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Engineering Department
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EPC Planning & Community
Development Department

# PAVEMENT DESIGN REPORT

## Redtail Ranch Subdivision
## El Paso County, Colorado

## PREPARED FOR:


**Michael Ludwig**
**4255 Arrowhead Drive**
**Colorado Springs, CO 80908**


## JOB NO. 162652

## October 11, 2019


**Respectfully Submitted,**

**RMG – Rocky Mountain Group**

**Brian Griffith, E.I.**
**Geotechnical Staff Engineer**

**Reviewed by,**

**RMG – Rocky Mountain Group**

**Geoff Webster, P.E.**
**Sr. Geotechnical Project Engineer**


COLORADO LICENSED
GEOFF WEBSTER
10/11/19
45046
PROFESSIONAL ENGINEER

SF 18-021

# TABLE OF CONTENTS

# GENERAL SITE AND PROJECT DESCRIPTION

**Location**

Redtail Ranch Subdivision is located northwest of the intersection of Vollmer Road and Shoup Road in the Black Forest area of El Paso County, Colorado. The location of the site is shown on the Site Vicinity Map, Figure 1

**Existing Conditions**

At the time of our field investigation, the proposed streets were close to grade and utility mains and services had been installed. Curb and gutter had not been installed.

**Project Description**

This Pavement Design Report was performed to determine the subsurface conditions present along the roadway alignments and to develop recommendations for the design and construction of the proposed flexible pavements.

The proposed streets included in this investigation are shown on Figure 2. The streets considered below are classified as Rural Local roads, and include Sanctuary Pine Drive and Ward Lane. All streets have 60-foot Right-of Ways and two 14-foot travel lanes.

# FIELD INVESTIGATION AND SUBSURFACE CONDITIONS

**Drilling**

The subsurface conditions on the site were investigated by drilling seven (7) exploratory test borings at 500-feet maximum spacing. The approximate locations of the test borings are presented in the Test Boring Location Plan, Figure 2.

The test borings were advanced with a power-driven, continuous-flight auger drill rig to depths of about 5 to 10 feet below the existing ground surface. Samples were obtained in general accordance with ASTM D-3550 utilizing a 2½-inch OD modified California sampler. Representative bulk samples of subsurface materials were obtained from each boring at a depth of approximately 0 to 2 feet below the existing ground surface. An Explanation of Test Boring Logs is presented in Figure 3. The Test Boring Logs are presented in Figures 4 through 7.

**Subsurface Materials**

The subsurface materials encountered in the test borings consisted of fairly well-graded silty and clayey sand. Samples of the material classified as SM and SC, in accordance with the Unified Classification System. For pavement design, combined bulk samples of the soil samples classified as A-2-4 in

accordance with the American Association of State Highway and Transportation Officials (ASSHTO) classification system. This soil classification is considered "excellent to good" as subgrade material.

**Groundwater**

Groundwater was not encountered in the test borings at the time of drilling. Groundwater is not expected to affect the construction of the pavements. Fluctuations in groundwater and subsurface moisture conditions may occur due to variations in precipitation and other factors not readily apparent at this time. Development of the property and adjacent properties may also affect groundwater levels.

# LABORATORY TESTING

**Laboratory Testing**

The moisture content for the recovered samples was obtained in the laboratory. Grain-size analysis and Atterberg Limits tests were performed on selected samples for classification purposes and to develop pertinent engineering properties. A Summary of Laboratory Test Results is presented in Figure 8. Soil Classification Data are presented in Figures 9 and 10.

A combined bulk sample of A-2-4 soil was tested to determine the optimum moisture-density relationship in accordance with ASTM D1557 (Modified Proctor compaction test). California Bearing Ratio, CBR tests were performed at varying densities with moisture content near optimum. At 95% of the maximum Modified Proctor density, the CBR of the bulk sample was 25. The Moisture-Density Relation Curve is presented in Figure 11. The CBR Test Results are presented in Figures 12 and 13.

The developer intends to install a composite roadway section consisting of Hot Mix Asphalt over Aggregate Base Course (ABC). RMG performed a Mix Design for this composite section.

# PAVEMENT DESIGN

The discussion presented below is based on the subsurface conditions encountered in the test borings, laboratory test results and the project characteristics previously described. If the subsurface conditions are different from those described in this report or the project characteristics change, RMG should be retained to review our recommendations and modify them, if necessary. The conclusions and recommendations presented in this report should be verified by RMG during construction.

The pavement design was performed using the El Paso County Engineering Criteria Manual, Appendix D. The pavement design parameters and design calculations are presented below.

**Street Classification – Rural Local**

1) Sanctuary Pine Drive and Ward Lane, including cul-de-sac
   ESAL = 36,500 (Table D-2)
   Serviceability Index = 2.0 (Table D-1)
   Reliability = 75% (Table D-1)

2) Strength coefficients (Table D-3)
   Asphalt (HMA): $a_1 = 0.44$
   Aggregate Base Course (ABC): $a_2 = 0.11$

3) Subgrade
   $M_r$ = CBR x 1500 = 25 x 1500 = 37,500 psi

4) Structural number (SN) = 1.0 (1993 AASHTO Empirical Equation for Flexible Pavements)

5) Composite asphalt/base course section
   Minimum HMA thickness = $D_1$ = 3 inches (Table D-2)
   ABC thickness = $D_2 = \{SN – (D_1 \times a_1)\} / a_2 = \{1.0 – (3 \times 0.44)\} / 0.11 < 0$ inches
   Use Minimum ABC thickness = 4 inches (Table D-2)
   SN = (3 x 0.44) + (4 x 0.11) = 1.76 > 1.0 (Min. SN required)

**Pavement Thickness**

Based on the design calculations, the recommended pavement section is presented below and on Figure 2.1

**Recommended Pavement Sections**

| | | |
|---|---|---|
| Sanctuary Pine Drive and Ward Lane, including cul-de-sac | 3” HMA | 4" ABC |

**Pavement Materials**

Pavement materials should be selected, prepared, and placed in accordance with El Paso County specifications and the *Pikes Peak Region Asphalt Paving Specifications*. Tests should be performed in accordance with the applicable procedures presented in the specifications.

**Soil Mitigation**

The PDCM notes that mitigation measures may be required for expansive soils, shallow ground water, subgrade instability, etc. Based on the AASHTO classification of for the soils in the subdivision, the subgrade soils evaluated for this pavement design can be expected to be nonexpansive. Groundwater or

wet and unstable soils were not encountered in the borings. Therefore, special mitigation measures do not appear to be necessary for subgrade preparation.

**Subgrade Preparation**

Subgrade for Redtail Ranch Subdivision shall be improved native soil. The native well-graded silty sand soil shall be moisture conditioned and compacted in accordance with the El Paso County Engineering Criteria Manual. Prior to placement of the pavement section the final subgrade shall be scarified to a depth of 12-inches, adjusted to within 2 percent of the optimum moisture content as determined by laboratory testing, and recompacted to County specifications. The subgrade shall then be proof-rolled with a heavy pneumatic tire vehicle. Areas that deform under wheel loads shall be removed and replaced with granular non-expansive soil. The final subgrade shall be compacted to a firm and unyielding condition, typically 95 percent of Modified Proctor.

**Surface Drainage**

Surface drainage is important for the satisfactory performance of pavement. Wetting of the subgrade soils or base course will cause a loss of strength that can result in pavement distress. Surface drainage should provide for efficient removal of storm-water runoff. Water should not pond on the pavement or at the edges of the pavement.

**Subgrade Observations and Testing**

The pavement thicknesses presented above assume pavement construction is completed in accordance with El Paso County specifications and the *Pikes Peak Region Asphalt Paving Specifications*. RMG should be present at the site during subgrade preparation, placement of fill, and construction of pavements to perform site observations and testing.

# CLOSING

Our field exploration was conducted to provide geotechnical information for pavement thickness design. Variations in subsurface conditions not indicated by the borings may be encountered. This report has been prepared for **Michael Ludwig** for application as an aid in the design of the proposed development in accordance with generally accepted geotechnical engineering practices. The analyses and recommendations in this report are based in part upon data obtained from exploratory borings and test pits, site observations and the information presented in referenced reports. The nature and extent of variations may not become evident until construction. If variations then become evident, RMG should be retained to re-evaluate the recommendations of this report, if necessary.

Our professional services were performed using that degree of care and skill ordinarily exercised, under similar circumstances, by geotechnical engineers practicing in this or similar localities. RMG Engineers does not warrant the work of regulatory agencies or other third parties supplying information which may have been used during the preparation of this report. No warranty, express or implied is made. Any contractor reviewing this report for bidding purposes must draw his own conclusions regarding site conditions and specific construction techniques to be used on this project.

This report is for the exclusive purpose of providing geotechnical information and pavement thickness design recommendations. The scope of services for this project does not include, either specifically or by implication, environmental assessment of the site or identification of contaminated or hazardous materials or conditions. Development of recommendations for the mitigation of environmentally related conditions, including but not limited to biological or toxicological issues, are beyond the scope of this report. If the Client desires investigation into the potential for such contamination or conditions, other studies should be undertaken.

If we can be of further assistance in discussing the contents of this report or analysis of the proposed development, from a geotechnical engineering point-of-view, please feel free to contact us.

# FIGURES


NOT TO SCALE

ARCHITECTS RMG ENGINEERS
ROCKY MOUNTAIN GROUP

*Southern Office*
Colorado Springs,CO
80918
(719) 548-0600
*Central Office:*
Englewood, CO 80112
(303) 688-9475
*Northern Office:*
Greeley / Evans, CO 80620
(970) 330-1071

# SITE VICINITY MAP

REDTAIL RANCH SUBDIVISION
EL PASO COUNTY, CO
MICHAEL LUDWIG

JOB No. 162652

FIG No. 1

DATE 10-11-2019

10' BFTA Public Trail Easement

Public Improvement,Utility Easement & Fire Access

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.OCK 2, GREEN
S SUBDIVISION
R-2.5
K. I-2, PG. 124
RRAL A. KANDRAK
.N., COLO. SPGS., CO
908-6429

WARD LANE - RURAL LOCAL, ASPHALT

LOT 5, BLOCK 1, GREEN MEADOWS SUBDIVISION
R-2.5
PLAT BK. I-2, PG. 124
OWNER: JOSEPH H. GOODREID & ALISON RAE KEY
6735 BUNDLEFLOWER CT., COLO. SPGS., CO
80923-8825

LOT 8, WALKER ESTATES
RR-5
PLAT BK. U-2, PG. 15
OWNER: JOHNNY J. & CAROL E. INMAN
CRAWFORD, CO 81415-0243

N89°06'51"E 1319.12'

569'

TB-7

LOT 12
5.250 AC

UNPLATTED
RR-5
REC. NO. 216146434
OWNER: JAMES ELLIS VINSON, SR. & VIRGINIA K. VINSON
12990 VOLLMER RD., COLO. SPGS., CO 80908-6408

S00°10'47"W 1396.64'

N01°08'20"E 27.32'
S84°04'27"E 40.25'

UNPLATTED
RR-5
REC. NO. 211018539
OWNER: CATHERINE M. BLAKE
12970 VOLLMER RD., COLO. SPGS., CO 80908-6408

N89°26'17"E 298.66'

EXISTING FENCE

N85°44'55"E 284.55'

N88°53'53"E 306.61'

540'

55'

425'

1424'

90'

40'

28'

298'

20' MVEA SUBDIVISION PERIMETER EASEMENT

40' FROM DEDICATED ROW 2040 MTCP TO PRESERVATION ROW EASEMENT 2060 MTCP

60' FROM SUBDIVISION PERIMETER TO PRESERVATION ROW EASEMENT 2060 MTCP

90' PRESERVATION ROW EASEMENT 2060 MTCP

50'

40'

60'

90'

543'

ROPOSED
ASEMENT
ADS

ALL EXISTING BUILDINGS AND CONCRETE TO BE REMOVED

TB-6

LOT 11
5.015 AC

LOT 10
5.013 AC

LOT 9
5.008 AC

LOT 8
5.019 AC
(TOTAL ACREAGE WITHOUT PRESERVATION ROW - 4.52 AC)

410'

505'

519'

WETLAND NO BUILD AREA

30'

S05°29'00"W(R)

90' DEDICATED ROW (2040 MTCP)

90' PRESERVATION ROW (2060 MTCP)

S00°56'48"W 990.07'

780

VOLLMER ROAD - PUBLIC
MINOR ARTERIAL, ASPHALT ROAD
- 60' ROW
FUTURE 2060 MTCP PRINCIPAL

ALL EXISTING BUILDINGS AND CONCRETE TO BE REMOVED

40' PUBLIC DRAINAGE EASEMENT

10' BFTA PROPOSED PUBLIC TRAIL EASEMENT

PROPOSED CLUSTER BOX UNIT MAILBOX KIOSK

DRAINAGE EASEMENT SEE DETAIL A OF PLAT

EXISTING POND TO BE FILLED

M.V.E. RIGHT-OF-WAY
2134 PG. 81
L ILLEGIBLE -
KER PLACE PLAT)/
O. 209017471
T POWER LINES)

NON-EXCLUSIVE EASEMENT FOR CESS, DRAINAGE AND DRIVEWAY ADING REC. NO. 20131909 BK 2007 PG 136

TB-4

TB-3

TB-2

TB-1

TB-5

534'

481'

651'

424'

515'

685'

410'

Δ=12°40'00"
R=600.00'
L=132.65'

Δ=11°48'42"
R=700.00'
L=144.31'

Δ=5°33'18"
R=700.00'
L=67.54'

S78°03'00"E 272.19'

N34°36'37"E 205.97'

SANCTUARY PINE DRIVE - PUBLIC
RURAL LOCAL, ASPHALT ROAD - 60' ROW

40' FUTURE ROADWAY EASEMENT

5' PUBLIC IMPROVEMENT & UTILITY EASEMENT

ALL EXISTING ROADS TO BE REMOVED

STORMWATER QUALITY EASEMENT

EXISTING POND WITH DAM TO REMAIN

160'-5"

306'-11"

65'

168'

324'-6"

EXISTING POND TO REMAIN

LOT 5

REFERENCE

0 500'

DENOTES APPROXIMATE LOCATION OF TEST BORINGS

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Colorado Springs, CO
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(719) 548-0600
*Central Office:*
Englewood, CO 80112
(303) 688-9475
*Northern Office:*
Greeley / Evans, CO 80620
(970) 330-1071
*Woodland Park Office:*
(719) 687-6077
*Monument Office:*
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*Pueblo / Canon City:*
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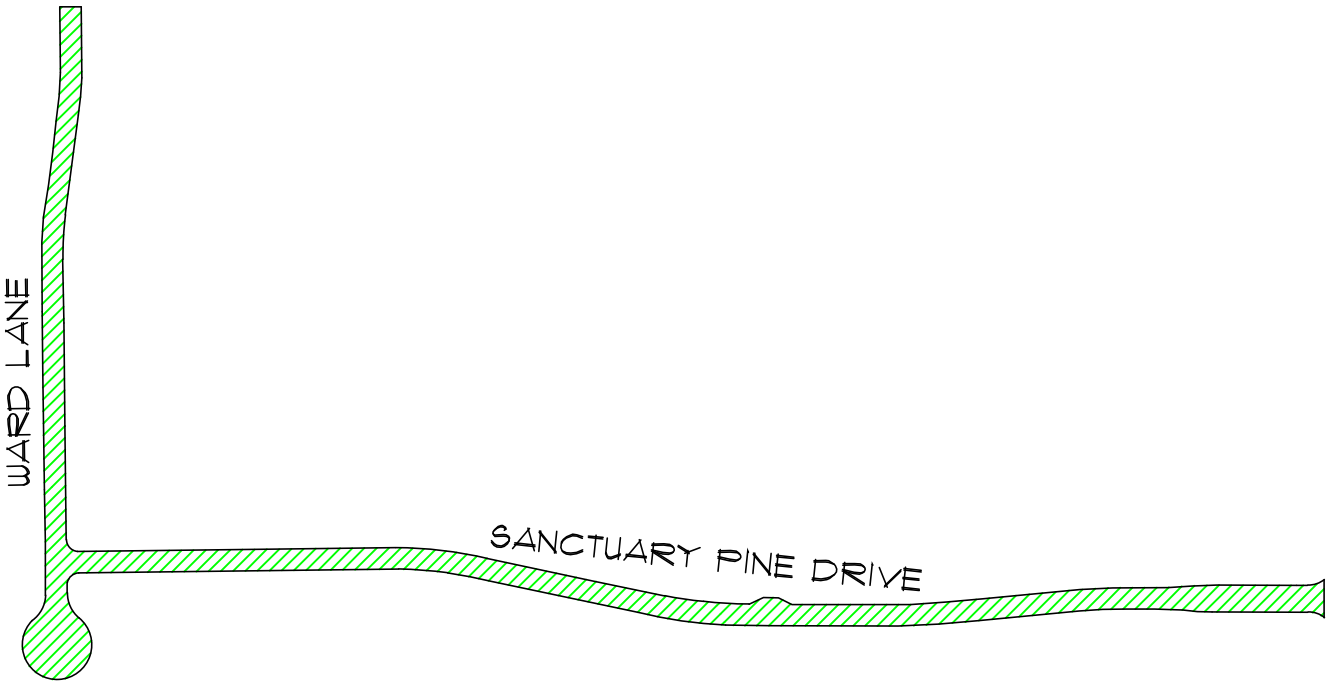
EL PASO COUNTY, CO
MICHAEL LUDWIG

| | |
|---|---|
| ENGINEER: | GW |
| DRAWN BY: | BG |
| CHECKED BY: | GW |
| ISSUED: | 10-11-19 |
| REVISION: | DATE: |
| | JOB #: |

TEST BORING LOCATION PLAN

SHEET No.
FIG-2




3" HMA OVER
4" ABC

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# PAVEMENT DESIGN

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EL PASO COUNTY, CO
MICHAEL LUDWIG

JOB No. 162652

FIG No. 2.1

DATE 10-11-2019

# SOILS DESCRIPTION


CLAYEY SAND


FILL: SAND, SILTY TO CLAYEY


SANDSTONE


SILTY SAND

UNLESS NOTED OTHERWISE, ALL LABORATORY
TESTS PRESENTED HEREIN WERE PERFORMED BY:
RMG - ROCKY MOUNTAIN GROUP
2910 AUSTIN BLUFFS PARKWAY
COLORADO SPRINGS, COLORADO

# SYMBOLS AND NOTES


XX — STANDARD PENETRATION TEST - MADE BY DRIVING A SPLIT-BARREL SAMPLER INTO THE SOIL BY DROPPING A 140 LB. HAMMER 30", IN GENERAL ACCORDANCE WITH ASTM D-1586. NUMBER INDICATES NUMBER OF HAMMER BLOWS PER FOOT (UNLESS OTHERWISE INDICATED).


XX — UNDISTURBED CALIFORNIA SAMPLE - MADE BY DRIVING A RING-LINED SAMPLER INTO THE SOIL BY DROPPING A 140 LB. HAMMER 30", IN GENERAL ACCORDANCE WITH ASTM D-3550. NUMBER INDICATES NUMBER OF HAMMER BLOWS PER FOOT (UNLESS OTHERWISE INDICATED).


FREE WATER TABLE


DEPTH AT WHICH BORING CAVED


BULK — DISTURBED BULK SAMPLE


AUG — AUGER "CUTTINGS"

4.5 — WATER CONTENT (%)


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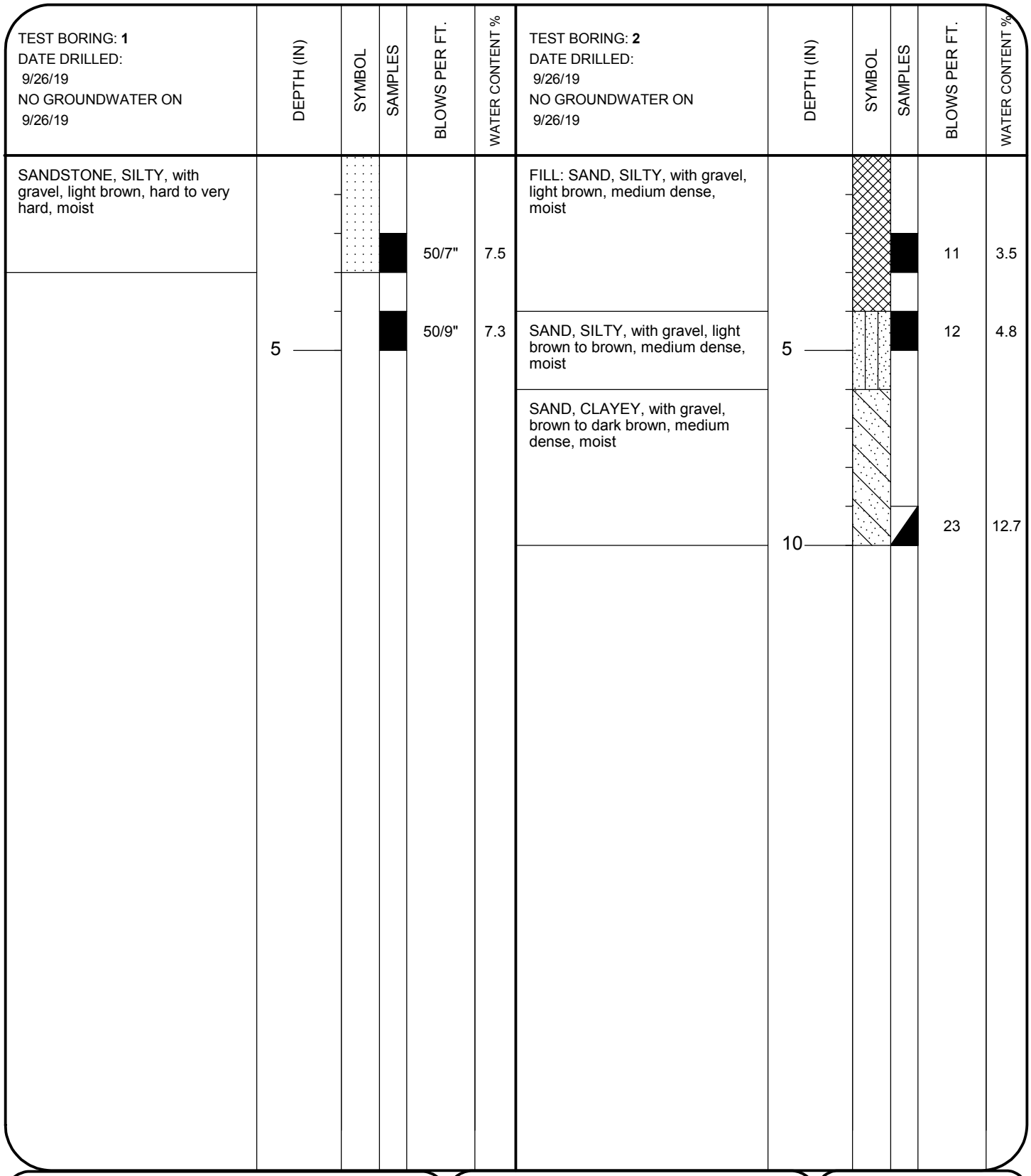
**EXPLANATION OF TEST BORING LOGS**

JOB No. 162652

FIGURE No. 3

DATE 10/11/19

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# TEST BORING LOG

JOB No. 162652

FIGURE No. 4

DATE 10/11/19

| TEST BORING: **3**<br>DATE DRILLED:<br>9/26/19<br>NO GROUNDWATER ON<br>9/26/19 | DEPTH (IN) | SYMBOL | SAMPLES | BLOWS PER FT. | WATER CONTENT % |
|---|---|---|---|---|---|
| SANDSTONE, SILTY, with gravel, light brown to brown, firm to medium hard, moist | | | | | |
| | | | | 37 | 9.6 |
| | | | | 50 | 9.0 |
| | 5 | | | | |

| TEST BORING: **4**<br>DATE DRILLED:<br>9/26/19<br>NO GROUNDWATER ON<br>9/26/19 | DEPTH (IN) | SYMBOL | SAMPLES | BLOWS PER FT. | WATER CONTENT % |
|---|---|---|---|---|---|
| SANDSTONE, CLAYEY, with gravel, light brown to olive with rust staining, medium hard, moist | | | | | |
| | | | | 50/7" | 9.1 |
| | | | | 50/9" | 9.8 |
| | 5 | | | | |


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# TEST BORING LOG

JOB No. 162652

FIGURE No. 5

DATE 10/11/19

| TEST BORING: **5**<br>DATE DRILLED:<br>9/26/19<br>NO GROUNDWATER ON<br>9/26/19 | DEPTH (IN) | SYMBOL | SAMPLES | BLOWS PER FT. | WATER CONTENT % |
|---|---|---|---|---|---|
| FILL: SAND, CLAYEY, with gravel, light brown to brown, loose to medium dense, moist | | | | 18 | 7.8 |
| | | | | 24 | 7.5 |
| | 5 | | | | |

| TEST BORING: **6**<br>DATE DRILLED:<br>9/26/19<br>NO GROUNDWATER ON<br>9/26/19 | DEPTH (IN) | SYMBOL | SAMPLES | BLOWS PER FT. | WATER CONTENT % |
|---|---|---|---|---|---|
| SANDSTONE, SILTY, with gravel, light brown, medium hard to hard, moist | | | | 50/10" | 15.7 |
| | | | | 50/6" | 8.1 |
| | 5 | | | | |
| | | | | 50/6" | 8.4 |
| | 10 | | | | |

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# TEST BORING LOG

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FIGURE No. 6

DATE 10/11/19

| TEST BORING: **7**<br>DATE DRILLED:<br>9/26/19<br>NO GROUNDWATER ON<br>9/26/19 | DEPTH (IN) | SYMBOL | SAMPLES | BLOWS PER FT. | WATER CONTENT % | |
|---|---|---|---|---|---|---|
| FILL: SAND, CLAYEY, with gravel, brown, medium dense, moist | | | | 23 | 4.1 | |
| SAND, SILTY, with gravel, light brown, loose, moist | 5 | | | 16 | 4.3 | |


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# TEST BORING LOG

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FIGURE No. 7

DATE 10/11/19

| Test Boring No. | Depth | Water Content (%) | Dry Density (pcf) | Liquid Limit | Plasticity Index | % Retained No.10 Sieve | % Retained No.40 Sieve | % Passing No. 200 Sieve | % Swell @ 100 psf | AASHTO Classification |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.0 | 7.5 | | NP | NP | 28.3 | 58.5 | 17.7 | | A-1-b (0) |
| 1 | 4.0 | 7.3 | | | | | | | | |
| 2 | 2.0 | 3.5 | | NP | NP | 29.2 | 60.3 | 16.6 | | A-1-b (0) |
| 2 | 4.0 | 4.8 | | | | | | | | |
| 2 | 9.0 | 12.7 | | | | | | | | |
| 3 | 2.0 | 9.6 | | 27 | 14 | 27.5 | 60.6 | 20.6 | | A-2-6 (0) |
| 3 | 4.0 | 9.0 | | | | | | | | |
| 4 | 2.0 | 9.1 | | 29 | 18 | 31.1 | 59.5 | 23.1 | | A-2-6 (1) |
| 4 | 4.0 | 9.8 | | | | | | | | |
| 5 | 2.0 | 7.8 | | 25 | 9 | 21.3 | 55.2 | 22.4 | | A-2-4 (0) |
| 5 | 4.0 | 7.5 | | | | | | | | |
| 6 | 2.0 | 15.7 | | NP | NP | 26.2 | 59.8 | 19.8 | | A-1-b (0) |
| 6 | 4.0 | 8.1 | | | | | | | | |
| 6 | 9.0 | 8.4 | | | | | | | | |
| 7 | 2.0 | 4.1 | | 23 | 7 | 27.0 | 57.0 | 18.6 | | A-2-4 (0) |
| 7 | 4.0 | 4.3 | | | | | | | | |

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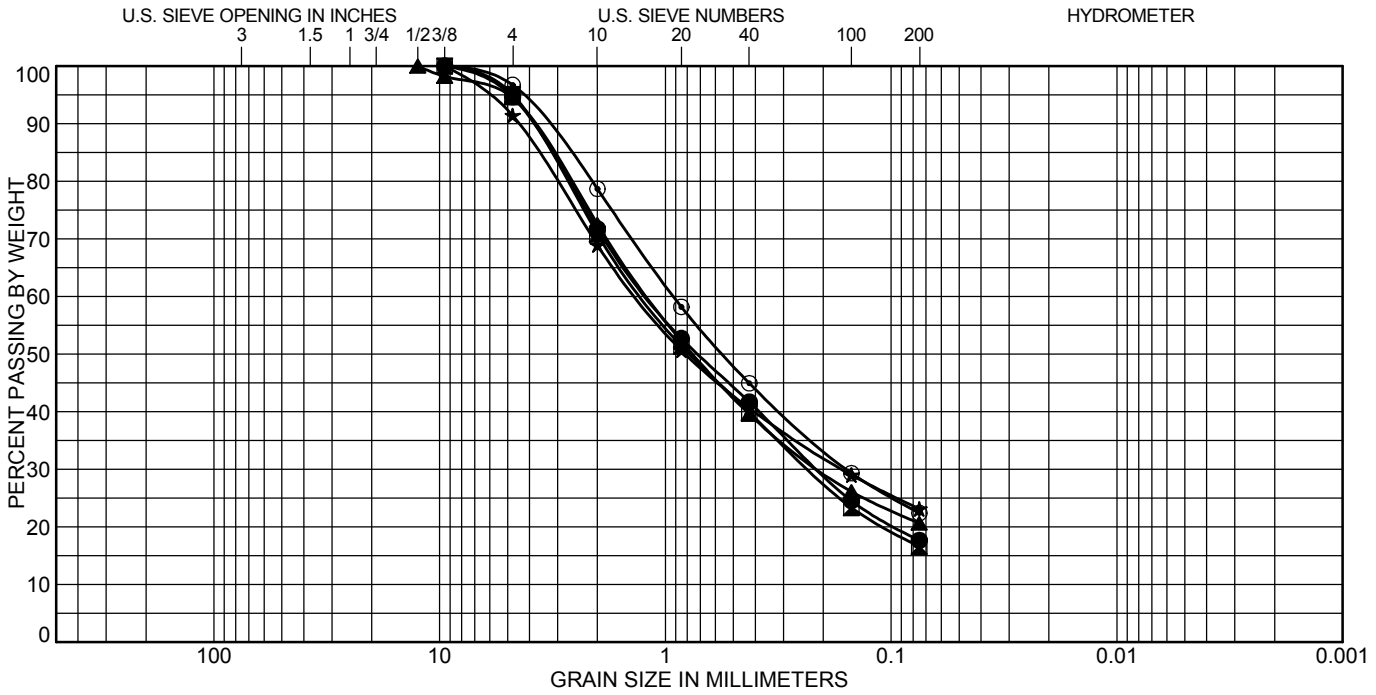
# SUMMARY OF LABORATORY TEST RESULTS

JOB No. 162652
FIGURE No. 8
PAGE 1 OF 1
DATE 10/11/19




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| Test Boring | | Depth (ft) | Classification | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | 1 | 2.0 | A-1-b (0) | NP | NP | NP | | |
| ⊠ | 2 | 2.0 | A-1-b (0) | NP | NP | NP | | |
| ▲ | 3 | 2.0 | A-2-6 (0) | 27 | 13 | 14 | | |
| ★ | 4 | 2.0 | A-2-6 (1) | 29 | 11 | 18 | | |
| ⊙ | 5 | 2.0 | A-2-4 (0) | 25 | 16 | 9 | | |

| Test Boring | | Depth (ft) | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|
| ● | 1 | 2.0 | 5.3 | 77.0 | 17.7 | |
| ⊠ | 2 | 2.0 | 5.0 | 78.4 | 16.6 | |
| ▲ | 3 | 2.0 | 5.5 | 73.9 | 20.6 | |
| ★ | 4 | 2.0 | 8.6 | 68.3 | 23.1 | |
| ⊙ | 5 | 2.0 | 3.3 | 74.3 | 22.4 | |

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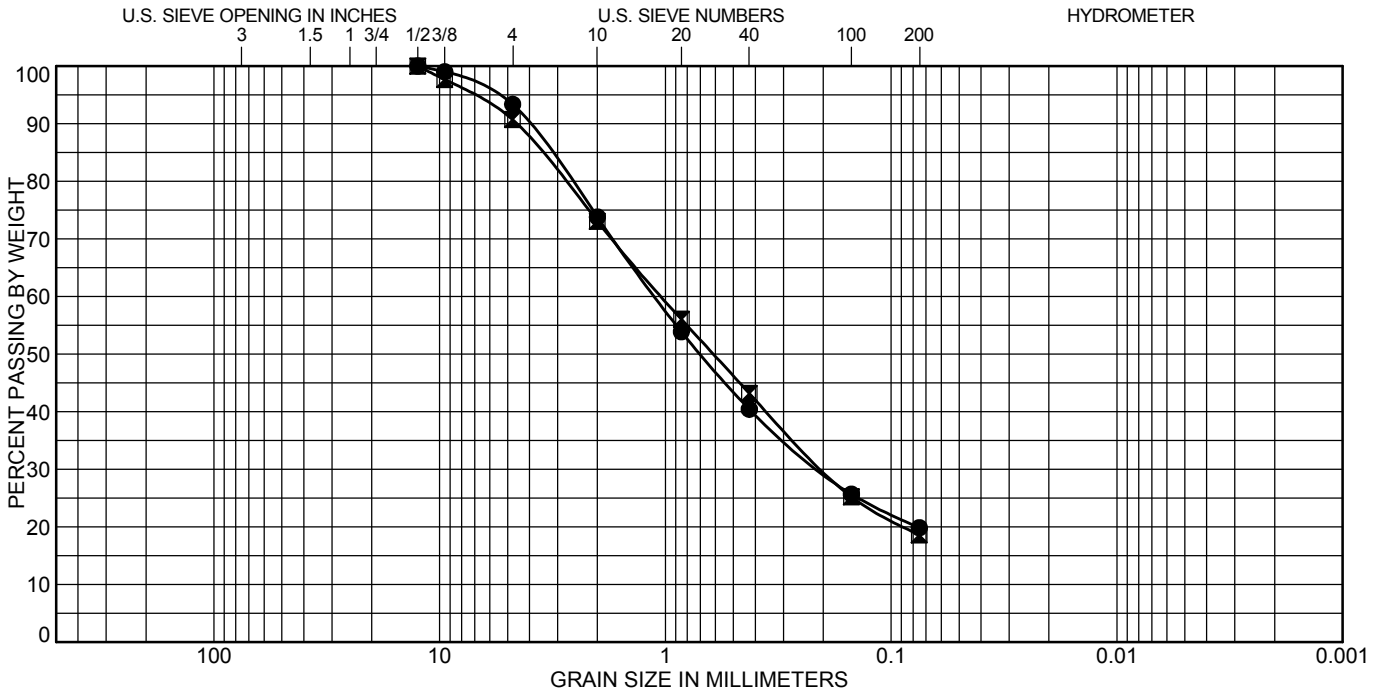
# SOIL CLASSIFICATION DATA

JOB No. 162652

FIGURE No. 9

DATE 10/11/19




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| Test Boring | | Depth (ft) | Classification | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | 6 | 2.0 | **A-1-b (0)** | **NP** | **NP** | **NP** | | |
| ⊠ | 7 | 2.0 | **A-2-4 (0)** | **23** | **16** | **7** | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

| Test Boring | | Depth (ft) | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|
| ● | 6 | 2.0 | **6.6** | **73.5** | **19.8** | |
| ⊠ | 7 | 2.0 | **9.3** | **72.1** | **18.6** | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

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# SOIL CLASSIFICATION DATA

JOB No. 162652

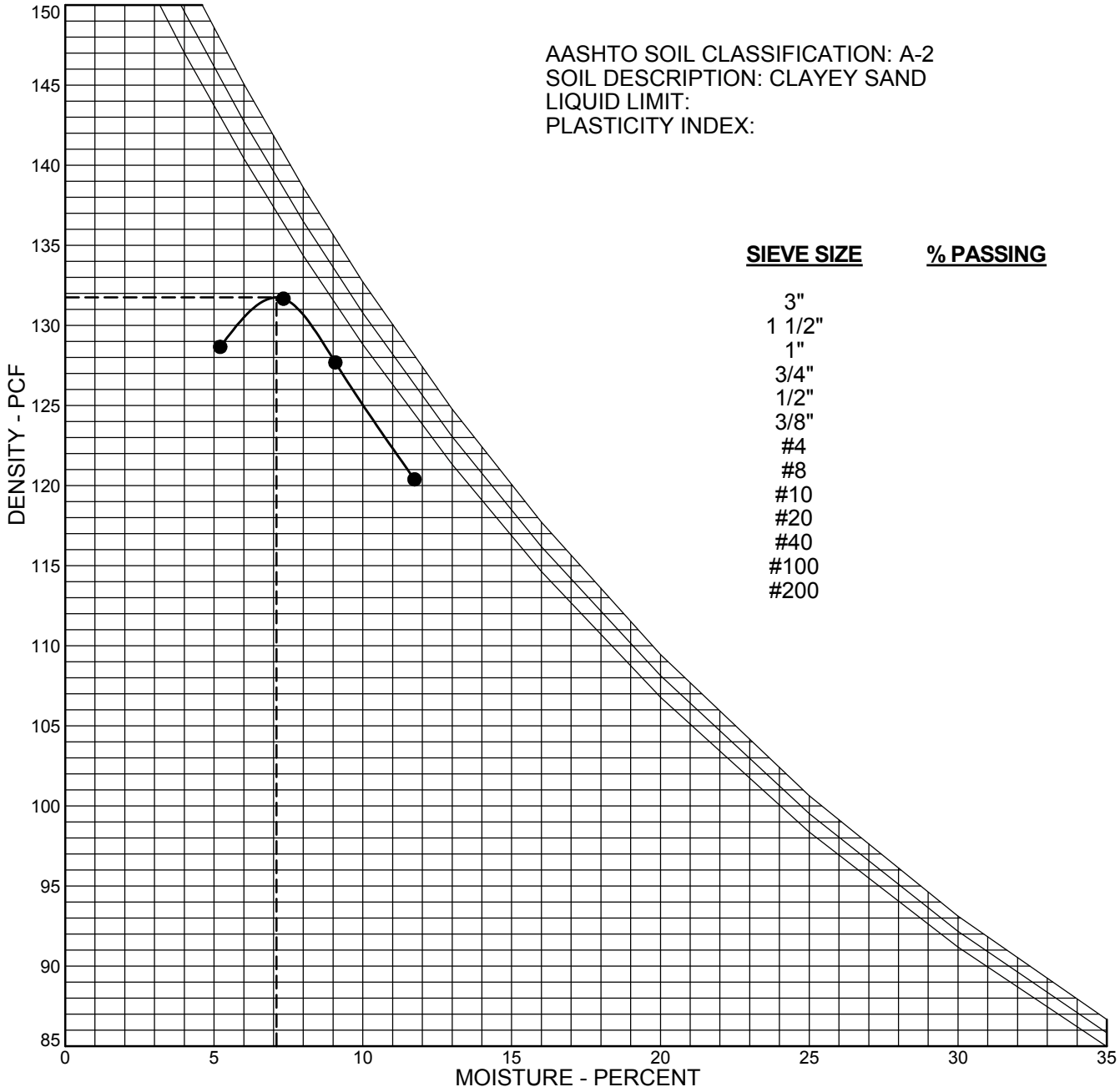
FIGURE No. 10

DATE 10/11/19

CLIENT: **Michael Ludwig**

SAMPLE NUMBER: **A-2 PROCTOR**

**PROJECT:** Redtail Ranch, Filing No. 1, El Paso County, Colorado




AASHTO SOIL CLASSIFICATION: A-2
SOIL DESCRIPTION: CLAYEY SAND
LIQUID LIMIT:
PLASTICITY INDEX:

| SIEVE SIZE | % PASSING |
|---|---|
| 3" | |
| 1 1/2" | |
| 1" | |
| 3/4" | |
| 1/2" | |
| 3/8" | |
| #4 | |
| #8 | |
| #10 | |
| #20 | |
| #40 | |
| #100 | |
| #200 | |

DESIGNATION **AASHTO 1557A**
MAX. DRY DENSITY **131.8 pcf**
OPTIMUM MOISTURE **7.1 %**
FRACTION USED **#4**
MOLD VOLUME **0.0332 cu.ft.**

NOTE:
ZERO AIR VOIDS CURVES PLOTTED FOR:
Gs = 2.60
Gs = 2.65
Gs = 2.70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# MOISTURE-DENSITY RELATION CURVE

JOB No. 162652

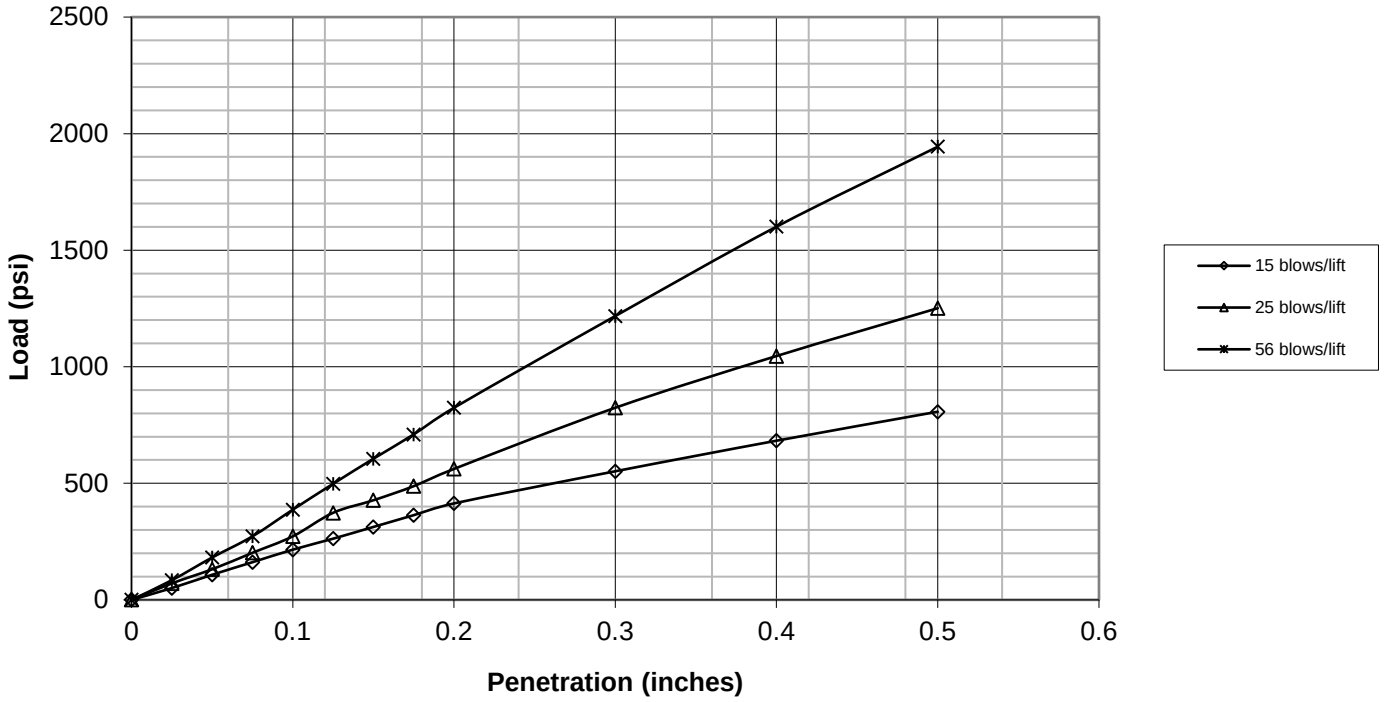
FIGURE No. 11

DATE 10/11/19

# CALIFORNIA BEARING RATIO TEST RESULTS

PROJECT: Redtail Ranch Subdivision
JOB NUMBER: 162652 TEST DATE: 10/8/2019
AASHTO A-2-4
SAMPLE NUMBER: CBR
SAMPLE LOCATION: Combined Bulk Sample
SOIL DESCRIPTION: Silty Sand / Clayey Sand

| | 15 blows/lift | 25 blows/lift | 56 blows/lift |
|---|---|---|---|
| Penetration (in) | Load (psi) | Load (psi) | Load (psi) |
| 0.000 | 0.0 | 0.0 | 0.0 |
| 0.025 | 50.4 | 70.6 | 84.1 |
| 0.050 | 107.6 | 131.2 | 181.6 |
| 0.075 | 161.4 | 201.8 | 272.4 |
| 0.100 | 215.2 | 272.4 | 386.7 |
| 0.125 | 262.3 | 373.3 | 497.7 |
| 0.150 | 312.8 | 427.1 | 605.3 |
| 0.175 | 363.2 | 487.6 | 709.6 |
| 0.200 | 413.6 | 561.6 | 823.9 |
| 0.300 | 551.5 | 823.9 | 1217.4 |
| 0.400 | 682.7 | 1045.9 | 1600.8 |
| 0.500 | 807.1 | 1251.0 | 1943.8 |




| | 15 blows/lift | 25 blows/lift | 56 blows/lift |
|---|---|---|---|
| Corrected Penetration (in) | Corrected Load (psi) | Corrected Load (psi) | Corrected Load (psi) |
| 0.1 | 21.5 | 27.2 | 38.7 |
| 0.2 | 27.6 | 37.4 | 54.9 |

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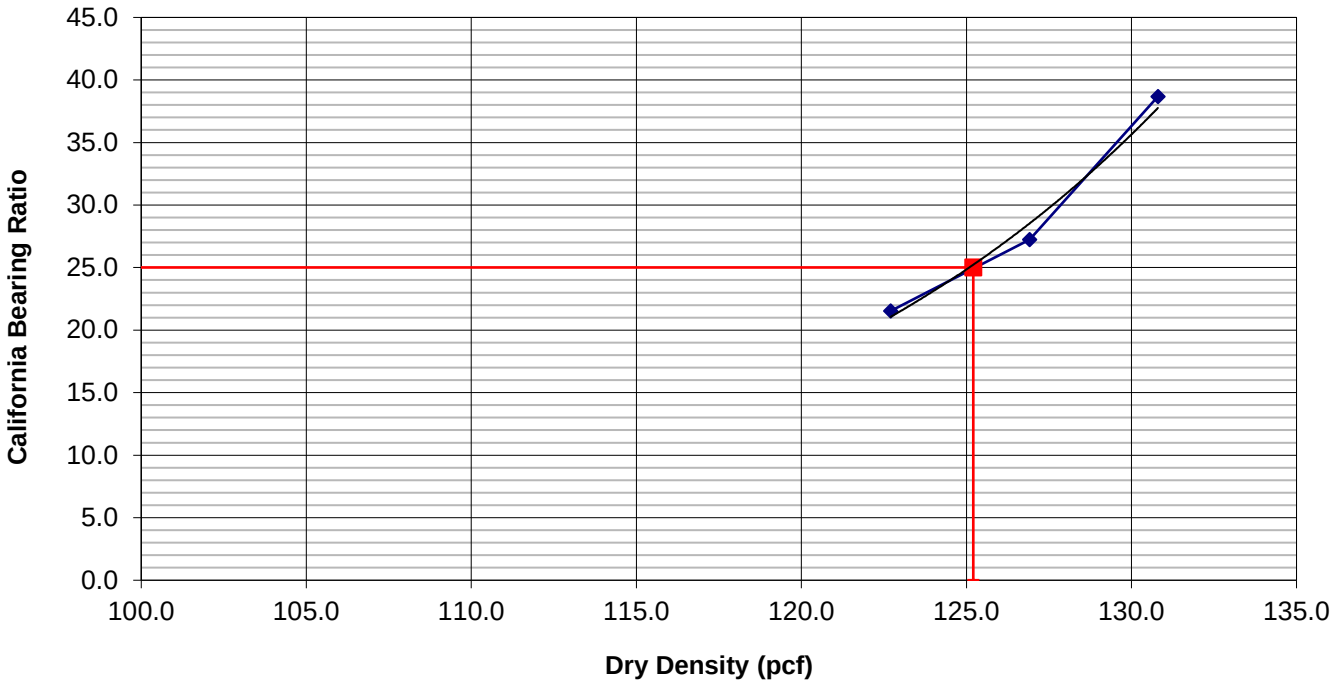
Figure No. 12

# CALIFORNIA BEARING RATIO TEST RESULTS

| | |
|---|---|
| PROJECT: | Redtail Ranch Subdivision |
| JOB NUMBER: | 162652 |
| AASHTO CLASSIFICATION: | A-2-4 |
| SAMPLE NUMBER: | CBR |
| SAMPLE LOCATION: | Combined Bulk Sample |
| SOIL DESCRIPTION: | Silty Sand / Clayey Sand |

TEST DATE: 10/8/2019

| | 15 blows/lift | 25 blows/lift | 56 blows/lift |
|---|---|---|---|
| Corrected California Bearing Ratio | 21.5 | 27.2 | 38.7 |
| Dry Density (pcf) | 122.7 | 126.9 | 130.8 |
| Percent Compaction | 93 | 96 | 99 |
| Percent Moisture After Soaking | 5.0 | 6.2 | 5.8 |
| Percent Expansion/Compression | 0.3 | 0.2 | 0.3 |
| Surcharge Weight (lbs) | 12.60 | 12.60 | 12.60 |




| **California Bearing Ratio** | **25.0** |
|---|---|
| Dry Density (pcf) | 131.8 |
| Percent Compaction | 95.00% |
| Target Dry Density | 125.2 |
| Compaction Test Method | ASTM D-698 |
| Condition of sample | Soaked |

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Figure No. 13

# APPENDIX A

# *1993 AASHTO Empirical Equation for Flexible Pavements*

Equation Solver | Variable Descriptions and Typical Values | Precautions

Type in data in the grey boxes and click the calculate button to see the output. To make additional calculations, change the desired input data and click the calculate button again. Click on the text descriptions of the input or output variables for more information.

## INPUT

### 1. Loading

Total Design ESALs ($W_{18}$): 36500

### 2. Reliability

Reliability Level in percent (R): 75

Combined Standard Error ($S_0$): 0.44

### 3. Serviceability

Initial Serviceability Index ($p_i$): 4.5

Terminal Serviceability Index ($p_t$): 2

### 4. Layer Parameters

Number of Base Layers: 0

| | a | m | $M_R$ | Min. Depth |
|---|---|---|---|---|
| Surface | 0.44 | 1.0 | N/A | 0 |
| Subgrade | N/A | N/A | 37500 | N/A |

## OUTPUT

### 1. Calculation Parameters

Standard Normal Deviate ($z_R$): -0.674

ΔPSI: 2.5

Design Structural Number (SN): 0.895

### 2. Layer Depths (to the nearest 1/2 inch)

Surface: 2.5

Total SN based on layer depths: 1.1

See Solution Details

Comments

Calculate