



ENTECH
ENGINEERING, INC.

505 ELKTON DRIVE
COLORADO SPRINGS, CO 80907
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February 3, 2022
Revised March 29, 2022

Tech Contractors
3575 Kenyon Street, Suite 200
San Diego, California 92110

Attn: Raul Guzman

Re: Pavement Recommendations - Revised
Rolling Hills at Meridian Ranch Filing No. 2, Phase 2
El Paso County, Colorado

APPROVED
Engineering Department

03/31/2022 4:50:23 PM

dsdnijkamp

**EPC Planning & Community
Development Department**

Dear Mr. Guzman:

As requested, Entech Engineering, Inc. has obtained samples of the subgrade soils from sections of the roadways in the Rolling Hills at Meridian Ranch, Filing No. 2, Phase 2, in El Paso County, Colorado. Laboratory testing to determine the pavement support characteristics of the soils was performed. This letter presents the results of the laboratory testing and provides pavement recommendations for the roadways.

Project Description

The roadways in this project consist of sections of Morning Hills Drive, Valley Peak Drive, and Rolling Ranch Drive, and includes Overlook Bluff Drive, Foggy Meadows Drive, Foggy Bend Lane, and Morning Ridge Drive. The site layout and the locations of the test borings, drilled at approximate 500-foot intervals, are shown on the Test Boring Location Map, Figure 1.

Subgrade Conditions

Thirteen exploratory test borings were drilled in the roadways to depths of approximately 5 to 10 feet. The Boring Logs are presented in Appendix A. Sieve Analysis and Atterberg Limit testing were performed on the subgrade soil samples obtained from the test borings for the purpose of classification. Two soil types and one bedrock type were encountered in the test borings. The soils encountered at subgrade depth consisted of one general soil type; Soil Type 1. The Type 1 soils consist of silty to slightly silty to clayey sand fill. Soil Type 2 and 3 were encountered at depths below the subgrade influence zone. This report evaluates and presents recommendations for the Type 1 soils, which design values were used for all of the roadway sections.

Sieve analyses performed on Type 1 subgrade soils indicated the percent passing the No. 200 sieve ranged from approximately 9 to 34 percent. Atterberg Limit Tests performed on the samples resulted in Liquid Limits ranging from no value to 39 and Plastic Indexes of non-plastic to 22 percent. Soil Type 1 classified as A-1-b, A-2-6, and A-2-4 soils based on the AASHTO classification system. These soils have good pavement support characteristics. Sulfate testing of the subgrade indicated that the soils exhibit a negligible potential for sulfate attack. Groundwater was not encountered in the test borings.

Swell testing was performed on several samples of the site subgrade soils based on their Plastic Indexes. Volume changes of 0.1 to 1.9 percent were measured on the soils at subgrade depth. Based on the low volume changes, mitigation is not required. Laboratory test results are presented in Appendix B and are summarized on Table 1.

EPC Project No. SF-2020

California Bearing Ratio (CBR) testing was performed on a sample of Soil Type 1 to determine the support characteristic of the subgrade soils for the roadway sections. The results of the CBR testing, are presented in Appendix B and summarized as follows:

Soil Type1 – Clayey Sand Fill

R @ 90% = 10.0
R @ 95% = 22.0
Use R = 20.0 for design

Classification Testing

Liquid Limit	30
Plasticity Index	14
Percent Passing 200	26.2
AASHTO Classification	A-2-6
Group Index	0
Unified Soils Classification	SC

Pavement Design

The CBR testing was used to determine pavement sections for this site. The pavement sections were determined utilizing the El Paso County "Pavement Design Criteria and Report". The following classifications and ESAL values were used for this portion of the filing. The cul-de-sac portions of Overlook Bluff Drive classifies as an urban local (low-volume) roadways, which used an 18k ESAL value of 36,500 for design. All of the remaining roadways in this phase classify as urban local roads, which used an 18K ESAL value of 292,000 for design. Pavement alternatives for asphalt over aggregate basecourse and cement stabilized subgrade sections are provided. Full depth asphalt sections are not allowed, per El Paso County. Design parameters used in the pavement analysis are as follows:

Reliability	
Local Low Volume & Urban Local	80%
Serviceability Index	
Local Low Volume & Urban Local	2.0
Resilient Modulus	4,940 psi
"R" Value Subgrade	20.0
Structural Coefficients:	
Hot Bituminous Pavement	0.44
Aggregate Basecourse	0.11
Cement Stabilized Subgrade	0.11

Pavement calculations are attached in Appendix C. Pavement sections recommended for this phase of the filing are summarized as follows:

Pavement Sections – Soil Type 1

Urban Local (low volume) – ESAL = 36,500
Overlook Bluff Drive - Cul-de-sac

<u>Alternative</u>	<u>Asphalt (in)</u>	<u>Basecourse (in)</u>	<u>Cement Stabilized Subgrade (in.)</u>
1. Asphalt + Basecourse	3.5*	6.5	--
2. Asphalt + Cement Subgrade	4.0	--	8.0

Urban Local – ESAL = 292,000
Valley Peak Drive, Rolling Ranch Drive, Morning Ridge Drive
Morning Hills Drive, Foggy Meadows Drive, Overlook Bluff Drive
And Foggy Bend Lane

<u>Alternative</u>	<u>Asphalt (in)</u>	<u>Basecourse (in)</u>	<u>Cement Stabilized Subgrade (in.)</u>
1. Asphalt + Basecourse	5.0	8.0	--
2. Asphalt + Cement Subgrade	4.5	--	10.0

* Minimum sections required by the El Paso County Pavement Design Criteria and Report.

Mitigation

El Paso County criteria requires mitigation of expansive soils for roadway subgrade that have a swell of 2 percent or greater with a 150 pound per square foot surcharge. All of the site subgrade soils tested exhibited low swell potentials which did not exceed the threshold. Mitigation is not required.

Roadway Construction - 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 its 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. Base course 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 8 inches, as determined by Roadway Classification. The depth of the required cement stabilized subgrade is shown in the previous table. 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 the appropriate 8 inches depth such that a uniform blend of soil and cement is achieved. Prior to application or mixing of the cement, the upper 8 inches of subgrade, as recommended 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.
- Pending the results of the field density testing, microfracturing of the stabilized subgrade will likely be required. Soil strengths in excess of 200 psi require microfracturing.

If significant grading is performed, the soils at subgrade may change. Modification to the pavement section recommendations 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,

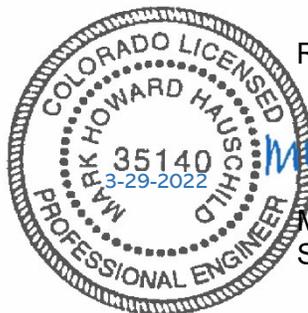
ENTECH ENGINEERING, INC.



Daniel P. Stegman

DPS/bs

Entech Job No. 213333
AAprojects/2021/213333 pr1 - Rev



Reviewed by:



Mark H. Hauschild, P.E.
Senior Engineer

TABLE

TABLE 1
SUMMARY OF LABORATORY TEST RESULTS

CLIENT TECH CONTRACTORS
 PROJECT ROLLING HILLS RANCH, F-2
 JOB NO. 213333

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	2	0-3			26.2	30	14		A-2-6		SC	FILL, SAND, CLAYEY
1	1	1-2	10.1	121.0	33.8	39	22		A-2-6	0.9	SC	SAND, CLAYEY
1	2	1-2	9.3	121.5	22.5	31	13		A-2-6	0.1	SC	FILL, SAND, CLAYEY
1	3	1-2			18.6	NV	NP		A-1-b		SM	FILL, SAND, SILTY
1	4	1-2			8.5	NV	NP	<0.01	A-1-b		SM-SW	FILL, SAND, SLIGHTLY SILTY
1	5	1-2	14.8	111.3	25.0	32	15		A-2-6	0.6	SC	FILL, SAND, CLAYEY
1	6	1-2	14.7	111.4	23.9	29	14		A-2-6	1.9	SC	FILL, SAND, CLAYEY
1	7	1-2			11.5	NV	NP	<0.01	A-1-b		SM-SW	FILL, SAND, SLIGHTLY SILTY
1	8	1-2			17.5	NV	NP		A-1-b		SM	FILL, SAND, SILTY
1	9	1-2			16.8	NV	NP		A-1-b		SM	FILL, SAND, SILTY
1	10	1-2			12.5	NV	NP		A-1-b		SM	FILL, SAND, SILTY
1	11	1-2			25.8	32	16	<0.01	A-2-6		SC	FILL, SAND, CLAYEY
1	12	1-2			18.5	NV	NP		A-1-b		SM	FILL, SAND, SILTY
1	13	1-2			20.5	NV	NP		A-2-4		SM	FILL, SAND, SILTY
2	6	10	17.1	112.3	61.7	45	23	<0.01	A-7-6	6.6	CL	CLAY, VERY SANDY
3	2	10			26.0	NV	NP	<0.01	A-2-4		SM	SANDSTONE, SILTY
3	4	5			10.5	NV	NP		A-1-b		SM-SW	SANDSTONE, SLIGHTLY SILTY
3	7	10			24.4	NV	NP		A-2-4		SM	SANDSTONE, SILTY
3	11	10	11.0	116.3	30.8	40	21	<0.01	A-2-6	0.4	SC	SANDSTONE, CLAYEY

FIGURES

APPENDIX A: Test Boring Logs

TEST BORING NO. 1
 DATE DRILLED 1/7/2022
 Job # 213333

TEST BORING NO. 2
 DATE DRILLED 12/27/2021
 CLIENT TECH CONTRACTORS
 LOCATION ROLLING HILLS RANCH, F-2

REMARKS

DRY TO 5', 1/7/22
 FILL 0-5', SAND, CLAYEY, FINE TO MEDIUM GRAINED, DARK BROWN TO BROWN, DENSE TO MEDIUM DENSE, MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
0-5	[Symbol]		35	9.4	1
5	[Symbol]		12	7.9	1
10					
15					
20					

REMARKS

DRY TO 10', 12/27/21
 FILL 0-9', SAND, CLAYEY, FINE TO MEDIUM GRAINED, DARK BROWN, MEDIUM DENSE, MOIST

SANDSTONE, SILTY, FINE TO COARSE GRAINED, TAN, VERY DENSE, MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
0-9	[Symbol]		24	8.2	1
5	[Symbol]		12	8.3	1
10	[Symbol]		50 6"	11.3	3
15					
20					



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TEST BORING LOG

DRAWN:	DATE:	CHECKED:	DATE:
		DS	1/6/22

JOB NO.:
 213333

FIG NO.:
 A- 1

TEST BORING NO. 3
 DATE DRILLED 12/27/2021
 Job # 213333

TEST BORING NO. 4
 DATE DRILLED 12/27/2021
 CLIENT TECH CONTRACTORS
 LOCATION ROLLING HILLS RANCH, F-2

REMARKS

DRY TO 5', 12/27/21
 FILL 0-5', SAND, SILTY, FINE TO
 COARSE GRAINED, BROWN,
 MEDIUM DENSE, MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
5	[Symbol]		17	8.8	1
5	[Symbol]		13	6.2	1

REMARKS

DRY TO 5', 12/27/21
 FILL 0-5', SAND, SLIGHTLY
 SILTY, FINE TO COARSE GRAINED,
 TAN, MEDIUM DENSE, MOIST
 SANDSTONE, SILTY, FINE TO
 COARSE GRAINED, TAN, VERY
 DENSE, MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
5	[Symbol]		20	8.1	1
5	[Symbol]		50 8"	7.2	3



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TEST BORING LOG

DRAWN: DATE: CHECKED: SW DATE: 1-10-22

JOB NO.:
213333

FIG NO.:
A- 2

TEST BORING NO. 5
 DATE DRILLED 12/27/2021
 Job # 213333

TEST BORING NO. 6
 DATE DRILLED 12/27/2021
 CLIENT TECH CONTRACTORS
 LOCATION ROLLING HILLS RANCH, F-2

REMARKS

DRY TO 5', 12/27/21

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

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
5	[Symbol]		11	8.1	1
5	[Symbol]		10	6.4	1
10					
15					
20					

REMARKS

DRY TO 10', 12/27/21

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

CLAY, VERY SANDY, BROWN,
 STIFF, MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
5	[Symbol]		15	11.3	1
5	[Symbol]		20	10.1	1
10	[Symbol]		29	15.3	2
15					
20					



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TEST BORING LOG

DRAWN:

DATE:

CHECKED: SW

DATE: 1-10-22

JOB NO.:
 213333

FIG NO.:
 A- 3

TEST BORING NO. 7
 DATE DRILLED 12/27/2021
 Job # 213333

TEST BORING NO. 8
 DATE DRILLED 12/27/2021
 CLIENT TECH CONTRACTORS
 LOCATION ROLLING HILLS RANCH, F-2

REMARKS

DRY TO 10', 12/27/21

FILL 0-7', SAND, SLIGHTLY SILTY,
 FINE TO COARSE GRAINED, TAN,
 LOOSE TO DENSE, MOIST

SANDSTONE, SILTY, FINE TO
 COARSE GRAINED, TAN, VERY
 DENSE, MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
0-7	(Dotted pattern)		7	5.3	1
7-10	(Dotted pattern)		36	9.0	1
10-10.8	(Dotted pattern)		50 8"	16.1	3

REMARKS

DRY TO 5', 12/27/21

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

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
0-5	(Dotted pattern)		7	4.1	1
5-10	(Dotted pattern)		16	8.6	1



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TEST BORING LOG

DRAWN:	DATE:	CHECKED: SW	DATE: 1-10-22
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JOB NO.:
 213333

FIG NO.:
 A- 4

TEST BORING NO. 9
 DATE DRILLED 12/27/2021
 Job # 213333

TEST BORING NO. 10
 DATE DRILLED 12/27/2021
 CLIENT TECH CONTRACTORS
 LOCATION ROLLING HILLS RANCH, F-2

REMARKS	Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type	REMARKS	Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
DRY TO 5', 12/27/21							DRY TO 5', 12/27/21						
FILL 0-5', SAND, SILTY, FINE TO COARSE GRAINED, BROWN, MEDIUM DENSE, MOIST	0-5	[Symbol]		16	8.2	1	FILL 0-5', SAND, SILTY, FINE TO COARSE GRAINED, BROWN, MEDIUM DENSE, MOIST	0-5	[Symbol]		24	6.7	1
	5	[Symbol]		18	9.8	1		5	[Symbol]		18	7.5	1
	10							10					
	15							15					
	20							20					



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TEST BORING LOG

DRAWN:	DATE:	CHECKED: SW	DATE: 1-10-22
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JOB NO.:
 213333

FIG NO.:
 A- 5

TEST BORING NO. 11
 DATE DRILLED 12/27/2021
 Job # 213333

TEST BORING NO. 12
 DATE DRILLED 12/27/2021
 CLIENT TECH CONTRACTORS
 LOCATION ROLLING HILLS RANCH, F-2

REMARKS	Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type	REMARKS	Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
DRY TO 10', 12/27/21 FILL 0-9, SAND, CLAYEY, FINE TO MEDIUM GRAINED, TAN, MEDIUM DENSE TO LOOSE, MOIST	5	[Symbol]		17	8.7	1	DRY TO 5', 12/27/21 FILL 0-5, SAND, SILTY, FINE TO COARSE GRAINED, BROWN, LOOSE TO MEDIUM DENSE, MOIST	5	[Symbol]		9	5.9	1
	5	[Symbol]		7	10.2	1		5	[Symbol]		11	17.9	1
SANDSTONE, CLAYEY, FINE TO COARSE GRAINED, TAN, VERY DENSE, MOIST	10	[Symbol]		50 11"	12.7	3		10	[Symbol]				
	15							15					
	20							20					



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TEST BORING LOG

DRAWN:

DATE:

CHECKED: SW

DATE: 1-10-22

JOB NO.:
 213333

FIG NO.:
 A-6

TEST BORING NO. 13
 DATE DRILLED 12/27/2021
 Job # 213333

TEST BORING NO.
 DATE DRILLED
 CLIENT TECH CONTRACTORS
 LOCATION ROLLING HILLS RANCH, F-2

REMARKS	Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type	REMARKS	Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
DRY TO 5', 12/27/21													
FILL 0-5', SAND, SILTY, FINE TO COARSE GRAINED, BROWN, LOOSE TO MEDIUM DENSE, MOIST TO DRY	0-5	(Symbol)		7	6.2	1							
	5	(Symbol)		15	1.3	1							
	10												
	15												
	20												



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TEST BORING LOG

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DATE:

SW 1-10-22

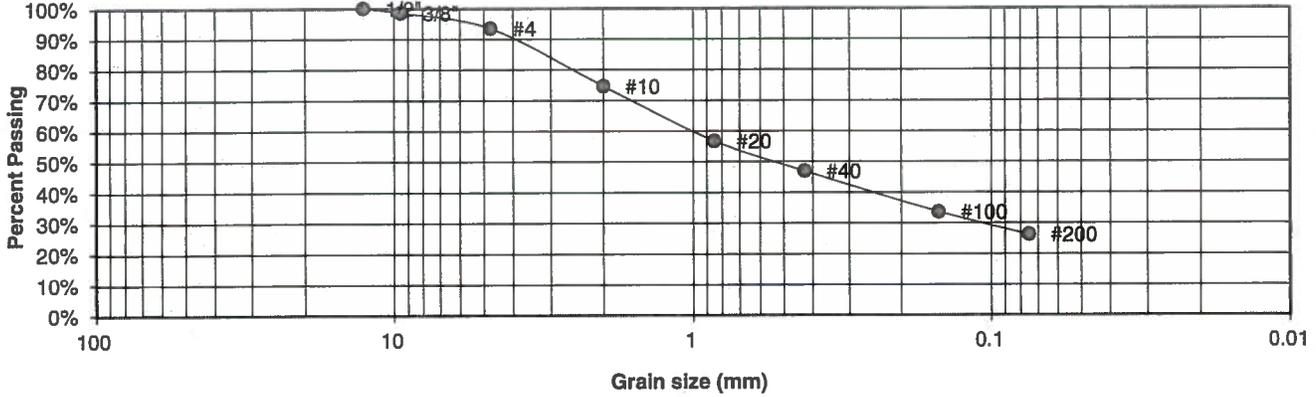
JOB NO.:
 213333

FIG NO.:
 A-7

APPENDIX B: Laboratory Testing Results

UNIFIED CLASSIFICATION	SC	CLIENT	TECH CONTRACTORS
SOIL TYPE #	1, CBR	PROJECT	ROLLING HILLS RANCH, F-2
TEST BORING #	2	JOB NO.	213333
DEPTH (FT)	0-3	TEST BY	BL
AASHTO CLASSIFICATION	A-2-6	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"	98.5%
4	93.5%
10	74.6%
20	56.8%
40	47.0%
100	33.6%
200	26.2%

Atterberg Limits	
Plastic Limit	16
Liquid Limit	30
Plastic Index	14

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



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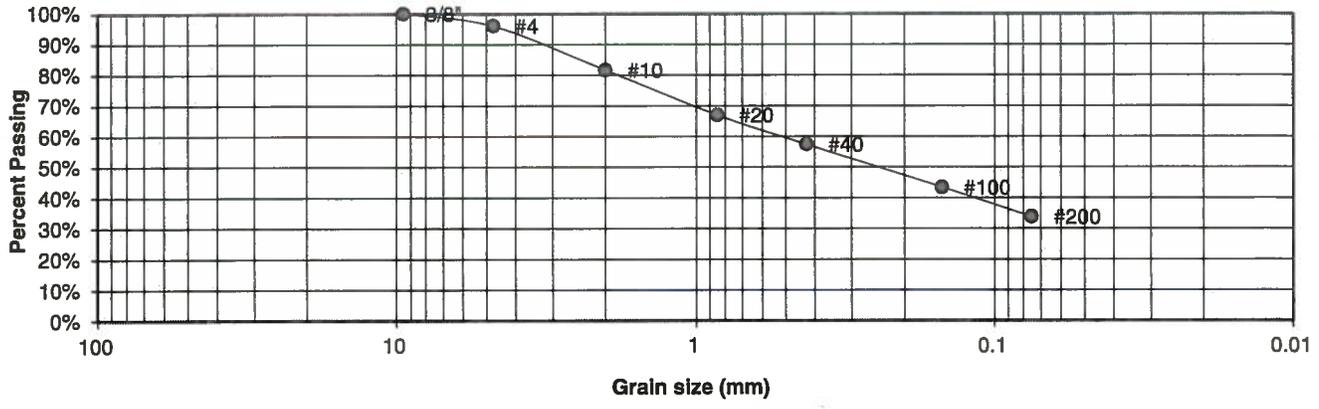
**LABORATORY TEST
RESULTS**

DRAWN:	DATE:	CHECKED: <i>SW</i>	DATE: <i>1-11-22</i>
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JOB NO.:
213333
FIG NO.:
B-1

<u>UNIFIED CLASSIFICATION</u>	SC	<u>CLIENT</u>	TECH CONTRACTORS
<u>SOIL TYPE #</u>	1	<u>PROJECT</u>	ROLLING HILLS RANCH, F-2
<u>TEST BORING #</u>	1	<u>JOB NO.</u>	213333
<u>DEPTH (FT)</u>	1-2	<u>TEST BY</u>	BL
<u>AASHTO CLASSIFICATION</u>	A-2-6	<u>GROUP INDEX</u>	2

**Sieve Analysis
Grain Size Distribution**



<u>U.S. Sieve #</u>	<u>Percent Finer</u>
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	96.1%
10	81.7%
20	67.0%
40	57.4%
100	43.4%
200	33.8%

<u>Atterberg Limits</u>	
Plastic Limit	17
Liquid Limit	39
Plastic Index	22
<u>Swell</u>	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	



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**LABORATORY TEST
RESULTS**

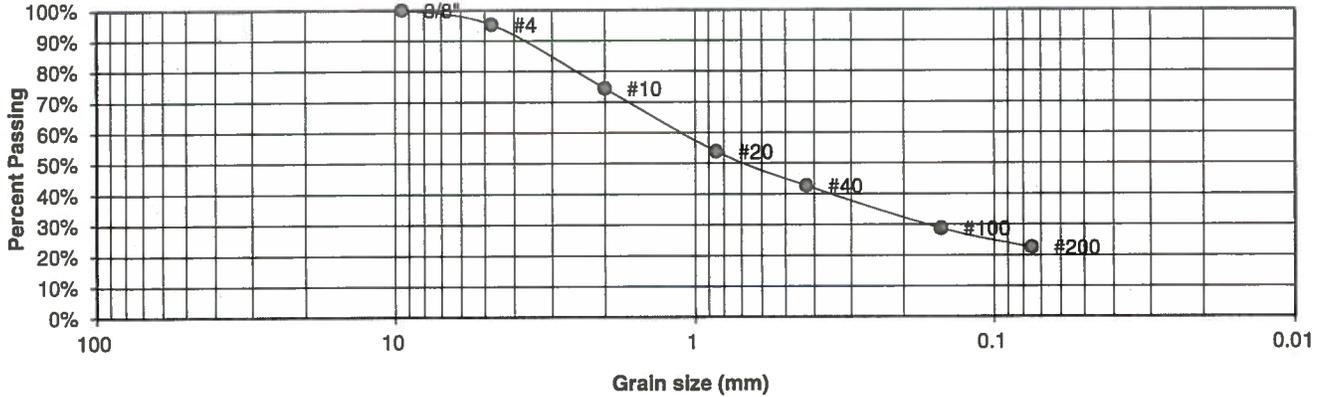
DRAWN:	DATE:	CHECKED: <i>SW</i>	DATE: <i>1-12-22</i>
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JOB NO.:
213333
FIG NO.:
B-2

UNIFIED CLASSIFICATION SC
SOIL TYPE # 1
TEST BORING # 2
DEPTH (FT) 1-2
AASHTO CLASSIFICATION A-2-6

CLIENT TECH CONTRACTORS
PROJECT ROLLING HILLS RANCH, F-2
JOB NO. 213333
TEST BY BL
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	95.3%
10	74.4%
20	53.9%
40	42.7%
100	28.7%
200	22.5%

Atterberg Limits	
Plastic Limit	18
Liquid Limit	31
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: <i>SW</i>	DATE: <i>1-11-22</i>
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JOB NO.:

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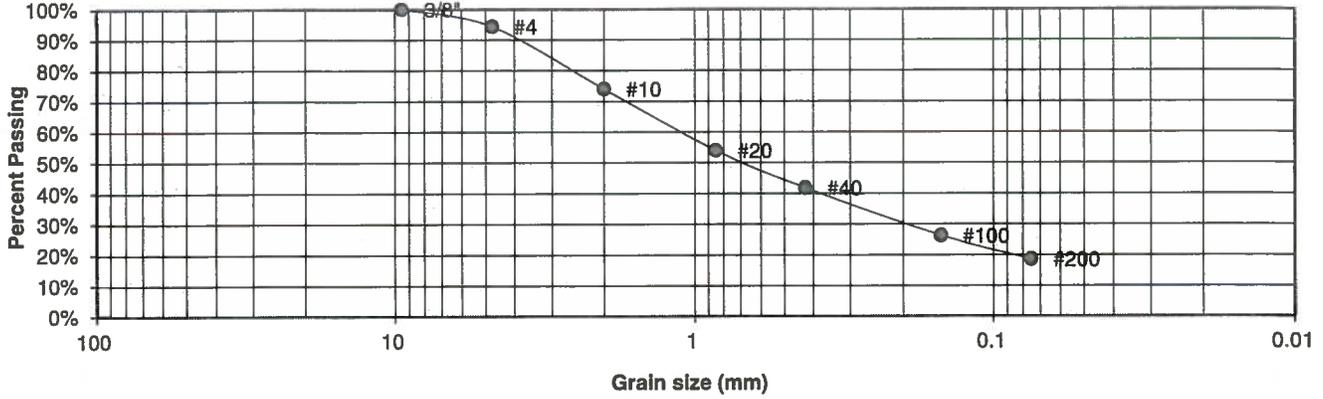
FIG NO.:

B-3

UNIFIED CLASSIFICATION SM
SOIL TYPE # 1
TEST BORING # 3
DEPTH (FT) 1-2
AASHTO CLASSIFICATION A-1-b

CLIENT TECH CONTRACTORS
PROJECT ROLLING HILLS RANCH, F-2
JOB NO. 213333
TEST BY BL
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	94.3%
10	74.0%
20	53.9%
40	41.8%
100	26.3%
200	18.6%

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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505 ELKTON DRIVE
COLORADO SPRINGS, COLORADO 80907

**LABORATORY TEST
RESULTS**

DRAWN:	DATE:	CHECKED: <i>SW</i>	DATE: <i>1-11-22</i>
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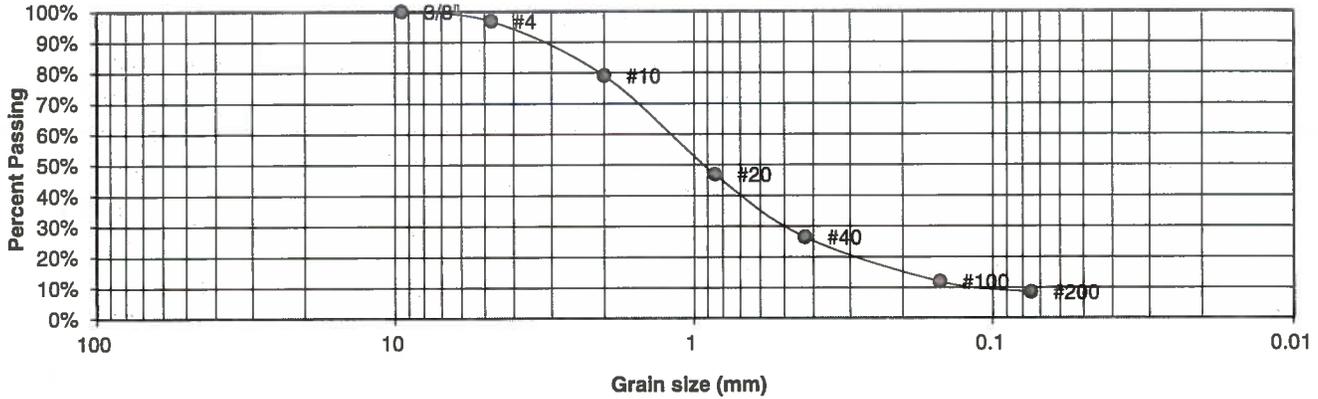
JOB NO.:

213333
FIG NO.:

B-4

UNIFIED CLASSIFICATION	SM-SW	CLIENT	TECH CONTRACTORS
SOIL TYPE #	1	PROJECT	ROLLING HILLS RANCH, F-2
TEST BORING #	4	JOB NO.	213333
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-1-b	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	96.9%
10	79.1%
20	46.9%
40	26.4%
100	11.9%
200	8.5%

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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DRAWN:	DATE:	CHECKED: <i>SW</i>	DATE: <i>1-11-22</i>
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JOB NO.:

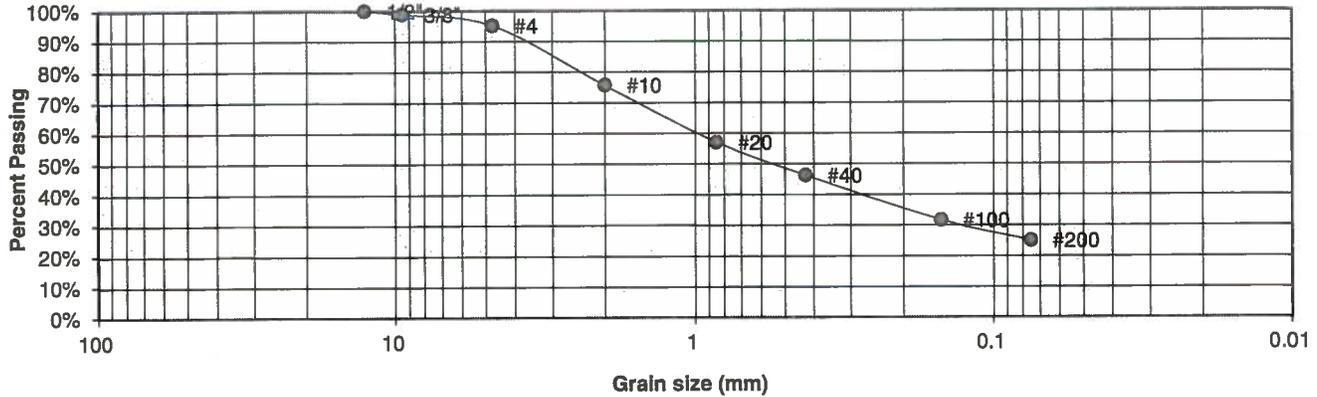
213333

FIG NO.:

B-5

UNIFIED CLASSIFICATION	SC	CLIENT	TECH CONTRACTORS
SOIL TYPE #	1	PROJECT	ROLLING HILLS RANCH, F-2
TEST BORING #	5	JOB NO.	213333
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-2-6	GROUP INDEX	1

**Sieve Analysis
Grain Size Distribution**



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	98.9%
4	95.2%
10	75.7%
20	57.1%
40	46.3%
100	31.6%
200	25.0%

Atterberg Limits	
Plastic Limit	17
Liquid Limit	32
Plastic Index	15

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



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RESULTS**

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JOB NO.:

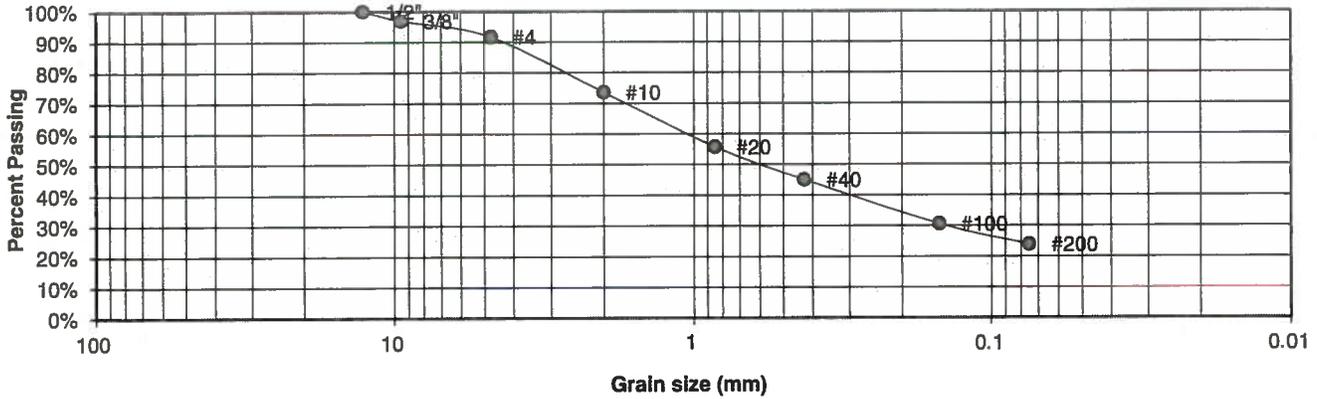
213333
FIG NO.:

B-6

UNIFIED CLASSIFICATION SC
SOIL TYPE # 1
TEST BORING # 6
DEPTH (FT) 1-2
AASHTO CLASSIFICATION A-2-6

CLIENT TECH CONTRACTORS
PROJECT ROLLING HILLS RANCH, F-2
JOB NO. 213333
TEST BY BL
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"	96.9%
4	91.7%
10	73.6%
20	55.7%
40	45.0%
100	30.6%
200	23.9%

Atterberg Limits	
Plastic Limit	16
Liquid Limit	29
Plastic Index	14

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



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JOB NO.:

213333

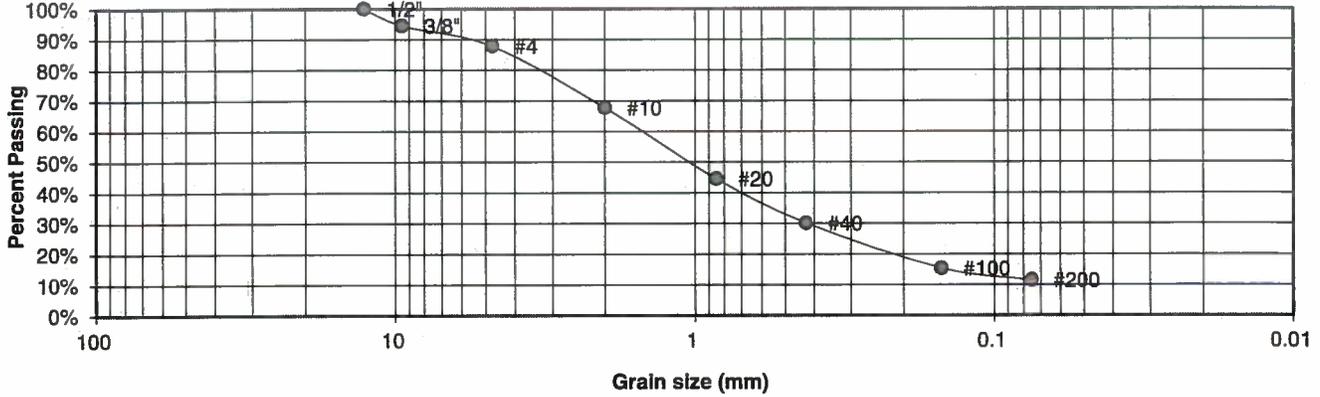
FIG NO.:

B 7

UNIFIED CLASSIFICATION SM-SW
SOIL TYPE # 1
TEST BORING # 7
DEPTH (FT) 1-2
AASHTO CLASSIFICATION A-1-b

CLIENT TECH CONTRACTORS
PROJECT ROLLING HILLS RANCH, F-2
JOB NO. 213333
TEST BY BL
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"	94.5%
4	87.8%
10	67.8%
20	44.6%
40	30.1%
100	15.4%
200	11.5%

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: SW	DATE: 1-11-22
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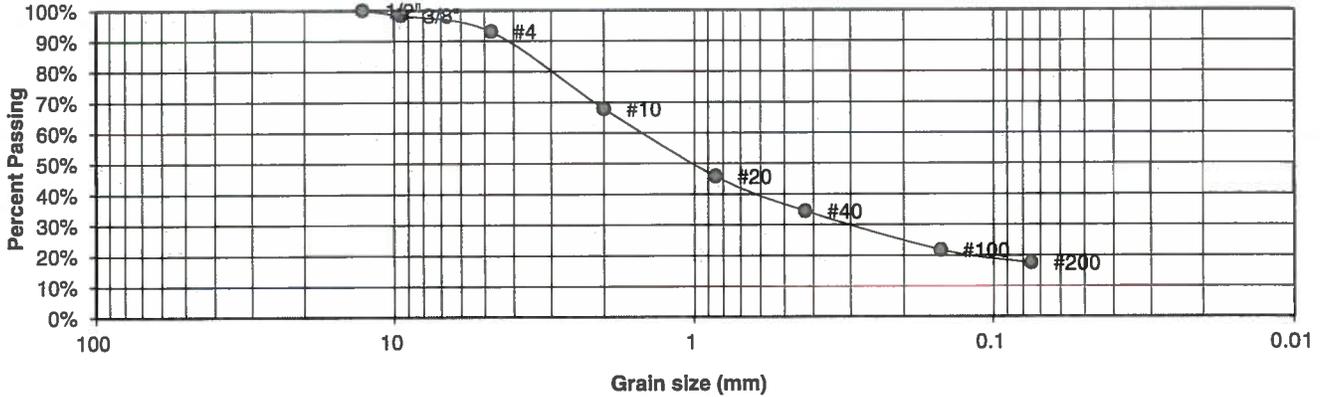
JOB NO.:

213333
FIG NO.:

B-8

UNIFIED CLASSIFICATION	SM	CLIENT	TECH CONTRACTORS
SOIL TYPE #	1	PROJECT	ROLLING HILLS RANCH, F-2
TEST BORING #	8	JOB NO.	213333
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-1-b	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"	98.3%
4	93.0%
10	67.9%
20	45.8%
40	34.5%
100	21.7%
200	17.5%

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: <i>SW</i>	DATE: <i>1-11-22</i>
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JOB NO.:

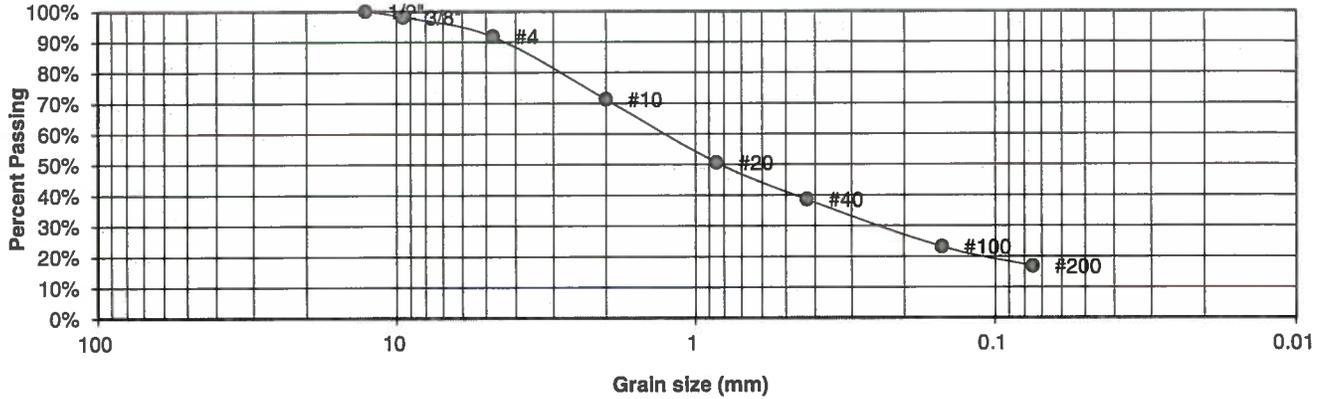
213333

FIG NO.:

B.9

UNIFIED CLASSIFICATION	SM	CLIENT	TECH CONTRACTORS
SOIL TYPE #	1	PROJECT	ROLLING HILLS RANCH, F-2
TEST BORING #	9	JOB NO.	213333
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-1-b	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"	98.1%
4	91.8%
10	71.3%
20	50.7%
40	38.6%
100	23.1%
200	16.8%

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: *SW*

DATE: *1-11-22*

JOB NO.:

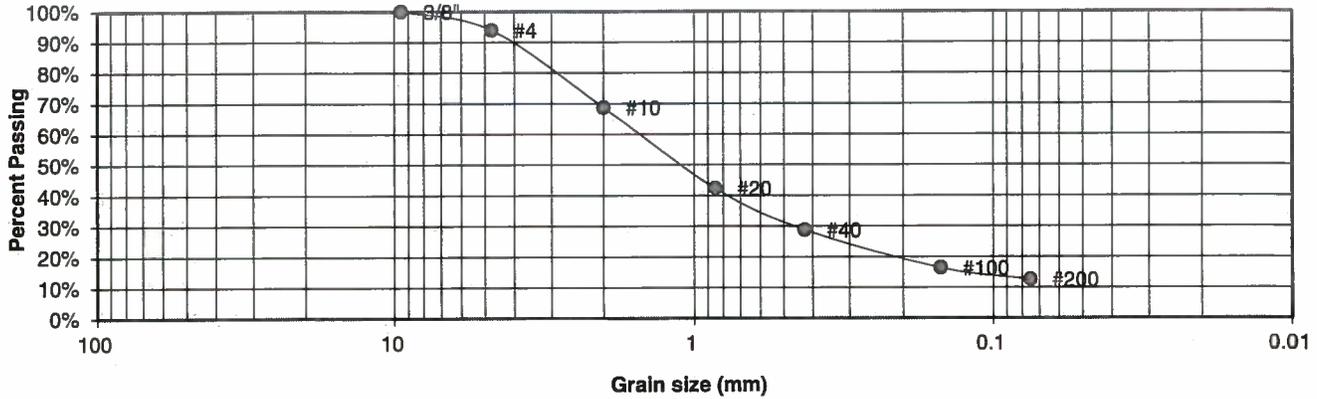
213333

FIG NO.:

B10

UNIFIED CLASSIFICATION	SM	CLIENT	TECH CONTRACTORS
SOIL TYPE #	1	PROJECT	ROLLING HILLS RANCH, F-2
TEST BORING #	10	JOB NO.	213333
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-1-b	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	93.9%
10	68.7%
20	42.3%
40	28.7%
100	16.3%
200	12.5%

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: <i>SW</i>	DATE: <i>1-11-22</i>
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JOB NO.:

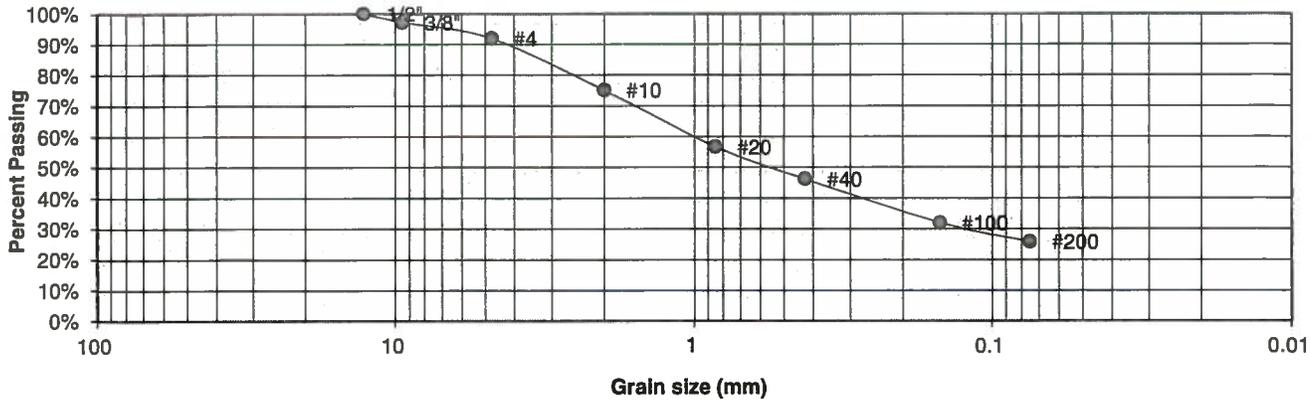
213333

FIG NO.:

B-11

UNIFIED CLASSIFICATION	SC	CLIENT	TECH CONTRACTORS
SOIL TYPE #	1	PROJECT	ROLLING HILLS RANCH, F-2
TEST BORING #	11	JOB NO.	213333
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-2-6	GROUP INDEX	1

**Sieve Analysis
Grain Size Distribution**



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	97.1%
4	91.9%
10	75.1%
20	56.7%
40	46.2%
100	31.9%
200	25.8%

Atterberg Limits	
Plastic Limit	16
Liquid Limit	32
Plastic Index	16

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



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RESULTS**

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JOB NO.:

213333

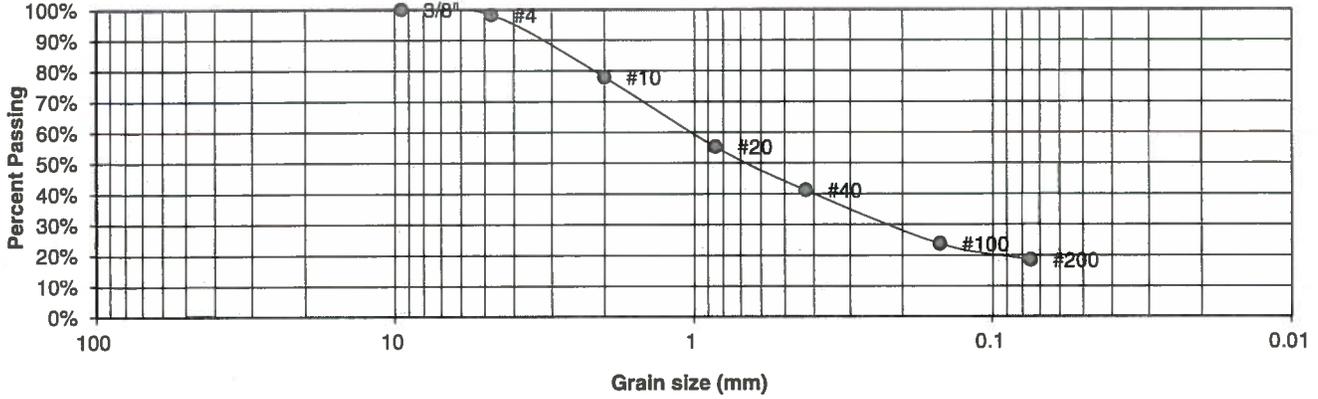
FIG NO.:

B-12

UNIFIED CLASSIFICATION SM
SOIL TYPE # 1
TEST BORING # 12
DEPTH (FT) 1-2
AASHTO CLASSIFICATION A-1-b

CLIENT TECH CONTRACTORS
PROJECT ROLLING HILLS RANCH, F-2
JOB NO. 213333
TEST BY BL
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	98.2%
10	77.9%
20	55.3%
40	41.2%
100	23.7%
200	18.5%

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**

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JOB NO.:

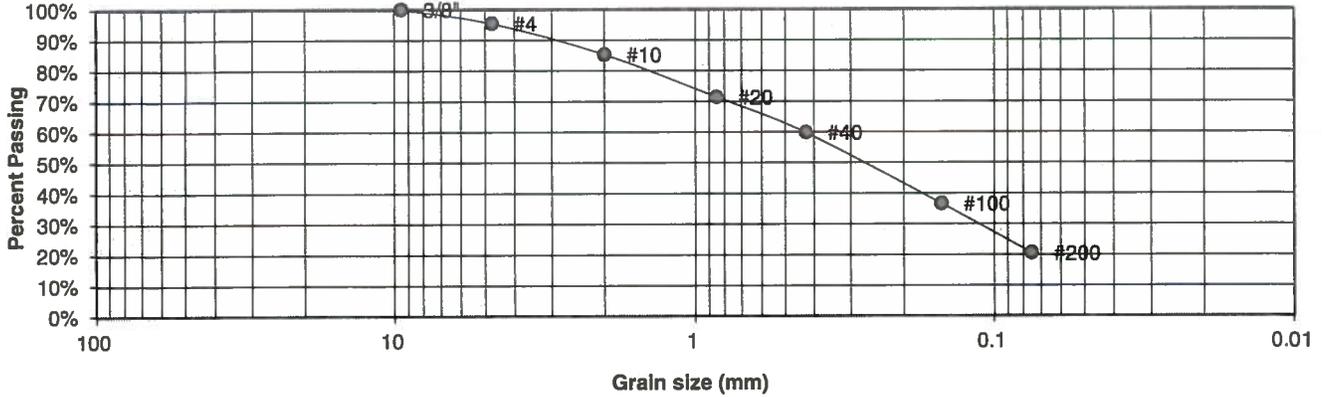
213333
FIG NO.:

B-13

UNIFIED CLASSIFICATION SM
SOIL TYPE # 1
TEST BORING # 13
DEPTH (FT) 1-2
AASHTO CLASSIFICATION A-2-4

CLIENT TECH CONTRACTORS
PROJECT ROLLING HILLS RANCH, F-2
JOB NO. 213333
TEST BY BL
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	95.4%
10	85.3%
20	71.4%
40	59.8%
100	36.6%
200	20.5%

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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RESULTS**

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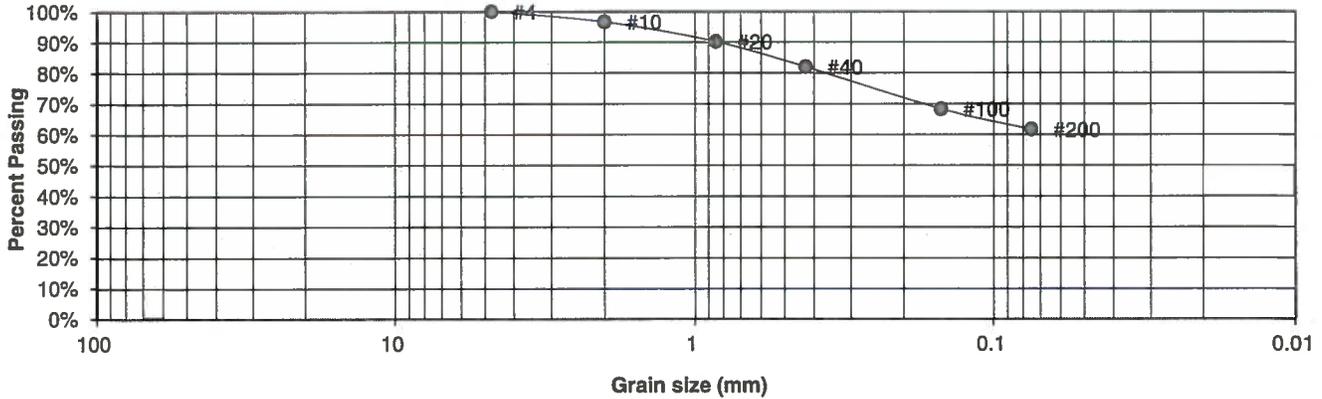
JOB NO.:

213333
FIG NO

B-14

UNIFIED CLASSIFICATION	CL	CLIENT	TECH CONTRACTORS
SOIL TYPE #	2	PROJECT	ROLLING HILLS RANCH, F-2
TEST BORING #	6	JOB NO.	213333
DEPTH (FT)	10	TEST BY	BL
AASHTO CLASSIFICATION	A-7-6	GROUP INDEX	12

**Sieve Analysis
Grain Size Distribution**



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	100.0%
10	96.6%
20	90.2%
40	82.0%
100	68.3%
200	61.7%

Atterberg Limits	
Plastic Limit	22
Liquid Limit	45
Plastic Index	23

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



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RESULTS**

DRAWN:	DATE:	CHECKED: SW	DATE: 1-11-22
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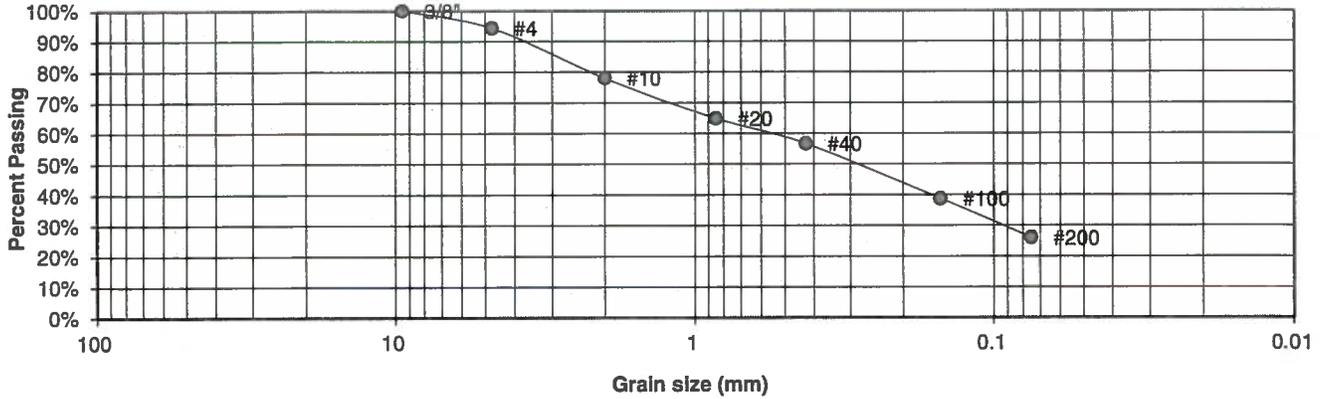
JOB NO.:

213333
FIG NO.:

B-15

UNIFIED CLASSIFICATION	SM	CLIENT	TECH CONTRACTORS
SOIL TYPE #	3	PROJECT	ROLLING HILLS RANCH, F-2
TEST BORING #	2	JOB NO.	213333
DEPTH (FT)	10	TEST BY	BL
AASHTO CLASSIFICATION	A-2-4	GROUP INDEX	0

**Sieve Analysis
Grain Size Distribution**



<u>U.S. Sieve #</u>	<u>Percent Finer</u>
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	94.3%
10	78.0%
20	64.9%
40	56.7%
100	38.7%
200	26.0%

<u>Atterberg Limits</u>	
Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

<u>Swell</u>	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	



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DATE:

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JOB NO.:

213333

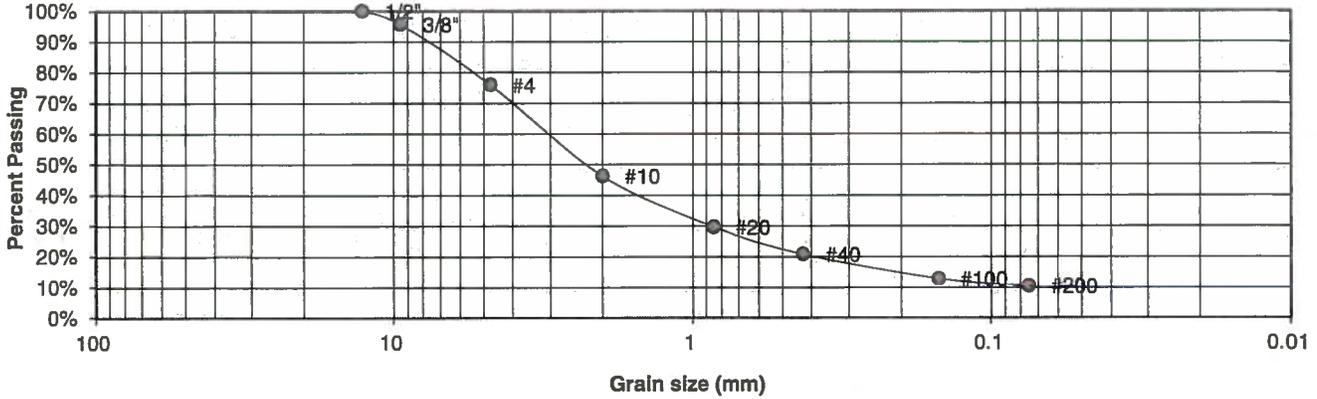
FIG NO.:

B16

UNIFIED CLASSIFICATION SM-SW
SOIL TYPE # 3
TEST BORING # 4
DEPTH (FT) 5
AASHTO CLASSIFICATION A-1-b

CLIENT TECH CONTRACTORS
PROJECT ROLLING HILLS RANCH, F-2
JOB NO. 213333
TEST BY BL
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"	95.7%
4	76.0%
10	46.3%
20	29.7%
40	20.8%
100	12.8%
200	10.5%

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: <i>SW</i>	DATE: <i>1-11-22</i>
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JOB NO.:

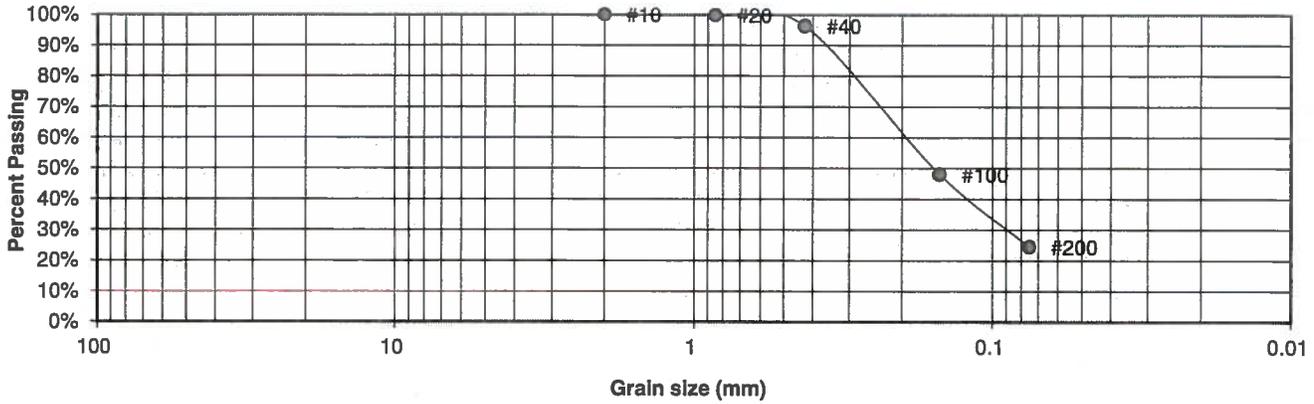
213333

FIG NO.:

B-17

<u>UNIFIED CLASSIFICATION</u>	SM	<u>CLIENT</u>	TECH CONTRACTORS
<u>SOIL TYPE #</u>	3	<u>PROJECT</u>	ROLLING HILLS RANCH, F-2
<u>TEST BORING #</u>	7	<u>JOB NO.</u>	213333
<u>DEPTH (FT)</u>	10	<u>TEST BY</u>	BL
<u>AASHTO CLASSIFICATION</u>	A-2-4	<u>GROUP INDEX</u>	0

**Sieve Analysis
Grain Size Distribution**



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	
10	100.0%
20	99.8%
40	96.2%
100	48.1%
200	24.4%

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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DRAWN:	DATE:	CHECKED: <i>SW</i>	DATE: <i>1-11-22</i>
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JOB NO.:

213333

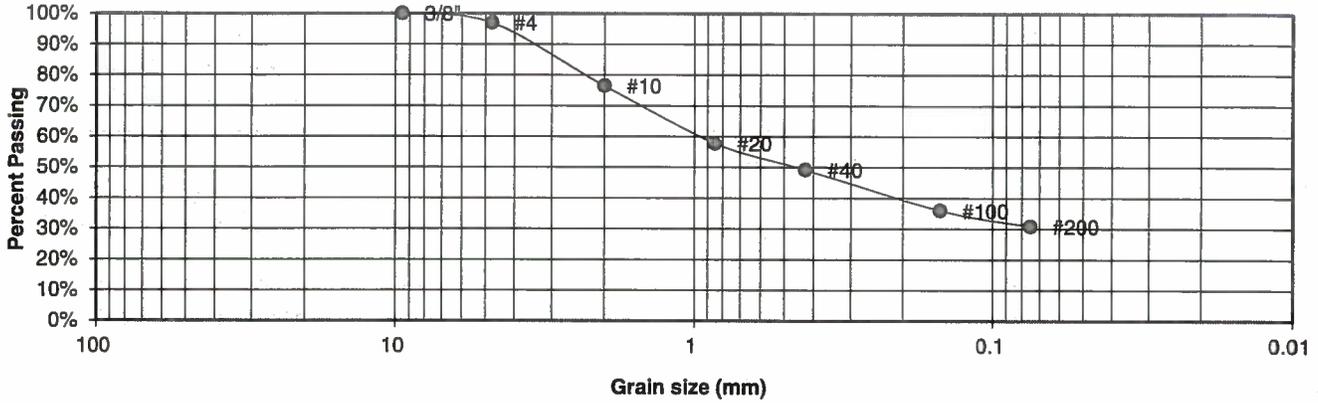
FIG NO.:

B-18

UNIFIED CLASSIFICATION SC
SOIL TYPE # 3
TEST BORING # 11
DEPTH (FT) 10
AASHTO CLASSIFICATION A-2-6

CLIENT TECH CONTRACTORS
PROJECT ROLLING HILLS RANCH, F-2
JOB NO. 213333
TEST BY BL
GROUP INDEX 2

**Sieve Analysis
Grain Size Distribution**



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	97.0%
10	76.4%
20	57.8%
40	49.2%
100	35.9%
200	30.8%

Atterberg Limits	
Plastic Limit	19
Liquid Limit	40
Plastic Index	21

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



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LABORATORY TEST RESULTS

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JOB NO.:

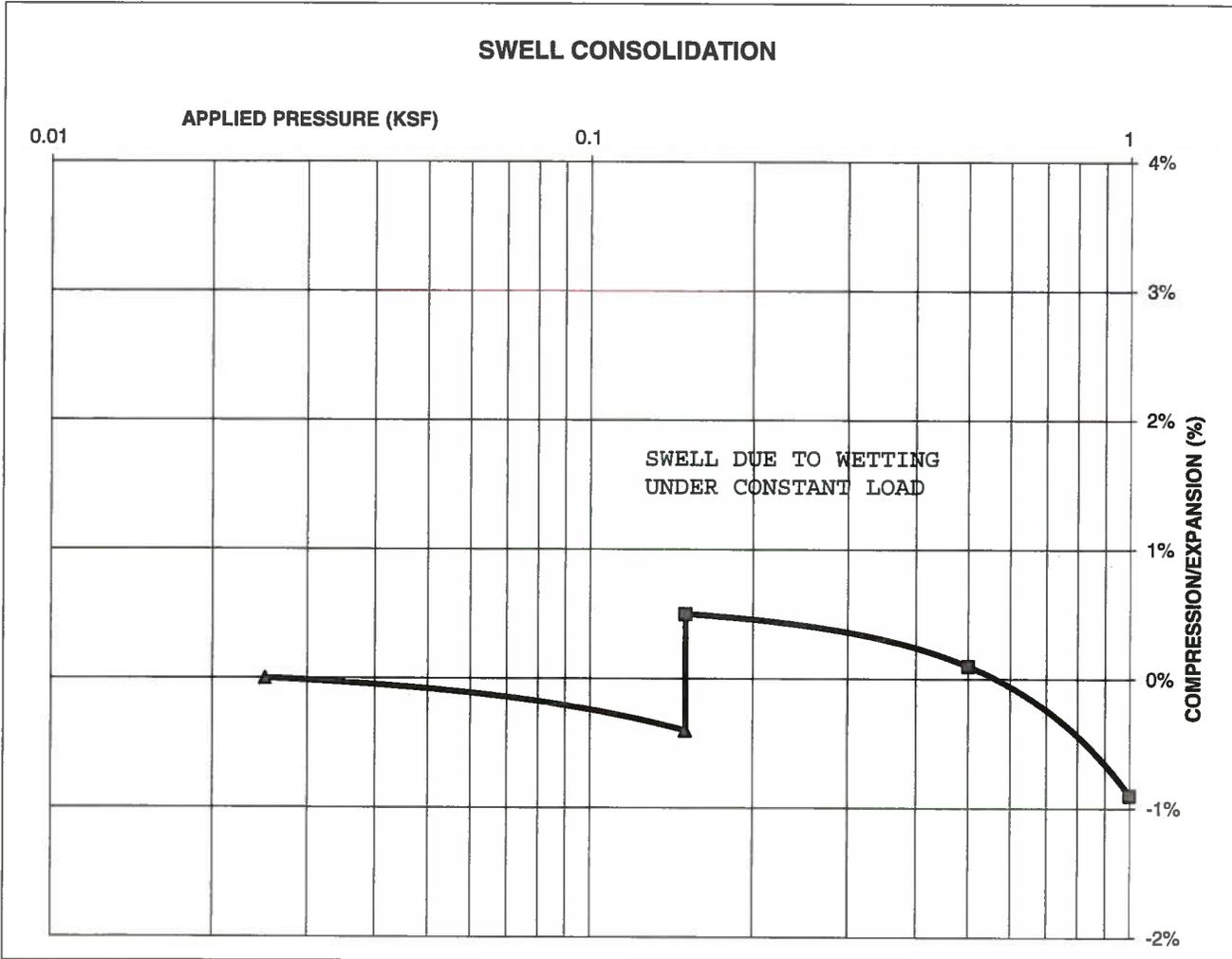
213333
FIG NO.:

B 19

CONSOLIDATION TEST RESULTS

TEST BORING #	1	DEPTH(ft)	1-2
DESCRIPTION	SC	SOIL TYPE	1
NATURAL UNIT DRY WEIGHT (PCF)	121		
NATURAL MOISTURE CONTENT	10.1%		
SWELL/CONSOLIDATION (%)	0.9%		

JOB NO. 213333
 CLIENT TECH CONTRACTORS
 PROJECT ROLLING HILLS RANCH, F-2



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**SWELL CONSOLIDATION
 TEST RESULTS**

DRAWN:

DATE:

CHECKED: SW

DATE: 1-11-22

JOB NO.:

213333

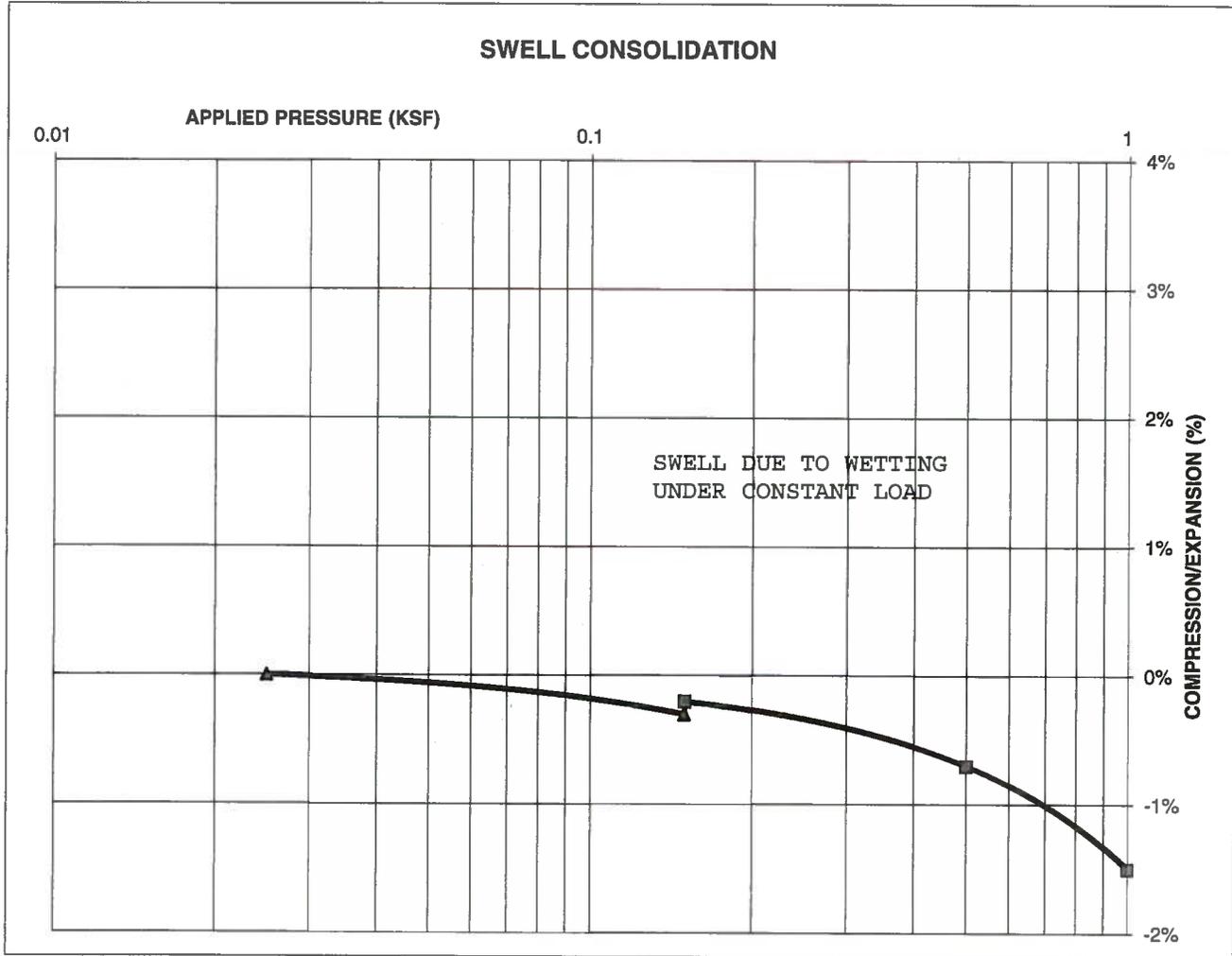
FIG NO.:

B-20

CONSOLIDATION TEST RESULTS

TEST BORING #	2	DEPTH(ft)	1-2
DESCRIPTION	SC	SOIL TYPE	1
NATURAL UNIT DRY WEIGHT (PCF)			122
NATURAL MOISTURE CONTENT			9.3%
SWELL/CONSOLIDATION (%)			0.1%

JOB NO. 213333
 CLIENT TECH CONTRACTORS
 PROJECT ROLLING HILLS RANCH, F-2



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**SWELL CONSOLIDATION
TEST RESULTS**

DRAWN:

DATE:

CHECKED:

DATE: 1-11-22

SW

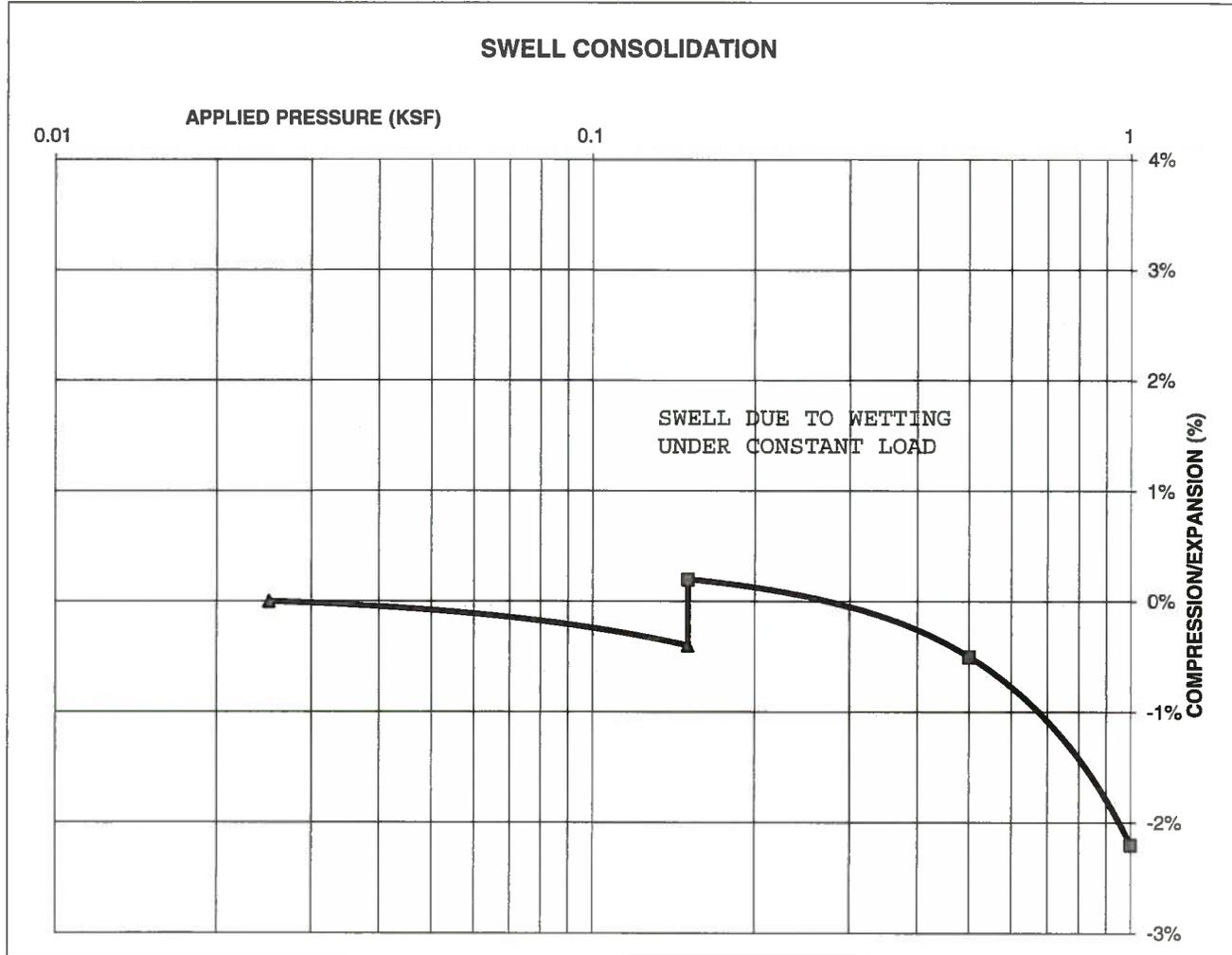
JOB NO.:
213333

FIG NO.:
B-21

CONSOLIDATION TEST RESULTS

TEST BORING #	5	DEPTH(ft)	1-2
DESCRIPTION	SC	SOIL TYPE	1
NATURAL UNIT DRY WEIGHT (PCF)	111		
NATURAL MOISTURE CONTENT	14.8%		
SWELL/CONSOLIDATION (%)	0.6%		

JOB NO. 213333
 CLIENT TECH CONTRACTORS
 PROJECT ROLLING HILLS RANCH, F-2



ENTECH
ENGINEERING, INC.

505 ELKTON DRIVE
 COLORADO SPRINGS, COLORADO 80907

**SWELL CONSOLIDATION
 TEST RESULTS**

DRAWN:

DATE:

CHECKED:

SW

DATE:

1-11-22

JOB NO.:

213333

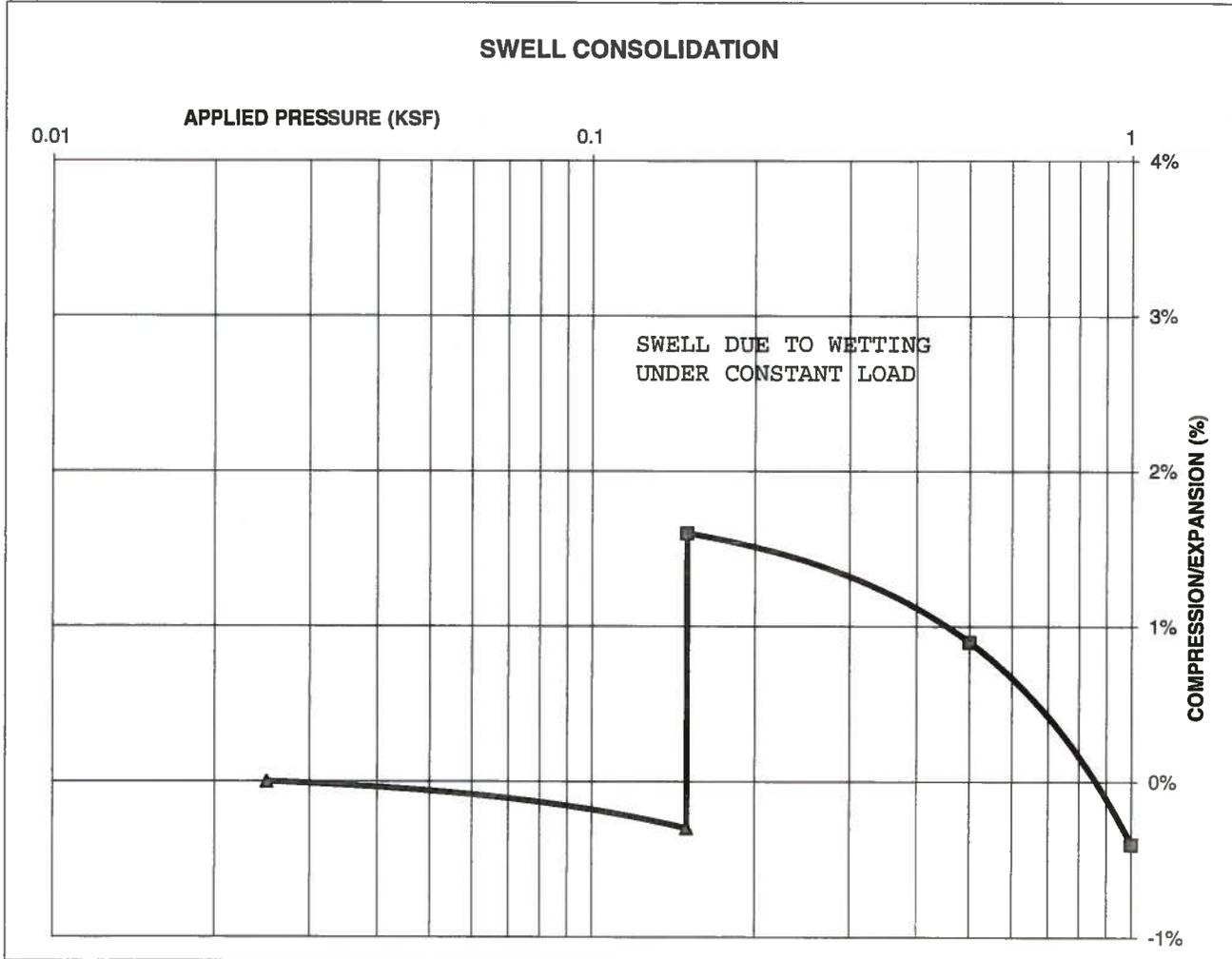
FIG NO.:

B-22

CONSOLIDATION TEST RESULTS

TEST BORING #	6	DEPTH(ft)	1-2
DESCRIPTION	SC	SOIL TYPE	1
NATURAL UNIT DRY WEIGHT (PCF)	111		
NATURAL MOISTURE CONTENT	14.7%		
SWELL/CONSOLIDATION (%)	1.9%		

JOB NO. 213333
 CLIENT TECH CONTRACTORS
 PROJECT ROLLING HILLS RANCH, F-2



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**SWELL CONSOLIDATION
 TEST RESULTS**

DRAWN:

DATE:

CHECKED:

SW

DATE:

1-11-22

JOB NO.:

213333

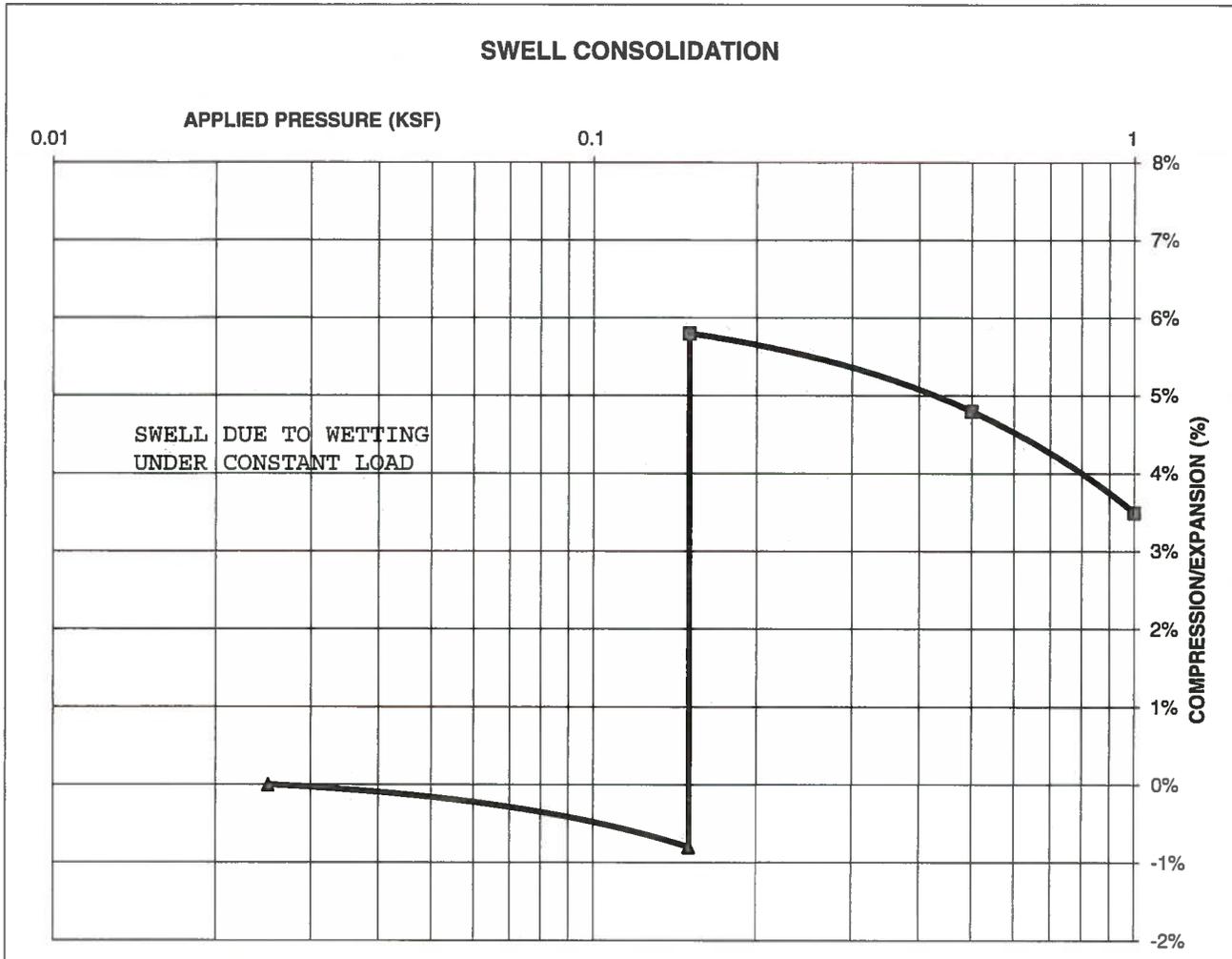
FIG NO.:

B-23

CONSOLIDATION TEST RESULTS

TEST BORING #	6	DEPTH(ft)	10
DESCRIPTION	CL	SOIL TYPE	2
NATURAL UNIT DRY WEIGHT (PCF)			112
NATURAL MOISTURE CONTENT			17.1%
SWELL/CONSOLIDATION (%)			6.6%

JOB NO. 213333
 CLIENT TECH CONTRACTORS
 PROJECT ROLLING HILLS RANCH, F-2



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 COLORADO SPRINGS, COLORADO 80907

SWELL CONSOLIDATION TEST RESULTS

DRAWN:	DATE:	CHECKED: <i>SW</i>	DATE: <i>1-11-22</i>
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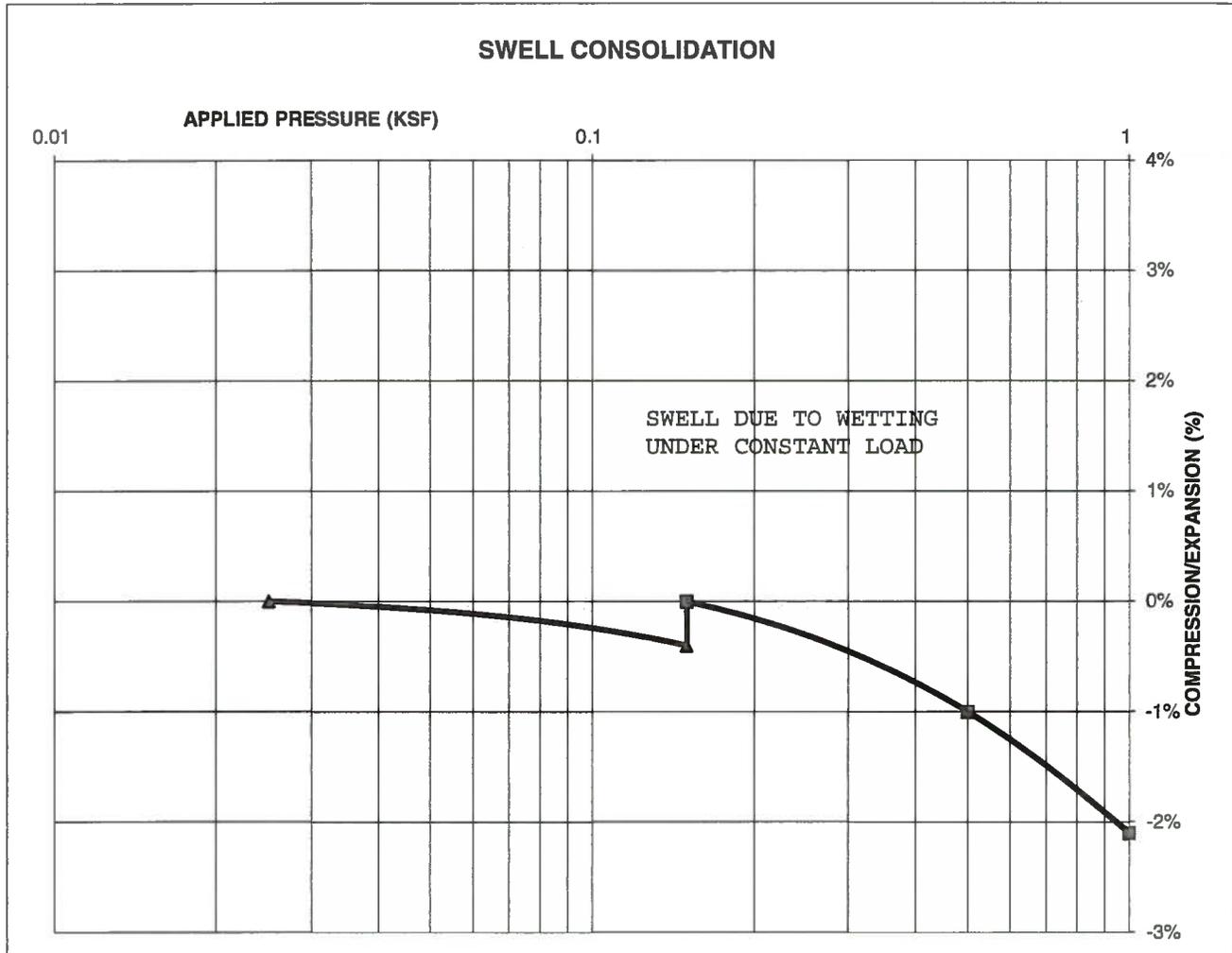
JOB NO.: 213333

FIG NO.: *B24*

CONSOLIDATION TEST RESULTS

TEST BORING #	11	DEPTH(ft)	10
DESCRIPTION	SC	SOIL TYPE	3
NATURAL UNIT DRY WEIGHT (PCF)			116
NATURAL MOISTURE CONTENT			11.0%
SWELL/CONSOLIDATION (%)			0.4%

JOB NO. 213333
 CLIENT TECH CONTRACTORS
 PROJECT ROLLING HILLS RANCH, F-2



**ENTECH
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505 ELKTON DRIVE
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**SWELL CONSOLIDATION
TEST RESULTS**

DRAWN:

DATE:

CHECKED:

DATE:

SW

1-11-22

JOB NO.:

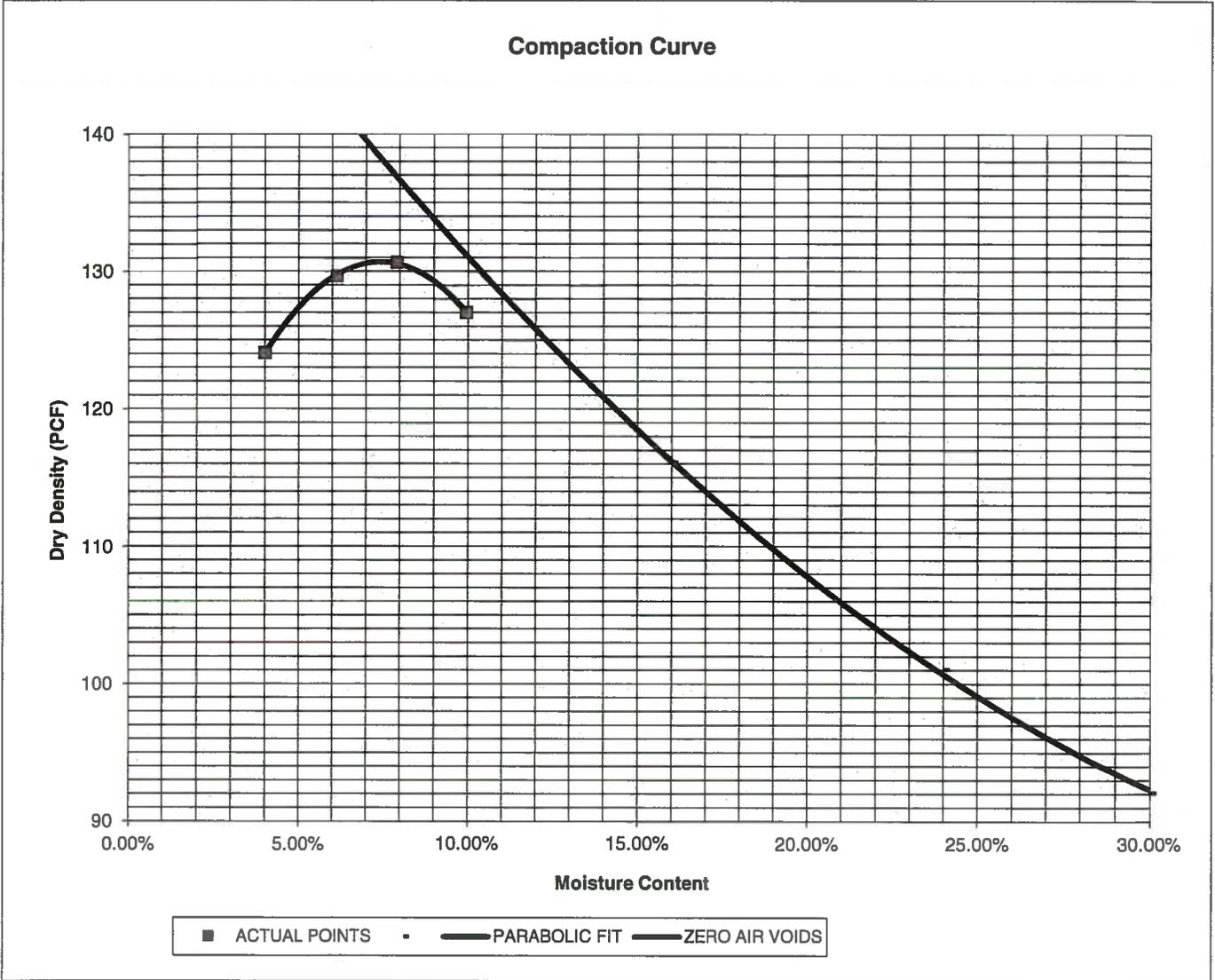
213333

FIG NO.:

B-25

PROJECT	ROLLING HILLS RANCH, F-2	CLIENT	TECH CONTRACTORS
SAMPLE LOCATION	TB-2 @ 0-3'	JOB NO.	213333
SOIL DESCRIPTION	FILL, SAND, CLAYEY, BROWN	DATE	12/29/21

IDENTIFICATION	SC	COMPACTION TEST #	1
TEST DESIGNATION / METHOD	ASTM D-1557-A	TEST BY	BC
MAXIMUM DRY DENSITY (PCF)	130.8	OPTIMUM MOISTURE	7.7%

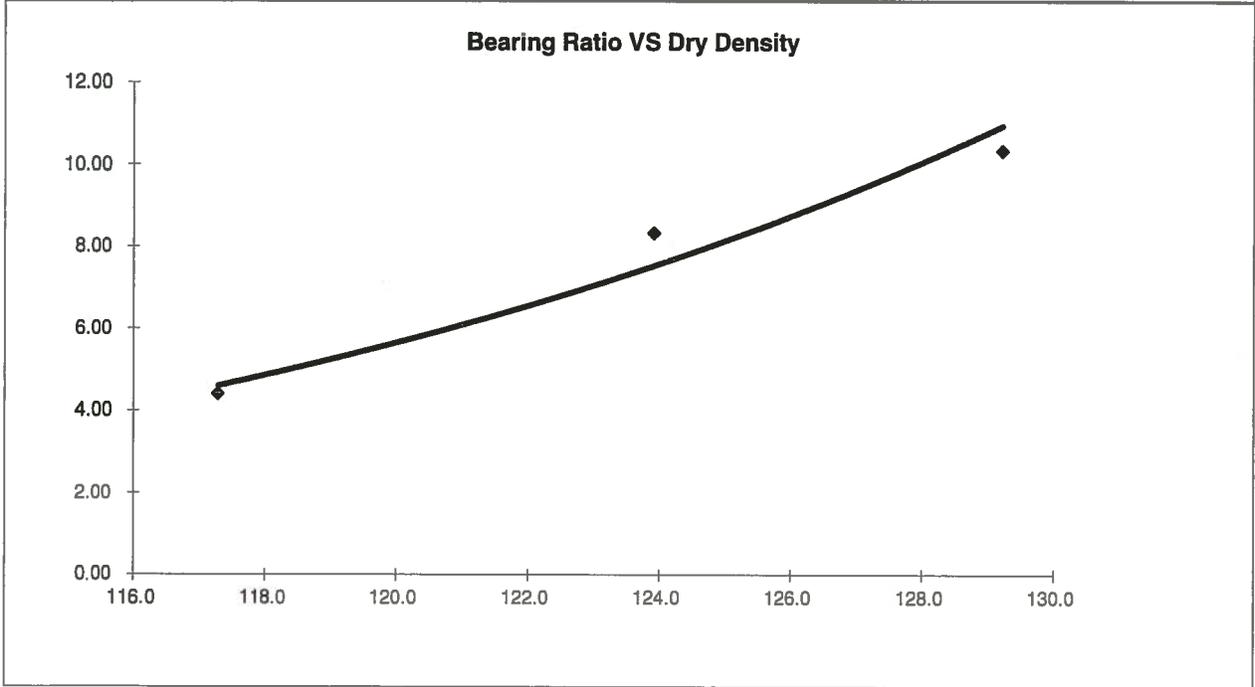
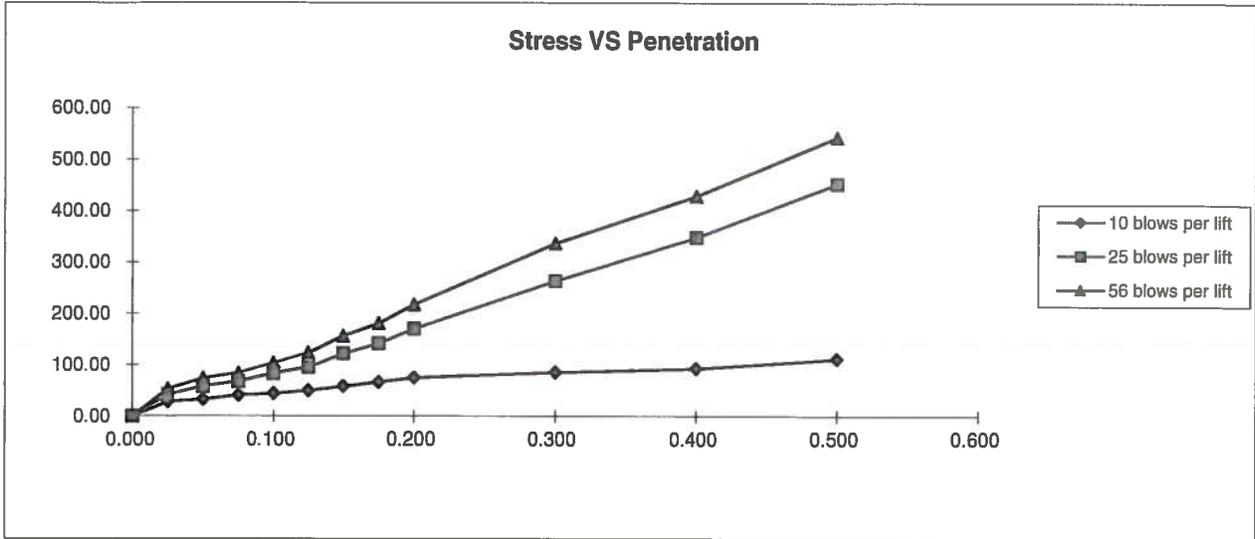



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MOISTURE DENSITY RELATION

DRAWN:	DATE:	CHECKED: <i>SW</i>	DATE: <i>1-11-22</i>
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JOB NO.:
213333
FIG NO.:
B-27



BEARING RATIO AT 90% OF MAX	4.67 ~ R VALUE	10.00
BEARING RATIO AT 95% OF MAX	8.45 ~ R VALUE	22.00

JOB NO: 213333
SOIL TYPE: 1



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CALIFORNIA BEARING RATIO

DRAWN:

DATE:

CHECKED: *SW*

DATE:

1-11-22

JOB NO:
213333

FIG NO:
B-29

APPENDIX C: Pavement Design Calculations

FLEXIBLE PAVEMENT DESIGN

DESIGN DATA

ROLLING HILLS AT MERIDIAN RANCH FILING 2, PHASE 2
OVERLOOK BLUFF DRIVE - CUL-DE-SAC -LOCAL LOW-VOLUME

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	36,500
Hveem Stabilometer (R Value) Results:	R =	17
Standard Deviation	S_o =	0.45
Loss in Serviceability	$\Delta\psi$ =	2.0
Reliability	Reliability =	80
Reliability (z-statistic)	Z_R =	-0.84
Soil Resilient Modulus	M_R =	4478

Weighted Structural Number (WSN): ➔ WSN = 2.25

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

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

Left	Right	Difference
4.56	4.56	0.0

Job No. 213333
Fig. No. C-1

DESIGN CALCULATIONS

DESIGN DATA

ROLLING HILLS AT MERIDIAN RANCH FILING 2, PHASE 2

OVERLOOK BLUFF DRIVE - CUL-DE-SAC -LOCAL LOW-VOLUME

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL = 36,500
Hveem Stabilometer (R Value) Results:	R = 17
Weighted Structural Number (WSN):	WSN = 2.25

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 (CURRENTLY NOT ALLOWED)

$$D_1 = (WSN)/C_1 = 5.1 \text{ inches of Full Depth Asphalt}$$

Use 5.5 inches Full Depth

FOR ASPHALT + AGGREGATE BASE COURSE SECTION

$$\text{Asphalt Thickness (t)} = \boxed{3.5} \text{ inches}$$

$$D_2 = ((WSN) - (t)(C_1))/C_2 = 6.5 \text{ inches of Aggregate}$$

Base Course, use 6.5 inches

RECOMMENDED ALTERNATIVES

1. 3.5 inches of Asphalt + 6.5 inches of Aggregate Base Course, or
2. 5.5 inches of Full Depth Asphalt

Job No. 213333

Fig. No. C-2

DESIGN CALCULATIONS

CEMENT TREATED SECTIONS

DESIGN DATA:

ROLLING HILLS AT MERIDIAN RANCH FILING 2, PHASE 2

OVERLOOK BIUFF LANE - CUL-DE-SAC -LOCAL LOW-VOLUME

Equivalent (18 kip) Single Axle Load Applications (ESAL): ESAL = 36,500

Hveem Stabilometer (R Value) Results: R = 20

Weighted Structural Number (WSN): WSN = 2.16

DESIGN EQUATION

$$WSN = C_1D_1 + C_2D_2$$

$C_1 = 0.44$ Strength Coefficient - Hot Bituminous Asphalt

$C_2 = 0.11$ 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)

$$D_1 = (WSN)/C_1 = 4.9 \text{ inches of Full Depth Asphalt}$$

Use 5.0 inches Full Depth

FOR ASPHALT + CEMENT TREATED SUBGRADE SECTION

Asphalt Thickness (t) = 4 inches

$$D_2 = ((WSN) - (t)(C_1))/C_2 = 4.0 \text{ inches}$$

Use 8.0 inches of Cement Treated Subgrade.

RECOMMENDED ALTERNATIVES

1. 4.0 inches of Asphalt + 8 inches of Cement Treated Subgrade.
2. 5.0 inches of Full Depth Asphalt

Job No. 213333

Fig. No. C-3

FLEXIBLE PAVEMENT DESIGN

DESIGN DATA

ROLLING HILLS AT MERIDIAN RANCH FILING 2, PHASE 2

LOCAL RESIDENTIAL

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	292,000
Hveem Stabilometer (R Value) Results:	R =	20
Standard Deviation	S_o =	0.45
Loss in Serviceability	$\Delta\psi$ =	2.0
Reliability	Reliability =	80
Reliability (z-statistic)	Z_R =	-0.84
Soil Resilient Modulus	M_R =	4940

Weighted Structural Number (WSN): ➔ WSN = 3.02

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

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

Left	Right	Difference
5.47	5.47	0.0

Job No. 213333

Fig. No. C-4

DESIGN CALCULATIONS

DESIGN DATA

ROLLING HILLS AT MERIDIAN RANCH FILING 2, PHASE 2

LOCAL RESIDENTIAL

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL = 292,000
Hveem Stabilometer (R Value) Results:	R = 20
Weighted Structural Number (WSN):	WSN = 3.02

DESIGN EQUATION

$$WSN = C_1 D_1 + C_2 D_2$$

$C_1 = 0.44$ 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 (CURRENTLY NOT ALLOWED)

$D_1 = (WSN)/C_1 = 6.9$ inches of Full Depth Asphalt

Use 7.0 inches Full Depth

FOR ASPHALT + AGGREGATE BASE COURSE SECTION

Asphalt Thickness (t) = inches

$D_2 = ((WSN) - (t)(C_1))/C_2 = 7.4$ inches of Aggregate

Base Course, use 8.0 inches

RECOMMENDED ALTERNATIVES

1. 5.0 inches of Asphalt + 8.0 inches of Aggregate Base Course, or
2. 7.0 inches of Full Depth Asphalt

Job No. 213333

Fig. No. C-5

DESIGN CALCULATIONS

CEMENT TREATED SECTIONS

DESIGN DATA:

ROLLING HILLS AT MERIDIAN RANCH FILING 2, PHASE 2

LOCAL RESIDENTIAL

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL =	292,000
Hveem Stabilometer (R Value) Results:	R =	20
Weighted Structural Number (WSN):	WSN =	3.02

DESIGN EQUATION

$$WSN = C_1D_1 + C_2D_2$$

$C_1 = 0.44$ Strength Coefficient - Hot Bituminous Asphalt

$C_2 = 0.11$ 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)

$$D_1 = (WSN)/C_1 = 6.9 \text{ inches of Full Depth Asphalt}$$

Use 7.0 inches Full Depth

FOR ASPHALT + CEMENT TREATED SUBGRADE SECTION

Asphalt Thickness (t) = 4.5 inches

$$D_2 = ((WSN) - (t)(C_1))/C_2 = 9.5 \text{ inches}$$

Use 10.0 inches of Cement Treated Subgrade.

RECOMMENDED ALTERNATIVES

1. 4.5 inches of Asphalt + 10 inches of Cement Treated Subgrade.
2. 7.0 inches of Full Depth Asphalt

Job No. 213333

Fig. No. C-6