Revised: May 24, 2021
February 18, 2021

ENTECH
ENGINEERING, INC.

505 ELKTON DRIVE
COLORADO SPRINGS, CO 80907
PHONE (719) 531-5599
FAX (719) 531-5238

M.A. Infrastructure
1230 Scarsbrook Court
Monument, CO 80132

Attn: Matt Dunston

Re: Pavement Recommendations - Revised
Walden Preserve Filing 4
Pinehurst Circle and Deboodt Court
El Paso County, Colorado

Dear Mr. Dunston:

As requested, Entech Engineering, Inc. obtained samples of the pavement subgrade soils from the proposed roadways at the above referenced site. Laboratory testing was performed in order to determine the pavement support characteristics of the soil. This letter presents the results of the laboratory testing and pavement recommendations for the roadways.

Project Description

The project will consist of paving of the proposed Deboodt Court and a portion of Pinehurst Circle in the Walden Preserve Filing No. 4 subdivision in El Paso County, Colorado. Subsurface Soil Investigation and laboratory testing were performed to determine the pavement support characteristics on the soils. The general layout of the site is presented in the Test Boring Location Map in Figure 1.

Subgrade Conditions

A total of five test borings were drilled along the roadways to depths of approximately 5 and 10 feet below the existing subgrade surface at the required sample frequency. At the time of our field investigation the subgrade was in good condition and adequate for vehicle traffic, including emergency vehicles.

The soils at the roadway subgrade depth consisted of silty to clayey sand fill (Soil Type 1) and very clayey sand to sandy clay fill (Soil Type 2). The Test Boring Logs are presented in Appendix A. Sieve Analyses and Atterberg Limit testing were performed on subgrade soil samples obtained from the test borings for the purpose of classification. The percent passing the No. 200 sieve for the Type 1 soils ranged from approximately 20 to 32 percent and 43 to 65 percent for the Type 2 soils. The Type 3 soils are beneath the subgrade influence zone.

The Type 1 soils classified as A-2-4 to A-2-6, which commonly exhibits good pavement support characteristics. The Type 2 soils classified as A-6 soils, which exhibit poor pavement support characteristics. Groundwater was not encountered in the test borings. Sulfate testing resulted in 0.00 to less than 0.01 percent soluble sulfate by weight, indicating a negligible potential for below grade concrete degradation due to sulfate attack.

Swell/Consolidation tests on the Type 1 soils resulted in a volume change of 1.4. Swell tests on the Type 2 soils resulted in volume changes of 0.8 to 1.5, which are below levels in which mitigation is required. Mitigation for expansive soils is not required on this site.

California Bearing Ratio (CBR) testing was performed on a representative subgrade sample of the Type 2 materials to determine the support characteristics of the subgrade soils for the roadway sections. The Type 2 soils were the only site materials analyzed as they will provide conservative sections for all of the site soils using cement stabilized subgrade. The results of the CBR testing, are presented in Appendix B and summarized as follows:

Soil Type 1 – Silty Sand Fill		Soil Type 2 – Very Clayey Sand Fill	
CBR 2		CBR 1	
R @ 95% = 65.0		R @ 95% = 6.0	
R @ 90% = 37.0		R @ 90% = 5.0	
Use R = 40.0 for design		Use R = 6.0 for design	
Classification Testing		Classification Testing	
Liquid Limit	NV	Liquid Limit	25
Plasticity Index	NP	Plasticity Index	14
Percent Passing 200	20.1	Percent Passing 200	42.7
AASHTO Classification	A-2-4	AASHTO Classification	A-6
Group Index	0	Group Index	2
Unified Soils Classification	SM	Unified Soils Classification	SC

Pavement Design

CBR testing was used to determine pavement sections for the roadways. Pavement sections were determined utilizing El Paso County Pavement Design Criteria Manual. Pinehurst Circle classifies as a Rural Minor Collector, which used an 18K ESAL value of 109,500 for design purposes. Deboodt Court classifies as Rural Local Road, which used an 18K ESAL value of 36,500 for design purposes. Pavement sections were determined for asphalt on cement stabilized subgrade.

Design parameters used in the pavement analysis for the roadways are as follows:

Reliability	80%
Δpsi (Rural Minor Collector)	2.5
Δpsi (Rural Local)	2.0
"R" Value Subgrade (Soil Type 1)	40.0
"R" Value Subgrade (Soil Type 2)	6.0
Resilient Modulus (Soil Type 1)	9,497 psi
Resilient Modulus (Soil Type 2)	3,126 psi
Hot Bituminous Pavement	0.45
Cement Stabilized Subgrade	0.12

The pavement design calculations are presented in Appendix C. Pavement section alternatives for the roadway sections are presented below. Any additional grading may result in subgrade soils with different support characteristics. The following pavement sections should be re-evaluated if additional grading is performed.

Pavement Sections
ESAL = 36,500 – Deboodt Court
Soil Type 1

Alternative	Asphalt (in)	Cement Stabilized Subgrade (in)
1. Asphalt Over Stabilized Subgrade	4.0	8.0

Pavement Sections
ESAL = 109,500 – Pinehurst Circle

Soil Type 1

Alternative	Asphalt (in)	Cement Stabilized Subgrade (in)
1. Asphalt Over Stabilized Subgrade	4.0	8.0

Soil Type 2

Alternative	Asphalt (in)	Cement Stabilized Subgrade (in)
1. Asphalt Over Stabilized Subgrade	4.0	10.0

Roadway Construction – Cement Stabilized Subgrade

Prior to placement of the asphalt, the subgrade shall be stabilized by addition of cement to a depth of at least 8 to 10-inches. The amount of cement applied shall be 2.0 percent (by weight) of the subgrade's maximum dry density as determined by the Modified Proctor Test (ASTM D-1557) for the Type 1 soils and by the Standard Proctor Test (ASTM D-698) for the Type 2 soils based on laboratory cement stabilization testing. The cement should be spread evenly on the subgrade surface and be thoroughly mixed into the subgrade over an 8 to 10-inch depth such that a uniform blend of soil and cement is achieved. Prior to application or mixing of the cement, the upper 8 to 10-inches of subgrade should be thoroughly moisture conditioned to the soil's optimum water content or as much as 2 percent more than the optimum water content as necessary to provide a compactable soil condition. Densification of the cement-stabilized subgrade should be completed to obtain a compaction of at least 95 percent of the subgrade maximum dry density as determined by the Standard Proctor Test (ASTM D-698). Satisfactory compaction of the subgrade shall occur within 90 minutes from the time of mixing the cement into the subgrade.

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Pinehurst Circle and Deboodt Court
El Paso County, Colorado

The following conditions shall be observed as part of the subgrade stabilization:

- Type I/II cement as supplied; a local supplier shall be used. All cement used for stabilization should come from the same source. If cement sources are changed a new laboratory mix design should be completed.

- Moisture conditioning of the subgrade and/or mixing of the cement into the subgrade shall not occur when soil temperatures are below 40° F. Cement treated subgrades should be maintained at a temperature of 40° F or greater until the subgrade has been compacted as required.

- Cement placement, cement mixing and compaction of the cement treated subgrade should be observed by a Soils Engineer. The Soils Engineer should complete in situ compaction tests and construct representative compacted specimens of the treated subgrade material for subsequent laboratory quality assurance testing.

If significant grading is performed, the soils at subgrade may change. Modification to the pavement sections should be evaluated after site grading is completed.

In addition to the above guidance, the asphalt, cement, subgrade conditions, compaction of materials and roadway construction methods shall meet the El Paso County specifications.

We trust that this has provided you with the information you required. The pavement sections provided are based on general site soil types. If you have any questions or need additional information, please do not hesitate to contact us.

Respectfully Submitted,

ENTECH ENGINEERING, INC.

Daniel P. Stegman

JCG/bs

Encl.

Entech Job No. 210191
AAprojects/2021/210191 pr – REV2

Reviewed by:

COLORADO LICENSED
JOSEPH COLLIN GOODE JR.
23725
PROFESSIONAL ENGINEER

5/25/21

Joseph C. Goode, Jr., P.E.
President

TABLE

TABLE 1

SUMMARY OF LABORATORY TEST RESULTS

CLIENT MA INFRASTRUCTURE
PROJECT WALDEN PRESERVE
JOB NO. 210191

SOIL TYPE	TEST BORING NO.	DEPTH (FT)	WATER (%)	DRY DENSITY (PCF)	PASSING NO. 200 SIEVE (%)	LIQUID LIMIT (%)	PLASTIC INDEX (%)	SULFATE (WT %)	AASHTO CLASS.	SWELL/ CONSOL (%)	UNIFIED CLASSIFICATION	SOIL DESCRIPTION
1, CBR	1	1-2			20.1	NV	NP	0.00	A-2-4		SM	FILL, SAND, SILTY
1	2	1-2			32.2	12	7		A-2-4		SC	FILL, SAND, CLAYEY
1	3	1-2	10.4	118.2	31.4	23	11		A-2-6	1.4	SC	FILL, SAND, CLAYEY
2, CBR	4	0-3	8.3	114.7	42.7	25	14		A-6	0.8	SC	FILL, SAND, VERY CLAYEY
2	4	1-2	6.9	119.7	44.6	25	13	<0.01	A-6	1.1	SC	FILL, SAND, VERY CLAYEY
2	5	1-2	11.5	115.1	64.8	30	18		A-6	1.5	CL	FILL, CLAY, SANDY
3	1	5			37.4	29	13		A-6		SC	SAND, VERY CLAYEY
3	3	10	9.2	117.8	45.1	26	12	<0.01	A-6	0.6	SC	SAND, VERY CLAYEY

FIGURE

SOIL TYPE 1:

ESAL = 109,500
4" ASPHALT OVER 8" OF CTS

ESAL = 36,500
4" ASPHALT OVER 8" OF CTS

SOIL TYPE 2:

ESAL = 109,500
4" ASPHALT OVER 10" OF CTS

*SOILS TRANSITIONS TO BE FIELD DETERMINED

TB- APPROXIMATE TEST BORING LOCATIONS AND NUMBERS

REVISION	BY

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TEST BORING LOCATION MAP
WALDEN PRESERVE FILING 4
EL PASO COUNTY, CO
FOR: M.A. INFRASTUCTURE

DRAWN JAC
CHECKED DPS
DATE 02/17/21
SCALE AS SHOWN
JOB NO. 210191
FIGURE No. 1

APPENDIX A: Test Boring Logs

TEST BORING NO. 1
DATE DRILLED 2/10/2021
Job # 210191

REMARKS

DRY TO 5', 2/10/21

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			50 7"	9.0	1
5			21	10.1	3
10					
15					
20					

FILL 0-4', SAND, SILTY, FINE TO COARSE GRAINED, BROWN, VERY DENSE, MOIST

SAND, SILTY, FINE TO COARSE GRAINED, TAN, MEDIUM DENSE, MOIST

TEST BORING NO. 2
DATE DRILLED 2/10/2021
CLIENT MA INFRASTRUCTURE
LOCATION WALDEN PRESERVE

REMARKS

DRY TO 5', 2/10/21

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			26	4.5	1
5			35	5.4	1
10					
15					
20					

FILL 0-5', SAND, CLAYEY, FINE TO COARSE GRAINED, BROWN, MEDIUM DENSE TO DENSE, MOIST

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TEST BORING LOG

DRAWN:	DATE:	CHECKED: DS	DATE: 2/24/21

JOB NO. 210191
FIG NO. A- 1

TEST BORING NO. 3
DATE DRILLED 2/10/2021
Job # 210191

REMARKS

DRY TO 10', 2/10/21

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			50 / 9"	5.8	1
5			40	4.6	1
10			10	10.6	3
15					
20					

FILL 0-9', SAND, CLAYEY, FINE TO COARSE GRAINED, BROWN, VERY DENSE TO DENSE, MOIST

SAND, VERY CLAYEY WITH ORGANICS, FINE GRAINED, DARK BROWN, MEDIUM DENSE, MOIST

TEST BORING NO. 4
DATE DRILLED 2/10/2021
CLIENT MA INFRASTRUCTURE
LOCATION WALDEN PRESERVE

REMARKS

DRY TO 5', 2/10/21

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			50 / 11"	5.6	2
5			33	8.1	2
10					
15					
20					

FILL 0-5', SAND, VERY CLAYEY, FINE TO COARSE GRAINED, BROWN TO TAN, VERY DENSE TO DENSE, MOIST

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TEST BORING LOG

DRAWN:	DATE:	CHECKED: DS	DATE: 4/16/21

JOB NO. 210191
FIG NO. A- 2

TEST BORING NO. 5
DATE DRILLED 2/10/2021
Job # 210191

TEST BORING NO.
DATE DRILLED
CLIENT MA INFRASTRUCTURE
LOCATION WALDEN PRESERVE

REMARKS

DRY TO 10', 2/10/21

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			22	7.0	2
5			27	3.3	2
10			33	7.6	3
15					
20					

FILL 0-5', CLAY, SANDY, BROWN, STIFF, MOIST

SAND, CLAYEY, FINE TO MEDIUM GRAINED, BROWN, DENSE, MOIST

REMARKS

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
5					
10					
15					
20					

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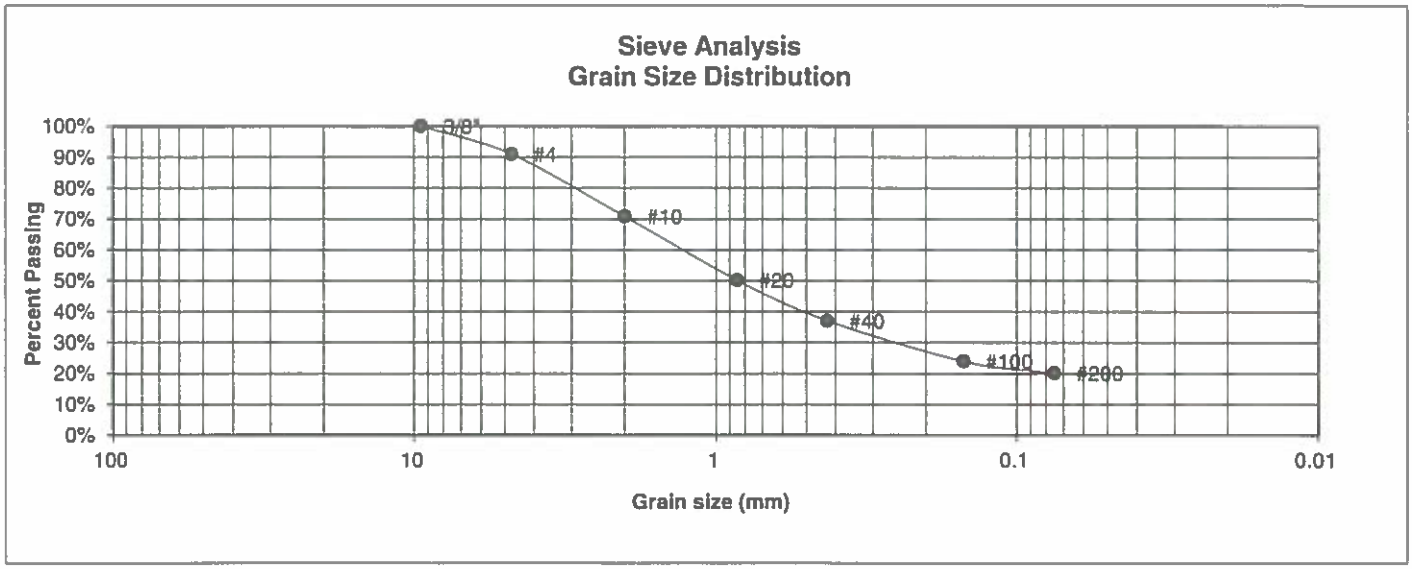
TEST BORING LOG

DRAWN:	DATE:	CHECKED:	DATE:
		TJJ	2-24-21

JOB NO.: 210191
FIG NO.: A- 3

APPENDIX B: Laboratory Test Results

UNIFIED CLASSIFICATION	SM	CLIENT	MA INFRASTRUCTURE
SOIL TYPE #	1, CBR	PROJECT	WALDEN PRESERVE
TEST BORING #	1	JOB NO.	210191
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-2-4	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	91.0%
10	70.9%
20	50.2%
40	37.1%
100	23.9%
200	20.1%

Atterberg Limits	
Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

Swell	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	

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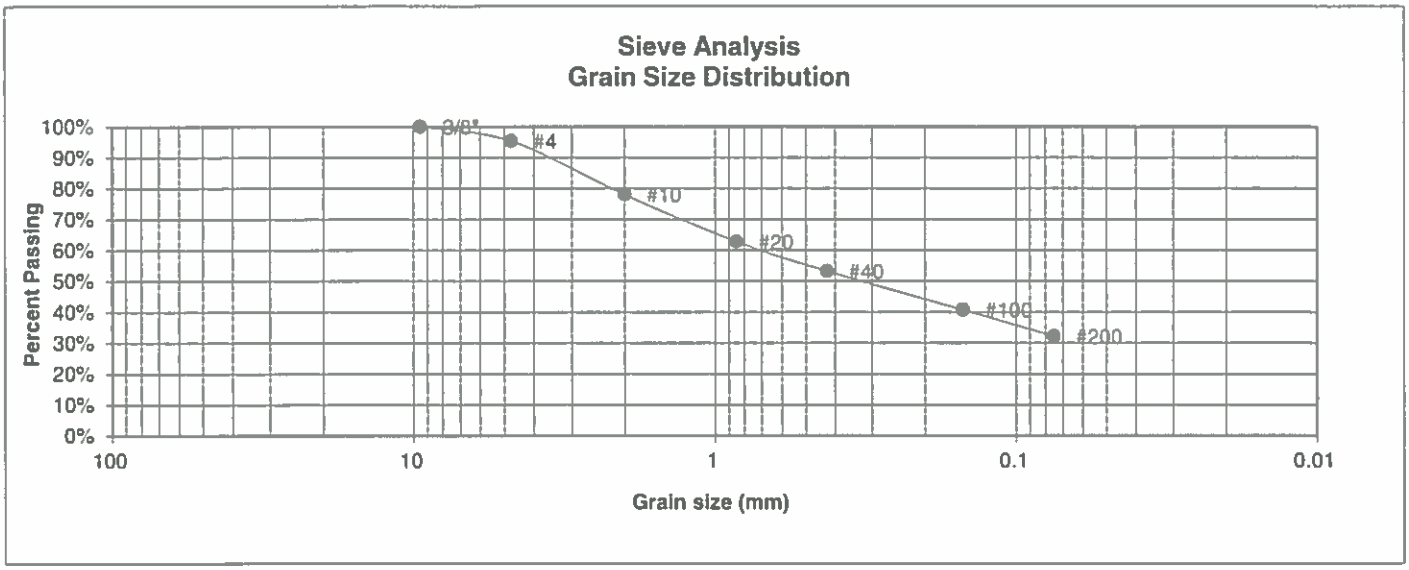
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED: DJ	DATE: 4/16/21

JOB NO.: 210191
FIG NO.: B-1

UNIFIED CLASSIFICATION	SC	CLIENT	MA INFRASTRUCTURE
SOIL TYPE #	1	PROJECT	WALDEN PRESERVE
TEST BORING #	2	JOB NO.	210191
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-2-4	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	95.3%
10	78.0%
20	62.8%
40	53.3%
100	40.7%
200	32.2%

Atterberg Limits	
Plastic Limit	5
Liquid Limit	12
Plastic Index	7

Swell	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	

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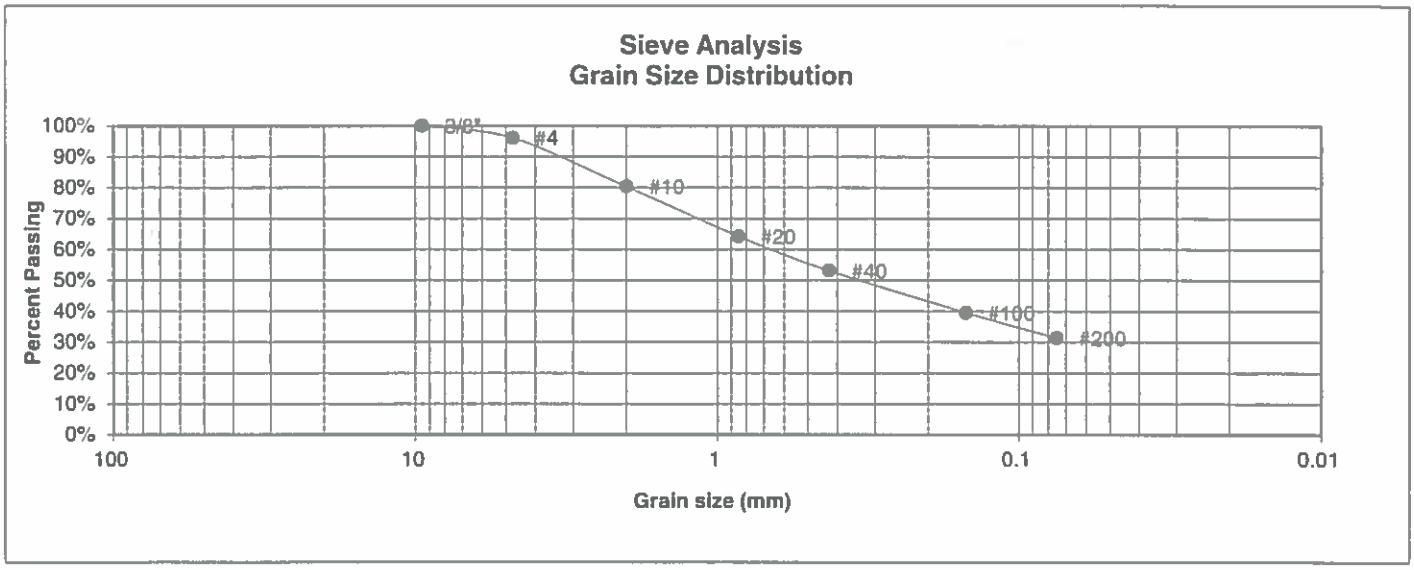
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
		DS	2/24/21

JOB NO. 210191
FIG NO. B-2

UNIFIED CLASSIFICATION	SC	CLIENT	MA INFRASTRUCTURE
SOIL TYPE #	1	PROJECT	WALDEN PRESERVE
TEST BORING #	3	JOB NO.	210191
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-2-6	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	96.1%
10	80.4%
20	64.2%
40	53.1%
100	39.5%
200	31.4%

Atterberg Limits	
Plastic Limit	13
Liquid Limit	23
Plastic Index	11

Swell	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	

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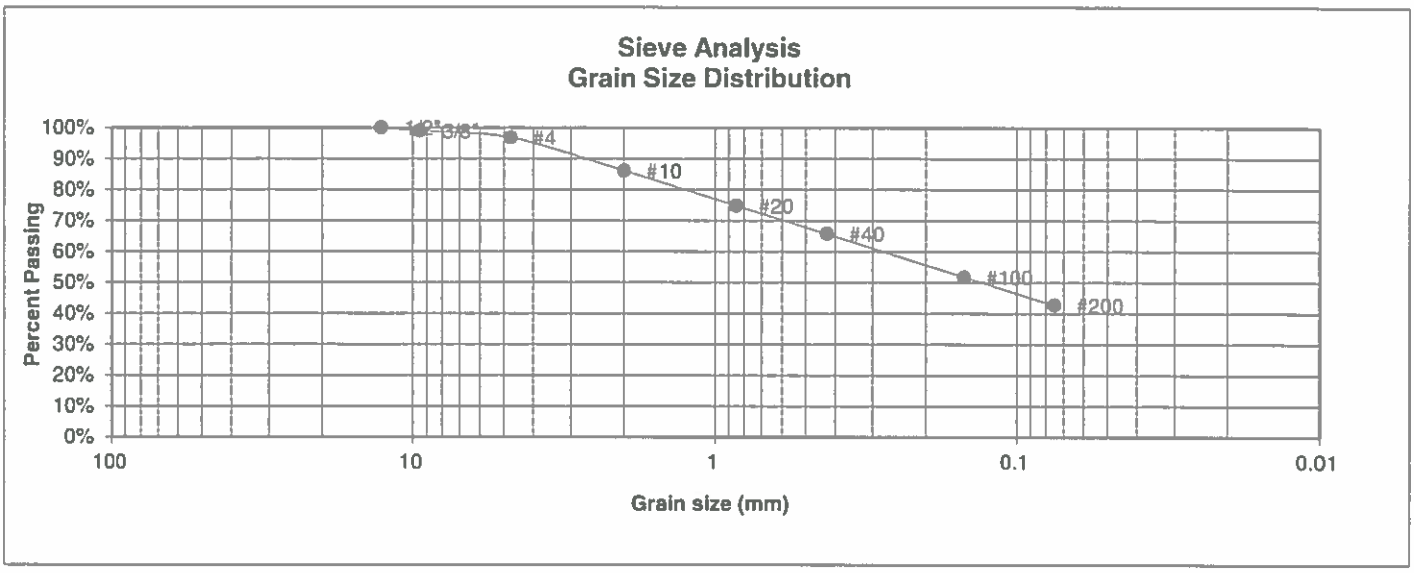
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED: DS	DATE: 2/24/21

JOB NO.: 210191
FIG NO.: B-3

UNIFIED CLASSIFICATION	SC	CLIENT	MA INFRASTRUCTURE
SOIL TYPE #	2, CBR	PROJECT	WALDEN PRESERVE
TEST BORING #	4	JOB NO.	210191
DEPTH (FT)	0-3	TEST BY	BL
AASHTO CLASSIFICATION	A-6	GROUP INDEX	2



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	99.0%
4	96.8%
10	86.1%
20	74.8%
40	65.7%
100	51.8%
200	42.7%

Atterberg Limits	
Plastic Limit	11
Liquid Limit	25
Plastic Index	14

Swell	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	

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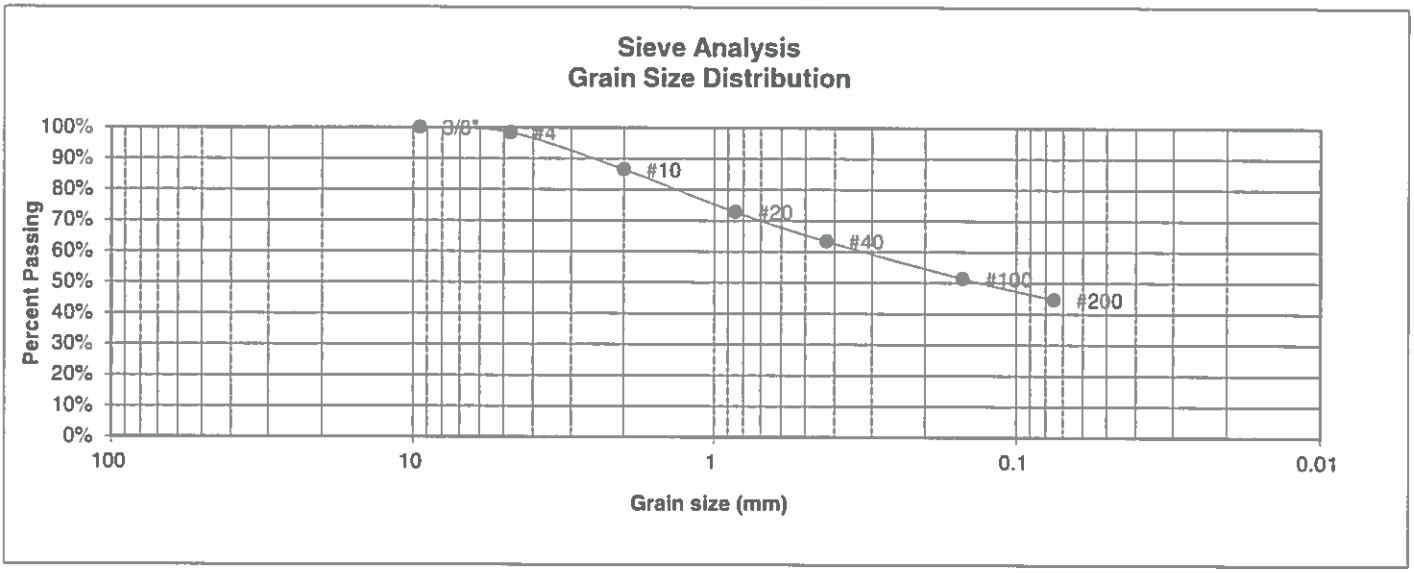
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
		DS	2/24/21

JOB NO: 210191
FIG NO: B-4

UNIFIED CLASSIFICATION	SC	CLIENT	MA INFRASTRUCTURE
SOIL TYPE #	2	PROJECT	WALDEN PRESERVE
TEST BORING #	4	JOB NO.	210191
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-6	GROUP INDEX	2



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	98.4%
10	86.5%
20	72.8%
40	63.4%
100	51.4%
200	44.6%

Atterberg Limits	
Plastic Limit	12
Liquid Limit	25
Plastic Index	13

Swell	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	

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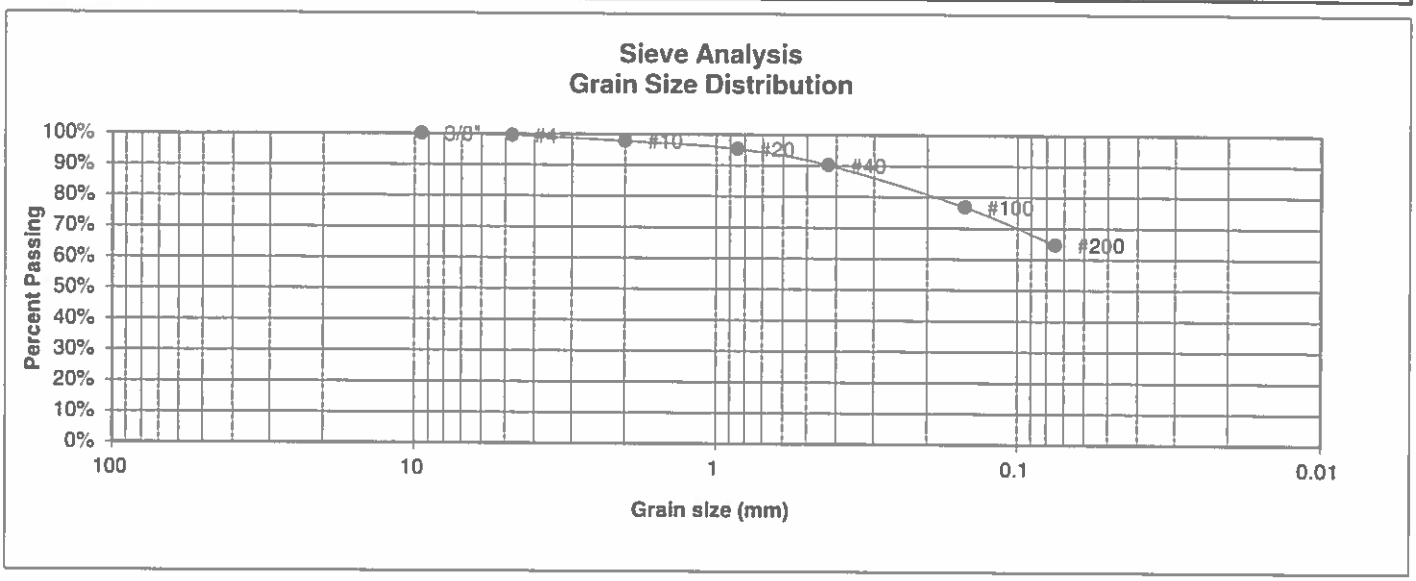
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
		DS	2/24/21

JOB NO. 210191
FIG NO. B-5

UNIFIED CLASSIFICATION	CL	CLIENT	MA INFRASTRUCTURE
SOIL TYPE #	2	PROJECT	WALDEN PRESERVE
TEST BORING #	5	JOB NO.	210191
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-6	GROUP INDEX	8



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	99.5%
10	97.8%
20	95.3%
40	90.2%
100	76.8%
200	64.8%

Atterberg Limits	
Plastic Limit	13
Liquid Limit	30
Plastic Index	18

Swell	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	

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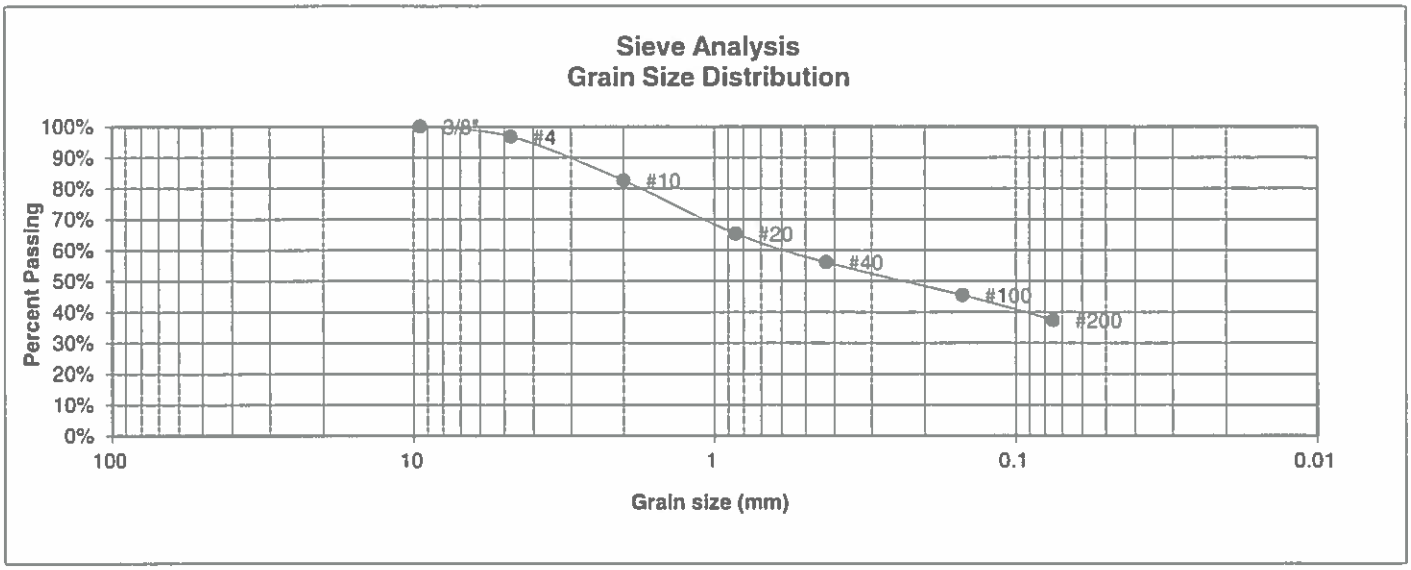
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
		DS	2/12/21

JOB NO. 210191
FIG NO. B-6

UNIFIED CLASSIFICATION	SC	CLIENT	MA INFRASTRUCTURE
SOIL TYPE #	3	PROJECT	WALDEN PRESERVE
TEST BORING #	1	JOB NO.	210191
DEPTH (FT)	5	TEST BY	BL
AASHTO CLASSIFICATION	A-6	GROUP INDEX	1



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	96.8%
10	82.6%
20	65.4%
40	56.1%
100	45.5%
200	37.4%

Atterberg Limits	
Plastic Limit	17
Liquid Limit	29
Plastic Index	13

Swell	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	

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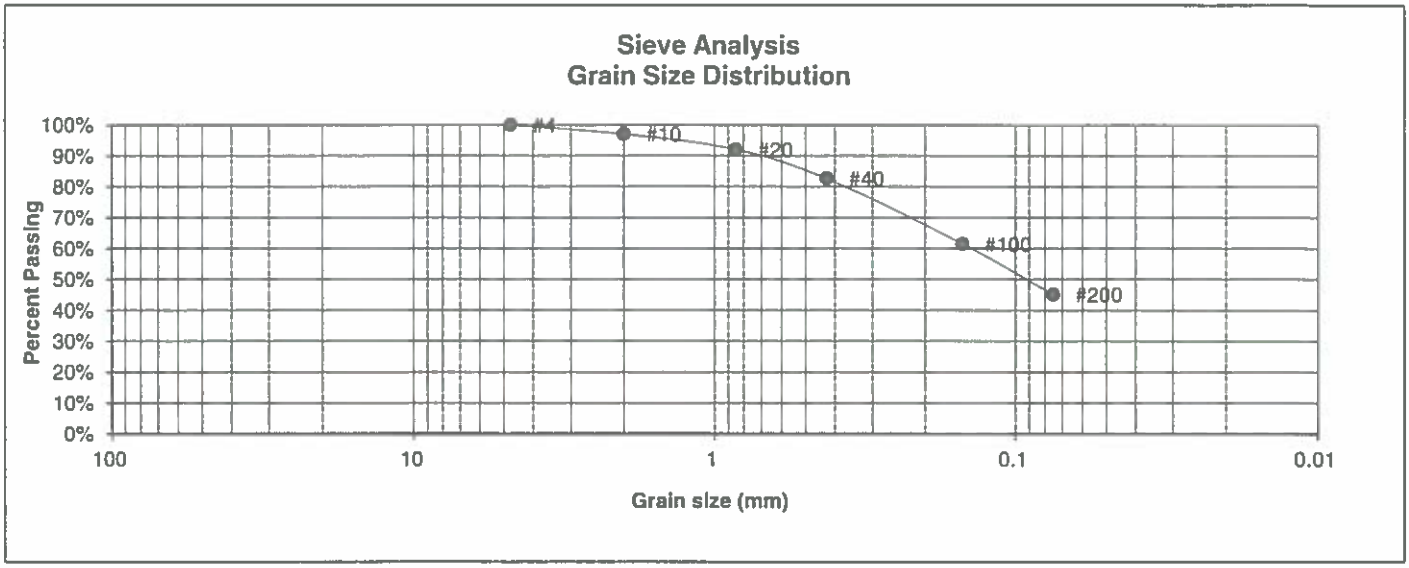
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
		DS	2/24/21

JOB NO.: 210191
FIG NO.: B-7

UNIFIED CLASSIFICATION	SC	CLIENT	MA INFRASTRUCTURE
SOIL TYPE #	3	PROJECT	WALDEN PRESERVE
TEST BORING #	3	JOB NO.	210191
DEPTH (FT)	10	TEST BY	BL
AASHTO CLASSIFICATION	A-6	GROUP INDEX	2



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	100.0%
10	97.0%
20	92.1%
40	82.6%
100	61.4%
200	45.1%

Atterberg Limits	
Plastic Limit	14
Liquid Limit	26
Plastic Index	12

Swell	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	

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LABORATORY TEST RESULTS

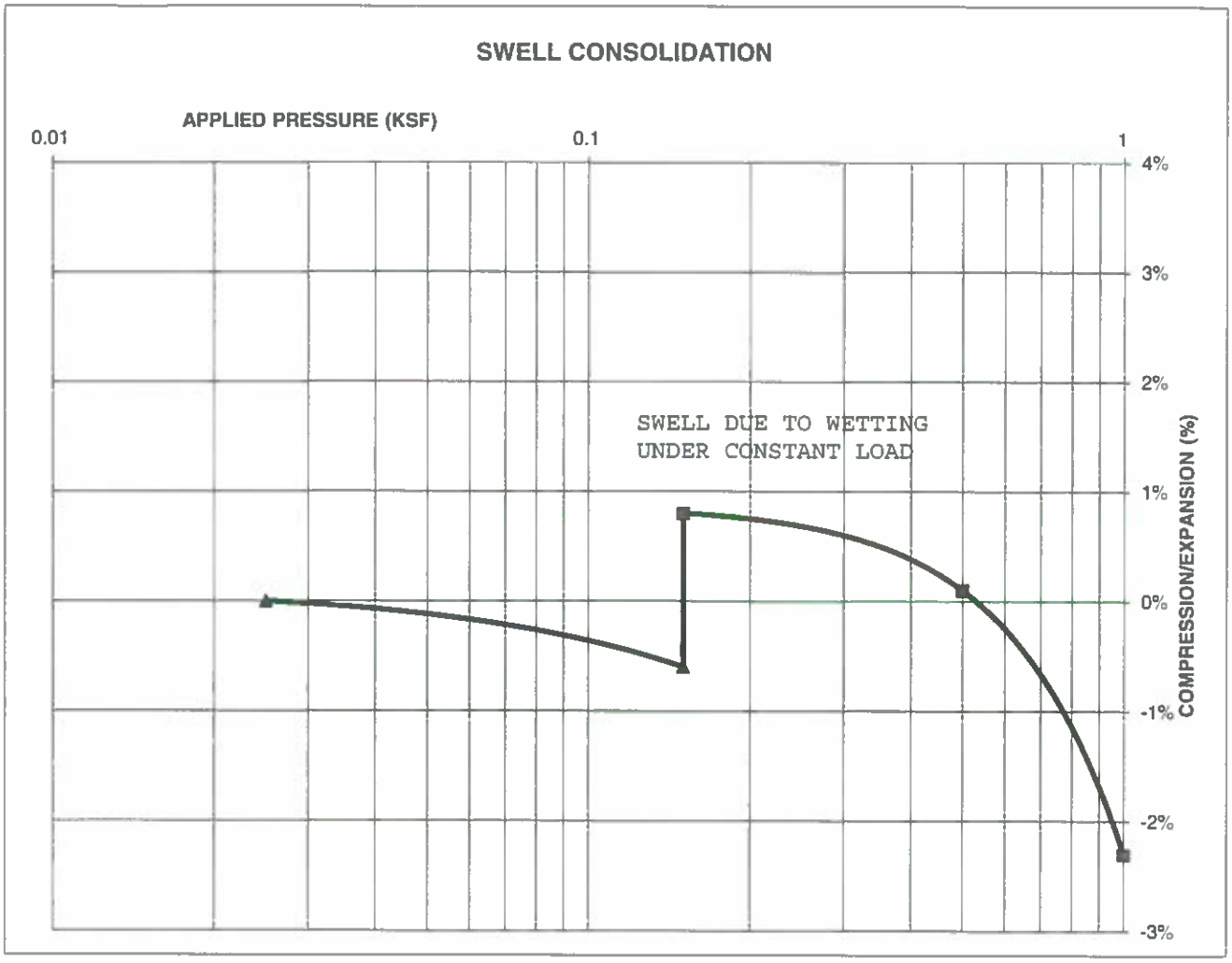
DRAWN:	DATE:	CHECKED:	DATE:
		DS	2/24/21

JOB NO. 210191
FIG NO. B-8

CONSOLIDATION TEST RESULTS

TEST BORING #	3	DEPTH(ft)	1-2
DESCRIPTION	SC	SOIL TYPE	1
NATURAL UNIT DRY WEIGHT (PCF)			118
NATURAL MOISTURE CONTENT			10.4%
SWELL/CONSOLIDATION (%)			1.4%

JOB NO. 210191
CLIENT MA INFRASTRUCTURE
PROJECT WALDEN PRESERVE



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SWELL CONSOLIDATION
TEST RESULTS

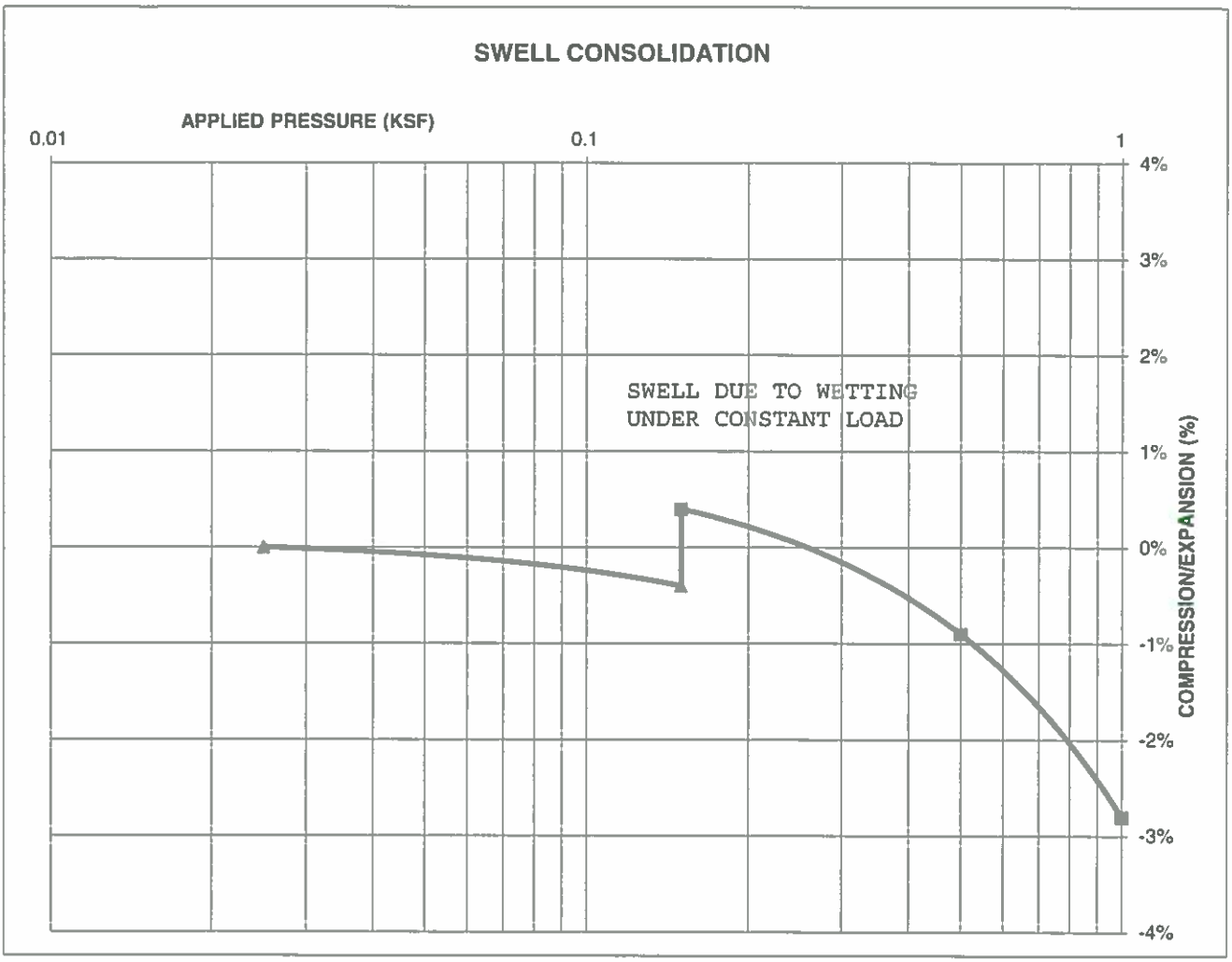
DRAWN:	DATE:	CHECKED:	DATE:
		DS	2/24/21

JOB NO.: 210191
FIG NO.: B-9

CONSOLIDATION TEST RESULTS

TEST BORING #	4	DEPTH(ft)	0-3
DESCRIPTION	SC	SOIL TYPE	2, CBR
NATURAL UNIT DRY WEIGHT (PCF)			115
NATURAL MOISTURE CONTENT			8.3%
SWELL/CONSOLIDATION (%)			0.8%

JOB NO. 210191
CLIENT MA INFRASTRUCTURE
PROJECT WALDEN PRESERVE



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SWELL CONSOLIDATION
TEST RESULTS

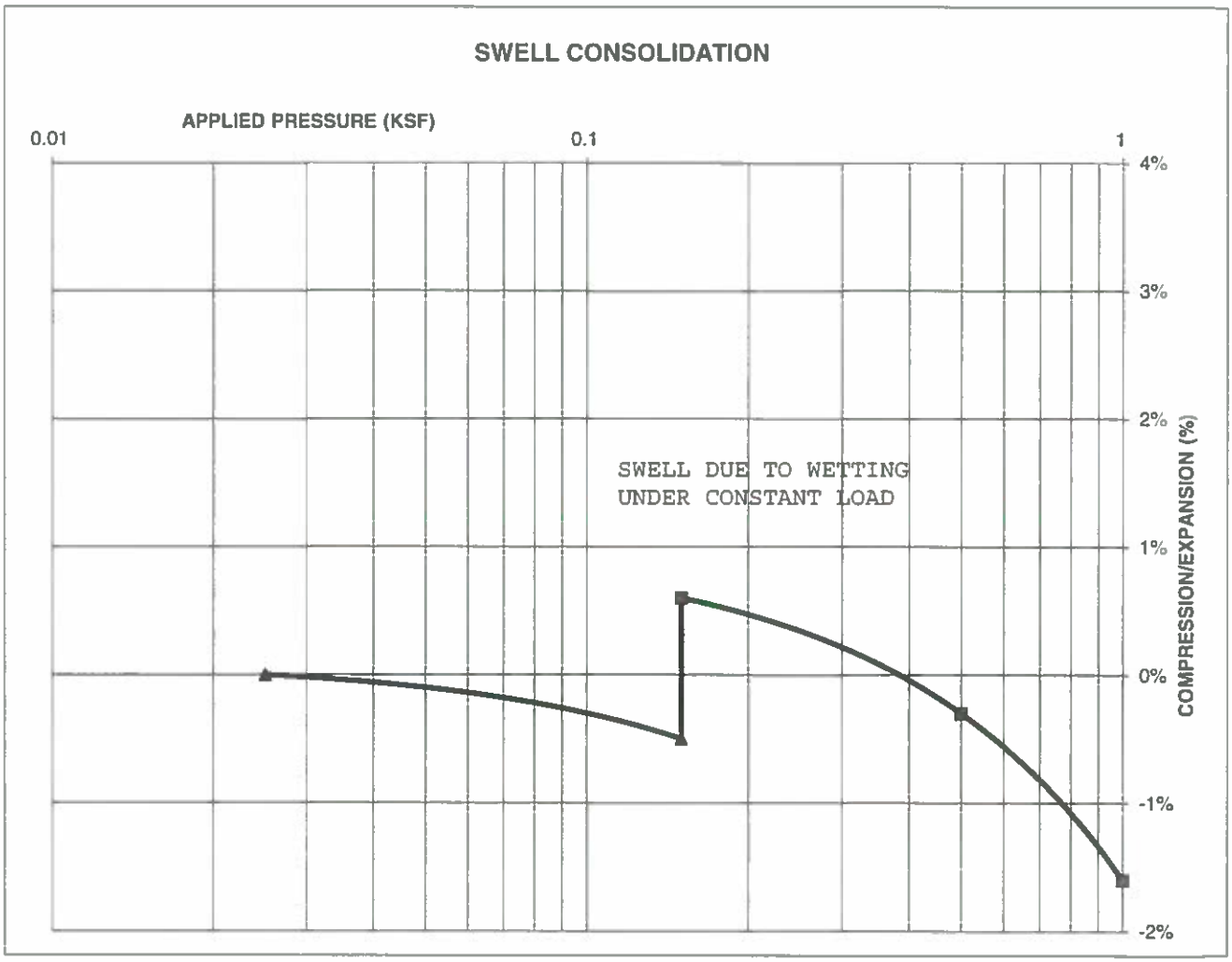
DRAWN:	DATE:	CHECKED:	DATE:
		DS	2/24/21

JOB NO. 210191
FIG NO. B-16

CONSOLIDATION TEST RESULTS

TEST BORING #	4	DEPTH(ft)	1-2
DESCRIPTION	SC	SOIL TYPE	2
NATURAL UNIT DRY WEIGHT (PCF)			120
NATURAL MOISTURE CONTENT			6.9%
SWELL/CONSOLIDATION (%)			1.1%

JOB NO. 210191
CLIENT MA INFRASTRUCTURE
PROJECT WALDEN PRESERVE



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SWELL CONSOLIDATION
TEST RESULTS

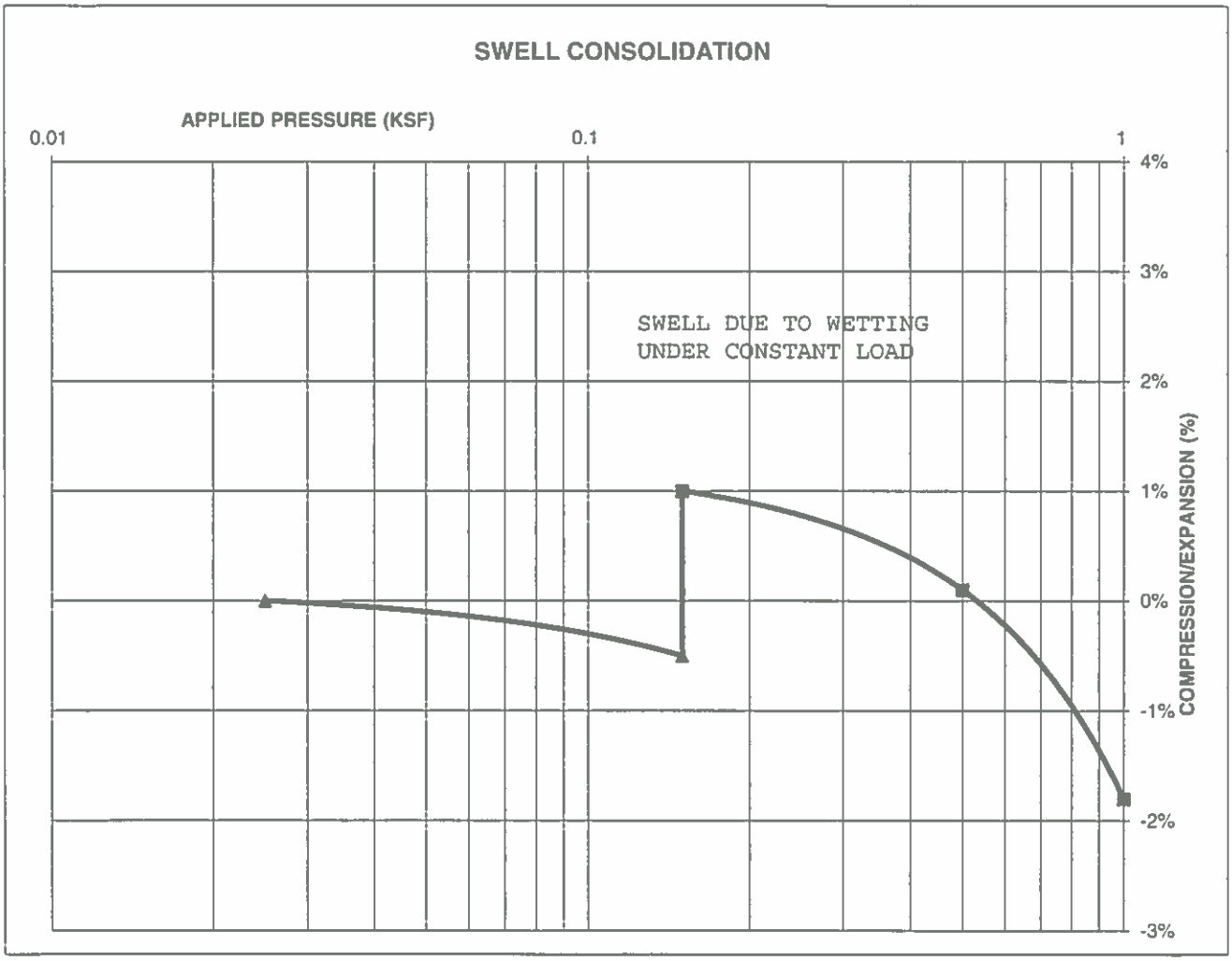
DRAWN:	DATE:	CHECKED:	DATE:
		DS	2/22/21

JOB NO.: 210191
FIG NO.: B-11

CONSOLIDATION TEST RESULTS

TEST BORING #	5	DEPTH(ft)	1-2
DESCRIPTION	CL	SOIL TYPE	2
NATURAL UNIT DRY WEIGHT (PCF)			115
NATURAL MOISTURE CONTENT			11.5%
SWELL/CONSOLIDATION (%)			1.5%

JOB NO. 210191
CLIENT MA INFRASTRUCTURE
PROJECT WALDEN PRESERVE



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SWELL CONSOLIDATION
TEST RESULTS

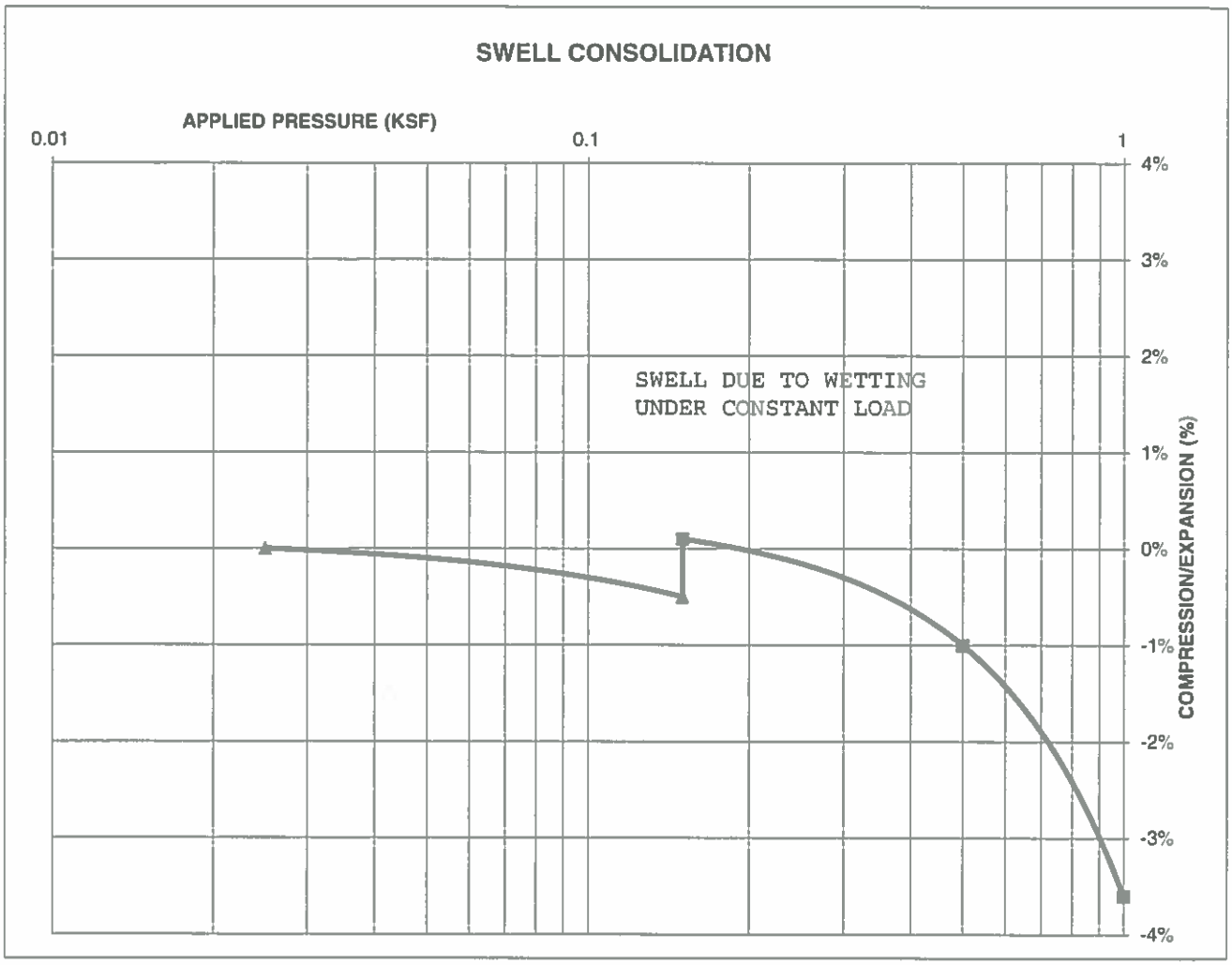
DRAWN	DATE	CHECKED	DATE
		PJS	2/24/21

JOB NO. 210191
FIG NO. B-12

CONSOLIDATION TEST RESULTS

TEST BORING #	3	DEPTH(ft)	10
DESCRIPTION	SC	SOIL TYPE	3
NATURAL UNIT DRY WEIGHT (PCF)			118
NATURAL MOISTURE CONTENT			9.2%
SWELL/CONSOLIDATION (%)			0.6%

JOB NO. 210191
CLIENT MA INFRASTRUCTURE
PROJECT WALDEN PRESERVE



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SWELL CONSOLIDATION
TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
		DS	2/24/21

JOB NO.: 210191
FIG NO.: B-18

CLIENT	MA INFRASTRUCTURE	JOB NO.	210191
PROJECT	WALDEN PRESERVE	DATE	2/16/2021
LOCATION	WALDEN PRESERVE	TEST BY	BL

BORING NUMBER	DEPTH, (ft)	SOIL TYPE NUMBER	UNIFIED CLASSIFICATION	WATER SOLUBLE SULFATE, (wt%)
TB-1	1-2	1	SM	0.00
TB-4	1-2	2	SC	<0.01
TB-3	10	3	SC	<0.01

QC BLANK PASS

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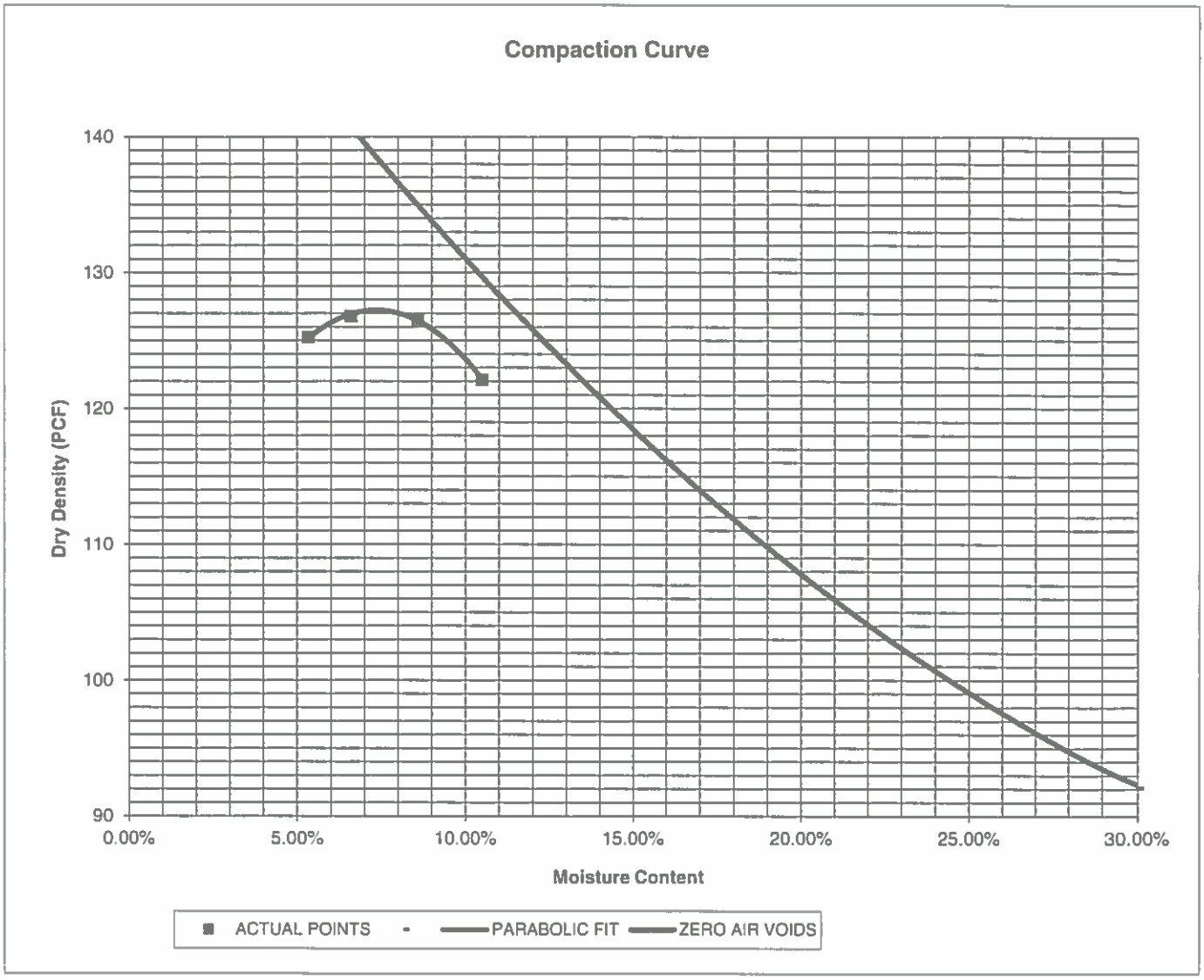
LABORATORY TEST
SULFATE RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
		DS	2/24/21

JOB NO.: 210191
FIG NO.: B-14

PROJECT	WALDEN PRESERVE	CLIENT	MA INFRASTRUCTURE
SAMPLE LOCATION	TB-1 @ 0-3'	JOB NO.	210191
SOIL DESCRIPTION	SAND, SILTY, TAN	DATE	02/17/21

IDENTIFICATION	SM	COMPACTION TEST #	2, SOIL TYPE #1
TEST DESIGNATION / METHOD	ASTM D-1557-A	TEST BY	BL
MAXIMUM DRY DENSITY (PCF)	127.2	OPTIMUM MOISTURE	7.2%



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MOISTURE DENSITY RELATION

DRAWN:	DATE:	CHECKED:	DATE:
		DS	2/24/21

JOB NO.: 210191

FIG NO.: B-15

CBR TEST LOAD DATA

JOB NO: 210191
CLIENT: MA INFRASTRUCTURE
PROJECT: WALDEN PRESERVE
SOIL TYPE: 1

PISTON DIAMETER (cm)	PISTON AREA (in^2)
4.958	2.993

PENETRATION DEPTH (INCHES)	10 BLOWS MOLD # 1 LOAD(LBS) (LBS)	STRESS (PSI)	25 BLOWS MOLD # 2 LOAD(LBS) (LBS)	STRESS (PSI)	56 BLOWS MOLD # 3 LOAD(LBS) (LBS)	STRESS (PSI)
0.000	0	0.00	0	0.00	0	0.00
0.025	74	24.73	189	63.16	268	89.56
0.050	229	76.52	409	136.67	530	177.11
0.075	334	111.61	515	172.10	960	320.80
0.100	374	124.98	597	199.50	1260	421.05
0.125	425	142.02	666	222.56	1530	511.28
0.150	514	171.76	753	251.63	1763	589.14
0.175	599	200.17	811	271.01	1964	656.31
0.200	673	224.89	871	291.06	2250	751.88
0.300	748	249.96	1037	346.53	3014	1007.18
0.400	856	286.05	1183	395.32	3665	1224.72
0.500	932	311.44	1341	448.12	4314	1441.60

FINAL MOISTURE CONTENT

	MOLD # 1	MOLD # 2	MOLD # 3
CAN #	117	340	345
WT. CAN	9.41	6.58	6.47
WT. CAN+WET	195.86	209.42	214.85
WT. CAN+DRY	176.34	191.9	198.17
WT. H20	19.52	17.52	16.68
WT. DRY SOIL	166.93	185.32	191.7
MOISTURE CONTENT	11.69%	9.45%	8.70%

WET DENSITY (PCF)		123.0	130.9	137.5
DRY DENSITY (PCF)		114.8	122.1	128.3
BEARING RATIO		12.50	19.95	42.11
90% OF DRY DENSITY	114.5			
95% OF DRY DENSITY	120.8			

BEARING RATIO AT 90% OF MAX	12.19	~ R VALUE	37
BEARING RATIO AT 95% OF MAX	18.69	~ R VALUE	65

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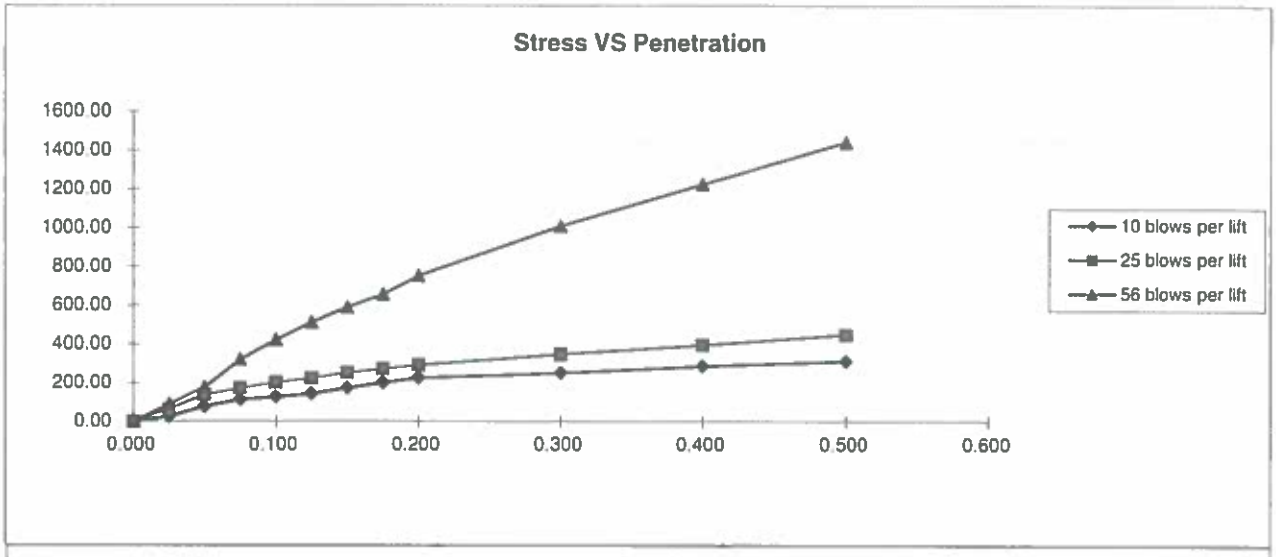
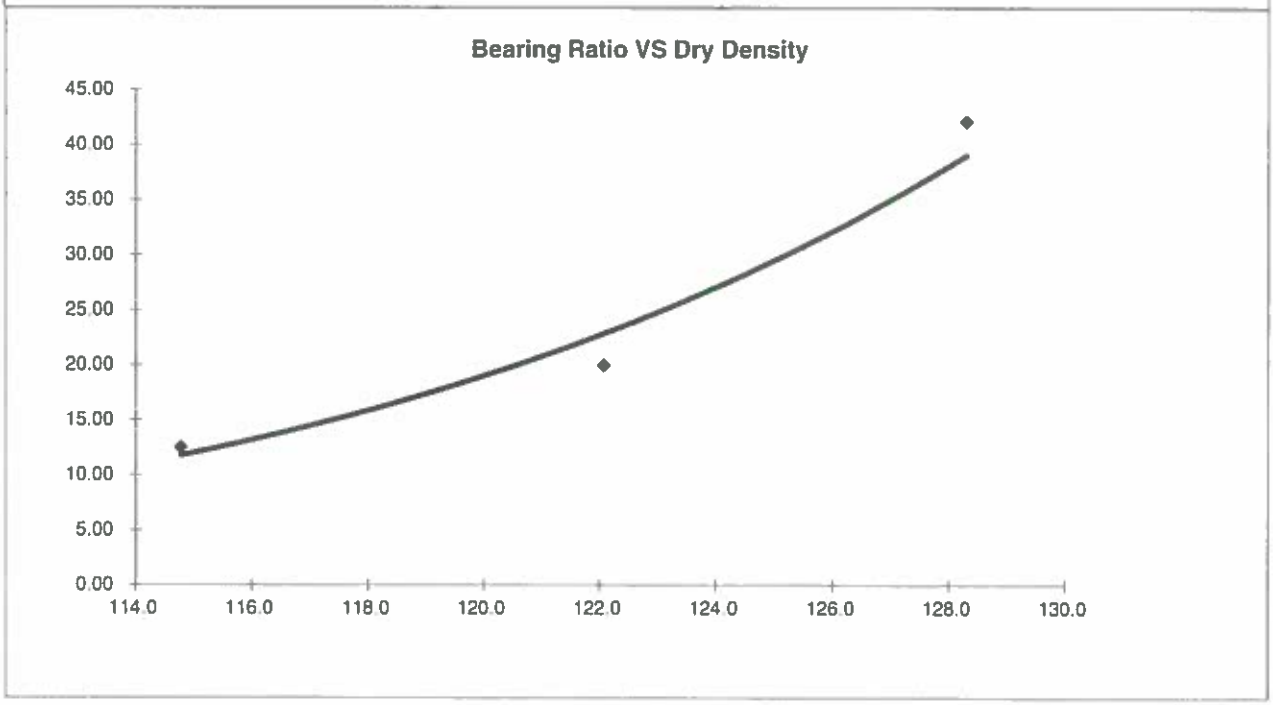
CBR TEST DATA

DRAWN:	DATE:	CHECKED:	DATE:
		TJS	2/24/21

JOB NO.: 210191
FIG NO.: Bulk





BEARING RATIO AT 90% OF MAX	12.19	~ R VALUE	37.00
BEARING RATIO AT 95% OF MAX	18.69	~ R VALUE	65.00

JOB NO: 210191
SOIL TYPE: I

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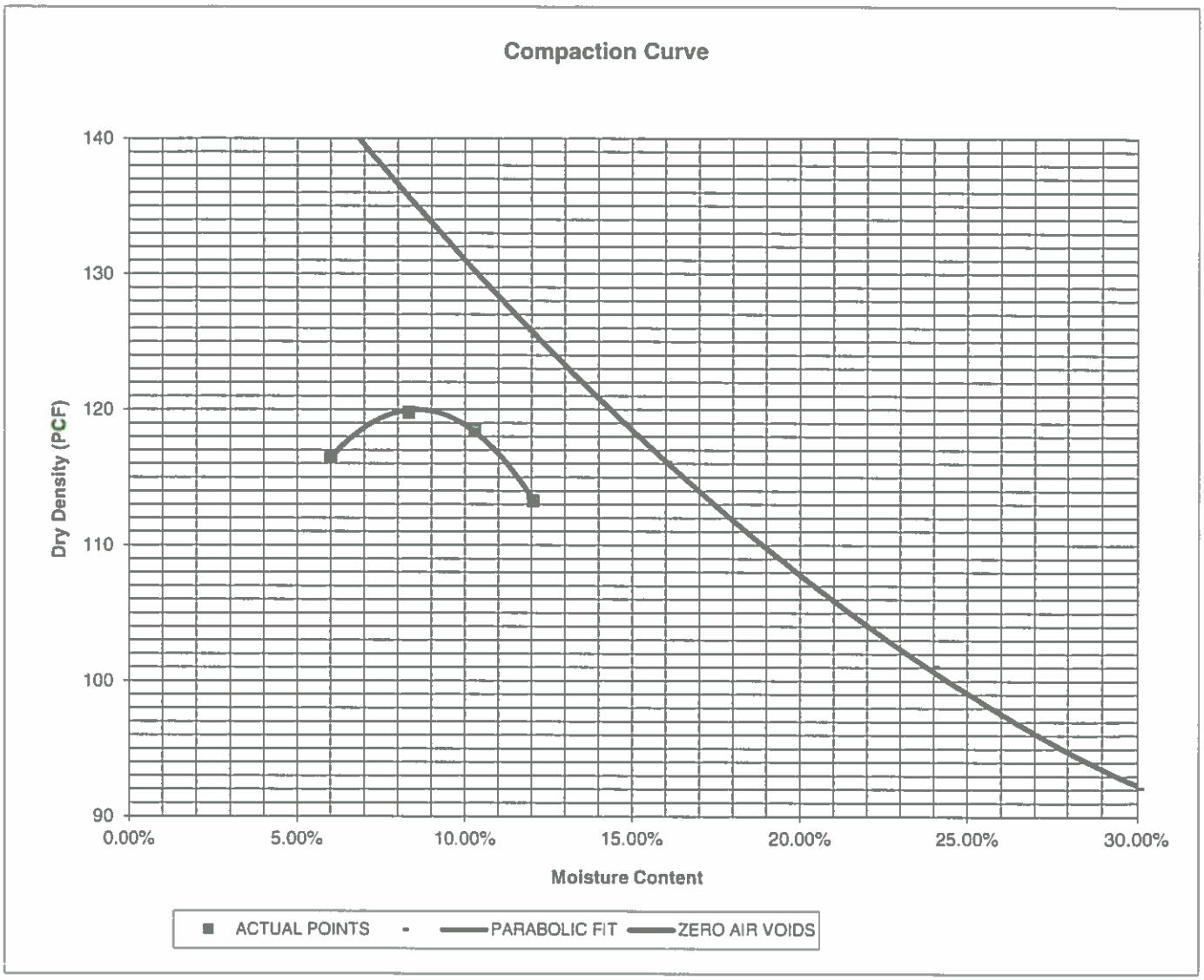
CALIFORNIA BEARING RATIO

DRAWN:	DATE:	CHECKED:	DATE:
		DS	2/24/21

JOB NO.: 210191
FIG NO.: B-17

PROJECT	WALDEN PRESERVE	CLIENT	MA INFRASTRUCTURE
SAMPLE LOCATION	TB-4 @ 0-3'	JOB NO.	210191
SOIL DESCRIPTION	FILL, SAND, V. CLAYEY, BROWN	DATE	02/16/21

IDENTIFICATION	SC	COMPACTION TEST #	1, SOIL TYPE #2
TEST DESIGNATION / METHOD	ASTM D-698-A	TEST BY	BL
MAXIMUM DRY DENSITY (PCF)	119.9	OPTIMUM MOISTURE	8.6%



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MOISTURE DENSITY RELATION

DRAWN:	DATE:	CHECKED:	DATE:
		DS	2/22/21

JOB NO.: 210191

FIG NO.: B-18

CBR TEST LOAD DATA

JOB NO: 210191
CLIENT: MA INFRASTRUCTURE
PROJECT: WALDEN PRESERVE
SOIL TYPE: 2

PISTON DIAMETER (cm)	PISTON AREA (in^2)
4.958	2.993

PENETRATION DEPTH (INCHES)	*10 BLOWS* MOLD # 1 LOAD(LBS) (LBS)	STRESS (PSI)	*25 BLOWS* MOLD # 2 LOAD(LBS) (LBS)	STRESS (PSI)	*56 BLOWS* MOLD # 3 LOAD(LBS) (LBS)	STRESS (PSI)
0.000	0	0.00	0	0.00	0	0.00
0.025	28	9.36	47	15.71	56	18.71
0.050	40	13.37	63	21.05	73	24.39
0.075	59	19.72	73	24.39	82	27.40
0.100	74	24.73	89	29.74	93	31.08
0.125	83	27.74	96	32.08	121	40.43
0.150	91	30.41	108	36.09	128	42.77
0.175	99	33.08	115	38.43	136	45.45
0.200	104	34.75	130	43.44	148	49.46
0.300	113	37.76	171	57.14	190	63.49
0.400	130	43.44	192	64.16	224	74.85
0.500	147	49.12	214	71.51	263	87.89

FINAL MOISTURE CONTENT

	MOLD #	1	MOLD #	2	MOLD #	3
CAN #		346		351		353
WT. CAN		6.8		6.77		6.7
WT. CAN+WET		178.45		185.84		204.25
WT. CAN+DRY		149.459		158.23		177.41
WT. H20		28.991		27.61		26.84
WT. DRY SOIL		142.659		151.46		170.71
MOISTURE CONTENT		20.32%		18.23%		15.72%
WET DENSITY (PCF)		120.6		124.6		129.2
DRY DENSITY (PCF)		111.0		114.7		119.0
BEARING RATIO		2.47		2.97		3.11
		0.92601748		0.9569374		0.99237116
90% OF DRY DENSITY	107.9					
95% OF DRY DENSITY	113.9					

BEARING RATIO AT 90% OF MAX	2.05	~ R VALUE	5
BEARING RATIO AT 95% OF MAX	2.86	~ R VALUE	6

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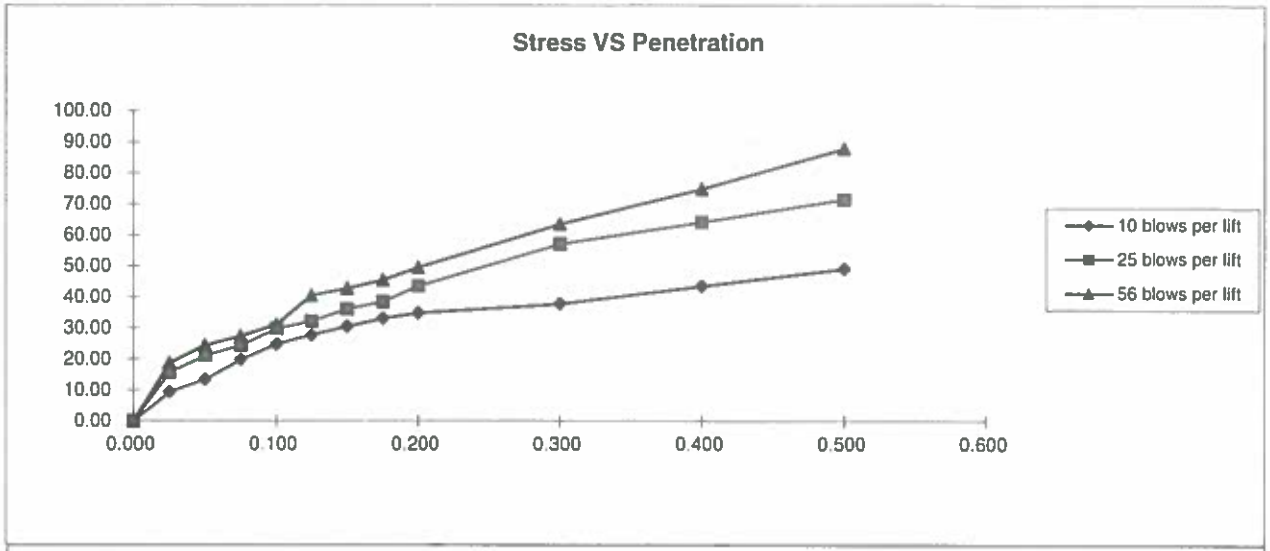
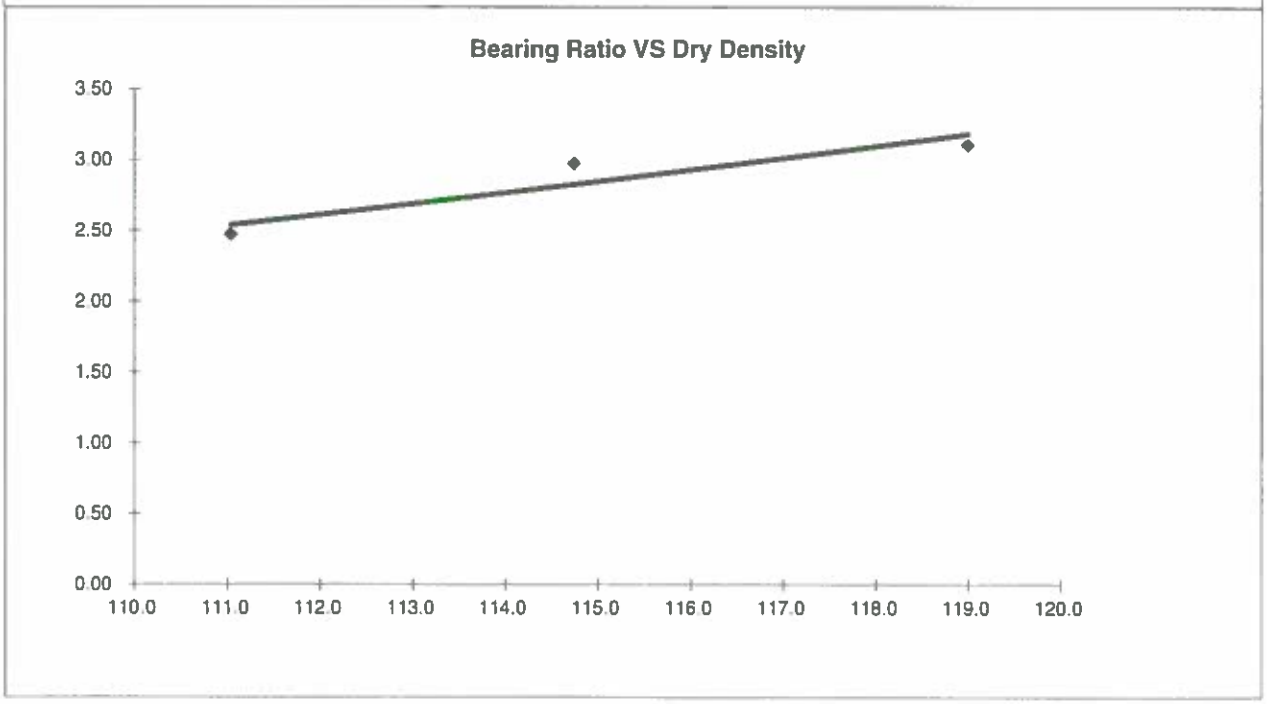
CBR TEST DATA

DRAWN:	DATE:	CHECKED:	DATE:
		DS	2/24/21

JOB NO.: 210191
FIG NO.: B-19





BEARING RATIO AT 90% OF MAX	2.05	~ R VALUE	5.00
BEARING RATIO AT 95% OF MAX	2.86	~ R VALUE	6.00

JOB NO: 210191
SOIL TYPE: 2

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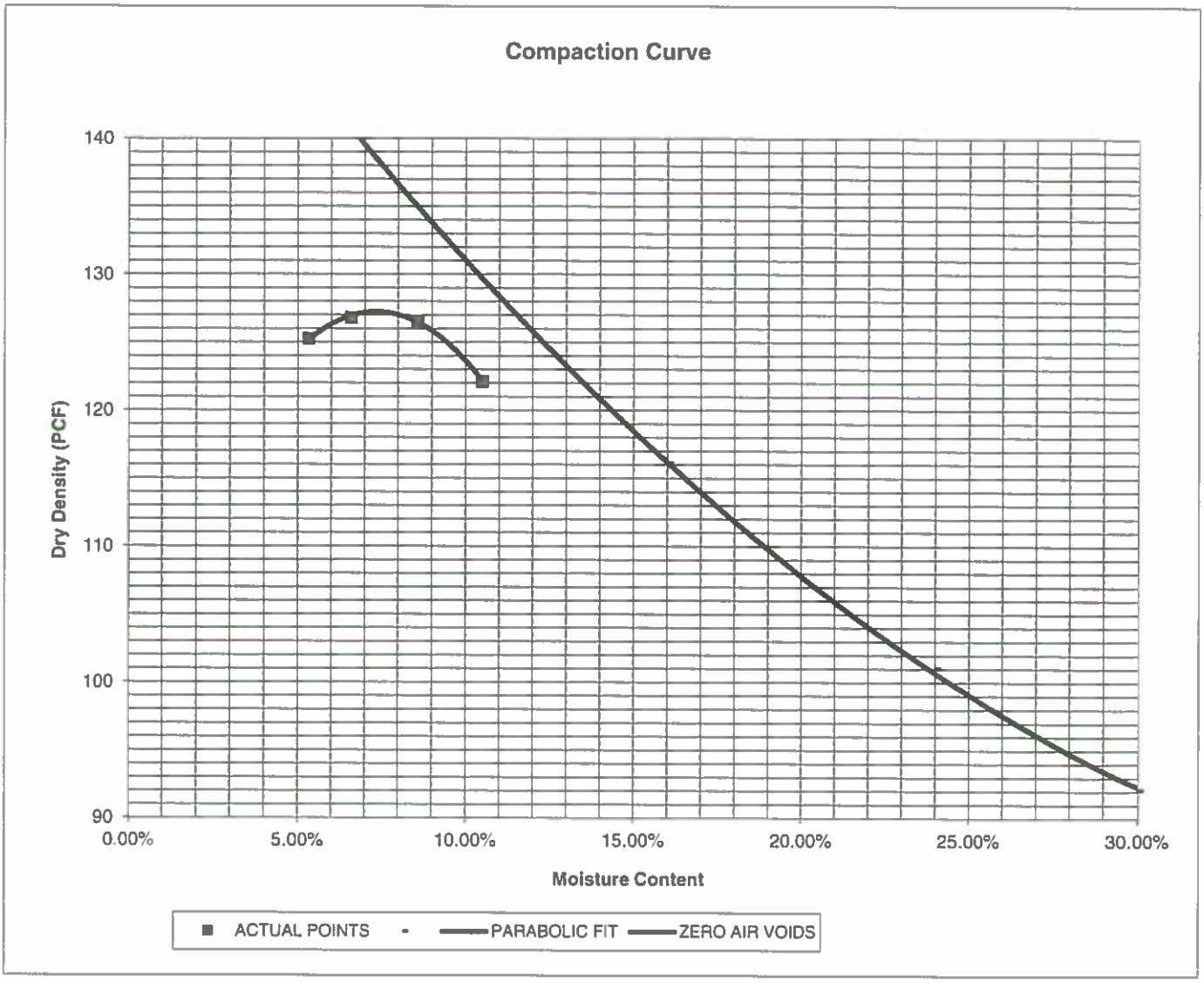
CALIFORNIA BEARING RATIO

DRAWN:	DATE:	CHECKED:	DATE:
		DS	2/22/21

JOB NO.: 210191
FIG NO.: B-2a

PROJECT	WALDEN PRESERVE	CLIENT	MA INFRASTRUCTURE
SAMPLE LOCATION	TB-1 @ 0-3'	JOB NO.	210191
SOIL DESCRIPTION	SAND, SILTY, TAN	DATE	02/17/21

IDENTIFICATION	SM	COMPACTION TEST #	2, SOIL TYPE #1
TEST DESIGNATION / METHOD	ASTM D-1557-A	TEST BY	BL
MAXIMUM DRY DENSITY (PCF)	127.2	OPTIMUM MOISTURE	7.2%



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MOISTURE DENSITY RELATION

DRAWN:	DATE:	CHECKED:	DATE:
		TS	4/16/21

JOB NO.: 210191

FIG NO.: B-21

CBR TEST LOAD DATA

JOB NO: 210191
CLIENT: MA INFRASTRUCTURE
PROJECT: WALDEN PRESERVE
SOIL TYPE: 1

PISTON DIAMETER (cm)	PISTON AREA (in²)
4.958	2.993

PENETRATION DEPTH (INCHES)	10 BLOWS MOLD # 1 LOAD(LBS) (LBS)	STRESS (PSI)	25 BLOWS MOLD # 2 LOAD(LBS) (LBS)	STRESS (PSI)	56 BLOWS MOLD # 3 LOAD(LBS) (LBS)	STRESS (PSI)
0.000	0	0.00	0	0.00	0	0.00
0.025	74	24.73	189	63.16	268	89.56
0.050	229	76.52	409	136.67	530	177.11
0.075	334	111.61	515	172.10	960	320.80
0.100	374	124.98	597	199.50	1260	421.05
0.125	425	142.02	666	222.56	1530	511.28
0.150	514	171.76	753	251.63	1763	589.14
0.175	599	200.17	811	271.01	1964	656.31
0.200	673	224.89	871	291.06	2250	751.88
0.300	748	249.96	1037	346.53	3014	1007.18
0.400	856	286.05	1183	395.32	3665	1224.72
0.500	932	311.44	1341	448.12	4314	1441.60

FINAL MOISTURE CONTENT

	MOLD # 1	MOLD # 2	MOLD # 3
CAN #	117	340	345
WT. CAN	9.41	6.58	6.47
WT. CAN+WET	195.86	209.42	214.85
WT. CAN+DRY	176.34	191.9	198.17
WT. H20	19.52	17.52	16.68
WT. DRY SOIL	166.93	185.32	191.7
MOISTURE CONTENT	11.69%	9.45%	8.70%

WET DENSITY (PCF)		123.0	130.9	137.5
DRY DENSITY (PCF)		114.8	122.1	128.3
BEARING RATIO		12.50	19.95	42.11
90% OF DRY DENSITY	114.5			
95% OF DRY DENSITY	120.8			

BEARING RATIO AT 90% OF MAX	12.19	~ R VALUE	37
BEARING RATIO AT 95% OF MAX	18.69	~ R VALUE	65

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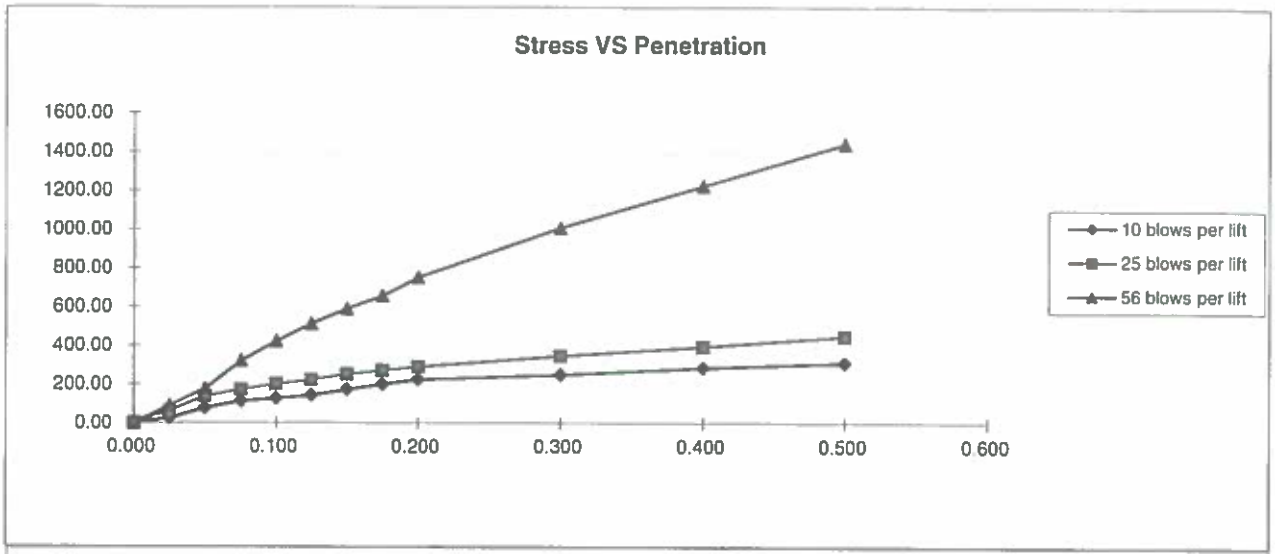
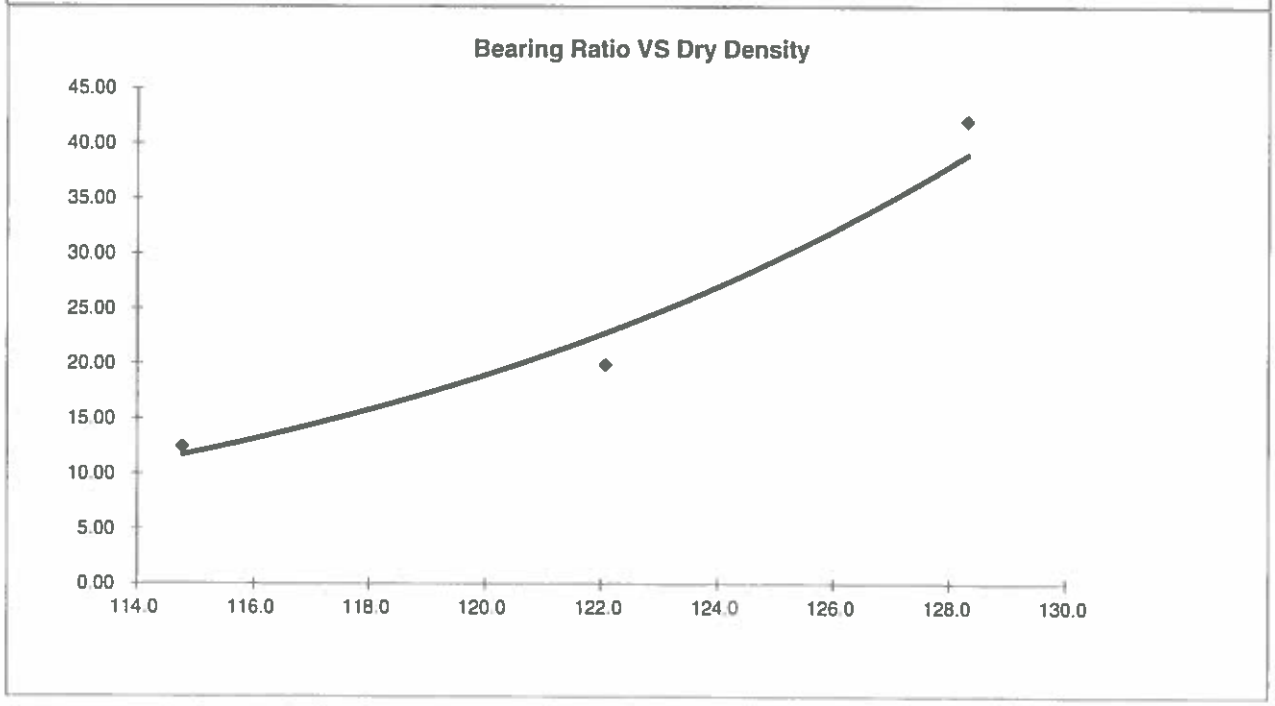
CBR TEST DATA

DRAWN:	DATE:	CHECKED:	DATE:
		DS	4/16/21

JOB NO.: 210191
FIG NO.: B-22





BEARING RATIO AT 90% OF MAX	12.19	~ R VALUE	37.00
BEARING RATIO AT 95% OF MAX	18.69	~ R VALUE	65.00

JOB NO: 210191
SOIL TYPE: 1

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CALIFORNIA BEARING RATIO

DRAWN:	DATE:	CHECKED:	DATE:
		DJ	4/16/21

JOB NO: 210191
FIG NO: B-23

APPENDIX C: Pavement Design Calculations

FLEXIBLE PAVEMENT DESIGN

DESIGN DATA

MA INFRASTRUCTURE - WALDEN PRESERVE FILING NO. 4
RURAL LOCAL - SOIL TYPE 1

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	36,500
Hveem Stabilometer (R Value) Results:	R =	40
Standard Deviation	S_o =	0.45
Loss in Serviceability	Δpsi =	2.0
Reliability	Reliability =	80
Reliability (z-statistic)	Z_R =	-0.84
Soil Resilient Modulus	M_R =	9497

Weighted Structural Number (WSN): → WSN = 1.68

DESIGN TABLES AND EQUATIONS

$S_1 = [(R - 5) / 11.29] + 3$

$M_R = 10^{[(S_1 + 18.72) / 6.24]}$

$k = M_R / 19.4$

Where:

M_R = resilient modulus (psi)

S_1 = the soil support value

R = R-value obtained from the Hveem stabilometer

CBR = California Bearing Ratio

Reliability (%)	Z_R (z-statistic)
80	-0.84
85	-1.04
90	-1.28
93	-1.48
94	-1.56
95	-1.65
96	-1.75
97	-1.88
98	-2.05
99	-2.33
99.9	-3.09
99.99	-3.75

$$\log_{10}W_{18} = Z_R * S_O + 9.36*\log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2 - 1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32*\log_{10}M_R - 8.07$$

Left	Right	Difference
4.56	4.56	0.0

Job No. 210191
Fig. No. C-1

DESIGN CALCULATIONS

CEMENT TREATED SECTIONS

DESIGN DATA: MA INFRASTRUCTURE - WALDEN PRESERVE FILING NO. 4

RURAL LOCAL - SOIL TYPE 1

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL =	36,500
Hveem Stabilometer (R Value) Results:	R =	40
Weighted Structural Number (WSN):	WSN =	1.68

DESIGN EQUATION

$$WSN = C_1D_1 + C_2D_2$$

C_1 = 0.44 Strength Coefficient - Hot Bituminous Asphalt
C_2 = 0.12 Strength Coefficient - Cement Treated Subgrade

D_1 = Depth of Asphalt (inches)
D_2 = Depth of Cement Treated Subgrade (inches)

FOR FULL DEPTH ASPHALT SECTION - (CURRENTLY NOT ALLOWED)

$D_1 = (WSN)/C_1$ = 3.8 inches of Full Depth Asphalt
Use N/A inches Full Depth

FOR ASPHALT + CEMENT TREATED SUBGRADE SECTION

Asphalt Thickness (t) = 4 inches
$D_2 = ((WSN) - (t)(C_1))/C_2$ = -0.7 inches
Use 8.0 inches of Cement Treated Subgrade

RECOMMENDED ALTERNATIVES

1. 4.0 inches of Asphalt + 8 inches of Cement Treated Subgrade
2. N/A inches of Full Depth Asphalt

Job No. 210191
Fig. No. C-2

FLEXIBLE PAVEMENT DESIGN

DESIGN DATA

MA INFRASTRUCTURE - WALDEN PRESERVE FILING NO. 4
RURAL MINOR COLLECTOR - SOIL TYPE I

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	109,500
Hveem Stabilometer (R Value) Results:	R =	40
Standard Deviation	S_o =	0.45
Loss in Serviceability	Δpsi =	2.0
Reliability	Reliability =	80
Reliability (z-statistic)	Z_R =	-0.84
Soil Resilient Modulus	M_R =	9497

Weighted Structural Number (WSN): → WSN = 2.02

DESIGN TABLES AND EQUATIONS

$S_1 = [(R - 5) / 11.29] + 3$

$M_R = 10^{[(S_1 + 18.72) / 6.24]}$

$k = M_R / 19.4$

Where:

M_R = resilient modulus (psi)

S_1 = the soil support value

R = R-value obtained from the Hveem stabilometer

CBR = California Bearing Ratio

Reliability (%)	Z_R (z-statistic)
80	-0.84
85	-1.04
90	-1.28
93	-1.48
94	-1.56
95	-1.65
96	-1.75
97	-1.88
98	-2.05
99	-2.33
99.9	-3.09
99.99	-3.75

$$\log_{10}W_{18} = Z_R * S_O + 9.36*\log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2 - 1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32*\log_{10}M_R - 8.07$$

Left	Right	Difference
5.04	5.04	0.0

Job No. 210191
Fig. No. C-3

DESIGN CALCULATIONS

CEMENT TREATED SECTIONS

DESIGN DATA: MA INFRASTRUCTURE - WALDEN PRESERVE FILING NO. 4

RURAL MINOR COLLECTOR - SOIL TYPE 1

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL =	109,500
Hveem Stabilometer (R Value) Results:	R =	40
Weighted Structural Number (WSN):	WSN =	2.02

DESIGN EQUATION

$$WSN = C_1D_1 + C_2D_2$$

C_1 = 0.44 Strength Coefficient - Hot Bituminous Asphalt
C_2 = 0.12 Strength Coefficient - Cement Treated Subgrade

D_1 = Depth of Asphalt (inches)
D_2 = Depth of Cement Treated Subgrade (inches)

FOR FULL DEPTH ASPHALT SECTION - (CURRENTLY NOT ALLOWED)

$D_1 = (WSN)/C_1$ = 4.6 inches of Full Depth Asphalt
Use N/A inches Full Depth

FOR ASPHALT + CEMENT TREATED SUBGRADE SECTION

Asphalt Thickness (t) = 4 inches
$D_2 = ((WSN) - (t)(C_1))/C_2$ = 2.2 inches
Use 8.0 inches of Cement Treated Subgrade

RECOMMENDED ALTERNATIVES

1. 4.0 inches of Asphalt + 8 inches of Cement Treated Subgrade
2. N/A inches of Full Depth Asphalt

Job No. 210191
Fig. No. C-4

FLEXIBLE PAVEMENT DESIGN

DESIGN DATA

MA INFRASTRUCTURE - WALDEN PRESERVE FILING NO. 4
RURAL MINOR COLLECTOR - SOIL TYPE 2

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	109,500
Hveem Stabilometer (R Value) Results:	R =	6
Standard Deviation	S_o =	0.45
Loss in Serviceability	Δpsi =	2.0
Reliability	Reliability =	80
Reliability (z-statistic)	Z_R =	-0.84
Soil Resilient Modulus	M_R =	3126

Weighted Structural Number (WSN): → WSN = 3.06

DESIGN TABLES AND EQUATIONS

$S_1 = [(R - 5) / 11.29] + 3$

$M_R = 10^{[(S_1 + 18.72) / 6.24]}$

$k = M_R / 19.4$

Where:

M_R = resilient modulus (psi)

S_1 = the soil support value

R = R-value obtained from the Hveem stabilometer

CBR = California Bearing Ratio

Reliability (%)	Z_R (z-statistic)
80	-0.84
85	-1.04
90	-1.28
93	-1.48
94	-1.56
95	-1.65
96	-1.75
97	-1.88
98	-2.05
99	-2.33
99.9	-3.09
99.99	-3.75

$$\log_{10} W_{18} = Z_R * S_O + 9.36 * \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2 - 1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 * \log_{10} M_R - 8.07$$

Left	Right	Difference
5.04	5.04	0.0

Job No. 210191
Fig. No. C-5

DESIGN CALCULATIONS

CEMENT TREATED SECTIONS

DESIGN DATA: MA INFRASTRUCTURE - WALDEN PRESERVE FILING NO. 4

RURAL MINOR COLLECTOR - SOIL TYPE 2

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL =	109,500
Hveem Stabilometer (R Value) Results:	R =	6
Weighted Structural Number (WSN):	WSN =	3.06

DESIGN EQUATION

$$WSN = C_1D_1 + C_2D_2$$

C_1 = 0.44 Strength Coefficient - Hot Bituminous Asphalt
C_2 = 0.12 Strength Coefficient - Cement Treated Subgrade

D_1 = Depth of Asphalt (inches)
D_2 = Depth of Cement Treated Subgrade (inches)

FOR FULL DEPTH ASPHALT SECTION - (CURRENTLY NOT ALLOWED)

$D_1 = (WSN)/C_1$ = 7.0 inches of Full Depth Asphalt
Use N/A inches Full Depth

FOR ASPHALT + CEMENT TREATED SUBGRADE SECTION

Asphalt Thickness (t) = 4 inches
$D_2 = ((WSN) - (t)(C_1))/C_2$ = 10.0 inches
Use 10.0 inches of Cement Treated Subgrade

RECOMMENDED ALTERNATIVES

1. 4.0 inches of Asphalt + 10 inches of Cement Treated Subgrade
2. N/A inches of Full Depth Asphalt

Job No. 210191
Fig. No. C-6

ENTECH
ENGINEERING, INC.
505 ELKTON DRIVE
COLORADO SPRINGS, CO 80907
PHONE (719) 531-5599
FAX (719) 531-5238

February 24, 2021

MA Infrastructure
1230 Scarsbrook Court
Monument, Colorado 80132

Attn: Matt Dunston

Re: Cement Stabilized Subgrade Results - Laboratory Testing
Walden Preserve Filing No. 4
Pinehurst Circle and Deboodt Court
El Paso County, Colorado

Ref: Pavement Recommendations Report by Entech Engineering, Inc., dated February 24, 2021, Entech Job No. 210191.

Dear Mr. Dunston:

As requested, personnel of Entech Engineering, Inc. have performed strength testing on two sets of three soil/cement composite samples of Soil Type 1 for the above reference project. Testing was performed on soil samples prepared with 2% and 4% Portland Cement Type 1/2, from Martin Marietta, near Pueblo, Colorado.

A compression strength of 160 psi is recommended for cement stabilized subgrade. The 5-day average strength value of the 2% mix was 193 psi. The 5-day average strength value of the 4% mix was 217 psi. A 2% mix is recommended based on the laboratory test results. A summary of the testing results is attached.

Pending the results of the field density testing, microfracturing of the stabilized subgrade may be required. Soil strengths in excess of 200 psi require microfracturing.

We trust this has provided you with the information you required. If you have any questions or need additional information, please do not hesitate to contact us.

Respectfully Submitted,

ENTECH ENGINEERING, INC.

Daniel P. Stegman

DPS/bs

Reviewed by:

Joseph C. Goode Jr., P.E.
President

COLORADO LICENSED
JOSEPH COLLIN GOODE
23725
PROFESSIONAL ENGINEER

Encl.
Entech Job No. 210191
AAprojects/2021/210191 cssr – lab

El Paso County File No. SF-1834

SUMMARY OF CTS TEST RESULTS

LAB TESTING

CLIENT MA INFRASTRUCTURE
PROJECT WALDEN PRESERVE
FIELD SAMPLE ID TB-4 @ 0-3'
SOIL ADDITIVE TYPE I/II CEMENT

JOB NO 210191
DATE 2/22/21
BY BL

ADDITIVE %	*WATER %*	*DENSITY (dry)*	*AGE (days)*	*STRENGTH (psi)*
2	8.6	113.9	5	189
2	8.6	113.9	5	182
2	8.6	114.1	5	206
			AVERAGE:	**193**
4	8.6	114.2	5	216
4	8.6	113.6	5	214
4	8.6	113.8	5	222
			AVERAGE:	**217**

CURING METHOD

100° HUMIDIFIED OVEN