November 16, 2007
TWEI No. 07.13.158

TCB
5757 Woodway, Suite 101 West
Houston, Texas 77057

Attn: Mr. David R. Kubala, P.E.

SUPPLEMENTAL GEOTECHNICAL STUDY
BUNKER HILL ROAD IMPROVEMENTS AND
BRIDGE REPLACEMENT PROJECT
INTERSTATE 10 TO LONG POINT ROAD
HOUSTON, TEXAS

Dear Mr. Kubala:

We are pleased to submit our supplemental letter for the geotechnical design and construction recommendations for the proposed Bunker Hill Road Improvement Project located along Long Point and Westview Roads in Houston, Texas. The supplemental study was performed in general accordance with our proposal (TWEI Proposal No. P07-G100) dated March 23, 2007. Tolunay-Wong Engineers, Inc. received authorization to proceed for this project in a letter issued by TCB on July 2, 2007.

Project Description

Tolunay-Wong Engineers, Inc., is pleased to submit this supplemental letter to provide additional geotechnical services for the Bunker Hill Road Improvements Project. TWEI previously performed a geotechnical study for the project located in Houston, Texas (Key Map 490 B and 450 X) (TWEI Project No. 06.13.322). We understand that the project area has been expanded to include paving and utilities along Long Point and Westview Roads and asphalt transitions for the various side streets between the Interstate 10 frontage road and Long Point Road. The length of the expansion along Long Point Road is approximately 1200 ft and along Westview Road approximately 1000 ft. We understand that utilities will be installed within the upper 14-ft depth along Long Point Road and within the upper 6-ft depth along Westview Road. Project details were provided during our telephone conversation and an e-mail transmittal on March 22, 2007. The project site layout is shown on Figure 1.

Scope of Study

The objectives of this study were to explore soil and ground water conditions at the project borings along the above referenced roadway alignments site to formulate geotechnical design recommendations and construction guidelines for the referenced project. The scope of the geotechnical study included the following work tasks:

- Drilling two (2) 15-ft and three (3) 25-ft deep borings (approximately one boring every 500-ft interval per The City of Houston requirements) along the proposed roadway and utility alignment to evaluate the subsurface conditions.
- Installing two (2) piezometers along the alignment to observe the static groundwater level.
- Performing laboratory tests on selected soil samples recovered from the borings to evaluate physical and engineering properties of the subsoil.
- Reviewing TWEI's previous geotechnical study for the Bunker Hill Road project (TWEI Project No. 06.13.322, Titled *Geotechnical Study, Bunker Hill Road Improvements and Bridge Replacement Interstate 10 to Long Point Road, Houston, Texas*, Dated December 19, 2006) to determine if the geotechnical engineering recommendations and construction guidelines provided in the previous report are applicable to the supplemental areas for the proposed roadway pavement and underground utilities.

A reconnaissance fault study was not part of TWEI's scope of work. Based on information provided by TCB, the fault study was performed by others. The fault study was not provided to TWEI during this study.

Field Exploration

The field exploration was performed on July 16 and 17, 2007. Five (5) soil borings were drilled to depths ranging from 15-ft to 25-ft within the project alignment to evaluate subsurface conditions. The project soil borings were drilled using a truck-mounted rig with hydraulic equipment drawdown. Two (2) 15-ft and three (3) 25-ft deep soil borings designated as B-1 through B-5 were drilled along the proposed pavement and utility alignments. The existing concrete pavements were cored prior to accessing the underlying soils. Boreholes B-1 and B-5 were converted to respective piezometers PZ-1 and PZ-5 upon completion of sampling. TWEI representatives were present at the site to coordinate the field activities and to log boreholes. The boring logs are presented in Appendix A. The piezometer installation reports are included in Appendix B. The approximate boring locations are shown on Figure 1. The boreholes were backfilled with a cement-bentonite mixture after obtaining fifteen minute, end of day, or next day water level readings.

Soil Sampling. Soil samples were typically obtained at 1-ft to 2-ft continual intervals to 12-ft depth, at the 13-ft to 15-ft depth interval (B-4 and B-5), and at 5-ft intervals thereafter to the 25-ft termination depth (B-1 through B-3).

Cohesive soil and soil inferred to be cohesive during drilling were obtained by hydraulically pushing a 3-in. diameter, thin-walled tube a distance of about 24 in. in accordance with ASTM D 1587. The soil samples were extruded in the field and visually classified by our field technician. Our field technician measured the penetration resistance of the recovered soil samples using a calibrated hand penetrometer. Representative portions of the recovered soil samples were wrapped in aluminum foil, sealed in plastic bags and transported to our laboratory.

Cohesionless soil samples and soil inferred to be cohesionless during drilling were typically obtained by driving a 2-in. diameter split-barrel. The sampler was driven about 18 in. by blows from a 140-lb. hammer free falling 30 in. in accordance with ASTM D 1586. Our field technician recorded the number of blows required to drive the sampler through each 6-in. interval. The sum of blows required to penetrate the final 12 in. is the Standard Penetration Test "N" value. Our technician visually classified the recovered soil samples in the split-barrel sampler and sealed representative portions in plastic bags for transport to our laboratory.

Water Level Measurements. The project borings were initially dry augered to boring termination depths or to a depth where free water was encountered, then continued with the wet rotary method to boring termination depths, to evaluate the ground water condition. The boreholes were left open for end of day or next-day ground water observation. The open boreholes were backfilled with cement/bentonite upon completion of ground water level observation. Water levels measured in open boreholes may not accurately reflect true (static) groundwater level. It should be noted that fluctuations in groundwater levels may occur with changes in seasonal and climatic conditions, and should be verified prior to construction. For extended groundwater monitoring, we installed a piezometer in each of the boreholes B-1 and B-5. We obtained water level measurements in the piezometers 1 and 35 days after piezometer installation.

Boring Logs and Piezometer Installation Reports. Our interpretations of general soil and water-level conditions at the boring locations are included on the boring logs and piezometer installation reports. The interpretations of the soil types throughout the boring depth and the locations of strata changes were based on the visual classifications during field sampling, and during laboratory testing, based on *Standard Practice for Classification of Soils for Engineering Purposes* (ASTM D 2487) and *Standard Practice for Description and Identification of Soils* [Visual – Manual Procedure] (ASTM D 2488). The project boring logs and a key to the terms and symbols used on the boring logs are presented in Appendix A. The piezometer installation reports are included in Appendix B.

Laboratory Testing

Laboratory tests were performed on selected soil samples recovered from the borings to measure their physical and engineering properties. The laboratory program consisted of moisture content, plasticity characteristics, amount of material in soils finer than the No. 200 sieve, and unconfined compression. Results of the soil tests are presented on the soil boring logs in Appendix A. A brief description of each test is given below.

- **Laboratory Determination of Water (Moisture) Content of Soil and Rock - ASTM D 2216.** The water content of a material, expressed as a percentage, is defined as the ratio of the mass of pore or free water in a given mass of material to the mass of the solid material particles. Moisture content can provide an indication of cohesive soil shear strength and compressibility when compared to Atterberg limits.
- **Liquid Limit, Plastic Limit, and Plasticity Index of Soils - ASTM D 4318.** These soil properties are used to distinguish different soil types and provide an evaluation of volume change potential when considered in conjunction with natural moisture content. The liquid limit and plastic limit of soils, referred to as the Atterberg limits, distinguish the boundaries of the several consistency states of plastic soils. The plasticity index of the soil is the difference between the liquid limit and the plastic limit.

- **Amount of Material in Soils Finer Than the No. 200 (75-µm) Sieve - ASTM D 1140.** This test determines the total amount of material in soils finer than the No. 200 sieve. The test result is presented as the percent of silt and clay sizes by weight in the sample.
- **Unconfined Compressive Strength of Cohesive Soil - ASTM D 2166.** This test determines the unconfined compressive strength of cohesive soil in the undisturbed, remolded or compacted condition, using strain-controlled application of the axial load. The unconfined compressive strength of a cohesive soil sample is twice its undrained shear strength.

General Site and Subsurface Conditions

Our interpretation of the site, soil, and groundwater conditions along the alignment are based on information obtained at the boring locations only. The project boring logs are presented in Appendix A. The piezometer reports are included in Appendix B. This information has been used as the basis for our conclusions and recommendations. Subsurface conditions may vary between boring locations. Significant variations at areas not explored by the project borings will require re-evaluation of our recommendations. The existing paving thicknesses, soil stratigraphy, soil properties, ground water conditions, and potential petroleum contaminated area are included in the following sections.

Existing Pavement Thicknesses. The boreholes drilled within the existing pavement were either cored or drilled through using a carbide-tipped auger. Pavement section thickness and composition are noted on each boring log where encountered. A summary of the pavement section thickness and composition at five borehole locations is presented in the following table.

Boring	Measured Section Thickness and Composition
B-1	8-inch Concrete over SANDY LEAN CLAY
B-2	7-inch Concrete over SANDY LEAN CLAY
B-3	7-inch Concrete over SILTY SAND "FILL" with limestone
B-4	9-inch Concrete over SANDY LEAN CLAY
B-5	8.5-inch Concrete over SANDY LEAN CLAY

Soil Stratigraphy. The generalized soil stratigraphy along the utility line and pavement alignments is inferred from Borings B-1 through B-5. The generalized soil stratigraphy beneath the pavement, along the Long Point and Westview Road alignments generally consists of a layered cohesive, semi-cohesive, cohesionless, and cohesive profile throughout the 15-ft to 25-ft depths explored. In Boring B-3, silty sand fill with limestone was observed below the paving and extended to 2-ft depth. Detailed descriptions of the soils encountered in the project borings are presented on the logs of borings in Appendix A.

It should be stressed that it is relatively difficult in practice to accurately delineate fill from similar natural soils. Fill classifications are made based upon visual observations and require considerable judgment. The interpreted fill depths may vary somewhat from actual conditions.

Soil Properties. We measured liquid limits ranging from 26% to 42%, with plasticity indices ranging from 8 to 22 on seven (7) semi-cohesive and cohesive clayey sands and sandy lean clays recovered from the upper 15-ft depth in Borings B-1 through B-5. In situ moisture contents of the tested soil samples were between two and seven percentage points less than their corresponding plastic limit. The plasticity data of the recovered low to medium plasticity cohesive, and semi-cohesive soil samples indicate low to moderate shrink/swell potential with variation in moisture content. Four selected cohesive soil samples yielded fines contents ranging from 52% to 58%. Three selected semi-cohesive soil samples yielded fines contents ranging from 37% to 49%.

We measured undrained shear strengths ranging from 2350 pounds per square foot (psf) to 5560 psf on seven (7) selected cohesive soil samples recovered from various depths during unconfined compression (UC) tests. Dry unit weights of nine (9) selected medium to high plasticity cohesive soil samples ranged from 85 pcf to 121 pcf. Based on undrained shear strengths and adjusted pocket penetrometer readings, the cohesive soil samples recovered from the project borings are inferred to have stiff to hard, but typically very stiff consistencies.

We measured SPT "N" values of 22 blows per foot to 48 blows per foot within silty sand and poorly graded sand with silt strata encountered at various depths in Borings B-1 through B-3, indicative of medium dense to dense, but mostly medium dense consistency. Fines contents of 19% to 27% were measured on selected silty sand samples in Borings B-1 and B-2. The poorly graded sand with silt samples recovered from the 23.5-ft depth in Borings B-2 and B-3 had a fines content of 10% and 8%, respectively.

Ground Water Conditions. Ground water levels were measured below existing grade during our field exploration program. Ground water level measurements are summarized in the following table:

Boring/ Piezometer No.	Installation Date	Boring / Piezometer Depth (ft)	Groundwater Level Depth (ft)			Caved Depth (ft)
			During Drilling	Observed in Open Borehole/Piezometer	Time Lapse	
B-1 PZ-1	07/17/07	25	23.5	-	-	-
				22.5	1 Day	
				22.2	35 Days	
B-2	07/17/07	25	22	19.6*	5.5 hours	19.6
B-3	7/16/07	25	22	19.1*	15 minutes	19.1
B-4	7/17/07	15	-	-	5 minutes	14.3
B-5 PZ-5	7/17/07	15	-	-	-	-
				Dry	1 Day	
				14.4	35 Days	

Note: * Borehole damp at caved depth.

Potentially Petroleum Contaminated Area. We did not encounter any unusual staining or hydrocarbon odors in the project borings during drilling.

Geotechnical Recommendations

TWEI previously provided geotechnical recommendations and construction considerations for the Bunker Hill Road project (TWEI Project No. 06.13.322, Titled *Geotechnical Study, Bunker Hill Road Improvements and Bridge Replacement Interstate 10 to Long Point Road, Houston, Texas*, Dated December 19, 2006). We understand that the project has been expanded to include paving and utilities along Long Point and Westview Roads. The length of the expansion along Long Point Road is approximately 1200 ft and along Westview Road approximately 1000 ft. We understand that along Long Point Road, utilities will be installed within the upper 14-ft depth and along Westview Road, utilities will be installed within the upper 6-ft depth.

Geotechnical recommendations and construction considerations provided in our previous report (TWEI Project No. 06.13.322) may be used for the supplemental work, as addressed herein, along Long Point and Westview Roads. TWEI Project No. 06.13.322 included recommendations and construction considerations for utilities and rigid pavement design. Included in the following paragraphs are static earth loads, traffic loads, and flexible pipe calculations.

Static Earth Loads on Pipe. Marston's formula given below can be used to calculate soil induced loads on a buried pipe/conduit, either rigid or flexible, installed in narrow trenches.

$W_c = C_d w B_d^2$ (For Rigid pipes, such as Ductile Iron pipes, Ref. AWWA M23, Eq. 4-1, pg. 23)
$W_c = C_d w B_d B_c$ (For Flexible pipes, such as PVC pipes, Ref. AWWA M23, Eq. 4-2, pg. 23)

Where:

W_c = load on conduit, in pounds per linear foot
C_d = load coefficient for conduits installed in trenches
w = unit weight of backfill, in pounds per cubic foot (pcf)
B_d = width of trench at top of the conduit, in feet
B_c = Horizontal width of conduit in feet

C_d is further defined as

$$C_d = \frac{1 - e^{-2K\mu'(H/B_d)}}{2K\mu'}$$

Where:

C_d = trench load coefficient
e = base of natural logarithms
$K = \tan^2(45° - \phi'/2)$
ϕ' = friction angle between backfill and soil
$\mu' = \tan\phi'$ = coefficient of friction between fill material and sides of trench
H = height of fill above top of pipe, in feet
B_d = width of trench at top of pipe, in feet

Recommended values for the product Kμ' for various soils (Ref. AWWA, M9, page 36) are

Kμ' = 0.1924 granular materials without cohesion
Kμ' = 0.1650 maximum for sand and gravel
Kμ' = 0.1500 maximum for saturated top soil
Kμ' = 0.1300 maximum for ordinary clay
Kμ' = 0.1100 maximum for saturated clay

Based on The City of Houston Standard Specifications *Section 02317- Excavation & Backfill for Utilities and Section 02320- Backfill Material*, TWEI recommends a conservative value for Kμ' = 0.1300 and a unit weight of fill material w = 125 pcf for the proposed open-cut trench excavations.

More conservatively, the prism load formula can be used to estimate earth loads on a flexible buried pipe. Prism load is the weight of the column of soil directly above the pipe for the full height of the backfill and is the maximum earth load that a buried flexible pipe can experience in nearly all cases.

Prism Load: $W_p = HwB_c$, pounds per linear foot

Design Example

Given: Determine the trench fill load W_c on a pipe assuming the following:

- Outside pipe diameter, B_c = 15-inch.
- H is 6-ft deep.
- Width of trench at top of the pipe B_d = 3-ft.
- Kμ' = 0.1300
- w = 125 pcf

Calculation Procedure: Trench fill load W_c on a pipe is computed as follows:

$$C_d = \frac{1 - e^{-2K\mu'(H/B_d)}}{2K\mu'} = \frac{1-e^{-2x0.1300(6\text{-ft}/3\text{-ft})}}{2x0.1300} = 1.56$$

$W_c = C_d w B_d B_c$ =1.56 x 125 x 3 x 1.25 = 731 lb/linear ft (for PVC Pipes)

Prism Load on PVC Pipe, W_p = 6 x 125 x 15/12 = 938 lb/linear ft.

Traffic Loads on Circular Pipe

Traffic loads on underground PVC pipes can be estimated from reference AWWA M23 Table 4-1, page 24. The following is a copy from the reference AWWA M23 Table 4-1 for specific invert elevations. Traffic live load on underground PVC pipe is independent of pipe diameter.

Highway Loads on Circular PVC Pipe (pounds per square inch)

Depth, ft	Traffic Live Load[1], W_L, psi
4.0	2.2
6.0	1.5
9.0	1.0
10.0	0.8
12.0	0.6
16.0	0.5
20.0	0.4

1 Assuming a four-lane road with AASHTO HS-20 truck centered in each 12-ft wide lane.

Design Example

Given: Determine the vertical pressures from highway traffic loads over a PVC pipe using the **Highway Loads on Circular PVC Pipe** Table above, assuming the following:

Pipe Size, D = 8-inch (minimum)
Soil Cover Over Pipe, H = 9-ft

Calculation Procedure: Pressure due to highway traffic loads over a 8-inch pipe with a minimum of 9-ft soil cover will experience a traffic live load of 1.0 psi.

Flexible Pipe Design Recommendations

A flexible pipe is by definition a pipe, which will deflect when subject to external loads, such as traffic, groundwater changes, soil settlement, etc., as opposed to rigid pipe, which carries all external loads by itself. The degree of deflection of a flexible pipe will depend on the pipe stiffness, support from the surrounding soils, and on external loads. Sprangler's Formula given below may be used to estimate flexible pipe deflection.

$$\Delta X = \frac{\left[D_e * K * (W_c + W_L) * R^3\right]}{\left(EI + 0.061 * E' * r^3\right)}$$

Based on project borings, we recommend the following values of the soil parameters in the above equation.

K = bedding constant = 0.10 (direct bury condition)
W_c = vertical soil load on the pipe per unit length in pounds per linear inch = w*H*D
w = unit weight of fill material = 120 pcf (recommended)
H = depth to the top of pipe (varies)
E' = modulus of soil reaction for a buried pipe, in psi = $S_c E'_b$ (Ref. AWWA M23 Eq. 4-12)

Where,

S_c = soil support combining factor from Reference AWWA M23 Table 4-4, pg. 29, dimensionless

E'_b = modulus of soil reaction of the pipe zone embedment from Reference AWWA M23 Table 4-5, pg 30

= 1,000 psi for SC3 category embedment material (GM, GC, SC, SM, GM-GC, etc) containing more than 12% fines

= 2,000 psi for SC2 category embedment material (GW, GP, SW, SP, GW-GC, SP-SM) containing 12% fines or less

= 3,000 psi for SC1 category embedment material (crushed rock and GP)

To determine S_c from Table 4-4 (reference AWWA M23), E'_n, modulus of soil reaction of the native soil at the pipe elevation should be determined. We recommend E'_n = 3,000 psi from Table 4-7 (reference AWWA M23, pg. 32) for native cohesive (stiff to very stiff) soils and cohesionless (loose to medium dense) soils within the upper 15-ft depth.

Asphalt Transitions. We understand that asphalt transitions may be used along the side streets of Bunker Hill Road (between the Interstate 10 frontage road and Long Point Road). Flexible transition sections should be according to The City of Houston Standard Pavement Repair Details shown on Drawing Nos. 02471-01 and 02471-02 or similar. The base course for the transition section shall extend 2 inches below the existing pavement.

Potential Fault Zone. A reconnaissance fault study was not part of the scope of work for the Bunker Hill Road Improvements and Bridge Replacement Project or this supplemental scope of work. TWEI understands that a reconnaissance fault study was performed by others. TWEI was not provided the results of the fault study and is not aware of the exact location(s) where the fault crosses the project site, nor the location(s) and size(s) of the hazard band(s). A formal review of the fault study should be performed, but, this task was outside the scope of services for this project. TWEI provided, under separate cover, generalized considerations for faulting at the site. The considerations should not be considered specific for the project site. A detailed review should be performed when the fault movement and hazard band(s) is clearly identified with respect to the project.

Design Review

Review of the design and construction plans as well as the specifications should be performed by TWEI before release. The review is aimed at determining if the geotechnical design recommendations and construction criteria presented in this report have been properly interpreted. A formal review of the fault study should be performed before construction. Design review is not within the scope of work authorized in this study. If desired, a separate proposal can be prepared for design review.

Construction Surveilance

Surveillance of the utilities installation, pavement subgrade preparation, and pavement construction are recommended and has been assumed in preparing our recommendations. These field services are required to check for changed conditions that may result in modifications to our recommendations. The quality of the construction practices will affect performance and construction activities should be monitored.

Limitations

This supplemental report has been prepared for the exclusive use of TCB, and their design team for specific application to the proposed Bunker Hill Road Improvements project in Houston, Texas. Our report has been prepared in accordance with generally accepted geotechnical engineering practice common to the local area. No other warranty, express or implied, is made.

The analyses and recommendations contained in this report are based on the data obtained from the referenced subsurface exploration. The borings indicated subsurface conditions only at the specific locations and time, and only to the depths penetrated. The borings do not necessarily reflect strata variations that may exist between boring locations. The validity of the recommendations is based in part on assumptions about the stratigraphy made by the Geotechnical Engineer. Such assumptions may be confirmed only during earthwork, utility and pavement construction. If subsurface conditions different from those described are noted during construction, recommendations in this report must be re-evaluated.

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

Closing Remarks

We appreciate the opportunity to be of service during this phase of the project, and we look forward to continuing our services during the construction phase and on future projects. Should you have any questions regarding this supplemental report or if we may be of further assistance, please do not hesitate to contact us.

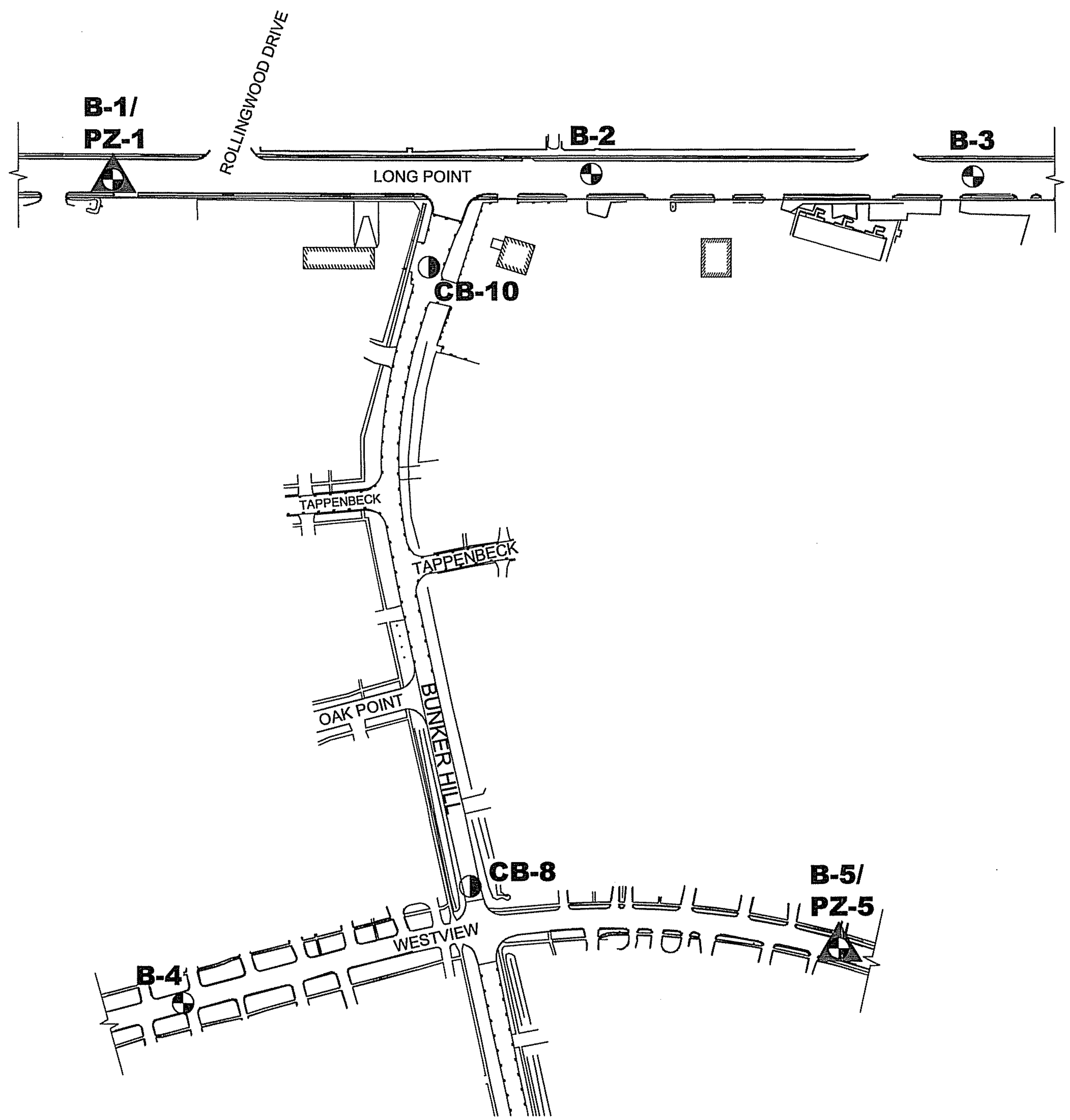
Sincerely,
TOLUNAY-WONG ENGINEERS, INC.

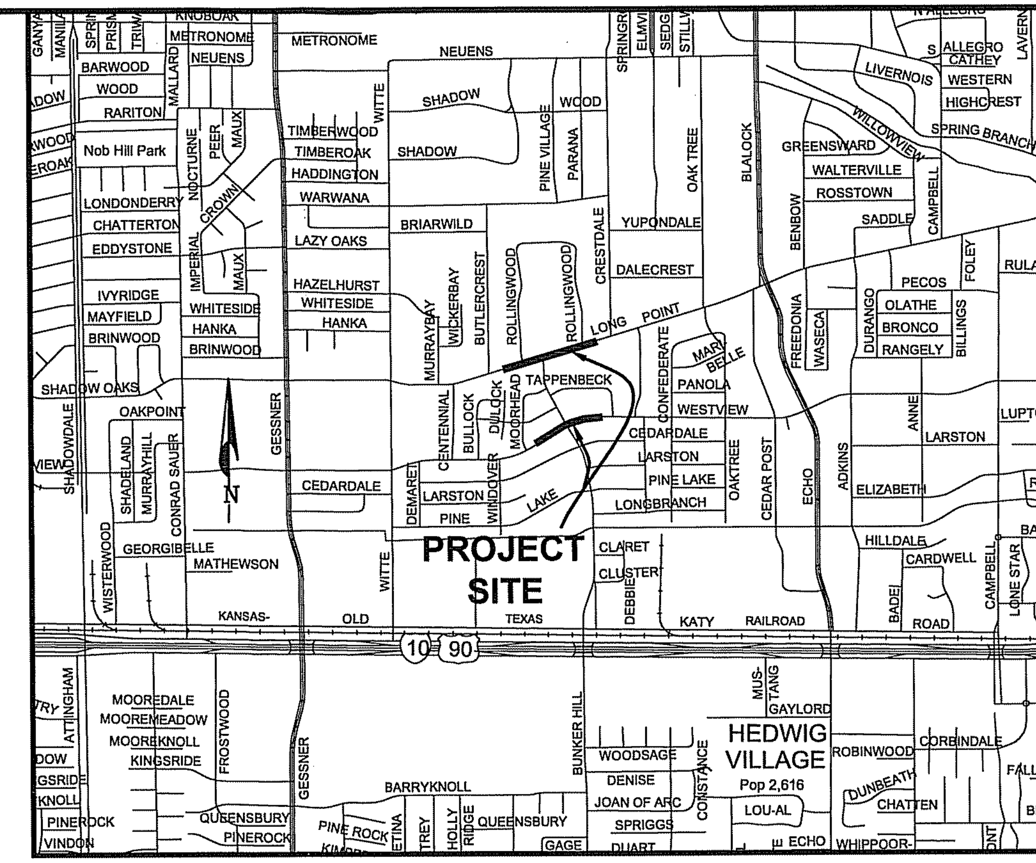
11/16/2007
Jenell S. Strachan, P.E.

Zeki A. Tolunay, P.E.

STATE OF TEXAS
JENELL S. STRACHAN
90311
LICENSED
PROFESSIONAL ENGINEER

Copies Submitted: 3
Attachments: Appendix A – Boring Logs – B-1 through B-5
Appendix B – Piezometer Installation Reports – PZ-1 and PZ-5





SITE VICINITY MAP

(SCALE: 1 INCH = 1/2 MILE)

N

0 100' 200'

APPROXIMATE BORING LOCATION

APPROXIMATE BORING/PIEZOMETER LOCATION

PREVIOUS BORING LOCATION FOR
TWEI PROJECT NO. 06.13.322

BUNKER HILL ROAD IMPROVEMENTS AND BUNKER REPLACEMENT INTERSTATE 10 TO LONG POINT ROAD HOUSTON, TEXAS	Tolunay-Wong Engineers, Inc.	PLAN OF BORINGS

APPENDIX A

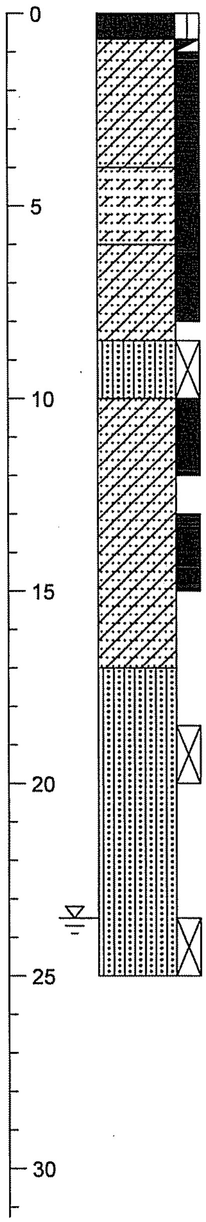
BORINGS B-1 THROUGH B-5

LOG OF BORING B-1

Project: Bunker Hill Road Improvements & Bridge Replacement
Interstate 10 to Long Point Road - Houston, Texas
Client: TCB
Houston, Texas

Project No.: 07.13.158
Date: 7-17-07
Elevation:

Dry Augered: 0 **to** 25 **ft** **Free Water During Drilling at:** 23.5 ft
Washed Bored: **to** **ft** **Water at:** (1) **Caving at:**



ELEVATION/ DEPTH	POCKET PEN. (tsf) or SPT	DESCRIPTION	Wc (%)	Dens. (pcf)	Qu or UU (tsf)	Str. (%)	LL	PI	Pass #200 (%)
0		8" Concrete							
	2.50	Stiff gray & tan SANDY LEAN CLAY (CL)	19						
		w/ sand pockets	17						
	3.50	-very stiff, w/ ferrous nodules below 2'	14						
	4.50	Tan & light gray CLAYEY SAND (SC) w/ sand seams & ferrous nodules	13				30	13	49
5	4.50	Very stiff-hard tan & gray SANDY LEAN CLAY (CL)	15						
	12/6" 14/6" 14/6"	Medium dense light gray & tan SILTY SAND (SM)							27
10	4.00	Hard tan & gray SANDY LEAN CLAY (CL) w/ sand partings	13	121	4.80	12			
	4.50	-very stiff-hard @ 13'-15'	14						
15		Dense tan SILTY SAND (SM) w/ clay seams							
	20/6" 20/6" 20/6"								19
20	14/6" 14/6" 19/6"		18						
25		Boring terminated @ 25 ft							
30									

Note(s): (1) Piezometer PZ-1 was placed within the open borehole upon completion of drilling.

TOLUNAY-WONG ENGINEERS, INC.

LOG OF BORING B-2

Project: Bunker Hill Road Improvements & Bridge Replacement
Interstate 10 to Long Point Road - Houston, Texas
Client: TCB
Houston, Texas

Project No.: 07.13.158
Date: 7-17-07
Elevation:

Dry Augered: 0 **to** 25 **ft** **Free Water During Drilling at:** 22 ft
Washed Bored: **to** **ft** **Water at:** Damp after 5.5 hours (1) **Caving at:** 19.6 ft

ELEVATION/ DEPTH	POCKET PEN. (tsf) or SPT	DESCRIPTION	Wc (%)	Dens. (pcf)	Qu or UU (tsf)	Str. (%)	LL	PI	Pass #200 (%)
0		7" Concrete							
		Tan & gray SANDY LEAN CLAY (CL)	17						
	2.50	Tan & gray CLAYEY SAND (SC) w/ sand seams	14				29	10	40
	4.50	Very stiff-hard tan & gray SANDY LEAN CLAY (CL)	13						
5	9/6" 11/6" 11/6"	Medium dense light gray & tan SILTY SAND (SM) w/ clay pockets							22
	10/6" 14/6" 17/6"		16						
10	4.50	Very stiff-hard tan & gray SANDY LEAN CLAY (CL)	14						
	4.50	-very stiff below 13'	15	117	3.38	9	35	18	58
15									
	11/6" 20/6" 24/6"	Dense tan SILTY SAND (SM)	12						
20									
	14/6" 22/6" 26/6"	Dense tan & light gray POORLY GRADED SAND w/ SILT (SP-SM) w/ clay seams							10
25		Boring terminated @ 25 ft							
30									

Note(s): (1) The open borehole was grouted with a cement/bentonite mixture using a tremie at the completion of the field work day.

TOLUNAY-WONG ENGINEERS, INC.

LOG OF BORING B-3

Project: Bunker Hill Road Improvements & Bridge Replacement
Interstate 10 to Long Point Road - Houston, Texas
Client: TCB
Houston, Texas

Project No.: 07.13.158
Date: 7-16-07
Elevation:

Dry Augered: 0 to 25 ft
Washed Bored: to ft
Free Water During Drilling at: 22 ft
Water at: (1) (2)
Caving at:

ELEVATION/ DEPTH	POCKET PEN. (tsf) or SPT	DESCRIPTION	Wc (%)	Dens. (pcf)	Qu or UU (tsf)	Str. (%)	LL	PI	Pass #200 (%)
0		7" Concrete							
		Brown & gray SILTY SAND "FILL" stabilized, w/ limestone & clay pockets	14						
	2.50	Very stiff gray & tan FAT CLAY w/ SAND (CH) w/ ferrous nodules & sand seams	56	85	3.12	7			
	4.50	Very stiff-hard gray & tan SANDY LEAN CLAY (CL) w/ ferrous nodules	13				39	22	52
5		-w/ calcareous nodules @ 4'-8'							
	4.50		13						
	3.25	-very stiff @ 8'-10'	16	109					
10	4.50	-w/ sand seams below 10'	13						
	4.50	Very stiff gray & tan FAT CLAY w/ SAND (CH) slickensided	16	112	3.61	7 *			
15									
	4.50	Light gray & tan CLAYEY SAND (SC) w/ ferrous nodules	14						
20		Medium dense light gray & tan POORLY GRADED SAND w/ SILT (SP-SM)							
	7/6" 10/6" 15/6"								8
25		Boring terminated @ 25 ft							
30									

Note(s): (1) Free water did not rise within the open borehole.
(2) The open borehole was grouted with a cement/bentonite mixture using a tremie the next day after drilling completion.

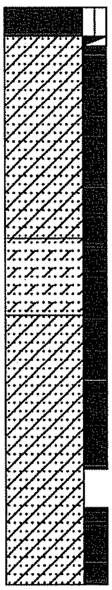
LOG OF BORING B-4

Project: Bunker Hill Road Improvements & Bridge Replacement
Interstate 10 to Long Point Road - Houston, Texas
Client: TCB
Houston, Texas

Project No.: 07.13.158
Date: 7-17-07
Elevation:

Dry Augered: 0 **to** 15 **ft**
Washed Bored: **to** **ft**

Free Water During Drilling at: Dry
Water at: Dry after 5 minutes (1)
Caving at: 14.3 ft



ELEVATION/ DEPTH	SOIL/SAMPLER SYMBOLS & FIELD DATA	POCKET PEN. (tsf) or SPT	DESCRIPTION	Wc (%)	Dens. (pcf)	Qu or UU (tsf)	Str. (%)	LL	PI	Pass #200 (%)
0			9" Concrete							
		2.50	Stiff brown & tan SANDY LEAN CLAY (CL)	30				42	21	53
			-w/ gravel to 1'	15						
		4.50	-tan & gray below 1'	13	121	5.56	9			
			-hard @ 2'-4'							
			-very stiff-hard, w/ ferrous nodules & sand seams below 4'							
5		4.50	-	12						
		3.25	Tan & gray CLAYEY SAND (SC) w/ ferrous nodules	11				26	8	37
		3.00	Very stiff light gray & tan SANDY LEAN CLAY (CL) w/ calcareous nodules -w/ ferrous nodules @ 8'-10'	18						
10		3.00		15	116	2.47	9			
		3.00		17						
15			Boring terminated @ 15 ft							
20										
25										
30										

Note(s): (1) The open borehole was grouted with a cement/bentonite mixture at the completion of the field work day.

TOLUNAY-WONG ENGINEERS, INC.

LOG OF BORING B-5

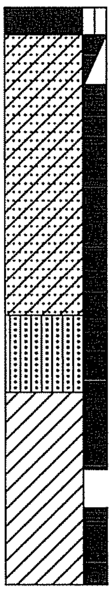
Project: Bunker Hill Road Improvements & Bridge Replacement
Interstate 10 to Long Point Road - Houston, Texas
Client: TCB
Houston, Texas

Project No.: 07.13.158
Date: 7-17-07
Elevation:

Dry Augered: 0 **to** 15 **ft**
Washed Bored: **to** **ft**

Free Water During Drilling at: Dry
Water at: (1)

Caving at:



ELEVATION/ DEPTH	POCKET PEN. (tsf) or SPT	DESCRIPTION	Wc (%)	Dens. (pcf)	Qu or UU (tsf)	Str. (%)	LL	PI	Pass #200 (%)
0		8.5" Concrete							
		Tan & gray SANDY LEAN CLAY (CL)	19						
	1.75	-stabilized to 2' -stiff @ 2'-4' -w/ ferrous nodules below 2'							
	2.00	-very stiff below 4'	16	114	2.35	14	35	16	52
5									
	4.25		17						
		Tan & gray SILTY SAND (SM)	21						
10	4.50	Very stiff-hard tan, reddish brown & gray SANDY LEAN CLAY (CL)	16	116					
	4.50		15						
15		Boring terminated @ 15 ft							
20									
25									
30									

Note(s): (1) Piezometer PZ-5 was placed within the open borehole upon compeltion of drilling.

TOLUNAY-WONG ENGINEERS, INC.

SYMBOLS AND TERMS USED ON BORING LOGS

Unified Soil Classifications
System Symbols

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

Sampler Symbols	**Meaning**
	Depth of thin - walled tube sample
	Depth of Standard Penetration Test (SPT)
	Depth of auger sample
	Depth of sampling attempt with no recovery
	TxDOT Cone Penetrometer Test

Field Test Data

2.50	Pocket penetrometer reading 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

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, clayey silts, and clayey sands.

Relative Density	Typical SPT "N" Value Range*
Very Loose	0-4
Loose	5-10
Medium Dense	11-30
Dense	31-50
Very Dense	Over 50

* "N" 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. The density designations correspond to a SPT "N" value range based on an effective overburden pressure of 1 tsf. Density descriptors may be modified because of variations in the effective overburden pressure.

CONSISTENCY OF COHESIVE SOILS

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

Pocket Penetrometer (tsf)	Typical Compressive Strength (tsf)	Consistency	Typical SPT "N" Value Range**
pp < 0.50	qu < 0.25	Very soft	≤ 2
0.50 ≤ pp < 0.75	0.25 ≤ qu < 0.50	Soft	3-4
0.75 ≤ pp < 1.50	0.50 ≤ qu < 1.00	Firm	5-8
1.50 ≤ pp < 3.00	1.00 ≤ qu < 2.00	Stiff	9-15
3.00 ≤ pp < 4.50	2.00 ≤ qu < 4.00	Very Stiff	16-30
pp ≥ 4.50	qu ≥ 4.00	Hard	≥ 31

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

APPENDIX B

PIEZOMETER INSTALLATION REPORTS PZ-1 AND PZ-5

PIEZOMETER COMPLETION

Date: 07/17/07

Dry Augered: 0.0 ft to 25.0 ft

Wash Bored: to

Drilling Fluid: None

PIEZOMETER DEVELOPMENT

Date: 7/18/2007

Method: Air Lift

WATER LEVEL READINGS

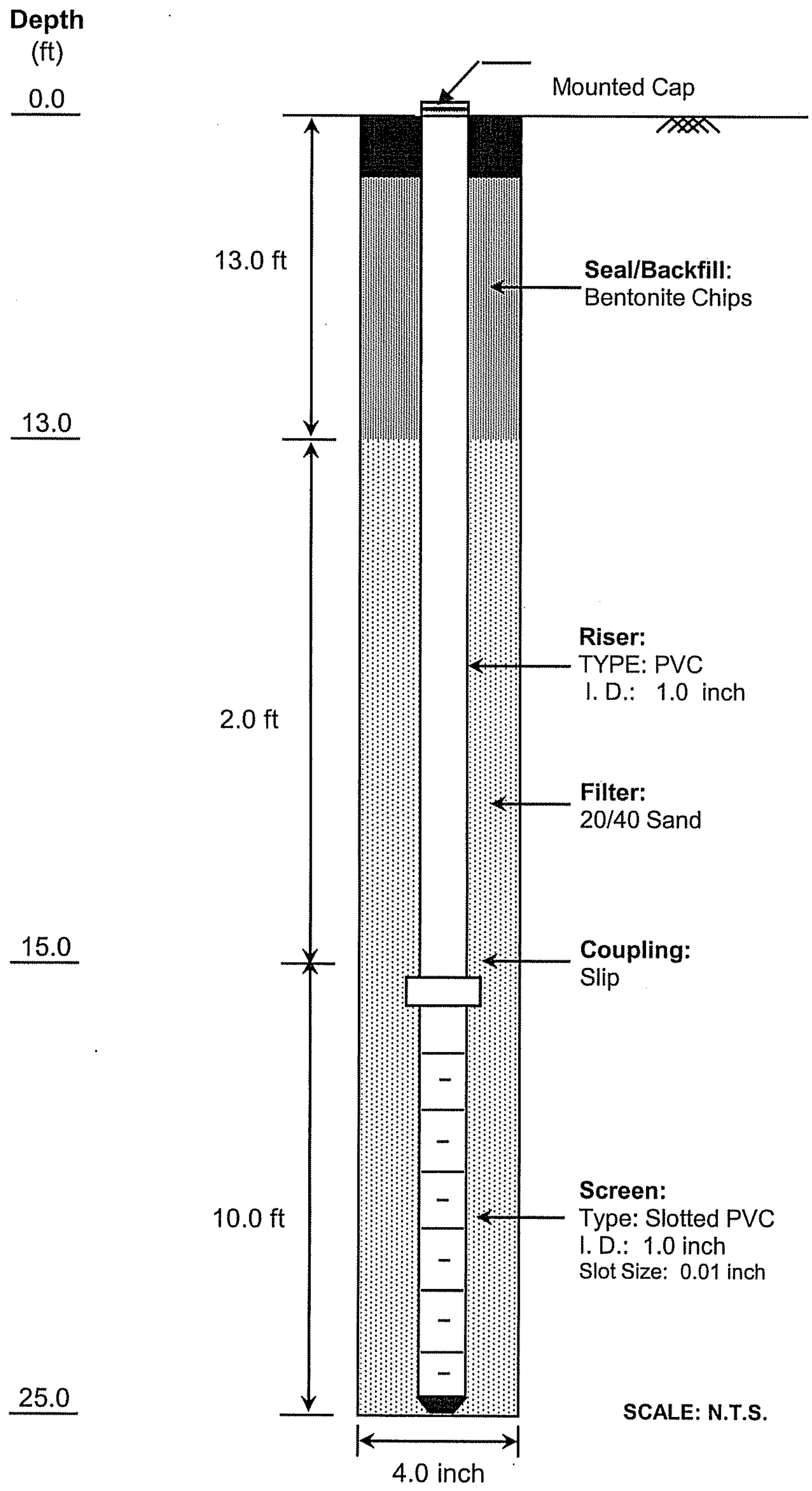
Free Water at: 23.5 ft

Date	Depth, ft*
07/18/07	22.50
08/21/07	22.20

*Depths are measured below existing grade

REMARKS

1. Borehole B-1 was converted into Piezometer PZ-1 upon completion of drilling.



Project: Bunker Hill Road Improvements and Bridge Replacement Interstate 10 to Long Point Road Houston, Texas

Tolunay-Wong Engineers, Inc.
Houston, Texas

Project Number: 07.13.158

Client: TCB Houston, Texas

Piezometer Installation Report: PZ-1

Figure

PIEZOMETER COMPLETION

Date: 07/17/07

Dry Augered: 0.0 ft to 15.0 ft

Wash Bored: to

Drilling Fluid: None

PIEZOMETER DEVELOPMENT

Date: 7/18/2007

Method: Dry

WATER LEVEL READINGS

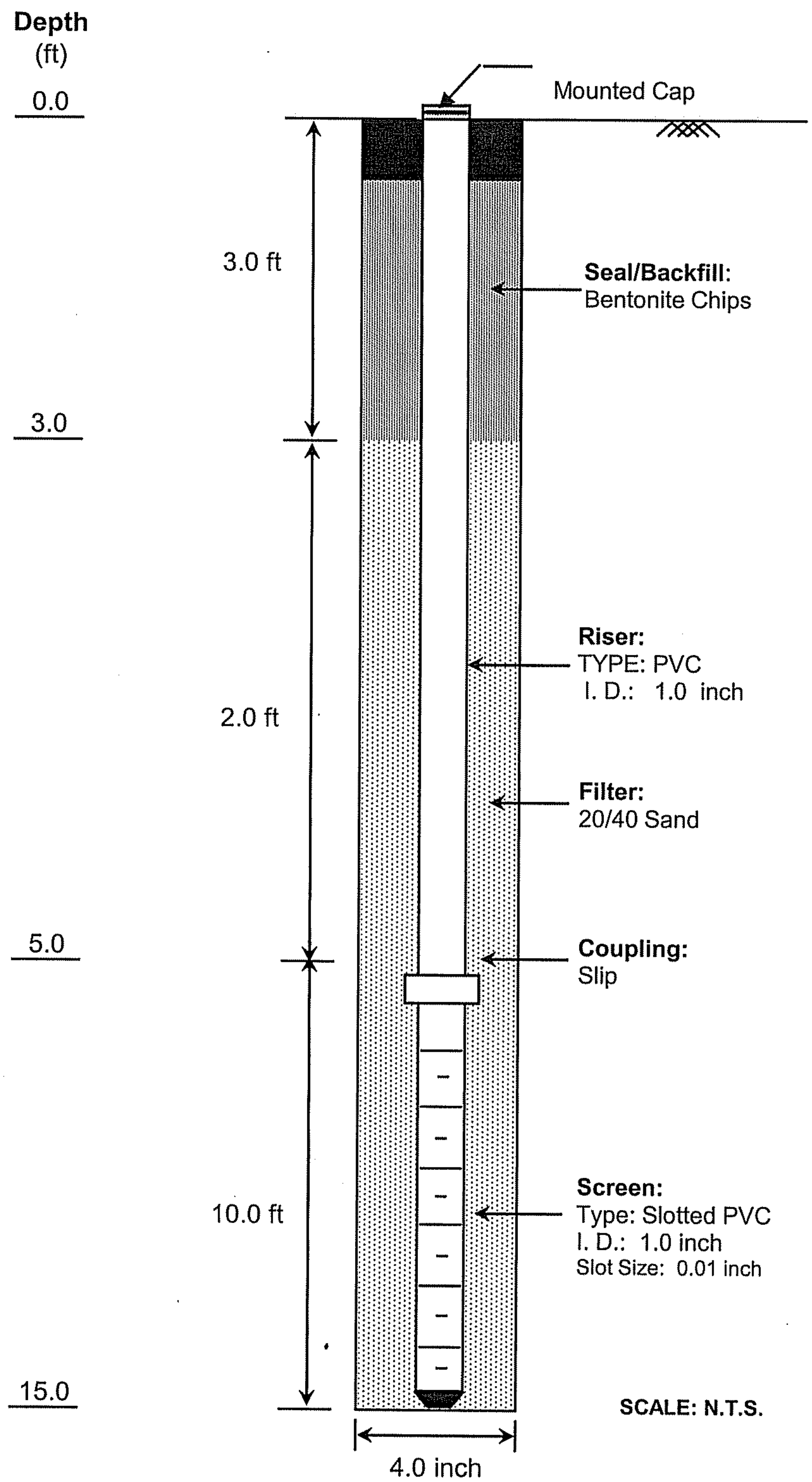
Free Water at: Dry

Date	Depth, ft*
07/18/07	Dry
08/21/07	14.40

*Depths are measured below existing grade

REMARKS

1. Borehole B-5 was converted into Piezometer PZ-5 upon completion of drilling.



Project:
Bunker Hill Road Improvements and Bridge Replacement Interstate 10 to Long Point Road
Houston, Texas

Tolunay-Wong Engineers, Inc.
Houston, Texas

Project Number: 07.13.158

Client:
TCB
Houston, Texas

Piezometer Installation Report:

PZ-5