PROJECT MANUAL
VOLUME 5 OF 6

Geotechnical Report

The City of Austin

Austin, Texas

MONTOPOLIS WATER RECLAMATION INITIATIVE (WRI) STORAGE RESERVOIR AND PUMP STATION PROJECT

CIP ID Number: 5267.035
IFB 6100 CLMC601
First advertisement date: July 18, 2016

Austin Water

It is the policy of the City of Austin to involve certified Minority Owned Business Enterprises (MBEs) and Women Owned Business Enterprises (WBEs) in City contracting. MBE and WBE goals for this solicitation are contained in Volume 4, MBE/WBE Procurement Program Package.

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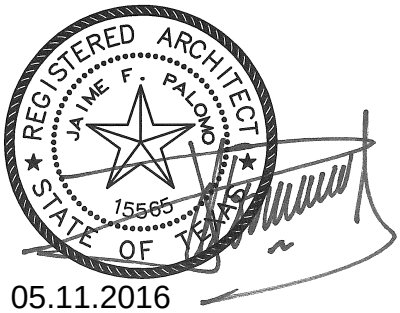

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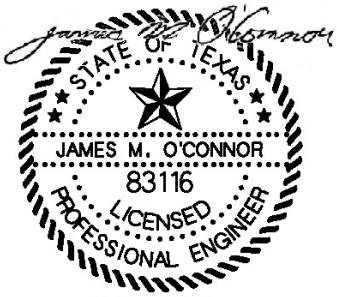

5/11/2016

CITY OF AUSTIN
AUSTIN WATER

BIDDING REQUIREMENTS
AND
CONTRACT DOCUMENTS

for the construction of the

MONTOPOLIS WATER RECLAMATION INITIATIVE (WRI) STORAGE RESERVOIR AND PUMP STATION PROJECT

C.I.P. ID No. 5267.035
IFB 6100 CLMC601
First Advertisement Date: July 18, 2016

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CH2M HILL
Austin, Texas
May 2016

Document Number		Title

VOLUME 1

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Additional standard specifications not found in the list above and cross- referenced standard specifications not found in the list above may be obtained as follows:
{City of Austin Standard Specifications, Series 100 through 16000, adopted April 6, 1986, as amended. Available for purchase from

American Legal Publishing Corporation	*Telephone*	*1-800-445-5588*
Folio Business Partners and Publishers	*FAX*	*1-513-763-3562*
432 Walnut Street, 12th Floor	*email*	*amlegal@aol.com*
Cincinnati, Ohio 45202	*Web Page*	*http://www.amlegal.com*

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VOL. 5	08/01/15	**Geotechnical Report**
VOL. 6	09/03/15	**Stormwater Pollution Prevention Plan (SWPPP)**

END

Engineering Report

Geotechnical Investigation for the Proposed Montopolis Pump Station Facilities, Austin, Texas

Prepared for

City of Austin, Texas

August, 2015

CH2MHILL®

TBPE Firm Number 3699

STATE OF TEXAS
CURTIS R. BASNETT
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PROFESSIONAL ENGINEER

10/14/2015

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Figure

4-1 Overexcavation and Backfill

Acronyms and Abbreviations

ASTM	American Society for Testing and Materials
bgs	below ground surface
CBR	California Bearing Ratio
CFA	Continuous Flight Auger
ft	feet
H	horizontal
N	Standard Penetration Resistance
OSHA	Occupational Safety and Health Administration
pcf	pounds per cubic foot
psf	pounds per square foot
psi	pounds per square inch
pvr	potential vertical rise
SPT	Standard Penetration Test
tcf	tons per cubic foot
USCS	Unified Soil Classification System
V	vertical

SECTION 1

Introduction

1.1 Purpose and Scope

CH2M HILL and the City of Austin conducted two separate geotechnical investigations for the design and construction of the proposed Montopolis pump station facilities. This report details the field exploration, laboratory testing, engineering analyses and recommendations for the design and construction of the proposed facilities.

The geotechnical investigations included the following tasks:

- Conduct a total of 13 continuous-flight-auger (CFA) soil borings with drilling depths ranging from 2 to 40 feet (ft) below the existing ground surface (bgs).
- Perform moisture contents, Atterberg Limits tests, swell tests, unconfined compression tests, sieve analyses and sulfate content tests on representative soil samples.
- Perform engineering analyses and develop geotechnical design and construction recommendations.
- Prepare this report to provide recommendations for the earthwork and foundation design of the proposed facilities.

1.2 Project Description and Proposed Construction

The proposed pump station is located at the northeast corner of the intersection of Montopolis Drive and E. Ben White Blvd. Currently, the project site is heavily wooded. Topography of the site slopes from north to south, from elevations 604 to 587 ft. The project location map is presented in the geotechnical data reports in Appendix A.

The proposed construction will consist of a 130-foot-in-diameter ground storage tank and a pump station. The detailed description of the proposed facilities, the plan dimension, approximate existing grade elevation, bottom elevation of base slab, estimated load, and type of construction are presented in Table 1-1. The detailed site plan is presented in Appendix B.

TABLE 1-1
General Structures Information

Structure Description	Plan Dimensions (ft)	Current Ground Elevation (ft, msl)	Top of Slab Elevation (ft, msl)	Estimated Unit Load	Type of Construction
4-MG Ground Storage Tank	130 dia x 40 tall	594 to 603	598.5	2,600 psf, wfl = 3,500 psf	Prestressed Concrete
Pump Station	70 X 75	589 to 594	594.0	wfl = 3,000 plf	1-story concrete masonry

Notes:

MG = million gallon
dia = diameter
msl = mean sea level
plf = pounds per linear foot
psf = pounds per square foot
wfl = wall footing load

SECTION 2

Geotechnical Exploration

2.1 Field Exploration

Field explorations were conducted by HVJ and Associates, Inc. of Austin, TX, and consisted of advancing a total of 13 CFA borings. The CFA borings were advanced to depths ranging from 2 to 40 ft bgs.

The borings were located in the field using surveying equipment. The boring location plan and the boring logs are presented in Appendix B.

2.1.1 Sampling Methods

Sampling methods included split spoon sampling and thin-walled tube sampling. These methods and sampling depth intervals are more fully described within HVJ's data reports presented in Appendix A. The groundwater table was not encountered immediately after completion of the borings except in boring B-11, which is believed to be perched groundwater at this specific location. As noted in HVJ's report, groundwater was not encountered in Boring B-11A, conducted within 5 feet from Boring B-11.

TABLE 2-1
Summary of Soil Borings

Boring ID	Estimated Ground Elevation (ft, msl) a	Soil Boring Depth (ft, bgs)	GWT Depth (ft, bgs)
B-1	607	2	Not encountered
B-2	610	2	Not encountered
B-3	609	10	Not encountered
B-4	601	30	Not encountered
B-5	600	40	Not encountered
B-6	595	30	Not encountered
B-7	590	40	Not encountered
B-8	613	40	Not encountered
B-9, B-9A	602	40	Not encountered
B-10	599	40	Not encountered
B-11, B-11A	594	40	37
B-12, B-12A	598	40	Not encountered
B-13	594	40	Not encountered

Note: Borings B-9A, B-11A, and B-12A were subsequently conducted on October 23 and 24, 2014 to obtain additional samples. These borings were conducted within 5 feet of their respective borings B-9, B-11, and B-12.

2.1.2 Laboratory Testing

All disturbed samples were visually classified in the field in accordance with the Unified Soil Classification System (USCS). To aid the soil classification and evaluation of engineering properties of the soils, ten P200 tests (percent passing the No. 200 sieve, ASTM D1140), 43 moisture content tests, and 27 Atterberg limit tests (ASTM D4318) were conducted by HVJ and Associates. Wet unit weights of 16 selected samples were also completed. To evaluate strength, 16 unconfined compression tests (ASTM D2166) were conducted. Swell testing (ASTM D4546 Method B) was also conducted on 5 samples.

Sulfate content testing was also completed on three samples. The laboratory results are presented in the soil boring logs in Appendix A and tabulated within the data reports.

SECTION 3

Subsurface Condition

The subsurface condition at the proposed facilities location generally consists of 1 to 2 feet of brown to dark brown highly plastic fat clay overlying 4 to 8 feet of very stiff sandy lean clay to lean clay, and very stiff to hard fat clay, which overlies hard fat clay and clayshale to the maximum depth of the borings of 40 ft. The groundwater table was not encountered in twelve of the borings immediately after completion of the borings. However, groundwater was encountered in B-11 at 37 feet bgs and is considered a potentially localized perched condition.

3.1 Shrink-Swell Soil

The tendency for a soil to shrink and swell with change in moisture content is a function of clay content and type, which are reflected in soil plasticity as defined by Atterberg Limits. A generalized relationship between shrink-swell (expansion) potential and the soil plasticity Index (P.I.) is shown in Table 3-1:

TABLE 3-1
General Relationship between P.I. and Shrink-Swell Potential

P. I. Range	Shrink-Swell Potential
0 - 15	Low
15 -25	Medium
25 - 35	High
Greater 35	Very High

The surficial stiff to hard clay at this site possess a high to very high shrink-swell potential. The amount of expansion that will actually occur with increase in moisture content is inversely related to the overburden pressure; that is, the larger the overburden pressure, the smaller the amount of expansion. Near surface soils are thus susceptible to shrink-swell behavior because of low overburden pressures.

Results of swell testing indicate the percent swell ranges from 0.15 to 2.95 percent. Load pressures ranged from 1,170 to 2,600 pounds per square foot (psf). The general trend of the data indicates swell pressures are less than 1 percent when overburden pressures are 2,200 psf or greater.

SECTION 4

Geotechnical Analyses and Recommendations

The findings of the subsurface investigation and laboratory testing were used to develop the following design analyses and recommendations.

4.1 Expansive Subgrade and Sloping Ground

Index testing and swell testing indicates the existing subgrade materials are highly expansive, consistent with the Taylor Formation (Taylor Group) encountered below the alluvium in the area. If not properly addressed, swell pressures could impact foundations resulting in foundation cracking, damage, and potential tilting of structures. These swell pressures would be caused by moisture content variations (low moisture to high moisture) of the subgrade soil. Excessive moisture can be introduced either through storm water runoff or from artificial means such as irrigation, leaky pipes or leaky facilities holding or pumping water, which would be possible based on the planned facilities.

Swell pressures range from 1,170 psf to 2,600 psf. If engineered fill and foundation pressures exceed these swell pressures, uplift will be negligible. Engineered solutions include removing the swelling soil and replacing with engineered backfill along with positive surface drainage away from foundation supports. Moisture barriers or water collection systems between the foundation system and swelling subgrade can also provide a means to stabilize moisture variations caused by leaky pipes or facilities.

Another method to address these conditions is to design foundation systems to resist potential swell pressures. This includes deep foundations. Deep foundations would extend below the anticipated active zone to anchor the foundation against uplift movement. Due to the intermediate geomaterial conditions, drilled shafts would be the preferred deep foundation to anchor the foundation against uplift swell pressures. In case this option is chosen, pile calculations to estimate axial uplift loads, axial uplift resistance, and axial compressive loads for 24-inch and 30-inch diameter drilled shafts are provided in the appendices. Deep foundations is preferred to resist potential uplift at the pump station. Anticipated foundation pressures for the ground storage tank are equal to or greater than the highest measured swell pressure. Therefore, uplift is not anticipated at this location.

Sloping ground conditions at the site requires back-cuts into the slope to achieve final floor elevations for the proposed structures. Based on review of the unconfined compression test results, these back-cuts will result in the structures being founded partially on hard clay/soft rock and structural fill, resulting in variable stiffness under the foundations. To avoid this condition, back-cuts should be over-excavated and replaced with the same structural fill placed in the fill portions of the foundation area. These back-cut over-excavations are typically 5 ft, based on review of the proposed grading plans. Back-cut over-excavations for the pump station are not required because it will be supported by piles, as noted above.

The following over-excavation and backfill procedures are recommended:

- For the ground storage tank, in cut areas of the subgrade, over-excavation the fat, hard clay to depths allowing a minimum of 5 feet of compacted structural fill below the bottom of footings and across the base slab. The bottom of the overexcavation should be extended to at least 4 feet from the edge of the perimeter footings. Once excavated, the bottom exposed subgrade should be protected from saturation or moisture changes. The placement of a concrete seal slab is recommended as soon as practicable after excavation and subgrade preparation. The seal slab is described in Section 4.8.2.
- After overexcavation and before structural fill placement, a perimeter drain consisting of a 4-inch-diameter perforated corrugated pipe with a filter sock should be installed on the concrete seal to allow drainage of potential water buildup within the structural fill. The bottom of the overexcavation should be graded to a minimum of 1-2 percent towards the downslope exit point of the pipe.

- Structural fill should meet the requirements as mentioned below in Section Fill and Backfill. The structural fill should be placed in 8-inch maximum loose lifts, with each lift compacted to at least 100 percent of the maximum dry density, as determined by TxDOT test method Tex-113-E.
- Around the perimeter of exposed footings, a 12-inch-thick compacted fat clay should be placed to prevent surface water from entering the compacted structural fill. The fat clays should be well processed and moisture conditioned to 2 to 3 percent above optimum moisture before placement.
- All exposed subgrades should be protected from flooding and backfilled as soon as practicable. Positive surface drainage should be provided to drain ponding storm water off of exposed subgrades.
- All surface water should be diverted from the proposed facilities by sloping the grade away from the facilities or by constructing a drainage swale.

Based on assessment of swell pressures, the percent swell, foundation and structural backfill pressures, along with recommended ground surface and subgrade preparations noted above, the anticipated swell uplift at the storage tank is estimated to be negligible. The pump station will be supported on piles founded at minimum tip elevations to resist uplift pressures.

The overexcavation and backfill requirements for the ground storage tank are illustrated in the Figure 4-1.

4.2 Subgrade Preparation for Access Road

Overexcavation of fat clay under the access road is also recommended. The overexcavation should be extended to 4 feet beyond the perimeter of the pavement and to 24 inches below the base course of the pavement. The overexcavation should be replaced with structural fill placed in 8-inch maximum loose lifts, with each lift compacted to at least 100 percent of the maximum dry density, as determined by TxDOT test method Tex-113-E.

4.3 General Excavation and Trench Excavation

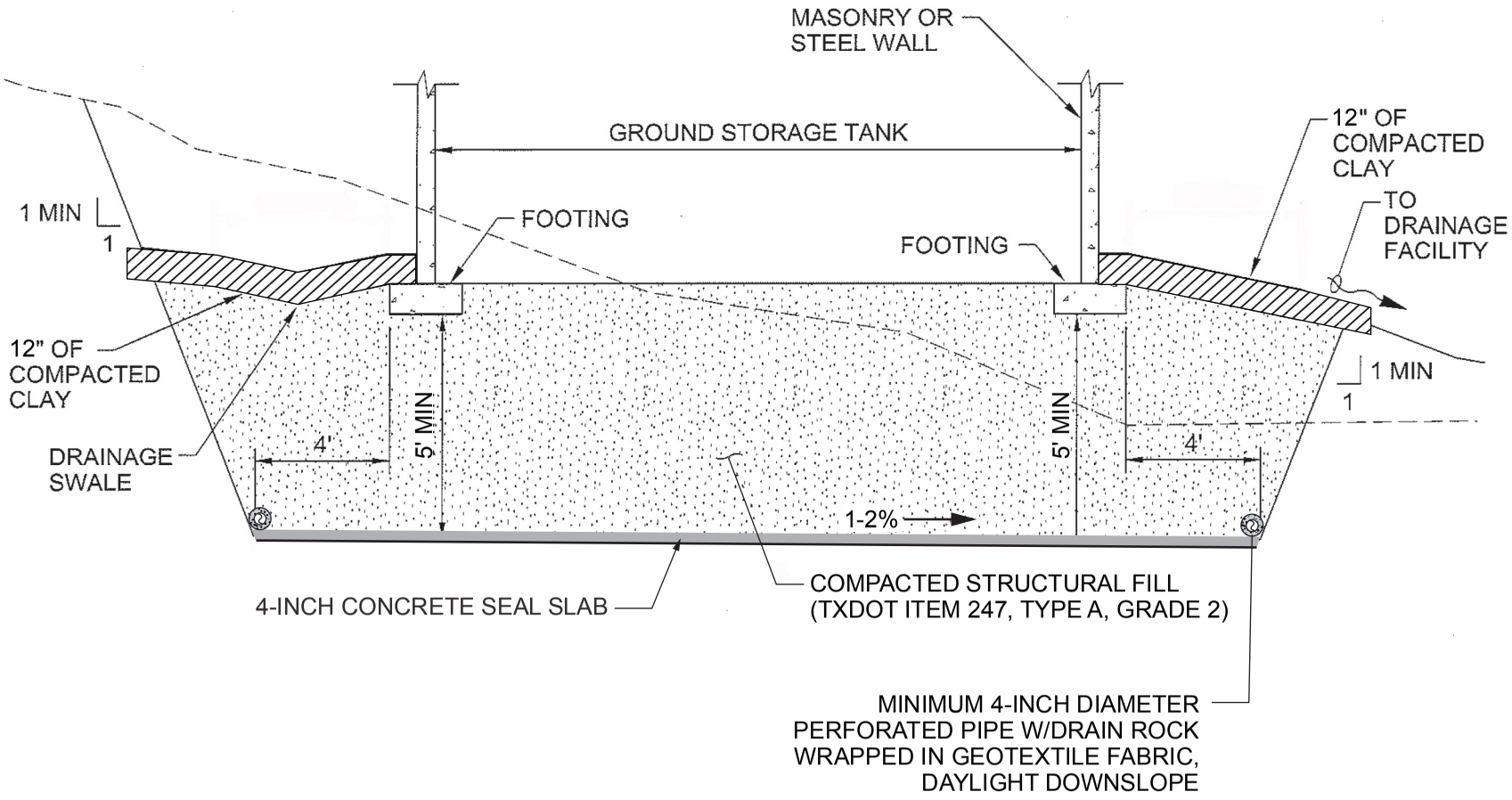
The borings indicate materials at the site can be excavated with conventional earth moving equipment, such as backhoes and front-end loaders. An un-braced temporary excavation with the side slope inclined at 1.5 horizontal (H) to 1 vertical (V) or flatter is expected to remain stable if it is not subjected to surcharge load or vibration. Excavations should be sloped or shored in accordance with Occupational Safety and Health Administration (OSHA) Standard 29 CFP part 1926, 652 requirements. Surface water runoff should be prevented from entering the excavation by berms, swales, or other methods. All grass, topsoil, and organic material should be stripped before excavation begins. Excavation should be conducted in accordance with all federal, state, and local ordinances protecting workers.

In areas where un-braced excavations are not practical, an excavation support system shall be installed. It is up to the excavation contractor to determine the support system. Excavations within the influence zone of an existing structure, utility, or pavement must be shored. The influence zone is defined at a slope ratio of 1.5H:1V from the nearest edge of an existing structure, utility, or pavement.

4.4 Fill and Backfill

4.4.1 Structural Fill

Structural fill is recommended for fill to be placed beneath slabs, footings, grade beams, and pavements. Structural fill should consist TxDOT Item 247, Type A, Grade 2 Flexible Base. The structural fill material should be placed in 8-inch maximum loose lifts, with each lift compacted to at least 100 percent of the maximum dry density, as determined by TxDOT test method Tex-113-E.



NOT TO SCALE

FIGURE 4-1
Overexcavation and Backfill Under Proposed Ground Storage Tank

Structural fill should be used for fill adjacent to walls. The structural fill should be compacted with plate vibratory compactors or hand-operated power tampers. For backfill that will support adjacent structures, the backfill material should be placed in 8-inch maximum loose lifts with each lift compacted to 100 percent of the maximum dry density, as determined by TxDOT test method Tex-113-E. To prevent excessive lateral pressure on external walls, large compaction equipment should not be allowed within a zone formed by a 45-degree slope from the base of the wall footing.

4.4.2 Pipe Zone Backfill

Backfill material for the pipe zone should consist of controlled, low strength material (CLSM). CLSM is a fluid mixture of Portland cement, water, and fine aggregates or fly ash. The consistency of the material is that of a slurry grout, and the material is placed like concrete. For use as a pipe zone backfill material, the mixture should be designed for a 28-day compressive strength of 100 to 150 pounds per square inch (psi).

If weak or soft subgrade soils are encountered during construction of the pipeline, such material should be over excavated a minimum depth of 1 foot below the proposed pipe invert and replaced with CLSM.

When placing CLSM, the contractor should ensure the pipe is properly anchored to prevent hydrostatic uplift.

4.4.3 Trench Backfill above Pipe Zone

Backfill material above the pipe zone may consist of moisture-conditioned excavated soil (earth fill). Such excavated soil shall be free of roots, debris, clay, organic material, rock larger than 3 inches, or other deleterious objects to be suitable for use as trench backfill above the pipe zone. Trench backfill should be placed and spread in layers with 10-inch maximum loose lifts and should be compacted to 95 to 102 percent of the maximum dry density at a moisture content of at least 2 percent above optimum, as determined by TxDOT test method Tex-114-E.

The recommendations noted in 4.4.2 and above will reduce the risk of swell movements from leaky pipes and surface water infiltration within the pipe zone. However, flexible pipe connections are recommended to address the potential for these movements.

4.4.4 Tank Sand Cushion

If required, a sand cushion shall consist of clean washed natural or manufactured sand conforming to the requirements of ASTM C144 with the additional requirement that the percent passing the No. 200 sieve not exceed 5 percent. Sand shall be free of chlorides or other corrosive and deleterious substances. Resistivity of saturated sand shall be not less than 10,000 OHM-CM.

4.5 Groundwater Control

Groundwater was not encountered in the borings, except for perched groundwater encountered in Boring B-11, at 37 feet bgs. Control of storm water may be necessary for trench excavation. Storm water that accumulates in the bottom of the excavation should be diverted by trenching to a low sump, and then pumped out by sump pump. Attempts should be made to divert storm water runoff away from open excavations by building temporary diversion berms or ditches. Exposed, over-excavated subgrades supporting structures should be protected from ponding storm water and backfilled with structural fill as quickly as possible.

4.6 Lateral Earth Pressures

Structural fill, as recommended above, should be used for backfill behind walls. For walls backfilled with structural fill, the equivalent earth pressures, in terms of equivalent fluid pressure, presented in Table 4-2 are recommended for calculating at-rest, active and passive earth pressures.

TABLE 4-2
Recommended Design Equivalent Fluid Pressure

Condition	Equivalent Fluid Pressure, Above Groundwater Table, psf/ft	Equivalent Fluid Pressure, Below Groundwater Table, psf/ft
At-Rest	60	94
Active	40	83
Passive	360	250

4.7 Thrust Restraints

Pressurized pipes and fittings are commonly joined with push-on or mechanical joints. These joints do not provide significant restraint against separation caused by thrust forces as a result of a change in direction or a change in pipe cross-section. To resist the thrust force it is recommended the use of restrained joints.

The design of thrust restraint system is primarily to estimate the length of pipe that must be restrained on each side of the thrust force location. Several parameters must be considered in the design of length of the thrust restraints. These parameters are; pipe size, internal pressure, depth of cover, and characteristics of the soil surrounding the pipe, such as, unit weight, friction angle, cohesion etcetera.

Assuming the backfill to be used is prepared in accordance with the recommendations of this report; it is recommended to use the following soil engineering properties for the restrained joint design:

- Drained friction angle (phi) = 24°
- Drained cohesion (c) = 200 pounds per square foot (psf)
- Unit weight of soil (gamma) =120 pounds per cubic foot (pcf)
- Allowable bearing capacity = 3,000 psf
- Soil/ductile iron pipe contact friction angle (δ) = 21°
- Modulus of Soil reaction = (E') = 3,000 psi
- Friction reduction factors:
  - Ductile Iron Pipe (wrapped) = 0.56
  - Ductile Iron Pipe (unwrapped) = 0.80

A geotechnical engineer should design thrust restraints using actual pipe testing pressures and the indices presented above.

4.8 Foundation Design Recommendations

4.8.1 Spread Footings and Slabs-on-Grade

Based on the soil profile encountered in the borings, and assuming the ground storage tank foundation will be prepared as recommended above, it is recommended that the proposed tank be supported with shallow spread footings and slab-on-grade or mat foundation provided that the foundation soil is prepared as recommended above. The spread footings should be designed using a maximum allowable net bearing pressure of 4,000 psf for the tank perimeter footing. This allowable bearing pressure can be increased 30 percent for short-term loads such wind loading. The tank wall footings should be at least 24 inches wide and embedded at least 1.5 feet below the finished grade.

The slabs-on-grade or mat foundation should be designed using a modulus of subgrade reaction for a 1-foot square plate of 150 tons per cubic foot (tcf) for the proposed facilities. This modulus of subgrade reaction should be adjusted to account for the difference in size between the plate and the actual foundation. The following equation provides the necessary adjustments:

$$K_s = K_1\left(\frac{B+1}{2B}\right)^2$$

where:

K_s = Adjusted modulus of subgrade reaction for square mat or raft foundation, (tcf)

K_1 = Modulus of subgrade reaction for a 1-foot square plate, (tcf)

B = Width of square mat or raft foundation, (feet)

The equation above applies to square mat or raft foundations. The following equation should be used to adjust Ks for rectangular mat of raft foundation:

$$K_r = \frac{K_s\left(1+\frac{B/L}{2}\right)}{1.5}$$

where:

K_r = Adjusted modulus of subgrade reaction for a rectangular mat or raft foundation, (tcf)

K_s and B = as defined above

L = Length of mat or foundation, (feet)

The total and differential settlements of the proposed facilities supported by the foundation recommended above and assuming the underlying fat clay will be over-excavated and replaced as recommended above, are estimated to be less than 1 inch and ½ inch, respectively. CH2M HILL believes that the estimated settlements are within tolerable limits for the proposed facilities.

A recommended coefficient of friction between mass concrete and structural fill is 0.50, assuming no visqueen or plastic sheeting is in place.

4.8.2 Concrete Seal Slab

Immediately after overexcavation and prior to structural backfill, a seal concrete slab should be placed over the excavated subgrade surface to preserve the moisture content of the soil and prevent rain from saturating the surface. The seal concrete slab should be at least 4 inches thick and have an unconfined compressive strength of 2000 psi.

4.8.3 Drilled Shaft Foundation

As previously noted, the proposed pump station will be supported on drilled shafts designed to resist potential uplift loads due to a swelling subgrade. Drilled shafts can be either 24 inch or 30 inch diameter, without belled tips. Axial uplift and compression capacities were estimated using the program Shaft, by Ensoft. Axial uplift was assumed acting on the shaft over a maximum active-zone depth of 15 feet below ground surface. The uplift shear stress acting on the shaft was assumed equivalent to the maximum side shear developed in compression. Based on the anticipated dead and live loads and the given cut-off elevations from the structural designer, the design tip elevations for the shafts are recommended in Table 4-3. Drilled shaft installation should follow the project specifications.

A minimum 8-inch-thick void form should be placed between the underlying subgrade surrounding the shafts and the bottom-of-slab to accommodate potential subgrade swell movements. This will also minimize swell pressures from impacting the bottom of the slab. Any fill that is needed surrounding grade beams or within the subgrade should consist of compacted structural fill, as noted. A minimum 4-inch diameter perforated pipe drains, similar to Figure 4-1, should be installed below and parallel with each pipe gallery to facilitate subgrade drainage in this area. The drains should daylight downslope.

TABLE 4-3
Recommended Drilled Shaft Foundation, Pump Station

Drilled Shaft Location	Drilled Shaft Numbers	Cut-off Elevation (feet)	Tip Elevation (feet)[1]	Length (feet)	Maximum factored load in Compression (tons)[2]	Allowable Axial Resistance (tons)[3]
Pump Station, Bottom-of-Slab	P-1 through P-7, P-22 through P-28, P-43 through P-49	592	559	33	37	175/275
Pump Station, Pipe Gallery, Bottom-of-Slab	P-8 through P-21, P-29 through P-42	585	568	17	62	144/200

[1] tip elevation controlled by swell uplift pressures and minimum pile dead load

[2] Includes dead and live loads

[3] allowable axial resistance in compression, 175 and 144 tons for 24-inch-diameter shaft, 275 and 200 tons for 30-inch-diameter diameter shaft

4.8.4 Seismicity

The project site is located in an area of low seismic activity. Based on the results of the soil borings conducted at the project site and additional subsurface information within the project region, the site is classified as D using the 2009 edition of the International Building Code (IBC2009).

4.9 Pavement Design Recommendations

New access roads and parking areas will be constructed for access to the facilities. The subgrade soil at the site mainly consists of highly plastic clay. The subgrade soil should be over-excavated as recommended or stabilized with lime to a depth of 12 inches and compacted to a minimum of 100 percent of the maximum dry density as determined by TxDOT test method Tex-113-E, assuming structural fill replacement. The moisture content of the stabilized material should be at optimum moisture content, ±2 percent. The lime stabilization should be performed in accordance with TxDOT Item 260. For the pavement design, a California Bearing Ratio (CBR) of 2 for the stabilized subgrade is recommended.

4.10 Summary

The findings and recommendations of this investigation are summarized below:

- Sloping foundation soil under the proposed ground storage tank should be over-excavated 5 feet below the bottom of the footings or base slab and replaced with structural fill (TxDOT Item 247, Type A, Grade 2) placed in 8-inch lifts and compacted to at least 100 percent of the maximum dry density as determined by TxDOT test method Tex-113-E.
- Exposed subgrades should be protected from ponding water by backfilling as quickly as practicable and providing positive surface drainage.
- A sub-drain consisting of a perforated drain pipe wrapped in a filter sock should be installed at the bottom of the excavation to drain potentially trapped water within the structural fill. The bottom of the overexcavation should be graded 1-2 percent in the direction of the exit point for the pipe at the ground surface. A sub-drain is also recommended at the pump station located below and parallel to the pipe galleries.

- The subgrade soil under pavement should be over-excavated to 24 inches below the bottom of base course and replaced with compacted structural fill or stabilized with lime to a depth of 12 inches. TxDOT Item 260 should be followed regarding lime stabilization.
- Side slopes for excavations shallower than 5 feet should be no steeper than 1.5 H to 1 V. Excavations deeper than 5 feet should be sloped in accordance with OSHA requirements.
- CLSM should be placed for pipe zone backfill material. Flexible pipe connections are recommended.
- Excavated materials (earth fill) can be placed as backfill above the pipe zone materials beneath roads in maximum 10-inch lifts and compacted to at least 95 to 102 percent of the maximum dry density as determined by TxDOT test method Tex-114-E, at 2% above optimum moisture content.
- A concrete seal slab should be immediately placed on top of exposed, over-excavated subgrade, below the ground storage tank, to preserve the moisture content and protect the exposed surface from saturation.
- To support the proposed ground storage tank, spread footings designed with a maximum allowable bearing net pressure of 4,000 psf for the tank perimeter footing is recommended. The tank wall footings should be at least 24 inches wide. A modulus of subgrade reaction of 150 tons per cubic foot (tcf) is recommended for the design of the slab-on-grade foundation.
- Drilled shaft foundations are recommended for support of the pump station. The shafts should be installed to tip elevations of 559 feet and 568 feet, as noted in Table 4-3.

SECTION 5

Limitations

This report has been prepared for the exclusive use of City of Austin, for specific application to the proposed pump station facilities. This report is in accordance with generally accepted geotechnical engineering practices. No other warranty, express or implied, is made.

The analyses and recommendations in this report are based on the data obtained from the soil borings. The borings indicate soil conditions only at specific locations, times, and only to the depths penetrated. They do not necessarily reflect strata variations that may exist between the boring locations. If variations in subsurface conditions from those described are noted during construction, recommendations in this report may need to be re-evaluated.

Information on actual subsurface conditions exists only at specific locations and dates indicated. Soil conditions and ground water levels at other locations may differ from conditions occurring at the boring locations. If any changes in the nature, design, or location of the pipelines are planned, the conclusions and recommendations contained in this report should not be considered valid unless the changes are reviewed and the conclusions of this report modified or verified in writing by a CH2M HILL geotechnical engineer. CH2M HILL is not responsible for any claims, damages, or liability associated with interpretation of subsurface data or reuse of the subsurface data or engineering analyses without the express written authorization of CH2M HILL.

SECTION 6

References

ASTM. *Test Method D1586 Method for Penetration Test and Split-Barrel Sampling of Soils.*

ASTM. *Test Method D2487 Standard Test Method for Classification of Soils for Engineering Purposes.*

ASTM. *Test Method D698 Test for Moisture-Density Relations of Soils. Using 10-lb Rammer and 18-inch Drop.*

ASTM. *Test Method D4318 Standard Test Method for Atterberg Limit Tests of Soil*.

Appendix A
Geotechnical Data Reports Prepared by HVJ

GEOTECHNICAL INVESTIGATION REPORT
MONTOPOLIS PUMP STATION FACILITIES
AUSTIN, TEXAS

SUBMITTED TO
CH2M HILL
12301 RESEARCH BLVD, BLDG. 4, STE 250
AUSTIN, TEXAS 78759

BY
HVJ ASSOCIATES, INC.
SEPTEMBER 30, 2013

HVJ REPORT NO. AG 10 11441

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September 30, 2013
Joe Jenkins, PE
CH2M Hill
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Austin, Texas 78759

Re: Geotechnical Investigation Data Report
Montopolis Pump Station Facilities
COA Facilities Rotation List (2010-2012)
Austin, Texas
Owner: City of Austin
HVJ Project No. AG 10 11441

Dear Mr. Jenkins:

Submitted herein is the geotechnical investigation report of our geotechnical investigation for the above referenced project. The study was performed in accordance with HVJ proposal number AG 10 11441.1 dated November 2, 2012.

It has been a pleasure to work for you on this project and we appreciate the opportunity to be of service. Please notify us if there are questions or if we may be of further assistance.

Sincerely,

HVJ ASSOCIATES, INC.
Texas Firm Registration No. F-000646

STATE OF TEXAS
JASON C. SCHWARZ
99343
LICENSED
PROFESSIONAL ENGINEER

Date: 9/30/2013

Jason Schwarz, P.E.
Project Manager

Zach Lootens, EIT
Staff Engineer

The seals appearing on this document were authorized by Jason Schwarz, P.E. 99343 on September 30, 2013. Alteration of a sealed document without proper notification to the responsible engineer is an offense under the Texas Engineering Practice Act.

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APPENDIX

LABORATORY TEST RESULTS SUMMARY ..... A

1 INTRODUCTION

1.1 General

HVJ Associates, Inc. (HVJ) was retained by CH2M Hill to perform a geotechnical investigation for the Montopolis Pump Station Facility. The proposed project is located approximately 0.3-0.5 miles northeast of Montopolis and SH71 intersection. The purpose of this project is to construct a new pump station/water tank.

1.2 Scope of Work

HVJ's scope of work is to provide information on subsurface conditions at the proposed location for the new pump station facility. The primary objective of this study was accomplished by:

- Task 1: Exploratory Borings
    - Drilled a total of 7 borings to depths of 2, 10, 30, and 40 feet below existing grade for a total drilling depth of 154 linear feet.
- Task 2: Laboratory Testing
    - Performed laboratory tests on select soil samples to determine the physical and engineering properties of the subsurface materials.
- Task 3: Data Report
    - This Data Report includes the following
        - Site vicinity map
        - Geology map
        - Plan of borings
        - Boring logs
        - Laboratory test results summary
        - Site Characterization

Subsequent sections of this report contain descriptions of the field exploration, laboratory testing program, the general site and subsurface conditions, and limitations.

2 FIELD EXPLORATION

2.1 General

The field exploration program undertaken for the project was conducted between July 16th, 2013 and July 26th, 2013. Seven (7) borings were completed to investigate subsurface conditions. The 7 borings were drilled to termination depths as follows: 2 (2 foot); 1 (10 foot); 2 (30 foot); 2 (40 foot). Borings were advanced using a B-53 Mobile truck mounted drill rig equipped with continuous flight augers as well as standard sampling equipment. Approximate boring locations are provided in the Plan of Borings, Plate 3. The final boring logs are presented in Plates 4 through 10 and a key to terms and symbols used is provided on Plate 11.

2.2 Sampling Methods and Field Testing

Fine grained, cohesive soils encountered were sampled using a 3-inch outer diameter thin-walled tube, which was pushed into the soil in general accordance with ASTM standard D 1587- *Thin Walled Tube Sampling of Soils*. The samples were extruded in the field and a calibrated pocket penetrometer was used to obtain an estimate of the unconfined compressive strength of the sample.

Standard Penetration Tests (SPTs) were conducted in non-cohesive soils within the soil strata. The requirement that TCP be conducted every five feet caused the SPTs to be performed with a slight deviation from ASTM D 1586 – *Penetration Test and Split-Barrel Sampling of Soils*. The procedure performed in the field consisted of driving a standardized 1.50 ± 0.005 inch inner diameter split-spoon sampler into undisturbed soil with a 140-pound hammer falling 30 inches. The split-spoon sampler was first seated 6 inches to penetrate any loose cuttings and was then driven an additional 12 inches with blows from the hammer. The number of hammer blows required to drive the sampler each 6-inch increment was recorded. The penetration resistance, or "N-value", is defined as the number of hammer blows required to drive the sampler the final 12 inches and was used in the field to estimate the density of granular soils or the consistency of cohesive soils. In very dense material the SPT test was typically stopped after 50 blows from the hammer and the measurement was recorded as 50 blows per distance penetrated (e.g. 50 over 3 inches).

Classification and field test results for both the thin-walled tube and split-spoon samples were recorded onto field logs, which included a visual description in accordance with ASTM D 2488 – *Visual Description and Identification of Soils*. After field documentation and logging was complete, the individual soil samples were either wrapped in plastic or placed in sealed containers to prevent loss of moisture and were transported to our laboratory for further examination and testing.

2.3 Groundwater Conditions

No groundwater was encountered during the investigation. However, groundwater observations made during drilling operations typically do not accurately reflect the true groundwater conditions. Therefore, the lack of free flowing groundwater into the boreholes should not be taken as confirmation the groundwater table is at a depth below the boring(s) termination depth. Additionally, it should be noted that groundwater levels may fluctuate seasonally in response to rainfall/climatic conditions and the boring were drilled during a period of extreme drought (potential drought of record).

2.4 Borehole Completion

All project borings were backfilled with soil cuttings, bentonite chips as required to meet existing surface conditions.

3 LABORATORY TESTING

3.1 General

Soil samples transported to our laboratory were further examined and described and a preliminary soil classification was assigned to each soil sample based on ASTM D 2487 – *Classification of Soil for Engineering Purposes.*

Classification testing, which included moisture contents, Atterberg limits, and percent passing the No. 200 sieve, was subsequently conducted on select samples. The results of these tests were used to confirm or modify the preliminary soil classifications.

The sampling information obtained in the field was used in conjunction with the laboratory examination and testing to generate final boring logs, provided in Plates 4 through 10. A Key of Terms and Symbols for the boring logs is provided on Plates 11A-B. The laboratory test results are provided on the final borings logs, as well as tabulated in Appendix A.

3.2 Atterberg Limits

Select samples were tested to determine the Atterberg Limits in accordance with ASTM D4318-10 (Tex 104E, and 105E). The Atterberg Limit test is used to classify the soil using the Unified Soil Classification System (USCS). The Atterberg Limit test consists of two parts: a liquid limit test and a plastic limit test. The liquid limit equipment setup consists of a brass cup partially filled with soil which is grooved with a specialized grooving tool, and then dropped freely from a specified height to the rubber base below at a constant rate of 2 drops per second. The liquid limit test is performed on soil that has been sieved through the No. 40 sieve and brought to a moisture content that would close the ½-inch groove within 20 to 30 blows for two consecutive tests. The moisture content of the soil is then measured and recorded as the liquid limit. The second part of the tests consists of a rolling a remolded sample between the tips of the fingers and a glass plate until transverse cracks appear at a rolled diameter of 1/8-inch. The moisture content of the rolled sample is taken and recorded as the plastic limit.

3.3 Percent Passing the No. 200 Sieve

Select soil samples were tested in accordance with ASTM D1140-00 (Tex 111E) to determine the amount of material finer than the No. 200 sieve for use in classification. An oven dried sample of material is weighed then washed over a 75-µm (No. 200) sieve, allowing clay and other particles to be dispersed and removed from the soil. The retained material is oven dried then reweighed. The loss in mass resulting from the washing is calculated as mass percent of the original sample and is reported as the percentage of material finer than a No. 200 sieve.

3.4 Moisture Content

Moisture content testing was performed on select soil samples to determine the in situ state of moisture of the soil. A fresh sample was weighed before being placed in an oven with a controlled temperature of 230°F and dried back to a constant mass. Upon the drying and reweighing of the sample, the total mass of water lost was recorded. The ratio of the water loss to the dried mass is recorded as the moisture content. This test was performed in accordance with ASTM D2216-10 (Tex 103E).

4 SITE CHARACTERIZATION

4.1 General Geology

According to the Geologic Atlas of Texas, Seguin Sheet (University of Texas Bureau of Economic Geology, 1974), the proposed project is located within an area characterized by High Terrace Deposits (Qht) and Taylor Group (Kta).

The High Terrace Deposits generally consist of gray to tan gravel, sand, silt, and clay. Gravel is commonly exposed to the surface in southeastern parts, and silty clay is in an upper part underlain by coarse soils in northwestern parts.

The Taylor Group has been divided into three formations, based on Keith Young (1965), from bottom to top: Sprinkle, Pecan Gap, and Bergstrom. The formations consist of calcareous, montmorillonitic, highly over-consolidated clay, marly clay, and clay shale varying in color and

calcium carbonate content. It is highly plastic, with high swelling potential, and very unstable. When left exposed to the air, it will slake. Thickness of the Taylor Group ranges from approximately 50 feet thick in the area of southeast Austin to approximately 300 feet thick in the area of Walnut Creek.

According to available geologic data, there are no mapped faults within the local vicinity of the project.

4.2 Subsurface Stratigraphy

Soil and groundwater conditions along the project alignment described herein are based on information obtained at the boring locations only. Significant variations at areas not explored by the project borings may require reevaluation of our findings and conclusions. Subsurface soils as encountered at the project location are discussed below.

In general, the subsurface encountered at the site can be characterized using three layers. The uppermost layer at the site ranges from 0-2 feet thick (absent in B-1) and consists of dark brown Fat Clay (CH) with varying amounts of sand and gravel. The middle layer was made up of a tan colored clayey soil that seemed to have increasing sand content in the north end of the project area. In this layer Clayey Sand (SC), Sandy Lean Clay (CL), and Lean Clay (CL) was encountered with thicknesses ranging from 4-7.5 feet. The lowest layer, containing tan and light gray Fat Clay (CH), extended past the termination depths of all borings. Table 2, below, shows the laboratory testing statistics for each layer described above.

Table 2: Soil Laboratory Summary

Laboratory Test	Average	Maximum	Minimum	Standard Deviation
Upper				
Moisture Content (%)	21	23	19	2.4
Liquid Limit (%)	66	72	60	8.5
Plasticity Index (%)	38	47	29	12.7
% Passing No. 200 Sieve	74	80	68	8.3
Middle				
Moisture Content (%)	10	11	9	0.9
Liquid Limit (%)	44	48	40	3.4
Plasticity Index (%)	22	28	18	3.4
% Passing No. 200 Sieve	85	96	70	11.3
Lower				
Moisture Content (%)	14	17	11	2.2
Liquid Limit (%)	55	63	49	5.1
Plasticity Index (%)	32	41	23	6.6
% Passing No. 200 Sieve	93	97	90	2.8

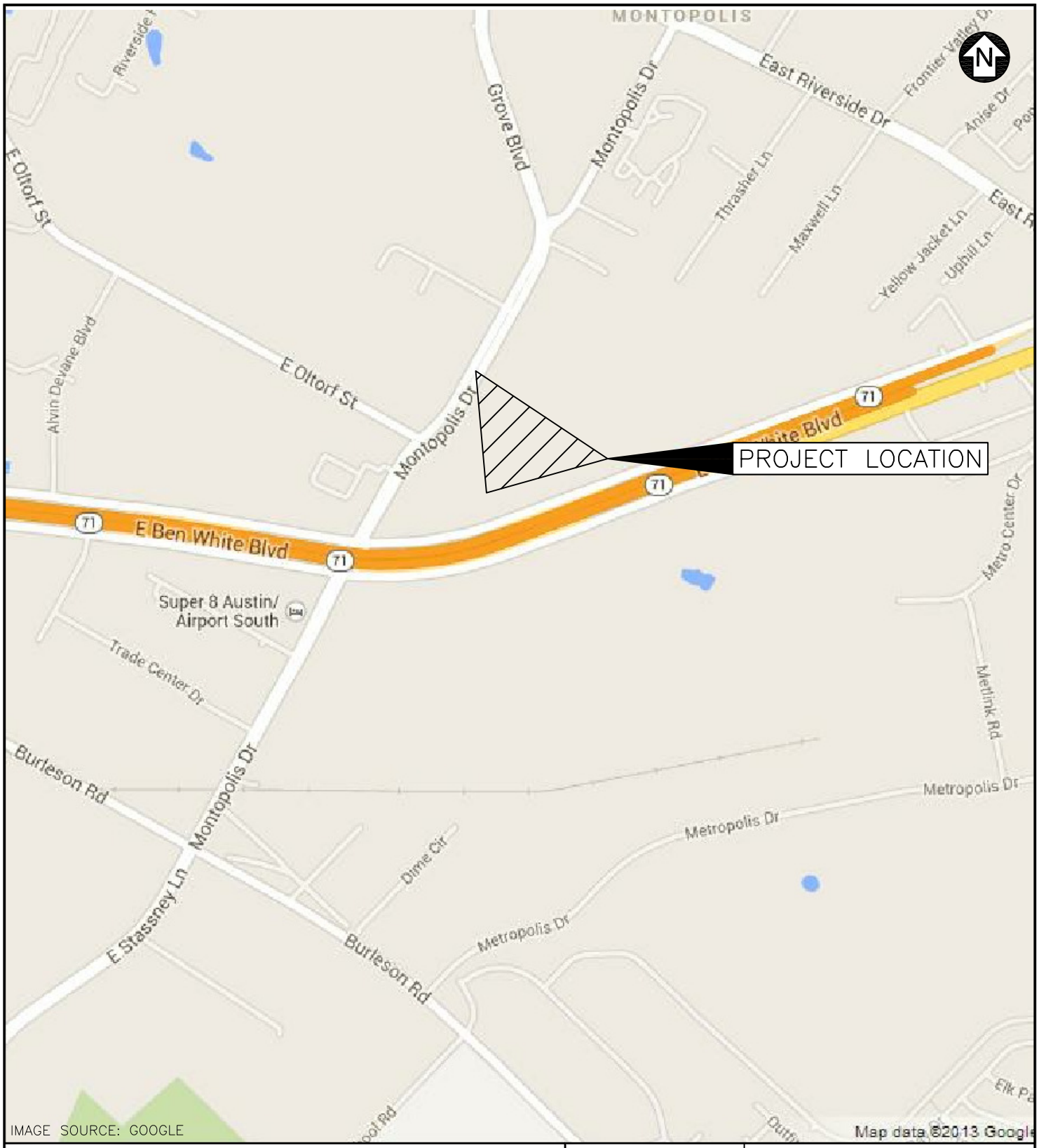
5 LIMITATIONS

This geotechnical data report has been issued for the exclusive use of CH2M Hill and the City of Austin for the Montopolis Water Pump Station Project.

In performing our geotechnical investigation, HVJ Associates, Inc. has endeavored to comply with generally accepted geotechnical engineering practice common in the local area. HVJ Associates, Inc. makes no warranty, express or implied. The information contained in this report is based on data obtained from subsurface exploration and laboratory testing, as well as preliminary project design information that has been provided to us.

The exploration methods used indicate subsurface conditions only at the specific location where samples were obtained, only at the time they were obtained, and only to the depths penetrated. Samples cannot be relied on to accurately reflect the strata variations that usually exist between sampling locations or areas where borings were not performed. Should any subsurface conditions other than those described in our test boring be encountered, HVJ Associates should be immediately notified so that further investigation and supplemental recommendations can be provided.

ILLUSTRATIONS



MAP LOCATION

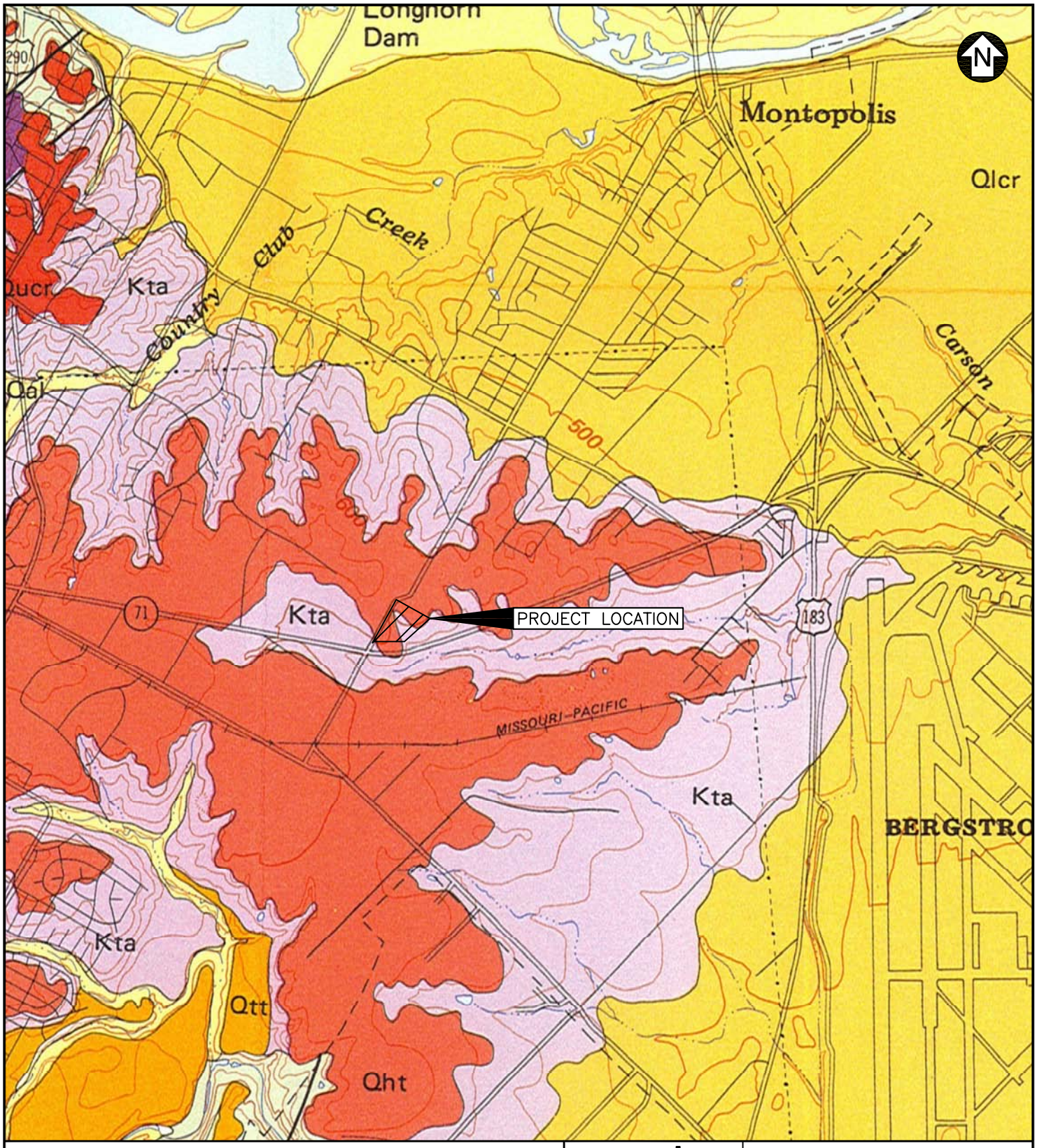
HVJ ASSOCIATES

SCALE: N.T.S		
DATE: 8/15/2013		
DRAWN BY: ZL	PROJ. CHK: JS	APPRV. BY: JS

SITE VICINITY MAP
MONTOPOLIS WATER PUMP STATION PROJECT
TRAVIS COUNTY
AUSTIN, TX

PROJECT NO.: AG 10 11441	FILENAME: VIC	PLATE 1

DATE:
FILE:



LEGEND

Qal Alluvium
Qtt Tributary Terrace Deposits
Qht High Terrace Deposits
Qucr Upper Colorado River Terrace Deposits
Qlcr Lower Colorado River Terrace Deposits
Kta Taylor Group

MAP LOCATION

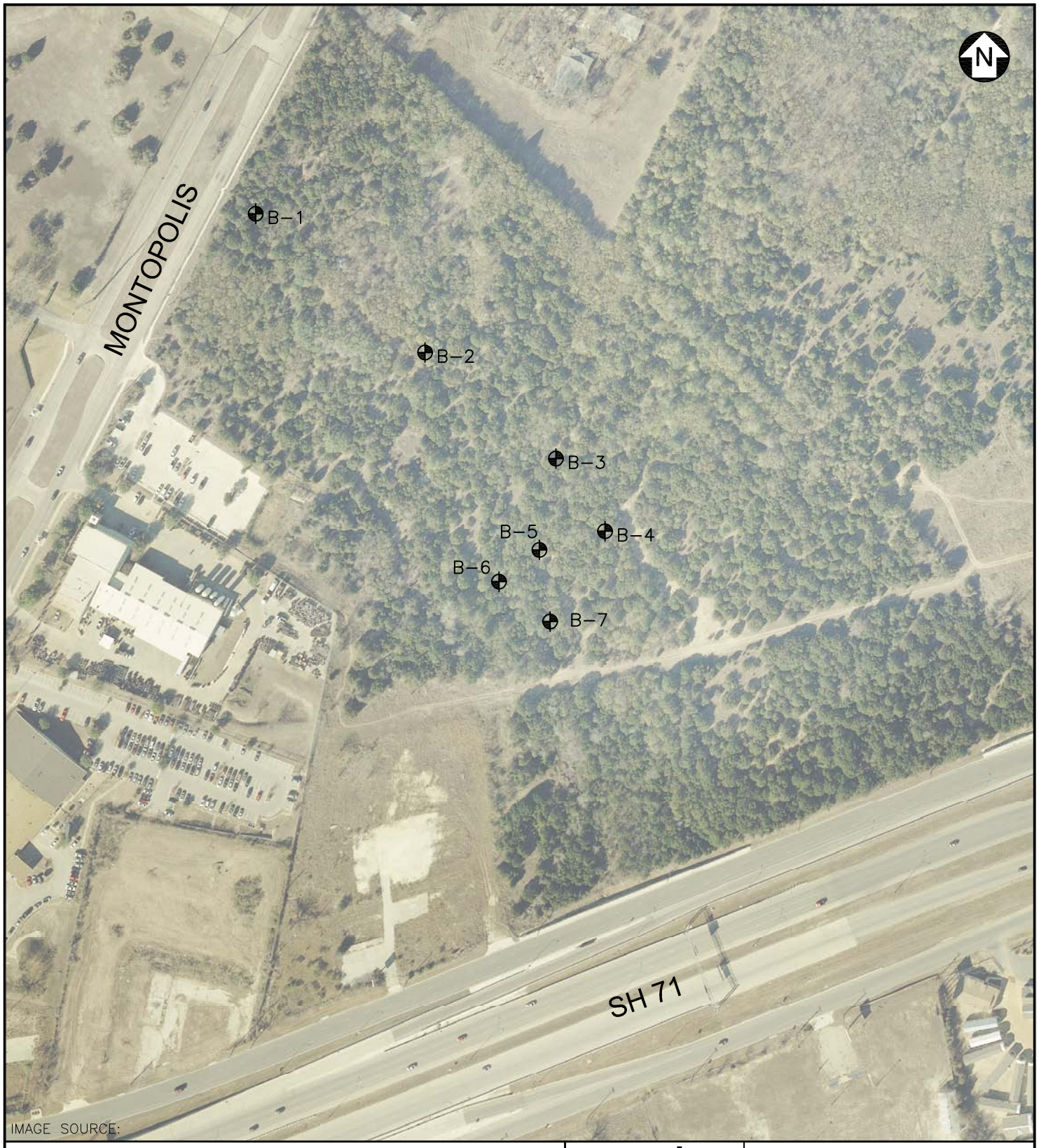
HVJ ASSOCIATES

SCALE: N.T.S		
DATE: 8/15/13		
DRAWN BY: ZL	PROJ. CHK: JS	APPRV. BY: JS

GEOLOGY MAP
MONTOPOLIS WATER PUMP STATION
TRAVIS COUNTY
AUSTIN, TX

PROJECT NO.: AG 10 11441	FILENAME: GEO	PLATE 2

DATE:
FILE:



Base Map Source: Google Maps

Bore Location

MAP LOCATION

HVJ ASSOCIATES

SCALE: N.T.S		
DATE: 8/19/2013		
DRAWN BY: ZL	PROJ. CHK: JS	APPRV. BY: JS

PLAN OF BORINGS
MONTOPOLIS PUMP STATION FACILITIES
AUSTIN, TEXAS

PROJECT NO.: AG 10 11441	FILENAME: POB	PLATE 3

DATE:
FILE:

LOG OF BORING

Project: Montopolis
Project No.: AG 1011441
Boring No.: B-1
Date: 7/26/2013
Elevation: 607 feet
Groundwater during drilling: ---
Northing: 10,052,562.9
Station: --
Groundwater after drilling: ---
Easting: 3,125,720.4
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF	SHEAR STRENGTH, TSF (0.5, 1.0, 1.5, 2.0) / MOISTURE ○ CONTENT, % PLASTIC LIMIT — LIQUID LIMIT (10 20 30 40 50 60 70 80 90)
0		Ligh brown, medium dense, **CLAYEY SAND WITH GRAVEL (SC)**. (High Terrace Deposits)			
605					
		NOTE: Borings were drilled dry and did not encounter groundwater while drilling. Boring elevations are approximate.			
5					
600					
10					

Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

PLATE 4

HVJ ASSOCIATES

LOG OF SOIL BORING MONTOPOLIS.GPJ HVJ.GDT 9/30/13

LOG OF BORING

Project: Montopolis
Project No.: AG 1011441
Boring No.: B-2
Date: 7/26/2013
Elevation: 610 feet
Groundwater during drilling: ---
Northing: 10,052,316.4
Station: --
Groundwater after drilling: ---
Easting: 3,126,021.2
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF	SHEAR STRENGTH, TSF (0.5, 1.0, 1.5, 2.0) / MOISTURE ○ CONTENT, % PLASTIC LIMIT — LIQUID LIMIT (10 20 30 40 50 60 70 80 90)
610 — 0		Dark brown, very stiff to hard, **FAT CLAY (CH)**, with trace of sand and limestone/chert 1-3" gravel. (Residual)			
		NOTE: Borings were drilled dry and did not encounter groundwater while drilling. Boring elevations are approximate.			
605 — 5					
600 — 10					

Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

HVJ ASSOCIATES

LOG OF SOIL BORING MONTOPOLIS.GPJ HVJ.GDT 9/30/13

LOG OF BORING

Project: Montopolis
Project No.: AG 1011441
Boring No.: B-3
Date: 7/16/2013
Elevation: 609 feet
Groundwater during drilling: ---
Northing: 10,052,127.9
Station: --
Groundwater after drilling: ---
Easting: 3,126,253.6
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF	SHEAR STRENGTH, TSF (0.5, 1.0, 1.5, 2.0) / MOISTURE CONTENT, % (PLASTIC LIMIT – LIQUID LIMIT) (10 20 30 40 50 60 70 80 90)
0	PP=4.5+ tsf	Dark brown, hard, **SANDY FAT CLAY (CH)**, with organics. (Residual)			
	17-20-29	Tan, dense, **CLAYEY SAND WITH GRAVEL (SC)**. (High Terrace Deposits)			
	14-26-25				
605					
5					
	15-25-35	Tan, hard, **FAT CLAY (CH)**, marly. (Taylor Group)			
		NOTE: Borings were drilled dry and did not encounter groundwater while drilling. Boring elevations are approximate.			
	18-22-32				
600					
10					

Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

HVJ ASSOCIATES

LOG OF SOIL BORING MONTOPOLIS.GPJ HVJ.GDT 9/30/13

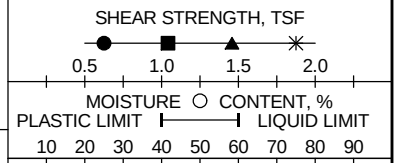
LOG OF BORING

Project: Montopolis
Boring No.: B-4
Groundwater during drilling: ---
Groundwater after drilling: ---

Date: 7/16/2013
Northing: 10,051,998.8
Easting: 3,126,340.8

Project No.: AG 1011441
Elevation: 601 feet
Station: --
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0 / 600	PP=4.5+ tsf	Dark brown, hard, **FAT CLAY (CH)**, with organics. (Residual)	80	
	6-8-10	Tan, very stiff, **SANDY LEAN CLAY (CL)**, marly. (Taylor Group)	70	
	9-10-9	Tan, very stiff, **LEAN CLAY (CL)**, marly. (Taylor Group)	91	
5 / 595	6-8-10		96	
	7-8-11	Tan and gray, very stiff to hard, **FAT CLAY (CH)**, marly. (Taylor Group)	94	
10 / 590	8-9-11		97	
15 / 585	PP=4.5+ tsf			
20				



Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

PLATE 7a

HVJ ASSOCIATES

LOG OF SOIL BORING MONTOPOLIS.GPJ HVJ.GDT 9/30/13

LOG OF BORING

Project: Montopolis
Boring No.: B-4
Groundwater during drilling: ---
Groundwater after drilling: ---

Date: 7/16/2013
Northing: 10,051,998.8
Easting: 3,126,340.8

Project No.: AG 1011441
Elevation: 601 feet
Station: --
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF	SHEAR STRENGTH, TSF (0.5, 1.0, 1.5, 2.0) / MOISTURE CONTENT, % (PLASTIC LIMIT – LIQUID LIMIT) (10 20 30 40 50 60 70 80 90)
20		Tan and gray, very stiff tohard, **FAT CLAY (CH)**, marly. (Taylor Group) [Cont...]			
580					
	PP=4.5+ tsf				
25					
575					
	PP=4.5+ tsf	NOTE: Borings were drilled dry and did not encounter groundwater while drilling. Boring elevations are approximate.			
30					
570					
35					
565					
40					

Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

PLATE 7b

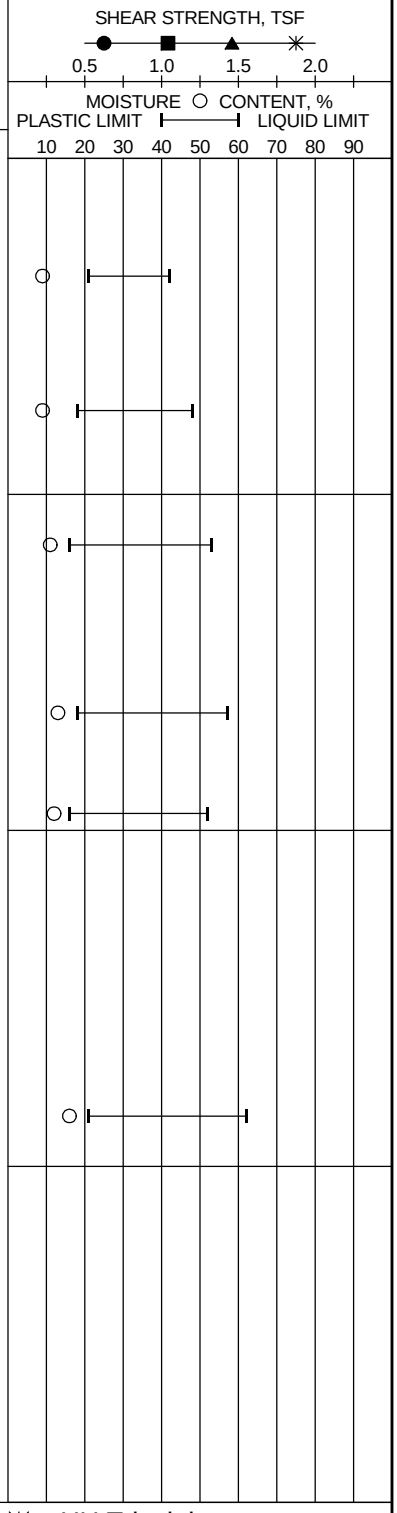
HVJ ASSOCIATES

LOG OF SOIL BORING MONTOPOLIS.GPJ HVJ.GDT 9/30/13

LOG OF BORING

Project: Montopolis
Project No.: AG 1011441
Boring No.: B-5
Date: 7/17/2013
Elevation: 600 feet
Groundwater during drilling: ---
Northing: 10,051,965.7
Station: --
Groundwater after drilling: ---
Easting: 3,126,224.2
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
600 — 0	PP=4.5+ tsf	Brown, hard, **SANDY FAT CLAY (CH)**. (Residual)		
	9-10-12	Tan, very stiff, **SANDY LEAN CLAY (CL)**, with calcareous deposits, marly. (Taylor Group)		
	6-7-10			
595 — 5	7-8-10	Tan and light gray, very stiff to hard, **FAT CLAY (CH)**, marly. (Taylor Group)		
	7-8-11			
	8-17-12			
590 — 10				
	PP=4.5+ tsf			
585 — 15				
	PP=4.5+ tsf			
580 — 20				



Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

PLATE 8a

HVJ ASSOCIATES

LOG OF SOIL BORING MONTOPOLIS.GPJ HVJ.GDT 9/30/13

LOG OF BORING

Project: Montopolis
Boring No.: B-5
Groundwater during drilling: ---
Groundwater after drilling: ---

Date: 7/17/2013
Northing: 10,051,965.7
Easting: 3,126,224.2

Project No.: AG 1011441
Elevation: 600 feet
Station: --
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF	SHEAR STRENGTH, TSF (0.5, 1.0, 1.5, 2.0) / MOISTURE CONTENT, % (PLASTIC LIMIT – LIQUID LIMIT) (10 20 30 40 50 60 70 80 90)
580 — 20		Tan and light gray, very stiff to hard, **FAT CLAY (CH)**, marly. (Taylor Group) [Cont...]			
	PP=4.5+ tsf				
575 — 25					
	PP=4.5+ tsf				
570 — 30					
	PP=4.5+ tsf				
565 — 35					
	PP=4.5+ tsf	NOTE: Borings were drilled dry and did not encounter groundwater while drilling. Boring elevations are approximate.			
560 — 40					

Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

PLATE 8b

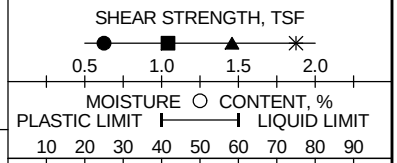
HVJ ASSOCIATES

LOG OF SOIL BORING MONTOPOLIS.GPJ HVJ.GDT 9/30/13

LOG OF BORING

Project: Montopolis
Project No.: AG 1011441
Boring No.: B-6
Date: 7/16/2013
Elevation: 595 feet
Groundwater during drilling: ---
Northing: 10,051,909.3
Station: --
Groundwater after drilling: ---
Easting: 3,126,152.5
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
595 — 0	PP=4.5+ tsf	Dark brown, hard, **FAT CLAY (CH)**, with organics. (Residual)	68	
	PP=4.5+ tsf	Tan to brown, hard, **LEAN CLAY WITH SAND (CL)**. (Taylor Group)		
		Tan, very stiff to hard, **LEAN CLAY (CL)**, marly. (Taylor Group)	84	
590 — 5	10-8-17		90	
	PP=4.5+ tsf		91	
		Tan and gray, hard, **FAT CLAY (CH)**, marly. (Taylor Group)		
585 — 10				
	PP=4.5+ tsf		94	
580 — 15				
	PP=4.5+ tsf			
575 — 20				



Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

PLATE 9a

HVJ ASSOCIATES

LOG OF SOIL BORING MONTOPOLIS.GPJ HVJ.GDT 9/30/13

LOG OF BORING

Project: Montopolis
Boring No.: B-6
Groundwater during drilling: ---
Groundwater after drilling: ---

Date: 7/16/2013
Northing: 10,051,909.3
Easting: 3,126,152.5

Project No.: AG 1011441
Elevation: 595 feet
Station: --
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF	SHEAR STRENGTH, TSF (0.5, 1.0, 1.5, 2.0) / MOISTURE CONTENT, % (PLASTIC LIMIT – LIQUID LIMIT) (10 20 30 40 50 60 70 80 90)
575 — 20		Tan and gray, hard, **FAT CLAY (CH)**, marly. (Taylor Group) [Cont...]			
	PP=4.5+ tsf				
570 — 25					
	PP=4.5+ tsf				
565 — 30		NOTE: Borings were drilled dry and did not encounter groundwater while drilling. Boring elevations are approximate.			
560 — 35					
555 — 40					

Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

PLATE 9b

HVJ ASSOCIATES

LOG OF SOIL BORING MONTOPOLIS.GPJ HVJ.GDT 9/30/13

LOG OF BORING

Project: Montopolis
Boring No.: B-7
Groundwater during drilling: ---
Groundwater after drilling: ---

Date: 7/17/2013
Northing: 10,051,838.4
Easting: 3,126,243.2

Project No.: AG 1011441
Elevation: 590 feet
Station: --
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF	SHEAR STRENGTH, TSF (0.5, 1.0, 1.5, 2.0) / MOISTURE CONTENT, % (PLASTIC LIMIT – LIQUID LIMIT) (10 20 30 40 50 60 70 80 90)
590 — 0	PP=4.5+ tsf	Dark brown, hard, **SANDY FAT CLAY (CH)**, with organics. (Residual)			
	PP=4.5+ tsf	Tan, hard, **SANDY LEAN CLAY (CL)**, with calcareous deposits, marly. (Taylor Group)			
585 — 5	7-7-9				
		Tan and gray, hard, **FAT CLAY (CH)**, marly. (Taylor Group)			
	PP=4.5+ tsf				
580 — 10					
	PP=4.5+ tsf				
575 — 15					
	PP=4.5+ tsf				
570 — 20					

Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

PLATE 10a

HVJ ASSOCIATES

LOG OF SOIL BORING MONTOPOLIS.GPJ HVJ.GDT 9/30/13

LOG OF BORING

Project: Montopolis
Project No.: AG 1011441
Boring No.: B-7
Date: 7/17/2013
Elevation: 590 feet
Groundwater during drilling: ---
Northing: 10,051,838.4
Station: --
Groundwater after drilling: ---
Easting: 3,126,243.2
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF	SHEAR STRENGTH, TSF (0.5, 1.0, 1.5, 2.0) / MOISTURE CONTENT, % (PLASTIC LIMIT – LIQUID LIMIT) (10 20 30 40 50 60 70 80 90)
570 — 20		Tan and gray, hard, **FAT CLAY (CH)**, marly. (Taylor Group) [Cont...]			
	PP=4.5+ tsf				
565 — 25					
	PP=4.5+ tsf				
560 — 30					
	PP=4.5+ tsf				
555 — 35					
	10-17-21	NOTE: Borings were drilled dry and did not encounter groundwater while drilling. Boring elevations are approximate.			
550 — 40					

Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

PLATE 10b

HVJ ASSOCIATES

LOG OF SOIL BORING MONTOPOLIS.GPJ HVJ.GDT 9/30/13

SOIL SYMBOLS

Soil Types

Clay, Silt, Sand, Fill

Modifiers

Clayey, Silty, Sandy Clay, Cemented

Construction Materials

Asphaltic Concrete, Stabilized Base, Fill or Debris, Base

SAMPLER TYPES

- Thin Walled Shelby Tube
- No Recovery
- Split Barrel
- Auger
- Liner Tube
- Jar Sample

WATER LEVEL SYMBOLS

- Groundwater level determined during drilling operations
- Groundwater level after drilling in open borehole or piezometer

SOIL GRAIN SIZE

Classification	Particle Size	Particle Size or Sieve No. (U.S. Standard)
Clay	< 0.002 mm	< 0.002 mm
Silt	0.002 - 0.075 mm	0.002 mm - #200 sieve
Sand	0.075 - 4.75 mm	#200 sieve - #4 sieve
Gravel	4.75 - 75 mm	#4 sieve - 3 in.
Cobble	75 - 200 mm	3 in. - 8 in.
Boulder	> 200 mm	> 8 in.

DENSITY OF COHESIONLESS SOILS

Descriptive Term	Penetration Resistance "N" * Blows/Foot
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	> 50

CONSISTENCY OF COHESIVE SOILS

Consistency	Undrained Shear Strength (tsf)
Very Soft	0 - 0.125
Soft	0.125 - 0.25
Firm	0.25 - 0.5
Stiff	0.5 - 1.0
Very Stiff	1.0 - 2.0
Hard	> 2.0

PENETRATION RESISTANCE

3/6	Blows required to penetrate each of three consecutive 6-inch increments per ASTM D-1586 *
50/4"	If more than 50 blows are required, driving is discontinued and penetration at 50 blows is noted
0/18"	Sampler penetrated full depth under weight of drill rods and hammer

* The N value is taken as the blows required to penetrate the final 12 inches

TERMS DESCRIBING SOIL STRUCTURE

Slickensided	Fracture planes appear polished or glossy, sometimes striated
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Inclusion	Small pockets of different soils, such as small lenses of sand scattered through a mass of clay
Parting	Inclusion less than 1/4 inch thick extending through the sample
Seam	Inclusion 1/4 inch to 3 inches thick extending through the sample
Layer	Inclusion greater than 3 inches thick extending through the sample
Laminated	Soil sample composed of alternating partings of different soil type
Stratified	Soil sample composed of alternating seams or layers of different soil type
Intermixed	Soil sample composed of pockets of different soil type and laminated or stratified structure is not evident
Calcareous	Having appreciable quantities of calcium carbonate
Ferrous	Having appreciable quantities of iron
Nodule	A small mass of irregular shape

HVJ ASSOCIATES

PROJECT NO.: AG 10 11441

DRAWING NO.: PLATE 11

KEY TO TERMS AND SYMBOLS USED ON BORING LOGS FOR SOIL

DATE: 9/30/2013 1:08:54 PM
FILE: P:\geo\Projects\2010\AG 10 11441 Montopolis Pump Station Facilities\CAD\Soil_Rock.dwg

APPENDIX A

LABORATORY TEST SUMMARY

LABORATORY TEST RESULTS SUMMARY
Project Name: Montopolis Pump Station
Project Number: AG 10 11441

Boring Number	Depth (ft)	% Passing No. 200 Sieve	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf)	Unconfined Compressive Strength (tsf)
B-4	0-1.5	80	72	47	22.6			
	1.5-3	70	48	23	9.4			
	4-5.5	91	42	23	8.7			
	6.5-8	96	46	28	11.1			
	9-10.5	94	51	27	11.6			
	13.5-15	97	63	35	14.9			
B-5	1-2.5		42	21	8.7			
	3-4.5		48	18	9.4			
	5-6.5		53	37	11.1			
	7.5-9		57	39	12.7			
	9-10.5		52	36	11.7			
	13.5-15		62	41	15.8			
B-6	0-2	68	60	29	19.2			
	2-4	84	40	20	10.3			
	5-6.5	90	50	23	13.3			
	7-9	91	49	25	15.3			
	13-15	94	56	28	17.4			

GEOTECHNICAL INVESTIGATION REPORT
MONTOPOLIS PUMP STATION FACILITIES
AUSTIN, TEXAS

SUBMITTED TO
CITY OF AUSTIN
505 BARTON SPRINGS ROAD
AUSTIN, TEXAS 78704

BY
HVJ ASSOCIATES, INC.
JANUARY 7, 2015

HVJ REPORT NO. AG 13 10756

HVJ ASSOCIATES

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January 7, 2015
Imane Mrini, PE
Public Works
City of Austin, Texas
505 Barton Springs Road
Austin, Texas 78704

Re: Geotechnical Investigation – Montopolis WRI Tank Geotechnical Investigation
Austin, Texas
Owner: City of Austin
HVJ Project No. AG 13 10756

Dear Ms Mrini:

Submitted herein is the geotechnical data report of our geotechnical investigation for the above referenced project. The study was performed in accordance with HVJ proposal number AG1310756 dated March 26, 2014 (Revised April 7, 2014).

It has been a pleasure to work for you on this project and we appreciate the opportunity to be of service. Please notify us if there are questions or if we may be of further assistance.

Sincerely,

HVJ ASSOCIATES, INC.
Texas Firm Registration No. F-000646

STATE OF TEXAS
JASON C. SCHWARZ
99343
LICENSED
PROFESSIONAL ENGINEER

Date: 1/7/2015

Jason Schwarz, P.E.
Senior Project Manager

Zach Lootens, EIT
Staff Engineer

Copies submitted: (1) electronic

The seal appearing on this document was authorized by Jason Schwarz, PE 99343 on January 7, 2015. Alteration of a sealed document without proper notification to the responsible engineer is an offense under the Texas Engineering Practice Act.

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1 INTRODUCTION

1.1 General

HVJ Associates, Inc. (HVJ) was retained by Public works division of the City of Austin to perform a geotechnical investigation for the Montopolis Pump Station Facility. The proposed project is located approximately 0.3-0.5 miles northeast of Montopolis and SH71 intersection. The purpose of this project is to construct a new pump station/water tank.

A prior geotechnical investigation for this project was performed by HVJ and submitted (report no. AG1011441) to the City of Austin and CH2M Hill on September 23, 2013. The boring locations for the aforementioned report (Borings B-1 thru B-7) along with the new borings performed for this report (Borings B-8 thru B-13) are shown on Plate 3, Plan of Borings. Borings (B-9A, B-11A, and B-12A) were drilled within 5 feet of the existing borings B-9, B-11, and B-12 and are not shown separately on the Plan of Borings for presentation purposes.

1.2 Scope of Work

HVJ's scope of work is to provide information on subsurface conditions at the proposed location for the new pump station facility. The primary objective of this study was accomplished by:

- Task 1: Exploratory Borings
    - Drilled a total of 9 borings, each to a depth of 40 feet below existing grade for a total drilling depth of 360 linear feet.
- Task 2: Laboratory Testing
    - Performed laboratory tests on select soil samples to determine the physical and engineering properties of the subsurface materials.
- Task 3: Data Report
    - This Data Report includes the following
        - Site vicinity map
        - Geology map
        - Plan of borings
        - Boring logs
        - Laboratory test results summary
        - Site Characterization

Subsequent sections of this report contain descriptions of the field exploration, laboratory testing program, the general site and subsurface conditions, and limitations.

2 FIELD EXPLORATION

2.1 General

The field exploration program undertaken for the project was conducted between May 16th, 2014 and June 4th, 2014. Six (6) borings (B-8 through B-13) were completed to investigate subsurface conditions. Three additional borings B-9A, B-11A, and B-12A to confirm the subsurface conditions. These three borings (B-9A, B-11A, and B-12A) were drilled within 5 feet of the existing borings B-9, B-11, and B-12 and are not shown separately on the Plan of Borings for presentation purposes. The borings were drilled to termination depths of 40 feet. Borings were advanced using a B-53 Mobile truck mounted drill rig equipped with continuous flight augers as well as standard sampling equipment. Approximate boring locations are provided in the Plan of Borings, Plate 3. The final boring logs are presented in Plates 4 through 9 and a key to terms and symbols used is provided on Plates 11 A-B.

2.2 Sampling Methods and Field Testing

Fine grained, cohesive soils encountered were sampled using a 3-inch outer diameter thin-walled tube, which was pushed into the soil in general accordance with ASTM standard D 1587- *Thin Walled Tube Sampling of Soils*. The samples were extruded in the field and a calibrated pocket penetrometer was used to obtain an estimate of the unconfined compressive strength of the sample.

Standard Penetration Tests (SPTs) were conducted within soil containing a substantial amount of sand or gravel or where the advancement of thin-walled tubes into the material was not possible. The SPTs were performed in accordance with ASTM D 1586 – *Penetration Test and Split-Barrel Sampling of Soils*. This procedure consisted of driving a standardized 1.50 ± 0.005 inch inner diameter split-spoon sampler into undisturbed soil with a 140-pound hammer falling 30 inches. The split-spoon sampler was first seated 6 inches to penetrate any loose cuttings, and was then driven an additional 12 inches with blows from the hammer. The number of hammer blows required to drive the sampler each 6-inch increment was then recorded. The penetration resistance, or "N-value," is defined as the number of hammer blows required to drive the sampler the final 12 inches. The N-value was used in the field to estimate either the density of granular soil or the consistency of cohesive soil. In very dense or hard material, where the SPT test reached 50 blows from the hammer, the test was terminated and the measurement was instead recorded as 50 blows per distance penetrated (e.g. 50 blows over 3 inches).

Classification and field test results for both the thin-walled tube and split-spoon samples were recorded onto field logs, which included a visual description in accordance with ASTM D 2488 – *Visual Description and Identification of Soils*. After field documentation and logging was complete, the individual soil samples were either wrapped in plastic or placed in sealed containers to prevent loss of moisture and were transported to our laboratory for further examination and testing.

2.3 Groundwater Conditions

Groundwater was encountered in one boring, B-11, at 37 feet below the surface. It should be noted that boring B-11A did not encounter groundwater and was drilled within 5 feet of the original boring location. This could be a perched groundwater table at the interface of the Fat Clay and the Clayshale which was encountered in B-13 at the same elevation (~557ft). However, groundwater observations made during drilling operations typically do not accurately reflect the true groundwater conditions. Therefore, the lack of free flowing groundwater into the boreholes should not be taken as confirmation the groundwater table is at a depth below the boring(s) termination depth. Additionally, it should be noted that groundwater levels may fluctuate seasonally in response to rainfall/climatic conditions and the boring were drilled during a period of extreme drought (potential drought of record).

2.4 Borehole Completion

All project borings were backfilled with soil cuttings, bentonite chips as required to meet existing surface conditions.

3 LABORATORY TESTING

3.1 General

Soil samples transported to our laboratory were further examined and described and a preliminary soil classification was assigned to each soil sample based on ASTM D 2487 – *Classification of Soil for Engineering Purposes.*

Classification testing, which included moisture contents, Atterberg limits, and percent passing the No. 200 sieve, was subsequently conducted on select samples. Advanced testing including unconfined compressive strength tests with wet and dry unit weight determinations, swell tests, and sulfate content tests were performed on select samples from the borings. The results of these tests were used to confirm or modify the preliminary soil classifications.

The sampling information obtained in the field was used in conjunction with the laboratory examination and testing to generate final boring logs, provided in Plates 4 through 9. A Key of Terms and Symbols for the boring logs is provided on Plates 10A-B. The laboratory test results are provided on the final borings logs, as well as tabulated in Appendix A.

3.2 Atterberg Limits

Select samples were tested to determine the Atterberg Limits in accordance with ASTM D4318-10 (Tex 104E, and 105E). The Atterberg Limit test is used to classify the soil using the Unified Soil Classification System (USCS). The Atterberg Limit test consists of two parts: a liquid limit test and a plastic limit test. The liquid limit equipment setup consists of a brass cup partially filled with soil which is grooved with a specialized grooving tool, and then dropped freely from a specified height to the rubber base below at a constant rate of 2 drops per second. The liquid limit test is performed on soil that has been sieved through the No. 40 sieve and brought to a moisture content that would close the ½-inch groove within 20 to 30 blows for two consecutive tests. The moisture content of the soil is then measured and recorded as the liquid limit. The second part of the tests consists of a rolling a remolded sample between the tips of the fingers and a glass plate until transverse cracks appear at a rolled diameter of 1/8-inch. The moisture content of the rolled sample is taken and recorded as the plastic limit.

3.3 Percent Passing the No. 200 Sieve

Select soil samples were tested in accordance with ASTM D1140-00 (Tex 111E) to determine the amount of material finer than the No. 200 sieve for use in classification. An oven dried sample of material is weighed then washed over a 75-µm (No. 200) sieve, allowing clay and other particles to be dispersed and removed from the soil. The retained material is oven dried then reweighed. The loss in mass resulting from the washing is calculated as mass percent of the original sample and is reported as the percentage of material finer than a No. 200 sieve.

3.4 Moisture Content

Moisture content testing was performed on select soil samples to determine the in situ state of moisture of the soil. A fresh sample was weighed before being placed in an oven with a controlled temperature of 230°F and dried back to a constant mass. Upon the drying and reweighing of the

sample, the total mass of water lost was recorded. The ratio of the water loss to the dried mass is recorded as the moisture content. This test was performed in accordance with ASTM D2216-10 (Tex 103E).

3.5 Unconfined Compressive Strength Testing

Select cohesive soil samples were tested for unconfined compressive strength in accordance with ASTM D2166-06. The intact specimen is placed in a loading device and is subjected to a load producing an axial strain at a rate between ½% and 2% per minute. The load is applied until failure occurs at the maximum rate of strain. The maximum axial strain is then used to calculate the soil's unconfined compressive strength.

3.6 Swell Test

The swell tests were performed in accordance with ASTM D4546 Method B. The swell test results can be interpreted to estimate one dimensional heave or settlement or stress-induced settlement following loading to a predetermined pressure and wetting-induced swelling. The test procedure involves placing an undisturbed sample in a consolidometer ring and placing a load on the sample to simulate field conditions. Once the initial load is applied, the sample is inundated and allowed to collapse or swell and deflections are measured. Results from the swell test can be found in Appendix B.

3.7 Sulfate Content

Sulfate content was determined in accordance with TEX-620-J. The results for this test can be found in Appendix C.

4 SITE CHARACTERIZATION

4.1 General Geology

According to the Geologic Atlas of Texas, Austin Sheet (University of Texas Bureau of Economic Geology, 1974), the proposed project is located within an area characterized by High Terrace Deposits (Qht) and Taylor Group (Kta).

The High Terrace Deposits generally consist of gray to tan gravel, sand, silt, and clay. Gravel is commonly exposed to the surface in southeastern parts, and silty clay is in an upper part underlain by coarse soils in northwestern parts.

The Taylor Group has been divided into three formations, based on Keith Young (1965), from bottom to top: Sprinkle, Pecan Gap, and Bergstrom. The formations consist of calcareous, montmorillonitic, highly over-consolidated clay, marly clay, and clay shale varying in color and calcium carbonate content. It is highly plastic, with high swelling potential, and very unstable. When left exposed to the air, it will slake. Thickness of the Taylor Group ranges from approximately 50 feet thick in the area of southeast Austin to approximately 300 feet thick in the area of Walnut Creek.

Although it is not shown on the map, it is our belief that the upper soils encountered are from the alluvium geological unit. Alluvium, which is made up of floodplain deposits, typically consists of a combination of various percentages of sand, silt, clay and/or gravel. Silts and clays associated with

this formation tend to be dark gray to dark brown and calcareous. Associated sand is largely composed of quartz whereas gravel alluvium can consists of both siliceous and/or carbonate material, mainly chert, quartzite, limestone and petrified wood fragments.

According to available geologic data, there are no mapped faults within the local vicinity of the project.

4.2 Subsurface Stratigraphy

Soil and groundwater conditions along the project alignment described herein are based on information obtained at the boring locations only. Significant variations at areas not explored by the project borings may require reevaluation of our findings and conclusions. Subsurface soils as encountered at the project location are discussed below.

In general, the subsurface encountered at the site can be characterized using three layers. The uppermost layer at the site ranges from 1-3 feet thick and consisted of dark brown Fat Clay (CH) with varying amounts of sand and gravel. The middle layer was made up of a tan and gray colored cohesive soil. This layer was composed of Lean Clay (CL) and Fat Clay (CH) and extended beyond the termination depths of every boring aside from B-13. The lowest layer, only present in B-13 at 36 feet below the surface, contained dark gray Clayshale. The Clayshale was fissile and had a low hardness consistency. Table 1, below, shows the laboratory testing statistics for middle and lower layer described above. Lab testing was not performed on soils found in the upper layer.

Table 1: Laboratory Test Statistics

Laboratory Test	Average	Maximum	Minimum	Standard Deviation	No. Tested
Middle Layer (Taylor Clay)					
% Passing No. 200 Sieve	95	98	90	2	15
Liquid Limit (%)	56	68	42	7	15
Plasticity Index (%)	40	51	29	6	15
Moisture Content (%)	16	23	8	4	30
Unconfined Compressive Strength (tsf)	9	15	5	3	15
Wet Unit Weight (pcf)	131	143	119	7	15
Lower Layer (Taylor Clayshale)					
Unconfined Compressive Strength (tsf)	10.5	-	-	-	1
Wet Unit Weight (pcf)	126	-	-	-	1

tsf=tons per square foot; pcf=pounds per cubic foot

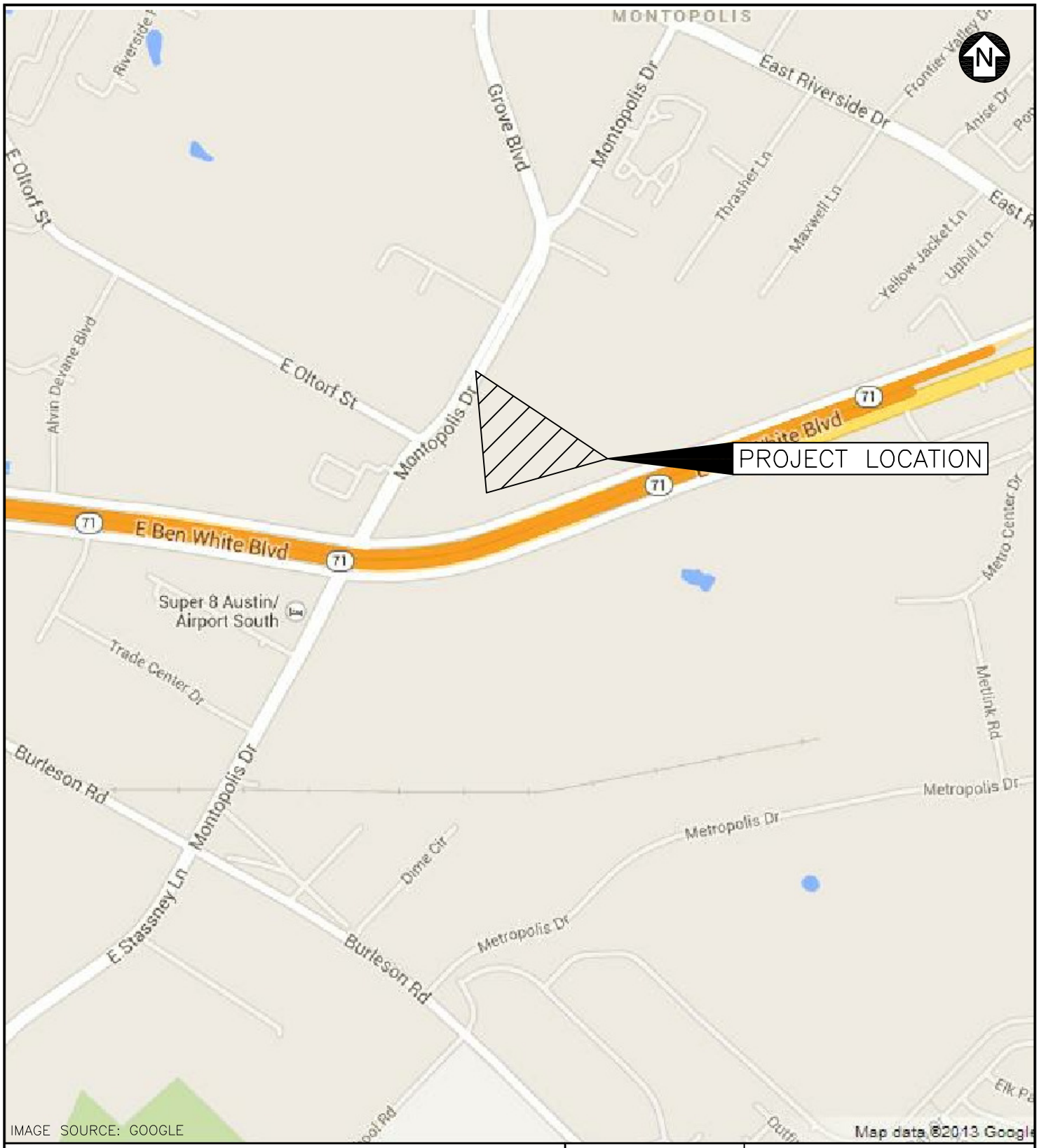
5 LIMITATIONS

This geotechnical data report has been issued for the exclusive use of the City of Austin for the Montopolis Water Pump Station Project.

In performing our geotechnical investigation, HVJ Associates, Inc. has endeavored to comply with generally accepted geotechnical engineering practice common in the local area. HVJ Associates, Inc. makes no warranty, express or implied. The information contained in this report is based on data obtained from subsurface exploration and laboratory testing, as well as preliminary project design information that has been provided to us.

The exploration methods used indicate subsurface conditions only at the specific location where samples were obtained, only at the time they were obtained, and only to the depths penetrated. Samples cannot be relied on to accurately reflect the strata variations that usually exist between sampling locations or areas where borings were not performed. Should any subsurface conditions other than those described in our test boring be encountered, HVJ Associates should be immediately notified so that further investigation and supplemental recommendations can be provided.

ILLUSTRATIONS



MAP LOCATION

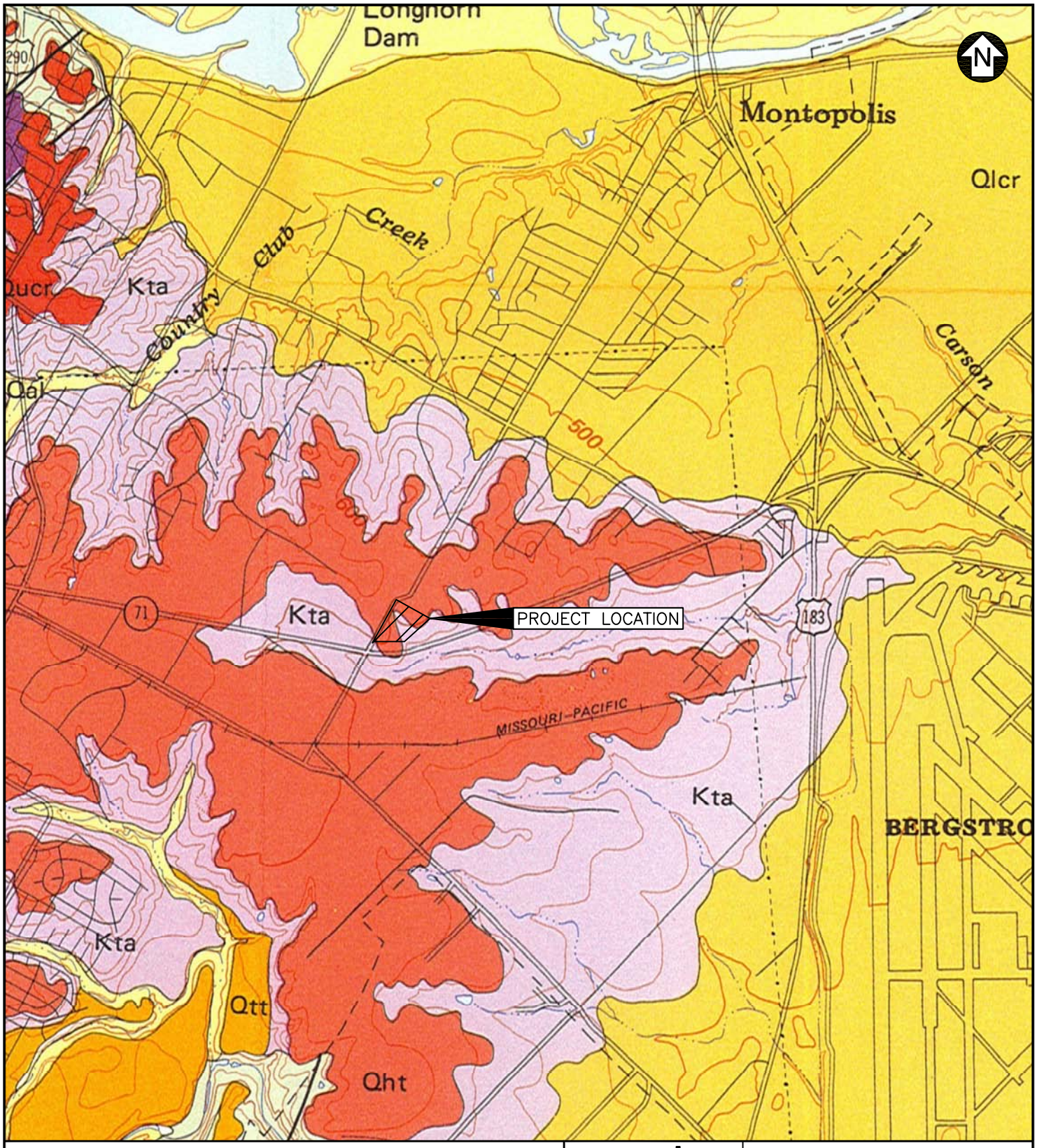
HVJ ASSOCIATES

SCALE: N.T.S		
DATE: 7/25/2014		
DRAWN BY: ZL	PROJ. CHK: JS	APPRV. BY: JS

SITE VICINITY MAP
MONTOPOLIS WRI TANK
TRAVIS COUNTY
AUSTIN, TX

PROJECT NO.: AG 13 10756	FILENAME: VIC	PLATE 1

DATE:
FILE:



LEGEND

Qal Alluvium
Qtt Tributary Terrace Deposits
Qht High Terrace Deposits
Qucr Upper Colorado River Terrace Deposits
Qlcr Lower Colorado River Terrace Deposits
Kta Taylor Group

MAP LOCATION

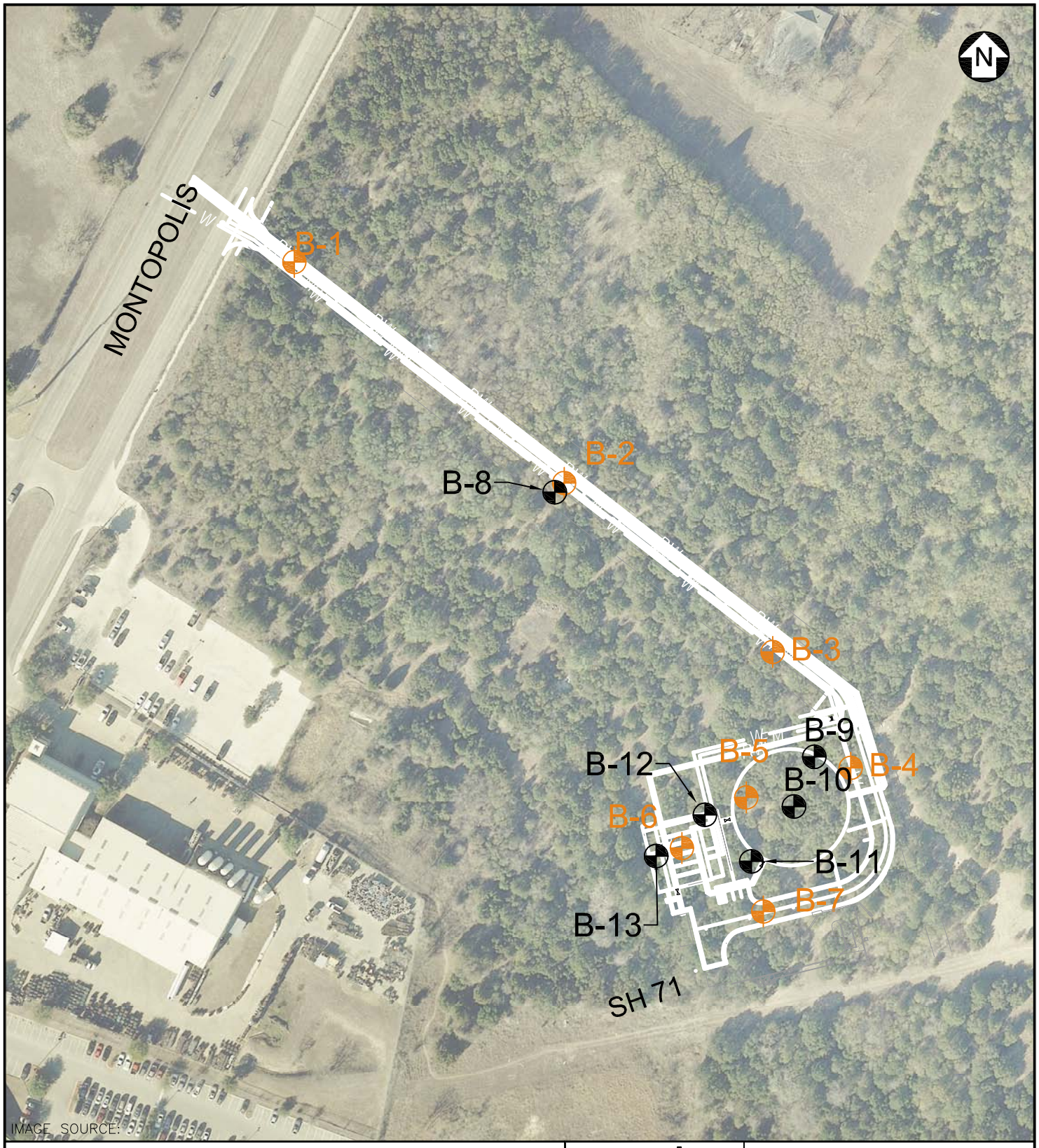
HVJ ASSOCIATES

SCALE: N.T.S		
DATE: 7/25/2014		
DRAWN BY: ZL	PROJ. CHK: JS	APPRV. BY: JS

GEOLOGY MAP
MONTOPOLIS WRI TANK
TRAVIS COUNTY
AUSTIN, TX

PROJECT NO.: AG 1310756	FILENAME: GEO	PLATE 2

DATE:
FILE:



Base Map Source: Google Maps

Bore Location (AG1011441)

Bore Location

MAP LOCATION

HVJ ASSOCIATES

SCALE: N.T.S		
DATE: 7/25/2014		
DRAWN BY: ZL	PROJ. CHK: JS	APPRV. BY: JS

PLAN OF BORINGS
MONTOPOLIS WRI TANK
AUSTIN, TEXAS

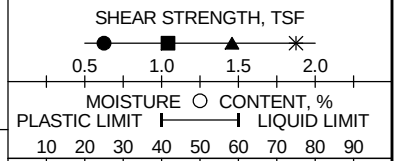
PROJECT NO.: AG 13 10756	FILENAME: POB	PLATE 3

DATE:
FILE:

LOG OF BORING

Project: Montopolis WRI Tank
Project No.: AG1310756
Boring No.: B-8
Date: 6/4/2014
Elevation: 613.1 feet
Groundwater during drilling: ---
Northing: 10,052,306.1
Station: --
Groundwater after drilling: ---
Easting: 3,126,010.7
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0	PP=3.0 tsf	Dark brown, very stiff, **FAT CLAY (CH)** , with fine to coarse subrounded to subangular gravel, and shell fragments. (Alluvium)		
	Refusal at 2' 12-9-8	Tan, hard, **LEAN CLAY (CL)** , with calcareous seams and nodules, and ferrous staining. (Taylor)		
610				
	11-9-10			
5				
	PP=4.5+ tsf 10-16-25			
605				
	12-14-23	Grayish tan, hard, **FAT CLAY (CH)** , blocky, with ferrous staining, and occasional calcareous seams and nodules. (Taylor)		
10				
600	PP=4.5+ tsf	- Unconfined Compressive Strength = 6.7 tsf		115
15				
595	PP=4.5+ tsf	- Unconfined Compressive Strength = 5.5 tsf		102
20				
590	PP=4.5+ tsf			
25				
585	PP=4.5+ tsf	- Unconfined Compressive Strength = 11.0 tsf		114
30				



Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

PLATE 4a

HVJ ASSOCIATES

LOG OF SOIL BORING BORELOGS.GPJ HVJ.GDT 8/7/14

LOG OF BORING

Project: Montopolis WRI Tank
Project No.: AG1310756
Boring No.: B-8
Date: 6/4/2014
Elevation: 613.1 feet
Groundwater during drilling: ---
Northing: 10,052,306.1
Station: --
Groundwater after drilling: ---
Easting: 3,126,010.7
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF	SHEAR STRENGTH, TSF (0.5, 1.0, 1.5, 2.0) / MOISTURE CONTENT, % (PLASTIC LIMIT – LIQUID LIMIT) (10 20 30 40 50 60 70 80 90)
30		Grayish tan, hard, **FAT CLAY (CH)** , blocky, with ferrous staining, and occasional calcareous seams and nodules. (Taylor) [Continued...]			
580	PP=4.5+ tsf				
35					
575	PP=4.5+ tsf				
40					
570					
45					
565					
50					
560					
55					
555					
60					

Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

PLATE 4b

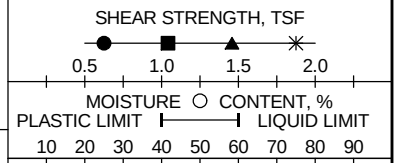
HVJ ASSOCIATES

LOG OF SOIL BORING BORELOGS.GPJ HVJ.GDT 8/7/14

LOG OF BORING

Project: Montopolis WRI Tank
Project No.: AG1310756
Boring No.: B-9
Date: 5/20/2014
Elevation: 602.4 feet
Groundwater during drilling: ---
Northing: 10,052,011.0
Station: --
Groundwater after drilling: ---
Easting: 3,126,300.1
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0	PP=4.5+ tsf	Dark brown, hard, **FAT CLAY (CH)** , with fine to coarse subrounded to subangular gravel, and shell fragments. (Alluvium)		
600	PP=3.5 tsf	Tan and gray, very stiff to hard, **FAT CLAY (CH)** , blocky, with calcareous seams and nodules, and ferrous staining. (Taylor)		
	PP=4.5+ tsf			
5				
	PP=4.5+ tsf			
595	PP=4.5+ tsf 9-15-19			
10				
590	PP=4.5+ tsf	- Unconfined Compressive Strength = 9.7 tsf		118
15				
585	PP=4.5+ tsf			
20				
580	PP=4.5+ tsf			
25				
575	PP=4.5+ tsf	- Unconfined Compressive Strength = 4.8 tsf		107
30				



Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

PLATE 5a

HVJ ASSOCIATES

LOG OF SOIL BORING BORELOGS.GPJ HVJ.GDT 8/7/14

LOG OF BORING

Project: Montopolis WRI Tank
Project No.: AG1310756
Boring No.: B-9
Date: 5/20/2014
Elevation: 602.4 feet
Groundwater during drilling: ---
Northing: 10,052,011.0
Station: --
Groundwater after drilling: ---
Easting: 3,126,300.1
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF	SHEAR STRENGTH, TSF (0.5, 1.0, 1.5, 2.0) / MOISTURE CONTENT, % (PLASTIC LIMIT – LIQUID LIMIT) (10 20 30 40 50 60 70 80 90)
30		Tan and gray, hard, **FAT CLAY (CH)** , blocky, with calcareous seams and nodules, and ferrous staining. (Taylor) [Continued...]			
570	PP=4.5+ tsf				
		- Unconfined Compressive Strength = 10.1 tsf		109	○
35					
565	PP=4.5+ tsf				
40					
560					
45					
555					
50					
550					
55					
545					
60					

Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

PLATE 5b

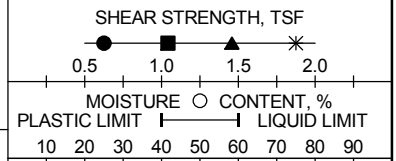
HVJ ASSOCIATES

LOG OF SOIL BORING BORELOGS.GPJ HVJ.GDT 8/7/14

LOG OF BORING

Project: Montopolis WRI Tank
Project No.: AG1310756
Boring No.: B-9A
Date: 10/23/2014
Elevation: 602 feet
Groundwater during drilling: ---
Northing: --
Station: --
Groundwater 24 hours after drilling: ---
Easting: --
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0	PP=4.5+ tsf	Dark brown, hard, **FAT CLAY (CH)** , with fine to coarse subrounded to subangular gravel, and shell fragments. (Alluvium)		
600	PP=4.5+ tsf			
	PP=4.5+ tsf	Tan and gray, very stiff to hard, **FAT CLAY (CH)** , blocky, with calcareous seams and nodules, and ferrous staining. (Taylor)		
5	PP=4.5+ tsf PP=4.5+ tsf			
595	PP=4.5+ tsf			
	PP=4.5+ tsf			
	PP=4.5+ tsf			
10				
590				
	PP=4.5+ tsf		98	
15				
585				
	PP=4.5+ tsf			
20				
580				
	PP=4.5+ tsf		97	
25				
575				
	PP=4.5+ tsf			
30				



Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

PLATE 9Aa

HVJ ASSOCIATES

LOG OF BORING

Project: Montopolis WRI Tank
Project No.: AG1310756
Boring No.: B-9A
Date: 10/23/2014
Elevation: 602 feet
Groundwater during drilling: ---
Northing: --
Station: --
Groundwater 24 hours after drilling: ---
Easting: --
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF	SHEAR STRENGTH, TSF (0.5, 1.0, 1.5, 2.0) / MOISTURE ○ CONTENT, % PLASTIC LIMIT — LIQUID LIMIT (10 20 30 40 50 60 70 80 90)
30		Tan and gray, hard, **FAT CLAY (CH)** , blocky, with calcareous seams and nodules, and ferrous staining. (Taylor) [Continued...]			
570					
	PP=4.5+ tsf				
35					
565					
	PP=4.5+ tsf				
40					
560					
45					
555					
50					
550					
55					
545					
60					

Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

PLATE 9Ab

HVJ ASSOCIATES

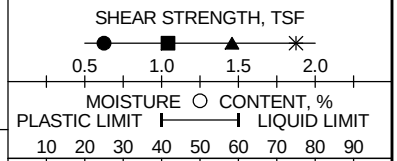
LOG OF BORING

Project: Montopolis WRI Tank
Boring No.: B-10
Groundwater during drilling: ---
Groundwater after drilling: ---

Date: 5/20/2014
Northing: 10,051,955.6
Easting: 3,126,277.4

Project No.: AG1310756
Elevation: 598.9 feet
Station: --
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0	PP=4.5+ tsf	Dark brown, hard, **FAT CLAY (CH)** , with fine to coarse subrounded to subangular gravel, and shell fragments. (Alluvium)		
	PP=3.5 tsf			
595 / 5	PP=4.5+ tsf	Tan and gray, hard, **FAT CLAY (CH)** , blocky, with calcareous seams and nodules, and ferrous staining. (Taylor) - Unconfined Compressive Strength = 5.8 tsf		121
	PP=4.5+ tsf			
	8-10-12			
590 / 10				
	PP=4.5+ tsf			
585 / 15			94	
	PP=4.5+ tsf			
580 / 20				
	PP=4.5+ tsf			
575 / 25			95	
	PP=4.5+ tsf			
570 / 30				



Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

PLATE 6a

HVJ ASSOCIATES

LOG OF BORING

Project: Montopolis WRI Tank
Project No.: AG1310756
Boring No.: B-10
Date: 5/20/2014
Elevation: 598.9 feet
Groundwater during drilling: ---
Northing: 10,051,955.6
Station: --
Groundwater after drilling: ---
Easting: 3,126,277.4
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF	SHEAR STRENGTH, TSF (0.5, 1.0, 1.5, 2.0) / MOISTURE CONTENT, % (PLASTIC LIMIT – LIQUID LIMIT) (10 20 30 40 50 60 70 80 90)
30		Tan and gray, hard, **FAT CLAY (CH)** , blocky, with calcareous seams and nodules, and ferrous staining. (Taylor) [Continued...]			
565	PP=4.5+ tsf				
35					
	PP=4.5+ tsf				
560			94		
40					
555					
45					
550					
50					
545					
55					
540					
60					

Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

PLATE 6b

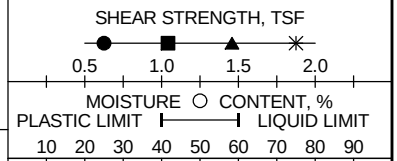
HVJ ASSOCIATES

LOG OF SOIL BORING BORELOGS.GPJ HVJ.GDT 8/7/14

LOG OF BORING

Project: Montopolis WRI Tank
Project No.: AG1310756
Boring No.: B-11
Date: 5/19/2014
Elevation: 594.3 feet
Groundwater during drilling: 37.0 feet
Northing: 10,051,894.4
Station: --
Groundwater after drilling: 37.0 feet 10 Min
Easting: 3,126,229.9
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0	PP=4.5+ tsf	Dark brown, hard, **FAT CLAY (CH)** , with fine to coarse subrounded to subangular gravel, and shell fragments. (Alluvium)		
	PP=4.5+ tsf	Tan and gray, hard, **FAT CLAY (CH)** , blocky, with calcareous seams and nodules, and ferrous staining. (Taylor)		
590 5	PP=4.5+ tsf			
	PP=4.5+ tsf			
	PP=4.5+ tsf	- Unconfined Compressive Strength = 4.9 tsf	96	103
585 10	PP=4.5+ tsf			
	PP=4.5+ tsf			
580 15				
	PP=4.5+ tsf			
575 20			92	
	PP=4.5+ tsf			
570 25		- Unconfined Compressive Strength = 9.8 tsf		114
	PP=4.5+ tsf			
565 30				



Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

PLATE 7a

HVJ ASSOCIATES

LOG OF SOIL BORING BORELOGS.GPJ HVJ.GDT 8/7/14

LOG OF BORING

Project: Montopolis WRI Tank
Project No.: AG1310756
Boring No.: B-11
Date: 5/19/2014
Elevation: 594.3 feet
Groundwater during drilling: 37.0 feet
Northing: 10,051,894.4
Station: --
Groundwater after drilling: 37.0 feet 10 Min
Easting: 3,126,229.9
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
30		Tan and gray, hard, **FAT CLAY (CH)** , blocky, with calcareous seams and nodules, and ferrous staining. (Taylor) [Continued...]		
560 35	PP=4.5+ tsf		93	
555 40	PP=4.5+ tsf	- Unconfined Compressive Strength = 11.2 tsf		110
550 45				
545 50				
540 55				
535 60				

SHEAR STRENGTH, TSF
0.5 1.0 1.5 2.0
MOISTURE ○ CONTENT, %
PLASTIC LIMIT LIQUID LIMIT
10 20 30 40 50 60 70 80 90

Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

PLATE 7b

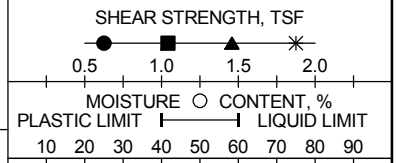
HVJ ASSOCIATES

LOG OF SOIL BORING BORELOGS.GPJ HVJ.GDT 8/7/14

LOG OF BORING

Project: Montopolis WRI Tank
Project No.: AG1310756
Boring No.: B-11A
Date: 10/23/2014
Elevation: 594 feet
Groundwater during drilling: ---
Northing: --
Station: --
Groundwater 24 hours after drilling: ---
Easting: --
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0	PP=4.5+ tsf	Dark brown, hard, **FAT CLAY (CH)** , with fine to coarse subrounded to subangular gravel, and shell fragments. (Alluvium)		
	PP=4.5+ tsf	Tan and gray, very stiff to hard, **FAT CLAY (CH)** , blocky, with calcareous seams and nodules, and ferrous staining. (Taylor)		
590 5	PP=4.5+ tsf			
	PP=4.5+ tsf			
	PP=4.5+ tsf			
585 10				
580 15	PP=4.5+ tsf		93	
575 20	PP=4.5+ tsf			
570 25	PP=4.5+ tsf			
565 30	PP=4.5+ tsf			



Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

PLATE 7Aa

HVJ ASSOCIATES

LOG OF SOIL BORING BORELOGS.GPJ HVJ.GDT 12/1/14

LOG OF BORING

Project: Montopolis WRI Tank
Project No.: AG1310756
Boring No.: B-11A
Date: 10/23/2014
Elevation: 594 feet
Groundwater during drilling: ---
Northing: --
Station: --
Groundwater 24 hours after drilling: ---
Easting: --
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF	SHEAR STRENGTH, TSF (0.5, 1.0, 1.5, 2.0) / MOISTURE CONTENT, % (PLASTIC LIMIT – LIQUID LIMIT) (10 20 30 40 50 60 70 80 90)
30		Tan and gray, hard, **FAT CLAY (CH)** , blocky, with calcareous seams and nodules, and ferrous staining. (Taylor) [Continued...]			
560	PP=4.5+ tsf				
35					
555	PP=4.5+ tsf				
40					
550					
45					
545					
50					
540					
55					
535					
60					

Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

PLATE 7Ab

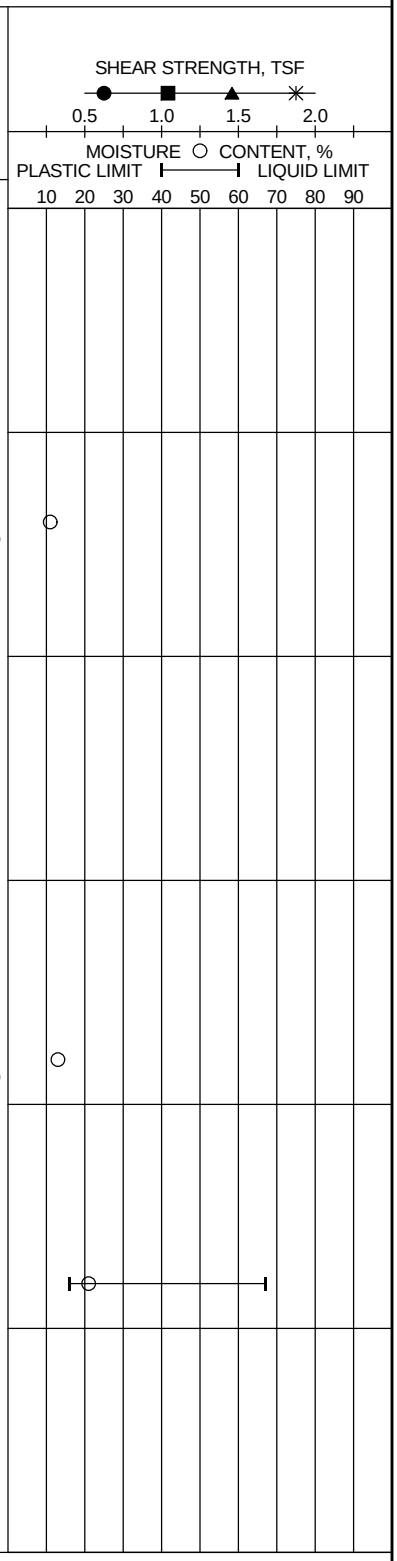
HVJ ASSOCIATES

LOG OF SOIL BORING BORELOGS.GPJ HVJ.GDT 12/1/14

LOG OF BORING

Project: Montopolis WRI Tank
Project No.: AG1310756
Boring No.: B-12
Date: 5/19/2014
Elevation: 597.6 feet
Groundwater during drilling: ---
Northing: 10,051,946.3
Station: --
Groundwater after drilling: ---
Easting: 3,126,178.1
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0	PP=4.5+ tsf	Dark brown, hard, **FAT CLAY (CH)** , with fine to coarse subrounded to subangular gravel, and shell fragments. (Alluvium)		
595	PP=4.5+ tsf	Tan and gray, hard, **FAT CLAY (CH)** , blocky, with calcareous seams and nodules, and ferrous staining. (Taylor)		
5	PP=4.5+ tsf			
	PP=4.5+ tsf			
590		- Unconfined Compressive Strength = 6.2 tsf		115
	PP=4.5+ tsf 8-8-9			
10				
585	PP=4.5+ tsf			
15				
580	PP=4.5+ tsf			
		- Unconfined Compressive Strength = 7.7 tsf		115
20				
575	PP=4.5+ tsf		95	
25				
570	PP=4.5+ tsf			
30				



Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

PLATE 8a

HVJ ASSOCIATES

LOG OF SOIL BORING BORELOGS.GPJ HVJ.GDT 8/7/14

LOG OF BORING

Project: Montopolis WRI Tank
Project No.: AG1310756
Boring No.: B-12
Date: 5/19/2014
Elevation: 597.6 feet
Groundwater during drilling: ---
Northing: 10,051,946.3
Station: --
Groundwater after drilling: ---
Easting: 3,126,178.1
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF	SHEAR STRENGTH, TSF (0.5, 1.0, 1.5, 2.0) / MOISTURE ○ CONTENT, % (PLASTIC LIMIT — LIQUID LIMIT; 10 20 30 40 50 60 70 80 90)
30		Tan and gray, hard, **FAT CLAY (CH)** , blocky, with calcareous seams and nodules, and ferrous staining. (Taylor) [Continued...]			
565	PP=4.5+ tsf				
35		- Unconfined Compressive Strength = 15.4 tsf		118	○
560	PP=4.5+ tsf				
40					
555					
45					
550					
50					
545					
55					
540					
60					

Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

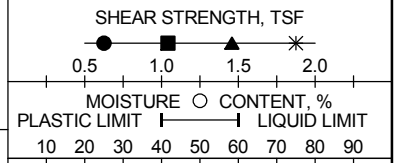
PLATE 8b

HVJ ASSOCIATES

LOG OF BORING

Project: Montopolis WRI Tank
Project No.: AG1310756
Boring No.: B-12A
Date: 10/24/2014
Elevation: 597 feet
Groundwater during drilling: ---
Northing: --
Station: --
Groundwater 24 hours after drilling: ---
Easting: --
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0	PP=4.5+ tsf	Dark brown, hard, **FAT CLAY (CH)** , with fine to coarse subrounded to subangular gravel, and shell fragments. (Alluvium)		
595	PP=4.5+ tsf	Tan and gray, very stiff to hard, **FAT CLAY (CH)** , blocky, with calcareous seams and nodules, and ferrous staining. (Taylor)		
	PP=4.5+ tsf			
5				
	PP=4.5+ tsf			
590				
	PP=4.5+ tsf			
10				
585				
	PP=4.5+ tsf		96	
15				
580				
	PP=4.5+ tsf		96	
20				
575				
	PP=4.5+ tsf			
25				
570				
	PP=4.5+ tsf			
30				



Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

PLATE 8Aa

HVJ ASSOCIATES

LOG OF SOIL BORING BORELOGS.GPJ HVJ.GDT 12/1/14

LOG OF BORING

Project: Montopolis WRI Tank
Project No.: AG1310756
Boring No.: B-12A
Date: 10/24/2014
Elevation: 597 feet
Groundwater during drilling: ---
Northing: --
Station: --
Groundwater 24 hours after drilling: ---
Easting: --
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF	SHEAR STRENGTH, TSF (0.5, 1.0, 1.5, 2.0) / MOISTURE CONTENT, % (PLASTIC LIMIT – LIQUID LIMIT) (10 20 30 40 50 60 70 80 90)
30		Tan and gray, hard, **FAT CLAY (CH)** , blocky, with calcareous seams and nodules, and ferrous staining. (Taylor) [Continued...]			
565					
	PP=4.5+ tsf				
35					
560					
	PP=4.5+ tsf				
40					
555					
45					
550					
50					
545					
55					
540					
60					

Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

PLATE 8Ab

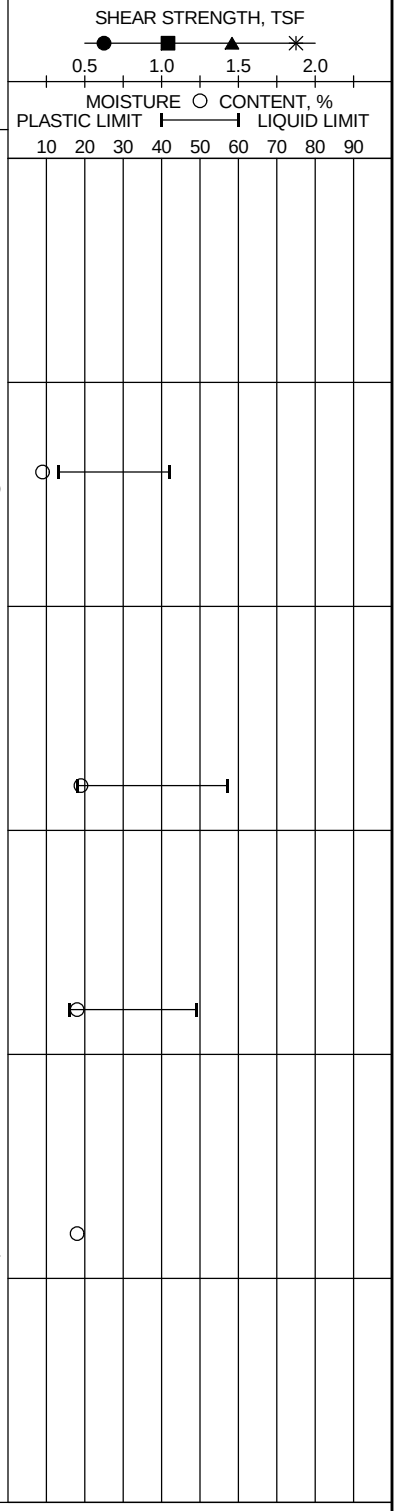
HVJ ASSOCIATES

LOG OF SOIL BORING BORELOGS.GPJ HVJ.GDT 12/1/14

LOG OF BORING

Project: Montopolis WRI Tank
Project No.: AG1310756
Boring No.: B-13
Date: 5/16/2014
Elevation: 593.5 feet
Groundwater during drilling: ---
Northing: 10,051,900.4
Station: --
Groundwater after drilling: ---
Easting: 3,126,123.8
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0	PP=3.0 tsf	Dark brown, very stiff to hard, **FAT CLAY (CH)** , with fine to coarse subrounded to subangular gravel, and shell fragments. (Alluvium)		
	PP=4.5+ tsf	Tan and gray, hard, **LEAN CLAY (CL)** , blocky, with calcareous seams and nodules, and ferrous staining. (Taylor)		
590	PP=4.5+ tsf			
5				
	PP=4.5+ tsf			
		- Unconfined Compressive Strength = 7.6 tsf	97	126
585	PP=4.5+ tsf			
10		Tan and gray, hard, **FAT CLAY (CH)** , blocky, with calcareous seams and nodules, and ferrous staining. (Taylor)		
580	PP=4.5+ tsf		90	
15				
		Tan and gray, hard, **LEAN CLAY (CL)** , blocky, with calcareous seams and nodules, and ferrous staining. (Taylor)		
575	PP=4.5+ tsf		93	
20				
570	PP=4.5+ tsf			
		- Unconfined Compressive Strength = 13.3 tsf		121
25				
565	PP=4.5+ tsf			
30				



Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

PLATE 9a

HVJ ASSOCIATES

LOG OF SOIL BORING BORELOGS.GPJ HVJ.GDT 8/7/14

LOG OF BORING

Project: Montopolis WRI Tank
Project No.: AG1310756
Boring No.: B-13
Date: 5/16/2014
Elevation: 593.5 feet
Groundwater during drilling: ---
Northing: 10,051,900.4
Station: --
Groundwater after drilling: ---
Easting: 3,126,123.8
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF	SHEAR STRENGTH, TSF (0.5, 1.0, 1.5, 2.0) / MOISTURE ○ CONTENT, % (PLASTIC LIMIT — LIQUID LIMIT) (10 20 30 40 50 60 70 80 90)
30		Tan and gray, hard, **LEAN CLAY (CL)** , blocky, with calcareous seams and nodules, and ferrous staining. (Taylor) [Continued...]			
560	PP=4.5+ tsf				
35					
		Gray, low hardness, **CLAYSHALE** , fissile, with calcareous seams and nodules, and ferrous staining. (Taylor)			
555	PP=4.5+ tsf				
40		- Unconfined Compressive Strength = 10.5 tsf		106	○
550					
45					
545					
50					
540					
55					
535					
60					

Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

PLATE 9b

HVJ ASSOCIATES

LOG OF SOIL BORING BORELOGS.GPJ HVJ.GDT 8/7/14

SOIL SYMBOLS

Soil Types

Clay | Silt | Sand | Fill

Modifiers

Clayey | Silty | Sandy Clay | Cemented

Construction Materials

Asphaltic Concrete | Stabilized Base | Fill or Debris | Base

SAMPLER TYPES

- Thin Walled Shelby Tube
- No Recovery
- Split Barrel
- Auger
- Liner Tube
- Jar Sample

WATER LEVEL SYMBOLS

- Groundwater level determined during drilling operations
- Groundwater level after drilling in open borehole or piezometer

SOIL GRAIN SIZE

Classification	Particle Size	Particle Size or Sieve No. (U.S. Standard)
Clay	< 0.002 mm	< 0.002 mm
Silt	0.002 - 0.075 mm	0.002 mm - #200 sieve
Sand	0.075 - 4.75 mm	#200 sieve - #4 sieve
Gravel	4.75 - 75 mm	#4 sieve - 3 in.
Cobble	75 - 200 mm	3 in. - 8 in.
Boulder	> 200 mm	> 8 in.

DENSITY OF COHESIONLESS SOILS

Descriptive Term	Penetration Resistance "N" * Blows/Foot
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	> 50

CONSISTENCY OF COHESIVE SOILS

Consistency	Undrained Shear Strength (tsf)
Very Soft	0 - 0.125
Soft	0.125 - 0.25
Firm	0.25 - 0.5
Stiff	0.5 - 1.0
Very Stiff	1.0 - 2.0
Hard	> 2.0

PENETRATION RESISTANCE

3/6	Blows required to penetrate each of three consecutive 6-inch increments per ASTM D-1586 *
50/4"	If more than 50 blows are required, driving is discontinued and penetration at 50 blows is noted
0/18"	Sampler penetrated full depth under weight of drill rods and hammer

* The N value is taken as the blows required to penetrate the final 12 inches

TERMS DESCRIBING SOIL STRUCTURE

Slickensided	Fracture planes appear polished or glossy, sometimes striated
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Inclusion	Small pockets of different soils, such as small lenses of sand scattered through a mass of clay
Parting	Inclusion less than 1/4 inch thick extending through the sample
Seam	Inclusion 1/4 inch to 3 inches thick extending through the sample
Layer	Inclusion greater than 3 inches thick extending through the sample
Laminated	Soil sample composed of alternating partings of different soil type
Stratified	Soil sample composed of alternating seams or layers of different soil type
Intermixed	Soil sample composed of pockets of different soil type and laminated or stratified structure is not evident
Calcareous	Having appreciable quantities of calcium carbonate
Ferrous	Having appreciable quantities of iron
Nodule	A small mass of irregular shape

HVJ ASSOCIATES

PROJECT NO.: AG 13 10756

DRAWING NO.: PLATE 10A

KEY TO TERMS AND SYMBOLS USED ON BORING LOGS FOR SOIL

DATE: 8/7/2014 10:03:00 AM
FILE: P:\geo\Projects\2013\AG 13 10756 Montopolis WRI Tank\CAD\Soil_Rock.dwg

ROCK TYPES

- Limestone
- Shale
- Sandstone
- Highly Weathered Limestone
- Weathered Shale
- Weathered Sandstone
- Weathered Limestone
- Dolomite
- Granite

SAMPLER TYPES

- Thin-Walled Tube
- Rock Core
- Standard Penetration Test
- Auger
- THD Cone Penetration Test
- Bag Sample

SOLUTION AND VOID CONDITIONS

Void	Interstice; a general term for pore space or other openings in rock.
Cavities	Small solutional concavities.
Vuggy	Containing small cavities, usually lined with a mineral of different composition from that of the surrounding rock.
Vesicular	Containing numerous small, unlined cavities, formed by expansion of gas bubbles or steam during solidification of the rock.
Porous	Containing pores, interstices, or other openings which may or may not interconnect.
Cavernous	Containing cavities or caverns, sometimes quite large. Most frequent in limestones and dolomites.

HARDNESS

Friable	Crumbles under hand pressure
Low Hardness	Can be carved with a knife, or UCS less than 100 tsf
Moderately Hard	Can be scratched easily with a knife, or UCS between 100 and 250 tsf
Hard	Can be scratched rarely with a knife, or UCS greater than 250 tsf
Very Hard	Cannot be scratched with a knife

WEATHERING GRADES OF ROCKMASS (1)

Slightly	Discoloration indicates weathering of rock material and discontinuity surfaces.
Moderately	Less than half of the rock material is decomposed or disintegrated to a soil.
Highly	More than half of the rock material is decomposed or disintegrated to a soil.
Completely	All rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.
Residual Soil	All rock material is converted to soil. The mass structure and material fabric are destroyed.

JOINT DESCRIPTION

SPACING		INCLINATION		SURFACES	
Very Close	<2"	Horizontal	0-5	Slickensided	Polished, grooved
Close	2"-12"	Shallow	5-35	Smooth	Planar
Medium Close	12"-3'	Moderate	35-65	Irregular	Undulating or granular
Wide	>3'	Steep	65-85	Rough	Jagged or pitted
		Vertical	85-90		

REFERENCES:

(1) British Standard (1981) Code of Practice for Site Investigation, BS 5930.

(2) The Bridge Div., Tx. Highway Dept. Foundation Exploration & Design Manual, 2nd Division, revised June, 1974.

BEDDING THICKNESS (2)

Very Thick	>4'
Thick	2'-4'
Thin	2"-2'
Very Thin	1/2"-2"
Laminated	0.08"-1/2"
Thinly Laminated	<0.08"

Information on each boring log is a compilation of subsurface conditions and soil and rock classifications obtained from the field as well as from laboratory testing of samples. Strata have been interpreted by commonly accepted procedures. The stratum lines on the logs may be transitional and approximate in nature. Water level measurements refer only to those observed at the times and places indicated, and may vary with time, geologic condition or construction activity.

HVJ ASSOCIATES

PROJECT NO.: AG 13 10756

DRAWING NO.: PLATE 10B

KEY TO TERMS AND SYMBOLS USED ON BORING LOGS FOR ROCK

DATE: 5/24/2013
FILE: P:\geo\Projects\2013\AG 13 10756 Montopolis WRI Tank\CAD\Soil_Rock.dwg

APPENDIX A

LABORATORY TEST SUMMARY

LABORATORY TEST RESULTS SUMMARY Montopolis WRI Tank AG1310756									
Boring Number	Depth (ft)	% Passing No. 200 Sieve	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf)	Unconfined Compressive Strength (tsf)	Pocket Penetrometer (tsf)
B-8	0-1								3.0
	2-3.5				17.2				
	6-6.5								4.5+
	6.5-8				8.4				
	13.5-14.5				11.5	128.1	114.9	6.7	4.5+
	18.5-19.5				16.8	118.8	101.7	5.5	4.5+
	23.5-24.5								4.5+
	28.5-29.5				18.9	135.3	113.7	11.0	4.5+
	33.5-34.5								4.5+
	38.5-39.5								4.5+
B-9	0-2								4.5+
	2-4								3.5
	4-6								4.5+
	6-7								4.5+
	7-7.5								4.5+
	13-15				10.2	130.5	118.2	9.7	4.5+
	18-19								4.5+
	23-25								4.5+
	28-30				17.5	125.9	107.1	4.8	4.5+
	33-35				18.7	129.9	109.5	10.1	4.5+
	38-40								4.5+
B-9A									
	0-1								4.5+
	2-4								4.5+
	4-5								4.5+
	5-5.5								4.5+
	7-8								4.5+
	8-9								4.5+
	9-9.5								4.5+
	13.5-15	97.8	53	37	16.0				4.5+
	18.5-20								4.5+
	23.5-24.3	96.8	59	43	15.4				4.5+
	28.5-29.4								4.5+
	33.5-35								4.5+
	38.5-40								4.5+

LABORATORY TEST RESULTS SUMMARY Montopolis WRI Tank AG1310756									
Boring Number	Depth (ft)	% Passing No. 200 Sieve	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf)	Unconfined Compressive Strength (tsf)	Pocket Penetrometer (tsf)
B-10	0-2								4.5+
	2-4								3.5
	4-6				10.4	133.8	121.1	5.8	4.5+
	6-7								4.5+
	13-15	94.2	59	42	11.7				4.5+
	18-20								4.5+
	23-25	94.7	55	39	16.6				4.5+
	28-30								4.5+
	33-34								4.5+
	38-40	93.8	52	38	17.3				4.5+
B-11	0-2								4.5+
	2-4								4.5+
	4-6								4.5+
	6-8	96.4	59	44	17.8	121.5	103.1	4.9	4.5+
	8-10								4.5+
	13-15								4.5+
	18-20	91.5	63	46	17.2				4.5+
	23-25				20.0	136.7	113.9	9.8	4.5+
	28-30								4.5+
	33-35	93.4	68	50	22.6				4.5+
	38-40				21.6	133.3	109.6	11.2	4.5+
B-11A									
	1-2								4.5+
	2-4								4.5+
	4-6								4.5+
	6-8								4.5+
	8-10								4.5+
	13.5-15	92.9	51	35	17.3				4.5+
	18.5-20								4.5+
	23.5-25								4.5+
	28.5-30								4.5+
	33.5-35								4.5+
	38.5-40								4.5+

LABORATORY TEST RESULTS SUMMARY Montopolis WRI Tank AG1310756									
Boring Number	Depth (ft)	% Passing No. 200 Sieve	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf)	Unconfined Compressive Strength (tsf)	Pocket Penetrometer (tsf)
B-12	0-2								4.5+
	2-4								4.5+
	4-6								4.5+
	6-8				10.9	128.0	115.4	6.2	4.5+
	8-8.5								4.5+
	13-15								4.5+
	18-20				13.2	130.1	114.9	7.7	4.5+
	23-25	95.3	67	51	20.7				4.5+
	28-30								4.5+
	33-35				17.5	138.7	118.0	15.4	4.5+
	38-40								4.5+
B-12A									
	0-2								4.5+
	2-4								4.5+
	4-6								4.5+
	6-8								4.5+
	8-10								4.5+
	13.5-15	96.4	54	40	18.4				4.5+
	18.5-20	96.0	54	38	18.7				4.5+
	23.5-25								4.5+
	28.5-30								4.5+
	33.5-35								4.5+
	38.5-40								4.5+
B-13	0-2								3.0
	2-4								4.5+
	4-6								4.5+
	6-8	96.6	42	29	9.1	137.9	126.4	7.6	4.5+
	8-10								4.5+
	13-15	89.6	57	38	19.5				4.5+
	18-20	93.1	49	33	17.9				4.5+
	23-25				18.0	143.0	121.1	13.3	4.5+
	28-30								4.5+
	33-35								4.5+
	38-40				18.4	126.0	106.4	10.5	4.5+

APPENDIX B

SWELL TEST RESULTS

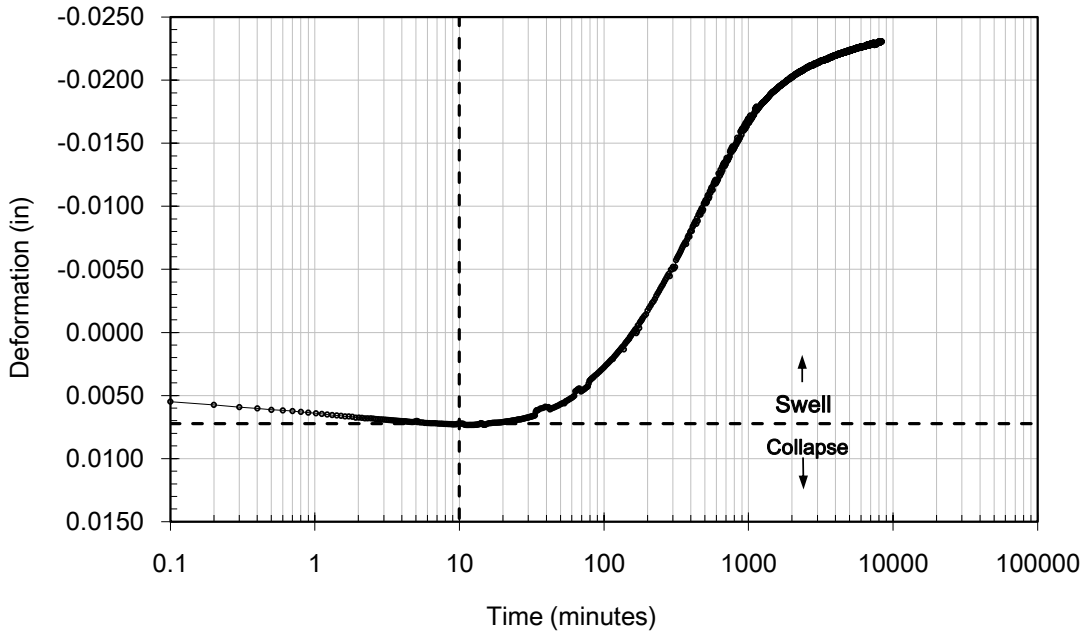
One-Dimensional Swell or Collapse of Cohesive Soils

Client:	HVJ Associates	TRI Log #:	E2391-19-08
Project:	Montopolis WRI Tank AG	Test Method:	ASTM D4546-B
Specimen:	B-9A (13-15)		
Loading Pressure:	1300 psf		

Specimen Properties[1]	Initial[2]	Inundation[3]	Final[4]
Water Content, ω (%)	14.0	-	20.9
Diameter, d (in)	2.497	-	-
Height, h (in)	0.992	0.990	1.019
Void Ratio, e	0.405	0.402	0.443
Degree of Saturation, S (%)	91.3	-	≈100
Strain (%)[5]	-0.229	0	**-2.949**

1. The undisturbed specimen was provided by the client. The specimen was trimmed using a trimming turntable and mounted. G_s was assumed to be 2.65. Calculations include measured machine deflections.
2. As trimmed in the specimen ring.
3. Height following seating load, first load application, and second load application. Sample was inundated with tap water 10 minutes after the second load application.
4. Strain Measurements are based on the height of the sample at Stage 4, inundation.
5. Sign convention: (+) Compression/Collapse, (-) Expansion/Swell

Finding: The soil was found to swell 2.95% under a load of 1300 psf.



Jeffrey A. Kuhn, Ph.D., P.E. 11/20/2014
Analysis & Quality Review/Date
Testing Performed By: Mark Fountain, Ph.D.

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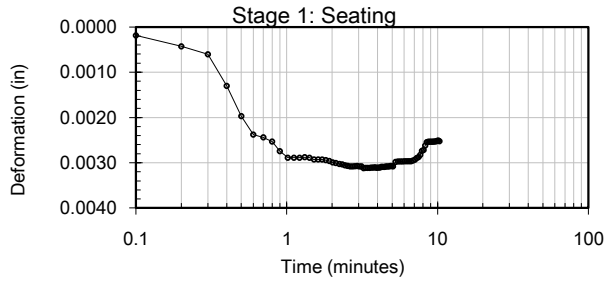
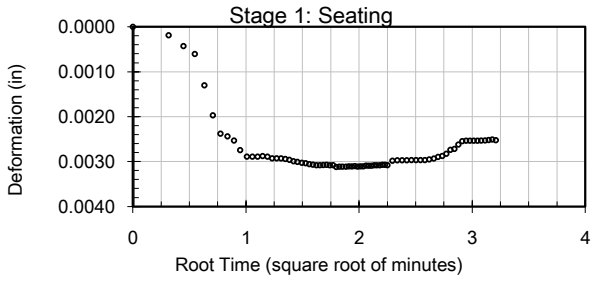
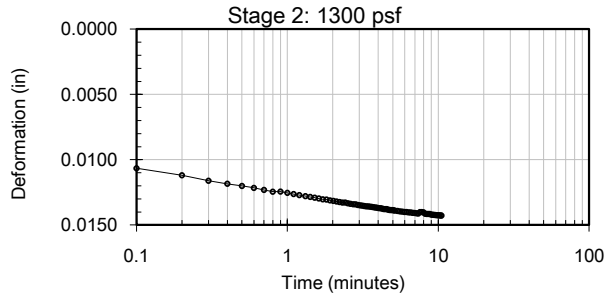
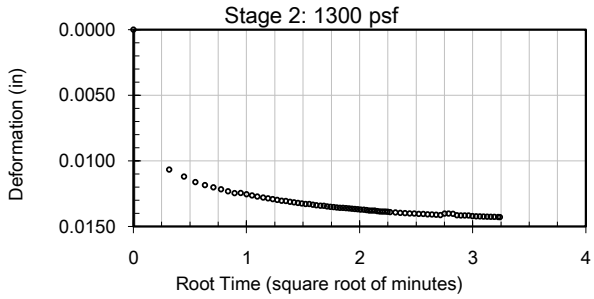
One-Dimensional Swell or Collapse of Cohesive Soils

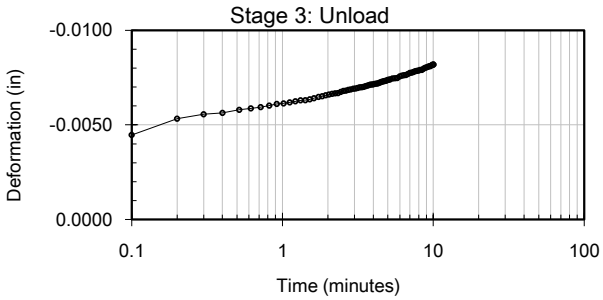
Client:	HVJ Associates	TRI Log #:	E2391-19-08
Project:	Montopolis WRI Tank AG	Test Method:	ASTM D4546-B
Specimen:	B-9A (13-15)		
Loading Pressure:	1300 psf		

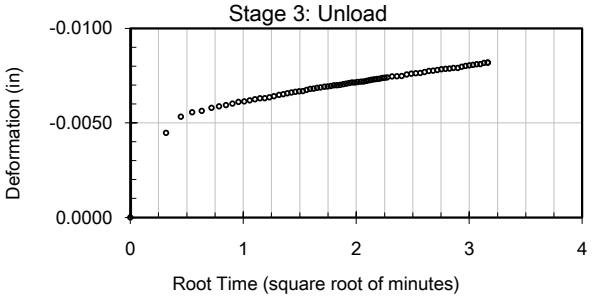


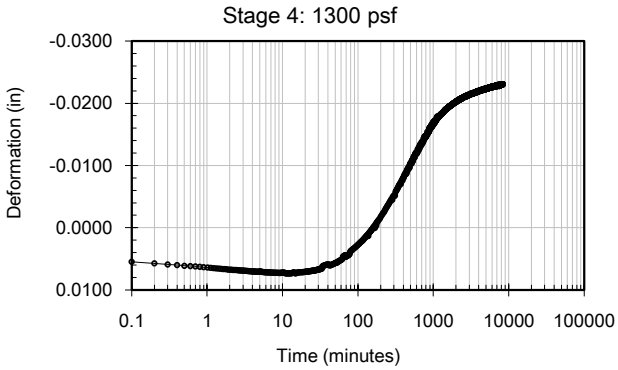


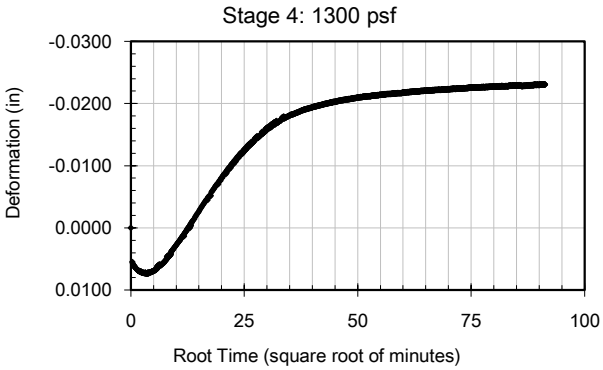












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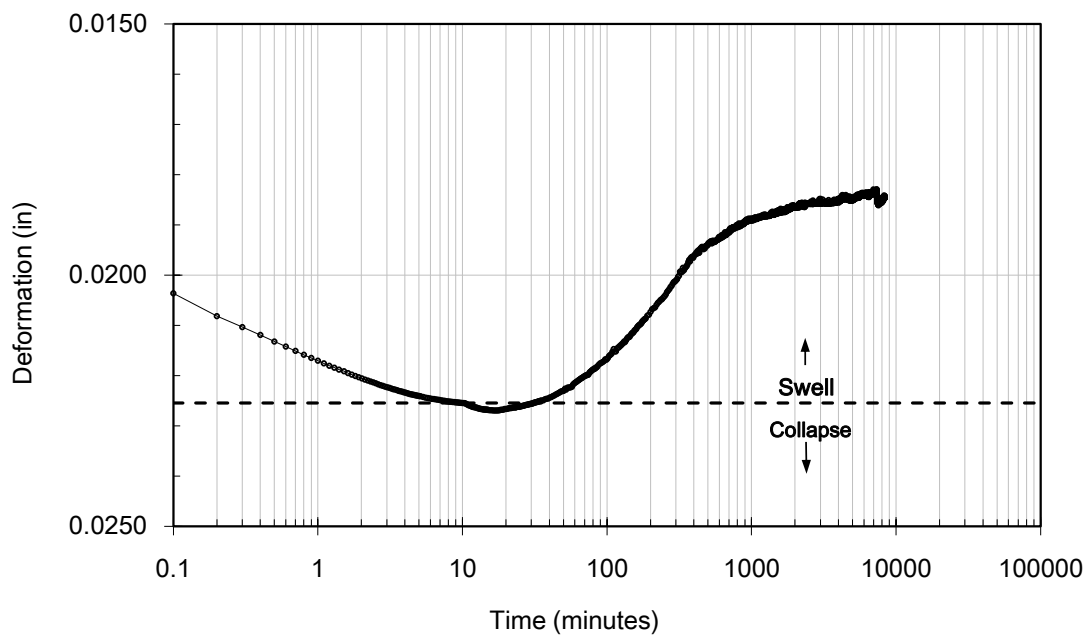
One-Dimensional Swell or Collapse of Cohesive Soils

Client:	HVJ Associates	TRI Log #:	E2391-19-08
Project:	Montopolis WRI Tank AG	Test Method:	ASTM D4546-B
Specimen:	B-9A (23.5-25)		
Loading Pressure:	2600 psf		

Specimen Properties[1]	Initial[2]	Inundation[3]	Final[4]
Water Content, ω (%)	14.5	-	19.9
Diameter, d (in)	2.499	-	-
Height, h (in)	1.003	1.001	1.004
Void Ratio, e	0.472	0.468	0.473
Degree of Saturation, S (%)	81.3	-	≈100
Strain (%)[5]	-0.210	0	**-0.286**

1. The undisturbed specimen was provided by the client. The specimen was trimmed using a trimming turntable and mounted. G_s was assumed to be 2.65. Calculations include measured machine deflections.
2. As trimmed in the specimen ring.
3. Height following seating load, first load application, and second load application. Sample was inundated with tap water 10 minutes after the second load application.
4. Strain Measurements are based on the height of the sample at Stage 4, inundation.
5. Sign convention: (+) Compression/Collapse, (-) Expansion/Swell

Finding: The soil was found to swell 0.29% under a load of 2600 psf.



Jeffrey A. Kuhn, Ph.D., P.E. 11/20/2014
Analysis & Quality Review/Date
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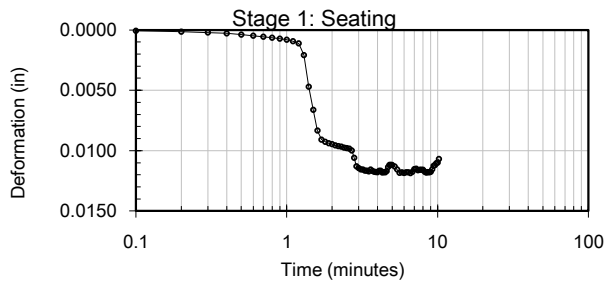
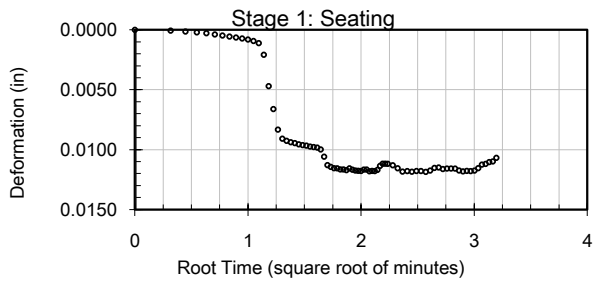
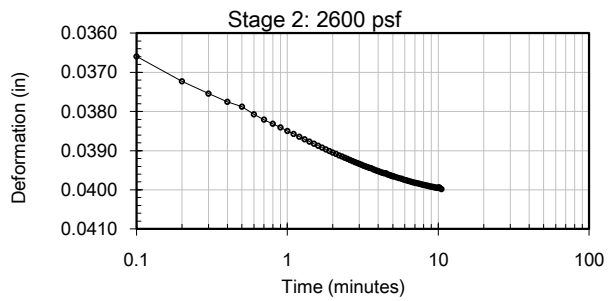
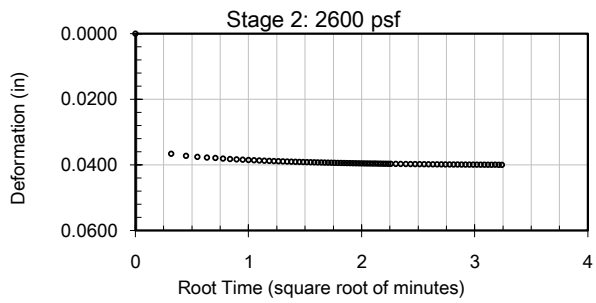
One-Dimensional Swell or Collapse of Cohesive Soils

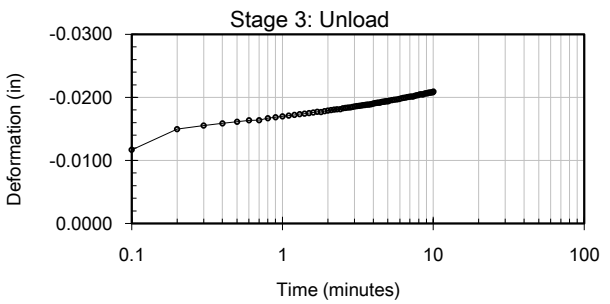
Client:	HVJ Associates	TRI Log #:	E2391-19-08
Project:	Montopolis WRI Tank AG	Test Method:	ASTM D4546-B
Specimen:	B-9A (23.5-25)		
Loading Pressure:	2600 psf		

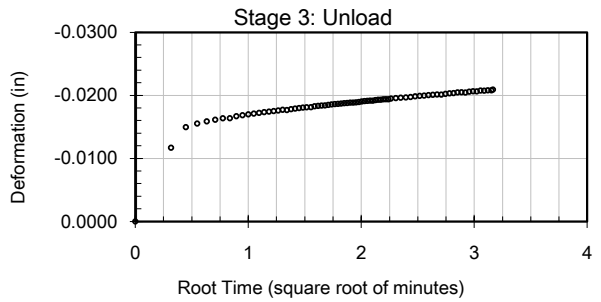


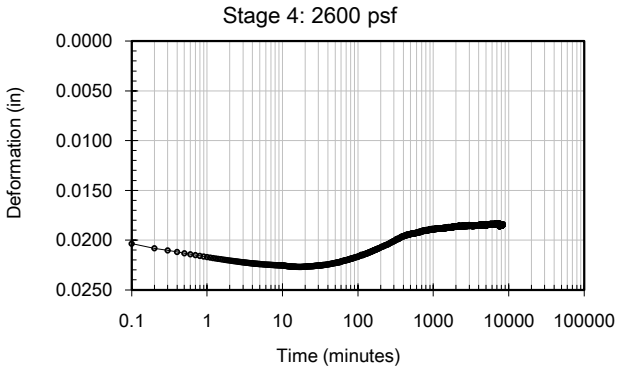


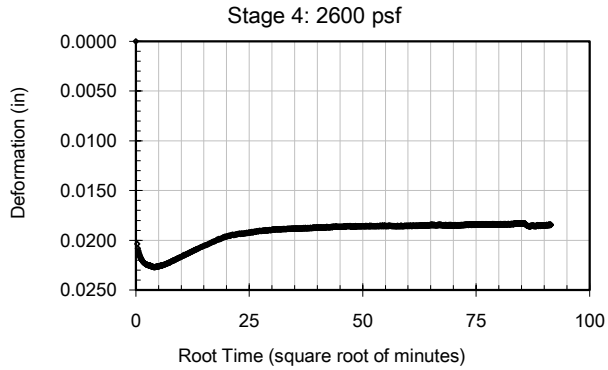












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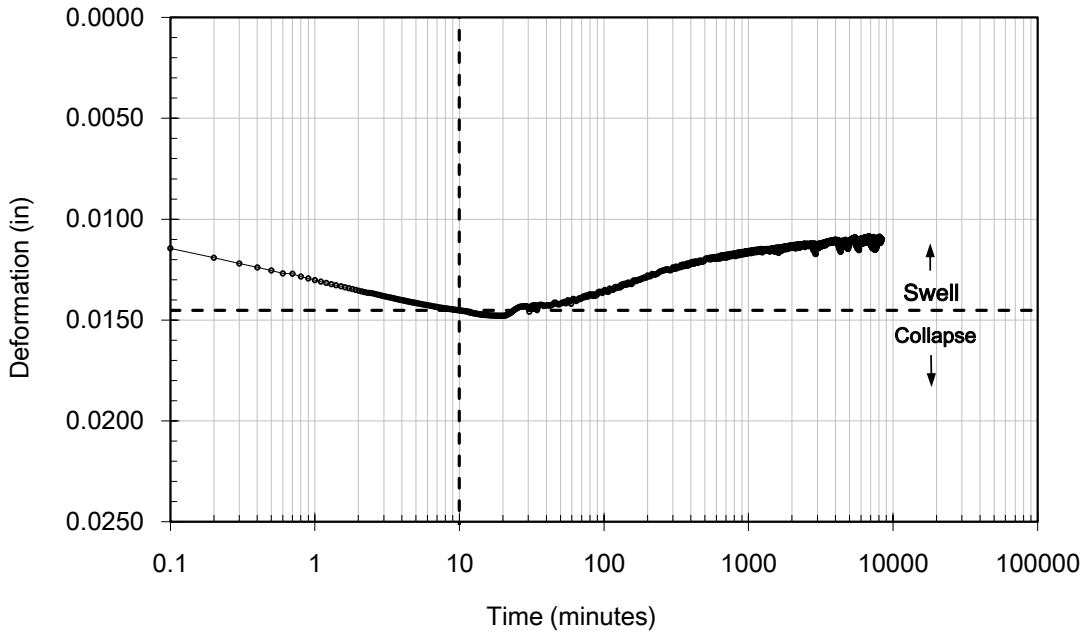
One-Dimensional Swell or Collapse of Cohesive Soils

Client:	HVJ Associates	TRI Log #:	E2391-19-08
Project:	Montopolis WRI Tank AG	Test Method:	ASTM D4546-B
Specimen:	B-11A (13.5-15)		
Loading Pressure:	2340 psf		

Specimen Properties[1]	Initial[2]	Inundation[3]	Final[4]
Water Content, ω (%)	15.8	-	20.3
Diameter, d (in)	2.497	-	-
Height, h (in)	0.999	0.996	0.997
Void Ratio, e	0.457	0.453	0.455
Degree of Saturation, S (%)	91.4	-	≈100
Strain (%)[5]	-0.256	0	**-0.149**

1. The undisturbed specimen was provided by the client. The specimen was trimmed using a trimming turntable and mounted. G_s was assumed to be 2.65. Calculations include measured machine deflections.
2. As trimmed in the specimen ring.
3. Height following seating load, first load application, and second load application. Sample was inundated with tap water 10 minutes after the second load application.
4. Strain Measurements are based on the height of the sample at Stage 4, inundation.
5. Sign convention: (+) Compression/Collapse, (-) Expansion/Swell

Finding: The soil was found to swell 0.15% under a load of 2340 psf.



Jeffrey A. Kuhn, Ph.D., P.E. 11/20/2014
Analysis & Quality Review/Date
Testing Performed By: Mark Fountain, Ph.D.

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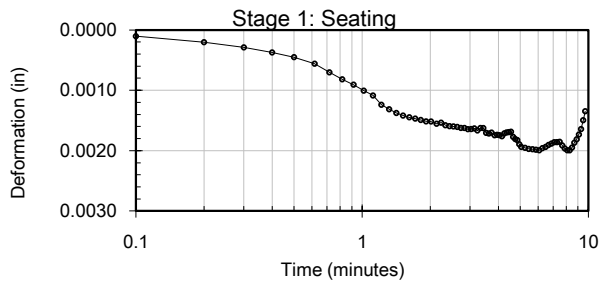
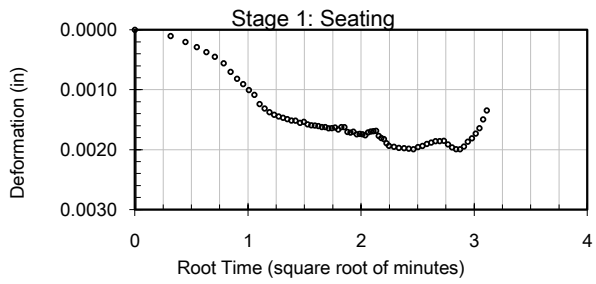
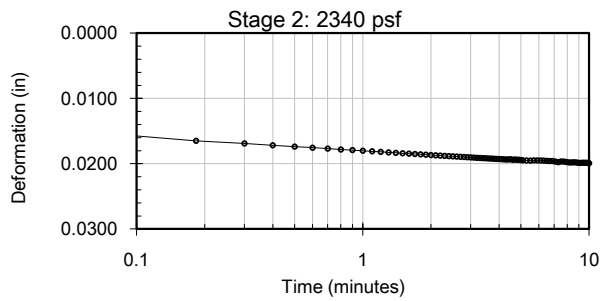
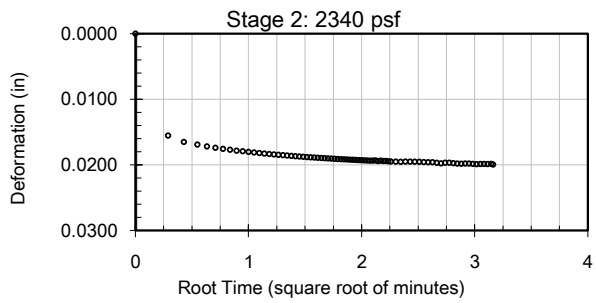
One-Dimensional Swell or Collapse of Cohesive Soils

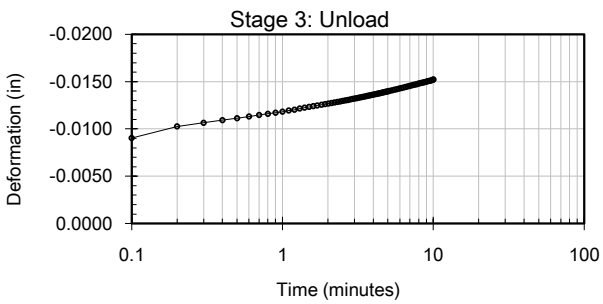
Client:	HVJ Associates	TRI Log #:	E2391-19-08
Project:	Montopolis WRI Tank AG	Test Method:	ASTM D4546-B
Specimen:	B-11A (13.5-15)		
Loading Pressure:	2340 psf		

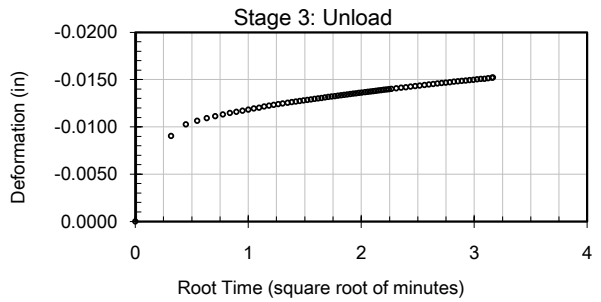


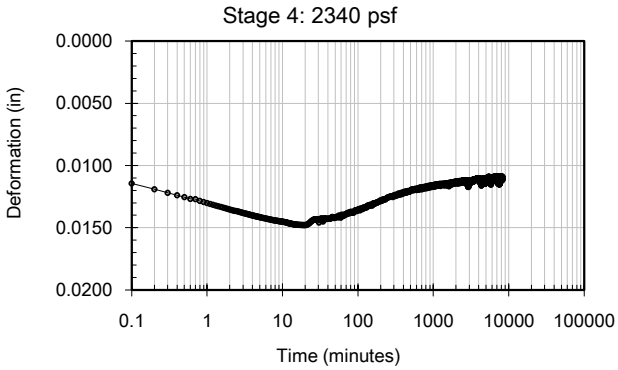


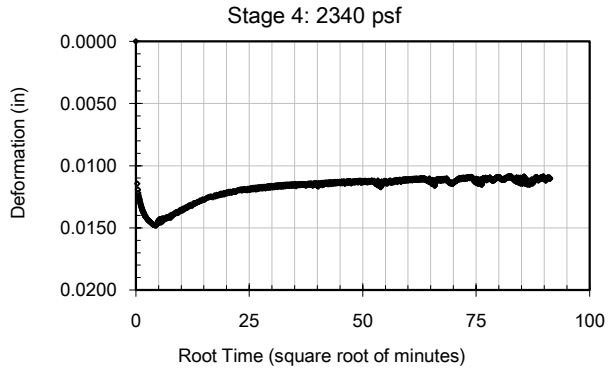












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TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

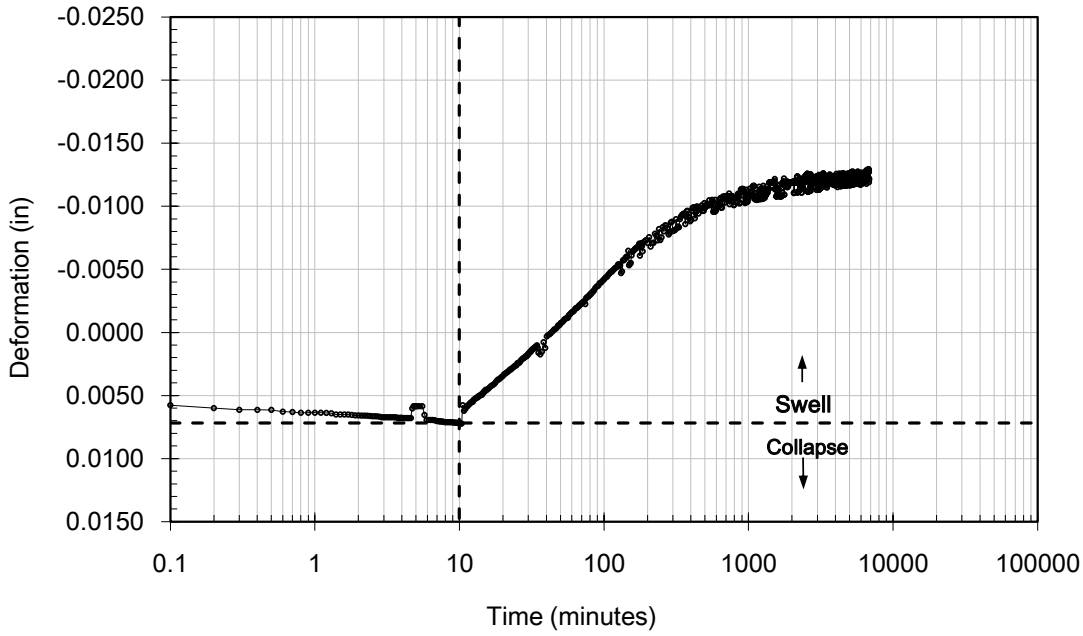
One-Dimensional Swell or Collapse of Cohesive Soils

Client:	HVJ Associates	TRI Log #:	E2391-19-08
Project:	Montopolis WRI Tank AG	Test Method:	ASTM D4546-B
Specimen:	B-12A (13.5-15)		
Loading Pressure:	1170 psf		

Specimen Properties[1]	Initial[2]	Inundation[3]	Final[4]
Water Content, ω (%)	17.7	-	20.6
Diameter, d (in)	2.495	-	-
Height, h (in)	0.998	0.996	1.015
Void Ratio, e	0.475	0.472	0.499
Degree of Saturation, S (%)	98.8	-	≈100
Strain (%)[5]	-0.199	0	**-1.842**

1. The undisturbed specimen was provided by the client. The specimen was trimmed using a trimming turntable and mounted. G_s was assumed to be 2.65. Calculations include measured machine deflections.
2. As trimmed in the specimen ring.
3. Height following seating load, first load application, and second load application. Sample was inundated with tap water 10 minutes after the second load application.
4. Strain Measurements are based on the height of the sample at Stage 4, inundation.
5. Sign convention: (+) Compression/Collapse, (-) Expansion/Swell

Finding: The soil was found to swell 1.84% under a load of 1170 psf.



Jeffrey A. Kuhn, Ph.D., P.E. 11/20/2014
Analysis & Quality Review/Date
Testing Performed By: Mark Fountain, Ph.D.

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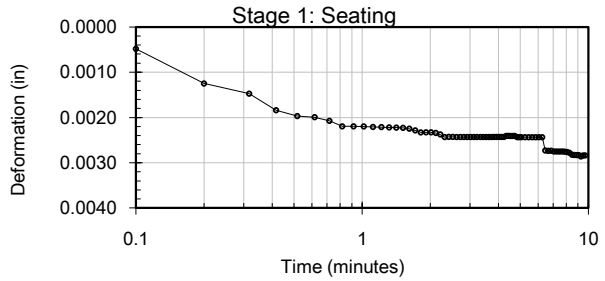

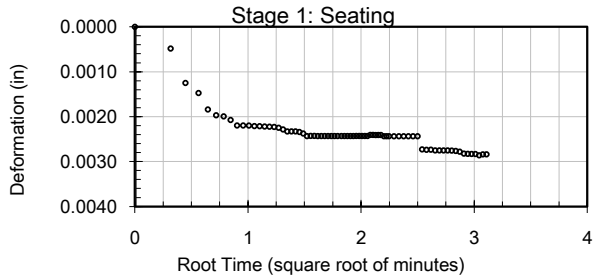

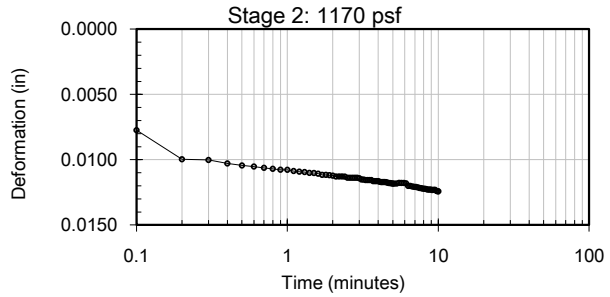

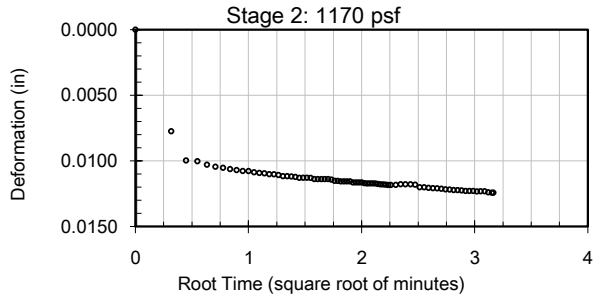

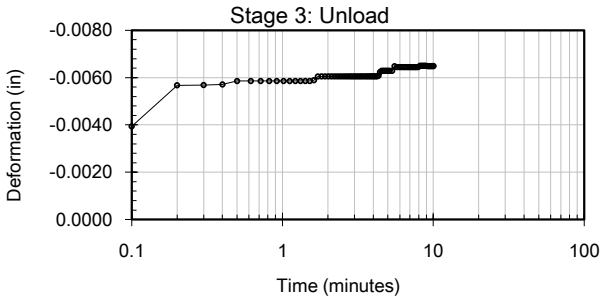

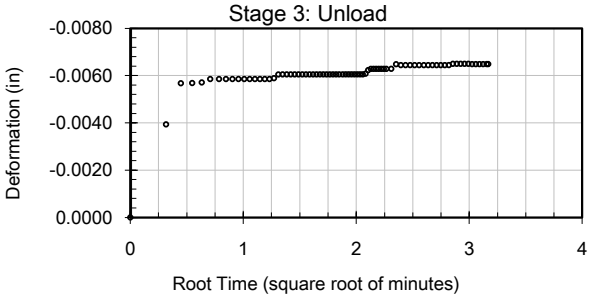

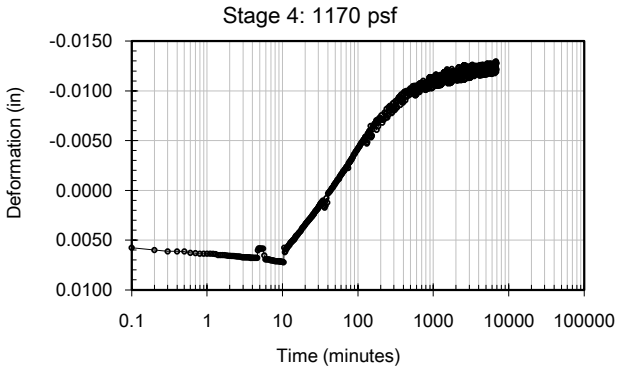

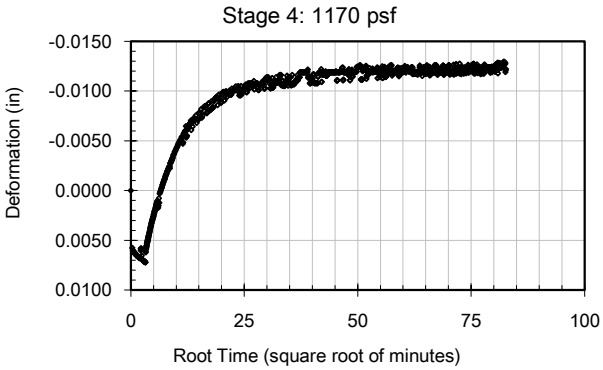

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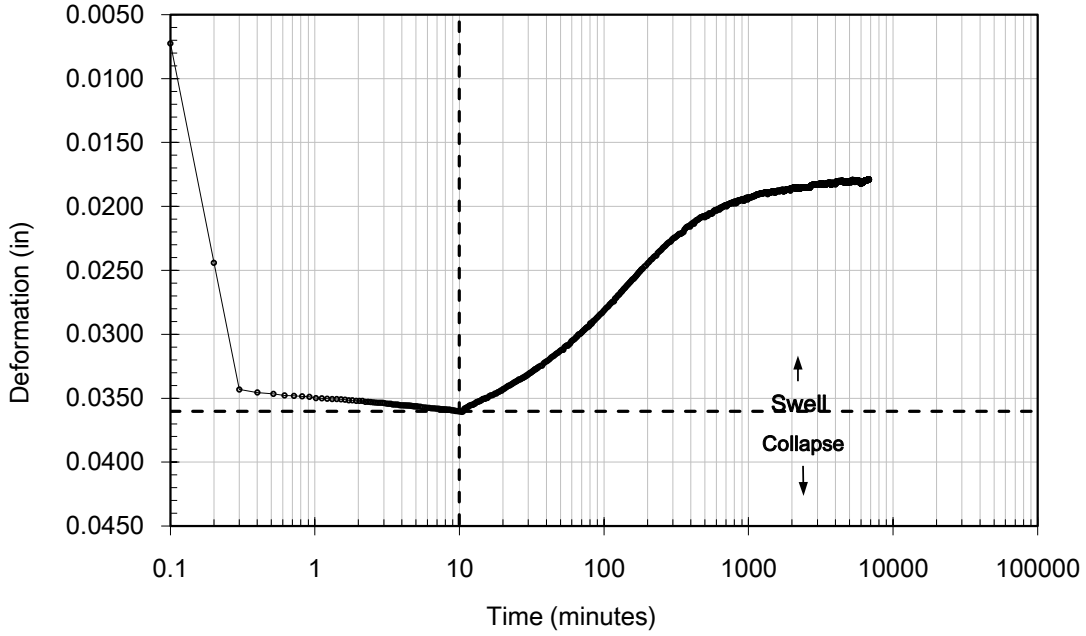
One-Dimensional Swell or Collapse of Cohesive Soils

Client:	HVJ Associates	TRI Log #:	E2391-19-08
Project:	Montopolis WRI Tank AG	Test Method:	ASTM D4546-B
Specimen:	B-12A (18.5-20)		
Loading Pressure:	1820 psf		

Specimen Properties[1]	Initial[2]	Inundation[3]	Final[4]
Water Content, ω (%)	18.9	-	23.0
Diameter, d (in)	2.498	-	-
Height, h (in)	0.992	0.990	1.007
Void Ratio, e	0.448	0.444	0.469
Degree of Saturation, S (%)	≈100	-	≈100
Strain (%)[5]	-0.226	0	**-1.693**

1. The undisturbed specimen was provided by the client. The specimen was trimmed using a trimming turntable and mounted. G_s was assumed to be 2.65. Calculations include measured machine deflections.
2. As trimmed in the specimen ring.
3. Height following seating load, first load application, and second load application. Sample was inundated with tap water 10 minutes after the second load application.
4. Strain Measurements are based on the height of the sample at Stage 4, inundation.
5. Sign convention: (+) Compression/Collapse, (-) Expansion/Swell

Finding: The soil was found to swell 1.69% under a load of 1820 psf.



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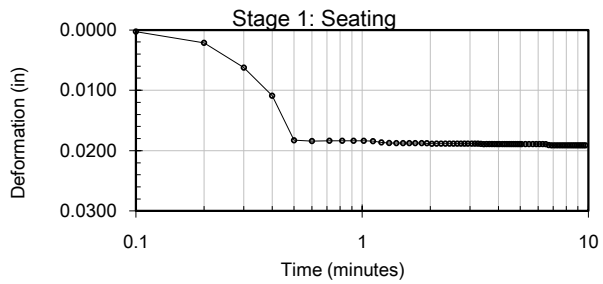
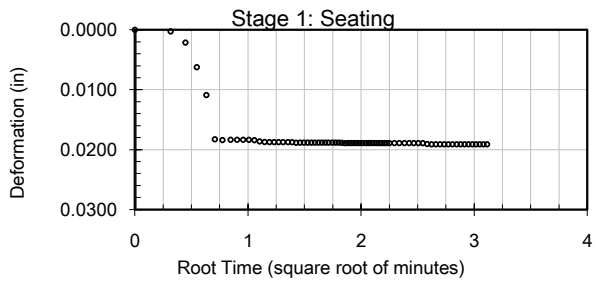
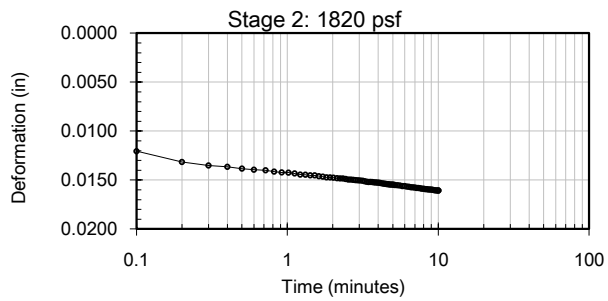
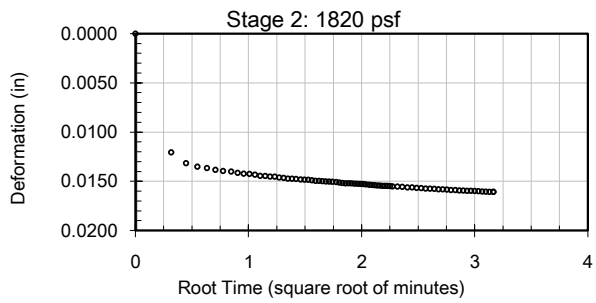
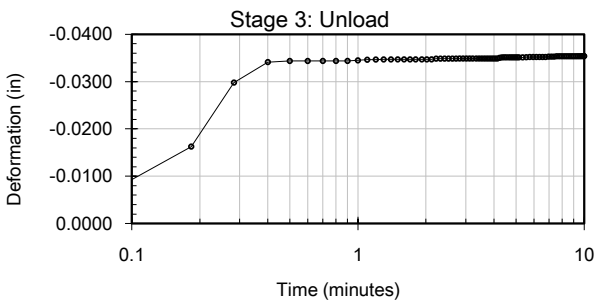
Project:	Montopolis WRI Tank AG	Test Method:	ASTM D4546-B
Specimen:	B-12A (18.5-20)		
Loading Pressure:	1820 psf		

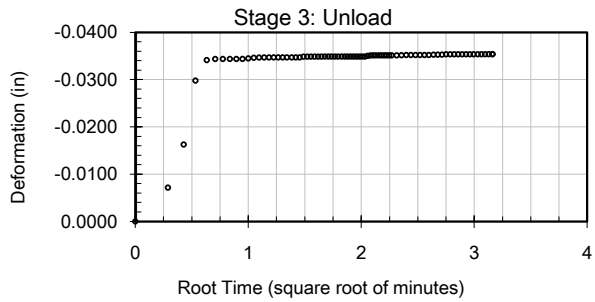


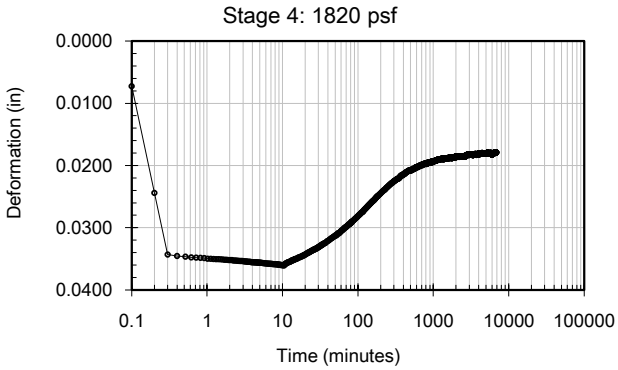


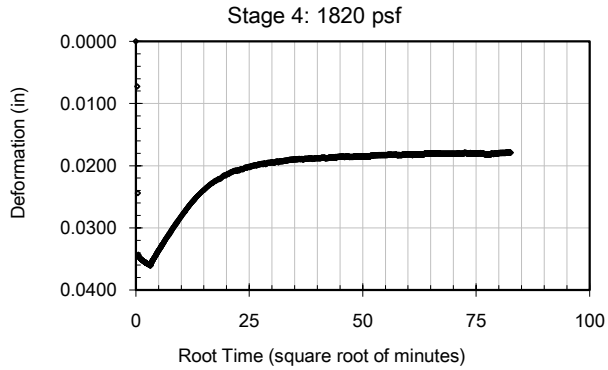












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APPENDIX C

SULFATE CONTENT RESULTS

July 07, 2014

Russell Sieg
HVJ Associates, Inc.
4201 Freidrich Lane, Suite 110
Austin, Texas 78744-1045
TEL: (512) 447-9081
FAX (512) 443-3442

Order No.: 1406310

RE: Montopolis WRI Tanks

Dear Russell Sieg:

DHL Analytical, Inc. received 3 sample(s) on 6/27/2014 for the analyses presented in the following report.

There were no problems with the analyses and all data for associated QC met EPA or laboratory specifications except where noted in the Case Narrative and all estimated uncertainties of results are within method specifications.

If you have any questions regarding these tests results, please feel free to call.

Sincerely,

John DuPont
General Manager

This report was performed under the accreditation of the State of Texas Laboratory Certification Number: T104704211-14-12

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AnalyticalQCSummaryReport 1406310 9

DHL ANALYTICAL

2300 Double Creek Drive • Round Rock, TX 78664
Phone (512) 388-8222 • FAX (512) 388-8229

№ 39378

CHAIN-OF-CUSTODY

CLIENT: HVJ ASSOCIATES
ADDRESS: 4201 FREIDRICH LN, #110
PHONE: 512-447-9081 FAX
DATA REPORTED TO: ZACH LOOTENS
ADDITIONAL REPORT COPIES TO:

DATE: 6/27/14 PAGE 1 OF 1
PO #: 14-0475A DHL WORK ORDER #: 1400310
PROJECT LOCATION OR NAME: MONTOPOLIS WRI TANK
CLIENT PROJECT #: AG1310756 COLLECTOR: K. ELLISON

Authorize 5% surcharge for TRRP report? ☐ Yes ☐ No

S=SOIL W=WATER A=AIR P=PAINT SL=SLUDGE OT=OTHER

PRESERVATION: HCl, HNO_3, H_2SO_4 ☐ NaOH ☐, ICE, UNPRESERVED

ANALYSES: BTEX ☐ MTBE ☐, TRPH 418.1 ☐, TPH 1005 ☐ TPH 1006 ☐, GASOLINE MOD 8015 ☐, DIESEL - MOD 8015 ☐, VOC 8260 ☐, SVOC 8270 ☐ PAH 8270 ☐ HOLDPAH ☐, 8081 PESTICIDES ☐ 8151 HERBICIDES ☐, 8082 PCBS ☐, TCLP - METALS (RCRA) ☐ TCLP VOC ☐, TCLP - PEST ☐ HERB ☐ Semi-VOC ☐, TOTAL METALS (RCRA) ☐ OTHER LIST ☐, LEAD - TOTAL ☐ D.W. 200.8 ☐ TCLP ☐, RCI ☐ TOX ☐ FLASHPOINT ☐, TDS ☐ % MOISTURE ☐ CYANIDE ☐, pH ☐ HEXAVALENT CHROMIUM ☐, EXPLOSIVES ☐ PECHLORATE ☐, CHLORIDE ☐ ANIONS ☐ ALKALINITY ☐, 6200.7 SULFATES

Field Sample I.D.	DHL Lab #	Date	Time	Matrix	Container Type	# of Containers	HCl	HNO_3	H_2SO_4 ☐ NaOH ☐	ICE	UNPRESERVED	6200.7 SULFATES	FIELD NOTES
B-1 4-5.5	01	6/8	11AM	Solid	4 OZ Jar	1					X	X	
B-2 6-7	02	6/8	12PM	Solid	4 OZ Jar	1					X	X	
B-3 6-7.5	03	6/8	1PM	Solid	4 OZ Jar	1					X	X	
TOTAL													

RELINQUISHED BY: (Signature) DATE/TIME 6/27/14 4:55p RECEIVED BY: (Signature)
RELINQUISHED BY: (Signature) DATE/TIME RECEIVED BY: (Signature)
RELINQUISHED BY: (Signature) DATE/TIME RECEIVED BY: (Signature)

☐ DHL DISPOSAL @ $5.00 each ☐ Return

TURN AROUND TIME
RUSH ☐ CALL FIRST
1 DAY ☐ CALL FIRST
2 DAY ☐
NORMAL ☒
OTHER ☐

LABORATORY USE ONLY:
RECEIVING TEMP: 26.6 THERM #: 57
CUSTODY SEALS - ☐ BROKEN ☐ INTACT ☒ NOT USED
☐ CARRIER BILL #
☐ APC DELIVERY
☒ HAND DELIVERED

DHL Analytical, Inc.

Sample Receipt Checklist

Client Name HVJ Associates, Inc. | Date Received: 6/27/2014

Work Order Number 1406310 | Received by MD

Checklist completed by: Signature 6/27/2014 Date | Reviewed by Initials 6/27/2014 Date

Carrier name Hand Delivered

Shipping container/cooler in good condition?	Yes ☑	No ☐	Not Present ☐
Custody seals intact on shippping container/cooler?	Yes ☐	No ☐	Not Present ☑
Custody seals intact on sample bottles?	Yes ☐	No ☐	Not Present ☑
Chain of custody present?	Yes ☑	No ☐	
Chain of custody signed when relinquished and received?	Yes ☑	No ☐	
Chain of custody agrees with sample labels?	Yes ☑	No ☐	
Samples in proper container/bottle?	Yes ☑	No ☐	
Sample containers intact?	Yes ☑	No ☐	
Sufficient sample volume for indicated test?	Yes ☑	No ☐	
All samples received within holding time?	Yes ☑	No ☐	
Container/Temp Blank temperature in compliance?	Yes ☑	No ☐	26.6 °C
Water - VOA vials have zero headspace?	Yes ☐	No ☐	No VOA vials submitted ☑
Water - pH<2 acceptable upon receipt?	Yes ☐	No ☐	NA ☑ LOT #
	Adjusted?		Checked by
Water - ph>9 (S) or ph>12 (CN) acceptable upon receipt?	Yes ☐	No ☐	NA ☑ LOT #
	Adjusted?		Checked by

Any No response must be detailed in the comments section below.

Client contacted _____ Date contacted: _____ Person contacted _____

Contacted by: _____ Regarding _____

Comments: _____

Corrective Action _____

Page 1 of 1

DHL Analytical, Inc. **Date:** *07-Jul-14*

CLIENT: HVJ Associates, Inc.
Project: Montopolis WRI Tanks
Lab Order: 1406310

CASE NARRATIVE

Samples were analyzed using the methods outlined in the following references:

Sulfate Content in Soil by Method TEX620J. (This parameter is not NELAC Certified)

All method blanks, sample duplicates, laboratory spikes, and/or matrix spikes met quality assurance objectives. For Sulfate Content in Soil Analysis, Sulfate was detected below the reporting limit for Method Blank-64458. The concentration detected in the samples is more than 5 times the concentration in the Method Blank. No further corrective action was taken.

DHL Analytical, Inc.

Date: *07-Jul-14*

CLIENT:	HVJ Associates, Inc.	**Client Sample ID:**	B-8, 4'-5.5'
Project:	Montopolis WRI Tanks	**Lab ID:**	1406310-01
Project No:	AG1310756	**Collection Date:**	06/08/14 11:00 AM
Lab Order:	1406310	**Matrix:**	SOIL

Analyses	Result	MDL	RL	Qual	Units	DF	Date Analyzed
CHLORIDE AND SULFATE CONTENT IN SOIL		**TEX620J**					Analyst: **AV**
Sulfate	32.8	19.9	49.8	JN	ppm-dry	10	07/03/14 09:54 AM

Qualifiers:				
	*	Value exceeds TCLP Maximum Concentration Level	B	Analyte detected in the associated Method Blank
	C	Sample Result or QC discussed in the Case Narrative	DF	Dilution Factor
	E	TPH pattern not Gas or Diesel Range Pattern	J	Analyte detected between MDL and RL
	MDL	Method Detection Limit	ND	Not Detected at the Method Detection Limit
	RL	Reporting Limit	S	Spike Recovery outside control limits
	N	Parameter not NELAC certified		

DHL Analytical, Inc.

Date: *07-Jul-14*

CLIENT:	HVJ Associates, Inc.	**Client Sample ID:**	B-9 6'-7'
Project:	Montopolis WRI Tanks	**Lab ID:**	1406310-02
Project No:	AG1310756	**Collection Date:**	06/08/14 12:00 PM
Lab Order:	1406310	**Matrix:**	SOIL

Analyses	Result	MDL	RL	Qual	Units	DF	Date Analyzed
CHLORIDE AND SULFATE CONTENT IN SOIL		**TEX620J**					Analyst: **AV**
Sulfate	22.2	20.0	50.0	JN	ppm-dry	10	07/03/14 10:23 AM

Qualifiers:				
	*	Value exceeds TCLP Maximum Concentration Level	B	Analyte detected in the associated Method Blank
	C	Sample Result or QC discussed in the Case Narrative	DF	Dilution Factor
	E	TPH pattern not Gas or Diesel Range Pattern	J	Analyte detected between MDL and RL
	MDL	Method Detection Limit	ND	Not Detected at the Method Detection Limit
	RL	Reporting Limit	S	Spike Recovery outside control limits
	N	Parameter not NELAC certified		

DHL Analytical, Inc.

Date: *07-Jul-14*

CLIENT:	HVJ Associates, Inc.	**Client Sample ID:**	B-10 6-7.5
Project:	Montopolis WRI Tanks	**Lab ID:**	1406310-03
Project No:	AG1310756	**Collection Date:**	06/08/14 01:00 PM
Lab Order:	1406310	**Matrix:**	SOIL

Analyses	Result	MDL	RL	Qual	Units	DF	Date Analyzed
CHLORIDE AND SULFATE CONTENT IN SOIL		**TEX620J**					Analyst: **AV**
Sulfate	59.4	19.8	49.6	N	ppm-dry	10	07/03/14 10:38 AM

Qualifiers:				
	*	Value exceeds TCLP Maximum Concentration Level	B	Analyte detected in the associated Method Blank
	C	Sample Result or QC discussed in the Case Narrative	DF	Dilution Factor
	E	TPH pattern not Gas or Diesel Range Pattern	J	Analyte detected between MDL and RL
	MDL	Method Detection Limit	ND	Not Detected at the Method Detection Limit
	RL	Reporting Limit	S	Spike Recovery outside control limits
	N	Parameter not NELAC certified		

DHL Analytical, Inc.

Date: *07-Jul-14*

CLIENT: HVJ Associates, Inc.
Work Order: 1406310
Project: Montopolis WRI Tanks

ANALYTICAL QC SUMMARY REPORT

RunID: IC_140703A

The QC data in batch 64458 applies to the following samples: 1406310-01A, 1406310-02A, 1406310-03A

Sample ID	**MB-64458**	Batch ID:	**64458**	TestNo:	**Tex620J**	Units:	**ppm-dry**
SampType:	**MBLK**	Run ID:	**IC_140703A**	Analysis Date:	**7/3/2014 9:03:41 AM**	Prep Date:	**7/1/2014**

Analyte	Result	RL	SPK value	Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Sulfate	3.91	5.00								N

Sample ID	**LCS-64458**	Batch ID:	**64458**	TestNo:	**Tex620J**	Units:	**ppm-dry**
SampType:	**LCS**	Run ID:	**IC_140703A**	Analysis Date:	**7/3/2014 9:18:18 AM**	Prep Date:	**7/1/2014**

Analyte	Result	RL	SPK value	Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Sulfate	221	4.98	199.2	0	111	80	120			N

Sample ID	**LCSD-64458**	Batch ID:	**64458**	TestNo:	**Tex620J**	Units:	**ppm-dry**
SampType:	**LCSD**	Run ID:	**IC_140703A**	Analysis Date:	**7/3/2014 9:32:54 AM**	Prep Date:	**7/1/2014**

Analyte	Result	RL	SPK value	Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Sulfate	221	4.97	198.8	0	111	80	120	0.055	20	N

Sample ID	**1406310-01A-DUP**	Batch ID:	**64458**	TestNo:	**Tex620J**	Units:	**ppm-dry**
SampType:	**DUP**	Run ID:	**IC_140703A**	Analysis Date:	**7/3/2014 10:09:04 AM**	Prep Date:	**7/1/2014**

Analyte	Result	RL	SPK value	Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Sulfate	34.9	49.9	0	32.80				6.16	25	N

Qualifiers:				
	B	Analyte detected in the associated Method Blank	DF	Dilution Factor
	J	Analyte detected between MDL and RL	MDL	Method Detection Limit
	ND	Not Detected at the Method Detection Limit	R	RPD outside accepted control limits
	RL	Reporting Limit	S	Spike Recovery outside control limits
	J	Analyte detected between SDL and RL	N	Parameter not NELAC certified

Appendix B
Site Plan and Soil Boring Locations

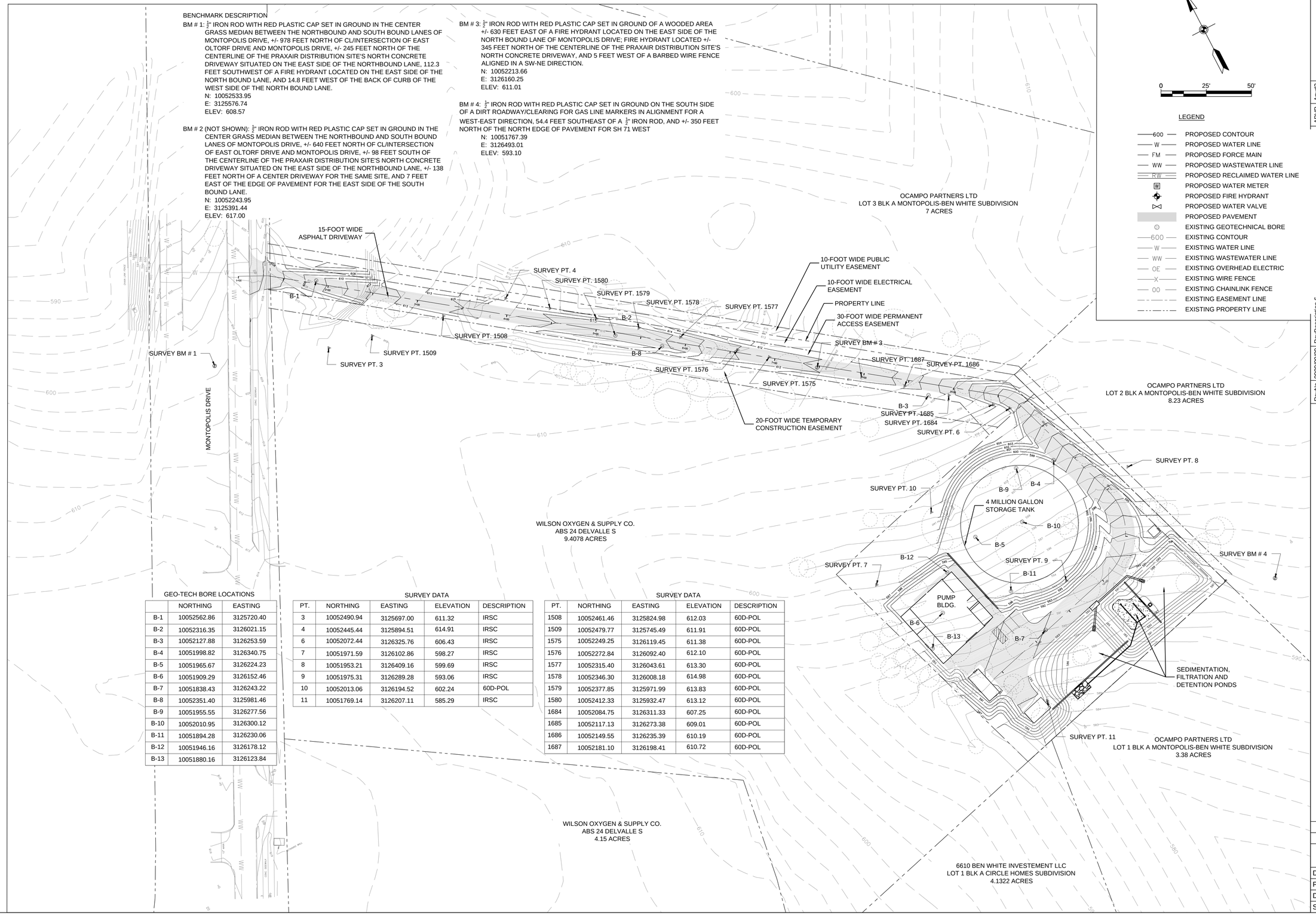
BENCHMARK DESCRIPTION

BM # 1: $\frac{3}{4}$" IRON ROD WITH RED PLASTIC CAP SET IN GROUND IN THE CENTER GRASS MEDIAN BETWEEN THE NORTHBOUND AND SOUTH BOUND LANES OF MONTOPOLIS DRIVE, +/- 978 FEET NORTH OF CL/INTERSECTION OF EAST OLTORF DRIVE AND MONTOPOLIS DRIVE, +/- 245 FEET NORTH OF THE CENTERLINE OF THE PRAXAIR DISTRIBUTION SITE'S NORTH CONCRETE DRIVEWAY SITUATED ON THE EAST SIDE OF THE NORTHBOUND LANE, 112.3 FEET SOUTHWEST OF A FIRE HYDRANT LOCATED ON THE EAST SIDE OF THE NORTH BOUND LANE, AND 14.8 FEET WEST OF THE BACK OF CURB OF THE WEST SIDE OF THE NORTH BOUND LANE.
N: 10052533.95
E: 3125576.74
ELEV: 608.57

BM # 2 (NOT SHOWN): $\frac{1}{2}$" IRON ROD WITH RED PLASTIC CAP SET IN GROUND IN THE CENTER GRASS MEDIAN BETWEEN THE NORTHBOUND AND SOUTH BOUND LANES OF MONTOPOLIS DRIVE, +/- 640 FEET NORTH OF CL/INTERSECTION OF EAST OLTORF DRIVE AND MONTOPOLIS DRIVE, +/- 98 FEET SOUTH OF THE CENTERLINE OF THE PRAXAIR DISTRIBUTION SITE'S NORTH CONCRETE DRIVEWAY SITUATED ON THE EAST SIDE OF THE NORTHBOUND LANE, +/- 138 FEET NORTH OF A CENTER DRIVEWAY FOR THE SAME SITE, AND 7 FEET EAST OF THE EDGE OF PAVEMENT FOR THE EAST SIDE OF THE SOUTH BOUND LANE.
N: 10052243.95
E: 3125391.44
ELEV: 617.00

BM # 3: $\frac{3}{4}$" IRON ROD WITH RED PLASTIC CAP SET IN GROUND OF A WOODED AREA +/- 630 FEET EAST OF A FIRE HYDRANT LOCATED ON THE EAST SIDE OF THE NORTH BOUND LANE OF MONTOPOLIS DRIVE; FIRE HYDRANT LOCATED +/- 345 FEET NORTH OF THE CENTERLINE OF THE PRAXAIR DISTRIBUTION SITE'S NORTH CONCRETE DRIVEWAY, AND 5 FEET WEST OF A BARBED WIRE FENCE ALIGNED IN A SW-NE DIRECTION.
N: 10052213.66
E: 3126160.25
ELEV: 611.01

BM # 4: $\frac{1}{2}$" IRON ROD WITH RED PLASTIC CAP SET IN GROUND ON THE SOUTH SIDE OF A DIRT ROADWAY/CLEARING FOR GAS LINE MARKERS IN ALIGNMENT FOR A WEST-EAST DIRECTION, 54.4 FEET SOUTHEAST OF A $\frac{3}{4}$" IRON ROD, AND +/- 350 FEET NORTH OF THE NORTH EDGE OF PAVEMENT FOR SH 71 WEST
N: 10051767.39
E: 3126493.01
ELEV: 593.10



LEGEND

600	PROPOSED CONTOUR
W	PROPOSED WATER LINE
FM	PROPOSED FORCE MAIN
WW	PROPOSED WASTEWATER LINE
RW	PROPOSED RECLAIMED WATER LINE
W	PROPOSED WATER METER
	PROPOSED FIRE HYDRANT
	PROPOSED WATER VALVE
	PROPOSED PAVEMENT
	EXISTING GEOTECHNICAL BORE
600	EXISTING CONTOUR
W	EXISTING WATER LINE
WW	EXISTING WASTEWATER LINE
OE	EXISTING OVERHEAD ELECTRIC
X	EXISTING WIRE FENCE
OO	EXISTING CHAINLINK FENCE
	EXISTING EASEMENT LINE
	EXISTING PROPERTY LINE

GEO-TECH BORE LOCATIONS

	NORTHING	EASTING
B-1	10052562.86	3125720.40
B-2	10052316.35	3126021.15
B-3	10052127.88	3126253.59
B-4	10051998.82	3126340.75
B-5	10051965.67	3126224.23
B-6	10051909.29	3126152.46
B-7	10051838.43	3126243.22
B-8	10052351.40	3125981.46
B-9	10051955.55	3126277.56
B-10	10052010.95	3126300.12
B-11	10051894.28	3126230.06
B-12	10051946.16	3126178.12
B-13	10051880.16	3126123.84

SURVEY DATA

PT.	NORTHING	EASTING	ELEVATION	DESCRIPTION
3	10052490.94	3125697.00	611.32	IRSC
4	10052445.44	3125894.51	614.91	IRSC
6	10052072.44	3126325.76	606.43	IRSC
7	10051971.59	3126102.86	598.27	IRSC
8	10051953.21	3126409.16	599.69	IRSC
9	10051975.31	3126289.28	593.06	IRSC
10	10052013.06	3126194.52	602.24	60D-POL
11	10051769.14	3126207.11	585.29	IRSC

SURVEY DATA

PT.	NORTHING	EASTING	ELEVATION	DESCRIPTION
1508	10052461.46	3125824.98	612.03	60D-POL
1509	10052479.77	3125745.49	611.91	60D-POL
1575	10052249.25	3126119.45	611.38	60D-POL
1576	10052272.84	3126092.40	612.10	60D-POL
1577	10052315.40	3126043.61	613.30	60D-POL
1578	10052346.30	3126008.18	614.98	60D-POL
1579	10052377.85	3125971.99	613.83	60D-POL
1580	10052412.33	3125932.47	613.12	60D-POL
1684	10052084.75	3126311.33	607.25	60D-POL
1685	10052117.13	3126273.38	609.01	60D-POL
1686	10052149.55	3126235.39	610.19	60D-POL
1687	10052181.10	3126198.41	610.72	60D-POL

60% SUBMITTAL

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SEPTEMBER 10, 2014
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NO.	DATE	DSGN	DR	CHK	REVISION	BY	APVD
RevNo	9999/09/09	D. MURPHY	J. GOESSLING	C. NEWTON	RevDescription 1 (Use Bottom Row First)	APVR	Apvd?
RevNo	9999/09/09				RevDescription 2	APVR	Apvd?
RevNo	9999/09/09				RevDescription 3	APVR	Apvd?
RevNo	9999/09/09				RevDescription 4	APVR	Apvd?
RevNo	9999/09/09				RevDescription 5	APVR	Apvd?
RevNo	9999/09/09				RevDescription 6	APVR	Apvd?

MONTOPOLIS RECYCLED WATER PUMP STATION

CITY OF AUSTIN - AUSTIN WATER UTILITY

K·FRIESE + ASSOCIATES
PUBLIC PROJECT ENGINEERING
1120 S. Capital of Texas Highway
Bldg. 2, Suite 100
Austin, Texas 78746
P: 512.330.1704 F: 512.330.1784
TBPE Firm Registration # 2225
www.kfriese.com

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MONTOPOLIS RECYCLED WATER PUMP STATION

60% PLANS
OVERALL SITE LAYOUT

1" = 40'

VERIFY SCALE

BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	July 2014
PROJ	PROJECT-NO
DWG	DRAWING-NO
SHEET	1 of 5

PurposeOfIssue

FILENAME: 0278_OVERALL SITE LAYOUT.DWG PLOT DATE: February 28, 2014 PLOT TIME: September 10, 2014

Appendix C
Calculations

Bearing Cacpacity Calculations

Project	Montopolis Pump Station	**Performed By**	VNV
Site	Storage Tank	**Date**	2/18/2015
Note			

Footing Dimensions

Footing width, **B**	4	ft
Footing length, **L**	402	ft
Unfactored horizontal load, **H**	0	kips
Unfactored vertical load, **V**	0	kips
Projected direction of load in the plane of the footing, **ɵ**	0	Deg
Footing embedment depth, $\mathbf{D_f}$	0	ft

Bearing Soil Data

Total unit weight, **ɤ**	120	pcf
Water unit weight, $\mathbf{ɤ_w}$	62.4	pcf
Friction angle, **ϕ**	34	Deg
Cohesion, **c**	0.1	ksf

Bearing capacity factors (AASHTO Table 10.6.3.1.2a-1)

Cohesion term, **Nc**	42.2
Surcharge term, **Nq**	29.4
Unit weight term, **Nɤ**	41.1

Shape factors

Sc	1.01
Sɤ	1.00
Sq	1.00

Load inclination factors

n	1.010
$\mathbf{i_c}$	1
$\mathbf{i_ɤ}$	1
$\mathbf{i_q}$	1

Groundwater Depth Coefficients

C_{wq}	1
$C_{wɤ}$	1

Nominal bearing resistance (AASHTO 10.6.3.1.2a-1)

$$q_n = cN_{cm} + ɤD_f N_{qm} C_{wq} + 0.5ɤBN_{ɤm} C_{wɤ}$$

Bearing capacity

qn	**14.074**	ksf

Factor of safety

FS	3

Allowable bearing capacity

qall	**4.691**	ksf

Bearing Cacpacity Calculations

Project	Montopolis Pump Station	**Performed By**	VNV
Site	Pump Station	**Date**	2/18/2015
Note		**Project Number**	

Footing Dimensions

Footing width, **B**	2	ft
Footing length, **L**	65	ft
Unfactored horizontal load, **H**	0	kips
Unfactored vertical load, **V**	0	kips
Projected direction of load in the plane of the footing, **θ**	0	Deg
Footing embedment depth, $\mathbf{D_f}$	0	ft

Bearing Soil Data

Total unit weight, **ɤ**	120	pcf
Water unit weight, $\mathbf{ɤ_w}$	62.4	pcf
Friction angle, **ϕ**	34	Deg
Cohesion, **c**	100	pcf

Bearing capacity factors (AASHTO, 2014, 7th Ed, Table 10.6.3.1.2a-1)

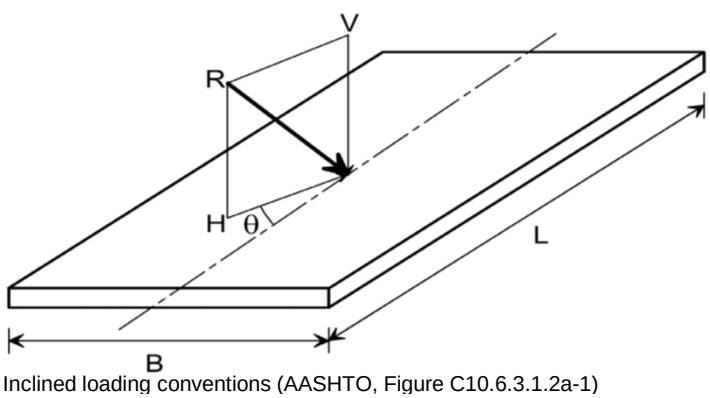
Cohesion term, **Nc**	42.2
Surcharge term, **Nq**	29.4
Unit weight term, **Nɤ**	41.1

Shape factors

Sc	1.02
Sɤ	0.99
Sq	1.01

Load inclination factors

n	1.03
$\mathbf{i_c}$	1
$\mathbf{i_ɤ}$	1
$\mathbf{i_q}$	1



Inclined loading conventions (AASHTO, Figure C10.6.3.1.2a-1)

Groundwater depth coefficients

$\mathbf{C_{wq}}$	1.0
$\mathbf{C_{wɤ}}$	1.0

Depth correction factor

$\mathbf{d_q}$	1.0

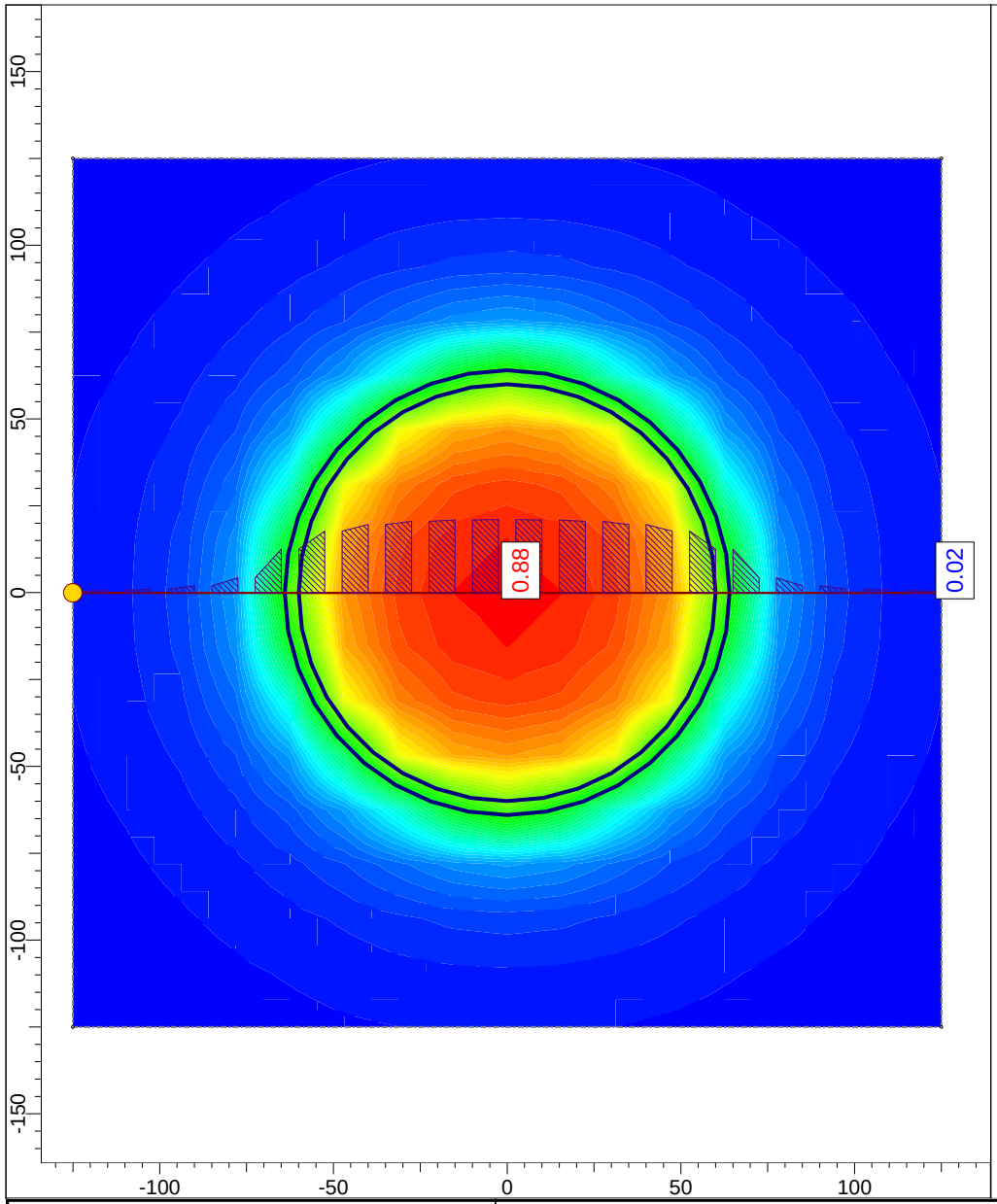
Nominal bearing resistance (AASHTO, 2014, 7th Ed, 10.6.3.1.2a-1)

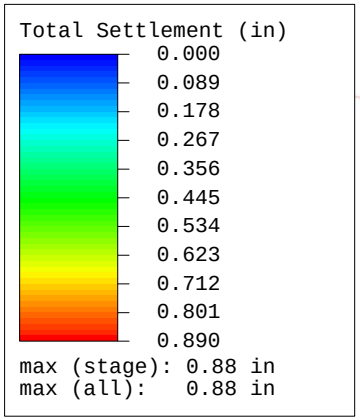
$$q_n = cN_{cm} + ɤD_f N_{qm} C_{wq} + 0.5ɤBN_{ɤm} C_{wɤ}$$

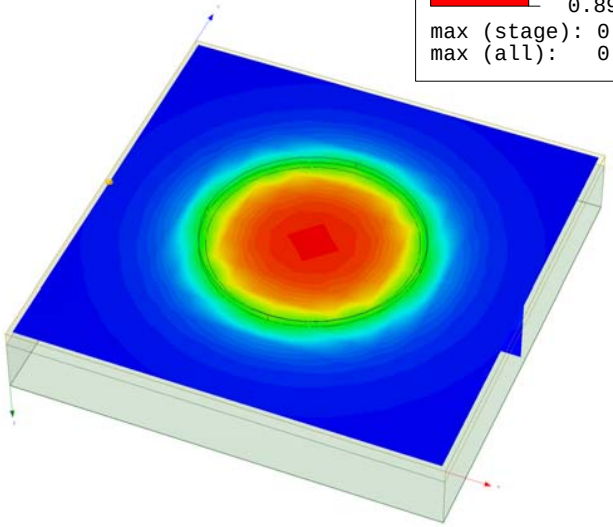
in which:

$$N_{cm} = N_c S_c i_c$$
$$N_{qm} = N_q S_q d_q i_q$$
$$N_{ɤm} = N_ɤ S_ɤ i_ɤ$$

Bearing capacity, $\mathbf{q_n}$	**9.18**	ksf
Factor of safety, FS	3	
Allowable bearing capacity, $\mathbf{q_{all}}$	**3.06**	ksf







rocscience	Project	Montopolis Pump Station Facility	
	Analysis Description	Storage Tank Settlement	
	Drawn By	VNV	Company: CH2M HILL
	Date	1/20/2015, 2:38:38 PM	File Name: Montopolis_Storage tank.s3z

SETTLE3D 3.004

Settle3D Analysis Information
Montopolis Pump Station Facility

Project Settings

Document Name	Montopolis_Storage tank.s3z
Project Title	Montopolis Pump Station Facility
Analysis	Storage Tank Settlement
Author	VNV
Company	CH2M HILL
Date Created	1/20/2015, 2:38:38 PM
Stress Computation Method	Westergaard
Use average properties to calculate layered stresses	

Stage Settings

Stage #	Name
1	Stage 1

Results

Time taken to compute: 0.629888 seconds

Stage: Stage 1

Data Type	Minimum	Maximum
Total Settlement [in]	0	0.880181
Consolidation Settlement [in]	0	0
Immediate Settlement [in]	0	0.880181
Loading Stress [ksf]	0	4
Total Stress [ksf]	0	6.86274
Total Strain	8.51767e-008	0.0024287
Degree of Consolidation [%]	0	0
Pre-consolidation Stress [ksf]	0.0502981	6.86117
Over-consolidation Ratio	1	1
Void Ratio	0	0
Hydroconsolidation Settlement [in]	0	0
Undrained Shear Strength	0	1.03802

Loads

1. Circular Load

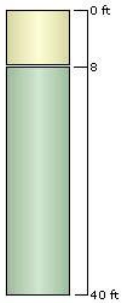
Radius	60 ft
Center	(1.46566e-014, -7.79708e-014)
Load Type	Flexible
Area of Load	11252.4 ft^2
Load	-1 ksf
Depth	0 ft
Installation Stage	Stage 1

2. Circular Load

Radius	64 ft
Center	(-7.5775e-016, -1.23134e-015)
Load Type	Flexible
Area of Load	12802.7 ft^2
Load	4 ksf
Depth	0 ft
Installation Stage	Stage 1

Soil Layers

Layer #	Type	Thickness [ft]	Depth [ft]
1	Structural Fill	8	0
2	Very Stiff Clay	32	8



Soil Properties

Property	Structural Fill	Very Stiff Clay
Color		
Unit Weight [kips/ft^3]	0.125	0.12
Immediate Settlement	Enabled	Enabled
Es [ksf]	3500	1150
Esur [ksf]	3500	1150
Undrained Su A [kips/ft2]	0	0
Undrained Su S	0.2	0.2
Undrained Su m	0.8	0.8

Query Lines

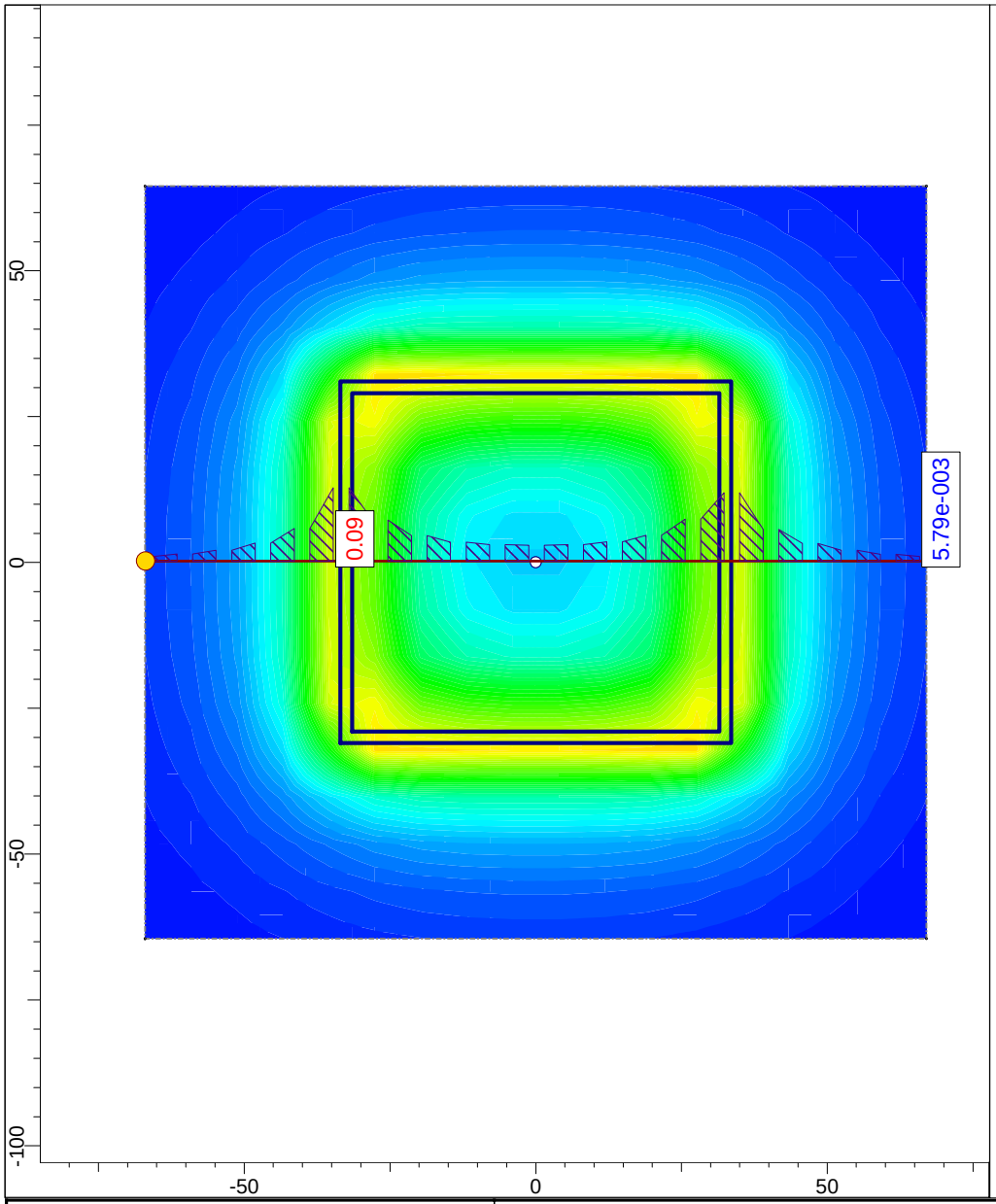
Line #	Start Location	End Location	Horizontal Divisions	Vertical Divisions
1	-125, -0.067417	125, -0.067417	20	Auto: 25

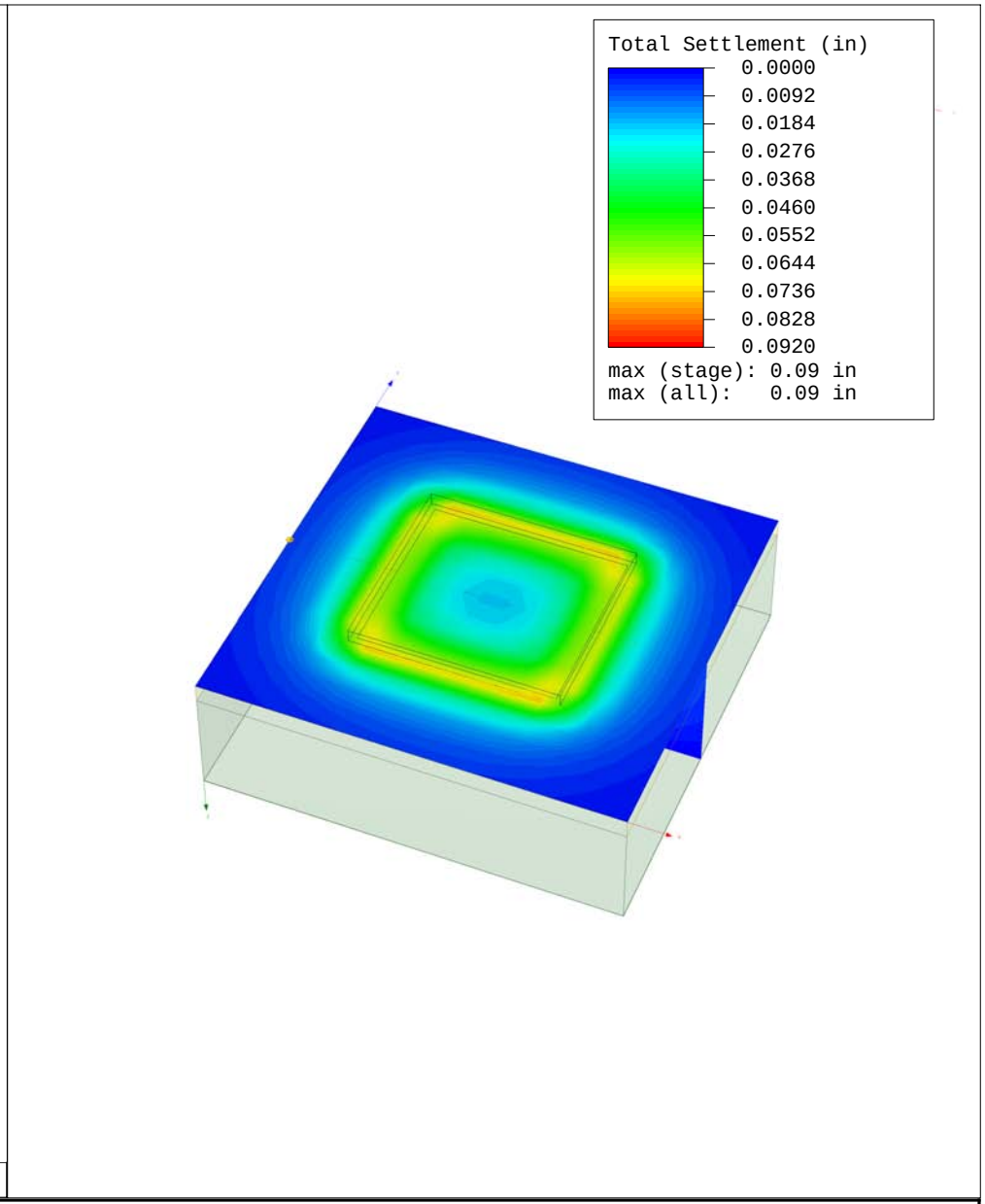
Field Point Grid

Number of points	289
Expansion Factor	2

Grid Coordinates

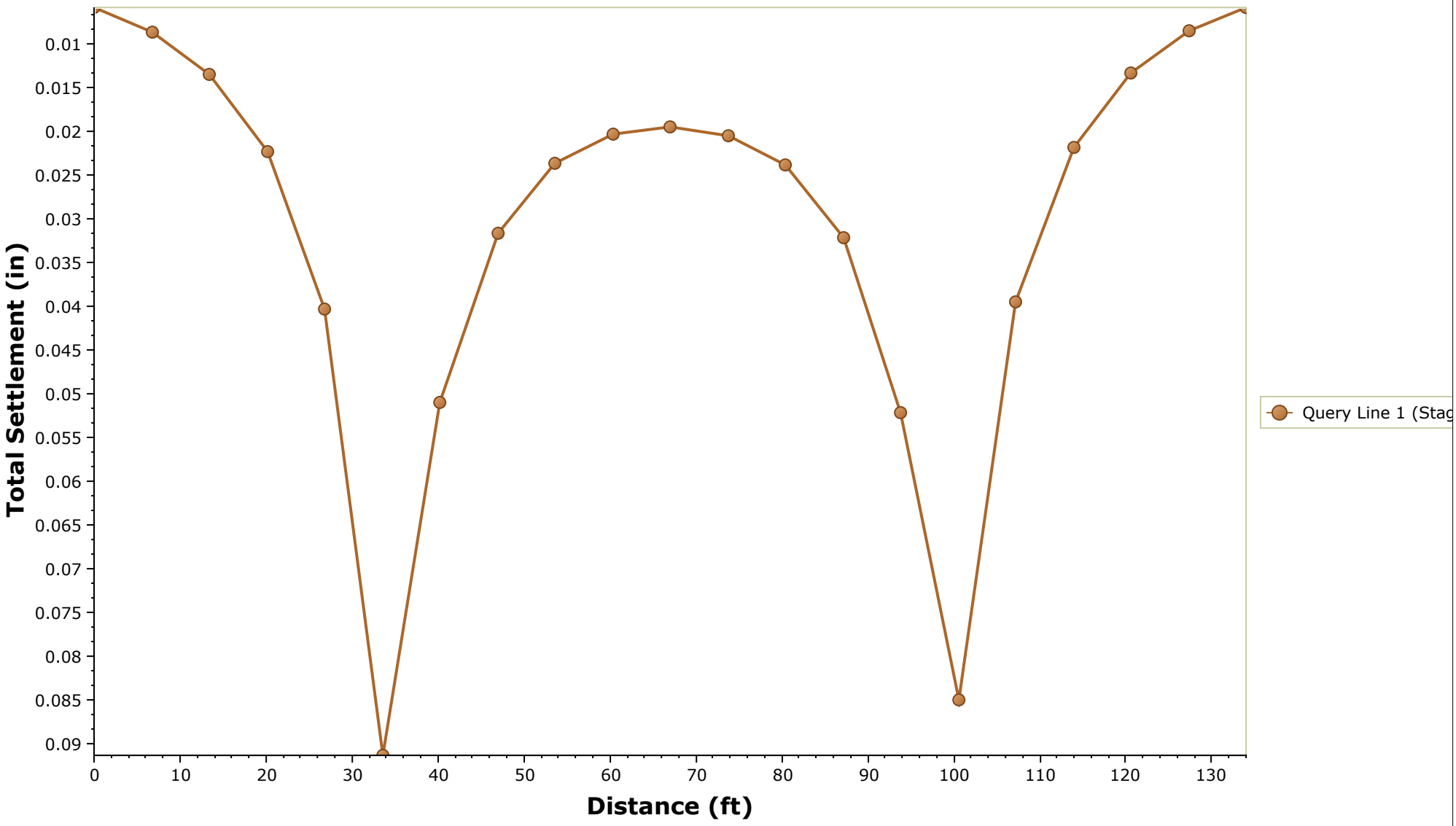
X [ft]	Y [ft]
128	128
128	-128
-128	-128
-128	128





rocscience SETTLE3D 3.004	*Project*	Montopolis Pump Station Facility	
	Analysis Description	Pump Station Settlement	
	Drawn By VNV	*Company*	CH2M HILL
	Date 1/20/2015, 2:38:38 PM	*File Name*	Montopolis_Pump station.s3z

Distance vs. Total Settlement



Reference Stage: None

rocscience	Project	Montopolis Pump Station Facility	
	Analysis Description	Pump Station Settlement	
	Drawn By	VNV	Company: CH2M HILL
	Date	1/20/2015, 2:38:38 PM	File Name: Montopolis_Pump station.s3z

SETTLE3D 3.004

Settle3D Analysis Information
Montopolis Pump Station Facility

Project Settings

Document Name	Montopolis_Pump station
Project Title	Montopolis Pump Station Facility
Analysis	Pump Station Settlement
Author	VNV
Company	CH2M HILL
Date Created	1/20/2015, 2:38:38 PM
Stress Computation Method	Westergaard
Use average properties to calculate layered stresses	

Stage Settings

Stage #	Name
1	Stage 1

Results

Time taken to compute: 0.068754 seconds

Stage: Stage 1

Data Type	Minimum	Maximum
Total Settlement [in]	0	0.0912658
Consolidation Settlement [in]	0	0
Immediate Settlement [in]	0	0.0912658
Loading Stress [ksf]	0	2.99815
Total Stress [ksf]	0	4.93303
Total Strain	2.16357e-008	0.000785669
Degree of Consolidation [%]	0	0
Pre-consolidation Stress [ksf]	0.00768645	4.93103
Over-consolidation Ratio	1	1
Void Ratio	0	0
Hydroconsolidation Settlement [in]	0	0
Undrained Shear Strength	0	0.970086

Loads

1. Rectangular Load

Length	67 ft
Width	62 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	4154 ft^2
Load	3 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
-33.5	-31
33.5	-31
33.5	31
-33.5	31

2. Rectangular Load

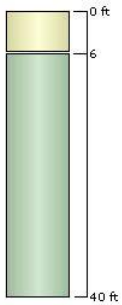
Length	63 ft
Width	58 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	3654 ft^2
Load	-3 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
-31.5	-29
31.5	-29
31.5	29
-31.5	29

Soil Layers

Layer #	Type	Thickness [ft]	Depth [ft]
1	Structural Fill	6	0
2	Very Stiff Clay	34	6



Soil Properties

Property	Structural Fill	Very Stiff Clay
Color		
Unit Weight [kips/ft^3]	0.125	0.12
Immediate Settlement	Enabled	Enabled
Es [ksf]	3500	1150
Esur [ksf]	3500	1150
Undrained Su A [kips/ft2]	0	0
Undrained Su S	0.2	0.2
Undrained Su m	0.8	0.8

Query Lines

Line #	Start Location	End Location	Horizontal Divisions	Vertical Divisions
1	-66.8738, 0.227	67.1262, 0.227	20	Auto: 25

Field Point Grid

Number of points 306
Expansion Factor 2

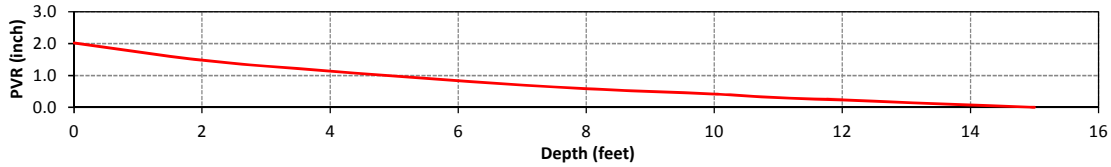
Grid Coordinates

X [ft]	Y [ft]
67	64.5
67	-64.5
-67	-64.5
-67	64.5

Potential Vertical Rise (PVR) for Expansive Soil

TxDOT: TEX-124-E

Project Montopolis WRI Tank
Boring No. B-4

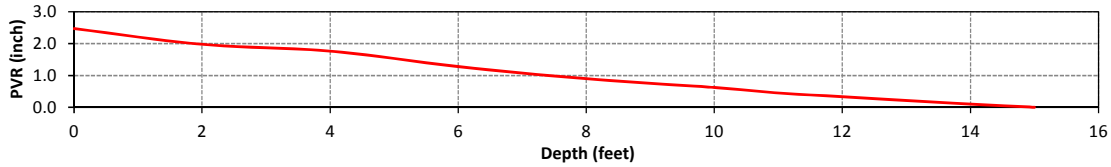


Depth to Bottom of Layer (ft)	Average Load (psi)	Liquid Limit (LL)	Dry 0.2LL+9	Average	Wet 0.47LL+2	Moisture Content (%)	Wet Density (pcf)	Dry Average Wet	Passing #40 Sieve (%)	Plasticity Index (PI)	Volume Swell (%)	Free Swell (%)	PVR (inches) Top Layer	PVR (inches) Bottom Layer	Differential Swell (inch)	Modified #40 Factor	Modified density Factor	PVR in Layers (inch)	Total PVR (inch)
0	0.00																		**2.02**
2	1.00	48	18.6	21.6	24.6	9.4	130	Dry	100	23	5.8	8.8	0.00	0.56	0.56	1.00	0.96	0.54	1.48
4	3.00	42	17.4	19.6	21.7	8.7	130	Dry	100	23	5.8	8.8	0.56	0.92	0.35	1.00	0.96	0.34	1.14
6	5.00	46	18.2	20.9	23.6	11.1	130	Dry	100	28	7.6	10.7	1.28	1.59	0.32	1.00	0.96	0.30	0.83
8	7.00	46	18.2	20.9	23.6	11.1	130	Dry	100	28	7.6	10.7	1.59	1.85	0.26	1.00	0.96	0.25	0.58
10	9.00	51	19.2	22.6	26.0	11.6	130	Dry	100	27	7.2	10.4	1.74	1.92	0.17	1.00	0.96	0.17	0.42
11	10.50	51	19.2	22.6	26.0	11.6	130	Dry	100	27	7.2	10.4	1.92	2.04	0.12	1.00	0.96	0.12	0.30
12	11.50	51	19.2	22.6	26.0	11.6	130	Dry	100	27	7.2	10.4	2.04	2.11	0.07	1.00	0.96	0.07	0.23
13	12.50	63	21.6	26.6	31.6	14.9	130	Dry	100	35	10.1	13.4	3.15	3.24	0.09	1.00	0.96	0.09	0.15
14	13.50	63	21.6	26.6	31.6	14.9	130	Dry	100	35	10.1	13.4	3.24	3.32	0.08	1.00	0.96	0.07	0.07
15	14.50	63	21.6	26.6	31.6	14.9	130	Dry	100	35	10.1	13.4	3.32	3.40	0.08	1.00	0.96	0.07	0.00

Potential Vertical Rise (PVR) for Expansive Soil

TxDOT: TEX-124-E

Project Montopolis WRI Tank
Boring No. B-5

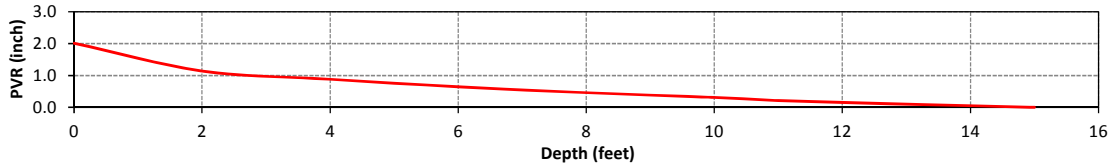


Depth to Bottom of Layer (ft)	Average Load (psi)	Liquid Limit (LL)	Dry 0.2LL+9	Average	Wet 0.47LL+2	Moisture Content (%)	Wet Density (pcf)	Dry Average Wet	Passing #40 Sieve (%)	Plasticity Index (PI)	Volume Swell (%)	Free Swell (%)	PVR (inches) Top Layer	PVR (inches) Bottom Layer	Differential Swell (inch)	Modified #40 Factor	Modified density Factor	PVR in Layers (inch)	Total PVR (inch)
0	0.00																		**2.47**
2	1.00	42	17.4	19.6	21.7	8.7	130	Dry	100	21	5.1	8.1	0.00	0.51	0.51	1.00	0.96	0.49	1.98
4	3.00	48	18.6	21.6	24.6	9.4	130	Dry	100	18	4.1	6.9	0.43	0.65	0.22	1.00	0.96	0.21	1.76
6	5.00	53	19.6	23.3	26.9	11.1	130	Dry	100	37	10.8	14.1	1.90	2.40	0.50	1.00	0.96	0.48	1.28
8	7.00	57	20.4	24.6	28.8	12.7	130	Dry	100	39	11.4	14.8	2.62	3.01	0.40	1.00	0.96	0.38	0.90
10	9.00	52	19.4	22.9	26.4	11.7	130	Dry	100	36	10.4	13.7	2.66	2.94	0.28	1.00	0.96	0.27	0.62
11	10.50	52	19.4	22.9	26.4	11.7	130	Dry	100	36	10.4	13.7	2.94	3.12	0.18	1.00	0.96	0.17	0.45
12	11.50	52	19.4	22.9	26.4	11.7	130	Dry	100	36	10.4	13.7	3.12	3.24	0.12	1.00	0.96	0.12	0.33
13	12.50	62	21.4	26.3	31.1	15.8	130	Dry	100	41	12.1	15.6	4.03	4.15	0.13	1.00	0.96	0.12	0.21
14	13.50	62	21.4	26.3	31.1	15.8	130	Dry	100	41	12.1	15.6	4.15	4.27	0.12	1.00	0.96	0.11	0.10
15	14.50	62	21.4	26.3	31.1	15.8	130	Dry	100	41	12.1	15.6	4.27	4.37	0.11	1.00	0.96	0.10	0.00

Potential Vertical Rise (PVR) for Expansive Soil

TxDOT: TEX-124-E

Project Montopolis WRI Tank
Boring No. B-6

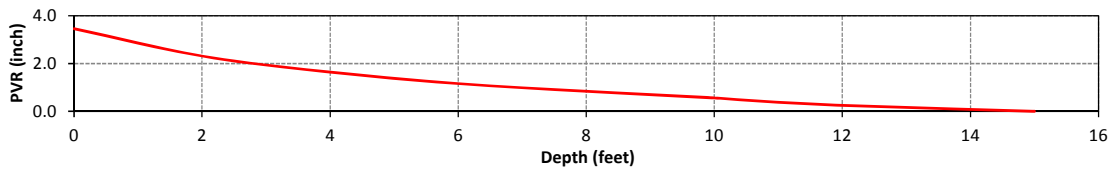


Depth to Bottom of Layer (ft)	Average Load (psi)	Liquid Limit (LL)	Dry 0.2LL+9	Average	Wet 0.47LL+2	Moisture Content (%)	Wet Density (pcf)	Dry Average Wet	Passing #40 Sieve (%)	Plasticity Index (PI)	Volume Swell (%)	Free Swell (%)	PVR (inches) Top Layer	PVR (inches) Bottom Layer	Differential Swell (inch)	Modified #40 Factor	Modified density Factor	PVR in Layers (inch)	Total PVR (inch)
0	0.00																		**2.01**
2	1.00	60	21.0	25.6	30.2	19.2	130	Dry	100	29	8.0	11.1	0.00	0.91	0.91	1.00	0.96	0.87	1.14
4	3.00	40	17.0	18.9	20.8	10.3	130	Dry	100	20	4.8	7.7	0.49	0.76	0.27	1.00	0.96	0.26	0.88
6	5.00	50	19.0	22.3	25.5	13.3	130	Dry	100	23	5.8	8.8	0.92	1.16	0.25	1.00	0.96	0.24	0.64
8	7.00	49	18.8	21.9	25.0	15.3	130	Dry	100	25	6.5	9.6	1.34	1.53	0.19	1.00	0.96	0.19	0.46
10	9.00	49	18.8	21.9	25.0	15.3	130	Dry	100	25	6.5	9.6	1.53	1.69	0.15	1.00	0.96	0.15	0.31
11	10.50	49	18.8	21.9	25.0	15.3	130	Dry	100	25	6.5	9.6	1.69	1.79	0.10	1.00	0.96	0.10	0.21
12	11.50	56	20.2	24.3	28.3	17.4	130	Dry	100	28	7.6	10.7	2.17	2.24	0.07	1.00	0.96	0.06	0.15
13	12.50	56	20.2	24.3	28.3	17.4	130	Dry	100	28	7.6	10.7	2.24	2.29	0.05	1.00	0.96	0.05	0.10
14	13.50	56	20.2	24.3	28.3	17.4	130	Dry	100	28	7.6	10.7	2.29	2.34	0.05	1.00	0.96	0.05	0.05
15	14.50	56	20.2	24.3	28.3	17.4	130	Dry	100	28	7.6	10.7	2.34	2.39	0.05	1.00	0.96	0.05	0.00

Potential Vertical Rise (PVR) for Expansive Soil

TxDOT: TEX-124-E

Project Montopolis WRI Tank
Boring No. B-9A

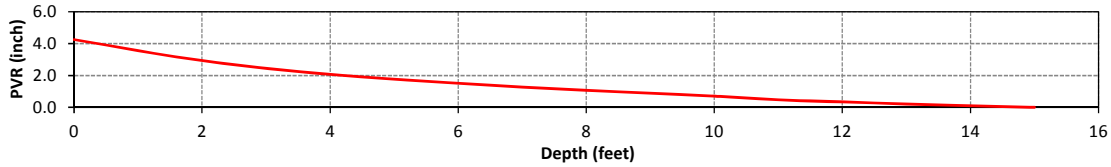


Depth to Bottom of Layer (ft)	Average Load (psi)	Liquid Limit (LL)	Dry 0.2LL+9	Average	Wet 0.47LL+2	Moisture Content (%)	Wet Density (pcf)	Dry Average Wet	Passing #40 Sieve (%)	Plasticity Index (PI)	Volume Swell (%)	Free Swell (%)	PVR (inches) Top Layer	PVR (inches) Bottom Layer	Differential Swell (inch)	Modified #40 Factor	Modified density Factor	PVR in Layers (inch)	Total PVR (inch)
0	0.00																		**3.46**
2	1.00	53	19.6	23.3	26.9	16	131	Dry	100	37	10.8	14.1	0.00	1.20	1.20	1.00	0.96	1.15	2.31
4	3.00	53	19.6	23.3	26.9	16	131	Dry	100	37	10.8	14.1	1.20	1.90	0.70	1.00	0.96	0.67	1.64
6	5.00	53	19.6	23.3	26.9	16	131	Dry	100	37	10.8	14.1	1.90	2.40	0.50	1.00	0.96	0.48	1.16
8	7.00	53	19.6	23.3	26.9	16	131	Dry	100	37	10.8	14.1	2.40	2.74	0.34	1.00	0.96	0.32	0.84
10	9.00	53	19.6	23.3	26.9	16	131	Dry	100	37	10.8	14.1	2.74	3.03	0.29	1.00	0.96	0.28	0.56
11	10.50	53	19.6	23.3	26.9	16	131	Dry	100	37	10.8	14.1	3.03	3.22	0.19	1.00	0.96	0.19	0.37
12	11.50	53	19.6	23.3	26.9	16	131	Dry	100	37	10.8	14.1	3.22	3.35	0.13	1.00	0.96	0.12	0.25
13	12.50	53	19.6	23.3	26.9	16	131	Dry	100	37	10.8	14.1	3.35	3.45	0.10	1.00	0.96	0.09	0.16
14	13.50	53	19.6	23.3	26.9	16	131	Dry	100	37	10.8	14.1	3.45	3.53	0.08	1.00	0.96	0.08	0.08
15	14.50	53	19.6	23.3	26.9	16	131	Dry	100	37	10.8	14.1	3.53	3.61	0.08	1.00	0.96	0.08	0.00

Potential Vertical Rise (PVR) for Expansive Soil

TxDOT: TEX-124-E

Project Montopolis WRI Tank
Boring No. B-10

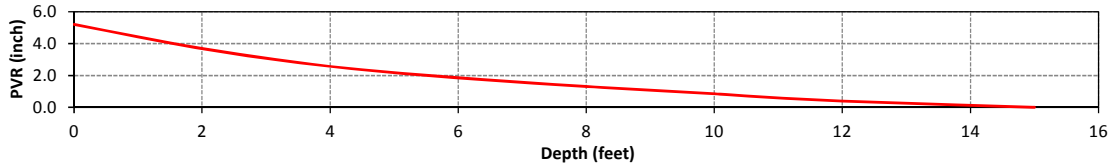


Depth to Bottom of Layer (ft)	Average Load (psi)	Liquid Limit (LL)	Dry 0.2LL+9	Average	Wet 0.47LL+2	Moisture Content (%)	Wet Density (pcf)	Dry Average Wet	Passing #40 Sieve (%)	Plasticity Index (PI)	Volume Swell (%)	Free Swell (%)	PVR (inches) Top Layer	PVR (inches) Bottom Layer	Differential Swell (inch)	Modified #40 Factor	Modified density Factor	PVR in Layers (inch)	Total PVR (inch)
0	0.00																		**4.25**
2	1.00	59	20.8	25.3	29.7	10	134	Dry	100	42	12.5	15.9	0.00	1.42	1.42	1.00	0.93	1.33	2.92
4	3.00	59	20.8	25.3	29.7	10	134	Dry	100	42	12.5	15.9	1.42	2.33	0.91	1.00	0.93	0.85	2.08
6	5.00	59	20.8	25.3	29.7	10	134	Dry	100	42	12.5	15.9	2.33	2.95	0.62	1.00	0.93	0.58	1.50
8	7.00	59	20.8	25.3	29.7	10	134	Dry	100	42	12.5	15.9	2.95	3.41	0.46	1.00	0.93	0.43	1.07
10	9.00	59	20.8	25.3	29.7	10	134	Dry	100	42	12.5	15.9	3.41	3.81	0.40	1.00	0.93	0.37	0.70
11	10.50	59	20.8	25.3	29.7	12	134	Dry	100	42	12.5	15.9	3.81	4.05	0.25	1.00	0.93	0.23	0.47
12	11.50	59	20.8	25.3	29.7	12	134	Dry	100	42	12.5	15.9	4.05	4.19	0.14	1.00	0.93	0.13	0.34
13	12.50	59	20.8	25.3	29.7	12	134	Dry	100	42	12.5	15.9	4.19	4.33	0.14	1.00	0.93	0.13	0.21
14	13.50	59	20.8	25.3	29.7	12	134	Dry	100	42	12.5	15.9	4.33	4.45	0.12	1.00	0.93	0.11	0.10
15	14.50	59	20.8	25.3	29.7	12	134	Dry	100	42	12.5	15.9	4.45	4.56	0.10	1.00	0.93	0.10	0.00

Potential Vertical Rise (PVR) for Expansive Soil

TxDOT: TEX-124-E

Project Montopolis WRI Tank
Boring No. B-11

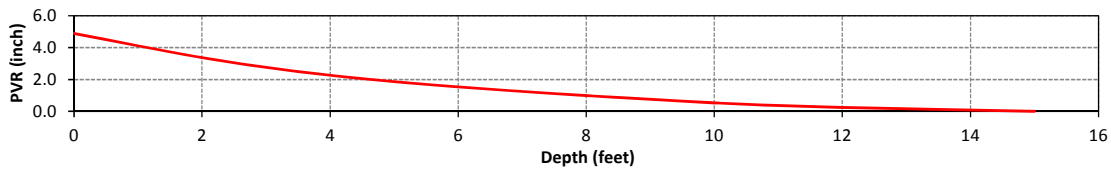


Depth to Bottom of Layer (ft)	Average Load (psi)	Liquid Limit (LL)	Dry 0.2LL+9	Average	Wet 0.47LL+2	Moisture Content (%)	Wet Density (pcf)	Dry Average Wet	Passing #40 Sieve (%)	Plasticity Index (PI)	Volume Swell (%)	Free Swell (%)	PVR (inches) Top Layer	PVR (inches) Bottom Layer	Differential Swell (inch)	Modified #40 Factor	Modified density Factor	PVR in Layers (inch)	Total PVR (inch)
0	0.00																		**5.21**
2	1.00	59	20.8	25.3	29.7	18	122	Dry	100	44	13.1	16.6	0.00	1.48	1.48	1.00	1.02	1.51	3.70
4	3.00	59	20.8	25.3	29.7	18	122	Dry	100	44	13.1	16.6	1.48	2.58	1.10	1.00	1.02	1.13	2.57
6	5.00	59	20.8	25.3	29.7	18	122	Dry	100	44	13.1	16.6	2.58	3.27	0.70	1.00	1.02	0.71	1.85
8	7.00	59	20.8	25.3	29.7	18	122	Dry	100	44	13.1	16.6	3.27	3.81	0.53	1.00	1.02	0.55	1.31
10	9.00	59	20.8	25.3	29.7	18	122	Dry	100	44	13.1	16.6	3.81	4.25	0.45	1.00	1.02	0.46	0.85
11	10.50	59	20.8	25.3	29.7	18	122	Dry	100	44	13.1	16.6	4.25	4.51	0.26	1.00	1.02	0.27	0.58
12	11.50	59	20.8	25.3	29.7	18	122	Dry	100	44	13.1	16.6	4.51	4.68	0.17	1.00	1.02	0.17	0.41
13	12.50	59	20.8	25.3	29.7	18	122	Dry	100	44	13.1	16.6	4.68	4.84	0.15	1.00	1.02	0.16	0.25
14	13.50	59	20.8	25.3	29.7	18	122	Dry	100	44	13.1	16.6	4.84	4.96	0.13	1.00	1.02	0.13	0.12
15	14.50	59	20.8	25.3	29.7	18	122	Dry	100	44	13.1	16.6	4.96	5.08	0.12	1.00	1.02	0.12	0.00

Potential Vertical Rise (PVR) for Expansive Soil

TxDOT: TEX-124-E

Project Montopolis WRI Tank
Boring No. B-11A

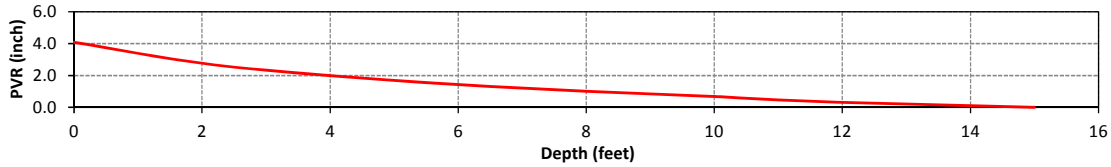


Depth to Bottom of Layer (ft)	Average Load (psi)	Liquid Limit (LL)	Dry 0.2LL+9	Average	Wet 0.47LL+2	Moisture Content (%)	Wet Density (pcf)	Dry Average Wet	Passing #40 Sieve (%)	Plasticity Index (PI)	Volume Swell (%)	Free Swell (%)	PVR (inches) Top Layer	PVR (inches) Bottom Layer	Differential Swell (inch)	Modified #40 Factor	Modified density Factor	PVR in Layers (inch)	Total PVR (inch)
0	0.00																		**4.89**
2	1.00	59	20.8	25.3	29.7	17.8	122	Dry	100	44	13.1	16.6	0.00	1.48	1.48	1.00	1.02	1.51	3.38
4	3.00	59	20.8	25.3	29.7	17.8	122	Dry	100	44	13.1	16.6	1.48	2.58	1.10	1.00	1.02	1.13	2.25
6	5.00	59	20.8	25.3	29.7	17.8	122	Dry	100	44	13.1	16.6	2.58	3.27	0.70	1.00	1.02	0.71	1.54
8	7.00	59	20.8	25.3	29.7	17.8	122	Dry	100	44	13.1	16.6	3.27	3.81	0.53	1.00	1.02	0.55	0.99
10	9.00	59	20.8	25.3	29.7	17.8	122	Dry	100	44	13.1	16.6	3.81	4.25	0.45	1.00	1.02	0.46	0.53
11	10.50	51	19.2	22.6	26.0	17.3	122	Dry	100	35	10.1	13.4	2.88	3.04	0.17	1.00	1.02	0.17	0.36
12	11.50	51	19.2	22.6	26.0	17.3	122	Dry	100	35	10.1	13.4	3.04	3.15	0.11	1.00	1.02	0.11	0.25
13	12.50	51	19.2	22.6	26.0	17.3	122	Dry	100	35	10.1	13.4	3.15	3.24	0.09	1.00	1.02	0.09	0.16
14	13.50	51	19.2	22.6	26.0	17.3	122	Dry	100	35	10.1	13.4	3.24	3.32	0.08	1.00	1.02	0.08	0.08
15	14.50	51	19.2	22.6	26.0	17.3	122	Dry	100	35	10.1	13.4	3.32	3.40	0.08	1.00	1.02	0.08	0.00

Potential Vertical Rise (PVR) for Expansive Soil

TxDOT: TEX-124-E

Project Montopolis WRI Tank
Boring No. B-12A

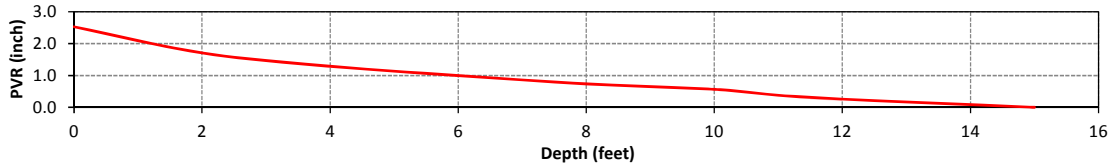


Depth to Bottom of Layer (ft)	Average Load (psi)	Liquid Limit (LL)	Dry 0.2LL+9	Average	Wet 0.47LL+2	Moisture Content (%)	Wet Density (pcf)	Dry Average Wet	Passing #40 Sieve (%)	Plasticity Index (PI)	Volume Swell (%)	Free Swell (%)	PVR (inches) Top Layer	PVR (inches) Bottom Layer	Differential Swell (inch)	Modified #40 Factor	Modified density Factor	PVR in Layers (inch)	Total PVR (inch)
0	0.00																		**4.09**
2	1.00	54	19.8	23.6	27.4	10.9	128	Dry	100	40	11.8	15.2	0.00	1.36	1.36	1.00	0.98	1.32	2.76
4	3.00	54	19.8	23.6	27.4	10.9	128	Dry	100	40	11.8	15.2	1.36	2.15	0.80	1.00	0.98	0.78	1.99
6	5.00	54	19.8	23.6	27.4	10.9	128	Dry	100	40	11.8	15.2	2.15	2.73	0.58	1.00	0.98	0.56	1.43
8	7.00	54	19.8	23.6	27.4	10.9	128	Dry	100	40	11.8	15.2	2.73	3.15	0.42	1.00	0.98	0.41	1.01
10	9.00	54	19.8	23.6	27.4	10.9	128	Dry	100	40	11.8	15.2	3.15	3.49	0.34	1.00	0.98	0.33	0.68
11	10.50	54	19.8	23.6	27.4	18.4	128	Dry	100	40	11.8	15.2	3.49	3.72	0.23	1.00	0.98	0.22	0.46
12	11.50	54	19.8	23.6	27.4	18.4	128	Dry	100	40	11.8	15.2	3.72	3.86	0.14	1.00	0.98	0.13	0.32
13	12.50	54	19.8	23.6	27.4	18.4	128	Dry	100	40	11.8	15.2	3.86	3.97	0.11	1.00	0.98	0.11	0.21
14	13.50	54	19.8	23.6	27.4	18.4	128	Dry	100	40	11.8	15.2	3.97	4.08	0.11	1.00	0.98	0.11	0.10
15	14.50	54	19.8	23.6	27.4	18.4	128	Dry	100	40	11.8	15.2	4.08	4.19	0.11	1.00	0.98	0.10	0.00

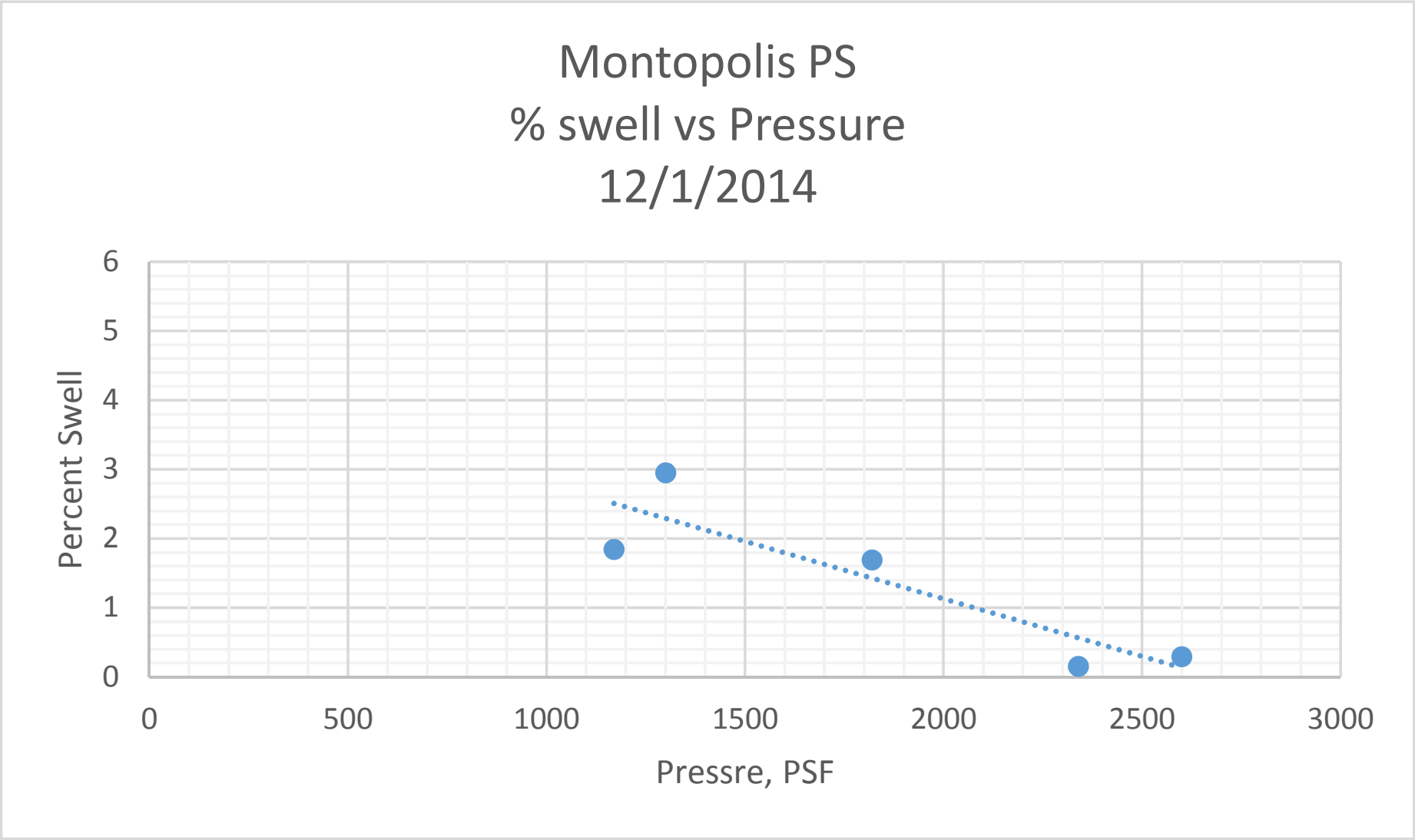
Potential Vertical Rise (PVR) for Expansive Soil

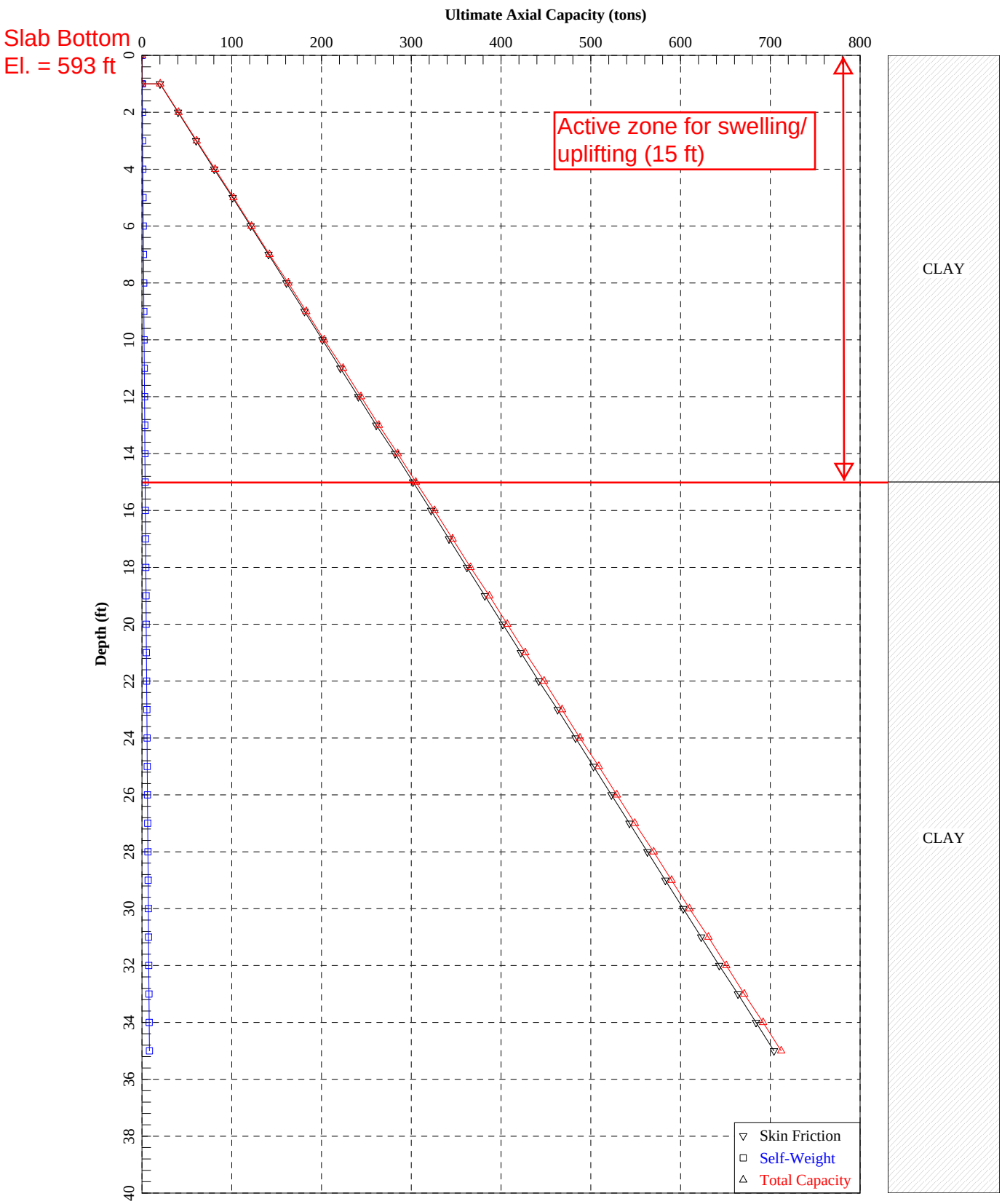
TxDOT: TEX-124-E

Project Montopolis WRI Tank
Boring No. B-13



Depth to Bottom of Layer (ft)	Average Load (psi)	Liquid Limit (LL)	Dry 0.2LL+9	Average	Wet 0.47LL+2	Moisture Content (%)	Wet Density (pcf)	Dry Average Wet	Passing #40 Sieve (%)	Plasticity Index (PI)	Volume Swell (%)	Free Swell (%)	PVR (inches) Top Layer	PVR (inches) Bottom Layer	Differential Swell (inch)	Modified #40 Factor	Modified density Factor	PVR in Layers (inch)	Total PVR (inch)
0	0.00																		**2.53**
2	1.00	42	17.4	19.6	21.7	9	138	Dry	100	29	8.0	11.1	0.00	0.91	0.91	1.00	0.91	0.82	1.71
4	3.00	42	17.4	19.6	21.7	9	138	Dry	100	29	8.0	11.1	0.91	1.37	0.46	1.00	0.91	0.42	1.29
6	5.00	42	17.4	19.6	21.7	9	138	Dry	100	29	8.0	11.1	1.37	1.69	0.32	1.00	0.91	0.29	1.00
8	7.00	42	17.4	19.6	21.7	9	138	Dry	100	29	8.0	11.1	1.69	1.98	0.28	1.00	0.91	0.26	0.74
10	9.00	42	17.4	19.6	21.7	9	138	Dry	100	29	8.0	11.1	1.98	2.17	0.19	1.00	0.91	0.17	0.56
11	10.50	57	20.4	24.6	28.8	20	138	Dry	100	38	11.1	14.5	3.18	3.39	0.21	1.00	0.91	0.19	0.38
12	11.50	57	20.4	24.6	28.8	20	138	Dry	100	38	11.1	14.5	3.39	3.52	0.13	1.00	0.91	0.12	0.26
13	12.50	57	20.4	24.6	28.8	20	138	Dry	100	38	11.1	14.5	3.52	3.62	0.10	1.00	0.91	0.09	0.17
14	13.50	57	20.4	24.6	28.8	20	138	Dry	100	38	11.1	14.5	3.62	3.71	0.09	1.00	0.91	0.08	0.08
15	14.50	57	20.4	24.6	28.8	20	138	Dry	100	38	11.1	14.5	3.71	3.80	0.09	1.00	0.91	0.08	0.00


Montopolis PS
% swell vs Pressure
12/1/2014
Percent Swell
6
5
4
3
2
1
0
0
500
1000
1500
2000
2500
3000
Pressre, PSF



Montopolis Pump Station_2ft_Diameter Drilled Shaft_Ultimate_Uplift

```
==========================================================================

                    SHAFT for Windows, Version 2012.7.10

                     Serial Number :  155987379

                  VERTICALLY LOADED DRILLED SHAFT ANALYSIS
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                         All Rights Reserved

==========================================================================


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Investigation\2015 Update\Calculations and Figure\SHAFT\
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     Name of output file         : .sfo
     Name of plot output file    : .sfp
     Name of runtime file        : .sfr


     ------------------------------------------------------------------------
                            Time and Date of Analysis
     ------------------------------------------------------------------------

               Date:  June 16, 2015     Time:  16:00:18

     Montopolis Pump Station


     PROPOSED DEPTH =      35.0 FT
     ----------------


     REDUCTION FACTOR APPLIED FOR UPLIFT FRICTION = 1.000
     ----------------------------------------------


     NUMBER OF LAYERS =    2
     ------------------


     WATER TABLE DEPTH =      36.0 FT.
     -------------------



     FACTOR OF SAFETY APPLIED TO THE ULTIMATE SIDE FRICTION CAPACITY = 1.00
     ----------------------------------------------------------
     FACTOR OF SAFETY APPLIED TO THE ULTIMATE BASE CAPACITY = 1.00
     -------------------------------------------------------


     SOIL INFORMATION
     ----------------

     LAYER NO 1----CLAY

       AT THE TOP

       STRENGTH REDUCTION FACTOR-ALPHA                    = 0.100E+01
       END BEARING COEFFICIENT-Nc                         = 0.900E+01
       UNDRAINED SHEAR STRENGTH, LB/SQ FT                 = 0.650E+04
       INTERNAL FRICTION ANGLE, DEG.                      = 0.000E+00
       BLOWS PER FOOT FROM STANDARD PENETRATION TEST      = 0.000E+00
       SOIL UNIT WEIGHT, LB/CU FT                         = 0.120E+03
       MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT           = 0.640E+04
       DEPTH, FT                                          = 0.000E+00


       AT THE BOTTOM

       STRENGTH REDUCTION FACTOR-ALPHA                    = 0.100E+01
       END BEARING COEFFICIENT-Nc                         = 0.900E+01
       UNDRAINED SHEAR STRENGTH, LB/SQ FT                 = 0.650E+04
       INTERNAL FRICTION ANGLE, DEG.                      = 0.000E+00
       BLOWS PER FOOT FROM STANDARD PENETRATION TEST      = 0.000E+00
       SOIL UNIT WEIGHT, LB/CU FT                         = 0.120E+03
       MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT           = 0.640E+04
       DEPTH, FT                                          = 0.150E+02


     LAYER NO 2----CLAY

       AT THE TOP

       STRENGTH REDUCTION FACTOR-ALPHA                    = 0.550E+00
       END BEARING COEFFICIENT-Nc                         = 0.900E+01
       UNDRAINED SHEAR STRENGTH, LB/SQ FT                 = 0.120E+05
       INTERNAL FRICTION ANGLE, DEG.                      = 0.000E+00
       BLOWS PER FOOT FROM STANDARD PENETRATION TEST      = 0.000E+00
```



```
       SOIL UNIT WEIGHT, LB/CU FT                         = 0.125E+03
       MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT           = 0.640E+04
       DEPTH, FT                                          = 0.150E+02


       AT THE BOTTOM

       STRENGTH REDUCTION FACTOR-ALPHA                    = 0.550E+00
       END BEARING COEFFICIENT-Nc                         = 0.900E+01
       UNDRAINED SHEAR STRENGTH, LB/SQ FT                 = 0.120E+05
       INTERNAL FRICTION ANGLE, DEG.                      = 0.000E+00
       BLOWS PER FOOT FROM STANDARD PENETRATION TEST      = 0.000E+00
       SOIL UNIT WEIGHT, LB/CU FT                         = 0.125E+03
       MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT           = 0.640E+04
       DEPTH, FT                                          = 0.400E+02


     DRILLED SHAFT INFORMATION
     -------------------------

       DIAMETER OF STEM          =    2.000  FT.
       DIAMETER OF BASE          =    2.000  FT.
       END OF STEM TO BASE       =    0.000  FT.
       ANGLE OF BELL             =    0.000  DEG.
       IGNORED TOP PORTION       =    0.000  FT.
       IGNORED BOTTOM PORTION    =    0.000  FT.
       AREA OF ONE PERCENT STEEL =    4.524  SQ.IN.
       ELASTIC MODULUS, Ec       = 0.360E+07 LB/SQ IN
       VOLUME OF UNDERREAM       =    0.000  CU.YDS.


     PREDICTED RESULTS
     -----------------

     QS     = ULTIMATE SIDE RESISTANCE;
     QB     = ULTIMATE BASE RESISTANCE;
     WT     = WEIGHT OF DRILLED SHAFT (FOR UPLIFT CAPACITY ONLY);
     QU     = TOTAL ULTIMATE RESISTANCE;
     QBD    = TOTAL ALLOWABLE LOAD USING A FACTOR OF SAFETY
              APPLIED TO THE ULTIMATE BASE RESISTANCE;
     QDN    = TOTAL ALLOWABLE LOAD USING FACTORS OF SAFETY
              APPLIED TO THE ULTIMATE SIDE RESISTANCE AND
              THE ULTIMATE BASE RESISTANCE.
```

LENGTH (FEET)	VOLUME (CU.YDS)	QS (TONS)	WT (TONS)	QU (TONS)	QBD (TONS)	QDN (TONS)	QU/VOLUME (TONS/CU.YDS)
0.5	0.06	10.05	0.12	10.17	10.17	10.17	174.82
1.0	0.12	20.11	0.24	20.34	20.34	20.34	174.82
1.5	0.17	30.16	0.35	30.52	30.52	30.52	174.82
2.0	0.23	40.22	0.47	40.69	40.69	40.69	174.82
2.5	0.29	50.27	0.59	50.86	50.86	50.86	174.83
3.0	0.35	60.33	0.71	61.03	61.03	61.03	174.83
3.5	0.41	70.38	0.82	71.21	71.21	71.21	174.83
4.0	0.47	80.44	0.94	81.38	81.38	81.38	174.82
4.5	0.52	90.49	1.06	91.55	91.55	91.55	174.83
5.0	0.58	100.54	1.18	101.72	101.72	101.72	174.83
5.5	0.64	110.60	1.30	111.89	111.89	111.89	174.83
6.0	0.70	120.65	1.41	122.07	122.07	122.07	174.83
6.5	0.76	130.71	1.53	132.24	132.24	132.24	174.83
7.0	0.81	140.76	1.65	142.41	142.41	142.41	174.83
7.5	0.87	150.82	1.77	152.58	152.58	152.58	174.83
8.0	0.93	160.87	1.89	162.76	162.76	162.76	174.82
8.5	0.99	170.92	2.00	172.93	172.93	172.93	174.82
9.0	1.05	180.98	2.12	183.10	183.10	183.10	174.82
9.5	1.11	191.03	2.24	193.27	193.27	193.27	174.83
10.0	1.16	201.09	2.36	203.44	203.44	203.44	174.83
10.5	1.22	211.14	2.47	213.62	213.62	213.62	174.83
11.0	1.28	221.20	2.59	223.79	223.79	223.79	174.82
11.5	1.34	231.25	2.71	233.96	233.96	233.96	174.82
12.0	1.40	241.31	2.83	244.13	244.13	244.13	174.82
12.5	1.45	251.36	2.95	254.31	254.31	254.31	174.82
13.0	1.51	261.41	3.06	264.48	264.48	264.48	174.82
13.5	1.57	271.47	3.18	274.65	274.65	274.65	174.82
14.0	1.63	281.52	3.30	284.82	284.82	284.82	174.82
14.5	1.69	291.58	3.42	294.99	294.99	294.99	174.82
15.0	1.75	301.63	3.53	305.17	305.17	305.17	174.82
15.5	1.80	311.69	3.65	315.34	315.34	315.34	174.82
16.0	1.86	321.74	3.77	325.51	325.51	325.51	174.82
16.5	1.92	331.80	3.89	335.68	335.68	335.68	174.82
17.0	1.98	341.85	4.01	345.86	345.86	345.86	174.82
17.5	2.04	351.90	4.12	356.03	356.03	356.03	174.82
18.0	2.09	361.96	4.24	366.20	366.20	366.20	174.82
18.5	2.15	372.01	4.36	376.37	376.37	376.37	174.82
19.0	2.21	382.07	4.48	386.54	386.54	386.54	174.82
19.5	2.27	392.12	4.60	396.72	396.72	396.72	174.82
20.0	2.33	402.18	4.71	406.89	406.89	406.89	174.82
20.5	2.39	412.23	4.83	417.06	417.06	417.06	174.82

21.0	2.44	422.28	4.95	427.23	427.23	427.23	174.82
21.5	2.50	432.34	5.07	437.41	437.41	437.41	174.82
22.0	2.56	442.39	5.18	447.58	447.58	447.58	174.82
22.5	2.62	452.45	5.30	457.75	457.75	457.75	174.82
23.0	2.68	462.50	5.42	467.92	467.92	467.92	174.82
23.5	2.73	472.56	5.54	478.09	478.09	478.09	174.82
24.0	2.79	482.61	5.66	488.27	488.27	488.27	174.82
24.5	2.85	492.67	5.77	498.44	498.44	498.44	174.82
25.0	2.91	502.72	5.89	508.61	508.61	508.61	174.82
25.5	2.97	512.77	6.01	518.78	518.78	518.78	174.82
26.0	3.03	522.83	6.13	528.96	528.96	528.96	174.82
26.5	3.08	532.88	6.24	539.13	539.13	539.13	174.82
27.0	3.14	542.94	6.36	549.30	549.30	549.30	174.82
27.5	3.20	552.99	6.48	559.47	559.47	559.47	174.82
28.0	3.26	563.05	6.60	569.64	569.64	569.64	174.82
28.5	3.32	573.10	6.72	579.82	579.82	579.82	174.83
29.0	3.37	583.16	6.83	589.99	589.99	589.99	174.83
29.5	3.43	593.21	6.95	600.16	600.16	600.16	174.83
30.0	3.49	603.26	7.07	610.33	610.33	610.33	174.83
30.5	3.55	613.32	7.19	620.51	620.51	620.51	174.83
31.0	3.61	623.37	7.31	630.68	630.68	630.68	174.83
31.5	3.67	633.43	7.42	640.85	640.85	640.85	174.83
32.0	3.72	643.48	7.54	651.02	651.02	651.02	174.83
32.5	3.78	653.54	7.66	661.19	661.19	661.19	174.83
33.0	3.84	663.59	7.78	671.37	671.37	671.37	174.83
33.5	3.90	673.64	7.89	681.54	681.54	681.54	174.83
34.0	3.96	683.70	8.01	691.71	691.71	691.71	174.83
34.5	4.01	693.75	8.13	701.88	701.88	701.88	174.83
35.0	4.07	703.81	8.25	712.06	712.06	712.06	174.83

RESULT FROM TREND (AVERAGED) LINE

TOP LOAD ton	TOP MOVEMENT IN.	TIP LOAD ton	TIP MOVEMENT IN.
0.3952E+00	0.7828E-04	0.2715E-03	0.1000E-04
0.1976E+01	0.3914E-03	0.1357E-02	0.5000E-04
0.3952E+01	0.7828E-03	0.2715E-02	0.1000E-03
0.1969E+03	0.3999E-01	0.1357E+00	0.5000E-02
0.2685E+03	0.5813E-01	0.2036E+00	0.7500E-02
0.3279E+03	0.7454E-01	0.2715E+00	0.1000E-01
0.5100E+03	0.1428E+00	0.6787E+00	0.2500E-01
0.6064E+03	0.2016E+00	0.1357E+01	0.5000E-01
0.6446E+03	0.2422E+00	0.2036E+01	0.7500E-01
0.6511E+03	0.2698E+00	0.2715E+01	0.1000E+00
0.6431E+03	0.4208E+00	0.4715E+01	0.2500E+00
0.5858E+03	0.6549E+00	0.6567E+01	0.5000E+00
0.5864E+03	0.7802E+00	0.7194E+01	0.6250E+00
0.5867E+03	0.9366E+00	0.7528E+01	0.7812E+00
0.5872E+03	0.1356E+01	0.8000E+01	0.1200E+01

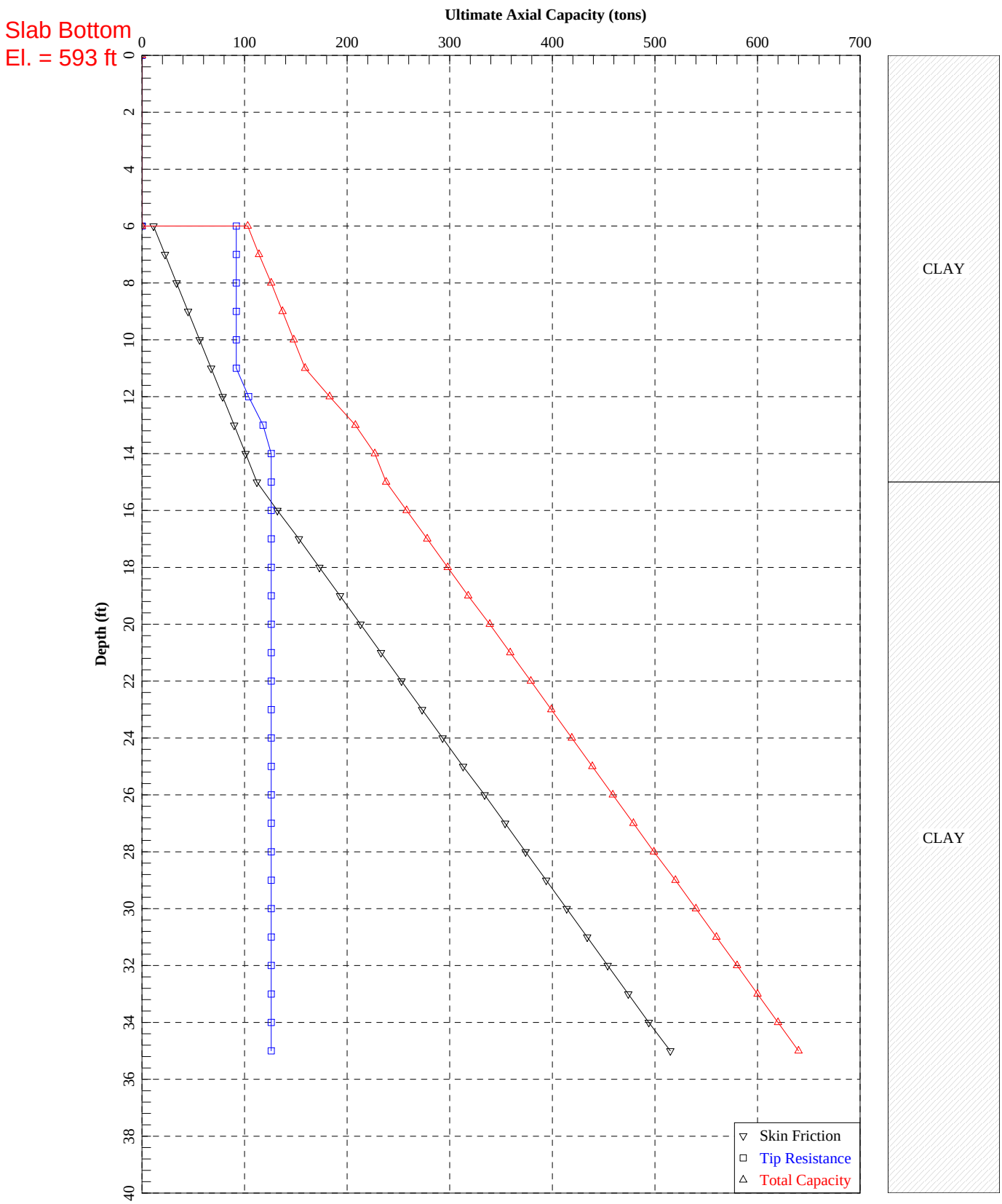
RESULT FROM UPPER-BOUND LINE

TOP LOAD ton	TOP MOVEMENT IN.	TIP LOAD ton	TIP MOVEMENT IN.
0.8178E+00	0.1352E-03	0.4055E-03	0.1000E-04
0.4089E+01	0.6761E-03	0.2028E-02	0.5000E-04
0.8178E+01	0.1352E-02	0.4055E-02	0.1000E-03
0.3415E+03	0.6579E-01	0.2028E+00	0.5000E-02
0.4225E+03	0.9024E-01	0.3041E+00	0.7500E-02
0.4799E+03	0.1105E+00	0.4055E+00	0.1000E-01
0.6334E+03	0.1813E+00	0.1014E+01	0.2500E-01
0.6825E+03	0.2255E+00	0.2028E+01	0.5000E-01
0.6971E+03	0.2564E+00	0.3041E+01	0.7500E-01
0.7045E+03	0.2847E+00	0.4055E+01	0.1000E+00
0.6918E+03	0.4344E+00	0.6261E+01	0.2500E+00
0.6457E+03	0.6708E+00	0.7574E+01	0.5000E+00
0.6461E+03	0.7960E+00	0.7952E+01	0.6250E+00
0.6463E+03	0.9523E+00	0.8114E+01	0.7812E+00
0.6464E+03	0.1371E+01	0.8207E+01	0.1200E+01

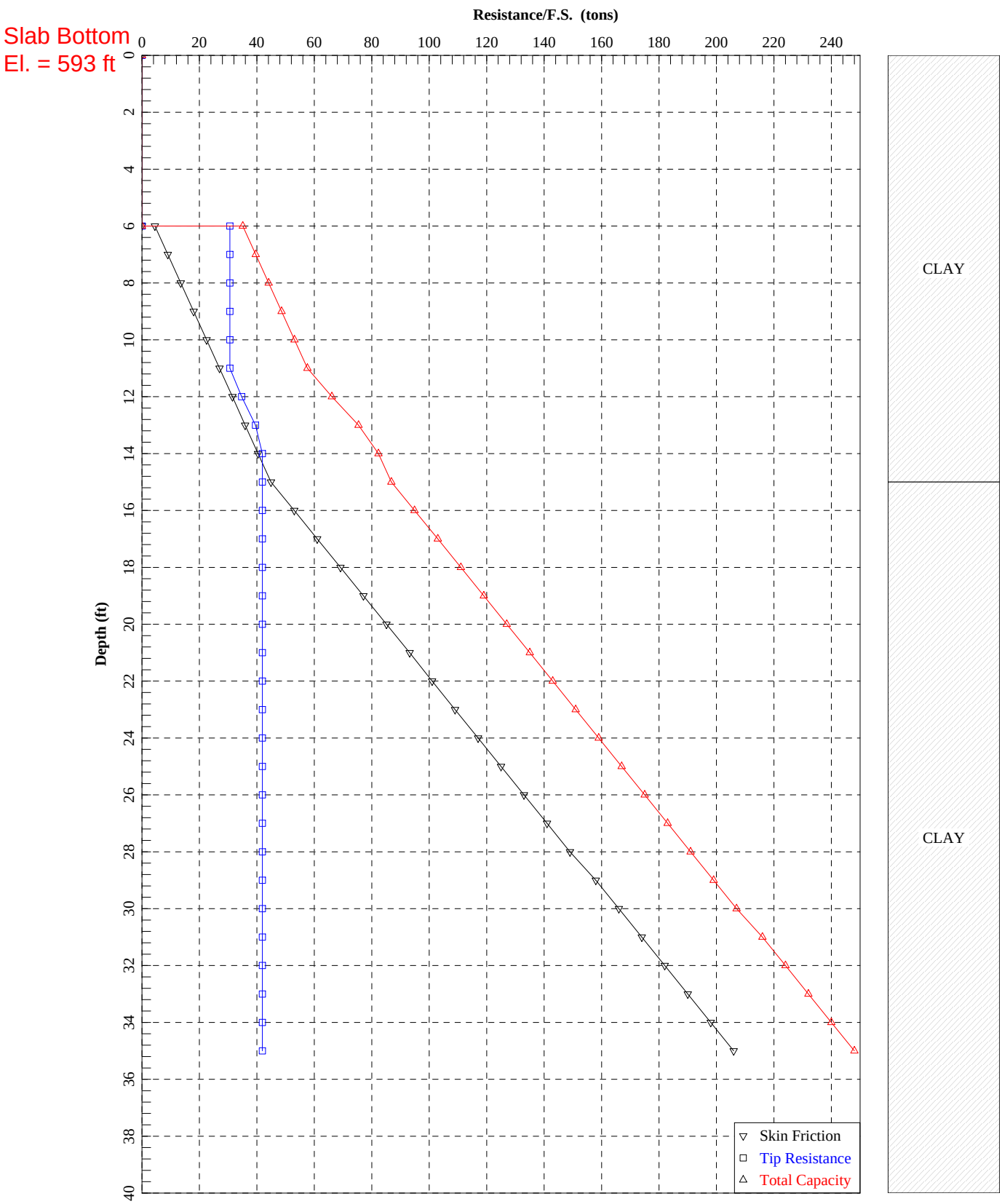
RESULT FROM LOWER-BOUND LINE

TOP LOAD ton	TOP MOVEMENT IN.	TIP LOAD ton	TIP MOVEMENT IN.
0.1533E+00	0.4065E-04	0.1375E-03	0.1000E-04
0.7666E+00	0.2032E-03	0.6873E-03	0.5000E-04
0.1533E+01	0.4065E-03	0.1375E-02	0.1000E-03
0.7866E+02	0.2058E-01	0.6873E-01	0.5000E-02
0.1177E+03	0.3092E-01	0.1031E+00	0.7500E-02
0.1544E+03	0.4109E-01	0.1375E+00	0.1000E-01
0.3311E+03	0.9639E-01	0.3437E+00	0.2500E-01
0.4865E+03	0.1655E+00	0.6873E+00	0.5000E-01
0.5570E+03	0.2142E+00	0.1031E+01	0.7500E-01
0.5878E+03	0.2505E+00	0.1375E+01	0.1000E+00
0.5871E+03	0.4065E+00	0.3169E+01	0.2500E+00

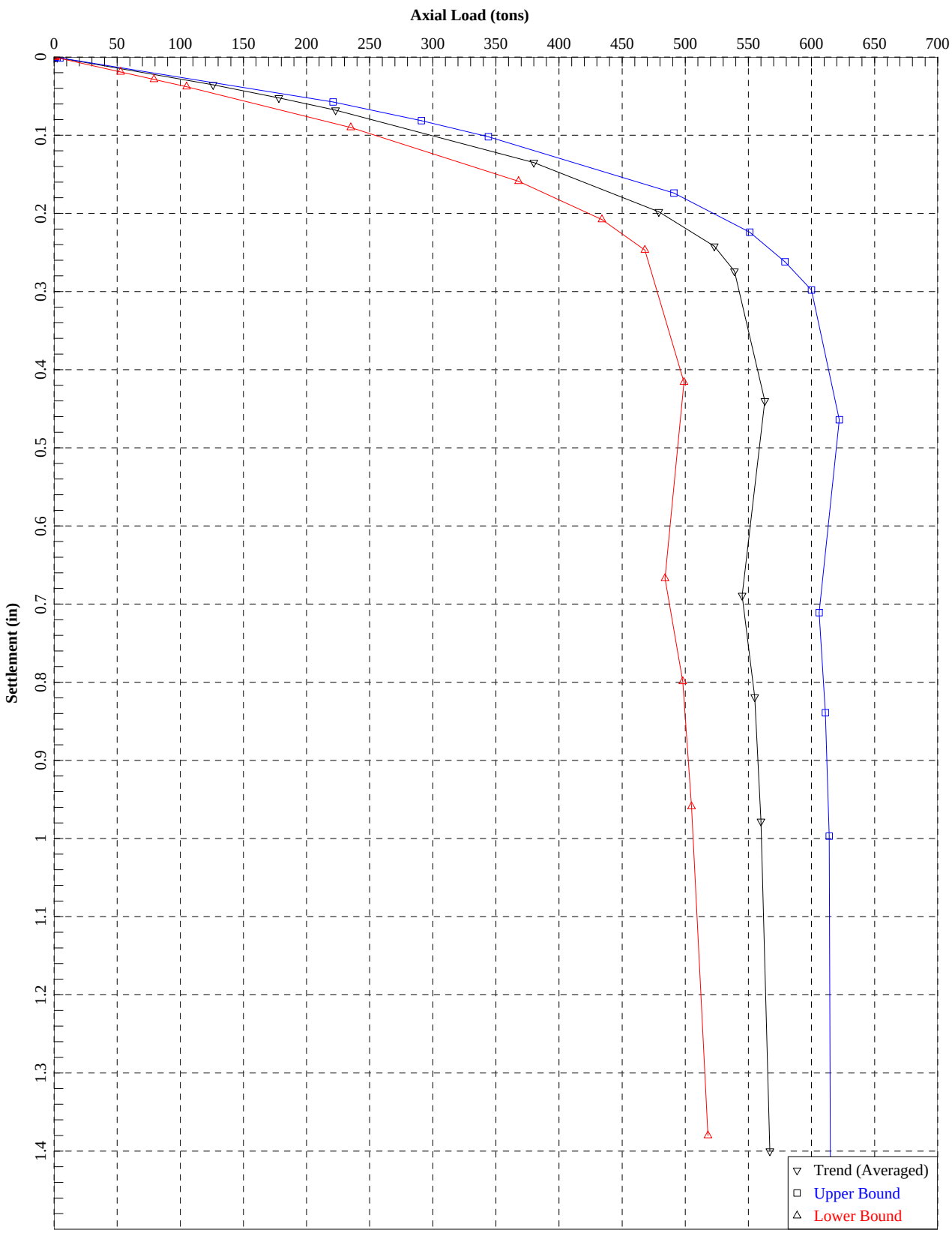
0.5258E+03	0.6389E+00	0.5560E+01	0.5000E+00
0.5267E+03	0.7644E+00	0.6437E+01	0.6250E+00
0.5272E+03	0.9209E+00	0.6932E+01	0.7812E+00
0.5280E+03	0.1340E+01	0.7753E+01	0.1200E+01



Montopolis Pump Station_2ft_Diameter Drilled Shaft_Ultimate_Compression



Montopolis Pump Station_2ft_Diameter Drilled Shaft_Ultimate_Compression



Montopolis Pump Station_2ft_Diameter Drilled Shaft_Compression

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==========================================================================

                    SHAFT for Windows, Version 2012.7.10

                     Serial Number :  155987379

                  VERTICALLY LOADED DRILLED SHAFT ANALYSIS
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                         All Rights Reserved

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Investigation\2015 Update\Calculations and Figure\SHAFT\
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     Name of output file         : .sfo
     Name of plot output file    : .sfp
     Name of runtime file        : .sfr


     --------------------------------------------------------------------------
                            Time and Date of Analysis
     --------------------------------------------------------------------------

               Date:  June 16, 2015     Time:  15:25:01

     Montopolis Pump Station


     PROPOSED DEPTH =      35.0 FT
     ----------------


     NUMBER OF LAYERS =    2
     ------------------


     WATER TABLE DEPTH =      36.0 FT.
     --------------------


     FACTOR OF SAFETY APPLIED TO THE ULTIMATE SIDE FRICTION CAPACITY = 2.50
     ----------------------------------------------------------------------
     FACTOR OF SAFETY APPLIED TO THE ULTIMATE BASE CAPACITY = 3.00
     -------------------------------------------------------------


     SOIL INFORMATION
     ----------------

     LAYER NO 1----CLAY

       AT THE TOP

       STRENGTH REDUCTION FACTOR-ALPHA                    = 0.550E+00
       END BEARING COEFFICIENT-Nc                         = 0.900E+01
       UNDRAINED SHEAR STRENGTH, LB/SQ FT                 = 0.650E+04
       INTERNAL FRICTION ANGLE, DEG.                      = 0.000E+00
       BLOWS PER FOOT FROM STANDARD PENETRATION TEST      = 0.000E+00
       SOIL UNIT WEIGHT, LB/CU FT                         = 0.120E+03
       MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT           = 0.640E+04
       DEPTH, FT                                          = 0.000E+00


       AT THE BOTTOM

       STRENGTH REDUCTION FACTOR-ALPHA                    = 0.550E+00
       END BEARING COEFFICIENT-Nc                         = 0.900E+01
       UNDRAINED SHEAR STRENGTH, LB/SQ FT                 = 0.650E+04
       INTERNAL FRICTION ANGLE, DEG.                      = 0.000E+00
       BLOWS PER FOOT FROM STANDARD PENETRATION TEST      = 0.000E+00
       SOIL UNIT WEIGHT, LB/CU FT                         = 0.120E+03
       MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT           = 0.640E+04
       DEPTH, FT                                          = 0.150E+02


     LAYER NO 2----CLAY

       AT THE TOP

       STRENGTH REDUCTION FACTOR-ALPHA                    = 0.550E+00
       END BEARING COEFFICIENT-Nc                         = 0.900E+01
       UNDRAINED SHEAR STRENGTH, LB/SQ FT                 = 0.120E+05
       INTERNAL FRICTION ANGLE, DEG.                      = 0.000E+00
       BLOWS PER FOOT FROM STANDARD PENETRATION TEST      = 0.000E+00
       SOIL UNIT WEIGHT, LB/CU FT                         = 0.125E+03
       MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT           = 0.640E+04
       DEPTH, FT                                          = 0.150E+02
```



```
       AT THE BOTTOM

       STRENGTH REDUCTION FACTOR-ALPHA                    = 0.550E+00
       END BEARING COEFFICIENT-Nc                         = 0.900E+01
       UNDRAINED SHEAR STRENGTH, LB/SQ FT                 = 0.120E+05
       INTERNAL FRICTION ANGLE, DEG.                      = 0.000E+00
       BLOWS PER FOOT FROM STANDARD PENETRATION TEST      = 0.000E+00
       SOIL UNIT WEIGHT, LB/CU FT                         = 0.125E+03
       MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT           = 0.640E+04
       DEPTH, FT                                          = 0.400E+02


     DRILLED SHAFT INFORMATION
     -------------------------

      DIAMETER OF STEM          =    2.000  FT.
      DIAMETER OF BASE          =    2.000  FT.
      END OF STEM TO BASE       =    0.000  FT.
      ANGLE OF BELL             =    0.000  DEG.
      IGNORED TOP PORTION       =    5.000  FT.
      IGNORED BOTTOM PORTION    =    0.000  FT.
      AREA OF ONE PERCENT STEEL =    4.524  SQ.IN.
      ELASTIC MODULUS, Ec       = 0.360E+07 LB/SQ IN
      VOLUME OF UNDERREAM       =    0.000  CU.YDS.


     PREDICTED RESULTS
     -----------------

     QS     = ULTIMATE SIDE RESISTANCE;
     QB     = ULTIMATE BASE RESISTANCE;
     WT     = WEIGHT OF DRILLED SHAFT (FOR UPLIFT CAPACITY ONLY);
     QU     = TOTAL ULTIMATE RESISTANCE;
     QBD    = TOTAL ALLOWABLE LOAD USING A FACTOR OF SAFETY
              APPLIED TO THE ULTIMATE BASE RESISTANCE;
     QDN    = TOTAL ALLOWABLE LOAD USING FACTORS OF SAFETY
              APPLIED TO THE ULTIMATE SIDE RESISTANCE AND
              THE ULTIMATE BASE RESISTANCE.
```

LENGTH (FEET)	VOLUME (CU.YDS)	QS (TONS)	QB (TONS)	QU (TONS)	QBD (TONS)	QDN (TONS)	QU/VOLUME (TONS/CU.YDS)
5.5	0.64	5.62	91.90	97.52	36.25	32.88	151.37
6.0	0.70	11.23	91.90	103.14	41.87	35.13	147.71
6.5	0.76	16.85	91.90	108.75	47.48	37.37	144.06
7.0	0.81	22.47	91.90	114.37	53.10	39.62	140.40
7.5	0.87	28.08	91.90	119.99	58.72	41.87	137.66
8.0	0.93	33.70	91.90	125.60	64.33	44.11	134.92
8.5	0.99	39.31	91.90	131.22	69.95	46.36	132.78
9.0	1.05	44.93	91.90	136.83	75.57	48.61	130.65
9.5	1.11	50.55	91.90	142.45	81.18	50.85	128.94
10.0	1.16	56.16	91.90	148.07	86.80	53.10	127.24
10.5	1.22	61.78	91.90	153.68	92.41	55.35	125.84
11.0	1.28	67.40	91.90	159.30	98.03	57.59	124.45
11.5	1.34	73.01	97.94	170.95	105.66	61.85	127.60
12.0	1.40	78.63	103.97	182.60	113.28	66.11	130.76
12.5	1.45	84.24	111.20	195.45	121.31	70.77	134.22
13.0	1.51	89.86	118.44	208.30	129.34	75.43	137.69
13.5	1.57	95.48	122.06	217.54	136.16	78.88	138.44
14.0	1.63	101.09	125.68	226.77	142.99	82.33	139.19
14.5	1.69	106.71	125.68	232.39	148.60	84.58	137.77
15.0	1.75	112.33	125.68	238.01	154.22	86.82	136.35
15.5	1.80	122.38	125.68	248.06	164.27	90.85	137.49
16.0	1.86	132.44	125.68	258.12	174.33	94.87	138.63
16.5	1.92	142.49	125.68	268.17	184.38	98.89	139.63
17.0	1.98	152.54	125.68	278.22	194.44	102.91	140.64
17.5	2.04	162.60	125.68	288.28	204.49	106.93	141.53
18.0	2.09	172.65	125.68	298.33	214.55	110.95	142.42
18.5	2.15	182.71	125.68	308.39	224.60	114.98	143.22
19.0	2.21	192.76	125.68	318.44	234.66	119.00	144.02
19.5	2.27	202.82	125.68	328.50	244.71	123.02	144.74
20.0	2.33	212.87	125.68	338.55	254.76	127.04	145.46
20.5	2.39	222.92	125.68	348.60	264.82	131.06	146.11
21.0	2.44	232.98	125.68	358.66	274.87	135.09	146.76
21.5	2.50	243.03	125.68	368.71	284.93	139.11	147.36
22.0	2.56	253.09	125.68	378.77	294.98	143.13	147.95
22.5	2.62	263.14	125.68	388.82	305.04	147.15	148.49
23.0	2.68	273.20	125.68	398.88	315.09	151.17	149.03
23.5	2.73	283.25	125.68	408.93	325.14	155.19	149.52
24.0	2.79	293.31	125.68	418.99	335.20	159.22	150.02
24.5	2.85	303.36	125.68	429.04	345.25	163.24	150.47
25.0	2.91	313.41	125.68	439.09	355.31	167.26	150.93
25.5	2.97	323.47	125.68	449.15	365.36	171.28	151.35
26.0	3.03	333.52	125.68	459.20	375.42	175.30	151.77
26.5	3.08	343.58	125.68	469.26	385.47	179.32	152.16
27.0	3.14	353.63	125.68	479.31	395.53	183.35	152.55
27.5	3.20	363.69	125.68	489.37	405.58	187.37	152.91

28.0	3.26	373.74	125.68	499.42	415.63	191.39	153.27
28.5	3.32	383.80	125.68	509.48	425.69	195.41	153.61
29.0	3.37	393.85	125.68	519.53	435.74	199.43	153.95
29.5	3.43	403.90	125.68	529.58	445.80	203.45	154.26
30.0	3.49	413.96	125.68	539.64	455.85	207.48	154.57
30.5	3.55	424.01	125.68	549.69	465.91	211.50	154.87
31.0	3.61	434.07	125.68	559.75	475.96	215.52	155.16
31.5	3.67	444.12	125.68	569.80	486.01	219.54	155.44
32.0	3.72	454.18	125.68	579.86	496.07	223.56	155.71
32.5	3.78	464.23	125.68	589.91	506.12	227.59	155.97
33.0	3.84	474.28	125.68	599.96	516.18	231.61	156.23
33.5	3.90	484.34	125.68	610.02	526.23	235.63	156.48
34.0	3.96	494.39	125.68	620.07	536.29	239.65	156.72
34.5	4.01	504.45	125.68	630.13	546.34	243.67	156.95
35.0	4.07	514.50	125.68	640.18	556.40	247.69	157.18

RESULT FROM TREND (AVERAGED) LINE

TOP LOAD ton	TOP MOVEMENT IN.	TIP LOAD ton	TIP MOVEMENT IN.
0.2439E+00	0.6892E-04	0.4137E-02	0.1000E-04
0.1219E+01	0.3446E-03	0.2068E-01	0.5000E-04
0.2439E+01	0.6892E-03	0.4137E-01	0.1000E-03
0.1258E+03	0.3544E-01	0.2068E+01	0.5000E-02
0.1777E+03	0.5219E-01	0.3103E+01	0.7500E-02
0.2231E+03	0.6787E-01	0.4137E+01	0.1000E-01
0.3803E+03	0.1350E+00	0.1034E+02	0.2500E-01
0.4794E+03	0.1978E+00	0.2068E+02	0.5000E-01
0.5226E+03	0.2419E+00	0.3103E+02	0.7500E-01
0.5389E+03	0.2744E+00	0.4137E+02	0.1000E+00
0.5628E+03	0.4399E+00	0.7185E+02	0.2500E+00
0.5450E+03	0.6892E+00	0.1001E+03	0.5000E+00
0.5546E+03	0.8192E+00	0.1096E+03	0.6250E+00
0.5596E+03	0.9780E+00	0.1147E+03	0.7812E+00
0.5668E+03	0.1401E+01	0.1219E+03	0.1200E+01

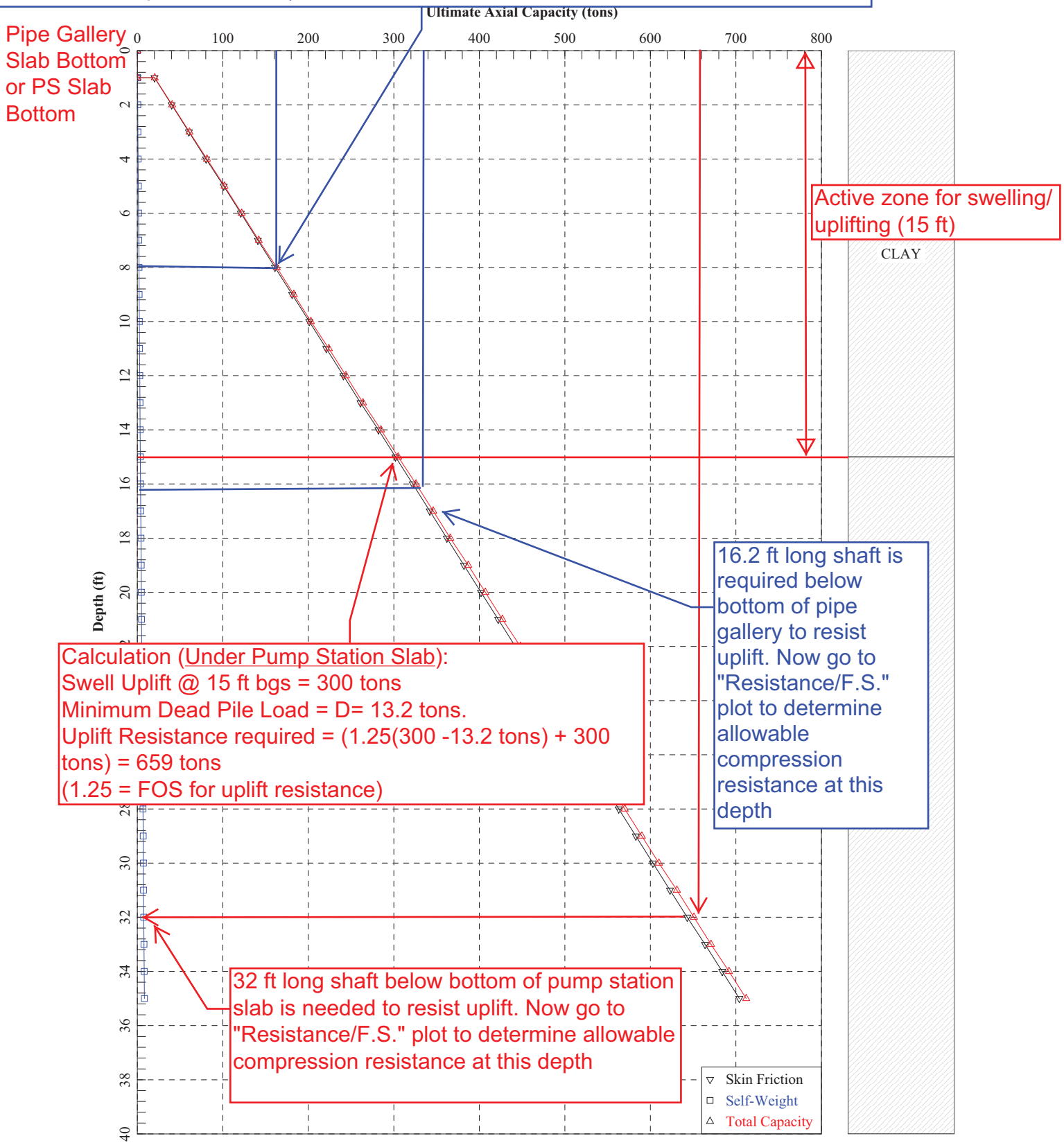
RESULT FROM UPPER-BOUND LINE

TOP LOAD ton	TOP MOVEMENT IN.	TIP LOAD ton	TIP MOVEMENT IN.
0.4680E+00	0.1138E-03	0.6179E-02	0.1000E-04
0.2340E+01	0.5691E-03	0.3090E-01	0.5000E-04
0.4680E+01	0.1138E-02	0.6179E-01	0.1000E-03
0.2213E+03	0.5749E-01	0.3090E+01	0.5000E-02
0.2914E+03	0.8139E-01	0.4634E+01	0.7500E-02
0.3437E+03	0.1016E+00	0.6179E+01	0.1000E-01
0.4906E+03	0.1737E+00	0.1545E+02	0.2500E-01
0.5505E+03	0.2245E+00	0.3090E+02	0.5000E-01
0.5787E+03	0.2625E+00	0.4634E+02	0.7500E-01
0.6002E+03	0.2981E+00	0.6179E+02	0.1000E+00
0.6224E+03	0.4635E+00	0.9541E+02	0.2500E+00
0.6056E+03	0.7112E+00	0.1154E+03	0.5000E+00
0.6114E+03	0.8391E+00	0.1212E+03	0.6250E+00
0.6139E+03	0.9967E+00	0.1236E+03	0.7812E+00
0.6153E+03	0.1416E+01	0.1251E+03	0.1200E+01

RESULT FROM LOWER-BOUND LINE

TOP LOAD ton	TOP MOVEMENT IN.	TIP LOAD ton	TIP MOVEMENT IN.
0.1029E+00	0.3743E-04	0.2095E-02	0.1000E-04
0.5147E+00	0.1871E-03	0.1047E-01	0.5000E-04
0.1029E+01	0.3743E-03	0.2095E-01	0.1000E-03
0.5271E+02	0.1895E-01	0.1047E+01	0.5000E-02
0.7914E+02	0.2847E-01	0.1571E+01	0.7500E-02
0.1047E+03	0.3792E-01	0.2095E+01	0.1000E-01
0.2349E+03	0.9018E-01	0.5237E+01	0.2500E-01
0.3675E+03	0.1586E+00	0.1047E+02	0.5000E-01
0.4342E+03	0.2084E+00	0.1571E+02	0.7500E-01
0.4683E+03	0.2468E+00	0.2095E+02	0.1000E+00
0.4988E+03	0.4156E+00	0.4828E+02	0.2500E+00
0.4844E+03	0.6673E+00	0.8473E+02	0.5000E+00
0.4977E+03	0.7992E+00	0.9808E+02	0.6250E+00
0.5053E+03	0.9593E+00	0.1056E+03	0.7812E+00
0.5178E+03	0.1385E+01	0.1181E+03	0.1200E+01

Shaft Calculation- (Under Pipe Gallery):
Swell Uplift @ 8 ft below bottom of pipe gallery = 160 tons (upper 7 ft of 15 ft removed)
Minimum Pile Dean Load = D= 18.3 tons.
Uplift Resistance required = (1.25(160 -18.3 tons) + 160 tons) = 337.1 tons
(1.25 = FOS for uplift resistance)



Montopolis Pump Station_2ft_Diameter Drilled Shaft_Ultimate_Uplift

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==========================================================================

                    SHAFT for Windows, Version 2012.7.10

                     Serial Number :  155987379

                  VERTICALLY LOADED DRILLED SHAFT ANALYSIS
                   (c) Copyright ENSOFT, Inc., 1987-2012
                         All Rights Reserved

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     Path to file locations      : \\AUSTIN\Proj\AustinTXCityof\472902MontopolisWRI\Preliminary Services\Geotechnical
Investigation\2015 Update\Calculations and Figure\SHAFT\
     Name of input data file     : .sfd
     Name of output file         : .sfo
     Name of plot output file    : .sfp
     Name of runtime file        : .sfr


     --------------------------------------------------------------------------
                          Time and Date of Analysis
     --------------------------------------------------------------------------

               Date:  June 16, 2015     Time:  16:00:18

     Montopolis Pump Station


     PROPOSED DEPTH =      35.0 FT
     ----------------


     REDUCTION FACTOR APPLIED FOR UPLIFT FRICTION = 1.000
     ----------------------------------------------


     NUMBER OF LAYERS =    2
     ------------------


     WATER TABLE DEPTH =      36.0 FT.
     -------------------


     FACTOR OF SAFETY APPLIED TO THE ULTIMATE SIDE FRICTION CAPACITY = 1.00
     ----------------------------------------------------------
     FACTOR OF SAFETY APPLIED TO THE ULTIMATE BASE CAPACITY = 1.00
     ----------------------------------------------------------


     SOIL INFORMATION
     ----------------

     LAYER NO 1----CLAY

       AT THE TOP

       STRENGTH REDUCTION FACTOR-ALPHA                    = 0.100E+01
       END BEARING COEFFICIENT-Nc                         = 0.900E+01
       UNDRAINED SHEAR STRENGTH, LB/SQ FT                 = 0.650E+04
       INTERNAL FRICTION ANGLE, DEG.                      = 0.000E+00
       BLOWS PER FOOT FROM STANDARD PENETRATION TEST      = 0.000E+00
       SOIL UNIT WEIGHT, LB/CU FT                         = 0.120E+03
       MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT           = 0.640E+04
       DEPTH, FT                                          = 0.000E+00


       AT THE BOTTOM

       STRENGTH REDUCTION FACTOR-ALPHA                    = 0.100E+01
       END BEARING COEFFICIENT-Nc                         = 0.900E+01
       UNDRAINED SHEAR STRENGTH, LB/SQ FT                 = 0.650E+04
       INTERNAL FRICTION ANGLE, DEG.                      = 0.000E+00
       BLOWS PER FOOT FROM STANDARD PENETRATION TEST      = 0.000E+00
       SOIL UNIT WEIGHT, LB/CU FT                         = 0.120E+03
       MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT           = 0.640E+04
       DEPTH, FT                                          = 0.150E+02


     LAYER NO 2----CLAY

       AT THE TOP

       STRENGTH REDUCTION FACTOR-ALPHA                    = 0.550E+00
       END BEARING COEFFICIENT-Nc                         = 0.900E+01
       UNDRAINED SHEAR STRENGTH, LB/SQ FT                 = 0.120E+05
       INTERNAL FRICTION ANGLE, DEG.                      = 0.000E+00
       BLOWS PER FOOT FROM STANDARD PENETRATION TEST      = 0.000E+00
```



```
       SOIL UNIT WEIGHT, LB/CU FT                         = 0.125E+03
       MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT           = 0.640E+04
       DEPTH, FT                                          = 0.150E+02


       AT THE BOTTOM

       STRENGTH REDUCTION FACTOR-ALPHA                    = 0.550E+00
       END BEARING COEFFICIENT-Nc                         = 0.900E+01
       UNDRAINED SHEAR STRENGTH, LB/SQ FT                 = 0.120E+05
       INTERNAL FRICTION ANGLE, DEG.                      = 0.000E+00
       BLOWS PER FOOT FROM STANDARD PENETRATION TEST      = 0.000E+00
       SOIL UNIT WEIGHT, LB/CU FT                         = 0.125E+03
       MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT           = 0.640E+04
       DEPTH, FT                                          = 0.400E+02


     DRILLED SHAFT INFORMATION
     -------------------------

      DIAMETER OF STEM          =    2.000  FT.
      DIAMETER OF BASE          =    2.000  FT.
      END OF STEM TO BASE       =    0.000  FT.
      ANGLE OF BELL             =    0.000  DEG.
      IGNORED TOP PORTION       =    0.000  FT.
      IGNORED BOTTOM PORTION    =    0.000  FT.
      AREA OF ONE PERCENT STEEL =    4.524  SQ.IN.
      ELASTIC MODULUS, EC       = 0.360E+07 LB/SQ IN
      VOLUME OF UNDERREAM       =    0.000  CU.YDS.


     PREDICTED RESULTS
     -----------------

     QS     = ULTIMATE SIDE RESISTANCE;
     QB     = ULTIMATE BASE RESISTANCE;
     WT     = WEIGHT OF DRILLED SHAFT (FOR UPLIFT CAPACITY ONLY);
     QU     = TOTAL ULTIMATE RESISTANCE;
     QBD    = TOTAL ALLOWABLE LOAD USING A FACTOR OF SAFETY
              APPLIED TO THE ULTIMATE BASE RESISTANCE;
     QDN    = TOTAL ALLOWABLE LOAD USING FACTORS OF SAFETY
              APPLIED TO THE ULTIMATE SIDE RESISTANCE AND
              THE ULTIMATE BASE RESISTANCE.
```

LENGTH (FEET)	VOLUME (CU.YDS)	QS (TONS)	WT (TONS)	QU (TONS)	QBD (TONS)	QDN (TONS)	QU/VOLUME (TONS/CU.YDS)
0.5	0.06	10.05	0.12	10.17	10.17	10.17	174.82
1.0	0.12	20.11	0.24	20.34	20.34	20.34	174.82
1.5	0.17	30.16	0.35	30.52	30.52	30.52	174.82
2.0	0.23	40.22	0.47	40.69	40.69	40.69	174.82
2.5	0.29	50.27	0.59	50.86	50.86	50.86	174.83
3.0	0.35	60.33	0.71	61.03	61.03	61.03	174.83
3.5	0.41	70.38	0.82	71.21	71.21	71.21	174.83
4.0	0.47	80.44	0.94	81.38	81.38	81.38	174.82
4.5	0.52	90.49	1.06	91.55	91.55	91.55	174.83
5.0	0.58	100.54	1.18	101.72	101.72	101.72	174.83
5.5	0.64	110.60	1.30	111.89	111.89	111.89	174.83
6.0	0.70	120.65	1.41	122.07	122.07	122.07	174.83
6.5	0.76	130.71	1.53	132.24	132.24	132.24	174.83
7.0	0.81	140.76	1.65	142.41	142.41	142.41	174.83
7.5	0.87	150.82	1.77	152.58	152.58	152.58	174.83
8.0	0.93	160.87	1.89	162.76	162.76	162.76	174.82
8.5	0.99	170.92	2.00	172.93	172.93	172.93	174.82
9.0	1.05	180.98	2.12	183.10	183.10	183.10	174.82
9.5	1.11	191.03	2.24	193.27	193.27	193.27	174.83
10.0	1.16	201.09	2.36	203.44	203.44	203.44	174.83
10.5	1.22	211.14	2.47	213.62	213.62	213.62	174.83
11.0	1.28	221.20	2.59	223.79	223.79	223.79	174.82
11.5	1.34	231.25	2.71	233.96	233.96	233.96	174.82
12.0	1.40	241.31	2.83	244.13	244.13	244.13	174.82
12.5	1.45	251.36	2.95	254.31	254.31	254.31	174.82
13.0	1.51	261.41	3.06	264.48	264.48	264.48	174.82
13.5	1.57	271.47	3.18	274.65	274.65	274.65	174.82
14.0	1.63	281.52	3.30	284.82	284.82	284.82	174.82
14.5	1.69	291.58	3.42	294.99	294.99	294.99	174.82
15.0	1.75	301.63	3.53	305.17	305.17	305.17	174.82
15.5	1.80	311.69	3.65	315.34	315.34	315.34	174.82
16.0	1.86	321.74	3.77	325.51	325.51	325.51	174.82
16.5	1.92	331.80	3.89	335.68	335.68	335.68	174.82
17.0	1.98	341.85	4.01	345.86	345.86	345.86	174.82
17.5	2.04	351.90	4.12	356.03	356.03	356.03	174.82
18.0	2.09	361.96	4.24	366.20	366.20	366.20	174.82
18.5	2.15	372.01	4.36	376.37	376.37	376.37	174.82
19.0	2.21	382.07	4.48	386.54	386.54	386.54	174.82
19.5	2.27	392.12	4.60	396.72	396.72	396.72	174.82
20.0	2.33	402.18	4.71	406.89	406.89	406.89	174.82
20.5	2.39	412.23	4.83	417.06	417.06	417.06	174.82

21.0	2.44	422.28	4.95	427.23	427.23	427.23	174.82
21.5	2.50	432.34	5.07	437.41	437.41	437.41	174.82
22.0	2.56	442.39	5.18	447.58	447.58	447.58	174.82
22.5	2.62	452.45	5.30	457.75	457.75	457.75	174.82
23.0	2.68	462.50	5.42	467.92	467.92	467.92	174.82
23.5	2.73	472.56	5.54	478.09	478.09	478.09	174.82
24.0	2.79	482.61	5.66	488.27	488.27	488.27	174.82
24.5	2.85	492.67	5.77	498.44	498.44	498.44	174.82
25.0	2.91	502.72	5.89	508.61	508.61	508.61	174.82
25.5	2.97	512.77	6.01	518.78	518.78	518.78	174.82
26.0	3.03	522.83	6.13	528.96	528.96	528.96	174.82
26.5	3.08	532.88	6.24	539.13	539.13	539.13	174.82
27.0	3.14	542.94	6.36	549.30	549.30	549.30	174.82
27.5	3.20	552.99	6.48	559.47	559.47	559.47	174.82
28.0	3.26	563.05	6.60	569.64	569.64	569.64	174.82
28.5	3.32	573.10	6.72	579.82	579.82	579.82	174.83
29.0	3.37	583.16	6.83	589.99	589.99	589.99	174.83
29.5	3.43	593.21	6.95	600.16	600.16	600.16	174.83
30.0	3.49	603.26	7.07	610.33	610.33	610.33	174.83
30.5	3.55	613.32	7.19	620.51	620.51	620.51	174.83
31.0	3.61	623.37	7.31	630.68	630.68	630.68	174.83
31.5	3.67	633.43	7.42	640.85	640.85	640.85	174.83
32.0	3.72	643.48	7.54	651.02	651.02	651.02	174.83
32.5	3.78	653.54	7.66	661.19	661.19	661.19	174.83
33.0	3.84	663.59	7.78	671.37	671.37	671.37	174.83
33.5	3.90	673.64	7.89	681.54	681.54	681.54	174.83
34.0	3.96	683.70	8.01	691.71	691.71	691.71	174.83
34.5	4.01	693.75	8.13	701.88	701.88	701.88	174.83
35.0	4.07	703.81	8.25	712.06	712.06	712.06	174.83

RESULT FROM TREND (AVERAGED) LINE

TOP LOAD ton	TOP MOVEMENT IN.	TIP LOAD ton	TIP MOVEMENT IN.
0.3952E+00	0.7828E-04	0.2715E-03	0.1000E-04
0.1976E+01	0.3914E-03	0.1357E-02	0.5000E-04
0.3952E+01	0.7828E-03	0.2715E-02	0.1000E-03
0.1969E+03	0.3999E-01	0.1357E+00	0.5000E-02
0.2685E+03	0.5813E-01	0.2036E+00	0.7500E-02
0.3279E+03	0.7454E-01	0.2715E+00	0.1000E-01
0.5100E+03	0.1428E+00	0.6787E+00	0.2500E-01
0.6064E+03	0.2016E+00	0.1357E+01	0.5000E-01
0.6446E+03	0.2422E+00	0.2036E+01	0.7500E-01
0.6511E+03	0.2698E+00	0.2715E+01	0.1000E+00
0.6431E+03	0.4208E+00	0.4715E+01	0.2500E+00
0.5858E+03	0.6549E+00	0.6567E+01	0.5000E+00
0.5864E+03	0.7802E+00	0.7194E+01	0.6250E+00
0.5867E+03	0.9366E+00	0.7528E+01	0.7812E+00
0.5872E+03	0.1356E+01	0.8000E+01	0.1200E+01

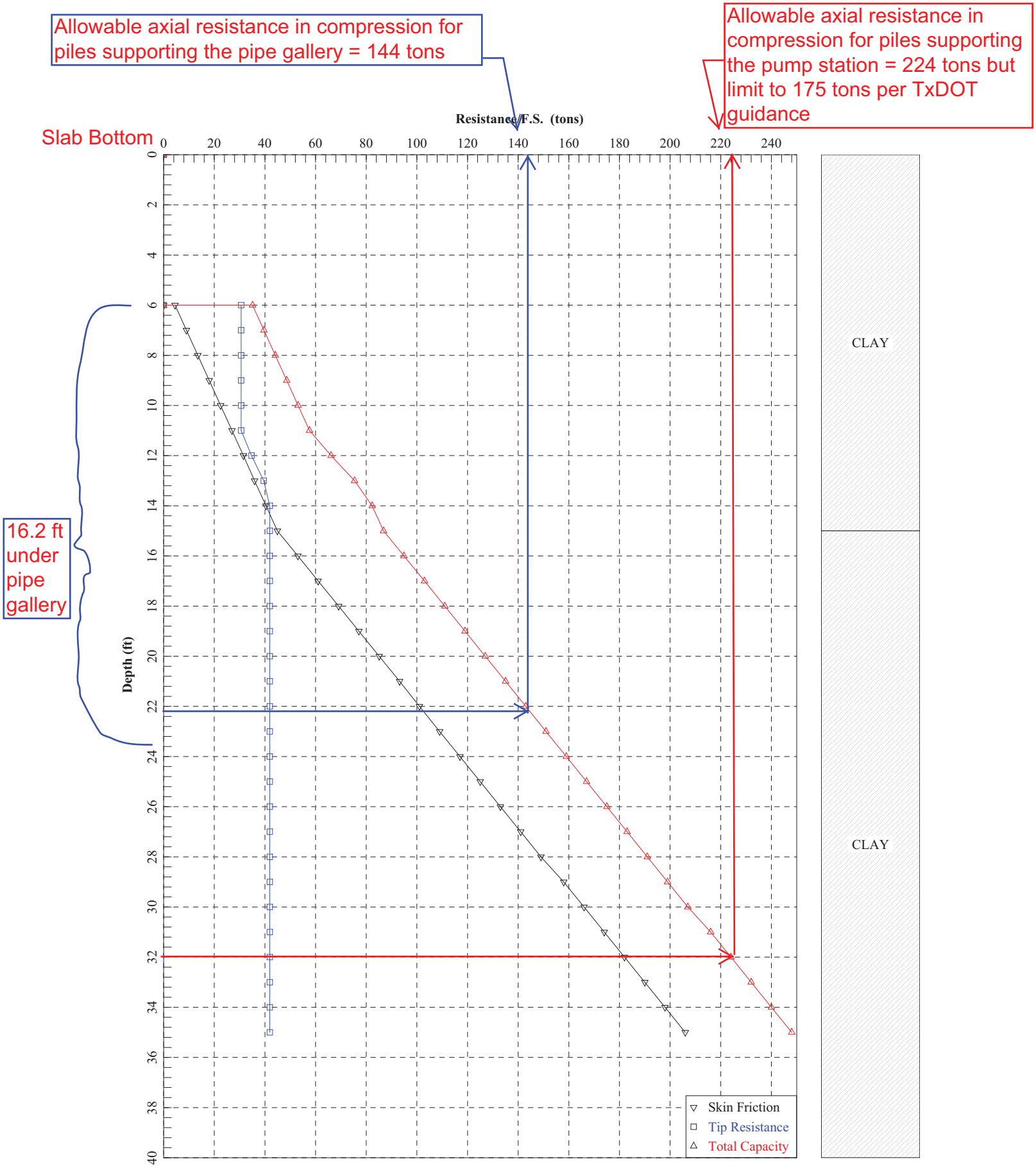
RESULT FROM UPPER-BOUND LINE

TOP LOAD ton	TOP MOVEMENT IN.	TIP LOAD ton	TIP MOVEMENT IN.
0.8178E+00	0.1352E-03	0.4055E-03	0.1000E-04
0.4089E+01	0.6761E-03	0.2028E-02	0.5000E-04
0.8178E+01	0.1352E-02	0.4055E-02	0.1000E-03
0.3415E+03	0.6579E-01	0.2028E+00	0.5000E-02
0.4225E+03	0.9024E-01	0.3041E+00	0.7500E-02
0.4799E+03	0.1105E+00	0.4055E+00	0.1000E-01
0.6334E+03	0.1813E+00	0.1014E+01	0.2500E-01
0.6825E+03	0.2255E+00	0.2028E+01	0.5000E-01
0.6971E+03	0.2564E+00	0.3041E+01	0.7500E-01
0.7045E+03	0.2847E+00	0.4055E+01	0.1000E+00
0.6918E+03	0.4344E+00	0.6261E+01	0.2500E+00
0.6457E+03	0.6708E+00	0.7574E+01	0.5000E+00
0.6461E+03	0.7960E+00	0.7952E+01	0.6250E+00
0.6463E+03	0.9523E+00	0.8114E+01	0.7812E+00
0.6464E+03	0.1371E+01	0.8207E+01	0.1200E+01

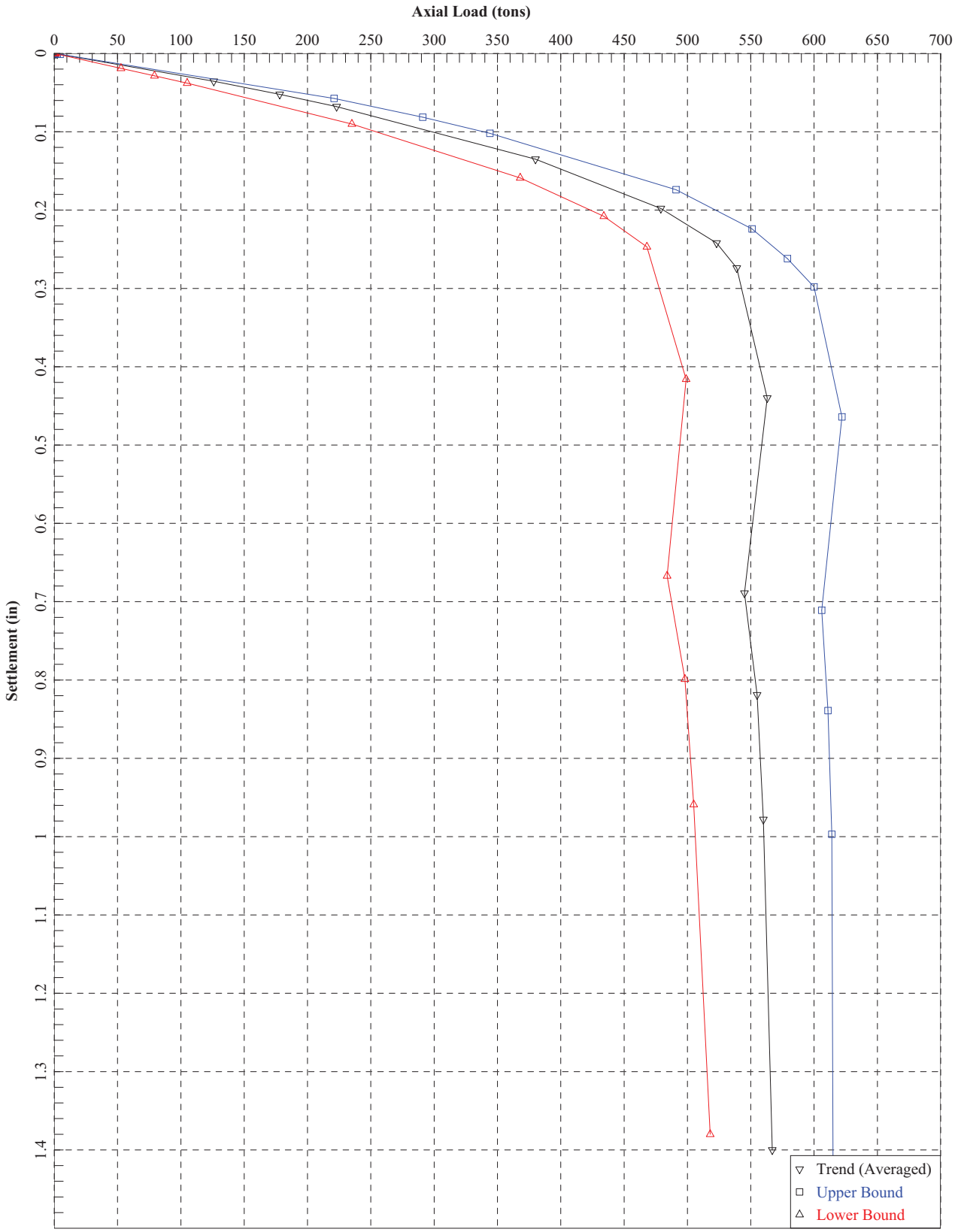
RESULT FROM LOWER-BOUND LINE

TOP LOAD ton	TOP MOVEMENT IN.	TIP LOAD ton	TIP MOVEMENT IN.
0.1533E+00	0.4065E-04	0.1375E-03	0.1000E-04
0.7666E+00	0.2032E-03	0.6873E-03	0.5000E-04
0.1533E+01	0.4065E-03	0.1375E-02	0.1000E-03
0.7866E+02	0.2058E-01	0.6873E-01	0.5000E-02
0.1177E+03	0.3092E-01	0.1031E+00	0.7500E-02
0.1544E+03	0.4109E-01	0.1375E+00	0.1000E-01
0.3311E+03	0.9639E-01	0.3437E+00	0.2500E-01
0.4865E+03	0.1655E+00	0.6873E+00	0.5000E-01
0.5570E+03	0.2142E+00	0.1031E+01	0.7500E-01
0.5878E+03	0.2505E+00	0.1375E+01	0.1000E+00
0.5871E+03	0.4065E+00	0.3169E+01	0.2500E+00

0.5258E+03	0.6389E+00	0.5560E+01	0.5000E+00
0.5267E+03	0.7644E+00	0.6437E+01	0.6250E+00
0.5272E+03	0.9209E+00	0.6932E+01	0.7812E+00
0.5280E+03	0.1340E+01	0.7753E+01	0.1200E+01



Montopolis Pump Station_2ft_Diameter Drilled Shaft_Ultimate_Compression



Montopolis Pump Station_2ft_Diameter Drilled Shaft_Compression

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==========================================================================

                    SHAFT for Windows, Version 2012.7.10

                     Serial Number :  155987379

                  VERTICALLY LOADED DRILLED SHAFT ANALYSIS
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Investigation\2015 Update\Calculations and Figure\SHAFT\
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     Name of plot output file    : .sfp
     Name of runtime file        : .sfr


     --------------------------------------------------------------------------
                            Time and Date of Analysis
     --------------------------------------------------------------------------

               Date:  June 16, 2015     Time:  15:25:01

     Montopolis Pump Station


     PROPOSED DEPTH =      35.0 FT
     ----------------


     NUMBER OF LAYERS =    2
     ------------------


     WATER TABLE DEPTH =      36.0 FT.
     --------------------


     FACTOR OF SAFETY APPLIED TO THE ULTIMATE SIDE FRICTION CAPACITY = 2.50
     ----------------------------------------------------------------------
     FACTOR OF SAFETY APPLIED TO THE ULTIMATE BASE CAPACITY = 3.00
     -------------------------------------------------------------


     SOIL INFORMATION
     ----------------

     LAYER NO 1----CLAY

       AT THE TOP

       STRENGTH REDUCTION FACTOR-ALPHA                    = 0.550E+00
       END BEARING COEFFICIENT-Nc                         = 0.900E+01
       UNDRAINED SHEAR STRENGTH, LB/SQ FT                 = 0.650E+04
       INTERNAL FRICTION ANGLE, DEG.                      = 0.000E+00
       BLOWS PER FOOT FROM STANDARD PENETRATION TEST      = 0.000E+00
       SOIL UNIT WEIGHT, LB/CU FT                         = 0.120E+03
       MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT           = 0.640E+04
       DEPTH, FT                                          = 0.000E+00


       AT THE BOTTOM

       STRENGTH REDUCTION FACTOR-ALPHA                    = 0.550E+00
       END BEARING COEFFICIENT-Nc                         = 0.900E+01
       UNDRAINED SHEAR STRENGTH, LB/SQ FT                 = 0.650E+04
       INTERNAL FRICTION ANGLE, DEG.                      = 0.000E+00
       BLOWS PER FOOT FROM STANDARD PENETRATION TEST      = 0.000E+00
       SOIL UNIT WEIGHT, LB/CU FT                         = 0.120E+03
       MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT           = 0.640E+04
       DEPTH, FT                                          = 0.150E+02


     LAYER NO 2----CLAY

       AT THE TOP

       STRENGTH REDUCTION FACTOR-ALPHA                    = 0.550E+00
       END BEARING COEFFICIENT-Nc                         = 0.900E+01
       UNDRAINED SHEAR STRENGTH, LB/SQ FT                 = 0.120E+05
       INTERNAL FRICTION ANGLE, DEG.                      = 0.000E+00
       BLOWS PER FOOT FROM STANDARD PENETRATION TEST      = 0.000E+00
       SOIL UNIT WEIGHT, LB/CU FT                         = 0.125E+03
       MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT           = 0.640E+04
       DEPTH, FT                                          = 0.150E+02
```



```
       AT THE BOTTOM

       STRENGTH REDUCTION FACTOR-ALPHA                    = 0.550E+00
       END BEARING COEFFICIENT-Nc                         = 0.900E+01
       UNDRAINED SHEAR STRENGTH, LB/SQ FT                 = 0.120E+05
       INTERNAL FRICTION ANGLE, DEG.                      = 0.000E+00
       BLOWS PER FOOT FROM STANDARD PENETRATION TEST      = 0.000E+00
       SOIL UNIT WEIGHT, LB/CU FT                         = 0.125E+03
       MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT           = 0.640E+04
       DEPTH, FT                                          = 0.400E+02


     DRILLED SHAFT INFORMATION
     -------------------------

       DIAMETER OF STEM          =    2.000  FT.
       DIAMETER OF BASE          =    2.000  FT.
       END OF STEM TO BASE       =    0.000  FT.
       ANGLE OF BELL             =    0.000  DEG.
       IGNORED TOP PORTION       =    5.000  FT.
       IGNORED BOTTOM PORTION    =    0.000  FT.
       AREA OF ONE PERCENT STEEL =    4.524  SQ.IN.
       ELASTIC MODULUS, Ec       = 0.360E+07 LB/SQ IN
       VOLUME OF UNDERREAM       =    0.000  CU.YDS.


     PREDICTED RESULTS
     -----------------

     QS     = ULTIMATE SIDE RESISTANCE;
     QB     = ULTIMATE BASE RESISTANCE;
     WT     = WEIGHT OF DRILLED SHAFT (FOR UPLIFT CAPACITY ONLY);
     QU     = TOTAL ULTIMATE RESISTANCE;
     QBD    = TOTAL ALLOWABLE LOAD USING A FACTOR OF SAFETY
              APPLIED TO THE ULTIMATE BASE RESISTANCE;
     QDN    = TOTAL ALLOWABLE LOAD USING FACTORS OF SAFETY
              APPLIED TO THE ULTIMATE SIDE RESISTANCE AND
              THE ULTIMATE BASE RESISTANCE.
```

LENGTH (FEET)	VOLUME (CU.YDS)	QS (TONS)	QB (TONS)	QU (TONS)	QBD (TONS)	QDN (TONS)	QU/VOLUME (TONS/CU.YDS)
5.5	0.64	5.62	91.90	97.52	36.25	32.88	151.37
6.0	0.70	11.23	91.90	103.14	41.87	35.13	147.71
6.5	0.76	16.85	91.90	108.75	47.48	37.37	144.06
7.0	0.81	22.47	91.90	114.37	53.10	39.62	140.40
7.5	0.87	28.08	91.90	119.99	58.72	41.87	137.66
8.0	0.93	33.70	91.90	125.60	64.33	44.11	134.92
8.5	0.99	39.31	91.90	131.22	69.95	46.36	132.78
9.0	1.05	44.93	91.90	136.83	75.57	48.61	130.65
9.5	1.11	50.55	91.90	142.45	81.18	50.85	128.94
10.0	1.16	56.16	91.90	148.07	86.80	53.10	127.24
10.5	1.22	61.78	91.90	153.68	92.41	55.35	125.84
11.0	1.28	67.40	91.90	159.30	98.03	57.59	124.45
11.5	1.34	73.01	97.94	170.95	105.66	61.85	127.60
12.0	1.40	78.63	103.97	182.60	113.28	66.11	130.76
12.5	1.45	84.24	111.20	195.45	121.31	70.77	134.22
13.0	1.51	89.86	118.44	208.30	129.34	75.43	137.69
13.5	1.57	95.48	122.06	217.54	136.16	78.88	138.44
14.0	1.63	101.09	125.68	226.77	142.99	82.33	139.19
14.5	1.69	106.71	125.68	232.39	148.60	84.58	137.77
15.0	1.75	112.33	125.68	238.01	154.22	86.82	136.35
15.5	1.80	122.38	125.68	248.06	164.27	90.85	137.49
16.0	1.86	132.44	125.68	258.12	174.33	94.87	138.63
16.5	1.92	142.49	125.68	268.17	184.38	98.89	139.63
17.0	1.98	152.54	125.68	278.22	194.44	102.91	140.64
17.5	2.04	162.60	125.68	288.28	204.49	106.93	141.53
18.0	2.09	172.65	125.68	298.33	214.55	110.95	142.42
18.5	2.15	182.71	125.68	308.39	224.60	114.98	143.22
19.0	2.21	192.76	125.68	318.44	234.66	119.00	144.02
19.5	2.27	202.82	125.68	328.50	244.71	123.02	144.74
20.0	2.33	212.87	125.68	338.55	254.76	127.04	145.46
20.5	2.39	222.92	125.68	348.60	264.82	131.06	146.11
21.0	2.44	232.98	125.68	358.66	274.87	135.09	146.76
21.5	2.50	243.03	125.68	368.71	284.93	139.11	147.36
22.0	2.56	253.09	125.68	378.77	294.98	143.13	147.95
22.5	2.62	263.14	125.68	388.82	305.04	147.15	148.49
23.0	2.68	273.20	125.68	398.88	315.09	151.17	149.03
23.5	2.73	283.25	125.68	408.93	325.14	155.19	149.52
24.0	2.79	293.31	125.68	418.99	335.20	159.22	150.02
24.5	2.85	303.36	125.68	429.04	345.25	163.24	150.47
25.0	2.91	313.41	125.68	439.09	355.31	167.26	150.93
25.5	2.97	323.47	125.68	449.15	365.36	171.28	151.35
26.0	3.03	333.52	125.68	459.20	375.42	175.30	151.77
26.5	3.08	343.58	125.68	469.26	385.47	179.32	152.16
27.0	3.14	353.63	125.68	479.31	395.53	183.35	152.55
27.5	3.20	363.69	125.68	489.37	405.58	187.37	152.91

28.0	3.26	373.74	125.68	499.42	415.63	191.39	153.27
28.5	3.32	383.80	125.68	509.48	425.69	195.41	153.61
29.0	3.37	393.85	125.68	519.53	435.74	199.43	153.95
29.5	3.43	403.90	125.68	529.58	445.80	203.45	154.26
30.0	3.49	413.96	125.68	539.64	455.85	207.48	154.57
30.5	3.55	424.01	125.68	549.69	465.91	211.50	154.87
31.0	3.61	434.07	125.68	559.75	475.96	215.52	155.16
31.5	3.67	444.12	125.68	569.80	486.01	219.54	155.44
32.0	3.72	454.18	125.68	579.86	496.07	223.56	155.71
32.5	3.78	464.23	125.68	589.91	506.12	227.59	155.97
33.0	3.84	474.28	125.68	599.96	516.18	231.61	156.23
33.5	3.90	484.34	125.68	610.02	526.23	235.63	156.48
34.0	3.96	494.39	125.68	620.07	536.29	239.65	156.72
34.5	4.01	504.45	125.68	630.13	546.34	243.67	156.95
35.0	4.07	514.50	125.68	640.18	556.40	247.69	157.18

RESULT FROM TREND (AVERAGED) LINE

TOP LOAD ton	TOP MOVEMENT IN.	TIP LOAD ton	TIP MOVEMENT IN.
0.2439E+00	0.6892E-04	0.4137E-02	0.1000E-04
0.1219E+01	0.3446E-03	0.2068E-01	0.5000E-04
0.2439E+01	0.6892E-03	0.4137E-01	0.1000E-03
0.1258E+03	0.3544E-01	0.2068E+01	0.5000E-02
0.1777E+03	0.5219E-01	0.3103E+01	0.7500E-02
0.2231E+03	0.6787E-01	0.4137E+01	0.1000E-01
0.3803E+03	0.1350E+00	0.1034E+02	0.2500E-01
0.4794E+03	0.1978E+00	0.2068E+02	0.5000E-01
0.5226E+03	0.2419E+00	0.3103E+02	0.7500E-01
0.5389E+03	0.2744E+00	0.4137E+02	0.1000E+00
0.5628E+03	0.4399E+00	0.7185E+02	0.2500E+00
0.5450E+03	0.6892E+00	0.1001E+03	0.5000E+00
0.5546E+03	0.8192E+00	0.1096E+03	0.6250E+00
0.5596E+03	0.9780E+00	0.1147E+03	0.7812E+00
0.5668E+03	0.1401E+01	0.1219E+03	0.1200E+01

RESULT FROM UPPER-BOUND LINE

TOP LOAD ton	TOP MOVEMENT IN.	TIP LOAD ton	TIP MOVEMENT IN.
0.4680E+00	0.1138E-03	0.6179E-02	0.1000E-04
0.2340E+01	0.5691E-03	0.3090E-01	0.5000E-04
0.4680E+01	0.1138E-02	0.6179E-01	0.1000E-03
0.2213E+03	0.5749E-01	0.3090E+01	0.5000E-02
0.2914E+03	0.8139E-01	0.4634E+01	0.7500E-02
0.3437E+03	0.1016E+00	0.6179E+01	0.1000E-01
0.4906E+03	0.1737E+00	0.1545E+02	0.2500E-01
0.5505E+03	0.2245E+00	0.3090E+02	0.5000E-01
0.5787E+03	0.2625E+00	0.4634E+02	0.7500E-01
0.6002E+03	0.2981E+00	0.6179E+02	0.1000E+00
0.6224E+03	0.4635E+00	0.9541E+02	0.2500E+00
0.6056E+03	0.7112E+00	0.1154E+03	0.5000E+00
0.6114E+03	0.8391E+00	0.1212E+03	0.6250E+00
0.6139E+03	0.9967E+00	0.1236E+03	0.7812E+00
0.6153E+03	0.1416E+01	0.1251E+03	0.1200E+01

RESULT FROM LOWER-BOUND LINE

TOP LOAD ton	TOP MOVEMENT IN.	TIP LOAD ton	TIP MOVEMENT IN.
0.1029E+00	0.3743E-04	0.2095E-02	0.1000E-04
0.5147E+00	0.1871E-03	0.1047E-01	0.5000E-04
0.1029E+01	0.3743E-03	0.2095E-01	0.1000E-03
0.5271E+02	0.1895E-01	0.1047E+01	0.5000E-02
0.7914E+02	0.2847E-01	0.1571E+01	0.7500E-02
0.1047E+03	0.3792E-01	0.2095E+01	0.1000E-01
0.2349E+03	0.9018E-01	0.5237E+01	0.2500E-01
0.3675E+03	0.1586E+00	0.1047E+02	0.5000E-01
0.4342E+03	0.2084E+00	0.1571E+02	0.7500E-01
0.4683E+03	0.2468E+00	0.2095E+02	0.1000E+00
0.4988E+03	0.4156E+00	0.4828E+02	0.2500E+00
0.4844E+03	0.6673E+00	0.8473E+02	0.5000E+00
0.4977E+03	0.7992E+00	0.9808E+02	0.6250E+00
0.5053E+03	0.9593E+00	0.1056E+03	0.7812E+00
0.5178E+03	0.1385E+01	0.1181E+03	0.1200E+01

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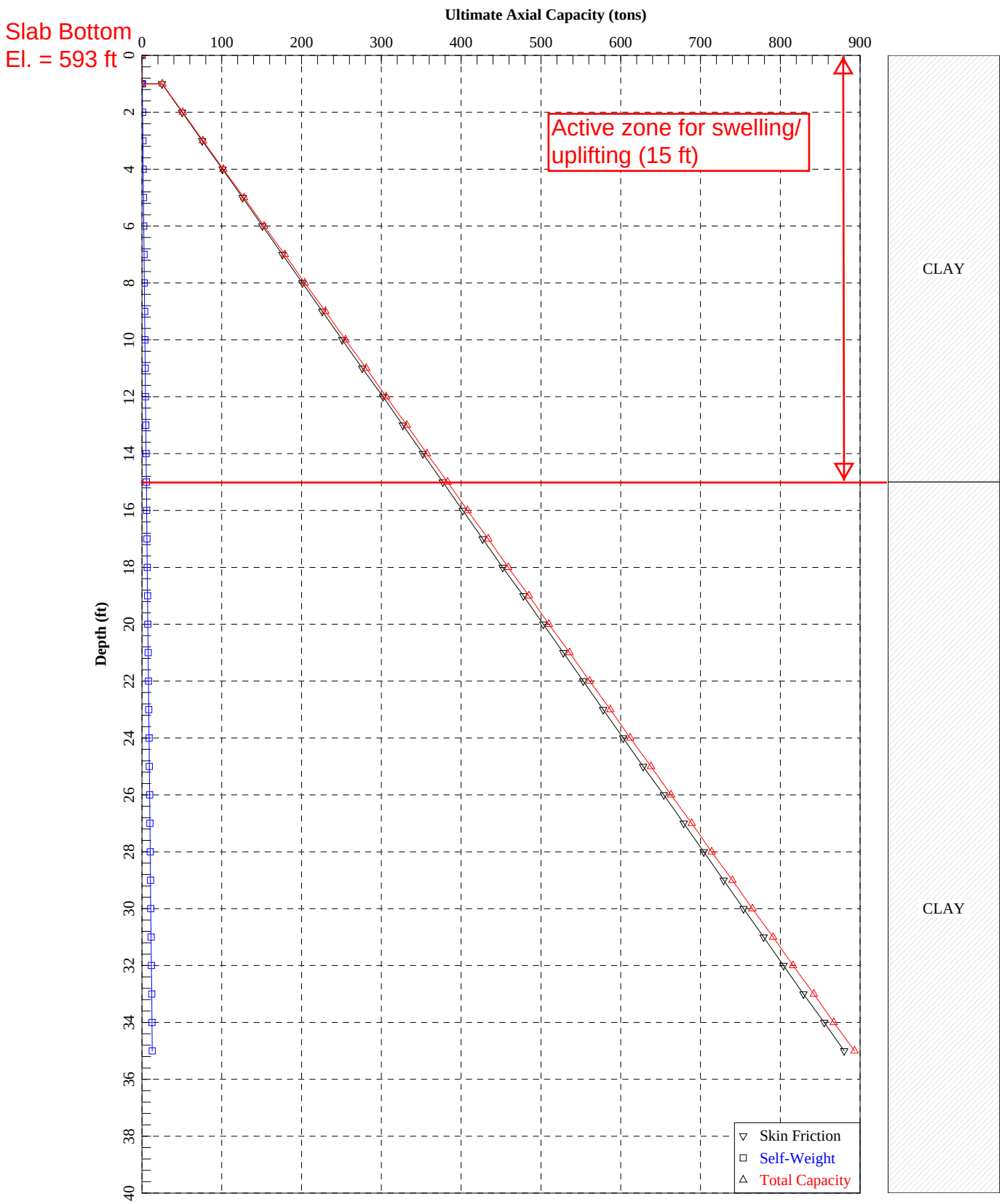

Montopolis Pump Station_2.5ft_Diameter Drilled Shaft_Ultimate_Uplift

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==========================================================================

                    SHAFT for Windows, Version 2012.7.10

                     Serial Number :  155987379

                  VERTICALLY LOADED DRILLED SHAFT ANALYSIS
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     --------------------------------------------------------------------------
                            Time and Date of Analysis
     --------------------------------------------------------------------------

               Date:  June 16, 2015     Time:  16:21:54

     Montopolis Pump Station


     PROPOSED DEPTH =      35.0 FT
     ----------------


     REDUCTION FACTOR APPLIED FOR UPLIFT FRICTION = 1.000
     ----------------------------------------------


     NUMBER OF LAYERS =    2
     ------------------


     WATER TABLE DEPTH =      36.0 FT.
     -------------------



     FACTOR OF SAFETY APPLIED TO THE ULTIMATE SIDE FRICTION CAPACITY = 1.00
     ----------------------------------------------------------
     FACTOR OF SAFETY APPLIED TO THE ULTIMATE BASE CAPACITY = 1.00
     -------------------------------------------------------


     SOIL INFORMATION
     ----------------

     LAYER NO 1----CLAY

       AT THE TOP

       STRENGTH REDUCTION FACTOR-ALPHA                    = 0.100E+01
       END BEARING COEFFICIENT-Nc                         = 0.900E+01
       UNDRAINED SHEAR STRENGTH, LB/SQ FT                 = 0.650E+04
       INTERNAL FRICTION ANGLE, DEG.                      = 0.000E+00
       BLOWS PER FOOT FROM STANDARD PENETRATION TEST      = 0.000E+00
       SOIL UNIT WEIGHT, LB/CU FT                         = 0.120E+03
       MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT           = 0.640E+04
       DEPTH, FT                                          = 0.000E+00


       AT THE BOTTOM

       STRENGTH REDUCTION FACTOR-ALPHA                    = 0.100E+01
       END BEARING COEFFICIENT-Nc                         = 0.900E+01
       UNDRAINED SHEAR STRENGTH, LB/SQ FT                 = 0.650E+04
       INTERNAL FRICTION ANGLE, DEG.                      = 0.000E+00
       BLOWS PER FOOT FROM STANDARD PENETRATION TEST      = 0.000E+00
       SOIL UNIT WEIGHT, LB/CU FT                         = 0.120E+03
       MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT           = 0.640E+04
       DEPTH, FT                                          = 0.150E+02


     LAYER NO 2----CLAY

       AT THE TOP

       STRENGTH REDUCTION FACTOR-ALPHA                    = 0.550E+00
       END BEARING COEFFICIENT-Nc                         = 0.900E+01
       UNDRAINED SHEAR STRENGTH, LB/SQ FT                 = 0.120E+05
       INTERNAL FRICTION ANGLE, DEG.                      = 0.000E+00
       BLOWS PER FOOT FROM STANDARD PENETRATION TEST      = 0.000E+00
```



```
       SOIL UNIT WEIGHT, LB/CU FT                         = 0.125E+03
       MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT           = 0.640E+04
       DEPTH, FT                                          = 0.150E+02


       AT THE BOTTOM

       STRENGTH REDUCTION FACTOR-ALPHA                    = 0.550E+00
       END BEARING COEFFICIENT-Nc                         = 0.900E+01
       UNDRAINED SHEAR STRENGTH, LB/SQ FT                 = 0.120E+05
       INTERNAL FRICTION ANGLE, DEG.                      = 0.000E+00
       BLOWS PER FOOT FROM STANDARD PENETRATION TEST      = 0.000E+00
       SOIL UNIT WEIGHT, LB/CU FT                         = 0.125E+03
       MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT           = 0.640E+04
       DEPTH, FT                                          = 0.450E+02


     DRILLED SHAFT INFORMATION
     -------------------------

      DIAMETER OF STEM          =    2.500  FT.
      DIAMETER OF BASE          =    2.500  FT.
      END OF STEM TO BASE       =    0.000  FT.
      ANGLE OF BELL             =    0.000  DEG.
      IGNORED TOP PORTION       =    0.000  FT.
      IGNORED BOTTOM PORTION    =    0.000  FT.
      AREA OF ONE PERCENT STEEL =    7.069  SQ.IN.
      ELASTIC MODULUS, Ec       = 0.360E+07 LB/SQ IN
      VOLUME OF UNDERREAM       =    0.000  CU.YDS.


     PREDICTED RESULTS
     -----------------

     QS     = ULTIMATE SIDE RESISTANCE;
     QB     = ULTIMATE BASE RESISTANCE;
     WT     = WEIGHT OF DRILLED SHAFT (FOR UPLIFT CAPACITY ONLY);
     QU     = TOTAL ULTIMATE RESISTANCE;
     QBD    = TOTAL ALLOWABLE LOAD USING A FACTOR OF SAFETY
              APPLIED TO THE ULTIMATE BASE RESISTANCE;
     QDN    = TOTAL ALLOWABLE LOAD USING FACTORS OF SAFETY
              APPLIED TO THE ULTIMATE SIDE RESISTANCE AND
              THE ULTIMATE BASE RESISTANCE.
```

LENGTH (FEET)	VOLUME (CU.YDS)	QS (TONS)	WT (TONS)	QU (TONS)	QBD (TONS)	QDN (TONS)	QU/VOLUME (TONS/CU.YDS)
0.5	0.09	12.57	0.18	12.75	12.75	12.75	140.26
1.0	0.18	25.14	0.37	25.50	25.50	25.50	140.26
1.5	0.27	37.70	0.55	38.26	38.26	38.26	140.26
2.0	0.36	50.27	0.74	51.01	51.01	51.01	140.26
2.5	0.45	62.84	0.92	63.76	63.76	63.76	140.26
3.0	0.55	75.41	1.10	76.51	76.51	76.51	140.26
3.5	0.64	87.98	1.29	89.26	89.26	89.26	140.26
4.0	0.73	100.54	1.47	102.02	102.02	102.02	140.26
4.5	0.82	113.11	1.66	114.77	114.77	114.77	140.27
5.0	0.91	125.68	1.84	127.52	127.52	127.52	140.27
5.5	1.00	138.25	2.03	140.27	140.27	140.27	140.27
6.0	1.09	150.82	2.21	153.03	153.03	153.03	140.26
6.5	1.18	163.38	2.39	165.78	165.78	165.78	140.27
7.0	1.27	175.95	2.58	178.53	178.53	178.53	140.27
7.5	1.36	188.52	2.76	191.28	191.28	191.28	140.27
8.0	1.45	201.09	2.95	204.03	204.03	204.03	140.26
8.5	1.55	213.66	3.13	216.79	216.79	216.79	140.26
9.0	1.64	226.22	3.31	229.54	229.54	229.54	140.26
9.5	1.73	238.79	3.50	242.29	242.29	242.29	140.27
10.0	1.82	251.36	3.68	255.04	255.04	255.04	140.27
10.5	1.91	263.93	3.87	267.79	267.79	267.79	140.27
11.0	2.00	276.50	4.05	280.55	280.55	280.55	140.27
11.5	2.09	289.06	4.23	293.30	293.30	293.30	140.27
12.0	2.18	301.63	4.42	306.05	306.05	306.05	140.26
12.5	2.27	314.20	4.60	318.80	318.80	318.80	140.26
13.0	2.36	326.77	4.79	331.55	331.55	331.55	140.26
13.5	2.45	339.34	4.97	344.31	344.31	344.31	140.26
14.0	2.55	351.90	5.15	357.06	357.06	357.06	140.26
14.5	2.64	364.47	5.34	369.81	369.81	369.81	140.26
15.0	2.73	377.04	5.52	382.56	382.56	382.56	140.26
15.5	2.82	389.61	5.71	395.32	395.32	395.32	140.26
16.0	2.91	402.18	5.89	408.07	408.07	408.07	140.26
16.5	3.00	414.74	6.08	420.82	420.82	420.82	140.26
17.0	3.09	427.31	6.26	433.57	433.57	433.57	140.26
17.5	3.18	439.88	6.44	446.32	446.32	446.32	140.26
18.0	3.27	452.45	6.63	459.08	459.08	459.08	140.26
18.5	3.36	465.02	6.81	471.83	471.83	471.83	140.26
19.0	3.45	477.58	7.00	484.58	484.58	484.58	140.26
19.5	3.55	490.15	7.18	497.33	497.33	497.33	140.26
20.0	3.64	502.72	7.36	510.08	510.08	510.08	140.26
20.5	3.73	515.29	7.55	522.84	522.84	522.84	140.26

21.0	3.82	527.86	7.73	535.59	535.59	535.59	140.26
21.5	3.91	540.42	7.92	548.34	548.34	548.34	140.26
22.0	4.00	552.99	8.10	561.09	561.09	561.09	140.26
22.5	4.09	565.56	8.28	573.84	573.84	573.84	140.26
23.0	4.18	578.13	8.47	586.60	586.60	586.60	140.26
23.5	4.27	590.70	8.65	599.35	599.35	599.35	140.26
24.0	4.36	603.26	8.84	612.10	612.10	612.10	140.26
24.5	4.45	615.83	9.02	624.85	624.85	624.85	140.26
25.0	4.55	628.40	9.21	637.60	637.60	637.60	140.26
25.5	4.64	640.97	9.39	650.36	650.36	650.36	140.26
26.0	4.73	653.54	9.57	663.11	663.11	663.11	140.26
26.5	4.82	666.10	9.76	675.86	675.86	675.86	140.26
27.0	4.91	678.67	9.94	688.61	688.61	688.61	140.26
27.5	5.00	691.24	10.13	701.37	701.37	701.37	140.26
28.0	5.09	703.81	10.31	714.12	714.12	714.12	140.26
28.5	5.18	716.38	10.49	726.87	726.87	726.87	140.26
29.0	5.27	728.94	10.68	739.62	739.62	739.62	140.26
29.5	5.36	741.51	10.86	752.37	752.37	752.37	140.26
30.0	5.45	754.08	11.05	765.13	765.13	765.13	140.26
30.5	5.55	766.65	11.23	777.88	777.88	777.88	140.26
31.0	5.64	779.22	11.41	790.63	790.63	790.63	140.26
31.5	5.73	791.78	11.60	803.38	803.38	803.38	140.26
32.0	5.82	804.35	11.78	816.13	816.13	816.13	140.26
32.5	5.91	816.92	11.97	828.89	828.89	828.89	140.26
33.0	6.00	829.49	12.15	841.64	841.64	841.64	140.26
33.5	6.09	842.06	12.33	854.39	854.39	854.39	140.26
34.0	6.18	854.62	12.52	867.14	867.14	867.14	140.26
34.5	6.27	867.19	12.70	879.89	879.89	879.89	140.26
35.0	6.36	879.76	12.89	892.65	892.65	892.65	140.26

RESULT FROM TREND (AVERAGED) LINE

TOP LOAD ton	TOP MOVEMENT IN.	TIP LOAD ton	TIP MOVEMENT IN.
0.2887E+00	0.4596E-04	0.3394E-03	0.1000E-04
0.1443E+01	0.2298E-03	0.1697E-02	0.5000E-04
0.2887E+01	0.4596E-03	0.3394E-02	0.1000E-03
0.1487E+03	0.2333E-01	0.1697E+00	0.5000E-02
0.2224E+03	0.3505E-01	0.2545E+00	0.7500E-02
0.2859E+03	0.4649E-01	0.3394E+00	0.1000E-01
0.5412E+03	0.1035E+00	0.8484E+00	0.2500E-01
0.6949E+03	0.1583E+00	0.1697E+01	0.5000E-01
0.7757E+03	0.2019E+00	0.2545E+01	0.7500E-01
0.8038E+03	0.2338E+00	0.3394E+01	0.1000E+00
0.8225E+03	0.3895E+00	0.6508E+01	0.2500E+00
0.7609E+03	0.6304E+00	0.9375E+01	0.5000E+00
0.7343E+03	0.7496E+00	0.1026E+02	0.6250E+00
0.7352E+03	0.8749E+00	0.1115E+02	0.7500E+00
0.7365E+03	0.1625E+01	0.1250E+02	0.1500E+01

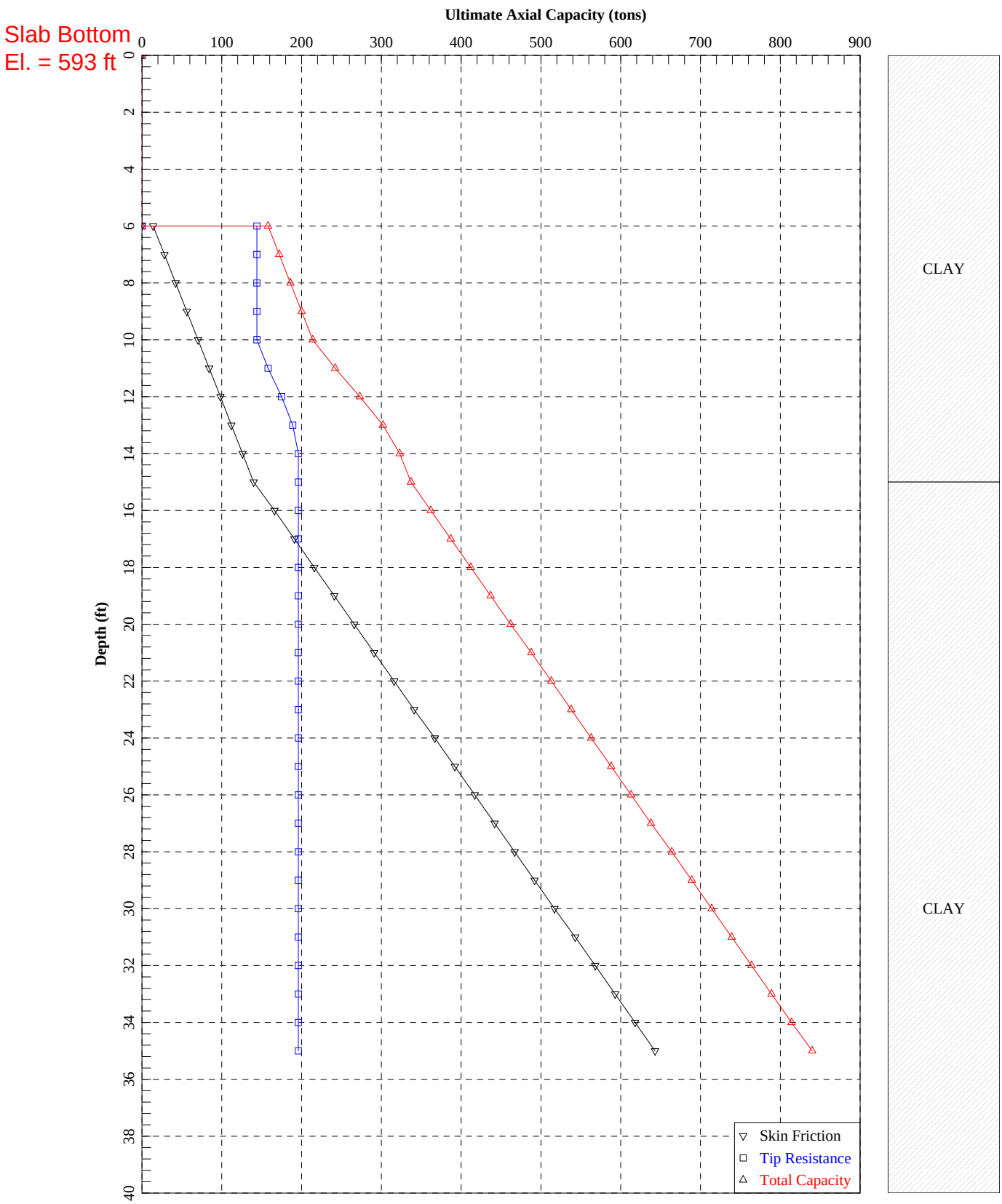
RESULT FROM UPPER-BOUND LINE

TOP LOAD ton	TOP MOVEMENT IN.	TIP LOAD ton	TIP MOVEMENT IN.
0.5408E+00	0.7113E-04	0.5069E-03	0.1000E-04
0.2704E+01	0.3556E-03	0.2534E-02	0.5000E-04
0.5408E+01	0.7113E-03	0.5069E-02	0.1000E-03
0.2803E+03	0.3652E-01	0.2534E+00	0.5000E-02
0.3879E+03	0.5391E-01	0.3802E+00	0.7500E-02
0.4714E+03	0.6969E-01	0.5069E+00	0.1000E-01
0.7288E+03	0.1371E+00	0.1267E+01	0.2500E-01
0.8247E+03	0.1844E+00	0.2534E+01	0.5000E-01
0.8570E+03	0.2169E+00	0.3802E+01	0.7500E-01
0.8722E+03	0.2455E+00	0.5069E+01	0.1000E+00
0.8845E+03	0.4001E+00	0.8978E+01	0.2500E+00
0.8253E+03	0.6409E+00	0.1130E+02	0.5000E+00
0.8095E+03	0.7624E+00	0.1183E+02	0.6250E+00
0.8101E+03	0.8876E+00	0.1237E+02	0.7500E+00
0.8105E+03	0.1638E+01	0.1282E+02	0.1500E+01

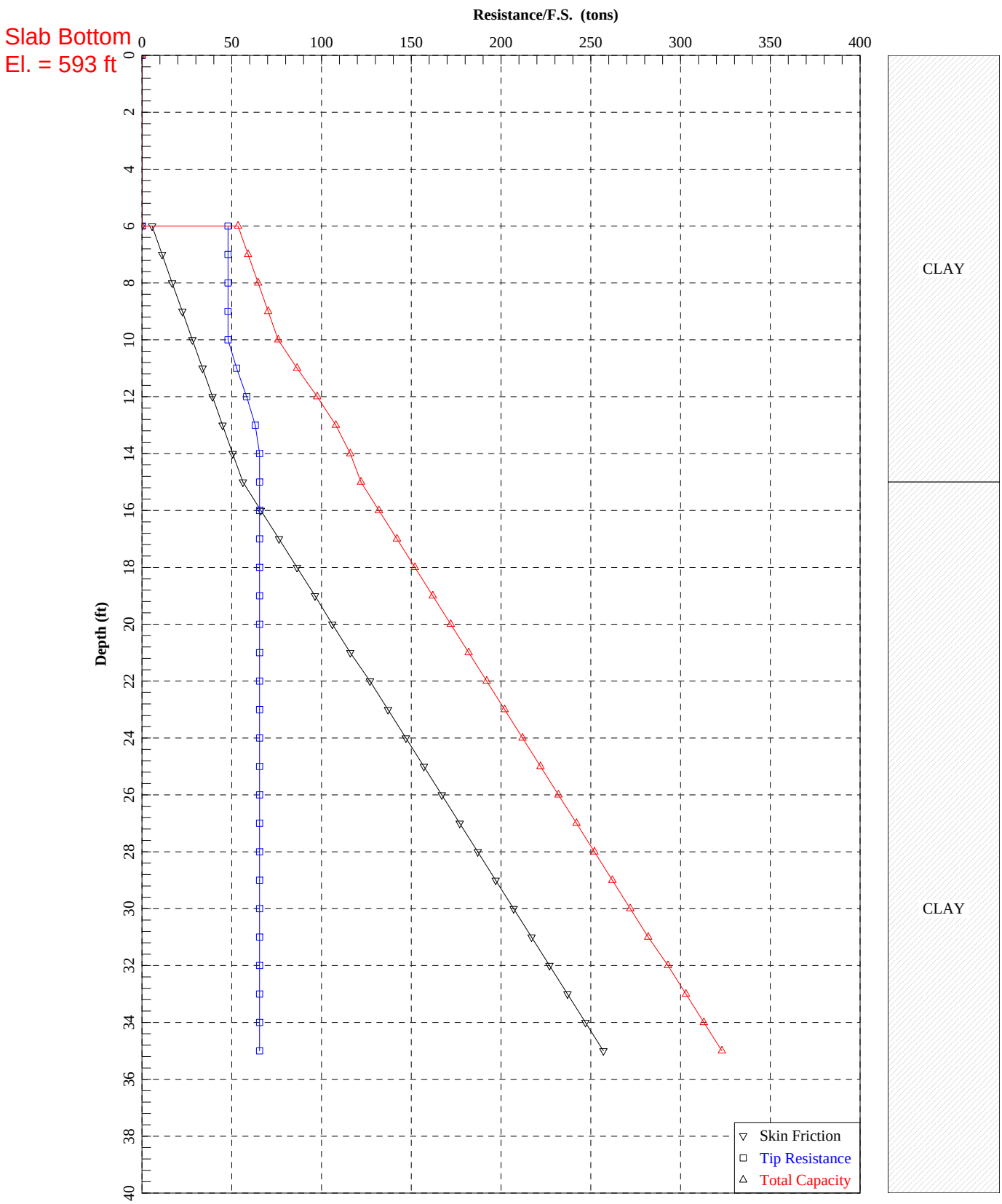
RESULT FROM LOWER-BOUND LINE

TOP LOAD ton	TOP MOVEMENT IN.	TIP LOAD ton	TIP MOVEMENT IN.
0.1255E+00	0.2748E-04	0.1718E-03	0.1000E-04
0.6275E+00	0.1374E-03	0.8591E-03	0.5000E-04
0.1255E+01	0.2748E-03	0.1718E-02	0.1000E-03
0.6366E+02	0.1380E-01	0.8591E-01	0.5000E-02
0.9572E+02	0.2074E-01	0.1289E+00	0.7500E-02
0.1277E+03	0.2767E-01	0.1718E+00	0.1000E-01
0.3022E+03	0.6818E-01	0.4296E+00	0.2500E-01
0.5045E+03	0.1257E+00	0.8591E+00	0.5000E-01
0.6261E+03	0.1735E+00	0.1289E+01	0.7500E-01
0.6898E+03	0.2113E+00	0.1718E+01	0.1000E+00
0.7606E+03	0.3790E+00	0.4038E+01	0.2500E+00

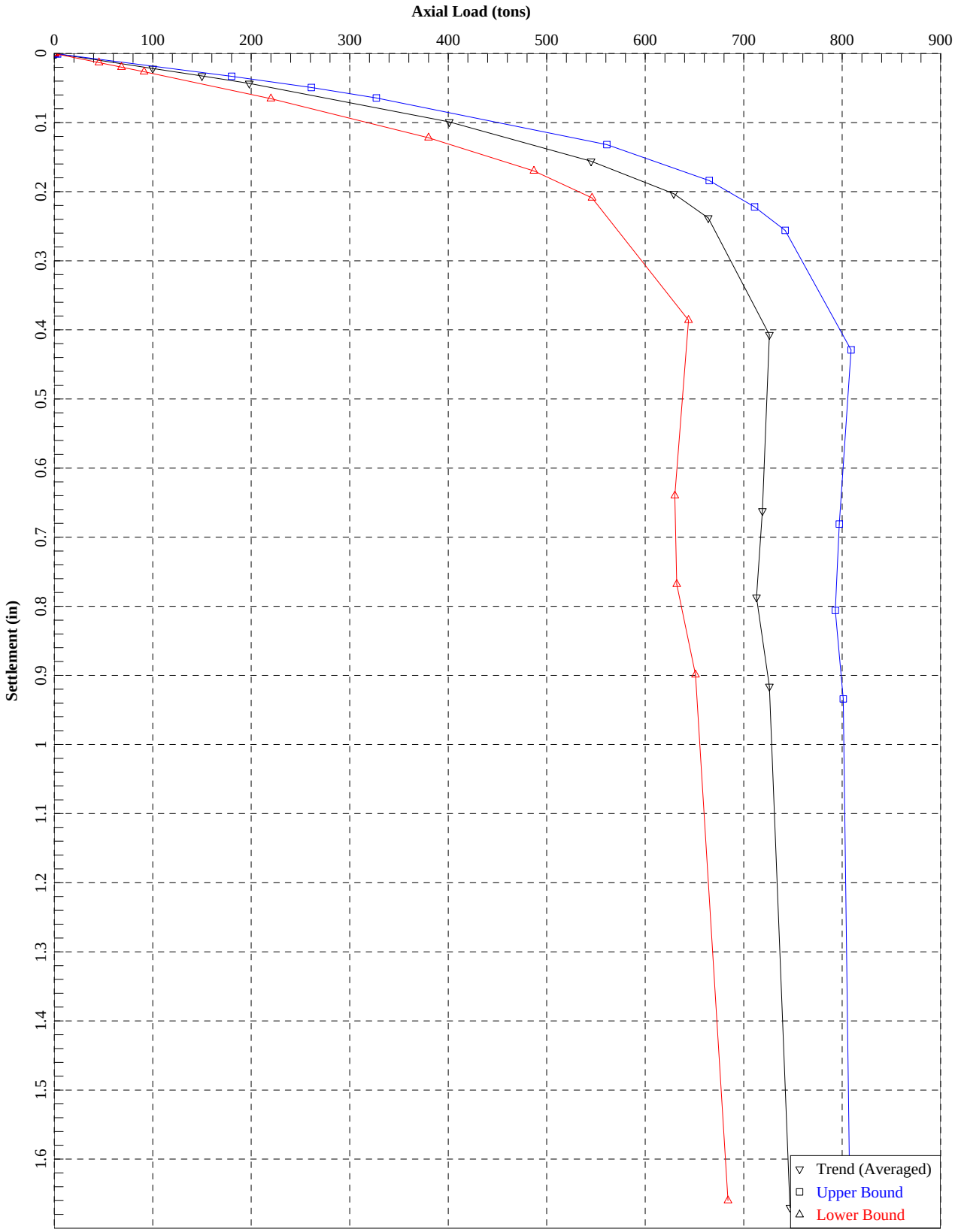
0.6802E+03	0.6162E+00	0.7453E+01	0.5000E+00
0.6590E+03	0.7367E+00	0.8688E+01	0.6250E+00
0.6602E+03	0.8621E+00	0.9923E+01	0.7500E+00
0.6624E+03	0.1613E+01	0.1211E+02	0.1500E+01



Montopolis Pump Station_2.5ft_Diameter Drilled Shaft_Ultimate_Compression



Montopolis Pump Station_2.5ft_Diameter Drilled Shaft_Allowable_Compression



Montopolis Pump Station_2.5ft_Diameter Drilled Shaft_Compression

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==========================================================================

                    SHAFT for Windows, Version 2012.7.10

                     Serial Number :  155987379

                  VERTICALLY LOADED DRILLED SHAFT ANALYSIS
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     Path to file locations      : \\AUSTIN\Proj\AustinTXCityof\472902MontopolisWRI\Preliminary Services\Geotechnical
Investigation\2015 Update\Calculations and Figure\SHAFT\
     Name of input data file     : .sfd
     Name of output file         : .sfo
     Name of plot output file    : .sfp
     Name of runtime file        : .sfr


     --------------------------------------------------------------------------
                            Time and Date of Analysis
     --------------------------------------------------------------------------

               Date:  June 16, 2015     Time:  16:25:43

     Montopolis Pump Station


     PROPOSED DEPTH =      35.0 FT
     ----------------


     NUMBER OF LAYERS =    2
     ------------------


     WATER TABLE DEPTH =      36.0 FT.
     --------------------


     FACTOR OF SAFETY APPLIED TO THE ULTIMATE SIDE FRICTION CAPACITY = 2.50
     ----------------------------------------------------------------------
     FACTOR OF SAFETY APPLIED TO THE ULTIMATE BASE CAPACITY = 3.00
     -------------------------------------------------------------


     SOIL INFORMATION
     ----------------

     LAYER NO 1----CLAY

       AT THE TOP

       STRENGTH REDUCTION FACTOR-ALPHA                    = 0.550E+00
       END BEARING COEFFICIENT-Nc                         = 0.900E+01
       UNDRAINED SHEAR STRENGTH, LB/SQ FT                 = 0.650E+04
       INTERNAL FRICTION ANGLE, DEG.                      = 0.000E+00
       BLOWS PER FOOT FROM STANDARD PENETRATION TEST      = 0.000E+00
       SOIL UNIT WEIGHT, LB/CU FT                         = 0.120E+03
       MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT           = 0.640E+04
       DEPTH, FT                                          = 0.000E+00


       AT THE BOTTOM

       STRENGTH REDUCTION FACTOR-ALPHA                    = 0.550E+00
       END BEARING COEFFICIENT-Nc                         = 0.900E+01
       UNDRAINED SHEAR STRENGTH, LB/SQ FT                 = 0.650E+04
       INTERNAL FRICTION ANGLE, DEG.                      = 0.000E+00
       BLOWS PER FOOT FROM STANDARD PENETRATION TEST      = 0.000E+00
       SOIL UNIT WEIGHT, LB/CU FT                         = 0.120E+03
       MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT           = 0.640E+04
       DEPTH, FT                                          = 0.150E+02


     LAYER NO 2----CLAY

       AT THE TOP

       STRENGTH REDUCTION FACTOR-ALPHA                    = 0.550E+00
       END BEARING COEFFICIENT-Nc                         = 0.900E+01
       UNDRAINED SHEAR STRENGTH, LB/SQ FT                 = 0.120E+05
       INTERNAL FRICTION ANGLE, DEG.                      = 0.000E+00
       BLOWS PER FOOT FROM STANDARD PENETRATION TEST      = 0.000E+00
       SOIL UNIT WEIGHT, LB/CU FT                         = 0.125E+03
       MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT           = 0.640E+04
       DEPTH, FT                                          = 0.150E+02
```



```
       AT THE BOTTOM

       STRENGTH REDUCTION FACTOR-ALPHA                    = 0.550E+00
       END BEARING COEFFICIENT-Nc                         = 0.900E+01
       UNDRAINED SHEAR STRENGTH, LB/SQ FT                 = 0.120E+05
       INTERNAL FRICTION ANGLE, DEG.                      = 0.000E+00
       BLOWS PER FOOT FROM STANDARD PENETRATION TEST      = 0.000E+00
       SOIL UNIT WEIGHT, LB/CU FT                         = 0.125E+03
       MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT           = 0.640E+04
       DEPTH, FT                                          = 0.450E+02


     DRILLED SHAFT INFORMATION
     -------------------------

      DIAMETER OF STEM          =    2.500  FT.
      DIAMETER OF BASE          =    2.500  FT.
      END OF STEM TO BASE       =    0.000  FT.
      ANGLE OF BELL             =    0.000  DEG.
      IGNORED TOP PORTION       =    5.000  FT.
      IGNORED BOTTOM PORTION    =    0.000  FT.
      AREA OF ONE PERCENT STEEL =    7.069  SQ.IN.
      ELASTIC MODULUS, Ec       = 0.360E+07 LB/SQ IN
      VOLUME OF UNDERREAM       =    0.000  CU.YDS.


     PREDICTED RESULTS
     -----------------

     QS     = ULTIMATE SIDE RESISTANCE;
     QB     = ULTIMATE BASE RESISTANCE;
     WT     = WEIGHT OF DRILLED SHAFT (FOR UPLIFT CAPACITY ONLY);
     QU     = TOTAL ULTIMATE RESISTANCE;
     QBD    = TOTAL ALLOWABLE LOAD USING A FACTOR OF SAFETY
              APPLIED TO THE ULTIMATE BASE RESISTANCE;
     QDN    = TOTAL ALLOWABLE LOAD USING FACTORS OF SAFETY
              APPLIED TO THE ULTIMATE SIDE RESISTANCE AND
              THE ULTIMATE BASE RESISTANCE.
```

LENGTH (FEET)	VOLUME (CU.YDS)	QS (TONS)	QB (TONS)	QU (TONS)	QBD (TONS)	QDN (TONS)	QU/VOLUME (TONS/CU.YDS)
5.5	1.00	7.02	143.60	150.62	54.89	50.67	149.30
6.0	1.09	14.04	143.60	157.64	61.91	53.48	144.50
6.5	1.18	21.06	143.60	164.66	68.93	56.29	139.69
7.0	1.27	28.08	143.60	171.68	75.95	59.10	134.88
7.5	1.36	35.10	143.60	178.70	82.97	61.91	131.28
8.0	1.45	42.12	143.60	185.72	89.99	64.72	127.68
8.5	1.55	49.14	143.60	192.74	97.01	67.52	124.87
9.0	1.64	56.16	143.60	199.76	104.03	70.33	122.07
9.5	1.73	63.18	143.60	206.78	111.05	73.14	119.83
10.0	1.82	70.20	143.60	213.80	118.07	75.95	117.59
10.5	1.91	77.22	150.80	228.02	127.49	81.16	119.35
11.0	2.00	84.24	157.99	242.24	136.91	86.36	121.11
11.5	2.09	91.27	166.39	257.65	146.73	91.97	123.13
12.0	2.18	98.29	174.78	273.07	156.55	97.58	125.15
12.5	2.27	105.31	181.98	287.29	165.97	102.78	126.35
13.0	2.36	112.33	189.18	301.50	175.39	107.99	127.55
13.5	2.45	119.35	192.78	312.12	183.61	112.00	127.17
14.0	2.55	126.37	196.38	322.74	191.83	116.01	126.78
14.5	2.64	133.39	196.38	329.76	198.85	118.81	125.13
15.0	2.73	140.41	196.38	336.78	205.87	121.62	123.48
15.5	2.82	152.98	196.38	349.35	218.43	126.65	123.94
16.0	2.91	165.54	196.38	361.92	231.00	131.68	124.40
16.5	3.00	178.11	196.38	374.49	243.57	136.70	124.81
17.0	3.09	190.68	196.38	387.06	256.14	141.73	125.22
17.5	3.18	203.25	196.38	399.62	268.71	146.76	125.58
18.0	3.27	215.82	196.38	412.19	281.27	151.78	125.94
18.5	3.36	228.38	196.38	424.76	293.84	156.81	126.26
19.0	3.45	240.95	196.38	437.33	306.41	161.84	126.59
19.5	3.55	253.52	196.38	449.90	318.98	166.87	126.88
20.0	3.64	266.09	196.38	462.46	331.55	171.89	127.17
20.5	3.73	278.66	196.38	475.03	344.11	176.92	127.43
21.0	3.82	291.22	196.38	487.60	356.68	181.95	127.70
21.5	3.91	303.79	196.38	500.17	369.25	186.98	127.94
22.0	4.00	316.36	196.38	512.74	381.82	192.00	128.18
22.5	4.09	328.93	196.38	525.30	394.39	197.03	128.40
23.0	4.18	341.50	196.38	537.87	406.95	202.06	128.61
23.5	4.27	354.06	196.38	550.44	419.52	207.08	128.81
24.0	4.36	366.63	196.38	563.01	432.09	212.11	129.01
24.5	4.45	379.20	196.38	575.58	444.66	217.14	129.20
25.0	4.55	391.77	196.38	588.14	457.23	222.17	129.38
25.5	4.64	404.34	196.38	600.71	469.79	227.19	129.55
26.0	4.73	416.90	196.38	613.28	482.36	232.22	129.72
26.5	4.82	429.47	196.38	625.85	494.93	237.25	129.88
27.0	4.91	442.04	196.38	638.42	507.50	242.27	130.04
27.5	5.00	454.61	196.38	650.98	520.07	247.30	130.19

28.0	5.09	467.18	196.38	663.55	532.63	252.33	130.33
28.5	5.18	479.74	196.38	676.12	545.20	257.36	130.47
29.0	5.27	492.31	196.38	688.69	557.77	262.38	130.61
29.5	5.36	504.88	196.38	701.26	570.34	267.41	130.73
30.0	5.45	517.45	196.38	713.82	582.91	272.44	130.86
30.5	5.55	530.02	196.38	726.39	595.47	277.46	130.98
31.0	5.64	542.58	196.38	738.96	608.04	282.49	131.10
31.5	5.73	555.15	196.38	751.53	620.61	287.52	131.21
32.0	5.82	567.72	196.38	764.09	633.18	292.55	131.32
32.5	5.91	580.29	196.38	776.66	645.75	297.57	131.43
33.0	6.00	592.86	196.38	789.23	658.31	302.60	131.53
33.5	6.09	605.42	196.38	801.80	670.88	307.63	131.63
34.0	6.18	617.99	196.38	814.37	683.45	312.66	131.73
34.5	6.27	630.56	196.38	826.93	696.02	317.68	131.82
35.0	6.36	643.13	196.38	839.50	708.59	322.71	131.91

RESULT FROM TREND (AVERAGED) LINE

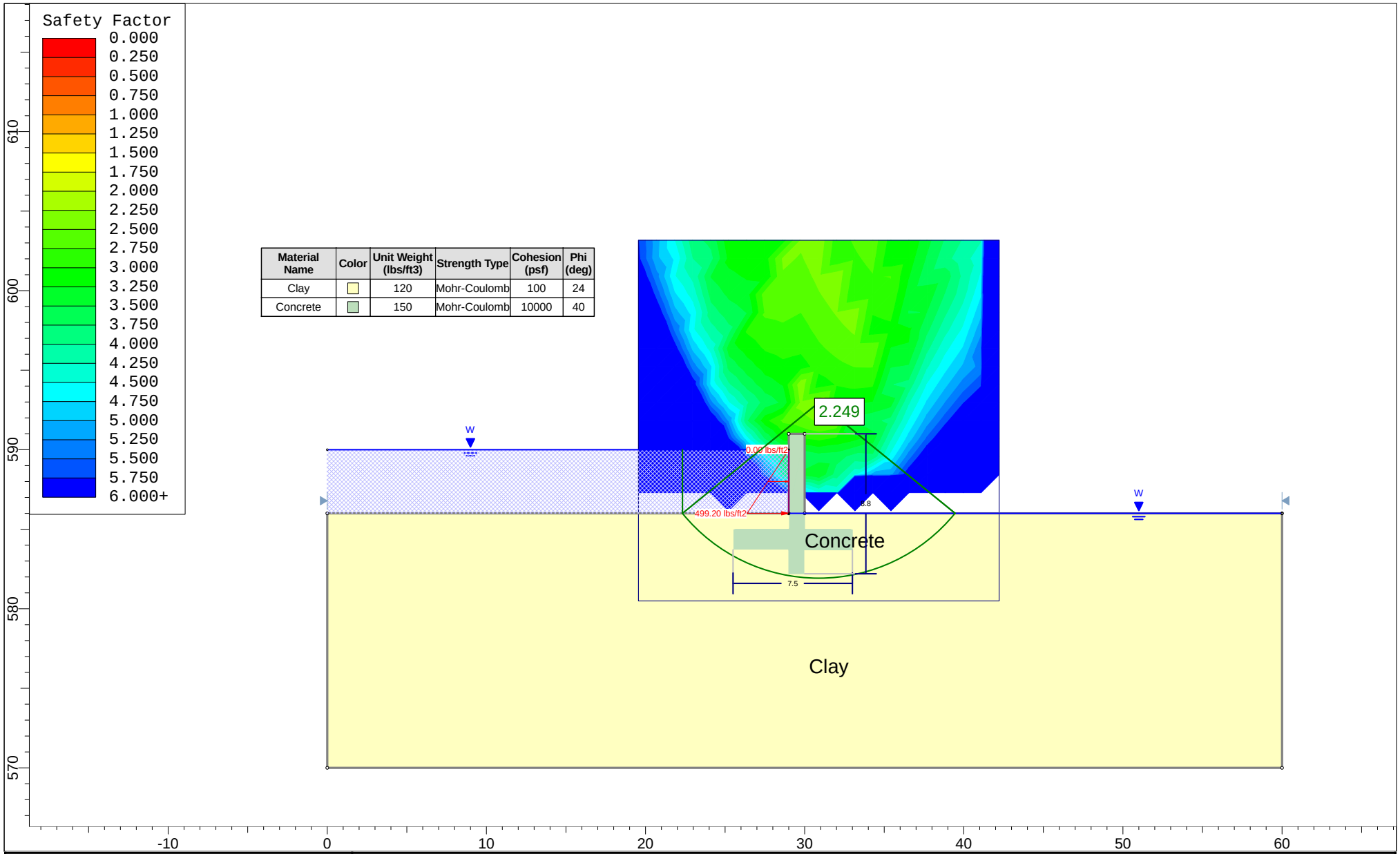
TOP LOAD ton	TOP MOVEMENT IN.	TIP LOAD ton	TIP MOVEMENT IN.
0.1945E+00	0.4274E-04	0.5171E-02	0.1000E-04
0.9726E+00	0.2137E-03	0.2586E-01	0.5000E-04
0.1945E+01	0.4274E-03	0.5171E-01	0.1000E-03
0.1000E+03	0.2171E-01	0.2586E+01	0.5000E-02
0.1502E+03	0.3261E-01	0.3878E+01	0.7500E-02
0.1976E+03	0.4341E-01	0.5171E+01	0.1000E-01
0.4010E+03	0.9913E-01	0.1293E+02	0.2500E-01
0.5446E+03	0.1560E+00	0.2586E+02	0.5000E-01
0.6294E+03	0.2026E+00	0.3878E+02	0.7500E-01
0.6644E+03	0.2376E+00	0.5171E+02	0.1000E+00
0.7264E+03	0.4074E+00	0.9917E+02	0.2500E+00
0.7194E+03	0.6623E+00	0.1429E+03	0.5000E+00
0.7125E+03	0.7867E+00	0.1564E+03	0.6250E+00
0.7260E+03	0.9162E+00	0.1699E+03	0.7500E+00
0.7466E+03	0.1673E+01	0.1905E+03	0.1500E+01

RESULT FROM UPPER-BOUND LINE

TOP LOAD ton	TOP MOVEMENT IN.	TIP LOAD ton	TIP MOVEMENT IN.
0.3446E+00	0.6425E-04	0.7724E-02	0.1000E-04
0.1723E+01	0.3213E-03	0.3862E-01	0.5000E-04
0.3446E+01	0.6425E-03	0.7724E-01	0.1000E-03
0.1797E+03	0.3304E-01	0.3862E+01	0.5000E-02
0.2606E+03	0.4924E-01	0.5793E+01	0.7500E-02
0.3272E+03	0.6441E-01	0.7724E+01	0.1000E-01
0.5613E+03	0.1324E+00	0.1931E+02	0.2500E-01
0.6647E+03	0.1842E+00	0.3862E+02	0.5000E-01
0.7109E+03	0.2221E+00	0.5793E+02	0.7500E-01
0.7423E+03	0.2563E+00	0.7724E+02	0.1000E+00
0.8091E+03	0.4287E+00	0.1368E+03	0.2500E+00
0.7966E+03	0.6811E+00	0.1722E+03	0.5000E+00
0.7931E+03	0.8058E+00	0.1803E+03	0.6250E+00
0.8013E+03	0.9335E+00	0.1885E+03	0.7500E+00
0.8082E+03	0.1686E+01	0.1954E+03	0.1500E+01

RESULT FROM LOWER-BOUND LINE

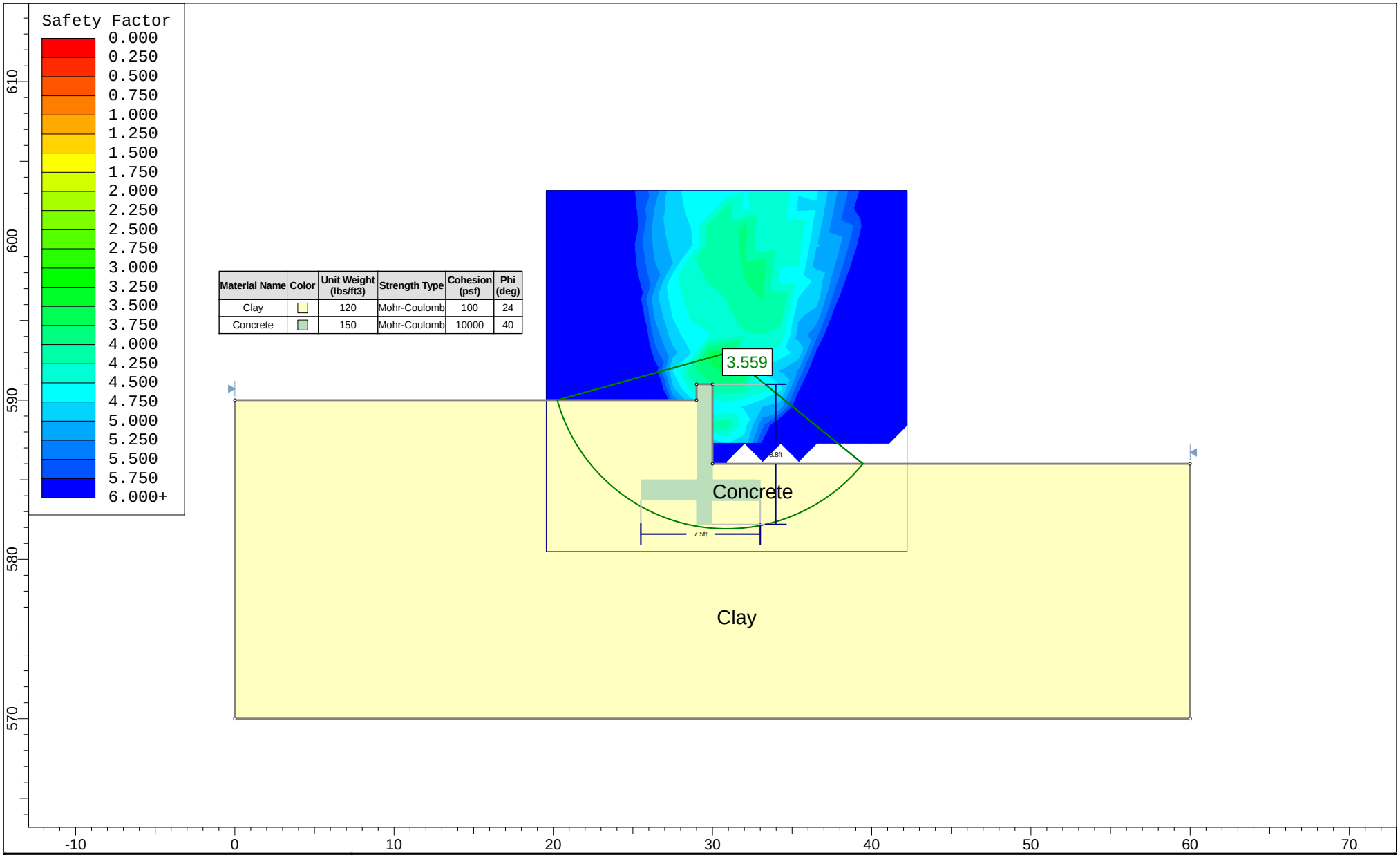
TOP LOAD ton	TOP MOVEMENT IN.	TIP LOAD ton	TIP MOVEMENT IN.
0.8970E-01	0.2622E-04	0.2618E-02	0.1000E-04
0.4485E+00	0.1311E-03	0.1309E-01	0.5000E-04
0.8970E+00	0.2622E-03	0.2618E-01	0.1000E-03
0.4543E+02	0.1318E-01	0.1309E+01	0.5000E-02
0.6829E+02	0.1979E-01	0.1964E+01	0.7500E-02
0.9115E+02	0.2641E-01	0.2618E+01	0.1000E-01
0.2201E+03	0.6537E-01	0.6546E+01	0.2500E-01
0.3804E+03	0.1219E+00	0.1309E+02	0.5000E-01
0.4868E+03	0.1702E+00	0.1964E+02	0.7500E-01
0.5459E+03	0.2088E+00	0.2618E+02	0.1000E+00
0.6441E+03	0.3862E+00	0.6153E+02	0.2500E+00
0.6301E+03	0.6405E+00	0.1136E+03	0.5000E+00
0.6319E+03	0.7676E+00	0.1324E+03	0.6250E+00
0.6508E+03	0.8988E+00	0.1512E+03	0.7500E+00
0.6841E+03	0.1660E+01	0.1846E+03	0.1500E+01



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Clay		120	Mohr-Coulomb	100	24
Concrete		150	Mohr-Coulomb	10000	40

SLIDEINTERPRET 6.029

Project	Montopolis Water Reclamation Initiative		
Analysis Description	Global Stability of Detention Pond Retaining Wall		
Drawn By VNV	*Scale* 1:100	*Company* CH2M	
Date 10/29/2015, 2:49:32 PM		*File Name* Slope Stability_Montopolis WRI.slim	



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Clay		120	Mohr-Coulomb	100	24
Concrete		150	Mohr-Coulomb	10000	40

SLIDEINTERPRET 6.029

Project	Montopolis Water Reclamation Initiative		
Analysis Description	Global Stability of Storage Tank Retaining Wall		
Drawn By VNV	*Scale* 1:100	*Company* CH2M	
Date 10/29/2015, 2:49:32 PM		*File Name* Slope Stability_Montopolis WRI_No water.slim	