FINAL
GEOTECHNICAL INVESTIGATION
SANITARY SEWER REPLACEMENT
GEORGE BUSH INTERCONTINENTAL AIRPORT
HOUSTON, TEXAS

SUBMITTED TO
RS&H, INC.
11011 RICHMOND AVENUE, SUITE 900
HOUSTON, TEXAS 77042

BY
HVJ ASSOCIATES, INC.
HOUSTON, TEXAS
DECEMBER 15, 2014

REPORT NO. HG1217962

HVJ ASSOCIATES

Houston
Austin
Dallas
San Antonio

6120 S. Dairy Ashford Rd.
Houston, TX 77072-1010
281.933.7388 Ph
281.933.7293 Fax
www.hvj.com

December 15, 2014

Mr. Broutin Sherrill, PE
RS&H, Inc.
11011 Richmond Avenue, Suite 900
Houston, Texas 77042

Re: Geotechnical Investigation
Sanitary Sewer Replacement
George Bush Intercontinental Airport
Houston, Texas
Owner: Houston Airport System (HAS)
HVJ Project No. HG1217962

Dear Mr. Sherrill:

Submitted herein is the final report of our geotechnical investigation for the above referenced project. The study was conducted in general accordance with our proposal number HG1217962 dated May 6, 2014 (Revised May 30, 2014) and is subject to the limitations presented in this report. We appreciate the opportunity of working with you on this project. Please read the entire report and notify us if there are questions concerning this report or if we may be of further assistance.

Sincerely,

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

NISHANT DAYAL
109464

S. Sanjeevan

Nishant Dayal, PE
Project Manager

Sanjeevan Selvaratnam, EIT
Staff Engineer

ND/SS

Date: 12/15/2014

Copies submitted: 1 (electronic) 2 (hard copies)

The seal appearing on this document was authorized by Nishant Dayal, PE 109464 on December 15, 2014. Alteration of a sealed document without proper notification to the responsible engineer is an offense under the Texas Engineering Practice Act.

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HVJ Associates, Inc. was retained by RS&H, Inc. to provide a geotechnical study for the proposed Sanitary Sewer Replacement at George Bush Intercontinental Airport, Houston, Texas. The project includes replacement of existing 18-inch diameter sanitary sewer line from Terminal A to Chaute Lift Station with 24-inch diameter pipes. It is understood that the proposed invert depths of the sanitary sewer line will range from 20 to 23 feet and proposed invert depths of the manholes will range from 21 to 23 feet below the existing grade. The purpose of this study is to provide design and construction recommendations for the proposed sanitary sewer line and manholes. Based on the subsurface conditions obtained by the soil borings, the findings and recommendations of this report are summarized below:

1. Cohesive and cohesionless soils were encountered above the invert depth of sanitary sewer line. Notably, cohesionless soil layers were encountered on borings B-1 and B-2 at the invert depth of sanitary sewer line and this may cause unstable face conditions for tunneling. Details of the subsurface stratigraphy encountered in the borings are shown on the boring logs presented in Appendix A.

2. Based on our desktop fault study, faulting is not anticipated to impact the project site. However, unmapped faults may exist near the project site. A detailed fault study is not within the scope of this study.

3. Based on the 30-day water level readings, we expect groundwater at a depth of approximately 9 feet below the existing ground throughout the project area.

4. Cohesive and cohesionless soils were encountered at the proposed sanitary sewer line invert depths. Recommendations for replacement of sanitary sewer line using open cut and tunneling techniques are presented in Sections 6 and 7 of this report.

5. Cohesive and cohesionless soils were encountered at the proposed manholes invert depths. Recommendations for the manholes are presented in Section 8 of this report.

Please note that this executive summary does not fully relate our findings and opinions. Those findings and opinions are only presented through our full report.

2 INTRODUCTION

2.1 Project Description

HVJ Associates, Inc. was retained by RS&H, Inc. to provide a geotechnical study for the Sanitary Sewer Replacement at George Bush Intercontinental Airport, Houston, Texas. The project includes replacement of existing 18-inch diameter sanitary sewer line from Terminal A to Chaute Lift Station with 24-inch diameter pipes. It is understood that the proposed invert depths of the sanitary sewer line will range from 20 to 23 feet and proposed invert depth of the manholes will range from 21 to 23 feet below the existing grade. The purpose of this study is to provide design and construction recommendations for the proposed sanitary sewer line and manholes. Based on the subsurface conditions obtained by the soil borings, the findings and recommendations of this report are summarized below:

2.2 Geotechnical Investigation Program

The major objectives of this study were to gather information on subsurface conditions at the site and to provide design and construction recommendations for the proposed sanitary sewer line and manholes. This investigation was performed in general accordance with the City of Houston Department of Public Works and Engineering Infrastructure Design Manual dated July 2012. The objectives were accomplished by:

- Drilling twelve (12) soil borings to a depth of 45 feet below the existing grade to determine soil stratigraphy and to obtain samples for laboratory testing.

- Installing two (2) piezometers to gain an understanding of the groundwater conditions at the site and to evaluate the potential need for dewatering during construction.

- Performing laboratory tests to determine physical and engineering characteristics of the soils.

- Performing engineering analyses to develop design guidelines and construction recommendations for the proposed sanitary sewer line and manholes.

Subsequent sections of this report contain descriptions of the field exploration, laboratory-testing program, general subsurface conditions, design recommendations, and construction considerations.

3 FIELD INVESTIGATION

3.1 Geotechnical Borings

The field exploration program undertaken at the project site was performed between August 18, 2014 and August 23, 2014. Subsurface conditions were investigated by drilling twelve (12) soil borings to a depth of 45 feet below the existing.

All boreholes excluding the ones with piezometers were backfilled with cement grout by tremie method in accordance with the City Guidelines and patched at the surface where applicable. The piezometers will be plugged after obtaining the 30 day water level readings. Approximate boring locations are presented on Plate 2 of the report.

3.2 Survey Data

The coordinates and elevation of borings were provided to us by RS&H, Inc. The coordinates and elevation of borings are presented in Table 3-1 below.

Table 3-1 Survey Data

Boring No.	Northing	Easting	Elevation (feet)
B-1	13,925,169.064	3,123,397.777	89.69
B-2	13,924,608.032	3,123,100.472	90.49
B-3	13,924,164.656	3,122,879.538	88.82
B-4	13,923,676.671	3,123,159.450	87.92
B-5	13,923,197.255	3,123,434.244	89.75
B-6	13,922,576.147	3,123,790.125	87.33
B-7	13,922,312.944	3,123,274.992	88.51
B-8	13,922,105.965	3,122,917.345	85.50
B-9	13,921,814.550	3,122,434.537	87.61
B-10	13,921,377.936	3,121,714.677	89.03
B-11	13,921,162.948	3,121,349.343	85.23
B-12	13,923,380.316	3,123,707.145	91.06

Coordinates shown are referenced to U.S. State Plane Texas South Central Zone, North American Datum 83. Elevations are referenced to North American Vertical Datum (NAVD) 88.

3.3 Sampling Methods

Soil samples were obtained continuously to the termination depth of the borings. Cohesive soil samples were obtained with a three-inch thin-walled (Shelby) tube sampler in general accordance with ASTM D-1587 standard. Each sample was removed from the sampler in the field, carefully examined, and then classified. The shear strength of the cohesive soils was estimated by a hand penetrometer in the field. Cohesionless soils were sampled with the split spoon sampler in accordance with ASTM D 1586 standard. Suitable portions of each sample were sealed and packaged for transportation to our laboratory.

Detailed descriptions of the soils encountered in the borings are given on the boring logs presented in Appendix A. A key to the soils classification and symbols used in the boring logs is also presented in Appendix A.

3.4 Water Level Measurements

Groundwater was measured at all boring locations during drilling operations. Two piezometers were installed at boring locations B-4 and B-8 to obtain the 24-hour, and 30-day water level readings. The piezometer set-up consists of 2-inch PVC screen surrounded by 20/40 sieve filter pack sand below a 2-inch diameter PVC riser which is surrounded by hydrated bentonite pellets. The installed piezometer was flush mounted with steel covers and surrounded in 4-foot by 4-foot by 2-inch concrete pads. Piezometer installation records and groundwater level data are provided in Appendix C. Piezometer "Well Report" and "Plugging Report" are also provided in Appendix C.

4 LABORATORY TESTING

Selected soil samples were tested in the laboratory to determine applicable physical and engineering properties. All tests were performed according to the relevant ASTM Standards. These tests consisted of moisture content measurement, percent passing No. 200 sieve, Atterberg limits, unconsolidated undrained compression and unit dry weight tests.

The Atterberg Limits and percent passing number 200 sieve tests were utilized to verify field classification by the Unified Soils Classification System (USCS), and the unconsolidated undrained compression tests was performed to obtain the undrained shear strength of the soil. The type and number of tests performed for this investigation are summarized below:

Table 4-1 Type and Number of test Performed

Type of Test	Number of Tests
Moisture Content (ASTM D2216)	54
Atterberg Limits (ASTM D4318)	40
Percent Passing No. 200 Sieve (ASTM D1140)	44
Unconsolidated Undrained Triaxial (ASTM D2850)	36

The laboratory test results are presented on the boring logs in Appendix A. The conversion between pocket penetrometer readings obtained in the field to the shear strength parameters presented in the borings logs were obtained using a conversion factor of 1/3. A summary of laboratory test results is provided in Appendix B.

5 SITE CHARACTERIZATION

5.1 General Geology

There are two major surface geological formations that exist in Greater Houston: The Beaumont formation and the Lissie formation. The Beaumont formation is a relatively younger formation generally found to the southeast of the Lissie formation. The Beaumont formation dips southeastward and extends beneath beach sand and waters of the Gulf of Mexico as far as the continental shelf. The project alignment is located in the Lissie formation. A geologic map is presented on Plate 3.

The Lissie formation is heterogeneous, containing interbedded layers of clay, sand and silt. It was deposited in mid-Pleistocene times in shallow coastal river channels and flood plains. The coastal plain in this region has a complex tectonic geology, several major features of which are: Gulf Coastal geosyncline, salt domes, major sea level fluctuations during the glacial stages, subsidence and faulting. Most faulting have ceased for millions of years, but some faults are still active.

5.2 Geologic Faulting

The tectonic history of the Texas Gulf Coast includes a relatively stable depositional cycle since the Cretaceous Period (about 65 million years). During this period the area was subjected to deposition of clays, silts, and sands resulting in over 30 thousand feet of sedimentary rocks. Underlying this clastic sequence are salt formations, which have migrated upwards to produce the typical salt dome features associated with the Texas Gulf Coast. In conjunction with salt movement, dewatering and compaction of some of the deeper sediments in the basin have resulted in the development of growth faults.

A literature review of surface faults near the project area was conducted based on the Bureau of Economic Geology, University of Texas at Austin, Geologic Atlas of Texas Houston Sheet, Paul Weaver Memorial Edition (revised in 1982). The primary objective of this review was to evaluate available information from published and open file reports. Based on our review, the project site is located approximately 3 miles east of Eureka Heights Fault and approximately 1.5 mile west of couple of unnamed faults. Faulting is not anticipated to impact the project site. However, unmapped faults may exist near the project site. A detailed fault study is not within the scope of this study.

5.3 Soil Stratigraphy

HVJ's interpretation of soil and groundwater conditions at the project site is based on information obtained at the boring locations only. This information has been used as the basis for our conclusions and recommendations. Significant variations at areas not explored by the project boring may require reevaluation of our findings and conclusions.

A generalized summary of the subsurface conditions in our borings is shown below in Table 5-1 through Table 5-3. Notably, cohesionless soil layers were encountered in borings B-1 and B-2 within the proposed invert depth of sanitary sewer line and this may cause unstable face conditions for tunneling. Details of the subsurface stratigraphy encountered in the borings are shown on the boring logs presented in Appendix A.

Substantial deviations from the summarized conditions exist at several of the boring locations and should be accounted for in the design and construction recommendations.

Table 5-1 Generalized Soil Profile (Borings B-2 through B-6, B-8 and B-12)

Stratum	Approximate Depth, Feet		Material
	From	To	
I	Surface	2.0	FILL
II	2.0	10.0-14.0	Cohesive Soil (CL)
III	10.0-14.0	16.0-23.0	Cohesionless Soil (SP, SP-SM, SC-SM)
IV	16.0-23.0	45.0	Cohesive Soil (CL, CH)

Table 5-2 Generalized Soil Profile (Borings B-1, B-7, B-9, B-10 and B-11)

Stratum	Approximate Depth, Feet		Material
	From	To	
I	Surface/Bottom of the Pavement	45.0	Cohesive Soil (CL, CL-ML, CH)

Note:

1. Boring B-1 comprised of a silty sand (SM) layer from 12 feet below the existing grade down to 22 feet below the existing grade.
2. Borings B-7 and B-10 comprised of a fill layer from the existing grade down to 2 feet below the existing grade.

Details of the subsurface stratigraphy at specific depths encountered in the borings are shown on the boring logs presented in Appendix A. Soil profile plates along the project alignment is presented in Appendix D.

The Casagrande's Plasticity Chart presented in Figure 5-1 illustrates the range of plasticity of the cohesive soils found during our investigation.

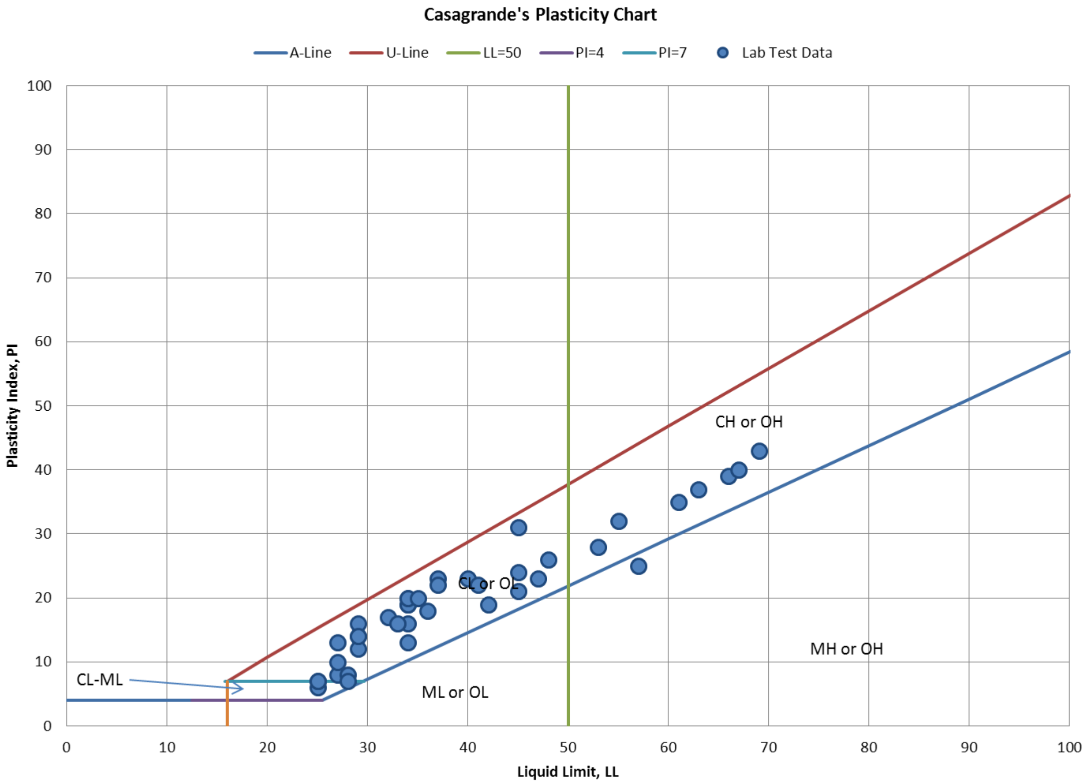


Figure 5-1 Casagrande's Plasticity Chart

5.4 Groundwater Conditions

Groundwater was encountered in borings B-1 through B-11 during drilling operations. Two piezometers were installed at boring locations B-4 (PZ-1) and B-8 (PZ-2) to obtain the 24-hour, and 30-day water level readings. Piezometer installation records are provided in Appendix C. Table 5-2 shows a record of the groundwater readings taken during drilling as well as the piezometer readings after 24 hours.

Table 5-2 Groundwater Observations

Boring No.	**Groundwater Depth First Encountered (feet)**	**Groundwater Reading**	
		Groundwater Depth after 24 Hours (feet)	**Groundwater Depth after 30 Days (feet)**
B-1	13	-	-
B-2	16	-	-
B-3	13.5	-	-
B-4 (PZ-1)	14	13.8	12.8
B-5	13.5	-	-
B-6	13.5	-	-
B-7	14	-	-
B-8 (PZ-2)	14	9.5	8.5
B-9	22	-	-
B-10	32	-	-

Boring No.	Groundwater Depth First Encountered (feet)	Groundwater Reading	
		Groundwater Depth after 24 Hours (feet)	Groundwater Depth after 30 Days (feet)
B-11	26	-	-
B-12	dry	-	-

Based on the 24-hour water level reading, we expect the groundwater to be at a depth of approximately 9 feet below existing ground throughout the project area. Water level for the 30-day reading will be added to the final report. It should be noted that groundwater levels determined during drilling may not accurately reflect the true groundwater conditions, and therefore should only be considered as approximate. Groundwater levels measured in open standpipe piezometers are, on the other hand are more accurate; however, these readings will fluctuate seasonally and in response to rainfall. Other factors that might impact piezometric groundwater levels include leakage from existing water lines, storm sewers and/or sanitary sewers.

6 UTILITY DESIGN CRITERIA AND RECOMMENDATIONS FOR OPEN CUT AND TRENCHLESS TECHNIQUES

6.1 General

The project includes replacement of existing 18-inch diameter sanitary sewer line from Terminal A to Chaute Lift Station with 24-inch diameter pipes. It is understood that the sanitary sewer line will be installed by open cut, tunneling and microtunneling techniques with invert depths from 20 to 23 feet. HVJ's recommendations for the installation of sanitary sewer line using open cut, tunneling and microtunneling techniques are presented below.

6.2 Geotechnical Parameters

Geotechnical design parameters are presented in Table 6-1. Design parameters given in the table are based on field and laboratory test data obtained at boring locations drilled for utilities at the approximate invert depth.

Table 6-1 Utility Design Parameters

Boring No.	Approximate Invert Depth (ft.)	Soil Description at Invert Depth	Total Unit Weight (pcf)	Undrained Shear Strength (psf)	Friction Angle (deg)	Allowable Bearing Capacity (psf)	E'_n, Long Term (psi)
B-1	20-23	Medium Dense Sand	120	-	30	6000	1000
B-2	20-23	Medium Dense Sand	120	-	30	6000	1000
B-3	20-23	Very Stiff Clay	130	3500	-	5900	1000
B-4	20-23	Stiff Clay	125	2000	-	3400	600
B-5	20-23	Stiff Clay	130	1500	-	2500	600
B-6	20-23	Very Stiff Clay	130	2200	-	3700	1000
B-7	20-23	Very Stiff Clay	135	2500	-	4200	1000
B-8	20-23	Very Stiff Clay	130	3000	-	5100	1000
B-9	20-23	Very Stiff Clay	135	2500	-	4200	1000

Boring No.	Approximate Invert Depth (ft.)	Soil Description at Invert Depth	Total Unit Weight (pcf)	Undrained Shear Strength (psf)	Friction Angle (deg)	Allowable Bearing Capacity (psf)	E'_n, Long Term (psi)
B-10	20-23	Very Stiff Clay	130	2500	-	4200	1000
B-11	20-23	Very Stiff Clay	125	2400	-	4000	1000
B-12	20-23	Stiff Clay	125	1800	-	3000	600

The values shown in the above table represent HVJ's interpretation of the soil properties based on the available laboratory and field test data. Use of the soil properties shown above may or may not be appropriate for a particular analysis, since choice of design parameters often depends on whether total or effective stress analysis is used, rate of loading, duration of loading, geometry of loaded area, and other factors. The total unit weight values shown above represent our interpretation of soil unit weight at natural moisture content. The undrained shear strength and allowable bearing capacity values represent our interpretation of the shear strength in clay soils based primarily on the results of unconsolidated undrained compression tests and hand penetrometer tests. The allowable bearing capacity includes a factor of safety of three.

6.3 Pipe Design

The loads imposed on underground pipes depend principally upon the method of installation, the weight of overburden soils, roadway traffic load, and loads due to existing surface structures. For design of rigid pipes installed using open-cut method, loads due to overburden and traffic can be determined from Plate 5.

The traffic load applied to the rigid pipe can be calculated using 85% of wheel load with an impact factor of 1.5 for one foot of soil cover, 50% of wheel load with an impact factor of 1.35 for 2 feet of cover, and 30% of wheel load with an impact factor of 1.15 for 3 feet of cover. This results in a total design traffic load on the pipe or manhole of about 1.28, 0.68 and 0.35 times the wheel load for 1, 2 and 3 feet of cover, respectively. For pipes with four or more feet of cover, the traffic loads may be taken as a surcharge equivalent to 250 psf.

6.4 Open Cut Bedding and Backfill

Pipe Bedding: Placing and compaction of embedment material should be in accordance with Section 02317, Items 3.08 and 3.09. If water bearing sands are encountered during excavation, we recommend groundwater control in accordance with Section 01578 of City of Houston Standard Specification to achieve stable trench conditions.

Trench Backfill: Trench backfill (initial backfill to the pavement base or subgrade) for utilities should be in accordance with Section 02317, Excavation and Backfill for Utilities, of the City of Houston Standard Specifications, January 2011.

As specified in Section 02317 item 3.09, for sanitary sewer pipe with diameter less than 36-inches, cement stabilized sand should be used as backfill material up to pavement. Select backfill with criteria discussed above should be used as 12-inch backfill under rigid pavements or flexible base material for asphalt pavements.

Fill material should be placed in loose lifts not exceeding eight inches, and should be compacted to 95 percent of the standard Proctor maximum dry density as determined by ASTM D 698 as specified City of Houston Standard Specifications, Section 02317. However, the backfill up to 12 inches above the top of the pipe should be compacted carefully so as to prevent structural damage to the pipe.

6.5 Utilities Installed by Trenchless Technique

HVJ understands that trenchless construction methods may be used to install the water line. It is understood that the trenchless techniques may consist of tunneling and microtunneling.

Pipe Design using Tunneling or Microtunneling Techniques: The sanitary sewer line may need to be installed by Microtunneling or Tunneling.

Microtunneling or Tunneling at a planned invert depth of 20-23 feet is expected to be in cohesionless soil near borings B-1 and B-2 of project area. Based on the 30-day water level readings, we expect groundwater at a depth of approximately 9 feet below the existing ground throughout the project area. The bore will be below the water table with about 11-14 feet of head above the crown.

We expect stable face conditions for tunneling in firm to hard clay. However, some bore instability may be encountered due to groundwater seepage. Tunneling equipment should be selected that is suitable for maintaining stable face below the groundwater table.

Geotechnical Properties: Recommended ranges of engineering design soil parameters for the cohesive soils that may be encountered in the pipe zone are summarized below.

For cohesive soils:

Total Unit Weight	122 – 133 pcf
Coefficient of Earth Pressure, K_o	0.7-1.0
Undrained Shear Strength	1000 – 3000 psf
Poisson's Ratio	0.40-0.49
Young's Modulus	2000 to 14000 psi

For pipes to be installed by jacking, whereby sections of pipe are jacked forward against the surrounding soil, pipes should be designed to resist significant bending moments, along with the jacking forces exerted on the pipe during installation. These loads generally exceed the overburden pressures that are typically determined based on the prism earth load to the ground surface, plus hydrostatic pressure and surcharge loads as shown on Plates 5A&5B. Therefore, pipes designed to resist construction loads during jacking operations should have adequate strength for most long-term overburden and traffic loads.

For pipes installed inside a primary liner the pipe design should be based on the prism earth load to the ground surface, plus hydrostatic and surcharge loads as shown on Plates 5A&5B and discussed in section 6.3.

During design, allowance should be made for any external loads, other than soil loads, which may be exerted on the pipe. These include loads from foundations for structures located near the sanitary sewer line and any possible future excavation to be performed near the pipelines.

Loss of Ground: Loss of ground refers to excess excavation during advancement of the bore, i.e. more ground is excavated at the face than the intended cylindrical volume of the bore itself. Some ground loss should be expected during any tunnel or microtunnel construction operation, and will cause settlement of the ground above the bore. With good construction techniques, ground loss can be held to acceptable levels. A properly designed and controlled microtunnel operation can eliminate or reduce immediate soil movement and subsidence to a tolerable level. Generally, bores constructed beneath pavement and buried utilities can be expected to create a loosened subgrade or bedding condition which may lead to subsequent deformations.

Large ground loss can result from uncontrolled flowing ground. The potential for such ground loss exists wherever water-bearing sands are encountered along the alignment. Careful dewatering of such layers will reduce the potential for development of flowing conditions, but local experience shows that complete dewatering is difficult to achieve. First, it is difficult to fully dewater the base of a permeable layer immediately above an impermeable layer. Second, due to the interbedded nature of the soils, all the water-bearing zones may not be intercepted even by closely spaced wells. Either of these conditions can result in the presence of unstable water-bearing soils even though a dewatering system has been installed. We did not encounter these conditions in the borings, however, some risks exists whenever boring beneath the groundwater table without dewatering in local soils.

<u>Influence of Microtunneling or Tunneling on Adjacent or Overlying Structures:</u> The construction of every microtunnel in soils is associated with a change in the state of stress in the ground and with the corresponding strains and displacement. In particular, some degree of settlement of the overlying ground surface is always induced. If such settlement, referred to as subsidence, is excessive, it may cause damage to structures, runways, taxiways and services located above the microtunnel or tunnel.

It should be noted that the existing foundation of the nearby structures and buried portion of existing pipelines within the zone of influence of the tunnel might be subject to possible distress due to tunnel-induced settlement. The zone of influence extends for a distance on either side of the centerline equal to the depth to the tunnel invert on level ground. While the recommendations we are providing intend to reduce the settlement and distress to these structures and pipelines within the zone of influence, they still should be monitored before and for a period after tunneling operations are completed. Generally, settlements due to tunneling are not anticipated after the tunneling operations are completed.

In order to minimize settlement due to tunneling operations the contractor should use well-established techniques and provide temporary support, by advancing the primary liner continuously, as tunneling progresses. No voids should be allowed between any temporary support and the surrounding soils, and with that purpose the injection of cement grout should be considered if it is deemed necessary to fill the voids.

7 UTILITY CONSTRUCTION RECOMMENDATIONS

7.1 General

This section is intended to address issues that might arise during construction. HVJ's recommendations are intended for use as guidelines in dealing with particular soil conditions. The topics addressed in this section include trench excavation stability, groundwater control, and open-cut construction considerations.

The recommendations contained herein are not intended to dictate construction methods or sequences. Instead they are provided solely to assist designers in identifying potential construction problems related to excavation, based upon findings derived from sampling. Depending upon the final design chosen for the project, the recommendations may also be useful to personnel who observe construction activity.

Prospective contractors for the project must evaluate potential construction problems on the basis of their review of the contract documents, their own knowledge of and experience in the local area, and on the basis of similar projects in other localities, taking into account their own proposed methods and procedures.

7.2 Open Cut Excavation Considerations

Excavations should satisfy two requirements. First, the soils above final grade must be removed without disturbing the soil below, which will support constructed facilities. Second, the sides of the excavation must be stable to prevent damage to adjacent streets and facilities as a result of either vertical or lateral movements of the soil. In addition, a satisfactory excavation procedure must include an adequate construction dewatering system to lower and maintain the water level at least a few feet below the lowest excavation grade.

Excavation Stability. Excavations shall be shored, laid back to a stable slope or some other equivalent means may be used to provide safety for workers and adjacent structures. Earth pressures for braced excavations are presented on Plates 5A & 5B. Assessment of the need for excavation sloping, use of trench boxes, or other measures required to provide a stable excavation, and the use of appropriate construction practices and/or equipment is the contractor's responsibility. The following comments are intended to represent common solutions to stability problems encountered in similar soil conditions in the Houston area, and may not be construed as excavation system design recommendations. The excavation operations shall be performed in accordance with 29 CFR Part 1926 subpart P, as amended, including rules published in the Federal Register, Vol. 54, No. 209, dated October 31, 1989, as a minimum. In addition, the provisions of legislation enacted by the Texas Legislature and City of Houston should be satisfied. Table 7-1 shows the classification of soils for excavations according to OSHA standards.

Table 7-1 OSHA Soil Type

Boring No.	OSHA Soil Type			
	Depth of Trench (ft.)			
	0 – 5	5 – 10	10-15	15 – 20
B-1	B	C	C	C
B-2	C	C	C	C
B-3	C	C	C	C
B-4	C	C	C	C
B-5	C	C	C	C
B-6	C	C	C	C
B-7	C	C	C	C
B-8	C	C	C	C
B-9	B	C	C	C
B-10	C	C	C	C
B-11	B	C	C	C
B-12	C	C	C	C

We recommend that a professional engineer should design temporary support for trenches deeper than 20 feet, and that the OSHA tables are not used below this depth.

In general, it is HVJ's opinion that the pressure distribution (for braced walls) should be used for design of sheeting or trench boxes. To reduce the potential for ground movement adjacent to the top of the excavation, the bracing should be preloaded in stages as the excavation is deepened. The detailed earth pressure diagrams are presented on Plates 5A & 5B.

The planned construction may be performed along alignments near existing utility installations (either crossing or paralleling the new alignments). The contractors should be aware of potential excavation stability problems while working in the vicinity of old trenches and the excavation system should be designed to accommodate this weak material (trench backfill).

The vertical walls of excavations should be located a safe distance from existing utilities in order to prevent movement in the soil mass behind the excavation that may adversely affect the utilities. We recommend that the horizontal distance of existing utilities should be greater than their vertical distance from the bottom of excavation.

7.3 Pit Construction Recommendations

It is our understanding that pits constructed for trenchless operations will vary in size depending on whether the pit is a drive or receive pit, size of machine, and length of pit. Pit construction should be in accordance with City of Houston Standard Specification 02447. Pit should be backfilled in accordance with City of Houston Standard Specification 02317.

Pit Excavation Stability: Pit excavations shall be shored or some other equivalent means may be used to provide safety for workers and adjacent structures. Assessment of the need for excavation shoring or other measures required to provide a stable excavation, and the use of appropriate construction practices and/or equipment is the contractor's responsibility.

The lateral earth pressures recommended for short-term design are generally lower than the long-term pressures as the state of stress in the soil changes from "at rest" to "active" conditions immediately after excavation. In calculating the "design" lateral earth pressures, a combination of lateral soil pressures; hydrostatic water pressures; and surcharge loads need to be considered. We recommend that a trapezoidal pressure distribution be used for the lateral soil pressure, and that the hydrostatic water pressure be computed by assuming the groundwater table to coincide with the ground surface. Calculation of these pressure components is explained on Plates 5A & 5B.

Pit Bottom Stability: Bottom instability results from inadequate shear strength in clay soils to resist stress relief at the base of the excavation, or from piping of water bearing granular soil. This mode of failure results in the loss of ground at the ground surface outside the pit and heave of the excavation base inside the pit. Pits are typically excavated approximately 4 feet below pipe invert depth. It is anticipated that the base of pit excavations will be in stiff to hard clay in the vicinity of borings B-1 through B-12. Our calculations indicate that pits in cohesive soils along will have a factor of safety against bottom heave in excess of 3.0. Our calculations assume that adequate dewatering has been performed to bring the water level to at least three feet below the base of the excavation.

Loss of Ground: Installation of pits may experience some loss of ground around the outside of the excavation due to sloughing of material into the excavation. If proper construction procedures are followed, little or no loss of ground should occur. If loss of ground is excessive, it may cause damage to structures, pavement and services located near the excavation. If loss of ground does occur, soft disturbed soils may develop beneath existing pavement and utilities located close to the excavation location.

Corrective measures to address loss of ground problems often include improved dewatering and/or grouting around the pit from the ground surface or within the pit. Repairs associated with loss of ground often include replacement of paving near the top of the pit, and making up for ground loss through placement of cement stabilized sand fill.

Groundwater Control: Pits for the utilities are anticipated to be in cohesive and cohesionless soils. Based on the piezometric readings and proposed invert depths, pits are anticipated to be constructed in wet conditions. Groundwater control can be performed as discussed in Section 7.6.

7.4 Select Fill and General Earthwork Recommendations

The select fill required to rise the grade or backfill should consist of sandy clay with a liquid limit less than 40 and a plasticity index between 8 and 20. Fill material that is used should be placed in loose lifts not exceeding eight inches and should be compacted to 95 percent of Standard Proctor maximum dry density as determined by ASTM D698.

7.5 Spoil Disposal

Spoil from construction will be generated from trench excavations. Soils that will be excavated from this project area will consist primarily of cohesive soils. Economically, possible uses of the cohesive spoil material may be limited to land reclamation, site grading, and final cover in sanitary landfill operations. These soils may not be suitable for use in engineered fill.

7.6 Groundwater Control

Based on our field investigation, groundwater seepage is expected during excavation at the invert depths of the utilities. Assessment of the need for groundwater control and installation of appropriate dewatering equipment is the contractor's responsibility at the time of construction. The following comments are intended to represent common solutions to groundwater control problems encountered in similar soil conditions in the Houston area, and may not be construed as dewatering system design recommendations. A conventional pump and sump arrangement may be adequate if water bearing cohesive soils are encountered during trench excavations. Well points or eductors may be utilized to lower the groundwater level to at least three feet below the excavation level where water bearing cohesionless soils are encountered. Well points are generally not effective below about 15 feet beneath the top of the well point, and deeper dewatering requires deep wells with submersible pumps and eductors.

Water bearing cohesionless soils were encountered in borings B-1, B-2 and B-6. Substantial head may exist in water bearing sands near borings B-1, B-2 and B-6 of the project area. Based on the 30-day water level readings, we expect groundwater at a depth of approximately 9 feet below existing ground throughout the project area. Based on these observations, we expect well point or educator dewatering may be necessary throughout the project area. Control of groundwater should be accomplished in a manner that will preserve the strength of the foundation soils, will not cause instability of the excavation, and will not result in damage to existing structures. Where necessary, the water will be lowered in advance of excavation by pump and sump arrangement, wells, well points, or similar methods. Open pumping should not be permitted if it results in boils, loss of fines, softening of the subgrade, or excavation instability. Discharge should be arranged to facilitate sampling by the owner's representative or engineer.

8 MANHOLE DESIGN RECOMMENDATIONS

8.1 General

The project involves construction of manholes near borings B-1, B-3, B-5, B-6, B-9, B-10 and B-11 at invert depths range from 21 to 23 feet below the existing grade. We have utilized the soils information from nearest borings to develop recommendations for the proposed manholes. Design guidelines and recommendations for the proposed manholes are discussed in the following sections.

8.2 Geotechnical Parameters

Geotechnical parameters for design are presented in Table 8-1. Soil parameters given in the table are based on field and laboratory data obtained at nearest boring location only within the given invert depth zone. It must be noted also that because of the nature of soil deposits, parameters at locations away from the borings may vary substantially from values reported in Table 8-1.

Table 8-1 Manholes Allowable Bearing Capacity

Boring No.	Approximate Invert Depth (ft.)	Soil Description at Invert Depth	Total Unit Weight (pcf)	Undrained Shear Strength (psf)	Friction Angle (deg)	Allowable Bearing Capacity (psf)
B-1	21-23	Medium Dense Sand	120	-	30	6000
B-3	21-23	Very Stiff Clay	130	3500	-	5900
B-5	21-23	Stiff Clay	130	1500	-	2500
B-6	21-23	Very Stiff Clay	130	2200	-	3700
B-9	21-23	Very Stiff Clay	135	2500	-	4200
B-10	21-23	Very Stiff Clay	130	2500	-	4200
B-11	21-23	Very Stiff Clay	125	2400	-	4000

The values shown in the above table represent our interpretation of the soil properties based on the available laboratory and field test data. Use of the soil properties shown above may or may not be appropriate for a particular analysis since choice of design parameters often depends on whether total or effective stress analysis is used, rate of loading, duration of loading, geometry of loaded area, and other factors. The total unit weight values shown above represent our interpretation of soil unit weight at natural moisture content.

8.3 Lateral Earth Pressure

The soil pressure exerted on manhole wall is mainly a function of the type of backfill and its method of placement. Over-compaction of backfill behind walls and utilization of highly plastic expansive clay backfill are practices that generally produce the highest wall pressures. In these cases, horizontal earth pressures exceeding the vertical earth pressure can be expected. Design at-rest lateral pressures for manhole structure walls may be calculated for each backfill type using the equivalent fluid densities for drained level backfill as stated in the following Table.

Table 8-2 Lateral Earth Pressure for Manhole Backfill

Fill Type	Equivalent Fluid Density (pcf)
Cohesive Soil (PI<20)	78
Bank Sand	59
Cohesive Soil (PI >20)	82
Cement Stabilized Sand	52

Over-compaction of the backfill should be avoided to prevent the increase of lateral earth pressures on the structure. The recommended design pressures do not include a groundwater pressure component.

8.4 Bedding and Backfill for Manholes.

Placing and compaction of embedment material should be in accordance with City of Houston Standard Specifications Section 02317, Items 3.08 and 3.09. We recommend that cement stabilized sand be used as backfill material and as specified in Section 02317, Item 3.09. Fill material should be placed in loose lifts not exceeding eight inches, and should be compacted to 95 percent of the standard Proctor maximum dry density as determined by ASTM D 698 and as specified City of Houston Standard Specifications, Section 02317.

8.5 Foundation Replacement.

In case the allowable bearing capacity beneath the manhole is not enough to withstand the bearing pressure, 1-2 feet of foundation soil replacement (cement stabilized sand) is recommended.

Replacement soil should be placed in loose lifts not exceeding eight inches, and should be compacted to 95 percent of the standard Proctor maximum dry density as determined by ASTM D 698 and as specified City of Houston Standard Specifications, Section 02317.

9 MONITORING

9.1 Excavation Safety

As required under OSHA regulations, the contractor should provide a "competent person" to inspect trench excavations daily before the start of work, as needed during the shift, and after every rainstorm or other hazard increasing occurrence. When the competent person finds evidence of a hazardous condition, exposed workers should be removed from the hazardous area until the necessary precautions have been taken to ensure their safety. A competent person means one who is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous or dangerous to workers, and who has authorization to take prompt corrective measures to eliminate them.

9.2 Construction Materials Testing

HVJ recommends that backfill be monitored by an accredited testing laboratory to verify that construction is performed in conformance with project specifications. HVJ routinely provides materials testing verification and observation services and would be pleased to do so for this project.

10 DESIGN REVIEW

HVJ should be retained to review the final design plans and specifications for this project to determine whether the geotechnical recommendations have been properly interpreted, and to confirm that the assumptions made at the time this report was prepared are consistent with the project as finally design.

11 LIMITATIONS

This investigation was performed for the exclusive use of RS&H, Inc. to provide geotechnical recommendations for the Sanitary Sewer Replacement at George Bush Intercontinental Airport, Houston, Texas. HVJ has endeavored to comply with generally accepted geotechnical engineering practice common in the local area. HVJ makes no warranty, express or implied. The analyses and recommendations contained in this report are based on data obtained from subsurface exploration, laboratory testing, the project information provided to us and our experience with similar soils and area conditions. The methods used indicate subsurface conditions only at the specific locations where samples were obtained, only at the time they were obtained, and only to the depths penetrated. Samples cannot be relied on to accurately reflect the strata variations that usually exist between sampling locations. Should any subsurface conditions other than those described in our boring logs be encountered, HVJ should be immediately notified so that further investigation and supplemental recommendations can be provided.

12 REFERENCES

1. City of Houston Department Of Public Works And Engineering (July 2012) "Infrastructure Design Manual"

PLATES

1 inch = 8904 feet

CITY OF HOUSTON

Department of Public Works and Engineering

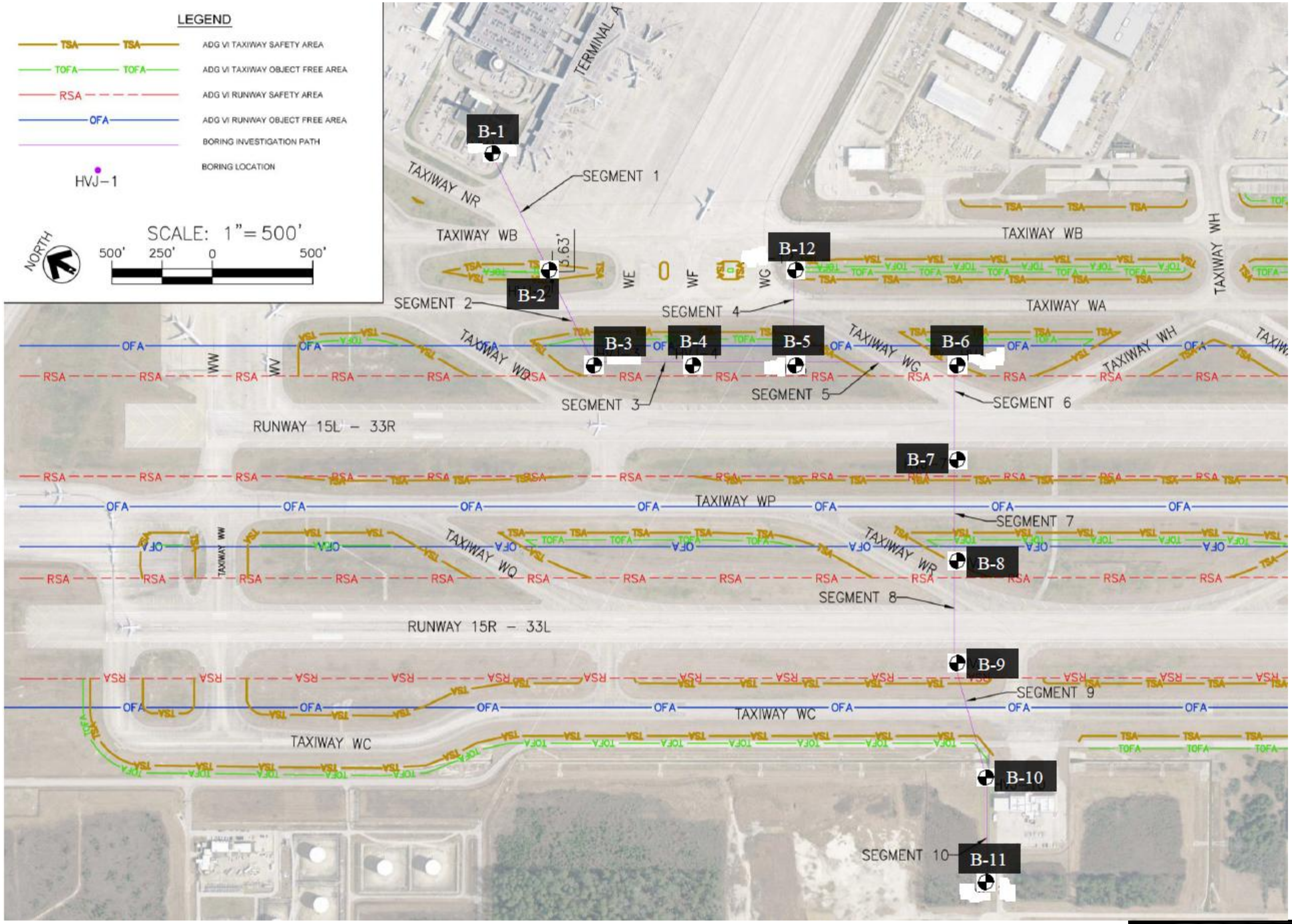
Geographic Information & Management System (GIMS)

HVJ ASSOCIATES
6120 S. Dairy Ashford Road
Houston, Texas 77072-1010
281.933.7388 Ph
281.933.7293 Fax

DATE: 09/10/2014	APPROVED BY: ND	PREPARED BY: SS

SITE VICINITY
SANITARY SEWER REPLACEMENT
GEORGE BUSH INTERCONTINENTAL AIRPORT

PROJECT NO.: HG1217962	DRAWING NO.: PLATE 1



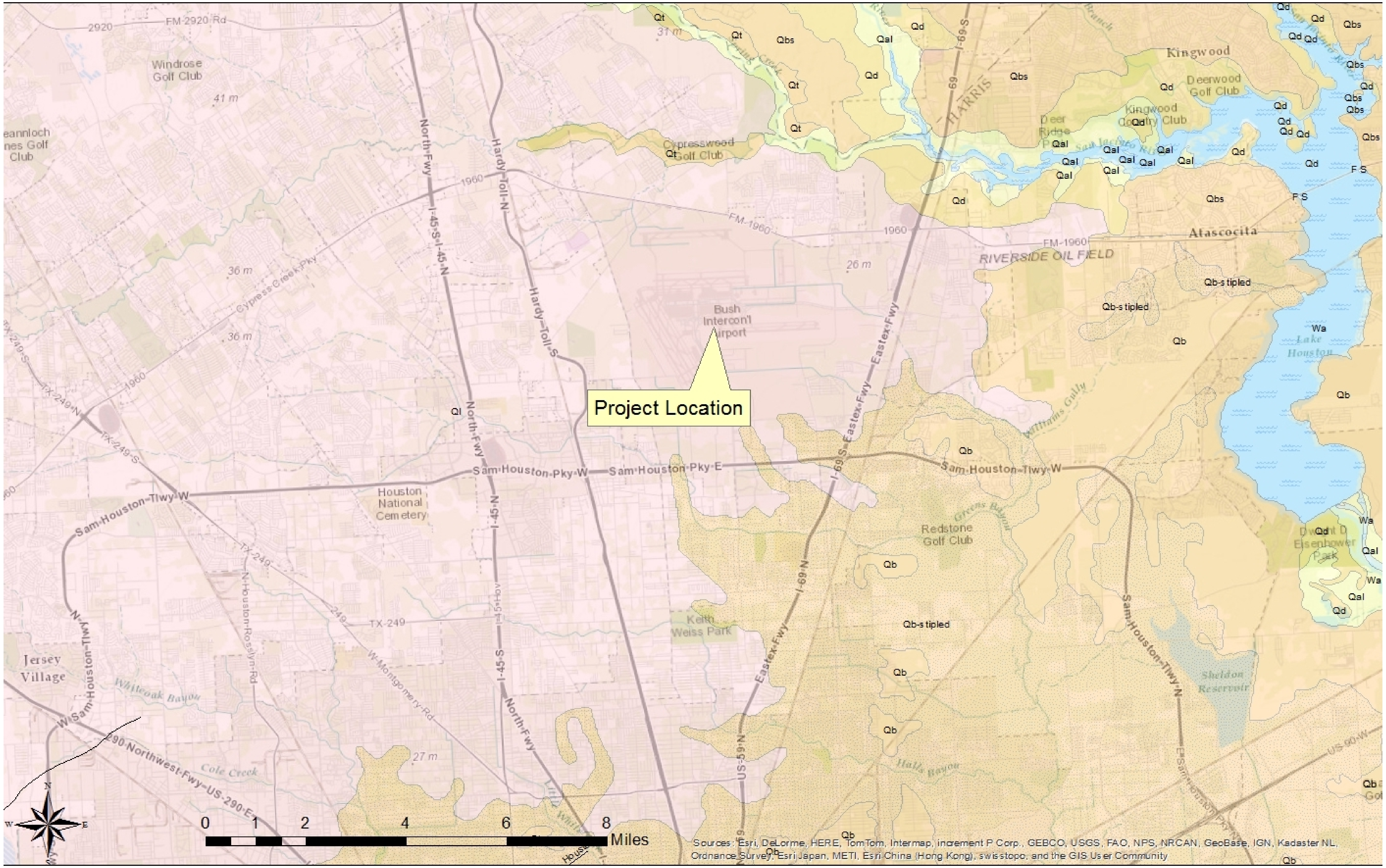
HVJ ASSOCIATES

6120 S. Dairy Ashford Road
Houston, Texas 77072-1010
281.933.7388 Ph
281.933.7293 Fax

DATE: 09/10/2014	APPROVED BY: ND	PREPARED BY: RE

PLAN OF BORINGS
SANITARY SEWER REPLACEMENT
GEORGE BUSH INTERCONTINENTAL AIRPORT

PROJECT NO.: HG1217962	DRAWING NO.: PLATE 2



🟥 Ql

Lissie Formation - Upper part, clay, slit, sand, and very minor siliceous gravel of granule and small pebble size gravel more abundant northwestward, locally calcareous, concretions of calcium carbonate, iron oxide, and iron-manganese oxides common in zone of weathering; fluviatile; surface fairly flat and featureless except for numerous rounded shallow depressions and pimple mounds, bower part, clay, silt, sand,

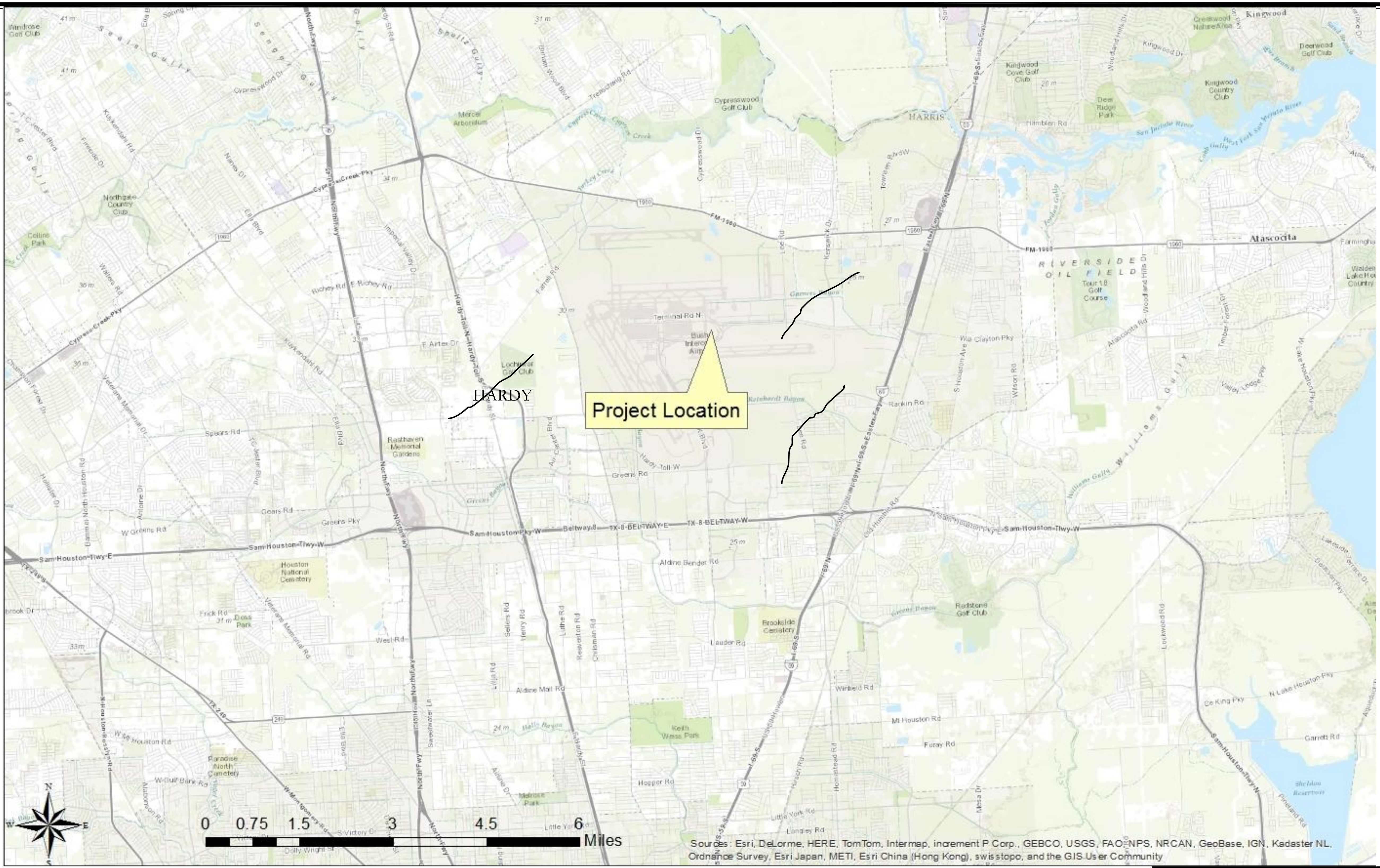
HVJ ASSOCIATES

6120 S. Dairy Ashford Road
Houston, Texas 77072-1010
281.933.7388 Ph
281.933.7293 Fax

DATE: 09/10/14	APPROVED BY: ND	PREPARED BY: SS

GEOLOGIC MAP
SANITARY SEWER REPLACEMENT
GEORGE BUSH INTERCONTINENTAL AIRPORT

PROJECT NO.: HG1217962	DRAWING NO.: PLATE 3



Sources: Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community

HVJ
ASSOCIATES

6120 S. Dairy Ashford Road
Houston, Texas 77072-1010
281.933.7388 Ph
281.933.7293 Fax

DATE: 09/10/14

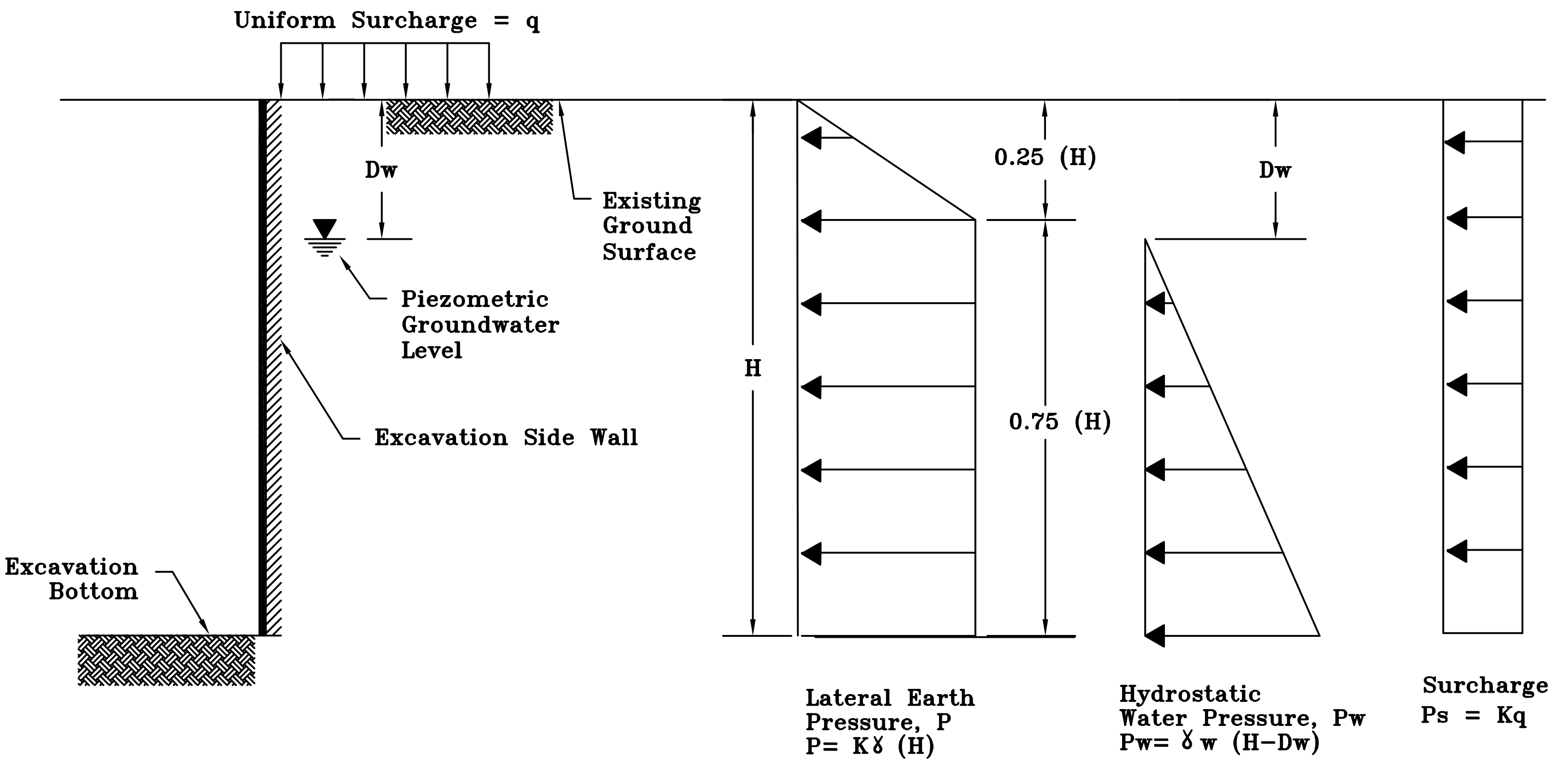
APPROVED BY:
ND

PREPARED BY:
SS

FAULT MAP
SANITARY SEWER REPLACEMENT
GEORGE BUSH INTERCONTINENTAL AIRPORT

PROJECT NO.:
HG1217962

DRAWING NO.:
PLATE 4



H, (ft) = Depth to Excavation Bottom

Ps, (psf) = Surcharge loading adjacent to Excavation wall

Dw, (ft) = Depth to groundwater below Existing grade

= Zero for temporary excavation

K = Lateral Earth Pressure coefficient

= Ka "active" for short−term conditions (use 0.50)

= Ko "at rest" for long−term conditions (use 1.0)

γ, (pcf) = Total unit weight above water table or submerged unit weight below groundwater level

γw, (pcf) = Unit weight of water = 62.4 pcf

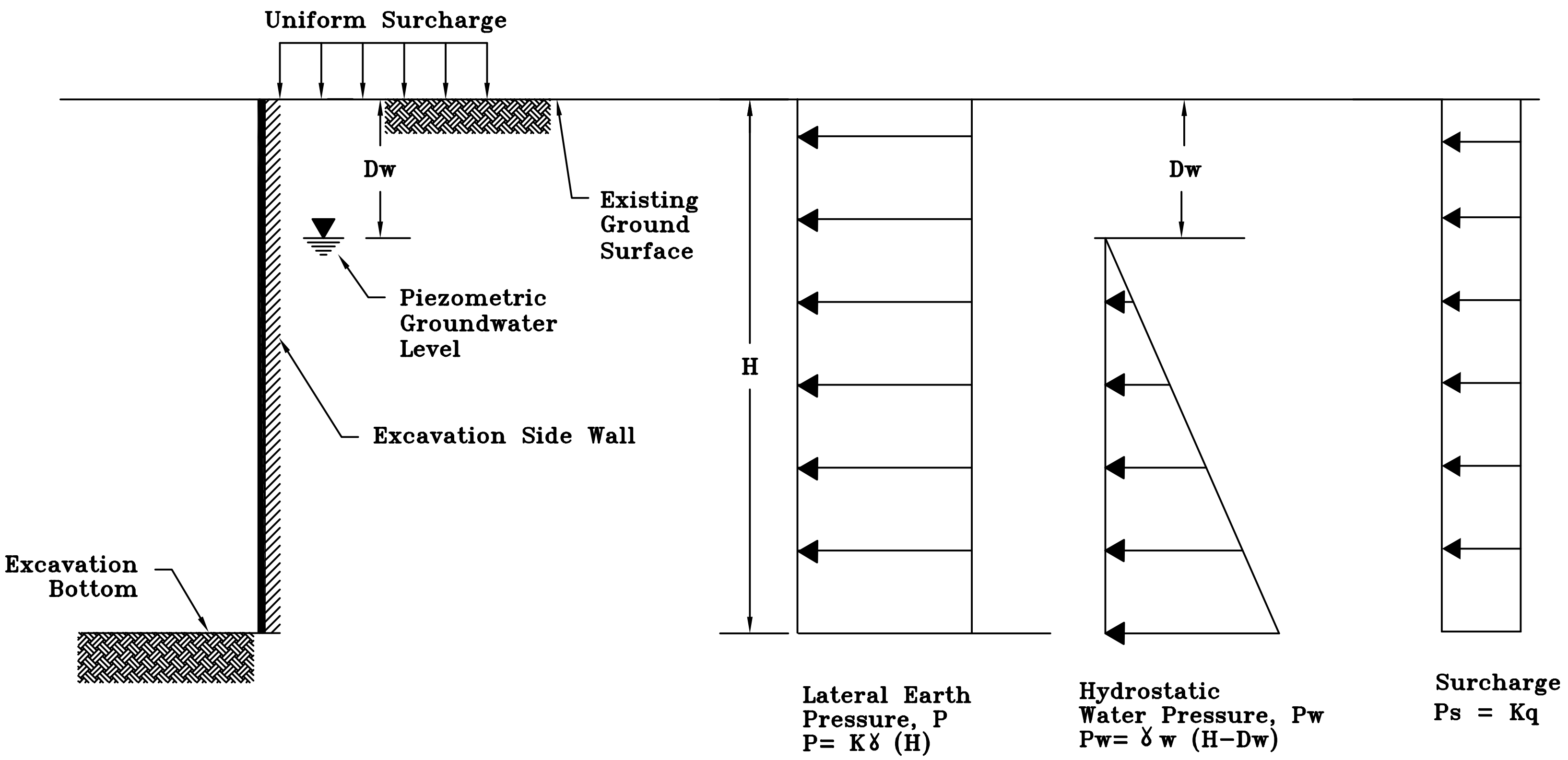
Note: **The pressure diagram shown is not appropriate for design of cantilever walls.**

HVJ ASSOCIATES

6120 S. Dairy Ashford Road
Houston, Texas 77072-1010
281.933.7388 Ph
281.933.7293 Fax

BRACED EXCAVATION
LATERAL EARTH PRESSURE DIAGRAM (CLAY)

PROJECT NO.:	DRAWING NO.:
HG1217962	PLATE 5A



H, (ft) = Depth to Excavation Bottom

Ps, (psf) = Surcharge loading adjacent to Excavation wall

Dw, (ft) = Depth to groundwater below Existing grade
= Zero for temporary excavation

K = Lateral Earth Pressure coefficient
= Ka "active" for short-term conditions (use 0.35)
= Ko "at rest" for long-term conditions (use 0.50)
γ, (pcf) = Total unit weight above water table or submerged unit weight below groundwater level
γw, (pcf) = Unit weight of water = 62.4 pcf

Note: **The pressure diagram shown is not appropriate for design of cantilever walls.**

HVJ ASSOCIATES
6120 S. Dairy Ashford Road
Houston, Texas 77072-1010
281.933.7388 Ph
281.933.7293 Fax

BRACED EXCAVATION
LATERAL EARTH PRESSURE DIAGRAM(SAND/SILT)

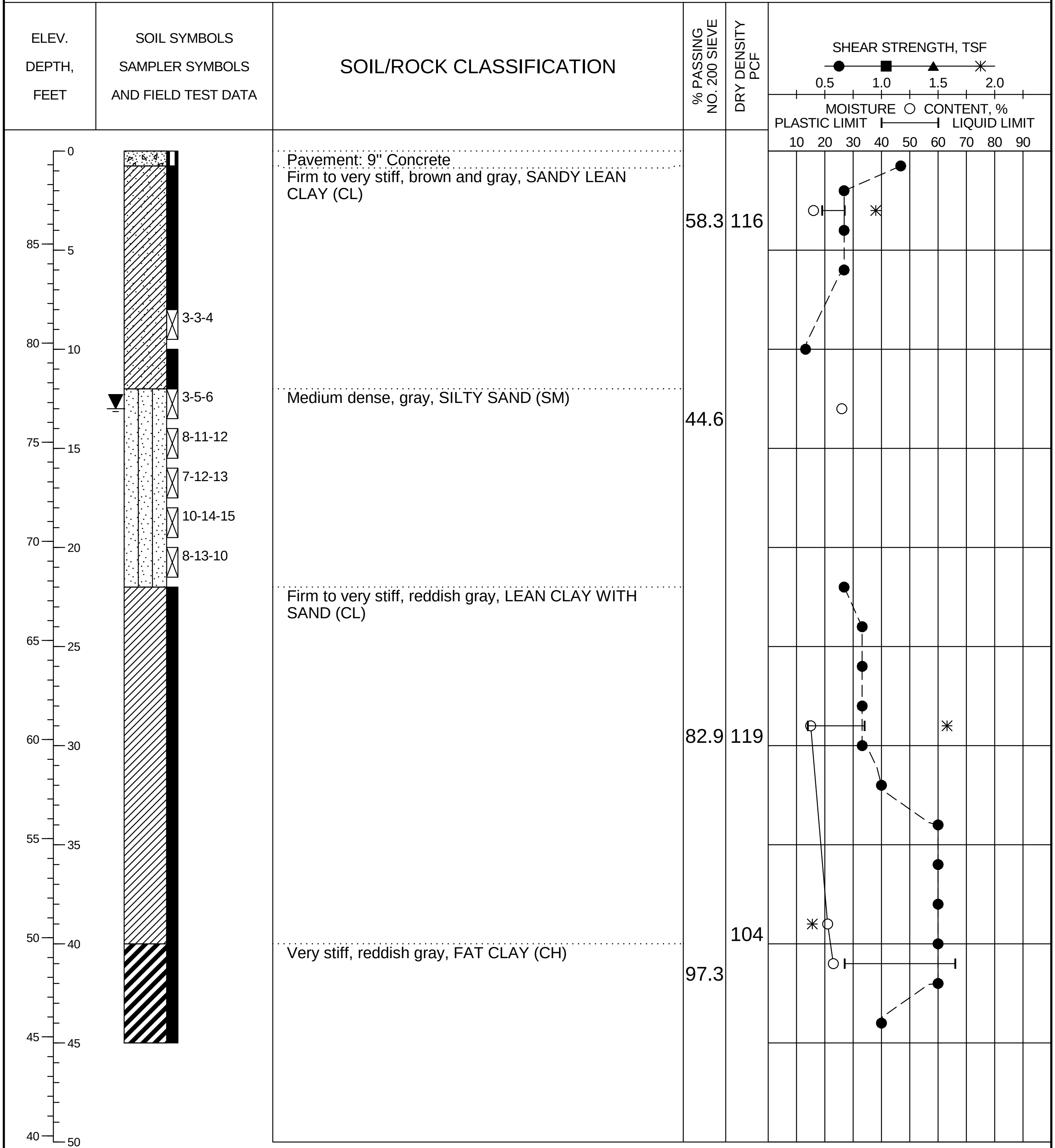
PROJECT NO.: HG1217962
DRAWING NO.: PLATE 5B

APPENDIX A

BORING LOGS AND KEY TO TERMS & SYMBOLS

LOG OF BORING

Project: Sanitary Sewer Replacement
Project No.: HG1217962
WBS No.:
Boring No.: B-1
Date: 8/23/2014
Elevation: 89.6914 feet
Groundwater during drilling: 13 feet
Northing: 13,925,169.1
Station: --
Groundwater after 24 hrs: ---
Easting: 3,123,397.8
Offset: --



Pavement: 9" Concrete

Firm to very stiff, brown and gray, SANDY LEAN CLAY (CL)

Medium dense, gray, SILTY SAND (SM)

Firm to very stiff, reddish gray, LEAN CLAY WITH SAND (CL)

Very stiff, reddish gray, FAT CLAY (CH)

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

PLATE A-1

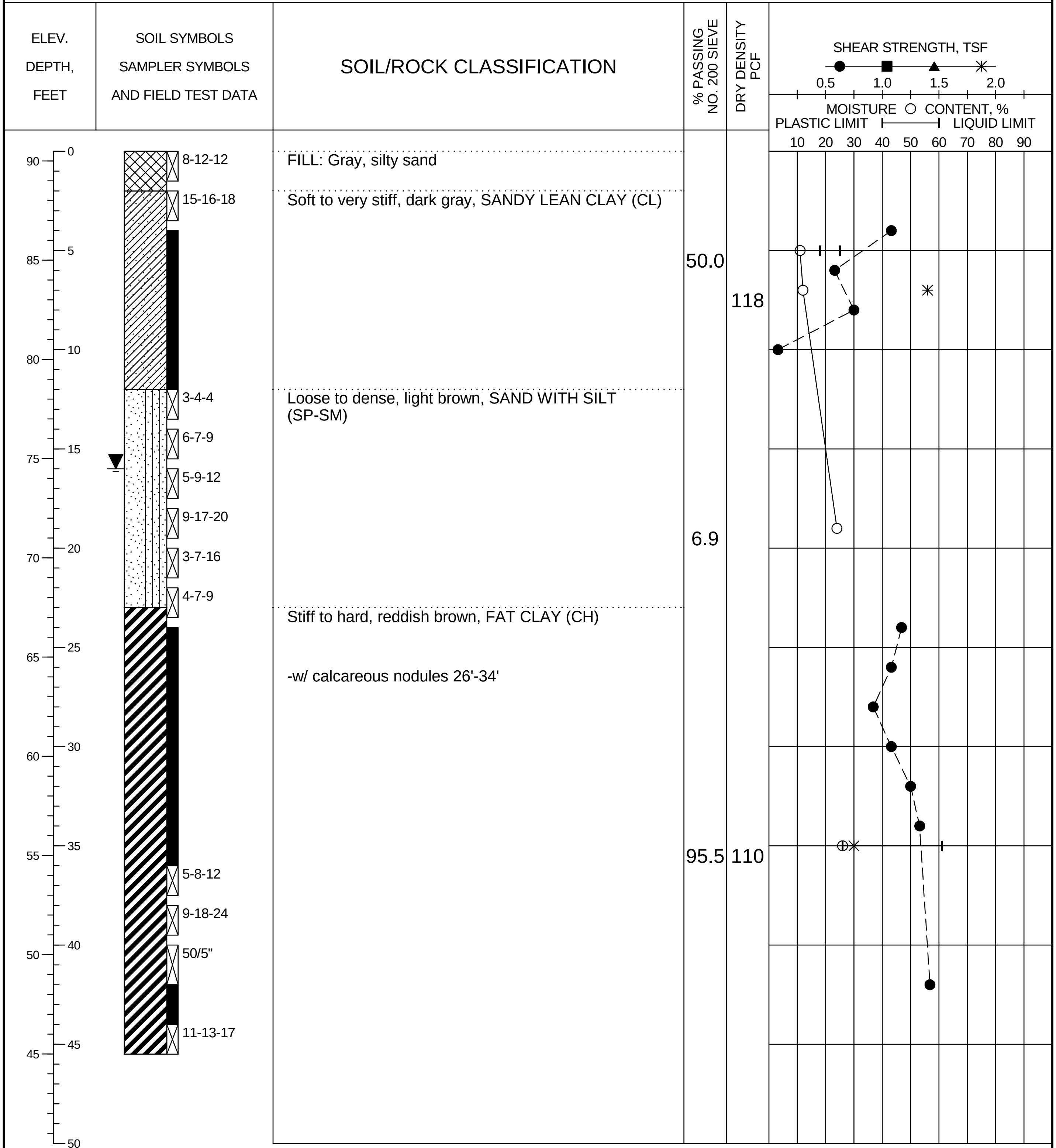
HVJ ASSOCIATES

LOG OF BORING

Project: Sanitary Sewer Replacement
Boring No.: B-2
Groundwater during drilling: 16 feet
Groundwater after 24 hrs: ---

Project No.: HG1217962
Date: 8/23/2014
Northing: 13,924,608.0
Easting: 3,123,100.5

WBS No.:
Elevation: 90.48919 feet
Station: --
Offset: --



FILL: Gray, silty sand

Soft to very stiff, dark gray, SANDY LEAN CLAY (CL)

Loose to dense, light brown, SAND WITH SILT (SP-SM)

Stiff to hard, reddish brown, FAT CLAY (CH)

-w/ calcareous nodules 26'-34'

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

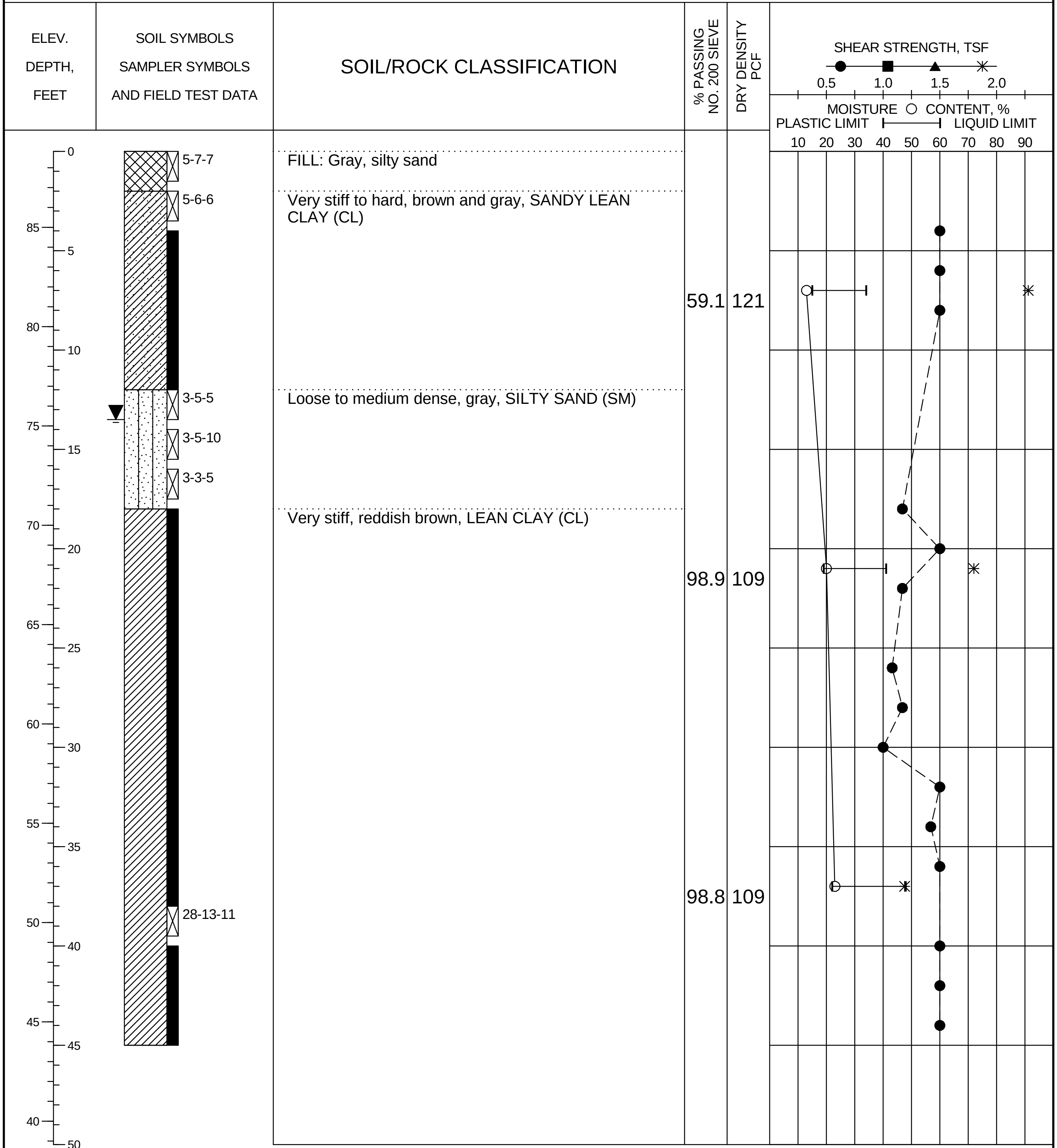
PLATE A-2

LOG OF BORING

Project: Sanitary Sewer Replacement
Boring No.: B-3
Groundwater during drilling: 13.5 feet
Groundwater after 24 hrs: ---

Project No.: HG1217962
Date: 8/20/2014
Northing: 13,924,164.7
Easting: 3,122,879.5

WBS No.:
Elevation: 88.82198 feet
Station: --
Offset: --



FILL: Gray, silty sand

Very stiff to hard, brown and gray, SANDY LEAN CLAY (CL)

Loose to medium dense, gray, SILTY SAND (SM)

Very stiff, reddish brown, LEAN CLAY (CL)

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

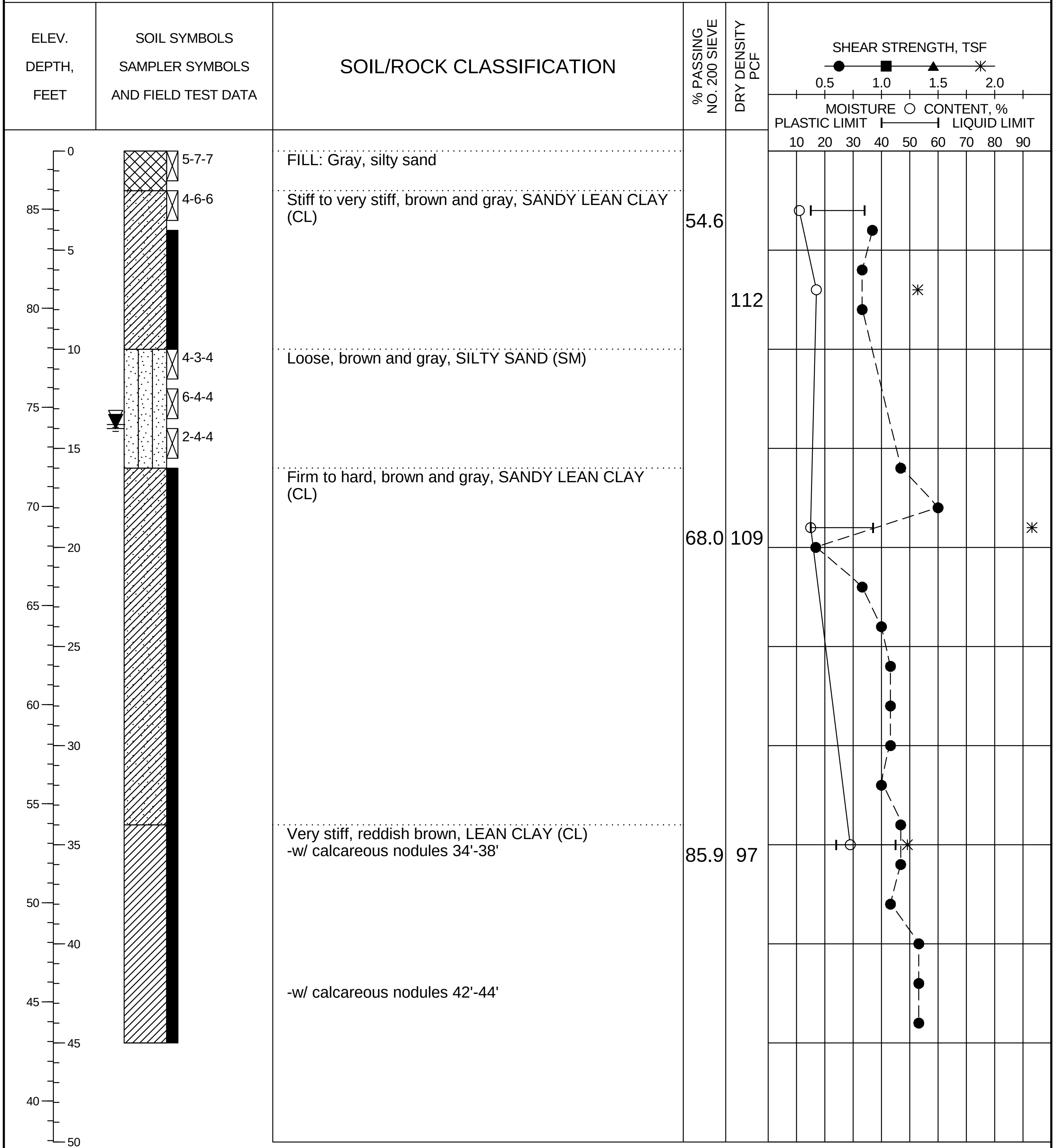
PLATE A-3

LOG OF BORING

Project: Sanitary Sewer Replacement
Boring No.: B-4
Groundwater during drilling: 14 feet
Groundwater after 24 hrs: 13.8 feet

Project No.: HG1217962
Date: 8/20/2014
Northing: 13,923,676.7
Easting: 3,123,159.4

WBS No.:
Elevation: 87.92288 feet
Station: --
Offset: --



SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
5-7-7	FILL: Gray, silty sand		
4-6-6	Stiff to very stiff, brown and gray, SANDY LEAN CLAY (CL)	54.6	112
4-3-4 6-4-4 2-4-4	Loose, brown and gray, SILTY SAND (SM)		
	Firm to hard, brown and gray, SANDY LEAN CLAY (CL)	68.0	109
	Very stiff, reddish brown, LEAN CLAY (CL) -w/ calcareous nodules 34'-38' -w/ calcareous nodules 42'-44'	85.9	97

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

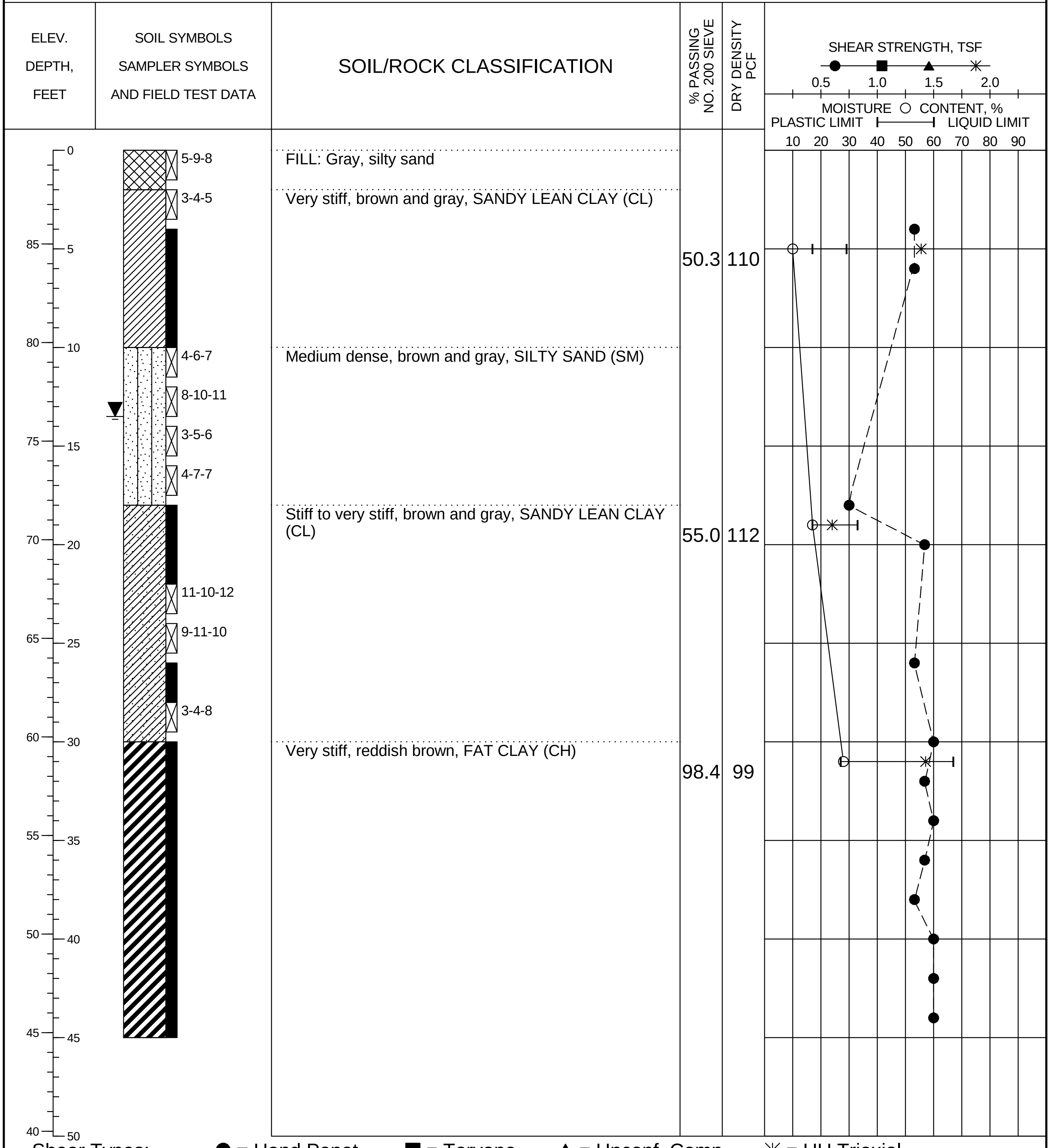
PLATE A-4

LOG OF BORING

Project: Sanitary Sewer Replacement
Boring No.: B-5
Groundwater during drilling: 13.5 feet
Groundwater after 24 hrs: ---

Project No.: HG1217962
Date: 8/20/2014
Northing: 13,923,197.3
Easting: 3,123,434.2

WBS No.:
Elevation: 89.74738 feet
Station: --
Offset: --



FILL: Gray, silty sand

Very stiff, brown and gray, SANDY LEAN CLAY (CL)

Medium dense, brown and gray, SILTY SAND (SM)

Stiff to very stiff, brown and gray, SANDY LEAN CLAY (CL)

Very stiff, reddish brown, FAT CLAY (CH)

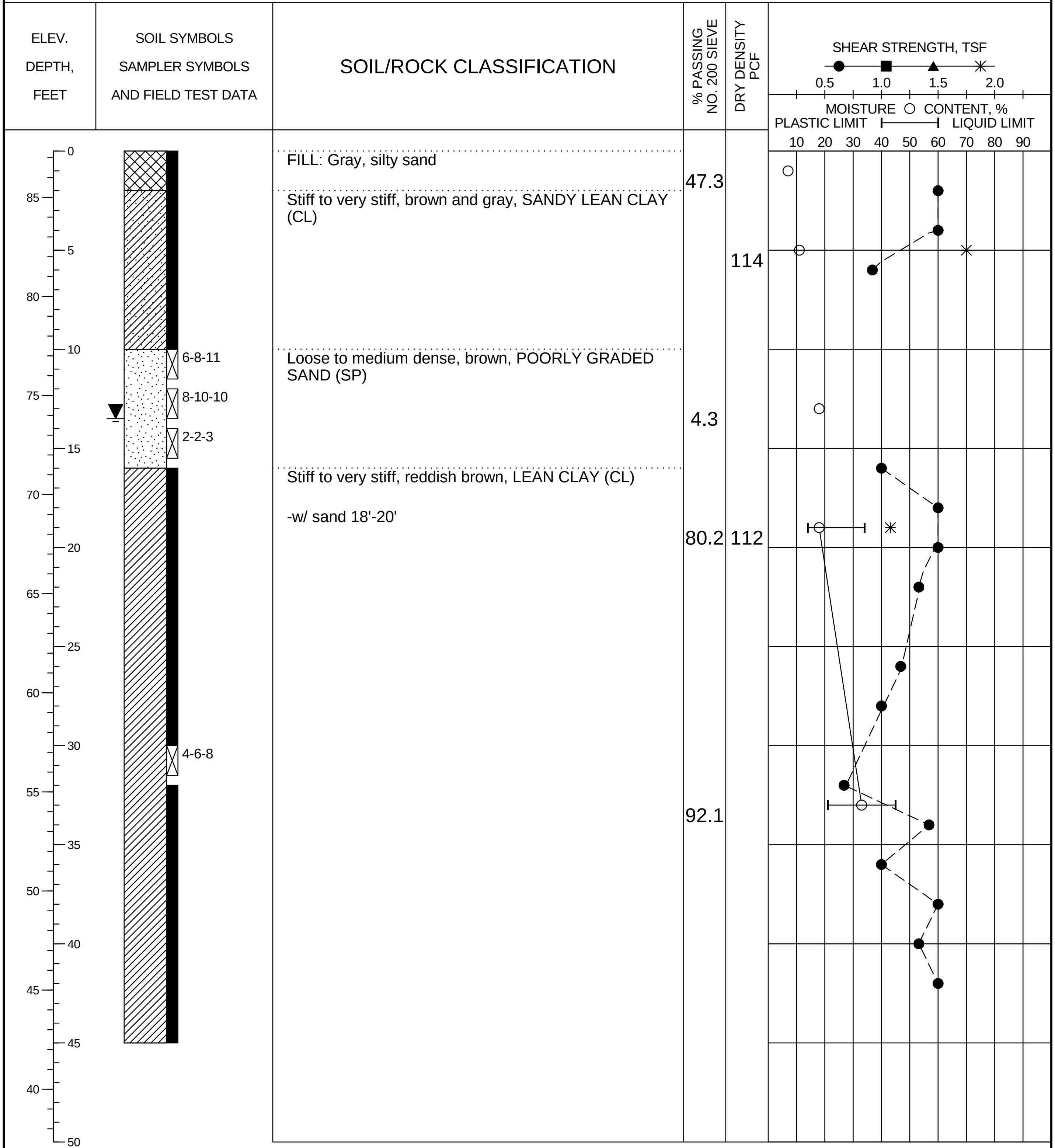
Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

PLATE A-5

HVJ ASSOCIATES

LOG OF BORING

Project: Sanitary Sewer Replacement
Project No.: HG1217962
WBS No.:
Boring No.: B-6
Date: 8/18/2014
Elevation: 87.32872 feet
Groundwater during drilling: 13.5 feet
Northing: 13,922,576.1
Station: --
Groundwater after 24 hrs: ---
Easting: 3,123,790.1
Offset: --



FILL: Gray, silty sand

Stiff to very stiff, brown and gray, SANDY LEAN CLAY (CL)

Loose to medium dense, brown, POORLY GRADED SAND (SP)

Stiff to very stiff, reddish brown, LEAN CLAY (CL)

-w/ sand 18'-20'

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

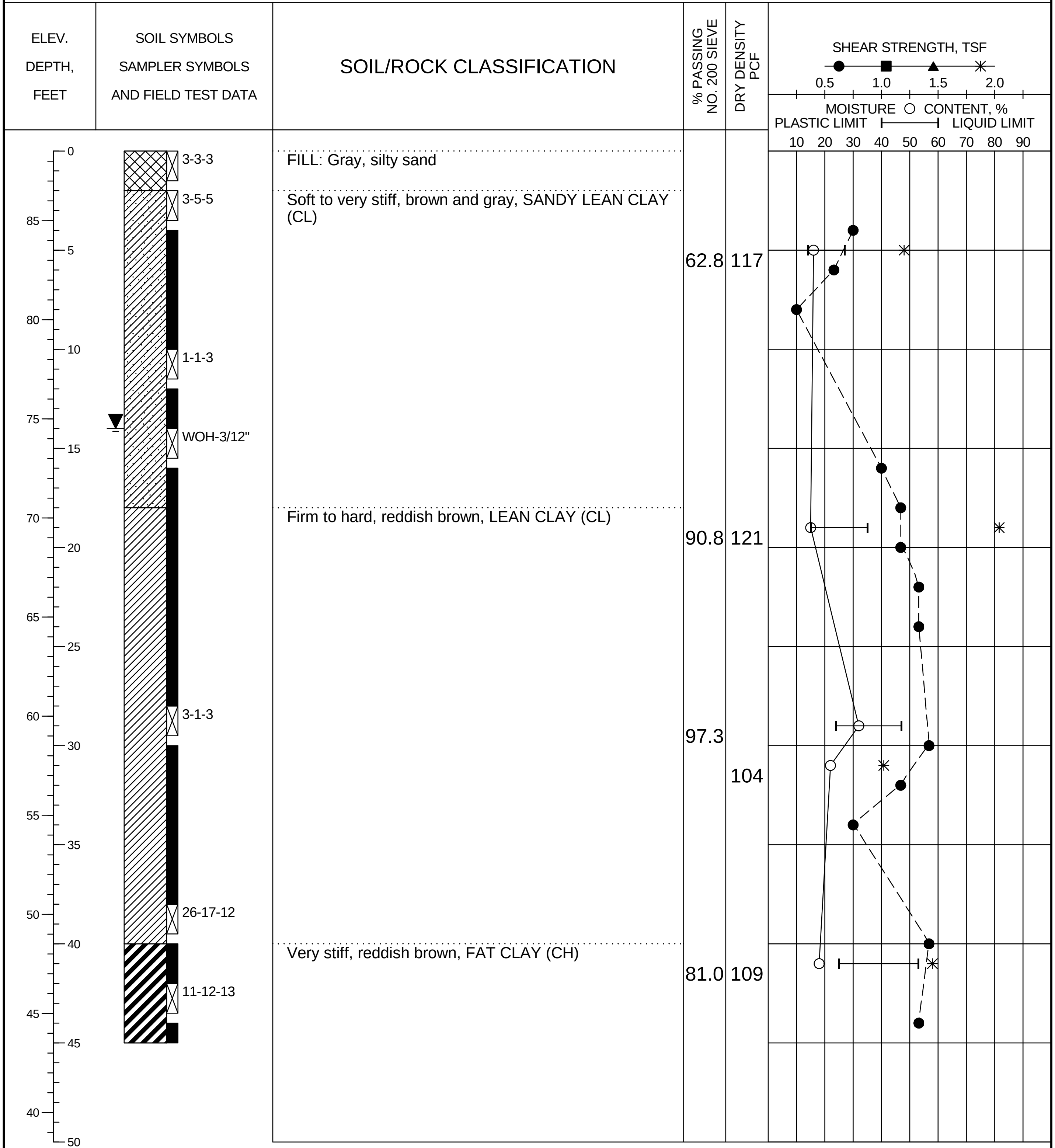
PLATE A-6

LOG OF BORING

Project: Sanitary Sewer Replacement
Boring No.: B-7
Groundwater during drilling: 14 feet
Groundwater after 24 hrs: ---

Project No.: HG1217962
Date: 8/19/2014
Northing: 13,922,312.9
Easting: 3,123,275.0

WBS No.:
Elevation: 88.50718 feet
Station: --
Offset: --



SOIL/ROCK CLASSIFICATION

FILL: Gray, silty sand

Soft to very stiff, brown and gray, SANDY LEAN CLAY (CL)

Firm to hard, reddish brown, LEAN CLAY (CL)

Very stiff, reddish brown, FAT CLAY (CH)

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

PLATE A-7

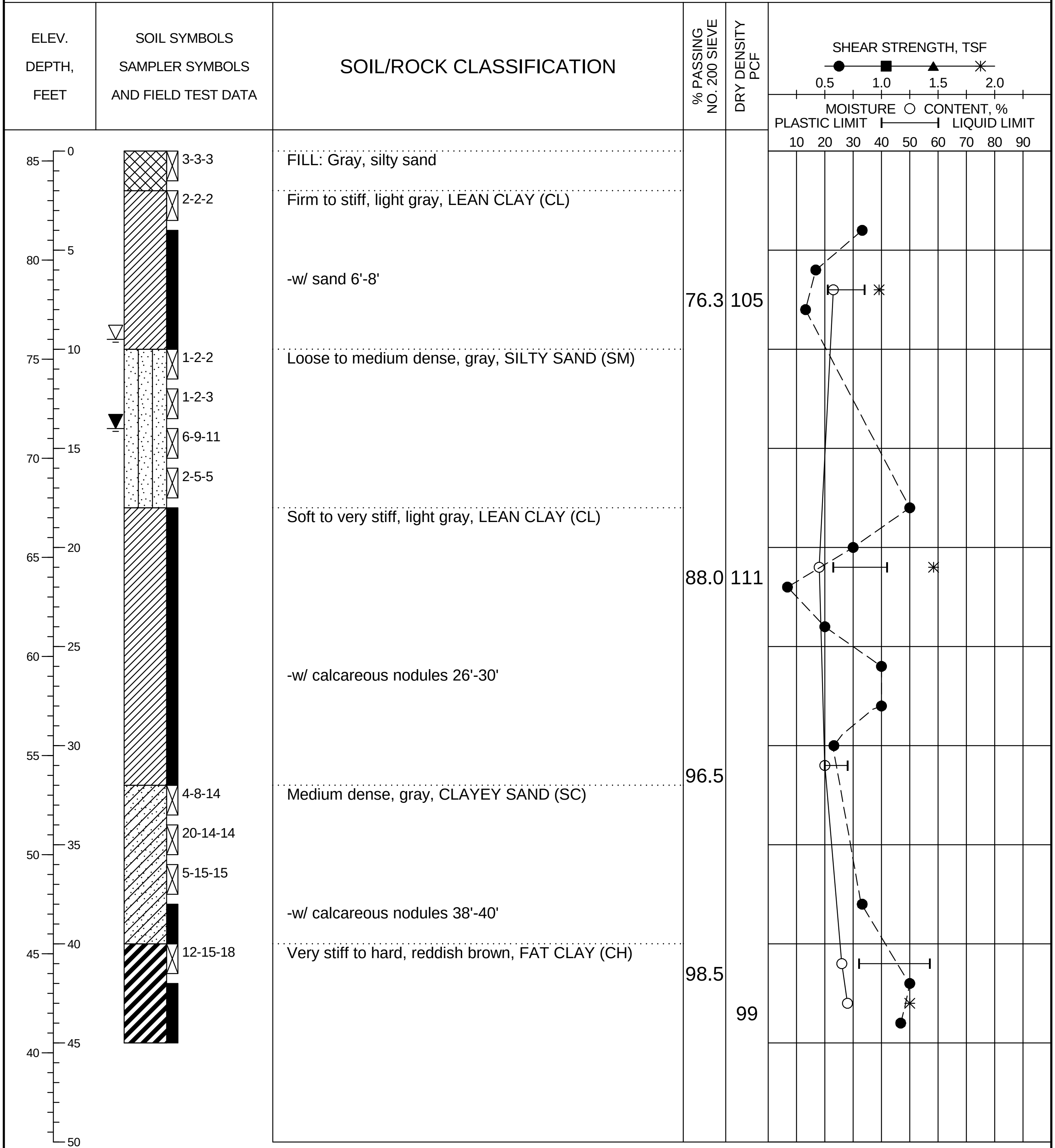
HVJ ASSOCIATES

LOG OF BORING

Project: Sanitary Sewer Replacement
Boring No.: B-8
Groundwater during drilling: 14 feet
Groundwater after 24 hrs: 9.5 feet

Project No.: HG1217962
Date: 8/23/2014
Northing: 13,922,106.0
Easting: 3,122,917.3

WBS No.:
Elevation: 85.49769 feet
Station: --
Offset: --



SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
3-3-3	FILL: Gray, silty sand		
2-2-2	Firm to stiff, light gray, LEAN CLAY (CL)		
	-w/ sand 6'-8'	76.3	105
1-2-2	Loose to medium dense, gray, SILTY SAND (SM)		
1-2-3			
6-9-11			
2-5-5			
	Soft to very stiff, light gray, LEAN CLAY (CL)		
		88.0	111
	-w/ calcareous nodules 26'-30'		
		96.5	
4-8-14	Medium dense, gray, CLAYEY SAND (SC)		
20-14-14			
5-15-15			
	-w/ calcareous nodules 38'-40'		
12-15-18	Very stiff to hard, reddish brown, FAT CLAY (CH)		
		98.5	
			99

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

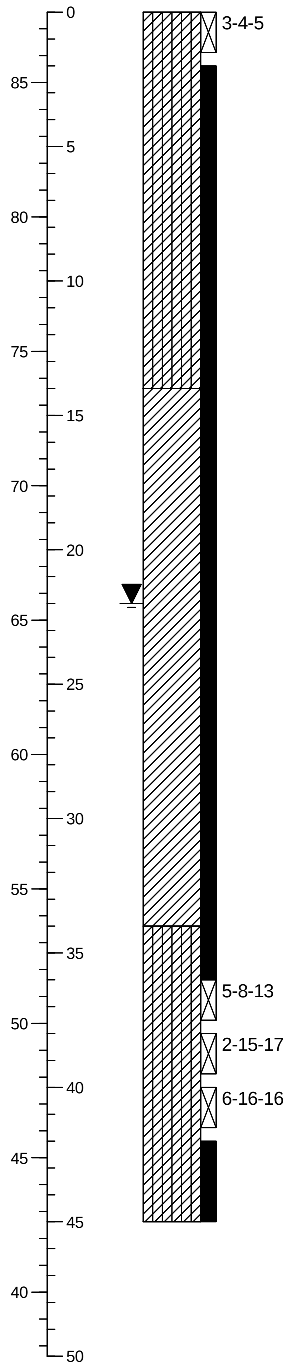
PLATE A-8

LOG OF BORING

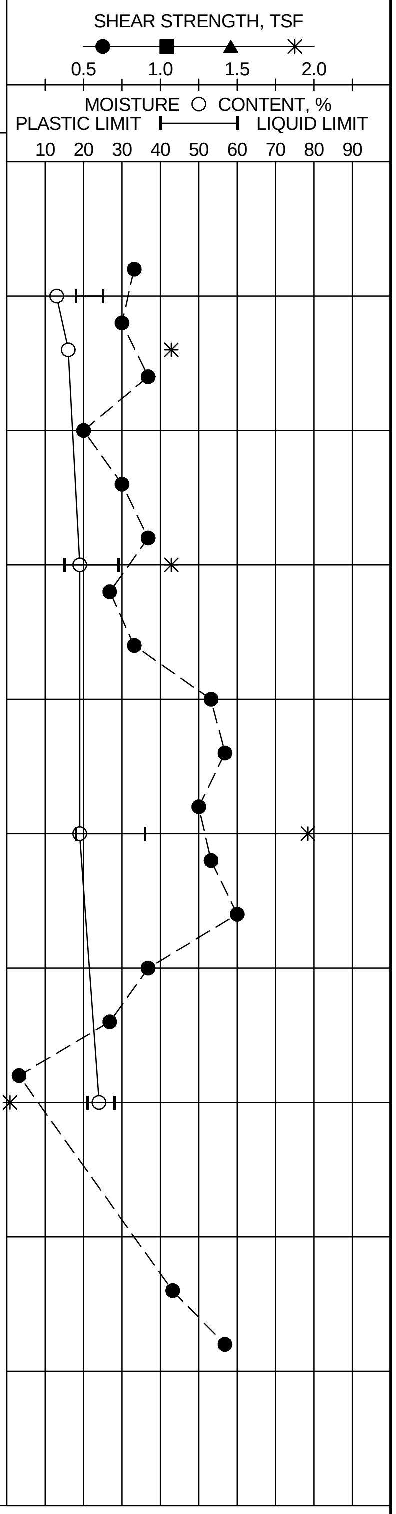
Project: Sanitary Sewer Replacement
Boring No.: B-9
Groundwater during drilling: 22 feet
Groundwater after 24 hrs: ---

Project No.: HG1217962
Date: 8/22/2014
Northing: 13,921,814.5
Easting: 3,122,434.5

WBS No.:
Elevation: 87.6138 feet
Station: --
Offset: --



SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
3-4-5	Stiff to very stiff, light gray, SANDY SILTY CLAY (CL-ML)		
		66.7	
	-w/ calcareous nodules 6'-14'		115
	Stiff to very stiff, brown and gray, LEAN CLAY (CL)	92.3	109
	-w/ sand 24'-26'		
	-w/ calcareous nodules 26'-30'	76.2	111
	Very soft to very stiff, brown and gray, SILTY CLAY WITH SAND (CL-ML)	79.8	108
5-8-13			
2-15-17			
6-16-16			



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

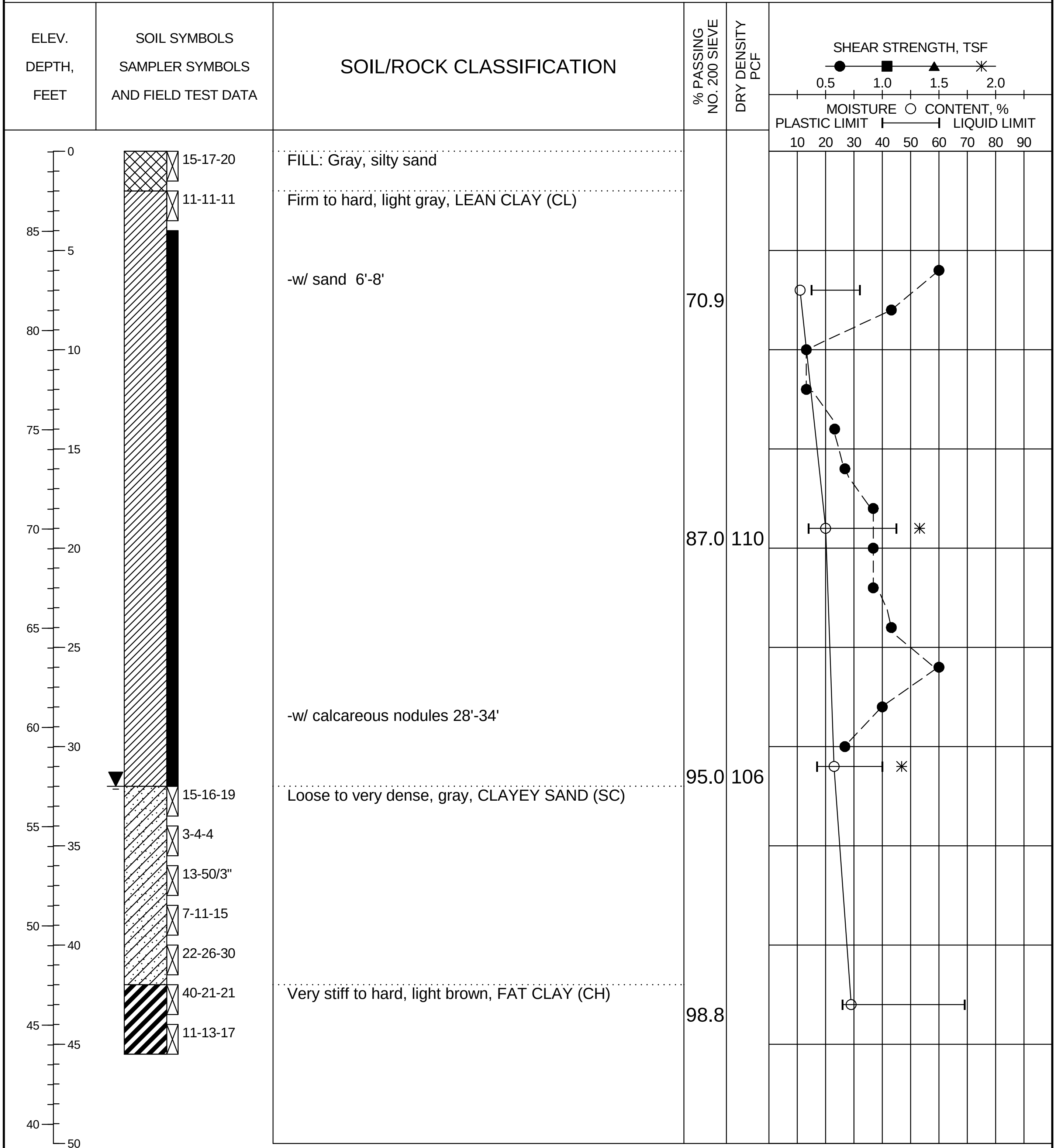
PLATE A-9

LOG OF BORING

Project: Sanitary Sewer Replacement
Boring No.: B-10
Groundwater during drilling: 32 feet
Groundwater after 24 hrs: ---

Project No.: HG1217962
Date: 8/22/2014
Northing: 13,921,377.9
Easting: 3,121,714.7

WBS No.:
Elevation: 89.03176 feet
Station: --
Offset: --



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

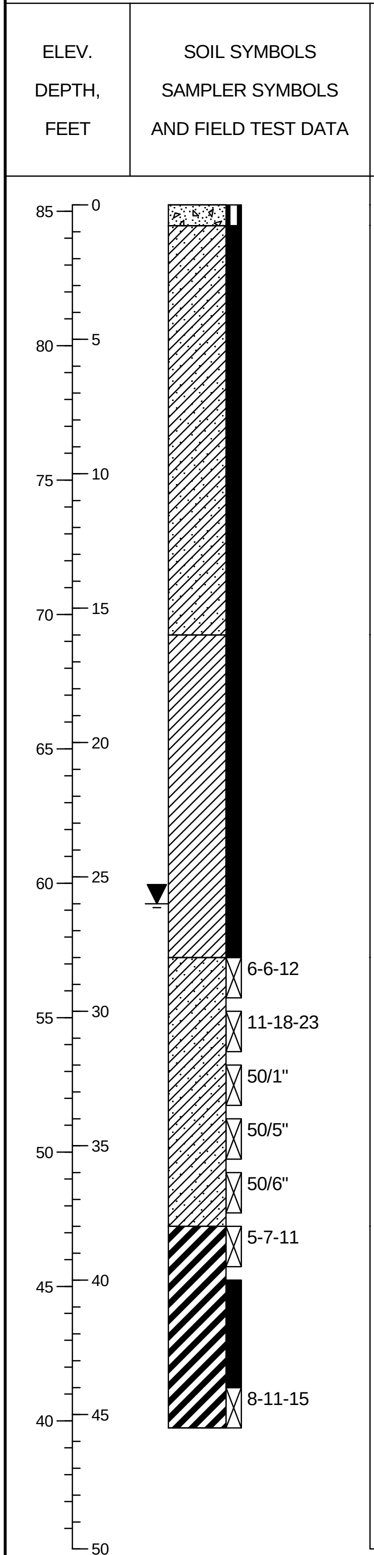
PLATE A-10

LOG OF BORING

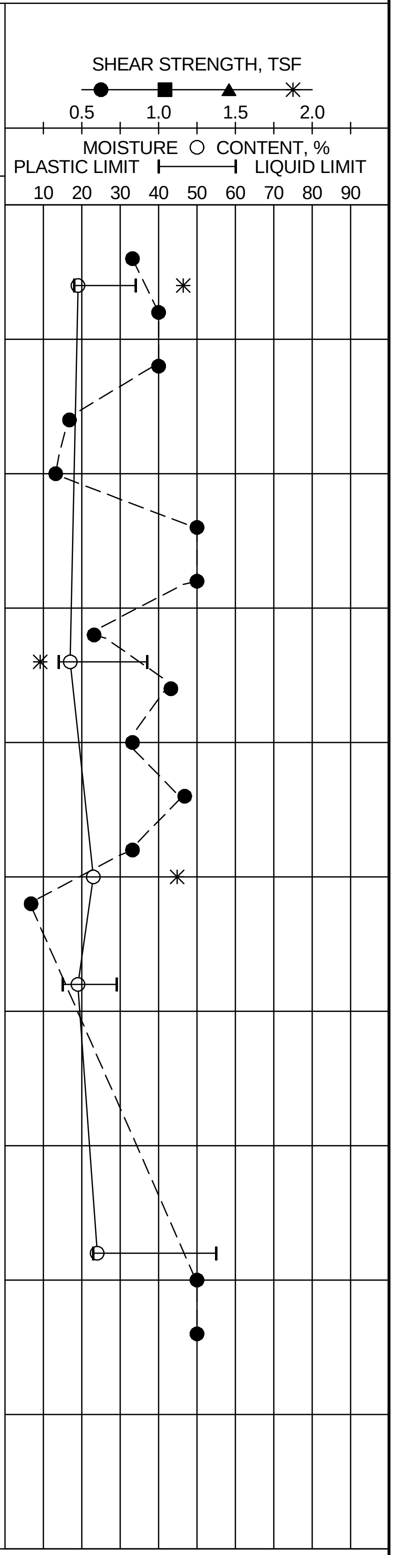
Project: Sanitary Sewer Replacement
Boring No.: B-11
Groundwater during drilling: 26 feet
Groundwater after 24 hrs: ---

Project No.: HG1217962
Date: 8/21/2014
Northing: 13,921,162.9
Easting: 3,121,349.3

WBS No.:
Elevation: 85.23276 feet
Station: --
Offset: --



SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
Pavement: 9.25" Concrete		
Firm to very stiff, gray, SANDY LEAN CLAY (CL)	50.4	115
-w/ calcareous nodules 12'-16'		
Soft to very stiff, brown and gray, LEAN CLAY (CL)	87.8	114
		103
Very stiff to hard, brown and gray, SANDY LEAN CLAY (CL)	68.2	
Very stiff, reddish brown, FAT CLAY (CH)	97.3	
-w/ calcareous nodules 40'-42'		



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

PLATE A-11

LOG OF SOIL BORING HG-12-17962.GPJ HVJ.GDT 9/29/14

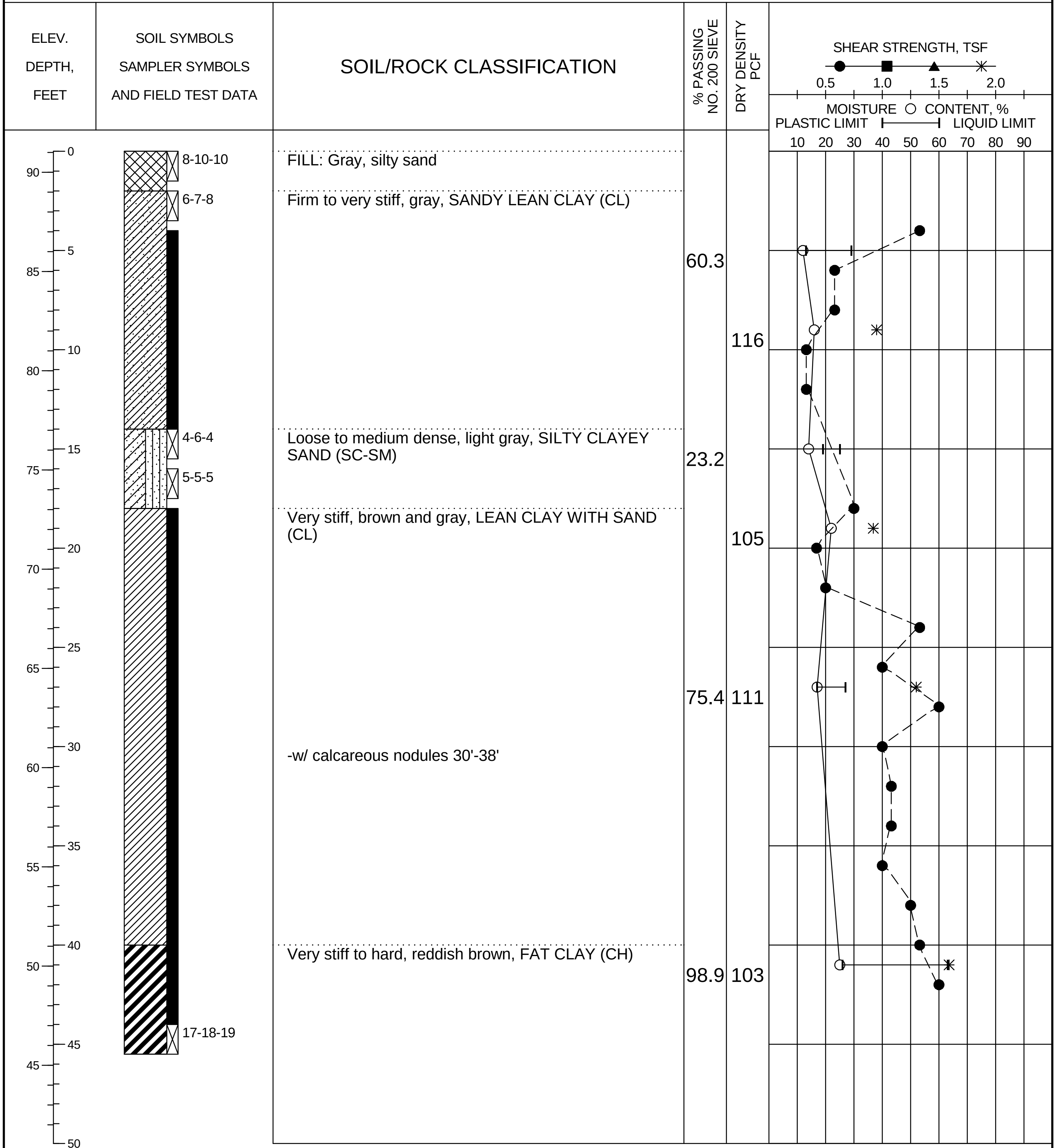
HVJ ASSOCIATES

LOG OF BORING

Project: Sanitary Sewer Replacement
Boring No.: B-12
Groundwater during drilling: Dry
Groundwater after 24 hrs: ---

Project No.: HG1217962
Date: 8/21/2014
Northing: 13,923,380.3
Easting: 3,123,707.1

WBS No.:
Elevation: 91.0552 feet
Station: --
Offset: --



FILL: Gray, silty sand

Firm to very stiff, gray, SANDY LEAN CLAY (CL)

Loose to medium dense, light gray, SILTY CLAYEY SAND (SC-SM)

Very stiff, brown and gray, LEAN CLAY WITH SAND (CL)

-w/ calcareous nodules 30'-38'

Very stiff to hard, reddish brown, FAT CLAY (CH)

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

HVJ ASSOCIATES

SOIL SYMBOLS

Soil Types

▨	▥	⬚	⁂
Clay	Silt	Sand	Gravel

Modifiers

▨	▥	⬚	⁂
Clayey	Silty	Sandy	Cemented

Construction Materials

▤	⁘	▩	⁖
Asphaltic Concrete	Stabilized Base	Fill or Debris	Portland Cement Concrete

SAMPLER TYPES

◩	Thin Walled Shelby Tube	◫	No Recovery
⊠	Split Barrel	▯	Core
◧	Liner Tube	⧗	Jar Sample

WATER LEVEL SYMBOLS

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

SOIL GRAIN SIZE

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

DENSITY OF COHESIONLESS SOILS

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

CONSISTENCY OF COHESIVE SOILS

Consistency	Undrained Shear Strength (tsf)	Penetration Resistance "N" * Blows/Foot
Very Soft	0 - 0.125	0 - 2
Soft	0.125 - 0.25	2 - 4
Firm	0.25 - 0.5	4 - 8
Stiff	0.5 - 1.0	8 - 16
Very Stiff	1.0 - 2.0	16 - 32
Hard	> 2.0	> 32

PENETRATION RESISTANCE

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

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

TERMS DESCRIBING SOIL STRUCTURE

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

HVJ ASSOCIATES

6120 S. Dairy Ashford Road
Houston, Texas 77072-1010
281.933.7388 Ph
281.933.7293 Fax

KEY TO TERMS AND SYMBOLS
USED ON BORING LOGS

PROJECT NO.: HG1217962

DRAWING NO.: PLATE A-13

APPENDIX B

SUMMARY OF LABORATORY TEST RESULTS

Project: Sanitary Sewer Replacement, George Bush Intercontinental Airport
Location: Houston, Texas
Number: HG1217962

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Moisture Content (%)	Total Unit Weight (pcf)	Shear Strength (UU) (tsf)	Shear Strength (Pocket Pen) (tsf)
B-1	0.8								1.17
B-1	2								0.67
B-1	3	27	19	8	58	15.7	134.7	0.95	
B-1	4								0.67
B-1	6								0.67
B-1	10								0.33
B-1	13				45	26.4			
B-1	22								0.67
B-1	24								0.83
B-1	26								0.83
B-1	28								0.83
B-1	29	34	14	20	83	15.4	137.9	1.58	
B-1	30								0.83
B-1	32								1
B-1	34								1.5
B-1	36								1.5
B-1	38								1.5
B-1	39					20.5	125.8	0.39	
B-1	40								1.5
B-1	41	66	27	39	97	22.5			
B-1	42								1.5
B-1	44								1
B-10	6								1.5
B-10	7	32	15	17	71	10.6			
B-10	8								1.08
B-10	10								0.33

Project: Sanitary Sewer Replacement, George Bush Intercontinental Airport
Location: Houston, Texas
Number: HG1217962

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Moisture Content (%)	Total Unit Weight (pcf)	Shear Strength (UU) (tsf)	Shear Strength (Pocket Pen) (tsf)
B-10	12								0.33
B-10	14								0.58
B-10	16								0.67
B-10	18								0.92
B-10	19	45	14	31	87	19.9	131.4	1.33	
B-10	20								0.92
B-10	22								0.92
B-10	24								1.08
B-10	26								1.5
B-10	28								1
B-10	30								0.67
B-10	31	40	17	23	95	23.4	131	1.17	
B-10	43	69	26	43	99	29.5			
B-11	2								0.83
B-11	3	34	18	16	50	18.9	136.4	1.16	
B-11	4								1
B-11	6								1
B-11	8								0.42
B-11	10								0.33
B-11	12								1.25
B-11	14								1.25
B-11	16								0.58
B-11	17	37	14	23	88	16.9	133.3	0.23	
B-11	18								1.08
B-11	20								0.83
B-11	22								1.17

Project: Sanitary Sewer Replacement, George Bush Intercontinental Airport
Location: Houston, Texas
Number: HG1217962

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Moisture Content (%)	Total Unit Weight (pcf)	Shear Strength (UU) (tsf)	Shear Strength (Pocket Pen) (tsf)
B-11	24								0.83
B-11	25					23.2	127	1.12	
B-11	26								0.17
B-11	29	29	15	14	68	19.1			
B-11	39	55	23	32	97	24			
B-11	40								1.25
B-11	42								1.25
B-12	4								1.33
B-12	5	29	13	16	60	11.9			
B-12	6								0.58
B-12	8								0.58
B-12	9					16.2	135	0.95	
B-12	10								0.33
B-12	12								0.33
B-12	15	25	19	6	23	13.8			
B-12	18								0.75
B-12	19					22.2	128	0.92	
B-12	20								0.42
B-12	22								0.5
B-12	24								1.33
B-12	26								1
B-12	27	27	17	10	75	17.4	130.4	1.3	
B-12	28								1.5
B-12	30								1
B-12	32								1.08
B-12	34								1.08

Project: Sanitary Sewer Replacement, George Bush Intercontinental Airport
Location: Houston, Texas
Number: HG1217962

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Moisture Content (%)	Total Unit Weight (pcf)	Shear Strength (UU) (tsf)	Shear Strength (Pocket Pen) (tsf)
B-12	36								1
B-12	38								1.25
B-12	40								1.33
B-12	41	63	26	37	99	24.6	128.4	1.59	
B-12	42								1.5
B-2	4								1.08
B-2	5	25	18	7	50	11.1			
B-2	6								0.58
B-2	7					12.3	132.2	1.4	
B-2	8								0.75
B-2	10								0.08
B-2	19				7	23.8			
B-2	24								1.17
B-2	26								1.08
B-2	28								0.92
B-2	30								1.08
B-2	32								1.25
B-2	34								1.33
B-2	35	61	26	35	96	25.9	138.4	0.75	
B-2	42								1.42
B-3	4								1.5
B-3	6								1.5
B-3	7	34	15	19	59	12.9	136.8	2.28	
B-3	8								1.5
B-3	18								1.17
B-3	20								1.5

Project: Sanitary Sewer Replacement, George Bush Intercontinental Airport
Location: Houston, Texas
Number: HG1217962

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Moisture Content (%)	Total Unit Weight (pcf)	Shear Strength (UU) (tsf)	Shear Strength (Pocket Pen) (tsf)
B-3	21	41	19	22	99	20.1	130.6	1.8	
B-3	22								1.17
B-3	26								1.08
B-3	28								1.17
B-3	30								1
B-3	32								1.5
B-3	34								1.42
B-3	36								1.5
B-3	37	48	22	26	99	23.4	133.9	1.19	
B-3	40								1.5
B-3	42								1.5
B-3	44								1.5
B-4	3	34	15	19	55	11.4			
B-4	4								0.92
B-4	6								0.83
B-4	7					16.9	131	1.32	
B-4	8								0.83
B-4	16								1.17
B-4	18								1.5
B-4	19	37	15	22	68	15.1	125.6	2.33	
B-4	20								0.42
B-4	22								0.83
B-4	24								1
B-4	26								1.08
B-4	28								1.08
B-4	30								1.08

Project: Sanitary Sewer Replacement, George Bush Intercontinental Airport
Location: Houston, Texas
Number: HG1217962

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Moisture Content (%)	Total Unit Weight (pcf)	Shear Strength (UU) (tsf)	Shear Strength (Pocket Pen) (tsf)
B-4	32								1
B-4	34								1.17
B-4	35	45	24	21	86	28.6	124.9	1.23	
B-4	36								1.17
B-4	38								1.08
B-4	40								1.33
B-4	42								1.33
B-4	44								1.33
B-5	4								1.33
B-5	5	29	17	12	50	10.4	121.2	1.39	
B-5	6								1.33
B-5	18								0.75
B-5	19	33	17	16	55	17.2	131.3	0.6	
B-5	20								1.42
B-5	26								1.33
B-5	30								1.5
B-5	31	67	27	40	98	28.2	127.3	1.43	
B-5	32								1.42
B-5	34								1.5
B-5	36								1.42
B-5	38								1.33
B-5	40								1.5
B-5	42								1.5
B-5	44								1.5
B-6	1				47	7.4			
B-6	2								1.5

Project: Sanitary Sewer Replacement, George Bush Intercontinental Airport
Location: Houston, Texas
Number: HG1217962

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Moisture Content (%)	Total Unit Weight (pcf)	Shear Strength (UU) (tsf)	Shear Strength (Pocket Pen) (tsf)
B-6	4								1.5
B-6	5					11.1	126.3	1.75	
B-6	6								0.92
B-6	13				4	18.5			
B-6	16								1
B-6	18								1.5
B-6	19	34	14	20	80	17.8	131.8	1.08	
B-6	20								1.5
B-6	22								1.33
B-6	26								1.17
B-6	28								1
B-6	32								0.67
B-6	33	45	21	24	92	33			
B-6	34								1.42
B-6	36								1
B-6	38								1.5
B-6	40								1.33
B-6	42								1.5
B-7	4								0.75
B-7	5	27	14	13	63	15.9	135.7	1.2	
B-7	6								0.58
B-7	8								0.25
B-7	16								1
B-7	18								1.17
B-7	19	35	15	20	91	15.3	139.4	2.04	
B-7	20								1.17

Project: Sanitary Sewer Replacement, George Bush Intercontinental Airport
Location: Houston, Texas
Number: HG1217962

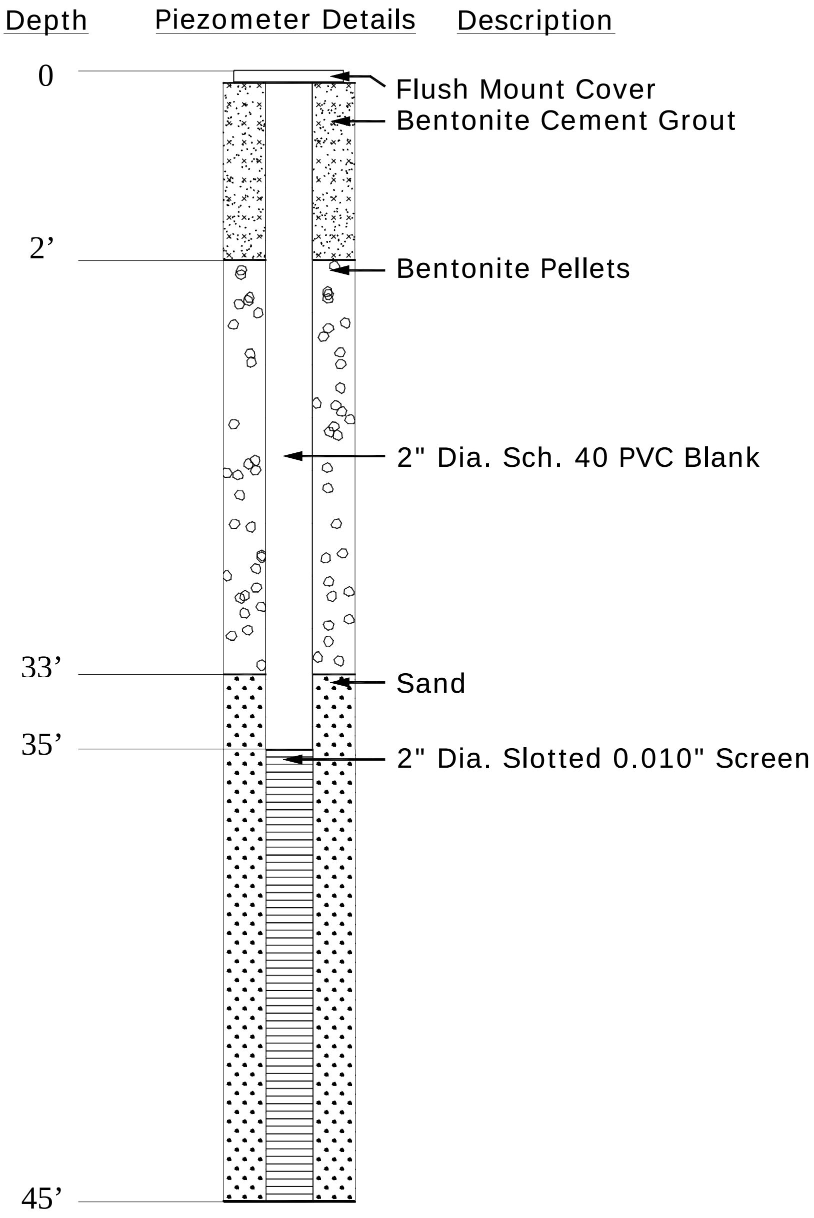
Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Moisture Content (%)	Total Unit Weight (pcf)	Shear Strength (UU) (tsf)	Shear Strength (Pocket Pen) (tsf)
B-7	22								1.33
B-7	24								1.33
B-7	29	47	24	23	97	31.5			
B-7	30								1.42
B-7	31					21.6	126.5	1.02	
B-7	32								1.17
B-7	34								0.75
B-7	40								1.42
B-7	41	53	25	28	81	17.9	128.5	1.45	
B-7	44								1.33
B-8	4								0.83
B-8	6								0.42
B-8	7	34	21	13	76	22.7	129.2	0.98	
B-8	8								0.33
B-8	18								1.25
B-8	20								0.75
B-8	21	42	23	19	88	18.1	130.6	1.46	
B-8	22								0.17
B-8	24								0.5
B-8	26								1
B-8	28								1
B-8	30								0.58
B-8	31	28	20	8	97	19.6			
B-8	38								0.83
B-8	41	57	32	25	99	26.2			
B-8	42								1.25

Project: Sanitary Sewer Replacement, George Bush Intercontinental Airport
Location: Houston, Texas
Number: HG1217962

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Moisture Content (%)	Total Unit Weight (pcf)	Shear Strength (UU) (tsf)	Shear Strength (Pocket Pen) (tsf)
B-8	43					28.1	126.7	1.25	
B-8	44								1.17
B-9	4								0.83
B-9	5	25	18	7	67	13.5			
B-9	6								0.75
B-9	7					15.6	133.3	1.07	
B-9	8								0.92
B-9	10								0.5
B-9	12								0.75
B-9	14								0.92
B-9	15	29	15	14	92	19.2	129.4	1.07	
B-9	16								0.67
B-9	18								0.83
B-9	20								1.33
B-9	22								1.42
B-9	24								1.25
B-9	25	36	18	18	76	18.6	132.2	1.96	
B-9	26								1.33
B-9	28								1.5
B-9	30								0.92
B-9	32								0.67
B-9	34								0.08
B-9	35	28	21	7	80	24.3	133.9	0.02	
B-9	42								1.08
B-9	44								1.42
Total		**40**	**40**	**40**	**44**	**54**	**36**	**36**	**179**

APPENDIX C

PIEZOMETER INSTALLATION RECORDS



Water Level Readings

Date	Depth (ft.)	Elev. (ft.)
08/21/14	13.8	87.9
09/20/14	12.8	86.9

NOTES:

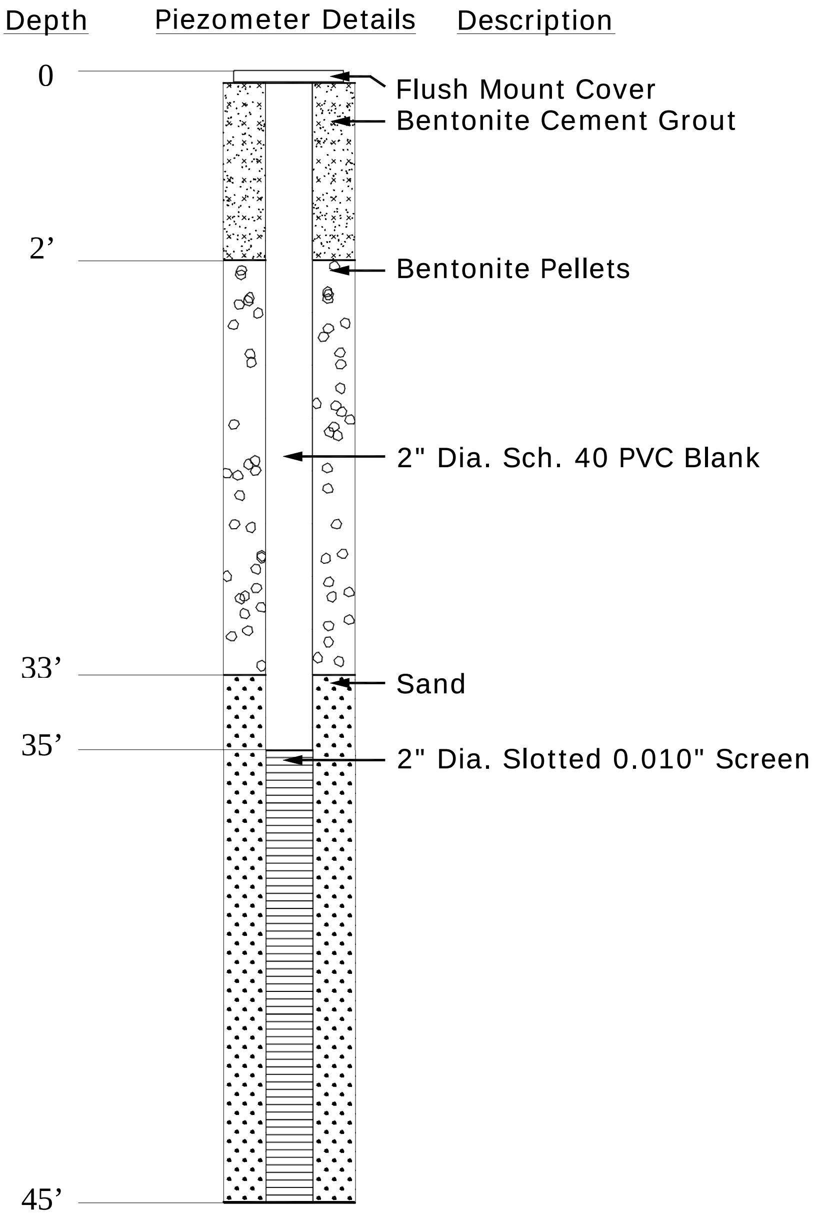
- Piezometer was installed on 08/20/14.
- See Plate 2 for boring location; see Plate A-1 for boring log.

HVJ ASSOCIATES

6120 S. Dairy Ashford Road
Houston, Texas 77072-1010
281.933.7388 Ph
281.933.7293 Fax

PIEZOMETER INSTALLATION REPORT
PIEZOMETER NO. PZ-1 (B-4)

PROJECT NO.:	DRAWING NO.:
HG1217962	PLATE C-1



Water Level Readings

Date	Depth (ft.)	Elev. (ft.)
08/23/14	9.5	85.5
09/22/14	8.5	84.5

NOTES:

- Piezometer was installed on 08/22/14.
- See Plate 2 for boring location; see Plate A-1 for boring log.

HVJ ASSOCIATES
6120 S. Dairy Ashford Road
Houston, Texas 77072-1010
281.933.7388 Ph
281.933.7293 Fax

PIEZOMETER INSTALLATION REPORT
PIEZOMETER NO. PZ-2 (B-8)

PROJECT NO.: HG1217962
DRAWING NO.: PLATE C-2

STATE OF TEXAS WELL REPORT for Tracking #383240

Owner:	**Houston Airport System**	Owner Well #:	**B4**
Address:	**16930 JFK BLVD** **Houston , TX 77032**	Grid #:	**65-06-1**
Well Location:	**N/A-IAH Airfield** **Houston , TX 77032**	Latitude:	**29° 59' 07" N**
Well County:	**Harris**	Longitude:	**095° 21' 08" W**
Elevation:	**No Data**	GPS Brand Used:	**Magellan**
Type of Work:	**New Well**	Proposed Use:	**Monitor**

Drilling Date:	Started: **8/20/2014** Completed: **8/20/2014**
Diameter of Hole:	Diameter: **4 in From Surface To 45 ft**
Drilling Method:	**Mud Rotary**
Borehole Completion:	Other: **(No Data)**
Annular Seal Data:	1st Interval: **From 0 ft to 33 ft with 2.5 bentonite (#sacks and material)** 2nd Interval: **No Data** 3rd Interval: **No Data** Method Used: **No Data** Cemented By: **No Data** Distance to Septic Field or other Concentrated Contamination: **No Data** Distance to Property Line: **No Data** Method of Verification: **No Data** Approved by Variance: **No Data**
Surface Completion:	**Surface Sleeve Installed**
Water Level:	Static level: **No Data** Artesian flow: **No Data**
Packers:	**20/40 33 to 45**
Plugging Info:	Casing or Cement/Bentonite left in well: **No Data**
Type Of Pump:	**No Data**
Well Tests:	**No Data**
Water Quality:	Type of Water: **No Data** Depth of Strata: **No Data** Chemical Analysis Made: **No Data** Did the driller knowingly penetrate any strata which contained undesirable constituents: **No Data**
Certification Data:	The driller certified that the driller drilled this well (or the well was drilled under the driller's direct supervision) and that each and all of the statements herein are true and correct. The driller understood that failure to complete the required items will result in the log(s) being returned for completion and resubmittal.
Company Information:	**Envirotech Drilling Services** **2718 South Brompton Drive** **Pearland , TX 77584**
Driller License Number:	**58171**

Licensed Well Driller Signature:	**Jaime Vasquez**
Registered Driller Apprentice Signature:	**No Data**
Apprentice Registration Number:	**No Data**
Comments:	**No Data**

IMPORTANT NOTICE FOR PERSONS HAVING WELLS DRILLED CONCERNING CONFIDENTIALITY

TEX. OCC. CODE Title 12, Chapter 1901.251, authorizes the owner (owner or the person for whom the well was drilled) to keep information in Well Reports confidential. The Department shall hold the contents of the well log confidential and not a matter of public record if it receives, by certified mail, a written request to do so from the owner.

Please include the report's Tracking number (Tracking **#383240**) on your written request.

Texas Department of Licensing & Regulation
P.O. Box 12157
Austin, TX 78711
(512) 463-7880

DESC. & COLOR OF FORMATION MATERIAL

From (ft) To (ft) Description
0-10 Brown and gray sandy clay
10-16 Brown and gray silty clay
16-34 Brown and gray sandy clay
34-45 Reddish brown clay

CASING, BLANK PIPE & WELL SCREEN DATA

Dia. New/Used Type Setting From/To
2 New PVC Riser 0-35 Sch. 40
2 New PVC Screen 35-45 .010

STATE OF TEXAS PLUGGING REPORT for Tracking #98436

Owner:	**Houston Airport System**	Owner Well #:	**B4**
Address:	**16930 JFK BLVD** **Houston , TX 77032**	Grid #:	**65-06-1**
Well Location:	**N/A- IAH Air Field** **Houston , TX 77032**	Latitude:	**29° 59' 07" N**
Well County:	**Harris**	Longitude:	**095° 21' 09" W**
		GPS Brand Used:	**Magellan**

Well Type: **Monitor**

HISTORICAL DATA ON WELL TO BE PLUGGED

Original Well Driller:	**Jaime Vasquez**
Driller's License Number of Original Well Driller:	**58171**
Date Well Drilled:	**8/20/2014**
Well Report Tracking Number:	**383240**
Diameter of Borehole:	**4 inches**
Total Depth of Borehole:	**45 feet**

Date Well Plugged:	**9/23/2014**
Person Actually Performing Plugging Operation:	**Brian Johnson**
License Number of Plugging Operator:	**58171**
Plugging Method:	**Pour in 3/8 bentonite chips when standing water in well is less than 100 feet in depth, cement top 2 feet.**
Plugging Variance #:	**No Data**
Casing Left Data:	1st Interval: **2 inches diameter, From 1 ft to 45 ft** 2nd Interval: **No Data** 3rd Interval: **No Data**
Cement/Bentonite Plugs Placed in Well:	1st Interval: **From 0 ft to 2 ft; Sack(s)/type of cement used: .5 cement** 2nd Interval: **From 2 ft to 45 ft; Sack(s)/type of cement used: 2.5 bentonite** 3rd Interval: **No Data** 4th Interval: **No Data** 5th Interval: **No Data**

Certification Data:	The plug installer certified that the plug installer plugged this well (or the well was plugged under the plug installer's direct supervision) and that each and all of the statements herein are true and correct. The plug installer understood that failure to complete the required items will result in the log(s) being returned for completion and resubmittal.
Company Information:	**Envirotech Drilling Services** **2718 South Brompton Drive** **Pearland , TX 77584** **58171**

Plug Installer License Number:	
Licensed Plug Installer Signature:	**Jaime Vasquez**
Registered Plug Installer Apprentice Signature:	**No Data**
Apprentice Registration Number:	**No Data**
Plugging Method Comments:	**No Data**

Please include the plugging report's tracking number (Tracking #**98436**) on your written request.

Texas Department of Licensing & Regulation
P.O. Box 12157
Austin, TX 78711
(512) 463-7880

STATE OF TEXAS WELL REPORT for Tracking #383253

Owner:	**Houston Airport System**	Owner Well #:	**B8**
Address:	**16930 JFK BLVD** **Houston , TX 77032**	Grid #:	**65-06-1**
Well Location:	**N/A-IAH Airfield** **Houston , TX 77032**	Latitude:	**29° 58' 23" N**
Well County:	**Harris**	Longitude:	**095° 21' 08" W**
Elevation:	**No Data**	GPS Brand Used:	**Magellan**
Type of Work:	**New Well**	Proposed Use:	**Monitor**

Drilling Date:	Started: **8/23/2014** Completed: **8/23/2014**
Diameter of Hole:	Diameter: **4 in From Surface To 45 ft**
Drilling Method:	**Mud Rotary**
Borehole Completion:	Other: **(No Data)**
Annular Seal Data:	1st Interval: **From 0 ft to 33 ft with 2.5 bentonite (#sacks and material)** 2nd Interval: **No Data** 3rd Interval: **No Data** Method Used: **No Data** Cemented By: **No Data** Distance to Septic Field or other Concentrated Contamination: **No Data** Distance to Property Line: **No Data** Method of Verification: **No Data** Approved by Variance: **No Data**
Surface Completion:	**Surface Sleeve Installed**
Water Level:	Static level: **No Data** Artesian flow: **No Data**
Packers:	**20/40 33 to 45**
Plugging Info:	Casing or Cement/Bentonite left in well: **No Data**
Type Of Pump:	**No Data**
Well Tests:	**No Data**
Water Quality:	Type of Water: **No Data** Depth of Strata: **No Data** Chemical Analysis Made: **No Data** Did the driller knowingly penetrate any strata which contained undesirable constituents: **No Data**
Certification Data:	The driller certified that the driller drilled this well (or the well was drilled under the driller's direct supervision) and that each and all of the statements herein are true and correct. The driller understood that failure to complete the required items will result in the log(s) being returned for completion and resubmittal.
Company Information:	**Envirotech Drilling Services** **2718 South Brompton Drive** **Pearland , TX 77584**
Driller License Number:	**58171**

Licensed Well Driller Signature:	**Jaime Vasquez**
Registered Driller Apprentice Signature:	**No Data**
Apprentice Registration Number:	**No Data**
Comments:	**No Data**

IMPORTANT NOTICE FOR PERSONS HAVING WELLS DRILLED CONCERNING CONFIDENTIALITY

TEX. OCC. CODE Title 12, Chapter 1901.251, authorizes the owner (owner or the person for whom the well was drilled) to keep information in Well Reports confidential. The Department shall hold the contents of the well log confidential and not a matter of public record if it receives, by certified mail, a written request to do so from the owner.

Please include the report's Tracking number (Tracking **#383253**) on your written request.

Texas Department of Licensing & Regulation
P.O. Box 12157
Austin, TX 78711
(512) 463-7880

DESC. & COLOR OF FORMATION MATERIAL

From (ft) To (ft) Description
0-10 Light gray clay
10-18 Gray silty sand
18-32 Light gray clay
32-40 Gray clay sand
40-45 Reddish brown clay

CASING, BLANK PIPE & WELL SCREEN DATA

Dia. New/Used Type Setting From/To
2 New PVC Riser 0-35 Sch. 40
2 New PVC Screen 35-45 .010

STATE OF TEXAS PLUGGING REPORT for Tracking #98437

Owner: **Houston Airport System**

Owner Well #: **B8**

Address:
16930 JFK BLVD
Houston , TX 77032

Grid #: **65-06-1**

Well Location:
N/A- ON IAH Airfield
Houston , TX 77032

Latitude: **29° 58' 23" N**

Well County: **Harris**

Longitude: **095° 21' 08" W**

GPS Brand Used: **Magellan**

Well Type: **Monitor**

HISTORICAL DATA ON WELL TO BE PLUGGED

Original Well Driller:	**Jaime Vasquez**
Driller's License Number of Original Well Driller:	**58171**
Date Well Drilled:	**8/23/2014**
Well Report Tracking Number:	**No Data**
Diameter of Borehole:	**4 inches**
Total Depth of Borehole:	**45 feet**
Date Well Plugged:	**9/23/2014**
Person Actually Performing Plugging Operation:	**Brian Johnson**
License Number of Plugging Operator:	**58171**
Plugging Method:	**Pour in 3/8 bentonite chips when standing water in well is less than 100 feet in depth, cement top 2 feet.**
Plugging Variance #:	**No Data**
Casing Left Data:	1st Interval: **2 inches diameter, From 1 ft to 45 ft** 2nd Interval: **No Data** 3rd Interval: **No Data**
Cement/Bentonite Plugs Placed in Well:	1st Interval: **From 0 ft to 2 ft; Sack(s)/type of cement used: .5 cement** 2nd Interval: **From 2 ft to 45 ft; Sack(s)/type of cement used: 2.5 bentonite** 3rd Interval: **No Data** 4th Interval: **No Data** 5th Interval: **No Data**
Certification Data:	The plug installer certified that the plug installer plugged this well (or the well was plugged under the plug installer's direct supervision) and that each and all of the statements herein are true and correct. The plug installer understood that failure to complete the required items will result in the log(s) being returned for completion and resubmittal.
Company Information:	**Envirotech Drilling Services** **2718 South Brompton Drive** **Pearland , TX 77584** **58171**

Plug Installer License Number:	
Licensed Plug Installer Signature:	**Jaime Vasquez**
Registered Plug Installer Apprentice Signature:	**No Data**
Apprentice Registration Number:	**No Data**
Plugging Method Comments:	**No Data**

Please include the plugging report's tracking number (Tracking **#98437**) on your written request.

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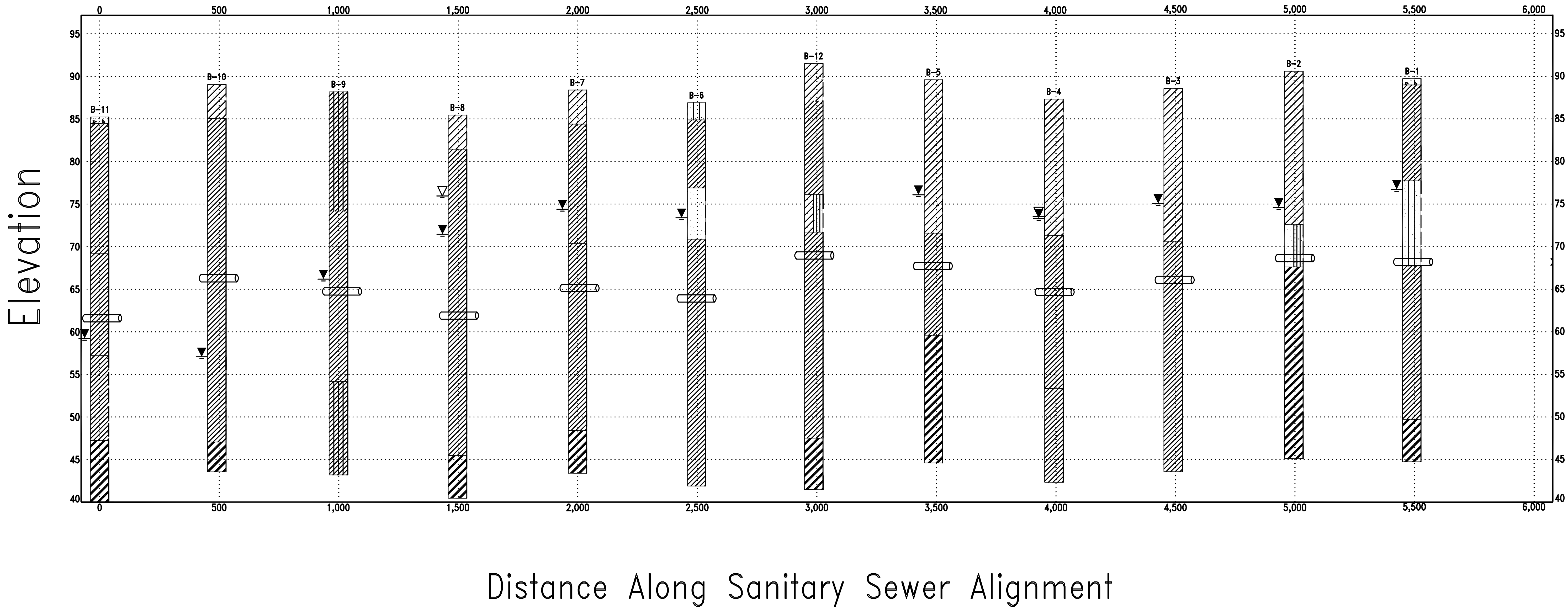
APPENDIX D

BORING LOG SOIL PROFILE



LEGEND:

- ▨ Concrete
- ⊠ Fill (made ground)
- ▨ Sandy Clay (CL)
- ▥ Silt (ML)
- ▦ Asphaltic Concrete
- ▨ Fat Clay (CH)
- ▨ Base
- ▨ Clayey Sand (SC)
- ▥ Silty Sand (SM)

▭ APPROXIMATE INVERT ELEVATION OF PROPOSED UTILITY

▽ 24 HOUR PIEZOMETER READING

▼ Groundwater reading during drilling

Note: Soil profile will be updated with elevations, distance and invert depths for the final report.

HVJ ASSOCIATES

6120 S. Dairy Ashford Road
Houston, Texas 77072-1010
281.933.7388 Ph
281.933.7293 Fax

DATE: 9/10/2014	APPROVED BY: ND	PREPARED BY: KL

BORING LOG PROFILE
SANITARY SEWER REPLACEMENT
GEORGE BUSH INTERCONTINENTAL AIRPORT

PROJECT NO.: HG1217962	DRAWING NO.: PLATE D-1