Terracon GeoReport

Carolina Storm Water Pond
North Carolina Drive and Alameda Avenue
El Paso, Texas
Terracon Project No. AU185096

Prepared for:
El Paso Water
El Paso, Texas
April 12, 2019

el paso WATER

April 12, 2019

El Paso Water
1154 Hawkins Blvd
El Paso, Texas 79925

Attn: Mr. Oscar Camacho, CFM

Re: Geotechnical Engineering Report
Carolina Stormwater Pond
North Carolina Drive and Alameda Avenue
El Paso, Texas
El Paso Water Task Order No.: 5
Terracon Project No.: AU185096

Dear Mr. Camacho:

Terracon Consultants, Inc. (Terracon) is pleased to submit our Geotechnical Engineering Report for the above referenced project in El Paso, Texas. We trust that this report is responsive to your project needs. Please contact us if you have any questions or if we can be of further assistance.

We appreciate the opportunity to work with you on this project and look forward to providing additional geotechnical engineering and construction materials testing services in the future.

Sincerely,

Terracon Consultants, Inc.
Texas PE Firm Registration #3272

STATE OF TEXAS
IVAN AVELAR
108468
LICENSED
PROFESSIONAL ENGINEER

(For:) Jessica M. Jimenez, E.I.T.
Senior Geotechnical Staff Engineer

Ivan Avelar, P.E.
Geotechnical Services Manager

Ruben Solis-Hernandez, P.E.
Office Manager

Enclosures
Copies Submitted: Addressee (1) Electronic

REPORT TOPICS

Note: This report was originally delivered in a web-based format. **Orange Bold** text in the report indicates a referenced section heading. For interactive features, please view your project online at client.terracon.com.

EXHIBITS

Geotechnical Engineering Report

Carolina Storm Water Pond
North Carolina Drive and Alameda Avenue
El Paso, Texas

Project No. AU185096
April 12, 2019

INTRODUCTION

Terracon Consultants, Inc. (Terracon) is pleased to submit our geotechnical engineering report for the proposed Carolina Stormwater Pond located near the northeast corner of the intersection of North Carolina Drive and Alameda Avenue in El Paso, Texas. This project was authorized by Robert L. Davidson, Contract Construction Administrator representing El Paso Water Utilities Public Service Board (Owner, Client). The project scope was performed in general accordance with Task Order Number 5 issued under the On-Call Contract Agreement, dated April 30th, 2018, between Terracon Consultants, Inc. and El Paso Water Utilities Public Service Board.

The purpose of this geotechnical engineering report is to describe the subsurface conditions observed at our test boring drilled for this project, analyze and evaluate the test data, and provide recommendations with respect to:

- Stratification in accordance with the Unified Soil Classification System (USCS)
- Groundwater levels (if observed), during and after completion drilling
- Recommendations for site preparation
- Construction guidelines and considerations for the proposed on-site storm water detention pond
- Other earthwork-related aspects of construction

Maps showing the site and boring location are shown in the **Site Location** and **Exploration Plan** sections. The results of the laboratory testing performed on soil samples obtained from the site during the field exploration are included on the boring log in the **Exploration Results** section of this report.

PROJECT DESCRIPTION

Our initial understanding of the project was provided in our cost estimate document and was discussed in the project planning stage. A period of collaboration has transpired since the project was initiated and our final understanding of the project conditions is as follows:

Item	Description
Location and parcel information	The project is located near the northeast corner of the intersection of North Carolina Drive and Alameda Avenue in El Paso, Texas. (Latitude: N31.741988°, Longitude: W106.376481°). Refer to **Exhibit D** for additional project location information.
Project description	The project will consist of the construction (excavation) of a storm water pond detention area.
Invert elevation	The pond will be constructed to a depth approximately 10 feet below existing grade.
Side slopes	We understand the side slopes are planned to be constructed at a rate of 3 (horizontal) to 1 (vertical) or flatter.
Free-standing retaining walls	Retaining walls are not expected to be constructed as part of site development to achieve final grades.
Pavements	Our scope of work did not include the provision of recommendations for the design or construction of maintenance access roads, and are therefore beyond the scope of this study.

SITE CONDITIONS

The following description of site conditions is derived from our site visit in association with the field exploration and our review of publicly available geologic and topographic maps.

Item	Description
Existing improvements	The site is a fenced, former water well head area with a small one-story building enclosure.
Current ground cover	Sparsely vegetated (appears to have been cleared and grubbed by others).
Existing topography	Appears relatively level.
Geology	A review of the *Geologic Map of Texas, Van Horn-El Paso Sheet* indicates the site is naturally underlain with Young Quaternary deposits (Qarl). This geologic setting consists of sands, gravels, silts, and mud and includes undivided young deposits in relatively active settings that may be inset against older deposits.

EXPLORATION AND TESTING PROCEDURES

Field Exploration

The following borings were advanced at this site according to the following table:

Number of Borings / Field Tests	Boring Depth (ft) [1]	Location
1 Soil Profile Boring (P-1)	25	Center of proposed pond
1 Soil Percolation Test (Perc-1)	10	Within 5 feet of the soil profile boring P-1

1. Below existing grade.

The location of the profile boring/field test is provided on our **Exploration Plan**. The location and elevation shown on the **Exploration Plan** and on the profile boring should be considered approximate.

Boring Layout and Elevations

The boring location was located in the field by a Terracon representative using a scaled site plan and a recreational-grade, hand-held GPS equipment. The ground surface elevation indicated on the boring log was estimated from available topographic maps published by the US Geological Survey (USGS).

Subsurface Exploration Procedures

We advanced the soil boring (and percolation test hole) with a truck-mounted CME 75 drilling equipment using continuous flight augers (hollow stem, 8-inch outside diameter) up to the aforementioned boring and field test termination depths.

In the soil profile boring, we obtained non-continuous soil samples by the split-barrel sampling procedure, where a standard, 2-inch outside-diameter, split-barrel sampler was driven 18 inches into the exposed soil layer at the proposed sampling depths. The sampler penetrates the soils with the kinetic energy of a 30-inch vertical fall strike by a 140-pound automatic SPT (Standard Penetration Test) hammer weight. We recorded the number of blows required to advance the soil sampler the last 12 inches of the 18-inch sampling interval as the standard penetration resistance value (N-value). This value was used to estimate the in situ relative density of cohesionless soils and consistency of cohesive soils. Our SPT hammers are calibrated in accordance with Terracon's quality standards to document the efficiency of the hammer system on our drill rig. Additional N-value definitions and interpretation information are presented in the **Supporting Information** section of this report.

The samples were tagged for identification, sealed to reduce moisture loss, and taken to our laboratory for further examination, testing, and classification. For safety considerations, our borings were backfilled immediately upon the completion of drilling with drill cuttings. Our team prepared a final soil profile boring log based on the field log after the completion of our drilling operations. The field boring log included visual classifications of the materials encountered during drilling and our interpretation of the subsurface conditions between samples. The final boring log is presented in **Exploration Results**, represent the engineer's interpretation of the field log and include modifications based on observations and tests of the samples in our laboratory.

Property Disturbance

We backfilled our borings with auger cuttings at the completion of our drilling operations. Our services do not include restoration of the original site conditions beyond backfilling our borings. Excess auger cuttings were disposed of at the site in the general vicinity of the profile boring. Because backfill material may settle within the boring location below the surface after some time, we recommend the boring location be checked periodically, and backfilled, if necessary.

Laboratory Testing

Samples retrieved during the field exploration were taken to the laboratory for further observation by the project geotechnical engineer and were classified in accordance with the Unified Soil Classification System (USCS), a description of which can be found in **Supporting Information**. At that time, the field descriptions were confirmed or modified as necessary and an applicable laboratory testing program was formulated to determine the physical and engineering properties of the subsurface materials.

Laboratory tests were conducted on selected soil samples and the test results are presented in **Exploration Results**. The laboratory test results were used for the geotechnical engineering analyses, and the development of foundation and earthwork recommendations. Laboratory tests were performed in accordance with the applicable ASTM, local or other accepted standards. Selected soil samples obtained from the site were tested for the following engineering properties:

- ASTM D2488-09 Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)
- ASTM D2216-10 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- ASTM D4318-10e1 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- ASTM D6913/6913M-17 Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

GEOTECHNICAL CHARACTERIZATION

Subsurface conditions on the project site can be generalized as loose to medium dense sands with varying amounts of silt. A 2½-foot thick sandy lean clay layer was encountered at approximately 21½ feet below existing grade.

Conditions observed within the boring location are indicated on the boring log. Stratification boundaries on the boring log represent the approximate location of changes in soil types; in situ, the transition between materials may be gradual. Details for the profile boring can be found in **Exploration Results**.

A discussion of field sampling and laboratory testing procedures and test results are presented in **Exploration and Testing Procedures**.

Groundwater

The boreholes were observed while drilling and after completion for the presence and level of groundwater. Groundwater was not observed at the soil profile boring P-1 during or upon completion of our drilling activities. These observations represent conditions at the time of the field exploration and may not be indicative of other times, circumstances (such as perched conditions), or at other locations.

GEOTECHNICAL OVERVIEW

Based on the information obtained from our subsurface exploration, the site can be developed for the proposed pond. A summary of our findings and recommendations is provided below.

- Groundwater was not observed at boring P-1 during or upon completion of our drilling operations. These observations represent conditions at the time of the field exploration and may not be indicative of other times, circumstances (such as perched conditions), or at other locations.

- The near surface soils predominantly consist of native, loose to medium dense sands with varying amounts of silt and are suitable for re-use as engineered fill (where applicable) based on soil classification.

- Effective drainage should be completed early in the construction sequence and maintained after construction. Additional site preparation recommendations, including subgrade improvement, fill placement (where applicable), and excavations are provided in the **Site Preparation** section of this report.

- Based on the soil conditions observed at boring P-1, which was drilled in the proposed detention pond area, the soils are generally considered loose to medium dense sands. These soils should support side slopes for the anticipated maximum excavation depth of 10 feet below existing grade with side slope declinations of 3 (horizontal): 1 (vertical) or flatter.

- A soil percolation (water infiltration rate) test was performed within the planned storm water retention pond area and the results are presented in the **Storm Water Detention Pond** section of this report.

This summary should be used in conjunction with the entire report for design purposes. Details were not included or fully developed in this section, and the report must be read in its entirely for a comprehensive understanding of the items contained herein. The section titled **General Comments** should be read for and understanding of the report limitations.

SITE PREPARATION

The following sections presents recommendations for grading and excavation on this project. Earthwork on the project should be evaluated by Terracon, which should include observation and testing of those tasks and materials, and of other geotechnical conditions exposed during the construction of the project. The recommendations presented for design and excavation of the proposed stormwater detention pond are contingent upon following the recommendations outlined herein.

Grading and Drainage

Temporary berms around the pond boundaries should be constructed to divert runoff into the pond slopes during excavation of the pond and during the installation of riprap. Water permitted to flow along the excavated slopes can result in scouring of the exposed soils. Additional recommendations for the design and construction of the pond are presented in the **Storm Water Detention Pond** section of this report.

Earthwork Considerations

We anticipate that excavations for the proposed construction can be accomplished with conventional earthmoving equipment. Upon completion of filling and grading, the contractor should avoid equipment or foot traffic over prepared subgrade surfaces to a practical extent.

As a minimum, excavations deeper than 4 feet (if applicable) should be performed in accordance with OSHA 29 CFR, Part 1926, Subpart P, “Excavations” and its appendices, and in accordance with any applicable local, state, and federal safety regulations. The contractor should be aware that slope height, slope inclination, and excavation depth should in no instance exceed those specified by these safety regulations. Flatter slopes than those dictated by these regulations may be required depending upon the soil conditions encountered and other external factors.

Construction site safety is the sole responsibility of the contractor who controls the means, methods and sequencing of construction operations. Under no circumstances shall the information provided herein be interpreted to mean that Terracon is assuming any responsibility for construction site safety or the contractor's activities; such responsibility shall neither be implied nor inferred.

SLOPE STABILITY

Mechanics of Stability

As used in engineering, a *Factor of Safety* (FS) is considered to be the sum of resisting forces (those forces which resist movement or failure) divided by the sum of driving forces (those forces which promote movement or failure). Therefore, to avoid movement or failure, the resisting forces must be greater than the driving forces and their ratio, or Factor of Safety, must be greater than 1. However, slopes that appear stable may have a factor of safety only slightly above 1. Sometimes only minor changes to slope geometry, surface water flow and/or groundwater levels can affect stability of slopes.

Movements related to instability can occur rapidly or slowly. Analyses techniques are based on principles of mechanics. Factors such as material strength, presence and orientation of weak layers, water (piezometric) pressures and the slope geometry are considered. Using "block-on-inclined-plane" model, when a block of soil rests on an inclined plane, the frictional resistance along this inclined plane of sliding is referred to as a stabilizing force, while the pull of gravity and the piezometric and seepage forces are referred to as destabilizing forces. When destabilizing forces exceed the stabilizing forces, movement occurs. Increasing or improving stability of slopes involves increasing the stabilizing forces and/or decreasing destabilizing forces.

Side Slopes

Based on the soil conditions observed at boring P-1, which was drilled in the proposed detention pond area, the soils are generally considered loose to medium dense sands. These soils should support side slopes for the anticipated maximum excavation of 10 feet below existing grade with side slope declinations of 3 (horizontal): 1 (vertical) or flatter. If the initial proposed depth of 10 feet is planned to be exceeded, or the side slopes are planned to be steeper that 3(H): 1 (V), Terracon should be notified to review and/or modify our recommendations provided in this subsection.

Erosion Protection Considerations

If suitable granular fill material (imported or available on-site) is used for the construction of the fill areas, rapid water runoff along the fill slopes could erode the exposed soil, causing gradual steepening, sloughing of the side slopes, and could lower the factor of safety of the constructed slope gradient. Therefore, the side slopes should be protected against sheet flow down the banks or concentrated high velocity water flow. Measures to protect the side slopes may include slope paving, rip-rap, or geogrid. Routine maintenance of the side slopes should be performed to reconstruct areas where sloughing and/or erosion have occurred.

STORM WATER DETENTION

The performance of a storm water retention basin depends heavily on the physical properties of the soil. These properties can include the permeability of the soils that will be exposed at the bottom and sides of the pond and the existence or lack of confining (impermeable) layers underneath the more permeable layers.

One percolation tests was conducted within the areas of proposed stormwater detention pond as shown on the **Exploration Plan**. Tests Perc-1 was conducted within the on-site soils at 10 feet below the existing ground surface. The test yielded relatively low soil percolation rates (low resistance to infiltration), which suggests high seepage rates. As with any seepage and storage volume detention analysis, a degree of conservatism should be considered when applying a limited number of field test results.

- We anticipate the soils can provide good subsurface drainage based on their classification and percolation testing, but if the recorded percolation rates may not be conducive to meeting the required basin capacity and drainage rates as designed, the soils at the bottom of the ponds should be over-excavated and replaced with rapidly draining soils (poorly graded sands, SP per USCS classification) to a necessary depth that provides the additional necessary retention capacity; alternatively, a vertical dry well drain system can be installed to bypass the surficial layers and allow the water to drain into the deeper soil strata (to a minimum of 5 feet below existing grades).
- The side slopes of the storm water detention pond may be constructed using on-site granular soils, provided that appropriate methods are used to control erosion of the side slopes. A slope of 3:1 (horizontal: vertical) <u>or flatter</u> should be used for design purposes.
- Protection of the side slopes from wind and runoff erosion actions can be provided with the placement of a filter fabric on top of the finished grades and cobble-size rock riprap on top of filter fabric.
- Periodic maintenance should be given to the bottom of the pond to prevent excessive accumulation of silts and clays that can decrease seepage rates.

The Project Civil Engineer should ultimately determine the appropriate invert elevation of the pond based on the required capacity, discharge, and infiltration rates and the geotechnical soil parameters provided in this report. A key consideration in final design of the pond should be that it is appropriately maintained to reduce the potential sediment build-up at the bottom of the pond which will compromise the infiltration rate of collected storm water run-off.

GENERAL COMMENTS

Our work was conducted with the understanding of the project as described in the proposal, and incorporated collaboration with the design team prior to completing our services. The design team collaborated with Terracon to confirm our project assumptions. Revision of our assumptions and understanding of the project to reflect actual conditions was based on those verifications and are reflected in this final report.

Our analysis and opinions were based upon our understanding of the geotechnical conditions in the area, the data obtained from the site exploration performed, and from our understanding of the project. Variations will occur between exploration point locations, across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our scope of services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence are intended for the exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices, with no third-party beneficiaries intended. Any third party access to services or correspondence is solely for information purposes only. Reliance upon the services and any work product is limited to our Client, and is not intended for third parties. Any use of the provided information by third parties is done solely at their own risk. No warranties, either expressed or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for that specific purposes to obtain the specific level of detail necessary for budgeting. Site safety, cost estimating for excavation support, and dewatering requirements/design(s) are the responsibility of others. In the event that changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

SITE LOCATION

Carolina Stormwater Pond ■ El Paso, TX
April 12, 2019 ■ Terracon Project No. AU185096

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY QUADRANGLES INCLUDE: EL PASO, TX (1/1/1997), FORT BLISS SE, TX (1/1/1994), YSLETA NW, TX (1/1/1994) and YSLETA, TX (1/1/1994).

EXPLORATION PLAN

Carolina Stormwater Pond ■ El Paso, TX

April 12, 2019 ■ Terracon Project No. AU185096

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

BORING LOG NO. P-1

PROJECT: Carolina Storm Water Pond

CLIENT: El Paso Water Utilities
El Paso, Texas

SITE: N Carolina Dr and Alameda Ave
El Paso, Texas

Mr. Oscar Camacho, CFM

LOCATION See Exploration Plan

Latitude: 31.742° Longitude: -106.3765°

Surface Elev.: 3686 (Ft.)

DEPTH	ELEVATION (Ft.)	Description	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		SILTY SAND (SM), brown, medium dense, with scattered gravel at the surface	11-9-5 N=14			
2.0	3684	**POORLY GRADED SAND WITH SILT (SP-SM)**, brown to grayish brown, loose to medium dense	4-8-9 N=17			
5			7-8-5 N=13			
			2-4-5 N=9	3		
10			8-11-12 N=23	5	NP	7
15			4-5-7 N=12	7		
20.0	3666	**POORLY GRADED SAND (SP)**, grayish brown, loose				
20			5-5-2 N=7			
21.5	3664.5	**SANDY LEAN CLAY (CL)**, brown, medium stiff, with sand pockets				
24.0	3662	**POORLY GRADED SAND WITH SILT (SP-SM)**, grayish brown, medium dense	5-9-9 N=18	24	38-18-20	57
25.0	3661	***Boring Terminated at 25 Feet***				
25						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger (8-inch O.D.) to 25 feet

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

Surface elevations are only approximate and were estimated from available topographic plans published by USGS.

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
7002 Commerce Ave
El Paso, TX

Boring Started: 03-18-2019 | Boring Completed: 03-18-2019

Drill Rig: CME 75 | Driller: Terracon

Project No.: AU185096

Summary of Laboratory Results

BORING ID	Depth (Ft.)	Soil Classification USCS	Water Content (%)	Liquid Limit	Plasticity Index	% Fines	% Sand	% Gravel
P-1	7.5 - 9		3					
P-1	10 - 11.5	POORLY GRADED SAND with SILT(SP-SM)	5	NP	NP	7.0	92.3	0.7
P-1	15 - 16.5		7					
P-1	23.5 - 25	SANDY LEAN CLAY(CL)	24	38	20	56.6	39.5	3.9

PROJECT: Carolina Storm Water Pond

SITE: NE Corner of N Carolina Dr and Alameda Ave
El Paso, Texas

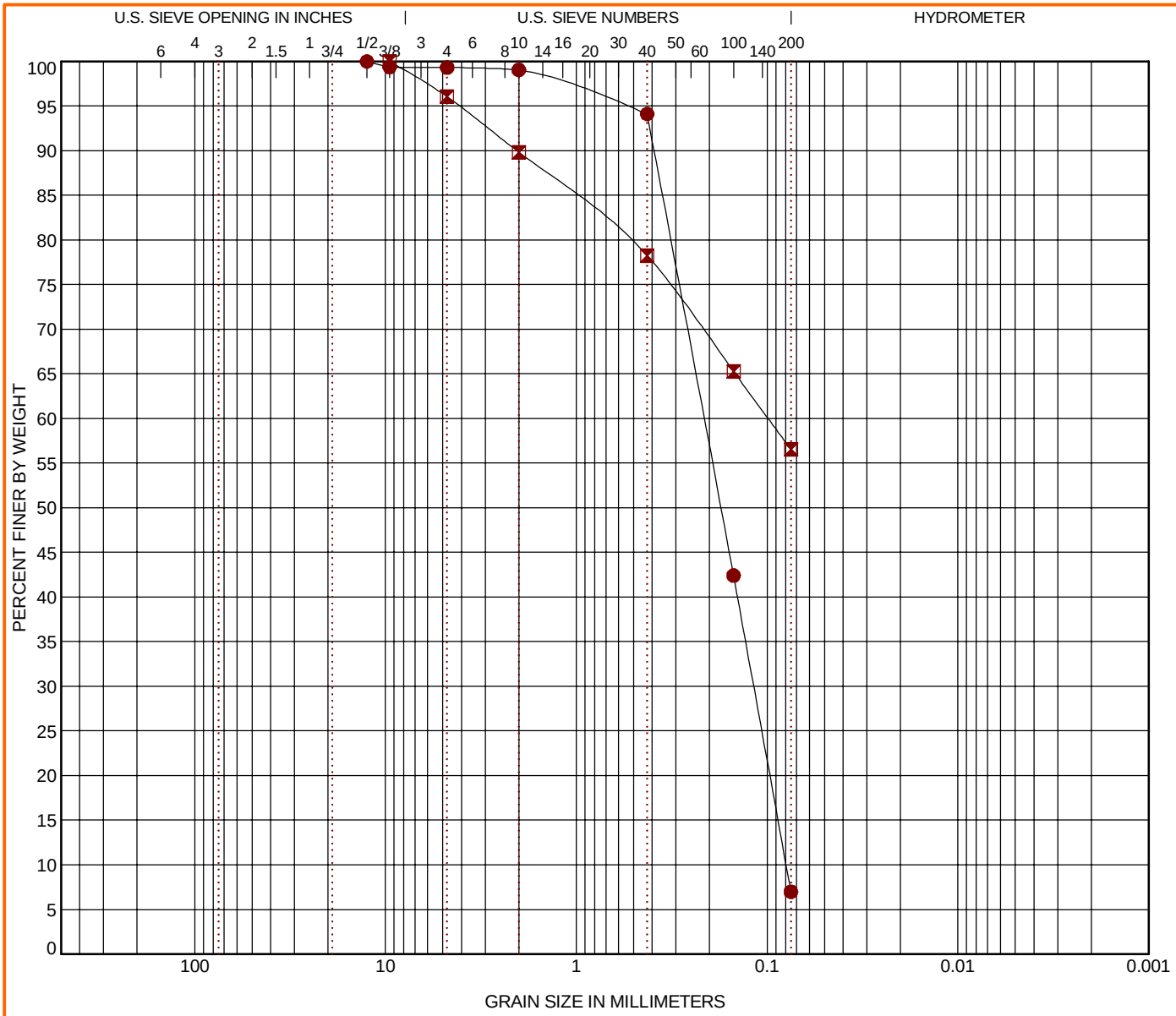
Terracon
7002 Commerce Ave
El Paso, TX

PROJECT NUMBER: AU185096

CLIENT: El Paso Water Utilities
El Paso, Texas

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
●	P-1	10 - 11.5	POORLY GRADED SAND with SILT (SP-SM)	5	NP	NP	NP	0.81	2.69
⊠	P-1	23.5 - 25	SANDY LEAN CLAY (CL)	24	38	18	20		

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
●	P-1	10 - 11.5	12.5	0.214	0.118	0.08	0.0	0.7	92.3		7.0	
⊠	P-1	23.5 - 25	9.5	0.099			0.0	3.9	39.5		56.6	

PROJECT: Carolina Storm Water Pond

SITE: NE Corner of N Carolina Dr and Alameda Ave
El Paso, Texas

Terracon
7002 Commerce Ave
El Paso, TX

PROJECT NUMBER: AU185096

CLIENT: El Paso Water Utilities
El Paso, Texas

FIELD PERCOLATION TEST REPORT

Project No.: AU185096

Project Name: Carolina Stormwater Pond

Percolation No.	Perc-1
Date Measured	3/18/2019
Measured by	Manny D.
Nominal Borehole Depth	10 ft below existing grade
Average Percolation Rate at Nominal Depth	**0.2 min/in (0.03 hr/ft)**

Soil percolation testing performed in general accordance to the Texas Department of Health, Percolation Test Procedures for Construction Standards For On-Site Sewage Facilities.

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

Carolina Storm Water Pond ■ El Paso, Texas

April 12, 2019 ■ Terracon Project No. AU185096

SAMPLING	WATER LEVEL	FIELD TESTS
Split Spoon	**Water Initially Encountered** **Water Level After a Specified Period of Time** **Water Level After a Specified Period of Time** Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.	**N** Standard Penetration Test Resistance (Blows/Ft.) **(HP)** Hand Penetrometer **(T)** Torvane **(DCP)** Dynamic Cone Penetrometer **UC** Unconfined Compressive Strength **(PID)** Photo-Ionization Detector **(OVA)** Organic Vapor Analyzer

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength Qu, (psi)**	**Standard Penetration or N-Value Blows/Ft.**
Very Loose	0 - 3	Very Soft	less than 3.50	0 - 1
Loose	4 - 9	Soft	3.5 to 7.0	2 - 4
Medium Dense	10 - 29	Medium Stiff	7.0 to 14.0	4 - 8
Dense	30 - 50	Stiff	14.0 to 28.0	8 - 15
Very Dense	> 50	Very Stiff	28.0 to 55.5	15 - 30
		Hard	> 55.5	> 30

RELATIVE PROPORTIONS OF SAND AND GRAVEL		RELATIVE PROPORTIONS OF FINES	
Descriptive Term(s) of other constituents	Percent of Dry Weight	**Descriptive Term(s) of other constituents**	**Percent of Dry Weight**
Trace	<15	Trace	<5
With	15-29	With	5-12
Modifier	>30	Modifier	>12

GRAIN SIZE TERMINOLOGY		PLASTICITY DESCRIPTION	
Major Component of Sample	**Particle Size**	**Term**	**Plasticity Index**
Boulders	Over 12 in. (300 mm)	Non-plastic	0
Cobbles	12 in. to 3 in. (300mm to 75mm)	Low	1 - 10
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)	Medium	11 - 30
Sand	#4 to #200 sieve (4.75mm to 0.075mm	High	> 30
Silt or Clay	Passing #200 sieve (0.075mm)		

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	Group Name [B]
Coarse Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu ≥ 4 and 1 ≤ Cc ≤ 3 [E]		GW	Well-graded gravel [F]
			Cu < 4 and/or 1 > Cc > 3 [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel [F,G,H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu ≥ 6 and 1 ≤ Cc ≤ 3 [E]		SW	Well-graded sand [I]
			Cu < 6 and/or 1 > Cc > 3 [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G,H,I]
			Fines classify as CL or CH		SC	Clayey sand [G,H,I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above "A" line [J]		CL	Lean clay [K,L,M]
			PI < 4 or plots below "A" line [J]		ML	Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K,L,M,N]
			Liquid limit - not dried			Organic silt [K,L,M,O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line		CH	Fat clay [K,L,M]
			PI plots below "A" line		MH	Elastic Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K,L,M,P]
			Liquid limit - not dried			Organic silt [K,L,M,Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.
[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[H] If fines are organic, add "with organic fines" to group name.
[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.
[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.
[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI ≥ 4 and plots on or above "A" line.
[O] PI < 4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.