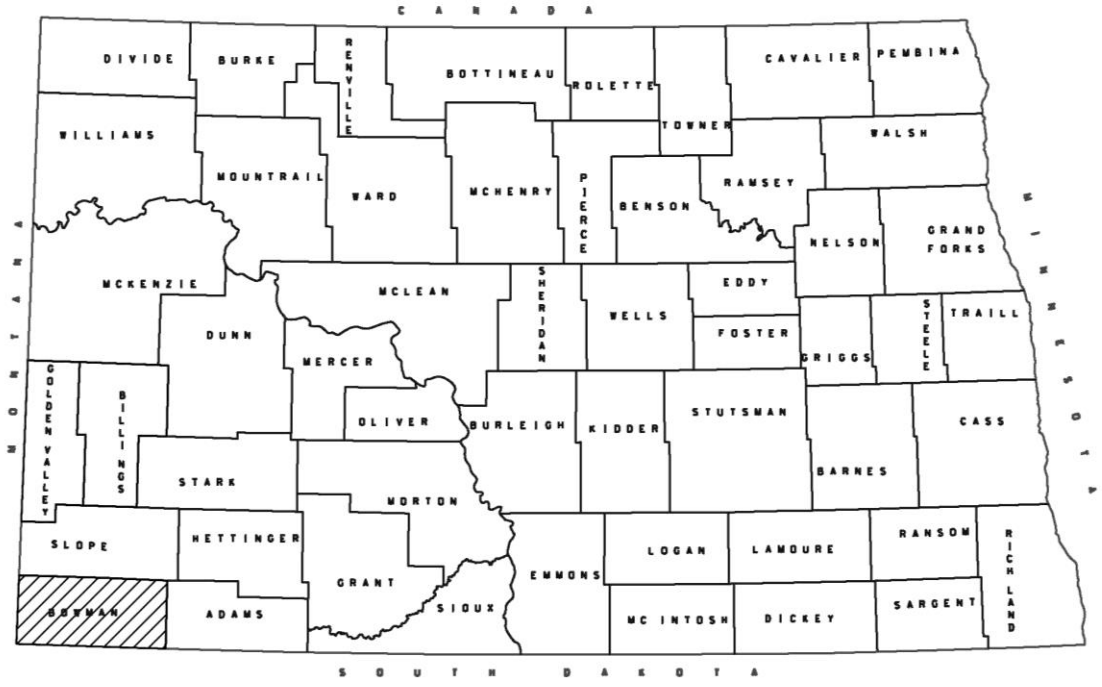
Deep Foundation Report and Analysis

PROJECT NO. SS-5-085(086)012

PCN 23772

COUNTY BOWMAN

Bridge #: 0085-012.746



PREPARED BY: HABTAMU ABERA YESHAW

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION
MATERIALS AND RESEARCH DIVISION

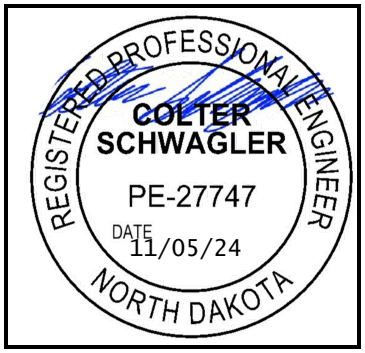
NOVEMBER 2024

SS-5-085(086)012

4 South of JCT US 12
Bridge #: 0085-012.746

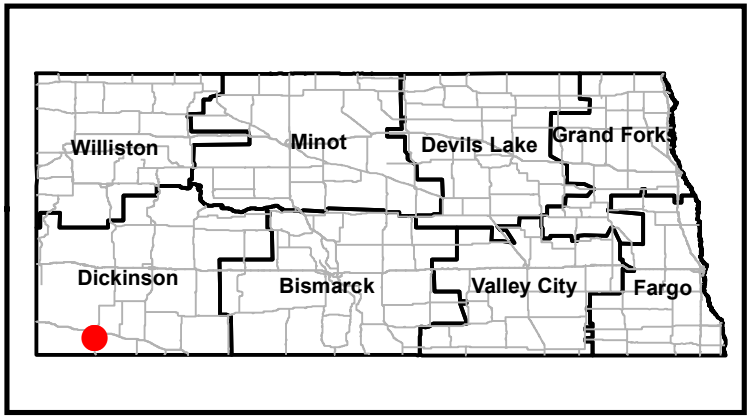
CERTIFICATION

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly registered professional engineer under the laws of the State of North Dakota. This document was originally issued and sealed by Colter Schwagler, Registration number PE-27747 on 11/04/2024 and the original document is stored at the North Dakota Department of Transportation.



4 SOUTH OF JCT US 12 Bridge
Deep Foundation Borings

Project: SS-5-085(086)012
PCN: 23772
Bridge: 0085-012.746
Scope: Structure Replacement
Location: 4 SOUTH OF JCT US 12



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Introduction

The purpose of the project is to address the existing deficiencies of the current structure by removing and replacing the bridge on the same alignment along the Hwy 85 corridor.

This report will provide foundation, settlement, and bridge end slope recommendations for the construction of the new structure.

Existing Structure Information

There is an existing bridge on Hwy 85 that will be removed as part of the project. The information for this structure is below.

Bridge # 0085-012.746
Main Structure Type: 3 Span Prestressed Concrete Beams
Length: 80'
Foundation Type: Untreated Timber Piling
Year Constructed: 1952

Soil Borings

A total of 2 borings were completed near the proposed structure. See the project location map for the boring locations.

Boring #1

Boring #1 has an elevation of approximately 2876 feet at the top of boring and is located near the proposed north abutment. This boring extends to a depth of 136 feet.

Boring #2

Boring #2 has an elevation of approximately 2885 feet at the top of boring and is located near the proposed south abutment. This boring extends to a depth of 136 feet.

Sampling and Testing Procedures

Shelby tube sampling and split spoon sampling were used to extract the samples from a hollow stem auger.

Shelby tube sampling provides an "undisturbed" sample of fine-grained soils for laboratory testing via a thin wall tube that is slowly pushed into the soils to be sampled. Densities were calculated according to the AASHTO test method T-296.

Split spoon samplers are utilized during the advancement of the boring to perform the Standard Penetration Test (SPT). The samples are considered "disturbed", due to the driving nature in which they are obtained. The SPT results in an N-value, or number of

blows required to drive the split spoon sampler 1 foot. This N-value is used to estimate the friction angle of non-cohesive soils and define the consistency of cohesive soils.

For cohesive soils, the shear strength values were determined from the Unconsolidated Undrained and Consolidated Undrained tests utilizing Shelby tubes samples.

The samples from the split spoon and Shelby tubes are submitted to the laboratory for determination of AASHTO classification, moisture content, dry density, sieve analysis, and Atterberg limits.

Test Results

A summary of the lab analysis has been included in Appendix B.

Proposed Structures

Main Structure Type: 2 Span

Foundation Type: Steel H-Piles

Foundation Recommendation

Steel Piling

Pile recommendations are given as termination elevations. The pile sizes that have been analyzed are HP10x42, HP12x53, and HP14x73. See Table 3 below for the recommended termination elevations.

The software APILE was used in conjunction with engineering judgment and past experience in pile driving in these types of soils to estimate the pile lengths. The output from this analysis is available upon request from the NDDOT Geotechnical Section.

Below are simplified soil profiles for each boring that was used to predict the unfactored nominal geotechnical resistance in APILE. A graphical representation of the unfactored nominal geotechnical resistance is also shown below in Figures 1-3. The nominal geotechnical resistance is used to help predict the pile termination elevations which can be found in Table 3 below.

Table 1 - Boring #1 Simplified Soil Profile - North Abutment

Layer	Depth (feet)	Elevation (feet)	Total Stress Strength Parameters	Effective Stress Strength Parameters	Effective Unit Weight (lb/ft^3)
Loose Brn Silty/Clayey Sand	0.0-6.0	2876.0-2870.0	-	ϕ'=31.2°	120
Loose Brn Silty/Clayey Sand	6.0-11.0	2870.0-2865.0	-	ϕ'=31.2°	57.6
Dense Brn/Gry Silty Sand, Some Coal Deposits	11.0-36.0	2865.0-2842.0	-	ϕ'=43.1°	57.6
Very Dense Gry/Dark Gry Sandy Silt	36.0-49.0	2842.0-2827.0	-	ϕ'=45°	57.6
Hard Gry/Dark Gry Silty Fat Clay With Sand	49.0-136.0	2827.0-2740.0	Su=4000 psf	-	57.6

Table 2 - Boring #2 Simplified Soil Profile - South Abutment

Layer	Depth (feet)	Elevation (feet)	Total Stress Strength Parameters (lb/ft^2)	Effective Stress Strength Parameters	Effective Unit Weight (lb/ft^3)
Loose Brn Silty/Clayey Sand	0.0-16.0	2885.0-2869.0	-	ϕ=31.2°	120
Dense Brn/Gry Silty Sand, Some Coal Deposits	16.0-38.0	2869.0-2846.0	-	ϕ'=43.1°	57.6
Very Dense Gry/Dark Gry Sandy Silt	38.0-54.0	2846.0-2831.0	-	ϕ'=45°	57.6
Hard Gry/Dark Gry Silty Fat Clay With Sand	54.0-136.0	2831.0-2749.0	Su=4000 psf	-	57.6

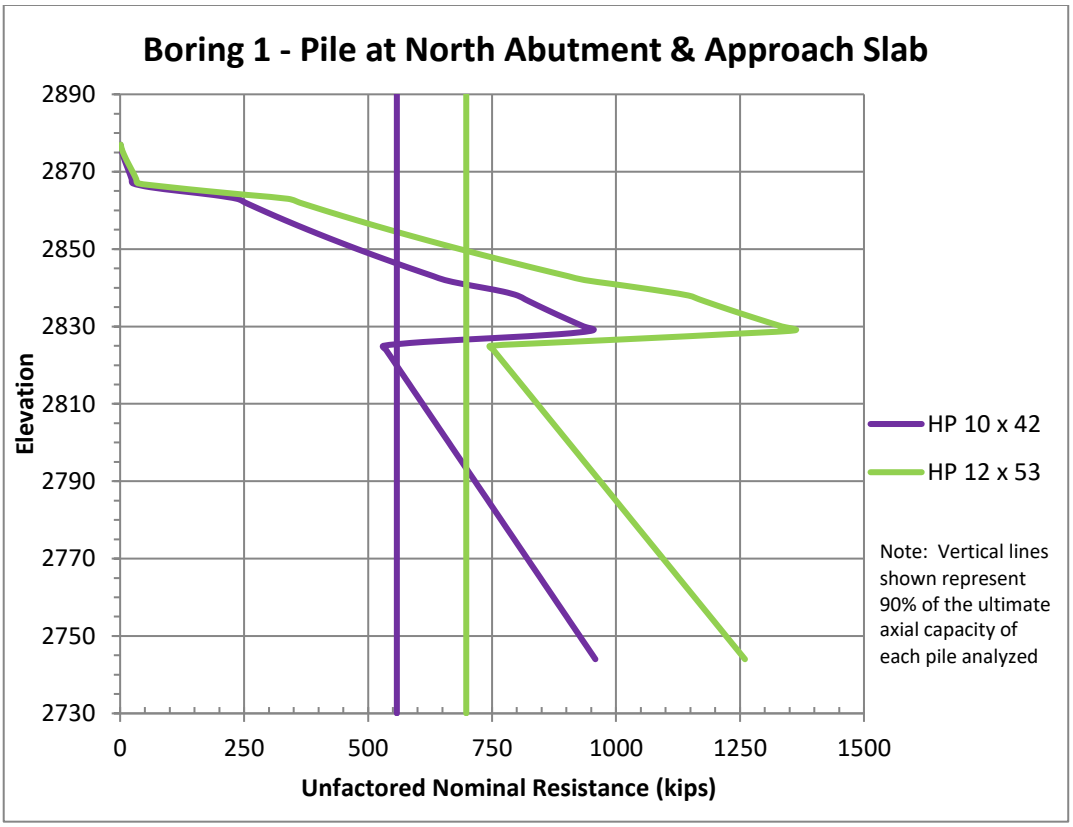


Figure 1: Nominal Resistance for Pile at North Approach Slab & Abutment

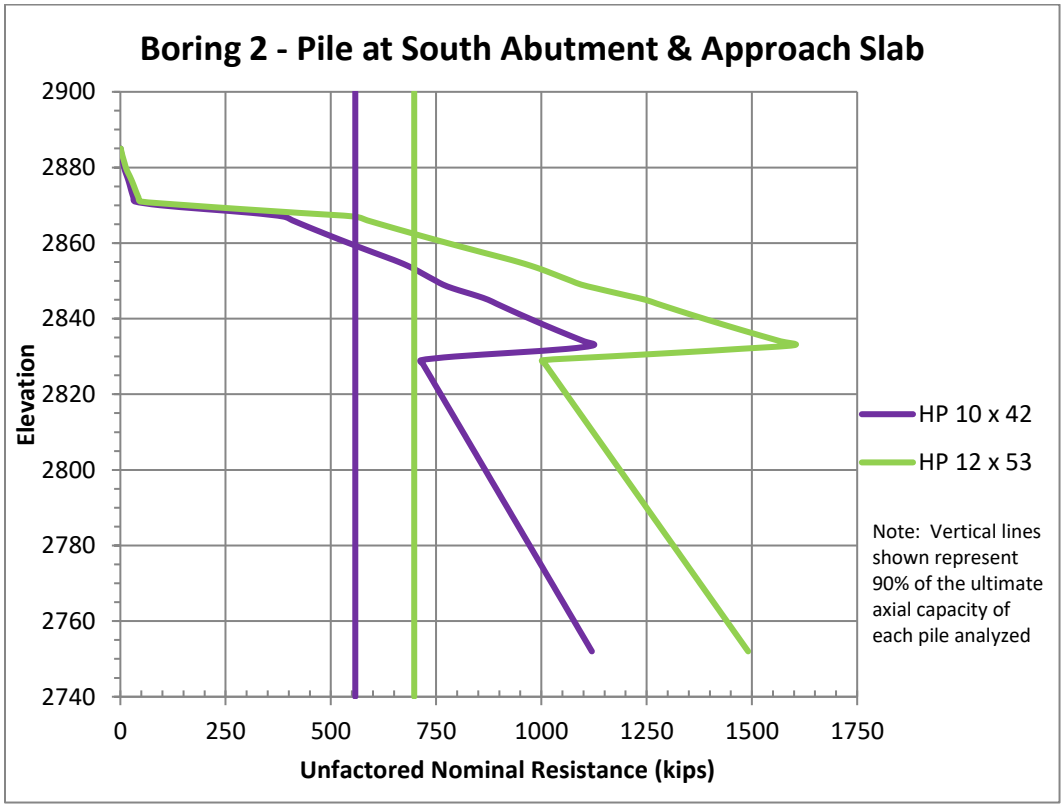


Figure 2: Nominal Resistance for Pile at South Abutment & Approach Slab

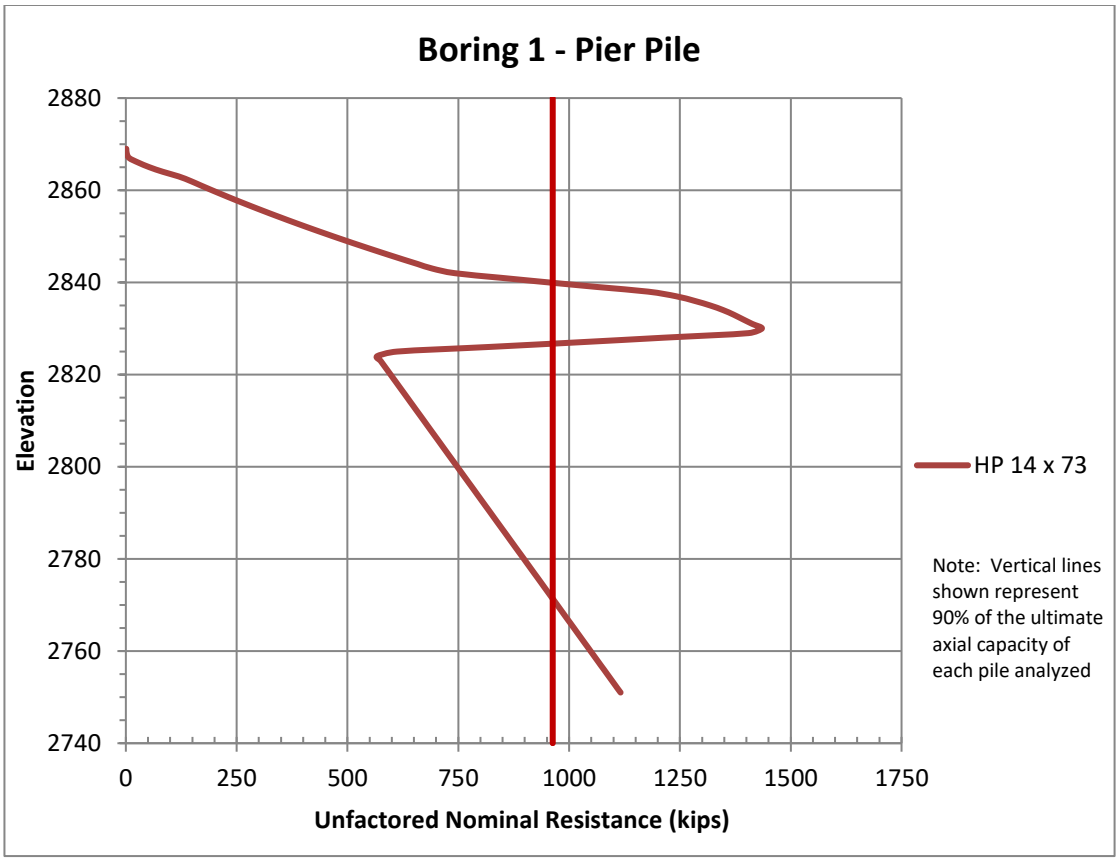


Figure 3: Nominal Resistance for Pier Pile

Based on the APILE information, past experience, and engineering judgment the pile termination elevations were selected as shown in the table below.

Table 3 - Pile Length Information

Pile Type	90% Ultimate Axial Capacity kips	North Approach Slab Termination Elevation	North Abutment Termination Elevation	Pier Termination Elevation	South Abutment Termination Elevation	South Approach Slab Termination Elevation
HP10x42	558	2846	2846	-	2859	2859
HP12x53	698	-	2849	-	2862	-
HP14x73	963	-	-	2839	-	-

Based on the sandy nature of the soil where some of the piles are estimated to reach bearing, the piles may go deeper than necessary. If the pile has not reached bearing 10 feet beyond the estimated depth, stop driving the pile and wait 24 hours to allow pile setup to occur. After 24 hours warm the hammer with a minimum of 20 blows by striking the ground or timber mats. Restrike the pile with 10 blows to determine if bearing has been achieved. If bearing was not achieved during restrike, continue to drive the pile until bearing is achieved.

Pile Tips

It is not anticipated that pile tips will be required for this bridge.

Downdrag

Due to the minimal amount of fill being placed at the structures, downdrag is not applicable.

Scour

The bridge section analyzed the hydraulic scour and estimated the pier scour in ft. Scour was accounted for in the estimation of the depth of the pier piling. A summary of the scour calculations is shown below in the Table 4.

Table 4 - Estimated Scour

Flood Frequency	Discharge (cfs)	Construction Scour (ft)	Pier Scour (ft)	Abutment Scour (ft)	
				Left	Right
50-yr	2366.3	0.0	3.41	0.0	0.0
100-yr	2923.3	0.0	3.59	0.0	0.0
200-yr	3529.0	0.0	3.77	0.0	0.0

Compaction Recommendation

Compact roadway embankment material to at least 90 percent of the maximum dry density with moisture content no less than the optimum moisture and no more than 5.0 percentage points above the optimum moisture. The Engineer will determine the maximum dry density and optimum moisture content as specified in ND T 180.

Compact the aggregate transitions at the bridge ends according to section 714.04 A.10.

Slope Recommendation

A slope stability analysis was conducted with Slope/W developed by Geo-Slope International. The analysis used a two-dimensional limit equilibrium method. Bridge division requested an analysis of 3:1 end slopes for the bridge ends. Slope stability analysis shows that the 3:1 slopes meet the required factor of safety for both North and South End slopes. The stability analysis outputs can be found in Appendix C.

Drainage Recommendation

The drainage of the bridge should be controlled so that water does not drain directly off the bridge ends and cause erosion around the wing wall. A combination of inlets, downdrains, and/or deckdrains should be used to control water runoff. Water should not be allowed to drain off the bridge to allow the in slopes and end slopes to become saturated, which is a common cause of slope failure.

Settlement Analysis/Recommendation

Minimal fill is proposed to be placed with this project; therefore, settlement mitigation is not recommended.

Pre-Boring

Minimal fill is proposed to be placed with this project; therefore, pre-boring is not recommended.

APPENDIX A

Boring Logs

LOG OF BORING SB - 1

NORTH DAKOTA DEPARTMENT OF TRANSPORATION
300 AIRPORT ROAD
BISMARCK, ND 58504

PROJECT NUMBER SS-5-085(086)012 **DATE STARTED** 7/15/24 **COMPLETED** 7/16/24

PCN 23772 **ELEVATION** 2876 ft

LOCATION Bowman County **Northing** 5117411.48 ft **Easting** 159208.16 ft

DRILLED BY Dallan **LOGGED BY** Jamie **DRILLING METHOD**

ENGINEER

NOTES Coordinate System: NAD_1983_UTM_Zone_14N

ELEVATION (ft)	DEPTH (ft)	MATERIAL DESCRIPTION	GRAPHIC LOG	AASHTO	USCS	SAMPLE TYPE & NUMBER	RECOVERY (%)	SPT N VALUE	MC / PL / LL / CLAY FRACTION (%)	TESTS & REMARKS
2870	0	Loose Brn Moist/Wet Silty/Clayey Sand, Water bearing at 6'		A-2-4	SM	3TW 218	90	6	0	
				A-2-4	SM	SS 219	55		0	
	10	2863.0 ft 13.0 ft		A-6	CL	3TW 220	90	12	20 31	γ_d = 93.0 pcf γ = 119.0 pcf phi=27.4, c'=1238 psf
				A-2-4	SM	SS 221	100		0	
2860		Dense Brn/Gry Moist Silty Sand		A-2-4	SP-SM	3TW 222	95		0	
				A-2-4	SM	SS 223	100		100	
	20			A-2-4	SM	SS 234	100	40	0	
2850				A-2-4	SM	SS 235	100	61	0	
	30			A-2-4	SM	SS 236	85	29	0	
		2842.0 ft 34.0 ft								
2840		Very Dense Gry Moist Sandy/Clayey Silt		A-4	ML	SS 237	65		100	
	40			A-4	SM	SS 238	75		100	
2830				A-4	CL-ML	SS 239	100	73	229	
		2827.0 ft 49.0 ft								
	50	Hard Gry/Dark Gry Moist Silty Fat Clay with Sand		A-7-6	CH	SS 240	100	33	25 97	
2820				A-7-6	CL	SS 241	100	33	21 46	
	60			A-7-6	CH	SS 242	100	44	23 51	
2810										
	70			A-4	SM	SS 243	100	62	233	
2800										
	80			A-7-6	CH	SS 244	100	36	19 61	
2790										
	90			A-7-6	CH	SS 245	100	35	19 71	
2780										
	100			A-7-6	CH	SS 246	100	37	23 92	
2770										
	110			A-7-6	CH	SS 247	100	45	18 71	
2760										
	120			A-7-6	CH	SS 248	100	42	22 64	
2750										
	130	2740.0 ft 136.0 ft		A-7-6	CH	SS 249	100	47	17 67	
2740										

Bottom of borehole at 136.0 ft

NORTH DAKOTA DEPARTMENT OF TRANSPORATION
300 AIRPORT ROAD
BISMARCK, ND 58504

LOG OF BORING SB - 2

PROJECT NUMBER SS-5-085(086)012 **DATE STARTED** 7/16/24 **COMPLETED** 7/18/24

PCN 23772 **ELEVATION** 2885 ft

LOCATION Bowman County **Northing** 5117370.58 ft **Easting** 159236.63 ft

DRILLED BY Dallan **LOGGED BY** Jamie **DRILLING METHOD**

ENGINEER

NOTES Coordinate System: NAD_1983_UTM_Zone_14N

ELEVATION (ft)	DEPTH (ft)	MATERIAL DESCRIPTION	AASHTO	USCS	SAMPLE TYPE & NUMBER	RECOVERY (%)	SPT N VALUE	MC / PL / LL / CLAY FRACTION (%)	TESTS & REMARKS
2885	0	Loose Brn Moist Silty/Clayey Sand	A-2-4	SC-SM	SS 250	50	9	17 29	
			A-6	SC	SS 251	70		0	
2880			A-2-4	SM	3TW 252	60	8	17 31	
			A-6	SC	SS 253	55		0	
	10		A-2-4	SM	3TW 254	70	11	18 42	
			A-7-6	SC	SS 255	60		20 37	
2870		2869.0 ft 16.0 ft	A-6	SC	3TW 256	85	37	0	
		Dense Gry Wet Silty Sand, Heavy Coal Deposit from 29' to 34'. Water bearing at 16'.	A-2-4	SM	SS 257	95	36	0	
	20		A-2-4	SM	SS 258	100			
2860					SS 259		41	0	
			A-2-4	SM	SS 260	100	42	0	
	30		A-2-4	SM	SS 261	90	40	0	
2850		2846.0 ft 39.0 ft							
	40	Very Dense Gry/Dark Gry Moist Silt with Sand	A-4	ML	SS 262	80	57	230	
			A-4	ML	SS 263	85	55	0	
2840									
	50								
		2831.0 ft 54.0 ft							
2830		Hard Gry/Dark Gry Moist Silty Fat Clay With Sand	A-7-6	CH	SS 264	100	27	27 71	
	60		A-7-6	CH	SS 265	100	37	22 52	
2820									
	70		A-7-6	CH	SS 266	100	39	21 56	
2810									
	80		A-7-6	CH	SS 267	100	41	22 54	
2800									
	90		A-7-6	CH	SS 270	100	34	22 50	
2790									
	100		A-7-6	CH	SS 271	100	39	19 69	
2780									
	110		A-7-6	CH	SS 272	100	30	24 52	
2770									
	120		A-7-6	CH				21 69	
2760									
	130								
2750		2749.0 ft 136.0 ft	A-7-6	CH	SS 274	100	38	19 61	

Bottom of borehole at 136.0 ft

NDDOT LOG LAT/LONG - 20171219.GDT - 10/25/24 09:38 - F:\LAB\PROJECTS\GINT\5-085(086)012.GPJ

APPENDIX B

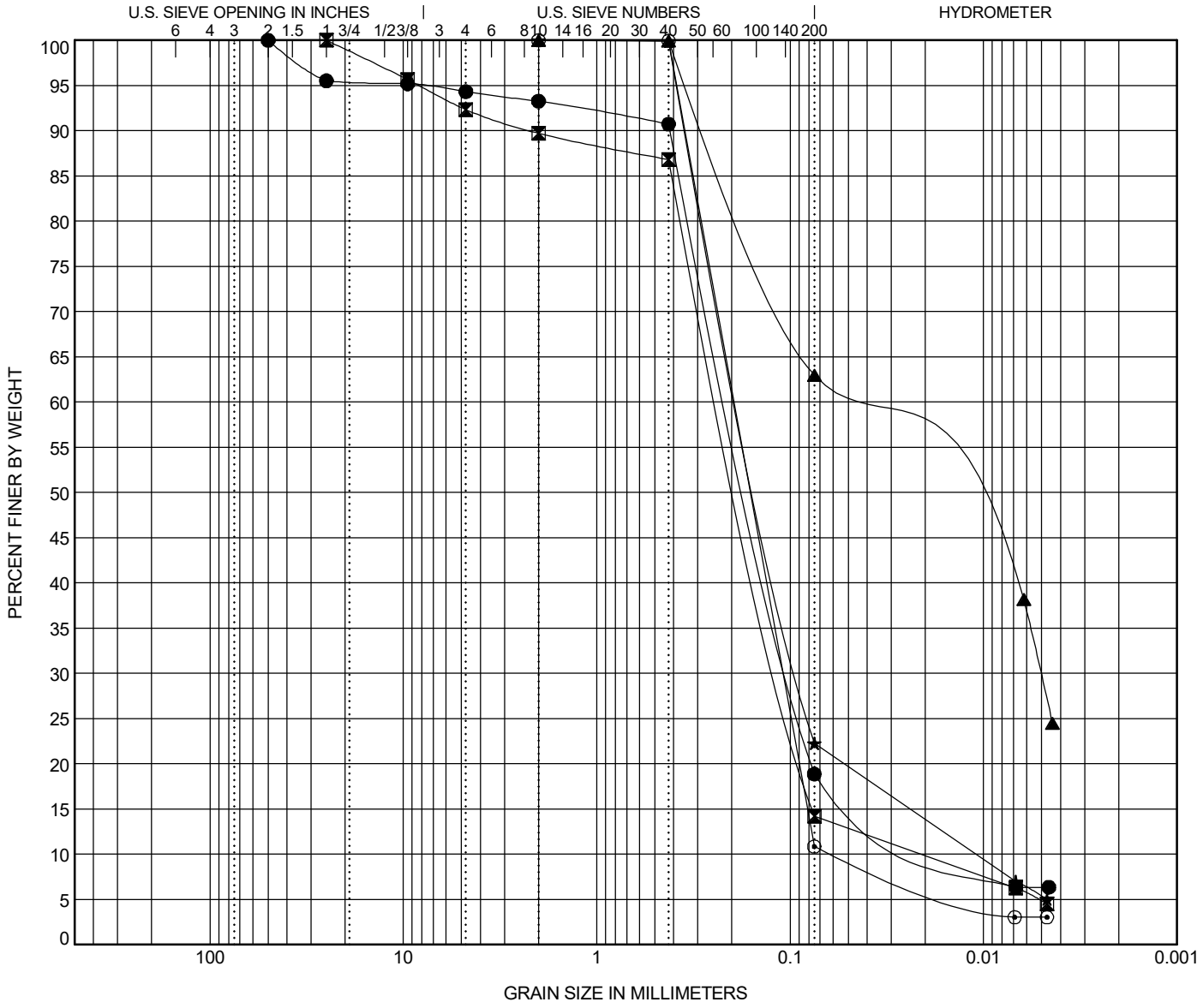
Lab Results

GRAIN SIZE DISTRIBUTION

NORTH DAKOTA DEPARTMENT OF TRANSPORATION
300 AIRPORT ROAD
BISMARCK, ND 58504

PROJECT NUMBER SS-5-085(086)012 **LOCATION** Bowman County

PCN 23772



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BOREHOLE	DEPTH	AASHTO Classification	USCS Classification	LL	PL	PI	Cc	Cu
● SB - 1	4.0	A-2-4 (0)	SM	NP	NP	NP	3.48	14.80
⊠ SB - 1	6.0	A-2-4 (0)	SM	NP	NP	NP	2.54	10.64
▲ SB - 1	9.0	A-6 (5)	CL	31	20	11		
★ SB - 1	11.0	A-2-4 (0)	SM	NP	NP	NP	4.18	15.96
⊙ SB - 1	14.0	A-2-4 (0)	SP-SM	NP	NP	NP	1.05	3.38

BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● SB - 1	4.0	50	0.202	0.098	0.014	5.7	75.5	18.9	
⊠ SB - 1	6.0	25	0.224	0.109	0.021	7.6	78.2	14.2	
▲ SB - 1	9.0	2	0.056	0.005		0.0	37.0	63.0	
★ SB - 1	11.0	2	0.174	0.089	0.011	0.0	77.7	22.3	
⊙ SB - 1	14.0	2	0.195	0.109	0.058	0.0	89.1	10.9	

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GRAIN SIZE DISTRIBUTION

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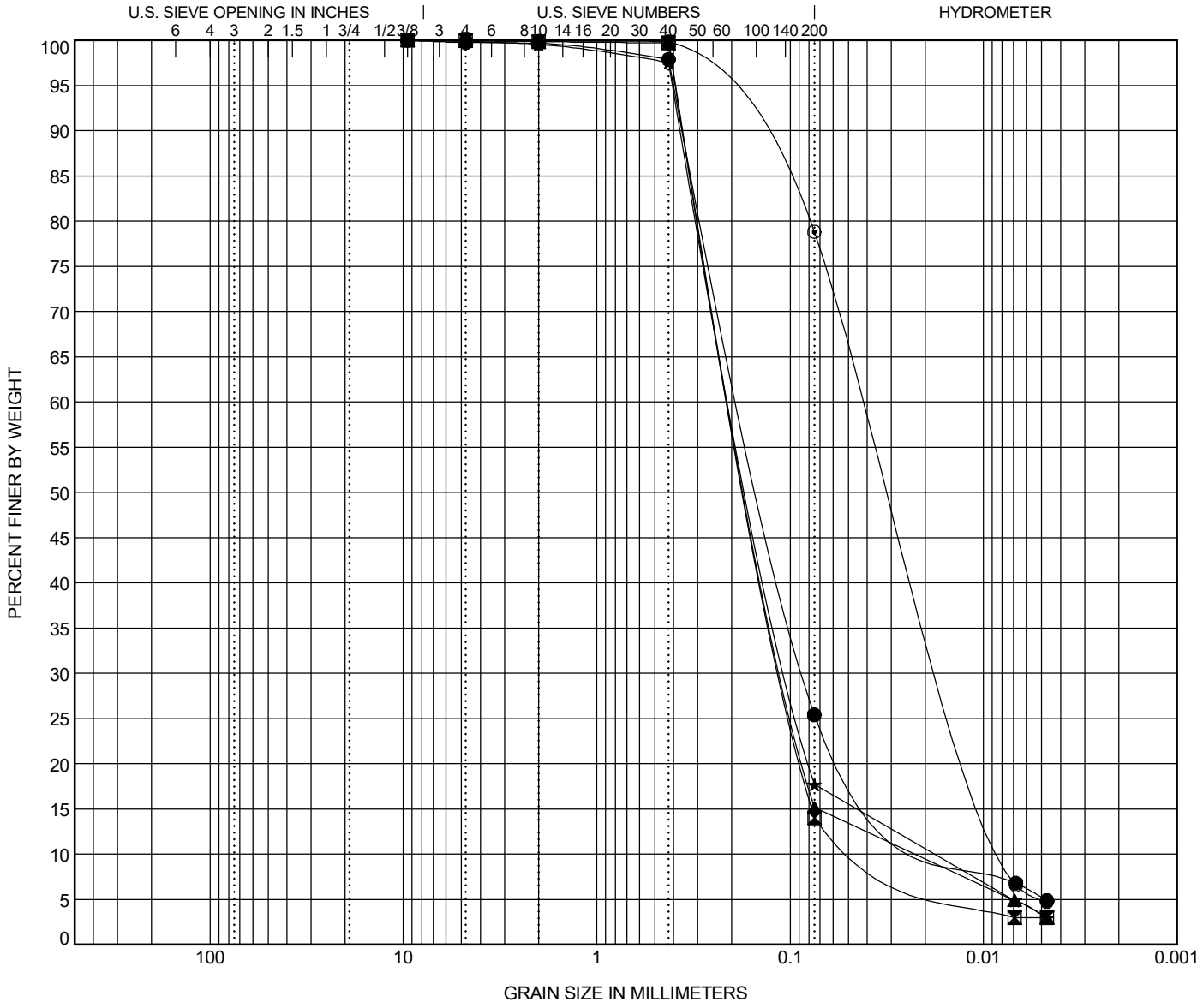

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BOREHOLE	DEPTH	AASHTO Classification	USCS Classification	LL	PL	PI	Cc	Cu
● SB - 1	16.0	A-2-4 (0)	SM	NP	NP	NP	3.98	16.72
⊠ SB - 1	19.0	A-2-4 (0)	SM	NP	NP	NP	1.80	6.06
▲ SB - 1	24.0	A-2-4 (0)	SM	NP	NP	NP	2.43	8.30
★ SB - 1	29.0	A-2-4 (0)	SM	NP	NP	NP	2.85	10.51
⊙ SB - 1	34.0	A-4 (0)	ML	NP	NP	NP	0.72	5.27

BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● SB - 1	16.0	9.5	0.172	0.084	0.01	0.2	74.4	25.4	
⊠ SB - 1	19.0	9.5	0.19	0.104	0.031	0.0	86.0	14.0	
▲ SB - 1	24.0	2	0.188	0.102	0.023	0.0	84.8	15.2	
★ SB - 1	29.0	9.5	0.188	0.098	0.018	0.1	82.2	17.7	
⊙ SB - 1	34.0	9.5	0.04	0.015	0.008	0.1	21.1	78.8	

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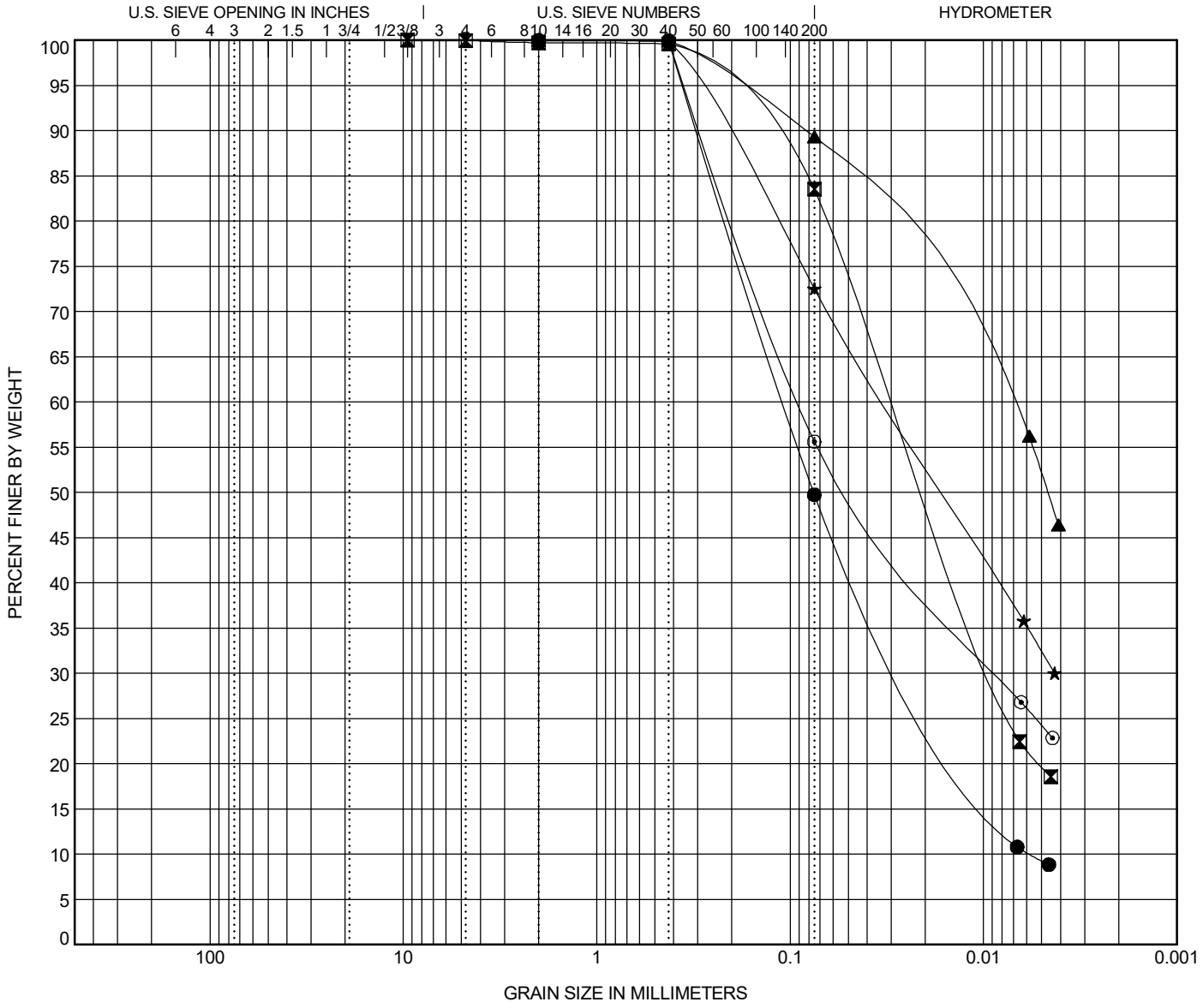

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BOREHOLE	DEPTH	AASHTO Classification	USCS Classification	LL	PL	PI	Cc	Cu
● SB - 1	39.0	A-4 (0)	SM	NP	NP	NP	0.79	18.63
⊠ SB - 1	44.0	A-4 (5)	CL-ML	29	22	7		
▲ SB - 1	49.0	A-7-6 (72)	CH	97	25	72		
★ SB - 1	54.0	A-7-6 (17)	CL	46	21	25		
⊙ SB - 1	64.0	A-7-6 (13)	CH	51	23	28		

BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● SB - 1	39.0	2	0.107	0.022	0.006	0.0	50.2	49.8	
⊠ SB - 1	44.0	9.5	0.029	0.009		0.0	16.5	83.5	
▲ SB - 1	49.0	2	0.008			0.0	10.7	89.3	
★ SB - 1	54.0	2	0.032			0.0	27.5	72.5	
⊙ SB - 1	64.0	2	0.089	0.008		0.0	44.4	55.6	

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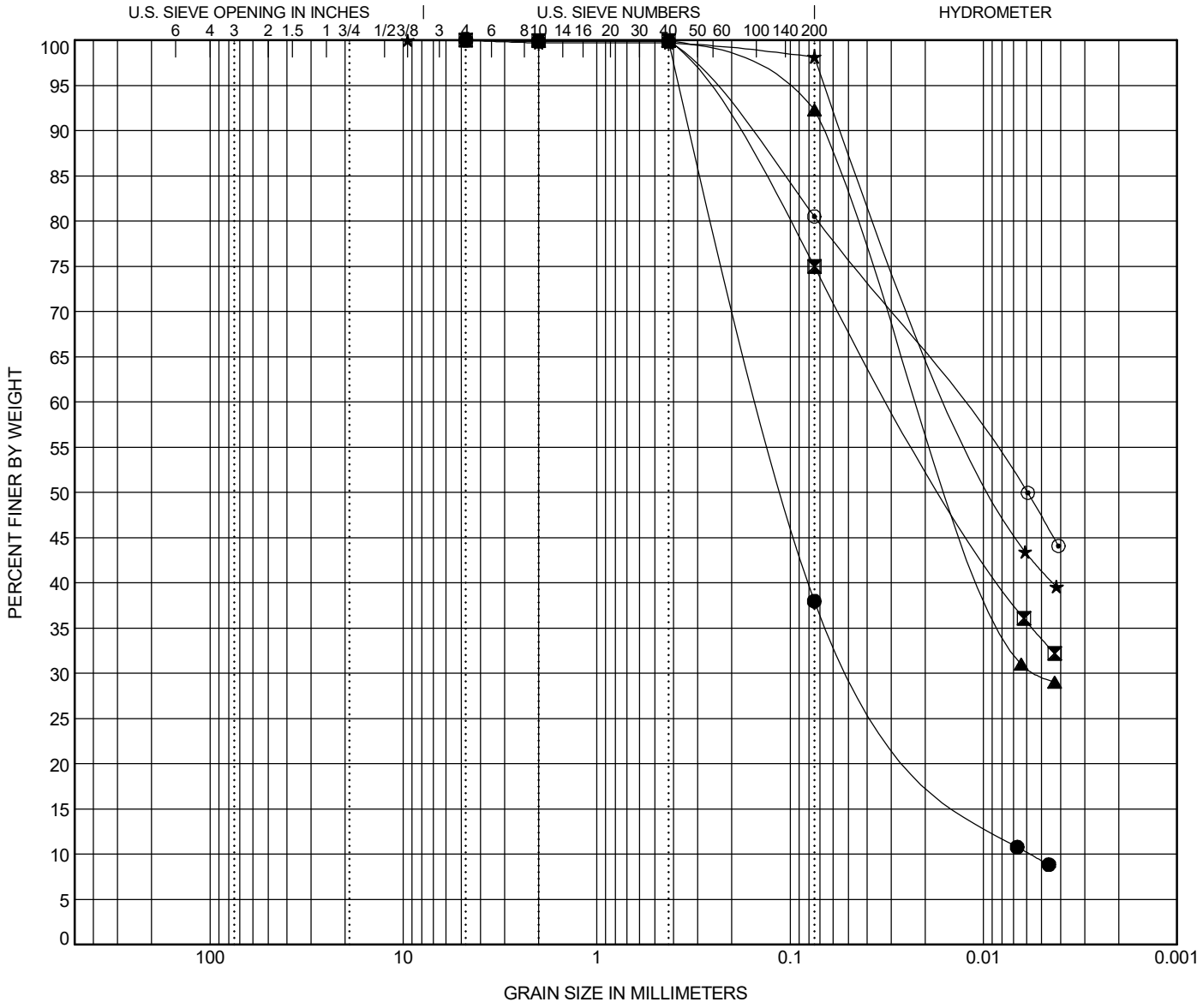

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BOREHOLE	DEPTH	AASHTO Classification	USCS Classification	LL	PL	PI	Cc	Cu
● SB - 1	74.0	A-4 (0)	SM	33	28	5	1.70	24.18
⊠ SB - 1	84.0	A-7-6 (31)	CH	61	19	42		
▲ SB - 1	94.0	A-7-6 (53)	CH	71	19	52		
★ SB - 1	104.0	A-7-6 (78)	CH	92	23	69		
⊙ SB - 1	114.0	A-7-6 (45)	CH	71	18	53		

BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● SB - 1	74.0	4.75	0.139	0.037	0.006	0.0	62.0	38.0	
⊠ SB - 1	84.0	4.75	0.029			0.0	25.0	75.0	
▲ SB - 1	94.0	2	0.02	0.005		0.0	7.7	92.3	
★ SB - 1	104.0	9.5	0.013			0.0	1.8	98.2	
⊙ SB - 1	114.0	4.75	0.014			0.0	19.5	80.5	

GRAIN SIZE DISTRIBUTION

NDDOT North Dakota Department of Transportation
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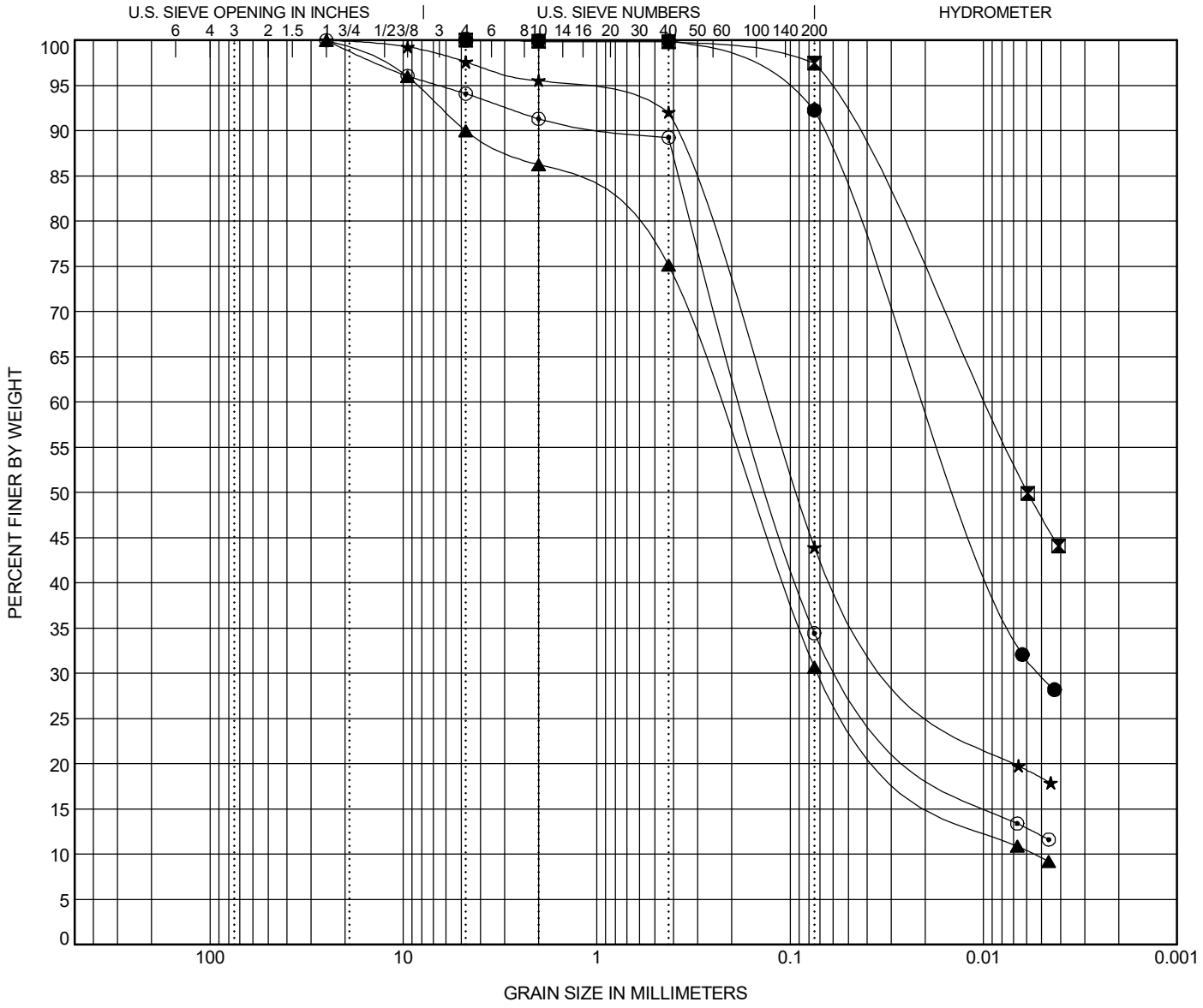


COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BOREHOLE	DEPTH	AASHTO Classification	USCS Classification	LL	PL	PI	Cc	Cu
● SB - 1	124.0	A-7-6 (43)	CH	64	22	42		
⊠ SB - 1	134.0	A-7-6 (54)	CH	67	17	50		
▲ SB - 2	0.0	A-2-4 (0)	SC-SM	25	20	5	3.70	42.98
★ SB - 2	2.0	A-6 (2)	SC	29	17	12		
⊙ SB - 2	4.0	A-2-4 (0)	SM	NP	NP	NP		

BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● SB - 1	124.0	4.75	0.02	0.005		0.0	7.7	92.3	
⊠ SB - 1	134.0	4.75	0.01			0.0	2.5	97.5	
▲ SB - 2	0.0	25	0.235	0.069	0.005	10.0	59.3	30.7	
★ SB - 2	2.0	25	0.134	0.018		2.4	53.7	43.9	
⊙ SB - 2	4.0	25	0.168	0.045		5.9	59.7	34.4	

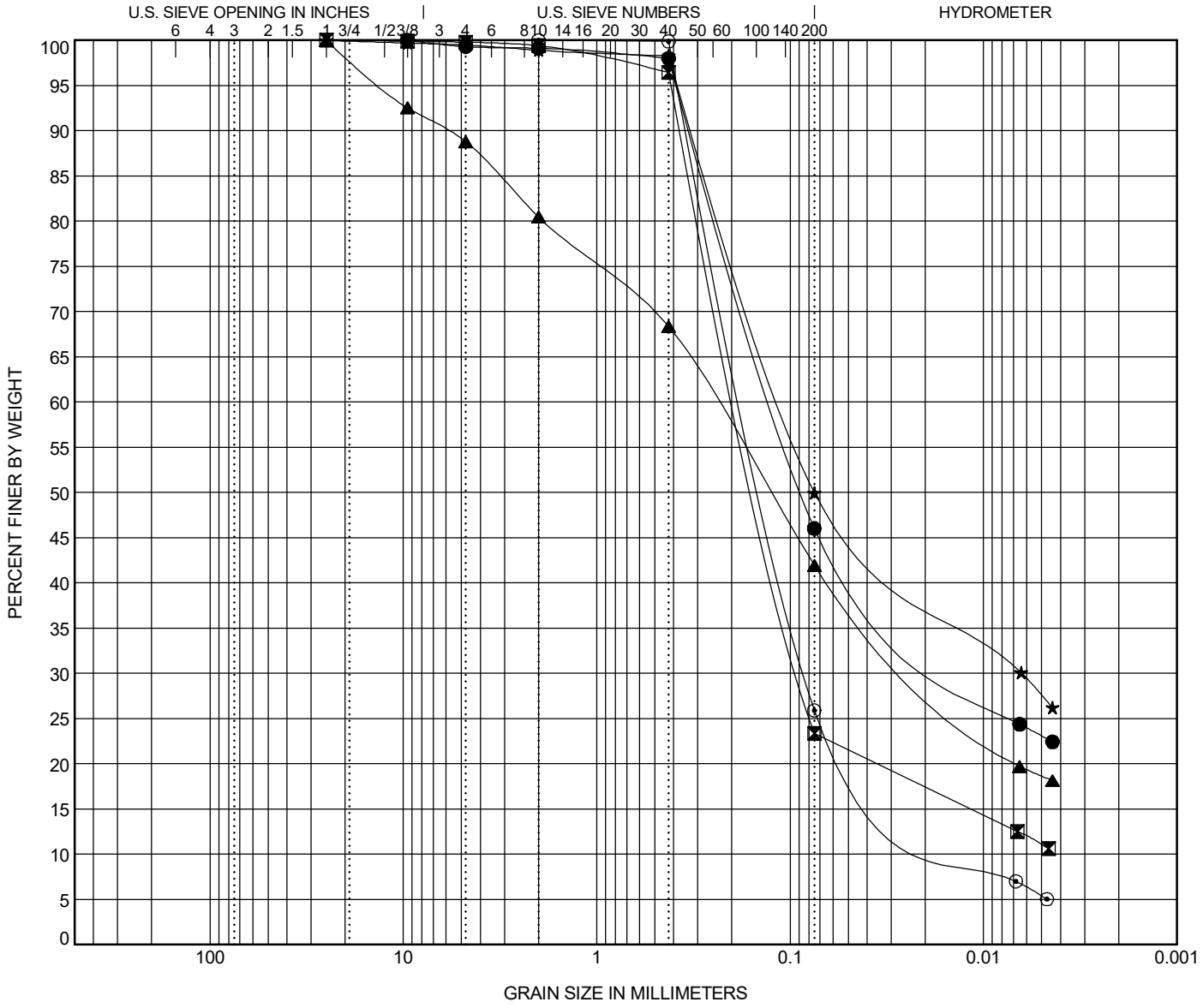
GRAIN SIZE - 20171219.GDT - 10/16/24 11:11 - F:\LAB\PROJECTS\GINT\5-085(086)012.GPJ

GRAIN SIZE DISTRIBUTION

NORTH DAKOTA DEPARTMENT OF TRANSPORATION
300 AIRPORT ROAD
BISMARCK, ND 58504

PROJECT NUMBER SS-5-085(086)012 **LOCATION** Bowman County

PCN 23772



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BOREHOLE	DEPTH	AASHTO Classification	USCS Classification	LL	PL	PI	Cc	Cu
●	SB - 2	6.0	A-6 (3)	SC	31	17	14		
⊠	SB - 2	9.0	A-2-4 (0)	SM	NP	NP	NP		
▲	SB - 2	11.0	A-7-6 (5)	SC	42	18	24		
★	SB - 2	14.0	A-6 (5)	SC	37	20	17		
⊙	SB - 2	16.0	A-2-4 (0)	SM	NP	NP	NP	4.11	16.78

	BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	SB - 2	6.0	9.5	0.12	0.012		0.7	53.3	46.0	
⊠	SB - 2	9.0	25	0.179	0.088		0.2	76.4	23.4	
▲	SB - 2	11.0	25	0.245	0.02		11.2	46.9	42.0	
★	SB - 2	14.0	25	0.108	0.006		0.5	49.5	50.0	
⊙	SB - 2	16.0	2	0.167	0.083	0.01	0.0	74.1	25.9	

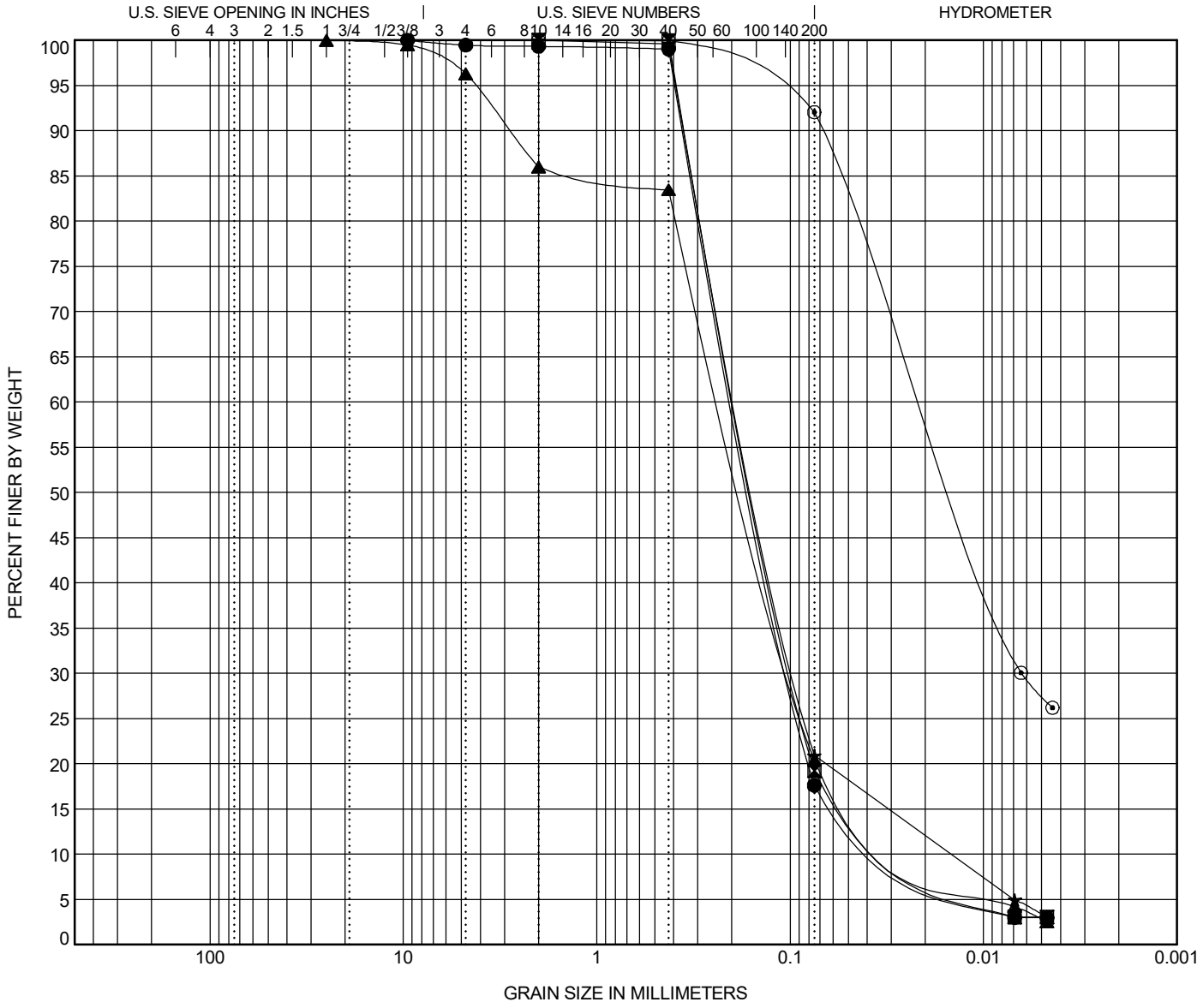
GRAIN SIZE - 20171219.GDT - 10/16/24 11:11 - F:\LAB\PROJECTS\GINT\5-085(086)012.GPJ

GRAIN SIZE DISTRIBUTION

NORTH DAKOTA DEPARTMENT OF TRANSPORATION
300 AIRPORT ROAD
BISMARCK, ND 58504

PROJECT NUMBER SS-5-085(086)012 **LOCATION** Bowman County

PCN 23772



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BOREHOLE	DEPTH	AASHTO Classification	USCS Classification	LL	PL	PI	Cc	Cu
● SB - 2	19.0	A-2-4 (0)	SM	NP	NP	NP	2.38	8.55
⊠ SB - 2	24.0	A-2-4 (0)	SM	NP	NP	NP	2.58	9.37
▲ SB - 2	29.0	A-2-4 (0)	SM	NP	NP	NP	2.64	13.77
★ SB - 2	34.0	A-2-4 (0)	SM	NP	NP	NP	3.23	12.11
⊙ SB - 2	39.0	A-4 (5)	ML	30	24	6		

BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● SB - 2	19.0	9.5	0.185	0.098	0.022	0.5	81.9	17.6	
⊠ SB - 2	24.0	2	0.18	0.095	0.019	0.0	80.8	19.2	
▲ SB - 2	29.0	25	0.223	0.098	0.016	3.7	75.9	20.4	
★ SB - 2	34.0	2	0.177	0.092	0.015	0.0	79.1	20.9	
⊙ SB - 2	39.0	2	0.021	0.006		0.0	7.9	92.1	

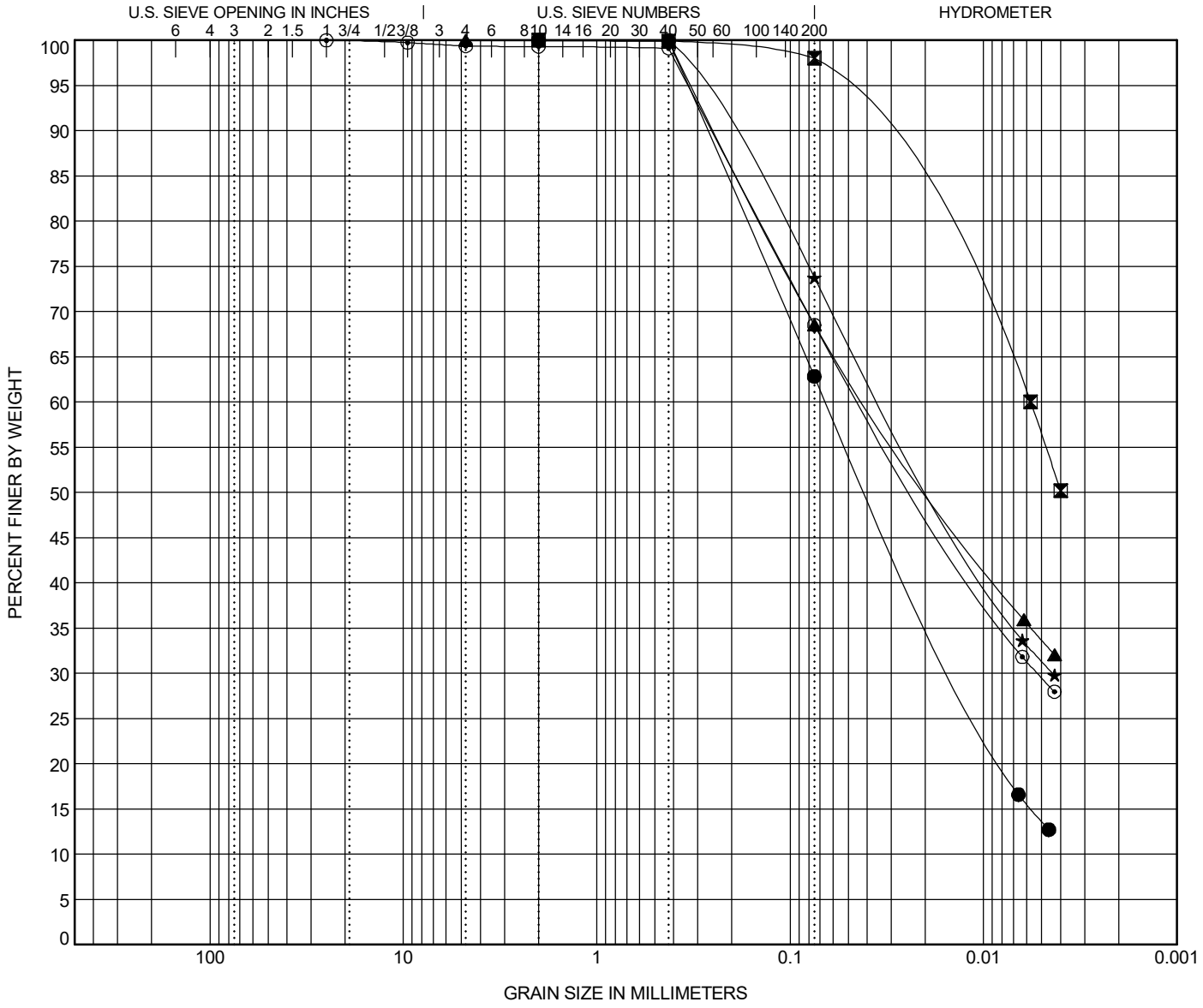
GRAIN SIZE - 20171219.GDT - 10/16/24 11:11 - F:\LAB\PROJECTS\GINT\5-085(086)012.GPJ

GRAIN SIZE DISTRIBUTION

NORTH DAKOTA DEPARTMENT OF TRANSPORATION
300 AIRPORT ROAD
BISMARCK, ND 58504

PROJECT NUMBER SS-5-085(086)012 **LOCATION** Bowman County

PCN 23772



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BOREHOLE	DEPTH	AASHTO Classification	USCS Classification	LL	PL	PI	Cc	Cu
● SB - 2	44.0	A-4 (0)	ML	NP	NP	NP		
⊠ SB - 2	54.0	A-7-6 (51)	CH	71	27	44		
▲ SB - 2	64.0	A-7-6 (20)	CH	52	22	30		
★ SB - 2	74.0	A-7-6 (26)	CH	56	21	35		
⊙ SB - 2	84.0	A-7-6 (21)	CH	54	22	32		

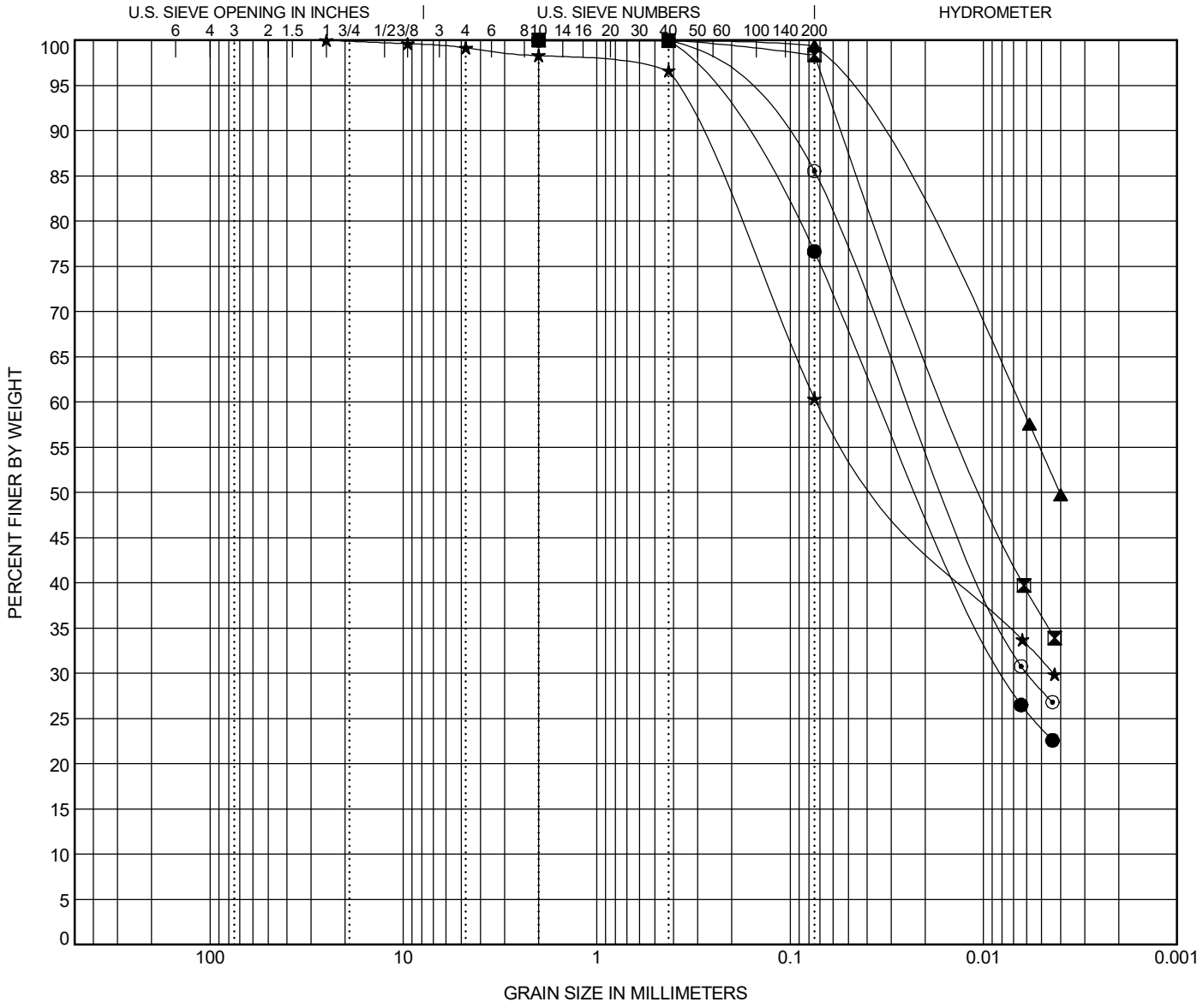
BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● SB - 2	44.0	2	0.065	0.013		0.0	37.2	62.8	
⊠ SB - 2	54.0	2	0.006			0.0	2.0	98.0	
▲ SB - 2	64.0	4.75	0.039			0.0	31.5	68.5	
★ SB - 2	74.0	2	0.032	0.004		0.0	26.2	73.8	
⊙ SB - 2	84.0	25	0.042	0.005		0.6	30.8	68.5	

GRAIN SIZE DISTRIBUTION

NORTH DAKOTA DEPARTMENT OF TRANSPORATION
300 AIRPORT ROAD
BISMARCK, ND 58504

PROJECT NUMBER SS-5-085(086)012 **LOCATION** Bowman County

PCN 23772



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BOREHOLE	DEPTH	AASHTO Classification	USCS Classification	LL	PL	PI	Cc	Cu
● SB - 2	94.0	A-7-6 (22)	CH	50	22	28		
⊠ SB - 2	104.0	A-7-6 (55)	CH	69	19	50		
▲ SB - 2	114.0	A-7-6 (32)	CH	52	24	28		
★ SB - 2	124.0	A-7-6 (26)	CH	69	21	48		
⊙ SB - 2	134.0	A-7-6 (38)	CH	61	19	42		

BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● SB - 2	94.0	2	0.033	0.008		0.0	23.3	76.7	
⊠ SB - 2	104.0	2	0.015			0.0	1.6	98.4	
▲ SB - 2	114.0	2	0.007			0.0	0.6	99.4	
★ SB - 2	124.0	25	0.072	0.004		0.8	38.8	60.4	
⊙ SB - 2	134.0	2	0.024	0.006		0.0	14.5	85.5	

SUMMARY OF LABORATORY RESULTS

NORTH DAKOTA DEPARTMENT OF TRANSPORATION
300 AIRPORT ROAD
BISMARCK, ND 58504

PROJECT NUMBER SS-5-085(086)012 **LOCATION** Bowman County

PCN 23772

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Size (mm)	%<#200 Sieve	AASHTO Classification	USCS Class-ification	Water Content (%)	Avg. Water Content (%)	Dry Density (pcf)	Satur-ation (%)	Void Ratio
SB - 1	4.0	NP	NP	NP	50	19	A-2-4 (0)	SM	25.5	25.5			
SB - 1	6.0	NP	NP	NP	25	14	A-2-4 (0)	SM	24.2	24.2			
SB - 1	9.0	31	20	11	2	63	A-6 (5)	CL	28.0	28.0	93.0		
SB - 1	11.0	NP	NP	NP	2	22	A-2-4 (0)	SM	28.0	28.0			
SB - 1	14.0	NP	NP	NP	2	11	A-2-4 (0)	SP-SM	27.1	27.1			
SB - 1	16.0	NP	NP	NP	9.5	25	A-2-4 (0)	SM	29.5	29.5			
SB - 1	19.0	NP	NP	NP	9.5	14	A-2-4 (0)	SM	26.3	26.3			
SB - 1	24.0	NP	NP	NP	2	15	A-2-4 (0)	SM	24.3	24.3			
SB - 1	29.0	NP	NP	NP	9.5	18	A-2-4 (0)	SM	25.9	25.9			
SB - 1	34.0	NP	NP	NP	9.5	79	A-4 (0)	ML	25.8	25.8			
SB - 1	39.0	NP	NP	NP	2	50	A-4 (0)	SM	27.1	27.1			
SB - 1	44.0	29	22	7	9.5	84	A-4 (5)	CL-ML	24.8	24.8			
SB - 1	49.0	97	25	72	2	89	A-7-6 (72)	CH	32.5	32.5			
SB - 1	54.0	46	21	25	2	73	A-7-6 (17)	CL	34.1	34.1			
SB - 1	64.0	51	23	28	2	56	A-7-6 (13)	CH	28.2	28.2			
SB - 1	74.0	33	28	5	4.75	38	A-4 (0)	SM	28.9	28.9			
SB - 1	84.0	61	19	42	4.75	75	A-7-6 (31)	CH	34.8	34.8			
SB - 1	94.0	71	19	52	2	92	A-7-6 (53)	CH	23.4	23.4			
SB - 1	104.0	92	23	69	9.5	98	A-7-6 (78)	CH	25.7	25.7			
SB - 1	114.0	71	18	53	4.75	81	A-7-6 (45)	CH	24.5	24.5			
SB - 1	124.0	64	22	42	4.75	92	A-7-6 (43)	CH	24.4	24.4			
SB - 1	134.0	67	17	50	4.75	97	A-7-6 (54)	CH	22.9	22.9			
SB - 2	0.0	25	20	5	25	31	A-2-4 (0)	SC-SM	13.8	13.8			
SB - 2	2.0	29	17	12	25	44	A-6 (2)	SC	12.0	12.0			
SB - 2	4.0	NP	NP	NP	25	34	A-2-4 (0)	SM	15.2	15.2			
SB - 2	6.0	31	17	14	9.5	46	A-6 (3)	SC	17.3	17.3			
SB - 2	9.0	NP	NP	NP	25	23	A-2-4 (0)	SM	11.9	11.9			
SB - 2	11.0	42	18	24	25	42	A-7-6 (5)	SC	13.8	13.8			
SB - 2	14.0	37	20	17	25	50	A-6 (5)	SC	28.4	28.4			
SB - 2	16.0	NP	NP	NP	2	26	A-2-4 (0)	SM	27.9	27.9			
SB - 2	19.0	NP	NP	NP	9.5	18	A-2-4 (0)	SM	25.7	25.7			
SB - 2	24.0	NP	NP	NP	2	19	A-2-4 (0)	SM	24.4	24.4			
SB - 2	29.0	NP	NP	NP	25	20	A-2-4 (0)	SM	25.6	25.6			
SB - 2	34.0	NP	NP	NP	2	21	A-2-4 (0)	SM	23.5	23.5			
SB - 2	39.0	30	24	6	2	92	A-4 (5)	ML	25.2	25.2			
SB - 2	44.0	NP	NP	NP	2	63	A-4 (0)	ML	23.7	23.7			
SB - 2	54.0	71	27	44	2	98	A-7-6 (51)	CH	32.7	32.7			
SB - 2	64.0	52	22	30	4.75	69	A-7-6 (20)	CH	30.3	30.3			
SB - 2	74.0	56	21	35	2	74	A-7-6 (26)	CH	23.9	23.9			
SB - 2	84.0	54	22	32	25	69	A-7-6 (21)	CH	27.5	27.5			
SB - 2	94.0	50	22	28	2	77	A-7-6 (22)	CH	30.7	30.7			
SB - 2	104.0	69	19	50	2	98	A-7-6 (55)	CH	23.9	23.9			
SB - 2	114.0	52	24	28	2	99	A-7-6 (32)	CH	26.1	26.1			

SUMMARY OF LABORATORY RESULTS

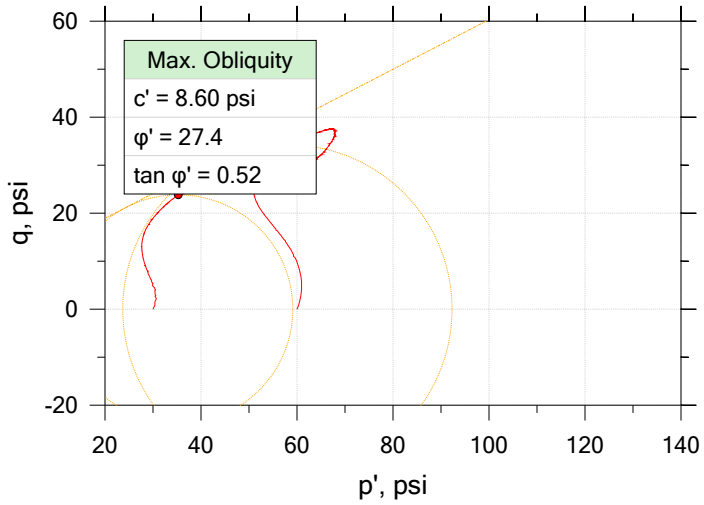
NORTH DAKOTA DEPARTMENT OF TRANSPORATION
300 AIRPORT ROAD
BISMARCK, ND 58504

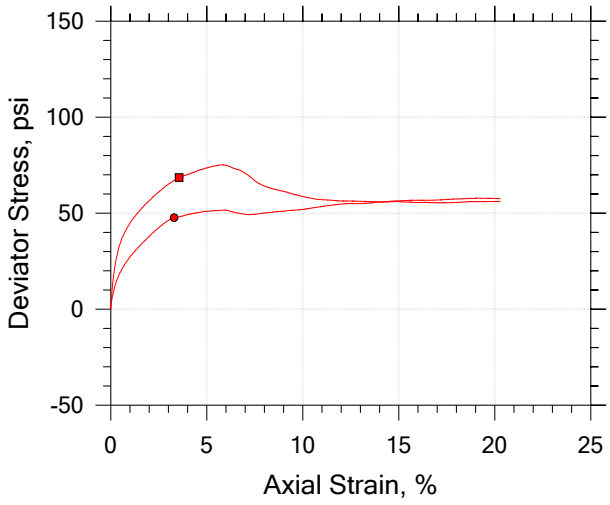
PROJECT NUMBER SS-5-085(086)012 **LOCATION** Bowman County

PCN 23772

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Size (mm)	%<#200 Sieve	AASHTO Classification	USCS Class-ification	Water Content (%)	Avg. Water Content (%)	Dry Density (pcf)	Satur-ation (%)	Void Ratio
SB - 2	124.0	69	21	48	25	60	A-7-6 (26)	CH	22.7	22.7			
SB - 2	134.0	61	19	42	2	86	A-7-6 (38)	CH	23.4	23.4			

Consolidated Undrained by AASHTO T297





Symbol		■	●		
Sample ID		SS -220 -24	SS -220 -24		
Depth		9.0 - 11.0	9.0 - 11.0		
Test Number		CU -21- 24	CU -22- 24		
Initial	Height, in	5.727	5.745		
	Diameter, in	2.851	2.852		
	Moisture Content (from Cuttings), %	28.0	28.6		
	Dry Density, pcf	93.6	92.4		
	Saturation (Wet Method), %	96.5	95.8		
	Void Ratio	0.768	0.791		
Final	Moisture Content, %	26.6	27.0		
	Dry Density, pcf	97.0	96.4		
	Cross-Sectional Area (Method A), in²	6.249	6.209		
	Saturation, %	100.0	100.0		
	Void Ratio	0.705	0.716		
	Back Pressure, psi	35.99	34.00		
Vertical Effective Consolidation Stress, psi		59.88	29.91		
Horizontal Effective Consolidation Stress, psi		60.00	29.99		
Vertical Strain after Consolidation, %		1.833	1.277		
Volumetric Strain after Consolidation, %		4.578	3.732		
Time to 50% Consolidation, min		0.0000	0.0000		
Shear Strength, psi		34.29	23.85		
Strain at Failure, %		3.56	3.30		
Strain Rate, %/min		20.00	20.00		
Deviator Stress at Failure, psi		68.58	47.69		
Effective Minor Principal Stress at Failure, psi		23.70	11.42		
Effective Major Principal Stress at Failure, psi		92.28	59.11		
B-Value		0.97	0.96		

Notes:
- Before Shear Saturation set to 100% for phase calculation.
- Moisture Content determined by ASTM D2216.
- Deviator Stress includes membrane correction.
- Values for c and φ determined from best-fit straight line for the specific test conditions. Actual strength parameters may vary and should be determined by an engineer for site conditions.

	Project Name: SS-5-085(086)012	Location: Bismarck, ND	Project Number:
	Boring Number: 1	Tester: MD	Checker: DT
	Sample Number: SS -220 -24	Test Date: 7/30/24	Depth: 9.0 - 11.0
	Test Number: CU -21- 24	Preparation:	Elevation:
	Description: 24" Gry Silty Sand with Cly Deposits		
	Remarks: Sample Test Depth 9.3 - 9.8		

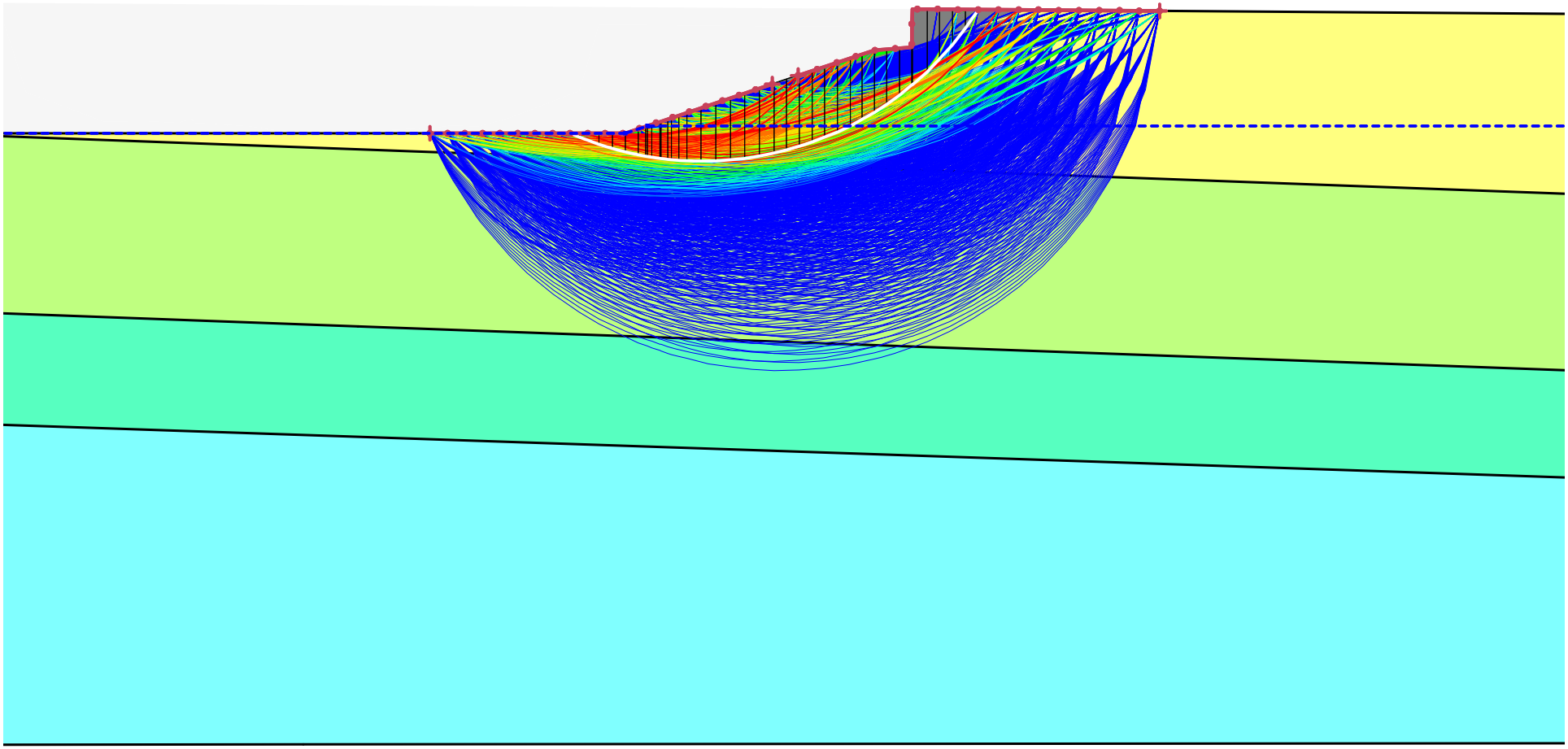
APPENDIX C

Stability Analysis Outputs

Effective Stress Analysis
Project Number: SS-5-085(086)012
PCN: 23772
4 South of JCT US 12
Bridge #: 0085-012.746
North Abutment_Global (3:1)

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Strength Function	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Concrete Abuttment	Mohr-Coulomb	150		10,000	0	0	1
	Layer 1_Loose Brn Silty/Clayey Sand	Mohr-Coulomb	120		0	31.7	0	1
	Layer 2_Dense Brn/Gry Silty Calyey Sand	Mohr-Coulomb	120		0	44.2	0	1
	Layer 3_Very Dense Gry/Drk Gry Sandy Silt	Mohr-Coulomb	120		0	45	0	1
	Layer 4_Hard Gry/Dark Gry Silty Fat Clay With Sand	Shear/Normal Fn.	120	Layer 4_Shear/Normal			0	1

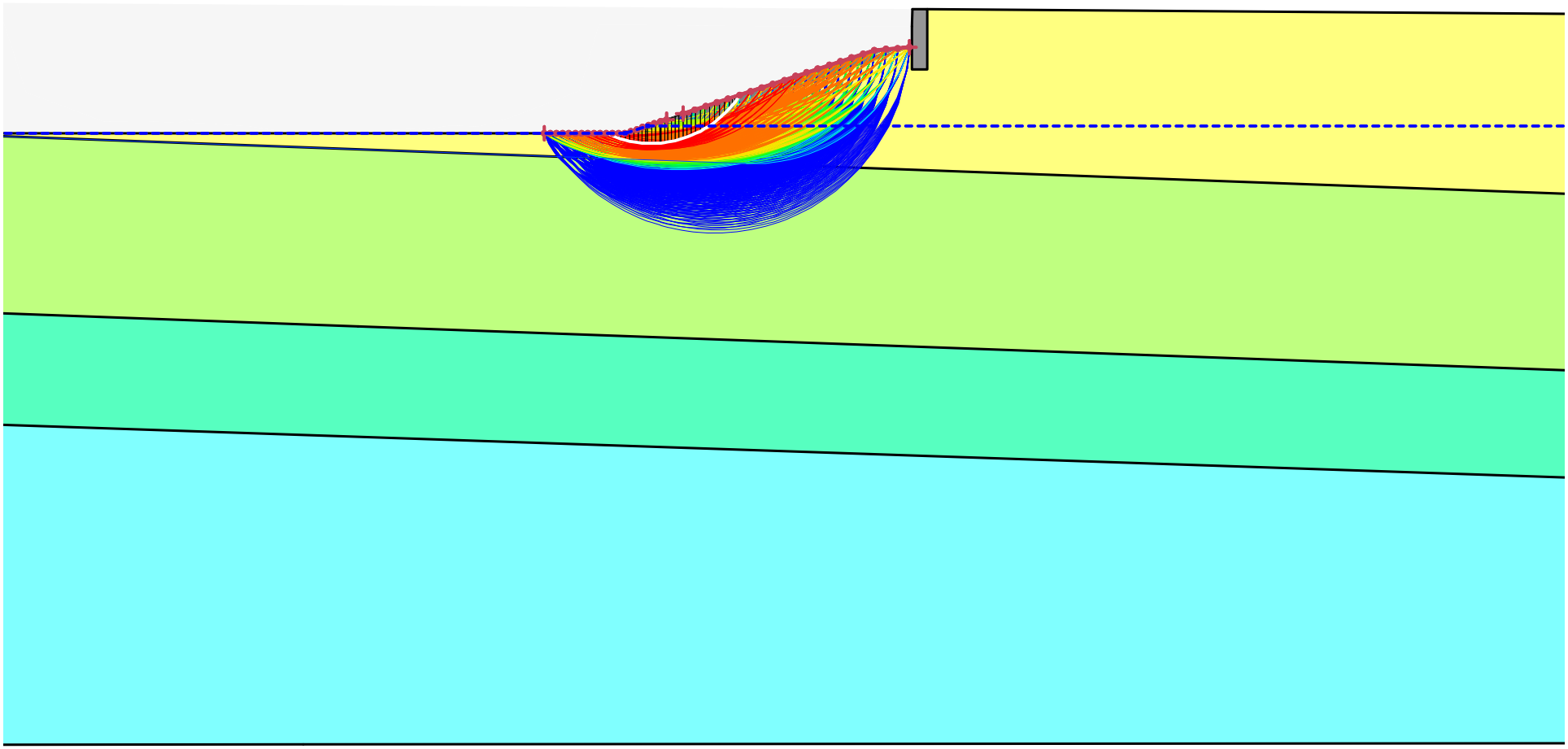
1.713



Effective Stress Analysis
Project Number: SS-5-085(086)012
PCN: 23772
4 South of JCT US 12
Bridge #: 0085-012.746
On Abutment_North (3:1)

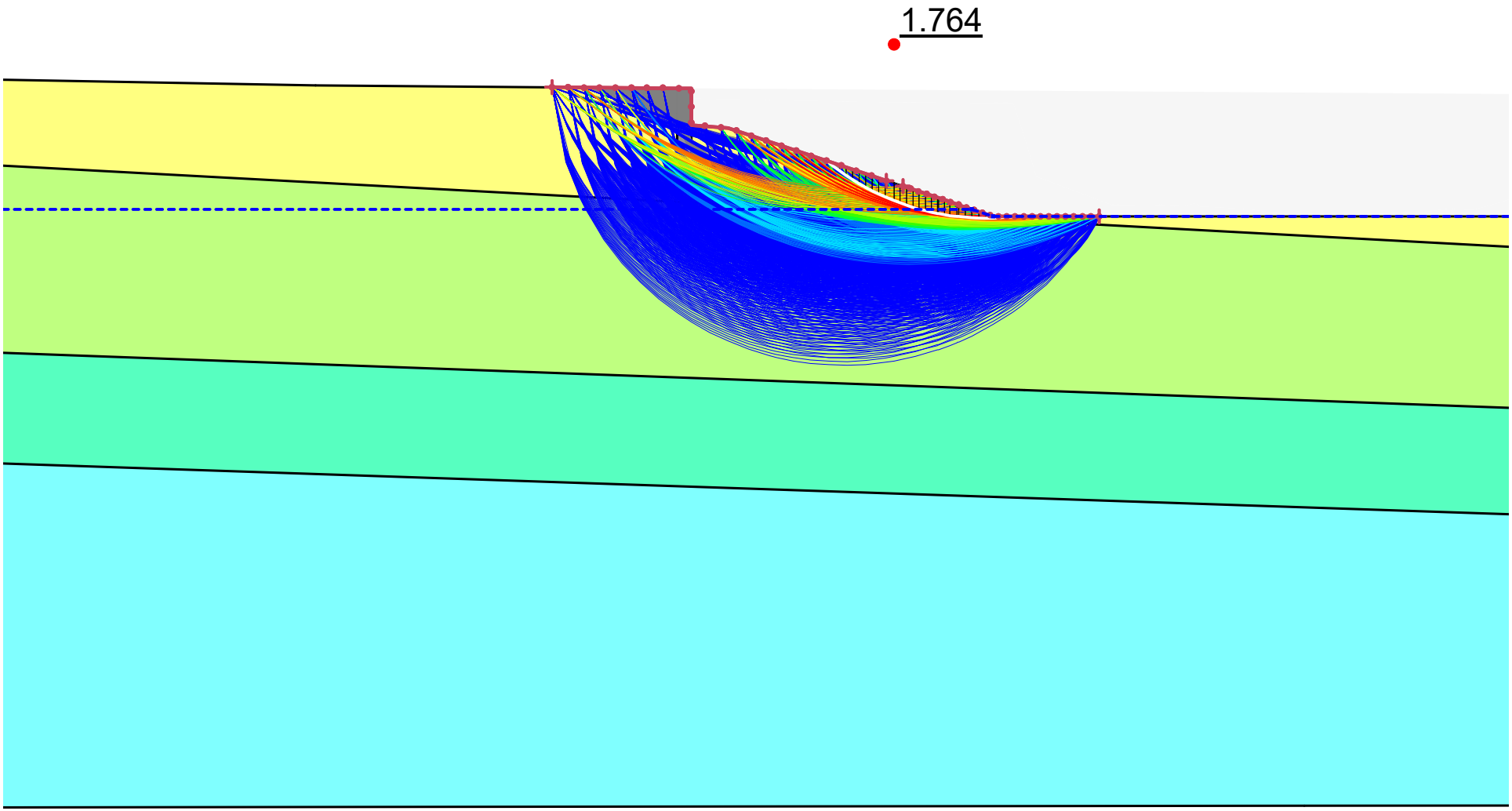
Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Strength Function	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Concrete Abuttment	Mohr-Coulomb	150		10,000	0	0	1
	Layer 1_Loose Brn Silty/Clayey Sand	Mohr-Coulomb	120		0	31.7	0	1
	Layer 2_Dense Brn/Gry Silty Calyey Sand	Mohr-Coulomb	120		0	44.2	0	1
	Layer 3_Very Dense Gry/Drk Gry Sandy Silt	Mohr-Coulomb	120		0	45	0	1
	Layer 4_Hard Gry/Dark Gry Silty Fat Clay With Sand	Shear/Normal Fn.	120	Layer 4_Shear/Normal			0	1

1.674



Effective Stress Analysis
Project Number: SS-5-085(086)012
PCN: 23772
4 South of JCT US 12
Bridge #: 0085-012.746
South Abutment_Global (3:1)

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Strength Function	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Concrete Abuttment	Mohr-Coulomb	150		10,000	0	0	1
	Layer 1_Loose Brn Silty/Clayey Sand	Mohr-Coulomb	120		0	31.7	0	1
	Layer 2_Dense Brn/Gry Silty Calyey Sand	Mohr-Coulomb	120		0	44.2	0	1
	Layer 3_Very Dense Gry/Drk Gry Sandy Silt	Mohr-Coulomb	120		0	45	0	1
	Layer 4_Hard Gry/Dark Gry Silty Fat Clay With Sand	Shear/Normal Fn.	120	Layer 4_Shear/Normal			0	1



Effective Stress Analysis
Project Number: SS-5-085(086)012
PCN: 23772
4 South of JCT US 12
Bridge #: 0085-012.746
On Abutment_South (3:1)

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Strength Function	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Concrete Abuttment	Mohr-Coulomb	150		10,000	0	0	1
	Layer 1_Loose Brn Silty/Clayey Sand	Mohr-Coulomb	120		0	31.7	0	1
	Layer 2_Dense Brn/Gry Silty Calyey Sand	Mohr-Coulomb	120		0	44.2	0	1
	Layer 3_Very Dense Gry/Drk Gry Sandy Silt	Mohr-Coulomb	120		0	45	0	1
	Layer 4_Hard Gry/Dark Gry Silty Fat Clay With Sand	Shear/Normal Fn.	120	Layer 4_Shear/Normal			0	1