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

PAVEMENT DESIGN REPORT
STERLING RANCH ROAD SEGMENT 2
DINES BOULEVARD TO BRIARGATE PARKWAY
EI PASO COUNTY, COLORADO

Prepared for:
SR LAND, LLC
20 Boulder Crescent, 1st Floor, Suite 100
Colorado Springs, CO 80903

Attn: Chaz Collins

October 27, 2023

Respectfully Submitted,

ENTECH ENGINEERING, INC.

COLORADO LICENSED
JOSEPH C GOODE III
52381
PROFESSIONAL ENGINEER

Digitally signed by Joseph C Goode III
Date: 2023.10.27 15:04:16 -06'00'

Joseph C. Goode III, P.E.
Sr. Engineer

Reviewed by:

Austin M. Nossokoff, P.E.
Sr. Engineer

JCG:AMN/ed
Entech Job No. 231661

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1 Introduction

Entech Engineering, Inc. (Entech) completed a subsurface investigation for the pavement design for Sterling Ranch Road between Dines Boulevard and Briargate Parkway in the Sterling Ranch subdivision in northeastern Colorado Springs, Colorado (refer to Figure 1). This report describes the subsurface investigation conducted for the proposed roadway improvements and provides pavement section alternatives and construction recommendations. The contents of this report, including the pavement design recommendations, are subject to the limitations and assumptions presented in Section 7.

2 Project Description

The proposed improvements include Sterling Ranch Road, Segment 2, between Dines Boulevard and Briargate Parkway within the Sterling Ranch subdivision. At the time of our subsurface exploration program, the existing roadways had been rough graded. Surrounding properties are comprised of vacant land and land being developed for future residential lots. Based on the development plans, Sterling Ranch Road is designated as a non-residential collector, with Briargate Parkway designated as an urban principal arterial roadway. This report provided recommendations for Sterling Ranch Road up to the Briargate Parkway intersection (does not include Brairgate Parkway).

3 Subsurface Explorations and Laboratory Testing

3.1 Subsurface Exploration Program

Subsurface conditions at the project site were explored by thirteen test borings, designated TB-1 through TB-13, drilled on October 12, 2023. The locations of the test borings are shown on the Site and Exploration Plan (Figure 2). The borings were drilled to depths of 5 to 10 feet below the existing ground surface (bgs). The drilling was performed using a truck-mounted, continuous flight auger drill rig supplied and operated by Entech. Descriptive boring logs providing the lithologies of the subsurface conditions encountered during drilling are presented in Appendix A. Groundwater levels were measured in each of the open boreholes at the conclusion of drilling.

Soil and bedrock samples were obtained from the borings utilizing the Standard Penetration Test (ASTM D1586) using a split-barrel California sampler. Results of the Standard Penetration Test (SPT) are included on the boring logs in terms of N-values expressed in blows per foot (bpf). Soil

and bedrock samples recovered from the borings were visually classified and recorded on the boring logs. The soil classifications were later verified utilizing laboratory testing and grouped by soil type. The soil type numbers are included on the boring logs. It should be understood that the soil descriptions shown on the boring logs may vary between boring locations and sample depths. It should also be noted that the lines of stratigraphic separation shown on the boring logs represent approximate boundaries between soil types and the actual stratigraphic transitions may be more gradual or variable with location.

3.2 Geotechnical Index and Engineering Property Testing

Water content testing (ASTM D2216) was performed on the samples recovered from the borings, and the results are shown on the boring logs. Grain-Size Analysis (ASTM D422) and Atterberg Limits testing (ASTM D4318) were performed on selected samples to assist in classifying the materials encountered in the borings.

For pavement design, a standard proctor (ASTM D698) and California Bearing Ratio (CBR) test (ASTM D1883) were completed. Soluble sulfate testing was performed on select soil samples to evaluate the potential for below grade degradation of concrete due to sulfate attack. The laboratory testing results are presented in Appendix B and summarized in Table B-1.

Strength testing was performed on two sets of soil/cement composite samples. Testing was performed on soil samples prepared with 2% and 4% Portland Cement Type 1/2. The 7-day average strength value of the 2% and 4% mix was 235 pounds per square inch (psi) and greater than 430 psi (sample strength exceeded the break machines capacity), respectively. A 2% mix is recommended based on the laboratory test results. A summary of the testing results is attached in Appendix B, Table B-2.

4 Subgrade Conditions

Three primary soil types and one bedrock type were encountered in the test borings drilled for the subsurface investigation. Each soil type was classified in accordance with the Unified Soil Classification System (USCS) and the American Association of State Highway and Transportation Officials (AASHTO) soil classification system using the laboratory testing results and the observations made during drilling.

4.1 Subsurface Conditions

Subsurface conditions along the proposed roadways consisted of loose to medium dense silty to clayey sand fill (Soil Type 1) and native, loose to medium dense clayey sand (Soil Type 2), and native silty sand (Soil Type 3). Sandstone was encountered at depths of 4 to 10 feet bgs in borings TB-1 and TB-4. When classified as a soil, the sandstone classified as dense, silty sand (Soil Type 4). Soil types and corresponding AASHTO soil classifications are listed as follows:

- Soil Type 1: A-1-b, A-2-4, and A-2-6
- Soil Type 2: A-6
- Soil Type 3: A-1-b
- Soil Type 4: A-1-b (sandstone)

Laboratory test results are presented in Appendix B and are summarized in Table B-1.

4.2 Groundwater

Groundwater was not encountered in the test borings. Groundwater fluctuations are likely and will depend on seasonal variations, local precipitation, runoff, and other factors. We do not anticipate groundwater to affect the proposed construction.

5 Pavement Design Recommendations

Pavement design recommendations were made in accordance with the El Paso County Engineering Criteria Manual.

5.1 Subgrade Conditions

California Bearing Ratio (CBR) testing was performed on a representative sample of the subgrade silty sand fill (Soil Type 1) from TB-1 to determine the support characteristic of the subgrade soils for the roadway section. The results of the CBR testing are presented in Appendix B and summarized in Exhibit 1.

Exhibit 1: Subsurface Laboratory Testing Summary

Design Parameter	Value
Soil Type	1 - Silty Sand Fill
CBR at 95%	15.76
Design CBR	10
Liquid Limit	26
Plasticity Index	14
Percent Passing 200	27.2
AASHTO Classification	A-2-6
Unified Soils Classification	SC

5.2 Swell Mitigation

El Paso County requires swell mitigation of expansive soils criteria for roadway subgrade with swell testing results greater than 2% under a 150 pounds per square foot (psf) surcharge. Given the classification of the soils, mitigation for expansive soils is not required on this site.

5.3 Traffic Loading

Traffic data is not available for Sterling Ranch Road between Dines and Briargate; however, the roadway is classified as a non-residential collector based on the current development plans. The El Paso County Pavement Design Criteria and Report provides default 18-kip equivalent single axle loading (ESAL) based street classifications. For design, a default ESAL value of 821,000 was used for the urban non-residential collector designation.

5.4 Pavement Design

The pavement sections were determined utilizing the El Paso County Engineering Criteria Manual, the CBR testing, and default ESAL. Design parameters used in the pavement analysis are presented in Exhibit 2.

Exhibit 2: Pavement Design Parameters

Design Parameter	Value
Reliability	85%
Standard Deviation	0.45
Serviceability Loss (Δ psi)	2.0
Design CBR	10
Resilient Modulus	15,000 psi
Structural Coefficients	
Hot Mix Asphalt	0.44
Aggregate Base Course	0.11
Cement Treated Subgrade	0.11

Pavement sections recommended for Sterling Ranch Road are summarized in Exhibit 3. The pavement design calculations are presented in Appendix C.

Exhibit 3: Recommended Pavement Sections

Pavement Area	Roadway Designation	Design ESAL	Alternative [1]
Sterling Ranch Road	Non-residential Collector	821,000	1. 4.0 inches HMA over 8.0 inches ABC
			2. 4.0 inches HMA over 10.0 inches CTS

ABC = Aggregate Base Course; ESAL = equivalent single axle loads; HMA = Hot Mix Asphalt; CTS = Cement Treated Subgrade

Notes:

1. All pavement alternatives meet the minimum sections required per El Paso County Pavement Design Criteria.

6 Construction Recommendations

Pavement design recommendations provided herein are contingent on good construction practices, and poor construction techniques may result in poor performance. Our analyses assumed that this project will be constructed according to the El Paso County Engineering Criteria Manual and the Pikes Peak Region Asphalt Paving Specifications.

6.1 Earthwork Recommendations for Pavement Subgrade

Proper subgrade preparation is required for adequate pavement performance. Paving areas should be cleared of all deleterious materials including but not limited to: existing pavements, utility poles, and fence poles. Surface vegetation, if any, should be removed by stripping, with the depth to be field determined.

6.1.1 Subgrade Preparation – Aggregate Base Course Alternatives

If pavement section alternatives are selected utilizing aggregate base course (ABC), the final subgrade surface should be scarified to a depth of 12 inches, moisture conditioned within 0% to 3% over the optimum water content, and recompacted to 95% of its maximum Modified Proctor dry density, ASTM D1557. The compacted surface below pavements should be proof-rolled with a fully loaded, tandem-axle, 10-yard dump truck or equivalent. Any areas that are delineated to be soft, loose, or yielding during proof-rolling should be removed and reconditioned or replaced.

6.1.2 Cement-treated Subgrade

For pavement section alternatives utilizing cement treated subgrade (CTS), the subgrade shall be stabilized prior to placement of the asphalt by the addition of cement to a depth of at least 10 inches. The amount of cement applied shall be a minimum of 2% (by weight) of the subgrade's maximum dry density as determined by the Modified Proctor Test (ASTM D1557) for granular soils or by the Standard Proctor Test (ASTM D698) for cohesive soils. A minimum compression strength of 160 pounds per square inch (psi) is recommended for cement stabilized subgrade. El Paso County recommends that the design mix be increased by 1% in the field to account for waste and construction variability. The cement should be spread evenly on the subgrade surface and be thoroughly mixed into the subgrade over a 10-inch depth, as specified, 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% 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% of the subgrade maximum dry density as determined by the Modified Proctor Test (ASTM D1557) or by the Standard Proctor Test (ASTM D698). 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 of Type 1L 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 degrees F. Cement-treated subgrades should be maintained at a temperature of 40 degrees 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 qualified geotechnical engineer. The geotechnical 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 may be required. Soil strengths greater than 275 psi require microfracturing.

6.1.3 Fill Placement and Compaction

Granular fill placed as part of the pavement subgrade shall consist of non-expansive, granular soil, free of organic matter, unsuitable materials, debris, and cobbles greater than 3 inches in diameter. Additionally, any granular fill placed as part of the roadway subgrade should have a minimum CBR of 10. All granular fill placed within the pavement subgrade should be compacted to a minimum of 95% of its maximum Modified Proctor Dry Density (ASTM D1557) at +/-2% of optimum moisture content. Fill material should be placed in horizontal lifts such that each finished lift has a compacted thickness of 6 inches or less. Entech should approve any imported fill to be used within the pavement subgrade area prior to delivery to the site.

6.2 Aggregate Base Course

ABC materials shall conform to the El Paso County Standard Specifications, Table D-6, Aggregate Base Course Materials. ABC materials should be compacted to a minimum of 95% of its maximum Modified Proctor Dry Density (ASTM D1557) at +/-2% of optimum moisture content.

6.3 Concrete Degradation Due to Sulfate Attack

Sulfate solubility testing was conducted on several samples recovered from the test borings to evaluate the potential for sulfate attack on concrete. The test results indicated less than 0.01% soluble sulfate (by weight). The test results indicate the sulfate component of the in-place soils presents a negligible exposure threat to concrete placed below the site grade.

Type I/II or Type 1L cement is recommended for concrete on the site. To further avoid concrete degradation during construction, it is recommended that concrete not be placed on frozen or wet ground. Care should be taken to prevent the accumulation or ponding of water in the foundation excavation prior to the placement of concrete. If standing water is present in the foundation excavation, it should be removed by ditching to sumps and pumping the water away from the foundation area prior to concrete placement. If concrete is placed during periods of cold temperatures, the concrete must be kept from freezing. This may require covering the concrete with insulated blankets and adding heat to prohibit freezing.

6.4 Construction Observation

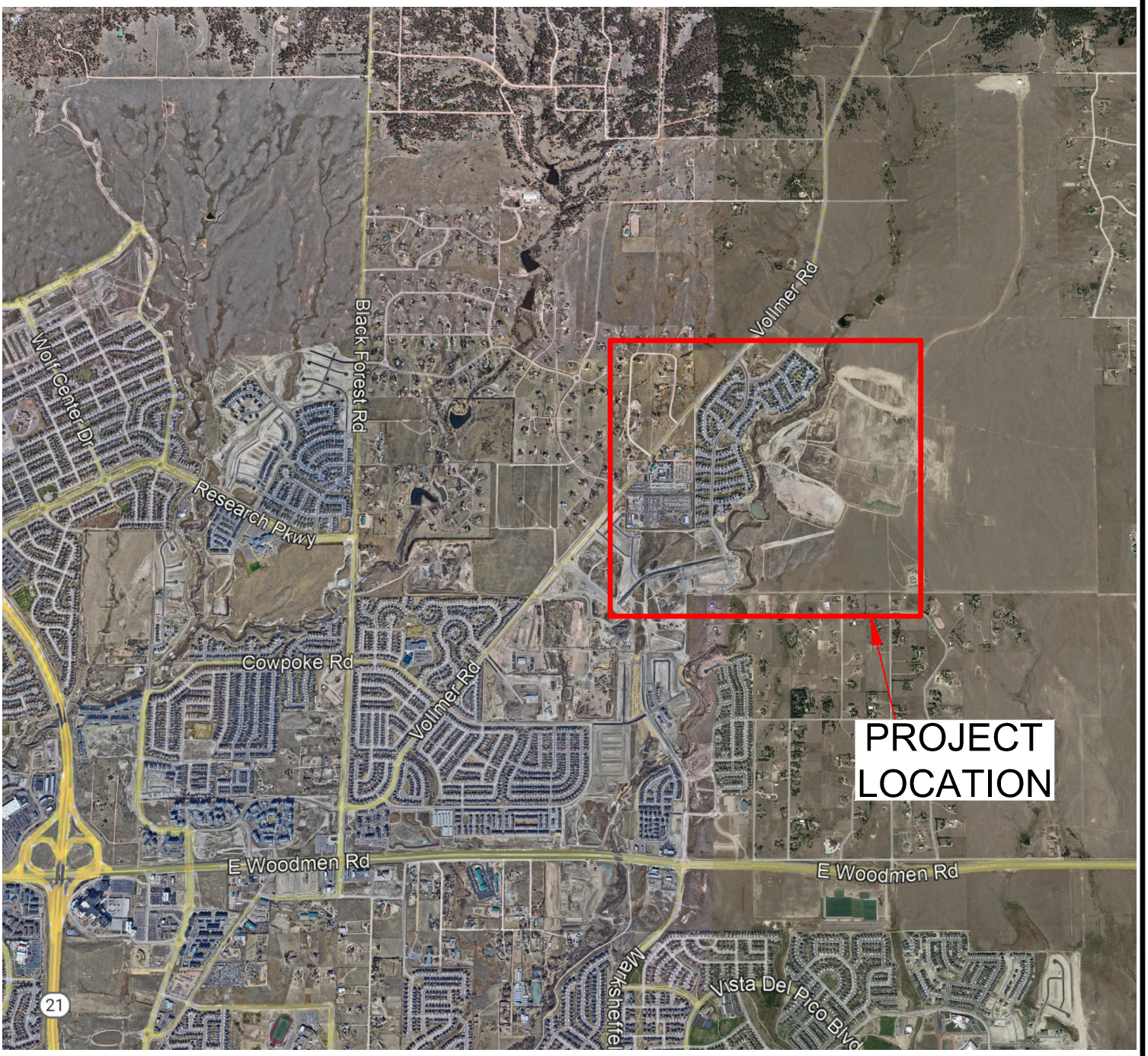
Subgrade preparation for pavement structures should be observed by Entech in order to verify that (1) no anomalies are present, (2) materials similar to those described in this report have been

encountered or placed, and (3) no soft spots, expansive or organic soil, or debris are present in the pavement subgrade prior to paving.

7 Closure

The subsurface investigation, geotechnical evaluation, and recommendations presented in this report are intended for use by SR Land, LLC with application to Sterling Ranch Road and Briargate Parkway, Segment 2, in the Sterling Ranch roadways paving project in Colorado Springs, Colorado. In conducting the subsurface investigation, laboratory testing, engineering evaluation, and reporting, Entech Engineering, Inc. endeavored to work in accordance with generally accepted professional geotechnical and geologic practices and principles consistent with the level of care and skill ordinarily exercised by members of the geotechnical profession currently practicing in the same locality and under similar conditions. No other warranty, expressed or implied, is made. During final design and/or construction, if conditions are encountered which appear different from those described in this report, Entech Engineering, Inc. requests to be notified so that the evaluation and recommendations presented herein can be reviewed and modified as appropriate.

If there are any questions regarding the information provided herein, or if Entech Engineering, Inc. can be of further assistance, please do not hesitate to contact us.



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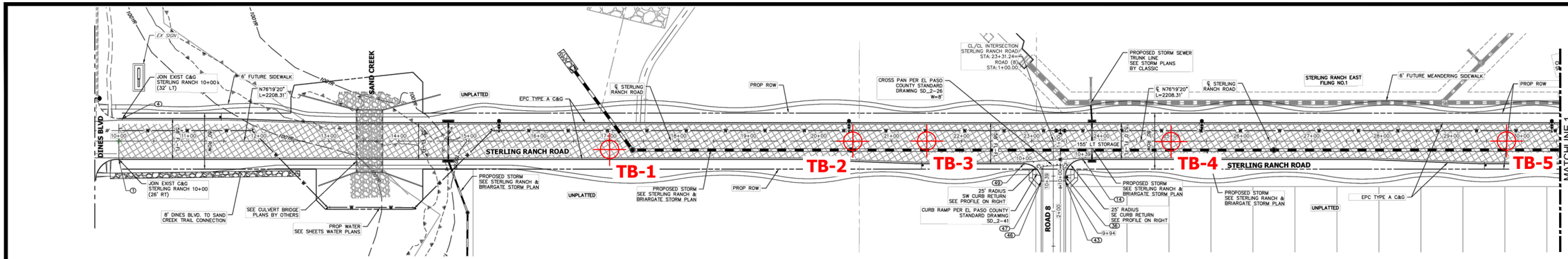
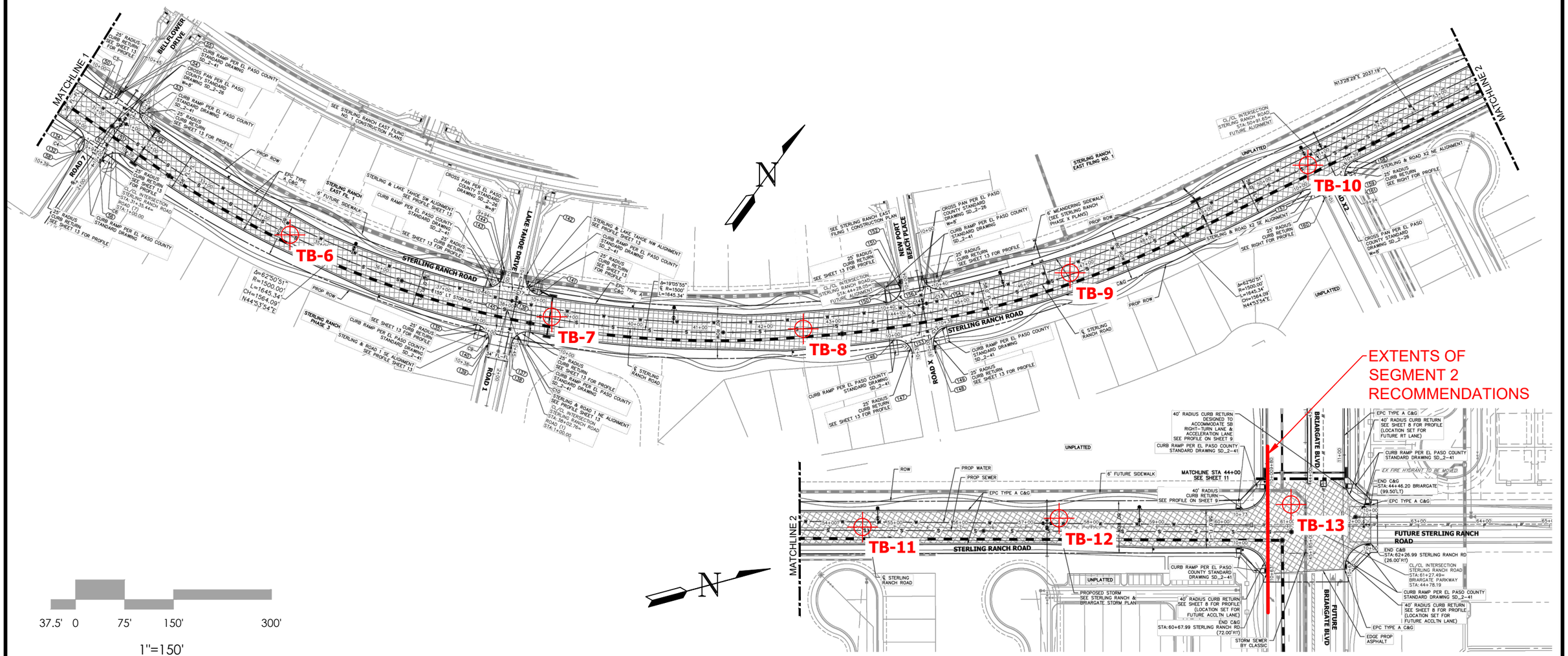
VICINITY MAP
STERLING RANCH ROAD, SEGMENT 2
SR LAND

JOB NO.
231661

FIG. 1





37.5' 0 75' 150' 300'

1"=150'

TB- APPROXIMATE TEST BORING LOCATION AND NUMBER

ENTECH ENGINEERING, INC.

SITE AND EXPLORATION PLAN

STERLING RANCH ROAD, SEGMENT 2
SR LAND

JOB NO. 231661

FIG. 2

APPENDIX A: Test Boring Logs

TEST BORING 1
DATE DRILLED 10/12/2023

REMARKS	Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
DRY TO 10', 10/12/23						
FILL 0-4', SAND, WITH SILT, TAN, DENSE, MOIST				44	10.1	1
SANDSTONE, VERY WEAK, TAN, HIGHLY WEATHERED (SAND, SILTY, VERY DENSE, MOIST)	5			50/11"	13.2	4
	10			50/9"	5.1	4
	15					
	20					

TEST BORING 2
DATE DRILLED 10/12/2023

REMARKS	Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
DRY TO 5', 10/12/23						
FILL 0-5', SAND, SILTY, GRAVELLY, LOOSE, BROWN, MOIST				9	8.9	1
	5			7	12.4	1
	10					
	15					
	20					

ENTECH ENGINEERING, INC.

TEST BORING LOGS

STERLING RANCH ROAD SEGMENT 2
SR LAND

JOB NO. 231661

FIG. A-1

TEST BORING 3
DATE DRILLED 10/12/2023

REMARKS

DRY TO 5', 10/12/23

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
FILL 0-5', SAND, GRAVELLY, SILTY, BROWN, MEDIUM DENSE, MOIST			11	8.7	1
5			10	6.2	1
10					
15					
20					

TEST BORING 4
DATE DRILLED 10/12/2023

REMARKS

DRY TO 10', 10/12/23

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
FILL 0-6', SAND, GRAVELLY, SILTY, BROWN, MEDIUM DENSE, MOIST			11	9.7	1
5			15	6.0	1
SANDSTONE, VERY WEAK, GRAY, MODERATELY WEATHERED (SAND, SILTY, VERY DENSE, MOIST)					
10			50	16.7	4
15					
20					

ENTECH ENGINEERING, INC.

TEST BORING LOGS

STERLING RANCH ROAD SEGMENT 2
SR LAND

JOB NO. 231661

FIG. A-2

TEST BORING 5
DATE DRILLED 10/12/2023

REMARKS

DRY TO 5', 10/12/23

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type	Description
			13	8.0	1	FILL 0-5', SAND, SILTY, GRAVELLY, BROWN, MEDIUM DENSE to VERY LOOSE, MOIST
5			3	7.3	1	
10						
15						
20						

TEST BORING 6
DATE DRILLED 10/12/2023

REMARKS

DRY TO 5', 10/12/23

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type	Description
			11	7.7	1	FILL 0-5', SAND, SILTY, GRAVELLY, BROWN, MEDIUM DENSE to LOOSE, MOIST
5			7	8.9	1	
10						
15						
20						

ENTECH ENGINEERING, INC.

TEST BORING LOGS

STERLING RANCH ROAD SEGMENT 2
SR LAND

JOB NO. 231661

FIG. A-3

TEST BORING 7
DATE DRILLED 10/12/2023

REMARKS

DRY TO 10', 10/12/23

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			11	2.1	1
5			13	2.0	1
10			45	7.3	3
15					
20					

FILL 0-5', SAND, GRAVELLY, SILTY, BROWN, MEDIUM DENSE, DRY

SAND, SILTY, GRAY, DENSE, MOIST

TEST BORING 8
DATE DRILLED 10/12/2023

REMARKS

DRY TO 5', 10/12/23

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			7	8.2	1
5			11	7.5	1
10					
15					
20					

FILL 0-5', SAND, CLAYEY, BROWN, LOOSE to MEDIUM DENSE, MOIST

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TEST BORING LOGS

STERLING RANCH ROAD SEGMENT 2
SR LAND

JOB NO. 231661

FIG. A-4

TEST BORING 9
DATE DRILLED 10/12/2023

REMARKS

DRY TO 5', 10/12/23

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			6	8.6	1
5			8	9.6	1
10					
15					
20					

FILL 0-5', SAND, CLAYEY, BROWN, LOOSE, MOIST

FILL, SAND, WITH SILT, TAN, MEDIUM DENSE, DRY

TEST BORING 10
DATE DRILLED 10/12/2023

REMARKS

DRY TO 10', 10/12/23

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			16	9.9	1
5			13	3.8	1
10			38	11.3	3
15					
20					

FILL 0-7', SAND, CLAYEY, BROWN, MEDIUM DENSE, MOIST

SAND, CLAYEY, BROWN, DENSE, MOIST

ENTECH ENGINEERING, INC.

TEST BORING LOGS

STERLING RANCH ROAD SEGMENT 2
SR LAND

JOB NO. 231661

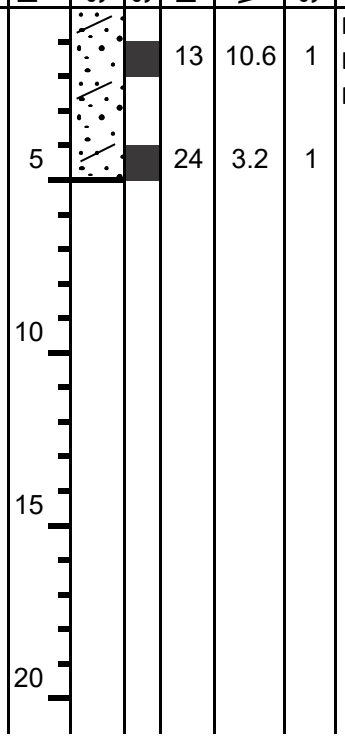
FIG. A-5

TEST BORING 11
DATE DRILLED 10/12/2023

REMARKS

DRY TO 5', 10/12/23

FILL 0-5', SAND, CLAYEY, BROWN, MEDIUM DENSE, MOIST



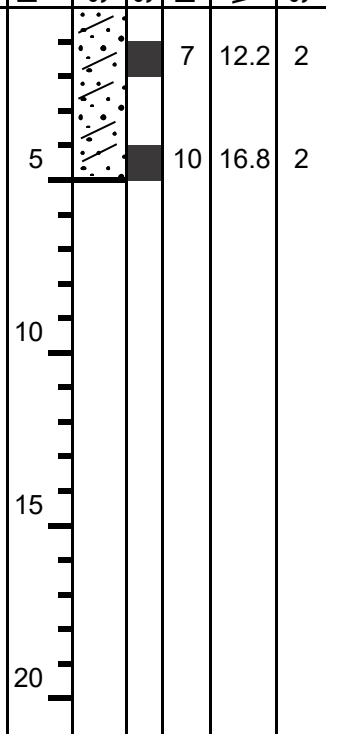
Blows per foot	Watercontent %	Soil Type
13	10.6	1
24	3.2	1

TEST BORING 12
DATE DRILLED 10/12/2023

REMARKS

DRY TO 5', 10/12/23

FILL 0-5', SAND, CLAYEY, BROWN, LOOSE to MEDIUM DENSE, MOIST



Blows per foot	Watercontent %	Soil Type
7	12.2	2
10	16.8	2

ENTECH ENGINEERING, INC.

TEST BORING LOGS

STERLING RANCH ROAD SEGMENT 2
SR LAND

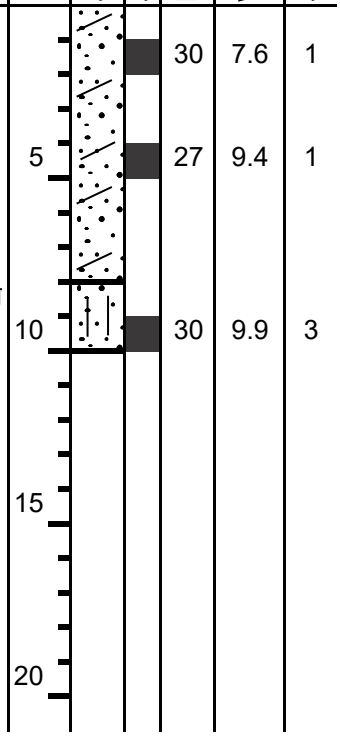
JOB NO. 231661

FIG. A-6

TEST BORING 13
DATE DRILLED 10/12/2023

REMARKS

DRY TO 5', 10/12/23



	Blows per foot	Watercontent %	Soil Type
FILL 0-8', SAND, CLAYEY, BROWN, DENSE to MEDIUM DENSE, MOIST	30	7.6	1
	27	9.4	1
SAND, SILTY, GRAY, DENSE, MOIST	30	9.9	3

ENTECH ENGINEERING, INC.

TEST BORING LOGS

STERLING RANCH ROAD SEGMENT 2
SR LAND

JOB NO.
231661

FIG. A-7

APPENDIX B: Laboratory Test Results

TABLE B-1
SUMMARY OF LABORATORY TEST RESULTS

SOIL TYPE	TEST BORING NO.	DEPTH (FT)	PASSING NO. 200 SIEVE (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTIC INDEX	SULFATE (WT %)	AASHTO CLASS.	USCS	SOIL DESCRIPTION
1, CBR	10	0-3	27.2	26	12	14		A-2-6	SC	FILL, SAND, CLAYEY
1	1	1-2	9.3	NV	NP	NP		A-1-b	SW-SM	FILL, SAND, WITH SILT
1	2	1-2	15.1	NV	NP	NP	<0.01	A-1-b	SM	FILL, SAND, SILTY
1	3	1-2	12.5	NV	NP	NP		A-1-b	SM	FILL, SAND, SILTY
1	4	1-2	12.5	NV	NP	NP		A-1-b	SM	FILL, SAND, SILTY
1	5	1-2	13.5	NV	NP	NP		A-1-b	SM	FILL, SAND, SILTY
1	6	1-2	14.0	NV	NP	NP		A-1-b	SM	FILL, SAND, SILTY
1	7	1-2	18.4	NV	NP	NP		A-2-4	SM	FILL, SAND, SILTY
1	8	1-2	26.4	27	18	9	<0.01	A-2-4	SC	FILL, SAND, CLAYEY
1	9	1-2	32.3	30	15	15		A-2-6	SC	FILL, SAND, CLAYEY
1	10	1-2	29.4	31	20	11		A-2-6	SC	FILL, SAND, CLAYEY
1	11	1-2	20.8	35	20	15		A-2-6	SC	FILL, SAND, CLAYEY
2	12	1-2	37.1	33	18	15		A-6	SC	FILL, SAND, CLAYEY
3	7	10	9.9	NV	NP	NP	0.01	A-1-b	SM	SAND, SILTY
3	10	10	25.9	30	20	10		A-1-b	SM	SAND, CLAYEY
4	1	10	18.7	NV	NP	NP		A-1-b	SM	SANDSTONE (SAND, SILTY)
4	4	10	12.3	20	17	3	<0.01	A-1-b	SM	SANDSTONE (SAND, SILTY)

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TABLE B-2
SUMMARY OF CTS TEST RESULTS

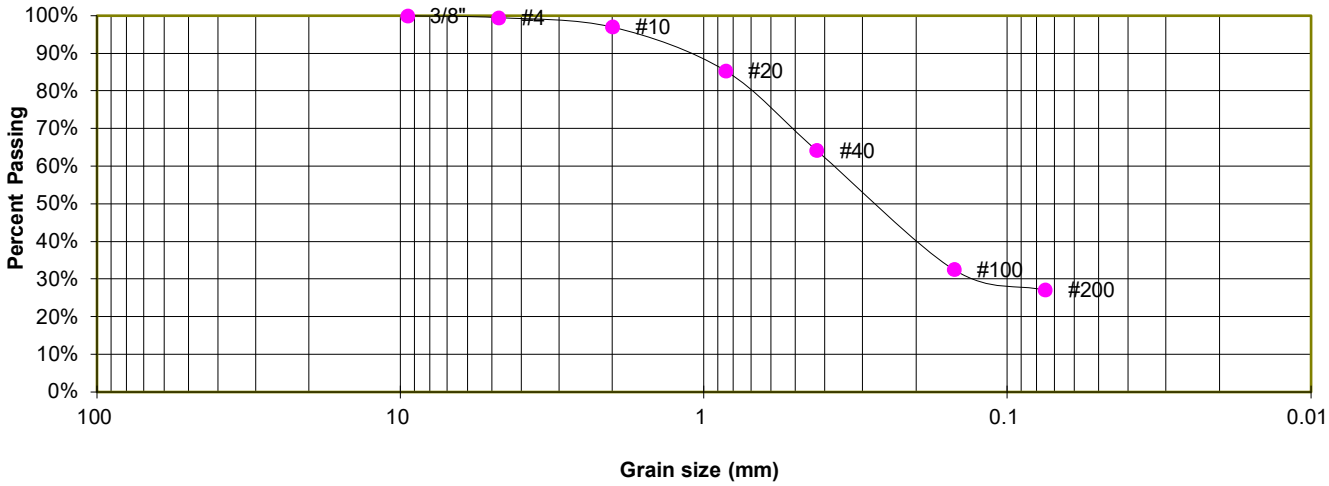
FIELD SAMPLE ID: SAND, SILTY
SOIL ADDITIVE: TYPE I/II CEMENT
CURING METHOD: 100° HUMIDIFIED OVEN

ADDITIVE %	*WATER %*	*DENSITY (dry)*	*AGE (days)*	*STRENGTH (psi)*
2	8.0	124.8	7	215
2	8.0	124.8	7	165
2	8.0	124.9	7	326
			AVERAGE:	**235**
4	8.0	124.7	7	430
4	8.0	125.0	7	430
4	8.0	124.9	7	430
			AVERAGE:	**430**

Note:

Each 4% specimen exceeded the maximum strength of the low strength break machine.

TEST BORING 10	SOIL DESCRIPTION FILL, SAND, CLAYEY
DEPTH (FT) 0-3	SOIL TYPE 1, CBR



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	99.5%
10	97.0%
20	85.4%
40	64.2%
100	32.6%
200	27.2%

ATTERBERG LIMITS

Plastic Limit	12
Liquid Limit	26
Plastic Index	14

SOIL CLASSIFICATION

USCS CLASSIFICATION:	SC
AASHTO CLASSIFICATION:	A-2-6
AASHTO GROUP INDEX:	0

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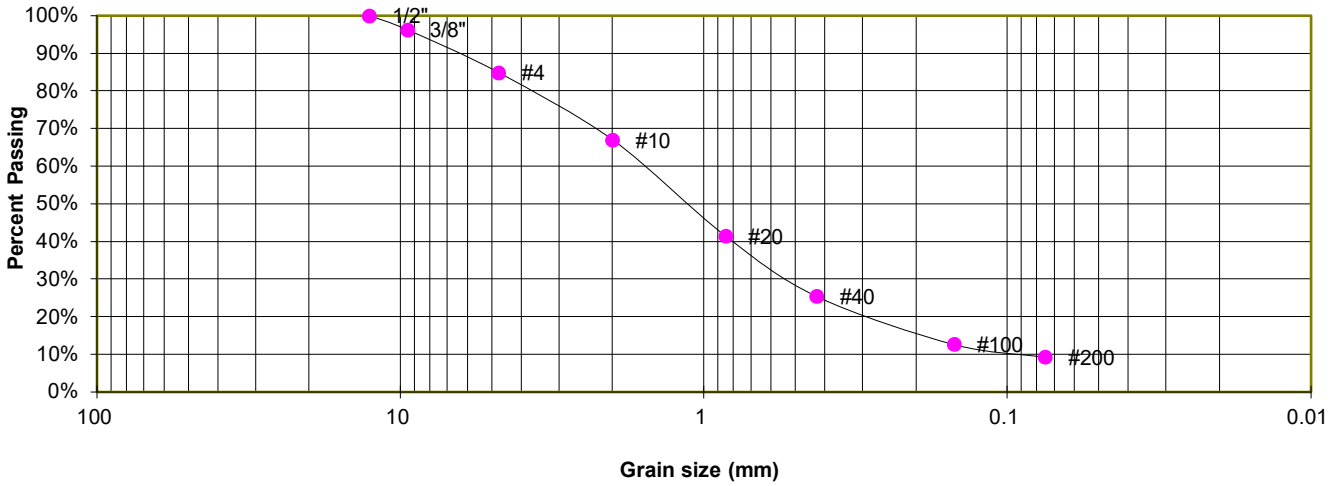
FIG. B-1

TEST BORING	1	SOIL DESCRIPTION	FILL, SAND, WITH SILT
DEPTH (FT)	1-2	SOIL TYPE	1



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	96.3%
4	84.9%
10	67.0%
20	41.5%
40	25.5%
100	12.7%
200	9.3%

ATTERBERG LIMITS

Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

SOIL CLASSIFICATION

USCS CLASSIFICATION: SW-SM
AASHTO CLASSIFICATION: A-1-b
AASHTO GROUP INDEX: 0

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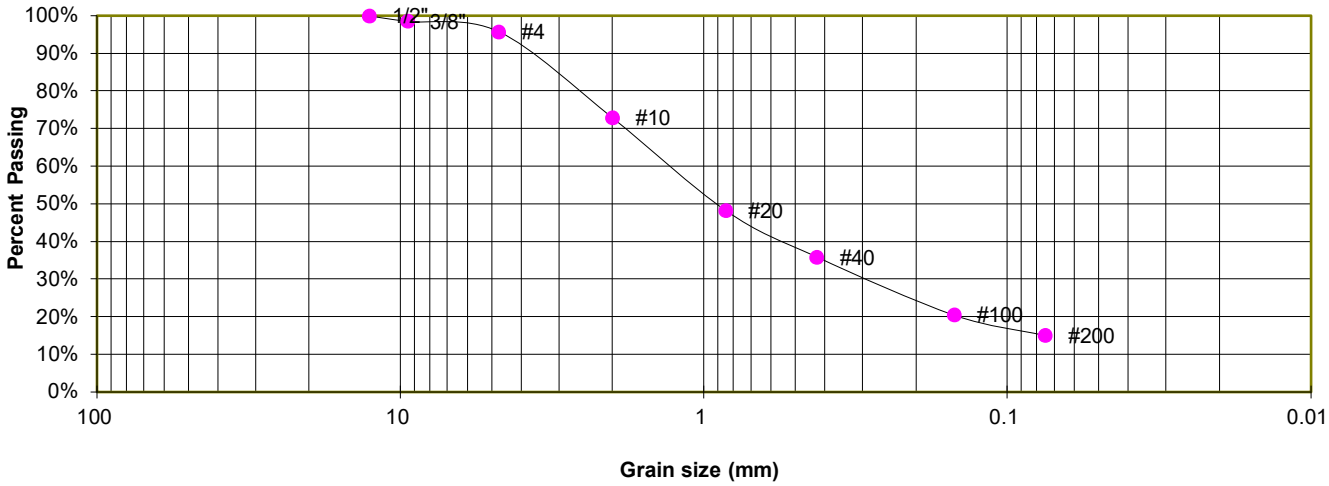
FIG. B-2

TEST BORING	2	SOIL DESCRIPTION	FILL, SAND, SILTY
DEPTH (FT)	1-2	SOIL TYPE	1



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	98.6%
4	95.8%
10	72.9%
20	48.3%
40	35.9%
100	20.5%
200	15.1%

ATTERBERG LIMITS

Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

SOIL CLASSIFICATION

USCS CLASSIFICATION:	SM
AASHTO CLASSIFICATION:	A-1-b
AASHTO GROUP INDEX:	0

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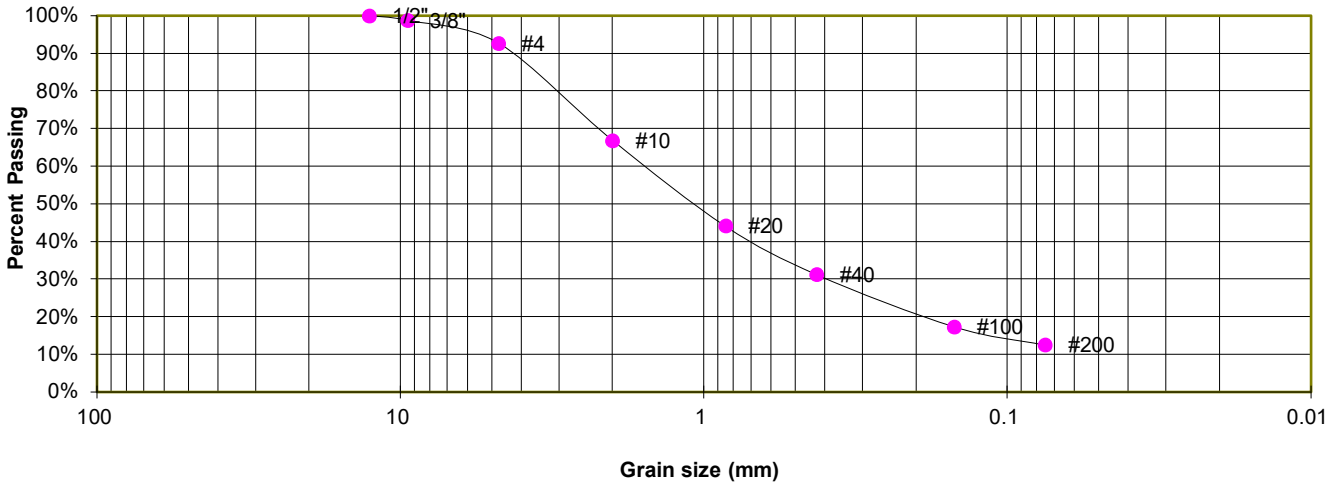
FIG. B-3

TEST BORING	3	SOIL DESCRIPTION	FILL, SAND, SILTY
DEPTH (FT)	1-2	SOIL TYPE	1



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	98.8%
4	92.7%
10	66.8%
20	44.1%
40	31.3%
100	17.4%
200	12.5%

ATTERBERG LIMITS

Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

SOIL CLASSIFICATION

USCS CLASSIFICATION:	SM
AASHTO CLASSIFICATION:	A-1-b
AASHTO GROUP INDEX:	0

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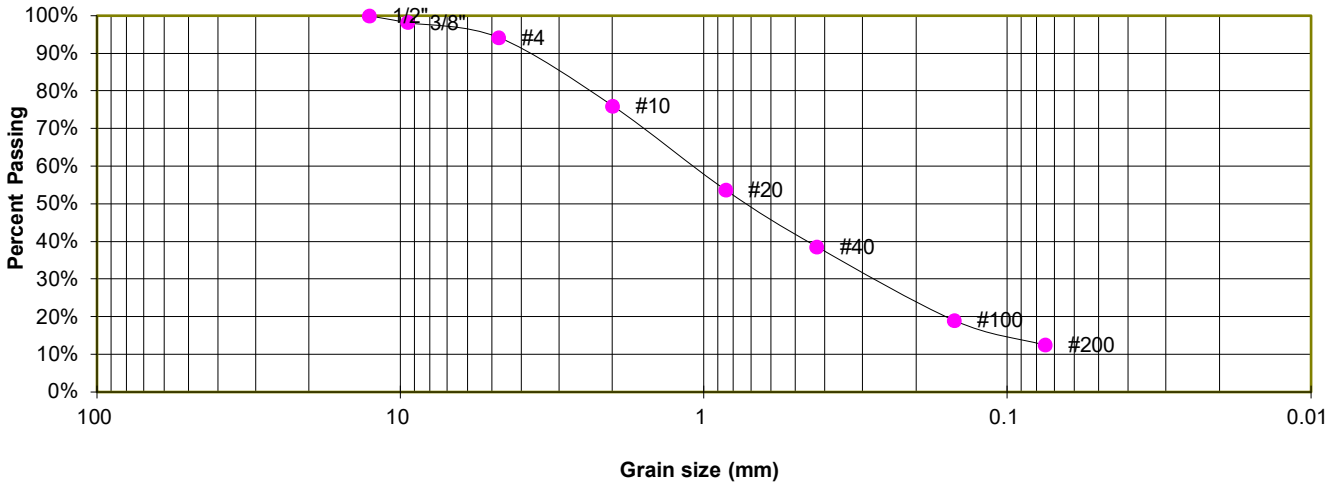
FIG. B-4

TEST BORING	4	SOIL DESCRIPTION	FILL, SAND, SILTY
DEPTH (FT)	1-2	SOIL TYPE	1



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	98.3%
4	94.2%
10	76.1%
20	53.7%
40	38.7%
100	19.1%
200	12.5%

ATTERBERG LIMITS

Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

SOIL CLASSIFICATION

USCS CLASSIFICATION:	SM
AASHTO CLASSIFICATION:	A-1-b
AASHTO GROUP INDEX:	0

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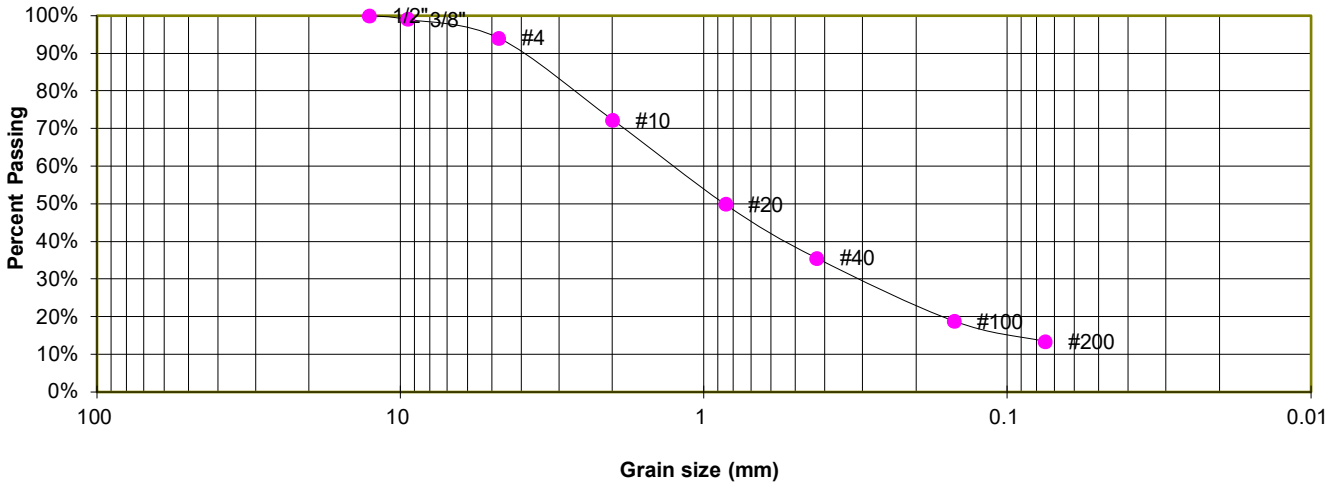
FIG. B-5

TEST BORING	5	SOIL DESCRIPTION	FILL, SAND, SILTY
DEPTH (FT)	1-2	SOIL TYPE	1



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	99.1%
4	94.1%
10	72.3%
20	49.9%
40	35.6%
100	18.9%
200	13.5%

ATTERBERG LIMITS

Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

SOIL CLASSIFICATION

USCS CLASSIFICATION:	SM
AASHTO CLASSIFICATION:	A-1-b
AASHTO GROUP INDEX:	0

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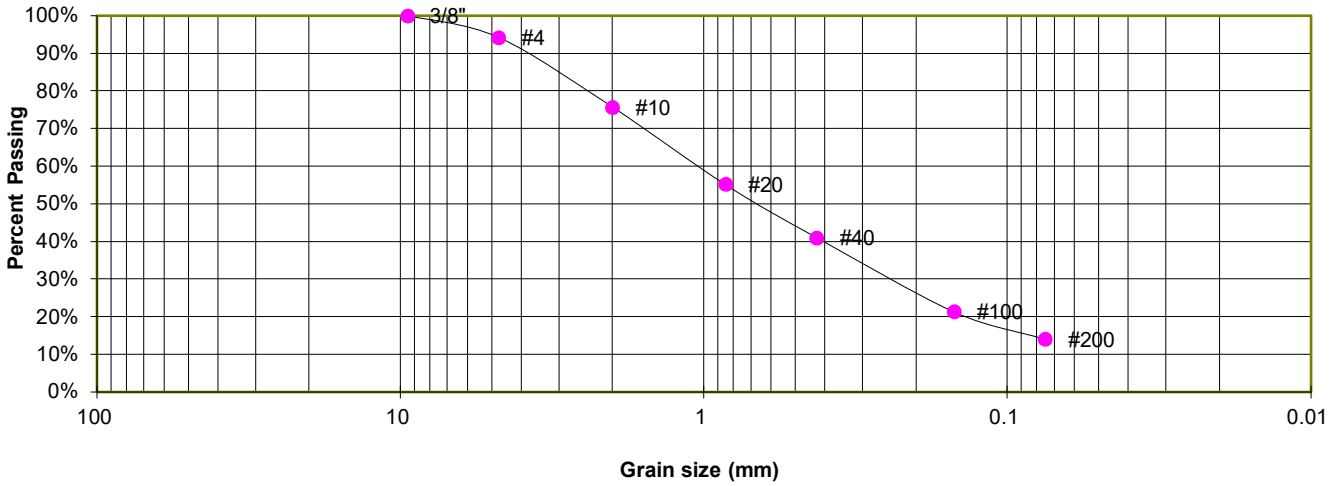
FIG. B-6

TEST BORING	6	SOIL DESCRIPTION	FILL, SAND, SILTY
DEPTH (FT)	1-2	SOIL TYPE	1



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	94.3%
10	75.7%
20	55.2%
40	41.0%
100	21.4%
200	14.0%

ATTERBERG LIMITS

Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

SOIL CLASSIFICATION

USCS CLASSIFICATION:	SM
AASHTO CLASSIFICATION:	A-1-b
AASHTO GROUP INDEX:	0

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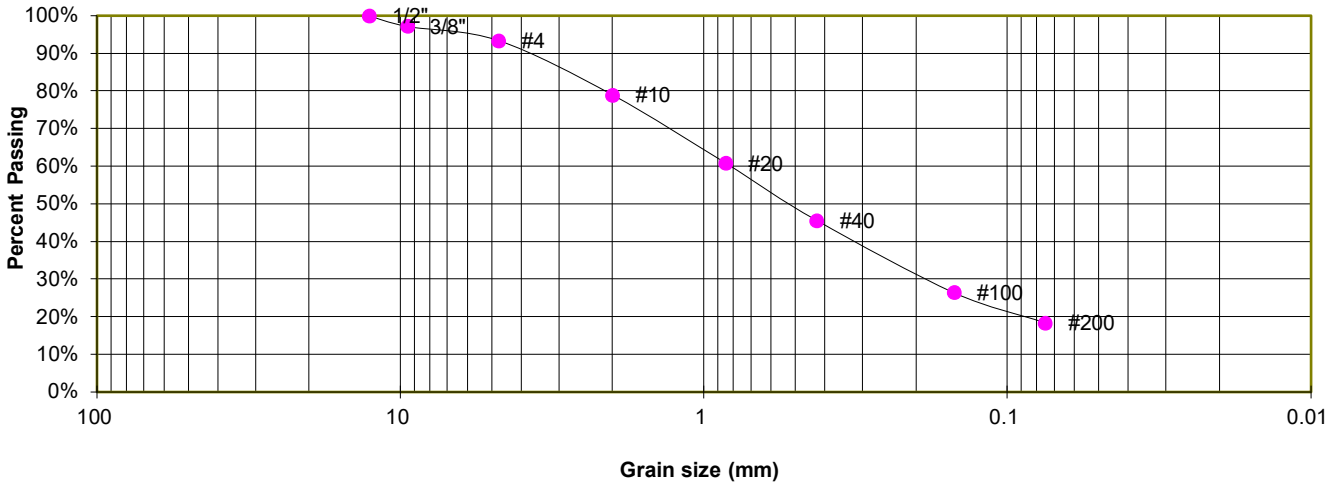
FIG. B-7

TEST BORING	7	SOIL DESCRIPTION	FILL, SAND, SILTY
DEPTH (FT)	1-2	SOIL TYPE	1



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	97.2%
4	93.4%
10	79.0%
20	60.9%
40	45.6%
100	26.5%
200	18.4%

ATTERBERG LIMITS

Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

SOIL CLASSIFICATION

USCS CLASSIFICATION:	SM
AASHTO CLASSIFICATION:	A-2-4
AASHTO GROUP INDEX:	0

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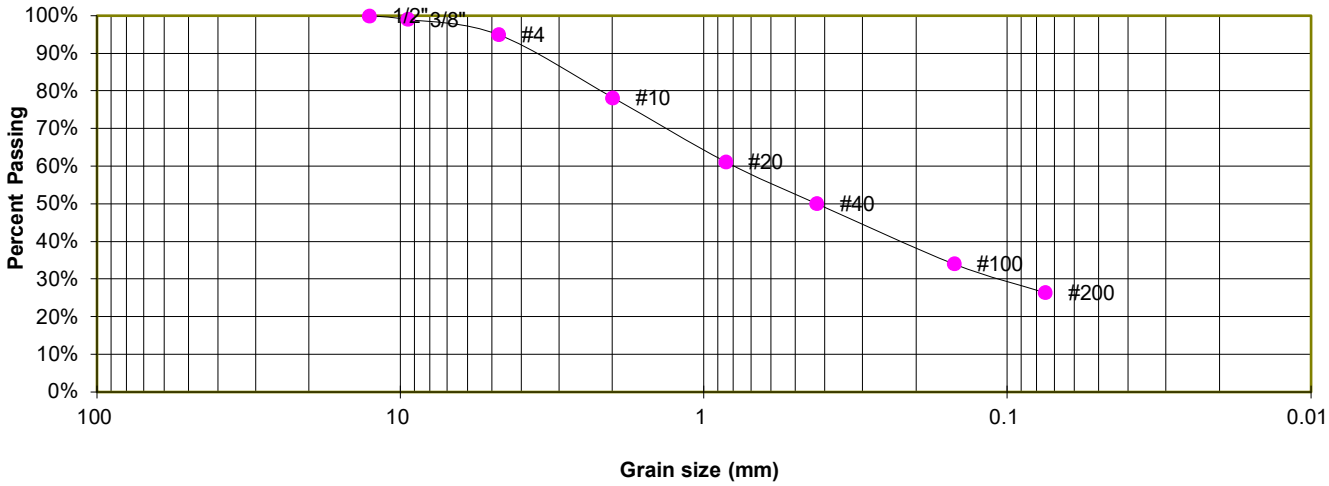
FIG. B-8

TEST BORING	8	SOIL DESCRIPTION	FILL, SAND, CLAYEY
DEPTH (FT)	1-2	SOIL TYPE	1



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	99.1%
4	95.0%
10	78.3%
20	61.2%
40	50.1%
100	34.1%
200	26.4%

ATTERBERG LIMITS

Plastic Limit	18
Liquid Limit	27
Plastic Index	9

SOIL CLASSIFICATION

USCS CLASSIFICATION:	SC
AASHTO CLASSIFICATION:	A-2-4
AASHTO GROUP INDEX:	0

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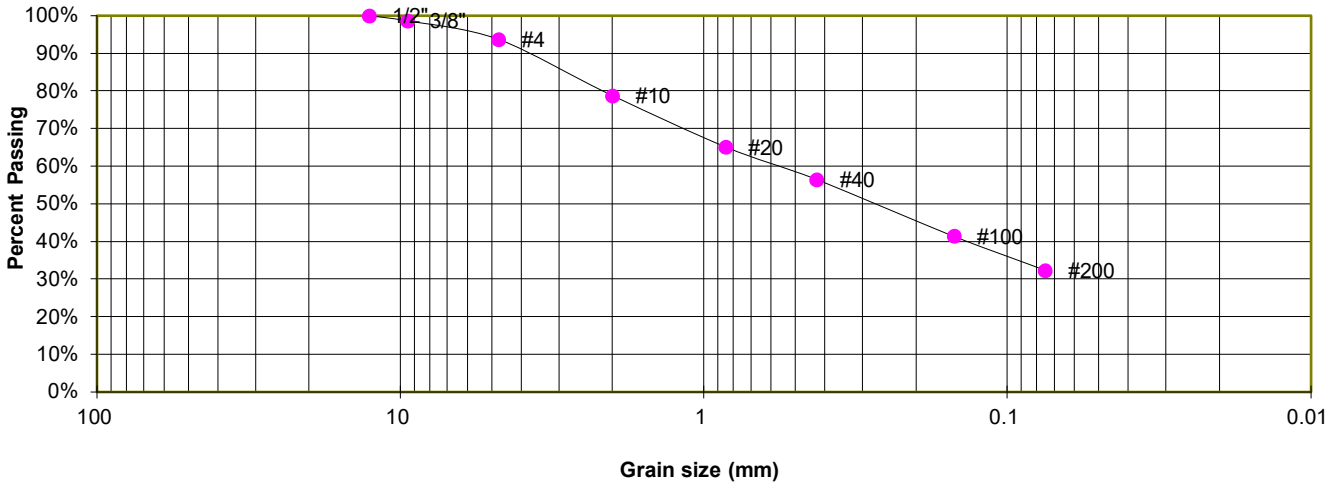
FIG. B-9

TEST BORING	9	SOIL DESCRIPTION	FILL, SAND, CLAYEY
DEPTH (FT)	1-2	SOIL TYPE	1



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	98.7%
4	93.7%
10	78.7%
20	65.2%
40	56.4%
100	41.5%
200	32.3%

ATTERBERG LIMITS

Plastic Limit	15
Liquid Limit	30
Plastic Index	15

SOIL CLASSIFICATION

USCS CLASSIFICATION:	SC
AASHTO CLASSIFICATION:	A-2-6
AASHTO GROUP INDEX:	1

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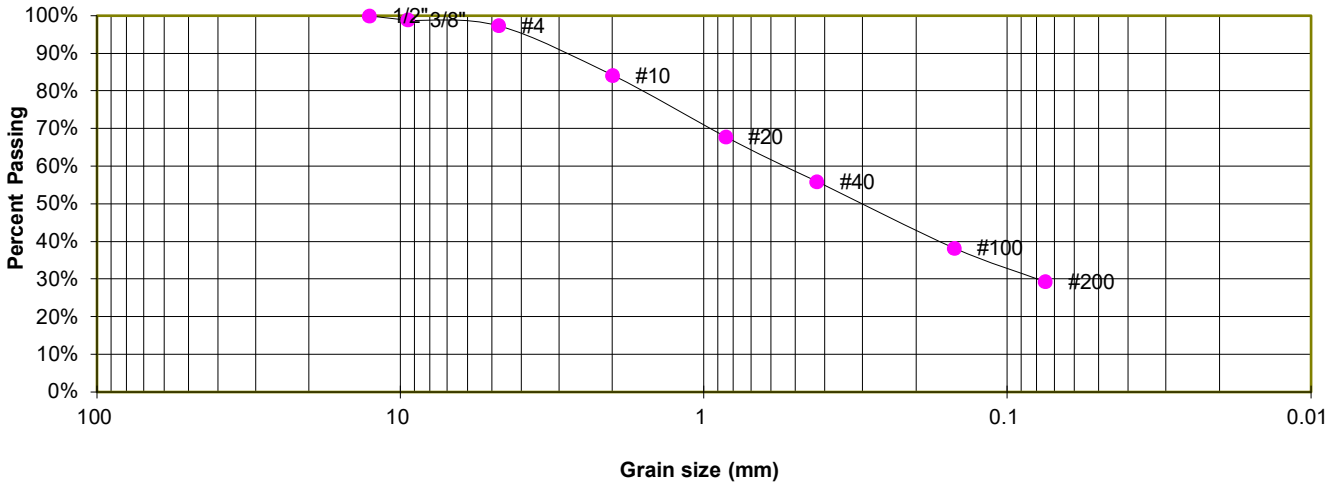
FIG. B-10

TEST BORING	10	SOIL DESCRIPTION	FILL, SAND, CLAYEY
DEPTH (FT)	1-2	SOIL TYPE	1



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	98.9%
4	97.4%
10	84.2%
20	67.9%
40	55.9%
100	38.3%
200	29.4%

ATTERBERG LIMITS

Plastic Limit	20
Liquid Limit	31
Plastic Index	11

SOIL CLASSIFICATION

USCS CLASSIFICATION:	SC
AASHTO CLASSIFICATION:	A-2-6
AASHTO GROUP INDEX:	0

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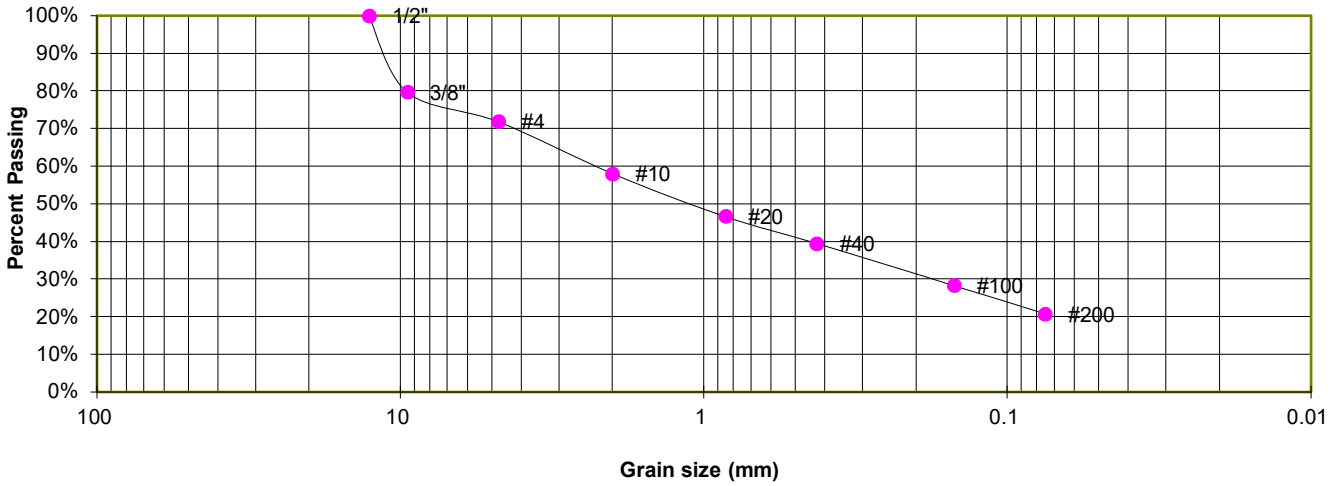
FIG. B-11

TEST BORING	11	SOIL DESCRIPTION	FILL, SAND, CLAYEY
DEPTH (FT)	1-2	SOIL TYPE	1



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	79.7%
4	71.8%
10	58.0%
20	46.7%
40	39.5%
100	28.4%
200	20.8%

ATTERBERG LIMITS

Plastic Limit	20
Liquid Limit	35
Plastic Index	15

SOIL CLASSIFICATION

USCS CLASSIFICATION:	SC
AASHTO CLASSIFICATION:	A-2-6
AASHTO GROUP INDEX:	0

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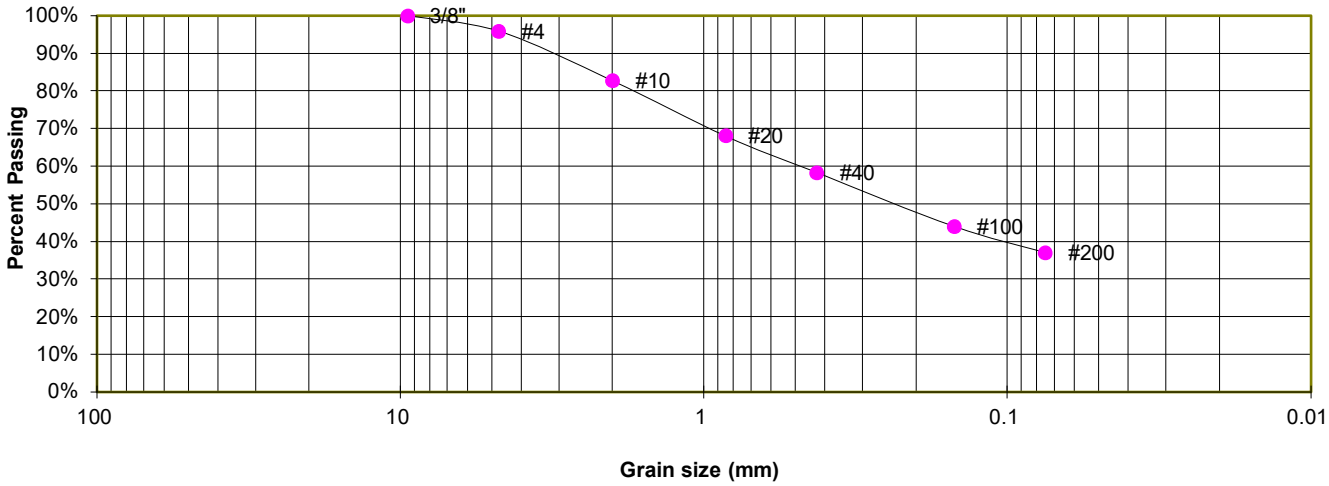
FIG. B-12

TEST BORING	12	SOIL DESCRIPTION	FILL, SAND, CLAYEY
DEPTH (FT)	1-2	SOIL TYPE	2



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	95.9%
10	82.8%
20	68.1%
40	58.3%
100	44.0%
200	37.1%

ATTERBERG LIMITS

Plastic Limit	18
Liquid Limit	33
Plastic Index	15

SOIL CLASSIFICATION

USCS CLASSIFICATION:	SC
AASHTO CLASSIFICATION:	A-6
AASHTO GROUP INDEX:	1

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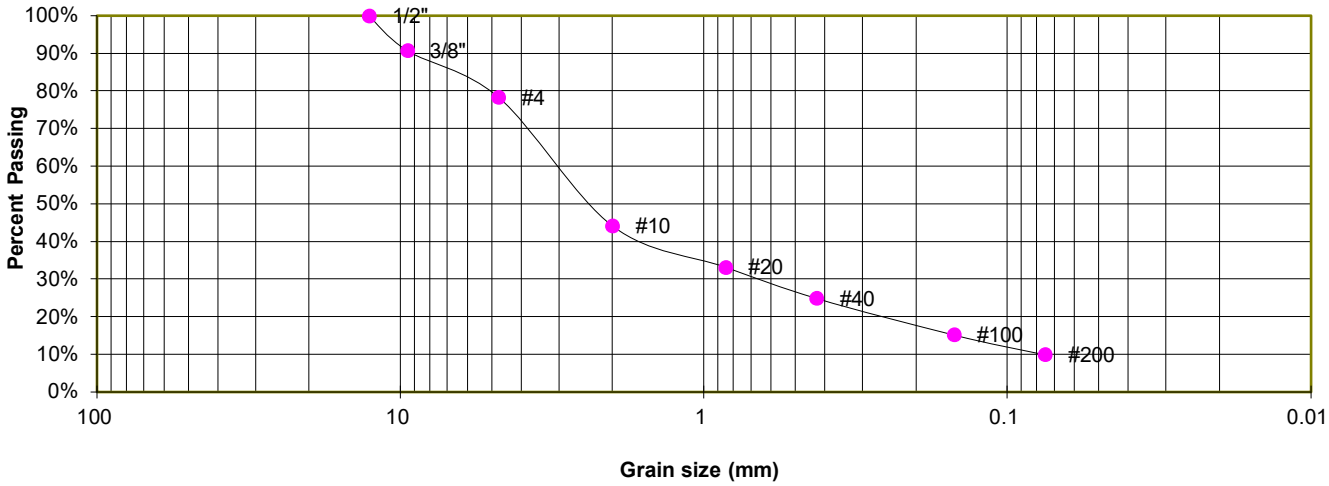
FIG. B-13

TEST BORING	7	SOIL DESCRIPTION	SAND, SILTY
DEPTH (FT)	10	SOIL TYPE	3



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	90.8%
4	78.3%
10	44.1%
20	33.2%
40	24.9%
100	15.2%
200	9.9%

ATTERBERG LIMITS

Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

SOIL CLASSIFICATION

USCS CLASSIFICATION:	SM
AASHTO CLASSIFICATION:	A-1-b
AASHTO GROUP INDEX:	0

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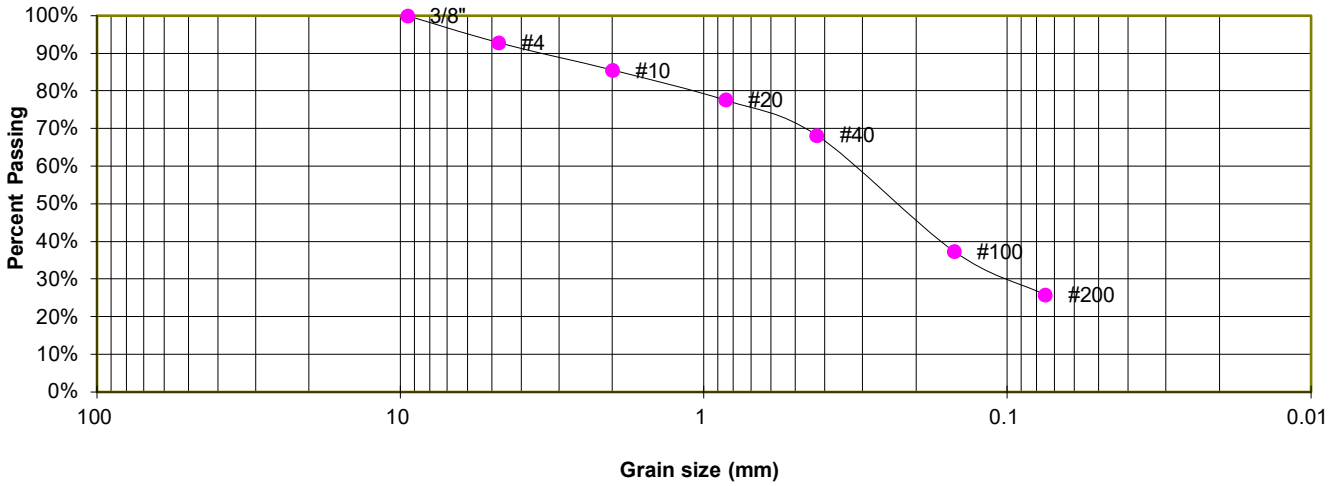
FIG. B-14

TEST BORING	10	SOIL DESCRIPTION	SAND, CLAYEY
DEPTH (FT)	10	SOIL TYPE	3



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	92.8%
10	85.6%
20	77.6%
40	68.2%
100	37.4%
200	25.9%

ATTERBERG LIMITS

Plastic Limit	20
Liquid Limit	30
Plastic Index	10

SOIL CLASSIFICATION

USCS CLASSIFICATION:	SM
AASHTO CLASSIFICATION:	A-1-b
AASHTO GROUP INDEX:	0

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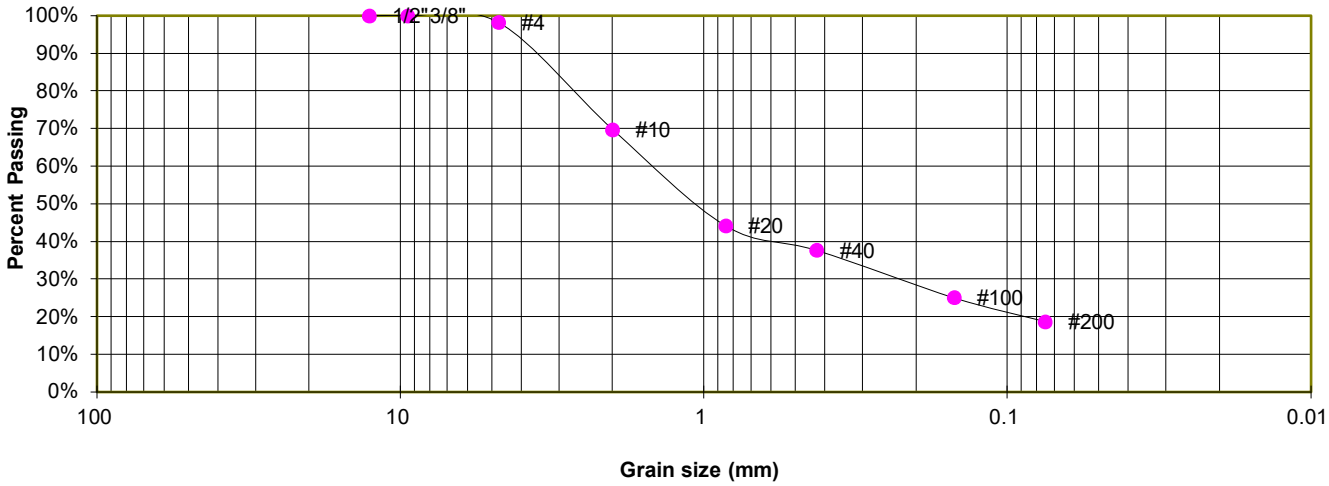
FIG. B-15

TEST BORING	1	SOIL DESCRIPTION	SANDSTONE (SAND, SILTY)
DEPTH (FT)	10	SOIL TYPE	4



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	100.0%
4	98.2%
10	69.7%
20	44.3%
40	37.7%
100	25.1%
200	18.7%

ATTERBERG LIMITS

Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

SOIL CLASSIFICATION

USCS CLASSIFICATION:	SM
AASHTO CLASSIFICATION:	A-1-b
AASHTO GROUP INDEX:	0

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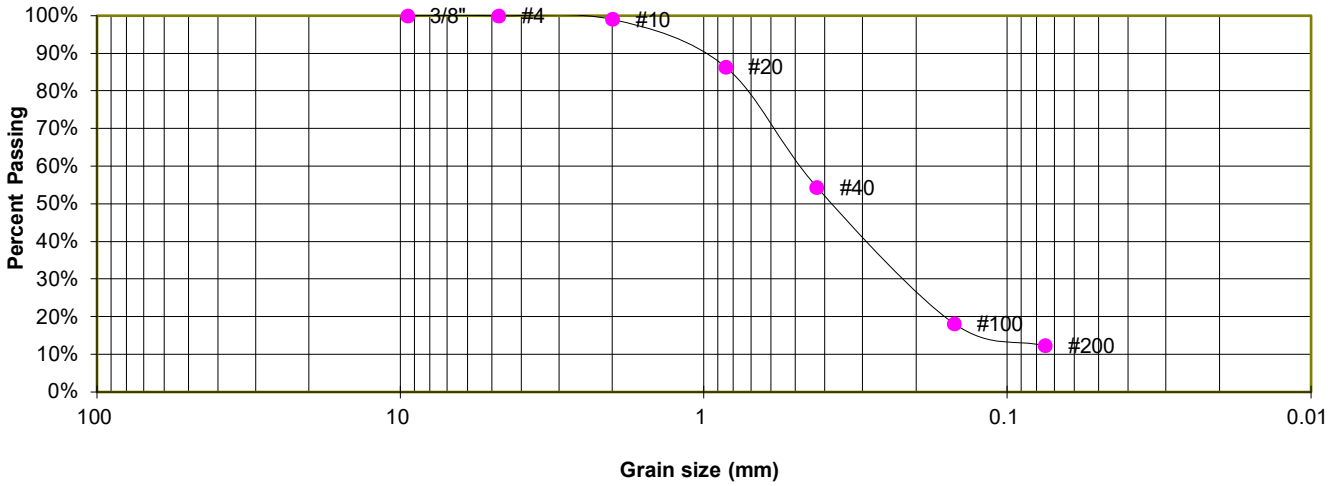
FIG. B-16

TEST BORING	4	SOIL DESCRIPTION	SANDSTONE (SAND, SILTY)
DEPTH (FT)	10	SOIL TYPE	4



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	100.0%
10	99.0%
20	86.4%
40	54.4%
100	18.2%
200	12.3%

ATTERBERG LIMITS

Plastic Limit	17
Liquid Limit	20
Plastic Index	3

SOIL CLASSIFICATION

USCS CLASSIFICATION:	SM
AASHTO CLASSIFICATION:	A-1-b
AASHTO GROUP INDEX:	0

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FIG. B-17

SAMPLE LOCATION TB-10 @ 0-3'	SOIL DESCRIPTION FILL, SAND, CLAYEY, BROWN
	SOIL TYPE 1

PROCTOR DATA

IDENTIFICATION:	SC
PROCTOR TEST #:	1
TEST BY:	BL
TEST DESIGNATION:	ASTM-1557-A
MAXIMUM DRY DENSITY (PCF):	131.8
OPTIMUM MOISTURE:	8

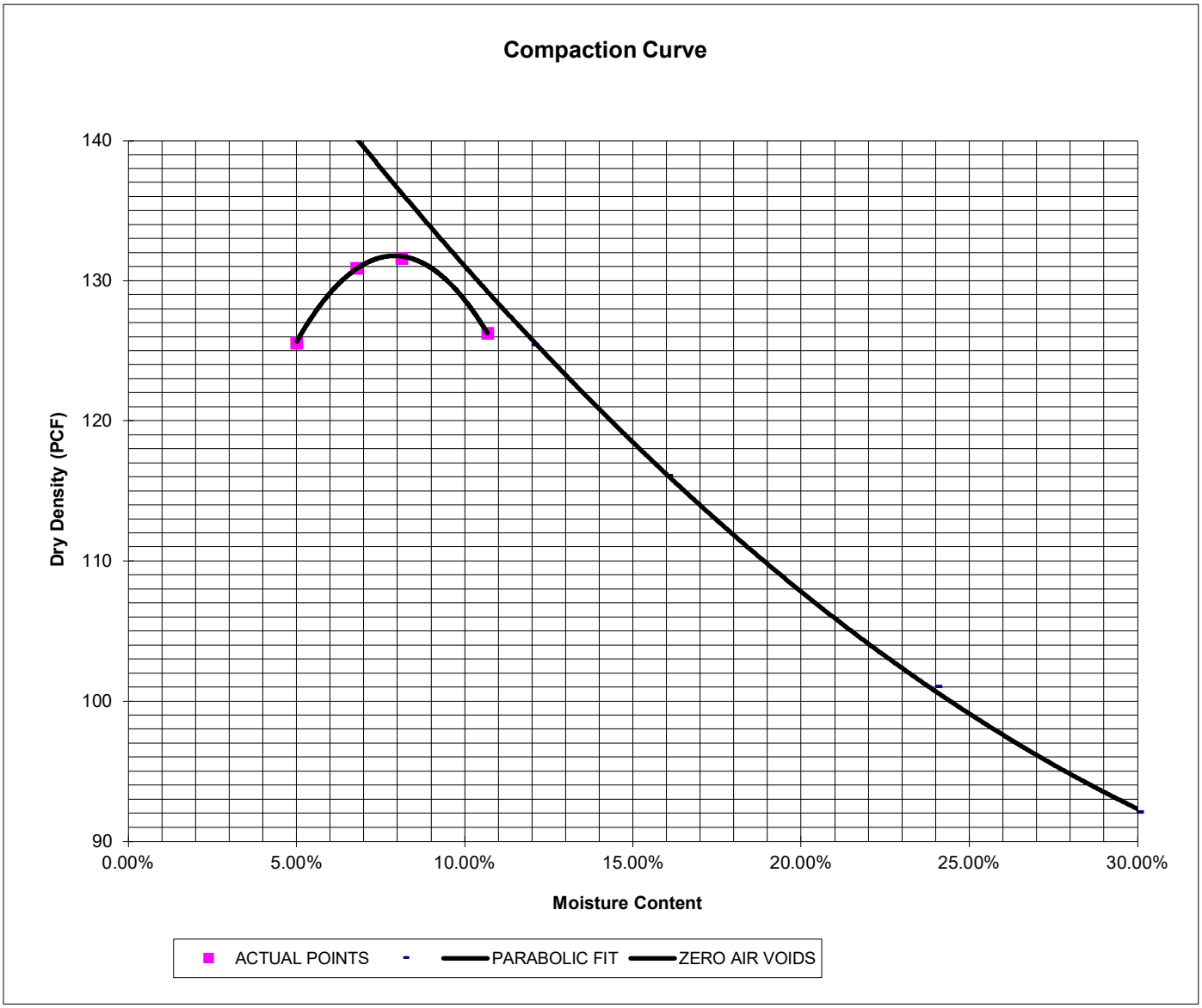

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FIG. B-18

SAMPLE LOCATION TB-10 @ 0-3'	SOIL DESCRIPTION FILL, SAND, CLAYEY, BROWN
DEPTH (FT) 0	SOIL TYPE 1

CBR TEST LOAD DATA

Piston Diameter (cm): 4.958
Piston Area (in^2): 2.993

Penetration Depth (inches)	*10 BLOWS* Mold # 1 Load (lbs)	Stress (psi)	*25 BLOWS* Mold # 2 Load (lbs)	Stress (psi)	*56 BLOWS* Mold # 3 Load (lbs)	Stress (psi)
0.000	0	0.00	0	0.00	0	0.00
0.025	96	32.08	188	62.82	470	157.06
0.050	148	49.46	326	108.94	837	279.70
0.075	173	57.81	410	137.01	1022	341.52
0.100	201	67.17	486	162.41	1286	429.74
0.125	241	80.53	715	238.93	1580	527.99
0.150	266	88.89	822	274.69	1709	571.09
0.175	296	98.91	900	300.75	1854	619.55
0.200	309	103.26	967	323.14	1973	659.31
0.300	355	118.63	1168	390.31	2685	897.24
0.400	400	133.67	1319	440.77	3062	1023.22
0.500	457	152.71	1488	497.24	3590	1199.66

MOISTURE AND DENSITY DATA

	Mold # 1	Mold # 2	Mold # 3
Can #	350	352	354
Wt. Can	8.02	7.98	7.98
Wt. Can+Wet	217.61	230.04	203.04
Wt. Can+Dry	187.8	203.5	183.1
Wt. H20	29.81	26.54	19.94
Wt. Dry Soil	179.78	195.52	175.12
Moisture Content	16.58%	13.57%	11.39%
Wet Density (PCF)	127.2	135.7	139.4
Dry Density (PCF)	117.8	125.6	129.1
% Compaction	89%	95%	98%
CBR	6.72	16.24	42.97

PROCTOR DATA

Maximum Dry Density (pcf)	131.8
Optimum Moisture	8
90% of Max. Dry Density (pcf)	118.6
95% of Max. Dry Density (pcf)	125.2

CBR at 90% of Max. Density = 7.75	~ R VALUE 17
CBR at 95% of Max. Density = 15.76	~ R VALUE 50

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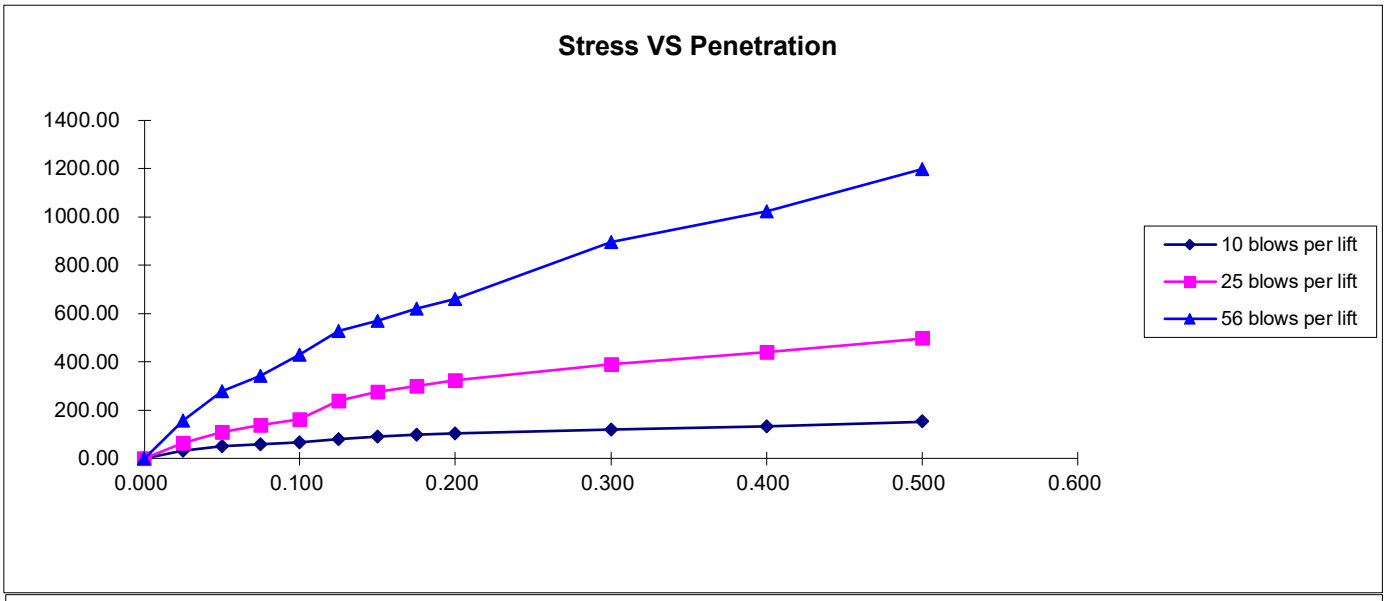
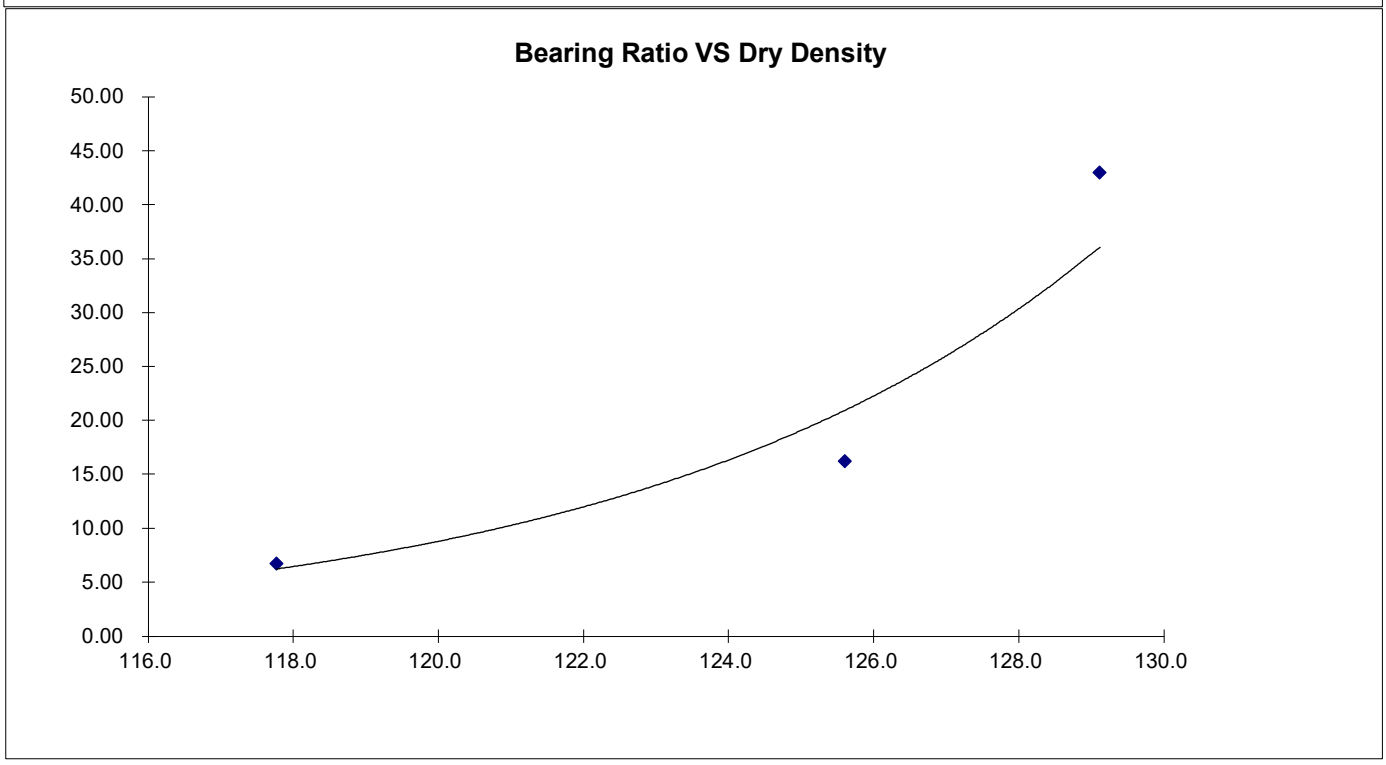
FIG. B-19

SAMPLE LOCATION TB-10 @ 0-3'	SOIL DESCRIPTION FILL, SAND, CLAYEY, BROWN
DEPTH (FT) 0	SOIL TYPE 0





ENTECH ENGINEERING, INC.

LABORATORY TEST RESULTS

STERLING RANCH ROAD SEGMENT 2
SR LAND

JOB NO.
231661

FIG. B-20

APPENDIX C: Pavement Design Calculations

FLEXIBLE PAVEMENT DESIGN

PROJECT DATA

Project Location Sterling Ranch Road

Job Number: 231661

DESIGN DATA

Equivalent (18-kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	821,000
Design CBR	CBR =	10
Standard Deviation	S_o =	0.45
Loss in Serviceability	Δpsi =	2.0
Reliability	Reliability =	85
Reliability (z-statistic)	Z_R =	-1.04
Soil Resilient Modulus	M_R =	15,000 psi

Required Structural Number (SN): → SN = 2.44

DESIGN EQUATIONS

Resilient Modulus

If using CBR:

M_R = (CBR) x 1,500

If using R-Value:

$M_R = 10^{[(S_i + 18.72) / 6.24]}$ where: S_1 = [(R-value - 5) / 11.29] + 3

Required Structural Number

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

Pavement Section Thickness

$SN^* = C_1D_1 + C_2D_2$ where:

C_1 = Strength Coefficient - HMA

C_2 = Strength Coefficient - ABC

D_1 = Depth of HMA (inches)

D_2 = Depth of ABC (inches)

RECOMMENED THICKNESSES

Layer	Material	Structural Layer	Thickness (D^*_i)	SN^*_i	SN
1	HMA	C_1 = 0.44	4.0 inches	1.760	-
2	ABC	C_2 = 0.11	8.0 inches	0.880	
			SN* =	2.640	2.44

Pavement SN > Required SN, Design is Acceptable

FIG. C-1

FLEXIBLE PAVEMENT DESIGN

PROJECT DATA

Project Location Sterling Ranch Road

Job Number: 231661

DESIGN DATA

Equivalent (18-kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	821,000
Design CBR	CBR =	10
Standard Deviation	S_o =	0.45
Loss in Serviceability	Δpsi =	2.0
Reliability	Reliability =	85
Reliability (z-statistic)	Z_R =	-1.04
Soil Resilient Modulus	M_R =	15,000 psi

Required Structural Number (SN): → SN = 2.44

DESIGN EQUATIONS

Resilient Modulus

If using CBR:

M_R = (CBR) x 1,500

If using R-Value:

$M_R = 10^{[(S_i + 18.72) / 6.24]}$ where: S_1 = [(R-value - 5) / 11.29] + 3

Required Structural Number

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

Pavement Section Thickness

$SN^* = C_1D_1 + C_2D_2$ where:

C_1 = Strength Coefficient - HMA

C_2 = Strength Coefficient - CTS

D_1 = Depth of HMA (inches)

D_2 = Depth of CTS (inches)

RECOMMENED THICKNESSES

Layer	Material	Structural Layer	Thickness (D^*_i)	SN^*_i	SN
1	HMA	C_1 = 0.44	4.0 inches	1.760	-
2	CTS	C_2 = 0.11	10.0 inches	1.100	
			SN* =	2.860	2.44

Pavement SN > Required SN, Design is Acceptable

FIG. C-2