Results of Geotechnical Investigation
Mead Ponds Toe Drain
Mead, Colorado

Prepared for:

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Project No. 110827

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1.0 INTRODUCTION

Engineering Analytics, Inc. (EA) is pleased to present this report for the Mead Ponds toe drain project in Mead, Colorado. This report presents the results of the geotechnical investigation, laboratory testing, and geotechnical analysis and design.

1.1 Scope of Work

The scope of work for this project includes the following:

1. Advancement of 5 exploratory borings.
2. Installation of 2 piezometers for ongoing groundwater monitoring.
3. Laboratory testing of soil samples.
4. Geotechnical analyses, including seepage and slope stability.

1.2 Site Description

The project site is located on the north side of Weld County Road 34 (Welker Avenue) approximately one half mile west of Weld County Road 5 on the west side of Mead, Colorado. The site consists of three water supply ponds (Red-tail Pond, Blue Heron Pond, and Veteran Pond) which are part of a park open to the public. The site is surrounded by irrigated farm fields with and a paved access road. The elevation of the site is approximately 5,120 feet above sea level. Figure 1-1 shows the site vicinity map for the Mead Ponds toe drain geotechnical site.

1.3 Report Layout

The purpose of this report is to present field observations, classification of the on-site soils, and results of the geotechnical analyses. Figure 1-2 shows the boring locations investigated by EA. The boring logs are included in Appendix A and show detailed descriptions of the subsurface conditions encountered. Appendix B includes the summary of laboratory test results. Appendix D includes the references used for this report.

2.0 FIELD INVESTIGATION

The drilling portion of the field investigation included the advancement and sampling of five (5) borings. The borings were drilled on March 19th, 2018. Three (3) borings (B-1 through B-3) advanced in the on the dam embankments and ranged in depth from fifteen (15) feet to twenty (20) feet below ground surface (bgs). Two (2) borings (P-1 and P-2) were advanced at toe of the dam for the purposes of installing piezometers and were advanced to a depth of ten (10) feet bgs. EA logged the in-situ soil conditions, collected soil samples, and recorded groundwater conditions. The locations of the borings are shown on Figure 1-2.

2.1 Boring Investigation Procedures

Drilling was performed by Elite Drilling, Inc. of Denver, Colorado. The borings were advanced using a CME 55 truck mounted rig using 4-inch continuous flight auger and continuous coring using a sample barrel inside a 4-inch hollow stem auger. Samples were recovered from the boring for visual classification in the field and for future laboratory testing. As the samples were obtained in the field, personnel from EA visually classified them. Representative portions of the samples were then returned to the laboratory for further examination and analysis. Boring logs, indicating the depth and identification of the various strata, and water level information are included in the Appendix B. Charts illustrating the soil classification procedure, and descriptive terminology and symbols on the Boring Logs are also included in the appendix.

Relatively undisturbed samples were obtained using a California Sampler that consists of a 2-1/2-inch outside diameter barrel with 2-inch diameter internal brass liners. Soil sampling was performed in accordance with ASTM D-3550, "Standard Practice for Thick Wall, Ring Lined, Split Barrel Drive Sampler", in a method similar to the common Standard Penetration Test (SPT). Using this procedure, the sampler was driven into the soil by successive blows of a 140-pound weight falling thirty inches. After an initial set, past the soil cuttings formed during drilling, the number of blows required to drive the sampler an additional twelve inches was recorded as the "penetration resistance" or "N value". The N value is an index of the relative density of cohesionless soils and the consistency of cohesive soils.

Bulk samples of disturbed soil were collected from auger cuttings.

Depth of soil sample collection was determined in the field by EA and varied depending on conditions encountered at each boring location.

Upon completion, borings located in the proposed dam embankment area were sealed using soil cuttings with a bentonite seal installed near the ground surface

Temporary piezometers were installed to a depth of approximatly10 feet bgs to measure shallow ground water.

2.2 Subsurface Conditions

The following summarizes the soil conditions encountered during the field investigation. All depths are relative to the ground surface at the time of the investigation. The boring logs in Appendix A provide a more detailed description of the materials encountered during the field investigation.

Topsoil: Topsoil was encountered in all borings at ground surface and extended to approximately one half (½) to one (1) foot below grade. The top soil is generally dark brown, moist, and supported short grass vegetation at the time of drilling.

Clay: Sandy clay was encountered beneath the top soil in all borings and extended to the full depth of the borings, with the exception of B-2, where the clay ended at nineteen (19) feet below grade. The clay was generally sandy, tan to brown, moist near the ground surface to saturated with depth, and very soft to stiff.

Sandstone: Sandstone was encountered at nineteen (19) feet below grade in B-2. The sandstone was generally fine grained, grey, and wet.

3.0 LABORATORY AND FIELD TESTING

Laboratory testing was conducted on selected samples obtained from the borings to determine engineering properties of the embankment clay and soils anticipated around the proposed toe drain. The laboratory testing program included moisture content and dry density determination, Atterberg limits, soil particle gradation tests including sieve analysis and a hydrometer gain size analysis, and a flexible wall permeability test. The laboratory and field test results are summarized in Appendix B.

Moisture Content and Dry Density: Moisture content and dry density measurements were conducted in accordance with ASTM test methods D 2216 and D 2937, respectively, on selected California samples. For the samples of sand tested, the moisture content ranged between 17.8% and 33.6% and the dry density ranged between 89.2 and 106.4 pcf.

Atterberg Limits: Atterberg limits were determined for several samples. The analyses were conducted in accordance with ASTM D 4318. The Atterberg limits were used to aid in classifying the soils. The Liquid Limit of the soils tested range from 29 to 37; the Plastic Limit was 15 on the three samples tested; and, the Plastic Index ranged from 14 to 22. This indicates the soils are generally low plastic.

Gradations/Grain Size Analysis: Gradations were conducted on three samples in accordance with ASTM D422 and D1140. The gradations indicated all three samples were clay with the percent passing the minus 200 sieve ranging from 68.2% to 85.1%. The remaining portion of the sample size indicates mainly fine sand.

Hydrometer Test: A hydrometer analysis was conducted on the soil to determine the soil gradation finer than the minus 200 sieve. This test was conducted in accordance with ASTM D422 and was used to determine the d_{15} of the clay soil for use in designing the filter material. The d_{15} was determined to be 0.001 mm.

Soil Permeability: The soil permeability has been estimated based on our experience and the gradations of the soil. With the soil having 68% to 85% passing the #200 sieve and a Plastic Index ranging from 14 to 22, we have estimated the permeability to range from approximately $1.0x10^{-5}$ cm/sec to $1.0x10^{-6}$ for the sandy clay.

4.0 RECOMMENDATIONS

Following are the general recommendation for the design and construction of the toe drain.

4.1 Seepage Analysis

To understand the seepage characteristics of the proposed dam, EA recommends a seepage analysis be conducted of the dam and dam foundation cross section. An analysis using a program, such as the SEEP/W finite element program by GEO-SLOPE International, Ltd. 2012, is recommended. The parameters listed in Table 4-1 are recommended for this analysis.

Table 4-1 Seepage Analysis Parameters

Material	Permeability - vertical	Permeability - horizontal
Native Foundation Soil	$K = 5.3 \times 10^{-5}$ cm/s (1) (1.74×10^{-6} ft/s)	$K = 5.3 \times 10^{-4}$ cm/s (1.74×10^{-5} ft/s)
Dam Embankment Soil	$K = 2.3 \times 10^{-6}$ cm/s (1) (7.55×10^{-10} ft/s)	$K = 2.3 \times 10^{-7}$ cm/s (7.55×10^{-9} ft/s)
Bedrock	Impermeable	Impermeable
Toe Drain Filter	$K = 2.0 \times 10^{-3}$ cm/s (2) (6.56×10^{-5} ft/s)	$K = 2.0 \times 10^{-3}$ cm/s (2) (6.56×10^{-5} ft/s)

(1) Based on laboratory testing and experience with similar soils.
(2) Based on Figure 19.5 Lambe and Whitman, 1969.

4.1.1 Seepage Results

In order to maintain the long term stability of the dam embankment, the formation of a phreatic surface on the downstream face of the dam must be prevented. The installation of a toe drain is expected to prevent this and the drain depth and extents must be determined to ensure the seepage is controlled and does not exit above the dam toe.

4.1.2 Filter Design

To prevent the movement of fines, the toe drain must be protected by a filter envelope. The filter shall be designed to meet the filter requirements specified in NRCS, Part 633, National Engineering Handbook, Chapter 26. The filter gradation limits shall be designed based on the soil gradations included in this report.

4.1.3 Pipe Perforation Design

The maximum perforation size for a pipe shall be designed in accordance with Table 26-7 of the NRCS Manual, Part 633, National Engineering Handbook, Chapter 26. The D_{85} of the filter must be greater than or equal to the pipe perforation size.

4.2 Drain Design

To control seepage through the dam, a toe drain shall be installed on the downstream slope of the reservoir. The proposed embankment material is suitable for construction of the embankment due to the low hydraulic conductivity. An 8-inch diameter perforated PVC pipe shall be used for the toe drain, with perforations no larger than 0.02 inches.

The toe drain shall be designed to have positive slope to the outfall and shall have cleanouts at the ends and cleanouts or manholes at major changes in direction. The toe drain shall be inspected with a camera after completion to check all joints and the general condition of the installed pipe.

The depth of the toe drain will be limited by the elevation of the culvert in the borrow ditch at the Southeast corner of the site. This controls the water flow off the site. A positive slope, preferably at least 1%, to the discharge point just upstream of the culvert will control the depth the toe drain can be set. The only other option to this would be to install a pumped system which is not as dependable as a gravity system

4.3 Grading and Stripping

All excavation areas shall be stripped of the topsoil. The topsoil shall be saved for covering the drain trench and re-vegetated.

4.4 Compaction

Earth materials placed over the drain trench shall be compacted in eight (8) inch lifts at 95% of the standard proctor density at +/- 2% of optimum moisture content. The toe drain filter materials shall be compacted by three (3) passes of a vibratory roller with the filter material being wet to saturated.

5.0 STANDARD OF CARE

The information contained in this report represents our findings at the time and location as indicated in this report. The methods utilized are in accordance with currently accepted engineering and testing procedures and other than this, no warranty, either expressed or implied, is intended.

Respectfully Submitted,
Engineering Analytics, Inc.

Duane H. Smith, P.E.

FIGURES

LEGEND

- **B-3** LOCATION OF BOREHOLE
- **P-2** LOCATION OF BOREHOLE WITH PIEZOMETER

SCALE IN FEET: 30' 0 60'

NORTH

WATER LINE

PIER

COVERED PICNIC AREA

CLEANOUTS

MH S2

B-3

P-2

BURIED VALVE

B-2

MH S3

MH S1

ONE-STORY FRAME

SHED

2 WATER VALVES

WATER TANK

CLEANOUT

OUTLET STRUCTURE

ENGRAVED ROCK FACE

MEAD RESERVOIR

GATE VALVES

SUPPLY DITCH

GRAVEL PARKING

CLEANOUT

STONE SIGN

B-1

P-1

MH S2

MH S1

DITCH

DITCH

DITCH

WELD COUNTY ROAD 34

PUMP HOUSE

ONSITE BENCHMARK
ELEVATION: 5116.18'
FOUND #5 REBAR

REVISIONS			
Revision	Date	Description	

Designed by:

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Designed by:

Approved by:

MEAD POND TOE DRAIN

BORING LOCATION PLAN

Project Number: 110827

Date: 9/13/2018

Sheet: ----

I:\110827 Mead Ponds\Mead Pond Site.dwg SAVED:9/13/18 PRINTED:9/14/18

APPENDIX A
BORING LOGS

Engineering Analytics, Inc.

BORING LOG

BORING NO. B-1

PROJECT	JOB NO.	SHEET	OF
Mead Reservoirs Toe Drain	110827	1	1

CLIENT	FIELD ENGINEER
JVA/ Town of Mead	WK

DRILLING COMPANY	DRILL RIG
Elite Drilling	CME 75

LOCATION	ELEVATION	DATE
South side of vetran pond		3-19-18

DEPTH (Feet)	LOG	DESCRIPTION OF MATERIAL	BLOWS/6 IN. INCREMENTS (PER FOOT)	REC.	REMARKS
0		TOPSOIL: dark brown, moist			El. -1.0
		CLAY: sandy, very soft to stiff, tan to brown, moist to saturated, fill			
5	4'-5'		6/8 (14)	9	
10	9'-10'		3/4 (7)	12	
15	14'-15'		0 for 12 (0)	12	
		EOH			El. -15.0
20					
25					
30					
35					

Engineering Analytics, Inc.

BORING LOG

BORING NO. B-2

PROJECT	JOB NO.	SHEET	OF
Mead Reservoirs Toe Drain	110827	1	1

CLIENT	FIELD ENGINEER
JVA/ Town of Mead	WK

DRILLING COMPANY	DRILL RIG
Elite Drilling	CME 75

LOCATION	ELEVATION	DATE
East side of vetran pond		3-19-18

DEPTH (Feet)	LOG	DESCRIPTION OF MATERIAL	BLOWS/6 IN. INCREMENTS (PER FOOT)	REC.	REMARKS
0		TOPSOIL: dark brown, moist			El. -0.5
		CLAY: sandy, medium soft to stiff, tan to brown, moist to wet, fill			
5	4'-5'		6/7 (13)	12	
10	9'-10'		5/7 (12)	10	
15	14'-15'		4/5 (9)	10	
	19'-20'	SANDSTONE: grey, wet, medium hard	15/40 (55)	10	El. -19.0
20		EOH			El. -20.0
25					
30					
35					

Engineering Analytics, Inc.

BORING LOG

BORING NO. B-3

PROJECT	JOB NO.	SHEET	OF
Mead Reservoirs Toe Drain	110827	1	1

CLIENT	FIELD ENGINEER
JVA/ Town of Mead	WK

DRILLING COMPANY	DRILL RIG
Elite Drilling	CME 75

LOCATION	ELEVATION	DATE
Eastern most berm		3-19-18

DEPTH (Feet)	LOG	DESCRIPTION OF MATERIAL	BLOWS/6 IN. INCREMENTS (PER FOOT)	REC.	REMARKS
0		TOPSOIL: dark brown, moist			El. -0.5
		CLAY: sandy, soft to stiff, tan to brown, moist to saturated, fill			
5	4'-5'		8/7 (15)	12	
10	9'-10'		5/6 (11)	12	
		estimated depth change from fill to native			
15	14'-15'		5/5 (10)	10	
20	19'-20'	sand lens	1/2 (3)	8	El. -20.0
		EOH			
25					
30					
35					

Engineering Analytics, Inc.

BORING LOG

BORING NO. P-1

PROJECT	JOB NO.	SHEET	OF
Mead Reservoirs Toe Drain	110827	1	1
CLIENT	FIELD ENGINEER		
JVA/ Town of Mead	WK		
DRILLING COMPANY	DRILL RIG		
Elite Drilling	CME 75		
LOCATION / ELEVATION	DATE		
Western piezometer	3-19-18		

DEPTH (Feet)	LOG	DESCRIPTION OF MATERIAL	BLOWS/6 IN. INCREMENTS (PER FOOT)	REC.	REMARKS
0		TOPSOIL: dark brown, moist			El. -1.0
	4'-5'	CLAY: sandy, soft to stiff, tan to brown, moist to saturated, fill	4/8 (12)	8	
5					
	9'-10'		1/2 (3)	10	
10		EOH - Install piezometer. Top of pipe 3'-8" above grade.			El. -10.0
15					
20					
25					
30					
35					

Engineering Analytics, Inc.

BORING LOG

BORING NO. P-2

PROJECT	JOB NO.	SHEET	OF
Mead Reservoirs Toe Drain	110827	1	1

CLIENT	FIELD ENGINEER
JVA/ Town of Mead	WK

DRILLING COMPANY	DRILL RIG
Elite Drilling	CME 75

LOCATION	ELEVATION	DATE
Eastern piezometer		3-19-18

DEPTH (Feet)	LOG	DESCRIPTION OF MATERIAL	BLOWS/6 IN. INCREMENTS (PER FOOT)	REC.	REMARKS
0		TOPSOIL: dark brown, moist			El. -1.0
		CLAY: sandy, very soft, brown, wet to saturated			
5	4'-5'		0 for 12" (12)	12	
	9'-10'	SANDSTONE: gray	50 for 4" (3)	4	El. -10.0
10		EOH - Install piezometer. Top of pipe 3'-8" above grade.			
15					
20					
25					
30					
35					

KEY TO SYMBOLS

Symbol Description

Strata symbols

Topsoil

Clay

Sandstone

Notes:

1. **Exploratory borings were drilled on 3-19-18 using a 4-inch diameter continuous flight power auger.**

2. **Boring locations were taped from existing features and elevations extrapolated from the final design schematic plan.**

3. **These logs are subject to the limitations, conclusions, and recommendations in this report.**

APPENDIX B
LABORATORY DATA

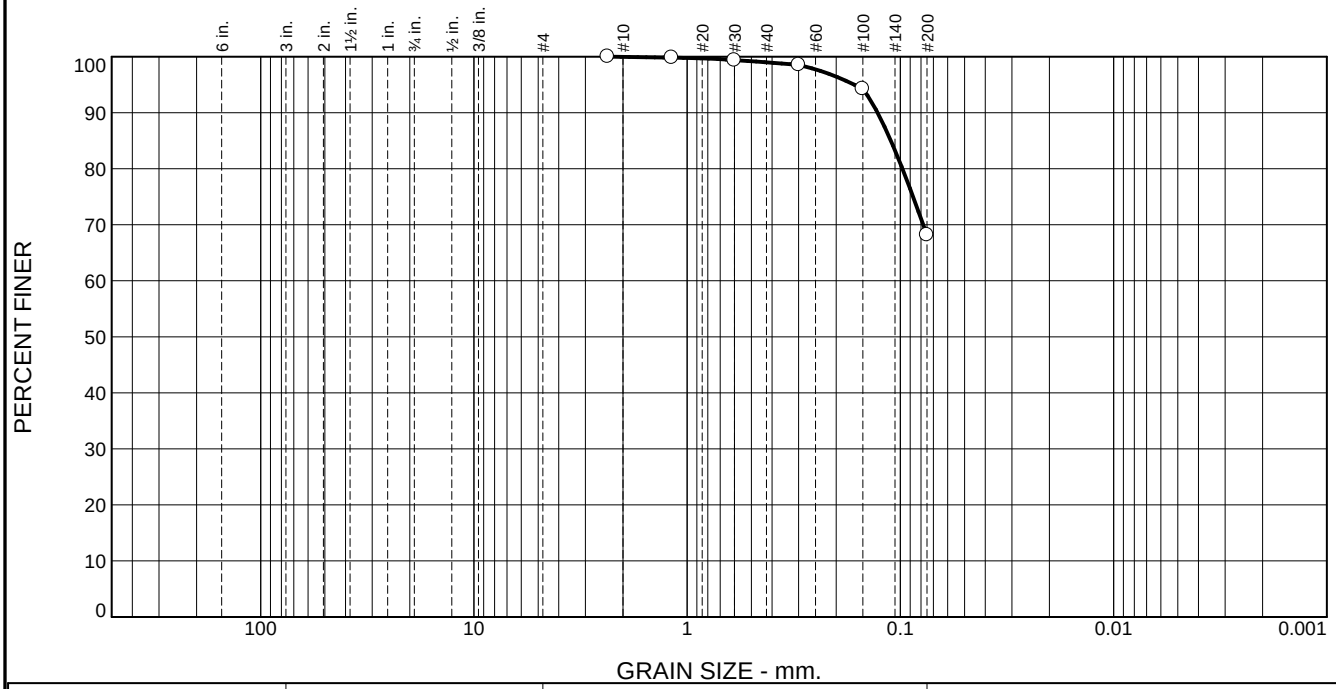
SUMMARY OF LABORATORY TEST RESULTS

JOB NAME: Mead Ponds JOB NUMBER: 110827 3/19/2018

Depth (ft.)	Sample Type	Blow Counts	Moisture (%)	Dry Density (pcf)	Atterbergs LL/PL/PI	% Passing 200 Sieve	Grain Size Analysis	Hydrometer	Permeability
B-1									
4-5	CA	6/8							
9-10	CA	3/4	28.1	93.3	30 / 15 / 15	68.2	(1)		
14-15	CA	0 for 12"	30.0	92.7					
B-2									
4-5	CA	6/7							
9-10	CA	5/7	20.7	100.3	37 / 15 / 22	85.1	(1)	(1)	
14-15	CA	4/5	24.2	98.3					
19-20	CA	15/40							
B-3									
4-5	CA	8/7							
9-10	CA	5/6	17.2	106.4					
14-15	CA	5/5	28.2	87.7					
19-20	CA	1/2	33.6	77.0					
1-9	Bulk								
P-1									
4-5	CA	4/8	26.1	89.2					
9-10	CA	1/2	29.5	90.6					
P-2									
4-5	CA	0 for 12"	30.1	97.0	29 / 15 / 14	69.7	(1)		
9-10	CA	50 for 4"							

*LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index N.P. = Non Plastic

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	1.0	30.8	68.2	

TEST RESULTS (AASHTO T 27)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#8	100.0		
#16	99.8		
#30	99.4		
#50	98.5		
#100	94.2		
#200	68.2		

* (no specification provided)

Material Description

Clay

Atterberg Limits (ASTM D 4318)

PL= 15 **LL=** 30 **PI=** 15

Classification

USCS (D 2487)= CL **AASHTO (M 145)=** A-6(8)

Coefficients

D_{90}= 0.1279 D_{85}= 0.1108 D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: **Date Tested:** 4/20/2018

Tested By: KG

Checked By: KG

Title:

Source of Sample: B-1 **Depth:** 9'-10' **Date Sampled:** 4/19/2018

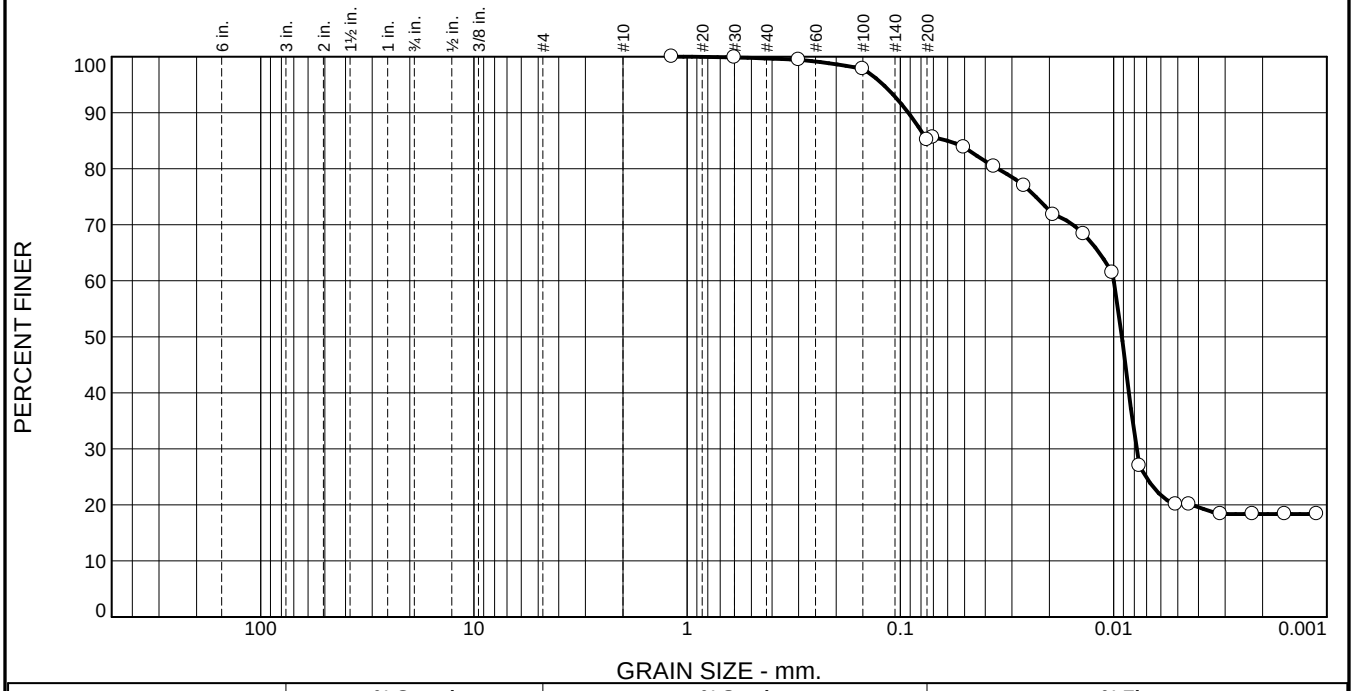
SMITH GEOTECHNICAL

Client: JVA Incorporated

Project: Mead Ponds Mead Ponds

Project No: 110827 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.3	14.6	65.0	20.1

TEST RESULTS (AASHTO T 27)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#16	100.0		
#30	99.9		
#50	99.4		
#100	97.8		
#200	85.1		
0.0704 mm.	85.6		
0.0504 mm.	83.9		
0.0364 mm.	80.4		
0.0263 mm.	77.0		
0.0192 mm.	71.8		
0.0138 mm.	68.3		
0.0102 mm.	61.5		
0.0076 mm.	27.0		
0.0051 mm.	20.1		
0.0044 mm.	20.1		
0.0031 mm.	18.4		
0.0022 mm.	18.4		
0.0016 mm.	18.4		
0.0011 mm.	18.4		

* (no specification provided)

Material Description

Clay

Atterberg Limits (ASTM D 4318)

PL= 15 **LL=** 37 **PI=** 22

Classification

USCS (D 2487)= CL **AASHTO (M 145)=** A-6(18)

Coefficients

D_{90}= 0.0918 D_{85}= 0.0602 D_{60}= 0.0100
D_{50}= 0.0091 D_{30}= 0.0078 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 3/29/2018 **Date Tested:** 4/19/2018

Tested By: KG

Checked By: KG

Title:

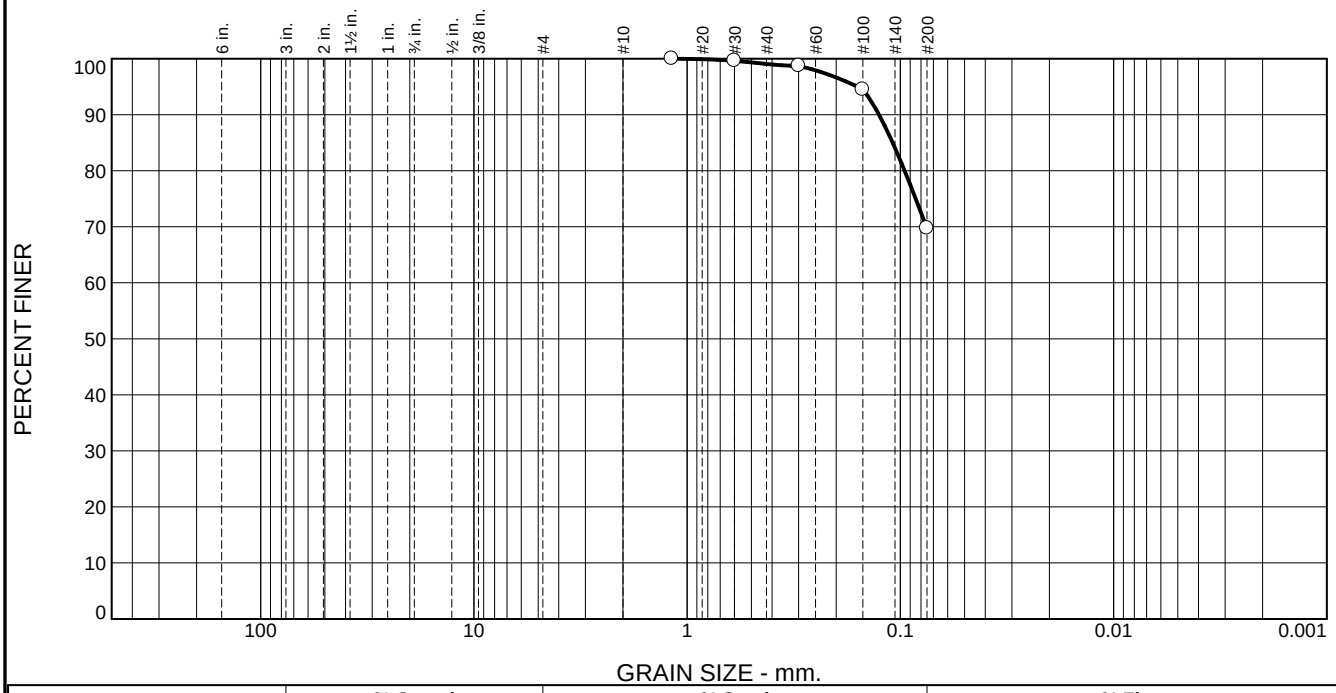
Source of Sample: B-2 **Depth:** 9'-10' **Date Sampled:** 3/29/2018

ENGINEERING ANALYTICS, INC.

Client: JVA Incorporated
Project: Mead Ponds Mead Ponds

Project No: 110827 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.9	29.4	69.7	

TEST RESULTS (AASHTO T 27)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#16	100.0		
#30	99.6		
#50	98.7		
#100	94.5		
#200	69.7		

* (no specification provided)

Material Description

Clay

Atterberg Limits (ASTM D 4318)

PL= 15 **LL=** 29 **PI=** 14

Classification

USCS (D 2487)= CL **AASHTO (M 145)=** A-6(7)

Coefficients

D_{90}= 0.1259 D_{85}= 0.1087 D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 3/29/2018 **Date Tested:** 4/19/2018

Tested By: KG

Checked By: KG

Title:

Source of Sample: P-2 **Depth:** 4'-5' **Date Sampled:** 3/29/2018

SMITH GEOTECHNICAL

Client: JVA Incorporated

Project: Mead Ponds Mead Ponds

Project No: 110827 **Figure**