GEOTECH ENGINEERING and TESTING

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Attention: Mr. Edward Quiroz, P.E.
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Subject: Trench Safety Recommendations
Proposed Pump and Lift Station Renewal/Rehabilitation
Post Oak Lane, Stablewood, Bayou Timber and Buckingham
City of Houston, Texas
WBS No. R-000267-0109-3

Gentlemen:

Submitted here are Geotech Engineering and Testing (GET) recommendations on trench safety for the above referenced project. The following is our trench safety recommendations together with the earth pressure diagram for the braced excavations.

General

Occupational Safety and Health Administration (OSHA) has required a trench protective system for trenches deeper than five-ft. Trenches that are deeper than five-ft, should be shored, sheeted, braced or laid back to a stable slope, or some other appropriate means of protection should be provided where workers might be exposed to moving ground or caving. OSHA developed a soil classification system to be used as a guideline in determining protective requirements for trench excavations.

OSHA classification system categorizes the soil and rock in four types based on shear strength and stability. These classifications are summarized in the following report sections.

Stable Rock

means natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed.

Type A Soil

means cohesive soils with an unconfined compressive strength of 1.5-ton per square foot (tsf) or greater. Examples of cohesive soils are: clay, silty clay, sandy clay, clay loam, silty clay loam, sandy clay loam, caliche and hardpan. No soil is Type A if:

- The soil is fissured; or
- The soil is subject to vibration from heavy traffic, pile driving or similar effects; or

- The soil has been previously disturbed; or
- The soil is part of a slope, layered system where the layers dip into the excavation on a slope of 4(h): 1(v) or greater; or
- The material is subject to other factors that would require it to be classified as a less stable material.

Type B Soil

- Cohesive soil with an unconfined compressive strength greater than 0.5 tsf but less than 1.5 tsf; or
- Granular cohesionless soils including: angular gravel, silt, silt loam, sandy loam, and in some case, silty clay loam and sandy clay loam; or
- Previously disturbed soils except those which would otherwise be classified as Type C soil; or
- Soil that meets the unconfined compressive strength or cementation requirements for Type A, but is fissured or subject to vibration; or
- Dry rock that is not stable; or
- Material that is part of a sloped, layered system where the layers dip into the excavation on a slope less steep than 4(h): 1(v), but only if the material would otherwise be classified as Type B.

Type C Soil

- Cohesive soil with an unconfined compressive strength of 0.5 tsf or less; or
- Granular soils including gravel, sand, and loamy sand; or
- Submerged soil or soil from which water is freely seeping; or
- Submerged rock that is not stable; or
- Materials in a sloped, layered system where the layers dip into the excavation on a slope 4 (h) : 1(v) or steeper.

Under the assumption that appropriate groundwater control measures are carried out, and the groundwater table, if present, is lowered and maintained at least 3 feet below the excavation depths, the stable cohesive soils (CL) & (CH), with unconfined compressive strength greater than 0.5 tsf, are classified as OSHA soil Type “B”. The granular soils, which are less stable, are classified as OSHA soil Type “C”.

Based on our geotechnical exploration and laboratory test results details of soil classifications at each boring are summarized below:

OSHA SOIL TYPE

Boring No.	Depth Range [1], ft	Soil Type	OSHA Soil Classification
B-1	0 – 2	Fill: Lean Clay (CL)	B
	2 – 14	Lean Clay (CL)	B
	14 – 23	Silty Sand (SM)	C
B-2	0 – 2	Fill: Lean Clay (CL)	C
	2 – 4	Lean Clay (CL)	C
	4 – 14	Lean Clay (CL)	B
	14 – 23	Poorly Graded Sand with Silt (SP-SM)	C
B-3	0 – 2	Fill: Silty Sand (SM)	C
	2 – 16	Lean Clay with Sand (CL)	B
	16 – 23	Poorly Graded Sand with Silt (SP-SM)	C
B-4	0 – 2	Fill: Silty Sand (SM)	C
	2 – 14	Lean Clay with Sand (CL)	B
	14 – 26	Poorly Graded Sand with Silt (SP-SM)	C
B-5	0 – 2	Fill: Sandy Silt (ML)	C
	2 – 14	Lean Clay with Sand (CL)	B
	14 – 26	Silty Sand (SM)	C
B-6	0 – 2	Fill: Sandy Silt (ML)	C
	2 – 14	Lean Clay with Sand (CL)	B
	14 – 26	Poorly Graded Sand with Silt (SP-SM)	C
B-7	0 – 2	Fill: Lean Clay with Sand (CL)	B
	2 – 14	Lean Clay with Sand (CL)	B
	14 – 36	Silty Sand (SM)	C
B-8	0 – 2	Fill: Lean Clay with Sand (CL)	B
	2 – 12	Lean Clay with Sand (CL)	B
	12 – 36	Silty Sand (SM)	C
B-9	0 – 2	Fill: Lean Clay with Sand (CL)	C
	2 – 14	Lean Clay with Sand (CL)	B
	14 – 36	Silty Sand (SM)	C

Boring No.	Depth Range [1], ft	Soil Type	OSHA Soil Classification
B-10	0 – 2	Fill: Lean Clay with Sand (CL)	B
	2 – 10	Lean Clay with Sand (CL)	B
	10 – 36	Poorly Graded Sand with Silt (SP-SM)	C
B-11	0 – 2	Fill: Lean Clay with Sand (CL)	B
	2 – 10	Lean Clay with Sand (CL)	B
	10 – 36	Poorly Graded Sand with Silt (SP-SM)	C
B-12	0 – 2	Fill: Fat Clay (CH)	B
	2 – 16	Fat Clay (CH)	B
	16 – 36	Silty Sand (SM)	C
B-13	0 – 2	Fill: Lean Clay with Sand (CL)	B
	2 – 12	Lean Clay with Sand (CL)	B
	12 – 38	Poorly Graded Sand with Silt (SP-SM)	C
B-14	0 – 2	Fill: Lean Clay with Sand (CL)	B
	2 – 16	Lean Clay with Sand (CL)	B
	16 – 38	Poorly Graded Sand with Silt (SP-SM)	C
B-15	0 – 2	Fill: Fat Clay (CH)	B
	2 – 14	Fat Clay (CH)	B
	14 – 21	Lean Clay with Sand (CL)	B
	21 – 31	Poorly Graded Sand with Silt (SP-SM)	C
B-16	0 – 2	Fill: Lean Clay with Sand (CL)	B
	2 – 6	Silty Sand (SM)	C
	6 – 14	Lean Clay with Sand (CL)	B
	14 – 31	Poorly Graded Sand with Silt (SP-SM)	C
B-17	0 – 14	Lean Clay with Sand (CL)	B
	14 – 31	Poorly Graded Sand with Silt (SP-SM)	C
B-18	0 – 2	Fill: Lean Clay with Sand (CL)	B
	2 – 14	Lean Clay with Sand (CL)	B
	14 – 31	Poorly Graded Sand with Silt (SP-SM)	C
B-19	0 – 2	Fill: Lean Clay with Sand (CL)	B

Boring No.	Depth Range [1], ft	Soil Type	OSHA Soil Classification
B-19	2 – 22	Lean Clay with Sand (CL)	B
	22 – 40	Silty Sand (SM)	C
B-20	0 – 2	Fill: Lean Clay with Sand (CL)	B
	2 – 8	Fat Clay (CH)	B
	8 – 22	Lean Clay with Sand (CL)	B
	22 – 40	Silty Sand (SM)	C
B-21	0 – 2	Fill: Silty Sand (SM)	C
	2 – 8	Fat Clay (CH)	B
	8 – 22	Lean Clay with Sand (CL)	B
	22 – 40	Silty Sand (SM)	C
B-22	0 – 2	Fill: Silty Sand (SM)	C
	2 – 6	Fat Clay (CH)	B
	6 – 22	Lean Clay with Sand (CL)	B
	22 – 30	Sandy Silt (ML)	C
	30 – 40	Poorly Graded Sand with Silt (SP-SM)	C
B-23	0 – 2	Fill: Silty Sand (SM)	C
	2 – 16	Lean Clay with Sand (CL)	B
	16 – 28	Fat Clay (CH)	B
	28 – 40	Silty Sand (SM)	C
B-24	0 – 2	Fill: Silty Sand (SM)	C
	2 – 8	Fill: Lean Clay with Sand (CL)	B
	8 – 43	Poorly Graded Sand with Silt (SP-SM)	C
	43 – 55	Fat Clay (CH)	C
B-25	0 – 4	Fill: Lean Clay with Sand (CL)	C
	4 – 48	Silty Sand (SM)	C
	48 – 55	Fat Clay (CH)	C
B-26	0 – 2	Fill: Silty Sand (SM)	C
	2 – 32	Poorly Graded Sand with Silt (SP-SM)	C
	32 – 40	Lean Clay with Sand (CL)	C

Boring No.	Depth Range [1], ft	Soil Type	OSHA Soil Classification
B-26	40 – 58	Fat Clay (CH)	C
	58 – 64	Lean Clay with Sand (CL)	C
	64 – 105	Silty Sand (SM)	C
B-27	0 – 6	Silty Sand (SM)	C
	6 – 12	Fat Clay (CH)	B
	12 – 38	Lean Clay with Sand (CL)	C
B-28	0 – 2	Fill: Fat Clay (CH)	C
	2 – 8	Fill: Fat Clay (CH)	B
	8 – 10	Fill: Fat Clay (CH)	C
	10 – 16	Fat Clay (CH)	B
	16 – 38	Fat Clay (CH)	C
B-29	0 – 2	Fill: Fat Clay (CH)	B
	2 – 14	Fat Clay (CH)	B
	14 – 16	Silty Sand (SM)	C
	16 – 18	Fat Clay (CH)	B
	16 – 22	Silty Sand (SM)	C
	22 – 38	Fat Clay (CH)	C
B-30	0 – 2	Fill: Lean Clay with Sand (CL)	C
	2 – 6	Lean Clay with Sand (CL)	B
	6 – 16	Fat Clay (CH)	B
	16 – 27	Lean Clay with Sand (CL)	B
	27 – 38	Sandy Silt (ML)	C
B-31	0 – 4	Fill: Lean Clay with Sand (CL)	C
	4 – 8	Fill: Lean Clay with Sand (CL)	B
	8 – 12	Fill: Lean Clay with Sand (CL)	C
	12 – 23	Silty Sand (SM)	C
B-32	0 – 4	Fill: Lean Clay with Sand (CL)	B
	4 – 6	Fill: Silty Sand (SM)	C
	6 – 8	Fill: Lean Clay with Sand (CL)	C

Boring No.	Depth Range [1], ft	Soil Type	OSHA Soil Classification
B-32	8 – 10	Fill: Lean Clay with Sand (CL)	B
	10 – 23	Silty Sand (SM)	C
B-33	0 – 2	Fill: Lean Clay with Sand (CL)	B
	2 – 10	Lean Clay with Sand (CL)	B
	10 – 23	Silty Sand (SM)	C
B-34	0 – 2	Fill: Silty Sand (SM)	C
	2 – 12	Silty Sand (SM)	C
	12 – 15	Fat Clay (CH)	B

Note: 1. Refer to each boring log for soils stratigraphy

Stockpiling of excavated materials may not be allowed near the banks of excavated areas. Generally, a distance of one-half the excavation depth on both sides of the trench should be kept clear of any excavated material.

Lift station and the trenches (pit) for auger boring operations for the sanitary sewerlines should be provided with proper trench support system. We understand that the lift station will be placed at a depth of approximately 60-ft below existing grade. The depths of the flow line for the sanitary sewerlines will range from 3- to 50-ft. The trenches should be provided with a temporary shoring system on excavations deeper than five-ft. The trenches can be made using shored, sheeted and braced, laid back stable slope or other means of appropriate protection system should be provided where workers are exposed to moving ground or caving. The slopes may be constructed in accordance with Table B-1 and shoring may be constructed in accordance with Table C-1.1, Table C-1.2 and Table C-1.3 of 29 CFR Part 1926 of OSHA.

In the event that a trench sheeting is used, the sheeting can be constructed in the form of cantilever sheeting or with bracing. Lateral earth pressures for each method used are summarized on Plate 1. The trenching and shoring operations should follow OSHA Standards. We recommend that a geotechnical engineer monitor all phases of trench excavation and bracing to assure trench safety.

Timber shoring as outlined in 29 CFR Part 1926 of OSHA recommendation may be used in the construction of trench supporting system.

For trench excavation, it is necessary to maintain the stability of the sides and base and not to disturb the soil below the excavation grade. In braced cuts, if the sheeting is terminated at the base of the cut, the bottom of the excavation can become unstable under certain conditions. The stability of the trench bottom is governed by the shear strength of the soils and the differential hydrostatic head. For cuts in cohesive soils (such as lean clay with sand (CL) and fat clay (CH)) stability of the bottom can be evaluated in accordance with the procedure outline on Plate 2. However, where cohesionless soils were encountered, dewatering will be required to prevent bottom blowup if the groundwater is encountered during construction. Design soil parameters presented on Plate 3 can be used for design.

Groundwater Conditions

We understand that the lift station will be placed at a depth of approximately 60-ft below existing grade. The depths of the flow line for the sanitary sewerlines will range from 3- to 50-ft. Our short-term field exploration along the alignments indicated that groundwater was encountered at depths ranging from 16- to 36-ft below the existing grade. Groundwater rose to depths ranging from 15- to 35-ft below the existing grade after 24 hours of drilling. The results of piezometer observations indicated that stabilized groundwater levels exist at depths of about 25.5- to 26-ft, 23- to 25-ft below the existing ground surface in piezometers PZ-2 (Boring B-11) and PZ-6 (Boring B-30), respectively. No groundwater was encountered at piezometers PZ-1, PZ-3, PZ-4 and PZ-5 installed at Borings B-6, B-18, B-19 and B-24, respectively. Therefore, groundwater dewatering system will be required near the borings where groundwater was encountered. **However, due to the presence of sands/silts subsoils and hydrostatic pressure build-up, bottom blow up may occur if an effective dewatering system is not in place at the time of construction.**

Fluctuation in groundwater can occur as a function of seasonal moisture variation. Groundwater control recommendations are presented in the following report sections.

In the event that groundwater is encountered during construction, it is our opinion that the well excavation can be dewatered using a wellpoint, multi-stage wellpoint system or ejector systems. Based on the field data, it is our opinion that groundwater should be lowered to a depth of at least three-ft below the deepest excavation grade in order to provide dry working conditions and firm bedding for construction of the facility. Since the wellpoint suction lift is about 15-ft, multi-stage wellpoint system or ejector systems may be used for dewatering. **Due to the presence of silty sands subsoils near the bottom depth of the lift station/sanitary sewerlines and the hydrostatic pressure, potential bottom blow up may occur if an effective dewatering system is not in place at the time of construction.** Design of a dewatering system should consider the amount of groundwater to be lowered and the permeability of the affected soils. The selection and proper implementation of an effective groundwater control system is the responsibility of the contractor. The design of groundwater and surface water should be in accordance with the City of Houston Specifications, Section 01578 − Control of Ground Water and Surface Water.

The results of our field exploration and laboratory testing indicate that unsatisfactory soils for excavation, such as soft clays and cohesionless soils encountered at various depths in the borings. A summary of the unsatisfactory soils locations and depths is as follows:

Boring(s)	Depth Range, ft.
B-1	14 to 23
B-2	14 to 23
B-3	0 to 2 /16 to 23
B-4	0 to 2 /14 to 23
B-5	0 to 2/14 to 26
B-6	0 to 2/ 14 to 26
B-7	14 to 36

B-8	12 to 36
Boring(s)	Depth Range, ft.
B-9	0 to 2/14 to 36
B-10	10 to 36
B-11	10 to 36
B-12	16 to 36
B-13	12 to 38
B-14	16 to 38
B-15	21 to 31
B-16	2 to 6/14 to 31
B-17	14 to 31
B-18	14 to 31
B-19	22 to 40
B-20	23 to 40
B-21	0 to 2/ 22 to 40
B-22	0 to 2/ 23 to 40
B-23	0 to 2/ 28 to 40
B-24	0 to 2/ 8 to 43
B-25	0 to 2/4 to 48
B-26	0 to 32/64 to 105
B-27	0 to 6/12 to 38
B-28	0 to 2
B-29	14 to 16/18 to 22
B-30	27 to 38
B-31	8 to 23
B-32	4 to 6/ 10 to 23
B-33	10 to 23
B-34	0 to 12

If these conditions are encountered during the time of construction, suitable groundwater control measures should be implemented in accordance with the "City of Houston Specifications, Section 01578 – Control of Groundwater and Surface Water". Furthermore, the contractor may have to over excavate additional 6 inches and remove unstable or unsuitable materials with approval by geotechnical engineer,

then place non-woven geotextile follows by compaction of 12-inch of crushed stone or 6-inch of reinforced concrete pad.
Due to potential variability of the on-site soils, unstable trench conditions may exist in the areas where we did not conduct our borings. If these conditions are encountered during the time of construction, a stable trench should be provided to allow proper bedding and installation.

Our recommendation on trench safety at the project site does not address the effects of excavations on existing buildings/facilities at the project site. This study was outside the scope of our work.

We appreciate the opportunity to be of service. Should you have any questions or need additional assistance, please call.

Very truly yours,

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Enclosure: Trench Lateral Earth Pressure Diagrams, Plate 1
Cut in Cohesive Soil, Plate 2
Design Soil Parameters, Plate 3