

September 20, 2018



ENTECH
ENGINEERING, INC.

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

Four Gates Land Development
17435 Roller Coaster Road
Monument, Colorado 80132

EPC 11/5/18
road should be
classified as rural local.

Attn: Marlene Brown

Re: Pavement Recommendations
Jackson Ranch Filing No. 3
Jackson Ranch Court and Mahaffie Court
Monument, Colorado

Dear Ms. Brown:

As requested, Entech Engineering, Inc. has obtained samples of the subgrade soils from a section of the proposed roadway in the Jackson Ranch Filing No. 3, in El Paso County, Colorado. This letter presents the results of the laboratory testing and pavement recommendations for the roadways.

Project Description

The project will consist of the pavement of the Mahaffie Court cul-de-sac and a section of Jackson Ranch Court extending north to future phasing. A Subsurface Soil Investigation and laboratory testing was 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

Four exploratory test borings were drilled on this site 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 soil samples obtained from all of the test borings for the purpose of classification. Sieve analyses indicated the subgrade soils percent passing the No. 200 sieve ranged from approximately 14 to 34 percent. Atterberg Limit Tests performed on samples resulted in Liquid Limits of 19, 21, and no value and Plastic Indexes of 4, 3, and non-plastic, respectively. The soils classify as A-2-4 and A-1-b soils based on the AASHTO classification system, which typically provide good pavement support characteristics.

Swell/Consolidation testing was not required on the subgrade soils based on the AASHTO Classification and the Plastic Indexes. Mitigation for expansive soils is not required for these roadway sections.

A California Bearing Ratio (CBR) test was performed on a representative soil sample to determine the pavement support characteristics of the subgrade soils. The laboratory test results are presented in Appendix B, in Table 1, and are summarized as follows:

SF 17-017

Four Gates Land Development
Pavement Recommendations
Jackson Ranch Filing No. 3
Jackson Ranch Court and Mahaffie Court
Monument, Colorado
Page Two

Soil Type – Silty Sand

R @ 90% = 60.0
R @ 95% = 73.0
Use R = 45.0 for design

Classification Testing

Liquid Limit	NV
Plasticity Index	NP
Percent Passing 200	33.2
AASHTO Classification	A-2-4
Group Index	0
Unified Soils Classification	SM
M _R	11,183 psi

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 roadways classify as a local low-volume street which uses an 18K ESAL value of 36,500 to determine the pavement sections. Pavement sections for asphalt over aggregate base course are provided. Design parameters used in the pavement analysis are as follows:

Reliability	80%
Standard Deviation	0.45
Serviceability Index, Local Low Volume	2.0
Resilient Modulus	11,183 psi
"R" Value Subgrade	45.0
Hot Bituminous Pavement	0.44
Base Course	0.11

Pavement calculations are attached in Appendix C. Pavement sections recommended for the site are summarized as follows:

Four Gates Land Development
Pavement Recommendations
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Pavement Sections

Local (low-volume) - ESAL = 36,500

<u>Alternative</u>	<u>Asphalt</u> <u>(in)</u>	<u>Base Course</u> <u>(in)</u>
1. Asphalt Over Base Course	3.0*	4.0*

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

Roadway Construction

Prior to placement of the asphalt, the subgrade should be scarified, moisture-conditioned, proofrolled and compacted to a minimum of 95% of its maximum Modified Proctor Dry Density, ASTM D-1557 at 1 to 3 percent over optimum moisture content. Any loose areas should be removed and replaced with suitable materials approved by Entech. Basecourse materials should be compacted to a minimum of 95% of its maximum Modified Proctor Dry Density, ASTM D-1557 at $\pm 2\%$ of optimum moisture content. Special attention should be given to areas adjacent to manholes, inlet structures and valves.

In addition to the above guidance, the asphalt, base course, 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/sc

Encl.

Entech Job No. 181382
F:\AA projects\2018\181382 pr

Reviewed by:

Stan C. Culp, P.E.
Senior Engineer



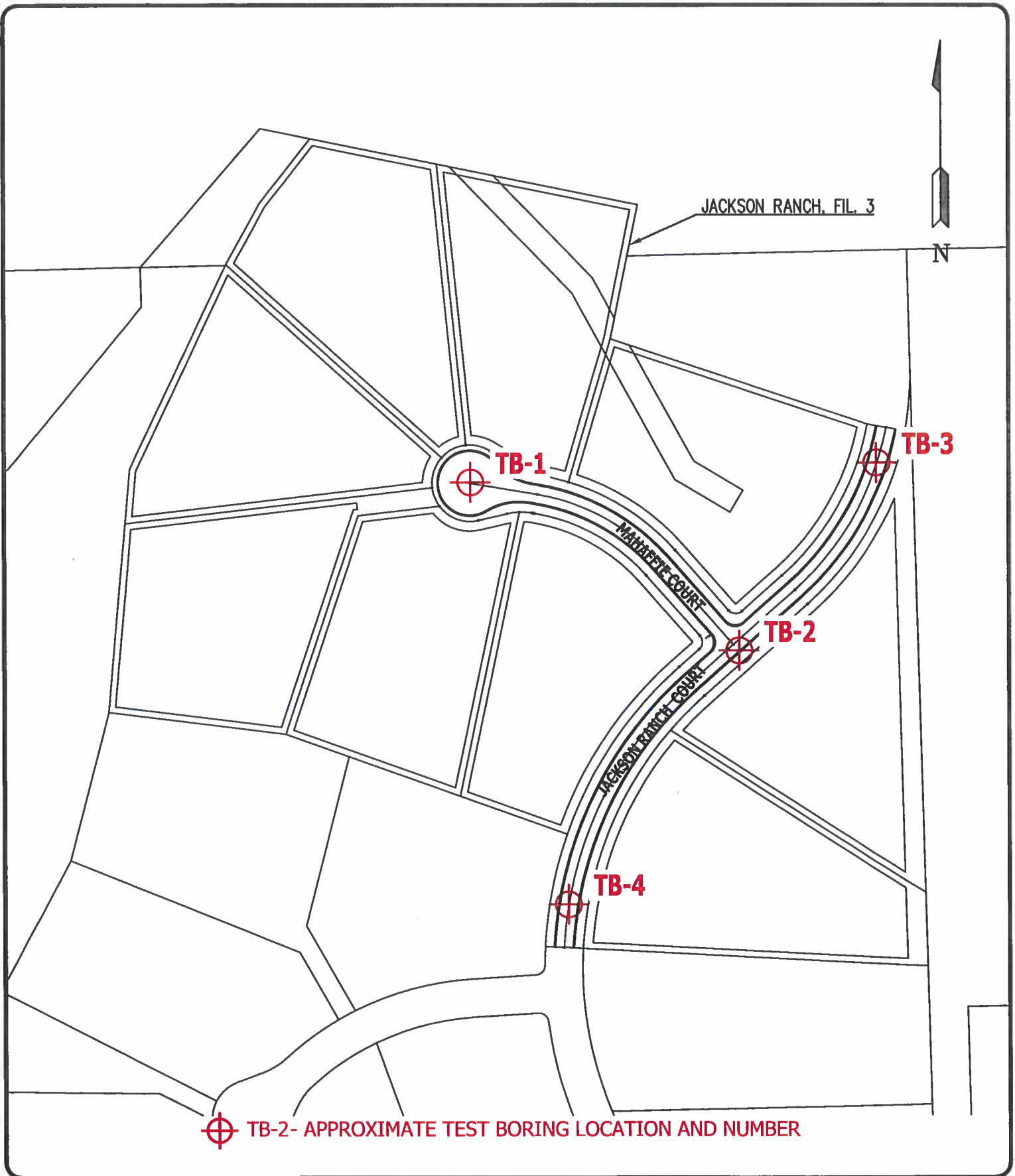

TABLE

TABLE 1
SUMMARY OF LABORATORY TEST RESULTS

CLIENT JACKSON RANCH, LLC
 PROJECT JACKSON RANCH, F-3
 JOB NO. 181382

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	2	1-2			33.7	21	3	<0.01	A-2-4		SM	FILL, SAND, SILTY
2, CBR #1	1	0-3			33.2	NV	NP		A-2-4		SM	SAND, SILTY
2	1	1-2			22.9	19	4		A-1-b		SM	SAND, SILTY
2	3	1-2			14.1	NV	NP		A-1-b		SM	SAND, SILTY
2	4	1-2			21.1	NV	NP		A-1-b		SM	SAND, SILTY
2	2	10			8.8	NV	NP	<0.01	A-1-b		SM-SW	SAND, SLIGHTLY SILTY
3	4	5			10.6	NV	NP	<0.01	A-1-b		SM-SW	SANDSTONE, SLIGHTLY SILTY

FIGURE

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TEST BORING LOCATION MAP
JACKSON RANCH, F3
EL PASO COUNTY, COLORADO
FOR: FOUR GATES LAND DEVELOPMENT

DRAWN BY: EDK	DATE DRAWN: 9/21/18	DESIGNED BY: SC	CHECKED: SC
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JOB NO.:
181382
FIG. NO.:
1

APPENDIX A: Test Boring Logs

TEST BORING NO. 1
 DATE DRILLED 9/13/2018
 Job # 181382

TEST BORING NO. 2
 DATE DRILLED 9/13/2018
 CLIENT JACKSON RANCH, LLC
 LOCATION JACKSON RANCH, F-3

REMARKS

DRY TO 5', 9/13/18
 SAND, SILTY, FINE TO COARSE
 GRAINED, TAN, LOOSE, MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
5			8	7.7	2
5			8	7.6	2
10					
15					
20					

REMARKS

DRY TO 10', 9/13/18
 FILL 0-4', SAND, SILTY, FINE
 TO COARSE GRAINED, BROWN,
 MEDIUM DENSE, MOIST
 SAND, SLIGHTLY SILTY, FINE
 TO COARSE GRAINED, TAN,
 MEDIUM DENSE TO DENSE,
 MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
5			28	6.8	1
5			24	4.6	2
10			33	4.2	2
15					
20					



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TEST BORING LOG

DRAWN:

DATE:

CHECKED:

DATE:

JOB NO.:
 181382

FIG NO.:
 A-1

TEST BORING NO. 3
 DATE DRILLED 9/13/2018
 Job # 181382

TEST BORING NO. 4
 DATE DRILLED 9/13/2018
 CLIENT JACKSON RANCH, LLC
 LOCATION JACKSON RANCH, F-3

REMARKS

DRY TO 5', 9/13/18
 SAND, SILTY, FINE TO COARSE
 GRAINED, TAN, MEDIUM
 DENSE, DRY TO MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
5			23	1.6	2
5			18	10.3	2

REMARKS

DRY TO 5', 9/13/18
 SAND, SILTY, FINE TO COARSE
 GRAINED, BROWN, MEDIUM
 DENSE, MOIST
 SANDSTONE, SLIGHTLY SILTY,
 FINE TO COARSE GRAINED,
 TAN, DENSE, MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
5			17	6.9	2
5			45	4.7	3



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TEST BORING LOG

DRAWN:

DATE:

CHECKED:

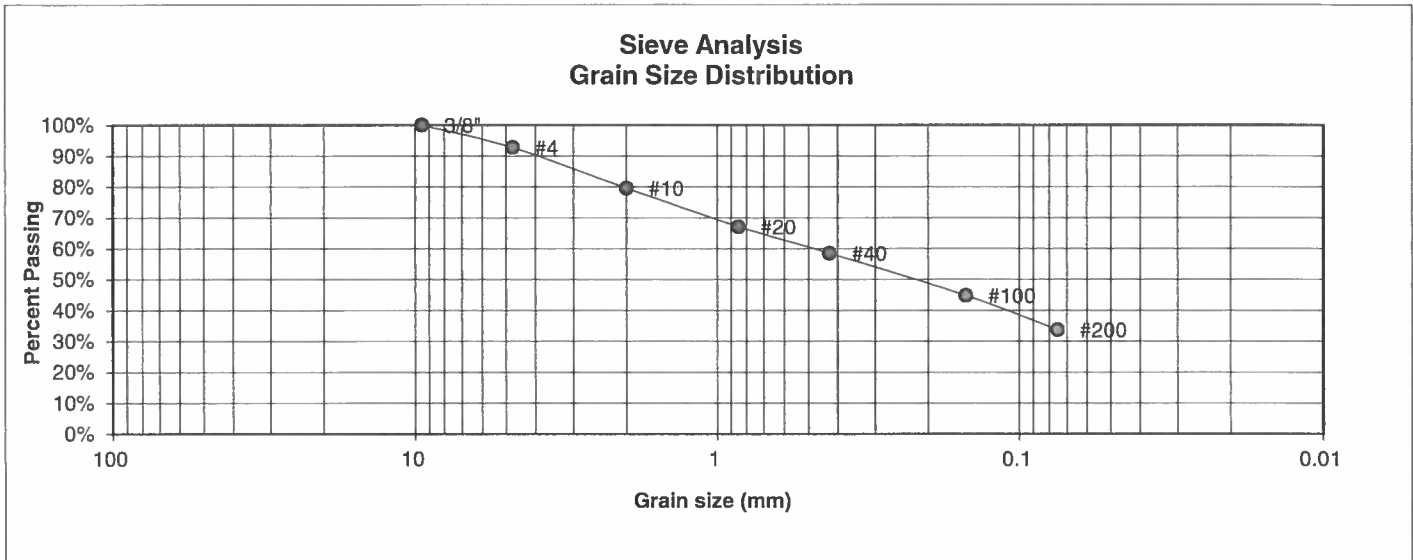
DATE:

JOB NO.:
 181382

FIG NO.:
 A-2

APPENDIX B: Laboratory Test Results

UNIFIED CLASSIFICATION	SM	CLIENT	JACKSON RANCH, LLC
SOIL TYPE #	1	PROJECT	JACKSON RANCH, F-3
TEST BORING #	2	JOB NO.	181382
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	92.7%
10	79.6%
20	67.2%
40	58.5%
100	44.8%
200	33.7%

Atterberg Limits	
Plastic Limit	18
Liquid Limit	21
Plastic Index	3

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



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**LABORATORY TEST
RESULTS**

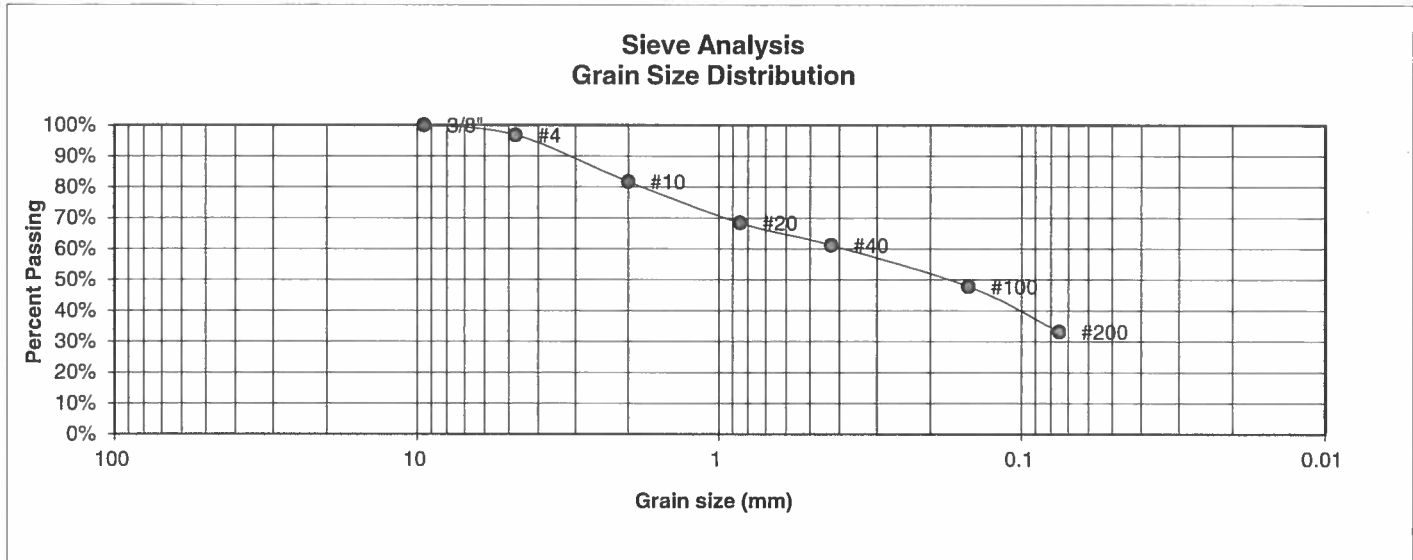
DRAWN:	DATE:	CHECKED:	DATE:
		SCC	9/20/18

JOB NO.:

181382
FIG NO.:

B-1

UNIFIED CLASSIFICATION	SM	CLIENT	JACKSON RANCH, LLC
SOIL TYPE #	2, CBR #1	PROJECT	JACKSON RANCH, F-3
TEST BORING #	1	JOB NO.	181382
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"	
3/8"	100.0%
4	96.8%
10	81.7%
20	68.4%
40	61.2%
100	47.8%
200	33.2%

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:
		SCC	9/20/18

JOB NO.:

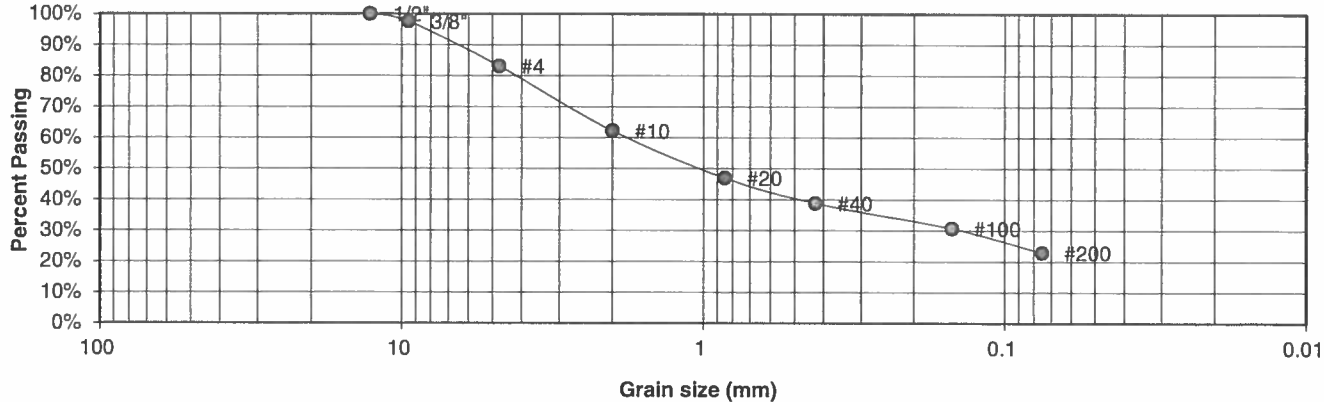
181382

FIG NO.:

B-2

UNIFIED CLASSIFICATION	SM	CLIENT	JACKSON RANCH, LLC
SOIL TYPE #	2	PROJECT	JACKSON RANCH, F-3
TEST BORING #	1	JOB NO.	181382
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\"	97.6%
4	83.1%
10	62.2%
20	47.0%
40	38.8%
100	30.7%
200	22.9%

Atterberg Limits	
Plastic Limit	15
Liquid Limit	19
Plastic Index	4

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



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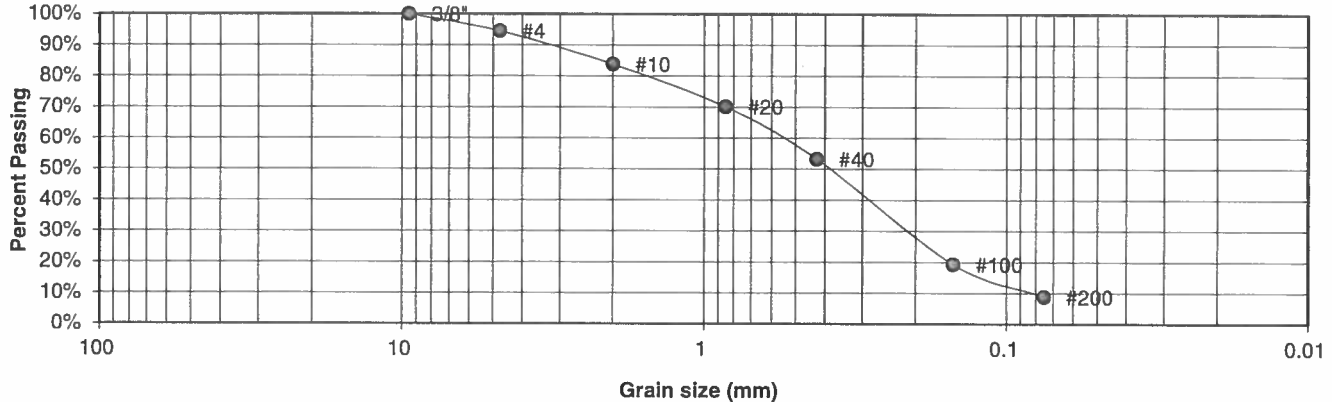
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED: <i>SCC</i>	DATE: <i>9/20/18</i>
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JOB NO.:
181382
FIG NO.:
B-3

<u>UNIFIED CLASSIFICATION</u>	SM-SW	<u>CLIENT</u>	JACKSON RANCH, LLC
<u>SOIL TYPE #</u>	2	<u>PROJECT</u>	JACKSON RANCH, F-3
<u>TEST BORING #</u>	2	<u>JOB NO.</u>	181382
<u>DEPTH (FT)</u>	10	<u>TEST BY</u>	BL
<u>AASHTO CLASSIFICATION</u>	A-1-b	<u>GROUP INDEX</u>	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	94.5%
10	83.8%
20	70.1%
40	53.3%
100	19.3%
200	8.8%

<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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**LABORATORY TEST
RESULTS**

DRAWN:	DATE:	CHECKED:	DATE:
		SCC	9/20/18

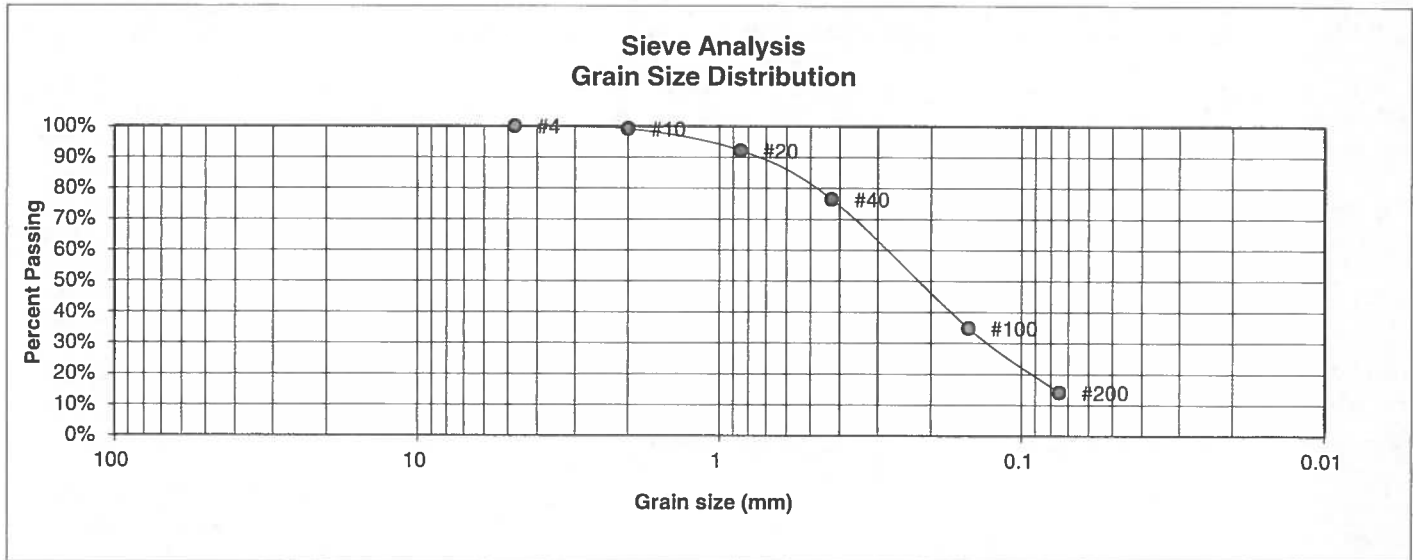
JOB NO.:

181382

FIG NO.:

B-4

<u>UNIFIED CLASSIFICATION</u>	SM	<u>CLIENT</u>	JACKSON RANCH, LLC
<u>SOIL TYPE #</u>	2	<u>PROJECT</u>	JACKSON RANCH, F-3
<u>TEST BORING #</u>	3	<u>JOB NO.</u>	181382
<u>DEPTH (FT)</u>	1-2	<u>TEST BY</u>	BL
<u>AASHTO CLASSIFICATION</u>	A-1-b	<u>GROUP INDEX</u>	0



<u>U.S. Sieve #</u>	<u>Percent Finer</u>
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	100.0%
10	99.2%
20	92.2%
40	76.4%
100	34.8%
200	14.1%

<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)	



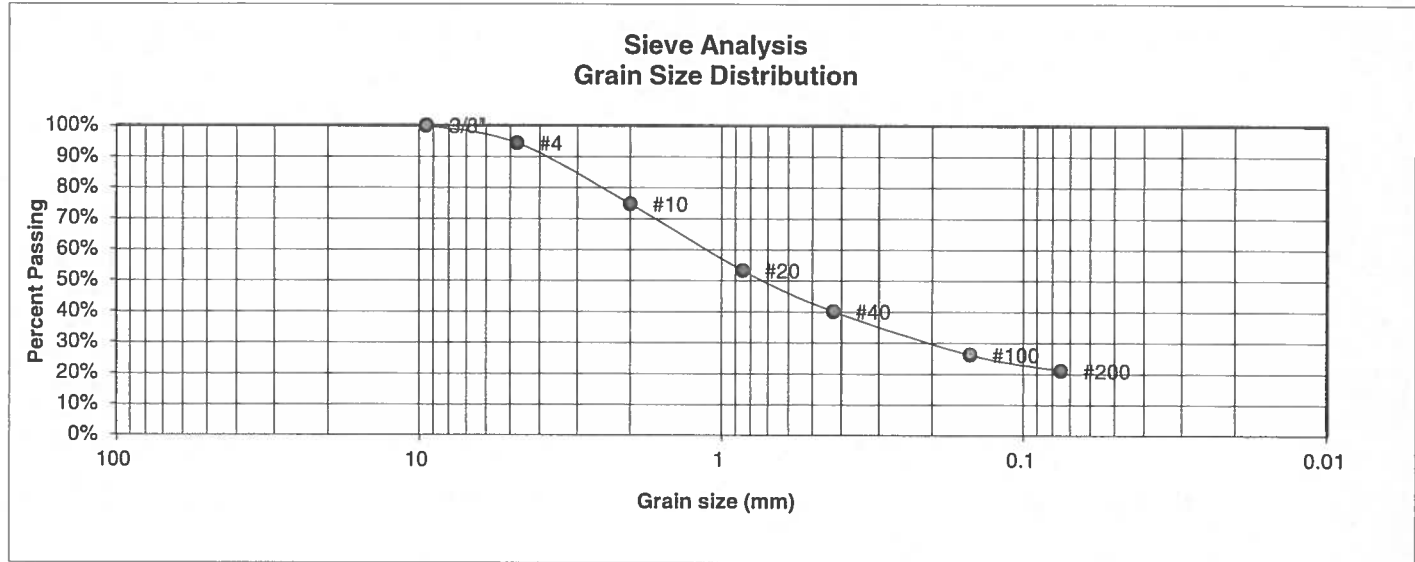
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**LABORATORY TEST
RESULTS**

DRAWN:	DATE:	CHECKED:	DATE:
		SCC	9/20/18

JOB NO.:
181382
FIG NO.:
B-5

<u>UNIFIED CLASSIFICATION</u>	SM	<u>CLIENT</u>	JACKSON RANCH, LLC
<u>SOIL TYPE #</u>	2	<u>PROJECT</u>	JACKSON RANCH, F-3
<u>TEST BORING #</u>	4	<u>JOB NO.</u>	181382
<u>DEPTH (FT)</u>	1-2	<u>TEST BY</u>	BL
<u>AASHTO CLASSIFICATION</u>	A-1-b	<u>GROUP INDEX</u>	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	94.5%
10	74.8%
20	53.3%
40	40.2%
100	26.2%
200	21.1%

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:
		SCC	9/20/18

JOB NO.:

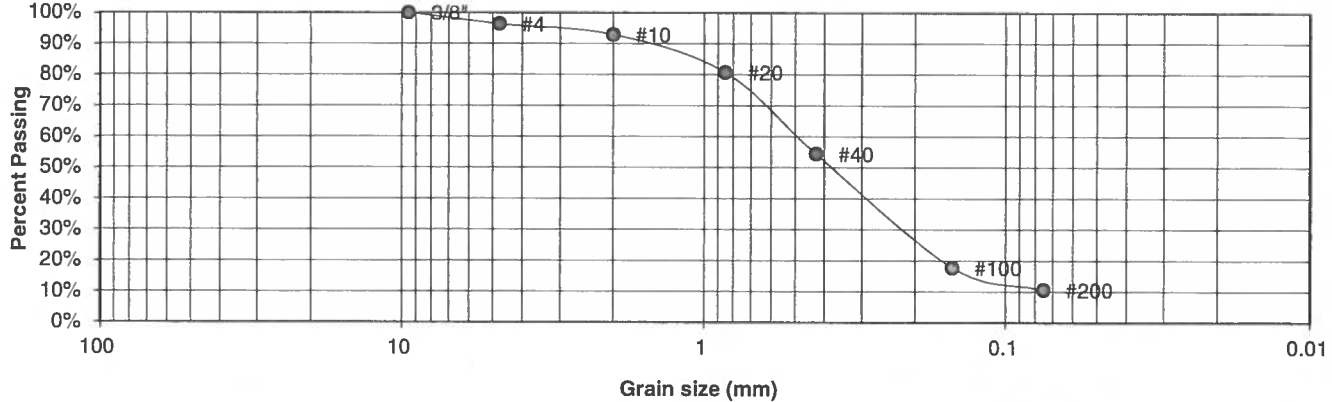
181382

FIG NO.:

B-6

UNIFIED CLASSIFICATION	SM-SW	CLIENT	JACKSON RANCH, LLC
SOIL TYPE #	3	PROJECT	JACKSON RANCH, F-3
TEST BORING #	4	JOB NO.	181382
DEPTH (FT)	5	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	96.3%
10	92.9%
20	80.7%
40	54.4%
100	17.8%
200	10.6%

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)

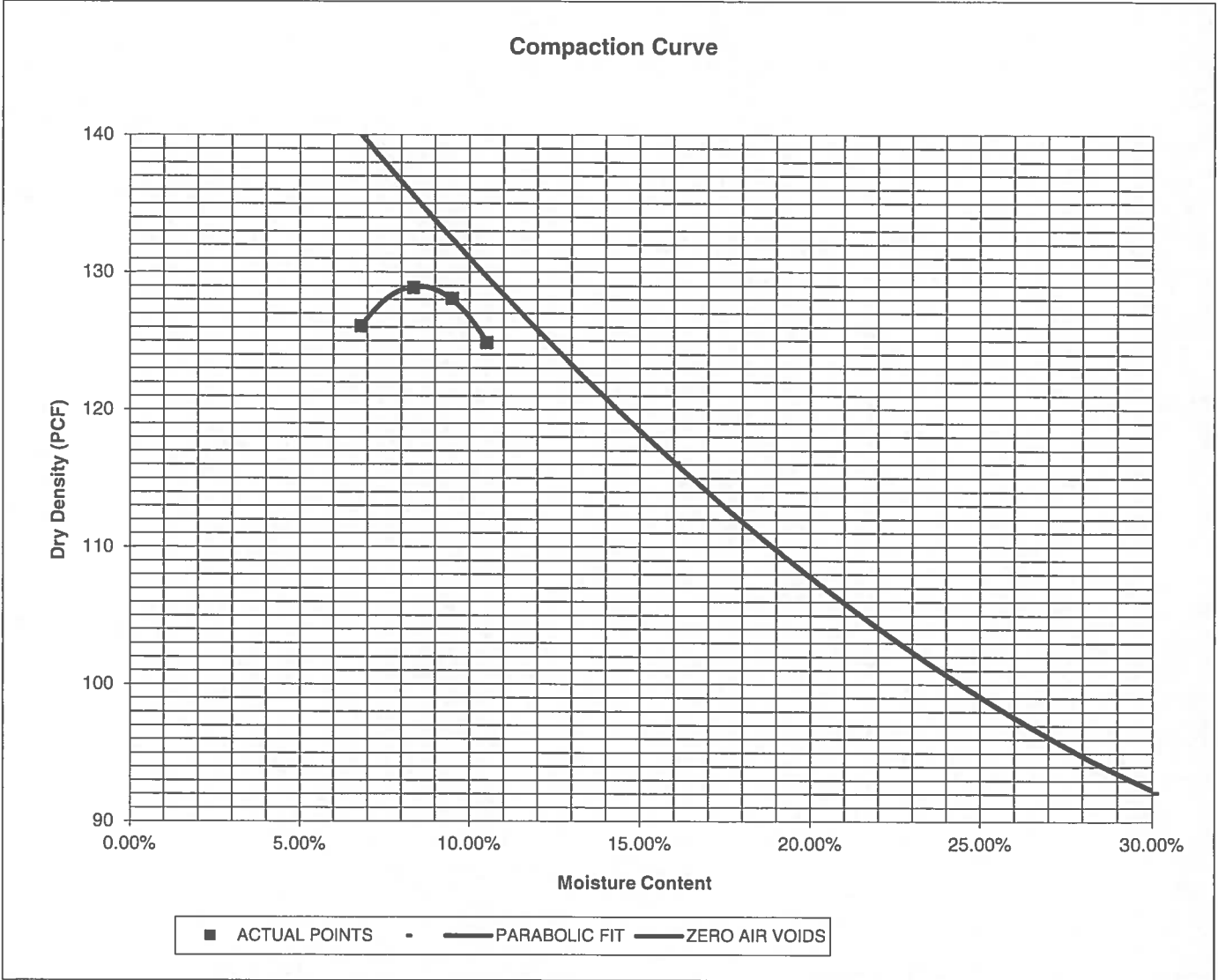


LABORATORY TEST RESULTS			
DRAWN:	DATE:	CHECKED:	DATE:
		SCL	9/20/18

JOB NO.:	181382
FIG NO.:	B-7

<u>PROJECT</u>	JACKSON RANCH, F-3	<u>CLIENT</u>	JACKSON RANCH, LLC
<u>SAMPLE LOCATION</u>	TB-1 @ 0-3'	<u>JOB NO.</u>	181382
<u>SOIL DESCRIPTION</u>	SAND, SILTY, TAN	<u>DATE</u>	09/17/18

<u>IDENTIFICATION</u>	SM	<u>COMPACTION TEST #</u>	1, SOIL TYPE #1
<u>TEST DESIGNATION / METHOD</u>	ASTM D-1557-A	<u>TEST BY</u>	DC
<u>MAXIMUM DRY DENSITY (PCF)</u>	128.9	<u>OPTIMUM MOISTURE</u>	8.6%




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MOISTURE DENSITY RELATION

DRAWN:	DATE:	CHECKED:	DATE:
		SCC	9/20/18

JOB NO.:
181382
FIG NO.:
B-8

CBR TEST LOAD DATA

JOB NO: 181382
 CLIENT: JACKSON RANCH, LLC
 PROJECT: JACKSON RANCH, F-3
 SOIL TYPE: 2, CBR #1

PISTON DIAMETER (cm)	PISTON AREA (in ²)	10 BLOWS		25 BLOWS		56 BLOWS	
4.958	2.99250919	MOLD # 1		MOLD # 17		MOLD # 16	
PENETRATION DEPTH (INCHES)	LOAD(LBS)	STRESS (PSI)	LOAD(LBS)	STRESS (PSI)	LOAD(LBS)	STRESS (PSI)	STRESS (PSI)
0.000	0	0.00	0	0.00	0	0.00	0.00
0.025	138	46.12	148	49.46	272	90.89	90.89
0.050	286	95.57	289	96.57	615	205.51	205.51
0.075	458	153.05	538	179.78	817	273.02	273.02
0.100	591	197.49	788	263.32	1087	363.24	363.24
0.125	731	244.28	1068	356.89	1357	453.47	453.47
0.150	834	278.70	1367	456.81	1651	551.71	551.71
0.175	932	311.44	1688	564.08	1942	648.95	648.95
0.200	1049	350.54	1980	661.65	2184	729.82	729.82
0.300	1470	491.23	3278	1095.40	3498	1168.92	1168.92
0.400	1782	595.49	4188	1399.49	4797	1603.00	1603.00
0.500	2141	715.45	5129	1713.95	6000	2005.01	2005.01

FINAL MOISTURE CONTENT

	MOLD # 1	MOLD # 17	MOLD # 16
CAN #	359	341	349
WT. CAN	6.76	7.15	6.9
WT. CAN+WET	178.91	172.79	171.59
WT. CAN+DRY	160.27	157.69	156.95
WT. H2O	18.64	15.1	14.64
WT. DRY SOIL	153.51	150.54	150.05
MOISTURE CONTENT	12.14%	10.03%	9.76%

WET DENSITY (PCF)	127.6	133.6	137.8
DRY DENSITY (PCF)	117.5	123.0	126.9

BEARING RATIO	19.75	26.33	36.32
---------------	-------	-------	-------

90% OF DRY DENSITY	116.0
95% OF DRY DENSITY	122.5

BEARING RATIO AT 90% OF MAX	17.93 ~ R VALUE	60
BEARING RATIO AT 95% OF MAX	25.66 ~ R VALUE	73



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 COLORADO SPRINGS, COLORADO 80907

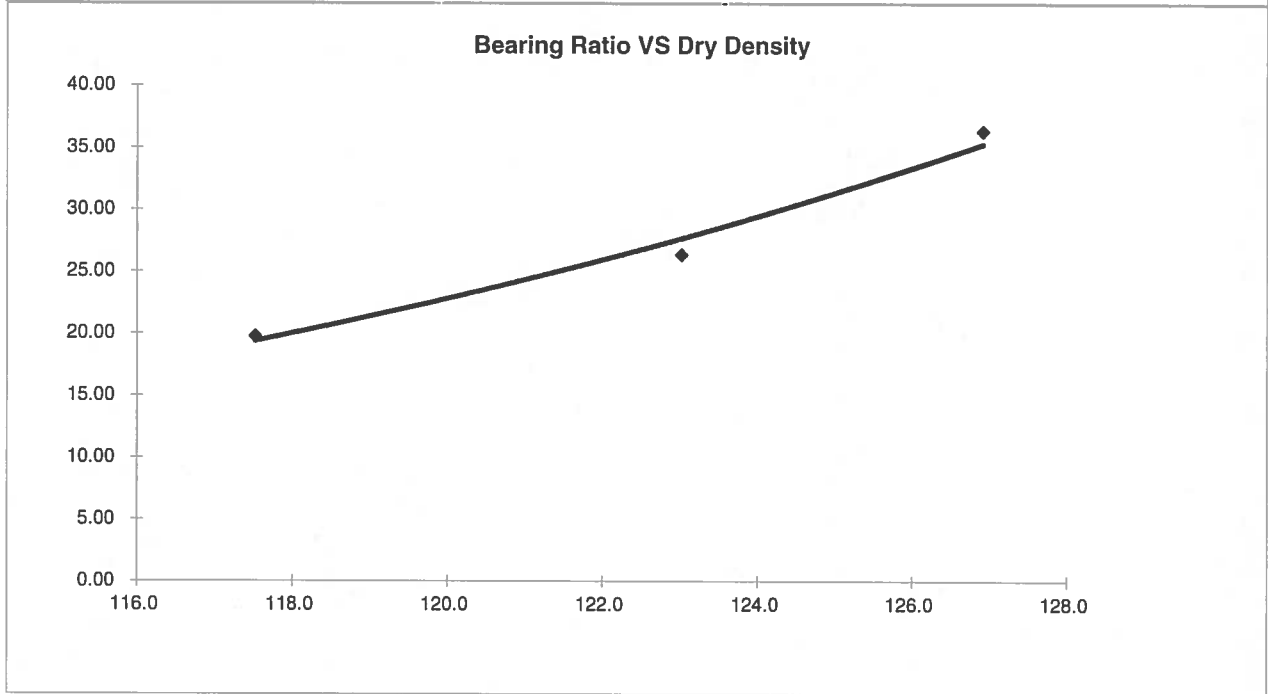
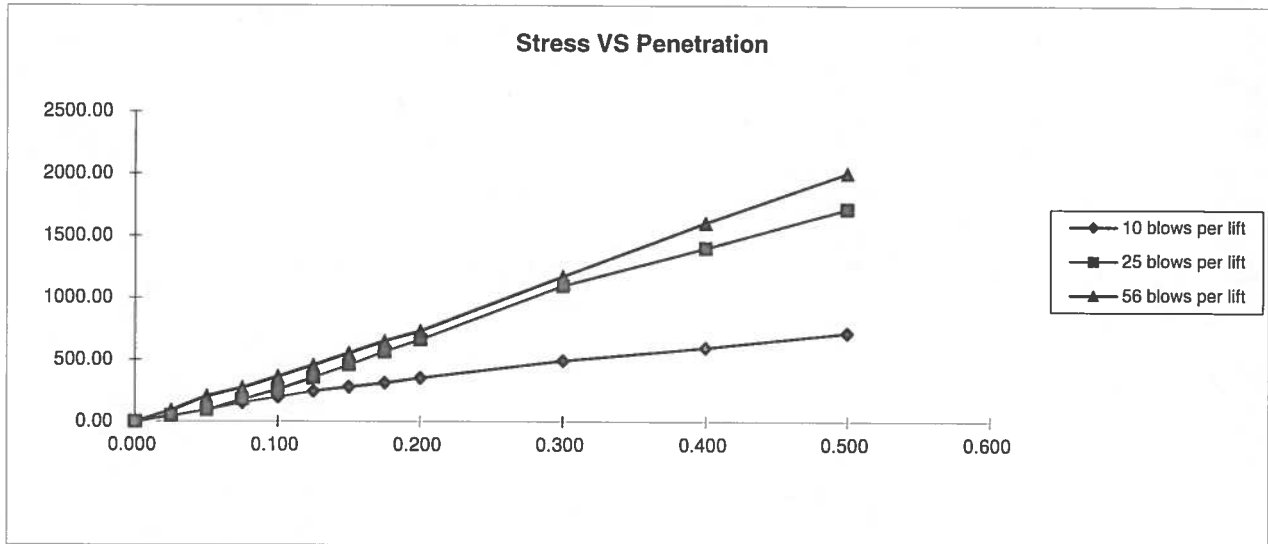
CBR TEST DATA

DRAWN:	DATE:	CHECKED:	DATE:
		SCC	9/20/18

JOB NO.:
 181382

FIG NO.:

B-9



BEARING RATIO AT 90% OF MAX	17.93 ~ R VALUE	60.00
BEARING RATIO AT 95% OF MAX	25.66 ~ R VALUE	73.00

JOB NO: 181382
 SOIL TYPE: 2, CBR #1



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CALIFORNIA BEARING RATIO

DRAWN:

DATE:

CHECKED:

DATE:

SC

9/20/18

JOB NO.:
 181382

FIG NO.:
 B-10

CLIENT	JACKSON RANCH, LLC	JOB NO.	181382
PROJECT	JACKSON RANCH, F-3	DATE	9/20/2018
LOCATION	JACKSON RANCH, F-3	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-2	10	2	SM-SW	<0.01
TB-4	5	3	SM-SW	<0.01

QC BLANK PASS



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 COLORADO SPRINGS, COLORADO 80907

**LABORATORY TEST
 SULFATE RESULTS**

DRAWN:	DATE:	CHECKED:	DATE:
		S CC	9/20/18

JOB NO.:
 181382
 FIG NO.:
 B-11

APPENDIX C: Pavement Design Calculations

FLEXIBLE PAVEMENT DESIGN

DESIGN DATA

JACKSON RANCH FILING NO. 3 - LOCAL LOW-VOLUME

SOIL TYPE 2, CBR # 1

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	36,500
Hveem Stabilometer (R Value) Results:	R =	45
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 =	11183

Weighted Structural Number (WSN): ➔ WSN = 1.57

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. 181382
Fig. No. C-1

DESIGN CALCULATIONS

DESIGN DATA JACKSON RANCH FILING NO. 3 - LOCAL LOW-VOLUME

SOIL TYPE 2, CBR # 1

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL = 36,500
Hveem Stabilometer (R Value) Results:	R = 45
Weighted Structural Number (WSN):	WSN = 1.57

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)

$D_1 = (WSN)/C_1 = 3.6$ inches of Full Depth Asphalt
Use 4.0 inches Full Depth

FOR ASPHALT + AGGREGATE BASE COURSE SECTION

Asphalt Thickness (t) = inches

$D_2 = ((WSN) - (t)(C_1))/C_2 = 2.3$ inches of Aggregate
Base Course, use 4.0 inches

RECOMMENDED ALTERNATIVES

1. 3.0 inches of Asphalt + 4.0 inches of Aggregate Base Course, or
2. 4.0 inches of Asphalt

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Fig. No. C-2