SAN ANTONIO WATER SYSTEM

MITCHELL LAKE CONSTRUCTED WETLANDS

GROUNDWATER PROTECTION PLAN

SUBMITTED TO:

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

STATE OF TEXAS
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Mitchell Lake Groundwater Protection Plan

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BMP	best management practice
BOD_5	five-day biochemical oxygen demand
CH	fat clay
CL	lean clay
COSA	City of San Antonio
DWZ	deep water zone
DO	dissolved oxygen
E. coli	Escherichia coli
ESA	environmental site assessment
ft msl	feet above mean sea level
FWS	free water surface
LCWRC	Leon Creek Water Recycling Center
LL	liquid limit
mg/L	milligrams per liter
MS4	Municipal Separate Storm Sewer System
NRCS	Natural Resources Conservation Service
PI	plasticity index
PL	plastic limit
SAWS	San Antonio Water System
TAC	Texas Administrative Code
SMCWRC	Steven M. Clouse Water Recycling Center
SWMP	Storm Water Management Plan
TCEQ	Texas Commission on Environmental Quality
TDS	total dissolved solids
TPDES	Texas Pollutant Discharge Elimination System
TSS	total suspended solids
USEPA	United States Environmental Protection Agency

1 Introduction

1.1 BACKGROUND

Mitchell Lake is located in south Bexar County, Texas (Figure 1). The lake surface covers approximately 513 acres at its present spillway elevation of 520.7 feet mean sea level (ft msl). The lake is an on-channel impoundment that consists of an earthen dam and the main body of the lake. The contributing watershed of the lake is approximately 8.7 square miles, excluding the area of the lake itself.

The lake is an invaluable public resource for environmental education and community stewardship. In 1973, the City of San Antonio (COSA) designated it as a Refuge for Shore Birds and Waterfowl. In 2004, the San Antonio Water System (SAWS) entered into an operating agreement with the National Audubon Society, thus establishing the first Audubon Nature Center in Texas.

The lake is also a historic remnant of the COSA sewage treatment operations. The lake was initially used as a receiving water body for storing raw or partially treated sewage, which was then used to irrigate crops. In 1901, a dam was constructed on the southern edge of an existing natural wetland that inundated the natural wetland and created the current lake. For many decades, the lake has been subject to waste disposal permits issued by the State of Texas.

1) In 1987, with the completion of the Steven M. Clouse Water Recycling Center[1] (SMCWRC), disposal of untreated or partially treated wastewater and treatment process residuals into the lake ceased. Today, the lake receives stormwater runoff from its drainage basin. To maintain a suitable habitat for shorebirds and waterfowl, SAWS intermittently discharges treated LCWRC effluent to the lake in order to maintain desirable lake levels.

Mitchell Lake currently is subject to Texas Pollutant Discharge Elimination System (TPDES) Permit No. WQ0010137004 issued by the Texas Commission on Environmental Quality (TCEQ).

[1] Renamed in 2018 to the Steven M. Clouse Water Recycling Center

The TPDES Permit specifies water quality limits for Total Suspended Solids (TSS); Five-Day Biochemical Oxygen Demand (BOD_5); *Escherichia coli* (*E.coli*); pH; and dissolved oxygen (DO).

Releases over the dam spillway occur periodically in response to significant rainfall events. Water from the lake is released through a gated-spillway structure into Cottonmouth Creek, which flows into the Medina River. When releases occur, SAWS is required to monitor and report flow, as well as sample and report water quality for the lake's permitted constituents. Due to the eutrophic nature of the lake and its correspondingly high phytoplankton biomass, the facility does not always meet the permit limits for pH, BOD_5, DO, and TSS.

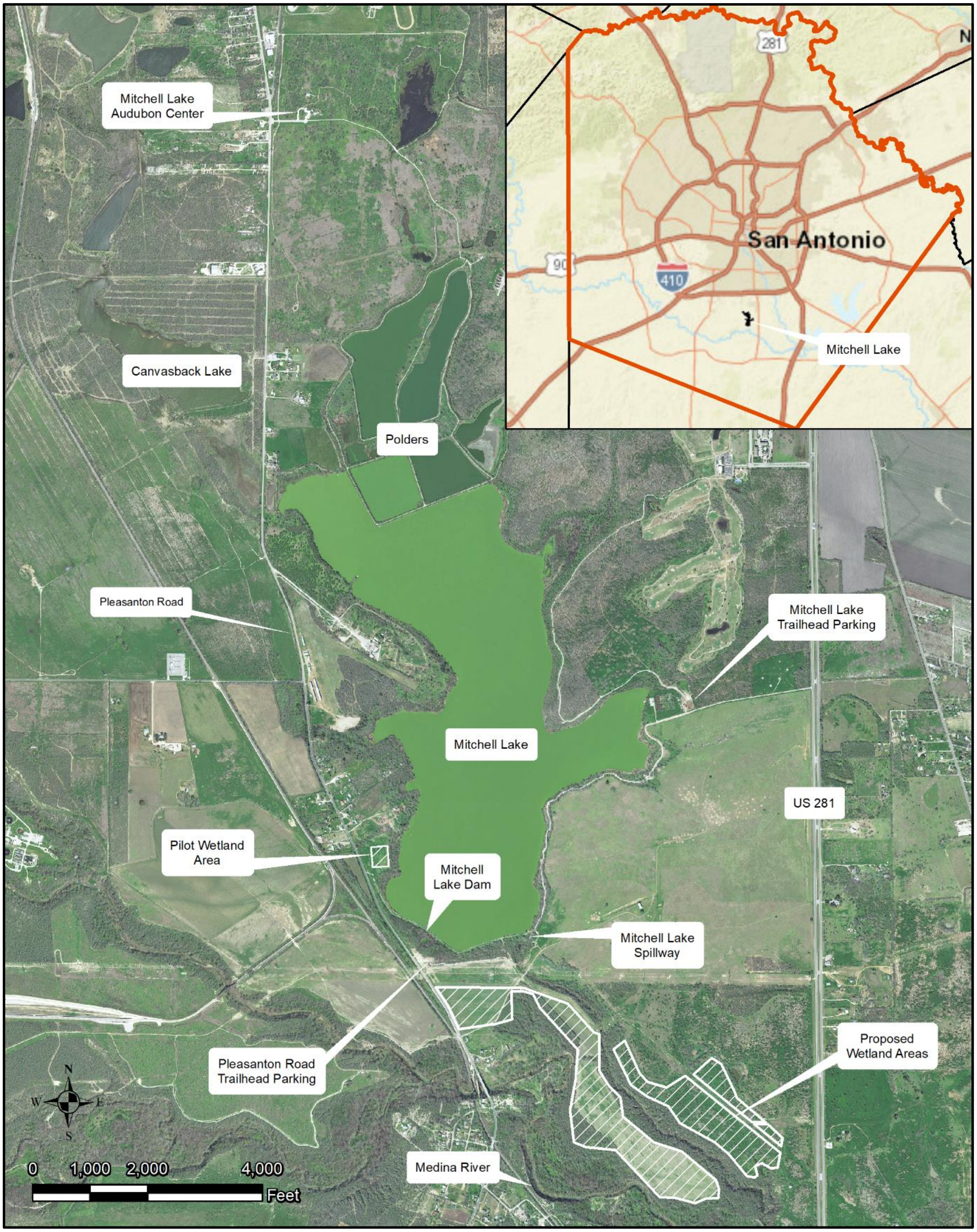

Figure 1
General Location of Project Components

SAWS is planning to construct approximately 115-acres of treatment wetlands downstream of the dam to improve the quality of water discharged from the lake. SAWS also plans to raise the top of the Mitchell Lake dam, increase the elevation of the spillway to 521.76 ft msl, increase the dam length, and add two outlet works structures within the dam to allow water to be diverted into the downstream wetland. The increase in the spillway elevation will increase lake storage from approximately 2,086 ac-ft to approximately 2,640 ac-ft, which is the total impoundment volume authorized by water rights Certificate of Adjudication 19-2153. After receiving stormwater inflow, the storage capacity of the lake will be restored by discharging the lake water through the outlet works into the wetland. Preferentially routing lake water through the wetland will improve the quality of the water being received at the Medina River. Under extreme rainfall conditions, incoming runoff from the watershed may exceed the available storage capacity of the lake, even with the discharge to the constructed wetland occurring at the maximum feasible rate. In this event, water will be released over the dam spillway and flow directly into Cottonmouth Creek.

1.2 RE-PERMITTING MITCHELL LAKE PERMIT UNDER AN MS4 PERMIT

Recent discussions have taken place between SAWS, the United States Environmental Protection Agency (US EPA) and the TCEQ regarding the permit framework under which Mitchell Lake will be regulated. These discussions have led to agreement that Mitchell Lake will be re-permitted as part of COSA's Municipal Separate Storm Sewer System (MS4) permit rather than under a TPDES permit for wastewater treatment facilities. The primary justifications for this change are based on the facts that Mitchell Lake:

1. Is an on-channel reservoir constructed on a natural waterway;
2. Receives significant stormwater inflows;
3. Has previously been recognized as Surface Water in the State; and
4. Is not, and does not, function as a treatment unit since it receives only stormwater and fully treated effluent discharged from LCWRC.

Under the MS4 permit, SAWS will be required to develop and implement a Stormwater Management Program (SWMP) for the lake to include, among other requirements, structural controls and pollution prevention measures to reduce the discharge of pollutants from the MS4 to the maximum extent practicable.

Pursuant to a Schedule of Activities outlined in USEPA Administrative Order CWA-06-2016-1770, SAWS is required to complete construction and place the lake/wetland system in operation by

September 30, 2024. The constructed wetland polishing water from Mitchell Lake will serve as the primary structural control and best management practice (BMP) for Mitchell Lake in the SWMP. It should be noted that TCEQ specifically highlights the use of constructed wetlands as an approved structural control for the protection of drinking water sources that acts "as a natural filter for inflows to a water body from a storm sewer system[2]."

1.3 PURPOSE OF REPORT

The purpose of this report is to provide a plan that will protect aquifers in the project area from potential impacts from the proposed constructed wetland. This report includes information regarding local aquifers; natural and artificial features of the area that could represent a recharge pathway; and actions to be taken to reduce the potential for impacts to groundwater.

[2] https://www.tceq.texas.gov/drinkingwater/SWAP/bmp.html

2 Groundwater

This section provides information regarding the presence of groundwater in the area of the proposed constructed wetland. Natural and artificial features which could represent recharge pathways to identified aquifers are also described.

2.1 LOCAL AQUIFERS

Groundwater occurs in both major and minor aquifers, which are defined by the Texas Water Development Board, or in perched aquifers. Beneath Mitchell Lake and vicinity, one major aquifer is found. Shallow, perched groundwater may also be found. A description of these groundwater sources is provided below:

2.1.1 <u>Aquifers</u>

The proposed constructed wetland is located over the Carrizo-Wilcox Aquifer (Figure 2), more specifically, the outcrop of the aquifer[3]. As Figure 2 indicates, the outcrop underlies a portion of Mitchell Lake as well. The Carrizo-Wilcox is defined by the TWDB as a major aquifer in Texas, extending from the Louisiana border to the border of Mexico in a wide band adjacent to and northwest of the Gulf Coast Aquifer. It consists of the Hooper, Simsboro, and Calvert Bluff formations of the Wilcox Group and the overlying Carrizo Formation of the Claiborne Group. The aquifer is primarily composed of sand locally interbedded with gravel, silt, clay, and lignite. Although the Carrizo-Wilcox Aquifer reaches 3,000 feet in thickness, the freshwater saturated thickness of the sands averages 670 feet.

[3] http://www.twdb.texas.gov/groundwater/aquifer/majors/carrizo-wilcox.aspd

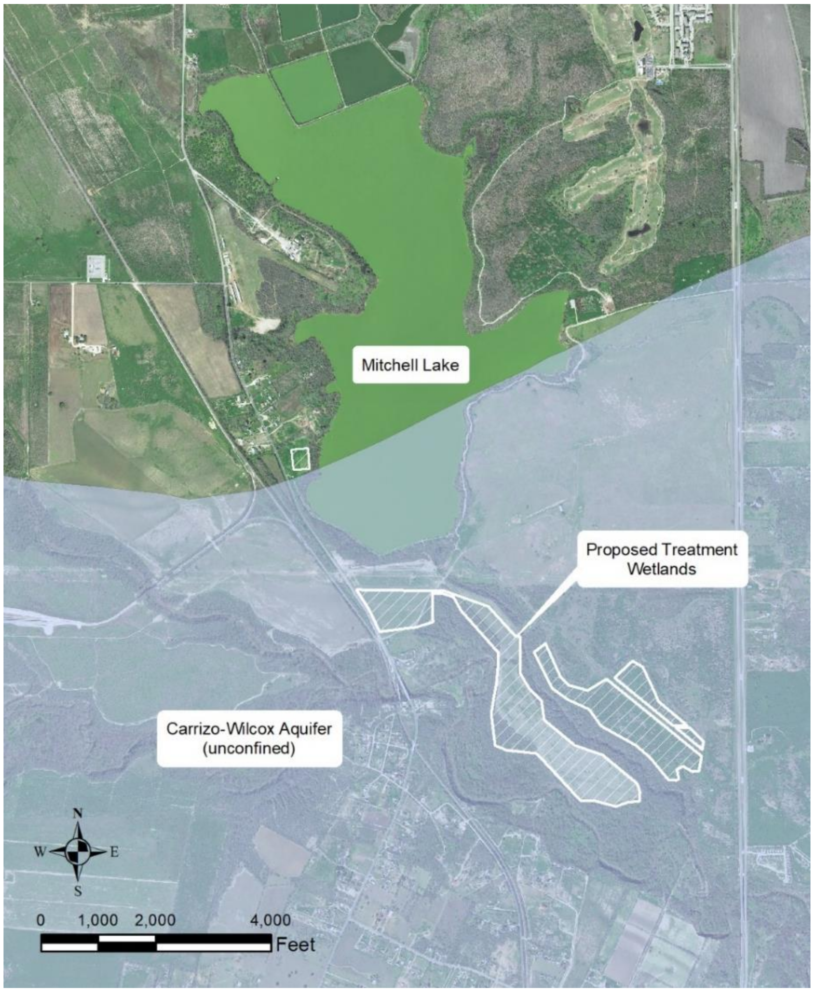

Figure 2
Major Aquifers Near Proposed Project Site

Water quality in the Carrizo-Wilcox Aquifer shows isolated areas of slightly saline to moderately saline groundwater in the eastern and central portions of the aquifer and more widespread areas of slightly-to-moderately saline groundwater in the southwest. Groundwater in the unconfined area is hard and typically has total dissolved solids (TDS) concentrations less than 1,000 milligrams per liter (mg/L). Groundwater in the confined area of the aquifer is generally softer and has TDS concentrations less than 1,000 mg/L except in the southern and western portions of the aquifer.

No minor aquifers identified by the Texas Water Development Board are known to exist within the footprint of the proposed treatment wetland.

2.1.2 Perched Groundwater

It is possible that shallow, perched, alluvium groundwater is present along the Medina River, which is located immediately adjacent to, but not within, the footprint of the proposed treatment wetland. Geotechnical testing conducted for the project included the advancement of twelve borings, each to a depth of 15 feet within the footprint of the proposed wetland. During drilling, no perched groundwater was encountered, and none entered the boreholes after 24 hours[4]. The full geotechnical report is provided as Appendix A-1.

2.2 SOILS AND GEOLOGY

2.2.1 Soils

The Natural Resources Conservation Service (NRCS) Soil Survey map[5] (Figure 3) and associated soil survey data indicates soils in the area of the proposed constructed wetland are Sunev clay loam (mapped as VcA and VcB). The typical profile of Sunev is clay loam from 0 to 32 inches and loam from 32 to 62 inches. Depth to groundwater is greater than 80 inches. The hydrologic soil group is B (moderately low runoff potential) and the permeability class rating is listed as moderate. Slopes are less than 5 percent.

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[4] Geotechnical Data Report, SAWS Mitchell Lake Project, Arias Geoprofessionals, June 11, 2018.

[5] http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

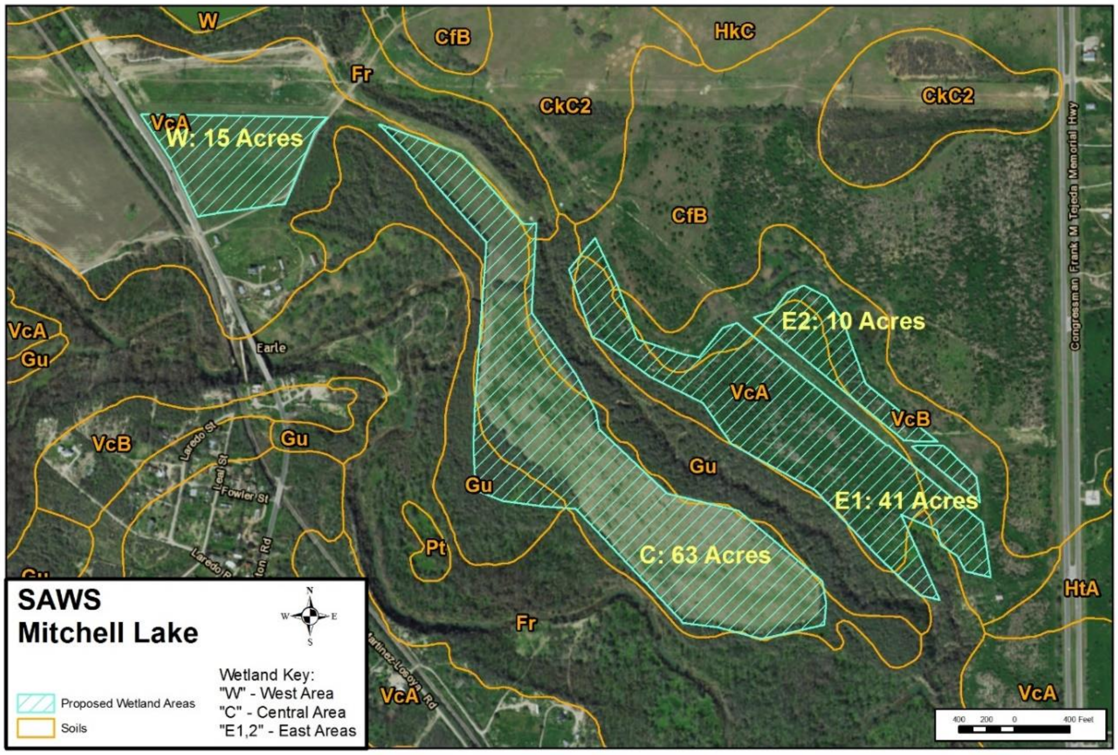

Figure 3
NRCS Soil Survey with Proposed Wetland Areas

The Geotechnical Data Report provided by Arias (Attachment A), generally characterizes surface soils in the area of the proposed constructed wetland as lean clay (CL), with some areas of fat clay (CH). The conclusions of the Geotechnical Data Report are consistent with NRCS descriptions of the soils found in the area.

2.2.2 Local Geology

The geology of the area, as described in various studies performed for the project,[6] is predominantly underlain by the Wilcox Group (Ewi, EAPwi) with lesser portions to the west and

[6] Phase I ESAs were conducted on each of two properties that make up the land on which the proposed project would be located, and included geologic assessments of the properties. Refer to the following documents: Phase I Environmental Site Assessment: 16795, Ltd. Property, Adams Environmental, Inc. Nov. 13, 2017. Phase I Environmental Site Assessment: Cook Trust Property, Adams Environmental, Inc. Feb. 27, 2018.

the south of the site underlain by Fluviatile terrace deposits (Qt). The Wilcox Group is comprised of three different stratigraphic units, the Hooper, Simsboro and Calvert Bluff formations; and is described as containing mostly mudstone and sand with various amounts of gravel, silt, clay and lignite.[7]

2.3 RECHARGE FEATURES

Recharge features are defined as natural or artificial features either on or beneath the ground surface that provide or create a significant hydrologic pathway between the ground surface and the underlying groundwater. Recharge features are discussed in the following sections.

2.3.1 Geomorphologic and Geologic Features

This section addresses natural surface features that can increase the introduction of surface water to the subsurface. These features may be landforms or physical characteristics that have developed in the sediments.

- Watercourses, springs, seeps, or ponds – No watercourses, springs, seeps, or ponds exist within the footprint of the proposed constructed wetland. Cottonmouth Creek and the Medina River are adjacent to the proposed wetland, and several erosional headwater gullies feeding these two watercourses surround the proposed wetland. These gullies will be avoided.
- Topographic depressions – No topographic depressions, such as playa lakes or prairie potholes, exist within the footprint of the proposed wetland.
- Faults or fractures – No faults or fractures are believed to be located within the footprint of the proposed wetland.
- Sinkholes – No sinkholes are known to exist within the footprint of the proposed wetland.

The area of the proposed constructed wetland is mapped by the Texas Water Development Board as being within the outcrop (i.e., unconfined zone) of the Carrizo-Wilcox Aquifer. As such, there is potential for recharge through impounded water on the land surface. Presently no

[7] Texas Aquifers Study: Groundwater Quantity, Quality, Flow, and Contributions to Surface Water, Texas Water Development Board Dec. 31, 2016.

impoundments exist within the footprint of the proposed wetland. Furthermore, the predominant soil type in the area is clay loam. Given these characteristics, it is likely that a significant portion of rainwater that falls within the footprint of the proposed constructed wetland is shed as runoff, entering the nearby watercourses and reducing the potential for recharge.

2.3.2 Artificial Features

Artificial features, or surface penetrations, have the potential to rapidly introduce surface water to the subsurface or directly into a source of groundwater.

- Water wells – No water wells are located within the footprint of the proposed constructed wetland.
- Oil/gas wells – Database searches conducted for the Phase I Environmental Site Assessments (ESAs) indicated one dry hole and one plugged and abandoned well were registered within (or immediately adjacent to) the footprint of the proposed wetland.
- Open excavations – No open excavations were observed within the footprint of the proposed constructed wetland.

3 Groundwater Protection Plan

The following sections describe the actions to be taken within the proposed constructed wetland to mitigate potential contamination of groundwater.

3.1 LINING OF CONSTRUCTED WETLAND

The constructed wetland will be designed in such a manner as to protect groundwater. This will primarily be accomplished with construction of clay liners within the footprint of all wetted areas within the system, using natural clays found on the site. Following is a discussion of the lining approach.

3.1.1 Description of Proposed Constructed Wetland

As proposed, the constructed wetland will be located on property recently acquired, or planned to be acquired, by SAWS. When the proposed wetland cells are laid out and accommodations are made for above and below ground utilities, general topography, and other geographic features, the resulting wetted area is expected to be approximately 115 acres. The proposed constructed wetland will be a free water surface (FWS) wetland. FWS wetlands resemble natural marshes in that they are shallow water bodies which include areas of both emergent and submerged aquatic vegetation, as well as areas of open water. An example of an FWS wetland is shown in Figure 4.

Figure 4
Example of Free Water Surface Constructed Wetland

As previously described, the Mitchell Lake dam will be modified, and two outlet works will be installed to convey water from the lake to the proposed constructed wetland. One outlet works will direct water into a wetland cell located in the west portion of the constructed wetland and the other to a wetland cell located in the east portion. The outlet works are intended to be passive structures, utilizing a weir gate that allows flow to pass into the wetland cells without human action. The sizing of the outlet works and pipes has not been determined yet because design flows have not been selected, to date. The pipes from each outlet works will have to cross multiple buried utilities. As design progresses, the alignments may change. Figure 5 shows the preliminary layout of the proposed constructed wetland.

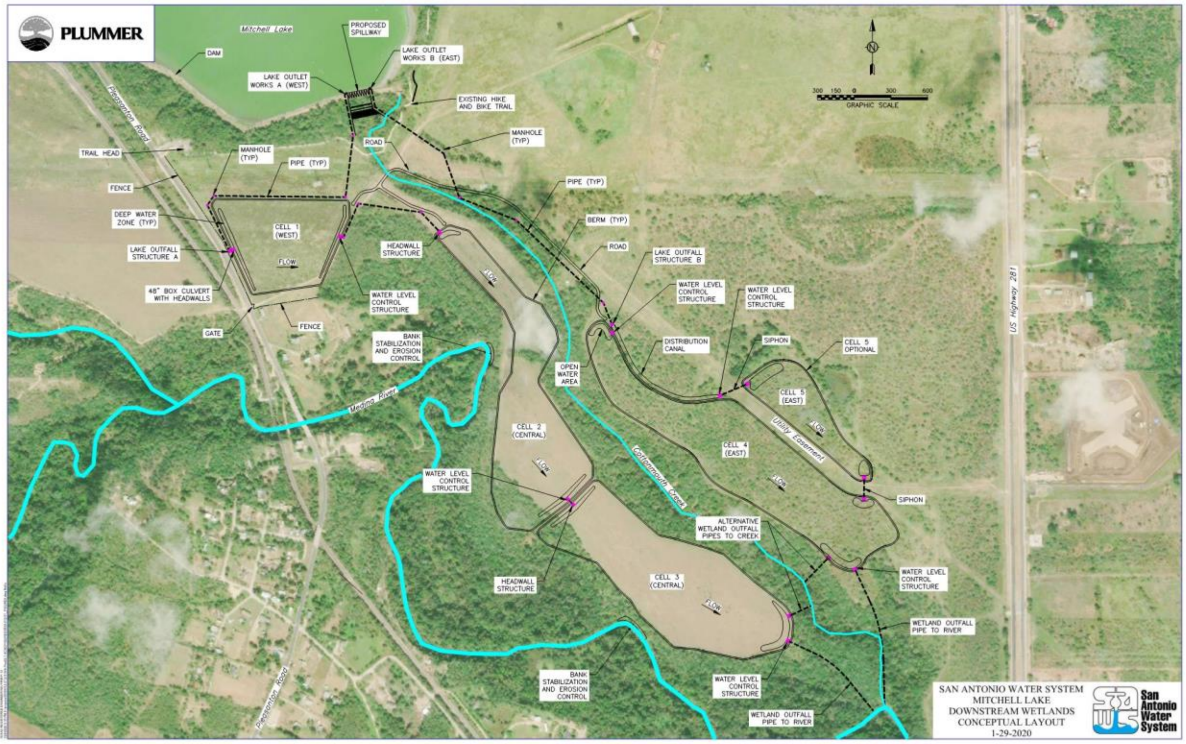

Figure 5
Preliminary Layout of Proposed Constructed Wetland

As shown in Figure 5, the proposed constructed wetland includes three major areas: west, central, and east. The west area consists of one wetland cell (Cell 1); the central area includes two cells (Cells 2 and 3); and the east area includes two cells (Cells 4 and 5). Design features of the cells include the following:

- Each wetland cell will be surrounded by a compacted soil berm, and the interior of the cell (i.e., "marsh zone") will be graded flat. The marsh zone will occupy about 95% of the total area of each cell.
- Each cell will include a small "deep water zone" (DWZ) at the inlet end of the cell. The inlet DWZ will be 3-to-4 feet deep and will distribute water laterally across the width of the cell. Some of the longer cells may include a DWZ at the approximate mid-point of the cell for redistribution of water across the cell. A smaller DWZ will be located at the outlet end of each cell for collection of water. In total, the DWZs will represent approximately 5% of the total wetted area within the wetland.
- Each cell will have a single water level control structure (outlet structure) that will set the water level in the cell. The water level control structure will be a passive structure;

conceptually, it is a concrete box structure fitted with a rectangular weir gate. The water level control structures will be set to maintain water depths of 4 to 8 inches throughout the marsh zone, with a maximum water depth of 12-inches.

- Each wetland cell will include a compacted clay soil liner, utilizing in-situ soils with high clay content. These soils will be re-worked in place and include additional placed and compacted clay soil, as necessary, to achieve a designated minimum thickness. The liner construction is discussed in more detail in the following section.
- Approximately 6 inches of loose topsoil will be placed on top of the compacted soil liner for plant root media.
- The cells will be planted with emergent aquatic vegetation, which will achieve full coverage of the marsh areas within the cells.
- The flat-graded cells will encourage sheet flow within the cell, optimizing treatment performance.
- Buried pipes will be used to convey water between the wetland cells.
- Wetland Cells 4 and 5, located east of Cottonmouth Creek, will operate in parallel to the west and central sections. Since a utility easement separates Cells 4 and 5, these two cells will also operate in parallel. In order to distribute water to each of the cells, an open water distribution canal is proposed that will convey lake water to each cell. Two weir structures will be located on the canal, regulating flow from the canal into Cells 4 and 5. The weir structure for Cell 5 would conceptually discharge into a siphon that would convey the water under the utilities into the cell. A water level control structure would be located at the outlet of Cell 5, and a siphon would conceptually be used to convey water under the utilities back into the lower end of Cell 4. Details of the interconnecting piping will be developed further in subsequent design phases.
- Cells 3 and 4 will include a final water level control structure and an outfall to the receiving stream. The design currently proposes the wetland to discharge to the Medina River, but the possibility of a discharge to Cottonmouth Creek also exists. The outfall structures are expected to incorporate cascade features, which will aerate the wetland discharge and increase the DO content of the water.

3.1.2 Liner Design Criteria

The design criteria for the constructed wetland liner is adopted[8] from 30 TAC §217.203(d)(1)(A), which states that "constructed wetlands …must be constructed with a liner material that has a coefficient of permeability of less than 1 x 10^{-7} cm/sec for a thickness of 2.0 feet for water depths less than or equal to 8.0 feet". The specific discharge (i.e., seepage rate) that will occur under these conditions will be used as the maximum allowable rate for design of the constructed wetland liner.

As previously noted, the water depth in the constructed wetland will be significantly less than 8 feet, and soils in the area of the wetland are predominantly clay (CL and CH). These two important factors will be considered in the design of the liner so that it will not only be protective of the underlying groundwater, but also as cost-effective as possible. The following section provides additional details regarding design of the liner and its construction.

3.1.3 Liner Design and Construction Approach

Design of the soil liner follows guidance provided by the United States Department of Agriculture (USDA) in their "Design and Construction Guidelines for Waste Impoundments Lined with Clay or Amendment-Treated Soil" design manual.

The first step is to identify the specific discharge that will occur under the conditions described in 30 TAC §217.203(d)(1)(A). This will be the maximum allowable rate for the constructed wetland liner. Equation 1 is used to determine this value.

Equation 1: Specific Discharge Equation[9]

$$\nu = k \frac{h}{d}$$

[8] It should be noted that under an MS4 permit, the constructed wetland will be considered a structural control and BMP in the SWMP and not a wastewater treatment unit as defined in §217.2 (74). Therefore, the liner design and construction standards detailed in 30 TAC Chapter 217, Subchapter H, Natural Treatment Units do not apply. Nevertheless, the design criteria selected for the constructed wetland will be adopted from these standards.

[9] USDA Agricultural Waste Management System Component Design Manual, Appendix 10D

Where,

v = specific discharge, cm/sec (calculated = 5.00×10^{-7})
k = coefficient of permeability = 1.00×10^{-7} cm/sec
h = depth of water above the liner (8 feet) + the thickness of the liner (2 feet) = 10 feet = 305 cm
d = thickness of the liner (2 feet) = 61 cm

For the conditions shown above, the calculated specific discharge for an impoundment with 8 feet of water and a liner 2 feet thick with a coefficient of permeability of 1.0×10^{-7} cm/sec is 5.00 x 10-7 cm/sec. Based on these conditions (adopted from TCEQ rules), **the target specific discharge for the constructed wetland will be 5.00×10^{-7} cm/sec or less**.

The next step is to consider the depth of water and the site-specific coefficient of permeability to determine the thickness of the liner. Equation 2 is obtained by substituting the term (H + d) for the term h in Equation 1 (where H is the depth of the water *above* the liner) and rearranging the terms. Site specific data for water depth and coefficient of permeability is used, along with the target specific discharge, to arrive at a minimum liner thickness.

Equation 2: Liner Thickness Equation[10]

$$d = \frac{kH}{(v - k)}$$

Where,

d = minimum thickness of the liner, cm
k = site-specific coefficient of permeability, cm/sec, determined by testing the soils used for the liner
H = depth of water above the liner, cm
For: Marsh zone = 30.5 cm (12 inches)
Deep water zone = 122 cm (4 feet)
v = target specific discharge, cm/sec = 5.00×10^{-7}

Equation 2 is applied to determine the liner thickness for the marsh zones (maximum water depth of 12 inches) and for the DWZs and water distribution canals (maximum water depth 4 feet). Tables 1 and 2 provide a summary of the calculated liner thickness for water depths of 1 and 4 feet, respectively. **Note that in no circumstances will a liner less than 12 inches in thickness be constructed.** In addition, a **maximum liner thickness of 2 feet is proposed**. To achieve the

[10] USDA Agricultural Waste Management System Component Design Manual, Appendix 10D

target specific discharge with a thickness of 2 feet, the clay soil must exhibit a coefficient of permeability that is no greater than that shown in Note A below Tables 1 and 2.

Table 1
Calculated and Design Liner Thickness for Wetland Marsh Zones (12” Max Water Depth)

Coefficient of permeability, *k* (cm/sec)	Calculated Liner Thickness Using Equation 2 (feet)	Design Liner Thickness (feet)
$< 2.52 \times 10^{-7}$	< 1.0	1.0
2.52×10^{-7}	1.0	1.0
3.02×10^{-7}	1.5	1.5
3.35×10^{-7}	2.0	2.0
$> 3.35 \times 10^{-7}$	> 2.0	Note A

A. Liner will not be constructed using material with *k* greater than 3.35×10^{-7} cm/sec.

Table 2
Calculated and Design Liner Thickness for Wetland DWZ and Canals
(4’ Max Water Depth)

Coefficient of permeability, *k* (cm/sec)	Calculated Liner Thickness Using Equation 2 (feet)	Design Liner Thickness (feet)
$< 1.00 \times 10^{-7}$	< 1.0	1.0
1.00×10^{-7}	1.0	1.0
1.37×10^{-7}	1.5	1.5
1.67×10^{-7}	2.0	2.0
$> 1.67 \times 10^{-7}$	> 2.0	Note A

A. Liner will not be constructed using material with *k* greater than 1.67×10^{-7} cm/sec.

To evaluate whether in-situ soils within the area of the proposed constructed wetland could be used as soil liner, Arias & Associates, Inc., was engaged to perform a geotechnical investigation. The geotechnical investigation[11] included both field exploration and laboratory testing. The field investigation included advancement of twenty (20) test borings, eleven (11) of which were located

[11] Geotechnical Data Report, SAWS Mitchell Lake Project, Arias Geoprofessionals, June 11, 2018

within the footprint of the proposed constructed wetland. The approximate location of the soil borings is shown in Figure 6.

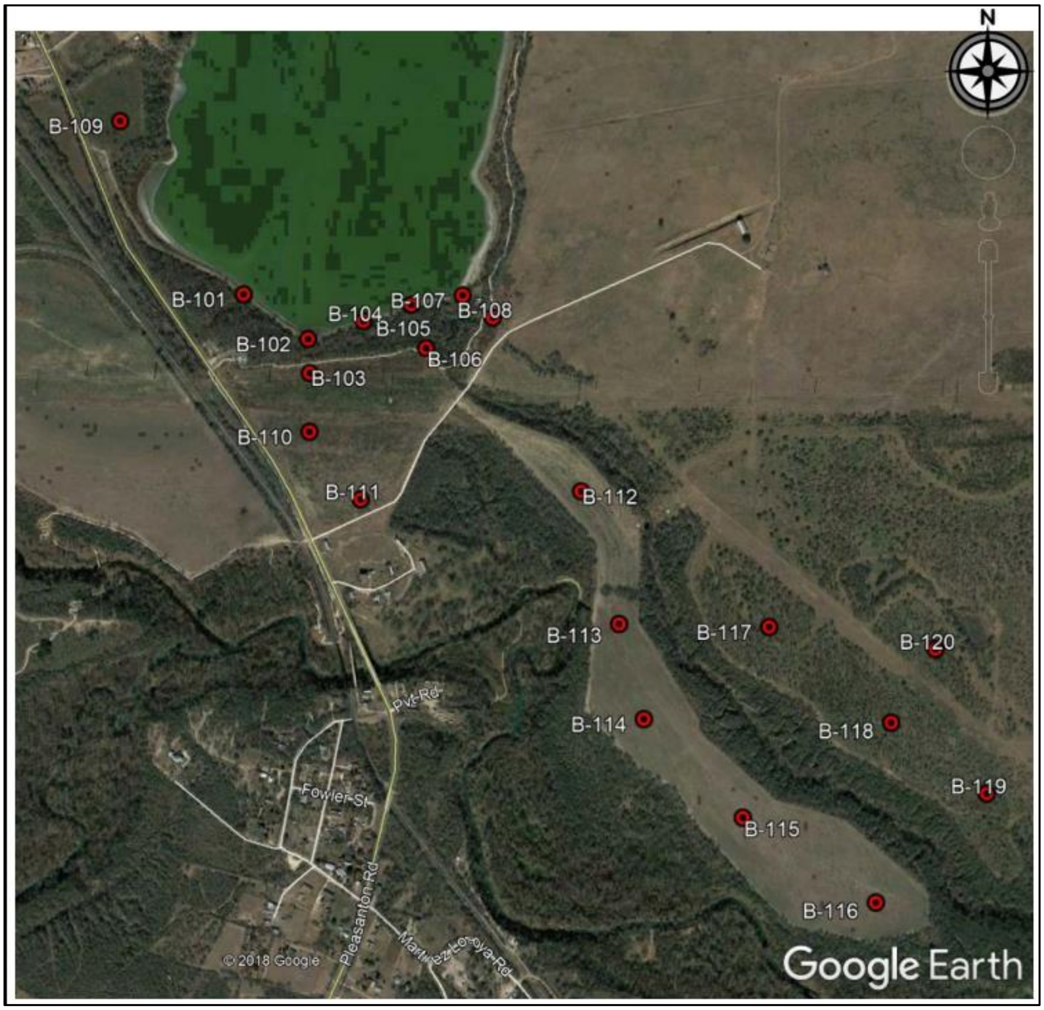

Figure 6
Location of Borings

The geotechnical investigation further included soil mechanics laboratory testing of selected samples taken from the soil borings. Laboratory tests conducted for evaluation of liner suitability included water (moisture) content of soil (ASTM D 2216); Atterberg Limits [liquid limit (LL); plastic limit (PL); plasticity index (PI)] (ASTM D 4318); particle size analysis (ASTM D 422); amount finer than #200 sieve (ASTM D 1140); and hydraulic conductivity (ASTM D 5084)[12]. Laboratory results of samples taken from 0 to 5 feet below ground surface in borings B-110 through B-120 were reviewed and compared to the soil liner requirements found in §217.203(e)(1)(A). Each sample met the minimum requirements for LL (>30%), PI (≥15) and percent passing a #200 sieve (≥30%).

Hydraulic conductivity testing (ASTM D 5084) was conducted on three undisturbed samples from borings B-110, B-114, and B-118. The results of these tests indicated that, while physical characteristics were suitable for an in-situ liner, the hydraulic conductivity (permeability) of each sample exceeded the maximum rate allowable of 1×10^{-7} cm/sec given in §217.203(e)(1)(A)(i).

Additional samples were obtained near borings B-110, B-113, and B-115 to determine if appropriate moisture and compactive effort would yield suitable results. The optimum moisture content to achieve the maximum dry density was obtained for each of these samples using ASTM D 698. The samples were then moistened to the optimum moisture content, placed in an apparatus and compacted to approximately 95% of the Standard Proctor density. The re-molded and compacted samples were then tested for hydraulic conductivity per ASTM D 5084. Two of the three samples resulted in hydraulic conductivity rates that were significantly less than the 1.0×10^{-7} cm/sec standard, while one sample was greater. A summary of the geotechnical testing results along with the TCEQ liner requirements are shown in Table 3. Results of the supplemental geotechnical testing are included in Appendix A-2.

[12] TCEQ uses the term "coefficient of permeability". The geotechnical report uses the term "hydraulic conductivity". The two terms are interchangeable.

Table 3
Summary of Geotechnical Testing Results a for Borings in the Proposed Constructed Wetland

Boring No.	Wetland Area	Soil Classification	Liquid Limit (%)	Plasticity Index	#200 Sieve (%)	Undisturbed Hydraulic Conductivity (cm/sec)	Remolded Hydraulic Conductivity (cm/sec)
TCEQ liner requirements [b]			*> 30*	*≥ 15*	*≥ 30*	*≤ 1.0 x 10^{-7}*	*≤ 1.0 x 10^{-7}*
B-110	West	CH, CL	47-50	30-32	95	4.1 x 10^{-5}	7.28 x 10^{-9}
B-111	West	CL	43	24	95	--	--
B-112	Central	CL	46	29	90	--	--
B-113	Central	CL	48	32	95	--	2.95 x 10^{-6}
B-114	Central	CL	33	18	70	1.6 x 10^{-6}	--
B-115	Central	CL	46	28	86	--	1.15 x 10^{-8}
B-116	Central	CL	50	31	94	--	--
B-117	East	CL	37	25	52	--	--
B-118	East	CL	40-43	25-28	80-87	2.3 x 10^{-5}	--
B-119	East	CL	47	26	82	--	--
B-120	East	CH	51	34	79	--	--

[a] Samples from 0 to 5 feet below ground surface.
[b] Ref. §217.203(d)(1)(A).

During design additional samples will be taken within the wetland area and tested to determine the coefficient of permeability when compacted to 95% of Standard Proctor Density. The resulting coefficient of permeability values will be used in Equation 2 to design the liner thickness, assuming the in-situ soils will be reworked (moistened and compacted) and used as soil liner within the respective wetland cell. The anticipated liner construction will generally be as follows:

- Clear and grub the site (if needed)
- Strip 6-inches of topsoil and stockpile nearby
- Excavate subsoil to required depth, accounting for design liner thickness and final grade. Stockpile subsoil nearby.
- Observe subsoil foundation and determine if any areas with undesirable soils exist (sand lenses, gravel or other highly permeable soils)
    - If so, excavate an additional 12 inches and install compacted clay meeting TCEQ liner requirements. Install in multiple lifts of 8-inches or less, uncompacted thickness, at the specified moisture and compaction requirements.
    - Adjust grade as needed to meet required subgrade foundation elevation.

- Disk the in-situ subgrade soil to a depth of approximately 8-inches and adjust moisture as needed to meet specifications. Compact to specified density to achieve required coefficient of permeability. This represents the lowermost layer of the soil liner.
- Place the previously excavated subsoil in successive lifts not exceeding 8-inches in thickness, moistening to the specified water content and compacting to the specified density to achieve the required coefficient of permeability. Each lift will be field tested for moisture and density. As described above and shown in Tables 1 and 2, the total liner thickness will not be less than 12-inches, nor more than 2-feet.
- Core samples will be taken of the final liner and tested per ASTM D 5084. The actual coefficient of permeability will be compared to the maximum acceptable values shown in Tables 1 and 2. If the coefficient of permeability is greater, actions will be taken to correct the issue.
- Liner thickness will be verified by comparing survey elevation of the subgrade and top of liner.
- Upon meeting the maximum specific discharge requirements, install 6-inches of previously stockpiled topsoil. Disk lightly for soil media.

3.2 OTHER ACTIONS

No fuels will be permanently stored at the proposed wetland site. The application of herbicides or pesticides is not anticipated to be conducted within the wetland.

4 Conclusion

The proposed Mitchell Lake constructed wetland is located in an area that includes the unconfined (outcrop) portion of the Carrizo-Wilcox Aquifer. As such, there is potential for recharge of the aquifer through impoundment of water on the land surface. To mitigate the potential for groundwater contamination, SAWS is proposing to install a low-permeability soil liner in the wetted areas of the constructed wetland. While not required to meet the liner requirements in 30 TAC Chapter 217, Subchapter H, the rules provided therein will be used as a guide for design of the liner. When designed and installed per these guidelines, the liner will significantly reduce the potential for seepage from the wetland and will provide a protective barrier from groundwater contamination.

APPENDIX A-1

GEOTECHNICAL REPORT

Geotechnical Data Report

SAWS
Mitchell Lake Wetland Project
San Antonio, Texas

Arias Project No. 2017-698

ARIAS GEOPROFESSIONALS

Prepared For:
Alan Plummer Associates, Inc.

June 11, 2018

ARIAS GEOPROFESSIONALS
13581 Pond Springs Road, Suite 210, Austin, Texas 78729 • Phone: (512) 428-5550 • Fax: (512) 428-5525

June 11, 2018
Arias Project No. 2017-698

VIA Email: tnoack@apaienv.com

Mr. Timothy Noack, P.E.
Alan Plummer Associates, Inc.
1777 NE Loop 410, Suite 500
San Antonio, Texas 78217

RE: **Geotechnical Data Report**
SAWS Mitchell Lake Wetland Project
San Antonio, Texas

Dear Mr. Noack,

Arias & Associates, Inc. (Arias) is pleased to submit this Geotechnical Data Report (GDR) for the above referenced project. Our services were performed according to the signed agreement for subconsultant services between Alan Plummer Associates, Inc. and Arias & Associates, Inc. dated November 17, 2017.

The purpose of this geotechnical study was to obtain subsurface and groundwater information along the proposed embankment dam and wetland area. The scope included a field investigation phase, laboratory testing, and preparation of this data report. It should be noted that our scope of services was limited to providing geotechnical data based upon our field and laboratory test results.

We sincerely appreciate the opportunity of working with you on this project and look forward to our continued association throughout final design and construction phases. Please do not hesitate to contact us about this report, or if we can be of further service.

Sincerely,
ARIAS GEOPROFESSIONALS, INC.
TBPE Registration No. F-32

STATE OF TEXAS
JERRY D. SHEPHERD
112142
LICENSED
PROFESSIONAL ENGINEER

Jerry D. Shepherd, P.E., D.GE
Senior Geotechnical Engineer
6-12-18

Christopher M. Szymczak, P.E.
Senior Geotechnical Engineer

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INTRODUCTION

The results of our Geotechnical Field Operations and Laboratory Testing Program for the proposed Mitchell Lake Wetland Project are presented in this Geotechnical Data Report (GDR). The project will consist of constructing wetlands at the downstream of the Mitchell Lake dam to improve the quality of discharge from Mitchell Lake. The project will also include causing necessary improvements to the dam to manage stormwater within the lake.

The geotechnical study was authorized on November 17, 2017 by Mr. Timothy Noack, P.E. with signing of an agreement for subconsultant services between Alan Plummer Associates, Inc. and Arias & Associates, Inc. The agreement outlines the authorized and agreed upon scope of services.

The purpose of this geotechnical investigation is to present geotechnical findings and results of analyses. This Geotechnical Data Report (GDR) presented herein is a compilation of the geotechnical field and laboratory data collected for the project.

FIELD EXPLORATION

The field exploration consisted of drilling twenty (20) test borings, designated B-101 through B-120, to depths ranging from 15- to 40- ft at the project site. Approximate boring locations are shown on the *Boring Location Plan* presented on Figure 2 in Appendix A. Boring locations should be considered approximate. A summary of boring information is presented in the following table.

Table 1: Boring Summary Table

Boring Designation	Date Drilled	Drill Depth, ft	GPS Latitude	GPS Longitude	Location
Mitchell Lake Dam and Spillway					
B-101	1/23/2018	40	29.27156	-98.49360	Top of Dam
B-102	1/23/2018	40	29.27066	-98.49212	Top of Dam
B-103	1/19/2018	40	29.26998	-98.49208	South of Dam
B-104	1/22/2018	40	29.27102	-98.49085	Top of Dam
B-105	1/22/2018	40	29.27135	-98.48975	Top of Dam
B-106	1/23/2018	40	29.27048	-98.48941	South end of Spillway
B-107	1/22/2018	40	29.27154	-98.48857	Top of Dam
Wetlands Downstream of Mitchell Lake & Pilot Wetlands					
B-108	3/14/2018	15	29.27109	-98.48788	Wetlands
B-109	1/22/2018	15	29.27507	-98.49645	Pilot Wetland
B-110	3/9/2018	15	29.26880	-98.49209	Wetlands
B-111	3/9/2018	15	29.26745	-98.49092	Wetlands
B-112	3/9/2018	15	29.26761	-98.48588	Wetlands
B-113	3/9/2018	15	29.26497	-98.48504	Wetlands
B-114	3/9/2018	15	29.26309	-98.48450	Wetlands
B-115	3/9/2018	15	29.26115	-98.48228	Wetlands
B-116	3/9/2018	15	29.25949	-98.47930	Wetlands
B-117	3/9/2018	15	29.26491	-98.48164	Wetlands
B-118	3/9/2018	15	29.26302	-98.47889	Wetlands
B-119	3/14/2018	15	29.26162	-98.47674	Wetlands
B-120	3/9/2018	15	29.26447	-98.47785	Wetlands
Groundwater was not encountered in the borings at the time of drilling.					

The borings were sampled using seamless push tubes for cohesive strata (ASTM D1587) and a split-barrel sampler while performing the Standard Penetration Test (SPT) (ASTM D1586).

Boring depths were measured from below the existing surface elevation at the time of drilling. A truck-mounted drill rig using dry and air rotary drilling methods together with the sampling tool noted was used to obtain samples. After completion of drilling, the boreholes were backfilled using the auger cuttings and bentonite mixture.

Detailed descriptions of subsurface conditions encountered in the borings are presented on the *Boring Logs* included in Appendix B. Sample type and interval are included on the individual soil boring logs at the respective sample depth. An Arias representative visually logged each recovered sample and selected representative samples for laboratory testing. *Site Photographs* of the drilling operation are presented in Appendix A, Figure 3.

SPT N-values for those intervals where the sampler was advanced for a 12-inch penetration after the initial 6-inch seating are shown on the individual boring logs included in Appendix B.

The GPS coordinates (horizontal datum NAD 83) obtained using a hand-held GPS device are shown on the boring logs and should be considered approximate. Drilling and groundwater notes, obtained at the time of boring, are also shown on the boring logs.

Soil classifications and borehole logging were conducted during the exploration by one of our field engineering technicians working under the supervision of our Geotechnical Engineer. Final soil classifications, as seen on the boring logs included in Appendix B, were determined in the laboratory based on laboratory and field test results and applicable ASTM procedures. The key to the terms and symbols used on the logs and the field test procedures is also included in Appendix B, following the boring logs.

LABORATORY TESTING

Arias performed soil mechanics laboratory tests on selected samples to aid in soil classification and to determine select engineering properties. The laboratory testing assignments were determined by Arias in general accordance with the proposed work scope. The test name and TxDOT or ASTM test methods are presented and summarized subsequently in Table 2:

Table 2: Laboratory Test Name, Method and Log Designation

Test Name	Test Method	Log Designation
Water (moisture) content of soil and rock by mass	ASTM D 2216	MC
Liquid limit, plastic limit and plasticity index of soils	ASTM D 4318	LL, PL, PI
Particle Size Analysis of Soils	ASTM D 422	--
Amount of Materials in Soils Finer than the (No. 200) Sieve	ASTM D 1140	-200
Multi-Stage Consolidated Undrained Triaxial Compression	ASTM D4767	--
Direct shear of soil under consolidated-drained conditions	ASTM D 3084	--
1-Dimensional Consolidation Properties of Soils Using Incremental Loading	ASTM D 2435	--
Hydraulic Conductivity	ASTM D5084	

The results of Atterberg Limits (ASTM D4318) and grain size analyses (ASTM D422), are shown on the boring logs at the respective sample depth, and presented in Appendix B. A Graphical presentation of the sieve analyses is presented in Appendix C. The results of the remaining tests are provided in the subsequent report sections and/or respective appendices of this report.

To evaluate one-dimensional (1-D) consolidation properties of the clay soils, incremental loading tests were performed on four (4) sample specimens in general accordance with ASTM D 2435. The results are presented as curves of vertical effective stress vs. axial strain in Appendix D.

To evaluate drained strength parameters, direct shear testing under consolidated drained testing was performed on four (4) recovered samples. The testing was performed on 3 separate specimens for each sample (i.e. multi-sample tests). Laboratory results for the direct shear testing are included in Appendix E.

To evaluate undrained shear strength parameters, multi-stage triaxial compression testing under consolidated-undrained conditions were performed on three (3) recovered samples. For each soil sample, the testing was performed on 3 separate specimens at 3 different confining stresses (i.e. multi-sample tests). The Laboratory results for the triaxial testing are included in Appendix F.

Falling-head hydraulic conductivity testing was performed on two (2) recovered samples in general accordance with ASTM D 2435. The tests were continued until a steady value of hydraulic conductivity was reached for each soil sample. Laboratory results for the hydraulic conductivity testing are included in Appendix G.

The soil laboratory testing for this project was done in accordance with applicable ASTM procedures with the specifications and definitions for these tests listed in Table 2. Remaining soil samples recovered from this exploration will be routinely discarded following submittal of this report.

SITE AND SUBSURFACE CONDITIONS

Geologic, generalized stratigraphic and groundwater conditions at the Project site are discussed in the following sections. The subsurface stratigraphic and groundwater conditions are based on conditions encountered at the boring locations at the time of exploration and to the depths explored.

Area Geology

According to the Geologic Map of Texas, San Antonio, the site is mapped as being underlain by the Fluviatile terrace deposits (Qt). Fluviatile terrace deposits are stream bed deposits typically consisting of clays, sands, silts, and gravels. Such deposits can contain point bars, cutbanks, oxbows, and abandoned channel segments associated with variations in stream bed activity. As a result, soil profiles in terrace deposit areas may vary greatly over relatively short distances. Key geotechnical engineering concerns for development supported on this formation are the expansive nature of the clays, the consistency or relative density of the deposits, and the absence/presence as well as thickness of potentially water-bearing gravels. Due to the alluvial nature of these deposits, significant variations can occur over short distances. A *Geologic Map* is presented on Figure 4 in Appendix A.

Site Stratigraphic and Engineering Properties

The general stratigraphic conditions at the boring locations are provided in Table 3. The presence and thickness of the various subsurface materials can be expected to vary away from and between the exploration locations. The descriptions conform to the Unified Soils Classification System.

Table 3: Generalized Subsurface Conditions and Engineering Properties

Stratum	Depth, ft.	Material Type	PI range	No. 200 range	PP Range, tsf	N range
FILL	0 – 6 to 6 – 11	Fill: Fat Clay (CH); Lean Clay, Sandy Lean Clay (CL); stiff to hard; dark to light brown, tan, gray; with trace gravel, trace calcareous deposits, ferrous stains	23 – 54	84 – 97	1.25 – 4.5+	11 – 48
CLAYEY MATERIAL	0 – 38 to 2 – 40	Fat Clay (CH); Lean Clay, Lean Clay with Sand, Sandy Lean Clay (CL); soft to hard; dark to light gray, dark to light brown, reddish brown, tan; with ferrous stains, sand seams (Not noted at B-108)	18 – 40	61 – 98	0.25 – 4.5+	10 – 50/3''
GRANULAR MATERIAL	0 – 4 to 4 – 15	Clayey Sand, Clayey Sand with Gravel (SC); loose to very dense; tan, brown; with calcareous nodules, ferrous stains (Noted at B-108 & B-109)	14 – 19	26 – 43	4.5+	10 – 50/2''

Where:

Depth	-	Depth from existing ground surface at the time of geotechnical study, feet
PI	-	Plasticity Index, %
-200	-	Percent passing U.S. Standard No. 200 sieve, %
N	-	Standard Penetration Test, N-value, in blows per foot (bpf)
PP	-	Pocket Penetrometer, tsf
UC	-	Unconfined Compressive Strength, tsf
Avg	-	Average value
Typ	-	Typical value
BTD	-	Boring Termination Depth

Soil conditions may vary between the sample boring locations. Transition boundaries or contacts, noted on the boring logs to separate soil types, are approximate. Actual contacts may be gradual and vary at different locations. If conditions encountered during construction indicate more variation than established as a result of this study, we should be contacted to evaluate the significance of the changed conditions relative to our recommendations.

Groundwater Occurrence.

A dry soil sampling method was used to obtain the soil samples. Groundwater was encountered during drilling only in borings B-101, B-105 and B-106. However, delayed water level readings taken after 24-hours indicated groundwater in borings B-101 through B-107, except for B-103. The groundwater levels observed in the borings during drilling and at completion of drilling or thereafter, are presented in Table 4.

Table 4: Water -Level Observations in boreholes

Boring No.	Depth Drilled, feet	Groundwater First Encountered	Groundwater at 24-hrs after Completion of drilling
		Depth, feet	Depth, feet
B-101	40	13.0	11.3
B-102	40	--	15.6
B-103	40	--	--
B-104	40	--	11.8
B-105	40	13.0	14.0
B-106	40	23.0	16.6
B-107	40	--	17.4

Granular soils (i.e. sand as well as sandy and/or gravelly soils) with the potential to store and transmit groundwater were encountered as part of this study. Although groundwater was encountered only in borings B-101, B-102 and B-104 through B-107 at the time of this study, it is possible that the more granular soils found may be water bearing at the time of construction. Groundwater levels should be verified immediately prior to construction.

Pockets or seams of calcareous deposits, gravel, sand, silt or open fractures and joints can retain and/or permit "perched" groundwater seepage. "Perched" groundwater flow or seepage may also occur at strata interfaces, particularly at clay/gravel, clay/sand, fill/natural soil and rock interfaces.

It should be noted that groundwater levels at the time of construction may differ from the observations obtained during the field exploration because perched groundwater is subject to seasonal conditions, recent rainfall, flooding, drought or temperature affects. Granular soils, such as sands and sandy soils, can readily transmit subsurface water. Groundwater levels should be verified immediately prior to construction.

The installation of temporary piezometers (observation wells) can be performed to obtain more accurate groundwater data. Additionally, pump and recharge tests can be performed using the piezometers to aid in estimating groundwater seepage rates. Subsurface water readings and seepage rates will generally provide an indication of groundwater conditions at that respective location and time. If needed, this information can be used to assist the contractor in developing construction dewatering plans. We should note that installing piezometers and performing groundwater testing was beyond our authorized scope of services for this project. We can provide these services if desired.

Due to the location of the proposed construction within a lake and floodplain area, the presence of groundwater should be anticipated during excavations. Both temporary and permanent groundwater controls will be necessary for proper embankment dam construction and suitable long-term performance. Temporary groundwater controls are typically the responsibility of the contractor and may consist of sumping and pumping and/or deep wells and well points.

GENERAL COMMENTS

This report was prepared as an instrument of service for this project exclusively for the use of Mr. Timothy Noack, P. E, Alan Plummer Associates, Inc. and their design team. If the development plans change relative to layout, size or anticipated loads or if different subsurface conditions are encountered, we should be informed and retained to ascertain the impact of these changes on our recommendations. We cannot be responsible for the potential impact of these changes if we are not informed.

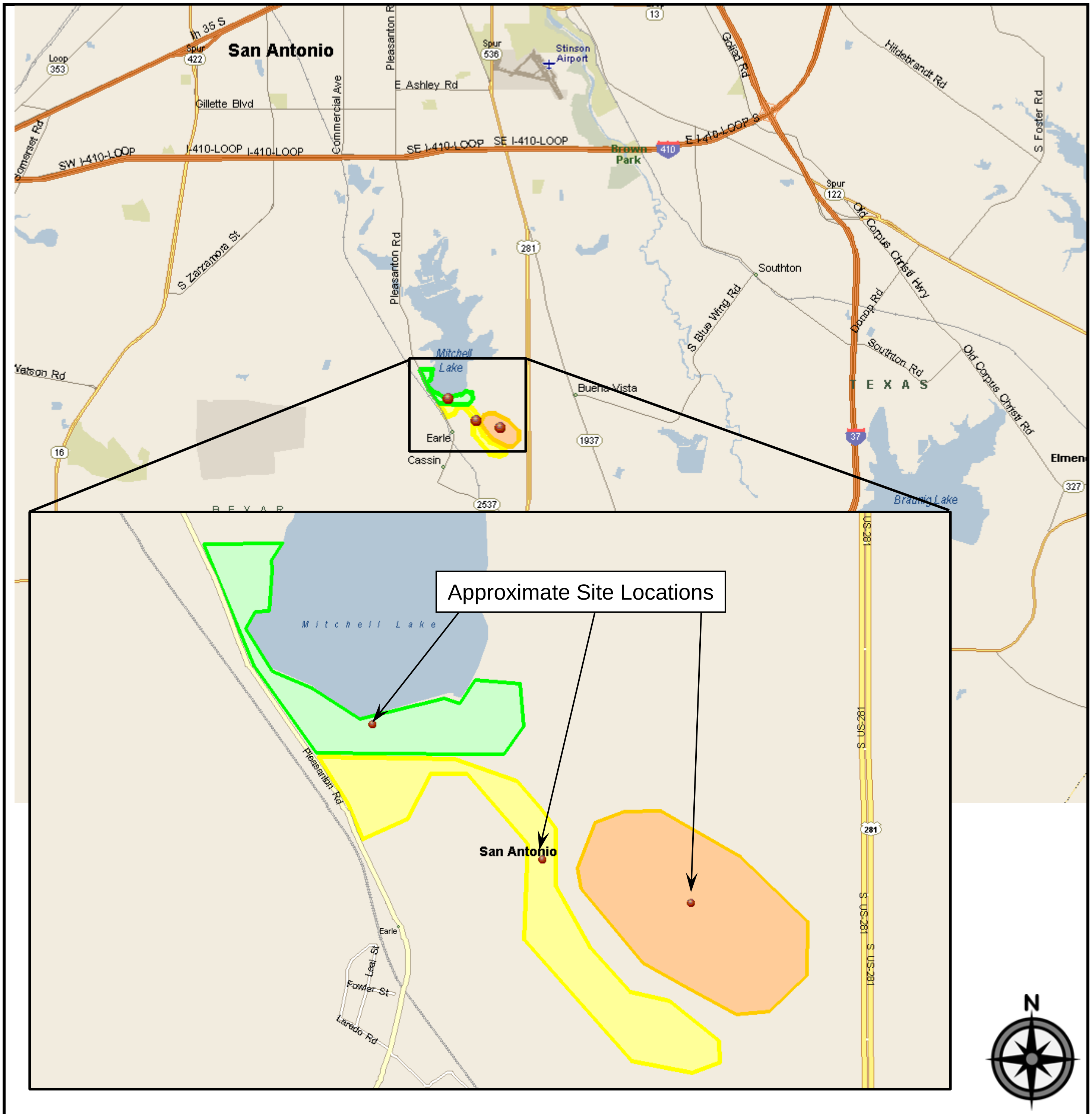
Subsurface Variations

Soil and groundwater conditions may vary between the sample boring locations. Transition boundaries or contacts, noted on the boring logs to separate soil/rock types, are approximate. Actual contacts may be gradual and vary at different locations. The contractor should verify that similar conditions exist throughout the proposed area of excavation. If different subsurface conditions or highly variable subsurface conditions are encountered during construction, we should be contacted to evaluate the significance of the changed conditions relative to our recommendations.

Standard of Care

Subject to the limitations inherent in the agreed scope of services as to the degree of care and amount of time and expenses to be incurred, and subject to any other limitations contained in the agreement for this work, Arias has performed its services consistent with that level of care and skill ordinarily exercised by other professional engineers practicing in the same locale and under similar circumstances at the time the services were performed. Information about this geotechnical report is provided in the ASFE publication included in Appendix H.

APPENDIX A: FIGURES



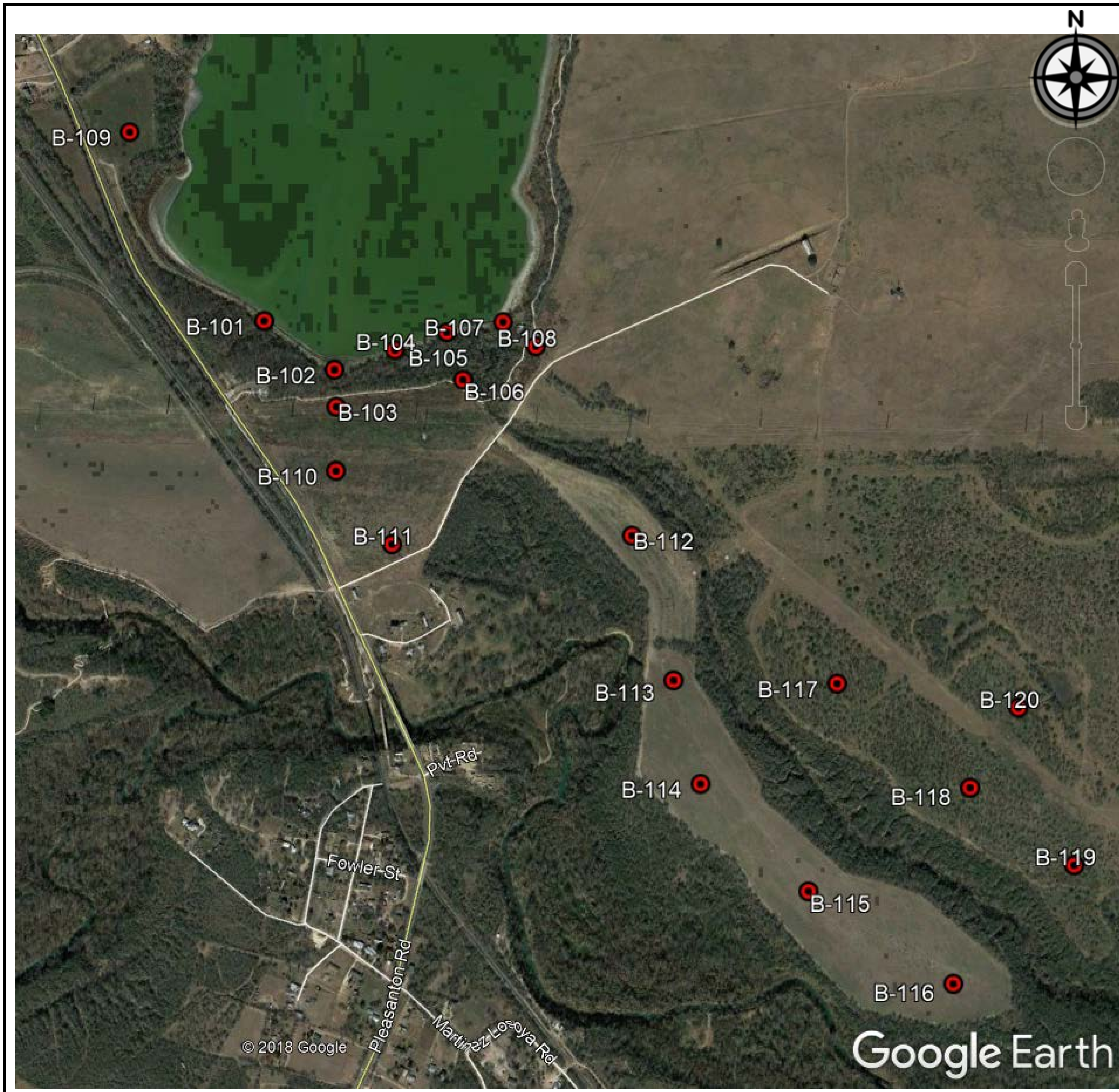
142 Chula Vista, San Antonio, Texas 78232
Phone: (210) 308-5884 • Fax: (210) 308-5886

VICINITY MAP

SAWS Mitchell Lake Wetland Project
San Antonio, Texas

Date: June 12, 2018	Job No.: 2017-698
Drawn By: RWL	Checked By: JDS
Approved By: CMS	Scale: N.T.S.

Figure 1



ARIAS GEOPROFESSIONALS

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BORING LOCATION PLAN

SAWS Mitchell Lake Wetland Project
San Antonio, Texas

Date: June 12, 2018	Job No.: 2017-698
Drawn By: SBS	Checked By: JDS
Approved By: CMS	Scale: N.T.S.

REVISIONS:

No.:	Date:	Description:

Figure 2

Photo 1 – View looking at Boring 103 drilling operations.

Photo 2 – View looking at Boring 105 drilling operations.

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142 Chula Vista, San Antonio, Texas 78232
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SITE PHOTOS

SAWS Mitchell Lake Wetland Project
San Antonio, Texas

Date: June 12, 2018	Job No.: 2017-698
Drawn By: RWL	Checked By: JDS
Approved By: CMS	Scale: N.T.S.

Appendix A

APPENDIX B: SOIL BORING LOGS AND KEY TO TERMS

Boring Log No. B-101

Project: **Mitchell Lake Wetland**
San Antonio, Texas

Location: See Boring Location Plan

Sampling Date: 1/23/18

Coordinates: N29°16'17.6" W98°29'36.8"

Backfill: Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	PP	N	-200
FILL: FAT CLAY (CH), very stiff, brown		SS	24					21	
- tan and gray below 2'		SS	23	24	78	54		23	97
- hard below 4'	5	T	23				4.5		
FILL: LEAN CLAY (CL), stiff, dark brown		T	24	18	47	29	2.0		95
	10	T	25				1.25		
FAT CLAY (CH), soft, dark gray, with ferrous stains		T	30	20	50	30	0.25		92
LEAN CLAY (CL), stiff, gray and brown	15	SS	23					12	
- very stiff from 18' to 20'	20	T	20	17	46	29	3.0		96
	25	T	23				1.0		
- very stiff below 28'	30	SS	27					30	

(continued)

Groundwater Data:
First encountered during drilling: 13-ft depth
After : 11.3-ft depth (30.3-ft open borehole depth)

Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: R. Arizola
Driller: Tero Drilling
Equipment: Truck-mounted drill rig
Single flight auger: 0 - 40 ft

Nomenclature Used on Boring Log

Split Spoon (SS) — Thin-walled tube (T)

▽ Water encountered during drilling
▼ Delayed water reading

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)
N = SPT Blow Count
-200 = % Passing #200 Sieve

Boring Log No. B-101 (continued)

Project: **Mitchell Lake Wetland**
San Antonio, Texas

Location: See Boring Location Plan

Sampling Date: 1/23/18

Coordinates: N29°16'17.6" W98°29'36.8"
Backfill: Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	PP	N	-200
LEAN CLAY (CL), stiff, gray and brown *(continued)*									
FAT CLAY (CH), very stiff, tan		T	20				3.25		
	35								
		T	21	18	50	32	3.5		97
	40								

Borehole terminated at 40 feet

Groundwater Data:
First encountered during drilling: 13-ft depth
After : 11.3-ft depth (30.3-ft open borehole depth)
Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: R. Arizola
Driller: Tero Drilling
Equipment: Truck-mounted drill rig
Single flight auger: 0 - 40 ft

Nomenclature Used on Boring Log

Split Spoon (SS)
Thin-walled tube (T)
Water encountered during drilling
Delayed water reading

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)
N = SPT Blow Count
-200 = % Passing #200 Sieve

2017-698.GPJ 5/31/18 (BORING LOG SA13-02,ARIASSA12-01.GDT,LIBRARY2013-01.GLB)

Boring Log No. B-102

Project: **Mitchell Lake Wetland**
San Antonio, Texas

Location: See Boring Location Plan

Sampling Date: 1/23/18

Coordinates: N29°16'14.4" W98°29'31.7"

Backfill: Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	PP	N	-200
FILL: LEAN CLAY (CL), very stiff to hard, brown, with trace gravel		SS	15					27	
		SS	15					28	
- with trace calcareous nodules from 4' to 6'	5	T	19	19	48	29	4.25		95
- becomes light brown with trace ferrous stains below 6'		T	19				4.5+		
		T	18				4.5+		
LEAN CLAY (CL), very stiff, dark gray and brown, with ferrous stains	10	SS	25	19	44	25		21	94
- firm from 13' to 15'		T	25				0.25		
	15								
- stiff from 18' to 30'		SS	27					15	
	20								
		T	25	16	40	24	1.0		94
	25								
- becomes gray and brown below 28'		T	21				1.5		
(continued)	30								

Groundwater Data:
During drilling: Not encountered
After : 15.6-ft depth (32.8-ft open borehole depth)
Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: R. Arizola
Driller: Tero Drilling
Equipment: Truck-mounted drill rig
Single flight auger: 0 - 40 ft

Nomenclature Used on Boring Log

Split Spoon (SS) | Thin-walled tube (T) | Delayed water reading

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)
N = SPT Blow Count
-200 = % Passing #200 Sieve

2017-698.GPJ 5/31/18 (BORING LOG SA13-02,ARIASSA12-01.GDT,LIBRARY2013-01.GLB)

Boring Log No. B-102 (continued)

Project: **Mitchell Lake Wetland**
San Antonio, Texas

Location: See Boring Location Plan

Sampling Date: 1/23/18

Coordinates: N29°16'14.4" W98°29'31.7"

Backfill: Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	PP	N	-200
LEAN CLAY (CL), very stiff, dark gray and brown, with ferrous stains *(continued)*	35	SS	25					30	
FAT CLAY (CH), very stiff, tan	40	T	24				3.0		

Borehole terminated at 40 feet

Groundwater Data:
During drilling: Not encountered
After : 15.6-ft depth (32.8-ft open borehole depth)
Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: R. Arizola
Driller: Tero Drilling
Equipment: Truck-mounted drill rig
Single flight auger: 0 - 40 ft

Nomenclature Used on Boring Log

Split Spoon (SS) Thin-walled tube (T)

Delayed water reading

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)
N = SPT Blow Count
-200 = % Passing #200 Sieve

Boring Log No. B-103

Project: **Mitchell Lake Wetland**
San Antonio, Texas

Location: See Boring Location Plan

Sampling Date: 1/19/18

Coordinates: N29°16'11.9" W98°29'31.5"

Backfill: Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	PP	N	-200
LEAN CLAY (CL), very stiff, brown to light brown		SS	22					24	
- hard below 2'		T	12				4.5+		
- becomes tan below 4.5'	5	T	13				4.5+		
		T	13	17	39	22	4.5+		95
- sandy from 8' to 12'		SS	17					30	
	10	SS	18					49	
- very stiff from 13' to 18'	15	T	20	17	39	22	2.5		96
- firm from 18' to 23'	20	T	24				0.75		
- stiff below 23'	25	SS	25					10	
FAT CLAY (CH), very stiff, tan	30	T					2.5		

(continued)

Groundwater Data:
During drilling: Not encountered

Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: R. Arizola
Driller: Tero Drilling
Equipment: Truck-mounted drill rig

Single flight auger: 0 - 38.8 ft

Nomenclature Used on Boring Log

Split Spoon (SS) Thin-walled tube (T)

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)

N = SPT Blow Count
** = Blow Counts During Seating Penetration
-200 = % Passing #200 Sieve

2017-698.GPJ 5/31/18 (BORING LOG SA13-02,ARIASSA12-01.GDT,LIBRARY2013-01.GLB)

Boring Log No. B-103 (continued)

Project: **Mitchell Lake Wetland**
San Antonio, Texas

Location: See Boring Location Plan

Sampling Date: 1/19/18

Coordinates: N29°16'11.9" W98°29'31.5"

Backfill: Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	PP	N	-200
FAT CLAY (CH), very stiff, tan *(continued)*									
- hard below 33', with gypsum crystals from 33' to 35'		T	20	18	54	36	4.25		97
	35								
		SS	21					**50/4"	
Borehole terminated at 38.8 feet									

Groundwater Data:
During drilling: Not encountered

Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: R. Arizola
Driller: Tero Drilling
Equipment: Truck-mounted drill rig

Single flight auger: 0 - 38.8 ft

Nomenclature Used on Boring Log

Split Spoon (SS)   Thin-walled tube (T)

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)

N = SPT Blow Count
** = Blow Counts During Seating Penetration
-200 = % Passing #200 Sieve

2017-698.GPJ 5/31/18 (BORING LOG SA13-02,ARIASSA12-01.GDT,LIBRARY2013-01.GLB)

Boring Log No. B-104

Project: **Mitchell Lake Wetland**
San Antonio, Texas

Sampling Date: 1/22/18

Coordinates: N29°16'15.7" W98°29'27.1"

Location: See Boring Location Plan

Backfill: Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	PP	N	-200
FILL: LEAN CLAY (CL), very stiff, brown, with trace gravel		SS	19					24	
- light brown below 2'		SS	13	19	44	25		26	93
- hard from 4' to 6'	5	T	13				4.5+		
		T	22				3.0		
- stiff below 8		T	21	18	45	27	1.5		88
- stiff from 10' to 15'	10	SS	26					11	
LEAN CLAY (CL), firm to stiff, dark gray									
- light gray below 13'		T	26	18	46	28	0.75		93
	15								
- very stiff to hard from 18'		SS	26					27	
	20								
		SS	23					37	
	25								
		T	27	16	43	27	1.0		94
(continued)	30								

Groundwater Data:
During drilling: Not encountered
After : 11.8-ft depth (30.3-ft open borehole depth)

Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: R. Arizola
Driller: Tero Drilling
Equipment: Truck-mounted drill rig
Single flight auger: 0 - 40 ft

Nomenclature Used on Boring Log

Split Spoon (SS)
Thin-walled tube (T)
Delayed water reading

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)
N = SPT Blow Count
-200 = % Passing #200 Sieve

2017-698.GPJ 5/31/18 (BORING LOG SA13-02,ARIASSA12-01.GDT,LIBRARY2013-01.GLB)

Boring Log No. B-104 (continued)

Project: **Mitchell Lake Wetland**
San Antonio, Texas

Location: See Boring Location Plan

Sampling Date: 1/22/18

Coordinates: N29°16'15.7" W98°29'27.1"

Backfill: Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	PP	N	-200
LEAN CLAY (CL), firm to stiff, dark gray *(continued)*									
- very stiff below 33'		T	21				3.0		
	35								
		T	18				3.25		
	40								

Borehole terminated at 40 feet

Groundwater Data:
During drilling: Not encountered
After : 11.8-ft depth (30.3-ft open borehole depth)
Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: R. Arizola
Driller: Tero Drilling
Equipment: Truck-mounted drill rig
Single flight auger: 0 - 40 ft

Nomenclature Used on Boring Log

Split Spoon (SS) | Thin-walled tube (T) | Delayed water reading

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)
N = SPT Blow Count
-200 = % Passing #200 Sieve

Boring Log No. B-105

Project: **Mitchell Lake Wetland**
San Antonio, Texas

Location: See Boring Location Plan

Sampling Date: 1/22/18

Coordinates: N29°16'16.9" W98°29'23.1"

Backfill: Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	PP	N	-200
FILL: LEAN CLAY (CL), very stiff, tan and gray, with trace gravel		SS	21					15	
- hard below 2'		SS	17					48	
FILL: LEAN CLAY (CL), hard, dark brown, with ferrous stains	5	T	15	16	42	26	4.5+		86
- becomes light brown and stiff below 7'		T	13				4.5+		
		T	18	17	40	23	2.0		84
LEAN CLAY (CL), stiff to very stiff, gray	10	T	23				1.75		
(water encountered during drilling ~13'; delayed water reading ~14')	15	SS	27	18	44	26		17	89
- hard below 18'	20	SS	20					69	
	25	T	20	18	52	34	4.5		95
(continued)	30	SS	20					86	

Groundwater Data:
First encountered during drilling: 13-ft depth
After : 14-ft depth (35.2-ft open borehole depth)

Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: R. Arizola
Driller: Tero Drilling
Equipment: Truck-mounted drill rig
Single flight auger: 0 - 40 ft

Nomenclature Used on Boring Log

Split Spoon (SS)   Thin-walled tube (T)

▽ Water encountered during drilling
▼ Delayed water reading

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)
N = SPT Blow Count
-200 = % Passing #200 Sieve

Boring Log No. B-105 (continued)

Project: **Mitchell Lake Wetland**
San Antonio, Texas

Location: See Boring Location Plan

Sampling Date: 1/22/18

Coordinates: N29°16'16.9" W98°29'23.1"

Backfill: Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	PP	N	-200
LEAN CLAY (CL), stiff to very stiff, gray *(continued)*									
FAT CLAY (CH), hard, tan, with trace calcareous deposits	35	SS	14					81/10"	
	40	SS	16					74	
Borehole terminated at 40 feet									

Groundwater Data:
First encountered during drilling: 13-ft depth
After : 14-ft depth (35.2-ft open borehole depth)

Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: R. Arizola
Driller: Tero Drilling
Equipment: Truck-mounted drill rig
Single flight auger: 0 - 40 ft

Nomenclature Used on Boring Log

Split Spoon (SS) | Thin-walled tube (T)

▽ Water encountered during drilling
▼ Delayed water reading

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)
N = SPT Blow Count
-200 = % Passing #200 Sieve

2017-698.GPJ 5/31/18 (BORING LOG SA13-02,ARIASSA12-01.GDT,LIBRARY2013-01.GLB)

Boring Log No. B-106

Project: **Mitchell Lake Wetland**
San Antonio, Texas

Location: See Boring Location Plan

Sampling Date: 1/23/18

Coordinates: N29°16'14.6" W98°29'22.7"

Backfill: Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	PP	N	-200
LEAN CLAY with Sand (CL), very stiff, brown		SS	17					25	
- becomes tan and hard below 2'		SS	10	16	40	24		39	81
	5	SS	13					42	
FAT CLAY (CH), hard, light brown		SS	12					79/11"	
		SS	14					50/5"	
	10	GB	10	17	57	40			97
	15	SS	19					45	
LEAN CLAY (CL), very stiff, tan		T	17				2.5		
	20								
- hard with calcareous deposits below 23'		T	17	14	43	29	4.0		89
	25								
		T	14				4.5		
(continued)	30								

Groundwater Data:
First encountered during drilling: 23-ft depth
After : 16.6-ft depth (27.3-ft open borehole depth)

Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: R. Arizola
Driller: Tero Drilling
Equipment: Truck-mounted drill rig
Single flight auger: 0 - 38.9 ft

Nomenclature Used on Boring Log

Split Spoon (SS)
Thin-walled tube (T)
Grab Sample (GB)
▽ Water encountered during drilling
▼ Delayed water reading

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)
N = SPT Blow Count
** = Blow Counts During Seating Penetration
-200 = % Passing #200 Sieve

Boring Log No. B-106 (continued)

Project: **Mitchell Lake Wetland**
San Antonio, Texas

Location: See Boring Location Plan

Sampling Date: 1/23/18

Coordinates: N29°16'14.6" W98°29'22.7"

Backfill: Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	PP	N	-200
LEAN CLAY (CL), very stiff, tan *(continued)*									
- stiff with sand from 33' to 36'		T	16	13	31	18	3.5		71
	35								
- hard and gravelly below 36'		SS	13					**50/5"	

Borehole terminated at 38.9 feet

Groundwater Data:
First encountered during drilling: 23-ft depth
After : 16.6-ft depth (27.3-ft open borehole depth)
Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: R. Arizola
Driller: Tero Drilling
Equipment: Truck-mounted drill rig
Single flight auger: 0 - 38.9 ft

Nomenclature Used on Boring Log

Split Spoon (SS)
Grab Sample (GB)
Thin-walled tube (T)
Water encountered during drilling
Delayed water reading

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)
N = SPT Blow Count
** = Blow Counts During Seating Penetration
-200 = % Passing #200 Sieve

2017-698.GPJ 5/31/18 (BORING LOG SA13-02,ARIASSA12-01.GDT,LIBRARY2013-01.GLB)

Boring Log No. B-107

Project: **Mitchell Lake Wetland**
San Antonio, Texas

Sampling Date: 1/22/18

Coordinates: N29°16'17.6" W98°29'18.9"

Location: See Boring Location Plan

Backfill: Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	PP	N	-200
FILL: SANDY LEAN CLAY (CL), hard, brown, with trace calcareous deposits		SS	12					32	
		SS	9					33	
	5	T	13				4.5+		
		T	12				4.5+		
		T	16	15	44	29	4.5+		61
SANDY LEAN CLAY (CL), very stiff, dark brown, with ferrous stains	10								
		SS	13					28	
- light gray, stiff with trace calcareous deposits from 13' to 18'		T	22	16	48	32	2.0		66
	15								
▼									
- soft and gray below 18'		T	24				0.25		
	20								
SANDY LEAN CLAY (CL), hard, brown, with ferrous stains		SS	29	16	40	24		50/5"	62
	25								
		SS	28					**50/5"	
(continued)	30								

Groundwater Data:
During drilling: Not encountered
After : 17.4-ft depth (25.7-ft open borehole depth)

Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: R. Arizola
Driller: Tero Drilling
Equipment: Truck-mounted drill rig
Single flight auger: 0 - 38.75 ft

Nomenclature Used on Boring Log

Split Spoon (SS) — Thin-walled tube (T) — ▼ Delayed water reading

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)

N = SPT Blow Count
** = Blow Counts During Seating Penetration
-200 = % Passing #200 Sieve

2017-698.GPJ 5/31/18 (BORING LOG SA13-02,ARIASSA12-01.GDT,LIBRARY2013-01.GLB)

Boring Log No. B-107 (continued)

Project: **Mitchell Lake Wetland**
San Antonio, Texas

Location: See Boring Location Plan

Sampling Date: 1/22/18

Coordinates: N29°16'17.6" W98°29'18.9"

Backfill: Cuttings

Soil Description	Depth (ft)		SN	WC	PL	LL	PI	PP	N	-200
SANDY LEAN CLAY (CL), hard, brown, with ferrous stains *(continued)*			SS	30					**50/4"	
	35		SS	27					**50/3"	
Borehole terminated at 38.75 feet										

Groundwater Data:
During drilling: Not encountered
After : 17.4-ft depth (25.7-ft open borehole depth)
Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: R. Arizola
Driller: Tero Drilling
Equipment: Truck-mounted drill rig
Single flight auger: 0 - 38.75 ft

Nomenclature Used on Boring Log

Split Spoon (SS) — Thin-walled tube (T) — Delayed water reading

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)

N = SPT Blow Count
** = Blow Counts During Seating Penetration
-200 = % Passing #200 Sieve

2017-698.GPJ 5/31/18 (BORING LOG SA13-02,ARIASSA12-01.GDT,LIBRARY2013-01.GLB)

Boring Log No. B-108

Project: **Mitchell Lake Wetland**
San Antonio, Texas

Location: See Boring Location Plan

Sampling Date: 3/14/18

Coordinates: N29°16'15.7" W98°29'16.2"

Backfill: Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	PP	N	-200
CLAYEY SAND with Gravel (SC), brown		T	12	15	30	15	4.5+		26
- very dense below 2'		T SS	9					**50/2"	
CLAYEY SAND (SC), tan and brown, with calcareous nodules	5	T	8	15	34	19	4.5+		43
		T	5						
- loose from 8' to 10'		SS	13					10	
- with ferrous stains below 10'	10	T	9	18	32	14			37
- dense below 13'		SS	15					37	
	15								

Borehole terminated at 15 feet

Groundwater Data:
During drilling: Not encountered

Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: J. Ramos
Driller: Eagle Drilling, Inc.
Equipment: Truck-mounted drill rig

Single flight auger: 0 - 15 ft

Nomenclature Used on Boring Log

Thin-walled tube (T) | Split Spoon (SS)

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)

N = SPT Blow Count
** = Blow Counts During Seating Penetration
-200 = % Passing #200 Sieve

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Boring Log No. B-109

Project: **Mitchell Lake Wetland**
San Antonio, Texas

Location: See Boring Location Plan

Sampling Date: 1/22/18

Coordinates: N29°16'30.3" W98°29'47.2"

Backfill: Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	N	-200
LEAN CLAY (CL), very stiff, brown		SS	12				22	
CLAYEY SAND with Gravel (SC), very dense, brown		SS	6				**50/5"	
	5	SS	3				50/5"	
		SS	5	15	32	17	**50/2"	42
LEAN CLAY with Sand (CL), hard, tan, with trace calcareous deposits and ferrous stains		SS	16				47	
	10	SS	18	18	42	24	81	74
		SS	19				50/5"	

Borehole terminated at 14.5 feet

Groundwater Data:
During drilling: Not encountered

Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: R. Arizola
Driller: Tero Drilling
Equipment: Truck-mounted drill rig

Single flight auger: 0 - 14.5 ft

Nomenclature Used on Boring Log

Split Spoon (SS)

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
N = SPT Blow Count

** = Blow Counts During Seating Penetration
-200 = % Passing #200 Sieve

2017-698.GPJ 5/31/18 (BORING LOG SA13-02,ARIASSA12-01.GDT,LIBRARY2013-01.GLB)

Boring Log No. B-110

Project: **Mitchell Lake Wetland**
San Antonio, Texas

Location: See Boring Location Plan

Sampling Date: 3/9/18

Coordinates: N29°16'7.6" W98°29'31.6"

Backfill: Cuttings

Soil Description	Depth (ft)		SN	WC	PL	LL	PI	PP	N	-200	DD	Uc
FAT CLAY (CH), hard, dark brown			T	18	18	50	32	4.5+		95		
LEAN CLAY (CL), hard, brown			T	13				4.5+				
	5		T	12	17	47	30	4.5+		95		
with trace calcareous deposits			SS	13					42			
			SS	15					24			
	10		T	15	18	42	24	4.5+		95	109	5.59 (9)
			T	18				4				
	15											

Borehole terminated at 15 feet

Groundwater Data:
During drilling: Not encountered

Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: J. Ramos
Driller: Eagle Drilling, Inc.
Equipment: Truck-mounted drill rig

Single flight auger: 0 - 15 ft

Nomenclature Used on Boring Log

Thin-walled tube (T) Split Spoon (SS)

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)

N = SPT Blow Count
-200 = % Passing #200 Sieve
DD = Dry Density (pcf)
Uc = Compressive Strength (tsf)

Boring Log No. B-111

Project: **Mitchell Lake Wetland**
San Antonio, Texas

Sampling Date: 3/9/18

Coordinates: N29°16'2.8" W98°29'27.3"

Location: See Boring Location Plan

Backfill: Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	PP	-200
LEAN CLAY (CL), hard, dark brown		T	15				4.5+	
- brown below 2'		T	13	19	43	24	4.5+	95
	5	T	12				4.5+	
		T	12	18	43	25	4.5+	96
		T	14				4.5+	
	10	T	16				4.5+	
		T	15				4.5+	
	15							

Borehole terminated at 15 feet

Groundwater Data:
During drilling: Not encountered

Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: J. Ramos
Driller: Eagle Drilling, Inc.
Equipment: Truck-mounted drill rig

Single flight auger: 0 - 15 ft

Nomenclature Used on Boring Log

■ Thin-walled tube (T)

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)
-200 = % Passing #200 Sieve

Boring Log No. B-112

Project: **Mitchell Lake Wetland**
San Antonio, Texas

Location: See Boring Location Plan

Sampling Date: 3/9/18

Coordinates: N29°16'3.4" W98°29'9.2"
Backfill: Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	PP	-200	DD	Uc
LEAN CLAY (CL), hard, dark brown to brown		T	18	17	46	29	4.5+	90		
- brown below 2'		T	11				4.5+			
	5	T	11				4.5+			
		T	12				4.5+			
		T	14	17	44	27	4.5+	98	109	9.13 (8)
	10	T	16				4.5+			
	15	T	18				4.5+			

Borehole terminated at 15 feet

Groundwater Data:
During drilling: Not encountered

Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: J. Ramos
Driller: Eagle Drilling, Inc.
Equipment: Truck-mounted drill rig

Single flight auger: 0 - 15 ft

Nomenclature Used on Boring Log

■ Thin-walled tube (T)

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)
-200 = % Passing #200 Sieve
DD = Dry Density (pcf)
Uc = Compressive Strength (tsf)

Boring Log No. B-113

Project: **Mitchell Lake Wetland**
San Antonio, Texas

Location: See Boring Location Plan

Sampling Date: 3/9/18

Coordinates: N29°15'53.9" W98°29'6.1"

Backfill: Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	PP	-200	DD	Uc
LEAN CLAY (CL), very stiff to hard, dark brown		T	16				4.0			
		T	12				4.5+			
	5	T	13	16	48	32	4.5+	95		
- brown below 6'		T	15				4.5+			
	10	T	15				4.5+			
FAT CLAY (CH), hard, light brown		T	17	17	50	33	4.5+	97	107	5.76 (9)
	15	T	20				4.5+			

Borehole terminated at 15 feet

Groundwater Data:
During drilling: Not encountered

Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: J. Ramos
Driller: Eagle Drilling, Inc.
Equipment: Truck-mounted drill rig

Single flight auger: 0 - 15 ft

Nomenclature Used on Boring Log

■ Thin-walled tube (T)

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)
-200 = % Passing #200 Sieve
DD = Dry Density (pcf)
Uc = Compressive Strength (tsf)

2017-698.GPJ 5/31/18 (BORING LOG SA13-02,ARIASSA12-01.GDT,LIBRARY2013-01.GLB)

Boring Log No. B-114

Project: **Mitchell Lake Wetland San Antonio, Texas**	Sampling Date: 3/9/18	
	Coordinates:	N29°15'47" W98°29'4.2"
Location: See Boring Location Plan	Backfill:	Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	PP	-200	DD	Uc
LEAN CLAY with Sand (CL), very stiff to hard, dark brown to brown		T	17	15	33	18	4.0	70		
		T	13				4.5+			
- with calcareous deposits below 4'	5	T	14				4.5+			
LEAN CLAY (CL), hard, light brown, with calcareous deposits		T	16				4.5+	85		
- very stiff from 8' to 10', tan brown below 8'		T	15	15	44	29	4.5+	97	107	2.35 (8)
	10	T	14				4.5+			
		T	10				4.5+			
	15									

Borehole terminated at 15 feet

Groundwater Data:
During drilling: Not encountered

Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: J. Ramos
Driller: Eagle Drilling, Inc.
Equipment: Truck-mounted drill rig

Single flight auger: 0 - 15 ft

Nomenclature Used on Boring Log

■ Thin-walled tube (T)

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)
-200 = % Passing #200 Sieve
DD = Dry Density (pcf)
Uc = Compressive Strength (tsf)

Boring Log No. B-115

Project: **Mitchell Lake Wetland**
San Antonio, Texas

Sampling Date: 3/9/18

Coordinates: N29°15'40.1" W98°28'56.2"

Location: See Boring Location Plan

Backfill: Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	PP	-200	DD	Uc
LEAN CLAY (CL), very stiff, dark brown		T	19				3.5			
		T	16	18	46	28	4.5+	86	98	3.44 (3)
- hard below 4'	5	T	15				4.5+			
		T	15				4.5+			
- brown below 8'		T	17	17	42	25	4.5+	96		
	10	T	18				4.5+			
	15	T	18				4.5+			

Borehole terminated at 15 feet

Groundwater Data:
During drilling: Not encountered

Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: J. Ramos
Driller: Eagle Drilling, Inc.
Equipment: Truck-mounted drill rig

Single flight auger: 0 - 15 ft

Nomenclature Used on Boring Log

■ Thin-walled tube (T)

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)

-200 = % Passing #200 Sieve
DD = Dry Density (pcf)
Uc = Compressive Strength (tsf)

Boring Log No. B-116

Project: **Mitchell Lake Wetland**
San Antonio, Texas

Location: See Boring Location Plan

Sampling Date: 3/9/18

Coordinates: N29°15'34.2" W98°28'45.5"

Backfill: Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	PP	-200	DD	Uc
LEAN CLAY (CL), hard, dark brown		T	17				4.5+			
- brown below 2'		T	19	19	50	31	4.5+	94		
	5	T	15				4.5+			
		T	18	16	46	30	4.5+	98		
		T	20				4.5+			
	10	T	19				4.5+			
	15	T	18	17	45	28	4	93	111	4.95 (12)

Borehole terminated at 15 feet

Groundwater Data:
During drilling: Not encountered

Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: J. Ramos
Driller: Eagle Drilling, Inc.
Equipment: Truck-mounted drill rig

Single flight auger: 0 - 15 ft

Nomenclature Used on Boring Log

■ Thin-walled tube (T)

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)

-200 = % Passing #200 Sieve
DD = Dry Density (pcf)
Uc = Compressive Strength (tsf)

Boring Log No. B-117

Project: **Mitchell Lake Wetland**
San Antonio, Texas

Sampling Date: 3/9/18

Coordinates: N29°15'53.6" W98°28'53.9"

Location: See Boring Location Plan

Backfill: Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	PP	N	-200
LEAN CLAY (CL), very stiff, dark brown		T	15				3.75		
SANDY LEAN CLAY (CL), hard, reddish brown		T	10	12	37	25	4.5+		52
- with calcareous deposits from 4' to 6'	5	T	8				4.5+		
		T	8				4.5+		
		SS	6	12	29	17		33	67
	10	SS	8					44	
	15	SS	7					49	

Borehole terminated at 15 feet

Groundwater Data:
During drilling: Not encountered

Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: J. Ramos
Driller: Eagle Drilling, Inc.
Equipment: Truck-mounted drill rig

Single flight auger: 0 - 15 ft

Nomenclature Used on Boring Log

Thin-walled tube (T) Split Spoon (SS)

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)
N = SPT Blow Count
-200 = % Passing #200 Sieve

Boring Log No. B-118

Project: **Mitchell Lake Wetland**
San Antonio, Texas

Location: See Boring Location Plan

Sampling Date: 3/9/18

Coordinates: N29°15'47" W98°28'43.3"

Backfill: Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	PP	N	-200
LEAN CLAY (CL), hard, dark brown		T	15	15	40	25	4.5+		87
LEAN CLAY (CL), hard, brown, with trace calcareous deposits		T	11				4.5+		
	5	T	10	15	43	28	4.5+		80
FAT CLAY (CH), hard, brown		SS	12					36	
		SS	12					49	
	10	SS	12	16	55	39		39	94
		SS	13					44	
	15								

Borehole terminated at 15 feet

Groundwater Data:
During drilling: Not encountered

Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: J. Ramos
Driller: Eagle Drilling, Inc.
Equipment: Truck-mounted drill rig

Single flight auger: 0 - 15 ft

Nomenclature Used on Boring Log

Thin-walled tube (T)   Split Spoon (SS)

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)

N = SPT Blow Count
-200 = % Passing #200 Sieve

2017-698.GPJ 5/31/18 (BORING LOG SA13-02,ARIASSA12-01.GDT,LIBRARY2013-01.GLB)

Boring Log No. B-119

Project: **Mitchell Lake Wetland**
San Antonio, Texas

Sampling Date: 3/14/18

Coordinates: N29°15'41.7" W98°28'36.3"

Location: See Boring Location Plan

Backfill: Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	PP	-200	DD	Uc
LEAN CLAY with Sand (CL), hard, dark brown		T	19				4.5+			
- brown below 2'		T	14	21	47	26	4.5+	82	120	12.13 (3)
	5	T	12				4.5+			
		T	13				4.5+			
LEAN CLAY (CL), hard, brown		T	15	21	49	28	4.5+	98		
	10	T	15				4.5+			
		T	14				4.5+			
	15									

Borehole terminated at 15 feet

Groundwater Data:
During drilling: Not encountered

Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: J. Ramos
Driller: Eagle Drilling, Inc.
Equipment: Truck-mounted drill rig

Single flight auger: 0 - 15 ft

Nomenclature Used on Boring Log

■ Thin-walled tube (T)

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)
-200 = % Passing #200 Sieve
DD = Dry Density (pcf)
Uc = Compressive Strength (tsf)

2017-698.GPJ 5/31/18 (BORING LOG SA13-02,ARIASSA12-01.GDT,LIBRARY2013-01.GLB)

Boring Log No. B-120

Project: **Mitchell Lake Wetland**
San Antonio, Texas

Location: See Boring Location Plan

Sampling Date: 3/9/18

Coordinates: N29°15'52.1" W98°28'40.3"

Backfill: Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	PP	N	-200
FAT CLAY with Sand (CH), very stiff, dark brown		T	20				3.75		
- hard with sand below 2'		T	13	17	51	34	4.5+		79
	5	T	13				4.5+		
SANDY LEAN CLAY (CL), hard, reddish brown		T	8	14	30	16	4.5+		54
		T	9				4.5+		
	10	T	10				4.5+		
- gray below 11'									
		SS	11	15	44	29		30	60
- sand seam at 14.5'	15								

Borehole terminated at 15 feet

Groundwater Data:
During drilling: Not encountered

Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: J. Ramos
Driller: Eagle Drilling, Inc.
Equipment: Truck-mounted drill rig

Single flight auger: 0 - 15 ft

Nomenclature Used on Boring Log

Thin-walled tube (T) Split Spoon (SS)

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)

N = SPT Blow Count
-200 = % Passing #200 Sieve

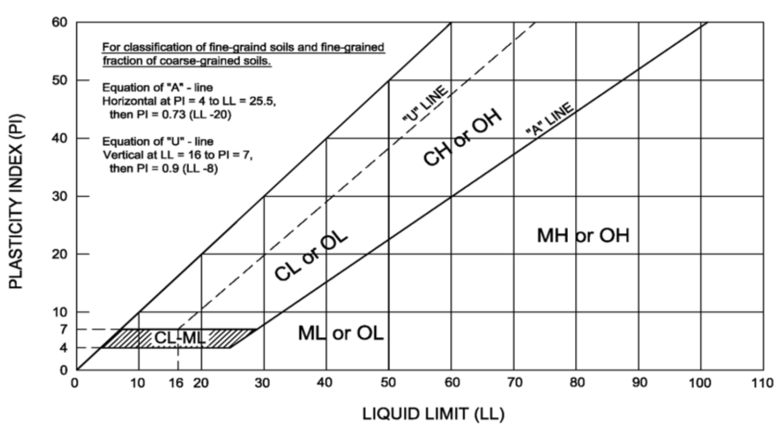
KEY TO TERMS AND SYMBOLS USED ON BORING LOGS

MAJOR DIVISIONS					GROUP SYMBOLS	DESCRIPTIONS
COARSE-GRAINED SOILS	More than half of material LARGER than No. 200 Sieve size	GRAVELS	More than Half of Coarse fraction is LARGER than No. 4 Sieve size	Clean Gravels (little or no Fines)	GW	Well-Graded Gravels, Gravel-Sand Mixtures, Little or no Fines
					GP	Poorly-Graded Gravels, Gravel-Sand Mixtures, Little or no Fines
				Gravels with Fines (Appreciable amount of Fines)	GM	Silty Gravels, Gravel-Sand-Silt Mixtures
					GC	Clayey Gravels, Gravel-Sand-Clay Mixtures
		SANDS	More than half of Coarse fraction is SMALLER than No. 4 Sieve size	Clean Sands (little or no Fines)	SW	Well-Graded Sands, Gravelly Sands, Little or no Fines
					SP	Poorly-Graded Sands, Gravelly Sands, Little or no Fines
				Sands with Fines (Appreciable amount of Fines)	SM	Silty Sands, Sand-Silt Mixtures
					SC	Clayey Sands, Sand-Clay Mixtures
FINE-GRAINED SOILS	More than half of material SMALLER than No. 200 Sieve size	SILTS & CLAYS		Liquid Limit less than 50	ML	Inorganic Silts & Very Fine Sands, Rock Flour, Silty or Clayey Fine Sands or Clayey Silts with Slight Plasticity
					CL	Inorganic Clays of Low to Medium Plasticity, Gravelly Clays, Sandy Clays, Silty Clays, Lean Clays
		SILTS & CLAYS		Liquid Limit greater than 50	MH	Inorganic Silts, Micaceous or Diatomaceous Fine Sand or Silty Soils, Elastic Silts
					CH	Inorganic Clays of High Plasticity, Fat Clays
FORMATIONAL MATERIALS		SANDSTONE				Massive Sandstones, Sandstones with Gravel Clasts
		MARLSTONE				Indurated Argillaceous Limestones
		LIMESTONE				Massive or Weakly Bedded Limestones
		CLAYSTONE				Mudstone or Massive Claystones
		CHALK				Massive or Poorly Bedded Chalk Deposits
		MARINE CLAYS				Cretaceous Clay Deposits
		GROUNDWATER			▼	Indicates Final Observed Groundwater Level
					▽	Indicates Initial Observed Groundwater Location

Density of Granular Soils	
Number of Blows per ft., N	Relative Density
0 - 4	Very Loose
4 - 10	Loose
10 - 30	Medium
30 - 50	Dense
Over 50	Very Dense

Consistency and Strength of Cohesive Soils		
Number of Blows per ft., N	Consistency	Unconfined Compressive Strength, q_u (tsf)
Below 2	Very Soft	Less than 0.25
2 - 4	Soft	0.25 - 0.5
4 - 8	Medium (Firm)	0.5 - 1.0
8 - 15	Stiff	1.0 - 2.0
15 - 30	Very Stiff	2.0 - 4.0
Over 30	Hard	Over 4.0

PLASTICITY CHART (ASTM D 2487-11)



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KEY TO TERMS AND SYMBOLS USED ON BORING LOGS

TABLE 1 Soil Classification Chart (ASTM D 2487-11)

Criteria of Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification: Group Symbol	Soil Classification: 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[D]	GW	Well-Graded Gravel[E]
			Cu < 4 and/or [Cc < or Cc > 3][D]	GP	Poorly-Graded Gravel[E]
		Gravels with Fines (More than 12% fines[C])	Fines classify as ML or MH	GM	Silty Gravel[E,F,G]
			Fines classify as CL or CH	GC	Clayey Gravel[E,F,G]
	Sands (50% or more of coarse fraction passes No. 4 sieve)	Clean Sands (Less than 5% fines[H])	Cu ≥ 6 and 1 ≤ Cc ≤ 3[D]	SW	Well-Graded Sand[I]
			Cu < 6 and/or [Cc < or Cc > 3][D]	SP	Poorly-Graded Sand[I]
		Sands with Fines (More than 12% fines[H])	Fines classify as ML or MH	SM	Silty Sand[F,G,I]
			Fines classify as CL or CH	SC	Clayey Sand[F,G,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) / (Liquid limit - not dried) <0.75	OL	Organic Clay[K,L,M,N] Organi 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 on or below "A" line	MH	Elastic Silt[K,L,M]
		organic	(Liquid limit - oven dried) / (Liquid limit - not dried) <0.75	OH	Organic Clay[K,L,M,P] 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 (75mm) 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] $Cu = D_{60}/D_{10}$ $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
[E] If soil contains ≥ 15% sand, add "with sand" to group name
[F] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM
[G] If fines are organic, add "with organic fines" to group name
[H] Sand 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
[I] If soil contains ≥ 15% gravel, add "with gravel" to group name
[J] If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay
[K] If soil contains 15% to < 30% 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

TERMINOLOGY

Boulders	Over 12-inches (300mm)
Cobbles	12-inches to 3-inches (300mm to 75mm)
Gravel	3-inches to No. 4 sieve (75mm to 4.75mm)
Sand	No. 4 sieve to No. 200 sieve (4.75mm to 0.075mm)
Silt or Clay	Passing No. 200 sieve (0.075mm)
Calcareous	Containing appreciable quantities of calcium carbonate, generally nodular

Parting	Inclusion < 1/8-inch thick extending through samples
Seam	Inclusion 1/8-inch to 3-inches thick extending through sample
Layer	Inclusion > 3-inches thick extending through sample

Stratified	Alternating layers of varying material or color with layers at least 6mm thick
Laminated	Alternating layers of varying material or color with the layers less than 6mm thick
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay
Homogeneous	Same color and appearance throughout

KEY TO TERMS AND SYMBOLS USED ON BORING LOGS

Hardness Classification of Intact Rock

Class	Hardness	Field Test		Approximate Range of Uniaxial Compression Strength kg/cm² (tons/ft²)
I	Extremely hard	Many blows with geologic hammer required to break intact specimen.		> 2,000
II	Very hard	Hand held specimen breaks with hammer end of pick under more than one blow.		2,000 – 1,000
III	Hard	Cannot be scraped or pealed with knife, hand held specimen can be broken with single moderate blow with pick.		1,000 – 500
IV	Soft	Can just be scraped or peeled with knife. Indentations 1mm to 3mm show in specimen with moderate blow with pick.		500 – 250
V	Very soft	Material crumbles under moderate blow with sharp end of pick and can be peeled with a knife, but is too hard to hand-trim for triaxial test specimen.		250 – 10

Rock Weathering Classifications

Grade	Symbol	Diagnostic Features
Fresh	F	No visible sign of Decomposition or discoloration. Rings under hammer impact.
Slightly Weathered	WS	Slight discoloration inwards from open fractures, otherwise similar to F.
Moderately Weathered	WM	Discoloration throughout. Weaker minerals such as feldspar decomposed. Strength somewhat less than fresh rock, but cores cannot be broken by hand or scraped by knife. Texture preserved.
Highly Weathered	WH	Most minerals somewhat decomposed. Specimens can be broken by hand with effort or shaved with knife. Core stones present in rock mass. Texture becoming indistinct, but fabric preserved.
Completely Weathered	WC	Minerals decomposed to soil, but fabric and structure preserved (Saprolite). Specimens easily crumbled or penetrated.
Residual Soil	RS	Advanced state of decomposition resulting in plastic soils. Rock fabric and structure completely destroyed. Large volume change.

Rock Discontinuity Spacing

Description for Structural Features: Bedding, Foliation, or Flow Banding	Spacing	Description for Joints, Faults or Other Fractures
Very thickly (bedded, foliated, or banded)	More than 6 feet	Very widely (fractured or jointed)
Thickly	2 – 6 feet	Widely
Medium	8 – 24 inches	Medium
Thinly	2½ – 8 inches	Closely
Very thinly	¾ – 2½ inches	Very closely
Description for Micro-Structural Features: Lamination, Foliation, or Cleavage	**Spacing**	**Descriptions for Joints, Faults, or Other Fractures**
Intensely (laminated, foliated, or cleaved)	¼ – ¾ inch	Extremely close
Very intensely	Less than ¼ inch	

Engineering Classification for in Situ Rock Quality

RQD %	Velocity Index	Rock Mass Quality
90 – 100	0.80 – 1.00	Excellent
75 – 90	0.60 – 0.80	Good
50 – 75	0.40 – 0.60	Fair
25 – 50	0.20 – 0.40	Poor
0 – 25	0 – 0.20	Very Poor

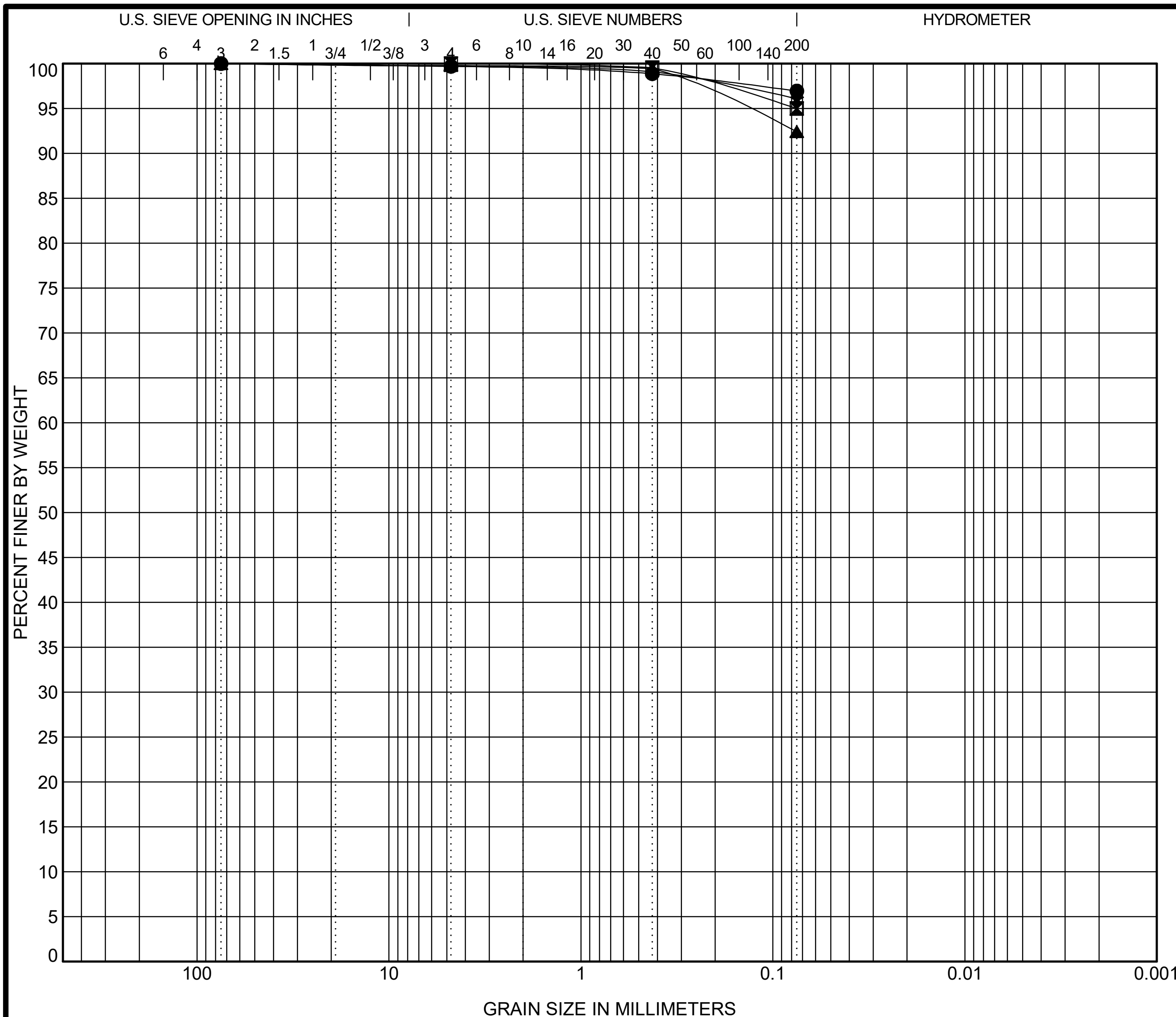
APPENDIX C: LABORATORY AND FIELD TEST PROCEDURES

FIELD EXPLORATION PROCEDURES

The field exploration program included drilling at selected locations within the site and intermittently sampling the encountered materials. The boreholes were drilled using either single flight auger (ASTM D 1452) or hollow-stem auger (ASTM D 6151). Samples of encountered materials were obtained using a split-barrel sampler while performing the Standard Penetration Test (ASTM D 1586), or by taking material from the auger as it was advanced (ASTM D 1452). The sample depth interval and type of sampler used is included on the soil boring log. Arias' field representative visually logged each recovered sample and placed a portion of the recovered sampled into a plastic bag for transport to our laboratory.

SPT N values and blow counts for those intervals where the sampler could not be advanced for the required 18-inch penetration are shown on the soil boring log. If the test was terminated during the 6-inch seating interval or after 10 hammer blows were applied used and no advancement of the sampler was noted, the log denotes this condition as blow count during seating penetration. Penetrometer readings recorded for thin-walled tube samples that remained intact also are shown on the soil boring log.

APPENDIX D: SIEVE ANALYSIS TEST RESULTS



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring	Elev	Depth	Classification	LL	PL	PI	Cc	Cu
●	**101**		**2.5**	**FAT CLAY (CH)**	**78**	**24**	**54**		
⧗	**101**		**6.0**	**LEAN CLAY (CL)**	**47**	**18**	**29**		
▲	**101**		**10.0**	**FAT CLAY (CH)**	**50**	**20**	**30**		
★	**101**		**18.0**	**LEAN CLAY (CL)**	**46**	**17**	**29**		

	Boring	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**101**	**2.5**	**75**				**0.3**	**2.7**	**96.9**	
⧗	**101**	**6.0**	**4.75**				**0.0**	**5.0**	**95.0**	
▲	**101**	**10.0**	**75**				**0.2**	**7.4**	**92.4**	
★	**101**	**18.0**	**75**				**0.3**	**3.6**	**96.1**	

Silt and clay fractions were determined using 0.002 mm as the maximum particle size for clay.

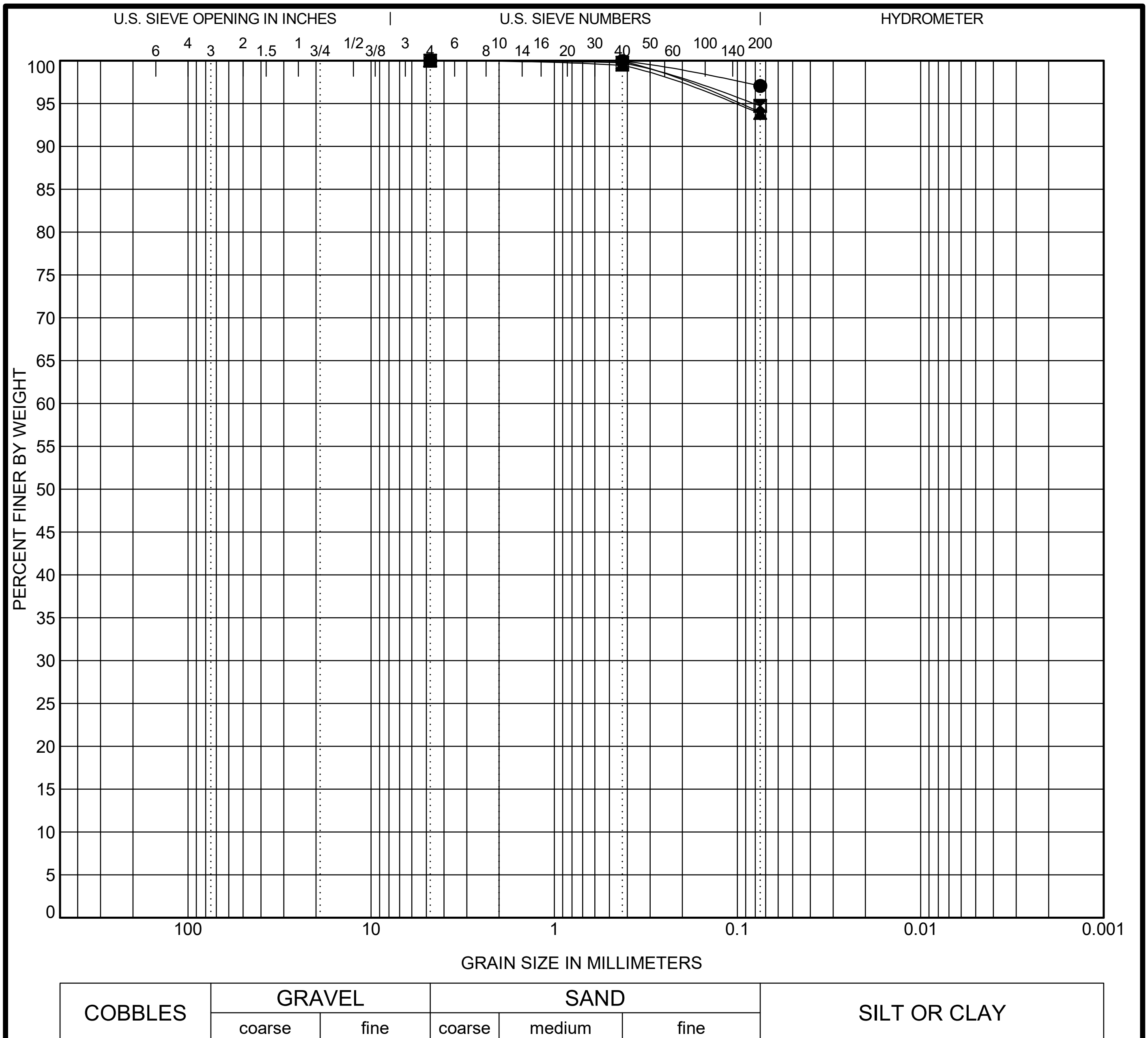
142 Chula Vista Drive
San Antonio, Texas 78232
Phone: (210) 308-5884

GRAIN SIZE DISTRIBUTION

Project: Mitchell Lake Wetland

Location: See Boring Location Plan

Job No.: 2017-698



	Boring	Elev	Depth	Classification	LL	PL	PI	Cc	Cu
●	**101**		**38.0**	**FAT CLAY (CH)**	**50**	**18**	**32**		
⧗	**102**		**4.0**	**LEAN CLAY (CL)**	**48**	**19**	**29**		
▲	**102**		**10.0**	**LEAN CLAY (CL)**	**44**	**19**	**25**		
★	**102**		**23.0**	**LEAN CLAY (CL)**	**40**	**16**	**24**		

	Boring	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**101**	**38.0**	**4.75**				**0.0**	**3.0**	**97.0**	
⧗	**102**	**4.0**	**4.75**				**0.0**	**5.3**	**94.7**	
▲	**102**	**10.0**	**4.75**				**0.0**	**6.2**	**93.8**	
★	**102**	**23.0**	**4.75**				**0.0**	**6.0**	**94.0**	

Silt and clay fractions were determined using 0.002 mm as the maximum particle size for clay.

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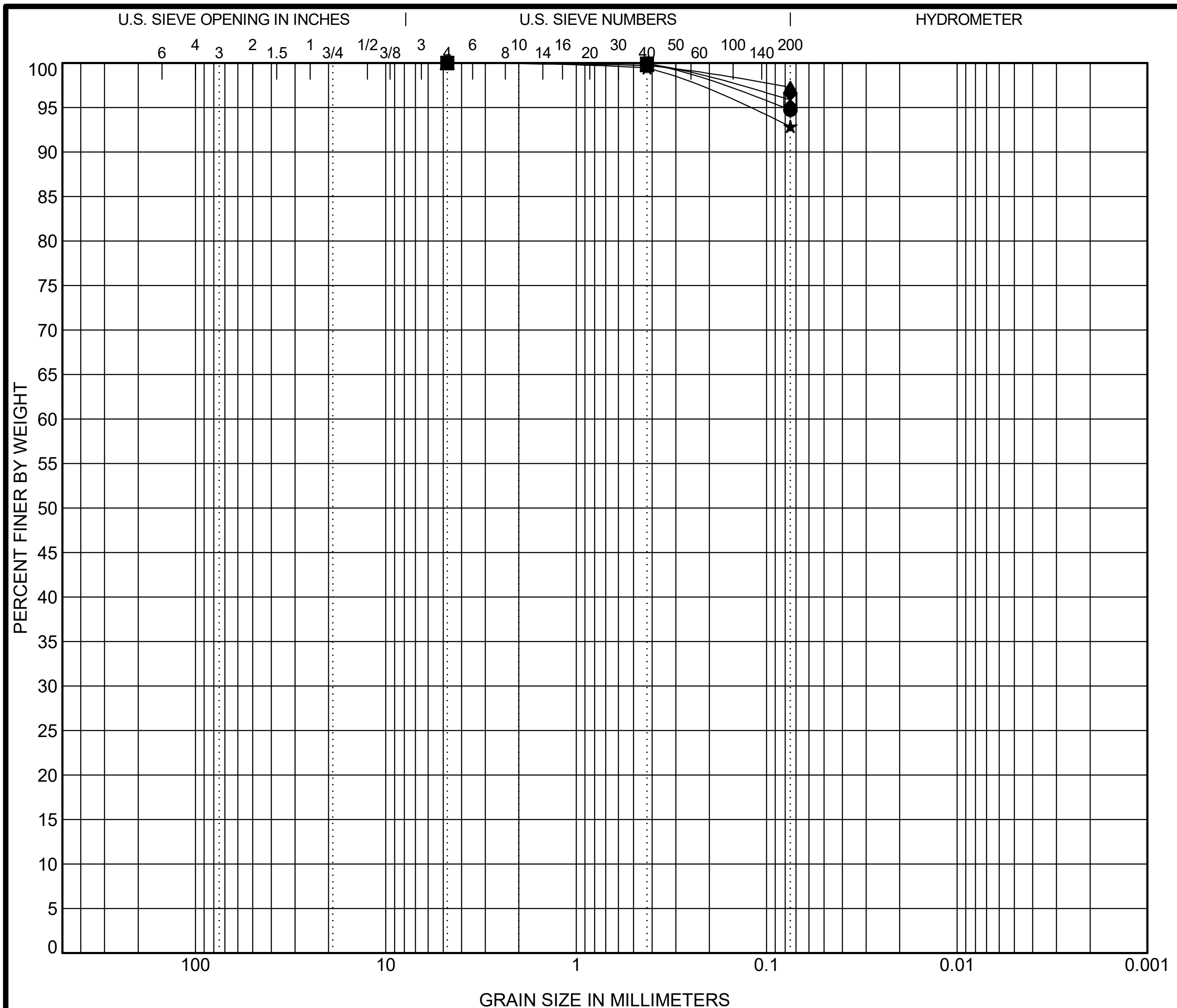
GRAIN SIZE DISTRIBUTION

Project: Mitchell Lake Wetland

Location: See Boring Location Plan

Job No.: 2017-698



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring	Elev	Depth	Classification	LL	PL	PI	Cc	Cu
●	**103**		**6.0**	**LEAN CLAY (CL)**	**39**	**17**	**22**		
⧗	**103**		**13.0**	**LEAN CLAY (CL)**	**39**	**17**	**22**		
▲	**103**		**33.0**	**FAT CLAY (CH)**	**54**	**18**	**36**		
★	**104**		**2.5**	**LEAN CLAY (CL)**	**44**	**19**	**25**		

	Boring	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**103**	**6.0**	**4.75**				**0.0**	**5.3**	**94.7**	
⧗	**103**	**13.0**	**4.75**				**0.0**	**4.2**	**95.8**	
▲	**103**	**33.0**	**4.75**				**0.0**	**2.7**	**97.3**	
★	**104**	**2.5**	**4.75**				**0.0**	**7.1**	**92.9**	

Silt and clay fractions were determined using 0.002 mm as the maximum particle size for clay.

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GRAIN SIZE DISTRIBUTION

Project: Mitchell Lake Wetland

Location: See Boring Location Plan

Job No.: 2017-698

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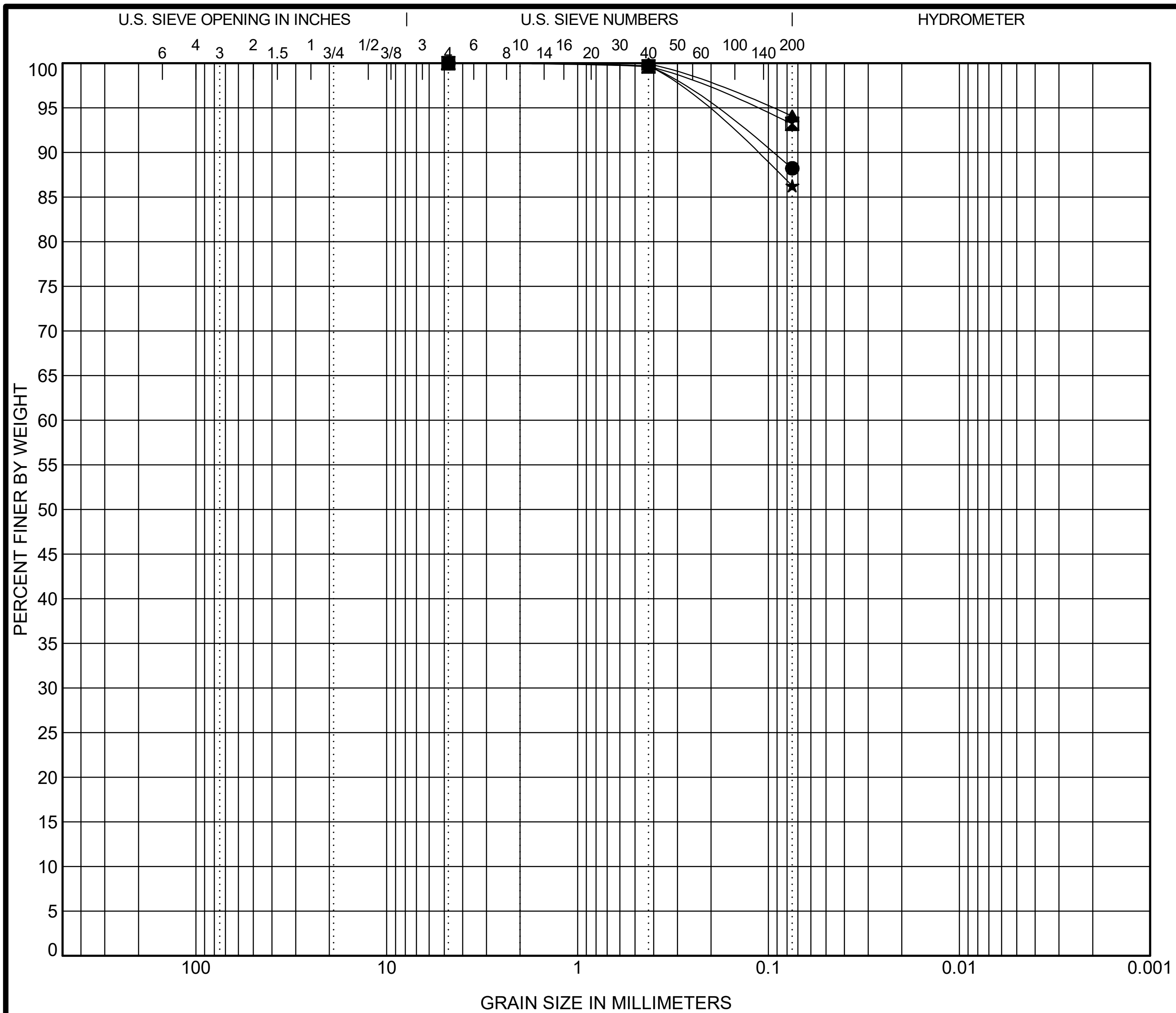

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring	Elev	Depth	Classification	LL	PL	PI	Cc	Cu
●	**104**		**8.0**	**LEAN CLAY (CL)**	**45**	**18**	**27**		
⊠	**104**		**13.0**	**LEAN CLAY (CL)**	**46**	**18**	**28**		
▲	**104**		**28.0**	**LEAN CLAY (CL)**	**43**	**16**	**27**		
★	**105**		**4.0**	**LEAN CLAY (CL)**	**42**	**16**	**26**		

	Boring	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**104**	**8.0**	**4.75**				**0.0**	**11.8**	**88.2**	
⊠	**104**	**13.0**	**4.75**				**0.0**	**6.8**	**93.2**	
▲	**104**	**28.0**	**4.75**				**0.0**	**5.9**	**94.1**	
★	**105**	**4.0**	**4.75**				**0.0**	**13.7**	**86.3**	

Silt and clay fractions were determined using 0.002 mm as the maximum particle size for clay.

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San Antonio, Texas 78232
Phone: (210) 308-5884

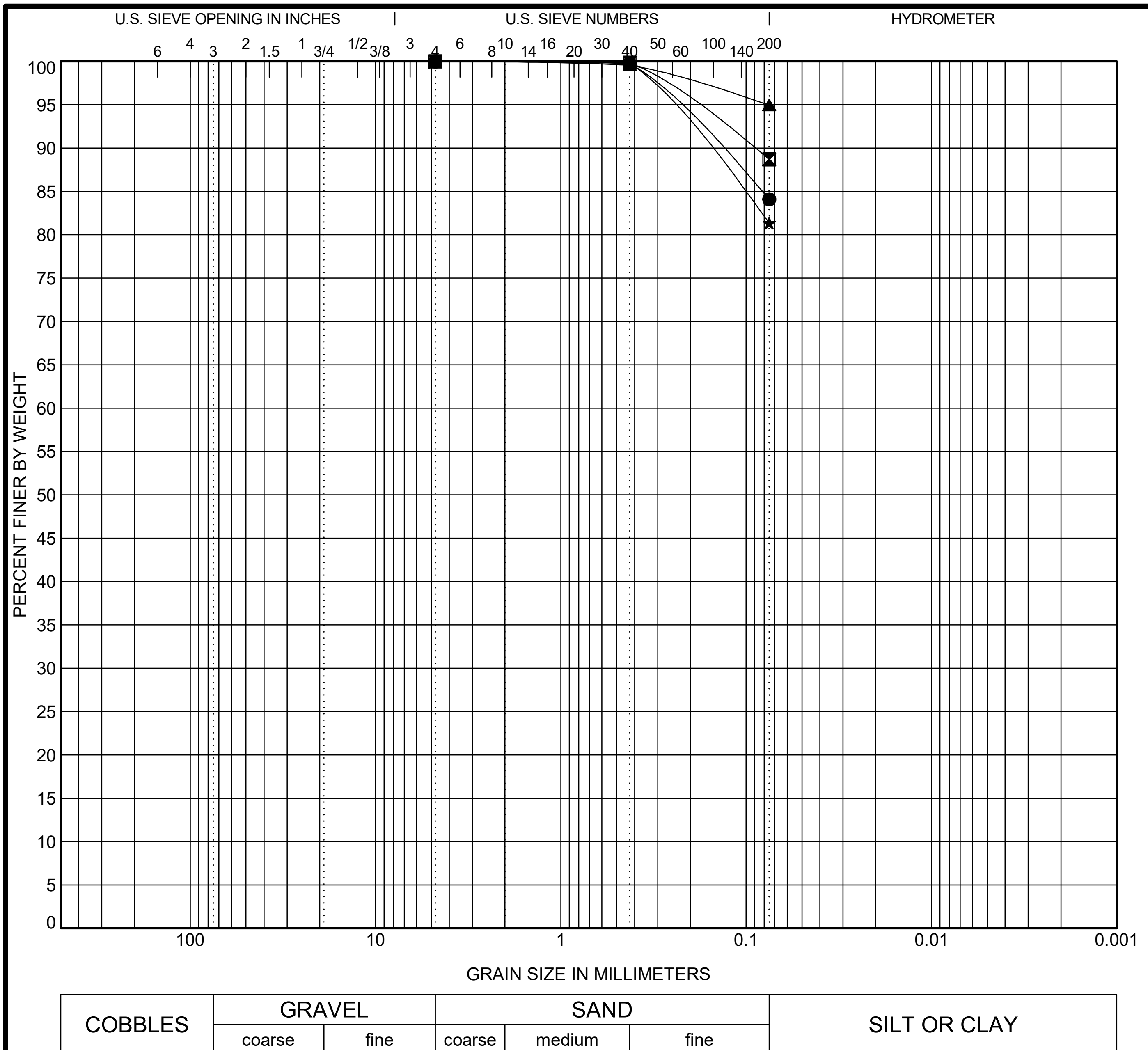
GRAIN SIZE DISTRIBUTION

Project: Mitchell Lake Wetland

Location: See Boring Location Plan

Job No.: 2017-698

Arias Geoprofessionals



	Boring	Elev	Depth	Classification	LL	PL	PI	Cc	Cu
●	**105**		**8.0**	**LEAN CLAY with SAND (CL)**	**40**	**17**	**23**		
⧗	**105**		**13.5**	**LEAN CLAY (CL)**	**44**	**18**	**26**		
▲	**105**		**23.0**	**FAT CLAY (CH)**	**52**	**18**	**34**		
★	**106**		**2.5**	**LEAN CLAY with SAND (CL)**	**40**	**16**	**24**		

	Boring	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt / %Clay
●	**105**	**8.0**	**4.75**				**0.0**	**15.9**	**84.1**
⧗	**105**	**13.5**	**4.75**				**0.0**	**11.3**	**88.7**
▲	**105**	**23.0**	**4.75**				**0.0**	**5.1**	**94.9**
★	**106**	**2.5**	**4.75**				**0.0**	**18.6**	**81.4**

Silt and clay fractions were determined using 0.002 mm as the maximum particle size for clay.

GRAIN SIZE DISTRIBUTION

Project: Mitchell Lake Wetland

Location: See Boring Location Plan

Job No.: 2017-698

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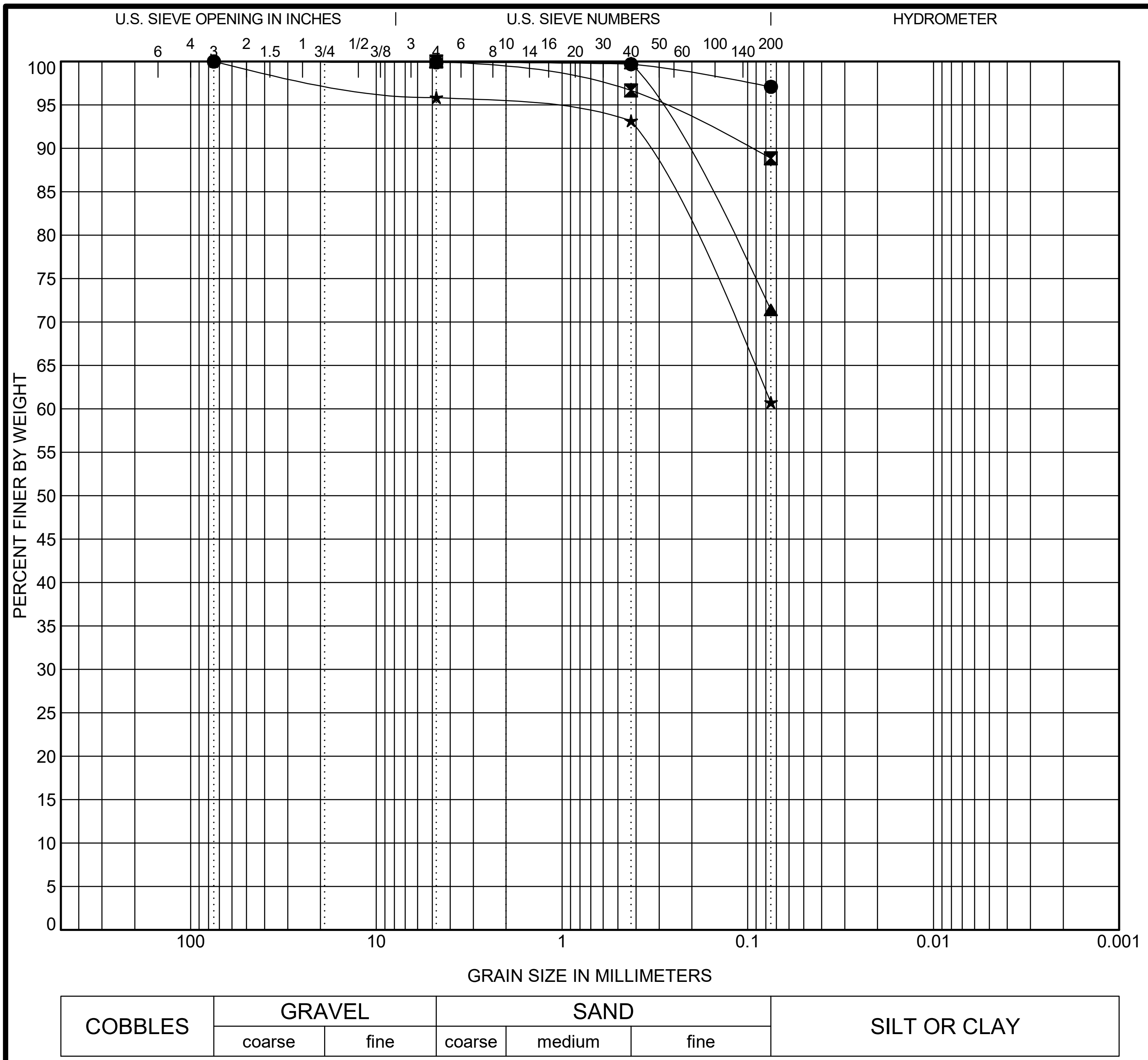

	Boring	Elev	Depth	Classification	LL	PL	PI	Cc	Cu
●	**106**		**10.0**	**FAT CLAY (CH)**	**57**	**17**	**40**		
⧗	**106**		**23.0**	**LEAN CLAY (CL)**	**43**	**14**	**29**		
▲	**106**		**33.0**	**LEAN CLAY with SAND (CL)**	**31**	**13**	**18**		
★	**107**		**8.0**	**SANDY LEAN CLAY (CL)**	**44**	**15**	**29**		

	Boring	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**106**	**10.0**	**75**				**0.1**	**2.8**	**97.1**	
⧗	**106**	**23.0**	**4.75**				**0.0**	**11.1**	**88.9**	
▲	**106**	**33.0**	**4.75**				**0.0**	**28.6**	**71.4**	
★	**107**	**8.0**	**75**				**4.2**	**35.1**	**60.7**	

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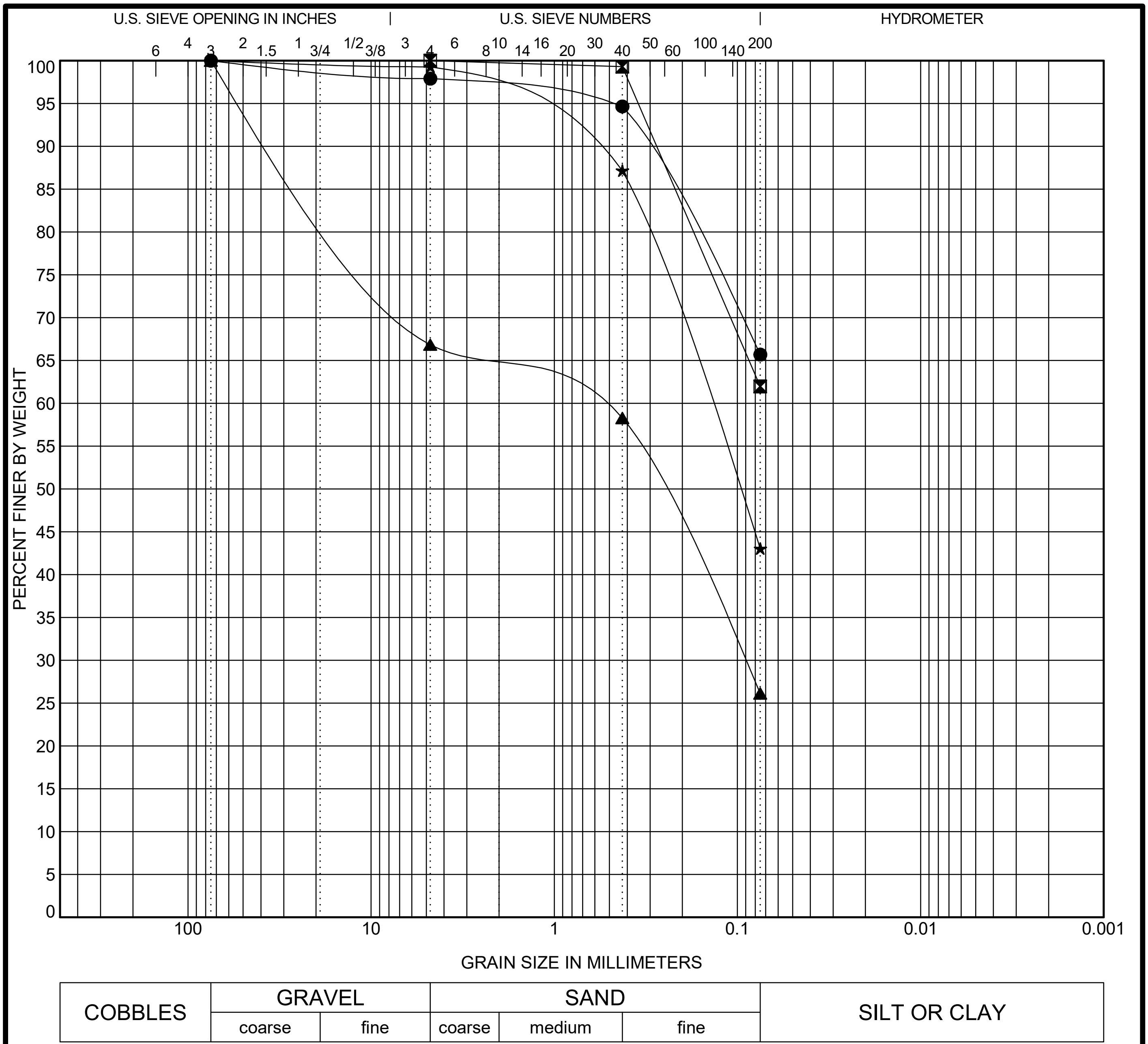

	Boring	Elev	Depth	Classification	LL	PL	PI	Cc	Cu
●	**107**		**13.0**	**SANDY LEAN CLAY (CL)**	**48**	**16**	**32**		
⊠	**107**		**23.5**	**SANDY LEAN CLAY (CL)**	**40**	**16**	**24**		
▲	**108**		**0.0**	**CLAYEY SAND with GRAVEL (SC)**	**30**	**15**	**15**		
★	**108**		**4.0**	**CLAYEY SAND (SC)**	**34**	**15**	**19**		

	Boring	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**107**	**13.0**	**75**				**2.1**	**32.2**	**65.7**	
⊠	**107**	**23.5**	**4.75**				**0.0**	**38.0**	**62.0**	
▲	**108**	**0.0**	**75**	**0.691**	**0.092**		**33.2**	**40.7**	**26.1**	
★	**108**	**4.0**	**75**	**0.146**			**0.7**	**56.2**	**43.0**	

Silt and clay fractions were determined using 0.002 mm as the maximum particle size for clay.

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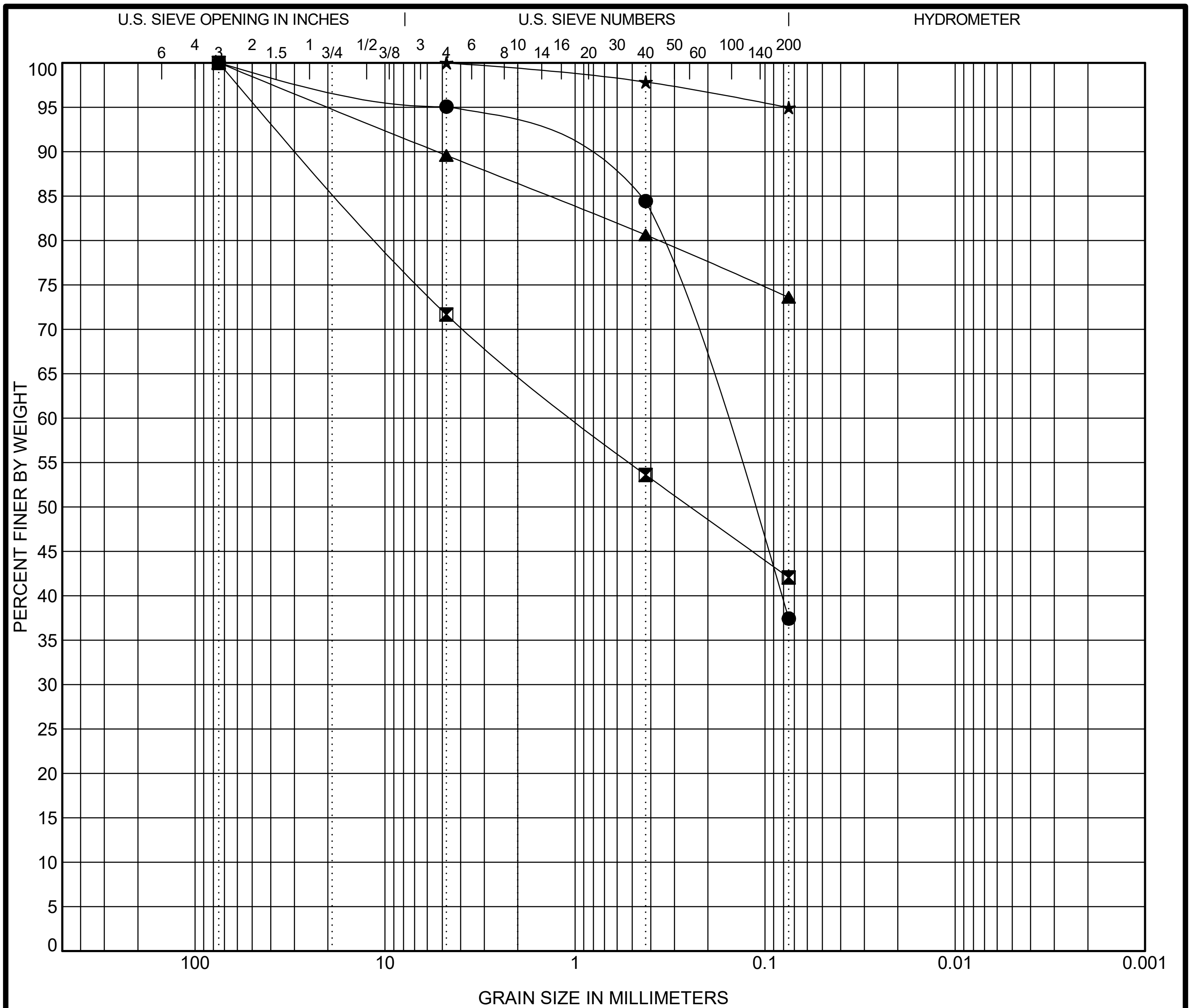

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring	Elev	Depth	Classification	LL	PL	PI	Cc	Cu
●	**108**		**10.0**	**CLAYEY SAND (SC)**	**32**	**18**	**14**		
⊠	**109**		**6.5**	**CLAYEY SAND with GRAVEL (SC)**	**32**	**15**	**17**		
▲	**109**		**10.0**	**LEAN CLAY with SAND (CL)**	**42**	**18**	**24**		
★	**110**		**0.0**	**FAT CLAY (CH)**	**50**	**18**	**32**		

	Boring	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**108**	**10.0**	**75**	**0.172**			**4.9**	**57.6**	**37.4**	
⊠	**109**	**6.5**	**75**	**0.999**			**28.3**	**29.6**	**42.0**	
▲	**109**	**10.0**	**75**				**10.4**	**16.0**	**73.6**	
★	**110**	**0.0**	**4.75**				**0.0**	**5.0**	**95.0**	

Silt and clay fractions were determined using 0.002 mm as the maximum particle size for clay.

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GRAIN SIZE DISTRIBUTION

Project: Mitchell Lake Wetland

Location: See Boring Location Plan

Job No.: 2017-698

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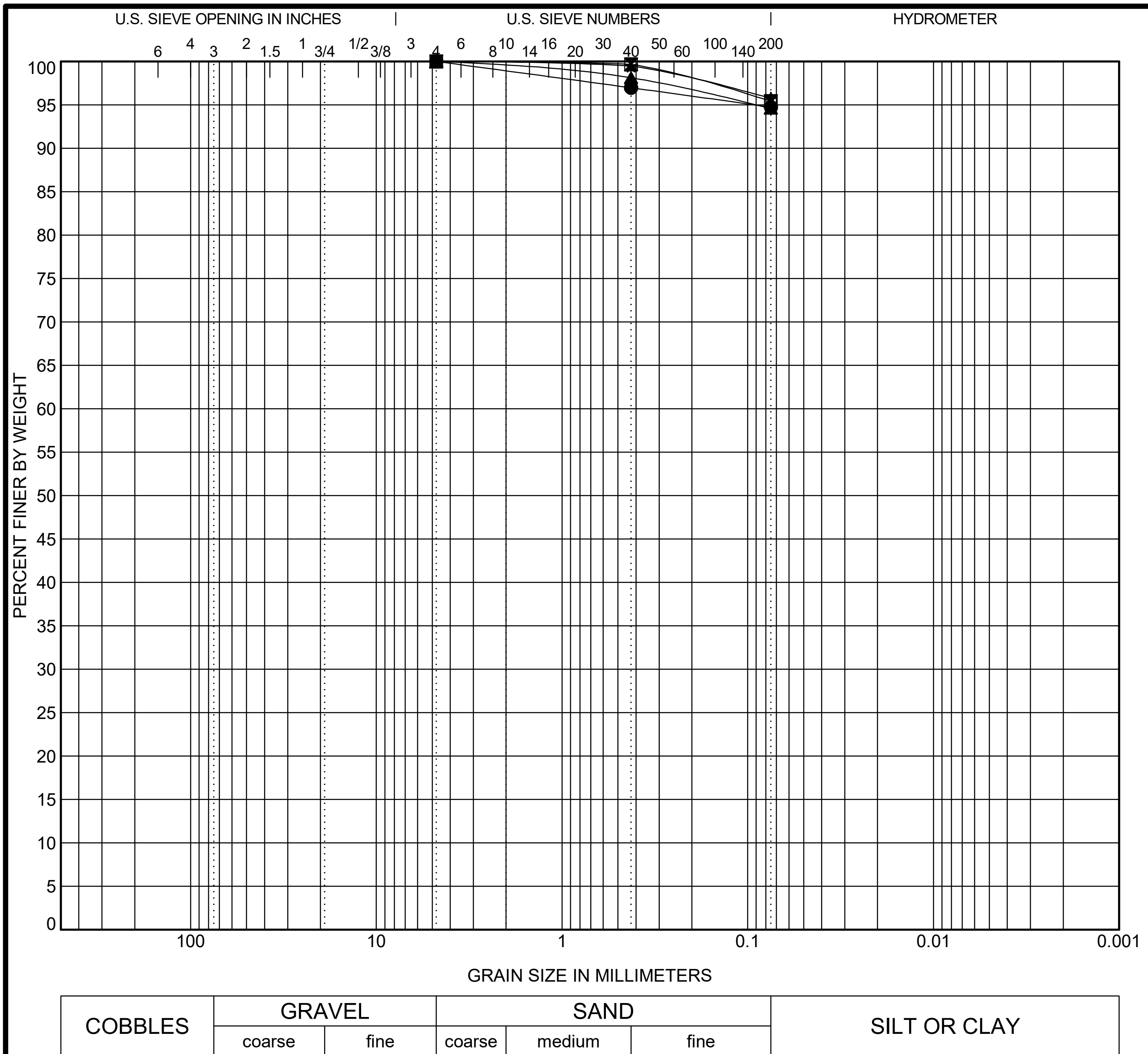

	Boring	Elev	Depth	Classification	LL	PL	PI	Cc	Cu
●	**110**		**4.0**	**LEAN CLAY (CL)**	**47**	**17**	**30**		
⧗	**110**		**10.0**	**LEAN CLAY (CL)**	**42**	**18**	**24**		
▲	**111**		**2.0**	**LEAN CLAY (CL)**	**43**	**19**	**24**		
★	**111**		**6.0**	**LEAN CLAY (CL)**	**43**	**18**	**25**		

	Boring	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**110**	**4.0**	**4.75**				**0.0**	**5.3**	**94.7**	
⧗	**110**	**10.0**	**4.75**				**0.0**	**4.6**	**95.4**	
▲	**111**	**2.0**	**4.75**				**0.0**	**5.4**	**94.6**	
★	**111**	**6.0**	**4.75**				**0.0**	**4.2**	**95.8**	

Silt and clay fractions were determined using 0.002 mm as the maximum particle size for clay.

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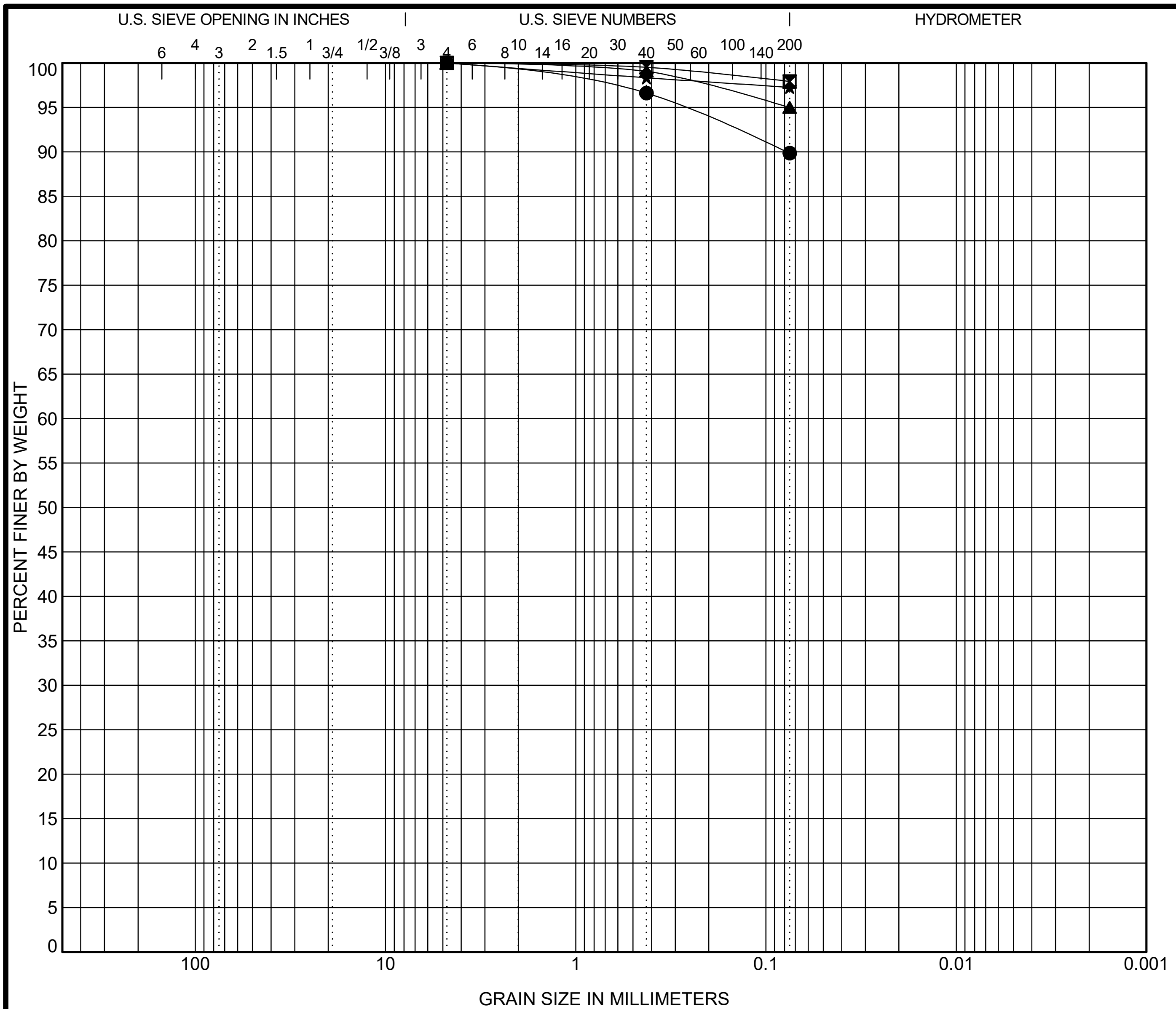
GRAIN SIZE DISTRIBUTION

Project: Mitchell Lake Wetland

Location: See Boring Location Plan

Job No.: 2017-698



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring	Elev	Depth	Classification	LL	PL	PI	Cc	Cu
●	**112**		**0.0**	**LEAN CLAY (CL)**	**46**	**17**	**29**		
⧗	**112**		**8.0**	**LEAN CLAY (CL)**	**44**	**17**	**27**		
▲	**113**		**4.0**	**LEAN CLAY (CL)**	**48**	**16**	**32**		
★	**113**		**10.0**	**FAT CLAY (CH)**	**50**	**17**	**33**		

	Boring	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**112**	**0.0**	**4.75**				**0.0**	**10.1**	**89.9**	
⧗	**112**	**8.0**	**4.75**				**0.0**	**2.1**	**97.9**	
▲	**113**	**4.0**	**4.75**				**0.0**	**5.0**	**95.0**	
★	**113**	**10.0**	**4.75**				**0.0**	**2.7**	**97.3**	

Silt and clay fractions were determined using 0.002 mm as the maximum particle size for clay.

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Project: Mitchell Lake Wetland

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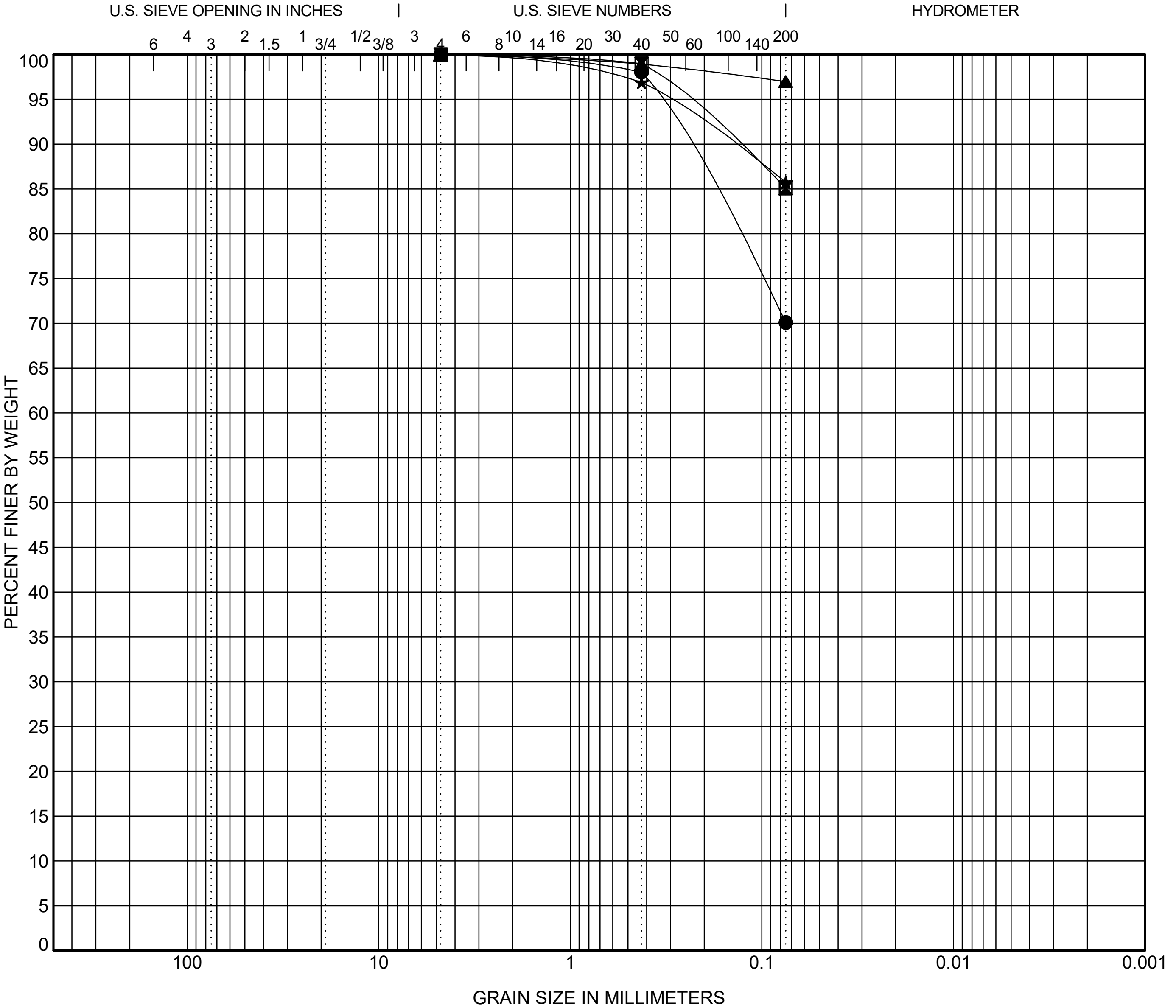

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring	Elev	Depth	Classification	LL	PL	PI	Cc	Cu
●	**114**		**0.0**	**LEAN CLAY with SAND (CL)**	**33**	**15**	**18**		
⧗	**114**		**6.0**						
▲	**114**		**8.0**	**LEAN CLAY (CL)**	**44**	**15**	**29**		
★	**115**		**2.0**	**LEAN CLAY (CL)**	**46**	**18**	**28**		

	Boring	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**114**	**0.0**	**4.75**				**0.0**	**29.9**	**70.1**	
⧗	**114**	**6.0**	**4.75**				**0.0**	**14.9**	**85.1**	
▲	**114**	**8.0**	**4.75**				**0.0**	**3.0**	**97.0**	
★	**115**	**2.0**	**4.75**				**0.0**	**14.3**	**85.7**	

Silt and clay fractions were determined using 0.002 mm as the maximum particle size for clay.

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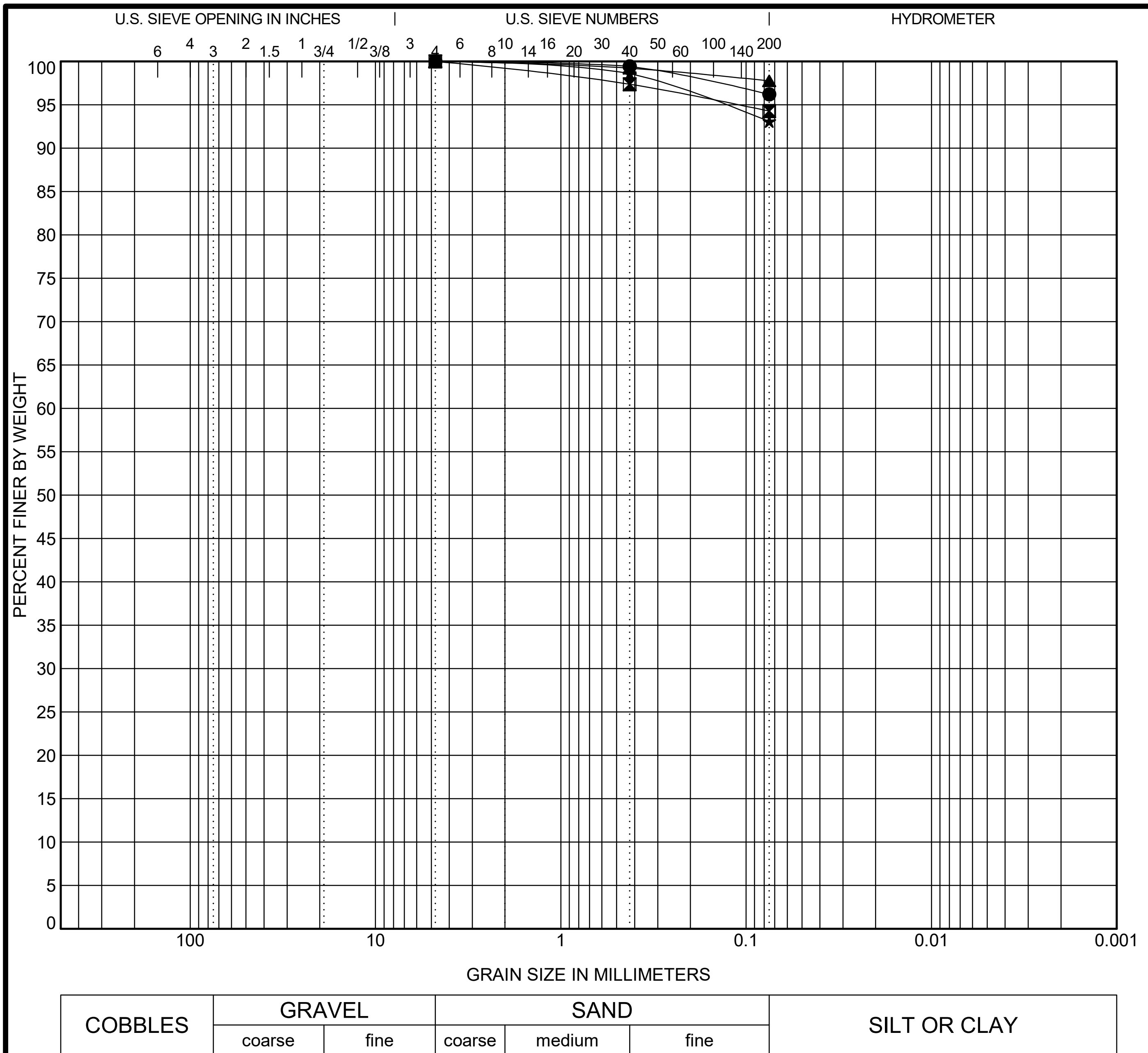

	Boring	Elev	Depth	Classification	LL	PL	PI	Cc	Cu
●	**115**		**8.0**	**LEAN CLAY (CL)**	**42**	**17**	**25**		
⧗	**116**		**2.0**	**FAT CLAY (CH)**	**50**	**19**	**31**		
▲	**116**		**6.0**	**LEAN CLAY (CL)**	**46**	**16**	**30**		
★	**116**		**13.0**	**LEAN CLAY (CL)**	**45**	**17**	**28**		

	Boring	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**115**	**8.0**	**4.75**				**0.0**	**3.8**	**96.2**	
⧗	**116**	**2.0**	**4.75**				**0.0**	**5.7**	**94.3**	
▲	**116**	**6.0**	**4.75**				**0.0**	**2.2**	**97.8**	
★	**116**	**13.0**	**4.75**				**0.0**	**6.9**	**93.1**	

Silt and clay fractions were determined using 0.002 mm as the maximum particle size for clay.

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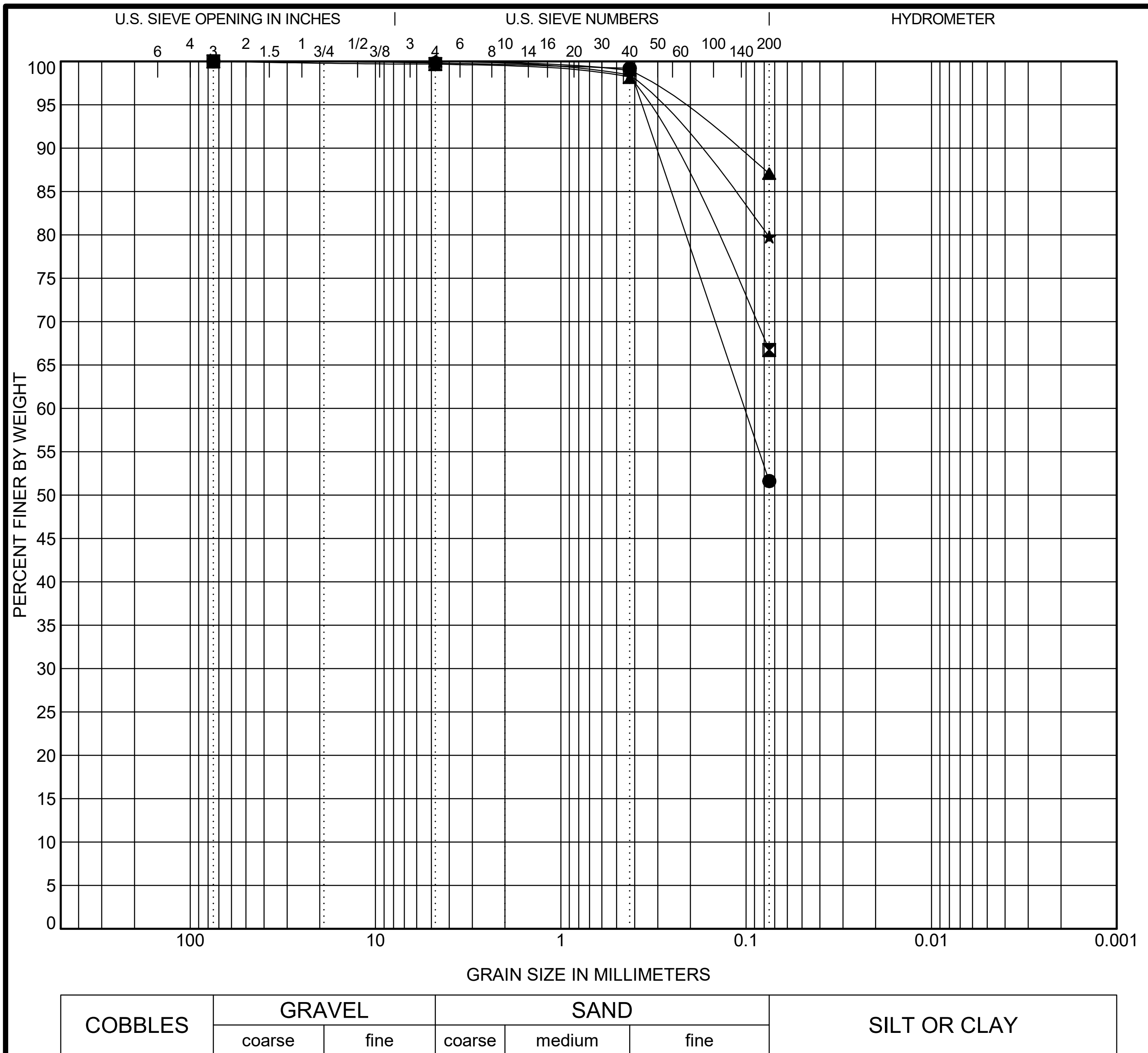

Boring	Elev	Depth	Classification	LL	PL	PI	Cc	Cu
● **117**		**2.0**	**SANDY LEAN CLAY (CL)**	**37**	**12**	**25**		
⧗ **117**		**8.0**	**SANDY LEAN CLAY (CL)**	**29**	**12**	**17**		
▲ **118**		**0.0**	**LEAN CLAY (CL)**	**40**	**15**	**25**		
★ **118**		**4.0**	**LEAN CLAY with SAND (CL)**	**43**	**15**	**28**		

Boring	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **117**	**2.0**	**75**	**0.102**			**0.2**	**48.2**	**51.6**	
⧗ **117**	**8.0**	**75**				**0.3**	**33.0**	**66.7**	
▲ **118**	**0.0**	**4.75**				**0.0**	**12.9**	**87.1**	
★ **118**	**4.0**	**4.75**				**0.0**	**20.2**	**79.8**	

Silt and clay fractions were determined using 0.002 mm as the maximum particle size for clay.

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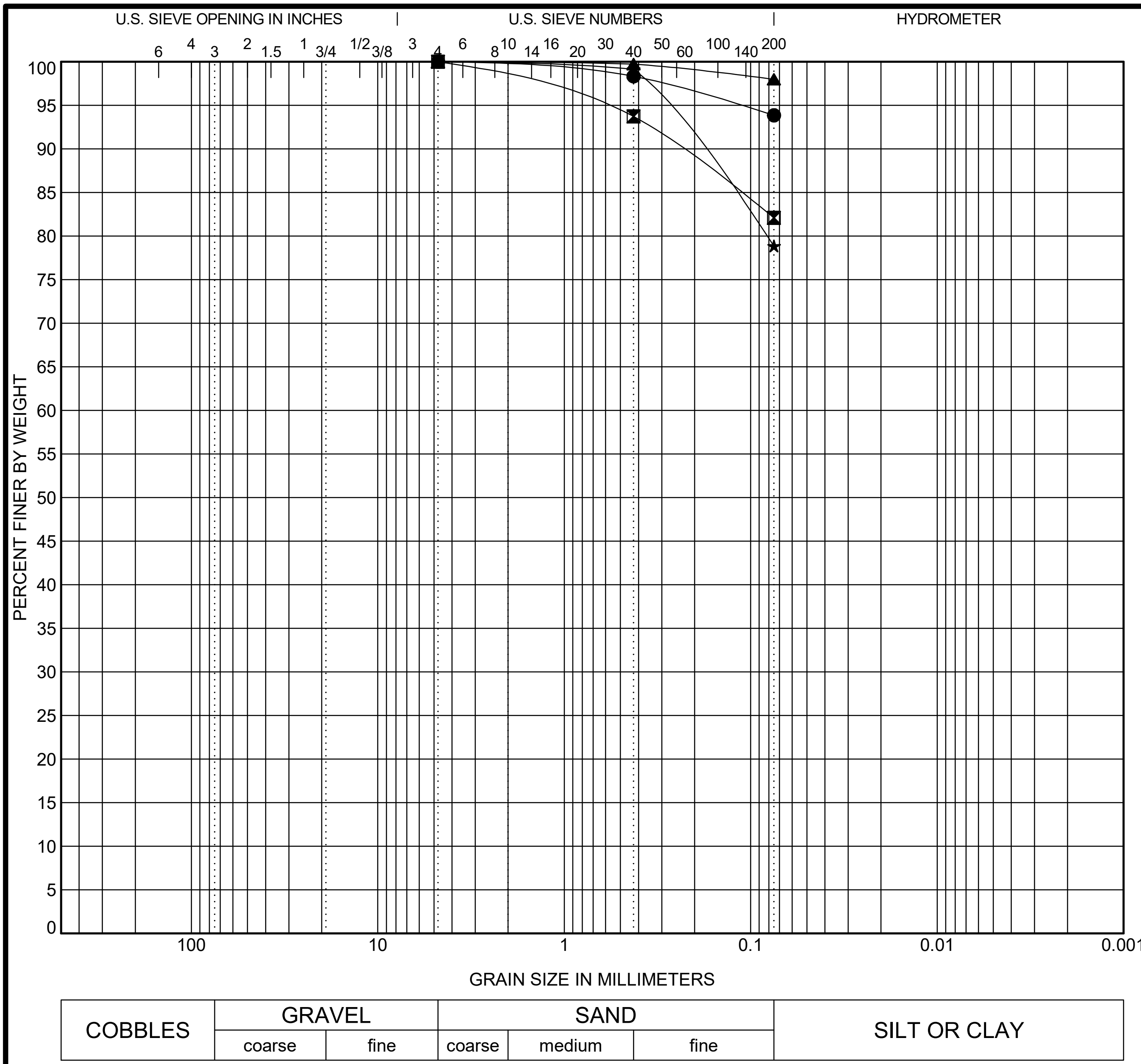

	Boring	Elev	Depth	Classification	LL	PL	PI	Cc	Cu
●	**118**		**10.0**	**FAT CLAY (CH)**	**55**	**16**	**39**		
⧗	**119**		**2.0**	**LEAN CLAY with SAND (CL)**	**47**	**21**	**26**		
▲	**119**		**8.0**	**LEAN CLAY (CL)**	**49**	**21**	**28**		
★	**120**		**2.0**	**FAT CLAY with SAND (CH)**	**51**	**17**	**34**		

	Boring	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**118**	**10.0**	**4.75**				**0.0**	**6.2**	**93.8**	
⧗	**119**	**2.0**	**4.75**				**0.0**	**17.9**	**82.1**	
▲	**119**	**8.0**	**4.75**				**0.0**	**2.0**	**98.0**	
★	**120**	**2.0**	**4.75**				**0.0**	**21.1**	**78.9**	

Silt and clay fractions were determined using 0.002 mm as the maximum particle size for clay.

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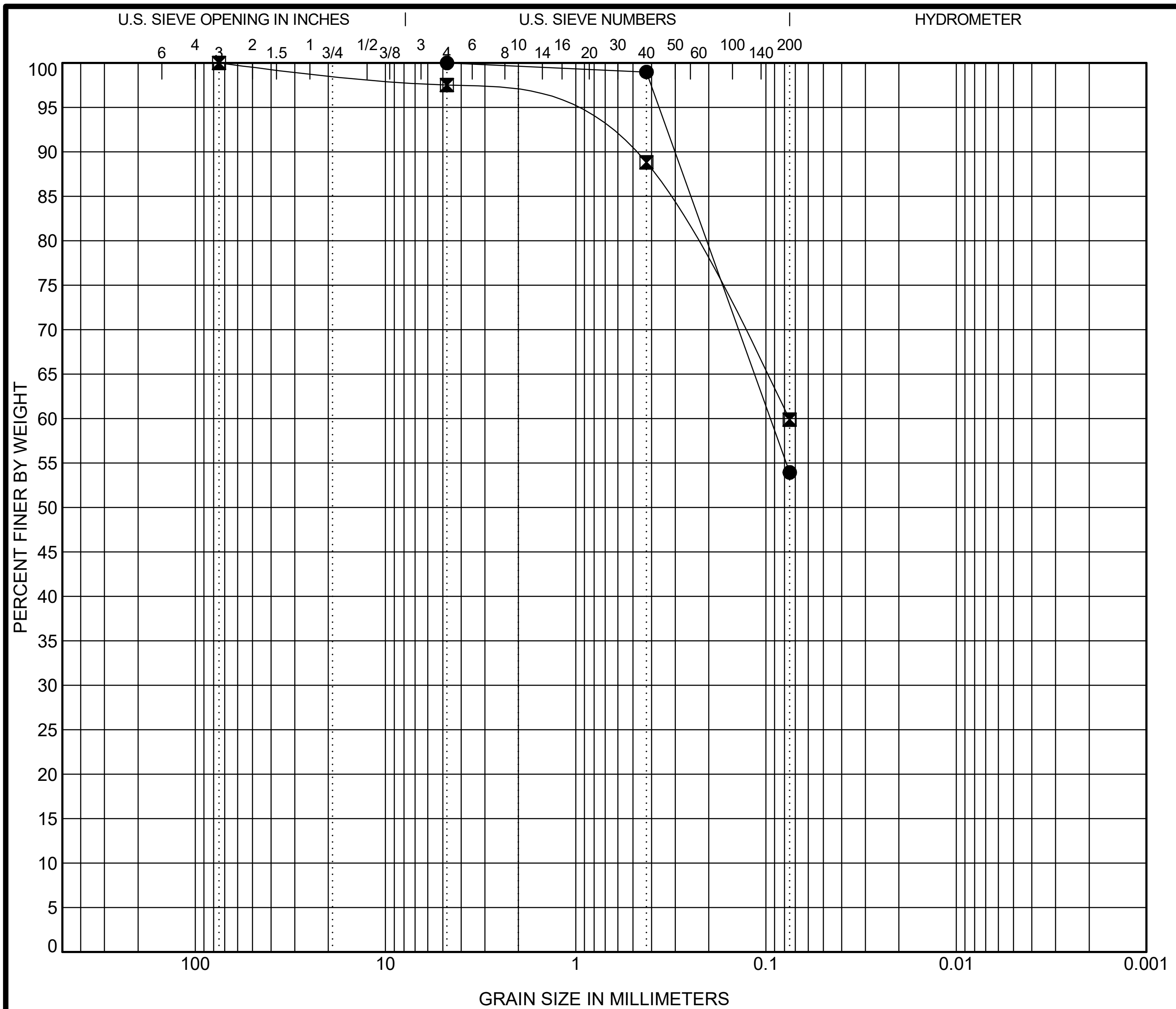
Location: See Boring Location Plan

Job No.: 2017-698



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring	Elev	Depth	Classification	LL	PL	PI	Cc	Cu
●	**120**		**6.0**	**SANDY LEAN CLAY (CL)**	**30**	**14**	**16**		
⊠	**120**		**13.0**	**SANDY LEAN CLAY (CL)**	**44**	**15**	**29**		

	Boring	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**120**	**6.0**	**4.75**	**0.095**			**0.0**	**46.1**	**53.9**	
⊠	**120**	**13.0**	**75**	**0.076**			**2.5**	**37.6**	**59.9**	

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Project: Mitchell Lake Wetland

Location: See Boring Location Plan

Job No.: 2017-698

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Arias Geoprofessionals

APPENDIX E: ONE-DIMENSIONAL CONSOLIDATION TEST RESULTS

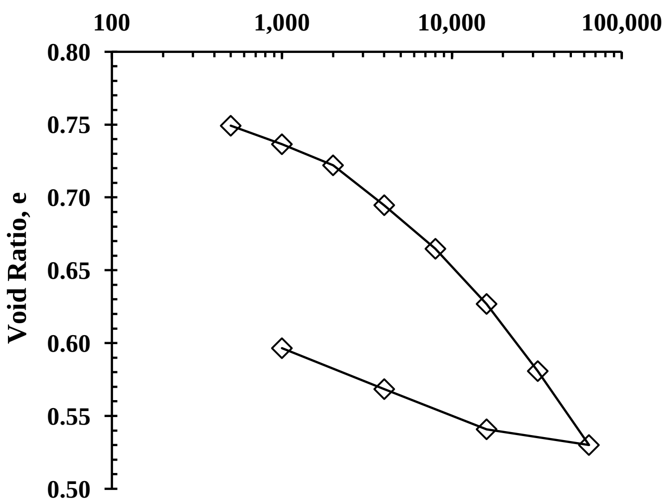
One-Dimensional Consolidation Properties of Soil

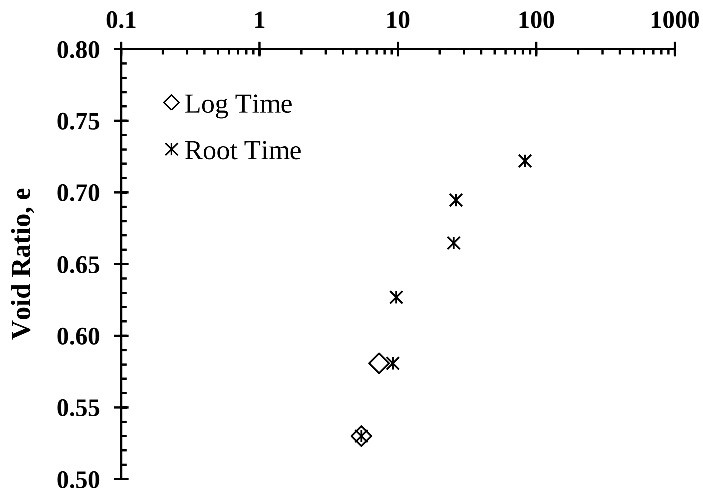
Client: Arias Geoprofessionals
Project: AA2018-142
Specimen: B-101 (6 - 8)

TRI Log No.: 35800.3
Test Method: ASTM D 2435, Method B

Soil Specimen Properties	
Initial Specimen Water Content (%)	22.1
Final Specimen Water Content (%)	20.2
Specimen Diameter (in)	2.499
Initial Specimen Height (in)	1.003
Final Specimen Height (in)	0.912
Final Differential Height (in)	0.091
Initial Dry Unit Weight, γ_o lb_f/ft^3	92.4
Final Dry Unit Weight, γ_f lb_f/ft^3	103.6
Initial Void Ratio, e_o	0.790
Final Void Ratio, e_f	0.596
Initial Degree of Saturation (%)	74.2
Preconsolidation Pressure (psf)	≈7800
Swell Pressure (psf), Maximum Measured	185
Compression Index, C_c	0.164
Recompression Index, C_r	0.018

σ'_v	e	Strain, ε	C_v (ft^2/year)	
(psf)	(-)	(%)	Log Time	Root Time
Initial	0.790	0.0	-	-
500	0.749	2.3	-	-
1,000	0.736	3.0	-	-
2,000	0.722	3.8	-	83
4,000	0.695	5.3	-	26
8,000	0.665	7.0	-	25
16,000	0.627	9.1	-	9.7
32,000	0.581	11.7	7.3	9.2
64,000	0.530	14.5	5.4	5.4
16,000	0.541	13.9	-	-
4,000	0.568	12.4	-	-
1,000	0.596	10.8	-	-





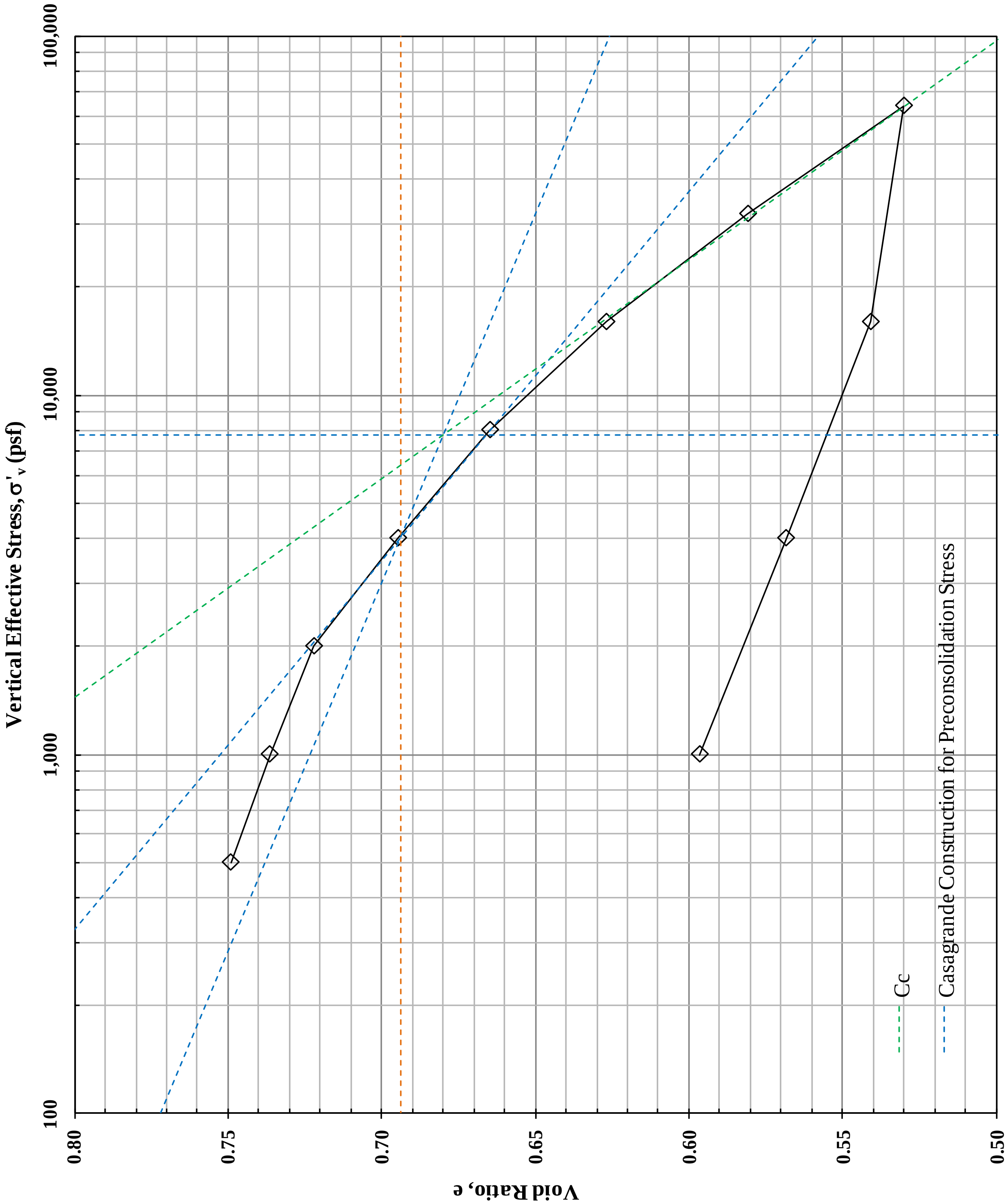
The undisturbed specimen was provided by the client. The specimen was trimmed using a trimming turntable and mounted. The specimen was inundated with tap water during testing. Coefficient of Consolidation was determined using the Log Time and Root Time Methods. A specific gravity of 2.75 was assumed for weight-volume calculations. Calculations include machine deflections measured at each loading step. The preconsolidation pressure was determined using the Casagrande construction technique.

Jeffrey A. Kuhn, Ph.D., P.E., 3/26/2018
Quality Review/Date

One-Dimensional Consolidation Properties of Soil

Client: Arias Geoprofessionals
Project: AA2018-142
Specimen: B-101 (6 - 8)

TRI Log No.: 35800.3
Test Method: ASTM D 2435, Method B



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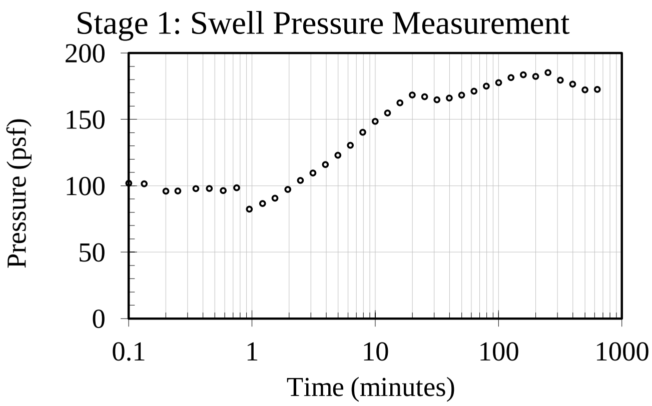
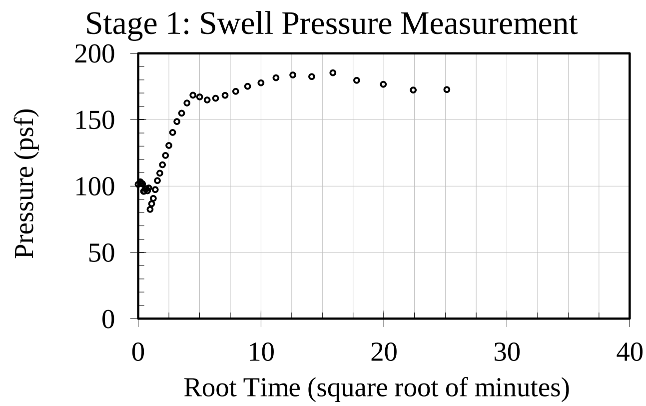
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

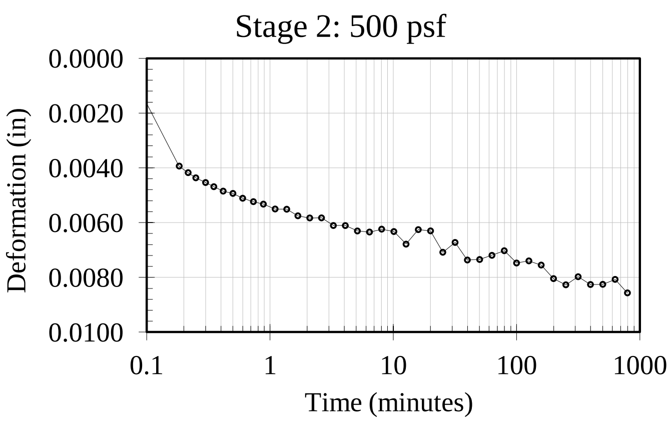
One-Dimensional Consolidation Properties of Soil

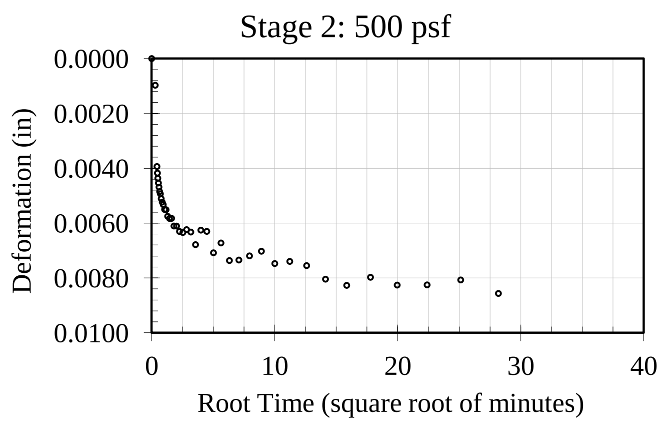
Client: Arias Geoprofessionals
Project: AA2018-142
Specimen: B-101 (6 - 8)

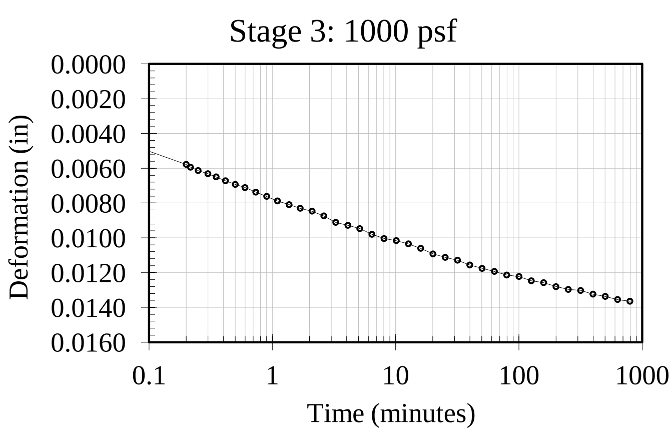
TRI Log No.: 35800.3
Test Method: ASTM D 2435, Method B

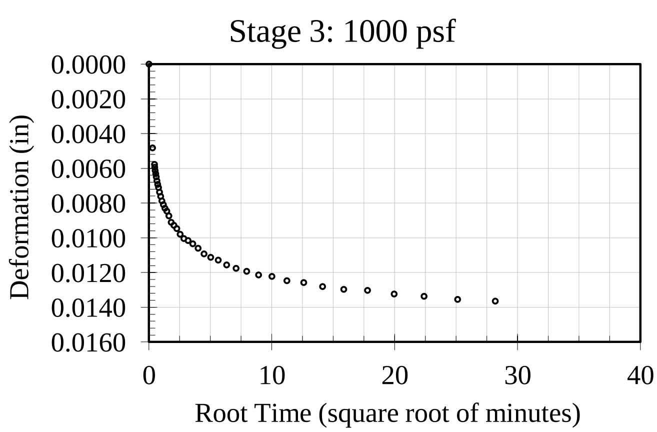








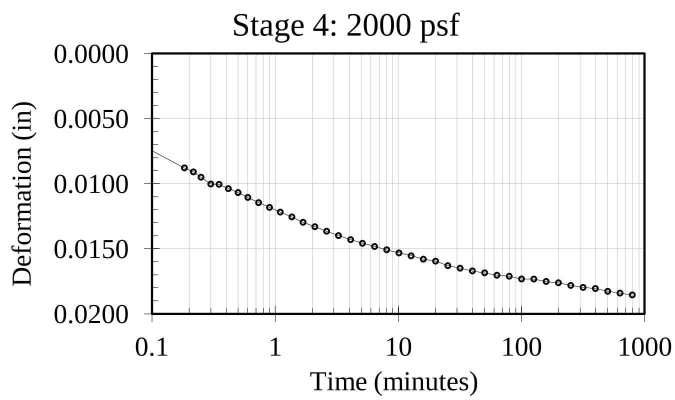


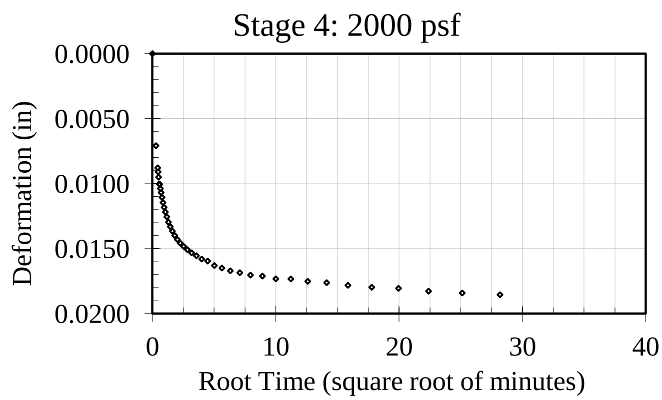


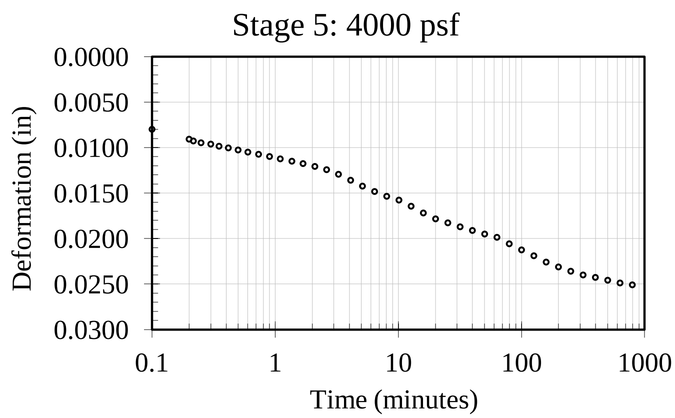
One-Dimensional Consolidation Properties of Soil

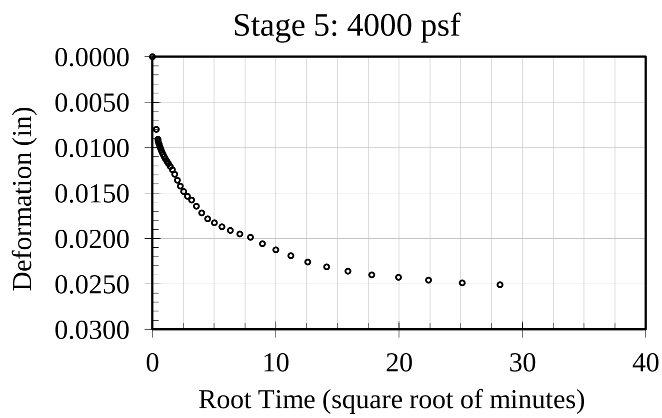
Client: Arias Geoprofessionals
Project: AA2018-142
Specimen: B-101 (6 - 8)

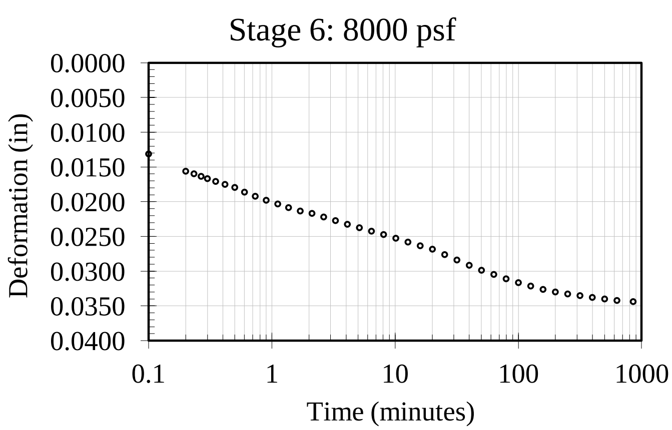
TRI Log No.: 35800.3
Test Method: ASTM D 2435, Method B

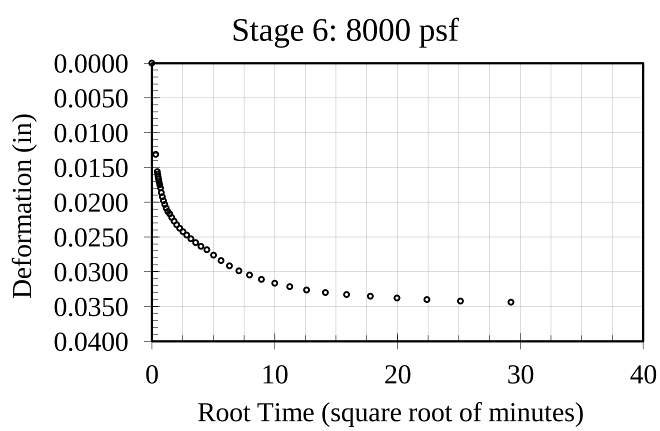










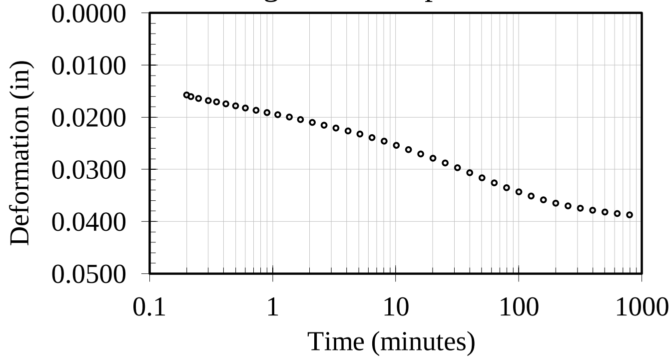


One-Dimensional Consolidation Properties of Soil

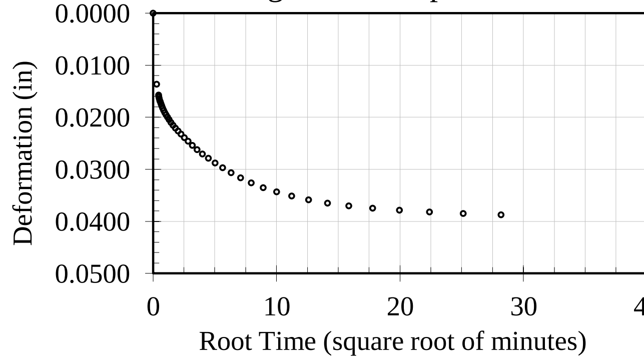
Client: Arias Geoprofessionals
Project: AA2018-142
Specimen: B-101 (6 - 8)

TRI Log No.: 35800.3
Test Method: ASTM D 2435, Method B

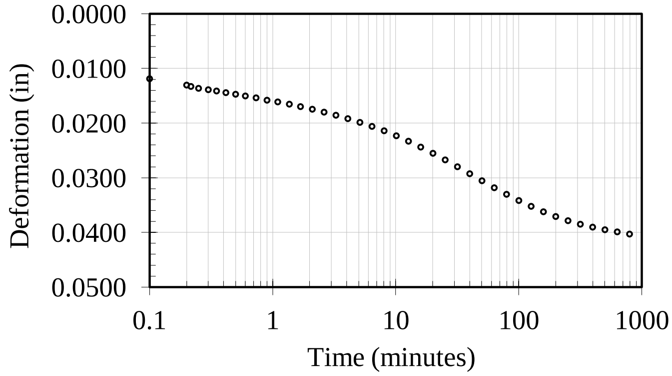
Stage 7: 16000 psf



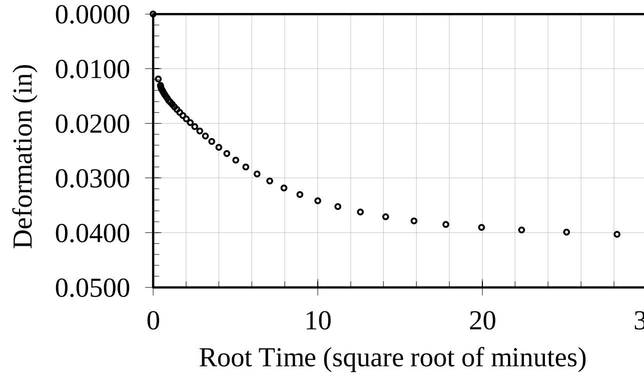
Stage 7: 16000 psf



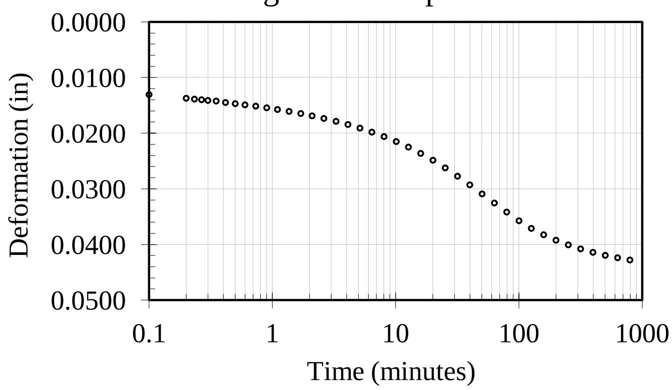
Stage 8: 32000 psf



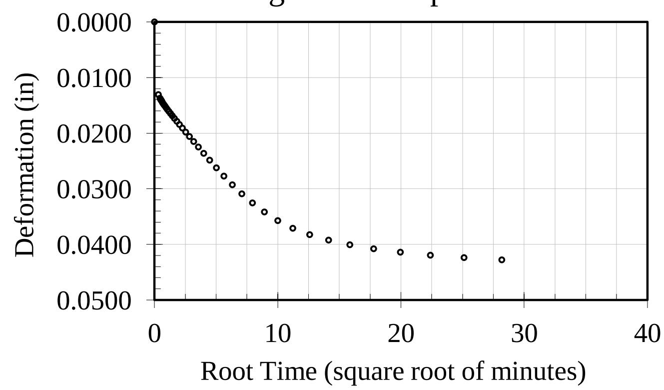
Stage 8: 32000 psf



Stage 9: 64000 psf



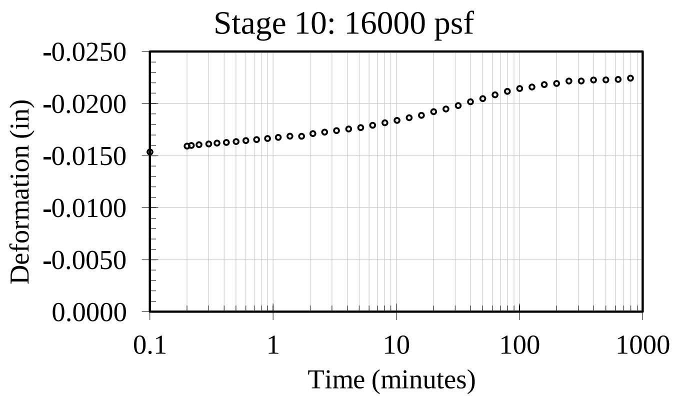
Stage 9: 64000 psf

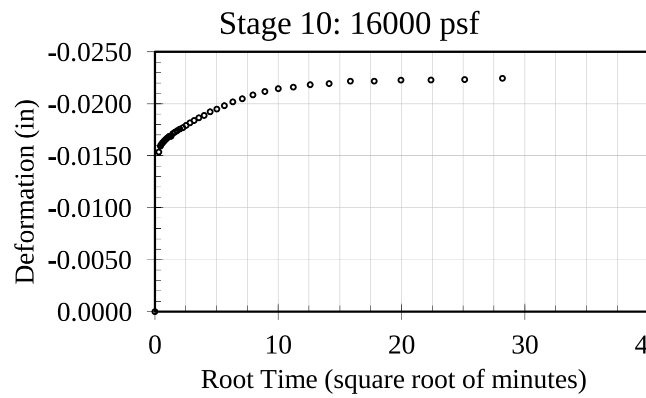


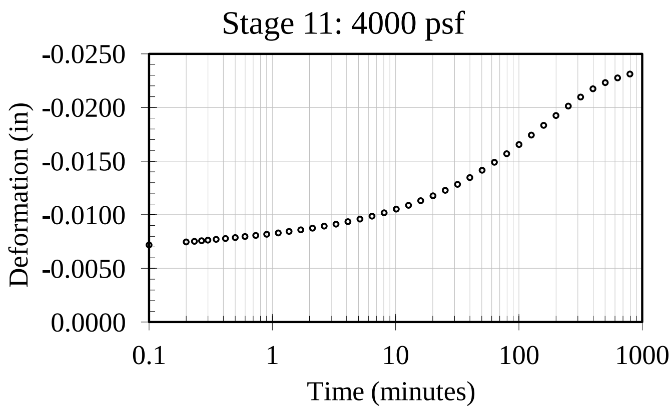
One-Dimensional Consolidation Properties of Soil

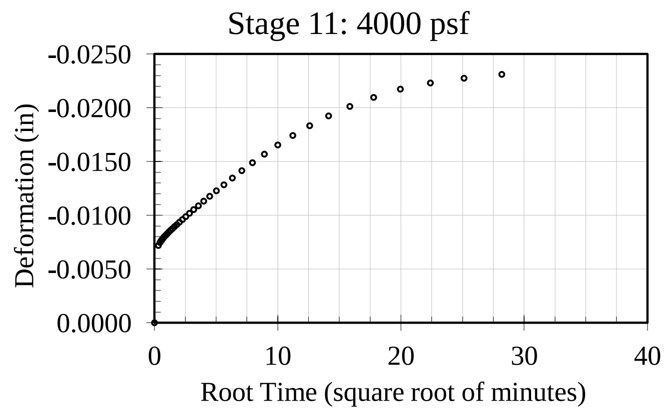
Client: Arias Geoprofessionals
Project: AA2018-142
Specimen: B-101 (6 - 8)

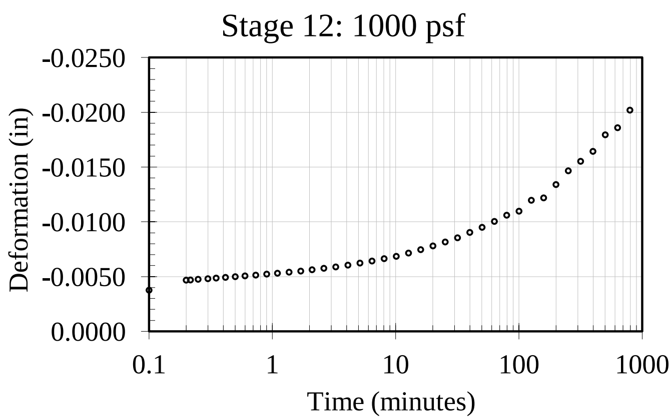
TRI Log No.: 35800.3
Test Method: ASTM D 2435, Method B

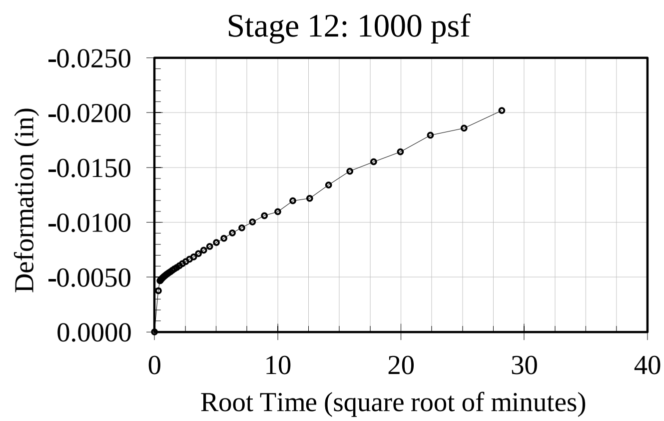












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9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

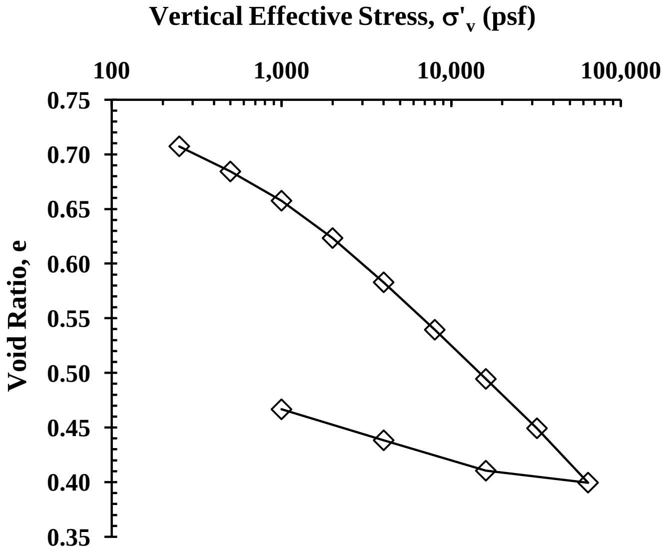
One-Dimensional Consolidation Properties of Soil

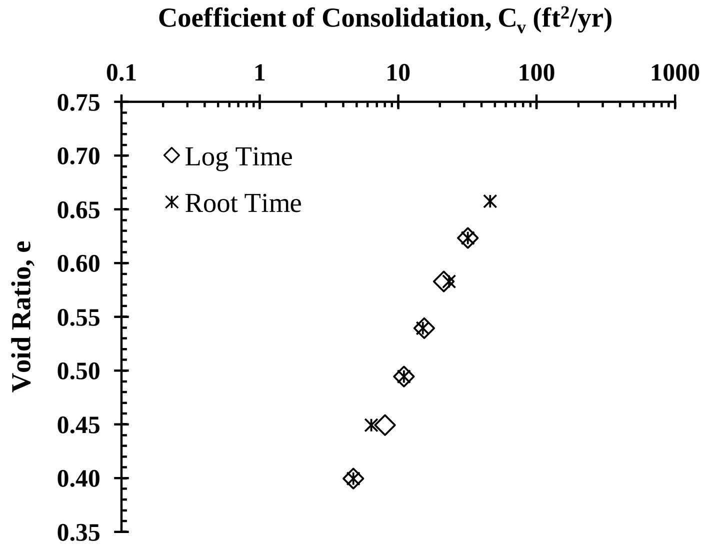
Client: Arias Geoprofessionals
Project: AA2018-142
Specimen: B-103 (13 - 15)

TRI Log No.: 35800.1
Test Method: ASTM D 2435, Method B

Soil Specimen Properties	
Initial Specimen Water Content (%)	21.1
Final Specimen Water Content (%)	16.9
Specimen Diameter (in)	2.497
Initial Specimen Height (in)	0.999
Final Specimen Height (in)	0.854
Final Differential Height (in)	0.144
Initial Dry Unit Weight, γ_o lb_f/ft^3	94.7
Final Dry Unit Weight, γ_f lb_f/ft^3	112.7
Initial Void Ratio, e_o	0.747
Final Void Ratio, e_f	0.467
Initial Degree of Saturation (%)	74.9
Preconsolidation Pressure (psf)	≈3000
Swell Pressure (psf), Maximum Measured	113
Compression Index, C_c	0.160
Recompression Index, C_r	0.165

σ'_v	e	Strain, ε	C_v (ft^2/year)	
(psf)	(-)	(%)	Log Time	Root Time
Initial	0.747	0.0	-	-
250	0.707	2.2	-	-
500	0.684	3.6	-	-
1,000	0.658	5.1	-	46
2,000	0.623	7.1	32	32
4,000	0.583	9.4	21	23
8,000	0.539	11.9	15	15
16,000	0.494	14.4	11	11
32,000	0.449	17.0	8.0	6.4
64,000	0.400	19.9	4.7	4.7
16,000	0.410	19.2	-	-
4,000	0.438	17.6	-	-
1,000	0.467	16.0	-	-





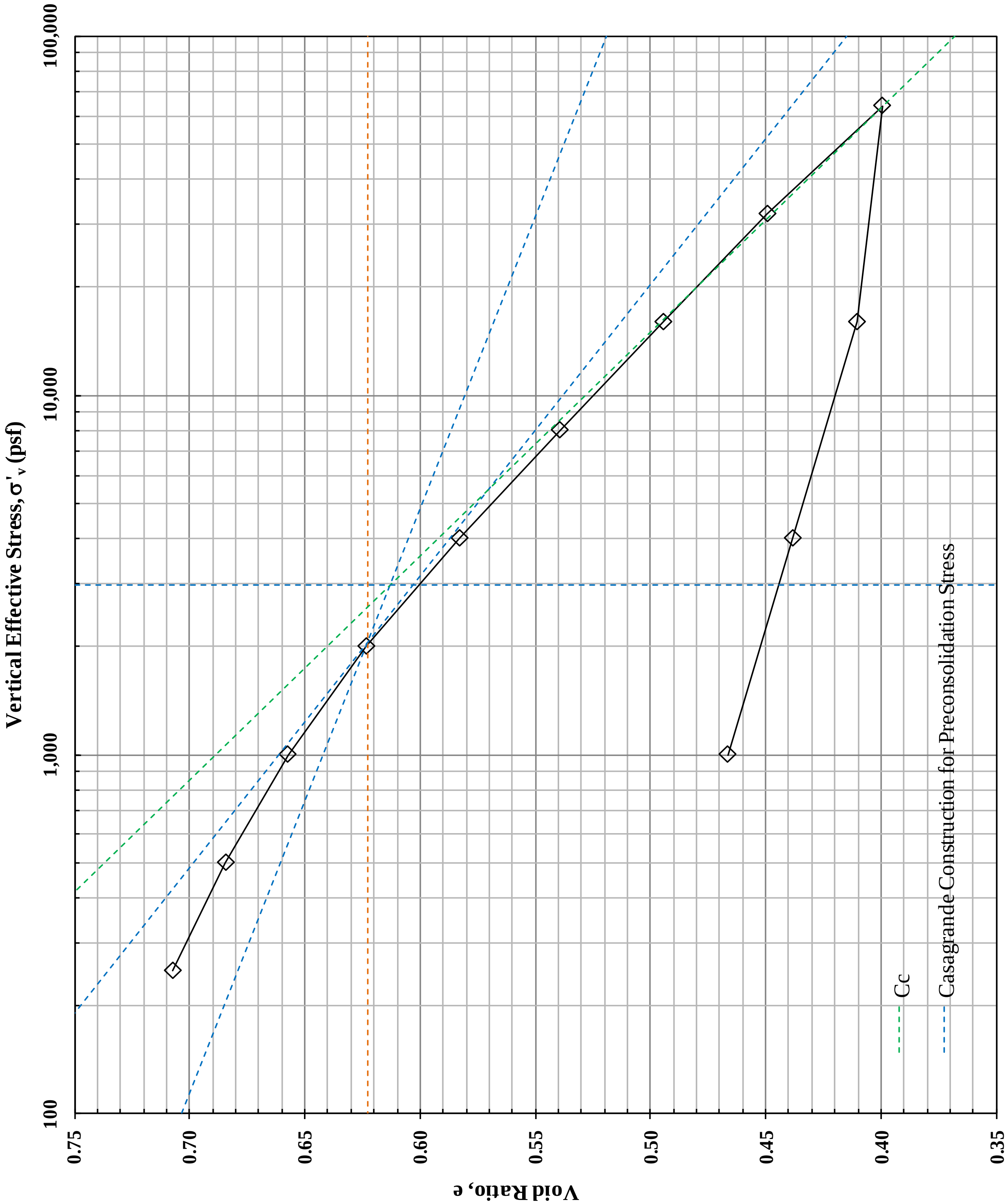
The undisturbed specimen was provided by the client. The specimen was trimmed using a trimming turntable and mounted. The specimen was inundated with tap water during testing. Coefficient of Consolidation was determined using the Log Time and Root Time Methods. A specific gravity of 2.75 was assumed for weight-volume calculations. Calculations include machine deflections measured at each loading step. The preconsolidation pressure was determined using the Casagrande construction technique.

Jeffrey A. Kuhn, Ph.D., P.E., 3/26/2018
Quality Review/Date

One-Dimensional Consolidation Properties of Soil

Client: Arias Geoprofessionals
Project: AA2018-142
Specimen: B-103 (13 - 15)

TRI Log No.: 35800.1
Test Method: ASTM D 2435, Method B



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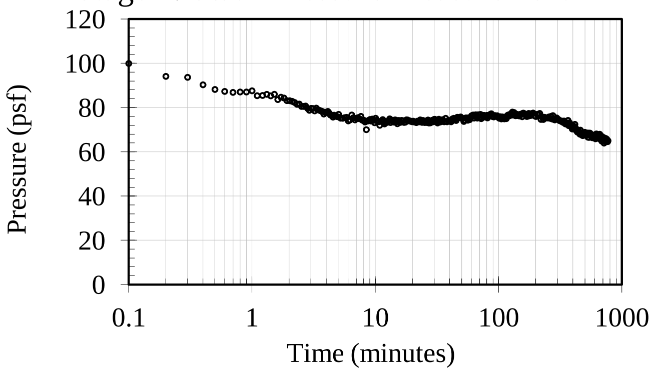
One-Dimensional Consolidation Properties of Soil

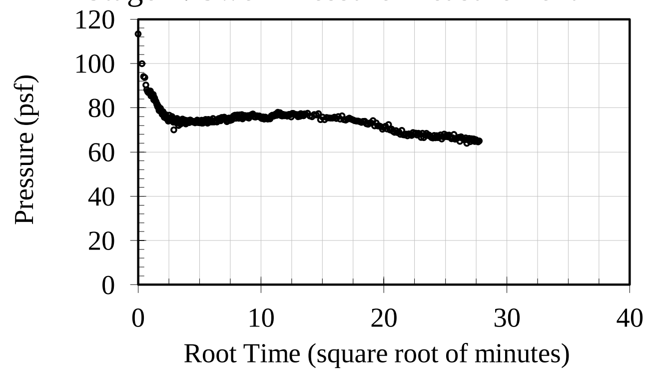
Client: Arias Geoprofessionals
Project: AA2018-142
Specimen: B-103 (13 - 15)

TRI Log No.: 35800.1
Test Method: ASTM D 2435, Method B

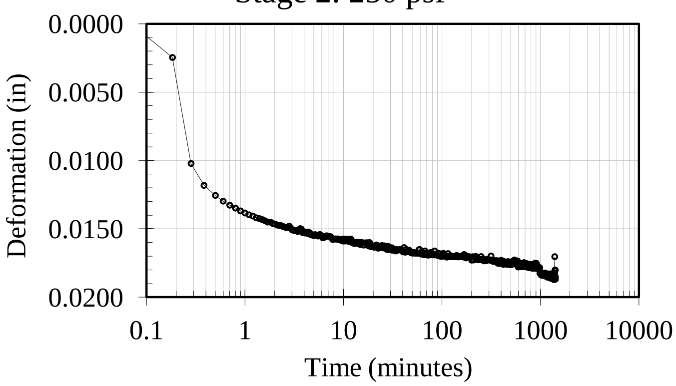
Stage 1: Swell Pressure Measurement



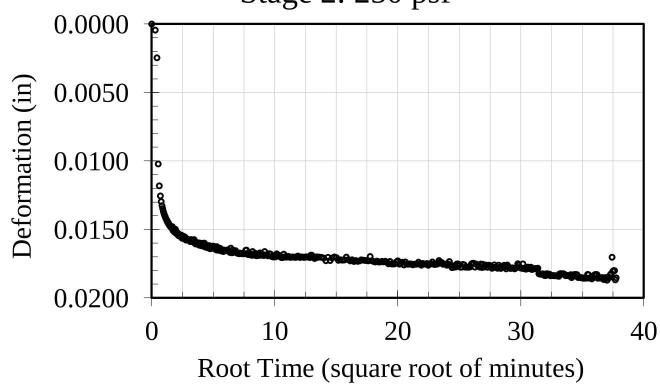
Stage 1: Swell Pressure Measurement



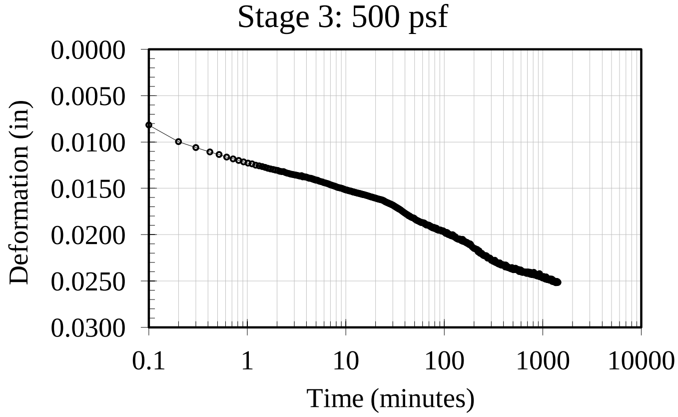
Stage 2: 250 psf



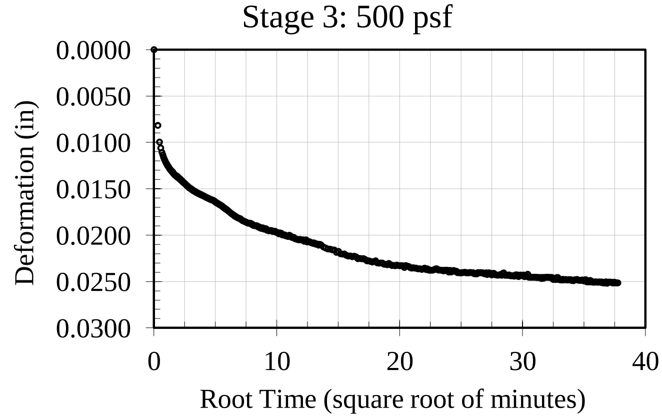
Stage 2: 250 psf



Stage 3: 500 psf



Stage 3: 500 psf



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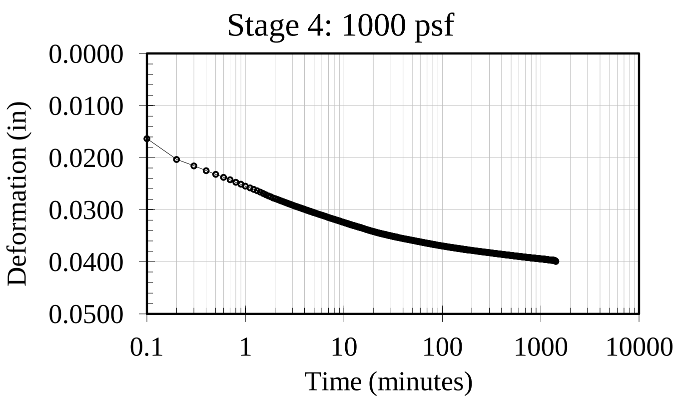
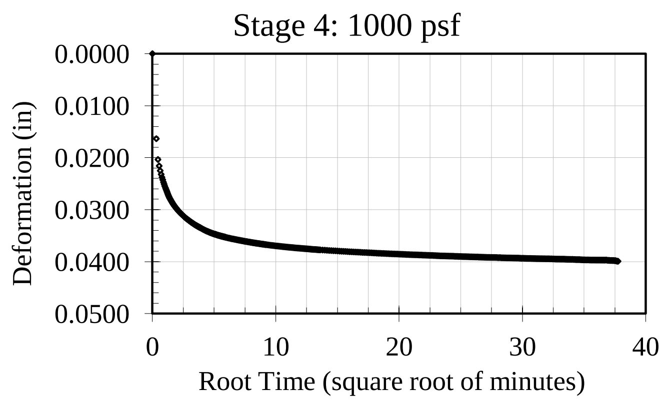
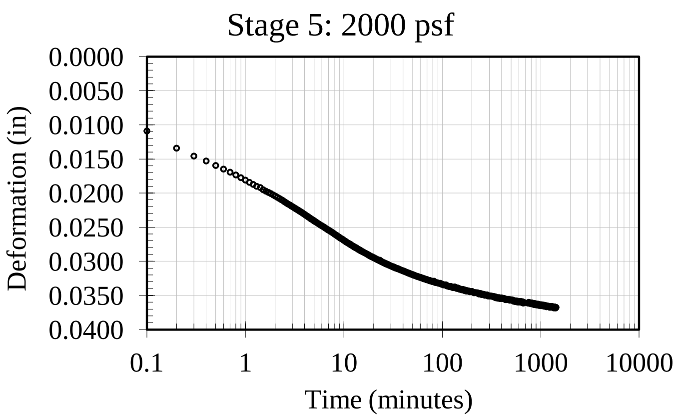
One-Dimensional Consolidation Properties of Soil

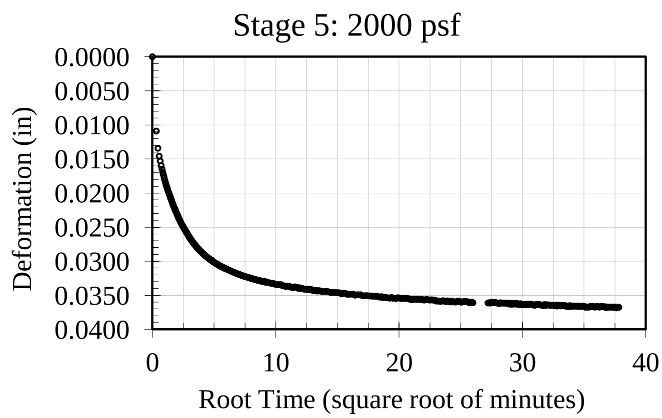
Client: Arias Geoprofessionals
Project: AA2018-142
Specimen: B-103 (13 - 15)

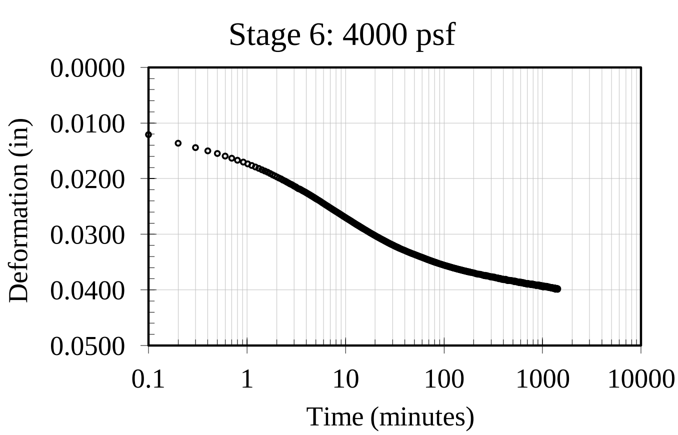
TRI Log No.: 35800.1
Test Method: ASTM D 2435, Method B

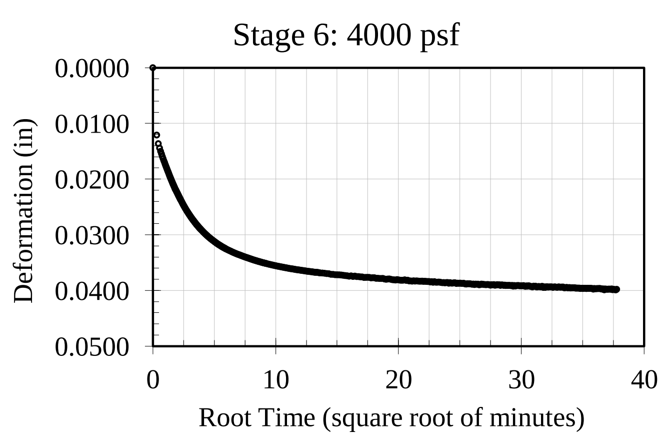












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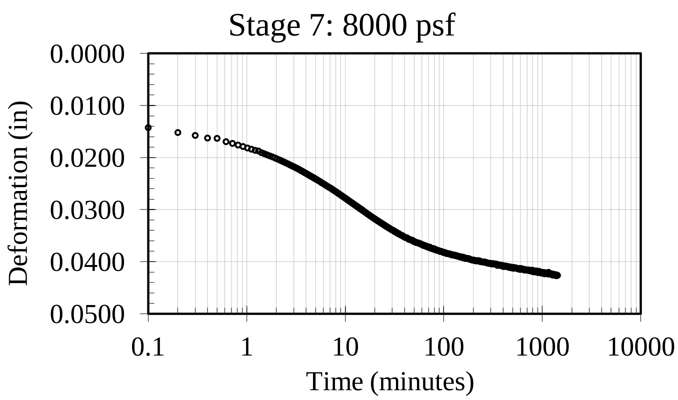
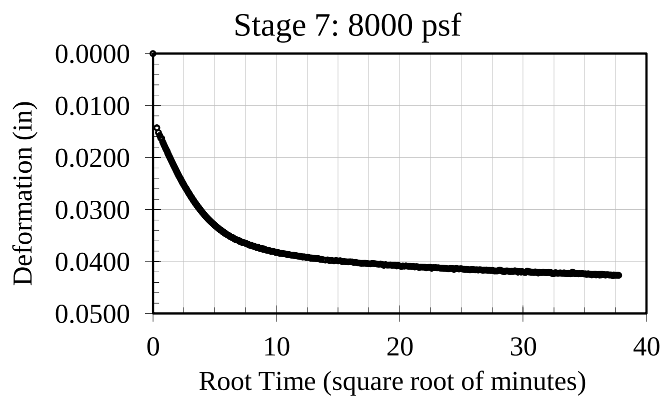
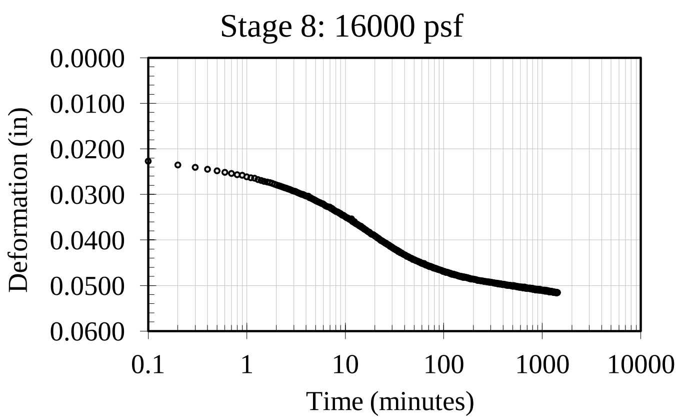
One-Dimensional Consolidation Properties of Soil

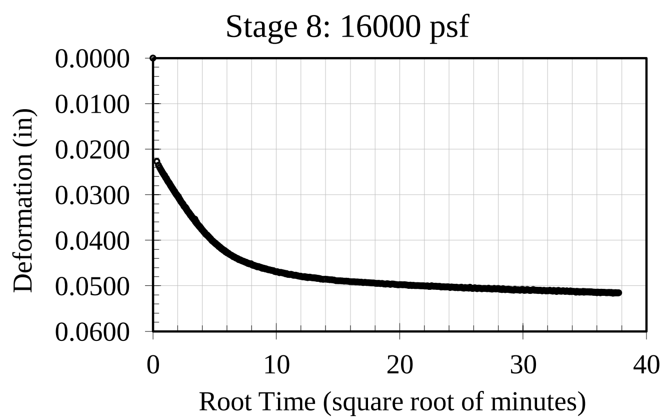
Client: Arias Geoprofessionals
Project: AA2018-142
Specimen: B-103 (13 - 15)

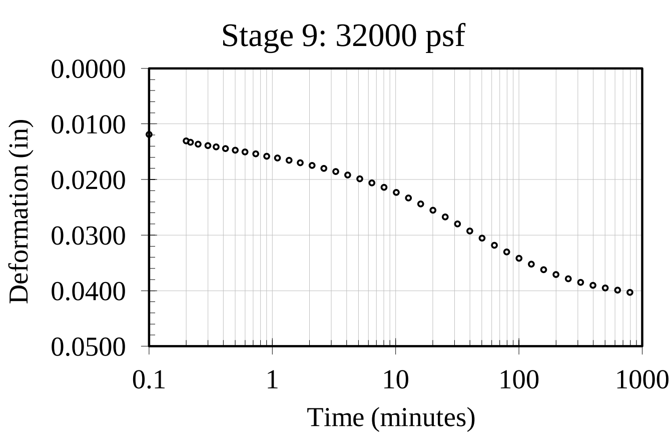
TRI Log No.: 35800.1
Test Method: ASTM D 2435, Method B

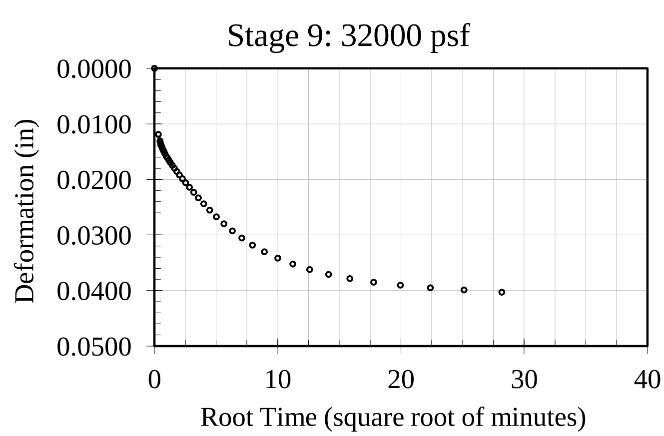












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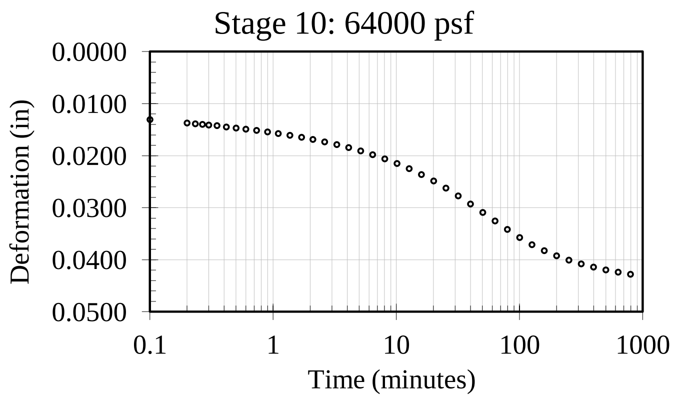
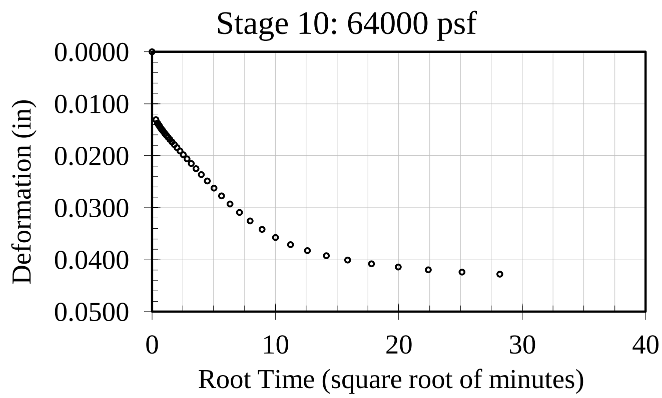
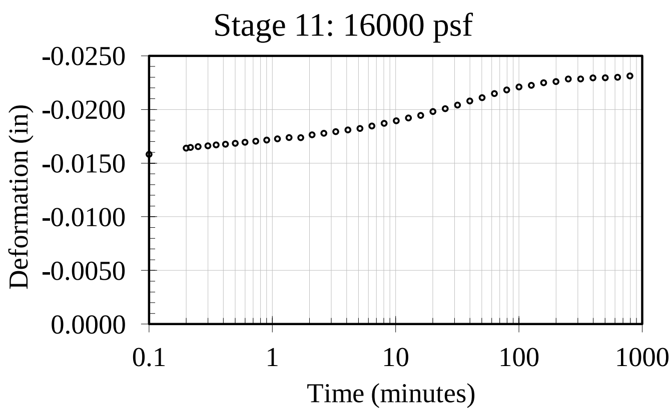
One-Dimensional Consolidation Properties of Soil

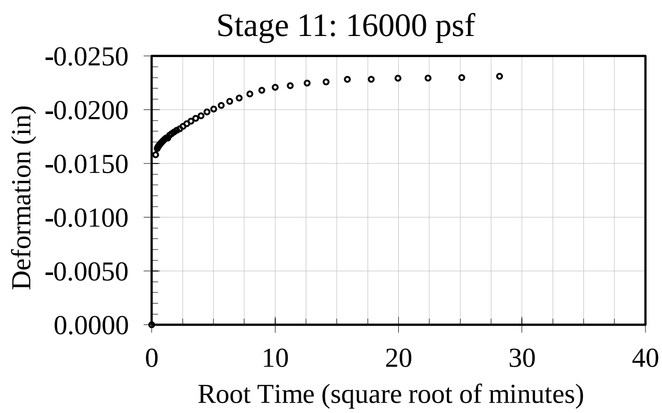
Client: Arias Geoprofessionals
Project: AA2018-142
Specimen: B-103 (13 - 15)

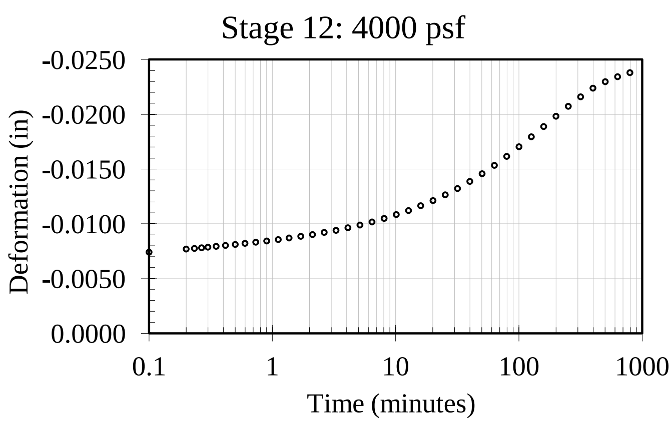
TRI Log No.: 35800.1
Test Method: ASTM D 2435, Method B

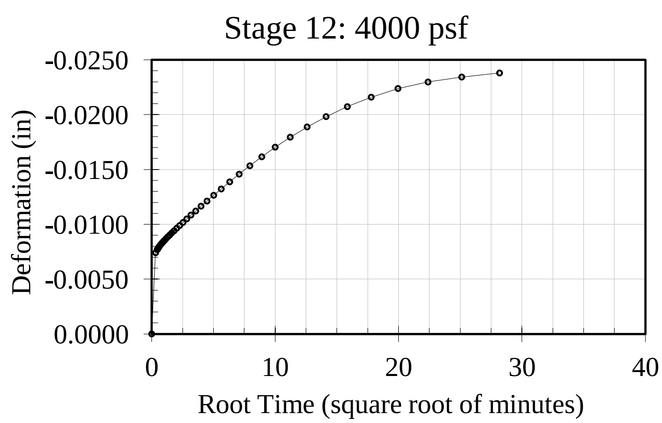








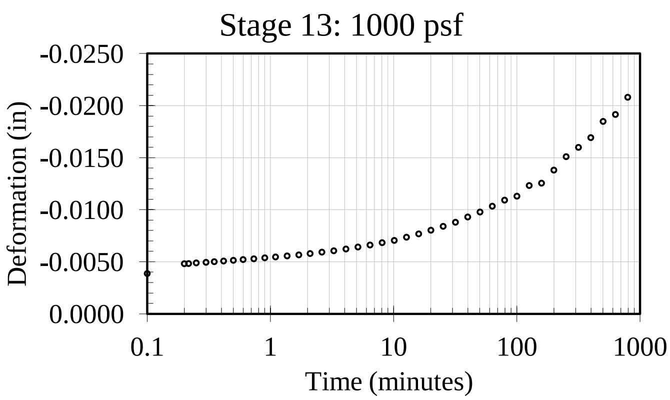


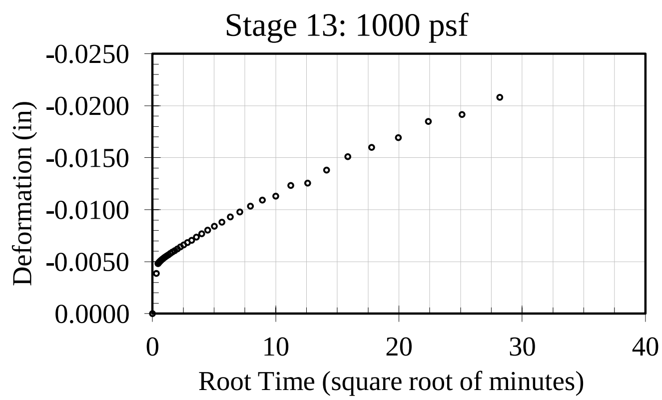


One-Dimensional Consolidation Properties of Soil

Client: Arias Geoprofessionals
Project: AA2018-142
Specimen: B-103 (13 - 15)

TRI Log No.: 35800.1
Test Method: ASTM D 2435, Method B





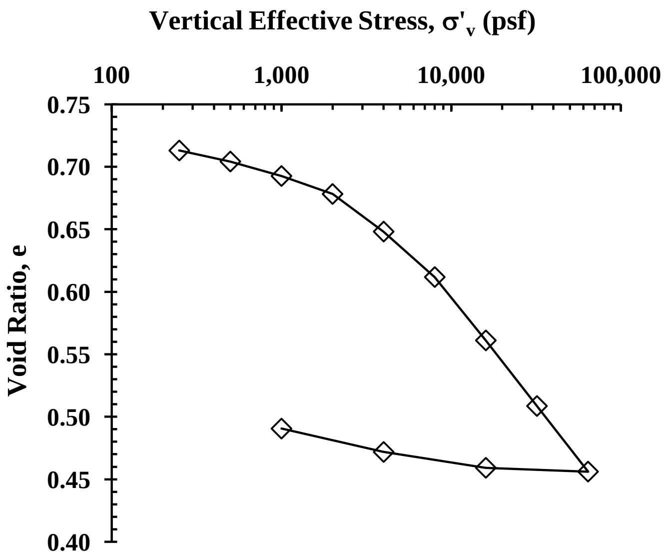
One-Dimensional Consolidation Properties of Soil

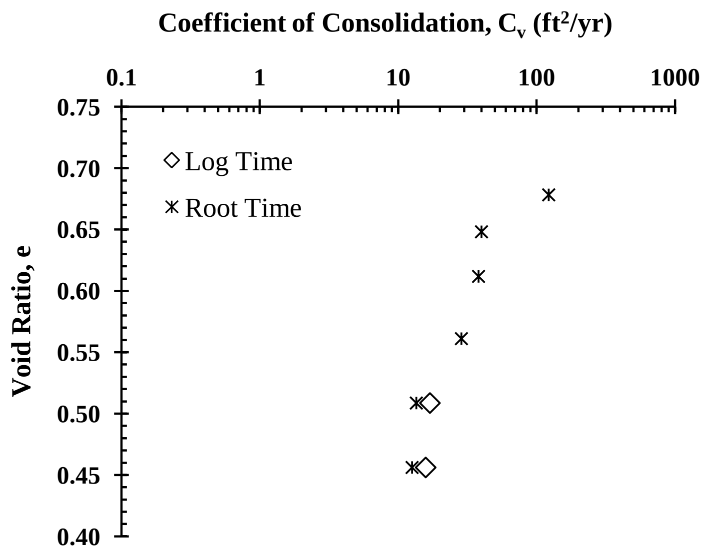
Client: Arias Geoprofessionals
Project: AA2018-142
Specimen: B-104 (28 - 30)

TRI Log No.: 35800.4
Test Method: ASTM D 2435, Method B

Soil Specimen Properties	
Initial Specimen Water Content (%)	25.7
Final Specimen Water Content (%)	20.2
Specimen Diameter (in)	2.499
Initial Specimen Height (in)	0.995
Final Specimen Height (in)	0.862
Final Differential Height (in)	0.133
Initial Dry Unit Weight, γ_o lb_f/ft^3	94.3
Final Dry Unit Weight, γ_f lb_f/ft^3	110.9
Initial Void Ratio, e_o	0.753
Final Void Ratio, e_f	0.491
Initial Degree of Saturation (%)	90.4
Preconsolidation Pressure (psf)	≈4900
Swell Pressure (psf), Maximum Measured	<100
Compression Index, C_c	0.175
Recompression Index, C_r	0.174

σ'_v	e	Strain, ε	C_v (ft^2/year)	
(psf)	(-)	(%)	Log Time	Root Time
Initial	0.753	0.0	-	-
250	0.713	2.3	-	-
500	0.704	2.8	-	-
1,000	0.693	3.5	-	-
2,000	0.678	4.3	-	120
4,000	0.648	6.0	-	40
8,000	0.612	8.1	-	38
16,000	0.561	11.0	-	29
32,000	0.509	14.0	17	14
64,000	0.456	17.0	16	13
16,000	0.459	16.8	-	-
4,000	0.472	16.1	-	-
1,000	0.491	15.0	-	-





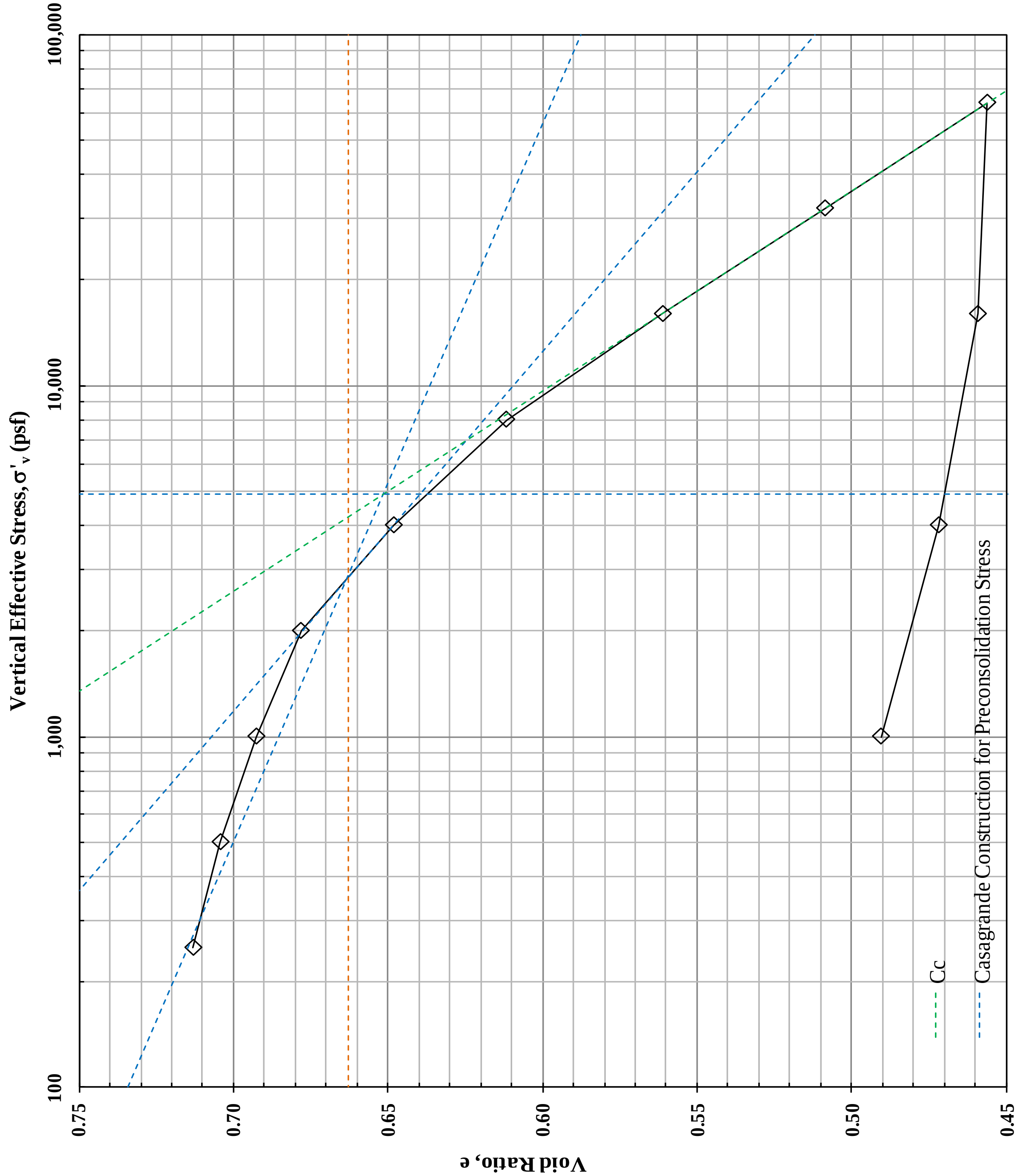
The undisturbed specimen was provided by the client. The specimen was trimmed using a trimming turntable and mounted. The specimen was inundated with tap water during testing. Coefficient of Consolidation was determined using the Log Time and Root Time Methods. A specific gravity of 2.75 was assumed for weight-volume calculations. Calculations include machine deflections measured at each loading step. The preconsolidation pressure was determined using the Casagrande construction technique.

Jeffrey A. Kuhn, Ph.D., P.E., 3/26/2018
Quality Review/Date

One-Dimensional Consolidation Properties of Soil

Client: Arias Geoprofessionals
Project: AA2018-142
Specimen: B-104 (28 - 30)

TRI Log No.: 35800.4
Test Method: ASTM D 2435, Method B



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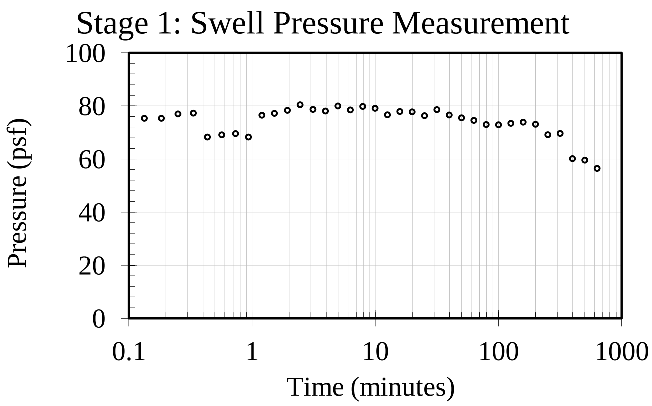
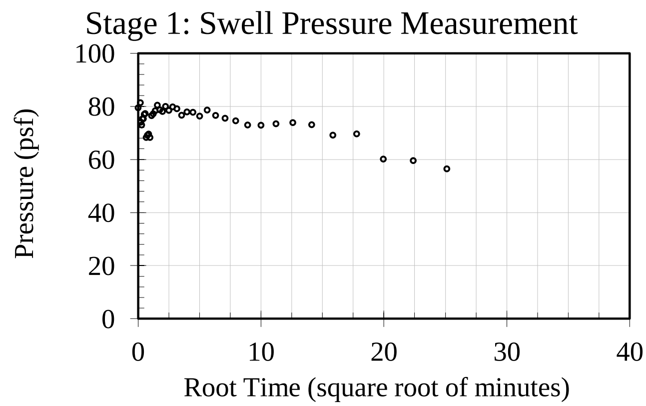
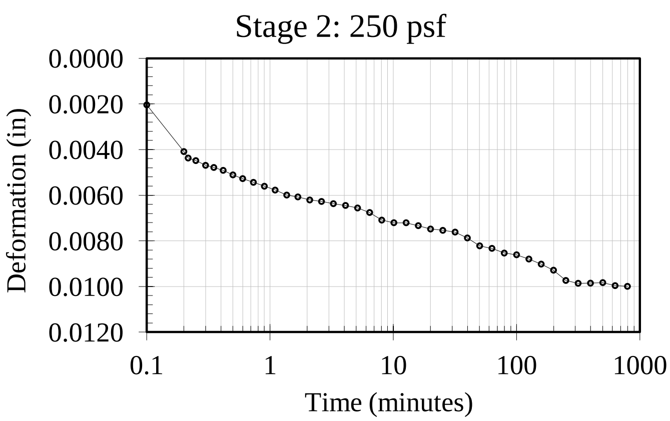
One-Dimensional Consolidation Properties of Soil

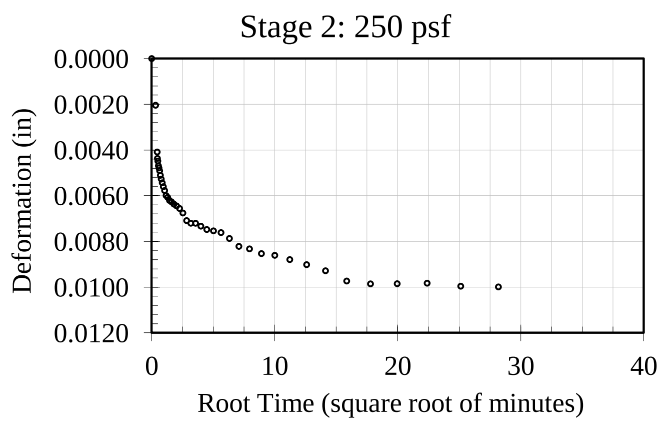
Client: Arias Geoprofessionals
Project: AA2018-142
Specimen: B-104 (28 - 30)

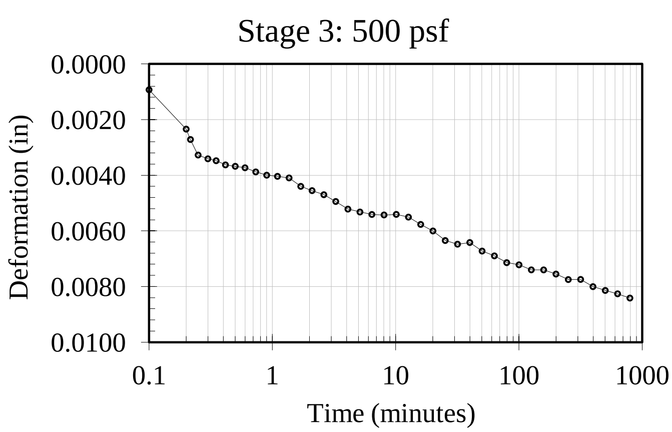
TRI Log No.: 35800.4
Test Method: ASTM D 2435, Method B

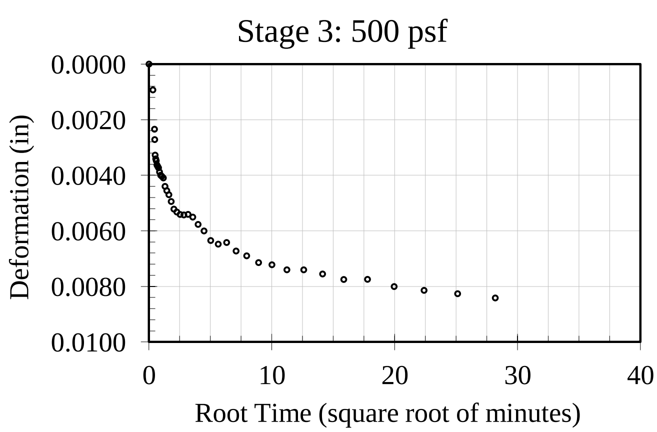












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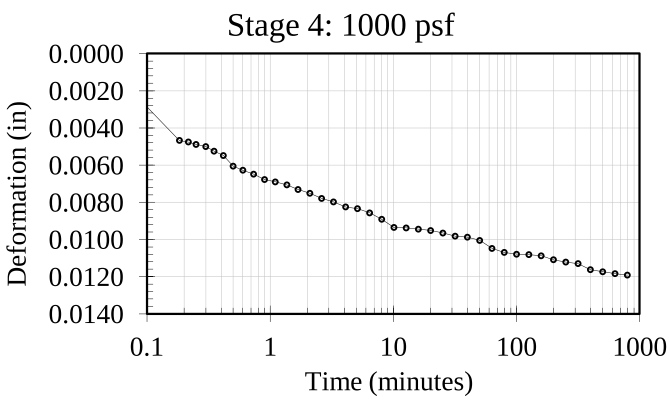
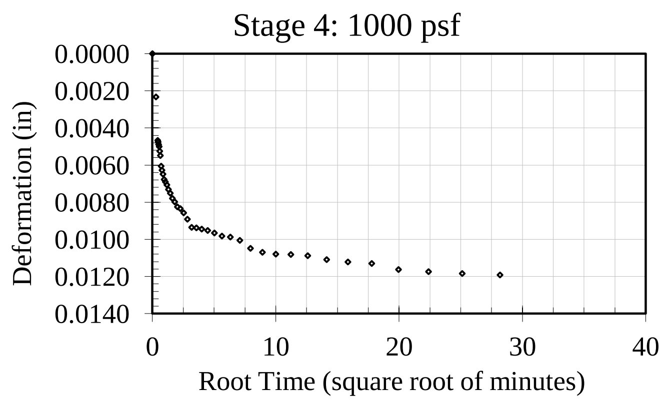
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

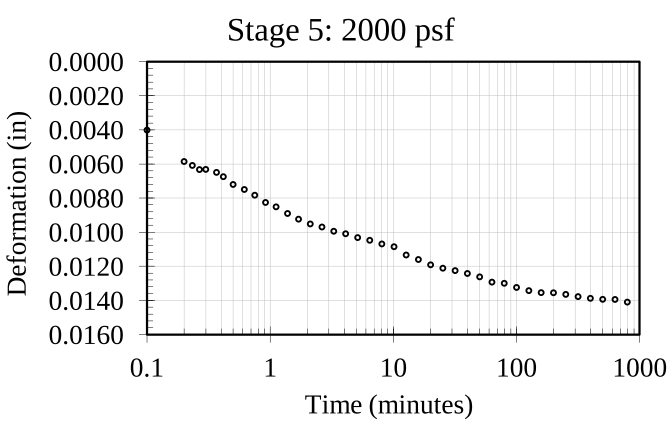
One-Dimensional Consolidation Properties of Soil

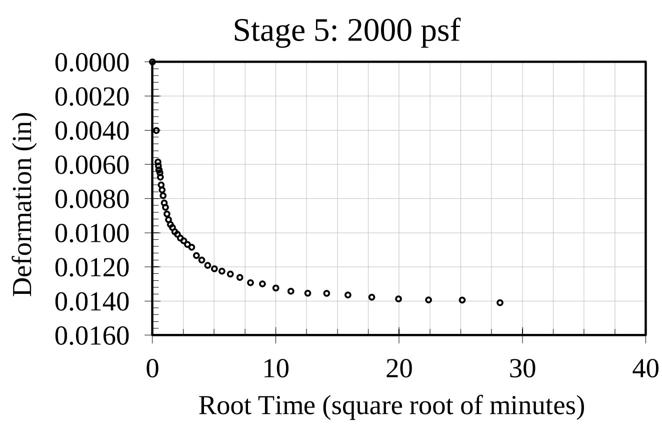
Client: Arias Geoprofessionals
Project: AA2018-142
Specimen: B-104 (28 - 30)

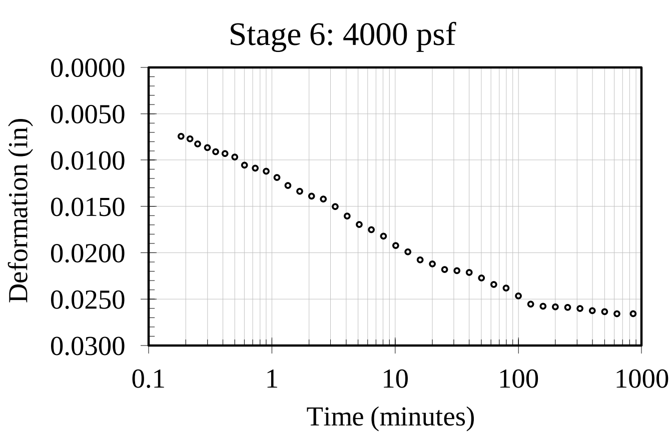
TRI Log No.: 35800.4
Test Method: ASTM D 2435, Method B

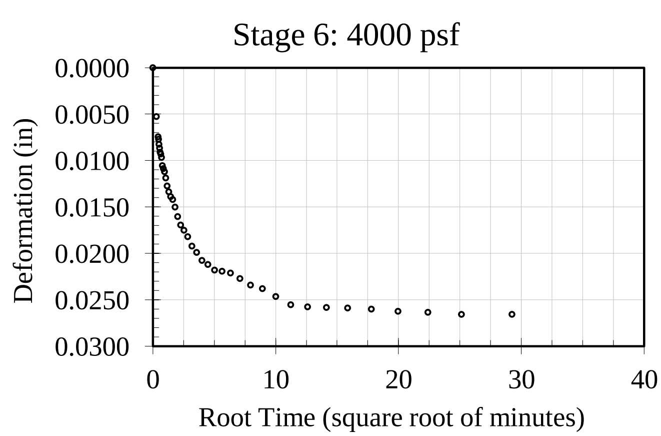










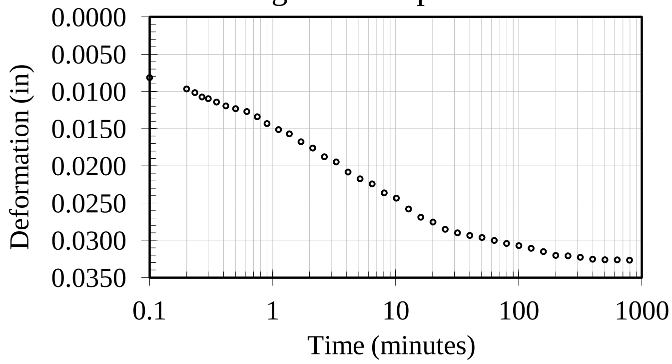


One-Dimensional Consolidation Properties of Soil

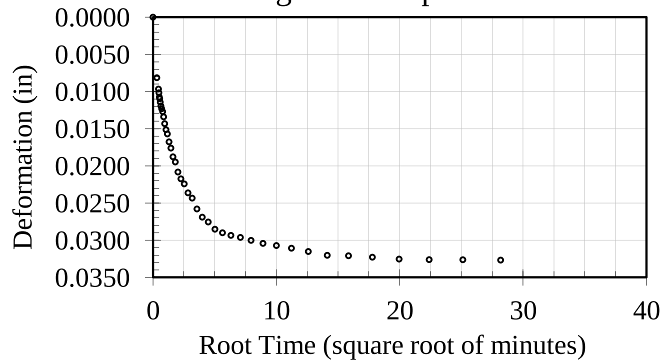
Client: Arias Geoprofessionals
Project: AA2018-142
Specimen: B-104 (28 - 30)

TRI Log No.: 35800.4
Test Method: ASTM D 2435, Method B

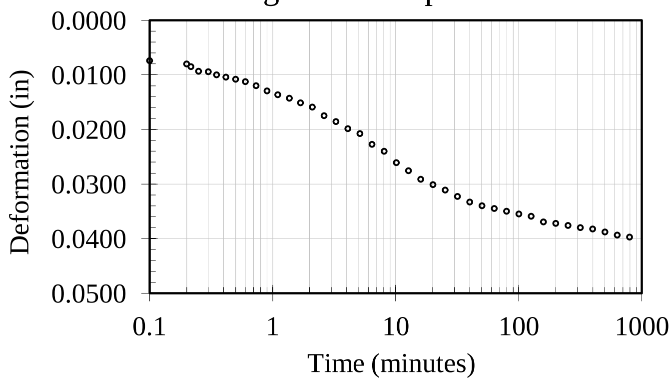
Stage 7: 8000 psf



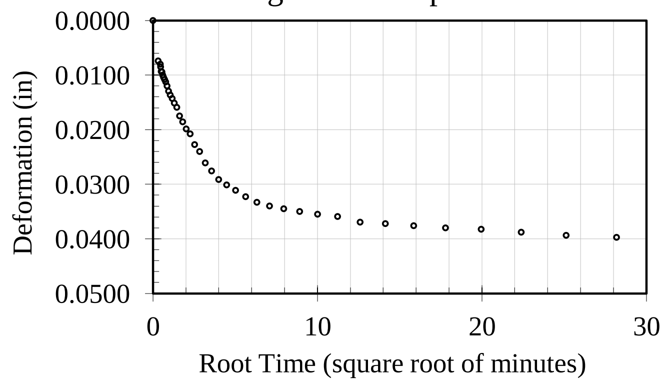
Stage 7: 8000 psf



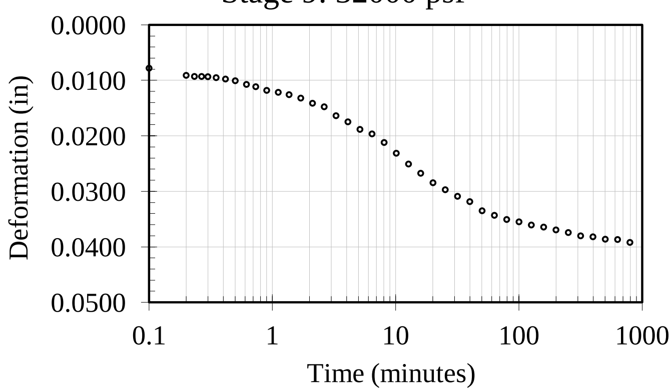
Stage 8: 16000 psf



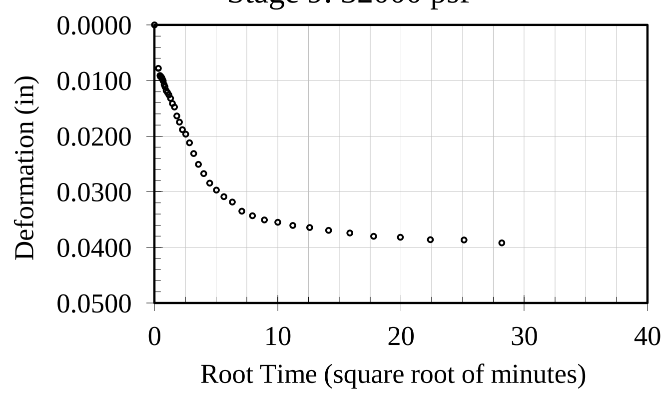
Stage 8: 16000 psf



Stage 9: 32000 psf



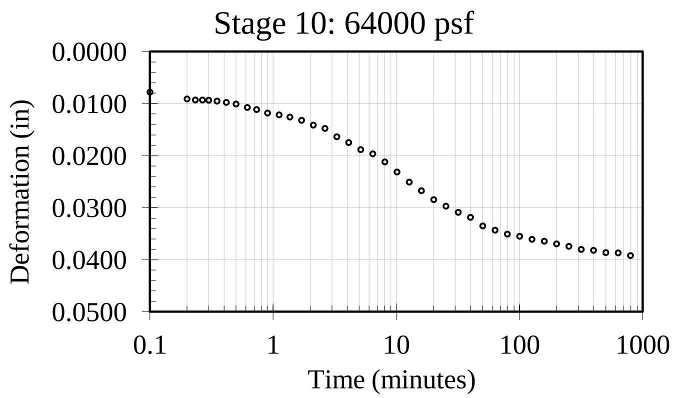
Stage 9: 32000 psf

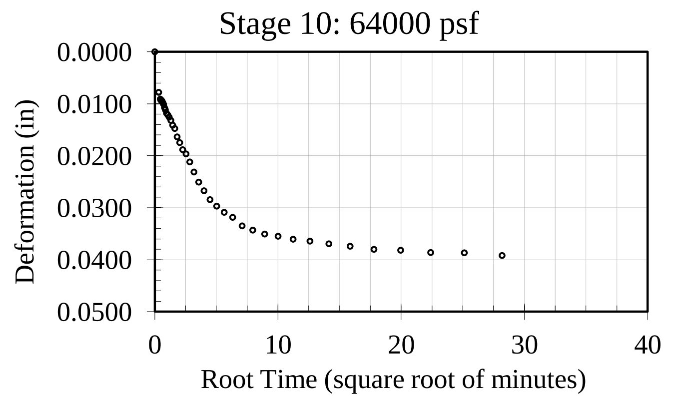


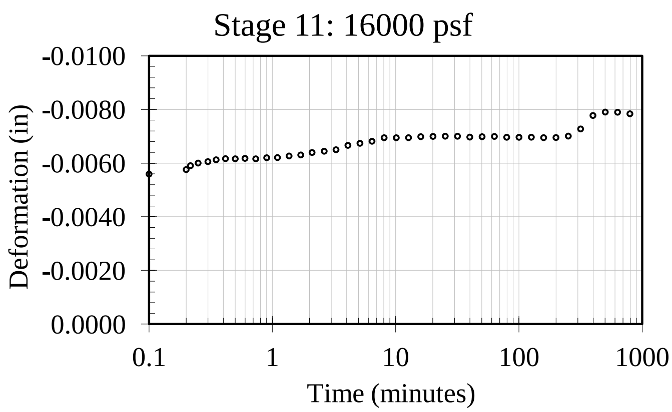
One-Dimensional Consolidation Properties of Soil

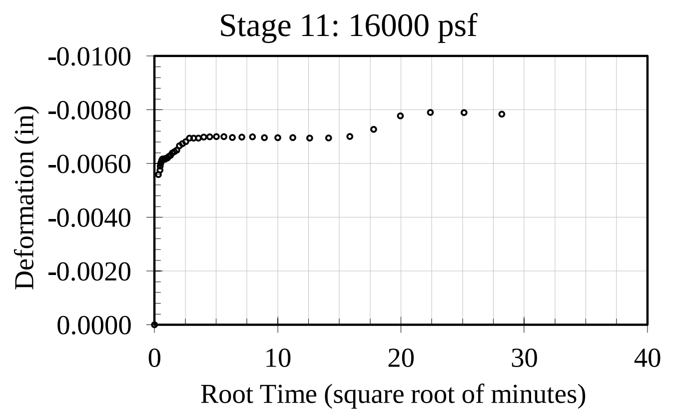
Client: Arias Geoprofessionals
Project: AA2018-142
Specimen: B-104 (28 - 30)

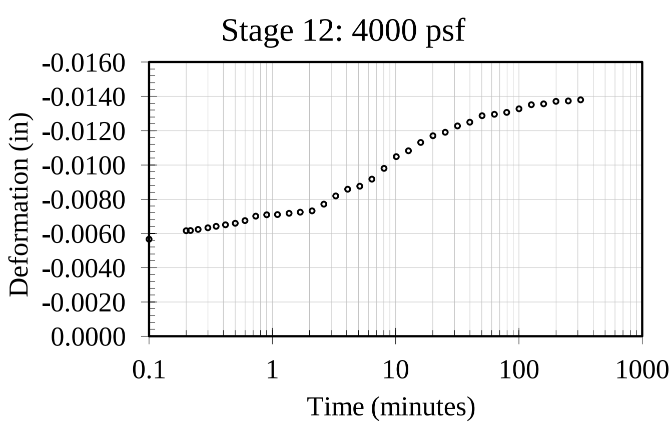
TRI Log No.: 35800.4
Test Method: ASTM D 2435, Method B

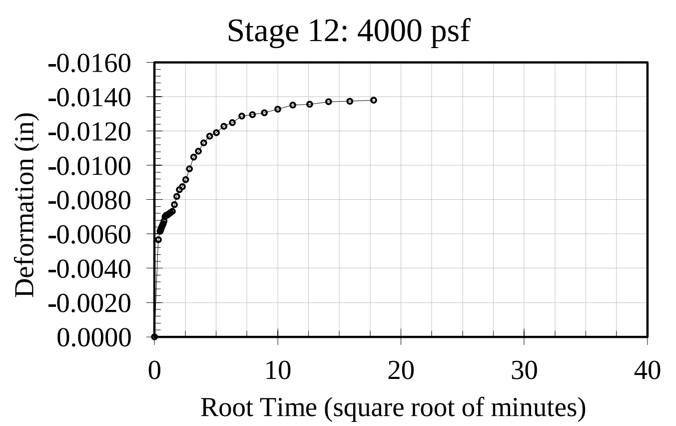








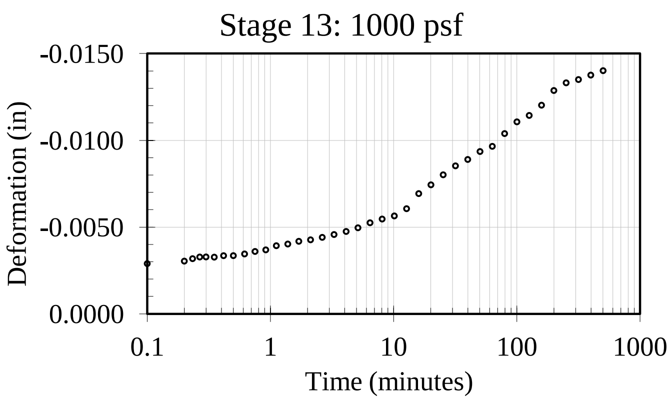


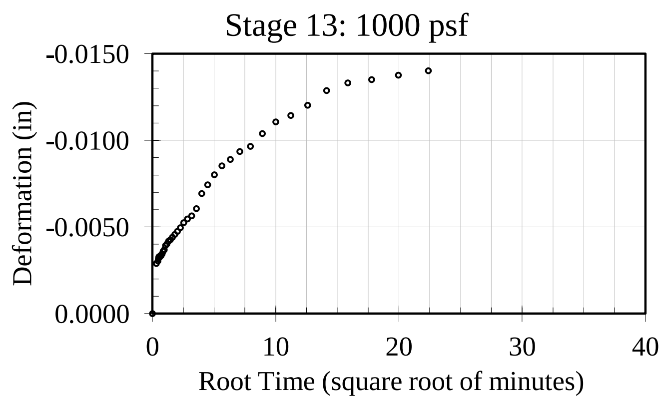


One-Dimensional Consolidation Properties of Soil

Client: Arias Geoprofessionals
Project: AA2018-142
Specimen: B-104 (28 - 30)

TRI Log No.: 35800.4
Test Method: ASTM D 2435, Method B





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9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

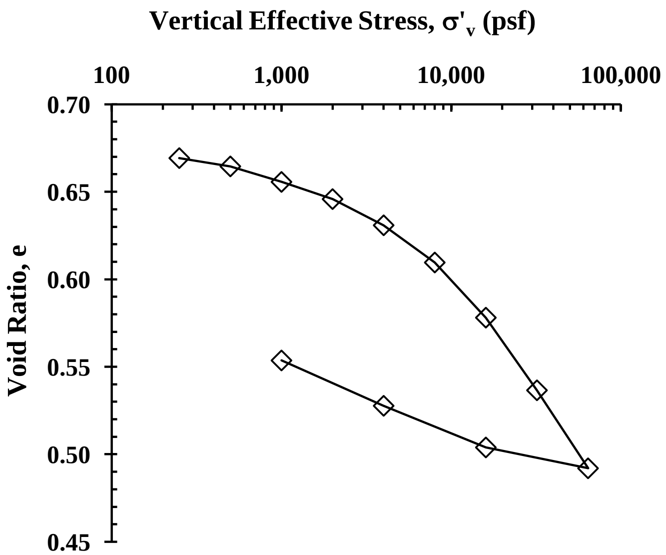
One-Dimensional Consolidation Properties of Soil

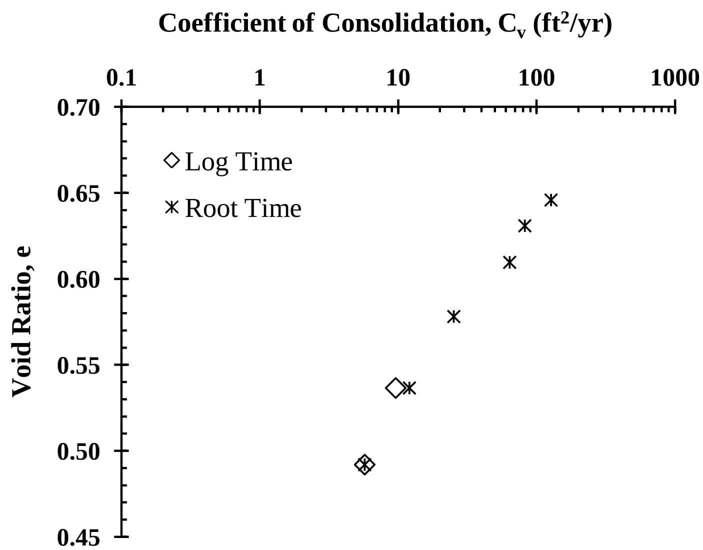
Client: Arias Geoprofessionals
Project: AA2018-142
Specimen: B-105 (23 - 25)

TRI Log No.: 35800.2
Test Method: ASTM D 2435, Method B

Soil Specimen Properties	
Initial Specimen Water Content (%)	20.8
Final Specimen Water Content (%)	18.7
Specimen Diameter (in)	2.486
Initial Specimen Height (in)	1.005
Final Specimen Height (in)	0.934
Final Differential Height (in)	0.071
Initial Dry Unit Weight, γ_o lb_f/ft^3	97.1
Final Dry Unit Weight, γ_f lb_f/ft^3	106.4
Initial Void Ratio, e_o	0.704
Final Void Ratio, e_f	0.554
Initial Degree of Saturation (%)	78.5
Preconsolidation Pressure (psf)	≈9000
Swell Pressure (psf), Maximum Measured	132
Compression Index, C_c	0.142
Recompression Index, C_r	0.148

σ'_v	e	Strain, ε	C_v (ft^2/year)	
(psf)	(-)	(%)	Log Time	Root Time
Initial	0.704	0.0	-	-
250	0.669	2.0	-	-
500	0.664	2.3	-	-
1,000	0.656	2.8	-	-
2,000	0.646	3.4	-	130
4,000	0.631	4.3	-	82
8,000	0.610	5.5	-	64
16,000	0.578	7.4	-	25
32,000	0.537	9.8	9.6	12
64,000	0.492	12.4	5.7	5.7
16,000	0.504	11.7	-	-
4,000	0.528	10.3	-	-
1,000	0.554	8.8	-	-





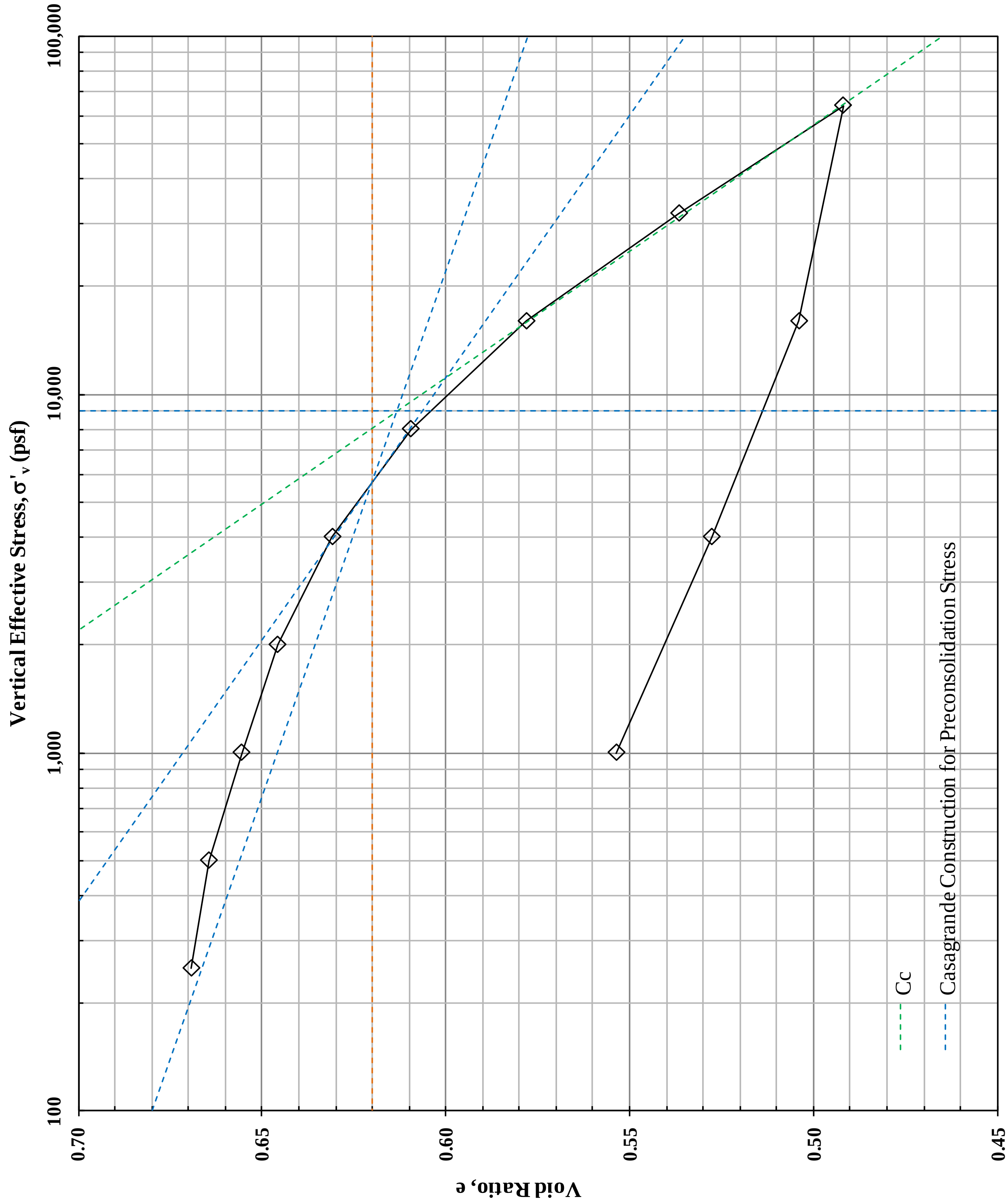
The undisturbed specimen was provided by the client. The specimen was trimmed using a trimming turntable and mounted. The specimen was inundated with tap water during testing. Coefficient of Consolidation was determined using the Log Time and Root Time Methods. A specific gravity of 2.75 was assumed for weight-volume calculations. Calculations include machine deflections measured at each loading step. The preconsolidation pressure was determined using the Casagrande construction technique.

Jeffrey A. Kuhn, Ph.D., P.E., 3/26/2018
Quality Review/Date

One-Dimensional Consolidation Properties of Soil

Client: Arias Geoprofessionals
Project: AA2018-142
Specimen: B-105 (23 - 25)

TRI Log No.: 35800.2
Test Method: ASTM D 2435, Method B



TRI ENVIRONMENTAL, INC.
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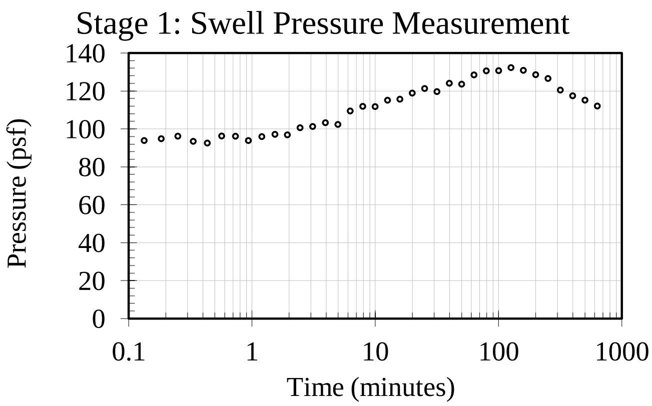
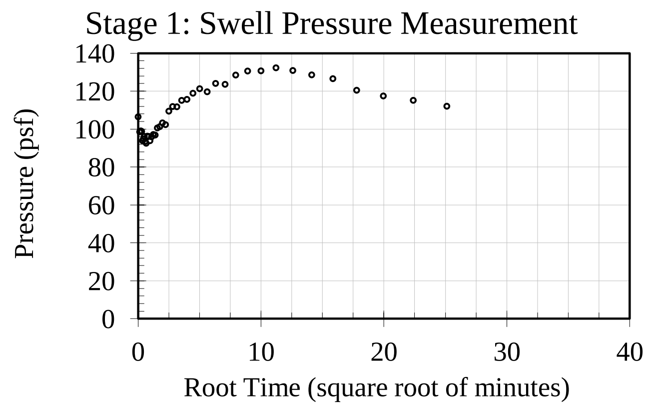
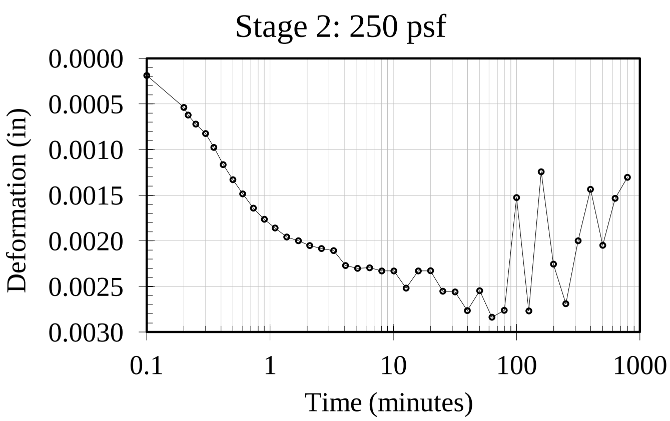
One-Dimensional Consolidation Properties of Soil

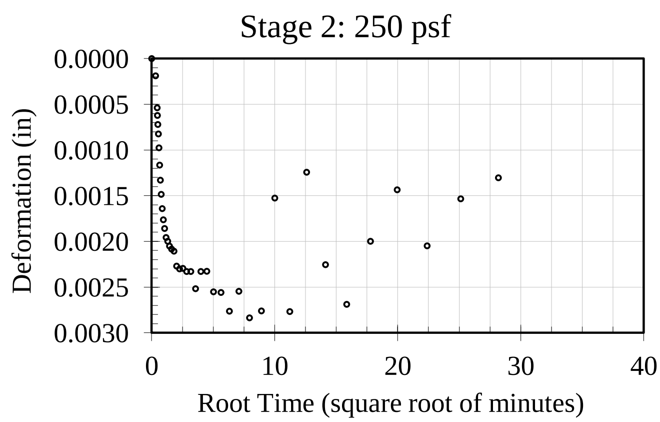
Client: Arias Geoprofessionals
Project: AA2018-142
Specimen: B-105 (23 - 25)

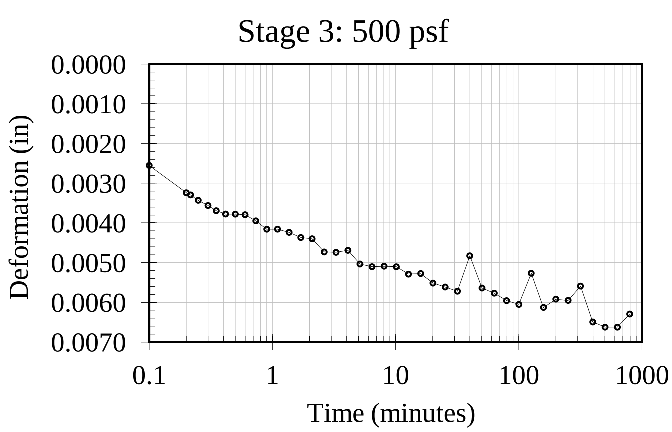
TRI Log No.: 35800.2
Test Method: ASTM D 2435, Method B

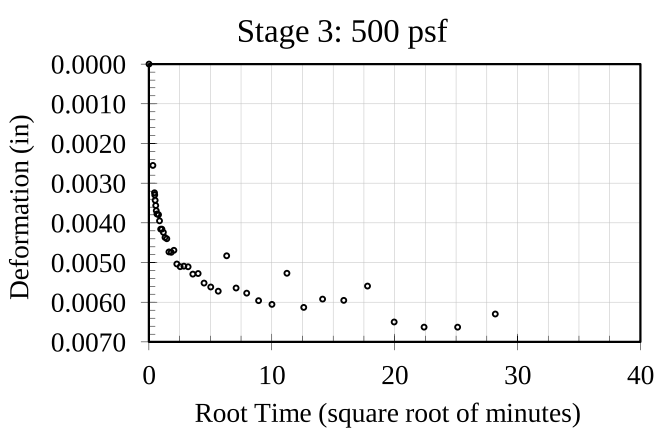








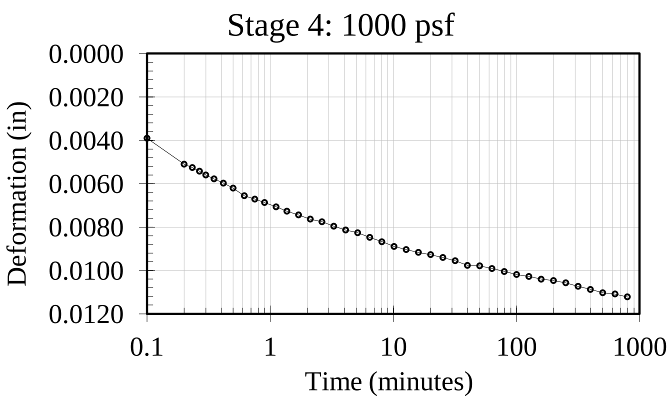


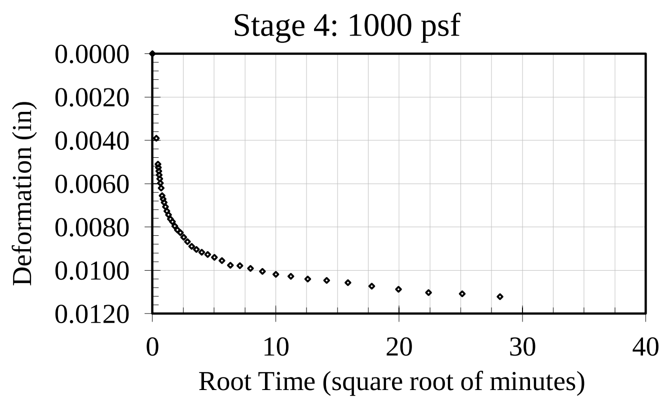


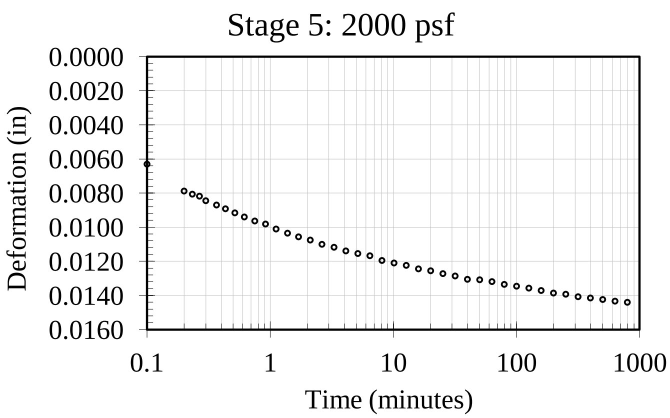
One-Dimensional Consolidation Properties of Soil

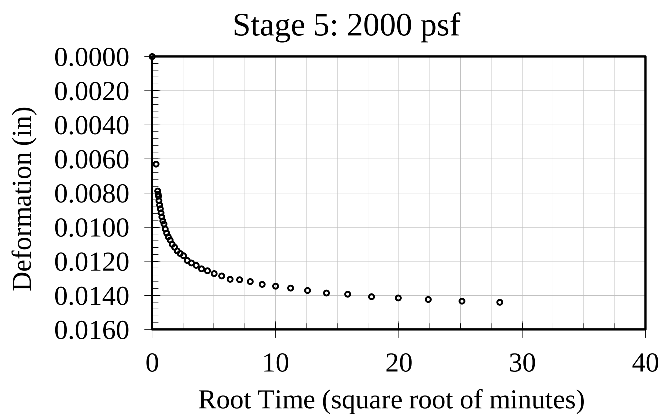
Client: Arias Geoprofessionals
Project: AA2018-142
Specimen: B-105 (23 - 25)

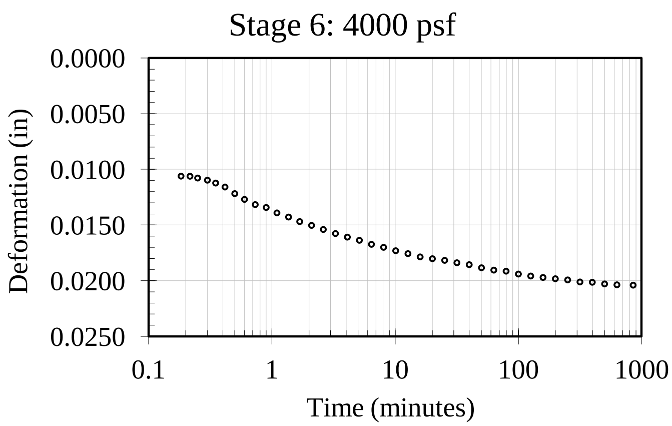
TRI Log No.: 35800.2
Test Method: ASTM D 2435, Method B

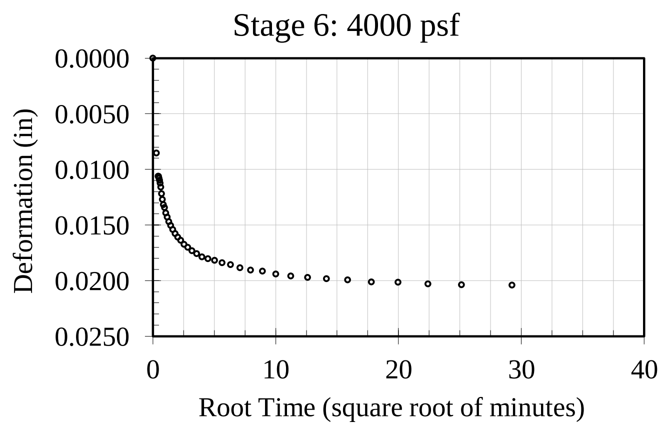








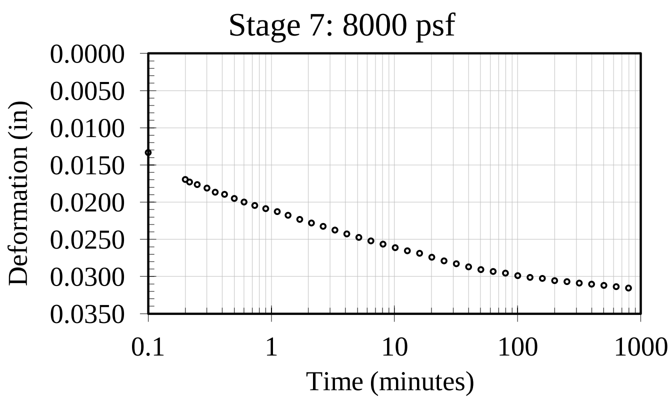


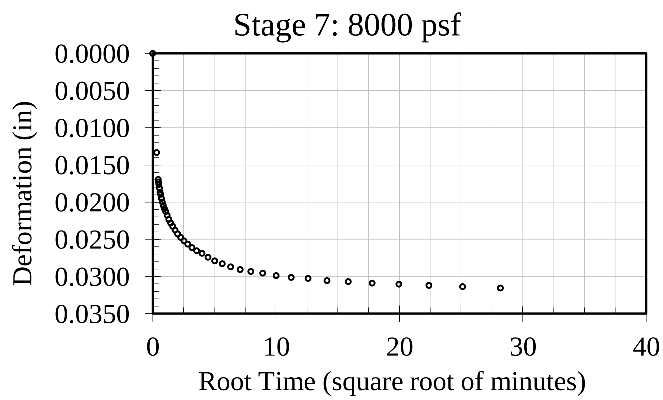


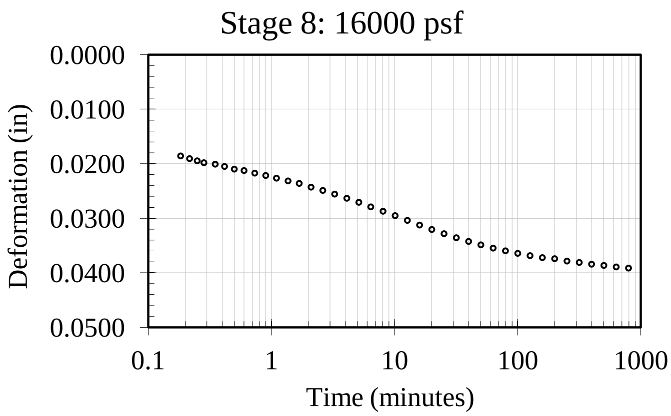
One-Dimensional Consolidation Properties of Soil

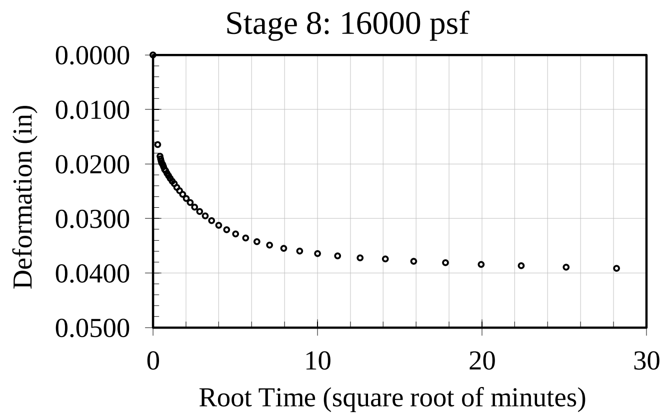
Client: Arias Geoprofessionals
Project: AA2018-142
Specimen: B-105 (23 - 25)

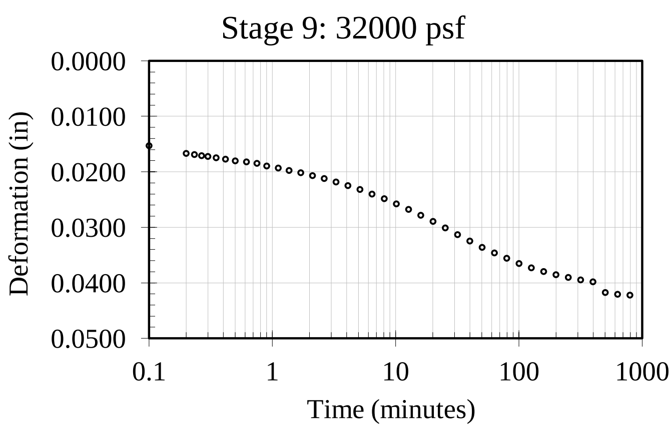
TRI Log No.: 35800.2
Test Method: ASTM D 2435, Method B

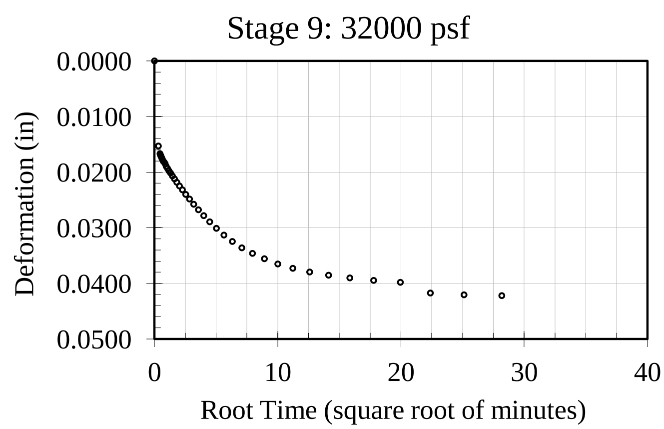








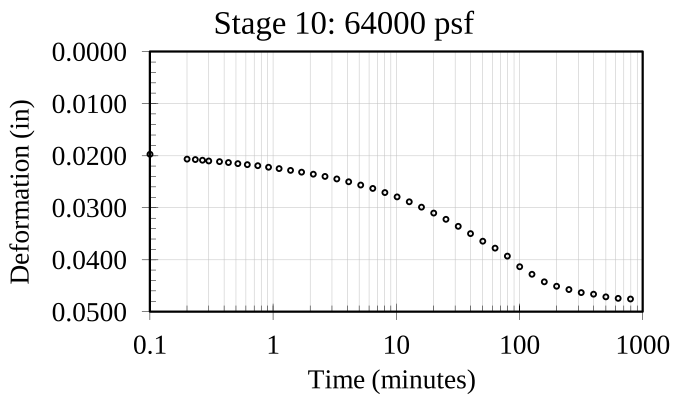


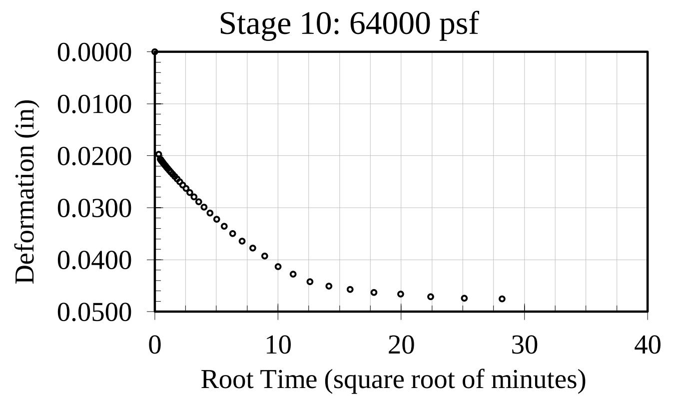


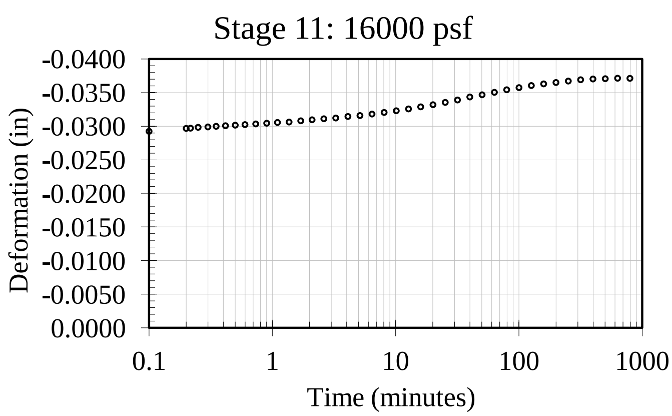
One-Dimensional Consolidation Properties of Soil

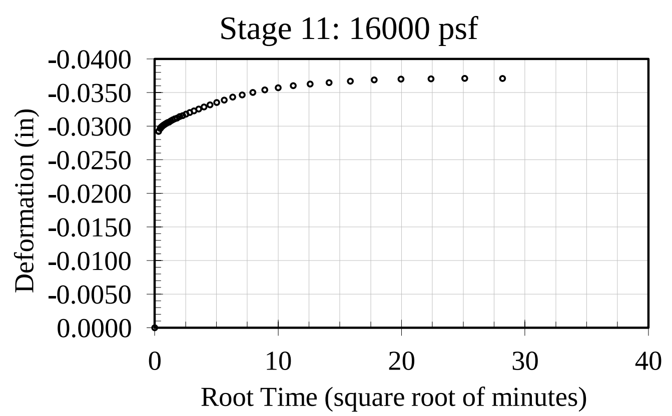
Client: Arias Geoprofessionals
Project: AA2018-142
Specimen: B-105 (23 - 25)

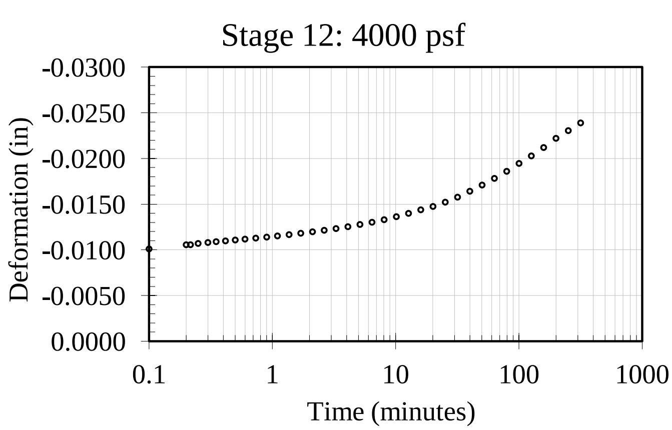
TRI Log No.: 35800.2
Test Method: ASTM D 2435, Method B

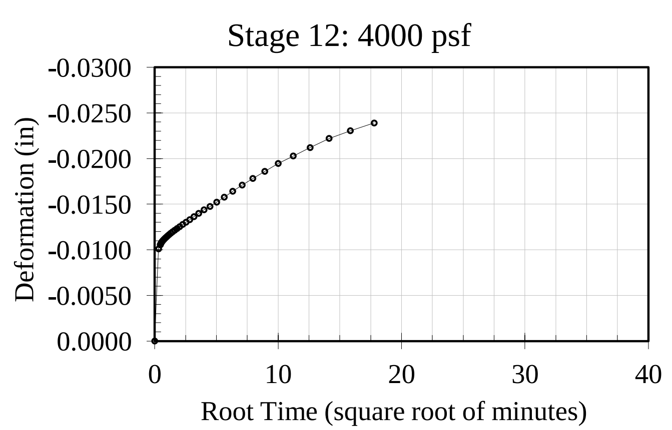








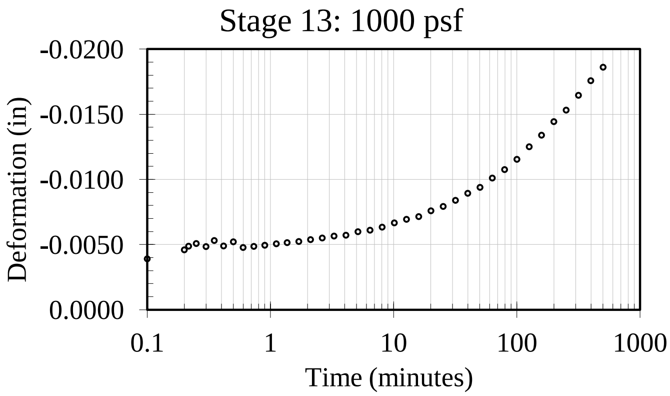


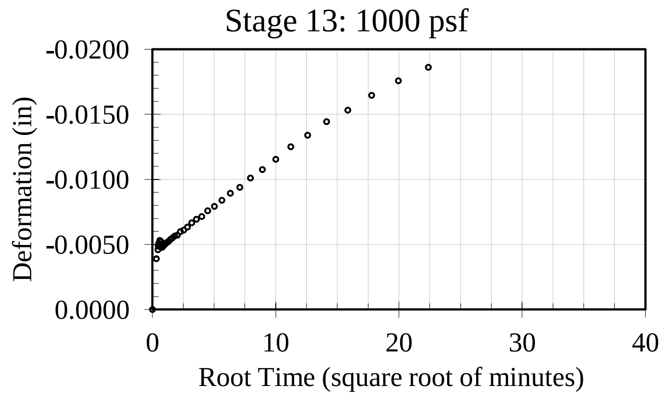


One-Dimensional Consolidation Properties of Soil

Client: Arias Geoprofessionals
Project: AA2018-142
Specimen: B-105 (23 - 25)

TRI Log No.: 35800.2
Test Method: ASTM D 2435, Method B



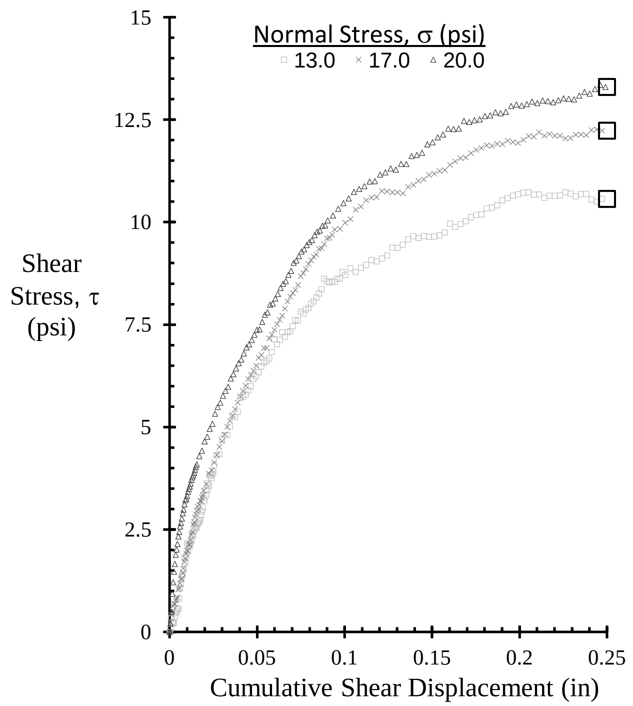


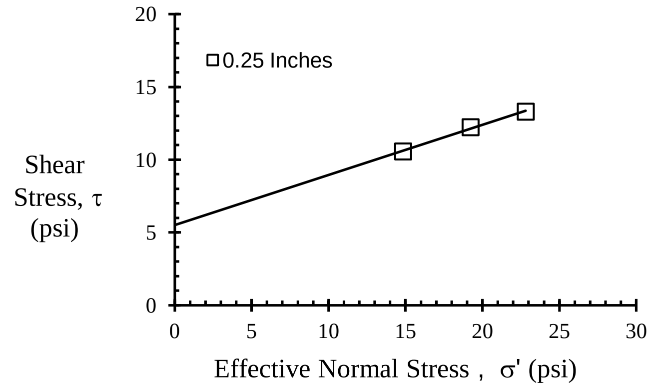
APPENDIX F: DIRECT SHEAR TEST RESULTS

Direct Shear of Soil Under Consolidated-Drained Conditions

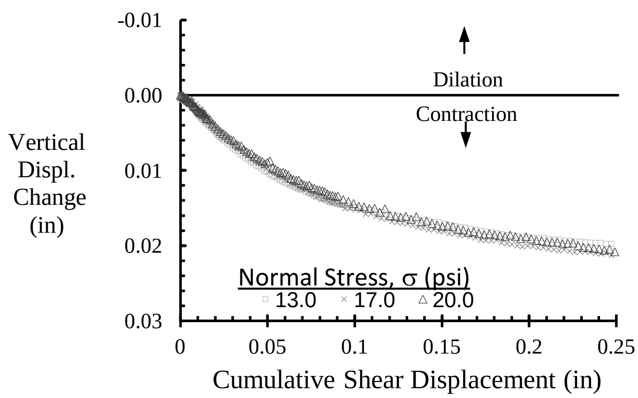
Client: Arias & Associates
Project: Mitchell Lake Wetland
Sample: B-103 (18 - 20)

TRI Log#: 36635.1
Test Method: ASTM D3080





Note: Area Correction Has Been Applied



	Sample Number	1	2	3
Initial Condition	Diameter, in	2.50	2.50	2.50
	Height, in (before consol)	1.00	1.00	1.00
	Water Content, %	23.5	23.0	23.0
	Saturation, %	90.9	90.4	86.7
	Dry Density, pcf	98.2	98.8	97.1
	Void Ratio	0.68	0.67	0.70
Post-Consol	Height, in (prior to shear)	0.99	1.00	0.99
	Dry Density, pcf	99.1	99.0	98.2
	Void Ratio	0.67	0.67	0.68
	Displacement rate (in/min)	1.0E-04	1.0E-04	1.0E-04
	Final Water Content, %	22.8	21.9	21.4
Peak	Normal Stress, σ' (psi)	-	-	-
	Shear Stress, τ (psi)	-	-	-
	Displacement (in)	-	-	-
	ϕ'_d, degrees	-		
	c'_d, psi	-		
0.25 Inches	Normal Stress, σ' (psi)	14.84	19.23	22.81
	Shear Stress, τ (psi)	10.57	12.23	13.30
	Secant Friction Angle, Degrees	35.4	32.5	30.2
	ϕ'_d, degrees	19.0		
	c'_d, psi	5.5		

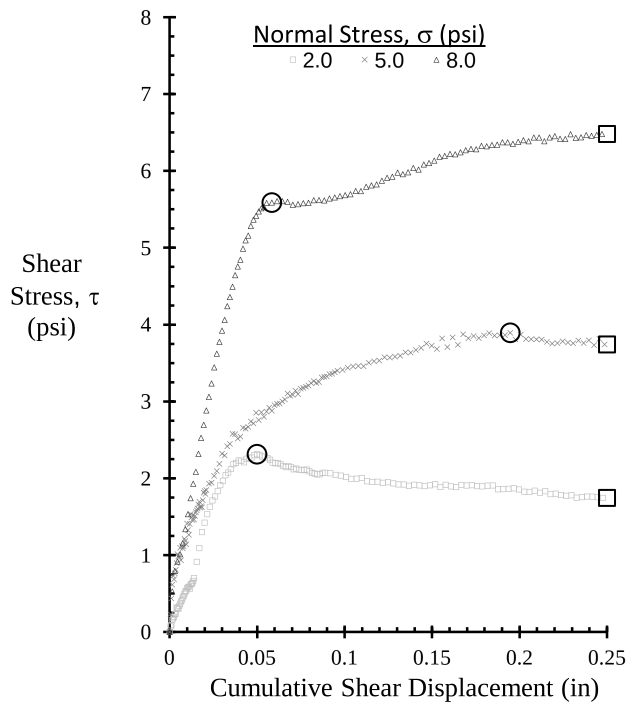
Note: The undisturbed soil samples were extruded and trimmed using a trimming turntable. A specific gravity of 2.65 was assumed for weight-volume calculations.

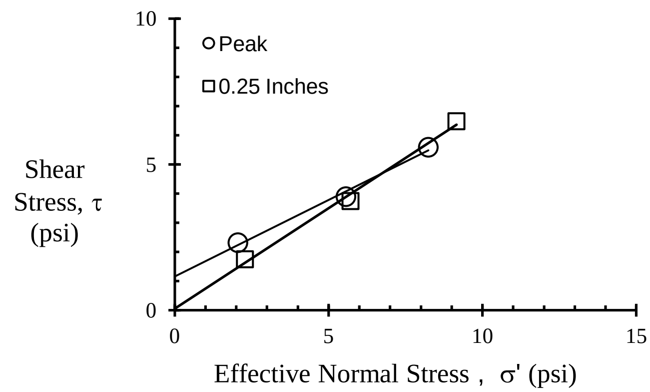
Jeffrey A. Kuhn, Ph.D., P.E., 4/27/18
Analysis & Quality Review/Date

Direct Shear of Soil Under Consolidated-Drained Conditions

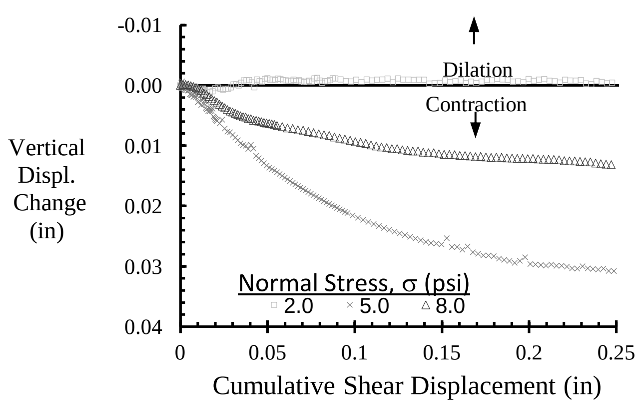
Client: Arias & Associates
Project: Mitchell Lake Wetland
Sample: B-110 (4 - 6)

TRI Log#: 36618.1
Test Method: ASTM D3080





Note: Area Correction Has Been Applied



	Sample Number	1	2	3
Initial Condition	Diameter, in	2.50	2.50	2.50
	Height, in (before consol)	1.00	1.00	1.00
	Water Content, %	13.0	12.9	12.7
	Saturation, %	56.1	50.8	53.7
	Dry Density, pcf	102.5	98.9	101.7
	Void Ratio	0.61	0.67	0.63
Post-Consol	Height, in (prior to shear)	1.00	1.00	1.00
	Dry Density, pcf	102.5	99.2	102.0
	Void Ratio	0.61	0.67	0.62
	Displacement rate (in/min)	1.0E-04	1.0E-04	1.0E-04
	Final Water Content, %	24.5	23.8	22.8
Peak	Normal Stress, σ' (psi)	2.05	5.56	8.24
	Shear Stress, τ (psi)	2.31	3.89	5.59
	Displacement (in)	0.05	0.19	0.06
	ϕ'_d, degrees	27.7		
	c'_d, psi	1.2		
0.25 Inches	Normal Stress, σ' (psi)	2.28	5.71	9.15
	Shear Stress, τ (psi)	1.74	3.74	6.48
	Secant Friction Angle, Degrees	37.4	33.2	35.3
	ϕ'_d, degrees	34.6		
	c'_d, psi	0.0		

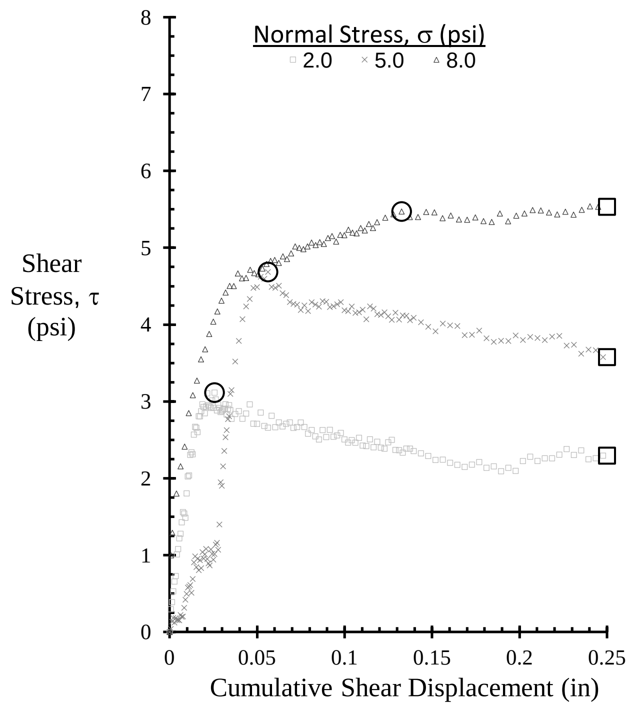
Note: The undisturbed soil samples were extruded and trimmed using a trimming turntable. A specific gravity of 2.65 was assumed for weight-volume calculations.

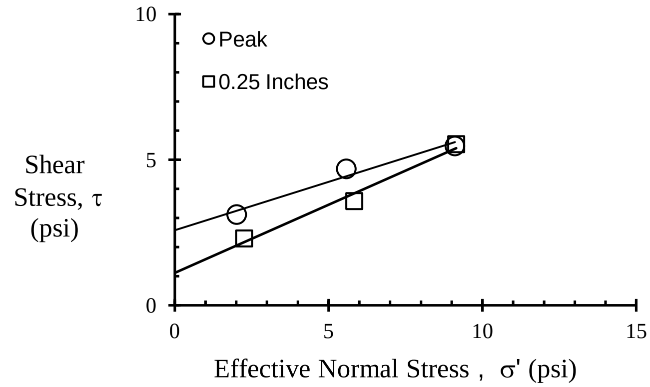
Jeffrey A. Kuhn, Ph.D., P.E., 4/27/18
Analysis & Quality Review/Date

Direct Shear of Soil Under Consolidated-Drained Conditions

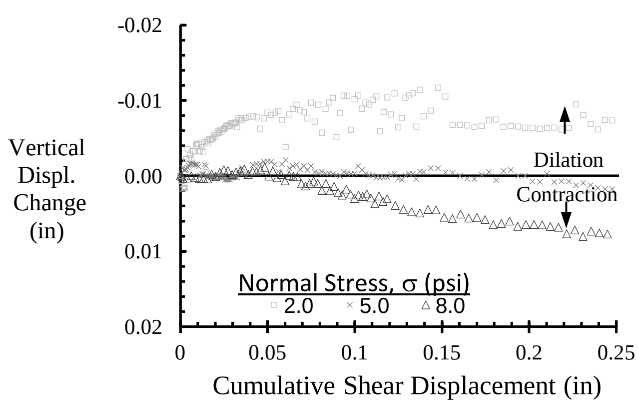
Client: Arias & Associates
Project: Mitchell Lake Wetland
Sample: B-113 (4' - 6')

TRI Log#: 36618.2
Test Method: ASTM D3080





Note: Area Correction Has Been Applied



	Sample Number	1	2	3
Initial Condition	Diameter, in	2.50	2.50	2.50
	Height, in (before consol)	1.00	1.00	1.00
	Water Content, %	14.4	14.4	14.3
	Saturation, %	64.3	69.3	67.9
	Dry Density, pcf	103.8	106.7	106.1
	Void Ratio	0.59	0.55	0.56
Post-Consol	Height, in (prior to shear)	1.00	1.00	1.00
	Dry Density, pcf	103.8	106.7	106.1
	Void Ratio	0.59	0.55	0.56
Displacement rate (in/min)		1.0E-04	1.0E-04	1.0E-04
Final Water Content, %		23.6	25.5	24.5
Peak	Normal Stress, σ' (psi)	2.01	5.58	9.10
	Shear Stress, τ (psi)	3.12	4.68	5.47
	Displacement (in)	0.03	0.06	0.13
	ϕ'_d, degrees	18.4		
	c'_d, psi	2.6		
0.25 Inches	Normal Stress, σ' (psi)	2.26	5.84	9.15
	Shear Stress, τ (psi)	2.30	3.58	5.53
	Secant Friction Angle, Degrees	45.5	31.5	31.2
	ϕ'_d, degrees	25.1		
	c'_d, psi	1.1		

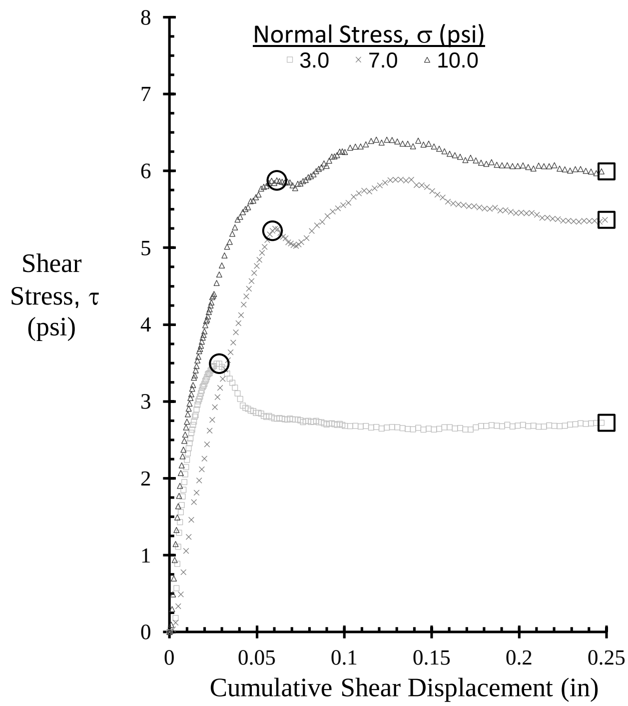
Note: The undisturbed soil samples were extruded and trimmed using a trimming turntable. A specific gravity of 2.65 was assumed for weight-volume calculations.

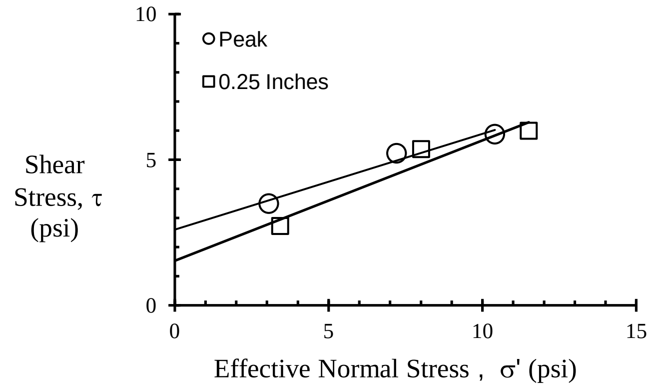
Jeffrey A. Kuhn, Ph.D., P.E., 4/27/18
Analysis & Quality Review/Date

Direct Shear of Soil Under Consolidated-Drained Conditions

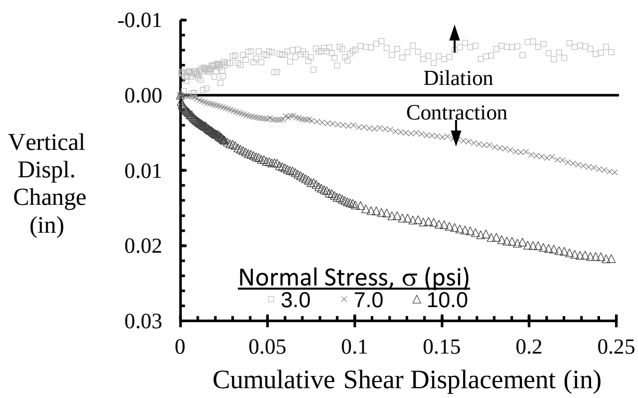
Client: Arias & Associates
Project: Mitchell Lake Wetland
Sample: B-114 (6' - 8')

TRI Log#: 36618.3
Test Method: ASTM D3080





Note: Area Correction Has Been Applied



	Sample Number	1	2	3
Initial Condition	Diameter, in	2.50	2.50	2.50
	Height, in (before consol)	1.00	1.00	1.00
	Water Content, %	16.1	17.0	16.9
	Saturation, %	71.3	80.8	73.2
	Dry Density, pcf	103.5	106.2	102.6
	Void Ratio	0.60	0.56	0.61
Post-Consol	Height, in (prior to shear)	1.00	1.00	1.00
	Dry Density, pcf	103.4	106.3	103.0
	Void Ratio	0.60	0.56	0.60
Displacement rate (in/min)		1.0E-04	1.0E-04	1.0E-04
Final Water Content, %		22.6	23.3	22.2
Peak	Normal Stress, σ' (psi)	3.06	7.21	10.40
	Shear Stress, τ (psi)	3.49	5.22	5.88
	Displacement (in)	0.03	0.06	0.06
	ϕ'_d, degrees	18.2		
	c'_d, psi	2.6		
0.25 Inches	Normal Stress, σ' (psi)	3.43	8.01	11.50
	Shear Stress, τ (psi)	2.72	5.36	5.99
	Secant Friction Angle, Degrees	38.5	33.8	27.5
	ϕ'_d, degrees	22.5		
	c'_d, psi	1.5		

Note: The undisturbed soil samples were extruded and trimmed using a trimming turntable. A specific gravity of 2.65 was assumed for weight-volume calculations.

Jeffrey A. Kuhn, Ph.D., P.E., 4/27/18
Analysis & Quality Review/Date

APPENDIX G: CONSOLIDATED-UNDRAINED TRIAXIAL TEST RESULTS

Multi-Stage Consolidated-Undrained Triaxial Compression

Client: Arias & Associates
Project: Mitchell Lake Wetland
Sample: B-102 (10 - 12)

TRI Log #: 36618.7
Test Method: ASTM D4767 Mod

Specimens			
Identification	-	-	-
Depth/Elev. (ft)	-	-	-
Eff. Consol. Stress (psi)	6.0	10.0	13.0
Initial Specimen Properties			
Avg. Diameter (in)	1.38	1.39	1.40
Avg. Height (in)	2.80	2.55	2.38
Avg. Water Content (%)	24.4	-	-
Bulk Density (pcf)	121.8	132.1	139.9
Dry Density (pcf)	97.9	-	-
Saturation (%)	91.2	-	-
Void Ratio, n	0.72	0.59	0.50
Specific Gravity (Assumed)	2.70		
Total Back-Pressure (psi)	54.1	54.1	54.1
B-Value, End of Saturation	0.96	-	-

Test Setup	
Specimen Condition	Undisturbed / Intact
Specimen Preparation	Trimmed
Mounting Method	Wet
Consolidation	Isotropic

Post-Consolidation / Pre-Shear			
Void Ratio	0.59	0.50	0.41
Area (in^2)	1.41	1.45	1.47

Shear / Post-Shear			
Avg. Water Content (%)	-	-	24.4
Rate of Strain (%/hr)	0.50	0.50	0.50

At Failure						
Failure Criterion: Peak Principal Stress	Difference, $(\sigma_1'-\sigma_3')_{max}$			Ratio, $(\sigma_1'/\sigma_3')_{max}$		
Axial Strain at Failure (%), $\varepsilon_{a,f}$	-	-	-	1.2	1.3	0.7
Minor Effective Stress (psi), $\sigma_3'{}_f$	-	-	-	3.0	6.3	8.7
Principal Stress Difference (psi), $(\sigma_1-\sigma_3)_f$	-	-	-	16.2	22.1	27.3
Pore Water Pressure, Δu_f (psi)	-	-	-	2.9	3.7	4.2
Major Effective Stress (psi), $\sigma_1'{}_f$	-	-	-	19.2	28.4	36.1
Secant Friction Angle (degrees)	-	-	-	46.7	39.6	37.6
Effective Friction Angle (degrees)	-			29.6		
Effective Cohesion (psi)	-			2.9		

Note: Multi-stage testing was performed for this sample. The first two stages were terminated in accordance with stress path tangency and/or peak principal stress ratio.

Please note that the presented M-C parameters are based on a linear regression in modified stress space, across all assigned effective consolidation stresses. This fit does not purported to capture typical curvature of envelopes that may, in particular, be observed across broader range in effective stresses. Please note that the stresses associated with peak principal stress ratioare presented in tabular form on the first page of the report. There are alternate interpretations to theses two failure criterion including but not limited to strain compatibility and post-peak.

Jeffrey A. Kuhn , Ph.D., P.E., 4/27/2018
Analysis & Quality Review/Date

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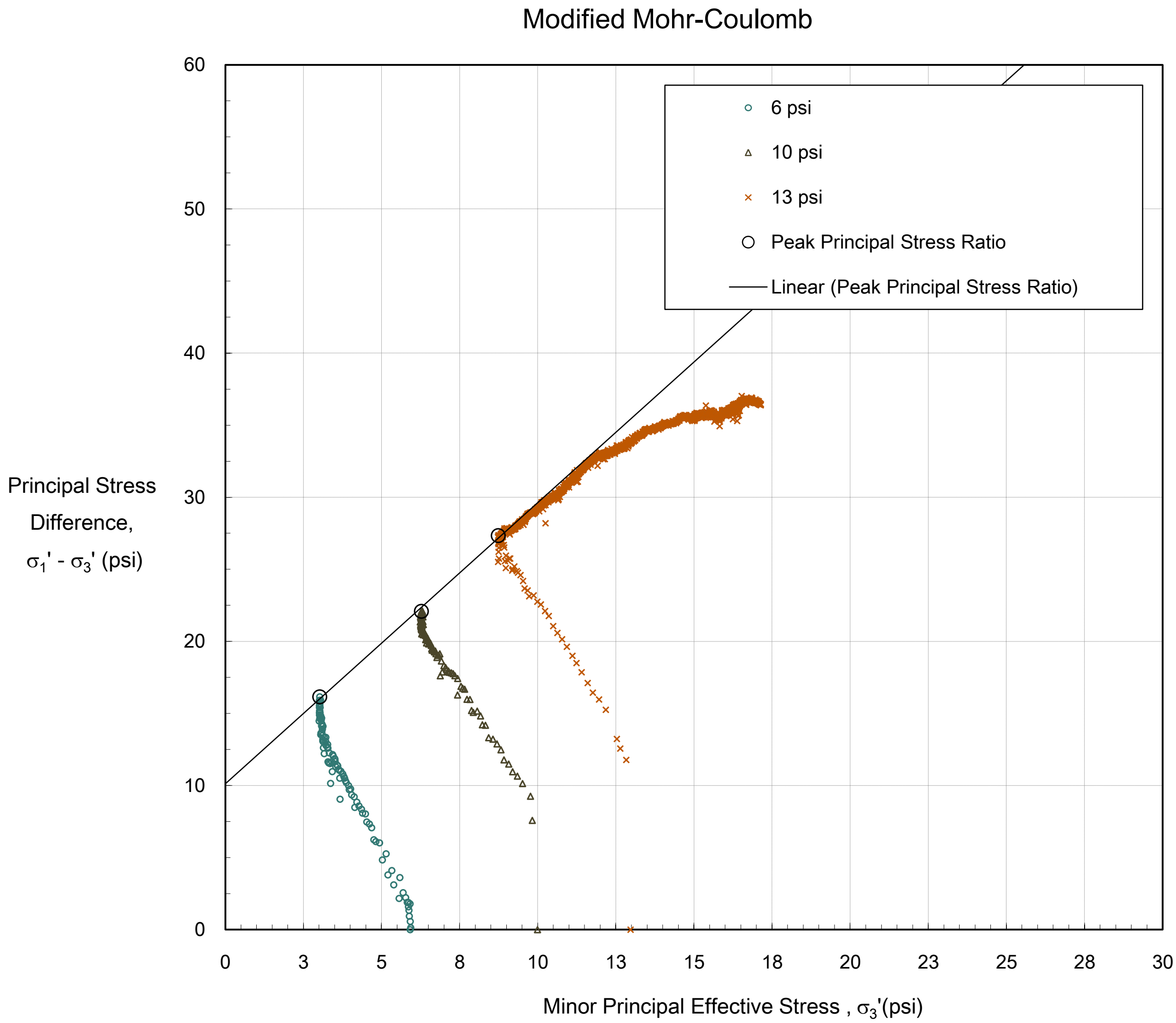
Multi-Stage Consolidated-Undrained Triaxial Compression

Client:	Arias & Associates	TRI Log #:	36618.7
Project:	Mitchell Lake Wetland	Test Method:	ASTM D4767 Mod
Sample:	B-102 (10 - 12)		



Failure Criterion: Peak Principal Stress	Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Effective Friction Angle (deg)	-	29.6
Effective Cohesion (psi)	-	2.9

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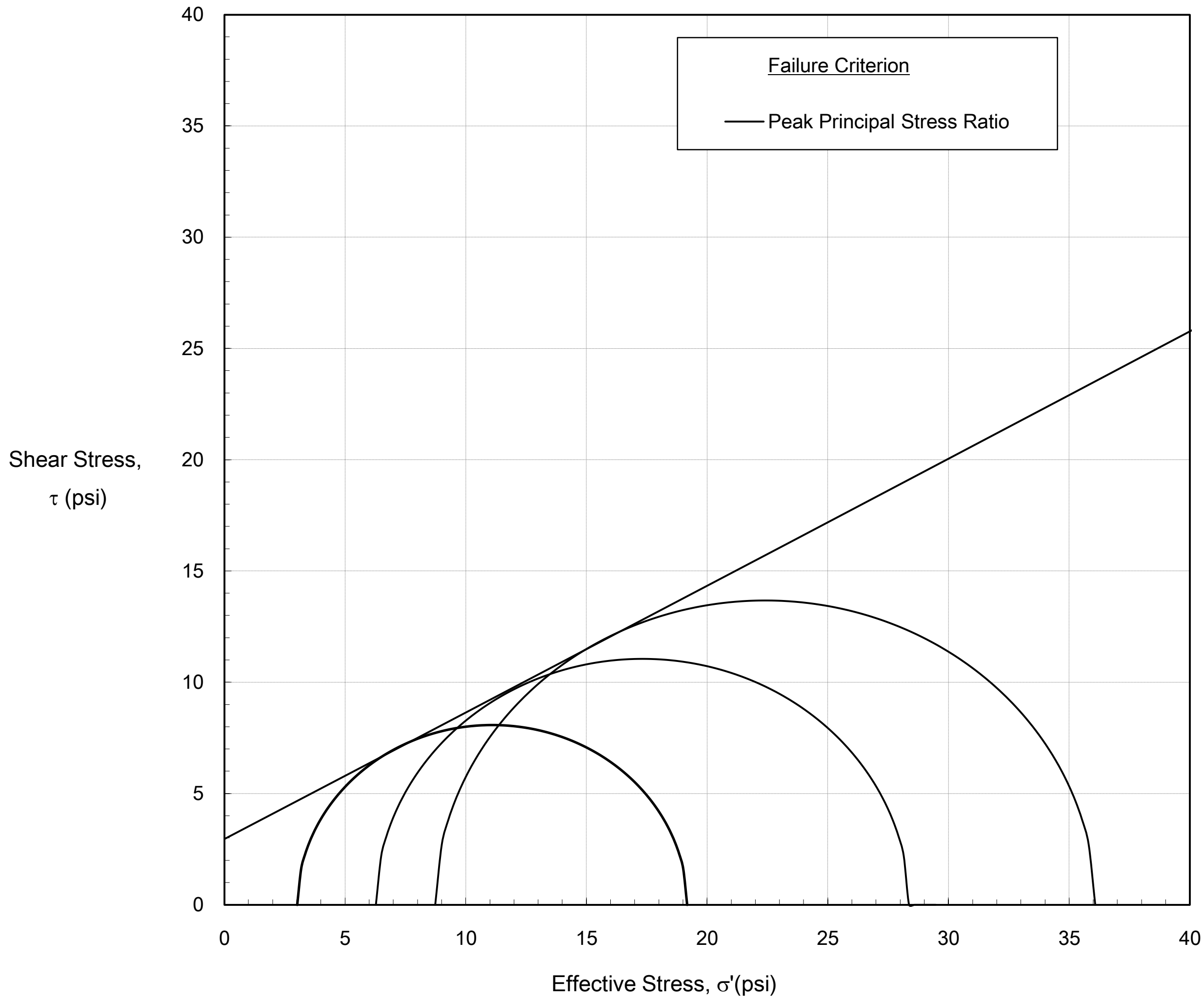
Multi-Stage Consolidated-Undrained Triaxial Compression

Client: Arias & Associates
Project: Mitchell Lake Wetland
Sample: B-102 (10 - 12)

TRI Log #: 36618.7
Test Method: ASTM D4767 Mod

Mohr-Coulomb

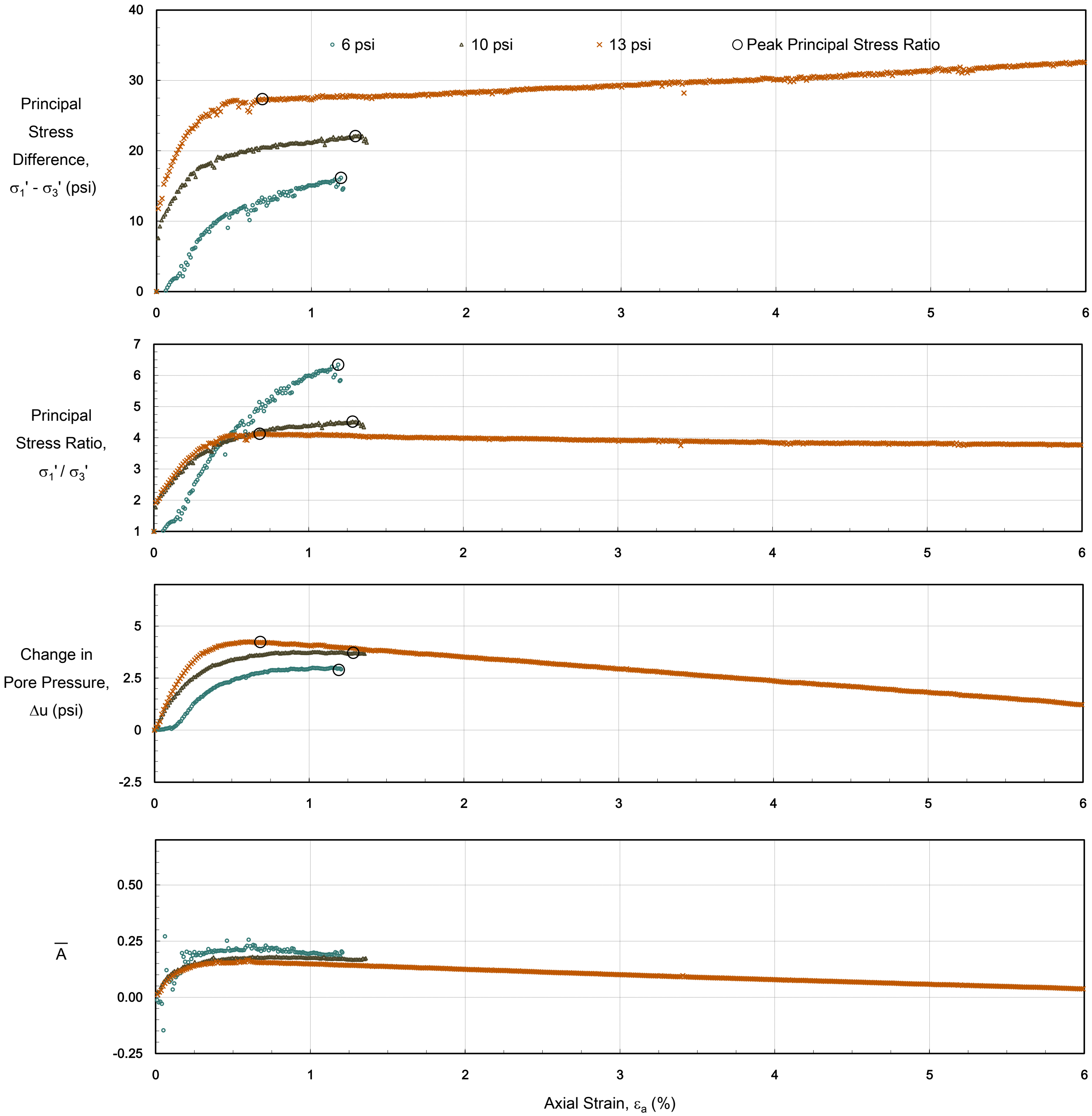


Failure Criterion: Peak Principal Stress	Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Effective Friction Angle (deg)	-	29.6
Effective Cohesion (psi)	-	2.9

Multi-Stage Consolidated-Undrained Triaxial Compression

Client: Arias & Associates
Project: Mitchell Lake Wetland
Sample: B-102 (10 - 12)

TRI Log #: 36618.7
Test Method: ASTM D4767 Mod



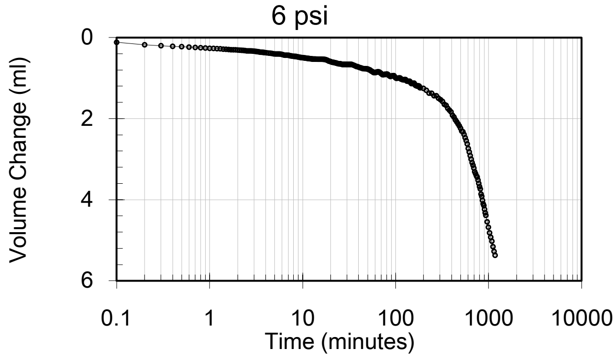
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

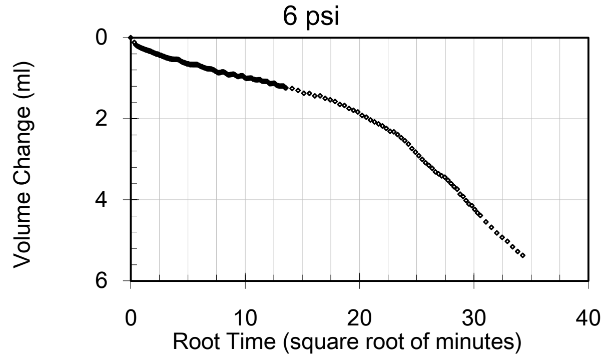
Multi-Stage Consolidated-Undrained Triaxial Compression

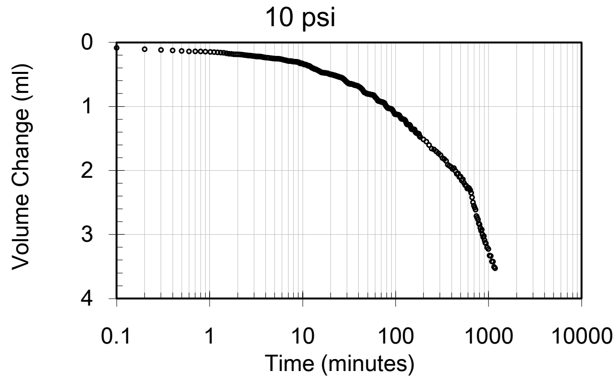
Client: Arias & Associates
Project: Mitchell Lake Wetland
Sample: B-102 (10 - 12)

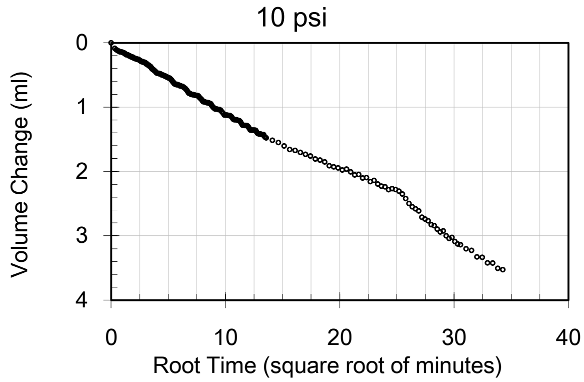
TRI Log #: 36618.7
Test Method: ASTM D4767 Mod

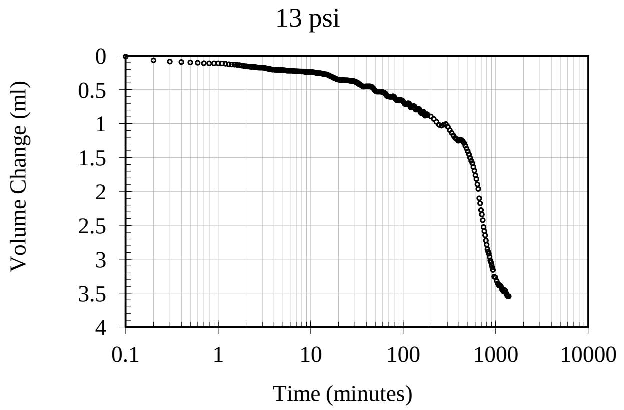
Consolidation

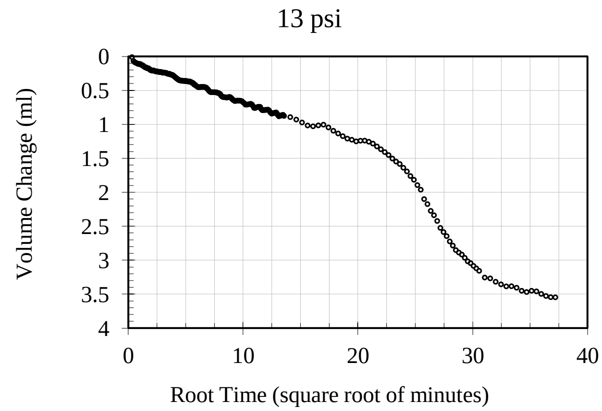












Multi-Stage Consolidated-Undrained Triaxial Compression

Client: Arias & Associates
Project: Mitchell Lake Wetland
Sample: B-104 (33' - 35')

TRI Log #: 36635.2
Test Method: ASTM D4767 Mod

Specimens			
Identification	-	-	-
Depth/Elev. (ft)	-	-	-
Eff. Consol. Stress (psi)	5.0	35.0	40.0
Initial Specimen Properties			
Avg. Diameter (in)	2.05	2.07	2.12
Avg. Height (in)	4.64	4.52	4.20
Avg. Water Content (%)	21.7	-	-
Bulk Density (pcf)	120.4	121.6	124.9
Dry Density (pcf)	98.9	-	-
Saturation (%)	83.4	-	-
Void Ratio, n	0.70	0.69	0.64
Specific Gravity (Assumed)	2.70		
Total Back-Pressure (psi)	54.1	54.1	54.1
B-Value, End of Saturation	0.97	-	-

Test Setup	
Specimen Condition	Undisturbed / Intact
Specimen Preparation	Trimmed
Mounting Method	Wet
Consolidation	Isotropic

Post-Consolidation / Pre-Shear			
Void Ratio	0.69	0.64	0.62
Area (in^2)	3.29	3.31	3.49

Shear / Post-Shear			
Avg. Water Content (%)	-	-	20.9
Rate of Strain (%/hr)	0.50	0.50	0.50

At Failure						
Failure Criterion: Peak Principal Stress	Difference, $(\sigma_1'-\sigma_3')_{max}$			Ratio, $(\sigma_1'/\sigma_3')_{max}$		
Axial Strain at Failure (%), $\varepsilon_{a,f}$	-	-	-	1.6	4.5	4.7
Minor Effective Stress (psi), $\sigma_3'_f$	-	-	-	2.5	15.3	24.2
Principal Stress Difference (psi), $(\sigma_1-\sigma_3)_f$	-	-	-	13.4	38.5	50.6
Pore Water Pressure, Δu_f (psi)	-	-	-	2.5	19.6	15.9
Major Effective Stress (psi), $\sigma_1'_f$	-	-	-	15.9	53.8	74.8
Secant Friction Angle (degrees)	-	-	-	46.9	33.8	30.7
Effective Friction Angle (degrees)	-			27.6		
Effective Cohesion (psi)	-			3.0		

Note: Multi-stage testing was performed for this sample. The first two stages were terminated in accordance with stress path tangency and/or peak principal stress ratio.

Please note that the presented M-C parameters are based on a linear regression in modified stress space, across all assigned effective consolidation stresses. This fit does not purported to capture typical curvature of envelopes that may, in particular, be observed across broader range in effective stresses. Please note that the stresses associated with peak principal stress ratioare presented in tabular form on the first page of the report. There are alternate interpretations to theses two failure criterion including but not limited to strain compatibility and post-peak.

Jeffrey A. Kuhn , Ph.D., P.E., 4/27/2018
Analysis & Quality Review/Date

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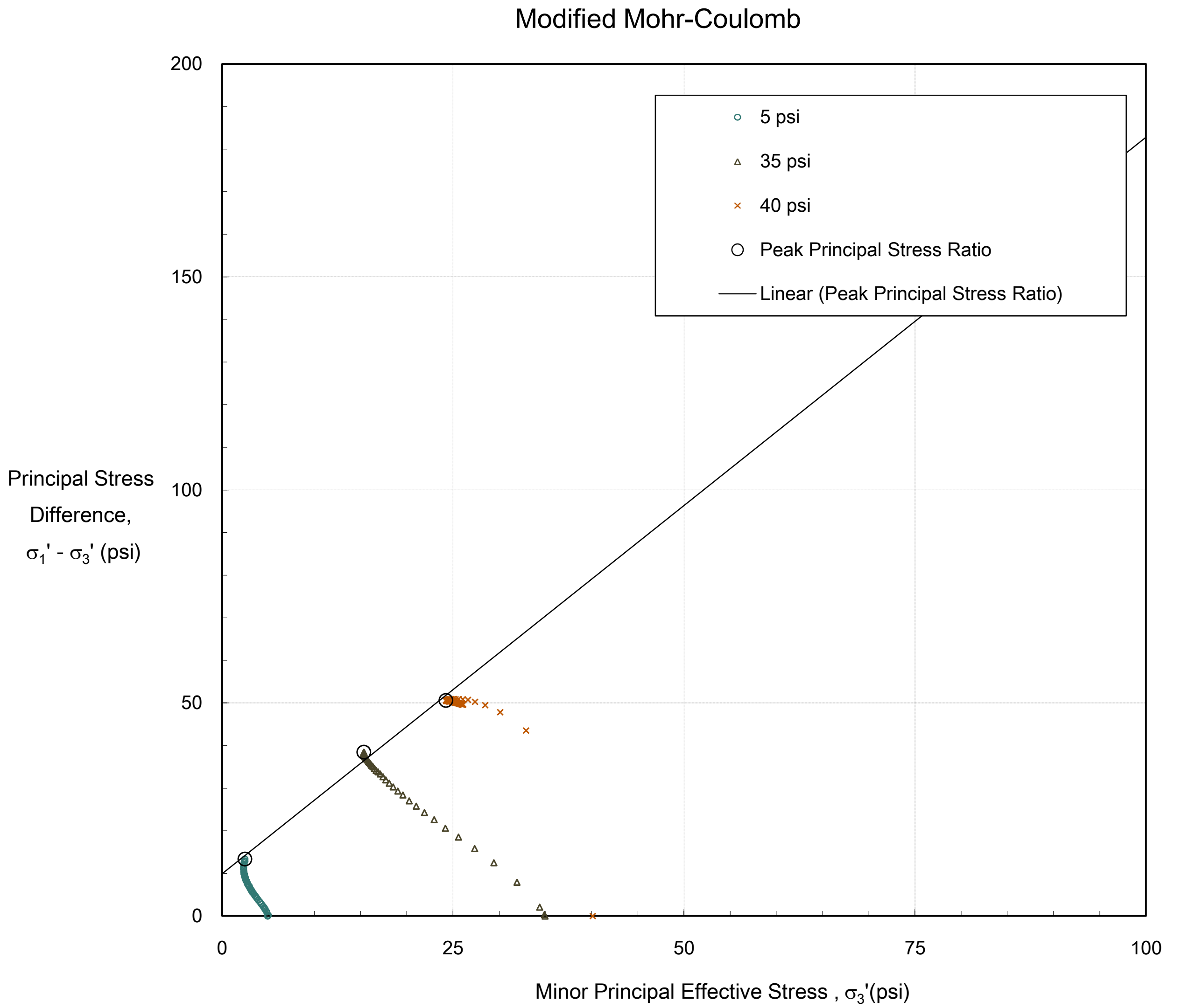
Multi-Stage Consolidated-Undrained Triaxial Compression

Client: Arias & Associates
Project: Mitchell Lake Wetland
Sample: B-104 (33' - 35')

TRI Log #: 36635.2
Test Method: ASTM D4767 Mod

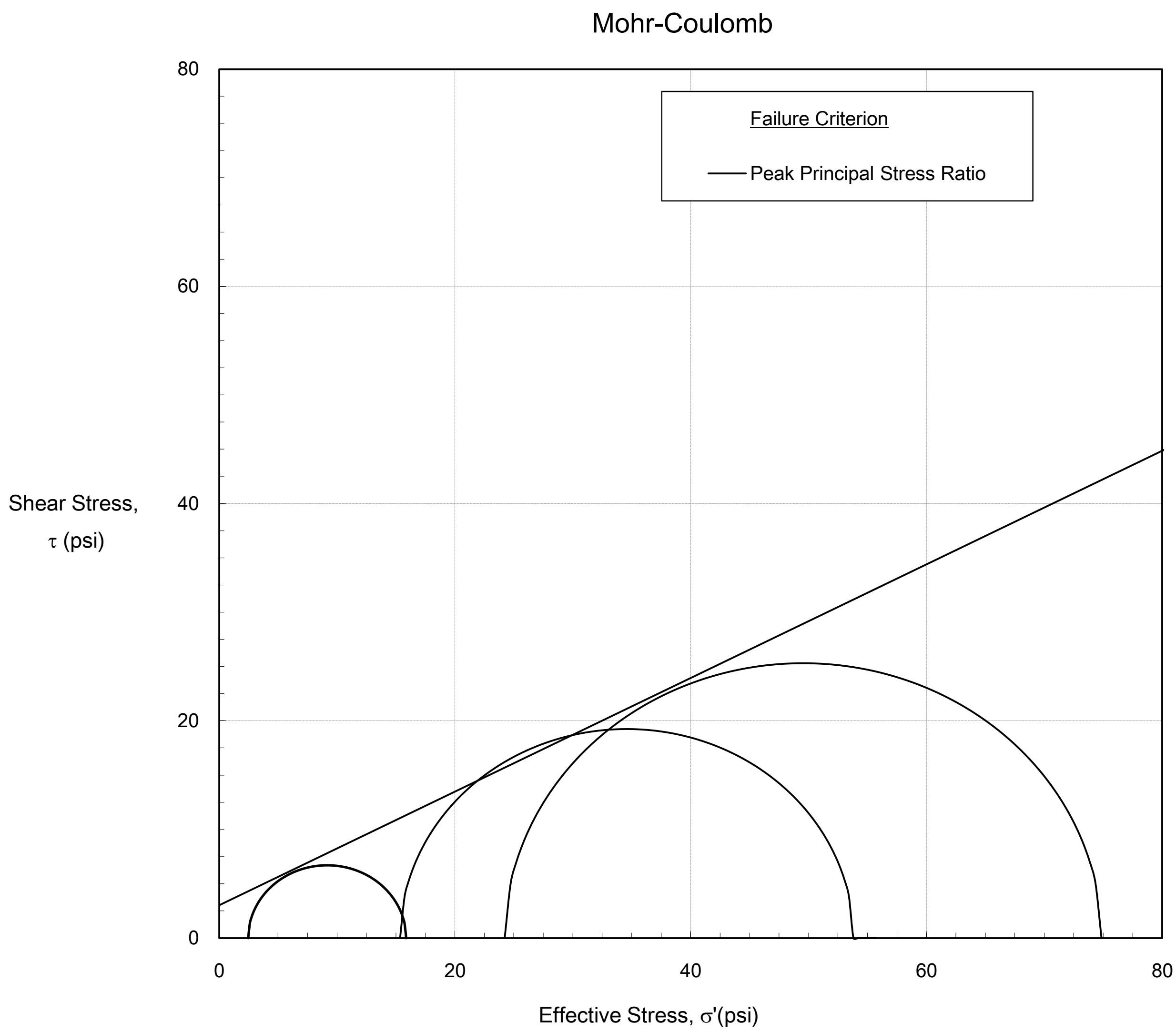


Failure Criterion: Peak Principal Stress	Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Effective Friction Angle (deg)	-	27.6
Effective Cohesion (psi)	-	3.0

Multi-Stage Consolidated-Undrained Triaxial Compression

Client: Arias & Associates
Project: Mitchell Lake Wetland
Sample: B-104 (33' - 35')

TRI Log #: 36635.2
Test Method: ASTM D4767 Mod



Failure Criterion: Peak Principal Stress	Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Effective Friction Angle (deg)	-	27.6
Effective Cohesion (psi)	-	3.0

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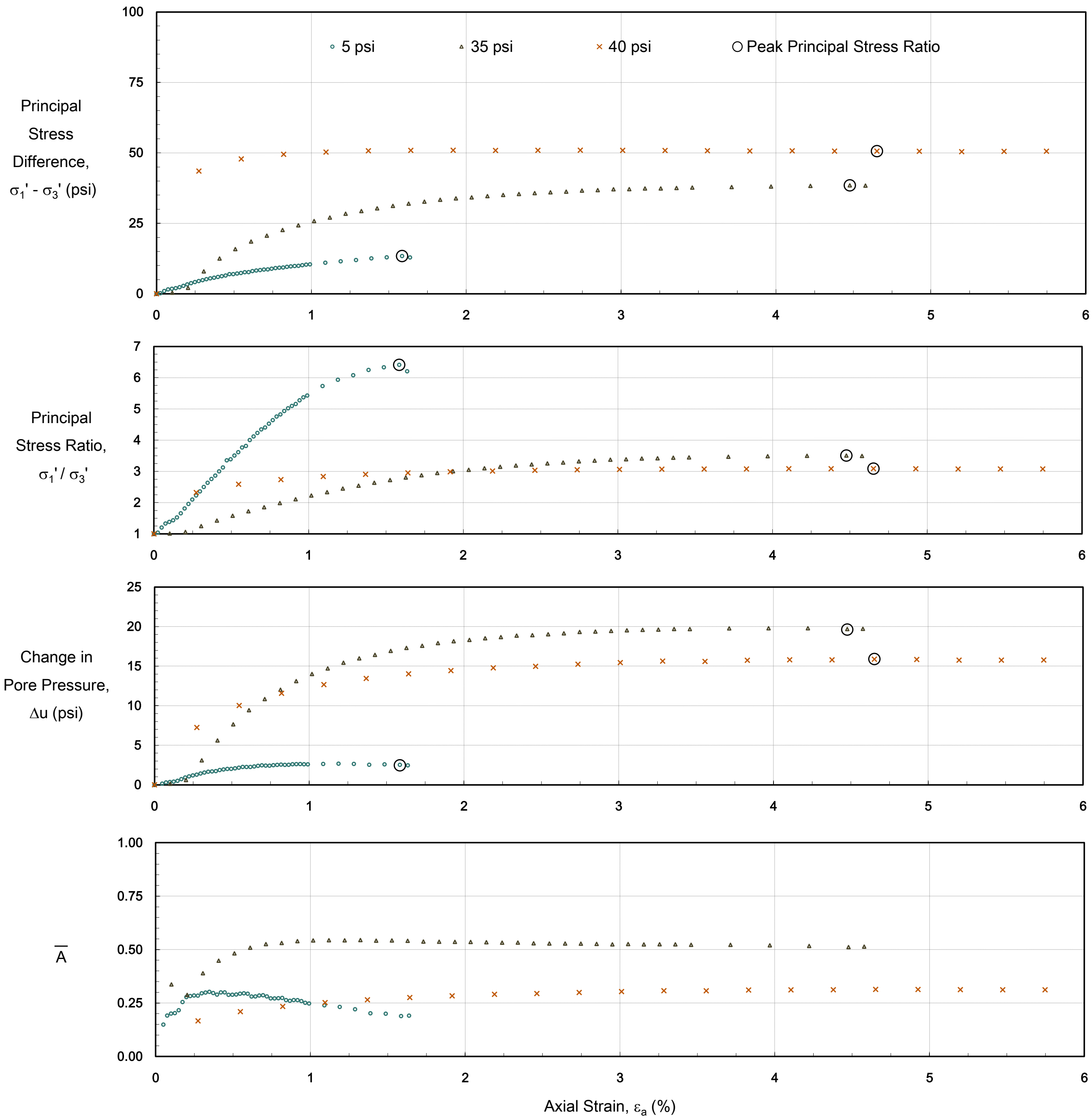
Multi-Stage Consolidated-Undrained Triaxial Compression

Client:	Arias & Associates	TRI Log #:	36635.2
Project:	Mitchell Lake Wetland	Test Method:	ASTM D4767 Mod
Sample:	B-104 (33' - 35')		



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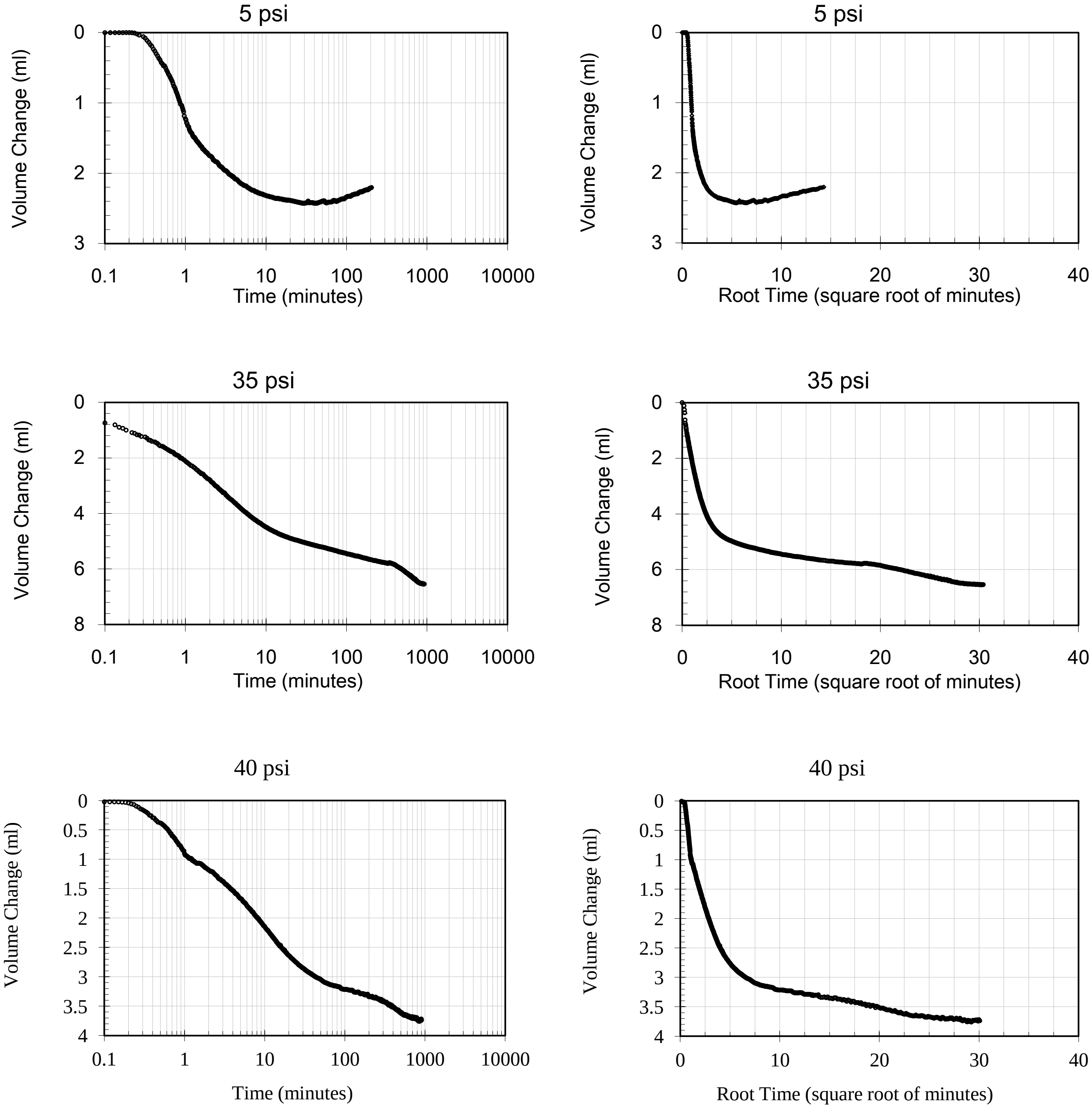
Multi-Stage Consolidated-Undrained Triaxial Compression

Client: Arias & Associates
Project: Mitchell Lake Wetland
Sample: B-104 (33' - 35')

TRI Log #: 36635.2
Test Method: ASTM D4767 Mod

Consolidation



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Consolidated-Undrained Triaxial Compression

Client: Arias & Associates
Project: Mitchel Lake Wetland
Sample: B-106 (23' - 25')

TRI Log #: 36618.6
Test Method: ASTM D4767

Specimens			
Identification	-	-	-
Depth/Elev. (ft)	-	-	-
Eff. Consol. Stress (psi)	16.0	21.0	25.0
Initial Specimen Properties			
Avg. Diameter (in)	1.39	1.44	1.48
Avg. Height (in)	3.48	2.95	3.34
Avg. Water Content (%)	15.7	17.0	17.1
Bulk Density (pcf)	126.0	131.7	129.8
Dry Density (pcf)	108.9	112.6	110.8
Saturation (%)	77.5	92.1	88.8
Void Ratio, n	0.55	0.50	0.52
Specific Gravity (Assumed)	2.70	2.70	2.70
Total Back-Pressure (psi)	54.0	54.6	54.5
B-Value, End of Saturation	0.96	0.95	0.97

Test Setup	
Specimen Condition	Undisturbed / Intact
Specimen Preparation	Trimmed
Mounting Method	Wet
Consolidation	Isotropic

Post-Consolidation / Pre-Shear			
Void Ratio	0.52	0.46	0.49
Area (in^2)	1.51	1.61	1.70

Shear / Post-Shear			
Avg. Water Content (%)	18.1	19.6	18.5
Rate of Strain (%/hr)	0.50	0.50	0.50

At Failure						
Failure Criterion: Peak Principal Stress	Difference, $(\sigma_1'-\sigma_3')_{max}$			Ratio, $(\sigma_1'/\sigma_3')_{max}$		
Axial Strain at Failure (%), $\varepsilon_{a,f}$	8.7	15.0	15.0	8.3	4.7	4.5
Minor Effective Stress (psi), $\sigma_3'_f$	16.0	20.7	26.1	15.9	11.8	15.1
Principal Stress Difference (psi), $(\sigma_1-\sigma_3)_f$	36.8	50.0	51.9	36.7	31.3	36.2
Pore Water Pressure, Δu_f (psi)	0.1	-0.3	-1.5	0.2	8.6	9.5
Major Effective Stress (psi), $\sigma_1'_f$	52.8	70.7	78.0	52.6	43.2	51.3
Secant Friction Angle (degrees)	32.3	33.2	29.9	32.4	34.7	33.0
Effective Friction Angle (degrees)	25.0			23.9		
Effective Cohesion (psi)	4.9			5.0		

Please note that the presented M-C parameters are based on a linear regression in modified stress space, across all assigned effective consolidation stresses. This fit does not purported to capture typical curvature of envelopes that may, in particular, be observed across broader range in effective stresses. Please note that the stresses associated with peak principal stress ratio and peak principal stress difference are presented in tabular form on the first page of the report. There are alternate interpretations to theses two failure criterion including but not limited to strain compatibility and post-peak.

Jeffrey A. Kuhn , Ph.D., P.E., 4/27/2018
Analysis & Quality Review/Date

TRI ENVIRONMENTAL, INC.
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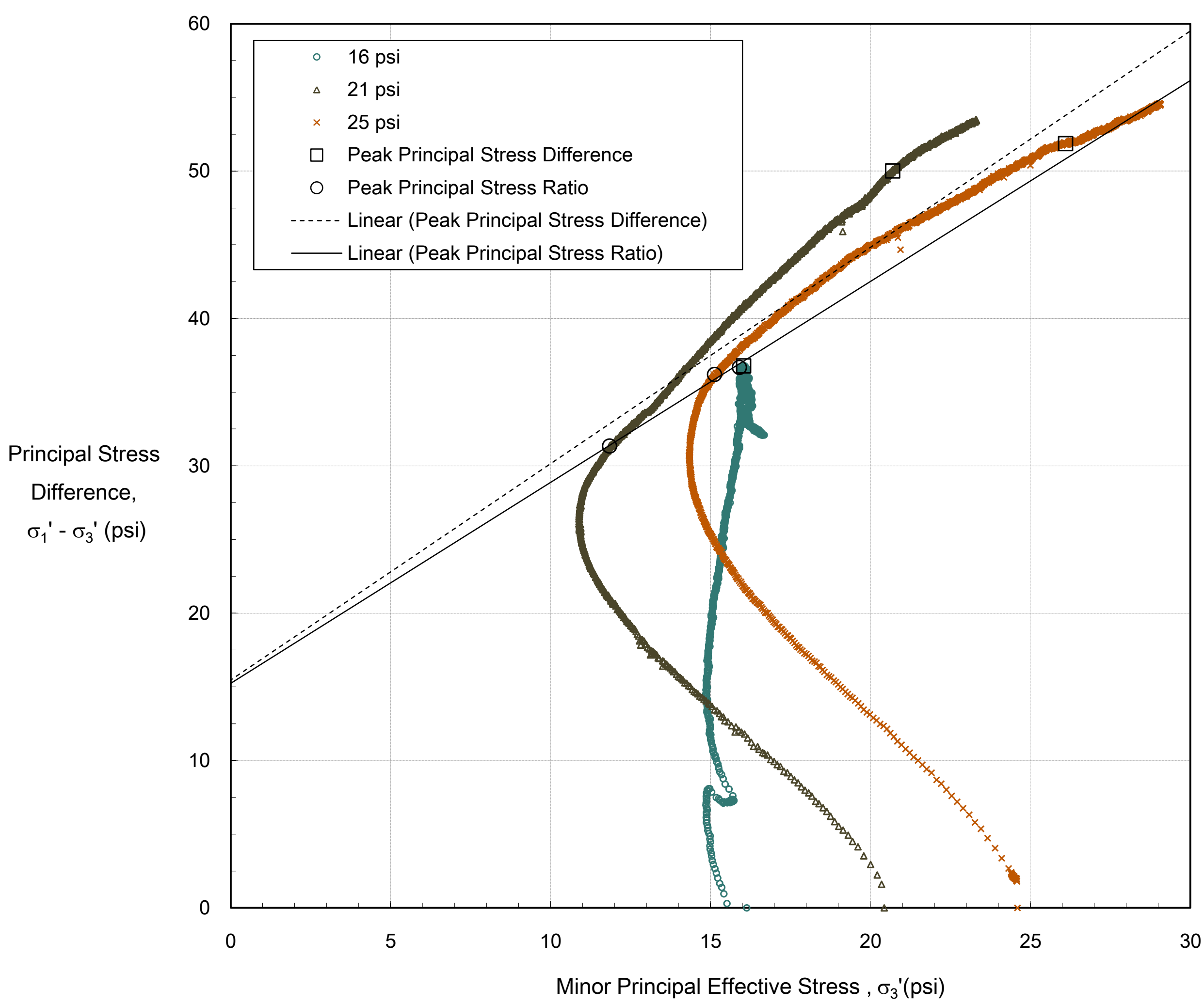
Consolidated-Undrained Triaxial Compression

Client: Arias & Associates
Project: Mitchel Lake Wetland
Sample: B-106 (23' - 25')

TRI Log #: 36618.6
Test Method: ASTM D4767

Modified Mohr-Coulomb



Failure Criterion: Peak Principal Stress	Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Effective Friction Angle (deg)	25.0	23.9
Effective Cohesion (psi)	4.9	5.0

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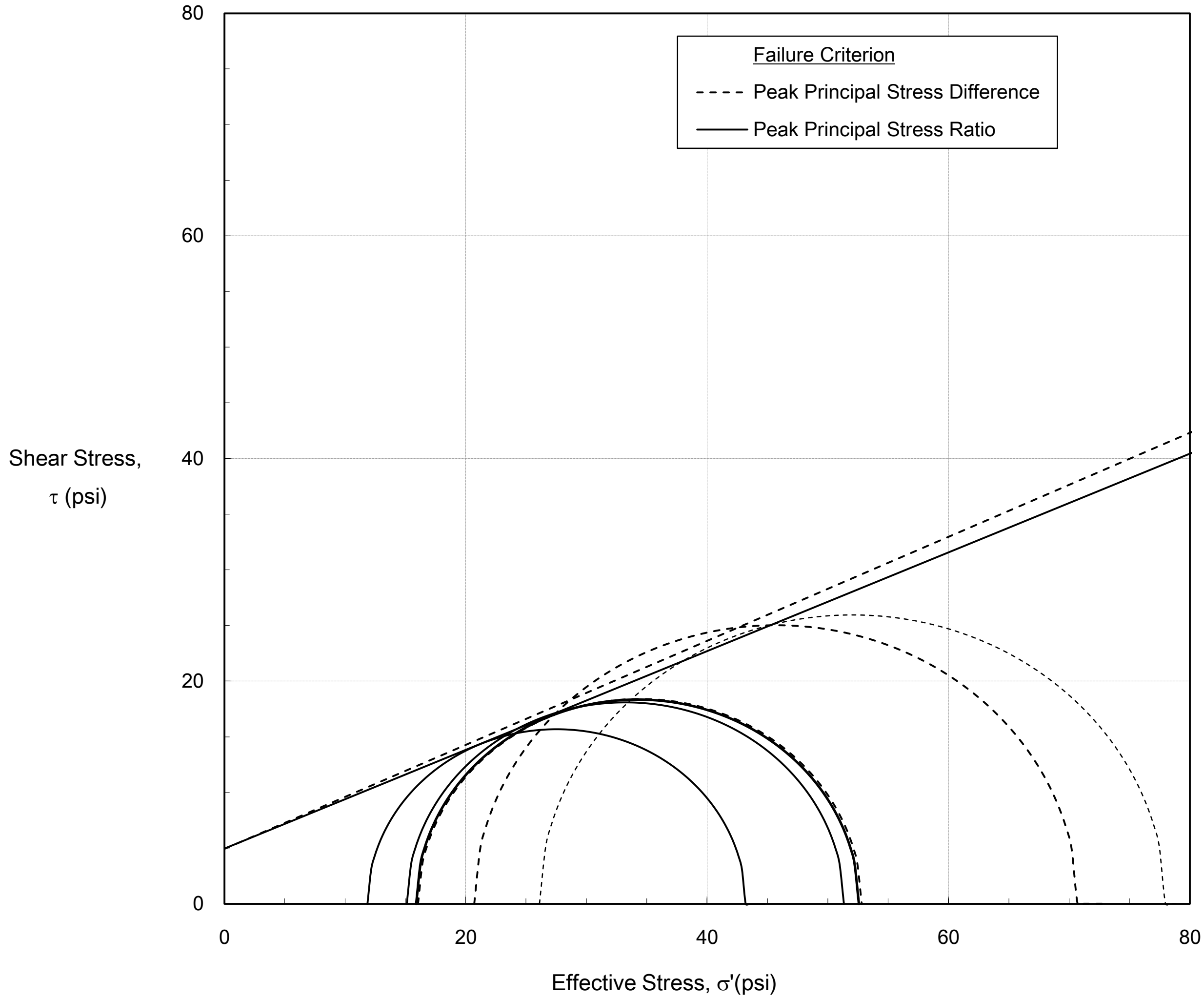
Consolidated-Undrained Triaxial Compression

Client: Arias & Associates
Project: Mitchel Lake Wetland
Sample: B-106 (23' - 25')

TRI Log #: 36618.6
Test Method: ASTM D4767

Mohr-Coulomb

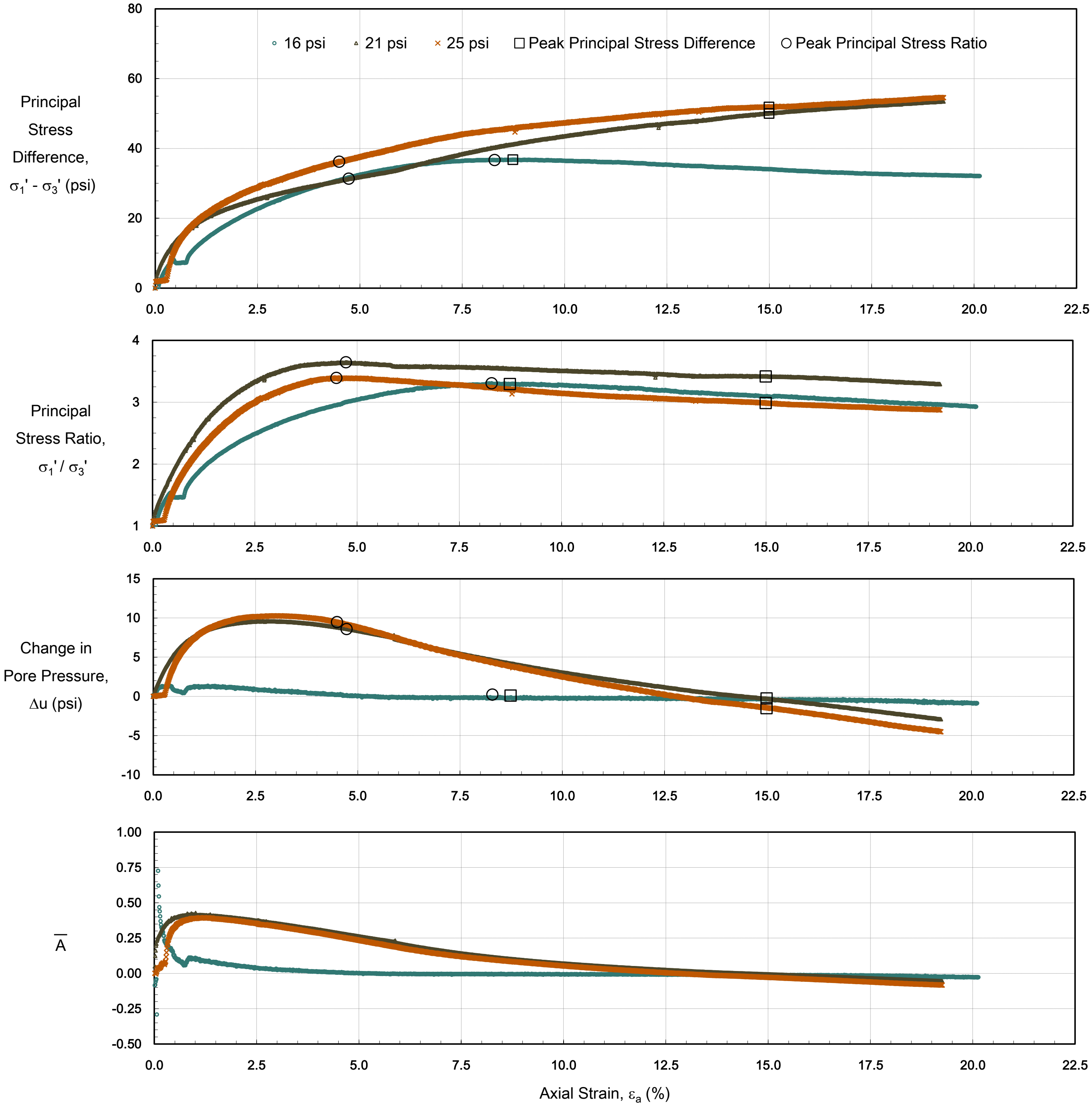


Failure Criterion: Peak Principal Stress	Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Effective Friction Angle (deg)	25.0	23.9
Effective Cohesion (psi)	4.9	5.0

Consolidated-Undrained Triaxial Compression

Client: Arias & Associates
Project: Mitchel Lake Wetland
Sample: B-106 (23' - 25')

TRI Log #: 36618.6
Test Method: ASTM D4767



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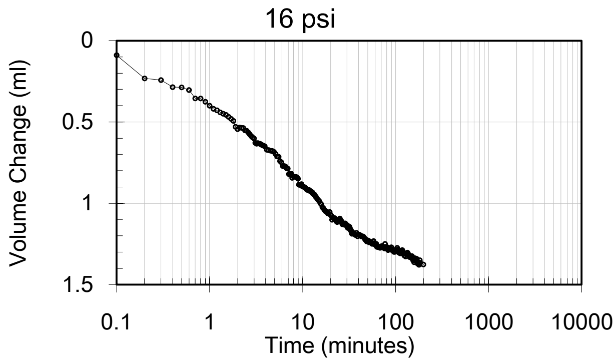
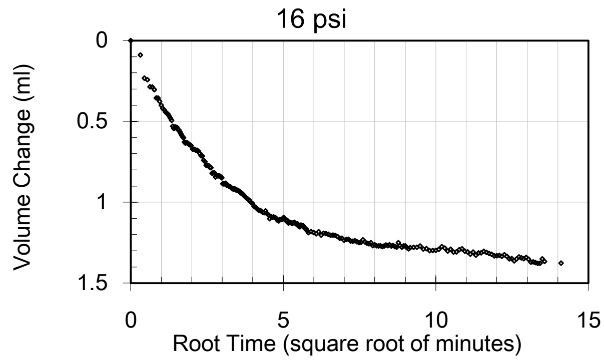
Consolidated-Undrained Triaxial Compression

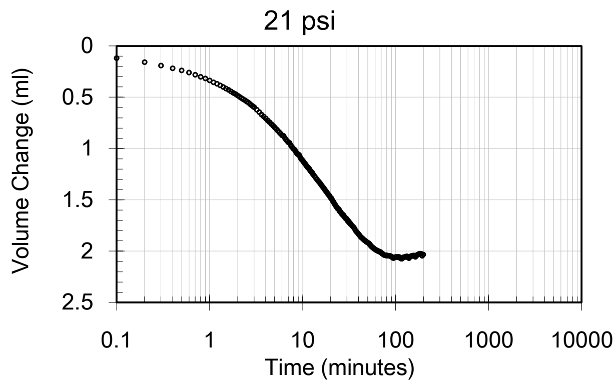
Client: Arias & Associates
Project: Mitchel Lake Wetland
Sample: B-106 (23' - 25')

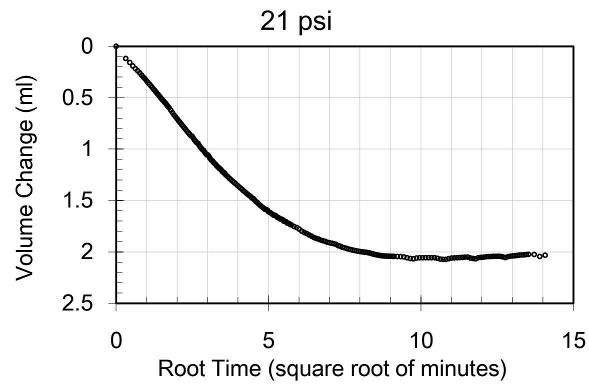
TRI Log #: 36618.6
Test Method: ASTM D4767

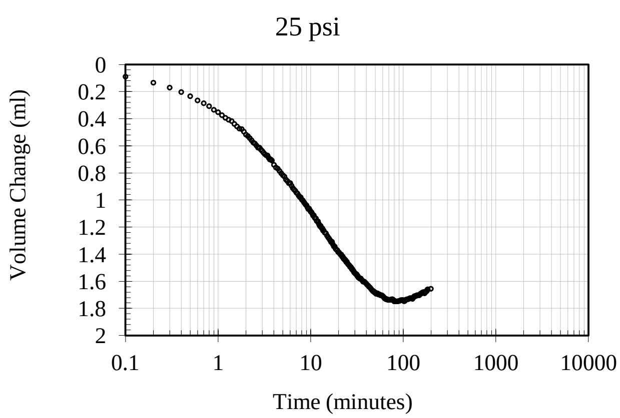
Consolidation

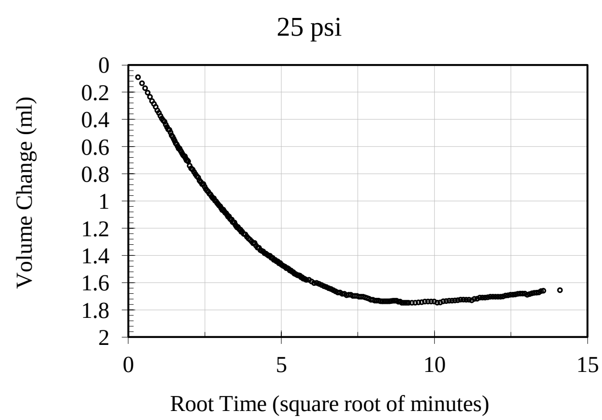












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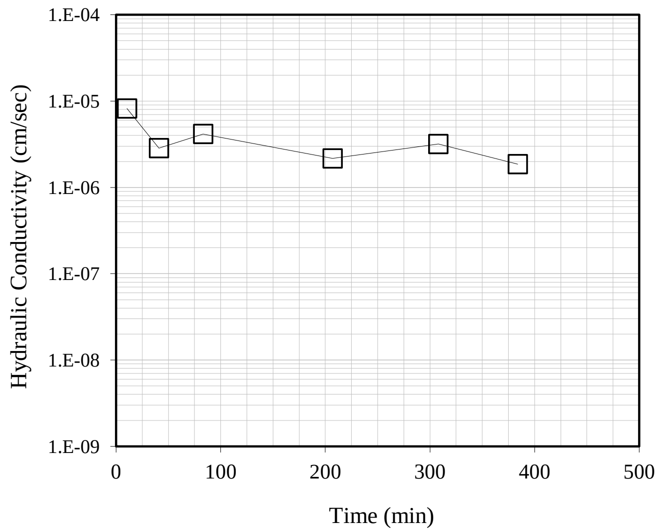
APPENDIX H: HYDRAULIC CONDUCTIVITY

Hydraulic Conductivity

Client: Arias & Associates
Project: Mitchell Lake Wetland
Sample ID: B-101 (8 - 10)

TRI Log #: 36635.3
Test Method: ASTM D5084 Method C



Initial Values	
Sample Condition	Undisturbed
Diameter (in)	2.66
Height (in)	1.60
Initial Mass (g)	276.4
Sample Area (in^2)	5.56
Water Content (%)	23.8
Total Unit Weight (pcf)	118.3
Dry Unit Weight (pcf)	95.5
Specific Gravity (Assumed)	2.65
Degree of Saturation	86.4
Void Ratio	0.73
Porosity	0.42
1 Pore Volume (cc)	61.6
Eff. Confining Stress (psi)	6.0
B-Value Prior to Permeation	0.99

Specimen Image

Time	Hydraulic Conductivity, K at 20° C
Min	cm/s
83.3	4.2E-06
207.0	2.2E-06
308.0	3.2E-06
384.0	1.9E-06
Average, Last 4 Readings	**2.8E-06**

Jeffrey A. Kuhn, Ph.D., P.E., 4/13/2018
Analysis & Quality Review/Date

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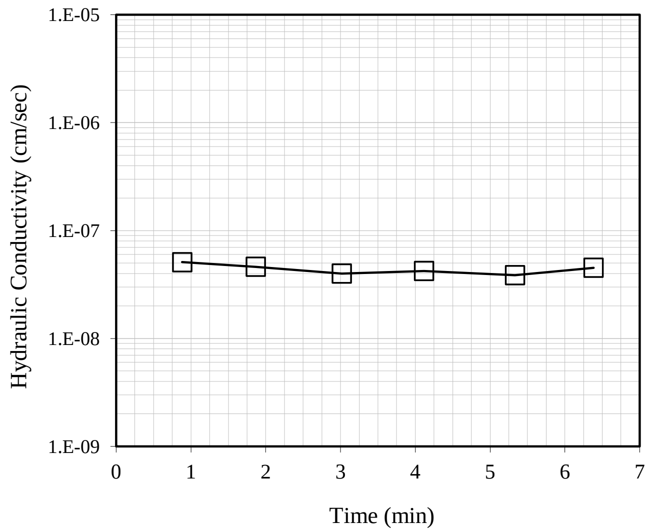
Hydraulic Conductivity

Client: Arias & Associates
Project: Mitchell Lake Wetland
Sample ID: B-105 (8 - 10)

TRI Log #: 36618.4
Test Method: ASTM D5084 Method F



Initial Values	
Sample Condition	Undisturbed
Diameter (in)	2.72
Height (in)	1.59
Initial Mass (g)	291.7
Sample Area (in^2)	5.82
Water Content (%)	20.4
Total Unit Weight (pcf)	119.7
Dry Unit Weight (pcf)	99.4
Specific Gravity (Assumed)	2.65
Degree of Saturation	81.6
Void Ratio	0.66
Porosity	0.40
1 Pore Volume (cc)	60.6
Eff. Confining Stress (psi)	21.0
B-Value Prior to Permeation	0.97

Specimen Image

Time	Hydraulic Conductivity, K at 20° C
Min	cm/s
3.0	4.0E-08
4.1	4.2E-08
5.3	3.9E-08
6.4	4.5E-08
Average, Last 2 Readings	**4.2E-08**

Jeffrey A. Kuhn, Ph.D., P.E., 4/27/2018
Analysis & Quality Review/Date

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APPENDIX I: ASFE INFORMATION – GEOTECHNICAL REPORT

Important Information about Your

Geotechnical Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared *solely* for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.*

A Geotechnical Engineering Report Is Subject to Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure contractors have sufficient time* to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations" many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a *geoenvironmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, a number of mold prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; ***none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.***

Rely, on Your ASFE-Member Geotechncial Engineer for Additional Assistance

Membership in ASFE/The Best People on Earth exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with your ASFE-member geotechnical engineer for more information.

ASFE
THE BEST PEOPLE ON EARTH

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Telephone: 301/565-2733 Facsimile: 301/589-2017
e-mail: info@asfe.org www.asfe.org

APPENDIX J: PROJECT QUALITY ASSURANCE

A Message to Owners

Construction materials engineering and testing (CoMET) consultants perform quality-assurance (QA) services to evaluate the degree to which constructors are achieving the specified conditions they're contractually obligated to achieve. Done right, QA can save you time and money; prevent unanticipated-conditions claims, change orders, and disputes; and reduce short-term and long-term risks, especially by detecting molehills before they grow into mountains.

Done right, QA can save you time and money; prevent claims and disputes; and reduce risks. Many owners don't do QA right because they follow bad advice.

Many owners don't do QA right because they follow bad advice; e.g., "CoMET consultants are all the same. They all have accredited facilities and certified personnel. Go with the low bidder." But there's no such thing as a standard QA scope of service, meaning that – to bid low – each interested firms *must* propose the cheapest QA service it can live with, jeopardizing service quality and aggravating risk for the entire project team. Besides, the advice is based on misinformation.

Fact: ***Most CoMET firms are not accredited***, and the quality of those that are varies significantly. Accreditation – which is important – nonetheless means that a facility met an accrediting body's minimum criteria. Some firms practice at a much higher level; others just barely scrape by. And what an accrediting body typically evaluates – management, staff, facilities, and equipment – can change substantially before the next review, two, three, or more years from now.

Most CoMET firms are not accredited. It's dangerous to assume CoMET personnel are certified.

Fact: ***It's dangerous to assume CoMET personnel are certified.*** Many have no credentials at all; some are certified by organizations of questionable merit, while others have a valid certification, but *not* for the services they're assigned.

Some CoMET firms – the "low-cost providers" – *want* you to believe that price is the only difference between QA providers. It's not, of course. Firms that sell low price typically lack the facilities, equipment, personnel, and insurance quality-oriented firms invest in to achieve the reliability concerned owners need to achieve quality in quality assurance.

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Firms that sell low price typically lack the facilities, equipment, personnel, and insurance quality-oriented firms invest in to achieve the reliability concerned owners need to achieve quality in quality assurance.

To derive maximum value from your investment in QA, require the CoMET firm's project manager to serve actively on the project team from beginning to end, a level of service that's relatively inexpensive and can pay huge dividends. During the project's planning and design stages, experienced CoMET professionals can help the design team develop uniform technical specifications and establish appropriate observation, testing, and instrumentation procedures and protocols. They can also analyze plans and specs much as constructors do, looking for the little errors, omissions, conflicts, and ambiguities that often become the basis for big extras and big claims. They can provide guidance about operations that need closer review than others, because of their criticality or potential for error or abuse. They can also relate their experience with the various constructors that have expressed interest in your project.

To derive maximum value, require the project manager to serve actively on the project team from beginning to end.

CoMET consultants' construction-phase QA services focus on two distinct issues: those that relate to geotechnical engineering and those that relate to the other elements of construction.

The geotechnical issues are critically important because they are essential to the "observational method" geotechnical engineers use to significantly reduce the amount of sampling they'd otherwise require. They apply the observational method by developing a sampling plan for a project, and then assigning field representatives to ensure samples are properly obtained, packaged, and transported. The engineers review the samples and, typically, have them tested in their own laboratories. They use the information they derive to characterize the site's subsurface and develop *preliminary* recommendations for the structure's foundations and for the specifications of various "geo" elements, like excavations, site grading, foundation-bearing grades, and roadway and parking-lot preparation and surfacing.

Geotechnical engineers cannot finalize their recommendations until they or their field representatives are on site to observe what's excavated to verify that the subsurface conditions the engineers predicted are those that actually exist.

When unanticipated conditions are observed, recommendations and/or specifications should be modified.

Responding to client requests, many geotechnical-engineering firms have expanded their field-services mix, so they're able to perform overall construction QA, encompassing – in addition to geotechnical issues – reinforced concrete, structural steel, welds, fireproofing, and so on. Unfortunately, that's caused some confusion. Believing that all CoMET consultants are alike, some owners take bids for the overall CoMET package, including the geotechnical field observation. *Entrusting geotechnical field observation to someone other than the geotechnical engineer of record (GER) creates a significant risk.*

Geotechnical engineers cannot finalize their recommendations until they are on site to verify that the subsurface conditions they predicted are those that actually exist. Entrusting geotechnical field observation to someone other than the geotechnical engineer of record (GER) creates a significant risk.

GERs have developed a variety of protocols to optimize the quality of their field-observation procedures. Quality-focused GERs meet with their field representatives before they leave for a project site, to brief them on what to look for and where, when, and how to look. (***No one can duplicate this briefing***, because no one else knows as much about a project's geotechnical issues.) And once they arrive at a project site, the field representatives know to maintain timely, effective communication with the GER, because that's what the GER has trained them to do. By contrast, it's extremely rare for a different firm's field personnel to contact the GER, even when they're concerned or confused about what they observe, because they regard the GER's firm as "the competition."

Divorcing the GER from geotechnical field operations is almost always penny-wise and pound-foolish. Still, because owners are given bad advice, it's commonly done, helping to explain why ***"geo" issues are the number-one source of construction-industry claims and disputes.***

Divorcing the GER from geotechnical field operations is almost always penny-wise and pound-foolish, helping to explain why "geo" issues are the number-one source of construction-industry claims and disputes.

To derive the biggest bang for the QA buck, identify three or even four quality-focused CoMET consultants. (If you don't know any, use the "Find a Geoprofessional" service available free at www.asfe.org.) Ask about the firms' ongoing and recent projects and the clients and client representatives involved; *insist upon receiving verification of all claimed accreditations, certifications, licenses, and insurance coverages.*

Insist upon receiving verification of all claimed accreditations, certifications, licenses, and insurance coverages.

Once you identify the two or three most qualified firms, meet with their representatives, preferably at their own facility, so you can inspect their laboratory, speak with management and technical staff, and form an opinion about the firm's capabilities and attitude.

Insist that each firm's designated project manager participate in the meeting. You will benefit when that individual is a seasoned QA professional familiar with construction's rough-and-tumble. Ask about others the firm will assign, too. There's no substitute for experienced personnel who are familiar with the codes and standards involved and know how to:

- read and interpret plans and specifications;
- perform the necessary observation, inspection, and testing;
- document their observations and findings;
- interact with constructors' personnel; and
- respond to the unexpected.

Important: Many of the services CoMET QA field representatives perform – like observing operations and outcomes – require the good judgment afforded by extensive training and experience, especially in situations where standard operating procedures do not apply. You need to know who will be exercising that judgment: a 15-year "veteran" or a rookie?

Many of the services CoMET QA field representatives perform require good judgment.

Also consider the tools CoMET personnel use. Some firms are passionate about proper calibration; others, less so. Passion is a good thing! Ask to see the firm's calibration records. If the firm doesn't have any, or if they are not current, be cautious. *You cannot trust test results derived using equipment that may be out of calibration.* Also ask a firm's representatives about their reporting practices, including report distribution, how they handle notifications of nonconformance, and how they resolve complaints.

Scope flexibility is needed to deal promptly with the unanticipated.

For financing purposes, some owners require the constructor to pay for CoMET services. ***Consider an alternative approach*** so you don't convert the constructor into the CoMET consultant's client. If it's essential for you to fund QA via the constructor, have the CoMET fee included as an allowance in the bid documents. This arrangement ensures that you remain the CoMET consultant's client, and it prevents the CoMET fee from becoming part of the constructor's bid-price competition. (Note that the International Building Code (IBC) *requires the owner to pay* for Special Inspection (SI) services commonly performed by the CoMET consultant as a service separate from QA, to help ensure the SI services' integrity. Because failure to comply could result in denial of an occupancy or use permit, having a contractual agreement that conforms to the IBC mandate is essential.)

If it's essential for you to fund QA via the constructor, have the CoMET fee included as an allowance in the bid documents. Note, too, that the International Building Code (IBC) requires the owner to pay for Special Inspection (SI) services.

CoMET consultants can usually quote their fees as unit fees, unit fees with estimated total (invoiced on a unit-fee basis), or lump-sum (invoiced on a percent-completion basis referenced to a schedule of values). No matter which method is used, estimated quantities need to be realistic. Some CoMET firms lower their total-fee estimates by using quantities they know are too low and then request change orders long before QA is complete.

Once you and the CoMET consultant settle on the scope of service and fee, enter into a written contract. Established CoMET firms have their own contracts; most owners sign them. Some owners prefer to use different contracts, but that can be a mistake when the contract was prepared for construction services. *Professional services are different.* Wholly avoidable problems occur when a contract includes provisions that don't apply to the services involved and fail to include those that do.

Some owners create wholly avoidable problems by using a contract prepared for construction services.

This final note: CoMET consultants perform QA for owners, not constructors. While constructors are commonly allowed to review QA reports as a *courtesy*, you need to make it clear that constructors do *not* have a legal right to rely on those reports; i.e., if constructors want to forgo their own observation and testing and rely on results derived from a scope created to meet *only* the needs of the owner, they *must do so at their own risk*. In all too many cases where owners have not made that clear, some constructors have alleged that they did have a legal right to rely on QA reports and, as a result, the CoMET consultant – not they – are responsible for their failure to deliver what they contractually promised to provide. The outcome can be delays and disputes that entangle you and all other principal project participants. Avoid that. Rely on a CoMET firm that possesses the resources and attitude needed to manage this and other risks as an element of a quality-focused service. Involve the firm early. Keep it engaged. And listen to what the CoMET consultant says. A good CoMET consultant can provide great value.

For more information, speak with your ASFE-Member CoMET consultant or contact ASFE directly.

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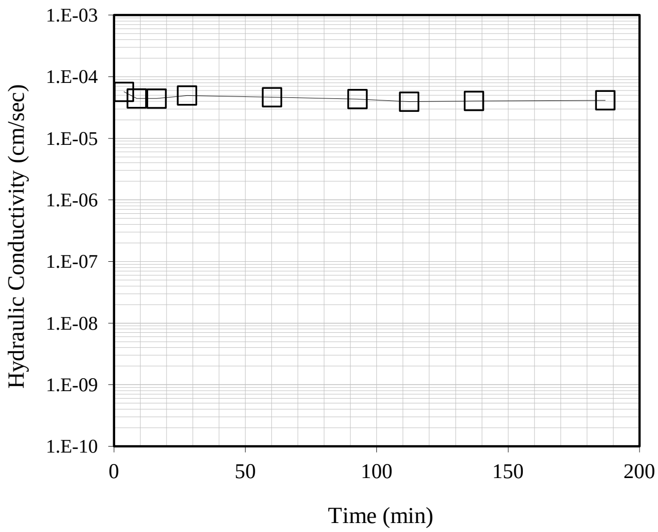
APPENDIX A-2

SUPPLEMENTAL GEOTECHNICAL TESTING RESULTS

Hydraulic Conductivity

Client: Arias & Associates
Project: Mitchell Lake Wetland
Sample ID: B-110 (2' - 4')

TRI Log #: 38882.1
Test Method: ASTM D5084 Method C



Initial Values	
Sample Condition	Undisturbed
Diameter (in)	2.75
Height (in)	2.08
Initial Mass (g)	393.3
Sample Area (in^2)	5.93
Water Content (%)	12.9
Total Unit Weight (pcf)	121.6
Dry Unit Weight (pcf)	107.7
Specific Gravity (Assumed)	2.73
Degree of Saturation	60.7
Void Ratio	0.58
Porosity	0.37
1 Pore Volume (cc)	74.2
Eff. Confining Stress (psi)	5.0
B-Value Prior to Permeation	0.96

Specimen Image

Time	Hydraulic Conductivity, K at 20° C
Min	cm/s
92.7	4.3E-05
112.3	3.9E-05
137.0	4.0E-05
187.0	4.1E-05
Average, Last 4 Readings	**4.1E-05**

Jeffrey A. Kuhn, Ph.D., P.E., 7/6/2018
Analysis & Quality Review/Date

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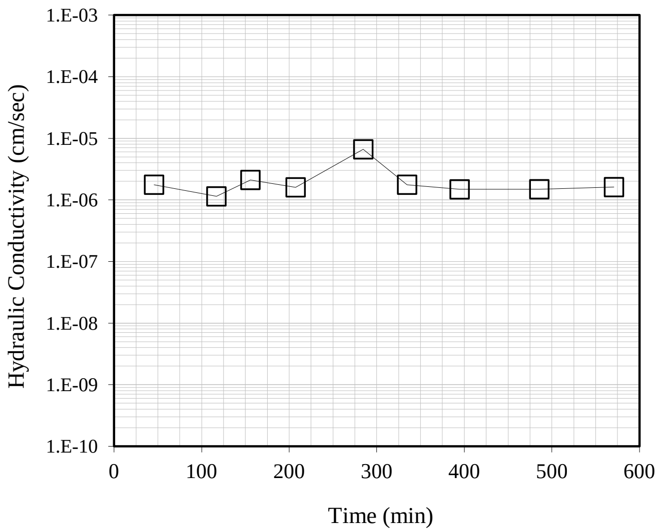
Hydraulic Conductivity

Client: Arias & Associates
Project: Mitchell Lake Wetland
Sample ID: B-114 (8' - 10')

TRI Log #: 38882.2
Test Method: ASTM D5084 Method C



Initial Values	
Sample Condition	Undisturbed
Diameter (in)	2.79
Height (in)	1.62
Initial Mass (g)	328.8
Sample Area (in^2)	6.11
Water Content (%)	15.6
Total Unit Weight (pcf)	126.3
Dry Unit Weight (pcf)	109.3
Specific Gravity (Assumed)	2.73
Degree of Saturation	76.1
Void Ratio	0.56
Porosity	0.36
1 Pore Volume (cc)	58.2
Eff. Confining Stress (psi)	5.0
B-Value Prior to Permeation	0.98

Specimen Image

Time	Hydraulic Conductivity, K at 20° C
Min	cm/s
334.6	1.8E-06
394.6	1.5E-06
485.6	1.5E-06
570.9	1.6E-06
Average, Last 4 Readings	**1.6E-06**

Jeffrey A. Kuhn, Ph.D., P.E., 7/6/2018
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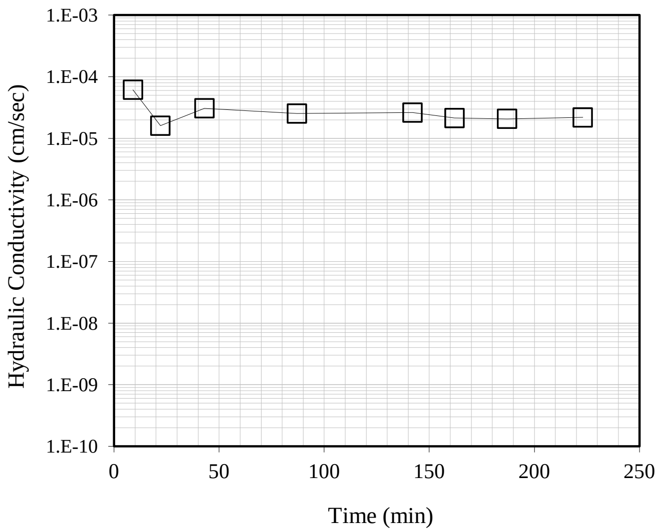
Hydraulic Conductivity

Client:	Arias & Associates
Project:	Mitchell Lake Wetland
Sample ID:	B-118 (2' - 4')

TRI Log #:	38882.3
Test Method:	ASTM D5084 Method C



Initial Values	
Sample Condition	Undisturbed
Diameter (in)	2.77
Height (in)	1.96
Initial Mass (g)	352.9
Sample Area (in^2)	6.01
Water Content (%)	11.1
Total Unit Weight (pcf)	114.1
Dry Unit Weight (pcf)	102.7
Specific Gravity (Assumed)	2.73
Degree of Saturation	45.8
Void Ratio	0.66
Porosity	0.40
1 Pore Volume (cc)	76.6
Eff. Confining Stress (psi)	5.0
B-Value Prior to Permeation	0.95

Specimen Image

Time	Hydraulic Conductivity, K at 20° C
Min	cm/s
142.0	2.6E-05
162.0	2.1E-05
187.0	2.1E-05
223.0	2.2E-05
Average, Last 4 Readings	**2.3E-05**

Jeffrey A. Kuhn, Ph.D., P.E., 7/6/2018

Analysis & Quality Review/Date

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

ARIAS GEOPROFESSIONALS
142 Chula Vista, San Antonio, Texas 78232 • Phone: (210) 308-5884 • Fax: (210) 308-5886

Hydraulic Conductivity Report

Customer: Mr. Tim Noack, P.E.
Principle
Allan Plummer Associates, Inc.

Project: Mitchell Lake Wetland
San Antonio, Texas

Report Date: February 15, 2019

Arias Report No.: 2017-698

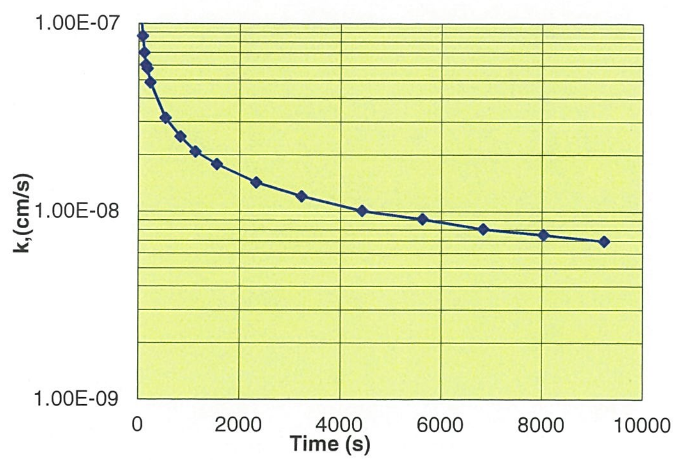
Soil Description: Dark Gray Brown (CH) CLAY
Material Origin: Near B-110
Date Delivered: December 20, 2018
Test Method: ASTM D5084 Method A

Lab ID: 18-1416P
Liquid Limit: 57
Plasticity Index: 35
% Passing No. 200 Sieve: 97

Sample Data

Sample Preperation:	Molded	
Avg. Dia.(cm):	10.13	
Length (cm):	11.63	
Wet Weight (g.):	1746.8	
Area (cm ^2):	80.63	
Volume (cm^3):	937.96	
Wet Density (pcf):	115.3	
Dry Density (pcf):	94.4	
Moisture Content (%):	22.2	
Estimated Gs:	2.75	
Deg. of Saturation %:	96	100 ± 5%
B Value:	0.96	Min. 0.95
Permeant Liquid:	Tap Water	

Hydraulic Conductivity vs. Time



Last Four Test Readings

Date	Elapsed Time (sec.)	K (cm/sec.)
2/12/2019	5640	9.11749E-09
2/12/2019	6840	8.06111E-09
2/12/2019	8040	7.51335E-09
2/12/2019	9240	6.95030E-09
	Average Conductivity:	7.91056E-09

Conductivity at 20 deg. C: 7.28088E-09

Respectfully Submitted,
Arias & Associates, Inc.
TBPE Registration No: F-32

Jerry D. Shepherd, P.E., D.GE
Senior Geotechnical Engineer
JS/as 2-19-19

cc: 1 above

STATE OF TEXAS
JERRY D. SHEPHERD
112142
LICENSED
PROFESSIONAL ENGINEER

142 Chula Vista, San Antonio, Texas 78232 • Phone: (210) 308-5884 • Fax: (210) 308-5886

Moisture Density Relationship Test Report

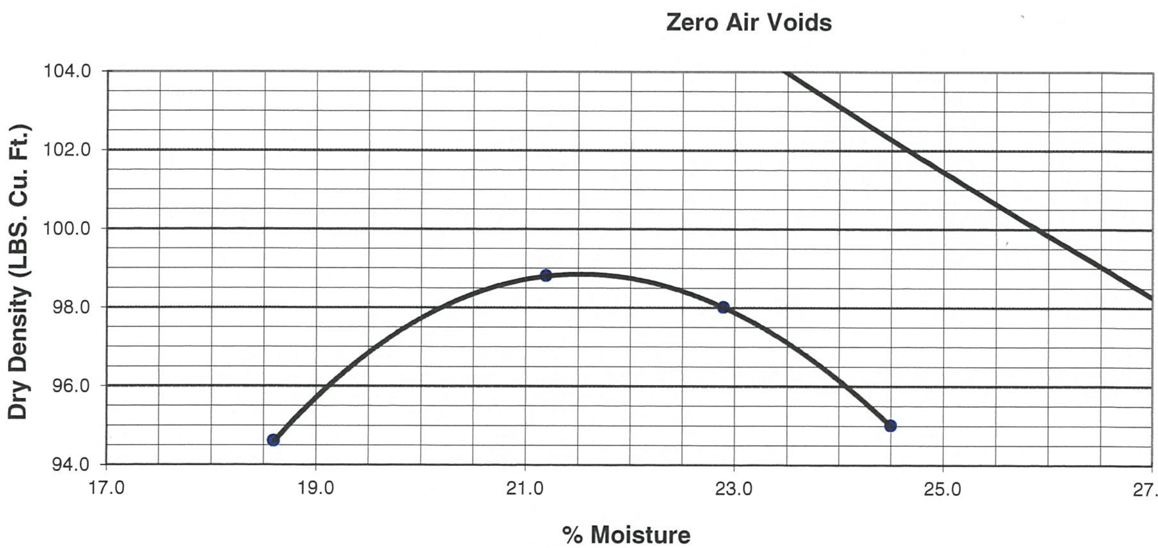
Customer: Mr. Tim Noack, P.E.
Principle
Allan Plummer Associates, Inc.

Project: Mitchell Lake Wetland
San Antonio, Texas

Report Date: February 15, 2019 **Arias Report No.:** 2017-698

Soil Description: Dark Gray Brown (CH), CLAY
Material Origin: Near B-110
Date Sampled: December 20, 2018
Sampled By: Bobby L.
Test Method: ASTM D698 Method A: Moist, Mechanical, ASTM D4318: Wet, Hand-rolled, Manual Liquid Limit, Metal Grooving Tool, ASTM D1140 Method B
Application:
Comments:

Test results for sample I.D.:	18-1416
Maximum Dry Density(lb/ft3):	98.9
Optimum Moisture Content (%):	21.6
Liquid Limit:	57
Plasticity Index:	35
(%) Passing No. 200 Sieve:	97
(Estimated) Specific Gravity:	2.75



Respectfully Submitted,
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Senior Geotechnical Engineer
JS/as 2-19-19

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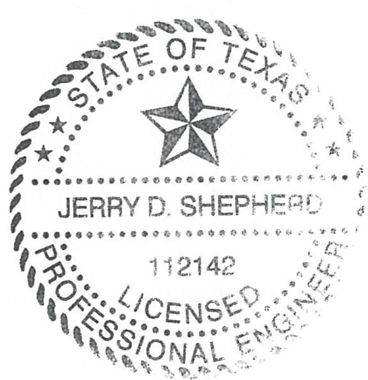

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Hydraulic Conductivity Report

Customer: Mr. Tim Noack, P.E.
Principle
Allan Plummer Associates, Inc.

Project: Mitchell Lake Wetland
San Antonio, Texas

Report Date: February 15, 2019

Arias Report No.: 2017-698

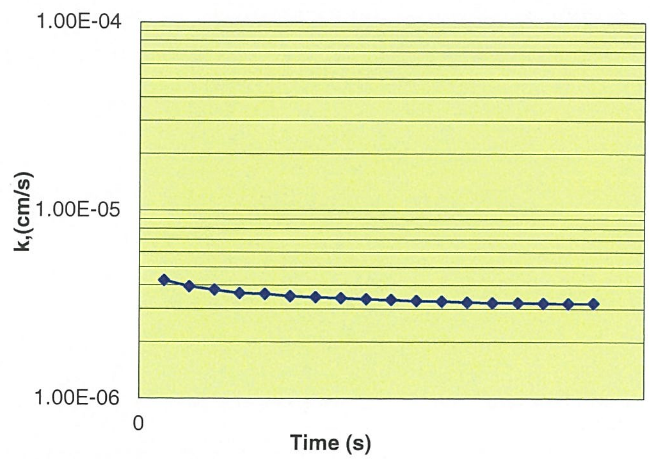
Soil Description: Brown (CL) CLAY with Sand
Material Origin: Near B-113
Date Delivered: December 20, 2018
Test Method: ASTM D5084 Method A

Lab ID: 18-1417P
Liquid Limit: 32
Plasticity Index: 16
% Passing No. 200 Sieve: 59

Sample Data

Sample Preperation:	Molded	
Avg. Dia.(cm):	10.13	
Length (cm):	11.63	
Wet Weight (g.):	1845.6	
Area (cm ^2):	80.63	
Volume (cm^3):	937.96	
Wet Density (pcf):	121.8	
Dry Density (pcf):	106.1	
Moisture Content (%):	14.8	
Estimated Gs:	2.75	
Deg. of Saturation %:	96	100 $\pm$ 5%
B Value:	0.96	Min. 0.95
Permeant Liquid:	Tap Water	

Hydraulic Conductivity vs. Time



Last Four Test Readings

Date	Elapsed Time (sec.)	K (cm/sec.)
2/8/2019	225	3.22679E-06
2/8/2019	240	3.21174E-06
2/8/2019	255	3.19765E-06
2/8/2019	270	3.20955E-06
	Average Conductivity:	3.21143E-06

Conductivity at 20 deg. C: **2.9558E-06**

Respectfully Submitted,
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TBPE Registration No: F-32

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Senior Geotechnical Engineer
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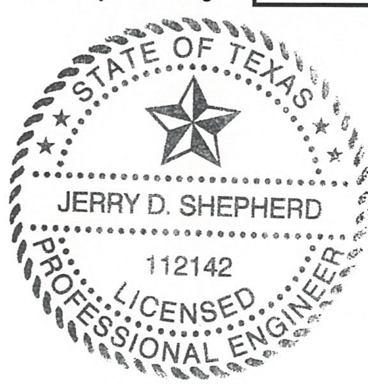

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Moisture Density Relationship Test Report

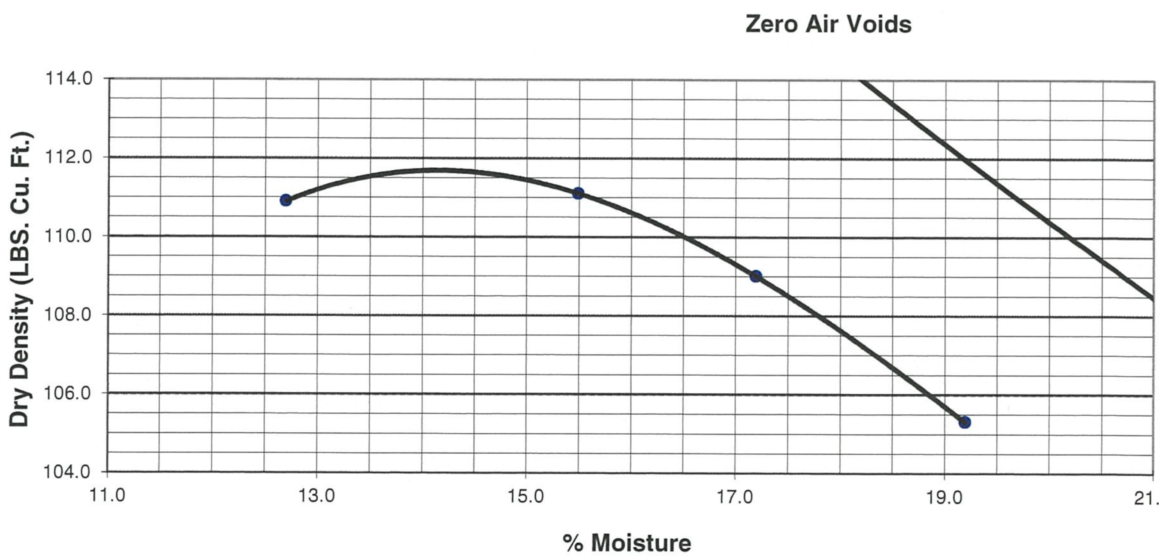
Customer: Mr. Tim Noack, P.E.
Principle
Allan Plummer Associates, Inc.

Project: Mitchell Lake Wetland
San Antonio, Texas

Report Date: February 15, 2019 **Arias Report No.:** 2017-698

Soil Description:	Brown (CL) CLAY with Sand
Material Origin:	Near B-113
Date Sampled:	December 20, 2018
Sampled By:	Bobby L.
Test Method:	ASTM D698 Method A: Moist, Mechanical, ASTM D4318: Wet, Hand-rolled, Manual Liquid Limit, Metal Grooving Tool, ASTM D1140 Method B
Application:	
Comments:	

Test results for sample I.D.:	18-1417
Maximum Dry Density(lb/ft3):	111.7
Optimum Moisture Content (%):	14.2
Liquid Limit:	32
Plasticity Index:	16
(%) Passing No. 200 Sieve:	59
(Estimated) Specific Gravity:	2.75



Respectfully Submitted,
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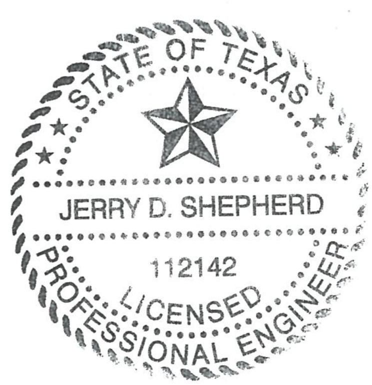

ARIAS GEOPROFESSIONALS

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Hydraulic Conductivity Report

Customer: Mr. Tim Noack, P.E.
Principle
Allan Plummer Associates, Inc.

Project: Mitchell Lake Wetland
San Antonio, Texas

Report Date: February 15, 2019

Arias Report No.: 2017-698

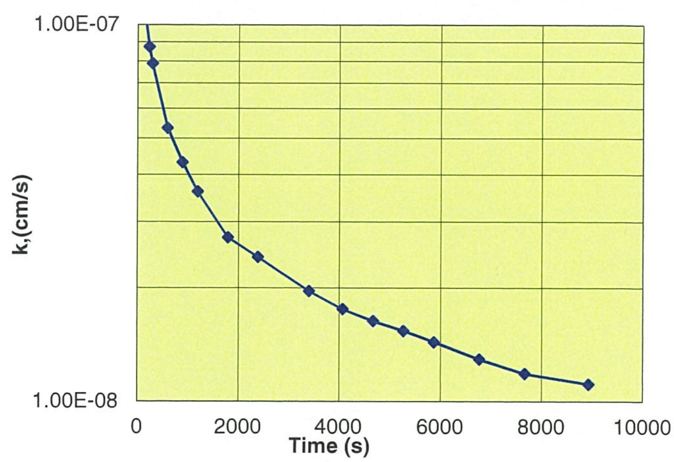
Soil Description: Brown (CL) Sandy CLAY
Material Origin: Near B-115
Date Delivered: December 20, 2018
Test Method: ASTM D5084 Method A

Lab ID: 18-1418P
Liquid Limit: 43
Plasticity Index: 24
% Passing No. 200 Sieve: 94

Sample Data

Sample Preperation:	Molded	
Avg. Dia.(cm):	10.13	
Length (cm):	11.63	
Wet Weight (g.):	1775.6	
Area (cm ^2):	80.63	
Volume (cm^3):	937.96	
Wet Density (pcf):	117.2	
Dry Density (pcf):	97.9	
Moisture Content (%):	19.8	
Estimated Gs:	2.75	
Deg. of Saturation %:	98	100 ± 5%
B Value:	0.98	Min. 0.95
Permeant Liquid:	Tap Water	

Hydraulic Conductivity vs. Time



Last Four Test Readings

Date	Elapsed Time (sec.)	K (cm/sec.)
2/4/2019	5880	1.43546E-08
2/4/2019	6780	1.29292E-08
2/4/2019	7680	1.18419E-08
2/4/2019	8940	1.11072E-08
	Average Conductivity:	1.25582E-08

Conductivity at 20 deg. C: 1.15586E-08

Respectfully Submitted,
Arias & Associates, Inc.
TBPE Registration No: F-32

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JS/as 2-19-19

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Moisture Density Relationship Test Report

Customer: Mr. Tim Noack, P.E.
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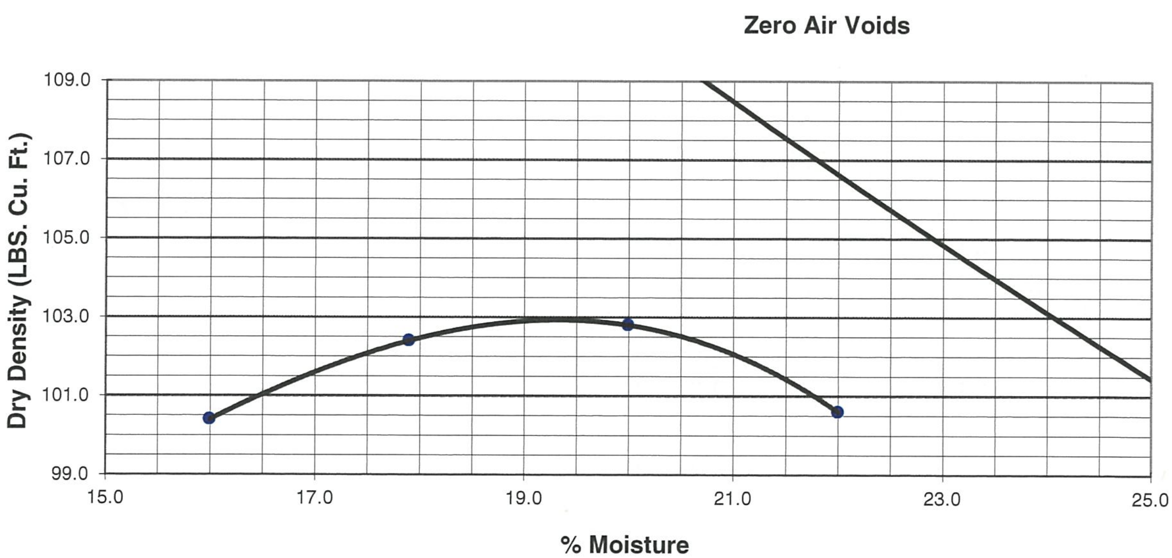
Allan Plummer Associates, Inc.

Project: Mitchell Lake Wetland
San Antonio, Texas

Report Date: February 15, 2019 **Arias Report No.:** 2017-698

Soil Description: Brown (CL) Sandy CLAY
Material Origin: Near B-115
Date Sampled: December 20, 2018
Sampled By: Bobby L.
Test Method: ASTM D698 Method A: Moist, Mechanical, ASTM D4318: Wet, Hand-rolled, Manual Liquid Limit, Metal Grooving Tool, ASTM D1140 Method B
Application:
Comments:

Test results for sample I.D.:	18-1418
Maximum Dry Density(lb/ft3):	103.0
Optimum Moisture Content (%):	19.4
Liquid Limit:	43
Plasticity Index:	24
(%) Passing No. 200 Sieve:	94
(Estimated) Specific Gravity:	2.75



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