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

September 15, 2020

FLRD #5
2138 Flying Horse Club Drive
Colorado Springs, Colorado 80921

Attn: Mark Sherwood

Re: Pavement Recommendations
Forest Lakes Filing No. 5
El Paso County, Colorado

SF 1915

Dear Mr. Sherwood:

As requested, Entech Engineering, Inc. has obtained samples of the pavement subgrade soils from the roadways in the Forest Lakes, Filing No. 5 subdivision in El Paso County, Colorado. This letter presents the results of the laboratory testing and pavement recommendations for the roadways.

Project Description

The roadways for this project consist of sections of, Mesa Top Road and Forest Lakes Drive. A Subsurface Soil Investigation and laboratory testing was performed in order to determine the pavement support characteristics of the soils. The general layout of the site is presented in the Test Boring Location Map in Figure 1.

Subgrade Conditions

Sixteen test borings were drilled along the roadways to depths of approximately 5 and 10 feet below the existing subgrade surface. The soils at the roadway subgrade depth consisted of silty to clayey sand fill (Soil Type 1), native silty sand (Soil Type 1A), very silty sand fill (Soil Type 2), and native very silty to very clayey sand (Soil Type 2A). The Type 1 soils were encountered in all of the borings with the exception of Test Boring Nos. 11-14, and 16, in which Soil Types 1, 1A, and 2A were encountered at subgrade depth. The Type 3 soils were not encountered in the subgrade influence zone. Groundwater was not encountered in the test borings. The Test Boring Logs are presented in Appendix A. Sieve Analyses and Atterberg Limit testing were performed on soil samples obtained from the test borings for the purpose of classification. The Type 1 soils percent passing the No. 200 sieve ranged from approximately 23 to 34 percent and classified as A-2-4 and A-1-b soils, using the AASHTO classification system. The Type 1A, 2, and 2A soils percent passing the No. 200 sieve ranged from approximately 35 to 40 percent and classified as A-2-4 and A-4 soils, using the AASHTO classification system. One general subgrade soil type was determined for pavement evaluation based on the laboratory testing (Type 1). The Type 1A, 2, and 2A soils will be grouped with the Type 1 soils due the limited areas in which they were encountered and their similar characteristics. Water-soluble sulfate tests results indicated that the soils exhibit a negligible potential for sulfate attack.

Swell/Consolidation Testing was not required on the site soils due to their plastic indexes. Mitigation of expansive soils on this site is not required. Laboratory test results are presented in Appendix B and are summarized on Table 1.

California Bearing Ratio (CBR) testing was performed on a representative sample to determine the support characteristics of the subgrade soils for the roadway section. The results of the CBR testing, are presented in Appendix B and summarized as follows:

Soil Type 1 – Silty Sand Fill
CBR 1
R @ 90% = 12.0
R @ 95% = 71.0
Use R = 50.0 for design

Classification Testing	
Liquid Limit	NV
Plasticity Index	NP
Percent Passing 200	27.3
AASHTO Classification	A-2-4
Group Index	0
Unified Soils Classification	SM

Pavement Design

CBR testing was used to determine pavement sections for the roadways. Pavement sections were determined utilizing El Paso County Engineering Criteria Manual. The roadways classify as urban residential collectors, which used an 18k ESAL value of 821,000 for design purposes. Alternative pavement sections were determined for asphalt supported on aggregate basecourse, and asphalt on cement stabilized subgrade.

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

Reliability	
Urban Residential Collector	85%
Standard Deviation	0.45
Δpsi	2.2
"R" Value Subgrade	50
Resilient Modulus	13,168 psi
Hot Bituminous Pavement	0.44
Aggregate Basecourse	0.11
Cement Stabilized Subgrade	0.12

The pavement design calculations are presented in Appendix C. Pavement section alternatives for the roadway sections are presented as follows. 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 – Soil Type 1

Urban Residential Collectors – ESAL = 821,000

Alternative	Asphalt** (in)	Basecourse (in)	Cement Stabilized Subgrade (in.)
1. Asphalt Over Basecourse	4.0*	8.0*	--
2. Cement Stabilized Subgrade	4.0*	--	10.0

*Minimum sections required per the El Paso County Engineering Criteria Manual.

Roadway Construction - Full Depth Asphalt and Asphalt on Aggregate Basecourse Alternatives

Prior to placement of the asphalt, the subgrade should be proofrolled and compacted to a minimum of 95 percent of the soils maximum Modified Proctor Dry Density, ASTM D-1557 at ± 2 percent of optimum moisture content. Any loose or soft areas should be removed and replaced with suitable materials. Basecourse materials should be compacted to a minimum of 95 percent of its maximum Modified Proctor Dry Density, ASTM D-1557 at ± 2 percent of optimum moisture content. Special attention should be given to areas adjacent to manholes, inlet structures and valves.

Roadway Construction – Cement Stabilized Subgrade Alternative

Prior to placement of the asphalt, the subgrade shall be stabilized by addition of cement to a depth of at least 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) based on laboratory cement stabilization testing. The cement should be spread evenly on the subgrade surface and be thoroughly mixed into the subgrade over a 10 inches depth such that a uniform blend of soil and cement is achieved. Prior to application or mixing of the cement, the upper 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 Modified Proctor Test (ASTM D-1557). Satisfactory compaction of the subgrade shall occur within 90 minutes from the time of mixing the cement into the subgrade.

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. If you have any questions or need additional information, please do not hesitate to contact us.

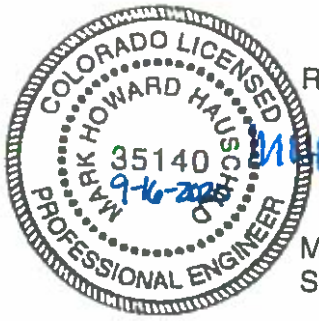
Respectfully Submitted,

ENTECH ENGINEERING, INC.

Daniel P. Stegman

DPS/bs

Entech Job No. 201782
AAprojects/2020/201782 - pr



Reviewed by:

Mark H. Hauschild, P.E.
Senior Engineer

TABLE

TABLE 1

SUMMARY OF LABORATORY TEST RESULTS

CLIENT FLRD #2
PROJECT FOREST LAKES, FILING 5
JOB NO. 201782

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	7	0-3			27.3	NV	NP		A-2-4		SM	FILL, SAND, SILTY
1	1	1-2			26.0	28	10		A-2-4		SC	FILL, SAND, CLAYEY
1	2	1-2			25.1	NV	NP	<0.01	A-1-b		SM	FILL, SAND, SILTY
1	3	1-2			29.4	NV	NP		A-2-4		SM	FILL, SAND, SILTY
1	4	1-2			33.7	NV	NP		A-2-4		SM	FILL, SAND, SILTY
1	5	1-2			31.5	NV	NP	<0.01	A-2-4		SM	FILL, SAND, SILTY
1	6	1-2			29.5	NV	NP		A-2-4		SM	FILL, SAND, SILTY
1	7	1-2			24.0	NV	NP		A-1-b		SM	FILL, SAND, SILTY
1	8	1-2			29.2	26	8	<0.01	A-2-4		SC	FILL, SAND, CLAYEY
1	9	1-2			32.3	NV	NP		A-2-4		SM	FILL, SAND, SILTY
1	10	1-2			30.6	NV	NP		A-2-4		SM	FILL, SAND, SILTY
1	15	1-2			22.9	NV	NP		A-1-b		SM	FILL, SAND, SILTY
1A	11	1-2			34.8	NV	NP	<0.01	A-2-4		SM	SAND, SILTY
2	13	1-2			40.4	NV	NP		A-4		SM	FILL, SAND, VERY SILTY
2	14	1-2			39.4	NV	NP	0.03	A-4		SM	FILL, SAND, VERY SILTY
2A	12	1-2			38.0	NV	NP		A-4		SM	SAND, VERY SILTY
2A	16	1-2			39.9	24	9		A-4		SC	SAND, VERY CLAYEY
3	10	10			27.5	NV	NP		A-2-4		SM	SANDSTONE, SILTY

FIGURE

REVISION	BY

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TB-1
TB-2
TB-3
TB-4
TB-5
TB-6
TB-7
TB-8
TB-9
TB-10
TB-11
TB-12
TB-13
TB-14
TB-15
TB-16

NOTE: SERVICES TO EXISTING HOME LOTS TO REMAIN IN SERVICE DURING CONSTRUCTION.

CAUTION !! EXISTING SERVICE CROSSING OF PROPOSED RETAINING WALL

TB- APPROXIMATE TEST BORING LOCATIONS AND NUMBERS

TEST BORING LOCATION MAP
FOREST LAKES FILING #5
EL PASO COUNTY, CO
FOR: FLRD #5

DRAWN	JAC
CHECKED	DPS
DATE	09/11/20
SCALE	AS SHOWN
JOB NO.	201752
FIGURE No.	1

APPENDIX A: Test Boring Logs

TEST BORING NO. 1
DATE DRILLED 8/26/2020
Job # 201782

REMARKS

DRY TO 10', 8/26/20

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			24	7.7	1
5			15	4.5	1
10			32	4.9	1
15					
20					

FILL 0-10', SAND, CLAYEY TO SILTY, FINE TO COARSE GRAINED, RED BROWN, MEDIUM DENSE, MOIST

TEST BORING NO. 2
DATE DRILLED 8/26/2020
CLIENT FLRD #2
LOCATION FOREST LAKES, FILING 5

REMARKS

DRY TO 5', 8/26/20

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			17	6.4	1
5			9	6.4	1
10					
15					
20					

FILL 0-5', SAND, SILTY, FINE TO COARSE GRAINED, RED BROWN, MEDIUM DENSE TO LOOSE, MOIST

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TEST BORING LOG

DRAWN:	DATE:	CHECKED:	DATE:
		DS	9/24/20

JOB NO.: 201782
FIG NO.: A- 1

TEST BORING NO. 3
DATE DRILLED 8/26/2020
Job # 201782

REMARKS

DRY TO 5', 8/26/20

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

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			15	4.6	1
5			20	6.0	1
10					
15					
20					

TEST BORING NO. 4
DATE DRILLED 8/26/2020
CLIENT FLRD #2
LOCATION FOREST LAKES, FILING 5

REMARKS

DRY TO 10', 8/26/20

FILL 0-10', SAND, SILTY, FINE TO COARSE GRAINED, RED BROWN, MEDIUM DENSE TO LOOSE, MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			13	9.7	1
5			14	7.6	1
10			9	7.7	1
15					
20					

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TEST BORING LOG

DRAWN:	DATE:	CHECKED:	DATE: 9/11/20

JOB NO.: 201782
FIG NO.: A- 2

TEST BORING NO. 5
DATE DRILLED 8/26/2020
Job # 201782

REMARKS

DRY TO 5', 8/26/20

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type	
			10	5.6	1	FILL 0-5', SAND, SILTY, FINE TO COARSE GRAINED, RED BROWN, MEDIUM DENSE, MOIST
5			10	4.8	1	
10						
15						
20						

TEST BORING NO. 6
DATE DRILLED 8/26/2020
CLIENT FLRD #2
LOCATION FOREST LAKES, FILING 5

REMARKS

DRY TO 5', 8/26/20

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type	
			9	5.6	1	FILL 0-5', SAND, SILTY, FINE TO COARSE GRAINED, RED BROWN, LOOSE, MOIST
5			5	4.8	1	
10						
15						
20						

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TEST BORING LOG

DRAWN:	DATE:	CHECKED	DATE: 9/11/20

JOB NO. 201782
FIG NO. A- 3

TEST BORING NO. 7
DATE DRILLED 8/26/2020
Job # 201782

REMARKS

DRY TO 10', 8/26/20

FILL 0-6', SAND, SILTY, FINE TO COARSE GRAINED, RED BROWN, DENSE TO MEDIUM DENSE, MOIST

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

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			33	4.2	1
5			28	4.8	1
10			28	3.5	1A
15					
20					

TEST BORING NO. 8
DATE DRILLED 8/27/2020
CLIENT FLRD #2
LOCATION FOREST LAKES, FILING 5

REMARKS

DRY TO 5', 8/27/20

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

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			25	7.8	1
5			21	8.0	1
10					
15					
20					

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TEST BORING LOG

DRAWN:	DATE:	CHECKED:	DATE:
			9/10/20

JOB NO. 201782
FIG NO. A- 4

TEST BORING NO. 9
DATE DRILLED 8/27/2020
Job # 201782

REMARKS

DRY TO 5', 8/27/20

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type	
			23	7.9	1	POSS. FILL 0-5', SAND, SILTY, FINE TO COARSE GRAINED, BROWN, MEDIUM DENSE, MOIST
5			21	8.6	1	
10						
15						
20						

TEST BORING NO. 10
DATE DRILLED 8/27/2020
CLIENT FLRD #2
LOCATION FOREST LAKES, FILING 5

REMARKS

DRY TO 10', 8/27/20

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type	
			19	8.4	1	POSS. FILL 0-4', SAND, SILTY, FINE TO COARSE GRAINED, TAN, MEDIUM DENSE, MOIST
5			17	7.2	1A	SAND, SILTY, FINE TO COARSE GRAINED, RED BROWN, MEDIUM DENSE, MOIST
10			50/4"	4.5	3	SANDSTONE, SILTY, FINE TO COARSE GRAINED, RED BROWN, VERY DENSE, MOIST
15						
20						

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TEST BORING LOG

DRAWN:	DATE:	CHECKED:	DATE:
			9/11/20

JOB NO.: 201782
FIG NO.: A- 5

TEST BORING NO. 11
DATE DRILLED 8/27/2020
Job # 201782

REMARKS

DRY TO 5', 8/27/20

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type	
			16	8.5	1A	SAND, SILTY, FINE TO COARSE GRAINED, BROWN, MEDIUM DENSE TO DENSE, MOIST
5			40	6.4	3	WEATHERED SANDSTONE, SILTY, FINE TO COARSE GRAINED, RED BROWN, DENSE, MOIST
10						
15						
20						

TEST BORING NO. 12
DATE DRILLED 8/27/2020
CLIENT FLRD #2
LOCATION FOREST LAKES, FILING 5

REMARKS

DRY TO 5', 8/27/20

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type	
			21	7.6	2A	SAND, VERY SILTY, FINE TO COARSE GRAINED, BROWN, MEDIUM DENSE, MOIST
5			20	7.4	2A	
10						
15						
20						

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TEST BORING LOG

DRAWN:	DATE:	CHECKED:	DATE: 9/11/20

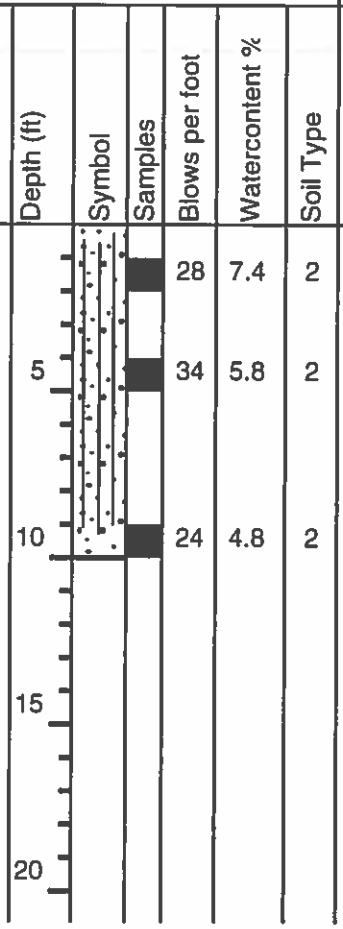
JOB NO.: 201782
FIG NO.: A- 6

TEST BORING NO. 13
DATE DRILLED 8/27/2020
Job # 201782

REMARKS

DRY TO 10', 8/27/20

FILL 0-10', SAND, VERY SILTY, FINE TO COARSE GRAINED, BROWN TO RED BROWN, MEDIUM DENSE TO DENSE, MOIST

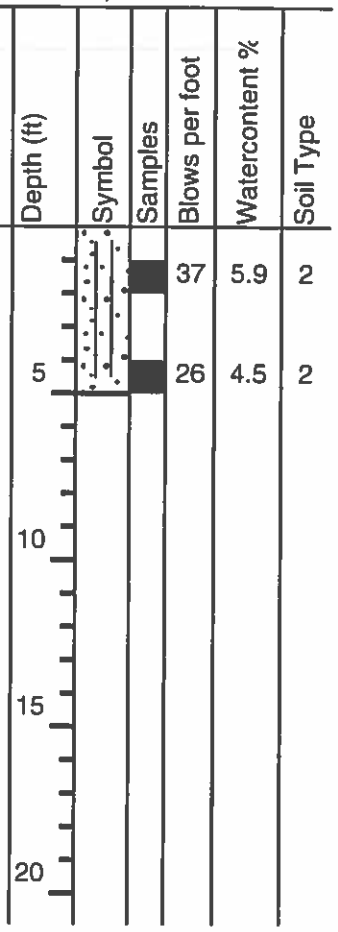


TEST BORING NO. 14
DATE DRILLED 8/27/2020
CLIENT FLRD #2
LOCATION FOREST LAKES, FILING 5

REMARKS

DRY TO 5', 8/27/20

FILL 0-5', SAND, VERY SILTY, FINE TO COARSE GRAINED, RED BROWN, MEDIUM DENSE TO DENSE, MOIST



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TEST BORING LOG

DRAWN:	DATE:	CHECKED:	DATE: 9/11/20

JOB NO.: 201782
FIG NO.: A- 7

TEST BORING NO. 15
DATE DRILLED 8/27/2020
Job # 201782

REMARKS

DRY TO 5', 8/27/20

FILL 0-5', SAND, SILTY WITH ORGANICS, FINE TO COARSE GRAINED, DARK BROWN, DENSE TO MEDIUM DENSE, MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			36	5.5	1
5			27	7.3	1
10					
15					
20					

TEST BORING NO. 16
DATE DRILLED 8/27/2020
CLIENT FLRD #2
LOCATION FOREST LAKES, FILING 5

REMARKS

DRY TO 10', 8/27/20

SAND, VERY CLAYEY, FINE GRAINED, RED BROWN, DENSE, MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			39	5.7	2A
5			39	4.3	2A
10			31	5.8	2A
15					
20					

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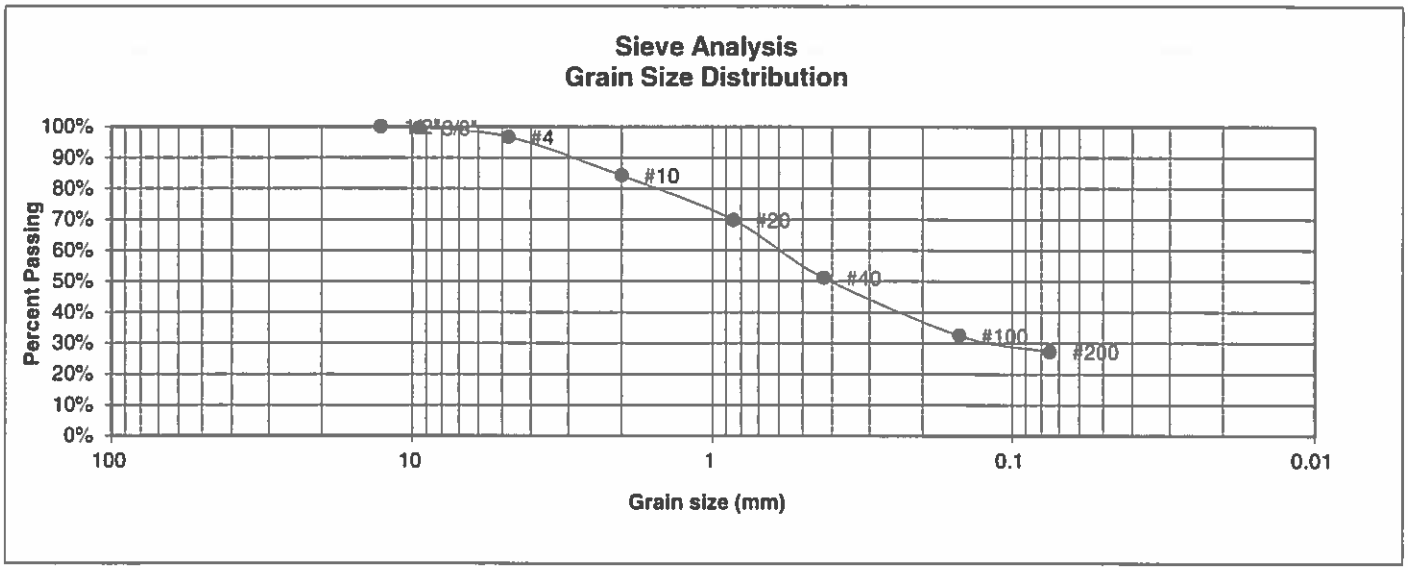
TEST BORING LOG

DRAWN:	DATE:	CHECKED:	DATE: 9/11/20

JOB NO.: 201782
FIG NO.: A- 8

APPENDIX B: Laboratory Test Results

UNIFIED CLASSIFICATION	SM	CLIENT	FLRD #2
SOIL TYPE #	1, CBR	PROJECT	FOREST LAKES, FILING 5
TEST BORING #	7	JOB NO.	201782
DEPTH (FT)	0-3	TEST BY	BL
AASHTO CLASSIFICATION	A-2-4	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	99.6%
4	96.7%
10	84.2%
20	69.8%
40	51.1%
100	32.4%
200	27.3%

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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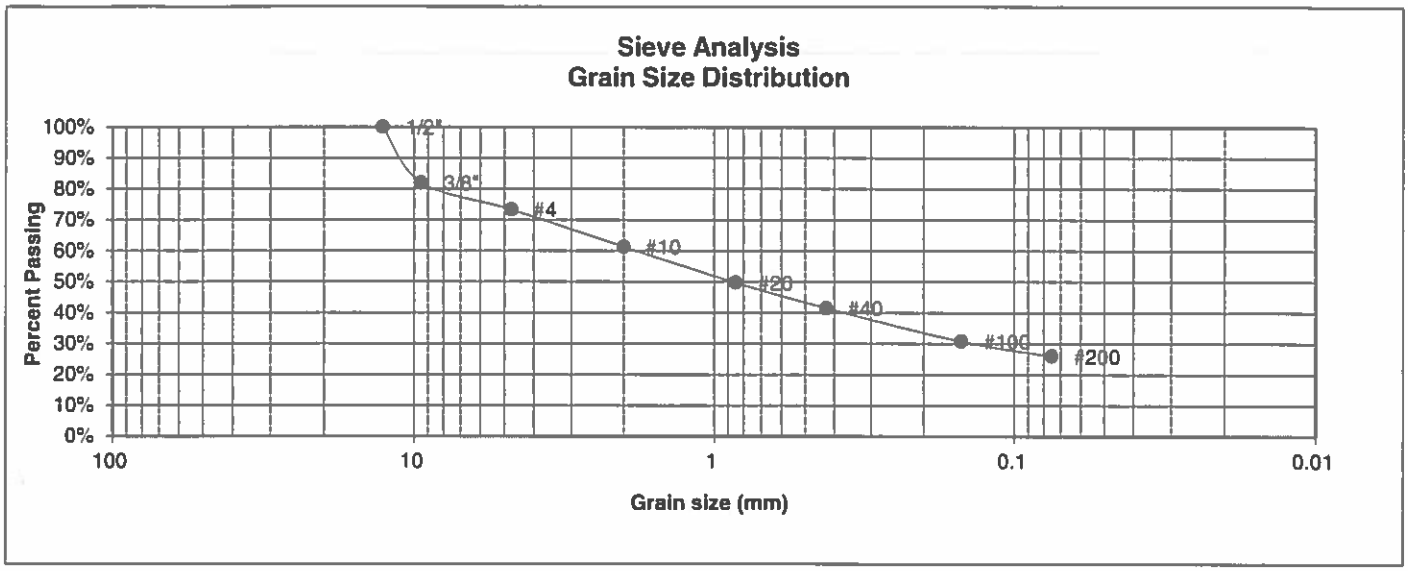
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
			9/11/20

JOB NO.: 201782
FIG NO.: B-1

UNIFIED CLASSIFICATION	SC	CLIENT	FLRD #2
SOIL TYPE #	1	PROJECT	FOREST LAKES, FILING 5
TEST BORING #	1	JOB NO.	201782
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"	100.0%
3/8"	82.0%
4	73.3%
10	61.3%
20	49.8%
40	41.5%
100	30.8%
200	26.0%

Atterberg Limits

Plastic Limit	17
Liquid Limit	28
Plastic Index	10

Swell

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

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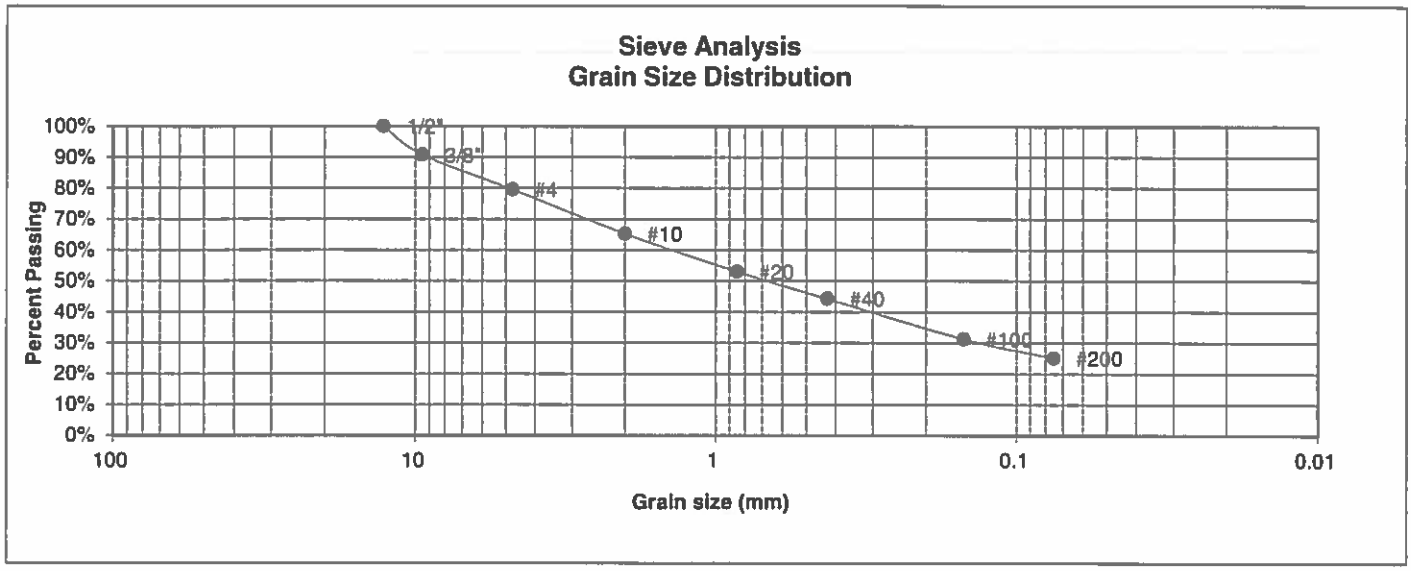
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE: 9/11/20

JOB NO.: 201782
FIG NO.: B-2

UNIFIED CLASSIFICATION	SM	CLIENT	FLRD #2
SOIL TYPE #	1	PROJECT	FOREST LAKES, FILING 5
TEST BORING #	2	JOB NO.	201782
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-1-b	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	90.7%
4	79.6%
10	65.3%
20	53.1%
40	44.3%
100	31.2%
200	25.1%

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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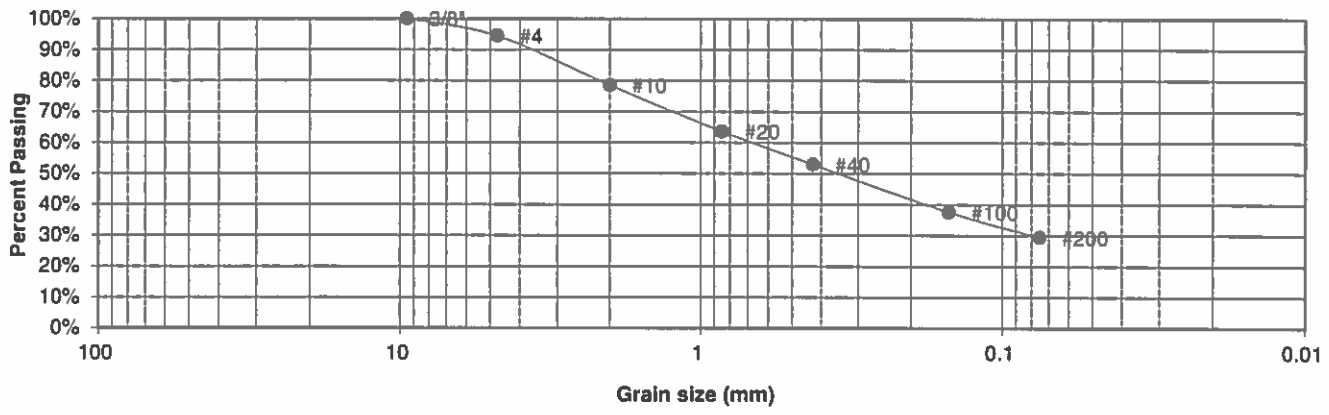
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
			9/11/20

JOB NO.: 201782
FIG NO.: B-3

UNIFIED CLASSIFICATION	SM	CLIENT	FLRD #2
SOIL TYPE #	1	PROJECT	FOREST LAKES, FILING 5
TEST BORING #	3	JOB NO.	201782
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-2-4	GROUP INDEX	0

Sieve Analysis
Grain Size Distribution



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	94.5%
10	78.6%
20	63.6%
40	52.9%
100	37.6%
200	29.4%

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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505 ELKTON DRIVE
COLORADO SPRINGS, COLORADO 80907

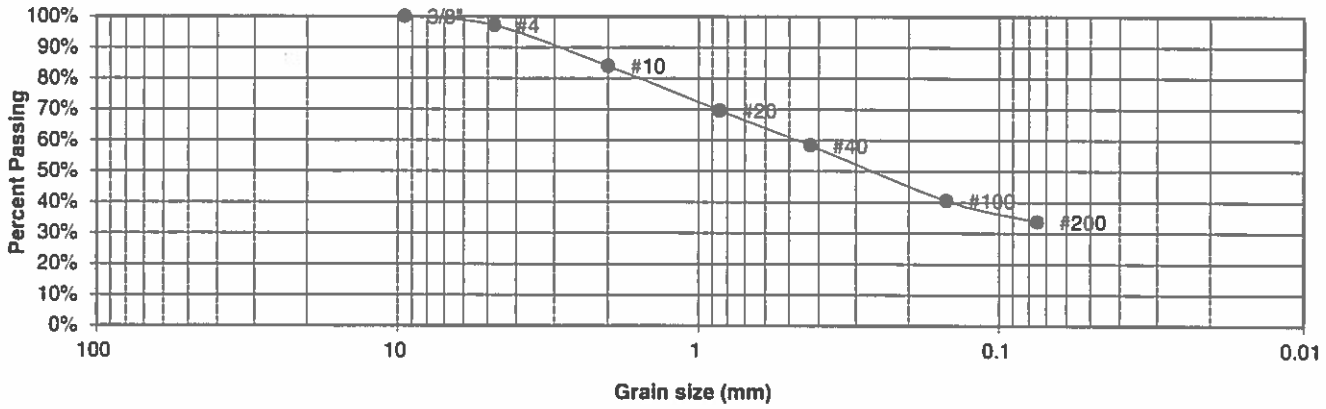
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
			9/11/20

JOB NO: 201782
FIG NO: B-4

UNIFIED CLASSIFICATION	SM	CLIENT	FLRD #2
SOIL TYPE #	1	PROJECT	FOREST LAKES, FILING 5
TEST BORING #	4	JOB NO.	201782
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-2-4	GROUP INDEX	0

Sieve Analysis
Grain Size Distribution



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	97.2%
10	84.0%
20	69.6%
40	58.3%
100	40.5%
200	33.7%

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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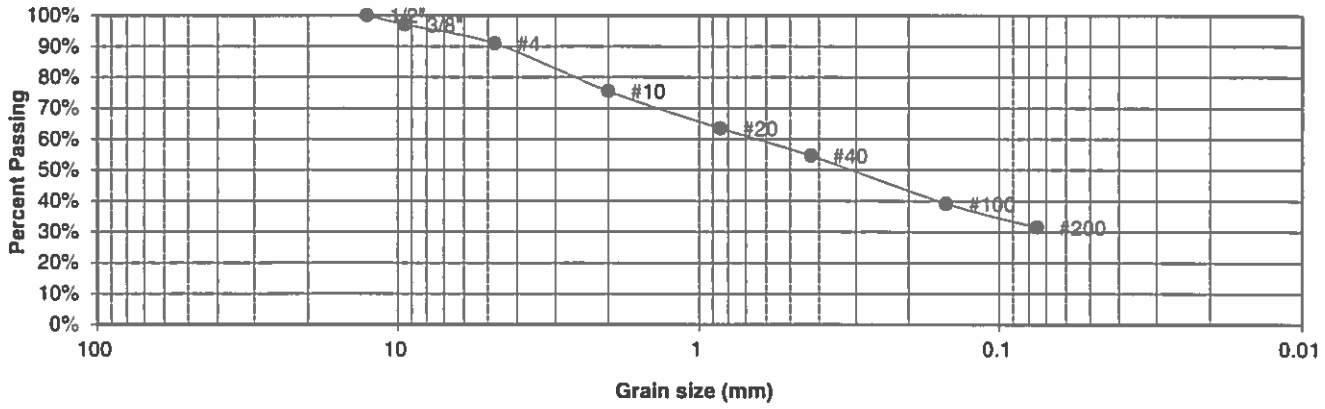
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE: 9/11/20

JOB NO.: 201782
FIG NO.: B-5

UNIFIED CLASSIFICATION	SM	CLIENT	FLRD #2
SOIL TYPE #	1	PROJECT	FOREST LAKES, FILING 5
TEST BORING #	5	JOB NO.	201782
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-2-4	GROUP INDEX	0

Sieve Analysis
Grain Size Distribution



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	97.0%
4	91.0%
10	75.5%
20	63.5%
40	54.6%
100	39.1%
200	31.5%

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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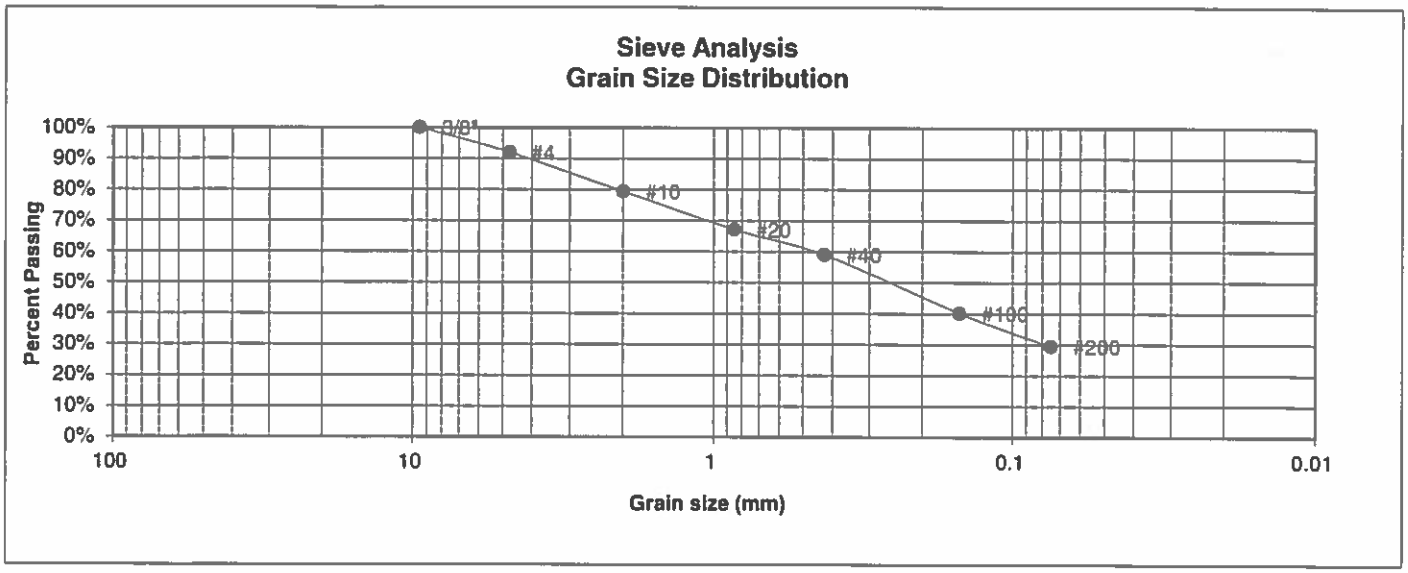
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
			9/11/21

JOB NO.: 201782
FIG NO.: B-6

UNIFIED CLASSIFICATION	SM	CLIENT	FLRD #2
SOIL TYPE #	1	PROJECT	FOREST LAKES, FILING 5
TEST BORING #	6	JOB NO.	201782
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	92.0%
10	79.4%
20	67.1%
40	59.1%
100	40.2%
200	29.5%

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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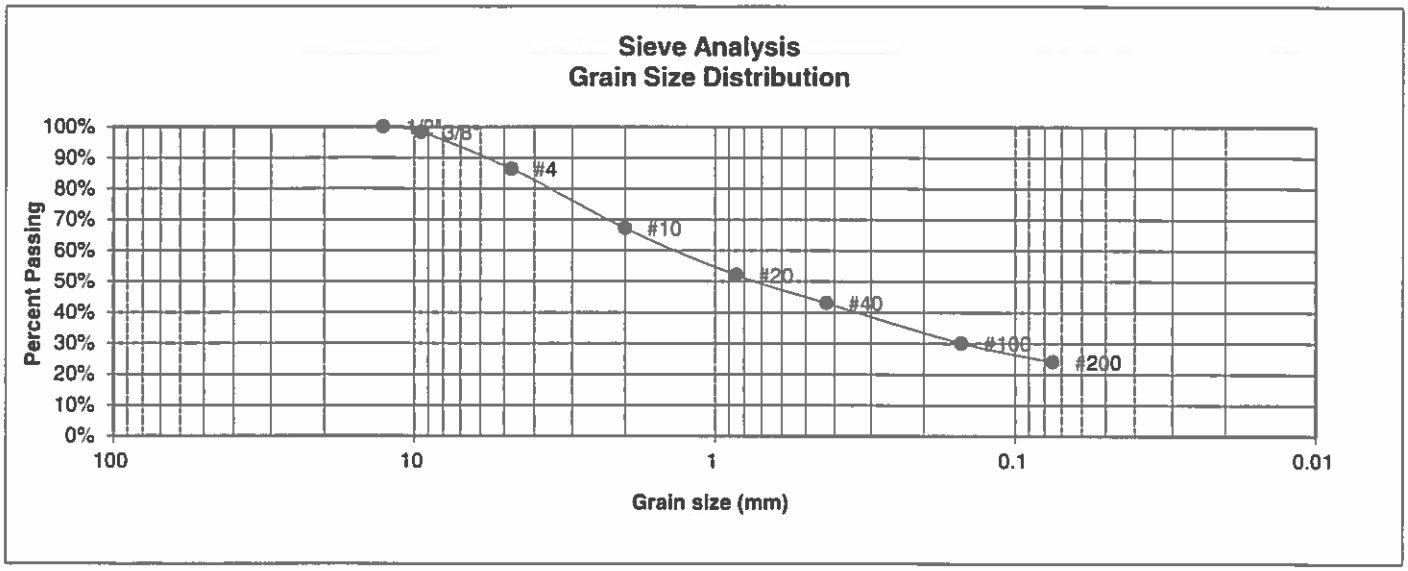
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
			4/11/20

JOB NO.: 201782
FIG NO.: B-7

UNIFIED CLASSIFICATION	SM	CLIENT	FLRD #2
SOIL TYPE #	1	PROJECT	FOREST LAKES, FILING 5
TEST BORING #	7	JOB NO.	201782
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-1-b	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	98.3%
4	86.5%
10	67.2%
20	52.1%
40	43.0%
100	30.1%
200	24.0%

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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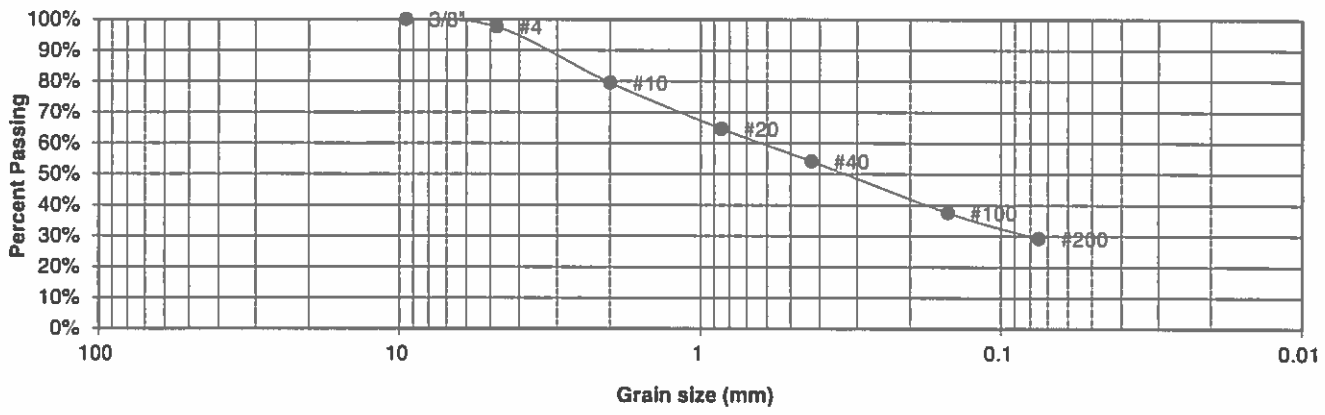
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
			9/11/20

JOB NO. 201782
FIG NO. B-8

UNIFIED CLASSIFICATION	SC	CLIENT	FLRD #2
SOIL TYPE #	1	PROJECT	FOREST LAKES, FILING 5
TEST BORING #	8	JOB NO.	201782
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-2-4	GROUP INDEX	0

Sieve Analysis
Grain Size Distribution



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	97.6%
10	79.5%
20	64.6%
40	54.2%
100	37.5%
200	29.2%

Atterberg Limits	
Plastic Limit	18
Liquid Limit	26
Plastic Index	8

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

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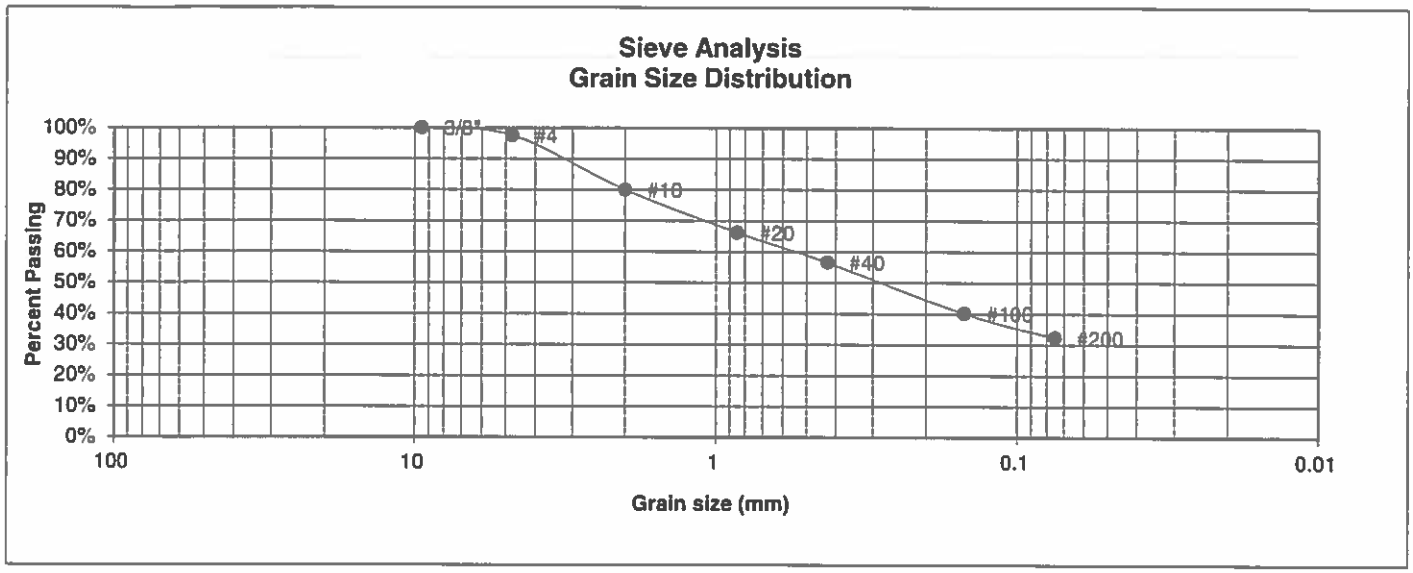
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
			9/11/20

JOB NO.: 201782
FIG NO.: B-9

UNIFIED CLASSIFICATION	SM	CLIENT	FLRD #2
SOIL TYPE #	1	PROJECT	FOREST LAKES, FILING 5
TEST BORING #	9	JOB NO.	201782
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	97.5%
10	80.0%
20	66.2%
40	56.6%
100	40.1%
200	32.3%

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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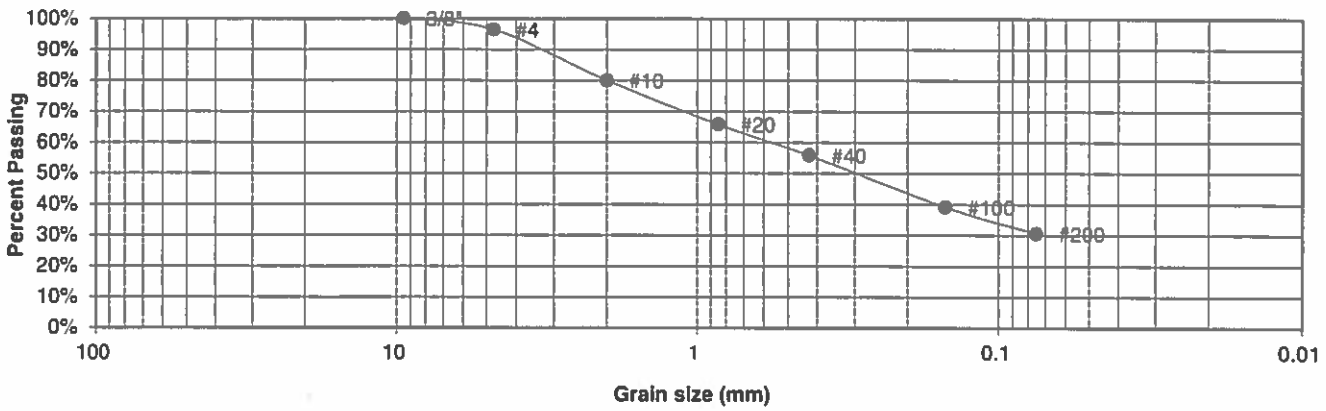
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE: 9/14/20

JOB NO.: 201782
FIG NO.: B-10

UNIFIED CLASSIFICATION	SM	CLIENT	FLRD #2
SOIL TYPE #	1	PROJECT	FOREST LAKES, FILING 5
TEST BORING #	10	JOB NO.	201782
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-2-4	GROUP INDEX	0

Sieve Analysis
Grain Size Distribution



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	96.5%
10	80.0%
20	65.8%
40	55.9%
100	39.1%
200	30.6%

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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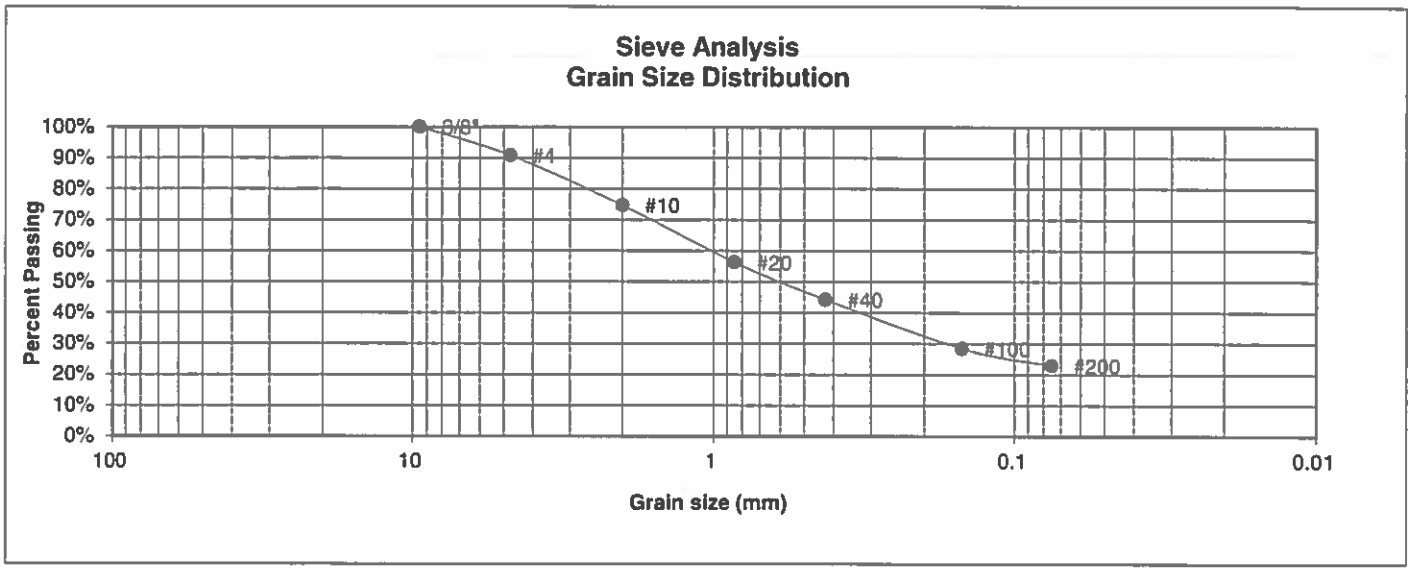
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
			9/11/20

JOB NO: 201782
FIG NO: B-11

UNIFIED CLASSIFICATION	SM	CLIENT	FLRD #2
SOIL TYPE #	I	PROJECT	FOREST LAKES, FILING 5
TEST BORING #	15	JOB NO.	201782
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-1-b	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	90.8%
10	74.7%
20	56.3%
40	44.2%
100	28.4%
200	22.9%

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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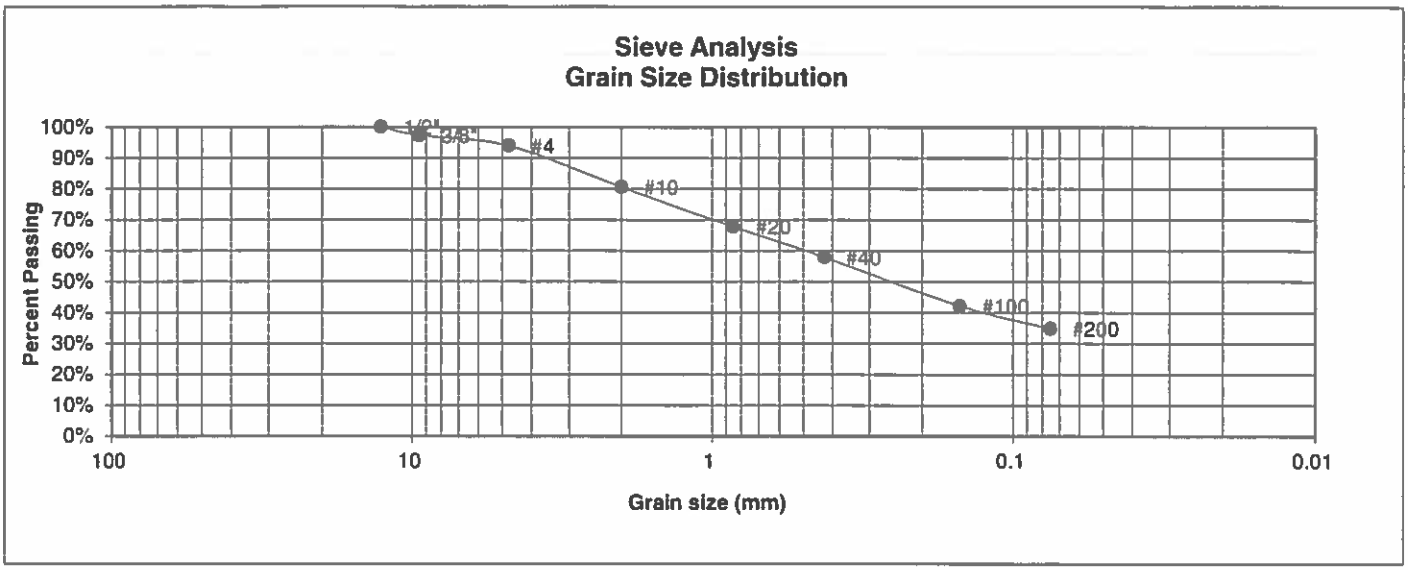
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
			9/11/20

JOB NO. 201782
FIG NO. 2-12

UNIFIED CLASSIFICATION	SM	CLIENT	FLRD #2
SOIL TYPE #	1A	PROJECT	FOREST LAKES, FILING 5
TEST BORING #	11	JOB NO.	201782
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"	100.0%
3/8"	97.3%
4	93.9%
10	80.6%
20	67.8%
40	57.9%
100	42.1%
200	34.8%

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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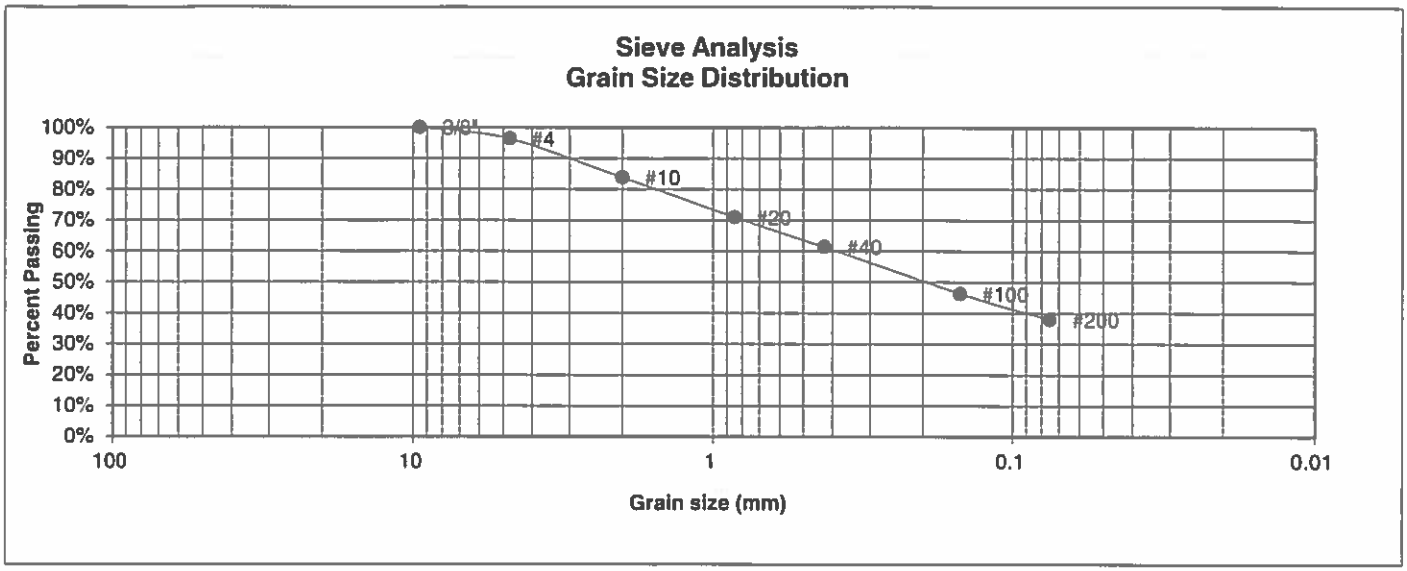
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
			9/11/20

JOB NO.: 201782
FIG NO.: B-13

UNIFIED CLASSIFICATION	SM	CLIENT	FLRD #2
SOIL TYPE #	2A	PROJECT	FOREST LAKES, FILING 5
TEST BORING #	12	JOB NO.	201782
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-4	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	96.4%
10	83.8%
20	71.0%
40	61.4%
100	46.3%
200	38.0%

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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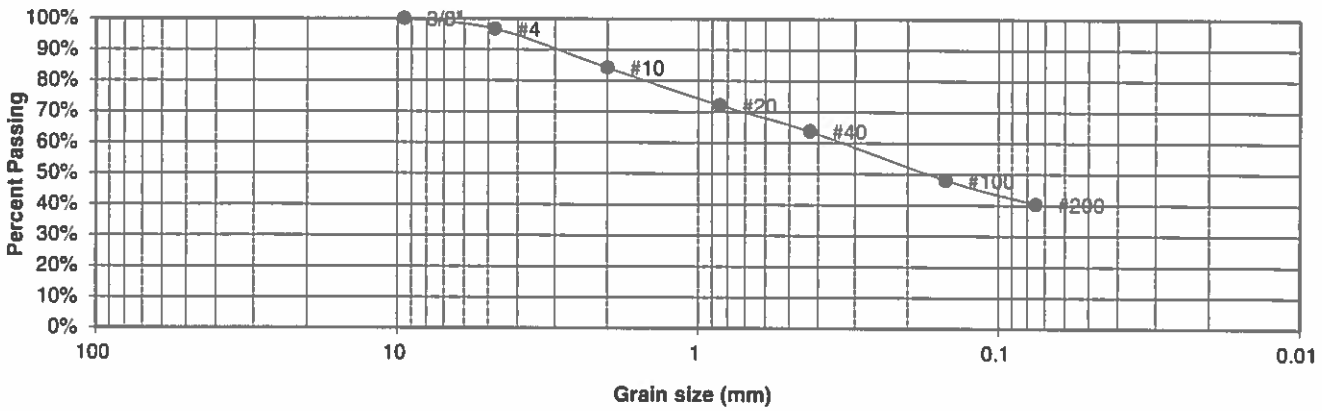
LABORATORY TEST RESULTS

DRAWN	DATE	CHECKED	DATE
			9/11/20

JOB NO.: 201782
FIG NO.: B-14

UNIFIED CLASSIFICATION	SM	CLIENT	FLRD #2
SOIL TYPE #	2	PROJECT	FOREST LAKES, FILING 5
TEST BORING #	13	JOB NO.	201782
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-4	GROUP INDEX	0

Sieve Analysis
Grain Size Distribution



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	96.7%
10	84.2%
20	72.1%
40	63.8%
100	48.1%
200	40.4%

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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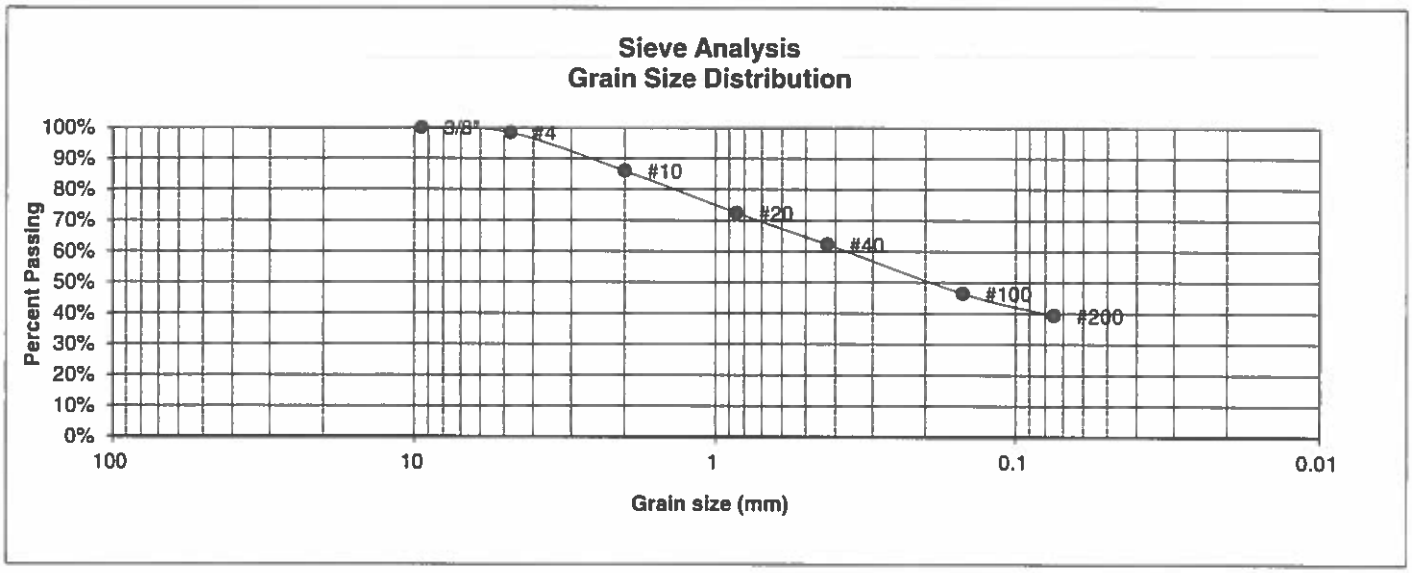
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
			9/11/20

JOB NO: 201782
FIG NO: B-15

UNIFIED CLASSIFICATION	SM	CLIENT	FLRD #2
SOIL TYPE #	2	PROJECT	FOREST LAKES, FILING 5
TEST BORING #	14	JOB NO.	201782
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-4	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	98.3%
10	86.0%
20	72.4%
40	62.3%
100	46.4%
200	39.4%

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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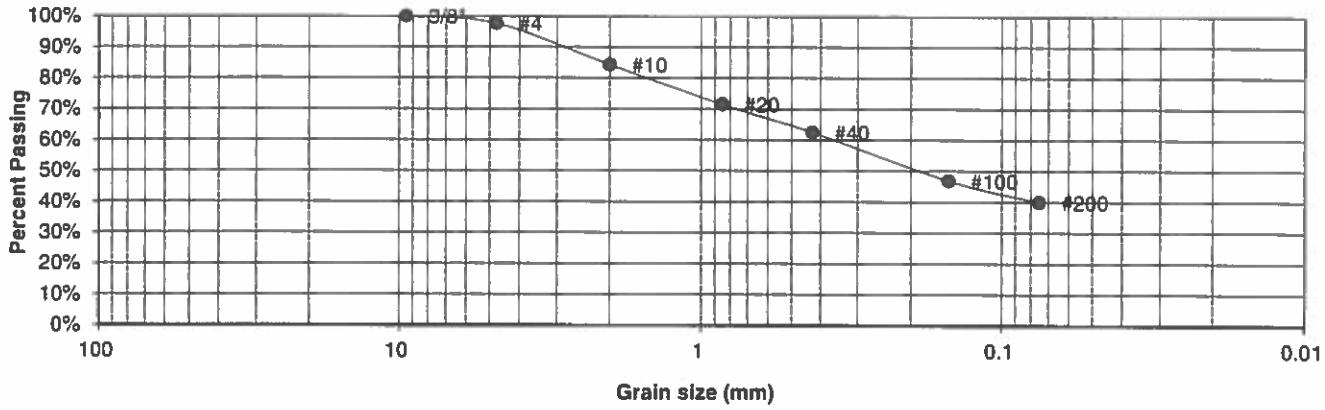
LABORATORY TEST RESULTS

DRAWN	DATE	CHECKED	DATE
			9/11/20

JOB NO. 201782
FIG NO. B-1c

UNIFIED CLASSIFICATION	SC	CLIENT	FLRD #2
SOIL TYPE #	2A	PROJECT	FOREST LAKES, FILING 5
TEST BORING #	16	JOB NO.	201782
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-4	GROUP INDEX	0

Sieve Analysis
Grain Size Distribution



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	97.6%
10	84.3%
20	71.5%
40	62.4%
100	46.8%
200	39.9%

Atterberg Limits	
Plastic Limit	15
Liquid Limit	24
Plastic Index	9

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

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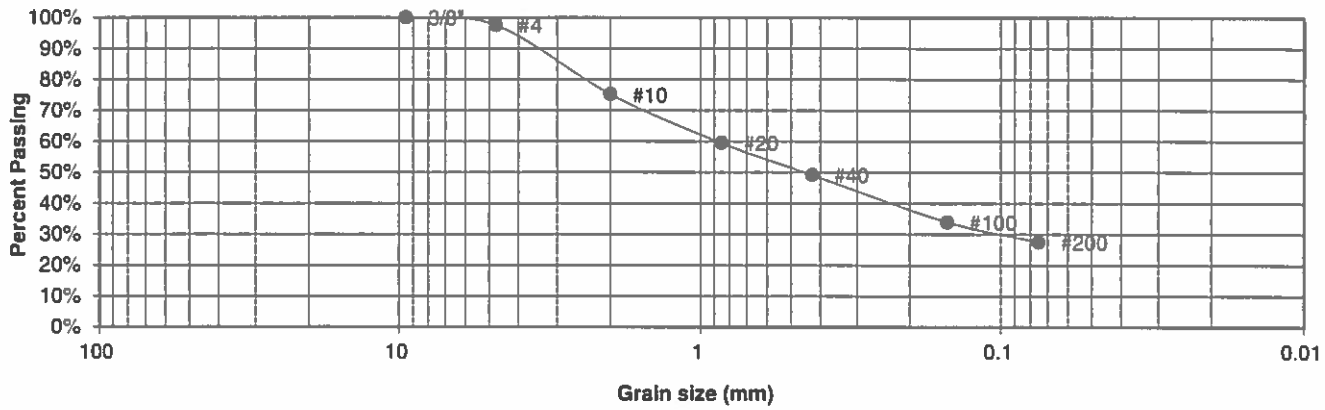
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
			9/11/20

JOB NO.: 201782
FIG NO.: 6-17

UNIFIED CLASSIFICATION	SM	CLIENT	FLRD #2
SOIL TYPE #	3	PROJECT	FOREST LAKES, FILING 5
TEST BORING #	10	JOB NO.	201782
DEPTH (FT)	10	TEST BY	BL
AASHTO CLASSIFICATION	A-2-4	GROUP INDEX	0

Sieve Analysis
Grain Size Distribution



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	97.6%
10	75.2%
20	59.5%
40	49.2%
100	33.9%
200	27.5%

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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COLORADO SPRINGS, COLORADO 80907

LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
			9/11/20

JOB NO.: 201782
FIG NO.: B-18

CLIENT	FLRD #2	JOB NO.	201782
PROJECT	FOREST LAKES, FILING 5	DATE	9/3/2020
LOCATION	FOREST LAKES, FILING 5	TEST BY	BL

BORING NUMBER	DEPTH, (ft)	SOIL TYPE NUMBER	UNIFIED CLASSIFICATION	WATER SOLUBLE SULFATE, (wt%)
TB-2	1-2	1	SM	<0.01
TB-5	1-2	1	SM	<0.01
TB-8	1-2	1	SC	<0.01
TB-11	1-2	1A	SM	<0.01
TB-14	1-2	2	SM	0.03

QC BLANK PASS

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COLORADO SPRINGS, COLORADO 80907

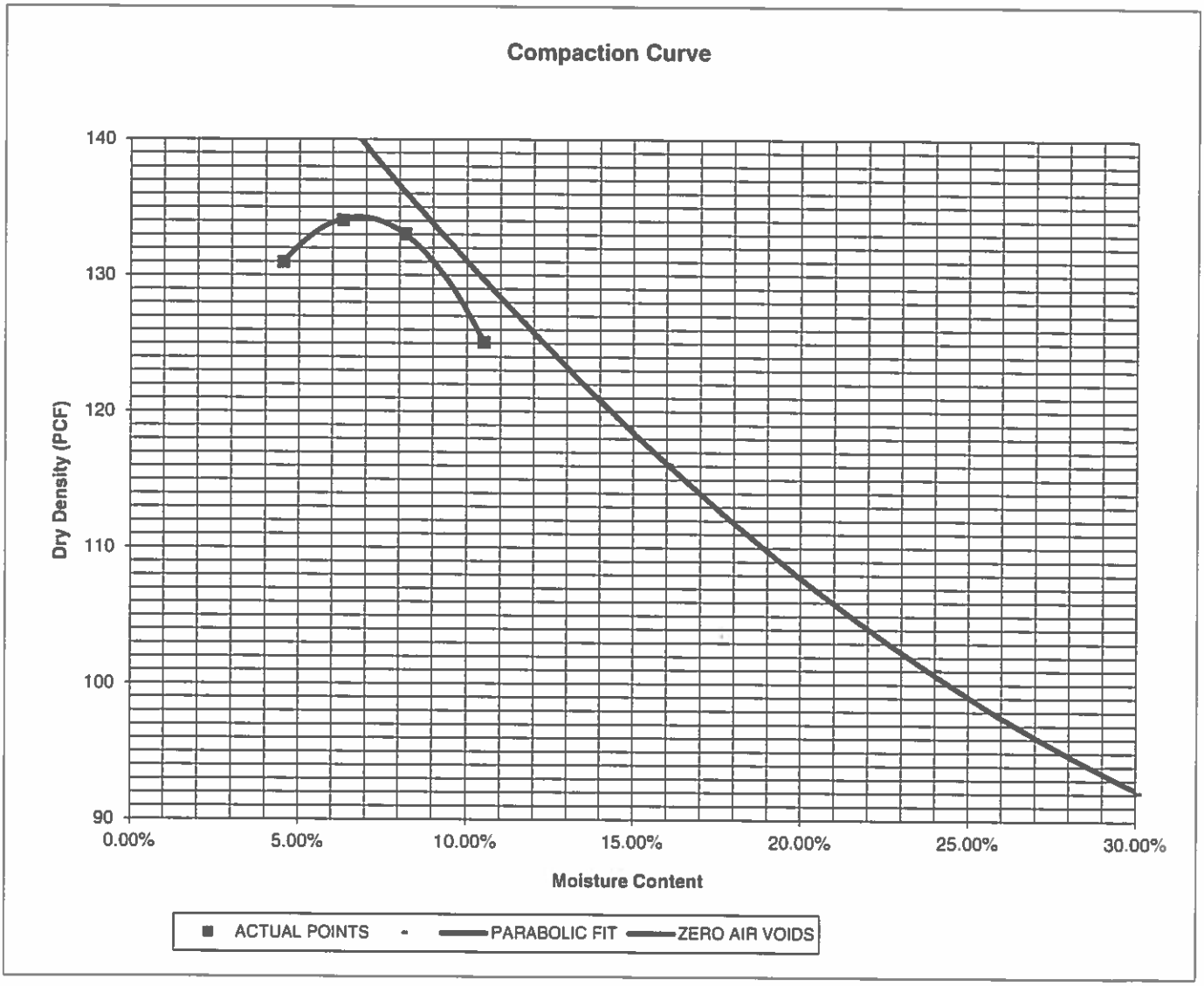
LABORATORY TEST
SULFATE RESULTS

DRAWN:	DATE	CHECKED	DATE
			9/11/20

JOB NO.: 201782
FIG NO.: B-19

PROJECT	FOREST LAKES, FILING 5	CLIENT	FLRD #2
SAMPLE LOCATION	TB-7 @ 0-3'	JOB NO.	201782
SOIL DESCRIPTION	SAND, SILTY, RED BROWN	DATE	08/27/20

IDENTIFICATION	SM	COMPACTION TEST #	1
TEST DESIGNATION / METHOD	ASTM D-1557-A	TEST BY	BL
MAXIMUM DRY DENSITY (PCF)	134.2	OPTIMUM MOISTURE	6.8%



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MOISTURE DENSITY RELATION

DRAWN:	DATE:	CHECKED:	DATE:
			9/11/20

JOB NO.: 201782

FIG NO.: B-20

CBR TEST LOAD DATA

JOB NO: 201782
CLIENT: FLRD #2
PROJECT: FOREST LAKES, FILING 5
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 # 6 LOAD(LBS) (LBS)	STRESS (PSI)	*56 BLOWS* MOLD # 13 LOAD(LBS) (LBS)	STRESS (PSI)
0.000	0	0.00	0	0.00	0	0.00
0.025	62	20.72	153	51.13	194	64.83
0.050	112	37.43	349	116.62	681	227.57
0.075	184	61.49	435	145.36	1072	358.23
0.100	265	88.55	563	188.14	1512	505.26
0.125	337	112.61	665	222.22	1910	638.26
0.150	389	129.99	736	245.95	2295	766.91
0.175	456	152.38	817	273.02	2777	927.98
0.200	515	172.10	970	324.14	3124	1043.94
0.300	599	200.17	1337	446.78	4500	1503.75
0.400	679	226.90	1661	555.05	5545	1852.96
0.500	824	275.35	2051	685.38	6000	2005.01

FINAL MOISTURE CONTENT

	MOLD # 1	MOLD # 6	MOLD # 13
CAN #	303	345	341
WT. CAN	7.89	8.4	8.34
WT. CAN+WET	211.21	232.12	183.39
WT. CAN+DRY	189.36	205.85	166.13
WT. H20	21.85	26.27	17.26
WT. DRY SOIL	181.47	197.45	157.79
MOISTURE CONTENT	12.04%	13.30%	10.94%
WET DENSITY (PCF)	130.7	135.5	141.4
DRY DENSITY (PCF)	122.4	126.9	132.4
BEARING RATIO	8.86	18.81	50.53

90% OF DRY DENSITY	120.8
95% OF DRY DENSITY	127.5

BEARING RATIO AT 90% OF MAX	5.27	~ R VALUE	12
BEARING RATIO AT 95% OF MAX	22.30	~ R VALUE	71

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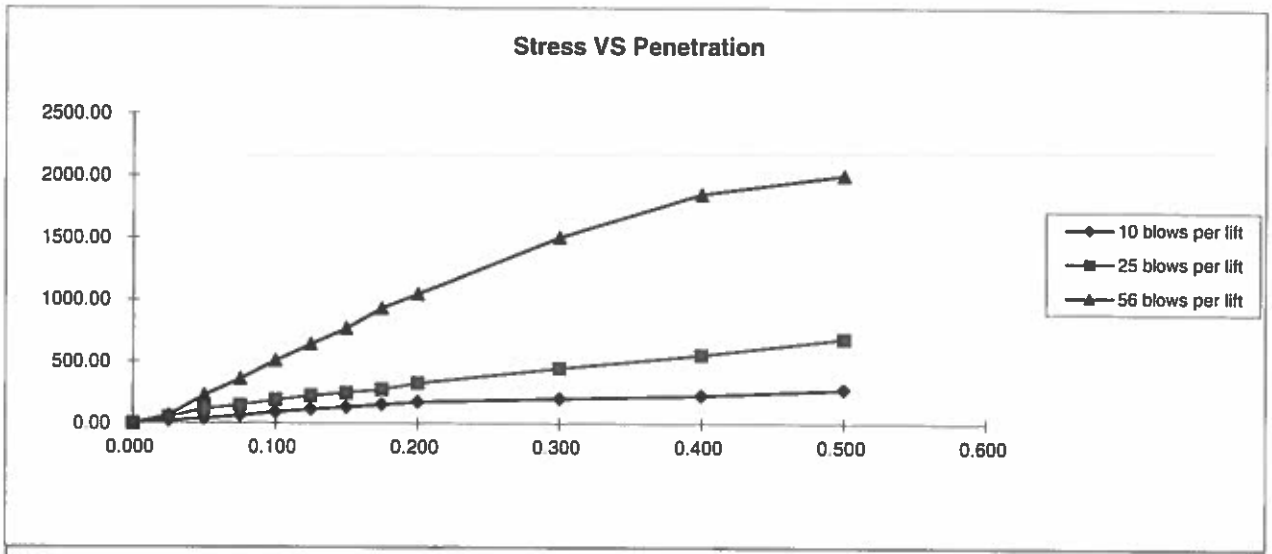
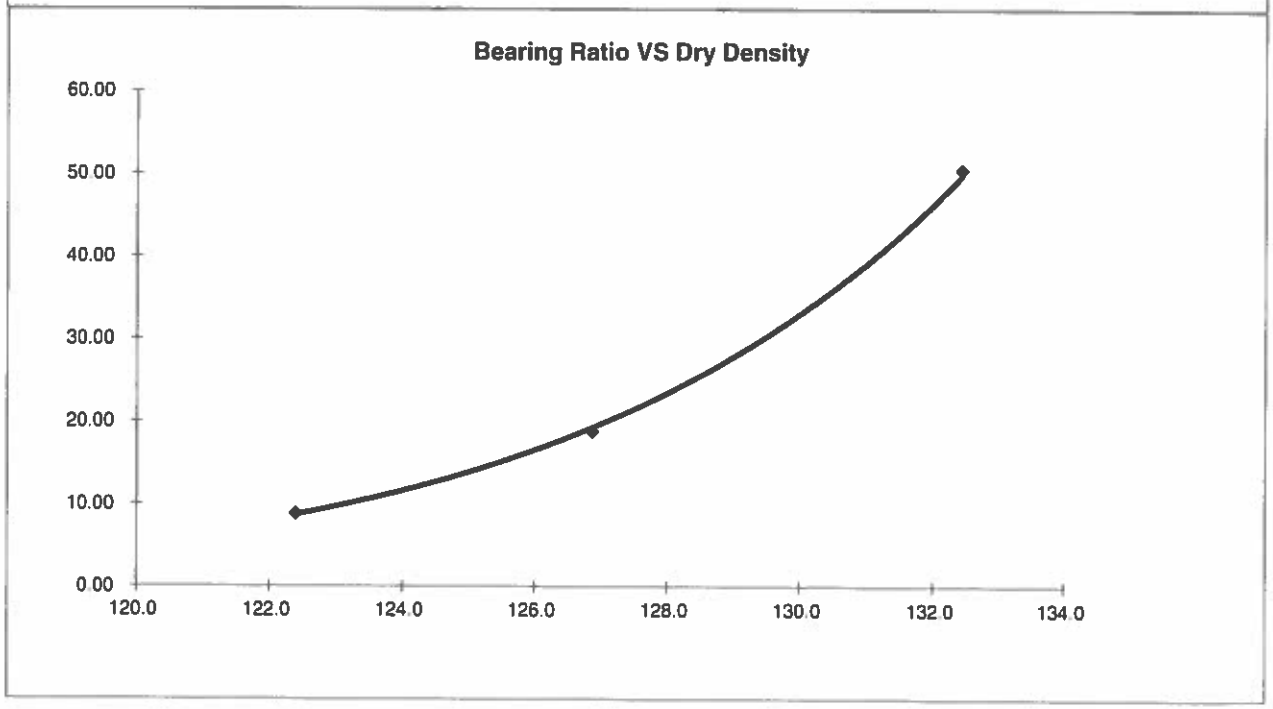
ENGINEERING, INC.
505 ELKTON DRIVE
COLORADO SPRINGS, COLORADO 80907

CBR TEST DATA

DRAWN:	DATE:	CHECKED:	DATE:
			9/11/20

JOB NO.: 201782
FIG NO.: 6-21





BEARING RATIO AT 90% OF MAX	5.27 ~ R VALUE	12.00
BEARING RATIO AT 95% OF MAX	22.30 ~ R VALUE	71.00

JOB NO: 201782
SOIL TYPE: 1

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COLORADO SPRINGS, COLORADO 80907

CALIFORNIA BEARING RATIO

DRAWN:	DATE:	CHECKED:	DATE:
			9/11/20

JOB NO.: 201782
FIG NO.: B22

APPENDIX C: Pavement Design Calculations

FLEXIBLE PAVEMENT DESIGN

DESIGN DATA — FLRD#5 - FOREST LAKES FILING NO.5
URBAN RESIDENTIAL COLLECTOR ROADS - SOIL TYPE 1

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	821,000
Hveem Stabilometer (R Value) Results:	R =	50
Standard Deviation	S_o =	0.45
Loss in Serviceability	Δpsi =	2.2
Reliability	Reliability =	85
Reliability (z-statistic)	Z_R =	-1.036
Soil Resilient Modulus	M_R =	13168

Weighted Structural Number (WSN): → WSN = 2.54

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)
60	-0.253
70	-0.524
75	-0.674
80	-0.841
85	-1.036
90	-1.282
95	-1.65
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
5.91	5.91	0.0

Job No. 201782
Fig. No. C-.1

DESIGN CALCULATIONS

DESIGN DATA — CLASSIC COMMUNITIES - MIDTOWN AT HANNAH RIDGE, F1
URBAN RESIDENTIAL COLLECTOR ROADS - SOIL TYPE 1

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL =	821,000
Hveem Stabilometer (R Value) Results:	R =	50
Weighted Structural Number (WSN):	WSN =	2.54

DESIGN EQUATION

$$WSN = C_1D_1 + C_2D_2$$

C_1 = 0.44 Strength Coefficient - Hot Bituminous Asphalt
C_2 = 0.11 Strength Coefficient - Aggregate Base Course

D_1 = Depth of Asphalt (inches)
D_2 = Depth of Base Course (inches)

FOR FULL DEPTH ASPHALT SECTION

$D_1 = (WSN)/C_1$ = 5.8 inches of Full Depth Asphalt
Use 6.0 inches Full Depth

FOR ASPHALT + AGGREGATE BASE COURSE SECTION

Asphalt Thickness (t) = [4] inches
$D_2 = ((WSN) - (t)(C_1))/C_2$ = 7.1 inches of Aggregate
Base Course, use 8.0 inches

RECOMMENDED ALTERNATIVES

1. 4.0 inches of Asphalt + 8.0 inches of Aggregate Base Course, or
2. 6.0 inches of Asphalt

Job No. 201782
Fig. No. C- 2

DESIGN CALCULATIONS

CEMENT TREATED SECTIONS

DESIGN DATA: FLRD#5 - FOREST LAKES FILING NO, 5
URBAN RESIDENTIAL COLLECTOR ROADS - SOIL TYPE 1
ALL ROADWAYS

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL =	821,000
Hveem Stabilometer (R Value) Results:	R =	50
Weighted Structural Number (WSN):	WSN =	2.54

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)

$D_1 = (WSN)/C_1$ = 5.8 inches of Full Depth Asphalt
Use 6.0 inches Full Depth

FOR ASPHALT + CEMENT TREATED SUBGRADE SECTION

Asphalt Thickness (t) = 4 inches
$D_2 = ((WSN) - (t)(C_1))/C_2$ = 6.5 inches
Use 10.0 inches of Cement Treated Subgrade.

RECOMMENDED ALTERNATIVES

1. 4.0 inches of Asphalt + 10 inches of Cement Treated Subgrade.
2. 6.0 inches of Full Depth Asphalt

Job No. 201782
Fig. No. C-3

ENTECH
ENGINEERING, INC.

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

September 15, 2020

FLRD #5
2138 Flying Horse Club Drive
Colorado Springs, Colorado 80921

Attn: Mark Sherwood

Re: Cement Stabilized Subgrade Results - Laboratory Testing
Forest Lakes Filing No. 5
El Paso county of Colorado

Ref: Pavement Recommendations Report by Entech Engineering, Inc., dated September 15, 2020, Entech Job No. 201782.

Dear Mr. Sherwood:

As requested, personnel of Entech Engineering, Inc. have performed strength testing on two sets of three soil/cement composite samples 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 209 psi. The 5-day average strength value of the 4% mix was 243 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 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,

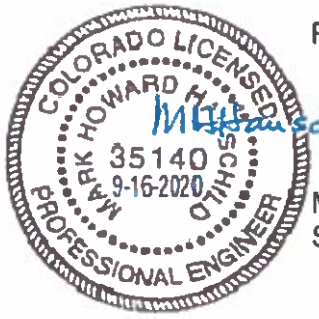
ENTECH ENGINEERING, INC.

Daniel P. Stegman

DPS/bs

Encl.

Entech Job No. 201782
AAprojects/2020/201782 cssr – lab



Reviewed by:

Mark H. Hauschild, P.E.
Senior Engineer

SUMMARY OF CTS TEST RESULTS

LAB TESTING

CLIENT FLRD #5
PROJECT FOREST LAKES, FILING 5
FIELD SAMPLE ID TB-7 @ 0-3'
SOIL ADDITIVE TYPE I/II CEMENT

JOB NO 201782
DATE 9/15/20
BY BL

ADDITIVE %	*WATER %*	*DENSITY (dry)*	*AGE (days)*	*STRENGTH (psi)*
2	6.8	127.1	5	199
2	6.8	126.6	5	216
2	6.8	127.4	5	211
			AVERAGE:	**209**
4	6.8	127.2	5	249
4	6.8	127.0	5	252
4	6.8	126.8	5	230
			AVERAGE:	**243**

CURING METHOD

100° HUMIDIFIED OVEN