REPORT
GEOTECHNICAL INVESTIGATION
PROPOSED BLOWERS FOUNDATION
SOUTHWEST WWTP IMPROVEMENTS
PACKAGE 3
WBS NO. R-000265-0103-3
CITY OF HOUSTON, TEXAS

FOR

GUPTA & ASSOCIATES, INC.
7322 SOUTHWEST FREEWAY, SUITE 410
HOUSTON, TEXAS 77074

PREPARED BY
ASSOCIATED TESTING LABORATORIES, INC.
HOUSTON, TEXAS

ATL REPORT G14-230

July 6, 2015

ESTABLISHED 1959

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Date: July 6, 2015

ATL Job No: G14-230

Gupta & Associates, Inc.
7322 Southwest Freeway, Suite 410
Houston, Texas 77074

Attention: Mr. Hoss Forouzan, P.E.

Reference: Geotechnical Investigation Report
Proposed Blowers Foundation
Southwest WWTP Improvements – Package 3
WBS NO. R-000265-0103-3
City of Houston, Texas

Gentlemen:

We have completed our report for the geotechnical investigation at the above referenced locations. Our findings, analysis and recommendations are submitted herein.

It has been a pleasure working with you on this project. Should you have any questions concerning this project work, please call us at (713) 748-3717.

Sincerely,

ASSOCIATED TESTING LABORATORIES, INC.

(TBPE Registration Number F-4560)

Peng Sia Tang, M.S.C.E., P.E.
Manager, Geotechnical Services

Jasbir Singh, P.E.
President

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EXECUTIVE SUMMARY

Associated Testing Laboratories, Inc. (ATL) has conducted a Geotechnical Investigation in support of the design and construction of the proposed improvements at the Southwest Wastewater Treatment Plant (WWTP) for the City of Houston, Texas. ATL understands that the proposed improvements include installation of blowers supported on elevated concrete pad foundation.

For this geotechnical investigation, a total of one (1) soil boring to a depth of 20 feet below the existing ground surface was drilled in the area of the proposed improvements. Based on the soil boring drilled at the project site, the subsurface conditions at the project site can be generalized as follows:

The subsurface soils at the project site, based on Boring B-1, consist of about 4 feet of hard, medium plasticity Sandy Lean Clays (CL) fill. The surface fill is underlain by stiff to hard Fat Clay with Sand (CH) soils to a depth of about 18 feet, followed by hard Sandy Lean Clay (CL) soils with slight plasticity to the bottom of the boring at 20 feet. Groundwater was not encountered during and at completion of drilling in Boring B-1. It should be noted that the groundwater level would fluctuate according to factors such as the amount of precipitations and ambient temperature preceding and at the time of construction

Based on the field investigation, laboratory testing, records and document review, the following findings and recommendations are provided:

- No observable unusual staining or hydrocarbon odor was noted during our inspection of the soil samples.
- A preliminary fault evaluation based on review of available fault maps indicates that no documented faults are located close to the project site. ATL does not recommend a Phase I fault investigation for this site.
- Foundation and construction recommendations for the proposed elevated concrete pad foundation supporting the blowers, as well as site and subgrade preparation are presented in Section 5 of this report.

GEOTECHNICAL INVESTIGATION
PROPOSED BLOWERS FOUNDATION
SOUTHWEST WWTP IMPROVEMENTS - PACKAGE 3
CITY OF HOUSTON, TEXAS

1.0 INTRODUCTION

1.1 General

This investigation was authorized by Gupta & Associates, Inc (GAI), with the acceptance of Associated Testing Laboratories, Inc. (ATL) Proposal No. CP14-0903 dated September 17, 2014, and execution of Subcontract for Consultant Services Agreement between GAI and ATL. Project details were provided by GAI. This report includes results of the field investigation, laboratory testing, geotechnical engineering analysis, and recommendations for the design and construction of proposed improvements at the Southwest Wastewater Treatment Plant (WWTP).

1.2 Location and Description of the Project

A site vicinity map for the project site is shown on Figure 1. The site layout and proposed improvements are shown on Figure 2. ATL understands that as part of the proposed Southwest Wastewater Treatment Plant Improvements-Package 3, blowers supported on elevated concrete pad are proposed to be installed at the Chlorine Contact Basin area, as shown in Figure 2.

1.3 Scope of Work

ATL understands that the proposed improvements entails installation of blowers in the Chlorine Contact Basin area that are to be supported on elevated concrete pad. ATL was requested and provided the following geotechnical services in support of the proposed improvements at the project site:

- Drilling and sampling a total of one (1) soil borings at the closest accessible location to the proposed improvements, to a depth of 20-ft below the existing ground surface.
- Conduct laboratory testing on select soil samples recovered from the soil boring.
- Develop boring log based on field and laboratory information to present the subsurface soil and groundwater conditions.
- Perform preliminary fault evaluation of each project site based on the review of available published fault maps and literature.
- Based on results from the field investigation, laboratory testing and gathered geological and subsurface information, perform geotechnical engineering analyses to develop geotechnical recommendations for the design and construction of the proposed foundation supporting the blowers.

2.0 SUBSURFACE INVESTIGATION PROGRAM

One (1) 20-ft deep soil borings was drilled at the closest accessible location to the proposed blowers foundation. The approximate location of the boring is shown in Figure 2.

The soil boring was drilled dry to the bottom of the borings. In cohesive soils, undisturbed soil samples were collected using a conventional 3-inch O.D. Shelby tube in general accordance with ASTM D1587. Cohesionless soils were sampled using split spoon sampler in general accordance with ASTM D1586. The soil borings were grouted with cement-bentonite using tremie at the completion of drilling.

All soil samples were examined, classified and logged in the field. A representative portion of each sample was sealed in aluminum foil and placed in containers to prevent moisture loss. All soil samples were properly labeled and subsequently transported to the ATL laboratory. All soil samples were classified according to Unified Soil Classification System (ASTM D-2487). The subsurface information is presented in the individual boring log and a key to soil classifications

and symbols used in the boring log are presented in Appendix 1.

3.0 LABORATORY TESTING PROGRAM

Samples obtained from the field were examined and classified again in our soil laboratory by a geotechnical technician under the supervision of an engineer. Laboratory testing was performed on select representative soil samples collected during the field investigation. The laboratory testing program included Atterberg Limits (ASTM D-4318), Percent Finer than No. 200 Sieve (ASTM D-1140, Density, Moisture Content (ASTM D-2216), Unconfined Compressive Strength (ASTM D-2166) and Unconsolidated Undrained Triaxial Strength (ASTM D-2850) tests. The results of laboratory tests are presented on the boring logs in Appendix 1. Overall numbers and types of tests performed for this study for this project are presented below:

TABLE 2

TYPE OF TEST	NUMBER OF TEST
Dry Density	4
Moisture Content	10
Atterberg Limits	5
Unconfined Compression	4
Sieve Analysis through No. 200 Sieve	3

4.0 SUBSURFACE AND SITE CONDITIONS

4.1 Area Geology

The projects sites are located within the Gulf Coast Structural Province, a huge sedimentary basin containing several thousand feet of sediments. In general, these sediments consist of loose sands, silts and clays which slope gently toward the Gulf of Mexico. The surface materials are

often altered and weakened by the weathering process.

The Southwest WWTP site is underlain by the Beaumont Formation of the Pleistocene age. This formation consists of over consolidated clays, silts and sands with some shell, calcium carbonate and iron oxides. These formations are quite strong and extend to an approximate depth of 100 feet. The materials of Beaumont Formation were deposited during the last of the interglacial periods. During interglacial periods when water from the melting glaciers flowed back into the ocean, the sea rose, the depended valley backfilled and several Pleistocene formations were deposited. Beaumont Formation may have been deposited during a mid-Wisconsin interglacial interval or during the Sangamon Stage, an interval between the Wisconsin and Illinoian Glaciations. The Sangamon Stage is currently estimated as taking place about 70,000 years ago. The Beaumont formation is the youngest formation of Pleistocene age that crops out in the proposed project area. Its origins are mainly fluvial and deltaic, but probably some small areas originated as coastal marsh and lagoonal deposits.

4.2 Geological Hazards

Among the geologic and geo-morphological features in this region are sedimentary deposits broken by structure such as normal faults, salt domes, etc. The sedimentary deposits slope gently toward the Gulf of Mexico. They are broken by normal faults, most of which dip toward the Gulf and extend downward many thousands of feet. The earth movements that caused these faults took place within the last 50,000 years. In general, the regional faults in the Houston area trend parallel to the Gulf Coast. Only the local faults over the salt domes show a radial pattern associated with the upthrust of the salt mass.

There are numerous faults and fault systems in the Greater Houston and surrounding area. The movement of many of these faults has been affected in recent history by area subsidence. The subsidence is theorized to have been exacerbated by the removal of oil and groundwater. As much as nine (9) feet of subsidence has taken place in the area east of Houston in the last 70

years. Conversion to surface water usage and the limiting of oil production has greatly reduced the subsidence rate in the area east of Houston.

Figure 3a and 3b show the documented principal active growth faults in the Houston area. Based on the published fault maps, no documented faults are located close to the Southwest WWTP site. Thus, ATL does not recommend a Phase I fault investigation for the proposed structures at this project site.

4.3 Potentially Hazardous Material

No observable unusual staining or hydrocarbon odors were noted during our inspection of the soil samples.

4.4 Site Stratigraphy and Geotechnical Characterization

The subsurface soils at the project site, based on Boring B-1, consist of about 4 feet of hard, medium plasticity Sandy Lean Clays (CL) fill. The surface fill is underlain by stiff to hard Fat Clay with Sand (CH) soils to a depth of about 18 feet, followed by hard Sandy Lean Clay (CL) soils with slight plasticity to the bottom of the boring at 20 feet.

The onsite Sandy Lean Clay (CL) fill has a liquid limit (LL) of about 36 and a plasticity index (PI) of about 19. The Fat Clays (CH) have LL ranging from about 52 to 75, and PI between about 33 and 52. The Sandy Lean Clays (CL) have a LL of about 23 and a PI of about 8
CH, CL and SM are soil classification in accordance with Unified Soils Classification System. Detailed stratigraphy and a key to terms and symbols used in the boring logs are presented in Appendix 1.

4.4.1 Suitability of Onsite Soils As Fill Material

The on-site Lean Clays (CL) fill have medium plasticity, and the underlying Fat Clays (CH) have high to very high plasticity. Clean Lean Clays with PI between 8 and 20 are suitable as select fill. The on-site Fat Clays (CH) are not suitable as select fill. The on-site Lean Clays not meeting select fill criteria and Fat Clays may be used as general fill in non-structural areas. Clean Lean Clays with PI above 20 and and Fat Clays may be used as select fill when treated with an adequate amount of lime. The optimum amount of lime to be used to stabilize the clay soils can be determined by conducting lime vs PI and/or pH series tests.

4.5 Groundwater

Groundwater information observed in the borehole during and at completion of drilling are summarized below:

TABLE 3

Boring	Groundwater Information		Caved in Depth
	During Drilling	At Completion of Drilling	
B-1	Dry	Dry	None

It should be noted that the groundwater level would fluctuate according to factors such as the amount of precipitations and ambient temperature preceding and at the time of construction, and the topography, surface drainage and the subsurface soil stratigraphy, etc. It should be noted that a detailed hydrogeological investigation of the proposed project area is beyond the scope of this investigation.

5.0 GEOTECHNICAL ENGINEERING RECOMMENDATIONS

We understand that the following improvements are planned at the Southwest WWTP site:

TABLE 4

Water Plant	Proposed Improvements
South WWTP (B-1)	Blowers and Elevated Concrete Pad Supporting the Blowers

5.1 Proposed Blowers Structure

ATL understands that blowers will be elevated 5 feet above the existing grade (above 500-year flood level). The structure will be supported on columns that in turn supported on driller shafts or piers.

5.1.1 Foundation for Blowers Structure

The blowers structure may be supported on drilled straight shafts or drilled-and-underreamed (belled bottom) footings founded in the stiff to very stiff clays at a depth of about fifteen (15) feet below the existing ground elevation. The drilled straight shafts and the bell-bottom footings should be designed for an allowable bearing capacity of 4,500 PSF total loads. This bearing capacity is based on a minimum safety factor of 2.0. Using a safety factor of 3.0, the allowable bearing capacity for dead load plus sustained live load is 3,000 PSF. A maximum shaft to bell ratio of 3.0 is recommended. For best results, standing water (if any) should be pumped out and footings poured immediately after the excavation has been made.

Equipment with high amplitude and/or frequency vibration shall be placed on vibration isolator (rubber/spring/pneumatic, etc.) recommended by the equipment manufacturer.

5.1.2 Foundation Construction

Placement of concrete should be accomplished as soon as possible to prevent changes in state of stress and caving of the foundation soils. Excavation/drilling of foundations should be inspected by an Associated Testing Laboratories representative to help assure the integrity of foundations

If a significant amount of sand/silt/calcareous nodules seams and/or pockets, or slickensides, are present, they could cause some sloughing of the excavation sidewalls and the under-reamed portion of the footings. This problem can usually be alleviated by using a temporary casing, and/or by steepening the belling angle, or by increasing the diameter of the shaft portion of the footing. Should sloughing persist, it may become necessary to use straight-sided shafts.

5.1.3 Foundation Settlement

Although detailed settlement analysis for the proposed foundation is not within the scope of this study, it is our opinion that foundations designed based on the recommendations given here will experience settlement that should be within the tolerable limit of the structure.

6.0 CONSTRUCTION REVIEW

6.1 Quality Control

Associated Testing Laboratories, Inc. (ATL) recommends implementation of a quality control program under the supervision of a Professional Engineer. Structural integrity and stability is particularly dependent on quality foundation installation. An independent testing laboratory should be assigned to test and inspect construction materials during the construction phase.

6.2 Monitoring

Despite the thoroughness of this geotechnical exploration, there is always the possibility that actual subsurface conditions may differ from the predicted conditions because conditions between soil borings can be different from those at specific boring locations. Associated Testing Laboratory, Inc. (ATL) recommends a regular inspection and overall project monitoring by a geotechnical engineer during the construction phase. The purpose of inspection is to provide sound engineering and judgement alternatives during construction, if unanticipated conditions occur.

7.0 LIMITATIONS

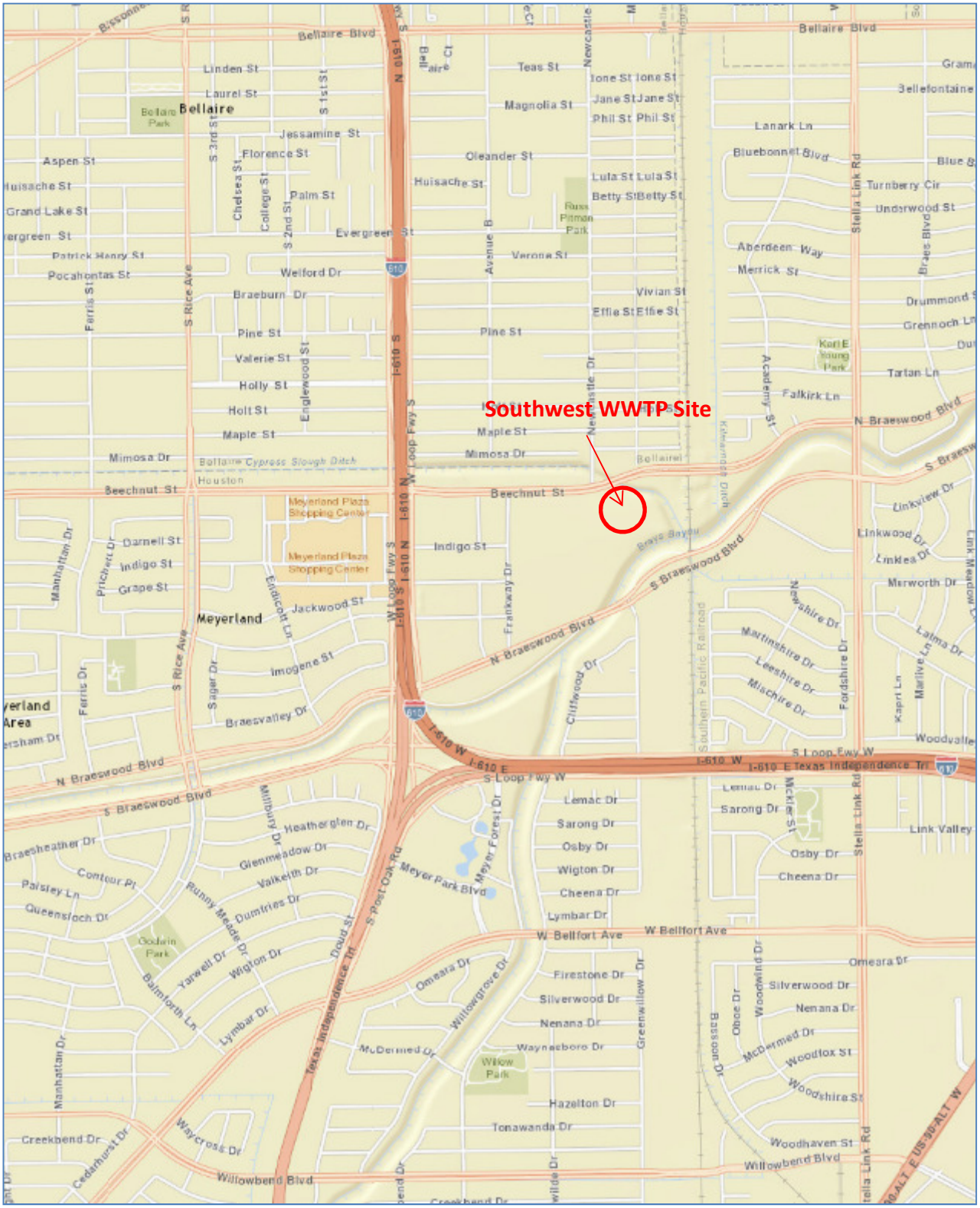
The recommendations contained in this report are based on data gained from test borings at the locations shown in Figure 2, a reasonable volume of laboratory tests, and professional interpretation and evaluation of such data, from the project information furnished. Should it become apparent during construction that soil conditions differ significantly from those discussed in this report, this office should be notified immediately so that an evaluation and any necessary adjustments can be made. Evaluation of any existing structures was not in our scope. Any analysis of slope stability, bulkhead or other buildings or features at the site, not within the scope of this investigation, ATL is not responsible for any problems caused by these features.

8.0 REFERENCES

1. Joseph E. Bowles (1982), Foundation Analysis and Design, 3rd ed., McGraw-Hill Book Company.
2. Braja M. Das (1985), Principles of Geotechnical Engineering, PWS Engineering.
3. Merlin G. Spangler and Richard L. Handy (1982), Soil Engineering, Fourth Edition, Harper & Row Publishers.
4. Alfreds R. Jumikis (1971), Foundation Engineering, Intext Educational Publishers.
5. W.L. Schroeder (1980), Soils in Construction, Second Edition, John Wiley & Sons.
6. Annual Book of ASTM Standards for Soils and Rock; Building Stones.
7. Harris County Soil Survey; USDA Soil Conservation Services.
8. Geologic Atlas of Texas; Bureau of Economic Geology, The University of Texas.
9. Groundwater Quality in Texas; Texas Natural Resources Conservation Commission.
10. E.J. Yoder and M.W. Witczak (1975), Principles of Pavement Design, John Wiley & Sons, Inc., Second Edition
11. Design of Pavement Structure; AASHTO 1993.
12. International Building Code (IBC) – 2006 and 2012.

FIGURES

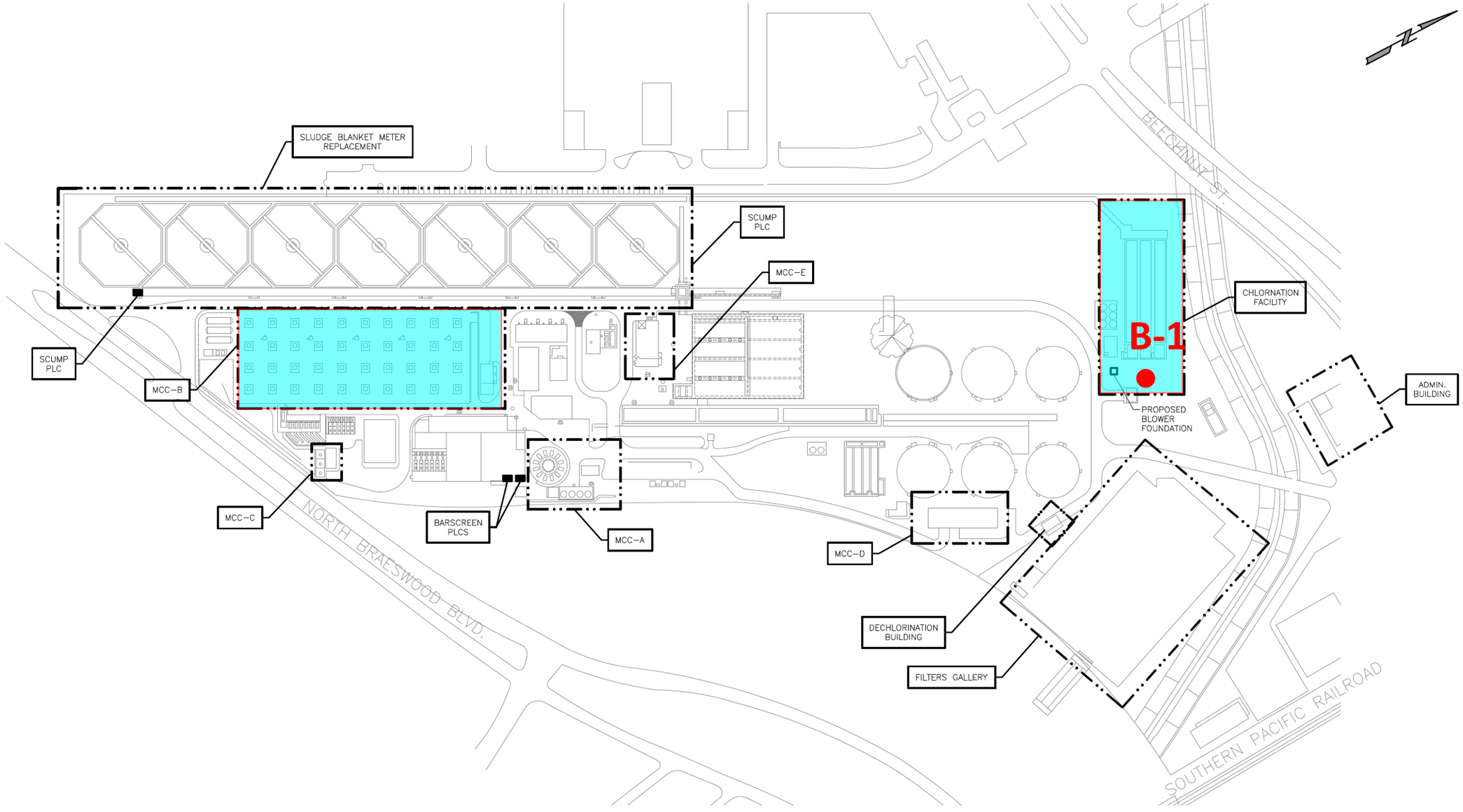
FIGURES



Drawing Source: City of Houston GIMS

SITE VICINITY MAP	ASSOCIATED TESTING LABAORATORIES, INC. 3143 YELLOWSTONE BLVD., HOUSTON, TEXAS TEL: (713) 748-3717 Fax: (713) 748-3748
PROPOSED BLOWERS FOUNDATION-SOUTHWEST WWTP IMPROVEMENTS-PACKAGE 3, CITY OF HOUSTON	WBS NO. R-000265-0103-3
	PROJECT NO. : G14-230 / FIGURE 1

PST 8/28/12



OVERALL SITE PLAN

Note: Map is not to scale. Boring locations are approximate.

LOCATION OF BORINGS

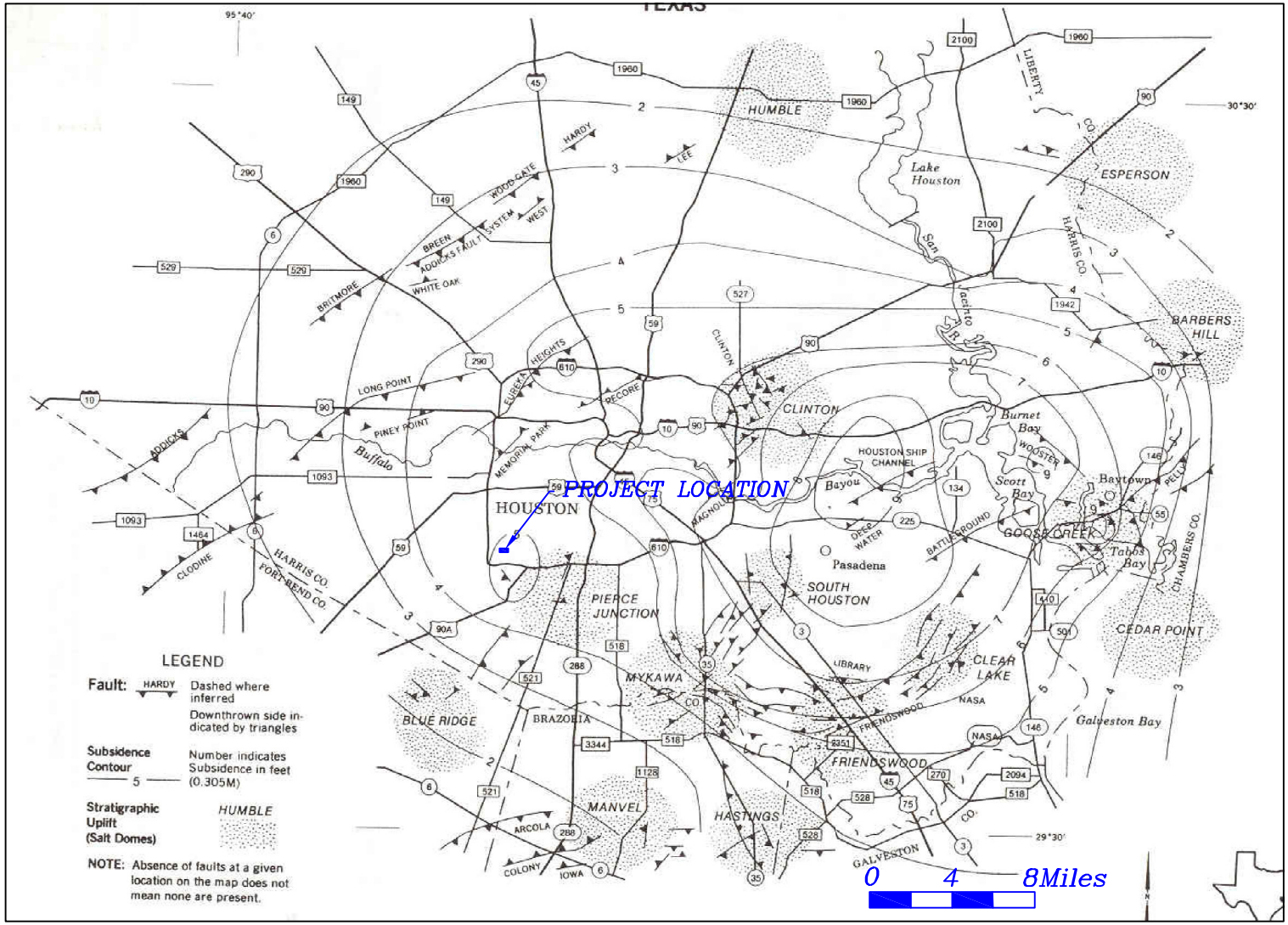
PROPOSED BLOWERS FOUNDATION
SOUTHWEST WWTP IMPROVEMENTS – PACKAGE 3

ASSOCIATED TESTING LABAORATORIES, INC.
3143 YELLOWSTONE BLVD., HOUSTON, TEXAS
TEL: (713) 748-3717 Fax: (713) 748-3748

WBS No. R-000265-0103-3

PROJECT NO. : G14-230

FIGURE 2



PRINCIPAL ACTIVE FAULTS IN HOUSTON AREA

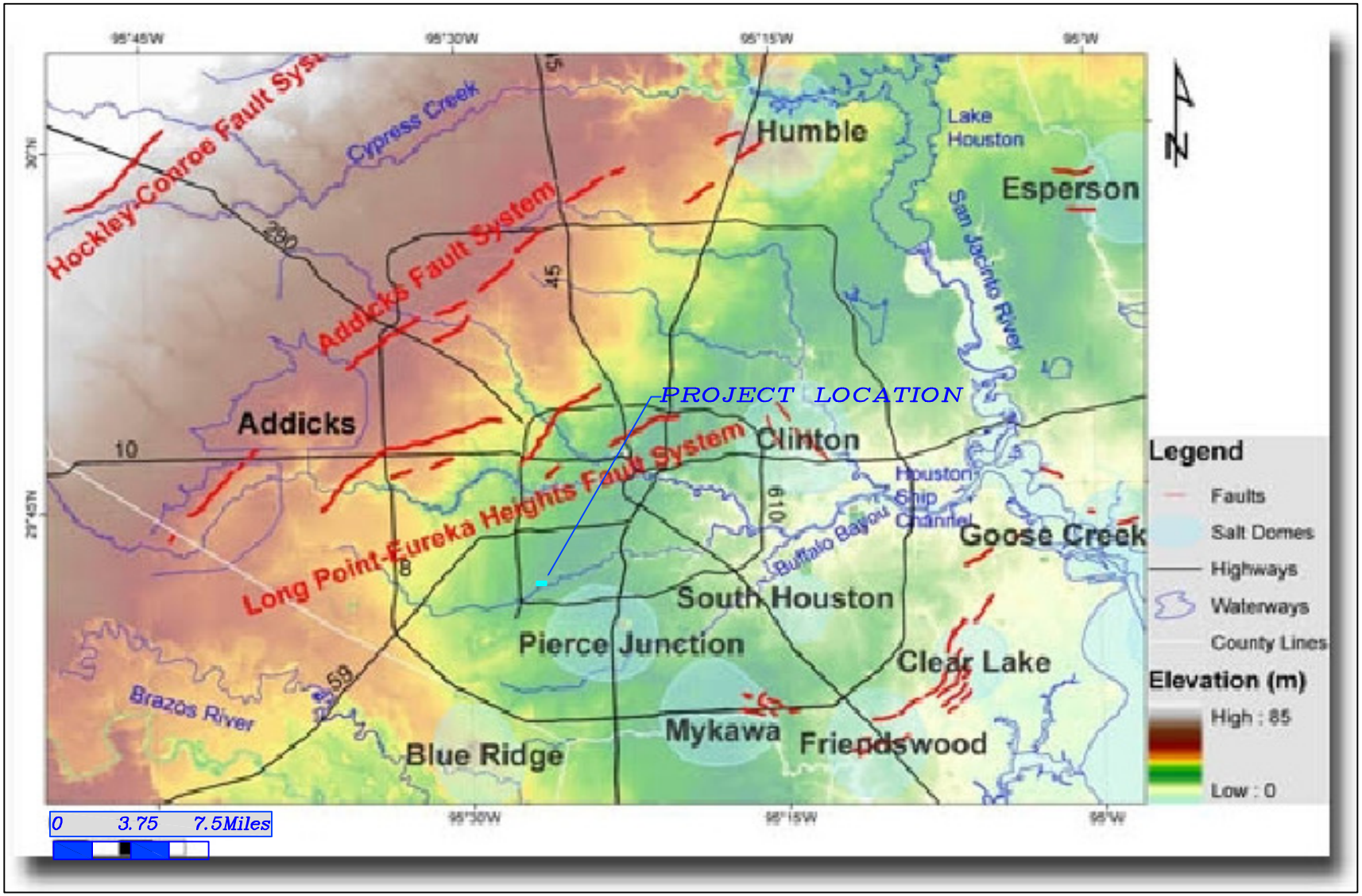
SOUTHWEST WASTEWATER TREATMENT PLANT IMPROVEMENTS (PACKAGE 3)

Associated Testing Laboratories, Inc.
3143 Yellowstone Blvd. Houston, Texas
Tel: (713) 748-3717 Fax: (713) 748-3748

WBS No. R-000265-0103-3

PROJECT NO. G14-230

FIGURE. 3a



ACTIVE SURFACE FAULTS ON LIDAR IMAGERY	Associated Testing Laboratories, Inc. 3143 Yellowstone Blvd. Houston, Texas Tel: (713) 748-3717 Fax: (713) 748-3748
SOUTHWEST WASTEWATER TREATMENT PLANT IMPROVEMENTS (PACKAGE 3)	WBS No. R-000265-0103-3
	PROJECT NO. G14-230 / FIGURE. 3b

APPENDIX 1

BORING LOGS AND KEY TO LOG TERMS AND SYMBOLS

LOG OF BORING B-1

PROJECT: Southwest Wastewater Treatment Plant Improvements (Package-3)
WBS No. R-000265-0103-3

PROJECT NO.: G14-230

LOCATION: N ; E

COMPLETION DEPTH: 20 FT

SURFACE ELEVATION: FT

DATE: 12/30/2014

SAMPLER: Shelby Tube/Split Spoon

DRY AUGER: 0 TO 20 FT

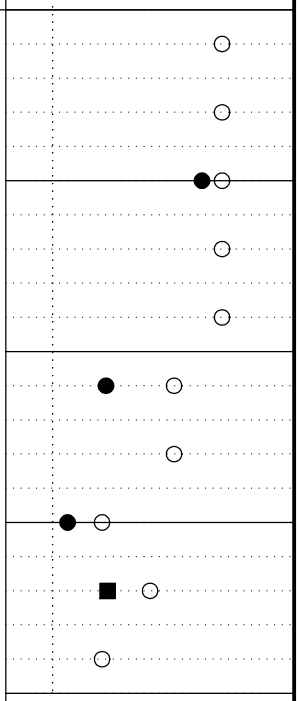
WET ROTARY: No TO No FT

ELEVATION, FT	DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST, BLOWS PER FOOT	PERCENT PASSING NO. 200 SIEVE	DRY UNIT WEIGHT, PCF	MOISTURE CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX, %
	0			Sandy Lean Clay (CL), hard, medium plasticity, light gray and tan with shells & roots (Fill up to 4 feet)		62		10	36	17	19
				..with calcareous nodules below 2'				8			
	5			Fat Clay (CH), hard, very high plasticity, light gray and tan			107	22	75	23	52
				..dark gray below 6'				23			
				..light gray and tan with calcareous nodules below 8'		89		21	67	21	46
	10			..very stiff below 10' (slickensided)			101	24			
				..with ferrous nodules below 12'				22			
	15			..stiff below 14' (slickensided)			102	22			
				..very stiff below 16'			113	18	52	19	33
	20			Sandy Lean Clay (CL), stiff, slight plasticity, light gray and tan		64		17	23	15	8

UNDRAINED SHEAR STRENGTH, TSF

○ *HAND PENETROMETER*
● *UNCONFINED COMPRESSION*
■ *UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION*
△ *TORVANE*

0.5 1.0 1.5 2.0 2.5



DEPTH TO WATER IN BORING:

▽ *FREE WATER 1ST ENCOUNTERED AT Dry FT. DURING DRILLING; AFTER 15.0 MIN. AT Dry FT.*

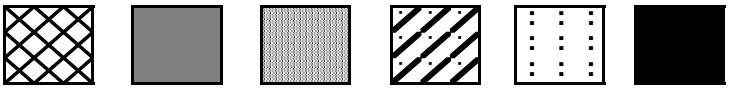
▼ *WATER DEPTH AT Dry FT., HOLE OPEN TO 20.0 FT. ON 12/30/2014*

Drilled By: Doug *Logged By:* PV

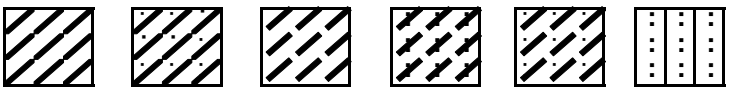
Associated Testing Labs, Inc

KEY TO LOG TERMS AND SYMBOLS

SOIL TYPE



CONC. | ASPHALT | FILL | SANDY FAT CLAY | P.GRADED SAND WITH SILT | PEAT



FAT CLAY | FAT CLAY WITH SAND | LEAN CLAY | SANDY LEAN CLAY | LEAN CLAY WITH SAND | SILTY SAND

SAMPLER TYPE

NO SAMPLE | AUGER SAMPLE | SHELBY TUBE | SPLIT SPOON

NO RECOVERY | ROCK CORE | 2" SHELBY TUBE | TXDOT CONE

UNIFIED SOIL CLASSIFICATION SYSTEM - ASTM D 2487

MAJOR DIVISIONS			LETTER SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS LESS THAN 50% PASSING No. 200 SIEVE	GRAVEL & GRAVELY SOILS LESS THAN 50% PASSING No.4 SIEVE	CLEAN GRAVELS LITTLE OR NO FINES	GW	WELL GRADEED GRAVELS,GRAVELSAND MIXTURES WITH LITTLE OR NO FINES
			GP	POORLY GRADED GRAVELS,GRAVEL SAND MIXTURES WITH LITTLE OR NO FINES
		W/ APPRECIATEBLE FINES	GM	SILTY GRAVELS,GRAVEL SAND-SILT MIXTURES
			GC	CLAYEY GRAVELS,GRAVEL SAND-CLAY MIXTURES
	SANDS MORE THAN 50% PASSING No.4 SIEVE	CLEAN SANDS LITTLE FINES	SW	WELL GRADED SAND,GRAVELY SAND (LITTLE FINES)
			SP	POORLY GRADED SANDS,GRAVELY SAND(L. FINES)
		SANDS WITH APPREA. FINES	SM	SILTY SANDS,SAND-SILT MIXTURES
			SC	CLAYEY SANDS,SAND-CLAY MIXTURES
FINE GRAINED SOILS LESS THAN 50% PASSING NO. 200 SIEVE	SILTS AND CLAYS LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS & VERY FINE SANDS,ROCK FLOUR SILTY OR CLAYEY FINE SANDS OR CLAYEY SILT W/PI
			CL	INORGANIC CLAY OF LOW TO MEDIUM PI LEAN CLAY, GRAVELY LEAN CLAYS,SANDY LEAN CLAYS,LEAN CLAYS WITH SAND
			OL	ORGANIC SILTS & ORGANIC SILTY CLAYS OF LOW PI
	SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS,MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS
			CH	INORGANIC CLAYS OF HIGH PLASTICITY FAT CLAYS, FAT CLAYS WITH SAND, SANDY FAT CLAYS, FAT CLAYS WITH GRAVEL
			OH	ORGANIC CLAYS OF MED TO HIGH PI, ORGANIC SILT
HIGHLY ORGANIC SOIL			FT	PEAT AND OTHER HIGHLY ORGANIC SOILS
UNCLASSIFIED FILL MATERIALS			ARTIFICIALLY DEPOSITED AND OTHER UNCLASSIFIED SOILS FILL MATERIALS	

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNDRAINED SHEAR STRENGTH IN TSF
VERY SOFT	LESS THAN 0.125
SOFT	0.125 TO 0.25
FIRM	0.25 TO 0.5
STIFF	0.5 TO 1.0
VERY STIFF	1.0 TO 2.0
HARD	GREATER THAN 2.0

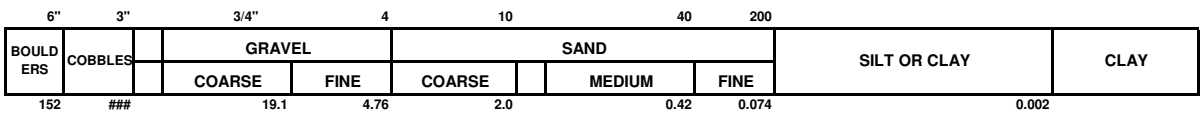
RELATIVE DENSITY - GRANULAR SOILS

CONSISTENCY	N-VALUE (BLOWS PER FT)
VERY LOOSE	0-4
LOOSE	5-10
MEDIUM DENSE	11-30
DENSE	31-50
VERY DENSE	>50 OR 50+

CONSISTENCY	THD-VALUE (BLOWS PER FT)
VERY LOOSE	0-8
LOOSE	8-20
SLIGHTLY COMPACT	20-40
COMPACT	40-80
DENSE	80-5"/100
VERY DENSE	5"/100 - 0"/100

CLASSIFICATION OF GRANULAR SOILS

U.S.STANDARD SIEVE SIZE(S)



GRAIN SIZE IN MM