Geotechnical Engineering Report

TOLUNAY-WONG ENGINEERS

Geotechnical Engineering Report
Proposed New Storage Tanks
West Jefferson County Municipal Water District
Jefferson County, Texas

Prepared for:

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TWE Project No. 23.23.170 / Report No. 148649

Date:

January 26, 2024

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ENGINEERS

January 26, 2024

Action Civil Engineers, PLLC
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Attn: Mr. Will Larrain
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Ref: Geotechnical Engineering Report
Proposed New Storage Tanks
West Jefferson County Municipal Water District
Jefferson County, Texas
TWE Project No. 23.23.170 / Report No. 148649

Dear Mr. Larrain,

Tolunay-Wong Engineers, Inc. (TWE) is pleased to submit this report of our geotechnical engineering study for the referenced project. This report contains a detailed description of the field and laboratory work performed for our study, the subsurface soil and groundwater conditions encountered and our geotechnical design and construction recommendations for support of the project.

We appreciate the opportunity to work with you on this phase of the project and we look forward to the opportunity to provide additional services as the project progresses. If you have any questions regarding this report or if we can be of further assistance, please contact us.

Sincerely,

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TABLE OF CONTENTS

TABLES/APPENDICES

TABLES

APPENDICES

1 INTRODUCTION/PROJECT DESCRIPTION

1.1 Introduction

This report presents the results of our geotechnical engineering study performed for the proposed new storage tanks for West Jefferson County Municipal Water District (WJCMWD) in Jefferson County, Texas. Our study was conducted in general accordance with TWE Proposal No. P23-B111 dated October 16, 2023 and authorized by execution of our proposal on October 18, 2023.

1.2 Project Description

The project includes one (1) 1,000,000-gal capacity ground storage tank at 14026 FM 365 and one (1) 500,000-gal capacity elevated water storage tank at 21721 FM 365. We understand the ground storage tank will have a diameter of about 86-ft with a height of about 24-ft. We anticipate this tank will be supported on a shallow foundation system such as a concrete ringwall with an improved interior soil pad or on a monolithic mat or slab-on-grade. We understand the elevated tank will be a pedesphere or multi-column design whereby individual shallow or deep foundations are anticipated beneath each pedestal or column. Preliminary conceptual tank exhibits were provided by the Client for reference and are attached herein. No additional project information was provided at the time of this report.

2 PURPOSE/SCOPE OF SERVICES

The purposes of our geotechnical study were to provide the geotechnical information and recommendations needed to assist the Client with the design and construction of suitable foundation systems for support of the proposed tanks. Our scope of services for the project consisted of:

1. Drilling and sampling one (1) test boring (TB) at the center of each tank and three (3) perimeter cone penetration tests (CPTs) at the 1,000,000-gal capacity ground storage tank site to evaluate subsurface stratigraphy and groundwater conditions;

2. Performing geotechnical laboratory tests on the recovered TB samples to evaluate the physical and engineering properties of the subsurface materials encountered;

3. Preparing a synopsis of our findings including existing project site conditions and subsurface soil and groundwater conditions as illustrated by the TB and CPT logs;

4. Providing geotechnical design recommendations for shallow foundation systems including suitable type and depth, allowable soil bearing capacity, lateral resistance, uplift resistance, resistance to overturning moments and settlement estimates;

5. Providing geotechnical design recommendations for deep foundation systems including suitable types and depths, ultimate axial compression and tension capacities, recommended factors of safety, lateral pile analysis soil design parameters, pile group considerations and settlement estimates; and,

6. Providing geotechnical construction recommendations including site development, subgrade preparation, excavation considerations, dewatering and groundwater control, fill and backfill placement, compaction requirements, foundation installation and quality control guidelines.

Our scope of services did not include any environmental assessments for the presence or absence of wetlands or of hazardous or toxic materials within or on the soil, air or water at this site. Any statements in this report or on the logs regarding odors, colors, and unusual items and conditions are strictly for the information of the Client.

3 FIELD PROGRAM

TWE conducted explorations of subsurface conditions by performing one (1) TB at the center of each tank to a depth of 100-ft below existing grade. At the location of the ground storage tank, we also performed three (3) CPTs along the perimeter of the proposed tank footprint to a depth of 75-ft below existing grade. The TBs were performed on November 15 and 16, 2023. The CPTs were performed on November 17, 2023. The exploration locations are shown on the location plans provided in Appendix B of this report.

3.1 Test Borings (TBs)

3.1.1 Drilling Methods

The test borings were performed in general accordance with the Standard Practice for Soil Investigation and Sampling by Auger Boring (ASTM D1452) using conventional buggy-mounted drilling equipment. The test borings were advanced using dry-auger drilling methods until groundwater was encountered. Following static groundwater level measurements, the borings were completed to depth using wash-rotary drilling methods. Soil samples were obtained continuously to a depth of 12-ft, at the 13-ft to 15-ft depth range and at 5-ft depth intervals thereafter until the boring completion depths were reached.

3.1.2 Sampling Methods

Fine-grained, cohesive soil samples were recovered from the test borings by hydraulically pushing a 3-in diameter, thin-walled tube a distance of about 24-in. The field sampling procedures were conducted in general accordance with the Standard Practice for Thin-Walled Tube Sampling of Soils (ASTM D1587). Our Geotechnician visually classified the recovered soils and obtained field strength measurements of the recovered soils using a calibrated pocket penetrometer and/or hand torvane device. The tube samples were extruded in the field, wrapped in foil, placed in moisture-sealed plastic bags and protected from disturbance prior to transport to the laboratory. The recovered soil sample depths and pocket penetrometer measurements are presented on the boring logs in Appendix C.

Cohesive soils thought to be coarse-grained during drilling, as well as cohesionless and semi-cohesionless soils, were collected with the Standard Penetration Test (SPT) sampler driven 18-in by blows from a 140-lb hammer falling 30-in in accordance with the Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils (ASTM D1586). The number of blows required to advance the sampler three (3) consecutive 6-in depths are recorded for each corresponding sample on the boring logs. The N-value, in blows per foot, is obtained from SPTs by adding the last two (2) blow count numbers. The consistency of cohesive soils and the relative density of cohesionless and semi-cohesionless soils can be inferred from the N-value. The samples obtained from the split-barrel sampler were visually classified, placed in moisture-sealed plastic bags and transported to our laboratory. SPT sampling intervals and blow counts are presented on the project boring logs in Appendix C.

3.1.3 Boring Logs

Our interpretations of general subsurface soil and groundwater conditions at the test boring locations are included on the project boring logs in Appendix C. The interpretations of the soil types throughout the boring depths and the locations of strata changes were based on visual classifications during field sampling and laboratory testing using the Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System) [ASTM D2487] and the Standard Practice for Description and Identification of Soils (Visual-Manual Procedure) [ASTM D2488]. A key to the symbols and terms used on the boring logs is also included in Appendix C.

3.1.4 Groundwater Measurements

Groundwater level measurements were attempted in the open boreholes during dry-auger drilling. Measurements were taken initially during dry-auger drilling when groundwater was first encountered and at 5-min intervals thereafter over a 15-min time period. The groundwater measurements observed within the soil boring are described in Section 5.3 of this report.

3.2 Cone Penetration Tests (CPTs)

CPT soundings were performed in accordance with Standard Test Method for Electronic Friction Cone and Piezocone Penetration Testing of Soils (ASTM D5778) utilizing a track-mounted rig with a minimum capacity of 20-tons. The CPT soundings were performed to a depth of 75-ft. The probed holes were backfilled to the caved depth with cement-bentonite grout upon completion.

CPT soundings were performed by hydraulically pushing a series of cylindrical rods, with an instrumented probe at the base, into the soil at a constant rate of approximately 2-cm/s. The probe consists of a cone tip, a side-friction sleeve, and a porous filter element. Continuous measurements of penetration resistance at the cone tip (q_c), friction on the cone sleeve (f_s) and pore water pressure (u_2) are recorded during penetration. These parameters are processed through published correlations and comparisons with laboratory testing and geotechnical borings to provide soil properties such as soil type, undrained shear strength, unit weight, over-consolidation ratio, relative density, soil friction angle and equivalent "N" values.

These properties, when correlated with data from test borings, provide a more complete understanding of the subsurface conditions. The locations and depths penetrated of the subsurface explorations performed for this project are illustrated in Appendix B. CPT sounding logs are presented in Appendix D.

4 LABORATORY SERVICES

A laboratory testing program was conducted on selected soil samples from the TBs to assist in classification and evaluation of the physical and engineering properties of the soils encountered within each tank site. Geotechnical laboratory tests were performed in general accordance with ASTM International standards. The types and brief descriptions of the geotechnical laboratory tests performed are presented in Table 4-1 below. Standard geotechnical laboratory test results are provided on the test boring logs presented in Appendix C.

Table 4-1: Geotechnical Laboratory Testing Program	
Test Description	**Test Method**
Amount of Material Finer than No. 200 Sieve	ASTM D1140
Water (Moisture) Content	ASTM D2216
One-Dimensional Consolidation	ASTM D2435
Unconsolidated-Undrained Triaxial Compression	ASTM D2850
Liquid Limit, Plastic Limit and Plasticity Index	ASTM D4318
Density (Unit Weight)	ASTM D7263

4.1 Consolidation Testing

Results of one-dimensional consolidation tests performed on selected cohesive soil samples from the TBs are summarized in Table 4-3 on the following page. The test reports for each test are included in Appendix E.

Sample disturbance issues related to consolidation test results are discussed in detail in published literature for soft clays (Anderson and Kolstad, 1979, DeGroot et al., 2005) as well as for over-consolidated clays (Sabatini et al., FHWA Circular No. 5, 2002). According to the referenced FHWA publication, sample disturbance can occur during handling and transportation to laboratory despite best efforts put in to maintain structural integrity and moisture condition of the samples.

Anderson and Kolstad (1979) suggest the volumetric strain required to consolidate the sample back to its in-situ vertical effective stress is a relative indicator of sample quality. Table 4-2 below presents the Sample Quality Designations (SQD) suggested by Anderson and Kolstad (1979) which were used for screening of the consolidation samples.

Table 4-2: Sample Quality Designation	
Volumetric Strain (%)	**Sample Quality Designation (Description)**
< 1	A (Very Good to Excellent)
1 – 2	B (Good)
2 – 4	C (Fair)
4 – 8	D (Poor)
> 8	E (Very Poor)

Actual SQD determinations for each sample tested are provided in Table 4-3 below. Tabulated compressibility parameters derived from the consolidation tests are also presented in Table 4-3.

Table 4-3: Summary of One-Dimensional Consolidation Test Data

Boring	Depth Interval (ft)	Soil Classification	e_0	P_c (tsf)	C_C	C_R	OCR	SQD
TB-1	6 - 8	CH	0.61	2.9	0.18	0.031	5.4	A
TB-1	33 - 35	CH	1.17	5.6	0.40	0.050	3.8	A
TB-2	6 - 8	SC	0.58	1.3	0.10	0.013	3.1	A

e_o = Initial Void Ratio
Pc = Pre-consolidation Pressure
C_c = Compression Index
C_r = Recompression Index
SQD = Sample Quality Designation
OCR = Overconsolidation Ratio

5 PROJECT SITE CONDITIONS

Our interpretations of soil and groundwater conditions within the project sites are based on information obtained from the referenced explorations. This information was used as the basis for our geotechnical conclusions and recommendations provided herein. Subsurface conditions could vary in areas not investigated by the project explorations. Significant variations in subsurface conditions encountered during construction at areas not investigated by the project explorations could require reassessment of our recommendations.

5.1 Site Description/Surface Conditions

The project sites for the ground storage tank and the elevated storage tank are located at 14026 FM 365 and 21721 FM 365, respectively, in Jefferson County, Texas. The existing ground surfaces at the proposed tank locations were relatively flat and grass-covered at the time of our field program. Drainage across the sites appeared to be adequate as no areas of ponded water were observed at the time of our field program. TWE utilized conventional track or highland buggy-mounted equipment to conduct the field explorations.

5.2 Subsurface Soil Stratigraphy

The generalized subsurface soil conditions within the project sites were interpreted from the logs presented in Appendices C and D herein. The generalized subsurface soil profiles considered for the project sites are summarized in Table 5-1 and 5-2 below.

Table 5-1: Generalized Subsurface Soil Stratigraphy - Ground Storage Tank

Depth Range (ft)		Strata Description
0	8	Firm to Stiff Clay
8	43	Stiff to Very Stiff Clay
43	58	Medium Dense Sand
58	68	Dense Sand
68	78	Very Dense Sand
78	100	Very Stiff to Hard Clay

Table 5-2: Generalized Subsurface Soil Stratigraphy - Elevated Storage Tank

Depth Range (ft)		Strata Description
0	4	Loose to Medium Dense Sand
4	6	Stiff to Very Stiff Clay
6	18	Very Loose Sand
18	33	Very Soft to Soft Clay
33	48	Firm to Stiff Clay
48	83	Stiff to Hard Clay
83	100	Very Dense Sand

5.3 Groundwater Observations

Groundwater level measurements were attempted in the open TB boreholes when groundwater was first encountered during dry-auger drilling and at 5-min intervals over a 15-min time period. At TB-1 within the ground storage tank site, groundwater was first encountered at a depth of 18.0-ft during dry-auger drilling with static water levels rising to a depth of 15.8-ft after 15-min. Groundwater was not encountered during dry auger drilling of TB-2 at the elevated storage tank site due to borehole instability. Caving of the borehole was measured at 7.8-ft below exiting grade.

Design groundwater levels of 16-ft and 6-ft were considered for the borings associated with the ground storage tank and elevated storage tank sites, respectively. However, the groundwater levels at the sites can fluctuate with climatic and seasonal variations and should be verified before construction. Accurate determination of static groundwater levels is typically made with standpipe piezometers. Installation of piezometers to evaluate long-term groundwater conditions within the project sites was not included in our scope of work.

5.4 Design Soil Parameters

Plots of design soil strength and unit weight interpreted from our field measurements and laboratory testing are presented in Appendix F. These design parameters were used as the basis of our engineering analyses and were selected using the subsurface data from the TBs and CPTs performed for this project, published references and our local experience. Please note the generalized design soil stratification and soil types along with depth, assumed for engineering analysis purposes, can vary in areas not investigated by the project explorations.

A line indicating the ratio of undrained cohesion to effective overburden pressure (c/p) equaling 0.22 is also superimposed on the undrained shear strength plot in Appendix F. This line represents the minimum value of undrained shear strength with depth according to the SHANSEP (Soil Stress History and Normalized Soil Engineering Properties) relation (Ladd and Foote, 1974).

5.5 Soil Shrink/Swell Potential

The tendency for soils to shrink and swell with change in moisture content is a function of clay content and type. These properties are generally defined by the Atterberg Limits. A generalized relationship between shrink/swell potential and the soil plasticity index is shown in Table 5-3 below.

Table 5-3: Relationship Between Plasticity Index and Shrink/Swell Potential

Plasticity Index Range	Shrink/Swell Potential
0 – 10	Very Low
10 – 15	Low
15 – 25	Medium
25 – 35	High
> 35	Very High

Based on Table 12-2 of the International Code Council (ICC) Geotechnical Engineers Handbook (2nd Edition).

The amount of expansion which could occur with increases in moisture content is inversely related to the overburden pressure. Therefore, the larger the overburden pressure, the smaller the amount of expansion. Near-surface soils are thus susceptible to shrink/swell behavior because they experience low amounts of overburden unless subjected to a sustained load from external sources. The zone of seasonal moisture variation (active zone) at these project sites is believed to be limited to the upper 6-ft depth range of existing grade.

We estimated potential shrink/swell movements using the Texas Department of Transportation (TxDOT) Method TEX-124-E for determination of Potential Vertical Rise (PVR). Considering the plasticity characteristics of the existing subgrade soils encountered at the project sites, the ground storage tank site appears to possess very high shrink/swell potential with PVR estimates on the order of 1.5-in to 3.5-in for wet to dry conditions, respectively. The upper soils within the elevated storage tank site appear to possess low to medium shrink/swell potential with anticipated PVR movements less than 1-in. No consideration was given for any sustained loads or external pressures on the native site soils, removal or replacement of existing soils with non-expansive structural fill or site grade raise with non-expansive structural fill.

Lightly-loaded shallow foundations constructed near grade or slabs-on-grade founded directly on expansive soils are typically sensitive to shrink/swell movements greater than about 1-in. Although movements caused by shrink/swell behavior are not anticipated to be a critical design concern for the ground storage tank site, a 3-ft deep removal of the native site soils and replacement with properly-compacted structural clay fill could be considered to mitigate potential shrink/swell movements to 1-in or less. Based on the upper soil conditions within the elevated storage tank site, removal and replacement with structural fill is not considered necessary for mitigation of potential shrink/swell movements.

6 GROUND STORAGE TANK DESIGN

Based on the information provided by the Client, we understand the new 1,000,000-gal capacity ground storage tank will have a diameter of 86-ft and sidewall height of 24-ft. We anticipate this tank will be supported on a shallow foundation system such as a concrete ringwall with an improved interior soil pad or on a monolithic mat or slab-on-grade.

The proposed tank foundation should be designed to distribute the tank loads to the foundation soils without causing bearing capacity failures and excessive total and differential movements. Also, settlement of the foundation soils due to hydrotest and sustained service loads should be within tolerable limits. Recommendations for conventional shallow concrete ringwall and monolithic mat/slab-on-grade foundations options for the ground storage tank are discussed in the following report sections.

6.1 Reinforced-Concrete Ringwall Foundation

A reinforced-concrete ringwall foundation will distribute the concentrated loads of the tank shell as well as provide a level and solid surface for tank shell construction. The tank foundation should be designed and constructed with applicable standards and guidelines determined by the Civil/Structural Engineer and Tank Manufacturer.

Based on the subsurface conditions encountered at the ground storage tank project site, a conventional concrete ringwall foundation with an improved interior soil pad is considered feasible for this site. We recommend the ringwall footing be placed at a minimum depth of 3-ft below existing grade. The width of the ringwall should be a minimum of 18-in to facilitate placement of reinforcing steel. Ultimately, the design ringwall depth and width should be selected by the Civil/Structural Engineer and Tank Manufacturer.

We recommend a controlled low-strength material (CLSM) seal slab be placed beneath the concrete ringwall and over the exposed subgrade bearing surface to protect the underlying soils from effects of weathering during foundation construction. Additional considerations pertaining to CLSM are provided in Section 8.2.2 of this report.

6.1.1 Lateral Earth Pressures

Ringwall foundations should be designed to resist direct hoop stress created by internal lateral earth pressure resulting from tank loads and the weight of the backfill confined within the ringwall. For tank ringwall design, TWE considers an at-rest (K_0) lateral earth pressure coefficient since the ringwall will be restrained and unable to move outward in response to lateral stress. To compute the lateral earth pressures due to the weight of the confined fill material, a triangular lateral stress distribution should be assumed.

Based on available published literature (Foundation Engineering Handbook, H-Y Fang, 2004), an at-rest lateral earth pressure coefficient (K_0) of 0.60 is recommended for properly-compacted structural clay fill material. This coefficient is considered a lower bound value based on proper compaction techniques and the assumption the backfill material within the tank ringwall will be normally-consolidated. The referenced literature indicates K_0 values are dependent on soil-stress history where over-consolidation would tend to increase the K_0 values.

Appropriate lateral earth pressure coefficients to be used for design of ringwall foundations will ultimately depend on the type of backfill material specified by the Civil/Structural Engineer and Tank Manufacturer. In addition, the ringwall should be designed to resist hydrostatic pressures from water pressure increases within the interior of the ringwall.

6.1.2 Stability

Ground storage tank stability is typically analyzed for either hydrotest or maximum operational loading conditions (whichever is greater) and is generally controlled by the undrained shear strength of the supporting soil. Tanks supported on ringwall foundations should satisfy three (3) separate bearing capacity concerns: (1) base shear (deep stability), (2) edge shear and (3) ringwall bearing capacity (punching shear). Unless a significant portion of the soil column is weak, base shear is typically not a critical issue. Base and edge shear stability issues and evaluation procedures for primarily cohesive soil profiles are discussed in detail by Duncan and D'Orazio (1984).

The mechanism of base shear failure is very similar to the mechanism for bearing failure of a shallow footing on clay. In this mode of failure, the entire tank acts as a single unit in which the entire base of the tank undergoes downward movement while the foundation soils are squeezed outward laterally from beneath the tank. For base shear stability, a minimum factor of safety of 1.5 is recommended.

In the case of edge shear failure, the near surface soils shear allowing a small section of the tank to distort, deform and subsequently rupture. Edge shear failure is possible because a steel tank is relatively flexible and when local failure occurs, a portion of its perimeter moves independently of the adjacent tank base area. Edge shear failure is the most common mode of bearing failure for ground storage tanks supported on shallow foundation systems. For edge shear stability, a minimum factor of safety of 1.5 is recommended.

As the load increases on the ringwall, vertical movement of the ringwall is accompanied by compression of the foundation soil directly underneath the ringwall. With continued downward movement, the foundation soils shear around the ringwall perimeter. Based on our experience with similar soils and our local practice, we computed allowable bearing pressures for the ringwall footing using a factor of safety of 2.0.

The edge shear and base shear stability of the storage tanks were evaluated based on the tank height and diameter provided by the Client and by assuming a specific gravity of 1.0 for water stored in the tank. Undrained base and edge shear stability evaluations using the pressures provided were performed using the methodology proposed by Duncan and D'Orazio (1984).

Computed factors of safety against the modes of failure described were evaluated using the available bearing capacity theories which consider the characteristics of the underlying foundation soils beneath the tank in comparison with the tank diameter. The stability evaluations were performed using the design soil parameters provided in Appendix F, Figure 1. The results of our tank stability analysis are summarized in Table 6-1 on the following page.

Table 6-1: Results of Tank Stability Analysis - Ground Storage Tank				
Tank Diameter (ft)	Tank Shell Height (ft)	Hydrotest Load (psf)	Factor of Safety (Base Shear)	Factor of Safety (Edge Shear)
86	24	1,498	6.4	3.9

The factors of safety in Table 6-1 exceed recommended minimum values which are typically on the order of 1.5 and 1.3, respectively, and are considered acceptable. Following the methodology recommended by Skempton (1951) for strip footings supported on clay, for a ringwall width of 1.5-ft (18-in) and bearing depth of 3-ft, an allowable bearing pressure beneath the tank ringwall of 3,950-psf was calculated assuming a factor of safety of 2.0. This value is based on native stiff clay site soils beneath the ringwall and properly-compacted structural clay fill within the interior of the ringwall. This value should be used when evaluating the punching shear failure mechanism during ringwall design.

6.1.3 Settlement

In addition to bearing capacity concerns, the tank should also perform adequately with regards to settlement from induced hydrotesting and long-term operating conditions. Settlements can be expected due to immediate elastic compression and long-term consolidation of the foundation soils beneath the tank footprint. Significant settlements of the new ground storage tank structure are not expected provided the surcharge loads exerted by the tank are no greater than the bearing capacity of the foundation soils within the new tank footprint.

We evaluated hydrotest and consolidation settlement of the ground storage tank using the computer program Settle 3 by Rocscience. Immediate (hydrotest) settlements were computed using estimated design elastic modulus values and a hydrotest loading of 1,498-psf assuming the tank is full of water to the sidewall height provided by the Client. Conventional Terzaghi's theory of one-dimensional consolidation was used for our analysis of long-term operating conditions. Long-term sustained loadings were estimated based on an average operating level of 75% of the provided tank sidewall height over the life of the tank. The estimated long-term sustained loading for the tank used for our long-term consolidation settlement analysis was 1,124-psf, respectively. The magnitudes of the computed long-term settlements were corrected to account for the three-dimensional excess pore water pressure dissipation effects as recommended by Skempton and Bjerrum (1957). The results of our settlement analyses are summarized in Table 6-2 below.

Table 6-2: Results of Tank Settlement Analysis - Ground Storage Tank				
Tank Diameter	Hydrotest Settlement (in)		Long-Term Settlement (in)	
	Center	Edge	Center	Edge
86-ft	Less than 1.0	Less than 1.0	1.0 - 1.5	Less than 1.0

Please note our empirical settlement estimates in Table 6-2 on the previous page could be +/-20% of the actual values. Immediate settlement (elastic undrained distortion) will be realized during tank hydrotesting whereby some rebound will occur once the hydrotest load is removed (typically about 40% to 60% of the elastic distortion). Long-term consolidation settlement will be dependent upon the sustained loading conditions of the tank over its service life but will typically occur over a duration of 10+ years. We recommend final tank piping connections be designed for the long-term settlement values provided in Table 6-2 on the previous page.

6.1.4 Tank Hydrotesting

A carefully monitored and staged hydrotesting program will be critical for the long-term performance of the proposed ground storage tank. TWE could assist the Client, Tank Manufacturer and Civil/Structural Engineer with the development of a hydrotesting program specific to the proposed ground storage tank. Hydrotesting generally consists of filling the tank with water under controlled conditions after construction is complete to check the competency of the tank shell and bottom, to verify the ability of the ringwall foundation to carry the loads imposed by the tank and to reduce the amount of settlement the tank will experience over its service duration.

We recommend the controlled, stage-loaded hydrotesting program for the tank be accompanied by a settlement monitoring program. A series of reference points should be established and surveyed around the concrete ringwall prior to hydrotesting. Spacing of reference points along the circumference of the ringwall should obey the applicable design standard or guideline. The minimum number of reference points along the tank ringwall to be established for the new tank should be based on the circumferential length of the tank along the ringwall. We recommend elevations of hydrotest hold points be established as follows:

1. Directly after construction of the ringwall and prior to installation of the tank shell to establish a baseline;
2. Once the tank shell is erected and directly before hydrotesting begins while the tank is still empty;
3. Once the hydrotest water height reaches the 25% full mark;
4. Once the hydrotest water height reaches the 50% full mark;
5. Once the hydrotest water height reaches the 75% full mark;
6. Once the hydrotest water height reaches the 100% full mark;
7. 24-hrs after the initial 100% full mark reading; and,
8. Directly after the tank is empty to determine rebound of the ringwall.

Settlement observations should be reviewed by the Client, Tank Manufacturer, Civil/Structural Engineer and TWE as hydrotesting proceeds to assess differential settlement, local slope, tank tilt and out-of-plane distortion. Corrective action should be taken if necessary. Criteria for acceptable settlement should be established by the applicable design standard or guideline. If excessive settlement rates are observed during the events outlined in Items 4 and 5 above, smaller loading increments could be required or tank filling could be halted and not resumed until the situation is reviewed and evaluated by the Project Team.

6.2 Monolithic Mat Foundation/Slab-on-Grade

A monolithic mat foundation or slab-on-grade could also be considered to support the proposed ground storage tank. A monolithic mat or slab foundation should provide uniform pressure distribution and thereby reduce the magnitude of differential settlement.

6.2.1 Allowable Bearing Pressure/Settlement

For design of mat or slab tank foundation options, a maximum allowable bearing pressure of 2,225-psf could be considered assuming a properly-compacted structural clay fill pad is provided beneath the proposed foundation as described in Section 5.5 of this report. This allowable bearing pressure value includes a factor of safety of 3.0 against soil shear failure and assumes the mat or slab will be embedded at least 1-ft below final grade within properly-compacted structural clay fill.

The estimated settlements provided in Section 6.1.3 of this report for the shallow ringwall foundation option could be used for preliminary design of the mat or slab foundation option. However, mat and slab foundations are typically controlled by allowable settlement considerations. Therefore, TWE should be contacted if these foundation options will be considered to update our tank foundation settlement analyses performed for the project to date.

6.2.2 Coefficient of Subgrade Reaction

Typical structural analysis for design of large mat or slab foundations requires a coefficient of subgrade modulus (k), which is defined as the ratio between the pressure at any given point on the surface of contact and the deformation produced by the load application at that point.

A subgrade modulus obtained from a 1-ft by 1-ft plate load test (k_1) is typically applicable to the design of pavements and lightly-loaded slabs where the stress influence from loading occurs at relatively shallow depth. These values are typically available in textbooks for various soil types. Published correlations (Terzaghi, 1948) to determine scaled down k values from the considering actual foundation sizes are also available in textbooks. However, in practice, the application of the scaling formula (Terzaghi, 1948) has severe limitations as the method assumes the soils are uniform beneath the mat foundation to infinite depth and the settlements are assumed to be linear elastic. The soils are often stratified and exhibit non-linear behavior due to load application.

For larger mat or slab foundations with increased loading conditions, the stress influence will be deeper whereby reduced k values should be used based on the foundation size, bearing pressure and predicted actual settlement. TWE should be contacted to evaluate k value for mat or slab foundation design on a case-by-case basis. For a large concrete mats or slabs bearing on a predominantly cohesive soil profile, typical k values are on the order of 5-pci to 20-pci based on our experience.

Structural Engineers often consider a single constant value for subgrade reaction modulus for mat or slab foundation design. However, subgrade reaction modulus is not a fundamental soil property but a function of several other factors including the following (Walker and Holland, 2016):

- Geometry of loaded surface area whereby loads with larger surface areas influence deeper soil deposits that can be very soft or compressible;
- Due to soil behavior being highly nonlinear, the subgrade modulus would be lower when subjected to larger loads;
- Soil stiffness and strength parameters as well as compressibility indices within the stress bulb;
- Type of loading (long term or short-term loads) for cases where the foundation soil is compressible; and,
- Mat/soil stiffness ratio which affects distribution of the soil bearing pressure.

The geometry of the loading surface and the type of loading must be provided by Structural Engineers for appropriate estimation of subgrade reaction. Using the former parameter, the Geotechnical Engineer will determine the depth to which stress influence extends. Using the latter parameter, the Geotechnical Engineer will decide whether to include consolidation in the calculation of subgrade reaction modulus. Once final mat or slab dimensions and loading have been established, TWE can assist with determination of modulus of subgrade reaction considering the actual foundation size and loading if published methods of adjustments of these values are not preferred for this project.

7 ELEVATED STORAGE TANK DESIGN

Based on the information provided by the Client, we understand the elevated tank will be a pedesphere or multi-column design whereby individual shallow or deep foundations are anticipated beneath each pedestal or column. Based on the soil subsurface and groundwater conditions encountered at the referenced tank site, we anticipate shallow spread footings and/or deep foundations such as straight-sided drilled shafts are suitable for supporting the elevated storage tank as discussed in the following report sections.

7.1 Shallow Spread Footings

Shallow spread footing systems can be considered provided some movement can be tolerated due to consolidation settlement of the underlying soils. The recommendations provided herein for square spread footings assume the foundations will be supported on competent native site soils at the recommended embedment depths.

7.1.1 Foundation Depth/Allowable Net Bearing Pressure

Individual spread footings can be placed in properly-prepared native soils above the static groundwater table within the elevated storage tank site. For the purposes of this report, we have assumed possible embedment depths of 2-ft, 5-ft and 10-ft below existing grade. Please note accurate groundwater measurements were not possible in the upper 12-ft depth range of boring TB-2 due to caving of the borehole at a depth of about 8-ft below existing grade. We anticipate the free groundwater level at this site is within the 10-ft to 12-ft depth range based on our field observations made at the time the boring was conducted. However, a design groundwater level of 6-ft below existing grade for design purposes.

Based on the loose sands encountered in the 6-ft to 18-ft depth range and the weak clays encountered from 18-ft to 33-ft below existing grade at this site, we recommend the allowable net soil bearing pressure be limited to 1,000-psf or less to keep total settlements less than 1-in. Settlements for shallow spread footings are discussed in further detail in Section 7.1.2 of this report.

Individual spread footings should have minimum widths of 24-in even if the actual bearing pressure is less than the design value. We recommend footings with widths greater than 10-ft be analyzed on a case-by-case basis to consider rigidity/flexibility ratio and footing settlements induced by the applied loads.

7.1.2 Settlement

We analyzed square rigid spread footings with widths of 2-ft, 4-ft, 6-ft, 8-ft and 10-ft at sustained net loading pressures of 500-psf and 1,000-psf considering embedment depths of 2-ft, 5-ft and 10-ft below existing grade within properly-prepared native site soils. The analyses were performed using the computer program Settle 3 by Rocscience, Inc. (Toronto, Canada). The immediate and consolidation settlement estimates for various footing sizes and pressures are provided in Appendix G. The magnitudes of the computed long-term settlements were corrected to account for the three-dimensional (3D) excess pore water pressure dissipation effects as recommended by Skempton and Bjerrum (1957).

Immediate settlements are typically completed during or shortly after construction. Consolidation settlements will occur within the first few years of service but could last for a period of 10+ years. Total settlements are computed as the summation of the immediate and consolidation settlements. The settlement estimates provided in Appendix G are approximated based on the information derived from this study. Actual settlements could vary ±20%.

The settlement estimates provided in Appendix G assume uniformly-loaded, rigid foundations with pressures no greater than the sustained net foundation loading pressured indicated. These estimates also assume the foundations will be designed and constructed in accordance with the recommendations provided in this report. In addition, the estimates assume the foundations will be isolated whereby the clear spacing between foundations will be at least the width of the larger adjacent foundation so stress influence between adjacent foundations is negligible.

7.1.3 Uplift Resistance

Resistance to vertical force (uplift) is provided by the weight of the concrete footing plus the weight of the soil directly above the footing. If the footings will be installed above the static groundwater level within the site, ultimate uplift resistance can be based on total unit weights of 120-pcf and 150-pcf for soil and concrete, respectively. In the case of submergence, ultimate uplift resistance should be based on buoyant unit weights of 60-pcf and 90-pcf for soil and concrete, respectively. The calculated ultimate uplift resistance should be reduced by a factor of safety of 1.2 to calculate the allowable uplift resistance.

7.1.4 Lateral Resistance

Resistance of spread footings to lateral loads can be provided by sliding resistance acting on the base of the foundation and by passive resistance of soil adjacent to the foundation. For design purposes, the sliding resistance and passive soil pressure can be assumed to be developed simultaneously. The lateral loads on spread footings are typically transient or short-term such as the wind load. Therefore, the passive resistance and the sliding resistance recommendations are provided below for short-term condition.

For transient or short-term conditions, a uniform allowable passive soil pressure of 750-psf for properly-compacted native site soils or structural clay fill against the foundations can be added to the footing lateral load capacities. This value includes a factor of safety of 2.0. We expect the allowable passive soil pressure will be developed at about 0.5-in of lateral foundation displacement. If lateral displacement tolerances are less than 0.5-in, about 50% of the allowable passive pressure can be used. The soil passive resistance in the upper 1-ft depth range should be neglected unless concrete paving is provided around the foundations.

If the lateral displacement tolerance is greater than or equal to 0.5-in, 100% of the allowable passive pressure for lateral foundation displacements can be used for design. In any case, the soil passive resistance in the upper 1-ft should be neglected unless paving around the foundation is provided. For concrete footings bearing on native soils at the site, a coefficient of friction of 0.40 can be used to compute base friction. Ultimate base friction can be taken as the normal vertical force times the friction coefficient. A factor of safety of 2.0 is recommended to compute allowable base friction.

For design purposes, sliding resistance and passive soil pressure can be assumed to be developed simultaneously.

7.1.5 Resistance to Overturning Moments

The design of shallow footings subjected to vertical loads and overturning moments should incorporate a stability ratio as selected by the Design Engineer in accordance with the project design guidance documents or specifications. The stability ratio is defined as the ratio of the stabilizing moment to overturning moment. The maximum foundation contact pressure should not exceed the recommended net allowable soil bearing pressure provided above.

7.1.6 Eccentrically Loaded Footing

Eccentrically loaded footings should be designed using reduced effective dimensions ($L' = L - 2e_L$, $B' = B - 2e_B$) of the footing, where e_L and e_B are load eccentricities in the length and width directions, respectively. For footings subjected to applied moment loadings, the eccentricities in any direction should be evaluated as the ratio of the corresponding applied moment and the vertical load.

The bearing pressure below the footing should be computed based on a reduced footing area using the effective footing dimensions ($A' = L' \times B'$). The maximum contact pressure below the footing should be less than the allowable bearing capacities provided herein.

7.2 Straight-Sided Drilled Shafts

This section applies to deep foundation recommendations pertaining to the 500,000-gal capacity elevated storage tank if shallow spread footings are not considered feasible. Based on the subsurface conditions encountered in boring TB-2, and our experience with similar elevated tank foundations in the project area, straight-sided drilled shafts (SSDSs) are considered a suitable foundation option. Based on the loose sands and weak clays encountered in boring TB-2, we anticipate the SSDSs will extend through these layers and will be tipped into the underlying competent clays at a minimum depth of 40-ft below existing grade. Geotechnical recommendations for the referenced deep foundation type are provided in the following sections.

7.2.1 Axial Capacity

We used the computer program SHAFT Version 2017 (Ensoft, Inc.) to compute ultimate axial compression and tension capacities of SSDSs with diameters of 18-in, 24-in and 36-in. The ultimate axial capacity curves for these specified foundation sizes are provided in Appendix H.

Ultimate axial capacity obtained from the curves in Appendix H should be reduced by an appropriate factor of safety to compute the allowable axial capacity. A factor of safety of 2.5 is recommended to compute allowable compression capacity based on the empirical capacity estimates provided in this report. A factor of safety of 3.0 is recommended to compute allowable tension capacity. Reduced factors of safety as low as 2.0 can be considered if a static, dynamic, or combination thereof, load testing program is performed. The buoyant weight of the shafts can be added to the tension capacity. However, the computed weight of the shaft should be reduced by a factor of 1.2 for design.

We discounted frictional resistance of the soils to 5-ft below existing grade to account for shaft cut-off elevation and possible disturbances during installation. Please note the tension capacity is based solely on soil/shaft interaction. Shafts and shaft cap connections should be structurally capable of resisting design uplift loads.

7.2.2 Individual Shaft Settlement

A detailed analysis of axial load versus settlement for deep foundations was beyond the scope of this investigation. However, for single-isolated shafts designed in accordance with this report, individual shaft settlements should be less than about 0.5-in. For a single element, the primary component of settlement is due to elastic shortening. Therefore, the variation of single shaft settlement with variation of loading could be approximated as a linear variation. If the shafts will have center-to-center spacing of less than three (3) diameters or widths, group efficiency should be evaluated.

7.2.3 Lateral Response

For deep foundations, lateral loads are resisted by the soil as well as the rigidity of the shaft. Response to lateral loads will vary with shaft type and properties, degree of fixity and spacing. Typically, lateral loads are analyzed using the p-y method in which the soil is modeled as a series of non-linear springs. This procedure with appropriate computer codes (i.e., LPILE by Ensoft, Inc.) has the advantage where major factors influencing soil resistance are inherently included in the semi-empirical p-y design criteria.

For the subsurface conditions observed within the elevated storage tank site, we recommend the soil design parameters in Appendix I for use with lateral analysis of pile foundations associated with this project. Horizontal loads acting on shaft caps, if applicable, can also be resisted by passive earth pressure acting on one (1) side of the cap. An allowable passive pressure of 750-psf can be used for properly-compacted Structural Clay Fill or General Fill material used as backfill around pile/shaft caps. This value should provide a factor of safety of 2.0 with respect to the ultimate value.

7.2.4 Group Considerations

If groups of shafts will be considered for this project, TWE should be contacted to evaluate the final shaft sizes, lengths and group spacing for static axial group effects, lateral group effects and shaft group settlement.

8 CONSTRUCTION CONSIDERATIONS

The performance of the new tanks will ultimately depend upon the underlying foundation soils and the quality of construction. Our recommendations for pertinent construction activities and observations are provided in the following report sections.

8.1 Site Preparation/Subgrade Proofrolling

Areas designated for new construction should be stripped of existing vegetation, organics, debris and other deleterious materials to the depth of competent subgrade capable of supporting proofrolling activities, if applicable. Isolated or localized areas requiring deeper stripping for removal of soft, wet or otherwise unsuitable soils to the depth of competent subgrade should be anticipated. The geotechnical design recommendations provided in this report, including bearing capacities and settlement estimates, are based on addressing areas where soft or otherwise unsuitable materials are encountered during proofrolling as recommended herein.

After stripping, areas designated for construction should be graded to establish positive drainage across the sites so ponding of surface water does not collect and inhibit site access or construction activities. After site grading is completed to establish positive drainage, the exposed subgrade soils should be proofrolled as indicated below.

Prior to placement of fill, backfill or improved surface materials, we recommend the existing subgrade soils be proofrolled by crossing the area repeatedly and methodically with a 10-ton minimum weight rubber-tired pneumatic compactor or a loaded dump truck to detect significant weak areas. We do not recommend using off-road earth moving equipment (e.g. loaders or scrapers) or tracked vehicles for proofrolling. Proofrolling should be performed during dry periods and not immediately after wet weather events.

Proofrolling should be observed and documented by TWE and areas which do not meet acceptance criteria should be delineated. Remedial options could include scarifying and recompacting, excavation and replacement and/or chemical treatment. If proofrolling demonstrates ruts less than 2-in deep, we recommend the surficial 6-in of material be scarified and recompacted. For areas where ruts exceed 2-in deep, we recommend the surficial 12-in of material be scarified and recompacted. The exposed subgrade soils should be moisture-conditioned to within 2% dry to 3% wet of optimum moisture content and compacted to at least 95% of the maximum dry density as determined by ASTM D698 (standard Proctor). If scarification and recompaction does not improve the subgrade conditions, we recommend over-excavation and replacement or chemical stabilization be considered to similar depths or deeper, as required, based on the subgrade conditions at the time of the construction activities.

Proper site drainage should be maintained during construction so ponding of surface runoff does not occur. If the subgrade is exposed to excess moisture, the natural soils will likely soften and lose strength. Once the soils soften and lose strength, it generally becomes necessary to either consider scarification and drying efforts, removal and replacement of the wet material with structural fill or stabilization using various chemical reagents.

8.2 Excavations

8.2.1 Groundwater Control/Dewatering

Shallow foundation excavations at the ground storage tank site should be able to be performed in the dry based on test boring TB-1. Based on the subsurface conditions encountered in project boring TB-2, we expect some groundwater seepage could be encountered within excavations below the 6-ft depth range at the elevated storage tank site.

In the event groundwater, perched water or seepage is encountered, provisions should be made to remove any water which accumulates within excavations to maintain a dry bottom. Provisions should also be made to divert surface water runoff from open excavations. If encountered, any water accumulations within foundation excavations should be pumped out immediately and not allowed to deteriorate the foundation soils. The Contractor should be responsible for assessing the need for appropriate dewatering systems within each site according to their construction sequence and planned activities.

Positive drainage should be established and maintained so ponding of surface water does not collect near foundation excavations or inhibit construction activities. If the subgrade soils are exposed to excess moisture, the bearing soils will likely soften and lose capacity. Once this occurs, it generally becomes necessary to either consider drying efforts, removal and replacement of the saturated material with structural fill or chemical stabilization.

8.2.2 OSHA Considerations

The sides of open excavations are susceptible to deterioration upon exposure and could become unstable. The Contractor's competent Supervisor should inspect all excavations and take appropriate safety measures including the use of trench shields and sloped excavations. We recommend Occupational Safety and Health Administration (OSHA) standards be observed with all excavations.

According to Occupational Safety and Health Administration (OSHA) standard 29 CFR - Subpart 1926 – Subpart P, if excavations are deeper than 5-ft and the excavations are not performed in stable rock, the excavations must be sloped, shored or shielded. Protective systems for use in excavations greater than 20-ft in depth should be designed by a registered Professional Engineer in accordance with OSHA standard 29 CFR – Part 1926.652(b) and (c). Soil classification, per OSHA guidelines, is based on three (3) types of soils: Type A, Type B and Type C.

Based on the OSHA definitions, the soils encountered within the elevated storage tank site and ground storage tank site can be interpreted as Types C and B, respectively. Cohesive soils with an undrained shear strength of 1,000-psf or more are classified as Type B whereas cohesive soils with an undrained shear strength less than 1,000-psf and cohesionless or semi-cohesionless sands are classified as Type C soils. Excavations in Type B soils should have side slopes no steeper than 1H:1V or sloped angles no steeper than 45° from the horizontal. Excavations in Type C soils should have side slopes no steeper than 1.5H:1V or sloped angles no steeper than 34° from the horizontal.

8.3 Fill/Backfill Materials

Fill material types can be grouped according to their application. Fill materials used to support foundations, structures and within pavement sections are typically identified as structural fill and are usually associated with engineering specifications. Our recommendations for structural fill are provided in the following subsections.

8.3.1 Structural Clay Fill

Structural clay fill used for the project should consist of clean lean clay (CL) or lean clay with sand (CL) material with a liquid limit (LL) less than 40 and a plasticity index (PI) between 10 and 20. Structural clay fill should be placed in thin lifts (maximum 8-in loose lifts), moisture conditioned between -2% to +3% of optimum moisture content and compacted to a minimum 95% of the maximum dry density as determined by ASTM D698 (standard Proctor).

8.3.2 Structural Fill Alternative

As a structural fill alternative, available clean site materials could be stabilized with a chemical admixture such as lime, cement, fly ash, or a combination thereof, depending on their soil type and corresponding properties. Chemically-modified soils can be used in all applications where structural fill is required.

The type and quantity of chemical stabilization required should be determined by TWE via a laboratory treatability study on the actual soils planned for use. TWE would be pleased to further evaluate the composition of available samples and potential stabilization options upon request. Actual reagent type and dosage requirements should be determined in the laboratory by TWE via plasticity index, pH or compressive strength methods on soil samples obtained after site stripping is performed.

8.3.3 Crushed Aggregate Flexible Base

Crushed aggregate flexible base material should be composed of crushed limestone meeting the requirements of TxDOT 2014 Standard Specifications Item 247, Type A, Grade 1-2. The aggregate material can be placed in maximum 6-in compacted lifts to at least 95% of the maximum dry density determined by ASTM D698 (standard Proctor) and to within ±3% of optimum moisture content.

8.3.4 Controlled Low-Strength Material

Controlled low-strength material (CLSM), or flowable fill, can be used for seal slabs beneath foundations and backfill around foundations. CLSM should be in accordance with published information from the American Concrete Institute (ACI) Committee 229R-99, the National Ready Mixed Concrete Association (NRMCA) Guide Specification for Controlled Low-Strength Materials (CLSM) and ASTM International standard test methods.

Prior to placing CLSM, a representative of TWE should observe and document the condition of the excavation subgrade to confirm the consistency and homogeneity of the subgrade soils. If soft, weak or otherwise unsuitable subgrade soils are encountered, the exposed soils should be over-excavated to competent soils and backfilled with structural fill or CLSM. CLSM should be thoroughly-mixed and the aggregate used should contain no more than 30% fines.

A minimum compressive strength of 50-psi at 7-days or 100-psi at 28-days should be achieved while remaining workable for placement. Construction activities over CLSM should not be performed until a minimum set time of 4-hrs has been achieved for the CLSM.

8.3.5 Fill/Backfill Compaction

Prior to use, samples of proposed fill and backfill materials should be obtained by TWE for laboratory testing of classification, index, gradation and moisture-density relationship properties. These tests will provide a basis for acceptance as well as evaluation of compaction when compared to in-place density test results. TWE should be retained to perform sufficient in-place density tests during placement of fill and backfill materials to verify compaction requirements are met.

Maximum loose lift thicknesses for fill placement will depend on the type of compaction equipment used and the material type. Recommended fill layers are summarized in Table 8-1 below.

Table 8-1: Maximum Fill/Backfill Loose Lift Thicknesses	
Description	**Maximum Loose Lift Thickness**
Structural Fill using Hand-Operated Equipment	4-in
Structural Fill using Conventional Equipment	8-in

8.3.6 Fill/Backfill Testing

We recommend any proposed source of fill and backfill material be tested by TWE for compliance with the project specifications prior to use. In addition, it is imperative specific provisions be made to include testing of the actual fill and backfill materials used to verify they meet the material specification requirements stated herein or in the project plans and specifications.

8.4 Shallow Foundation Construction

The performance of shallow foundation systems associated with the project will be highly dependent upon the quality of construction. Thus, we recommend shallow foundation construction be monitored by TWE to help evaluate construction activities in accordance with this report.

Excavations for construction of shallow foundations could be either open-cut and formed, neatly-excavated or temporarily shored using proprietary systems. Excavations for shallow foundations should be made with a smooth-mouthed bucket or hand labor. Foundation excavation bottoms should be level, suitably benched and free of any loose, wet or weak soils which have been impacted by surface runoff, groundwater seepage or the construction process.

Positive drainage should be established and maintained so ponding of surface water does not collect in or near foundation excavations or impact the bearing soils. If the bearing soils are exposed to excess moisture, they will likely soften and lose capacity. Once this occurs, it generally becomes necessary to either consider drying efforts, removal and replacement of the saturated material with structural fill or chemical stabilization.

In the event groundwater, perched water or seepage is encountered, provisions should be made to remove any water which accumulates within shallow foundation excavations to maintain a dry bottom. Provisions should also be made to divert surface water runoff from the open excavations. If encountered, any water accumulations within foundation excavations should be pumped out immediately and not allowed to deteriorate the foundation soils.

8.5 Drilled Shaft Installation

The performance of the elevated storage tank supported on straight-sided drilled shafts will be directly related to the Contractor's adherence to the recommendations in this report and the project plans and specifications. Therefore, we recommend shaft installation monitoring services be provided by TWE for this project. Shaft installation monitoring services will provide verification the shafts are installed in accordance with the intentions of this report and the following items:

1. All shaft excavations should be observed by TWE to determine when the proper bearing stratum is encountered and to record other observations regarding shaft construction such as size, installation method and other pertinent items related to casing, slurry, reinforcement and concrete as applicable.
2. Shaft excavations should be checked for size and depth prior to the placement of concrete. Precautions should be taken during the placement of reinforcement and concrete to prevent the loose excavated material from falling into the excavation.
3. Drilled shafts should be installed in accordance with the "Manual on Drilled Shafts: Construction Procedures and Design Methods", [U.S. Department of Transportation-Federal Highway Administration (Pub. No. FHWA-IF-99-025) and ADSC: The International Association of Foundation Drilling Contractors (Pub. No. ADSC-TL-4), August 1999] by Lymon, C. Reese and Michael W. O'Neill
4. SSDS depths at the elevated storage tank site will depend upon the loads imposed. Based on the subsurface conditions encountered in boring TB-2, we anticipate the need for drilling slurry or casing to maintain shaft sidewall stability and facilitate proper drilled shaft installation. If slurry is utilized, the slurry should be left in the excavation until completion of drilling and the concrete should be placed with the use of a tremie to displace the slurry from the bottom up immediately upon completion of drilling.
5. Slurry should be checked for density, viscosity, sand content and pH during construction. It is recommended that the "Manual on Drilled Shafts: Construction Procedures and Design Methods", [U.S. Department of Transportation-Federal Highway Administration (Pub. No. FHWA-IF-99-025) and ADSC: The International Association of Foundation Drilling Contractors (Pub. No. ADSC-TL-4), August 1999] by Lymon, C. Reese and Michael W. O'Neill be used as a guide for developing slurry placement and material specifications.

6. Prompt placement of concrete in the shaft excavations as they are completed, cleaned and inspected is strongly recommended to limit deterioration of the bearing stratum. Under no circumstances should a shaft be drilled which cannot be filled with concrete before the end of the workday.

9 DESIGN REVIEW/REPORT LIMITATIONS

9.1 Design Review/Construction Monitoring

9.1.1 Geotechnical Design Review

Geotechnical review of the design drawings and specifications should be performed by TWE prior to construction. This review is recommended to check the geotechnical recommendations and construction guidelines presented herein have been properly interpreted and incorporated into the construction documents. At this time, design review is outside of the scope of this study.

9.1.2 Construction Monitoring

We recommend construction activities be monitored by TWE. TWE would be pleased to assist in the development of a plan for construction monitoring to be incorporated in the overall quality control program. Construction surveillance by TWE has been assumed in preparing our recommendations. These field services are required to check for changes in conditions which could result in modifications to our recommendations. Performance of the project structures will be directly related to the Contractor's adherence to the recommendations in this report and the project plans and specifications. TWE would be pleased to provide these services to verify construction is performed in accordance with the intentions of this report upon request.

9.2 Limitations

9.2.1 Scope of Study

The scope of this study, as well as the conclusions and recommendations provided herein, were developed based on our understanding of the project. Assumptions were made when specific information was unknown. Revisions to our conclusions and recommendations could be necessary as a result of any significant project changes or if our assumptions are incorrect.

Construction dewatering design, earth retention design and construction site safety are the responsibility of the Contractor and have not been addressed herein. The scope of our study did not include evaluation of geologic faults. In addition, assessment of environmental conditions, including investigation for hazardous materials/pollutants/wastes, regulatory compliance, threatened or endangered species, cultural resources, floodplains, and jurisdictional wetlands were beyond the scope of our study.

9.2.2 Warranty

The professional services which form the basis for this report have been performed using a degree of care and skill ordinarily exercised, under similar circumstances, by reputable geotechnical engineers practicing in the same locality. No warranty, expressed or implied, is made as to the professional advice set forth.

9.2.3 Subsurface Variations

Our interpretations of subsurface conditions are based on subsurface data obtained at the project exploration locations only and only at the times of our field explorations. Subsurface variations could exist between the exploration location and at areas not investigated within each tank site. The validity of our recommendations is based, in part, on assumptions made about subsurface conditions in areas not explored. Such assumptions can only be confirmed during construction. Therefore, construction observations by TWE are recommended to check for variations in subsurface conditions. Significant changes from our assumptions could require modification to our findings and recommendations.

9.2.4 Report Reliance

This report was prepared as an instrument of service for the sole and exclusive use by Action Civil Engineers, PLLC and their designated project design team, subject to the limitations stated herein and with specific application to the referenced project. This report should not be applied for any other purpose or project, except as described herein.

No third party may use or rely upon the information provided herein without the written consent of TWE. If any party other than Action Civil Engineers, PLLC chooses to rely on this instrument without our consent, said party expressly waives any rights it may otherwise have to claim its reliance on this instrument of professional service that resulted in injury, loss, or damage of any kind and will defend and indemnify TWE from any such claim.

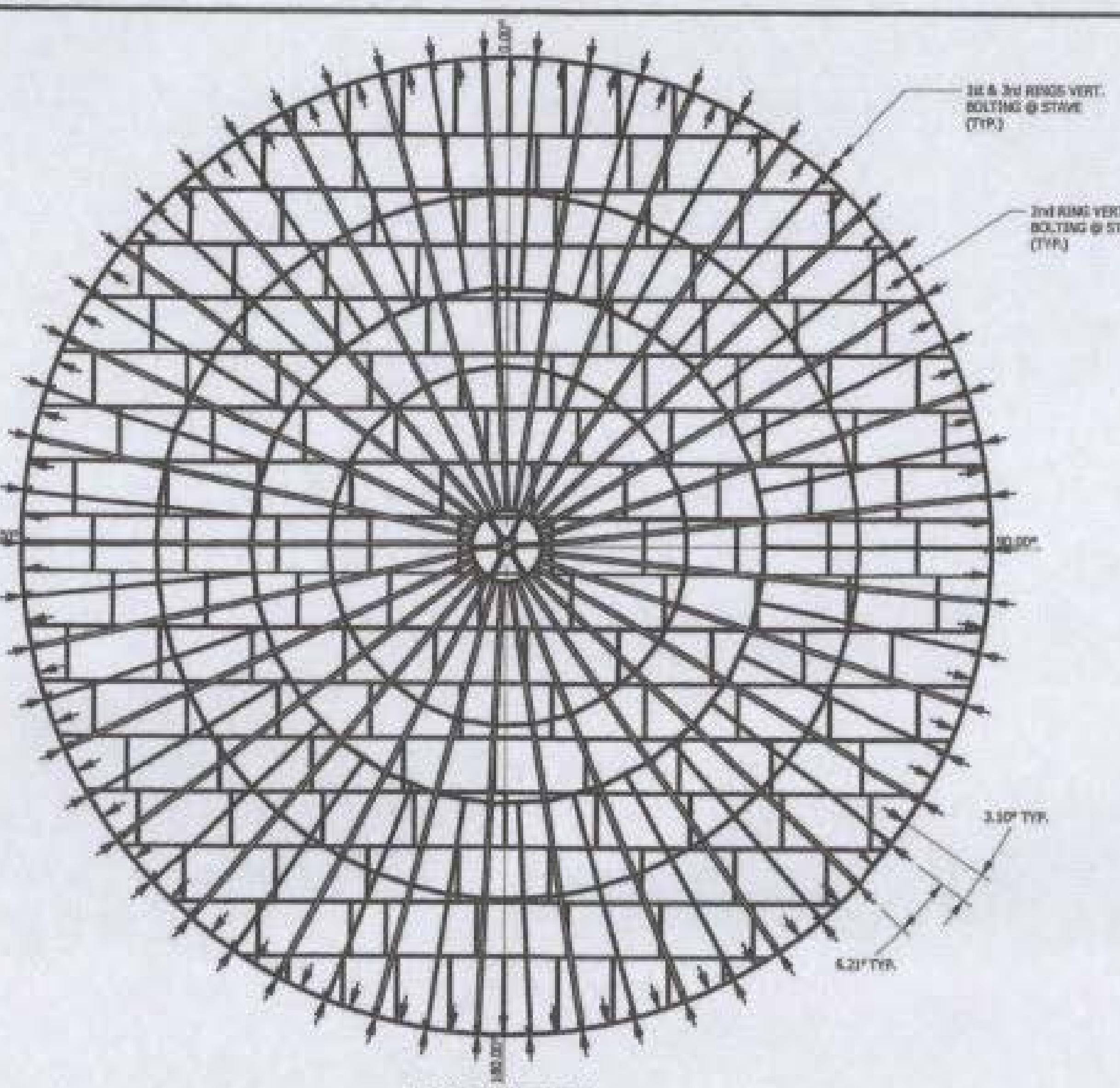
9.2.5 Report Distribution

This report is intended to be used in its entirety. This report should be considered as a whole and should not be distributed or made available in partial form.

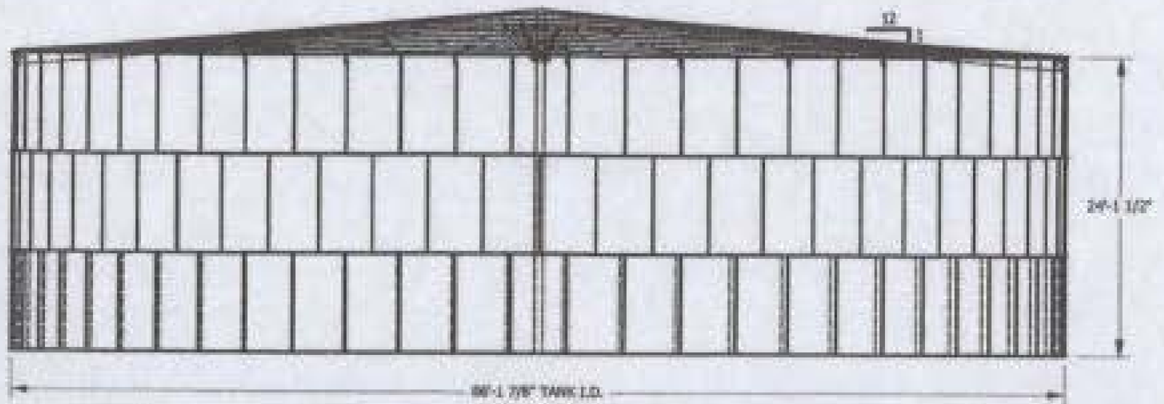
If any changes in the nature, design or location of the project are planned, the conclusions and recommendations contained in this report should not be considered valid unless the changes are reviewed and the conclusions modified or verified in writing by TWE, who is not responsible for any claims, damages or liability associated with interpretation or reuse of the subsurface data or engineering analyses without the expressed written authorization of TWE.

APPENDIX A

CLIENT-PROVIDED INFORMATION

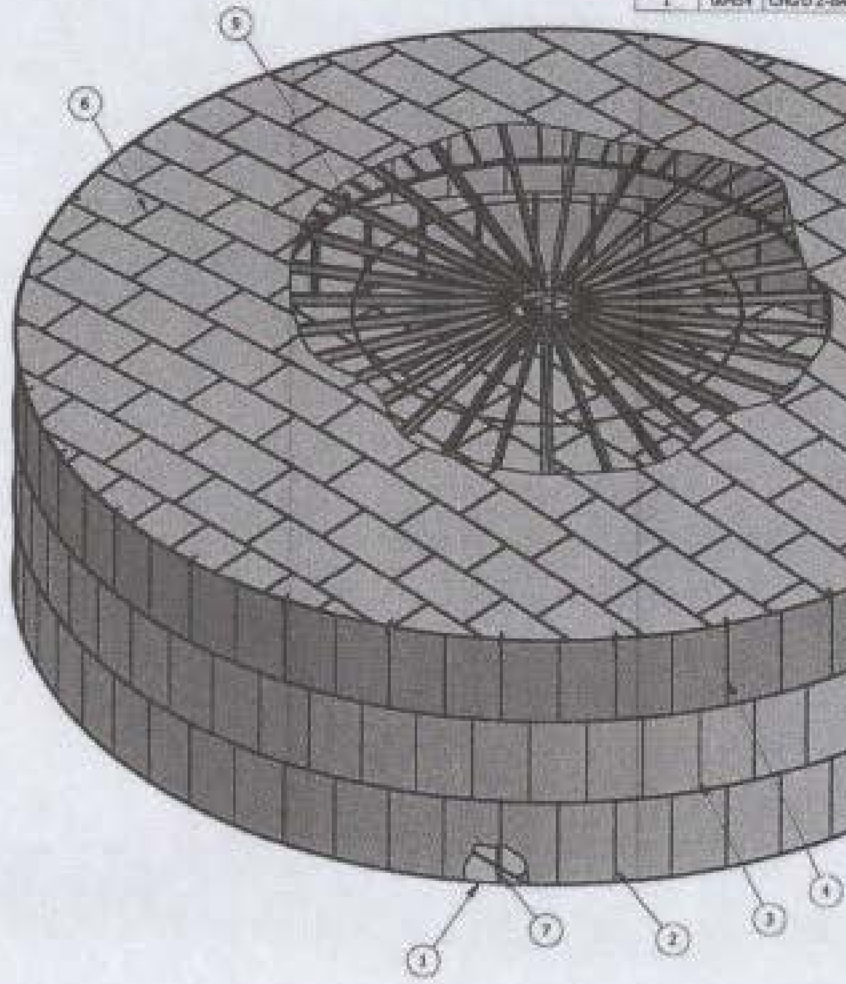


PLAN ORIENTATION



ELEVATION

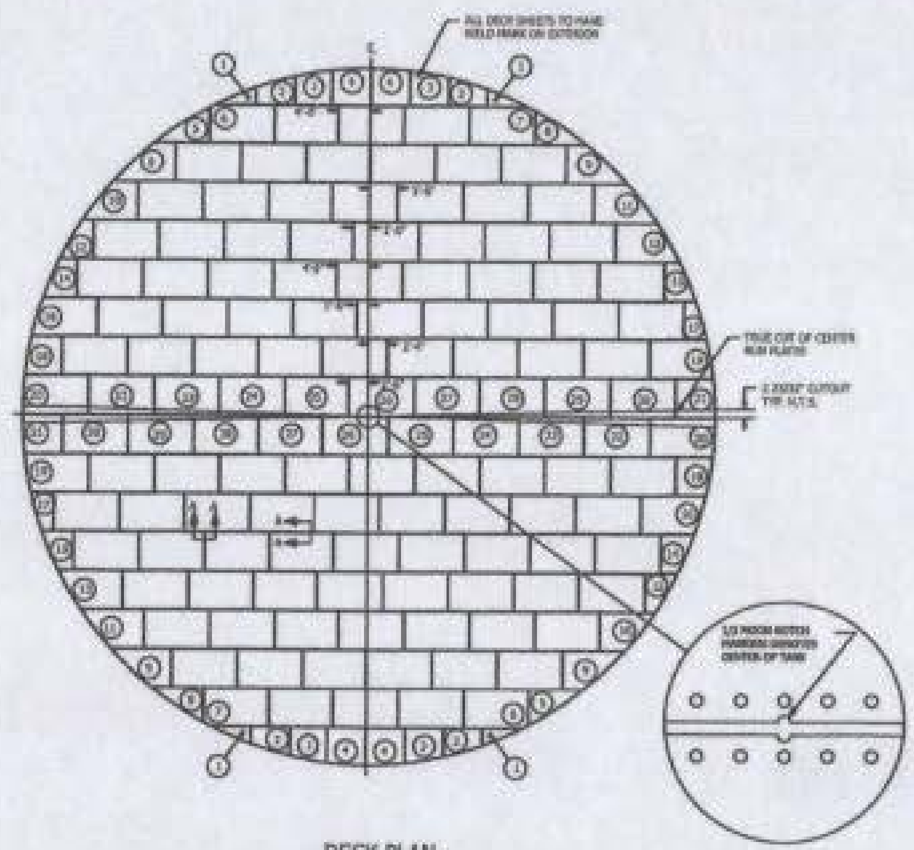
STCI REVISION HISTORY						
REV	ECO	DESCRIPTION	DATE	DESIGNER	CHECKED	APPROVED
1	00454	CHG'D Z-BAR TO GR.50	02/15/10	E KEHR	BB	BB



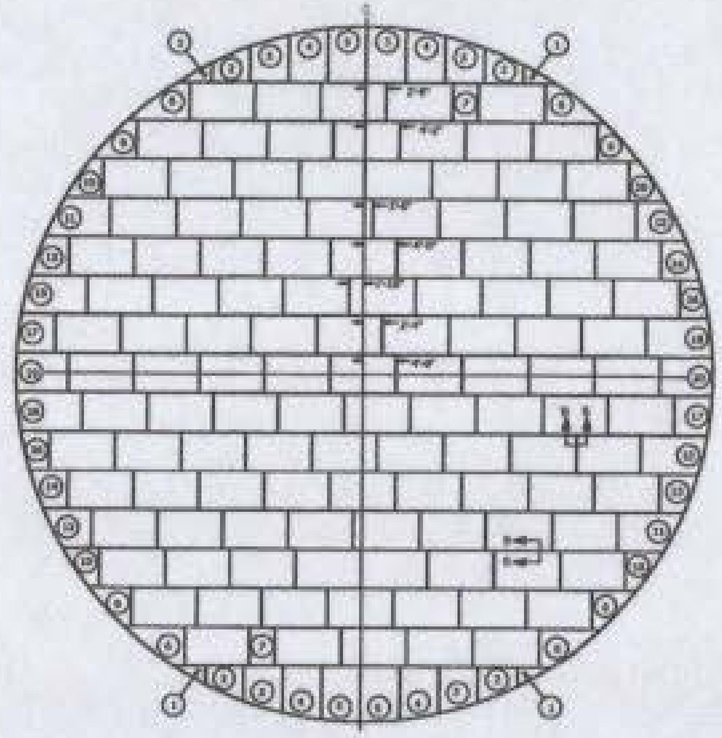
ITEM	PART NUMBER	DESCRIPTION	QTY	UOM
8	8624-001-HWK	HARDWARE KIT, 86'-1 7/8" x 24'-1 1/2" HIGH (AWWA)	1	EA
7	9996-659-199	Z-BAR, 5/16" THK. x 7'-11 1/2" LG., GR.50	58	EA
6	8602-001-001	12GA, 86'-1 7/8"Ø, SQ. DECK ASSY	1	EA
5	9012-146-001	ROOF STRUCTURE 86'-1 7/8"x24'-1 1/2" HIGH w/10"SQ.BASE,8"Ø COL,ROLLED RAFTER HAT.	1	EA
4	8604-003-199	86'-1 7/8"Ø,8 GA, GR.40, SR, 58" STAVE	58	EA
3	8604-002-199	86'-1 7/8"Ø, 1/4" THK, A-36, DR, 60" STAVE	58	EA
2	8604-001-199	86'-1 7/8"Ø, 5/16" THK, GR.50, TR, 62" STAVE	58	EA
1	8600-001-001	12GA, 86'-1 7/8"Ø, SQ. BTM ASSY	1	EA

BILL OF MATERIALS

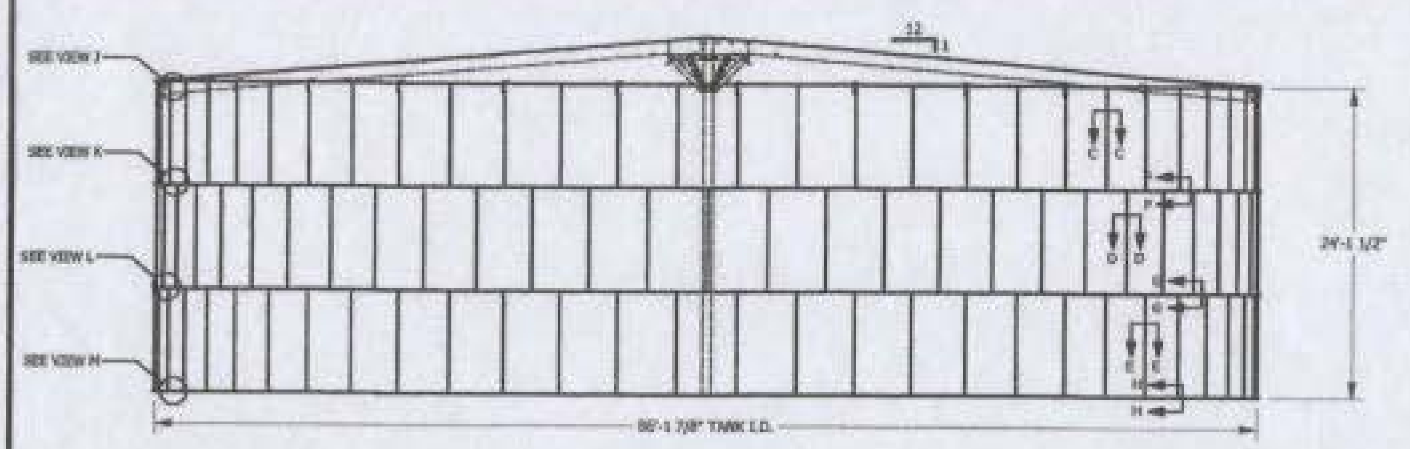
UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES. TOLERANCES ARE:	CUSTOMER:	COMPANY INC.®	9580 LUCAS RANCH RD. RANCHO CUCAMONGA, CA. 91730 Phone: (909) 912-0580 Fax: (909) 912-0586
MATERIAL:	DRAWN BY: C. Pichette	TITLE: 86'-1 7/8" DIA x 24'-1 1/2" HIGH BOLTED STEEL TANK AWWA D103-97 (FPC)	
FINISH:	CHECKED: BB/JM	SIZE: B	REV: 1
DO NOT SCALE DRAWING	APPROVED: BB/JM	PART#: 8624-001-002	SHEET: 1 OF 3



DECK PLAN



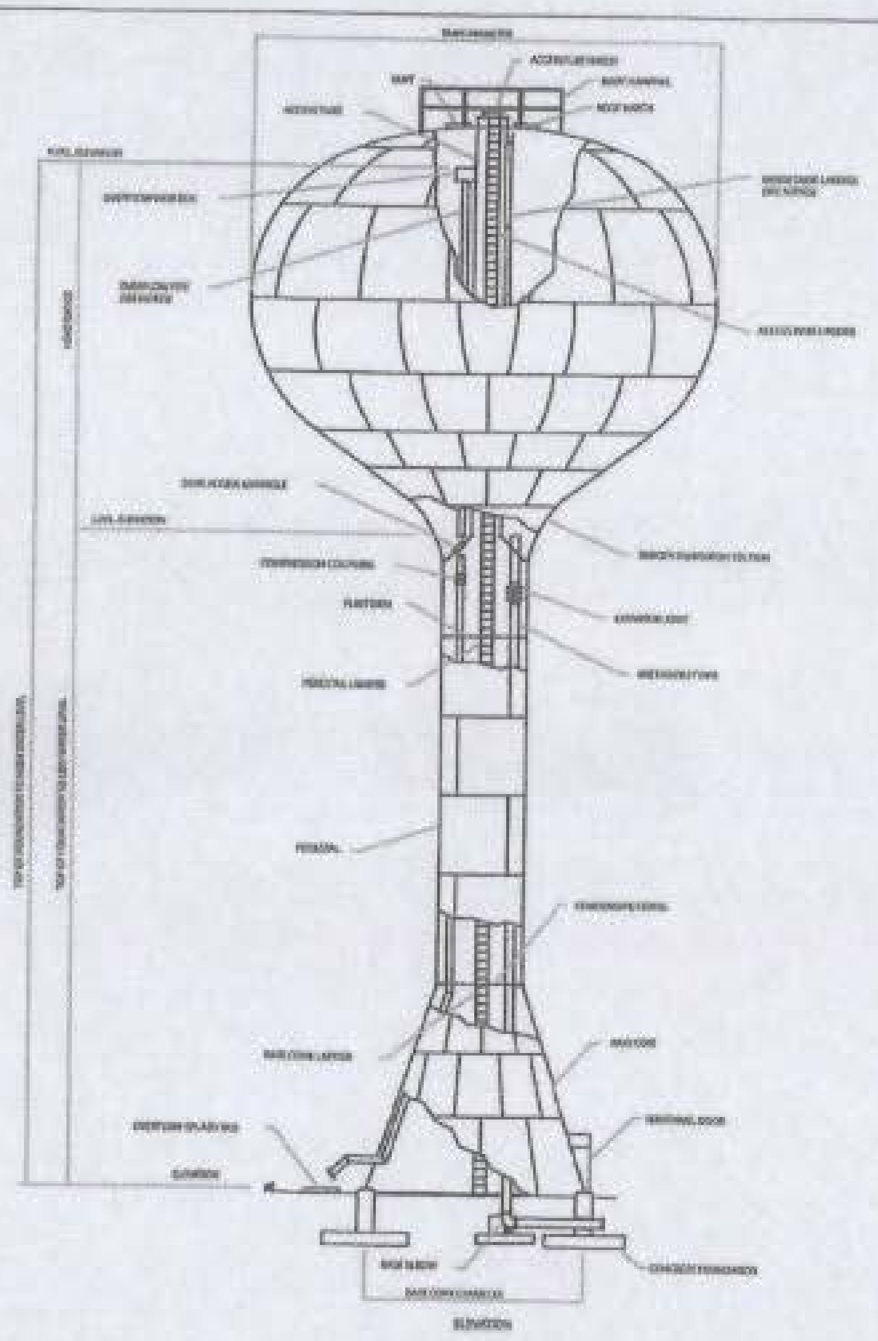
BOTTOM PLAN



3 RING ELEVATOIN

COMPANY INC.®
9500 LUCAS RANCH RD.
RANCHO CUCAMONGA, CA. 91730
Phone: (909) 912-8550
Fax: (909) 912-8583

TITLE: 86'-1 7/8" DIA x 24'-1 1/2" HIGH BOLTED STEEL TANK AWWA D103-97 (FPC)			
SIZE: B	PROJECT:		REV: 1
SCALE:	PART#: 8624-001-002	SHEET: 3 OF 3	



NOTES:

DESIGN:
TANK AND SUPPORT STRUCTURE SHALL BE DESIGNED, FABRICATED AND ERECTED IN ACCORDANCE WITH AWWA D100-96 AND THE PROJECT SPECIFICATIONS.

WIND LOAD:______
SNOW LOAD:______
SEISMIC ZONE:_____

TANK ERECTOR SHALL GROUT UNDER BASE PLATE RING.

MATERIALS:
STEEL PLATE: ASTM A283 GR.C / A36
STRUCTURAL STEEL SHAPES: ASTM A36
LADDER RUNGS: ASTM A706

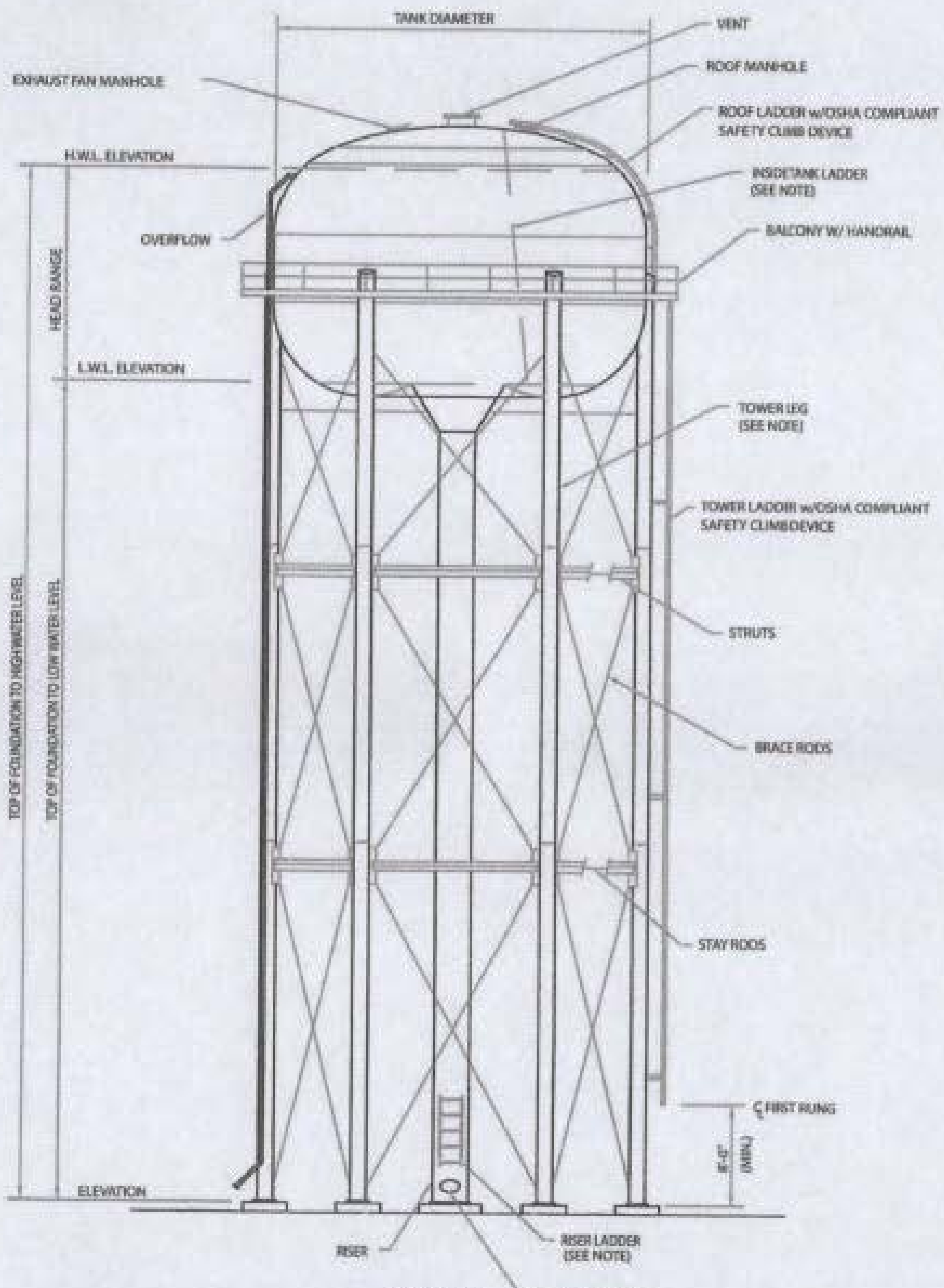
GENERAL:
- ACCESSORIES SHOWN ON ELEVATION DRAWING ARE ROTATED FOR CLARITY.
- ALL HANDRAILS, PLATFORM LANDINGS, WALKWAYS, LADDERS, AND SAFETY CLIMB DEVICES SHALL CONFORM WITH CURRENT OSHA STANDARDS.
- SEE PROJECT SPECIFICATIONS FOR SHOP AND FIELD PAINT REQUIREMENTS.
- STERILIZE TANK IN ACCORDANCE WITH AWWA C652-92 AND PROJECT SPECIFICATIONS.
- FOR TANKS LOCATED IN REGIONS WHERE FREEZING CONDITIONS MAY OCCUR, CONSIDERATION SHALL BE MADE TO ROUTE OVERFLOW PIPE INSIDE ACCESS TUBE AND OMIT INSIDE TANK LADDER.

REV. NO.		DATE	REMARKS

CALDWELL TANKS, INC.
LOUISVILLE, KY. NEWNAN, GA.

BY:	TAG:
DATE:	DRAWING NO. PED-1.DWG

B



ELEVATION

NOTES:

DESIGN:

TANK AND TOWER SHALL BE DESIGNED, FABRICATED AND ERECTED IN ACCORDANCE WITH AWWA D100-96 AND PROJECT SPECIFICATIONS.

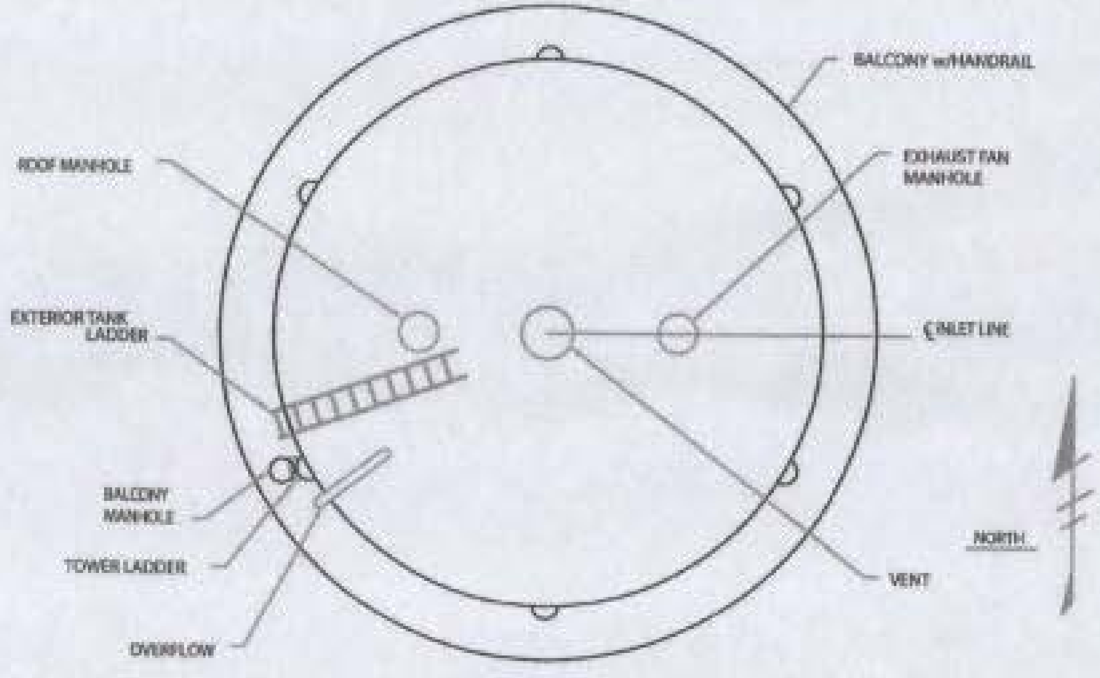
WIND LOAD:________
SNOW LOAD:________
SEISMIC ZONE:________

MATERIALS:

STEEL PLATE: ASTM A283 GR. C / A36
STRUCTURAL STEEL SHAPES: ASTM A36
BRACE RODS AND STAY RODS: ASTM A36
LADDER RUNGS: ASTM A706

GENERAL:

- ACCESSORIES SHOWN ON ELEVATION DRAWING ARE ROTATED FOR CLARITY.
- ALL HANDRAILS, PLATFORM LANDINGS, WALKWAYS, LADDERS, AND SAFETY CLIMB DEVICES SHALL CONFORM WITH CURRENT OSHA STANDARDS.
- SEE PROJECT SPECIFICATIONS FOR SHOP AND FIELD PAINT REQUIREMENTS.
- STERLIZE TANK IN ACCORDANCE WITH AWWA C652-92 AND PROJECT SPECIFICATIONS.
- FOR TANKS LOCATED IN REGIONS WHERE FREEZING CONDITIONS MAY OCCUR COSIDERATION SHALL BE GIVEN TO OMISSION OF INSIDE TANK LADDER.
- NUMBER OF TOWER LEGS PER MANUFACTURER'S STANDARD DESIGN.



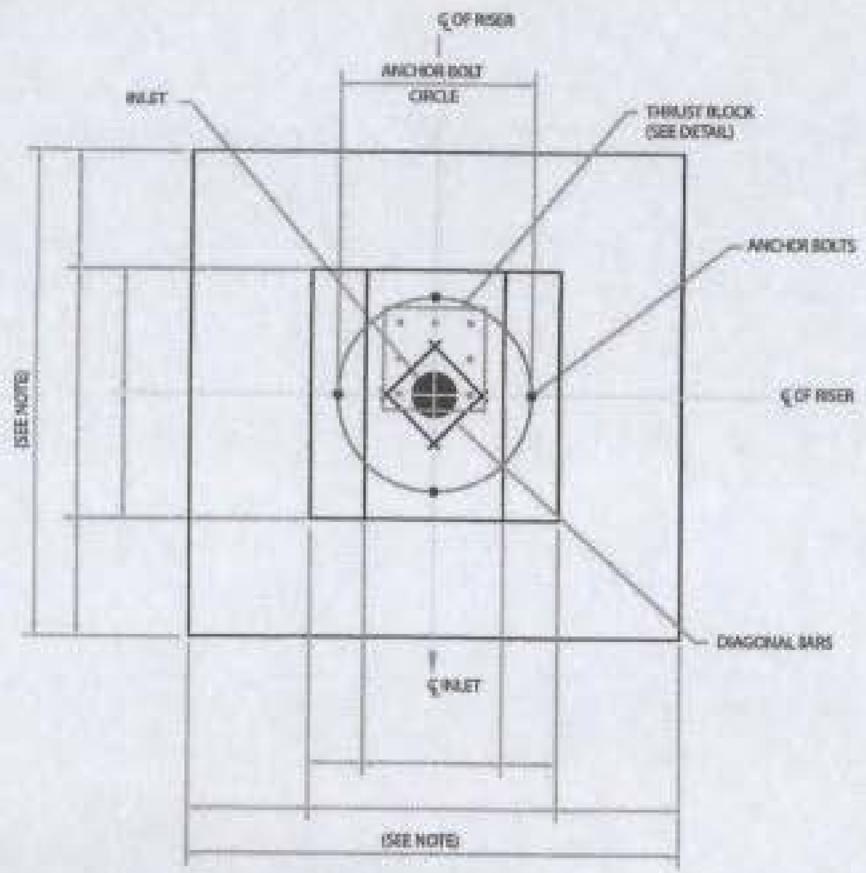
ORIENTATION

REV. BY	DATE	REMARKS

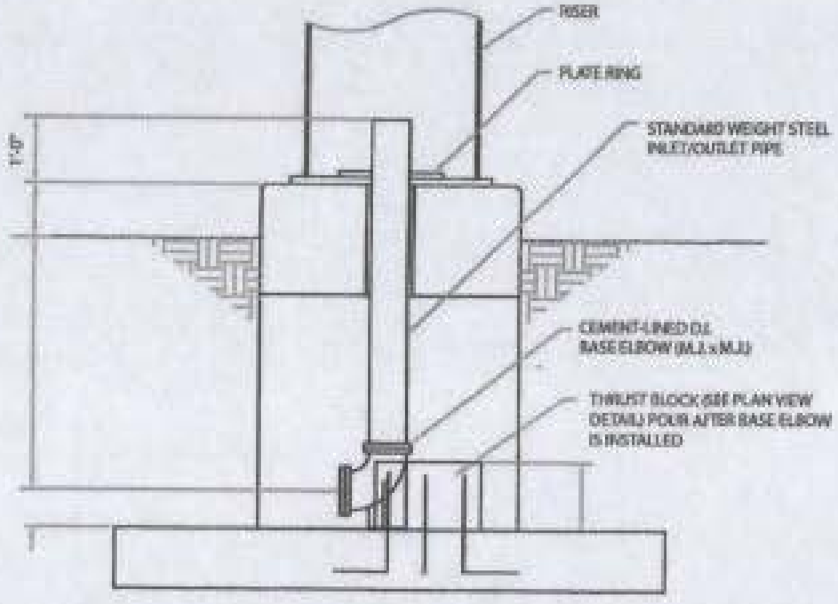
CALDWELL TANKS, INC.
LOUISVILLE, KY. NEWNAN, GA.

BY:	TITLE: ELEVATION DETAILS
DATE:	DRAWING NO.: TB-1.DWG

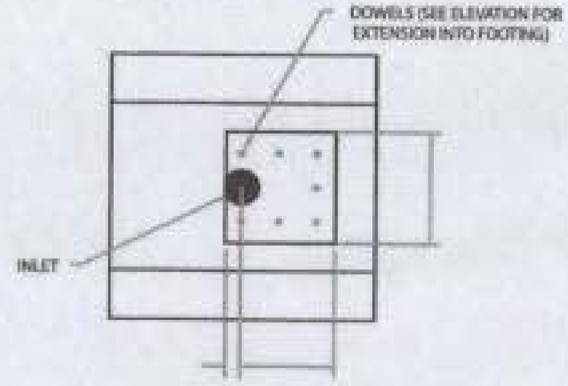
C



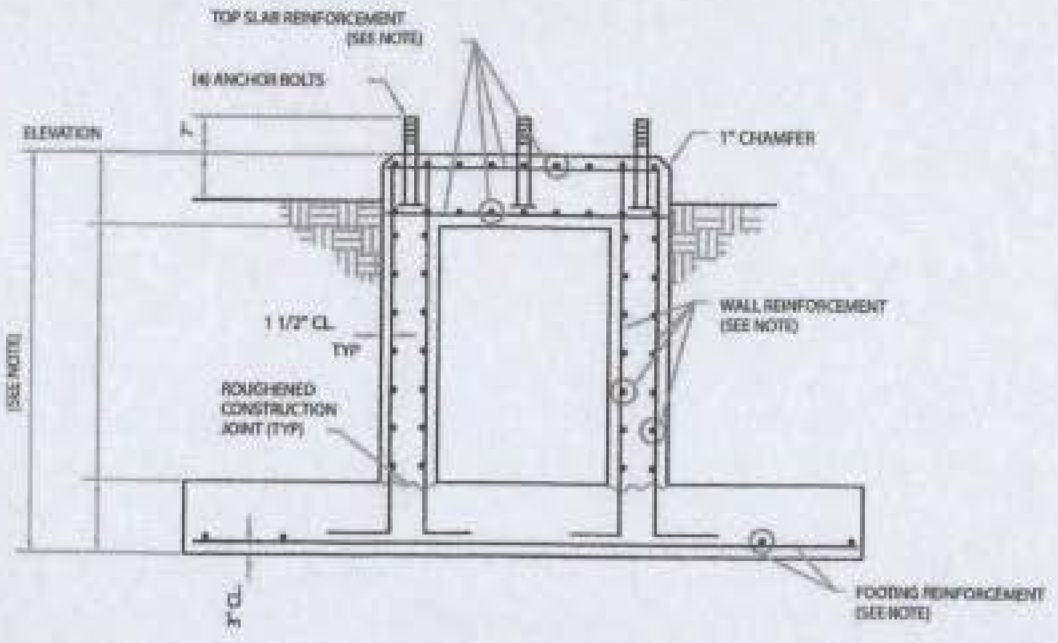
CENTER PIER PLAN



INLET/OUTLET PIPE



PLAN VIEW DETAIL
OF THRUST BLOCKING



SECTION THRU CENTER PIER
(PIPING NOT SHOWN)

NOTE:
CENTER PIER FOUNDATION DIMENSIONS AND CONCRETE REINFORCEMENT REQUIREMENTS SHALL BE DETERMINED BY TANK CONTRACTOR.

REV.	BY:	DATE	REMARKS

CALDWELL TANKS, INC.
LOUISVILLE, KY. NEWNAN, GA.

BY:
DATE:
TITLE: CENTER PIER FOUNDATION
DRAWING NO.: OE-F2.DWG

NOTES:

FOUNDATION DESIGN WILL BE THE RESPONSIBILITY OF THE TANK CONTRACTOR.

PEDESTAL AND FOOTING DIMENSIONS AND CONCRETE REINFORCEMENT SHALL BE DETERMINED BY THE TANK CONTRACTOR.

FOUNDATION CONSTRUCTION SHALL COMPLY WITH AWWA D100-96, A.C.I. 318-99, A.C.I. 301-96 AND APPLICABLE SECTIONS OF THE PROJECT SPECIFICATIONS AND THE PROJECT SOILS REPORT.

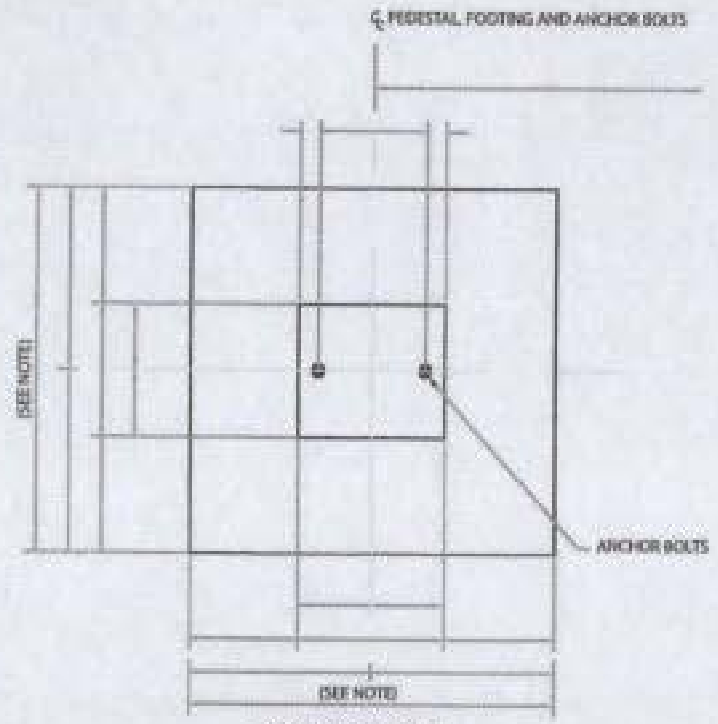
CONCRETE COMPRESSIVE STRENGTH SHALL BE 4,000 PSI @ 28 DAYS.

REINFORCEMENT SHALL CONFORM TO A.S.T.M. A615 GR. 60.

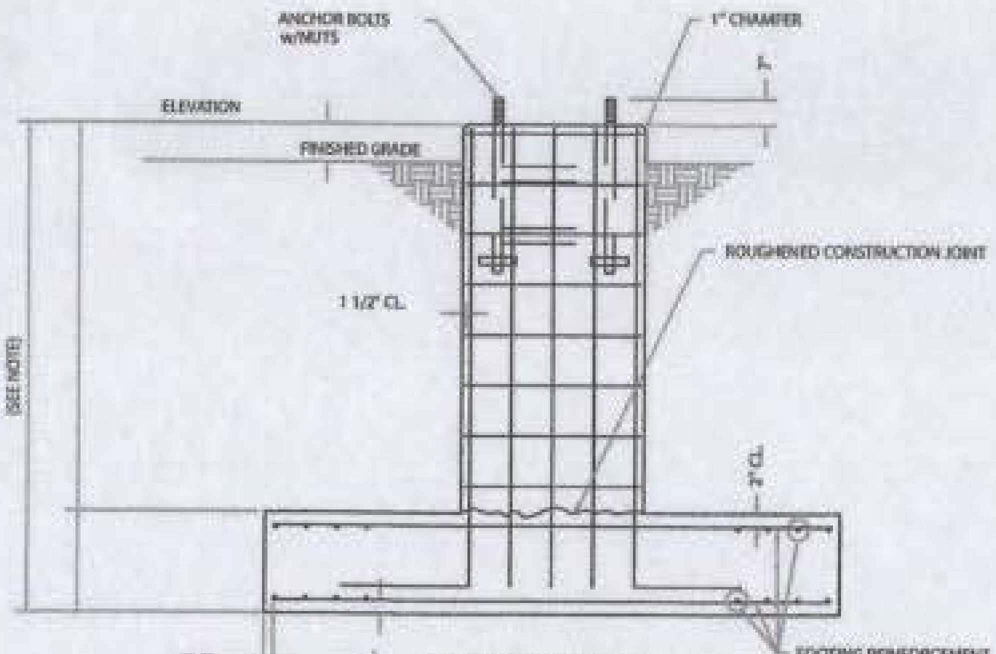
CONSTRUCTION JOINTS SHALL BE ROUGHENED ACROSS ENTIRE FACE WITH 1/4" MINIMUM DEPTH INDENTATIONS.

THE TOP OF CONCRETE FOR ALL PIERS INCLUDING THE CENTER PIER SHALL BE LEVEL AND SHALL BE THE SAME ELEVATION (UNLESS OTHERWISE NOTED BY A SPECIFIED ELEV.) WITH A MAXIMUM DIFFERENTAL OF (+-) 1/4".

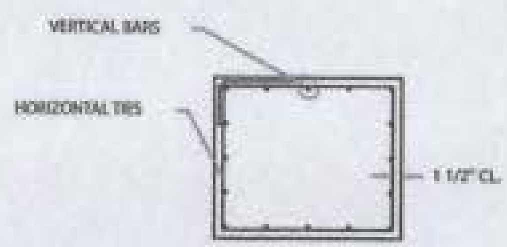
ANCHOR BOLTS SHALL BE PLACED WITHIN (+-) 1/8" OF THE PLAN DIMENSIONS AT THE TOP OF THE CONCRETE, PLUMB WITHIN 1/4" IN 12" AND EXTEND WITHIN 1/2" OF THE SPECIFIED PROJECTION ABOVE THE TOP OF THE FOUNDATION.



COLUMN PIER PLAN



COLUMN PIER ELEVATION



PEDESTAL SECTION

REV.	BY	DATE	REMARKS

CALDWELL TANKS, INC.
LOUISVILLE, KY. NEWNAN, GA.

BY:
DATE:
TITLE: COLUMN PIER FOUNDATION
DRAWING NO.: LEG-F1.DWG

APPENDIX B

EXPLORATION LOCATION PLANS

VICINITY MAP

TEST BORING COORDINATES

BORING	DEPTH	LATITUDE	LONGITUDE
CPT-1	75.74'	29° 55' 7.40" N	94° 10' 35.83" W
CPT-2	75.81'	29° 55' 6.66" N	94° 10' 36.20" W
CPT-3	75.79'	29° 55' 6.66" N	94° 10' 35.46" W
TB-1	100'	29° 55' 6.97" N	94° 10' 35.83" W

LEGEND

SYMBOL	DESCRIPTION
◑	CPT LOCATION
◕	SOIL BORING LOCATION

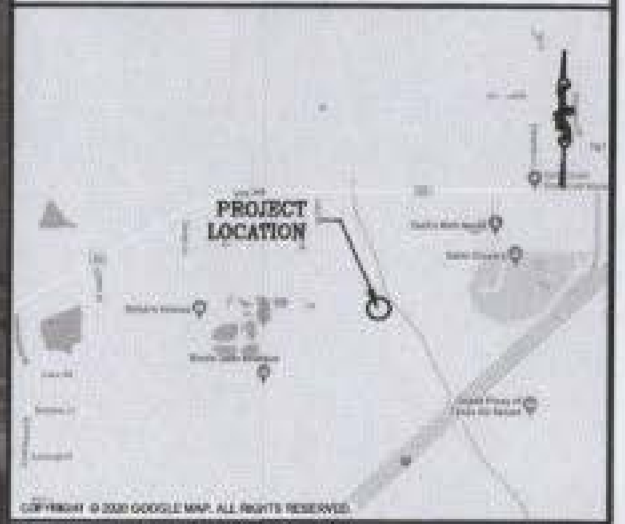
Tolunay-Wong Engineers, Inc.

EXPLORATION LOCATION PLAN
PROPOSED NEW 1,000,000-GAL GROUND STORAGE TANK
WEST JEFFERSON COUNTY MUNICIPAL WATER DISTRICT
JEFFERSON COUNTY, TEXAS

Drawn	M.A.	01-04-2023
Checked	T.O.	01-04-2023
Approved	T.G.H.	01-05-2023
Scale	N.T.S.	

TWE DRAWING NO. 23.23.170-1

VICINITY MAP



TEST BORING COORDINATES

BORING	DEPTH	LATITUDE	LONGITUDE
TB-2	100'	29° 55' 51.09" N	94° 17' 0.79" W

LEGEND

SYMBOL	DESCRIPTION
⊕	SOIL BORING LOCATION

Tolunay-Wong Engineers, Inc.

TEST BORING LOCATION PLAN
PROPOSED NEW 500,000-GAL ELEVATED STORAGE TANK
WEST JEFFERSON COUNTY MUNICIPAL WATER DISTRICT
JEFFERSON COUNTY, TEXAS

Drawn	M.A.	01-04-2024
Checked	T.O.	01-04-2024
Approved	T.C.H.	01-05-2024
Scale	N.T.S.	

TWE DRAWING NO. 23.23.170-2

APPENDIX C

TB LOGS AND KEY TO SYMBOLS AND TERMS

LOG OF BORING TB-1

PROJECT: WJCMWD - New Storage Tanks
Jefferson County, Texas

CLIENT: Action Civil Engineering, PLLC
Port Arthur, Texas

COORDINATES: N 29° 55' 06.66"
W 95° 10' 35.83"

SURFACE ELEVATION: --

DRILLING METHOD:
Dry Augered: 0' to 20'
Wash Bored: 20' to 100'

DEPTH (FT)	MATERIAL DESCRIPTION	(P) POCKET PEN (tsf) (T) TORVANE (tsf)	STD. PENETRATION TEST BLOWCOUNT	N_{60}	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	LAB MINI VANE SHEAR (tsf)	COMPRESSIVE STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	PASSING #200 SIEVE (%)	OTHER TESTS PERFORMED
0	Stiff gray FAT CLAY (CH), with ferrous nodules	(P)1.50												
	-becomes brown and tan at 2'	(P)1.50			29	94	72	52		1.17	7	3		
	-with sand seams from 4' to 8'	(P)2.00												
5	-with calcareous nodules from 6' to 40'	(P)2.75												
		(P)1.50			25		62	39						CON
10		(T)0.60			35	87				1.07	11	9		
	-slickensided from 13' to 35'	(P)1.50			40		103	66						
15														
		(P)2.25												
20														
		(P)2.25			37	83	102	73		1.20	7	20		
25														
		(P)2.50												
30														
		(P)2.25			41									CON
35														

COMPLETION DEPTH: 100 ft
DATE BORING STARTED: 11/16/2023
DATE BORING COMPLETED: 11/16/2023
LOGGER: C. Hughes
PROJECT NO.: 23.23.170

NOTES: Free Water Depth = 18.0-ft. 15-min Static Water Depth = 15.8-ft. 15-min Total Hole Depth = 17.1-ft. Borehole was backfilled with cement-bentonite grout. CON: One-Dimensional Consolidation.

LOG OF BORING TB-1

PROJECT: WJCMWD - New Storage Tanks
Jefferson County, Texas

CLIENT: Action Civil Engineering, PLLC
Port Arthur, Texas

COORDINATES: N 29° 55' 06.66" W 95° 10' 35.83"
SURFACE ELEVATION: --
DRILLING METHOD:
Dry Augered: 0' to 20'
Wash Bored: 20' to 100'

ELEVATION (FT)	DEPTH (FT)	SAMPLE TYPE	SYMBOL	MATERIAL DESCRIPTION	(P) POCKET PEN (tsf) (T) TORVANE (tsf)	STD. PENETRATION TEST BLOWCOUNT	N60	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	LAB MINI VANE SHEAR (tsf)	COMPRESSIVE STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	PASSING #200 SIEVE (%)	OTHER TESTS PERFORMED
	35			Stiff, brown and tan FAT CLAY (CH), with ferrous nodules													
				-with sand seams from 38' to 40'	(P)2.25			27		58	30						
	40																
				Medium dense gray SILTY SAND (SM)		6/6" 8/6" 8/6"		22								48	
	45																
						8/6" 12/6" 12/6"											
	50																
						9/6" 11/6" 9/6"											
	55																
				-becomes dense at 58.5'		9/6" 18/6" 17/6"		22								21	
	60																
						10/6" 15/6" 20/6"											
	65																
				Very dense gray POORLY GRADED SAND with SILT (SP-SM)		8/6" 20/6" 50/5"											
	70																

COMPLETION DEPTH: 100 ft
DATE BORING STARTED: 11/16/2023
DATE BORING COMPLETED: 11/16/2023
LOGGER: C. Hughes
PROJECT NO.: 23.23.170

NOTES: Free Water Depth = 18.0-ft. 15-min Static Water Depth = 15.8-ft. 15-min Total Hole Depth = 17.1-ft. Borehole was backfilled with cement-bentonite grout. CON: One-Dimensional Consolidation.

TOLUNAY-WONG ENGINEERS, INC.

LOG OF BORING TB-1

PROJECT: WJCMWD - New Storage Tanks
Jefferson County, Texas

CLIENT: Action Civil Engineering, PLLC
Port Arthur, Texas

COORDINATES: N 29° 55' 06.66" W 95° 10' 35.83"
SURFACE ELEVATION: --
DRILLING METHOD:
Dry Augered: 0' to 20'
Wash Bored: 20' to 100'

DEPTH (FT)	MATERIAL DESCRIPTION	(P) POCKET PEN (tsf) (T) TORVANE (tsf)	STD. PENETRATION TEST BLOWCOUNT	N_{60}	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	LAB MINI VANE SHEAR (tsf)	COMPRESSIVE STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	PASSING #200 SIEVE (%)	OTHER TESTS PERFORMED
70–78	Very dense gray POORLY GRADED SAND with SILT (SP-SM)													
73.5			10/6" 28/6" 50/3"		23								11	
78–100	Very stiff gray FAT CLAY (CH), with ferrous nodules -with sand seams from 78.5' to 90'		8/6" 10/6" 11/6"		26		57	35						
83		(P)4.50			22	103				3.51	7	70		
88		(P)3.75			21		62	43						
93	-becomes brown and tan with calcareous nodules and slickensides at 93'	(P)3.25												
98		(P)4.25												
100	Bottom @ 100'													

COMPLETION DEPTH: 100 ft
DATE BORING STARTED: 11/16/2023
DATE BORING COMPLETED: 11/16/2023
LOGGER: C. Hughes
PROJECT NO.: 23.23.170

NOTES: Free Water Depth = 18.0-ft. 15-min Static Water Depth = 15.8-ft. 15-min Total Hole Depth = 17.1-ft. Borehole was backfilled with cement-bentonite grout. CON: One-Dimensional Consolidation.

TOLUNAY-WONG ENGINEERS, INC.

LOG OF BORING TB-2

PROJECT: WJCMWD - New Storage Tanks
Jefferson County, Texas

CLIENT: Action Civil Engineering, PLLC
Port Arthur, Texas

COORDINATES: N 29° 55' 41.10"
W 94° 14' 00.70"

SURFACE ELEVATION: --

DRILLING METHOD:
Dry Augered: 0' to 12'
Wash Bored: 12' to 100'

ELEVATION (FT)	DEPTH (FT)	MATERIAL DESCRIPTION	(P) POCKET PEN (tsf) (T) TORVANE (tsf)	STD. PENETRATION TEST BLOWCOUNT	N_{60}	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	LAB MINI VANE SHEAR (tsf)	COMPRESSIVE STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	PASSING #200 SIEVE (%)	OTHER TESTS PERFORMED
	0	Medium dense tan SILTY SAND (SM)		3/6" 5/6" 12/6"		11									
		-becomes loose at 2.5'		5/6" 3/6" 4/6"										24	
	5	Very stiff, gray and tan SANDY LEAN CLAY (CL), with ferrous nodules	(P)2.50			19	109				2.35	12	4		
		Gray and tan CLAYEY SAND (SC)				20		37	23					32	CON
	10	Very loose, gray and tan SILTY SAND (SM)		2/6" 1/6" 3/6"		25								12	
				1/6" 2/6" 1/6"											
	15	Very loose gray CLAYEY SAND (SC)		2/6" 1/6" 1/6"		34								35	
	20	Very soft gray SANDY FAT CLAY (CH)		1/6" 2/6" 1/6"		36								64	
	25	Very soft gray FAT CLAY (CH)		WOH/ 18"											
	30			1/6" 2/6" 1/6"		52		64	41						
	35	-firm from 33' to 40'	(P)1.00			49	76	64	39		0.77	3	28		

COMPLETION DEPTH: 100 ft
DATE BORING STARTED: 11/15/2023
DATE BORING COMPLETED: 11/15/2023
LOGGER: C. Hughes
PROJECT NO.: 23.23.170

NOTES: Groundwater was not encountered during dry auger drilling due to borehole instability. Caving of the borehole was noted at 7.8-ft below existing grade. WOH: Weight of Hammer. CON: One-Dimensional Consolidation.

LOG OF BORING TB-2

PROJECT: WJCMWD - New Storage Tanks
Jefferson County, Texas

CLIENT: Action Civil Engineering, PLLC
Port Arthur, Texas

COORDINATES: N 29° 55' 41.10"
W 94° 14' 00.70"

SURFACE ELEVATION: --

DRILLING METHOD:
Dry Augered: 0' to 12'
Wash Bored: 12' to 100'

ELEVATION (FT)	DEPTH (FT)	SAMPLE TYPE	SYMBOL	MATERIAL DESCRIPTION	(P) POCKET PEN (tsf) (T) TORVANE (tsf)	STD. PENETRATION TEST BLOWCOUNT	N_{60}	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	LAB MINI VANE SHEAR (tsf)	COMPRESSIVE STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	PASSING #200 SIEVE (%)	OTHER TESTS PERFORMED
	35			Firm gray FAT CLAY (CH)													
	38				(P)1.00												
	43			-becomes gray and tan at 43' -stiff from 43' to 50'	(P)2.00												
	48				(P)2.75			24	101	54	35		1.91	10	41		
	53			-becomes hard at 53'	(P)4.50			22								96	
	58			Stiff, gray and tan LEAN CLAY (CL)	(P)2.50			25	101	33	15		1.64	15	49		
	63			Stiff, gray and tan FAT CLAY (CH)	(P)3.00												
	68				(P)2.75			31		85	56						
	70																

COMPLETION DEPTH: 100 ft
DATE BORING STARTED: 11/15/2023
DATE BORING COMPLETED: 11/15/2023
LOGGER: C. Hughes
PROJECT NO.: 23.23.170

NOTES: Groundwater was not encountered during dry auger drilling due to borehole instability. Caving of the borehole was noted at 7.8-ft below existing grade. WOH: Weight of Hammer. CON: One-Dimensional Consolidation.

TOLUNAY-WONG ENGINEERS, INC.

LOG OF BORING TB-2

PROJECT: WJCMWD - New Storage Tanks
Jefferson County, Texas

CLIENT: Action Civil Engineering, PLLC
Port Arthur, Texas

COORDINATES: N 29° 55' 41.10"
W 94° 14' 00.70"

SURFACE ELEVATION: --

DRILLING METHOD:
Dry Augered: 0' to 12'
Wash Bored: 12' to 100'

ELEVATION (FT)	DEPTH (FT)	SAMPLE TYPE	SYMBOL	MATERIAL DESCRIPTION	(P) POCKET PEN (tsf) (T) TORVANE (tsf)	STD. PENETRATION TEST BLOWCOUNT	N_{60}	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	LAB MINI VANE SHEAR (tsf)	COMPRESSIVE STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	PASSING #200 SIEVE (%)	OTHER TESTS PERFORMED
				Stiff, gray and tan FAT CLAY (CH)													
					(P)3.00			35	83				1.99	13	62		
	75																
				-becomes very stiff at 78'	(P)3.00												
	80																
				Very dense gray SILTY SAND (SM)		28/6" 37/6" 39/6"		23								22	
	85																
						32/6" 41/6" 30/6"											
	90																
						15/6" 34/6" 40/6"		24								25	
	95																
						19/6" 40/6" 41/6"											
	100			Bottom @ 100'													
	105																

COMPLETION DEPTH: 100 ft
DATE BORING STARTED: 11/15/2023
DATE BORING COMPLETED: 11/15/2023
LOGGER: C. Hughes
PROJECT NO.: 23.23.170

NOTES: Groundwater was not encountered during dry auger drilling due to borehole instability. Caving of the borehole was noted at 7.8-ft below existing grade. WOH: Weight of Hammer. CON: One-Dimensional Consolidation.

TOLUNAY-WONG ENGINEERS, INC.

KEY TO SYMBOLS AND TERMS USED ON BORING LOGS FOR SOIL

Most Common Unified Soil Classifications System Symbols

Lean Clay (CL)	Well Graded Sand (SW)
Lean Clay w/ Sand (CL)	Well Graded Sand w/ Gravel (SW-GM)
Sandy Lean Clay (CL)	Poorly Graded Sand (SP)
Fat Clay (CH)	Poorly Graded Sand w/ Silt (SP-SM)
Fat Clay w/ Sand (CH)	Silt (ML)
Sandy Fat Clay (CH)	Elastic Silt (MH)
Silty Clay (CL-ML)	Elastic Silt w/ Sand (MH-SP)
Sandy Silty Clay (CL-ML)	Silty Gravel (GM)
Silty Clayey Sand (SC-SM)	Clayey Gravel (GC)
Clayey Sand (SC)	Well Graded Gravel (GW)
Sandy Silt (ML)	Well Graded Gravel w/ Sand (SP-GM)
Silty Sand (SM)	Poorly Graded Gravel (GP)
Silt w/ Sand (ML)	Peat

Miscellaneous Materials

Fill Concrete Asphalt and/or Base

Sampler Symbols	**Meaning**
	Pavement core
	Thin - walled tube sample
	Standard Penetration Test (SPT)
	Auger sample
	Sampling attempt with no recovery
	TxDOT Cone Penetrometer Test

Field Test Data

2.50	Pocket penetrometer reading in tons per square foot
(T)1.13	Torvane Measurement in tons per square foot
8/6"	Blow count per 6 - in. interval of the Standard Penetration Test
	Observed free water during drilling
	Observed static water level

Laboratory Test Data

Wc (%)	Moisture content in percent
Dens. (pcf)	Dry unit weight in pounds per cubic foot
Qu (tsf)	Unconfined compressive strength in tons per square foot
UU (tsf)	Compressive strength under confining pressure in tons per square foot
Str. (%)	Strain at failure in percent
LL	Liquid Limit in percent
PI	Plasticity Index
#200 (%)	Percent passing the No. 200 mesh sieve
( )	Confining pressure in pounds per square inch
*	Slickensided failure
**	Did not fail @ 15% strain

RELATIVE DENSITY OF COHESIONLESS & SEMI-COHESIONLESS SOILS

The following descriptive terms for relative density apply to cohesionless soils such as gravels, silty sands, and sands as well as semi-cohesive and semi-cohesionless soils such as sandy silts, and clayey sands.

Relative Density	Typical N_{60} Value Range*
Very Loose	0-4
Loose	5-10
Medium Dense	11-30
Dense	31-50
Very Dense	Over 50

* N_{60} is the number of blows from a 140-lb weight having a free fall of 30-in. required to penetrate the final 12-in. of an 18-in. sample interval, corrected for field procedure to an average energy ratio of 60% (Terzaghi, Peck, and Mesri, 1996).

CONSISTENCY OF COHESIVE SOILS

The following descriptive terms for consistency apply to cohesive soils such as clays, sandy clays, and silty clays.

Typical Compressive Strength (tsf)	Consistency	Typical SPT "N_{60}" Value Range**
$q_u < 0.25$	Very soft	≤ 2
$0.25 \leq q_u < 0.50$	Soft	3-4
$0.50 \leq q_u < 1.00$	Firm	5-8
$1.00 \leq q_u < 2.00$	Stiff	9-15
$2.00 \leq q_u < 4.00$	Very Stiff	16-30
$q_u \geq 4.00$	Hard	≥ 31

** An "N_{60}" value of 31 or greater corresponds to a hard consistency. The correlation of consistency with a typical SPT "N_{60}" value range is approximate.

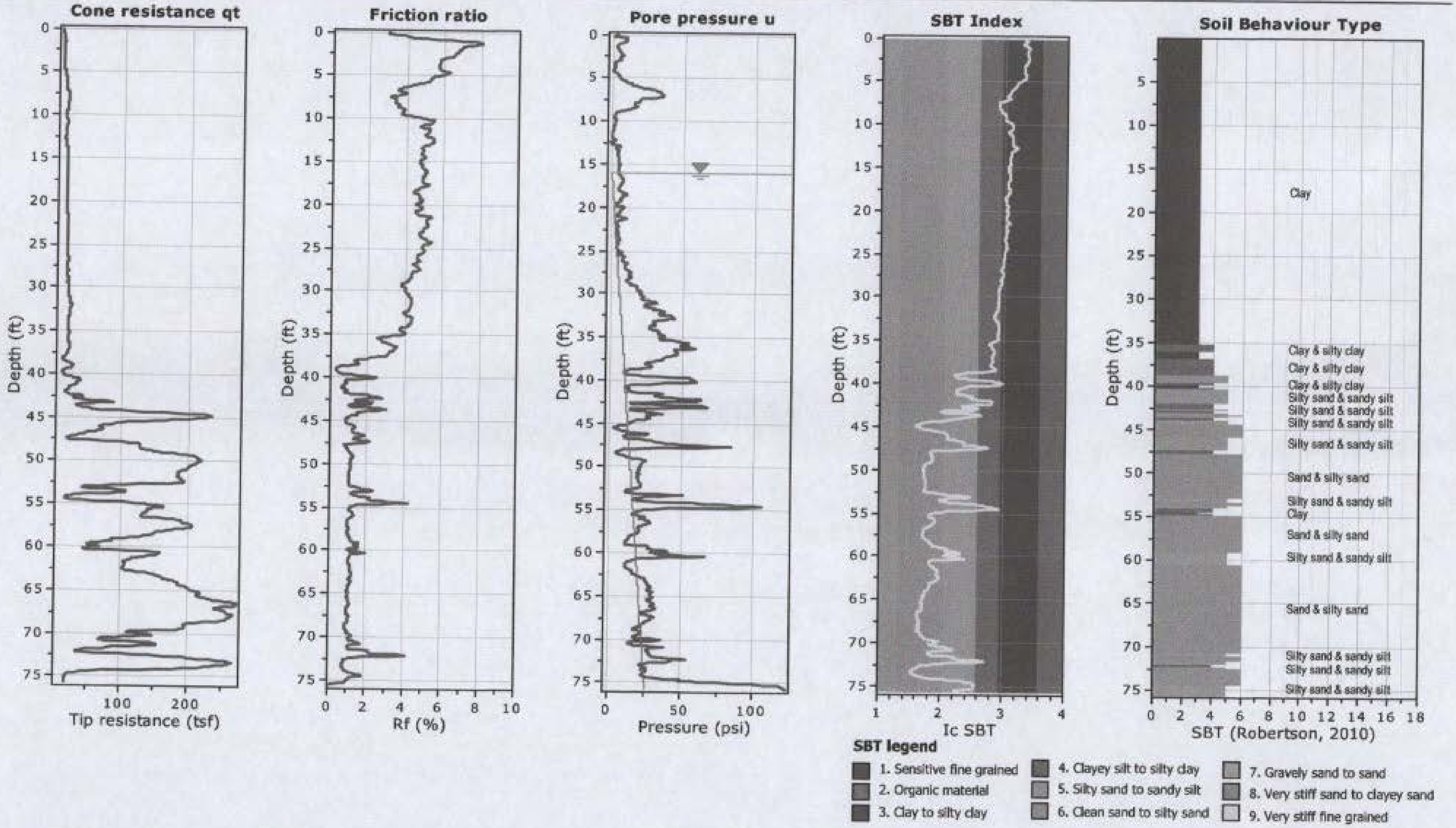
APPENDIX D

CPT SOUNDING LOGS

Tolunay-Wong Engineers, Inc.
TOLUNAY-WONG ENGINEERS
2455 W. Cardinal Drive
Beaumont, Texas
http://www.tweinc.com

Project: WJCMWD - New Storage Tanks
Location: Jefferson County, Texas

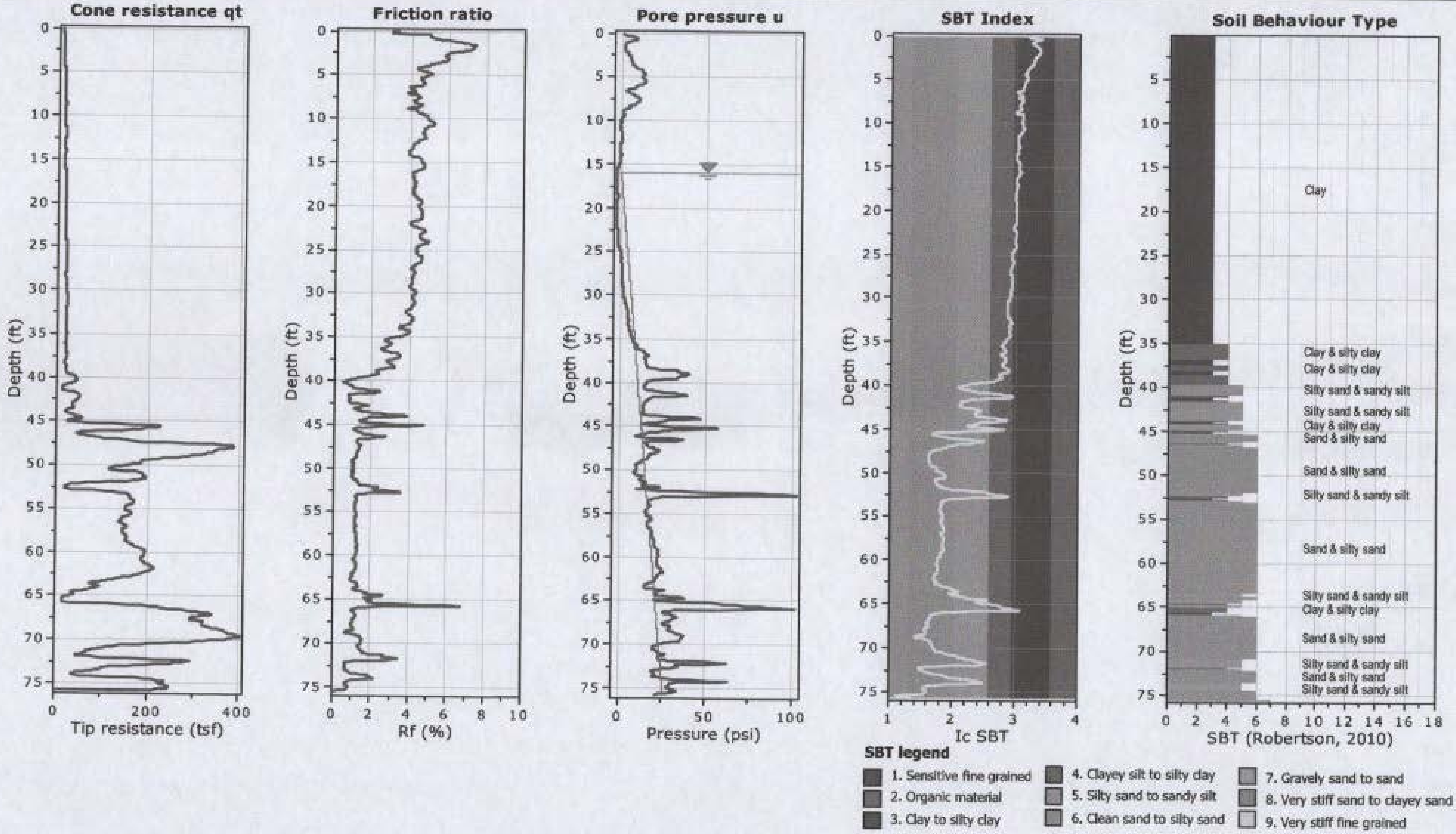
CPT-1
Total depth: 75.74 ft, Date: 11/17/2023
Coords: 29°55'7.4" N 94°10'35.83" E
Cone Type: 15-cm2
Cone Operator: Sixto C.



Tolunay-Wong Engineers, Inc.
2455 W. Cardinal Drive
Beaumont, Texas
http://www.tweinc.com

Project: WJCMWD - New Storage Tanks
Location: Jefferson County, Texas

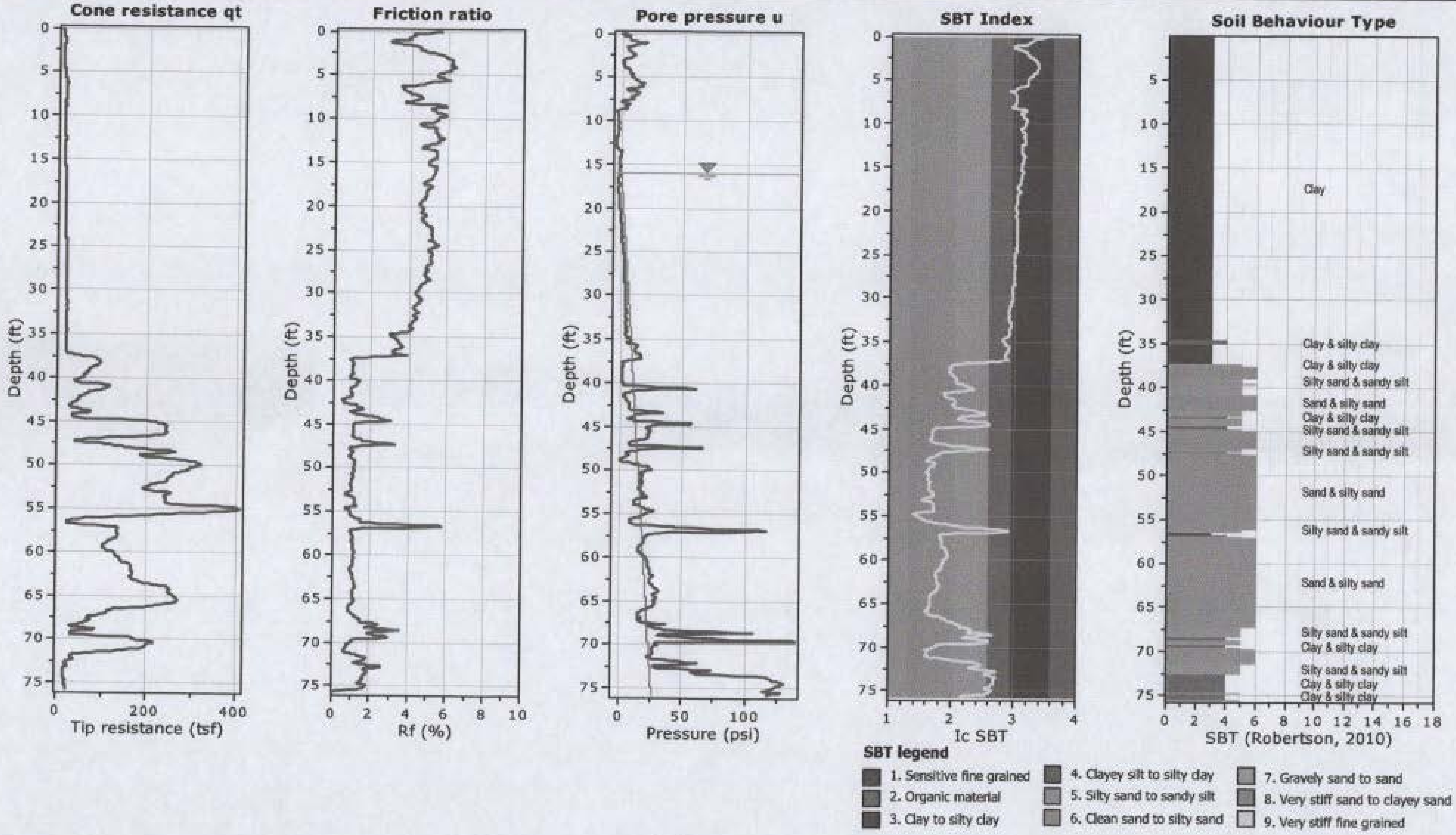
CPT-2
Total depth: 75.81 ft, Date: 11/17/2023
Coords: 29°55'6.66" N 94°10'36.2" E
Cone Type: 15-cm2
Cone Operator: Sixto C.



Tolunay-Wong Engineers, Inc.
2455 W. Cardinal Drive
Beaumont, Texas
http://www.tweinc.com

Project: **WJCMWD - New Storage Tanks**
Location: **Jefferson County, Texas**

CPT-3
Total depth: 75.79 ft, Date: 11/17/2023
Coords: 29°55'6.66" N 94°10'35.46" E
Cone Type: 15-cm2
Cone Operator: Sixto C.



APPENDIX E

RESULTS OF ONE-DIMENSIONAL CONSOLIDATION TESTING

CONSOLIDATION TEST REPORT

Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
92.4 %	20.9 %	104.7	62	39	2.70	CH		0.610

MATERIAL DESCRIPTION

Stiff, brown and tan FAT CLAY (CH), with calcareous nodules

Project No. 23.23.170 **Client:** Action Civil Engineering, PLLC

Project: WJCMWD - New Storage Tanks
Jefferson County, Texas

Source of Sample: TB-1 **Depth:** 8-10

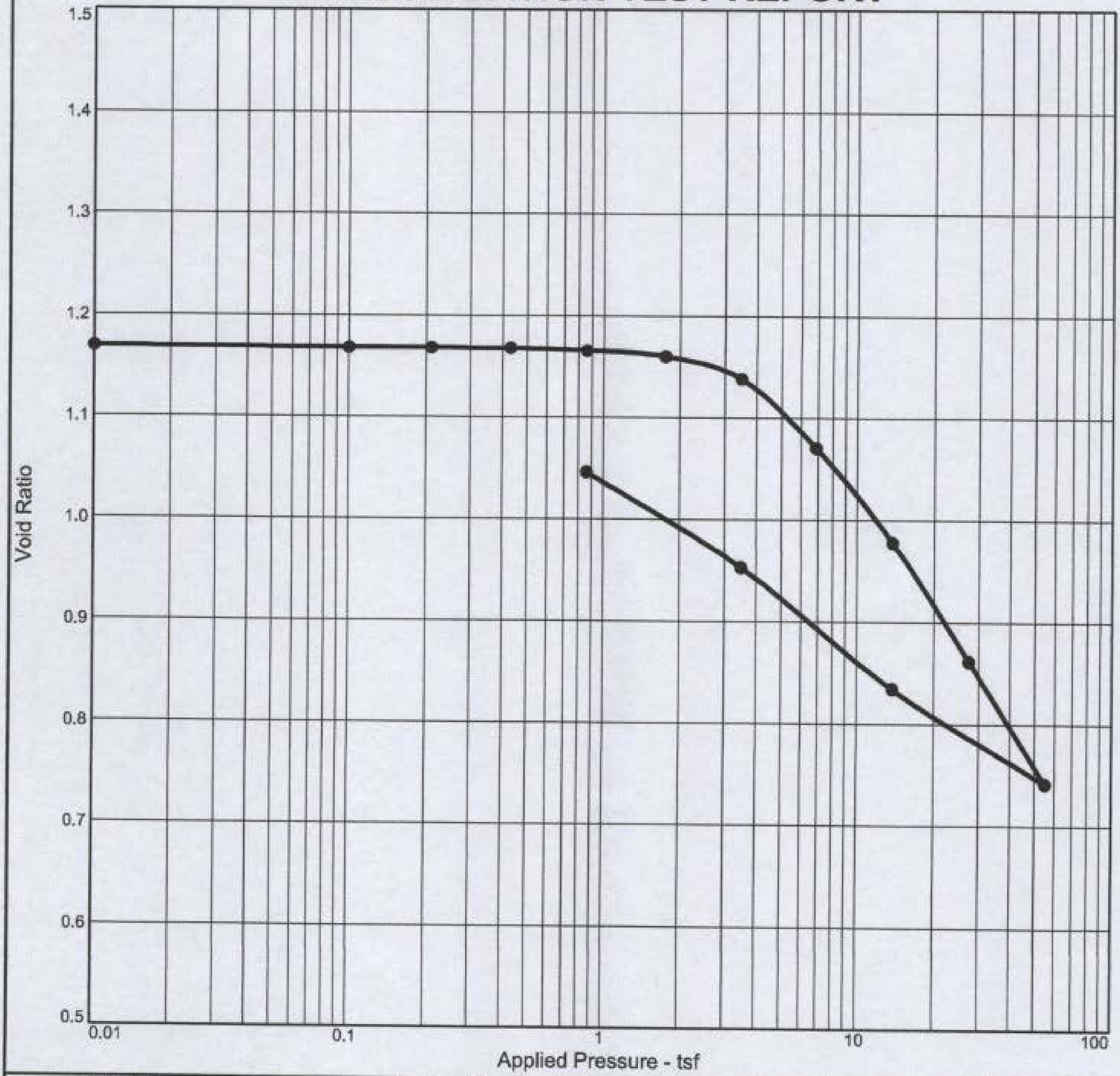
Tolunay-Wong Engineers, Inc.

Beaumont, TX

Remarks:
ASTM D2435 - Method B
Specific Gravity: Assumed

Figure

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
99.2 %	41.4 %	80.6	--	--	2.80	CH		1.169

MATERIAL DESCRIPTION

Stiff, brown and tan FAT CLAY (CH), with slickensides

Project No. 23.23.170 **Client:** Action Civil Engineering, PLLC

Project: WJCMWD - New Storage Tanks
Jefferson County, Texas

Source of Sample: TB-1 **Depth:** 33-35

Tolunay-Wong Engineers, Inc.

Beaumont, TX

Remarks:
ASTM D2435 - Method B
Specific Gravity: Assumed

Figure

CONSOLIDATION TEST REPORT

Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
93.1 %	20.0 %	106.7	37	23	2.70	SC		0.580

MATERIAL DESCRIPTION

Gray and tan CLAYEY SAND (SC)

Project No. 23.23.170 **Client:** Action Civil Engineering, PLLC

Project: WJCMWD - New Storage Tanks
Jefferson County, Texas

Source of Sample: TB-2 **Depth:** 6-8

Tolunay-Wong Engineers, Inc.

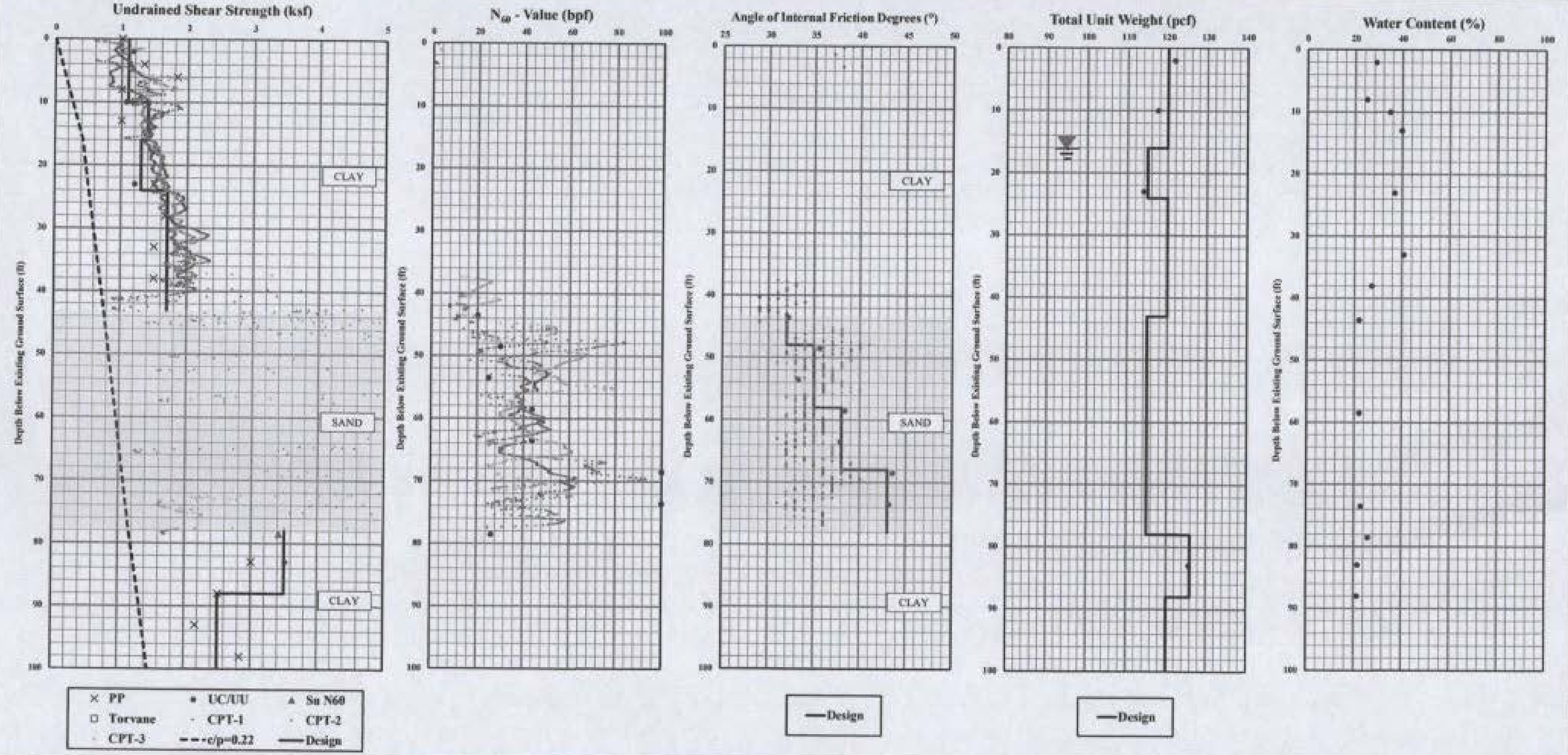
Beaumont, TX

Remarks:
ASTM D2435 - Method B
Specific Gravity: Assumed

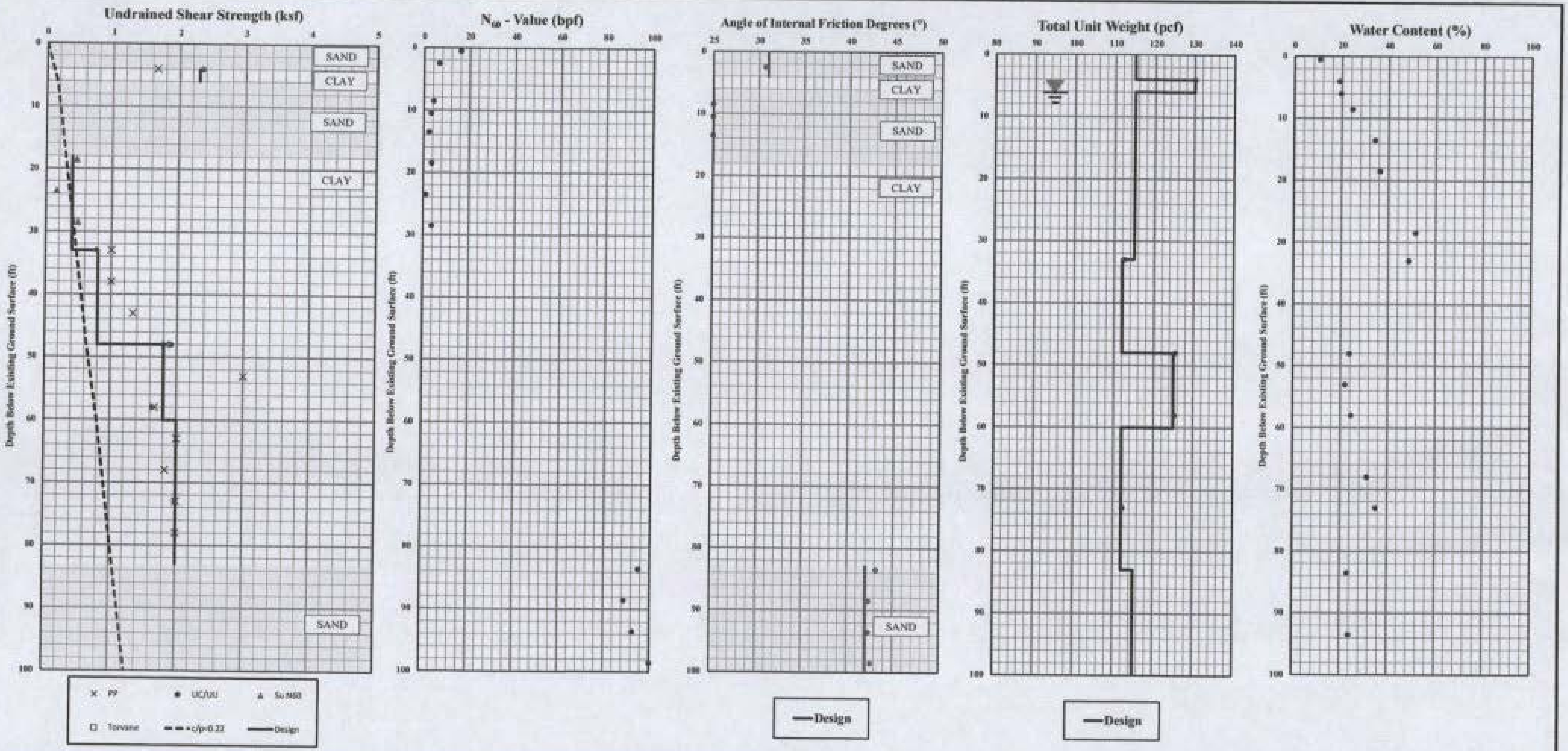
Figure

APPENDIX F

SOIL DESIGN PARAMETERS



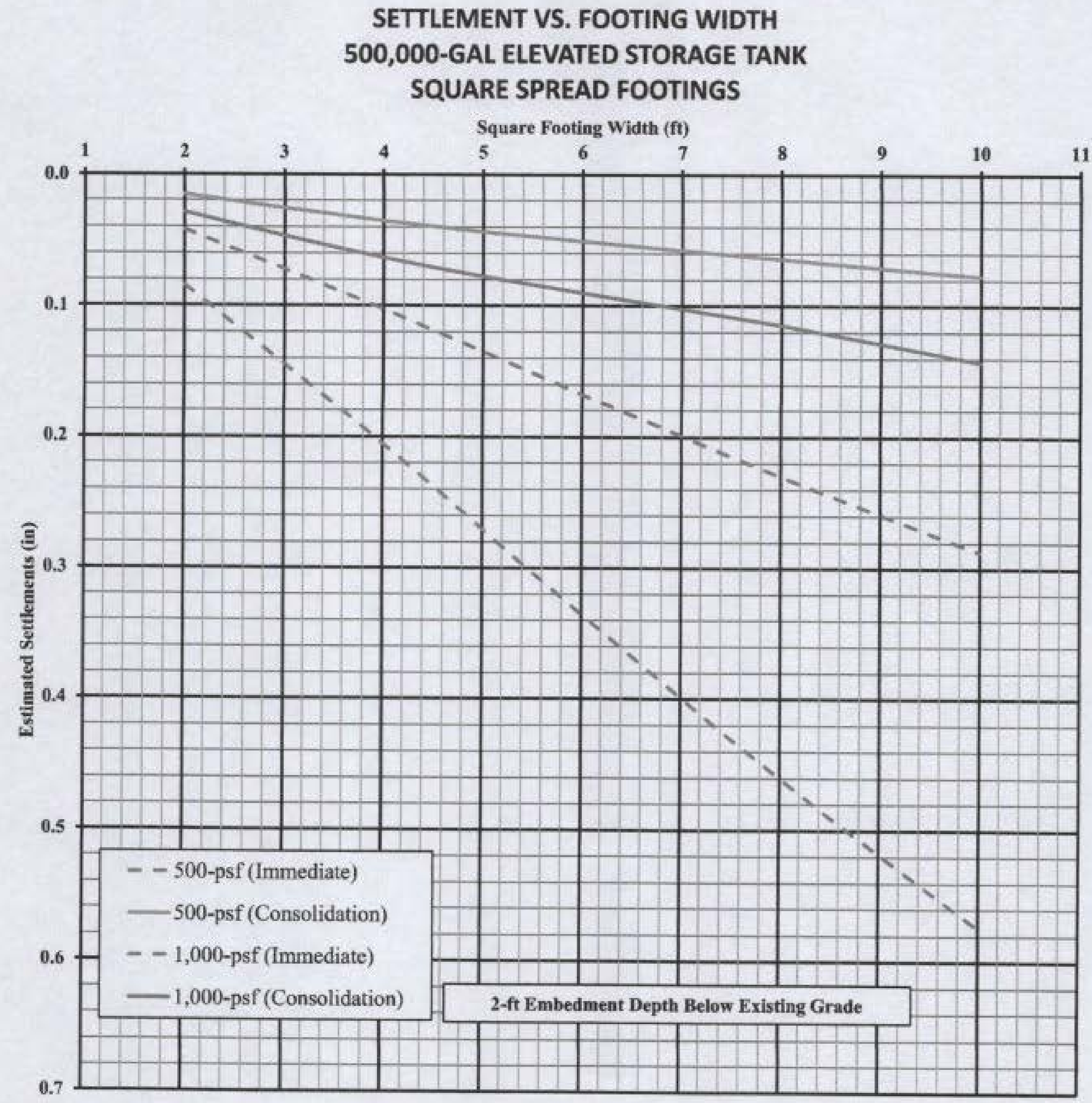
WJCMWD - New Storage Tanks Jefferson County, Texas	TOLUNAY-WONG ENGINEERS	Project Number: 23.23.170 Report Number: 148649
Action Civil Engineering, PLLC Port Arthur, Texas	**Design Soil Parameters 1,000,000-Gal Ground Storage Tank (TB-1 & CPT-1 through CPT-3)**	Appendix F Figure 1



WJCMWD - New Storage Tanks Jefferson County, Texas	TOLUNAY-WONG ENGINEERS	Project Number: 23.23.170 Report Number: 148649
Action Civil Engineering, PLLC Port Arthur, Texas	**Design Soil Parameters** **500,000-Gal Elevated Storage Tank (TB-2)**	Appendix F Figure 2

APPENDIX G

ELEVATED STORAGE TANK SPREAD FOOTING WIDTH VS SETTLEMENT PLOTS

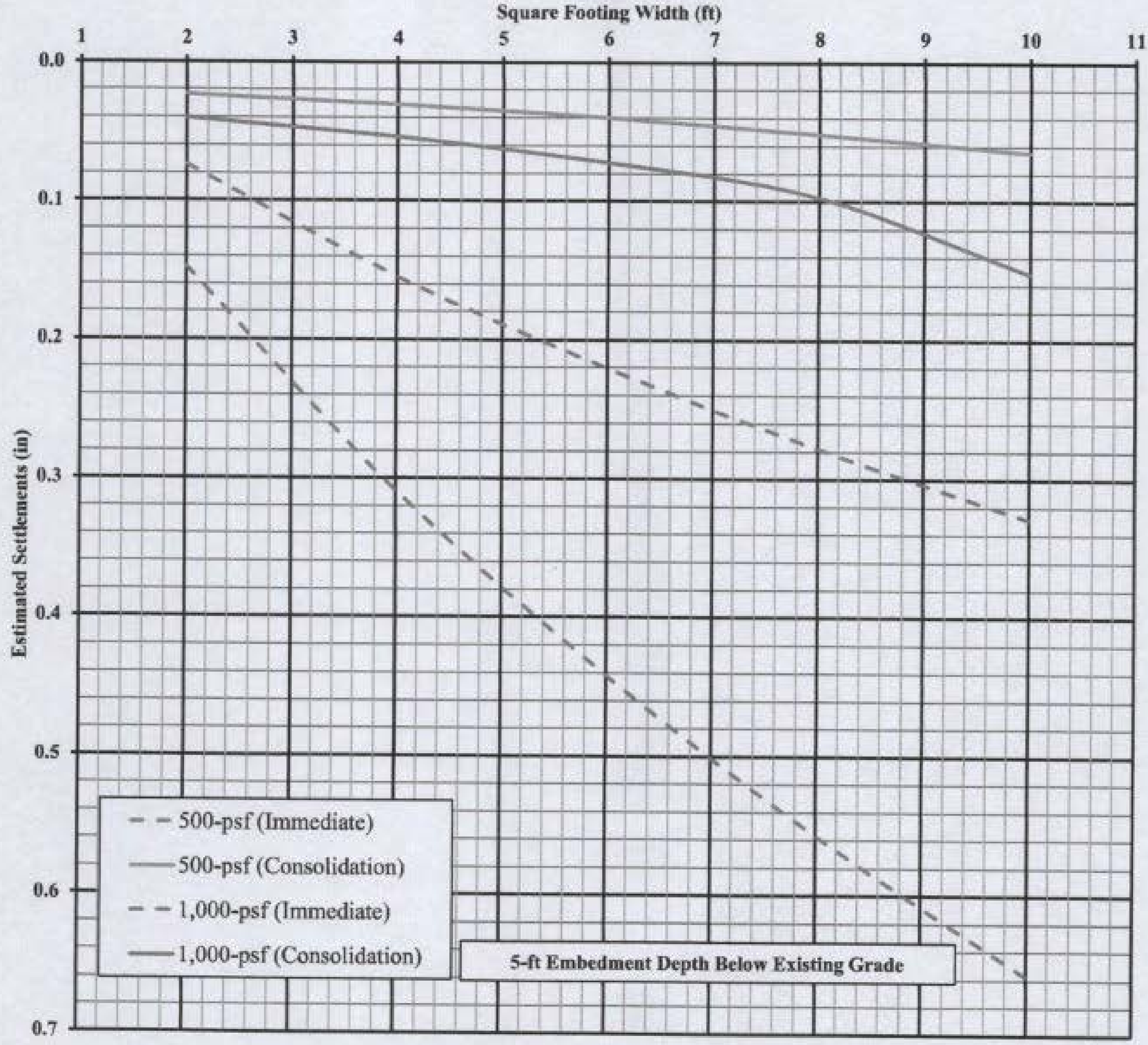


NOTES:

(1) The estimated settlements are for individual rigid square spread footings bearing on properly-prepared native subgrade at a depth of 2-ft below existing grade assuming uniform bearing pressure.
(2) Total settlement can be computed by estimating immediate and consolidation settlements separately from the plots and adding them together.
(3) The estimated settlements are valid for isolated foundation conditions wherein the clear spacing between adjacent foundations is at least the width of the largest foundation. TWE should be contacted to evaluate the influence of adjacent foundations if clear spacing is considered an issue.
(4) Settlement for rectangular footings having a length (L) to width (B) ratio of 2 or less can be computed from the above chart using the width of an equivalent square footing (i.e., for a 4-ft by 8-ft rectangular footing, the equivalent width of a square footing will be 5.66-ft).
(5) Immediate settlements will occur during construction or immediately upon loading. Consolidation settlements will occur under sustained net load over a period of approximately 10+ years after construction.

Project: WJCMWD - New Storage Tanks Jefferson County, Texas	Tolunay-Wong Engineers, Inc.	**Project No.** 23.23.170 **Report No.** 148649
Client: Action Civil Engineering, PLLC Port Arthur, Texas	**Settlement vs. Footing Size** **500,000-gal Elevated Storage Tank** **Square Spread Footings** **(2-ft Embedment Depth)**	**Appendix: G** **Figure: 1**

SETTLEMENT VS. FOOTING WIDTH
500,000-GAL ELEVATED STORAGE TANK
SQUARE SPREAD FOOTINGS

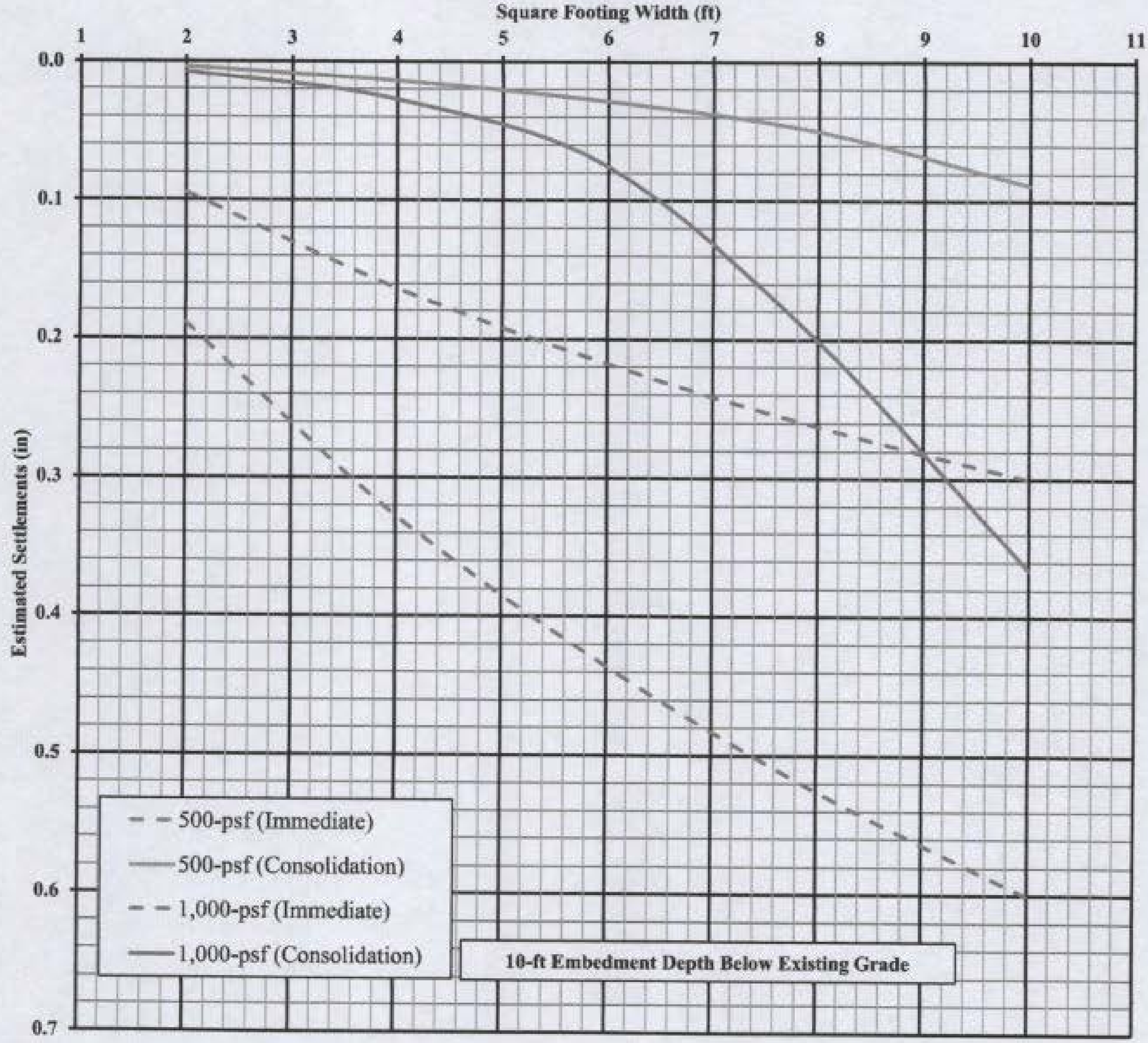


NOTES:

(1) The estimated settlements are for individual rigid square spread footings bearing on properly-prepared native subgrade at a depth of 5-ft below existing grade assuming uniform bearing pressure.
(2) Total settlement can be computed by estimating immediate and consolidation settlements separately from the plots and adding them together.
(3) The estimated settlements are valid for isolated foundation conditions wherein the clear spacing between adjacent foundations is at least the width of the largest foundation. TWE should be contacted to evaluate the influence of adjacent foundations if clear spacing is considered an issue.
(4) Settlement for rectangular footings having a length (L) to width (B) ratio of 2 or less can be computed from the above chart using the width of an equivalent square footing (i.e., for a 4-ft by 8-ft rectangular footing, the equivalent width of a square footing will be 5.66-ft).
(5) Immediate settlements will occur during construction or immediately upon loading. Consolidation settlements will occur under sustained net load over a period of approximately 10+ years after construction.

Project: WJCMWD - New Storage Tanks Jefferson County, Texas	**Tolunay-Wong Engineers, Inc.**	**Project No.** 23.23.170 **Report No.** 148649
Client: Action Civil Engineering, PLLC Port Arthur, Texas	**Settlement vs. Footing Size** **500,000-gal Elevated Storage Tank** **Square Spread Footings** **(5-ft Embedment Depth)**	**Appendix: G** **Figure: 2**

SETTLEMENT VS. FOOTING WIDTH
500,000-GAL ELEVATED STORAGE TANK
SQUARE SPREAD FOOTINGS



NOTES:

(1) The estimated settlements are for individual rigid square spread footings bearing on properly-prepared native subgrade at a depth of 10-ft below existing grade assuming uniform bearing pressure.

(2) Total settlement can be computed by estimating immediate and consolidation settlements separately from the plots and adding them together.

(3) The estimated settlements are valid for isolated foundation conditions wherein the clear spacing between adjacent foundations is at least the width of the largest foundation. TWE should be contacted to evaluate the influence of adjacent foundations if clear spacing is considered an issue.

(4) Settlement for rectangular footings having a length (L) to width (B) ratio of 2 or less can be computed from the above chart using the width of an equivalent square footing (i.e., for a 4-ft by 8-ft rectangular footing, the equivalent width of a square footing will be 5.66-ft).

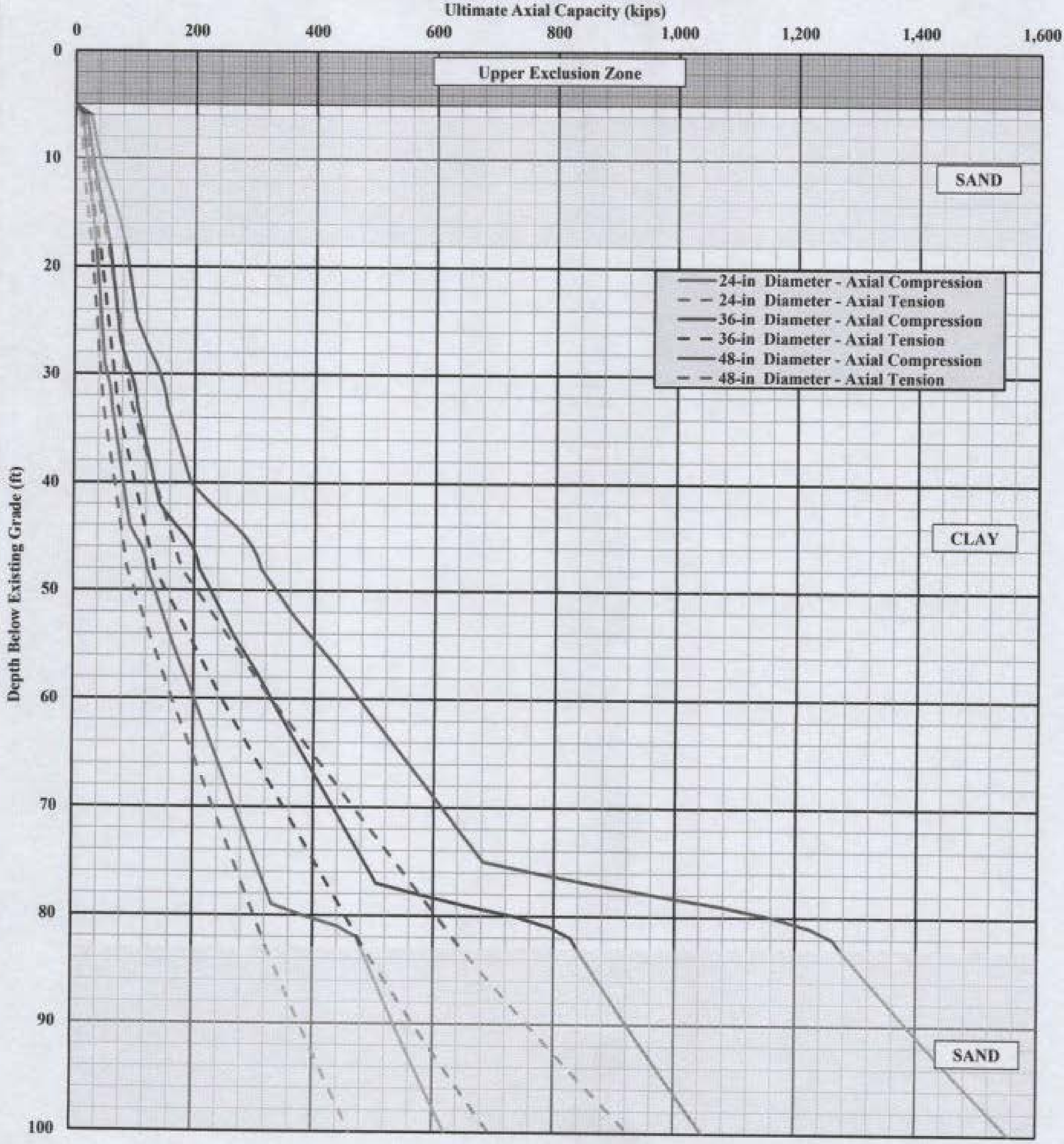
(5) Immediate settlements will occur during construction or immediately upon loading. Consolidation settlements will occur under sustained net load over a period of approximately 10+ years after construction.

Project: WJCMWD - New Storage Tanks Jefferson County, Texas	**Tolunay-Wong Engineers, Inc.**	**Project No.** 23.23.170 **Report No.** 148649
Client: Action Civil Engineering, PLLC Port Arthur, Texas	**Settlement vs. Footing Size** **500,000-gal Elevated Storage Tank** **Square Spread Footings** **(10-ft Embedment Depth)**	**Appendix: G** **Figure: 3**

APPENDIX H

ELEVATED STORAGE TANK ULTIMATE AXIAL SHAFT CAPACITIES

ULTIMATE AXIAL CAPACITY VERSUS DEPTH
STRAIGHT-SIDED DRILLED SHAFTS



NOTES:

1) Center-to-center spacing of the shaft should be at least three (3) times the shaft diameter.
2) A factor of safety of 2.5 is recommended for allowable compression loads.
3) A factor of safety of 3.0 is recommended for allowable tension loads (does not include the weight of pile).
4) Reduced factors of safety can be considered if a load testing program (static, dynamic or combination) is performed.

Project WJCMWD - New Storage Tanks Jefferson County, Texas	**Tolunay-Wong Engineers, Inc.**	Project No. 23.23.170 Report No. 148649
Client Action Civil Engineering, PLLC Port Arthur, Texas	**Ultimate Axial Capacity vs. Depth Straight-Sided Drilled Shafts 500,000-Gal Elevated Storage Tank**	Appendix H Figure 1

APPENDIX I

ELEVATED STORAGE TANK LPILE PARAMETERS

Lateral Pile Analysis Soil Design Parameters - 500,000-gal Elevated Storage Tank

LPILE Soil Type	Depth (ft)		Effective Unit Weight, γ' (pcf)	Cohesion, c (psf)	Friction Angle (°)	Static Lateral Modulus, *k* (pci)	Strain Factor, ε_{50}
	Top	Bottom					
Sand (Reese)	0	4	115	--	31	25	--
Stiff Clay without Free Water	4	6	130	2,300	--	1,000	0.005
Sand (Reese)	6	18	53	--	25	20	--
Soft Clay (Matlock)	18	33	53	400	--	30	0.020
Stiff Clay without Free Water	33	48	50	800	--	100	0.010
Stiff Clay without Free Water	48	60	63	1,800	--	500	0.007
Stiff Clay without Free Water	60	83	50	2,000	--	500	0.007
Sand (Reese)	83	100	53	--	42	125	--

WJCMWD - New Storage Tanks Jefferson County, Texas	**Tolunay-Wong Engineers, Inc.**	Project Number: 23.23.170 Report Number: 148649
Action Civil Engineering, PLLC Port Arthur, Texas	**Lateral Pile Analysis Soil Design Parameters**	Appendix I Figure 1

Project Drawings

VICINITY MAP

TEST BORING COORDINATES

BORING	DEPTH	LATITUDE	LONGITUDE
CPT-1	75'	29° 55' 7.40" N	94° 10' 35.83" W
CPT-2	75'	29° 55' 6.68" N	94° 10' 36.20" W
CPT-3	75'	29° 55' 6.66" N	94° 10' 35.46" W
TB-1	100'	29° 55' 6.97" N	94° 10' 35.83" W

LEGEND

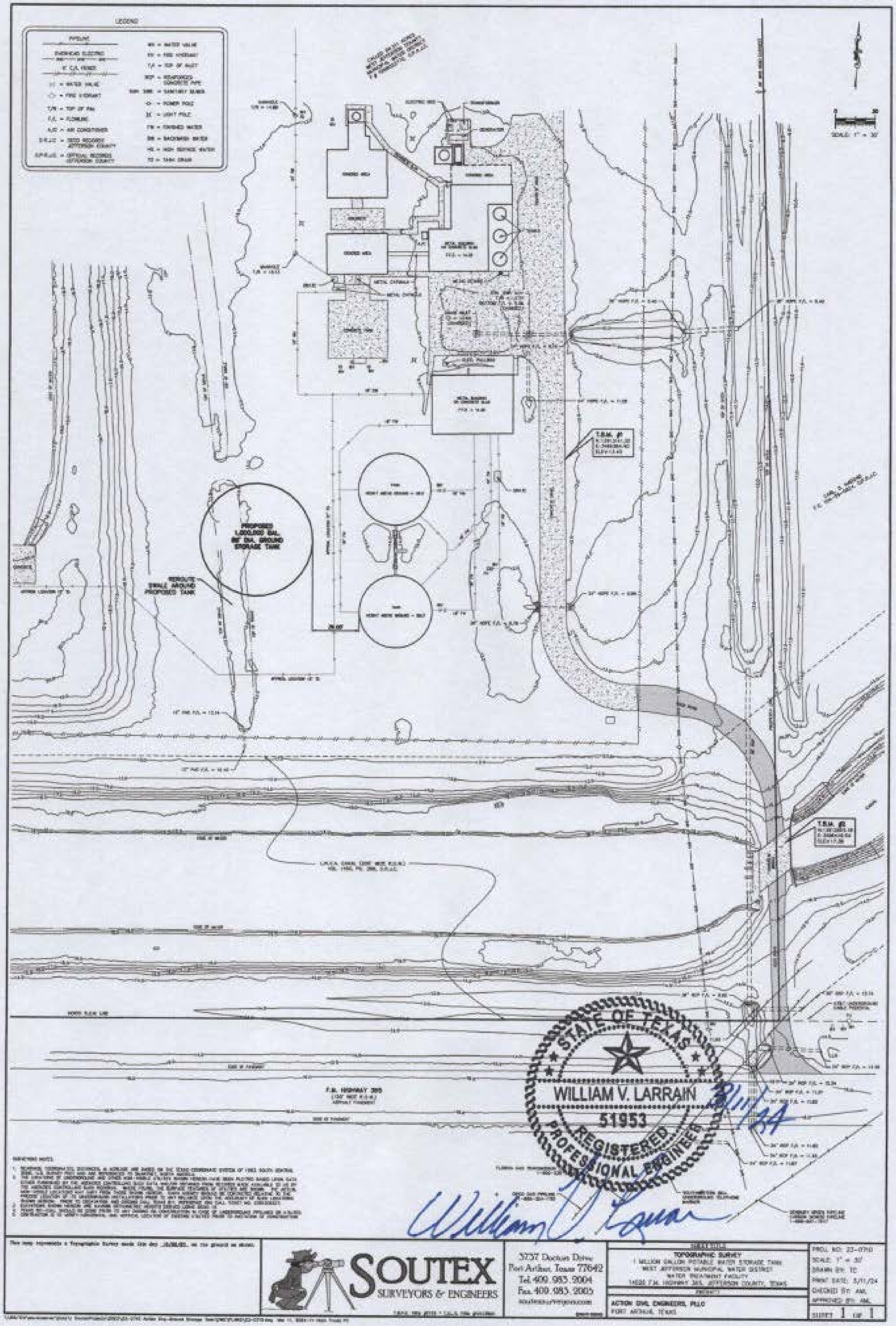
SYMBOL	DESCRIPTION
◑	CPT LOCATION
⊕	SOIL BORING LOCATION

Tolunay-Wong Engineers, Inc.

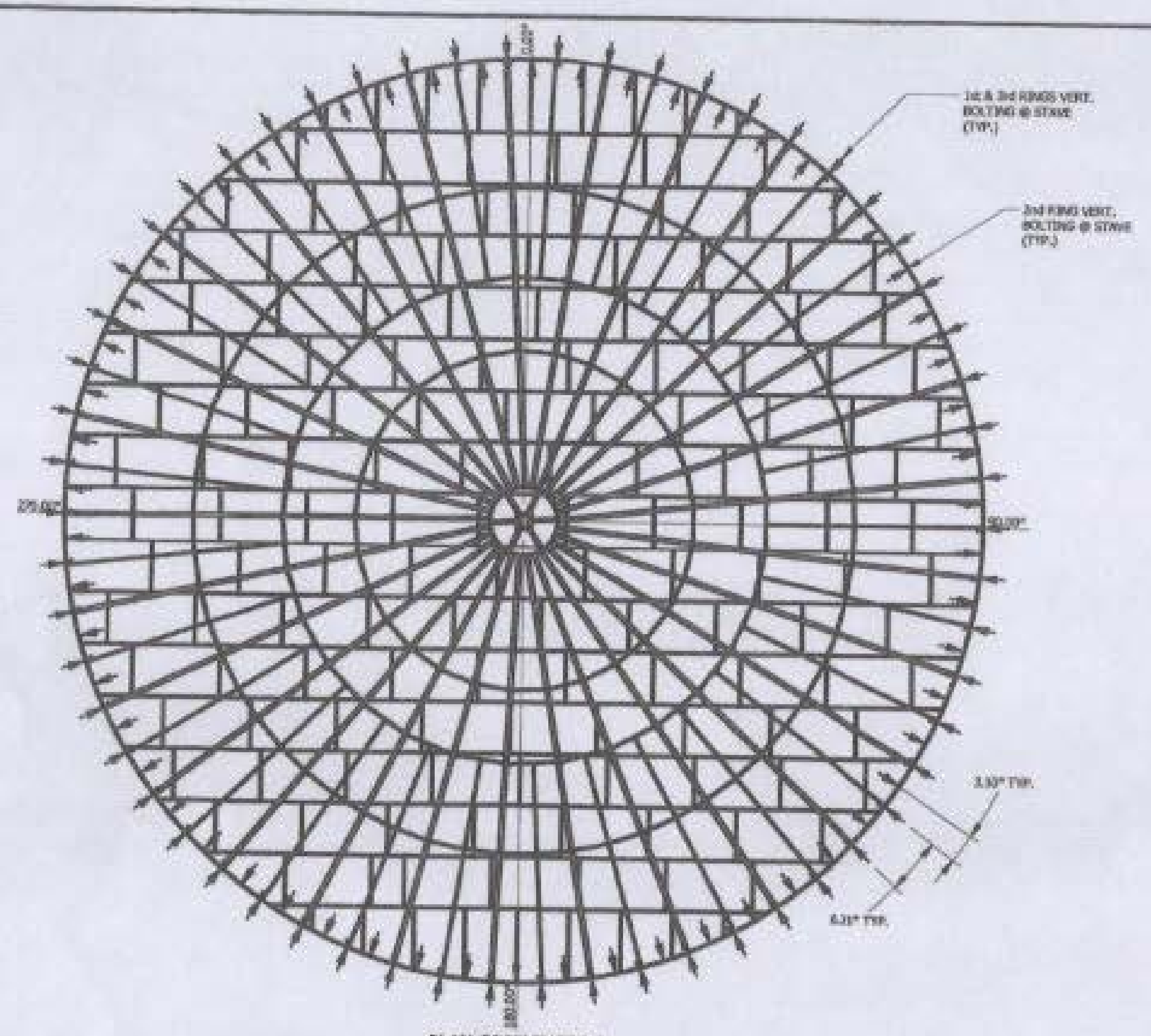
EXPLORATION LOCATION PLAN
PROPOSED NEW 1,000,000-GAL GROUND STORAGE TANK
WEST JEFFERSON COUNTY MUNICIPAL WATER DISTRICT
ACTION CIVIL ENGINEERS, PLLC
NEDERLAND, TEXAS

Drawn	N.S.	10-30-2023
Checked	T.O.	10-30-2023
Approved	T.G.H.	10-30-2023
Scale	N.T.S.	

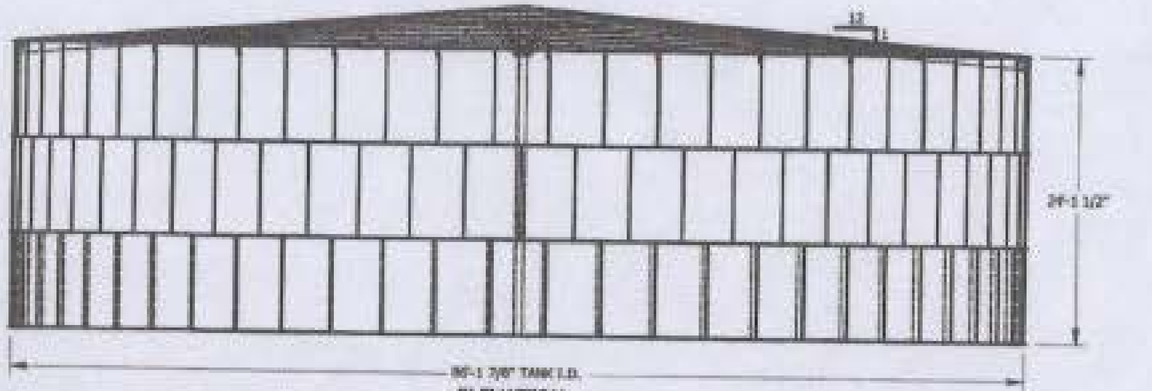
TWE DRAWING NO. 23.23.170-1


LEGEND
PROPOSED 1,000,000 GAL. 88' DIA. GROUND STORAGE TANK
T.B.M. #1
T.B.M. #2
F.M. HIGHWAY 365
STATE OF TEXAS
WILLIAM V. LARRAIN
51953
REGISTERED PROFESSIONAL ENGINEER
SOUTEX
SURVEYORS & ENGINEERS
3737 Doctors Drive
Port Arthur, Texas 77642
Tel. 409.983.2004
Fax. 409.983.2005
TOPOGRAPHIC SURVEY
1 MILLION GALLON POTABLE WATER STORAGE TANK
WEST JEFFERSON MUNICIPAL WATER DISTRICT
WATER TREATMENT FACILITY
14600 F.M. HIGHWAY 365, JEFFERSON COUNTY, TEXAS
ACTION CIVIL ENGINEERS, PLLC
PORT ARTHUR, TEXAS
PROJ. NO. 23-0710
SCALE: 1" = 30'
DRAWN BY: TC
PRINT DATE: 3/11/24
CHECKED BY: AML
APPROVED BY: AML
SHEET 1 OF 1

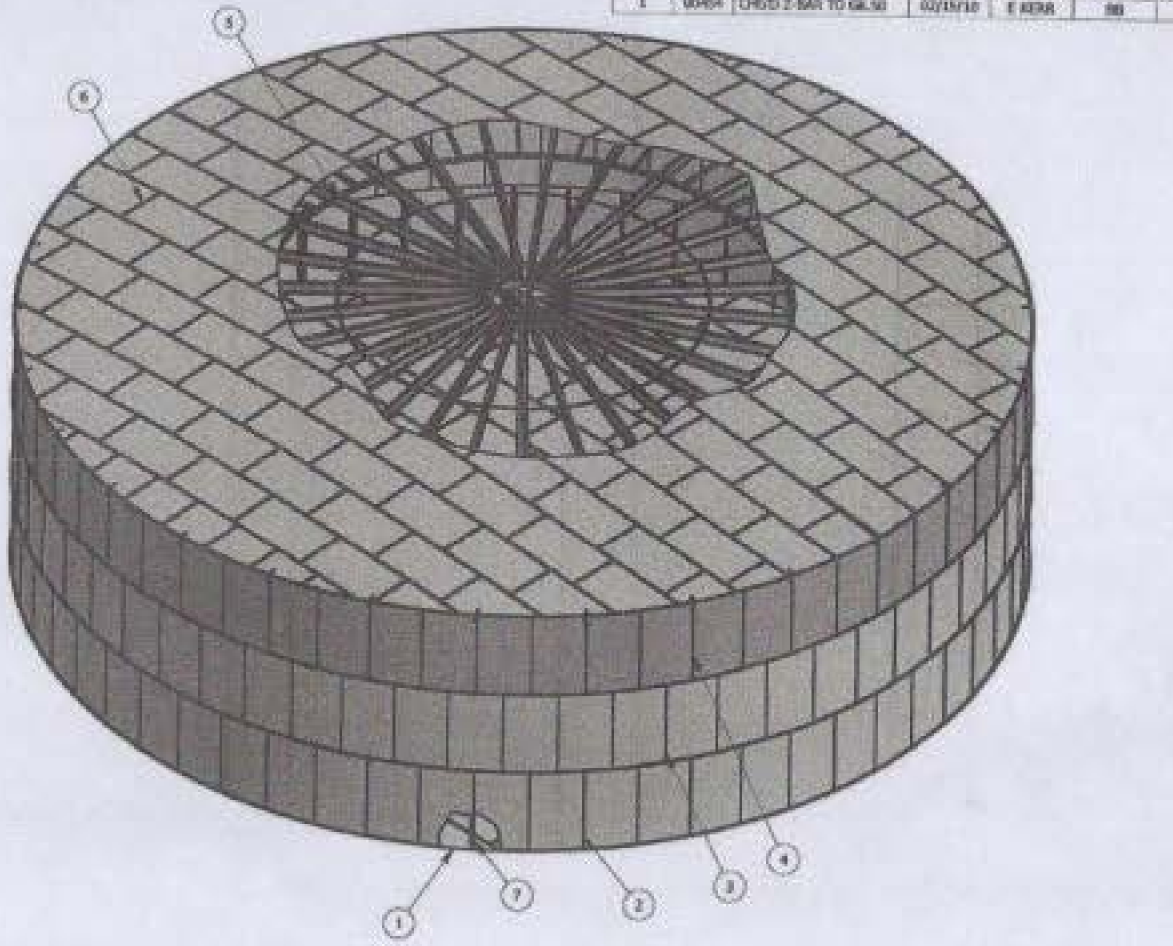
STCI REVISION HISTORY						
REV	ECO	DESCRIPTION	DATE	DESIGNER	CHECKED	APPROVED
1	00454	CHG'D Z-BAR TO GR.50	02/15/10	E KERR	BB	BB



PLAN ORIENTATION



ELEVATION



ITEM	PART NUMBER	DESCRIPTION	QTY	UOM
8	8624-001-HWK	HARDWARE KIT, 86'-1 7/8" x 24'-1 1/2" HIGH (AWWA)	1	EA
7	9990-059-159	Z-BAR, 5/16" THK. x 7'-11 1/2" LG., GR.50	58	EA
6	8602-001-001	12GA, 86'-1 7/8"Ø, SQ. DECK ASSY	1	EA
5	9012-146-001	ROOF STRUCTURE 86'-1 7/8"x24'-1 1/2" HIGH w/18"SQ.BASE,6"Ø COL,ROLLED RAFTER HAT.	1	EA
4	8604-003-199	86'-1 7/8"Ø,8 GA, GR.40, DR, 58" STAVE	58	EA
3	8604-002-199	86'-1 7/8"Ø, 1/4" THK, A-36, DR, 60" STAVE	58	EA
2	8604-001-199	86'-1 7/8"Ø, 5/16" THK, GR.50, TR, 62" STAVE	58	EA
1	8600-001-001	12GA, 86'-1 7/8"Ø, SQ. BTM ASSY	1	EA

BILL OF MATERIALS

COMPANY INC.®

9500 LUCAS RANCH RD.
RANCHO CUCAMONGA, CA. 91730
Phone: (909) 912-0580
Fax: (909) 912-0585

CUSTOMER	
APPROVALS	DATE
DRAWN BY: C. Pichetta	11/19/2004
CHECKED: BB/JM	11/30/2004
APPROVED: BB/JM	11/30/2004
TITLE	86'-1 7/8" DIA x 24'-1 1/2" HIGH BOLTED STEEL TANK AWWA D103-97 (FPC)
SIZE	B
REV	1
PART#	8624-001-002
SHEET	1 OF 3

DO NOT SCALE DRAWING

GENERAL NOTES:

THE FOUNDATION IS DESIGNED FOR THE FOLLOWING LOADING CRITERIA:

DEAD WEIGHT OF THE TANK:	80,000 LBF
LIVE LOAD ON THE TANK ROOF:	25 PSF

WIND LOAD:

WIND SPEED	150 MPH
IMPORTANCE CATEGORY	III
EXPOSURE	C

SEISMIC LOAD:

S_S: 0.075	S_1: 0.07	S_{DS}: 0.044
PGA: 0.037	TL: 12	
SEISMIC DESIGN CATEGORY	B	
SITE CLASS	D	
SEISMIC IMPORTANCE FACTOR	1.25	

FOUNDATION NOTES:

1. SOIL BEARING PRESSURE: 2,000 PSF UNDER THE RING BEAM FOUNDATION AND THE SLAB

GEOTECHNICAL INVESTIGATION REPORT PREPARED BY:
TOLUNAY-WONG ENGINEERS, INC.
2455 WEST CARDINAL DRIVE
BEAUMONT, TEXAS 77705 T: (409) 840-4214

2. THE FOUNDATION SHALL BE READ IN CONJUNCTION WITH TANK MANUFACTURING DRAWINGS AND THE GEOTECHNICAL REPORT.

3. UNDERCUT 3 FT DEEP AND REMOVAL OF THE NATIVE SITE SOILS AND REPLACEMENT WITH PROPERLY-COMPACTED STRUCTURAL CLAY PER GEOTECHNICAL REPORT RECOMMENDATION.

4. FILL BACKFILL MATERIALS SHALL BE PER GEOTECHNICAL REPORT SECTION 6.3

5. POSITIVE DRAINAGE AWAY FROM THE STRUCTURE SHOULD BE PROVIDED AND STRICTLY MAINTAINED DURING THE LIFE OF THE STRUCTURES. AFTER SITE GRADING IS COMPLETED TO ESTABLISH POSITIVE DRAINAGE, THE EXPOSED SUBGRADE SOILS SHOULD BE PROOFROLLED PER GEOTECHNICAL REPORT SECTION 6.1

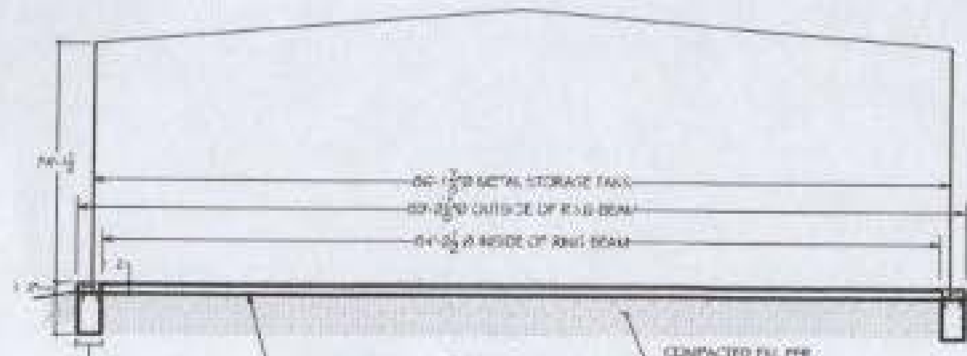
6. REINFORCING STEEL SHALL COMPLY WITH ASTM A615, GRADE 60. IT SHALL BE CLEAN AND FREE OF ANY BOND INHIBITING COATING OR MUD. IT SHALL BE PROPERLY POSITIONED AND SUPPORTED TO ASSURE THE DESIGN SPACING AND COVER IS MAINTAINED. FOR SLABS ON GRADE, USE FULL SIZE CONCRETE BRICKS AS SUPPORT WITH SPACING NOT EXCEEDING 30 INCHES. DO NOT BREAK THE CONCRETE BRICKS.

7. PROVIDE A LAP LENGTH AS RECOMMENDED BELOW UNLESS OTHERWISE NOTED IN THE DRAWINGS.

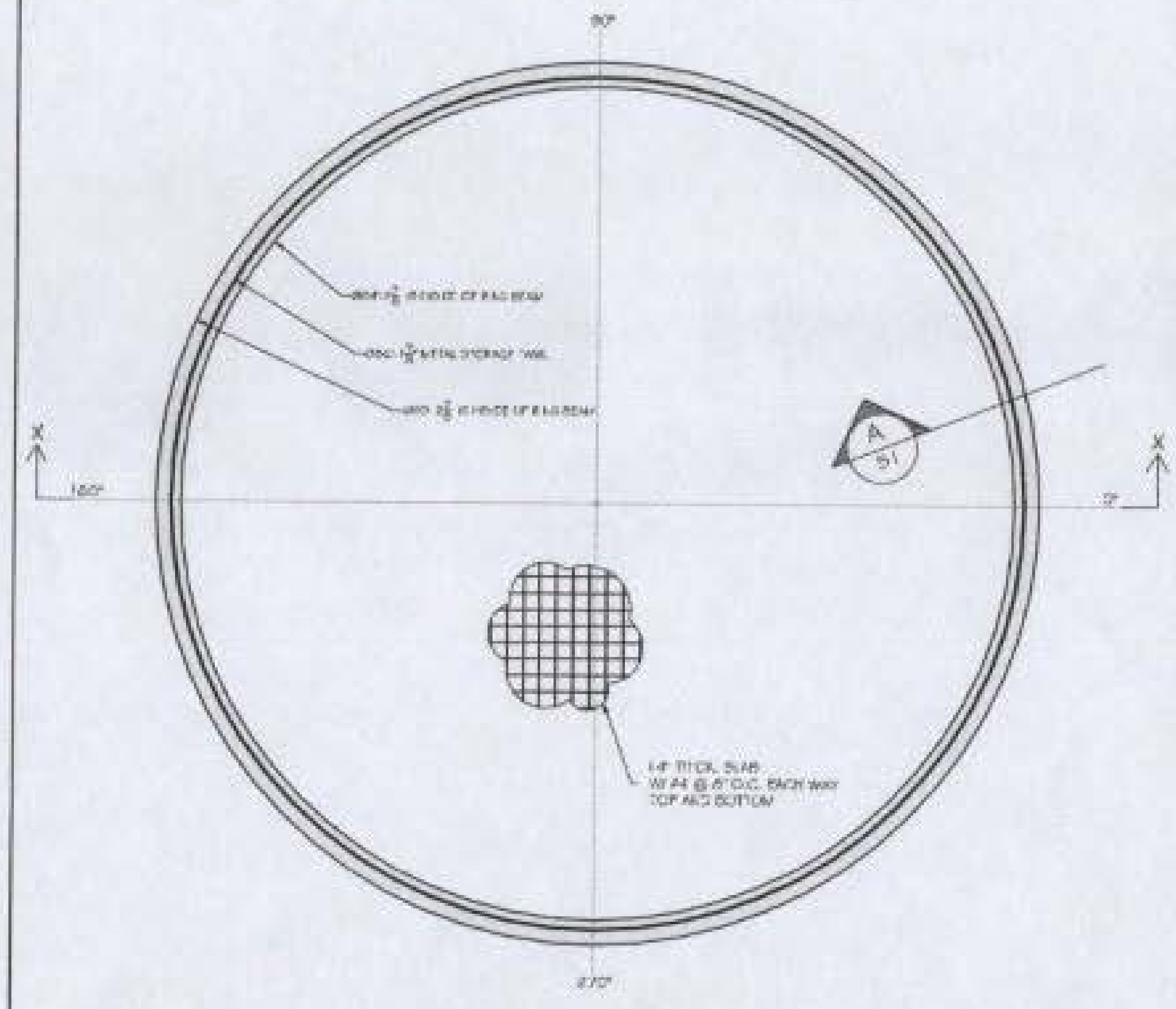
BAR SIZE	DIAMETER (IN)	MIN. DEVELOPMENT LENGTH (IN)
#4	0.50	25.0
#5	[illegible]	42.0

8. CONCRETE SHALL HAVE A MINIMUM COMPRESSIVE STRENGTH OF 4,000 PSI AT 28 DAYS.

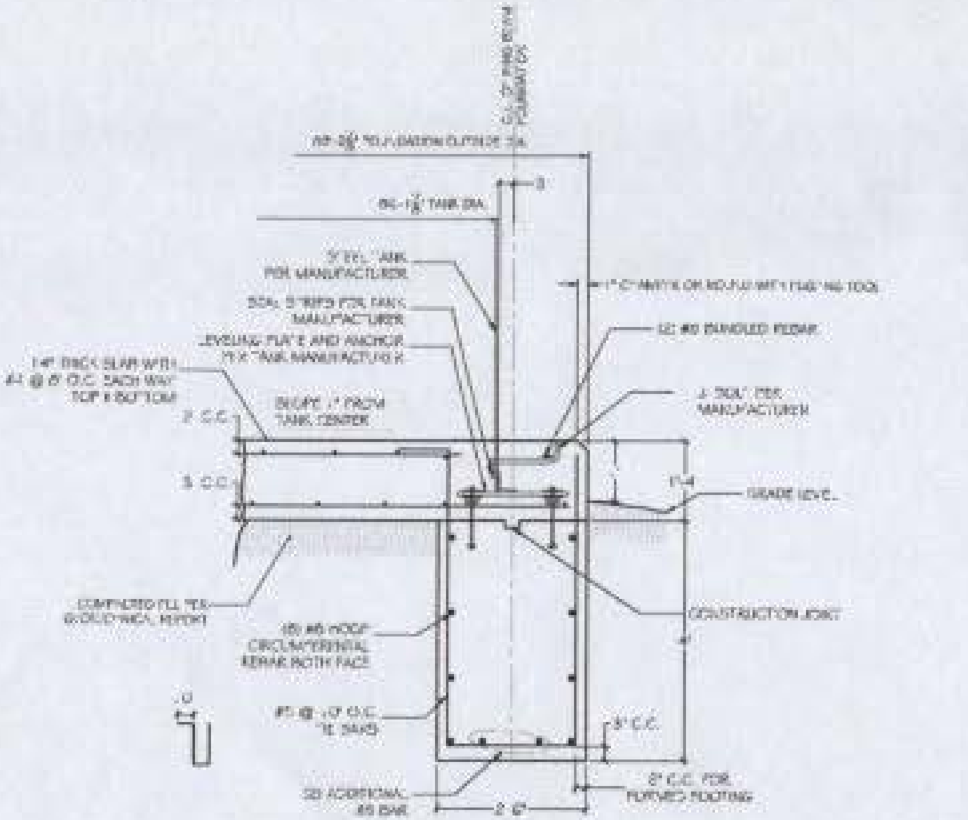
9. CONCRETE PLACEMENT & CURING:
   A. PLACE CONCRETE IN ACCORDANCE WITH ACI 318-14 AND ACI 304.
   B. CURE CONCRETE FOLLOWING ACI 308R-16: GUIDE TO EXTERNAL CURING OF CONCRETE.



SECTION X-X



FOUNDATION PLAN



SECTION A-A: FOOTING

SCALE: 3/4" = 1'-0"

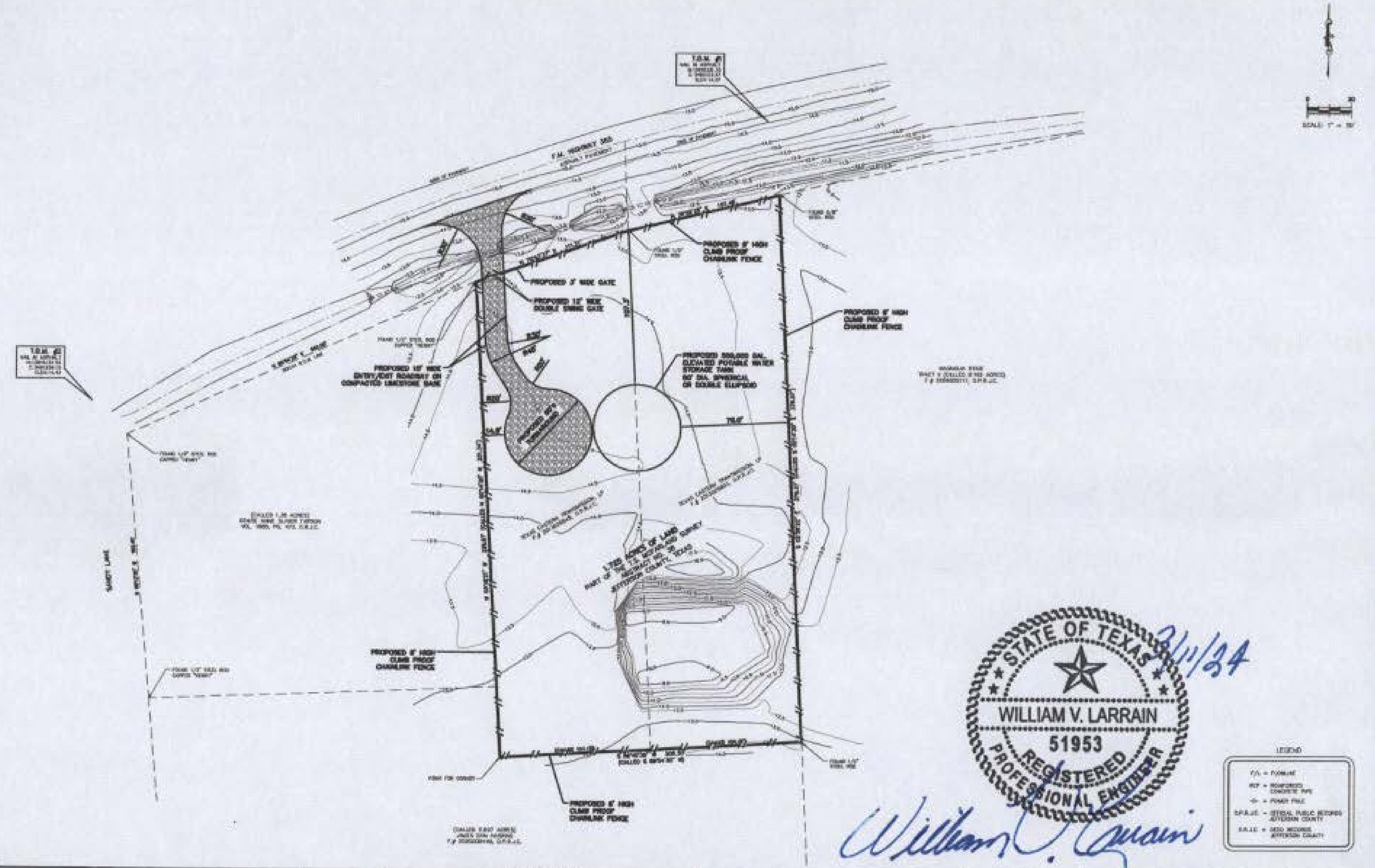
PROPOSED NEW STORAGE TANK FOUNDATION
WEST JEFFERSON COUNTY MUNICIPAL WATER DISTRICT
JEFFERSON COUNTY, TEXAS

Date: 03/01/24

FOUNDATION PLAN AND NOTE

SHEET S-1

STATE OF TEXAS
WILLIAM V. LARRAIN
51953
REGISTERED PROFESSIONAL ENGINEER
3/7/24
William J. Larrain



This survey represents a Topographic Survey made this day ______ on the ground as shown.

SURVEYORS NOTES

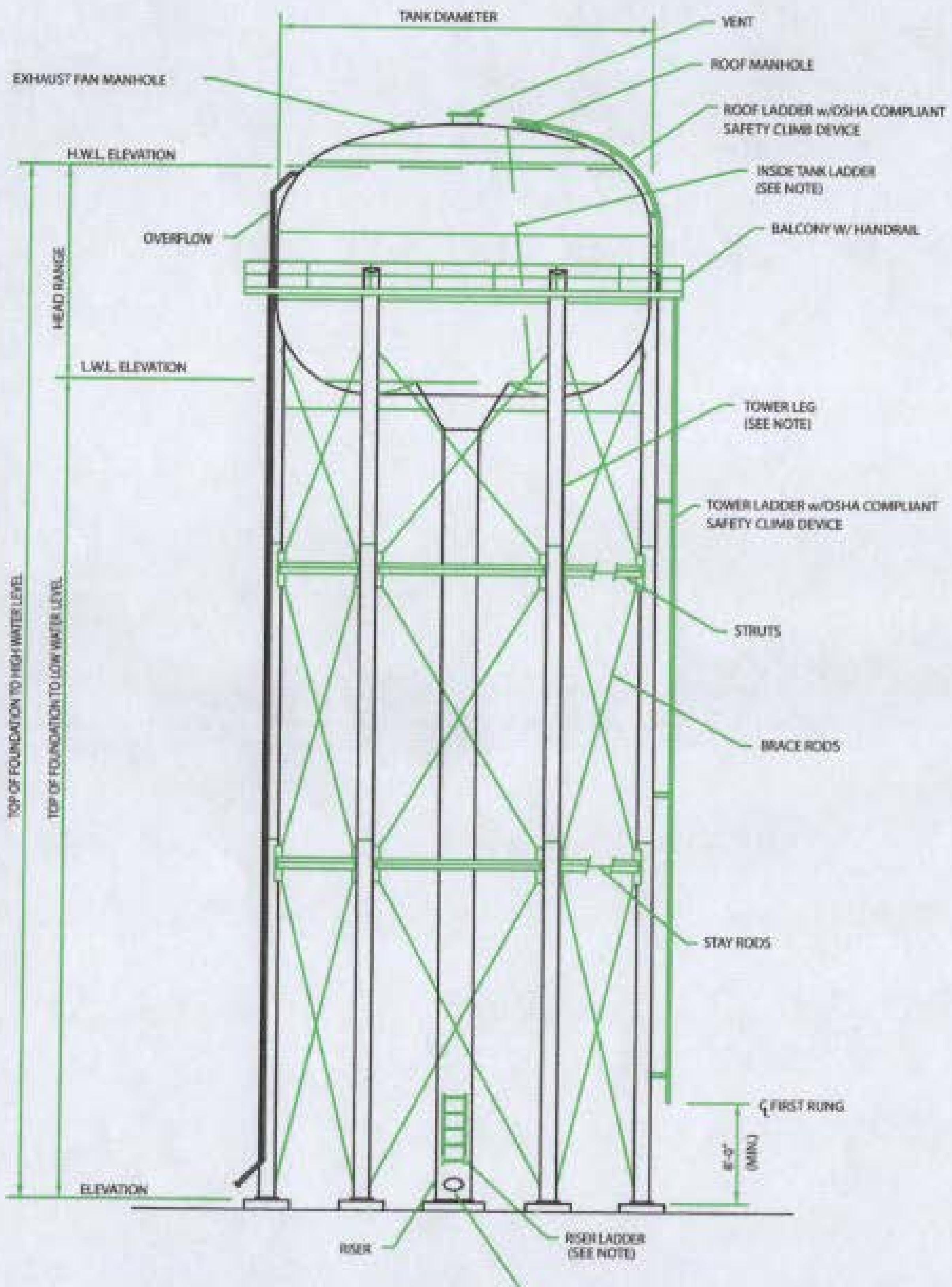
SOUTEX
SURVEYORS & ENGINEERS

3737 Doctors Drive
Port Arthur, Texas 77642
Tel. 409.983.2004
Fax 409.983.2005

SHEET TITLE
TOPOGRAPHIC SURVEY
PROPOSED 500,000 GALLON ELEVATED POTABLE WATER STORAGE TANK, WEST JEFFERSON MUNICIPAL WATER DISTRICT WATER TREATMENT FACILITY
31721 F.M. HIGHWAY 365, JEFFERSON COUNTY, TEXAS

PROJECT
ASTRON CIVIL ENGINEERS, PLLC
PORT ARTHUR, TEXAS

PROJ. NO. 24-0709
SCALE: 1" = 30'
PRINT DATE: 3/11/24
DRAWN BY: TC
CHECKED BY: AML
APPROVED BY: AML
SHEET 1 OF 1



ELEVATION

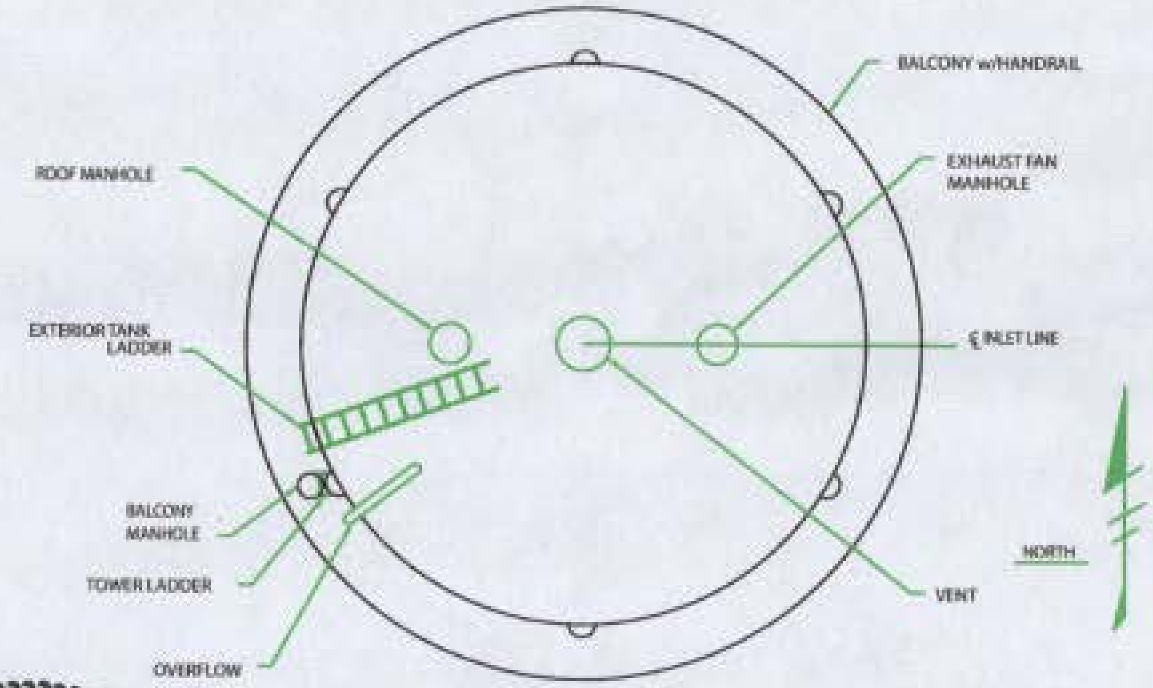
NOTES:
DESIGN:

TANK AND TOWER SHALL BE DESIGNED, FABRICATED AND ERECTED IN ACCORDANCE WITH AWWA D100-96 AND PROJECT SPECIFICATIONS.

WIND LOAD:________
SNOW LOAD:________
SEISMIC ZONE:________

MATERIALS:
STEEL PLATE: ASTM A283 GR. C / A36
STRUCTURAL STEEL SHAPES: ASTM A36
BRACE RODS AND STAY RODS: ASTM A36
LADDER RUNGS: ASTM A706

GENERAL:
- ACCESSORIES SHOWN ON ELEVATION DRAWING ARE ROTATED FOR CLARITY.
- ALL HANDRAILS, PLATFORM LANDINGS, WALKWAYS, LADDERS, AND SAFETY CLIMB DEVICES SHALL CONFORM WITH CURRENT OSHA STANDARDS.
- SEE PROJECT SPECIFICATIONS FOR SHOP AND FIELD PAINT REQUIREMENTS.
- STERILIZE TANK IN ACCORDANCE WITH AWWA C652-92 AND PROJECT SPECIFICATIONS.
- FOR TANKS LOCATED IN REGIONS WHERE FREEZING CONDITIONS MAY OCCUR COSIDERATION SHALL BE GIVEN TO OMISSION OF INSIDE TANK LADDER.
- NUMBER OF TOWER LEGS PER MANUFACTURER'S STANDARD DESIGN.



ORIENTATION

STATE OF TEXAS
WILLIAM V. LARRAIN
51953
REGISTERED
PROFESSIONAL ENGINEER

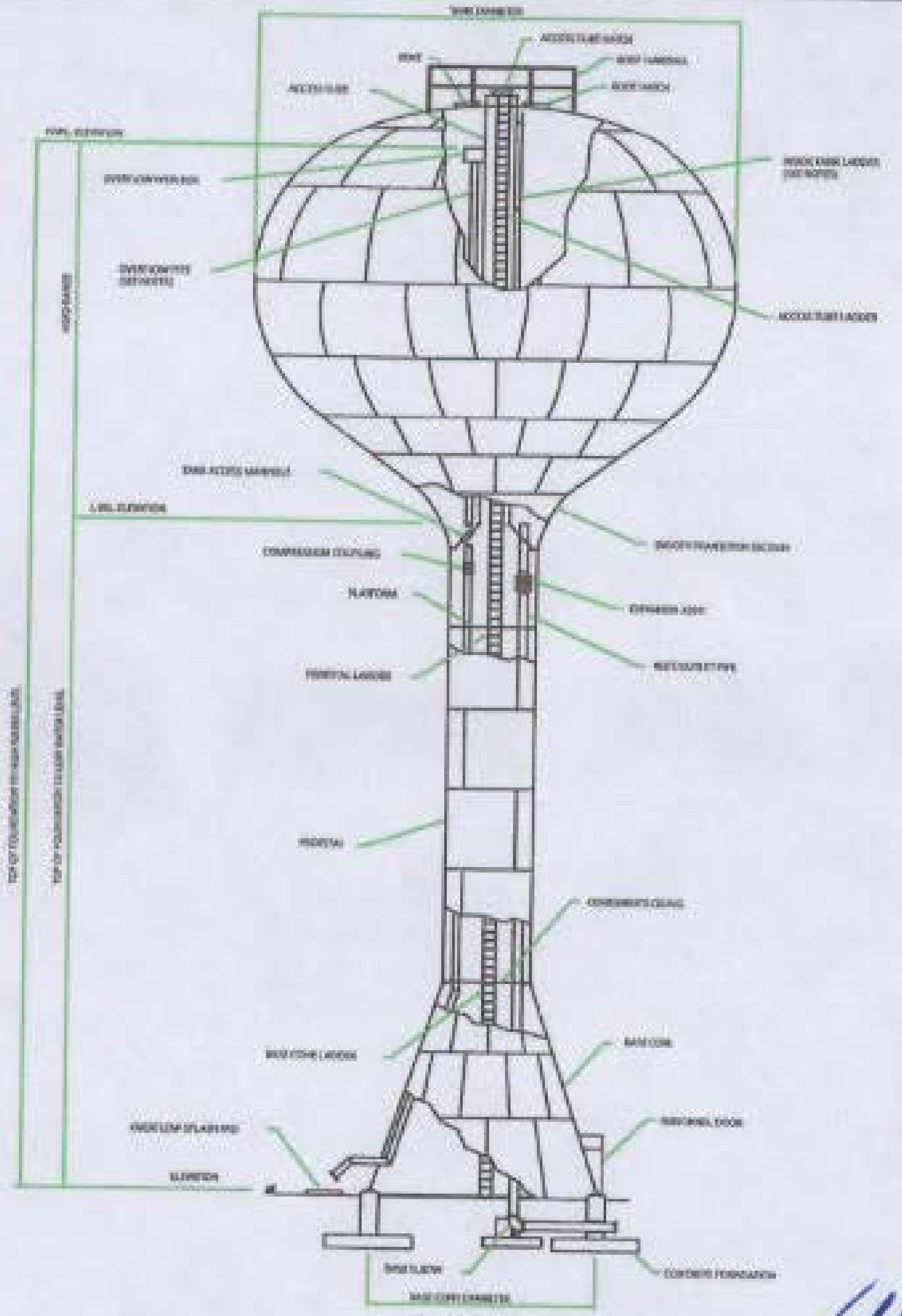
2/11/24

William V. Larrain

REV.	BY	DATE	REMARKS

BY:	TITLE: ELEVATION DETAILS
DATE:	DRAWING NO: TB-1.DWG

08



ELEVATION

NOTES:

DESIGN:
TANK AND SUPPORT STRUCTURE SHALL BE DESIGNED, FABRICATED AND ERECTED IN ACCORDANCE WITH AWWA D100-96 AND THE PROJECT SPECIFICATIONS.

WIND LOAD:______
SNOW LOAD:______
SEISMIC ZONE:_____

TANK ERECTOR SHALL GROUT UNDER BASE PLATE RING.

MATERIALS:
STEEL PLATE: ASTM A283 GR.C / A36
STRUCTURAL STEEL SHAPES: ASTM A36
LADDER RUNGS: ASTM A706

GENERAL:
- ACCESSORIES SHOWN ON ELEVATION DRAWING ARE ROTATED FOR CLARITY.
- ALL HANDRAILS, PLATFORM LANDINGS, WALKWAYS, LADDERS, AND SAFETY CLIMB DEVICES SHALL CONFORM WITH CURRENT OSHA STANDARDS.
- SEE PROJECT SPECIFICATIONS FOR SHOP AND FIELD PAINT REQUIREMENTS.
- STERILIZE TANK IN ACCORDANCE WITH AWWA C652-92 AND PROJECT SPECIFICATIONS.
- FOR TANKS LOCATED IN REGIONS WHERE FREEZING CONDITIONS MAY OCCUR, CONSIDERATION SHALL BE MADE TO ROUTE OVERFLOW PIPE INSIDE ACCESS TUBE AND OMIT INSIDE TANK LADDER.

STATE OF TEXAS
WILLIAM V. LARRAIN
51953
REGISTERED
PROFESSIONAL ENGINEER

8/1/24

William V. Larrain

REV.	BY	DATE	REMARKS

BY:	TITLE
DATE:	DRAWING NO. PED-1.DWG

Bidding Proposals

PROPOSAL II

1,000,000 GALLONS
GROUND STORAGE POTABLE WATER GALVANIZED, BOLTED STEEL TANK
ACE Job No. 123-02C

SCOPE OF WORK

Furnish and construct a 1,000,000 gallons capacity, potable water **Bolted Steel**, ground storage tank including foundation, steel erection, welding, shrouding if necessary, blasting, and ductile iron, mechanical joint fittings, interconnective piping with existing on-site ground storage tanks, and electrical, all related tank construction, welding if required and coating testing, disinfection, site development, and final clean up. Amount bid is to include all labor, materials, equipment, insurance, payroll, taxes, permits, and supervision to provide a complete and functional project.

Bid for Proposal II as outlined in the Scope of Work for 1,000,000 Gallon bolted steel, galvanized Storage Tank for the Lump Sum Amount of:

____ Dollars

And____ Cents.

($________________________)

Bid price must be written in words and the written words shall govern amount bid.

STATEMENT FOR SEPARATE CONTRACT COMPLIANCE

Non-consumable Material and Installed Equipment:

$____________________

Skilled Labor and Consumable Materials, Tool
and construction equipment:

$____________________

The undersigned agrees to commence work within ten (10) days after the date of written notice to commence work and to substantially complete the work on which he has bid within____ calendar days as provided in the General Conditions of the Agreement. Enclosed herewith is a cashier's check, certified check, or bid bond in the sum of 5% of the greatest amount bid which it is agreed shall be collected and retained by the OWNER as liquidating damages in the event this proposal is accepted by the OWNER within sixty (60) days after the date advertised for the reception of bids and the undersigned fails to execute the contract and the required bond with the OWNER, under the conditions hereof, within ten (10) days after the date said proposal is accepted, otherwise said check or bond shall be returned to the undersigned upon demand.

CONTRACTOR____________________

BY____________________________

ADDRESS_______________________

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PHONE_________________________

PROPOSAL II

1,000,000 GALLONS
GROUND STORAGE POTABLE WATER WELDED STEEL TANK

ACE Job No. 123-01C (Alternate Proposal 2)

SCOPE OF WORK

Furnish and construct a 1,000,000-gallon capacity potable water **Welded Steel**, painted, ground storage tank including foundation, steel erection, welding as may be required, and ductile iron, mechanical joint, interconnective piping with existing on-site ground storage tanks, and electrical, all related tank construction, testing, disinfection, site development, and final clean up. The amount bid is to include all labor, materials, equipment, insurance, payroll, taxes, permits, and supervision to provide a complete and functional project.

Bid for Proposal II as outlined in the Scope of Work for 1,000,000 Gallon prestressed concrete, Storage Tank for the Lump Sum Amount of:

____ Dollars

And____ Cents.

($_______________________)

Bid price must be written in words and the written words shall govern amount bid.

STATEMENT FOR SEPARATE CONTRACT COMPLIANCE

Non-consumable Material and Installed Equipment:

$____________________

Skilled Labor and Consumable Materials, Tool,
and construction equipment:

$____________________

The undersigned agrees to commence work within ten (10) days after the date of written notice to commence work and to substantially complete the work on which he has bid within____ calendar days as provided in the General Conditions of the Agreement. Enclosed herewith is a cashier's check, certified check, or bid bond in the sum of 5% of the greatest amount bid which it is agreed shall be collected and retained by the OWNER as liquidating damages in the event this proposal is accepted by the OWNER within sixty (60) days after the date advertised for the reception of bids and the undersigned fails to execute the contract and the required bond with the OWNER, under the conditions hereof, within ten (10) days after the date said proposal is accepted, otherwise said check or bond shall be returned to the undersigned upon demand.

CONTRACTOR____________________

BY______________________________

ADDRESS_______________________

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PHONE_________________________

PROPOSAL II

1,000,000 GALLONS
GROUND STORAGE POTABLE WATER PRESTRESSED CONCRETE TANK

ACE Job No. 123-02C (Alternate Proposal 1)

SCOPE OF WORK

Furnish and construct a 1,000,000-gallon capacity potable water **Prestressed Concrete**, ground storage tank including foundation, steel erection, welding as may be required, and ductile iron, mechanical joint, interconnective piping with existing on-site ground storage tanks, and electrical, all related tank construction, testing, disinfection, site development, and final clean up. The amount bid is to include all labor, materials, equipment, insurance, payroll, taxes, permits, and supervision to provide a complete and functional project.

Bid for Proposal II as outlined in the Scope of Work for 1,000,000 Gallon prestressed concrete, Storage Tank for the Lump Sum Amount of:

____ Dollars

And____ Cents.

($________________________)

Bid price must be written in words and the written words shall govern amount bid.

STATEMENT FOR SEPARATE CONTRACT COMPLIANCE

Non-consumable Material and Installed Equipment:

$__________________

Skilled Labor and Consumable Materials, Tool
and construction equipment:

$__________________

The undersigned agrees to commence work within ten (10) days after the date of written notice to commence work and to substantially complete the work on which he has bid within____ calendar days as provided in the General Conditions of the Agreement. Enclosed herewith is a cashier's check, certified check, or bid bond in the sum of 5% of the greatest amount bid which it is agreed shall be collected and retained by the OWNER as liquidating damages in the event this proposal is accepted by the OWNER within sixty (60) days after the date advertised for the reception of bids and the undersigned fails to execute the contract and the required bond with the OWNER, under the conditions hereof, within ten (10) days after the date said proposal is accepted, otherwise said check or bond shall be returned to the undersigned upon demand.

CONTRACTOR____________________

BY______________________________

ADDRESS_______________________

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PHONE__________________________

PROPOSAL III

PAINTING OF LETTERS AND LOGO ON PROPOSAL I OR II

ACE Job No. 123-03C

SCOPE OF WORK

LETTERING and LOGO

The words "West Jefferson Co. Municipal Water District" are to be painted on the **Elevated Tank** in block style with Seven-foot-tall letters and not to exceed two bays in length for either case. Letters are to be Black without a band. County Logo is to also be seven (7') foot tall and follow the color scheme represented on the Jefferson County logo.

Bid for Proposal III as outlined in Scope of Work for Lettering and Logo for Lump Sum Amount of:

______________________________ Dollars

And ______________________________ Cents.

Bid price must be written in words and written words shall govern amount bid.

STATEMENT FOR SEPARATE CONTRACT COMPLIANCE

Non-consumable Material and Installed Equipment:

Skilled Labor and Consumable Materials,
Tools and Construction Equipment:

TOTAL: ____________________

The undersigned agrees to commence work within ten (10) days after the date of written notice to commence work and to substantially complete the work on which he has bid within____ calendar days as provided in the General Conditions of the Agreement. Enclosed herewith is a cashier's check, certified check, or bid bond in the sum of 5% of the greatest amount bid which it is agreed shall be collected and retained by the OWNER as liquidating damages in the event this proposal is accepted by the OWNER within sixty (60) days after the date advertised for the reception of bids and the undersigned fails to execute the contract and the required bond with the OWNER, under the conditions hereof, within ten (10) days after the date said proposal is accepted, otherwise said check or bond shall be returned to the undersigned upon demand.

CONTRACTOR____________________

BY______________________________

ADDRESS________________________

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PHONE__________________________

SUPPLEMENTAL ITEMS PROPOSAL

WEST JEFFERSON COUNTY MUNICIPAL WATER DISTRICT

DISTRIBUTION SYSTEM IMPROVEMENTS-WATER STORAGE FACILITIES

ACE Job No.123-01C

NO.	ITEM	UNIT	QUANTITY	UNIT PRICE BID WRITTEN IN WORDS		UNIT PRICE WRITTEN IN FIGURES		TOTAL PRICE BID WRITTEN IN FIGURES	
				DOLLARS	CENTS	DOLLARS	CENTS	DOLLARS	CENTS
1.	MAN HOURS	HOUR	10						
2.	TRUCK HOURS	HOUR	10						
3.	BACK HOE / LOADER HOUR	HOUR	10						
4.	EXTRA CLASS A CONCRETE - BULK	C.Y.	10						
5.	EXTRA CLASS A CONCRETE - FORMED	C.Y.	10						
6.	SERVICE LINE HDPE 3/4" OR 1"	Ft.	100						
7.	SERVICE CLAMP 3/4" OR 1"	Ea.	10						
8.	METER BOX DFW-D-1200	Ea.	10						
9.	ADDITIONAL 6-FOOT CLIMB PROOF FENCE	Ft.	10						
10.	ADDITIONAL REINFORCEMENT STEEL	Lbs.	100						

PROPOSAL I

500,000 GALLONS
ELEVATED POTABLE WATER STEEL STORAGE TANK

ACE Job No. 123-01C

SCOPE OF WORK

Furnish and construct a 500,000-gallon capacity potable water **Double Ellipsoidal**, multi-leg elevated storage tank high water level elevation **156.00 MSL** including foundation, steel erection, welding, shrouding, blasting, and standard three coat paint system for the interior and exterior tank surfaces, and electrical, all related tank construction, welding and coating testing, disinfection, site development, and final clean up. Amount bid is to include all labor, materials, equipment, insurance, payroll, taxes, permits, and supervision to provide a complete and functional project.

Bid for Proposal I as outlined in the Scope of Work for 500,000 Gallon Elevated Storage Tank for the Lump Sum Amount of:

____ Dollars

And____ Cents.

($____________________)

Bid price must be written in words and the written words shall govern amount bid.

STATEMENT FOR SEPARATE CONTRACT COMPLIANCE

Non-consumable Material and Installed Equipment:

$____________________

Skilled Labor and Consumable Materials, Tool and construction equipment:

$____________________

The undersigned agrees to commence work within ten (10) days after the date of written notice to commence work and to substantially complete the work on which he has bid within____ calendar days as provided in the General Conditions of the Agreement. Enclosed herewith is a cashier's check, certified check, or bid bond in the sum of 5% of the greatest amount bid which it is agreed shall be collected and retained by the OWNER as liquidating damages in the event this proposal is accepted by the OWNER within sixty (60) days after the date advertised for the reception of bids and the undersigned fails to execute the contract and the required bond with the OWNER, under the conditions hereof, within ten (10) days after the date said proposal is accepted, otherwise said check or bond shall be returned to the undersigned upon demand.

CONTRACTOR____________________

BY______________________________

ADDRESS_______________________

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PHONE_________________________

PROPOSAL I – ALTERNATE BID

500,000 GALLONS
ELEVATED POTABLE WATER STEEL STORAGE TANK

ACE Job No. 123-01C (Alternate Proposal)

SCOPE OF WORK

Furnish and construct a 500,000-gallon capacity potable water's **Single Pedestal Spheroid** elevated storage tank high water level elevation **156 MSL** including foundation, steel erection, welding, shrouding, blasting, and standard three coat paint system for the interior and exterior tank surfaces, and electrical, all related tank construction, welding and coating testing, disinfection, site development, and final clean up. Amount bid is to include all labor, materials, equipment, insurance, payroll, taxes, permits, and supervision to provide a complete and functional project.

Bid for Proposal I as outlined in the Scope of Work for 500,000 Gallon Elevated Storage Tank for the Lump Sum Amount of:

____ Dollars

And____ Cents.

($________________________)

Bid price must be written in words and the written words shall govern amount bid.

STATEMENT FOR SEPARATE CONTRACT COMPLIANCE

Non-consumable Material and Installed Equipment:

$____________________

Skilled Labor and Consumable Materials, Tool
and construction equipment:

$____________________

The undersigned agrees to commence work within ten (10) days after the date of written notice to commence work and to substantially complete the work on which he has bid within____ calendar days as provided in the General Conditions of the Agreement. Enclosed herewith is a cashier's check, certified check, or bid bond in the sum of 5% of the greatest amount bid which it is agreed shall be collected and retained by the OWNER as liquidating damages in the event this proposal is accepted by the OWNER within sixty (60) days after the date advertised for the reception of bids and the undersigned fails to execute the contract and the required bond with the OWNER, under the conditions hereof, within ten (10) days after the date said proposal is accepted, otherwise said check or bond shall be returned to the undersigned upon demand.

CONTRACTOR____________________

BY______________________________

ADDRESS_______________________

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PHONE__________________________