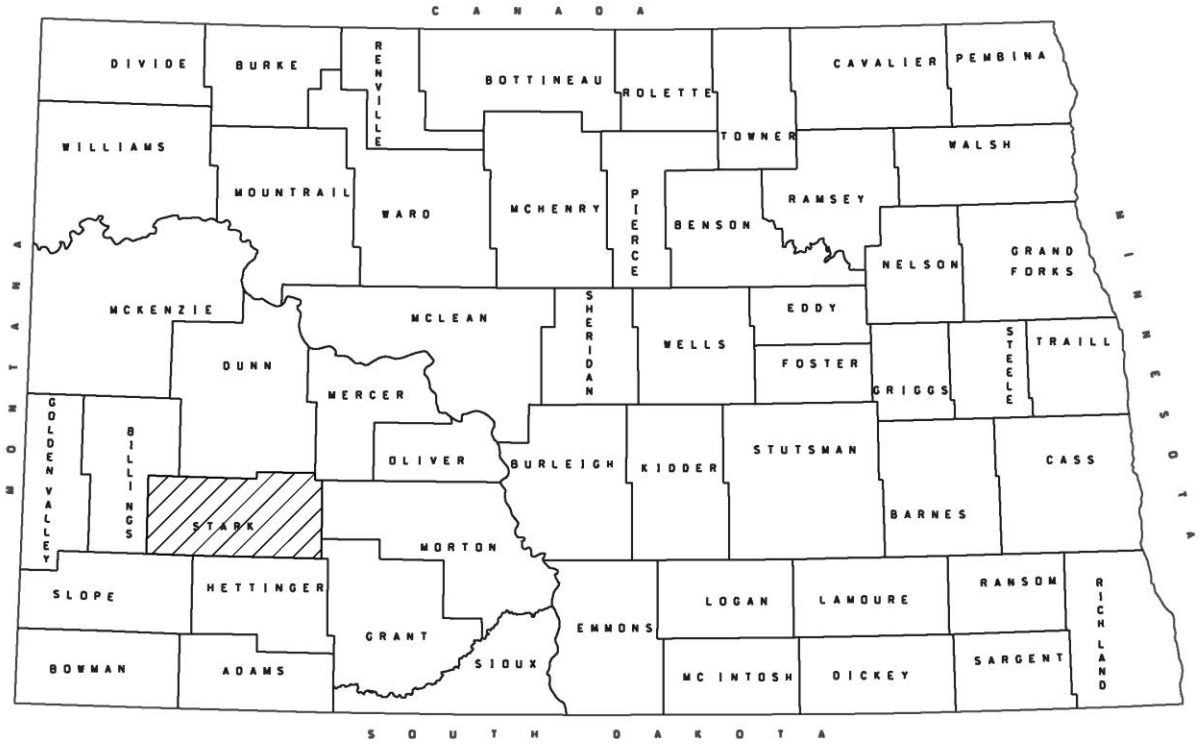
LINEAR SOILS SURVEY AND RECOMMENDATIONS

Project NO. NHU-IM-5-094(160)903

PCN 23695

County Stark

I-94, I-94 W to State Ave



PREPARED BY: HABTAMU ABERA YESHAW

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION MATERIAL AND RESEARCH DIVISION

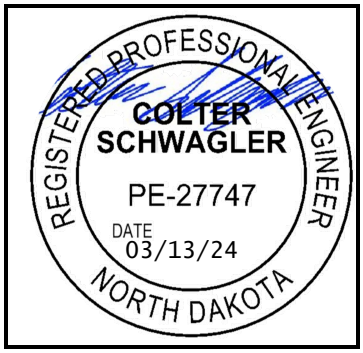
MARCH 2024

NHU-5-094(160)903

I-94B, I-94 W to State Ave

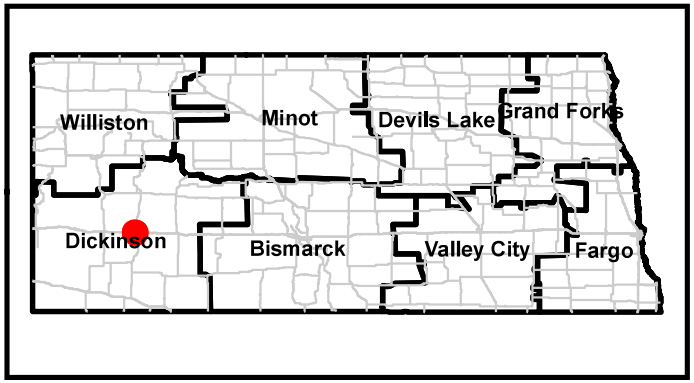
CERTIFICATION

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 3/13/2024 and the original document is stored at the North Dakota Department of Transportation.



Project Location

Project: NHU-IM-5-094(160)903
PCN: 23695
Scope: Reconstruction
Location: I-94, I-94 W to State Ave



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Introduction

Location: I-94B, I-94 W to State Ave
Reference Points: 903.603 to 905.070
Project Length: 1.467 Miles
Proposed Project Scope: Reconstruction
Investigation Scope: 1 boring every 500’

Maintenance Review

Date of Maintenance Review: 3/27/2023
Materials and Research Person Conducting the Review: Jamie Naumann
Maintenance Person Conducting Review: Aaron Auer

Table 1 - Identified Maintenance Areas

Location RP + Feet	Distress Identified	Maintenance Comments	Drilling Required
903+3184 to 905+0369	Other	No maintenance areas. Crack seal in 2022. Hand patches on transition cracks from asphalt to concrete in 2022.	NO

Summary of Soil Investigation

The soil investigation was completed on 5/15/2023. The investigation consisted of 13 borings.

Table 2 - Boring Locations Summary

Boring Location	Pavement Distress	Justification for Boring	Boring Depth	Boring Locations/Comments
903+3184 to 905+0369	Other	Reconstruction	5 Feet	1 boring every 500’ along the roadway within the project limits. A total number of approximately 16 borings.

Map of the boring locations are shown in Appendix C. The lab results and included in Appendix E.

Summary of Soil Analysis

Soil Sample Distribution

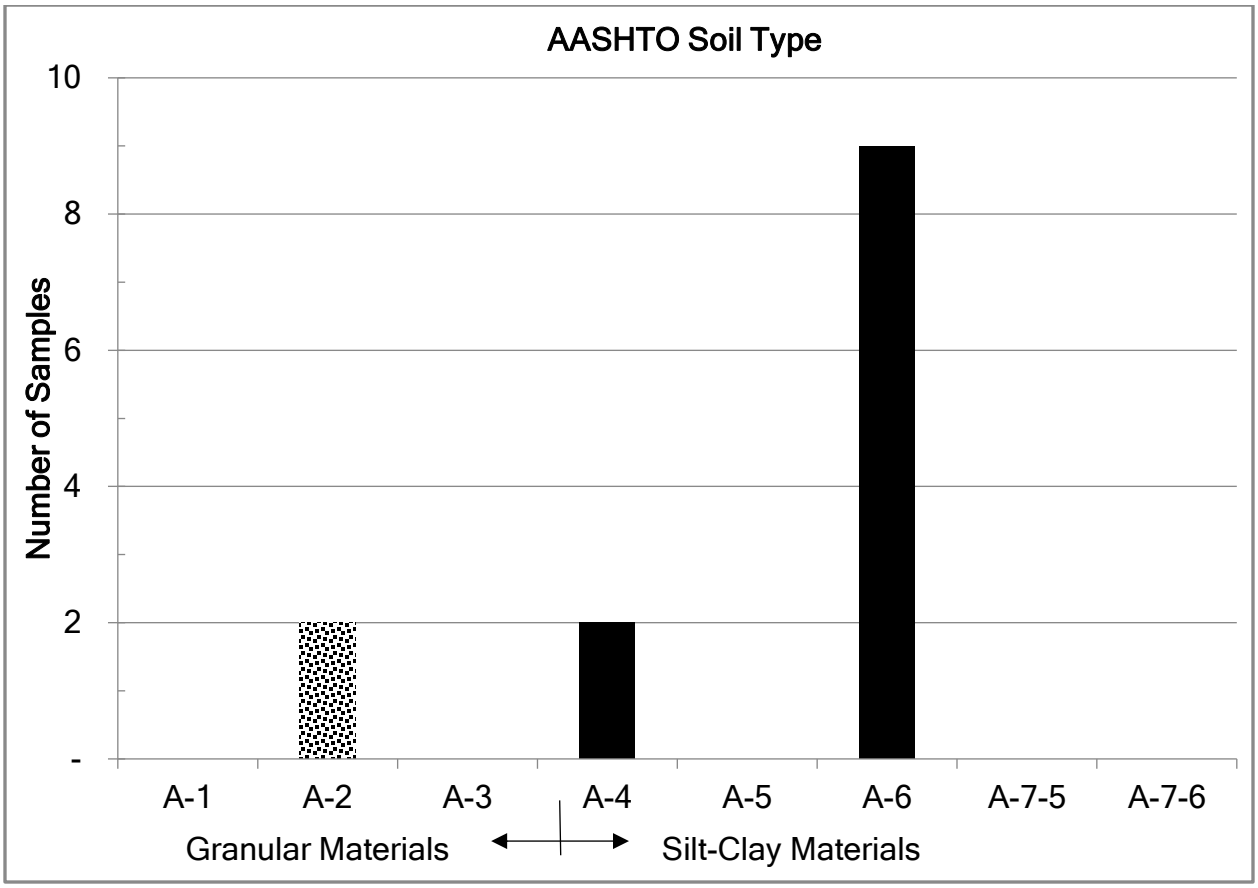


Figure 1 - Soil Sample Distribution

Design Recommendations

Project Limits – 903+3184 to 905+0369: The project geologically falls in the Sentinel Butte Formation with gray-brown silt, sand, clay, sandstone, and lignite; river, lake, and swamp sediments; as thick as 600 feet. The soils within the project limits are primarily clayey sands. In order to provide a sufficient working platform complete 12 inches of subgrade prep along the project limits.

Design Information

Pipe Replacement: None

Compaction Method: T-180

Subgrade Prep:

Location RP+ Feet	Recommendation	Justification
903+3184 to 905+0369	12” Subgrade prep along the project limits	The subgrade needs to provide a sufficient working platform to allow for the compaction of base material.

Subcut Recommendations: None

Drainage: None

Plan Notes

None

The recommendations in this report are based on the scope specified in the Introduction. If the scope of work, vertical profile or horizontal alignment is changed, in either the conceptual phase or the design phase, the Geotechnical Engineer must be notified as soon as possible to ensure that there is adequate geotechnical information addressing these areas.

APPENDIX A

SOIL CLASSIFICATION

AASHTO Classification System

Table 5.1. AASHTO Classification System

General Classification	*Granular materials (35% or less passing No. 200 Sieve (0.075 mm)*							*Silt-clay Materials More than 35% passing No. 200 Sieve (0.075 mm)*			
Group Classification	*A—1*		*A—3*	*A—2*				*A—4*	*A—5*	*A—6*	*A—7*
	A—1—a	*A—1—b*		*A—2—4*	*A—2—5*	*A—2—6*	*A—2—7*				*A—7—5 A—7—6*
(*a*) Sieve Analysis: Percent Passing											
(*i*) 2.00 mm (No. 10)	50 max										
(*ii*) 0.425 mm (No. 40)	30 max	50 max	51 min								
(*iii*) 0.075 mm (No. 200)	15 max	25 max	10 max	35 max	35 max	35 max	35 max	36 min	36 min	36 min	36 min
(*b*) Characteristics of fraction passing 0.425 mm (No. 40)											
(*i*) Liquid limit				40 max	41 min	40 max	41 min	40 max	41 min	40 max	41 min
(*ii*) Plasticity index	6 max		N.P.	10 max	10 max	11 min	11 min	10 max	10 max	11 min	11 min*
(*c*) Usual types of significant Constituent materials	Stone Fragments Gravel and sand		Fine Sand	Silty or Clayey Gravel Sand				Silty Soils		Clayey Soils	
(*d*) General rating as subgrade.	Excellent to Good							Fair to Poor			

* If plasticity index is equal to or less than (liquid Limit—30), the soil is A—7—5 (*i.e.* PL > 30%)
If plasticity index is greater than (Liquid Limit—30), the soil is A—7—6 (*i.e.* PL < 30%)

Unified Soil Classification System, USCS

Table 5.2 Unified Soil Classification System (Based on Material Passing 76.2-mm Sieve)

Criteria for assigning group symbols				Group symbol
Coarse-grained soils More than 50% of retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[a]	$C_u \geq 4$ and $1 \leq C_c \leq 3$[c]	GW
			$C_u < 4$ and/or $1 > C_c > 3$[c]	GP
		Gravels with Fines More than 12% fines[a,d]	$PI < 4$ or plots below "A" line (Figure 5.3)	GM
			$PI > 7$ and plots on or above "A" line (Figure 5.3)	GC
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[b]	$C_u \geq 6$ and $1 \leq C_c \leq 3$[c]	SW
			$C_u < 6$ and/or $1 > C_c > 3$[c]	SP
		Sands with Fines More than 12% fines[b,d]	$PI < 4$ or plots below "A" line (Figure 5.3)	SM
			$PI > 7$ and plots on or above "A" line (Figure 5.3)	SC
Fine-grained soils 50% or more passes No. 200 sieve	Silts and clays Liquid limit less than 50	Inorganic	$PI > 7$ and plots on or above "A" line (Figure 5.3)[e]	CL
			$PI < 4$ or plots below "A" line (Figure 5.3)[e]	ML
		Organic	$\frac{\text{Liquid limit — oven dried}}{\text{Liquid limit — not dried}} < 0.75$; see Figure 5.3; OL zone	OL
	Silts and clays Liquid limit 50 or more	Inorganic	PI plots on or above "A" line (Figure 5.3)	CH
			PI plots below "A" line (Figure 5.3)	MH
		Organic	$\frac{\text{Liquid limit — oven dried}}{\text{Liquid limit — not dried}} < 0.75$; see Figure 5.3; OH zone	OH
Highly Organic Soils	Primarily organic matter, dark in color, and organic odor			Pt

[a] Gravels with 5 to 12% fine require dual symbols: GW-GM, GW-GC, GP-GM, GP-GC.

[b] Sands with 5 to 12% fines require dual symbols: SW-SM, SW-SC, SP-SM, SP-SC.

[c] $C_u = \frac{D_{60}}{D_{10}}$; $C_c = \frac{(D_{30})^2}{D_{60} \times D_{10}}$

[d] If $4 \leq PI \leq 7$ and plots in the hatched area in Figure 5.3, use dual symbol GC-GM or SC-SM.

[e] If $4 \leq PI \leq 7$ and plots in the hatched area in Figure 5.3, use dual symbol CL-ML.

Plasticity Chart :

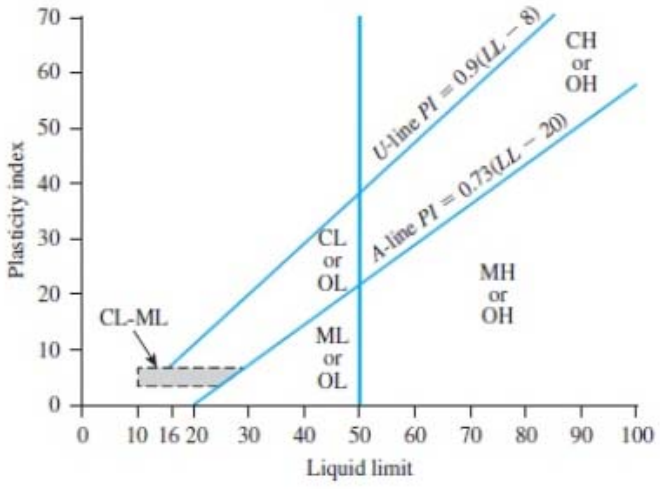


Table 7-12. Frost susceptibility classification of soils (NCHRP 1-37A).

Frost Group	Degree of Frost Susceptibility	Type of Soil	Percentage Finer than 0.075 mm (# 200) by wt.	Typical Soil Classification
F1	Negligible to low	Gravelly soils	3-10	GC, GP, GC-GM, GP-GM
F2	Low to medium	Gravelly soils	10-20	GM, GC-GM, GP-GM
		Sands	3-15	SW, SP, SM, SW-SM, SP-SM
F3	High	Gravelly Soils	Greater than 20	GM-GC
		Sands, except very fine silty sands	Greater than 15	SM, SC
		Clays PI>12	—	CL, CH
F4	Very high	All Silts	—	ML-MH
		Very Fine Silty Sands	Greater than 15	SM
		Clays PI<12	—	CL, CL-ML
		Varied clays and other fine grained, banded sediments	—	CL, ML, SM, CH

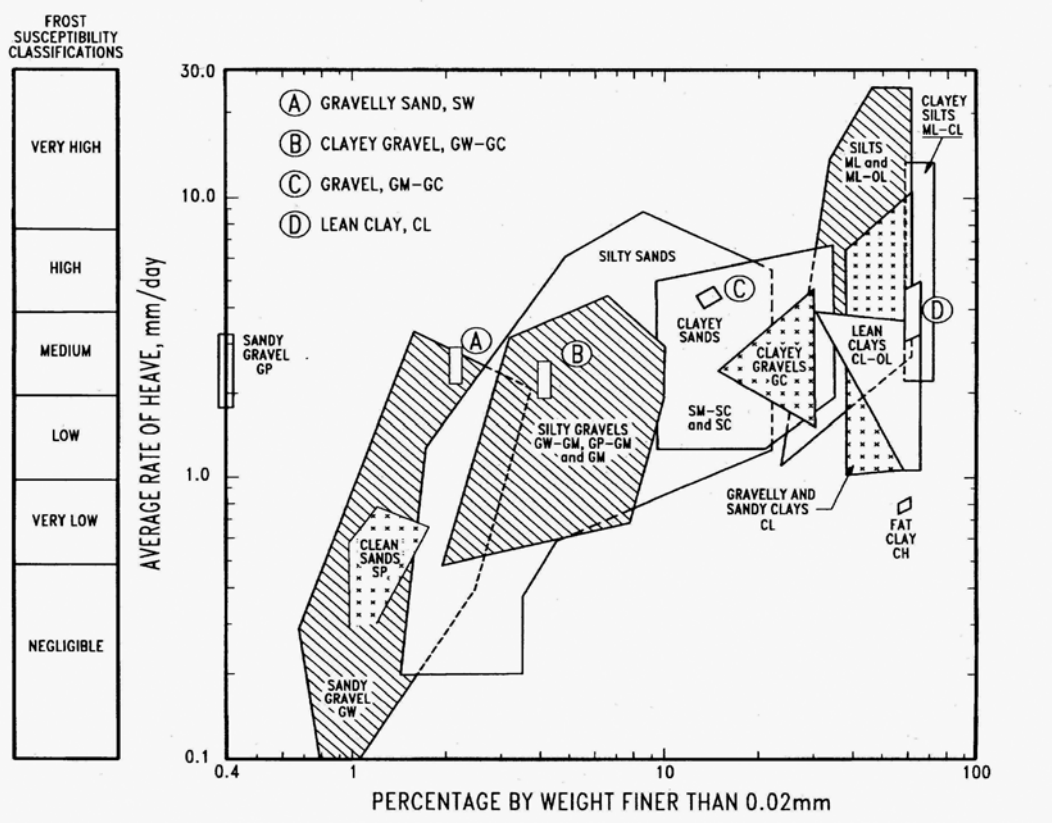


Figure 7-20. Average rate of heave versus % fines for natural soil gradations (Kaplar, 1974).

Frost Depth Map

*Values shown are in meters

APPENDIX B

MAINTENANCE REVIEW AND SUBSURFACE INVESTIGATION SCOPE

PAVEMENT EVALUATION LOG FOR LINEAR SOIL SURVEY

North Dakota Department of Transportation, Materials & Research

SFN 60472 (6-2017)

Sheet 1 of 1

Project Number	PCN	Date of Survey
NHU-5-094(160)903	23695	03/27/2023

Section Maintenance Contact	Completed By
Aaron Auer	Jamie Naumann

Highway Reference Points	Surface Types
903+3184 to 905+0369	Asphalt

Location	Pavement Distress	Description	Maintenance Comment	Picture Number	Drilling Required
903+3184 to 905+0369	Other	NA	No maintenence areas. Crack seal in 2022. Hand pathches on transition cracks from asphalt to concrete in 2022.	NA	No

Comments

APPENDIX C

BORING LOCATIONS

Legend

- Reference Point
- Boring Locations

0 500 1,000 Feet

Project Number: NHU-5-094(160)903

Legend

- Reference Point
- Boring Locations

0 500 1,000 Feet

Project Number: NHU-5-094(160)903

Legend

- Reference Point
- Boring Locations

0 500 1,000 Feet

Project Number: NHU-5-094(160)903

Legend

- Reference Point
- Boring Locations

0 500 1,000 Feet

Project Number: NHU-5-094(160)903

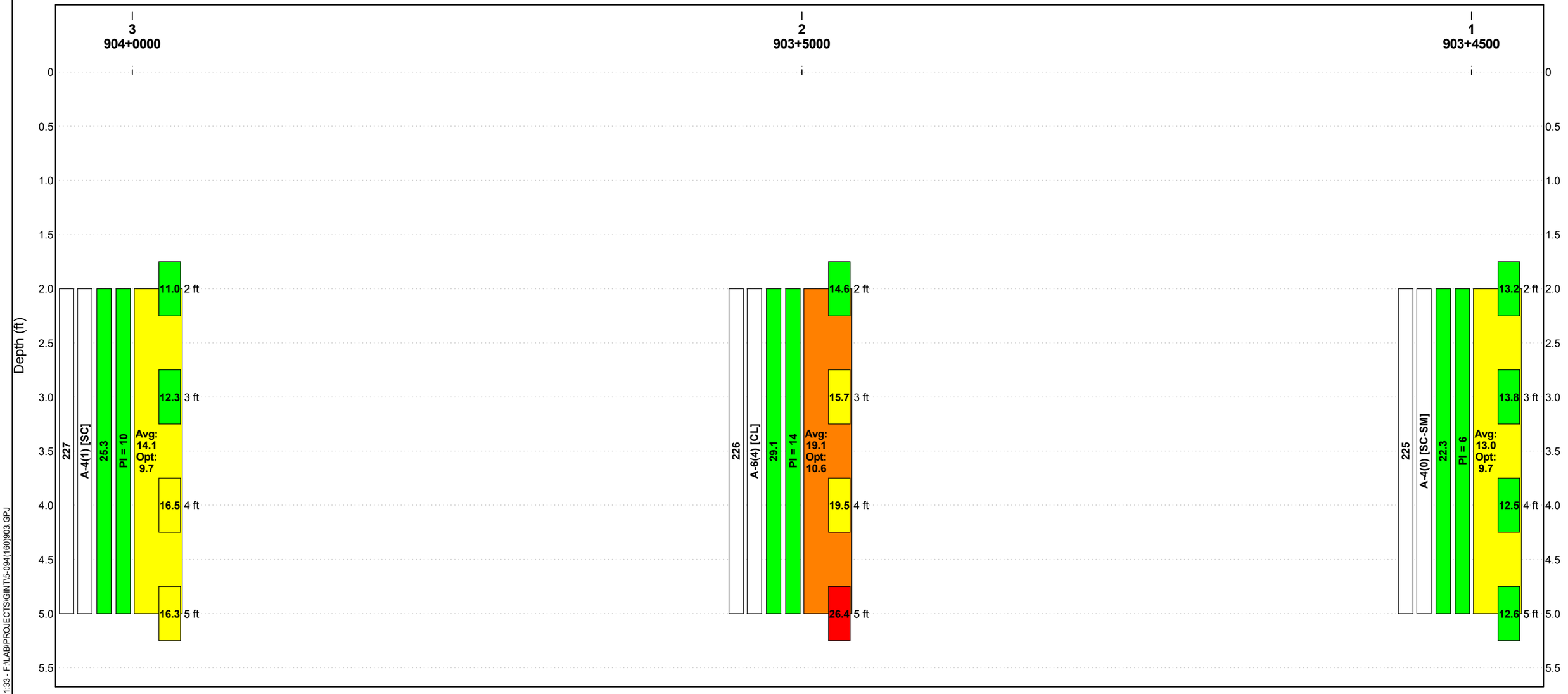
APPENDIX D

SUMMARY OF SOILS ANALYSIS

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

PROJECT NUMBER NHU-IM-5-094(160)903 **PCN** 23695

LOCATION Stark County



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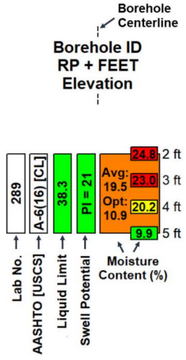


Liquid Limit	LL<50	50<=LL<60	LL>=60	
Swell Potential	Low	Marginal	High	
Moisture Content	Below PL	0-5% Over PL	>5% Over PL	Non-Plastic
Avg. In-Place Moisture Content	MC < Opt	0<=MC<6% Over Opt	6<=MC<10% Over Opt	10<=MC<16% Over Opt	MC>16% Over Opt

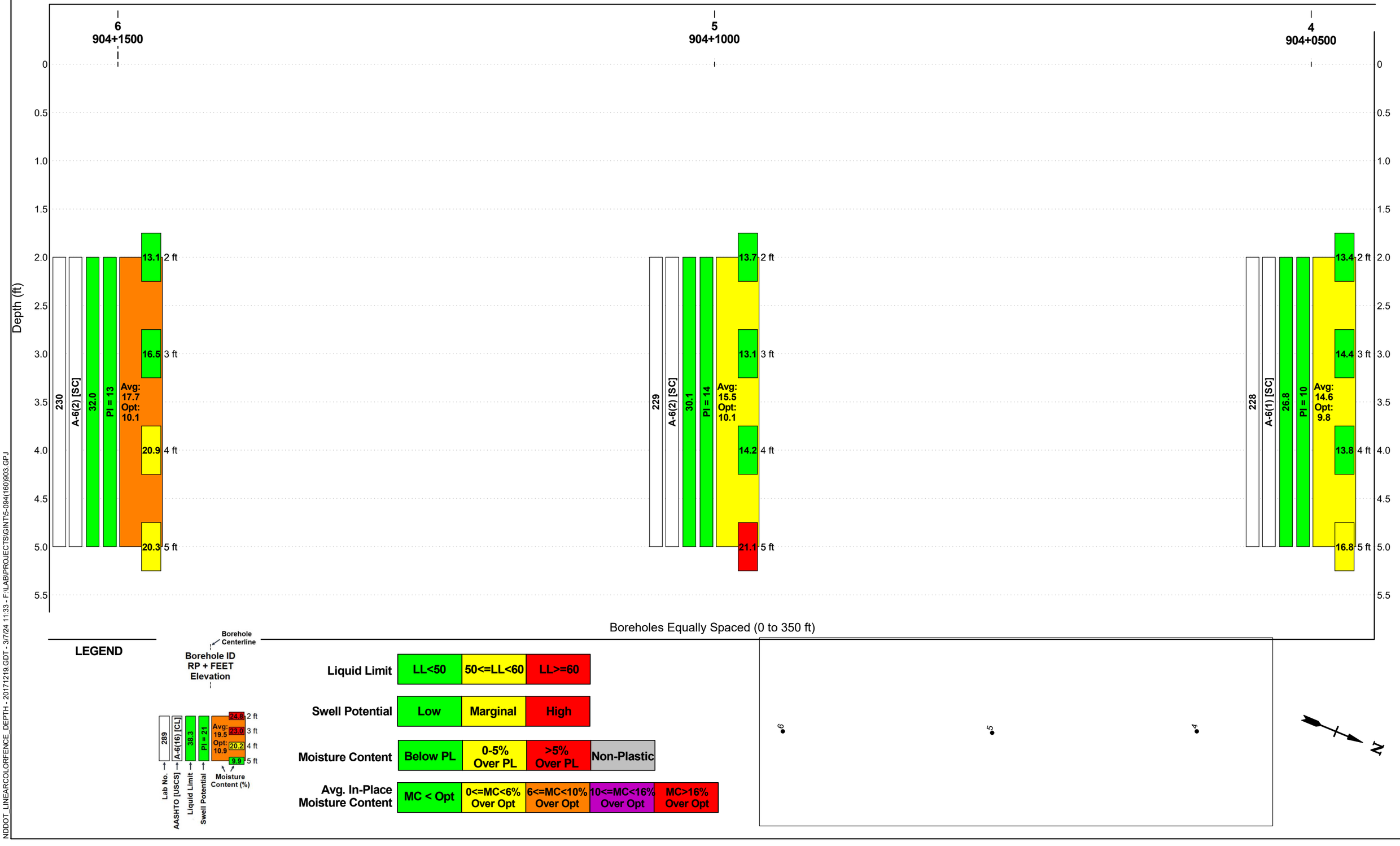
Boreholes Equally Spaced (0 to 240 ft)

NDDOT_LINEARCOLORFENCE_DEPTH - 20171219.GDT - 3/7/24 11:33 - F:\LAB\PROJECTS\GINT\5-094(160)903.GPJ

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

PROJECT NUMBER NHU-IM-5-094(160)903 **PCN** 23695

LOCATION Stark County



LEGEND

Liquid Limit	LL<50	50<=LL<60	LL>=60	
Swell Potential	Low	Marginal	High	
Moisture Content	Below PL	0-5% Over PL	>5% Over PL	Non-Plastic
Avg. In-Place Moisture Content	MC < Opt	0<=MC<6% Over Opt	6<=MC<10% Over Opt	10<=MC<16% Over Opt	MC>16% Over Opt

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NORTH DAKOTA DEPARTMENT OF TRANSPORATION
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BISMARCK, ND 58504

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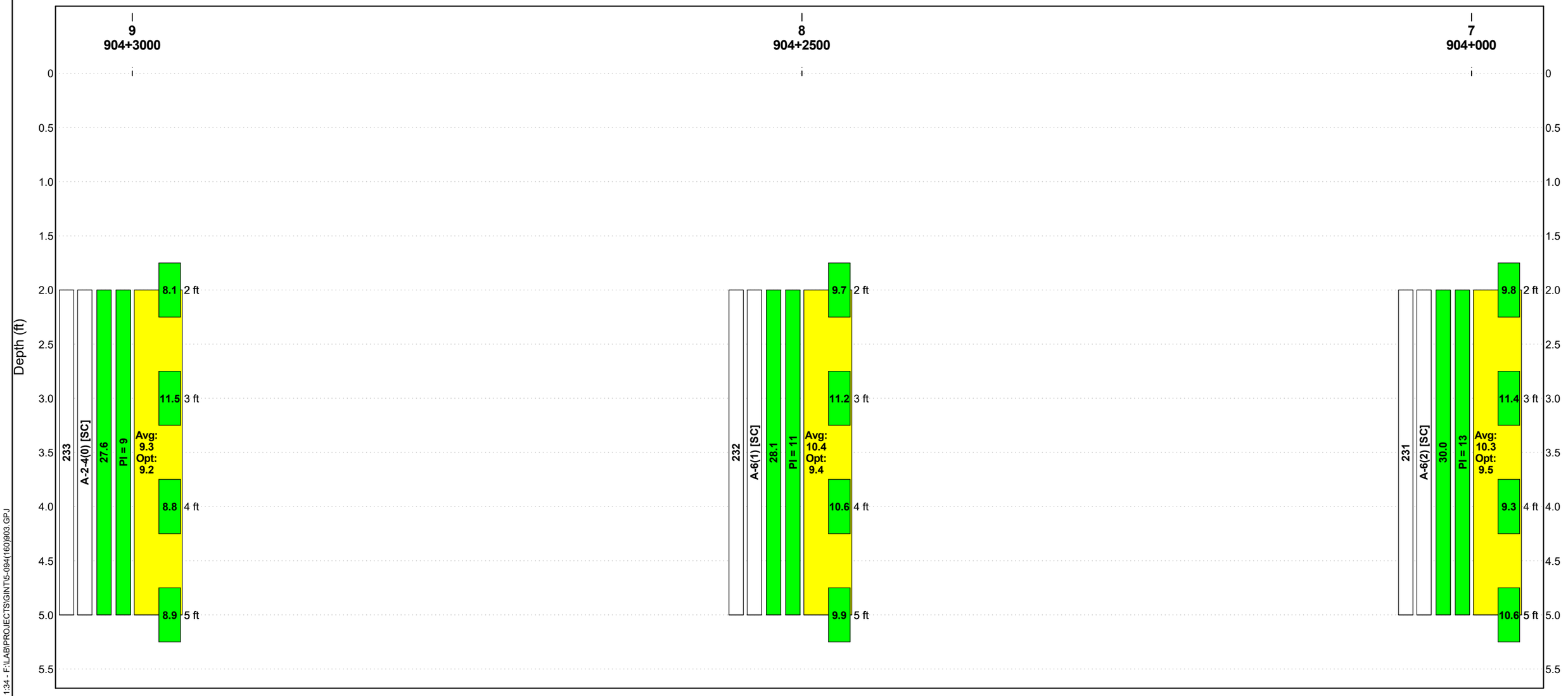
LOCATION Stark County



Boreholes Equally Spaced (0 to 350 ft)

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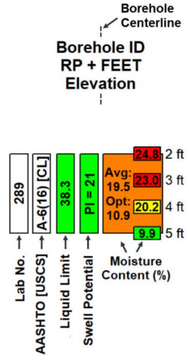
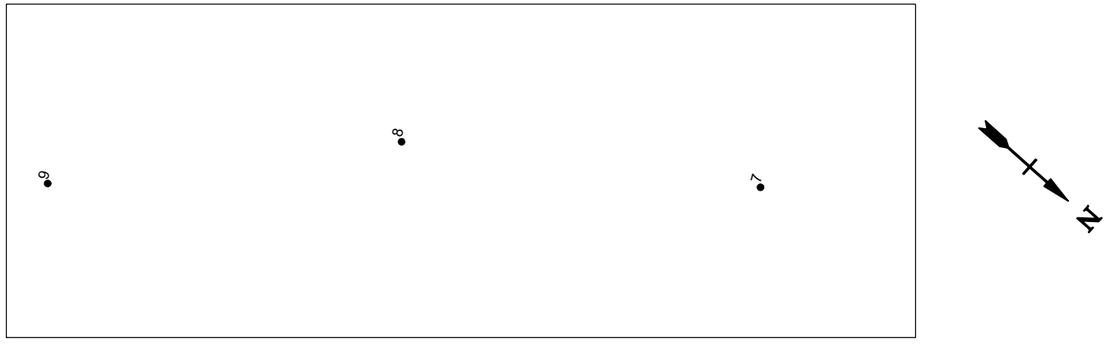


Liquid Limit	LL<50	50<=LL<60	LL>=60	
Swell Potential	Low	Marginal	High	
Moisture Content	Below PL	0-5% Over PL	>5% Over PL	Non-Plastic
Avg. In-Place Moisture Content	MC < Opt	0<=MC<6% Over Opt	6<=MC<10% Over Opt	10<=MC<16% Over Opt	MC>16% Over Opt



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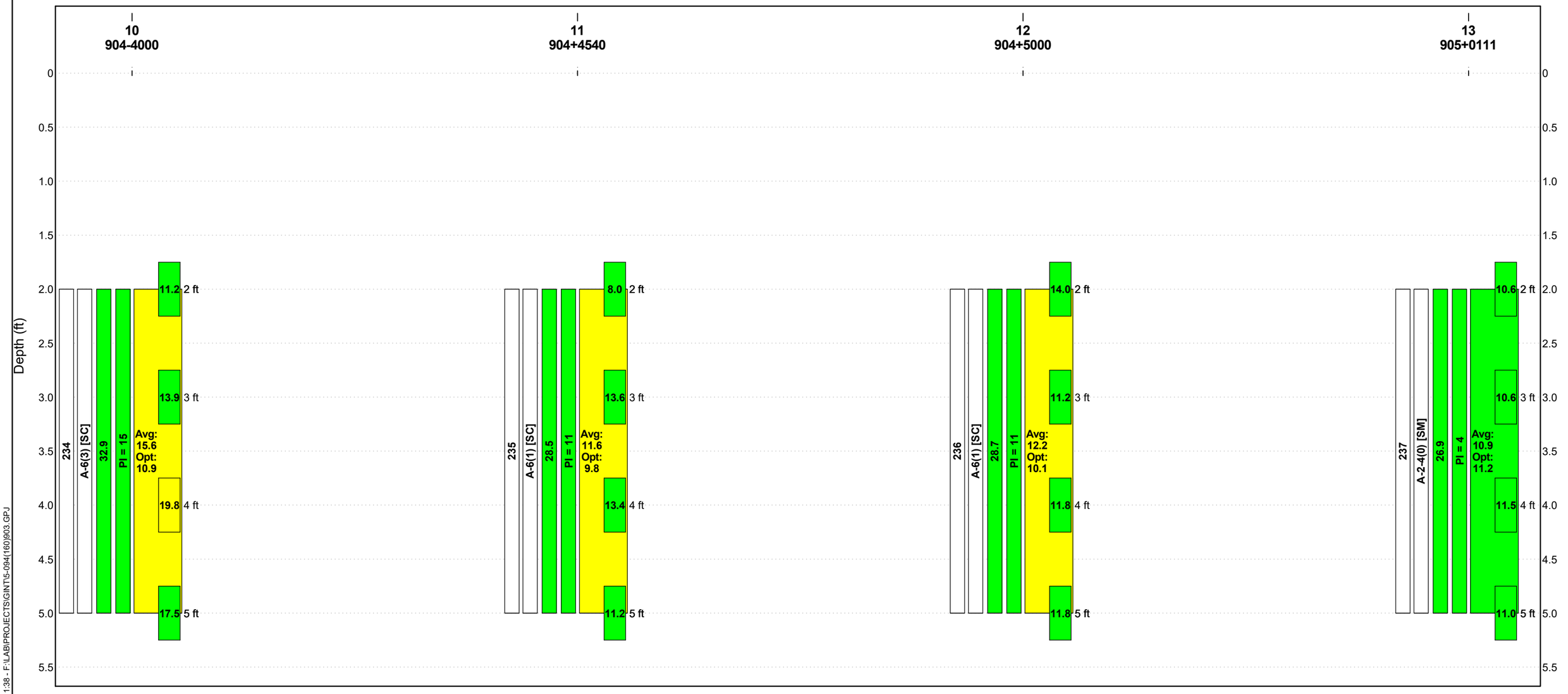
NDDOT
North Dakota Department of Transportation

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

PROJECT NUMBER NHU-IM-5-094(160)903 **PCN** 23695

LOCATION Stark County



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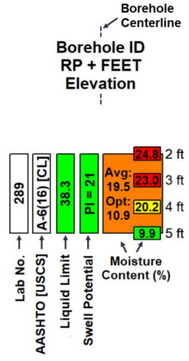
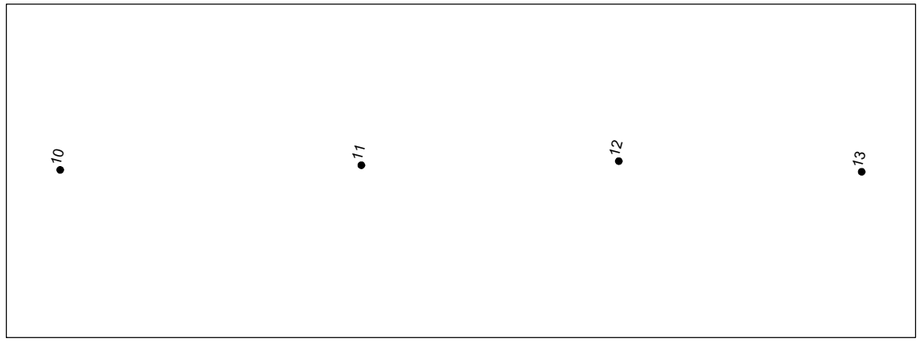


Liquid Limit	LL<50	50<=LL<60	LL>=60	
Swell Potential	Low	Marginal	High	
Moisture Content	Below PL	0-5% Over PL	>5% Over PL	Non-Plastic
Avg. In-Place Moisture Content	MC < Opt	0<=MC<6% Over Opt	6<=MC<10% Over Opt	10<=MC<16% Over Opt	MC>16% Over Opt

Boreholes Equally Spaced (0 to 450 ft)



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APPENDIX E

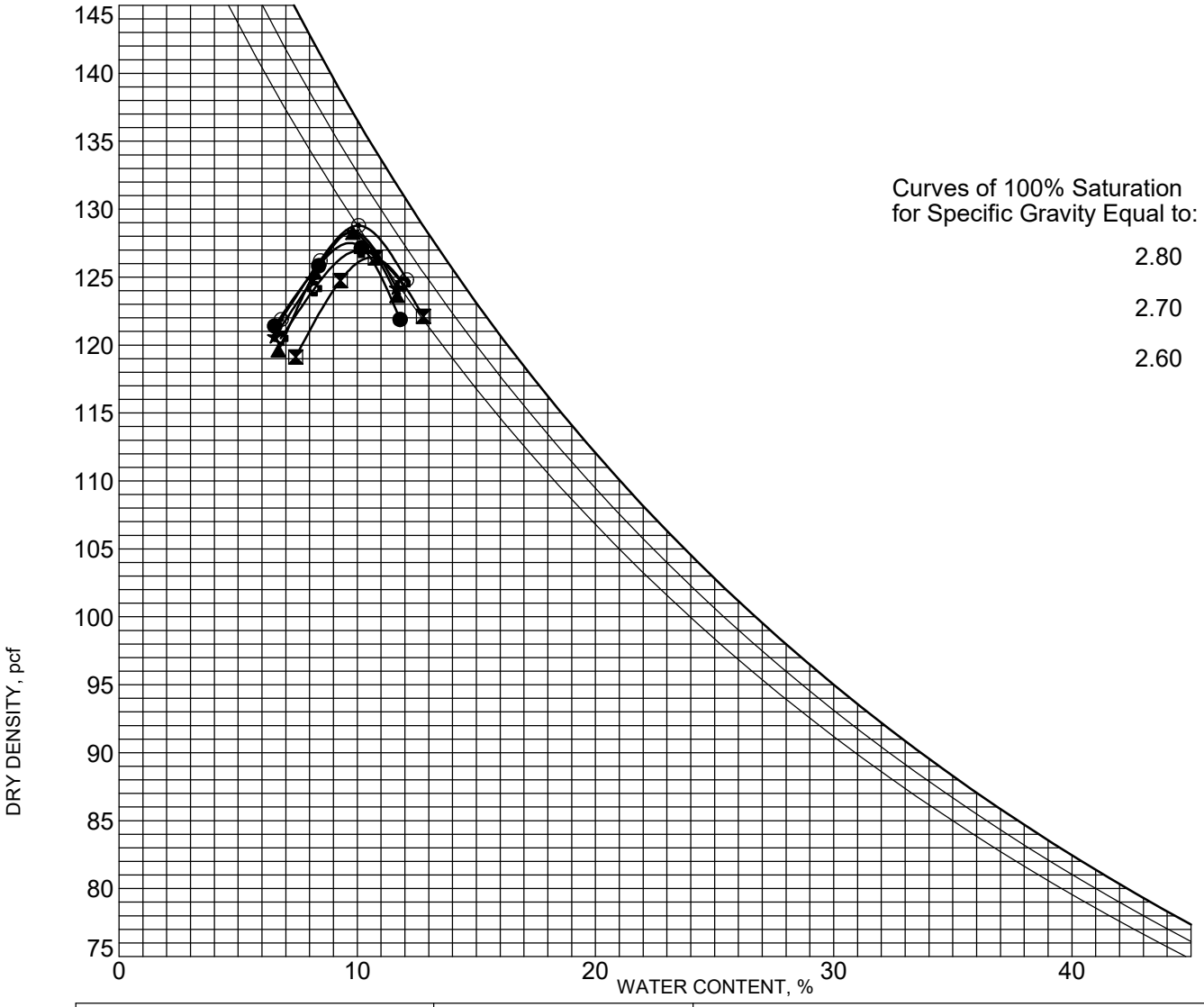
LAB RESULTS

MOISTURE-DENSITY RELATIONSHIP

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

PROJECT NUMBER NHU-5-094(160)903 **LOCATION** Stark County

PCN 23695



BOREHOLE		DEPTH	AASHTO Classification	USCS Description
●	1	2.0	A-4 (0)	SILTY, CLAYEY SAND(SC-SM)
⊠	2	2.0	A-6 (4)	SANDY LEAN CLAY(CL)
▲	3	2.0	A-4 (1)	CLAYEY SAND(SC)
★	4	2.0	A-6 (1)	CLAYEY SAND(SC)
⊙	5	2.0	A-6 (2)	CLAYEY SAND(SC)
✿	6	2.0	A-6 (2)	CLAYEY SAND(SC)

BOREHOLE		DEPTH	Test Method	LL	PL	PI	Max DD	Optimum WC
●	1	2.0	AASHTO T-180 Method A	22	17	5	127.5 PCF	9.7 %
⊠	2	2.0	AASHTO T-180 Method A	29	15	14	126.4 PCF	10.6 %
▲	3	2.0	AASHTO T-180 Method A	25	15	10	128.3 PCF	9.7 %
★	4	2.0	AASHTO T-180 Method A	27	16	11	128.3 PCF	9.8 %
⊙	5	2.0	AASHTO T-180 Method A	30	16	14	128.8 PCF	10.1 %
✿	6	2.0	AASHTO T-180 Method A	32	19	13	127.0 PCF	10.1 %

MOISTURE-DENSITY RELATIONSHIP

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300 AIRPORT ROAD
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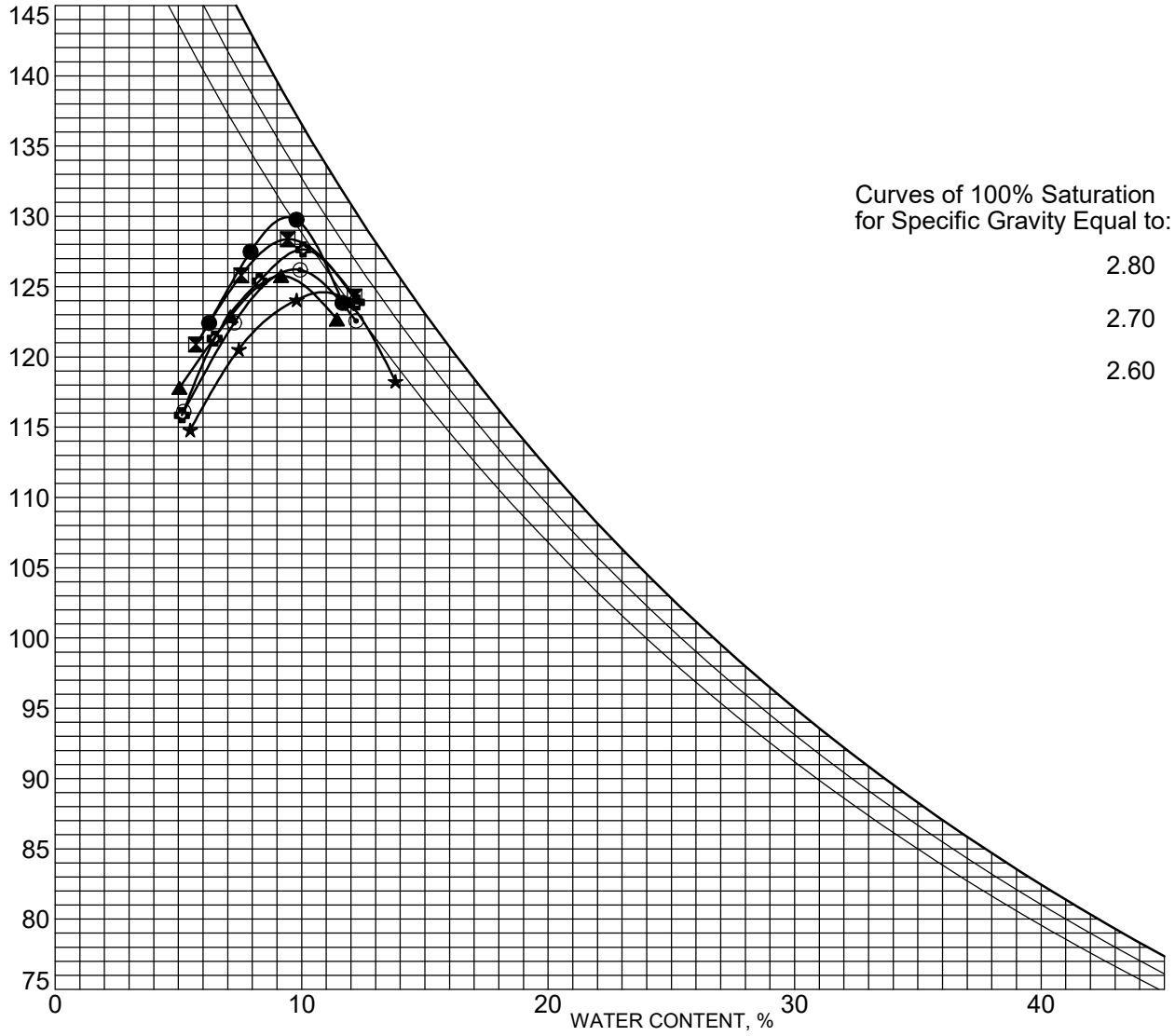

BOREHOLE		DEPTH	AASHTO Classification	USCS Description
●	7	2.0	A-6 (2)	CLAYEY SAND(SC)
⊠	8	2.0	A-6 (1)	CLAYEY SAND(SC)
▲	9	2.0	A-2-4 (0)	CLAYEY SAND(SC)
★	10	2.0	A-6 (3)	CLAYEY SAND(SC)
⊙	11	2.0	A-6 (1)	CLAYEY SAND(SC)
✿	12	2.0	A-6 (1)	CLAYEY SAND(SC)

BOREHOLE		DEPTH	Test Method	LL	PL	PI	Max DD	Optimum WC
●	7	2.0	AASHTO T-180 Method A	30	17	13	129.9 PCF	9.5 %
⊠	8	2.0	AASHTO T-180 Method A	28	17	11	128.4 PCF	9.4 %
▲	9	2.0	AASHTO T-180 Method A	28	19	9	125.8 PCF	9.2 %
★	10	2.0	AASHTO T-180 Method A	33	18	15	124.6 PCF	10.9 %
⊙	11	2.0	AASHTO T-180 Method A	29	17	12	126.2 PCF	9.8 %
✿	12	2.0	AASHTO T-180 Method A	29	18	11	127.6 PCF	10.1 %

MOISTURE-DENSITY RELATIONSHIP

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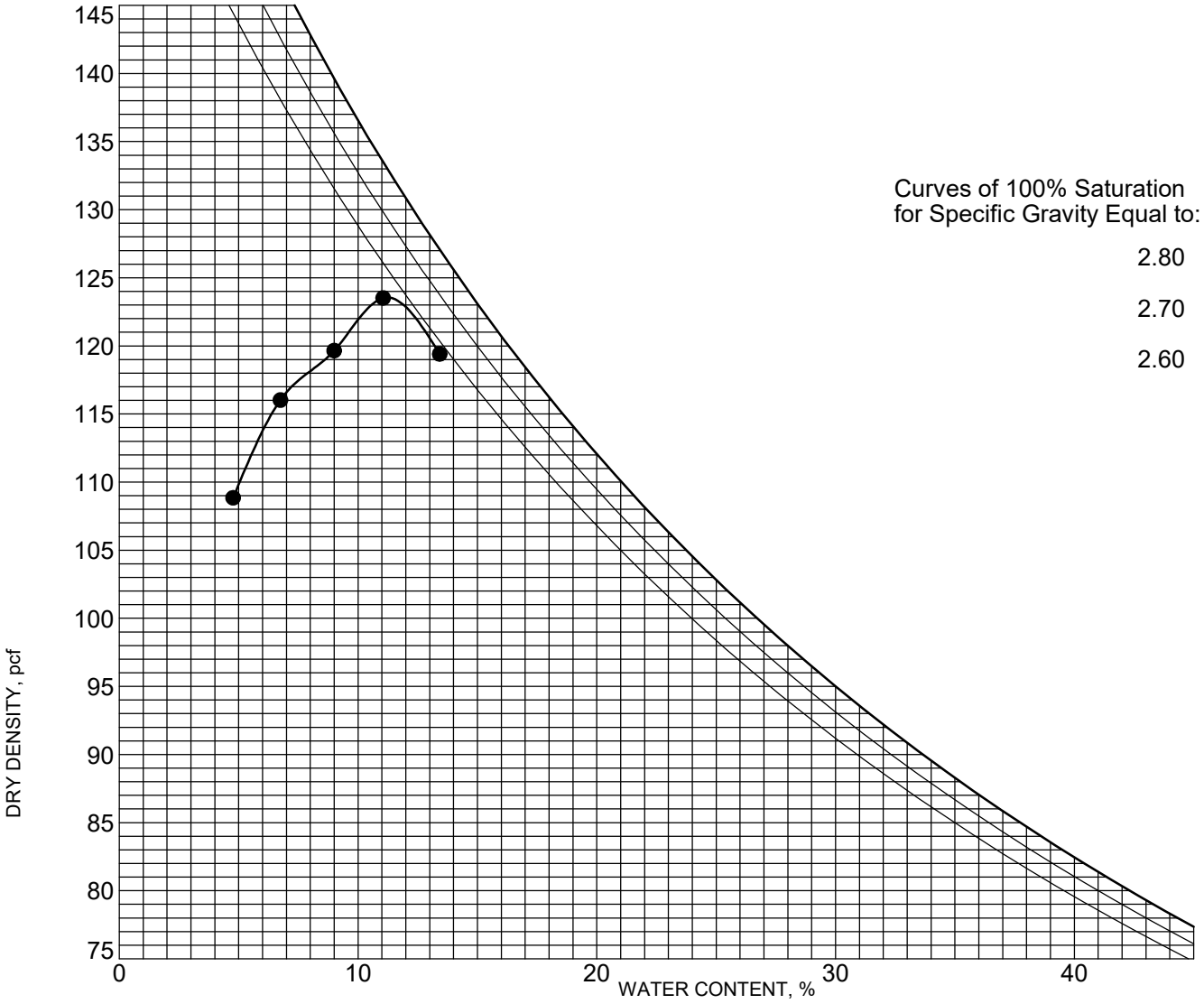

	BOREHOLE	DEPTH	AASHTO Classification	USCS Description
●	**13**	**2.0**	**A-2-4 (0)**	**SILTY SAND(SM)**

	BOREHOLE	DEPTH	Test Method	LL	PL	PI	Max DD	Optimum WC
●	**13**	**2.0**	**AASHTO T-180 Method A**	**27**	**23**	**4**	**123.6 PCF**	**11.2 %**

GRAIN SIZE DISTRIBUTION

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

PROJECT NUMBER NHU-5-094(160)903 **LOCATION** Stark County

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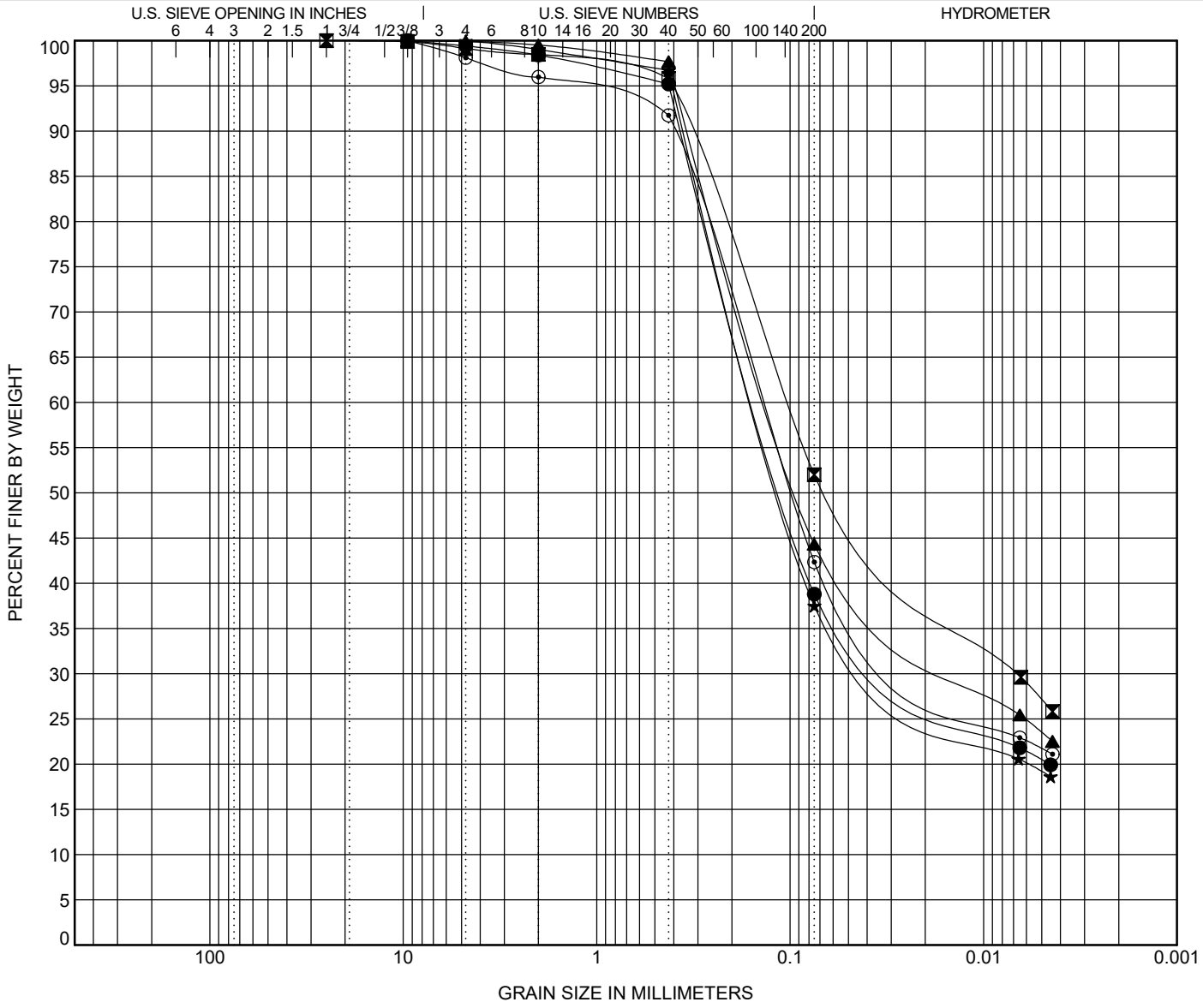


COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BOREHOLE	DEPTH	AASHTO Classification	USCS Classification	LL	PL	PI	Cc	Cu
●	1	2.0	A-4 (0)	SC-SM	22	17	5		
⊠	2	2.0	A-6 (4)	CL	29	15	14		
▲	3	2.0	A-4 (1)	SC	25	15	10		
★	4	2.0	A-6 (1)	SC	27	16	11		
⊙	5	2.0	A-6 (2)	SC	30	16	14		

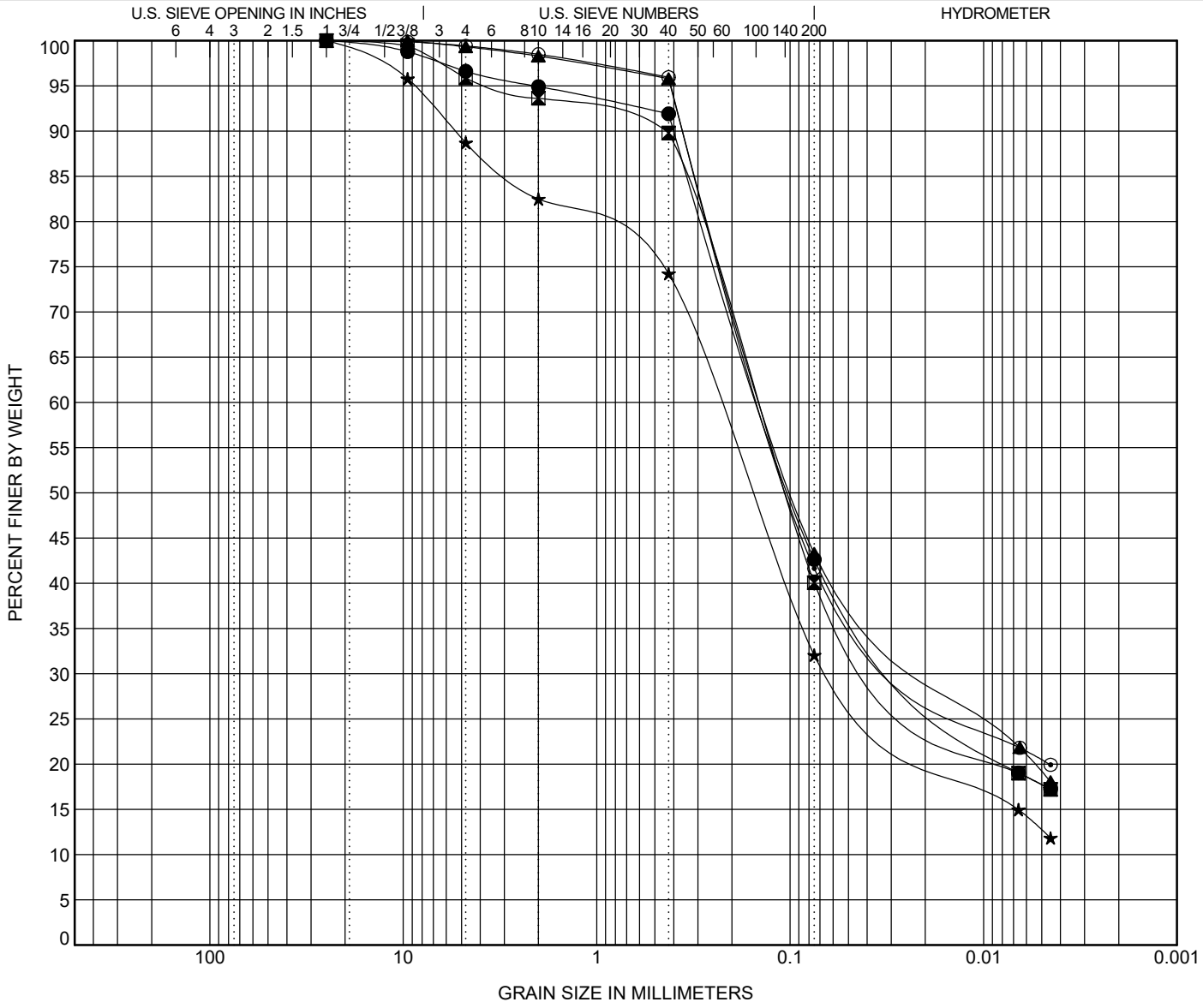
	BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	1	2.0	9.5	0.144	0.021		0.6	60.6	38.8	
⊠	2	2.0	25	0.103	0.007		0.9	47.1	52.0	
▲	3	2.0	9.5	0.125	0.012		0.1	55.6	44.3	
★	4	2.0	9.5	0.145	0.026		0.1	62.4	37.5	
⊙	5	2.0	9.5	0.139	0.016		1.9	55.8	42.3	

GRAIN SIZE DISTRIBUTION

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

PROJECT NUMBER NHU-5-094(160)903 **LOCATION** Stark County

PCN 23695



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BOREHOLE	DEPTH	AASHTO Classification	USCS Classification	LL	PL	PI	Cc	Cu
● 6	2.0	A-6 (2)	SC	32	19	13		
⊠ 7	2.0	A-6 (2)	SC	30	17	13		
▲ 8	2.0	A-6 (1)	SC	28	17	11		
★ 9	2.0	A-2-4 (0)	SC	28	19	9		
⊙ 10	2.0	A-6 (3)	SC	33	18	15		

BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● 6	2.0	25	0.138	0.02		3.4	54.0	42.6	
⊠ 7	2.0	25	0.15	0.024		4.1	55.8	40.0	
▲ 8	2.0	9.5	0.13	0.016		0.7	56.0	43.3	
★ 9	2.0	25	0.237	0.056		11.3	56.7	32.0	
⊙ 10	2.0	25	0.135	0.018		0.6	57.8	41.6	

GRAIN SIZE DISTRIBUTION

NORTH DAKOTA DEPARTMENT OF TRANSPORATION
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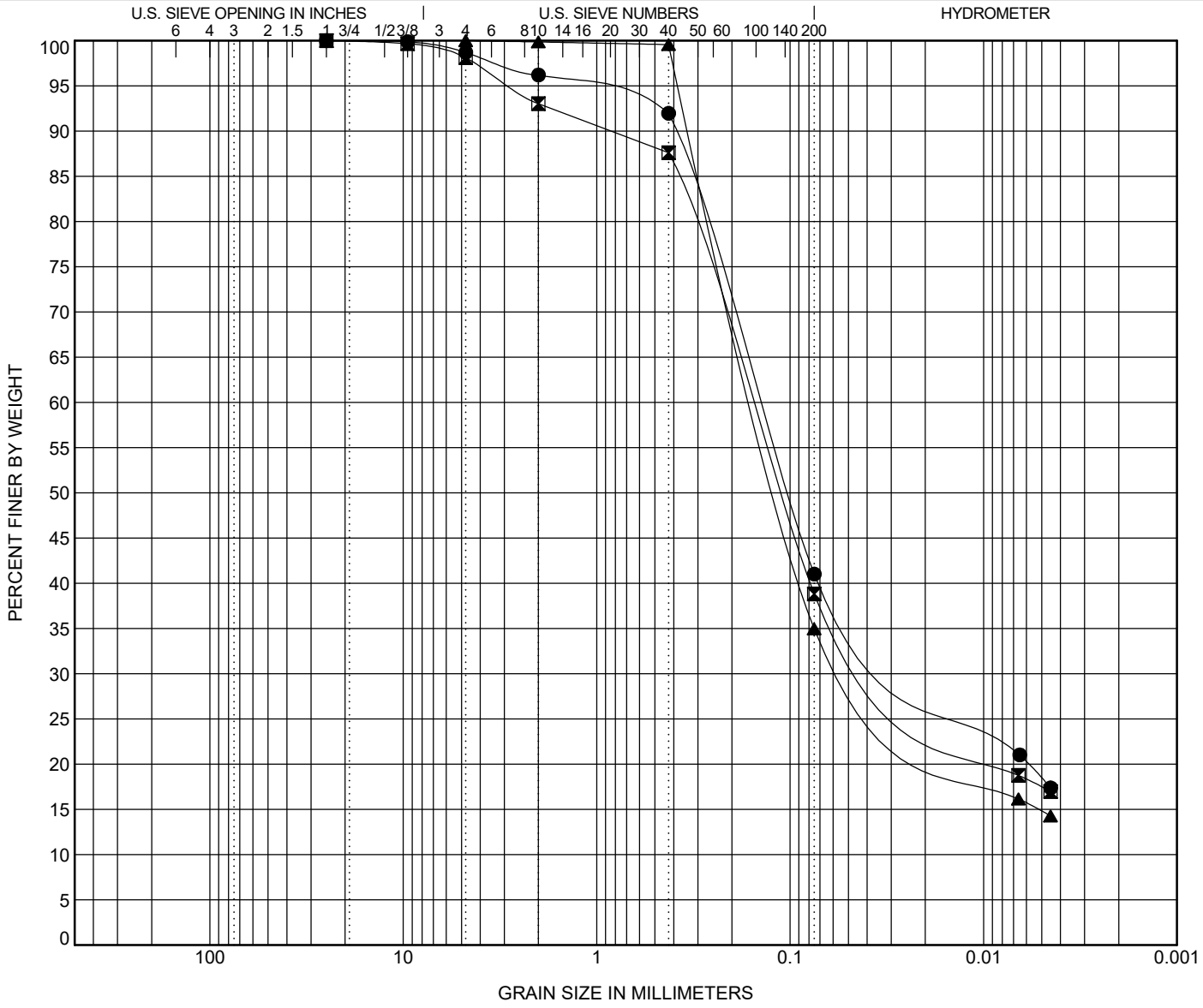

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BOREHOLE		DEPTH	AASHTO Classification	USCS Classification	LL	PL	PI	Cc	Cu
●	11	2.0	A-6 (1)	SC	29	17	12		
⊠	12	2.0	A-6 (1)	SC	29	18	11		
▲	13	2.0	A-2-4 (0)	SM	27	23	4		

BOREHOLE		DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	11	2.0	25	0.143	0.019		1.3	57.7	41.0	
⊠	12	2.0	25	0.159	0.026		1.9	59.3	38.8	
▲	13	2.0	4.75	0.147	0.04		0.0	65.0	35.0	

SUMMARY OF LABORATORY RESULTS

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

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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
1	2.0	22	17	5	9.5	39	A-4 (0)	SC-SM	13.2	13.0			
1	3.0								13.8	13.0			
1	4.0								12.5	13.0			
1	5.0								12.6	13.0			
2	2.0	29	15	14	25	52	A-6 (4)	CL	14.6	19.1			
2	3.0								15.7	19.1			
2	4.0								19.5	19.1			
2	5.0								26.4	19.1			
3	2.0	25	15	10	9.5	44	A-4 (1)	SC	11.0	14.1			
3	3.0								12.3	14.1			
3	4.0								16.5	14.1			
3	5.0								16.3	14.1			
4	2.0	27	16	11	9.5	38	A-6 (1)	SC	13.4	14.6			
4	3.0								14.4	14.6			
4	4.0								13.8	14.6			
4	5.0								16.8	14.6			
5	2.0	30	16	14	9.5	42	A-6 (2)	SC	13.7	15.5			
5	3.0								13.1	15.5			
5	4.0								14.2	15.5			
5	5.0								21.1	15.5			
6	2.0	32	19	13	25	43	A-6 (2)	SC	13.1	17.7			
6	3.0								16.5	17.7			
6	4.0								20.9	17.7			
6	5.0								20.3	17.7			
7	2.0	30	17	13	25	40	A-6 (2)	SC	9.8	10.3			
7	3.0								11.4	10.3			
7	4.0								9.3	10.3			
7	5.0								10.6	10.3			
8	2.0	28	17	11	9.5	43	A-6 (1)	SC	9.7	10.4			
8	3.0								11.2	10.4			
8	4.0								10.6	10.4			
8	5.0								9.9	10.4			
9	2.0	28	19	9	25	32	A-2-4 (0)	SC	8.1	9.3			
9	3.0								11.5	9.3			
9	4.0								8.8	9.3			
9	5.0								8.9	9.3			
10	2.0	33	18	15	25	42	A-6 (3)	SC	11.2	15.6			
10	3.0								13.9	15.6			
10	4.0								19.8	15.6			
10	5.0								17.5	15.6			
11	2.0	29	17	12	25	41	A-6 (1)	SC	8.0	11.6			
11	3.0								13.6	11.6			
11	4.0								13.4	11.6			

SUMMARY OF LABORATORY RESULTS

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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
11	5.0								11.2	11.6			
12	2.0	29	18	11	25	39	A-6 (1)	SC	14.0	12.2			
12	3.0								11.2	12.2			
12	4.0								11.8	12.2			
12	5.0								11.8	12.2			
13	2.0	27	23	4	4.75	35	A-2-4 (0)	SM	10.6	10.9			
13	3.0								10.6	10.9			
13	4.0								11.5	10.9			
13	5.0								11.0	10.9			