GEOTECHNICAL INVESTIGATION
RAMPART STREET DRAINAGE IMPROVEMENTS
WBS NO. M-000265-0001-3
HOUSTON, TEXAS

SUBMITTED TO
KLOTZ ASSOCIATES
1160 DAIRY ASHFORD, SUITE 500
HOUSTON, TEXAS 77079

BY
HVJ ASSOCIATES, INC.
HOUSTON, TEXAS

JANUARY 3, 2014

REPORT NO. HG1110720
KEY MAP NO.531 J

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August 28, 2013, **updated January 3, 2014**

Mr. Ralph Cox, PE
Vice President
Klotz Associates
1160 Dairy Ashford, Suite 500
Houston, Texas 77079

Re: Geotechnical Investigation
Rampart Street Drainage Improvements
WBS No. M-000265-0001-3
Owner: City of Houston
HVJ Report No. HG1110720

Dear Mr. Cox:

Submitted herein is the final report of our geotechnical investigation for the above referenced project, updated to include additional requested pavement recommendations. The study was conducted in general accordance with our proposal number HG1110720 dated January 25, 2011 (revised November 9, 2012)and is subject to the limitations presented in this report.

We appreciate the opportunity of working with you on this project. Please notify us if we may be of further assistance.

Sincerely,
HVJ ASSOCIATES, INC.
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The seals appearing on this document were authorized by Muhammad Mustafa, PE, 73803 and Linda Barlow, PE, 63878 on January 3, 2014. The geotechnical investigations presented in Sections 1 through 7 was complete under the direction of Mr. AlAawar; the pavement recommendations presented in Sections 8 through 10 were developed by Ms. Barlow. Alteration of a sealed document without proper notification to the responsible engineer is an offense under the Texas Engineering Practice Act. The following lists the pages which complete this report:

- Main Text – 22 pages
- Plates – 8 pages
- Appendix A – 22 pages
- Appendix B – 10 pages
- Appendix C – 4 pages
- Appendix D – 21 pages

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APPENDICES

1 EXECUTIVE SUMMARY

HVJ Associates, Inc. was retained by Klotz Associates to provide geotechnical services for the proposed Rampart Street storm sewer improvements along Pine from Renwick west to approximately 500 feet east of Hillcroft, along Valerie and Flack from Rampart west to approximately 500 feet east of Hillcroft, along Rampart from Flack north to Clarewood, along Clarewood from Rampart east to Mullins, and along Mullins from Clarewood north to High Star in Houston, Texas. The project also includes replacement of asphalt and concrete pavement in accordance with City of Houston pavement replacement ordinances. Based on the information provided by Klotz Associates, it is understood that the invert depth of the proposed storm sewers ranges between 5 and 20.5 feet below the existing grade.

The purpose of this study is to provide design and construction recommendations for the proposed pavement reconstruction and storm sewer utilities. The geotechnical investigation, laboratory testing and report preparation was performed in accordance with Chapter 11 of the City of Houston Department of Public Works and Engineering Infrastructure Design Manual, July 2012.

Based on the subsurface conditions revealed by the soil borings, the findings and recommendations of this report are summarized below:

1. The subsurface soils at the site generally comprise of firm to hard sandy lean clays, lean clays, fat clays and loose to dense sands with silt in most of the borings. Fill material comprising of lean clay with shell fragments was encountered in some of the borings. A more detail and complete findings is presented in section 5.3 of this report.

2. Groundwater was encountered at almost all the boring locations except at B-1, B-2, B-15, B-16, B-17 and B-18 during the drilling operations. Four piezometers were installed at boring locations B-3 (PZ-1), B-8 (PZ-2), B-13 (PZ-3) and B-18 (PZ-4). The 24-hour water level readings at four piezometers are provided in Section 5.4. Piezometer installation records and groundwater level data are provided in Appendix D.

3. A literature review of surface faults was made from published reports. The primary objective of this review was to evaluate available information from published reports and open file reports. Based on our review, no fault was located within two miles radius from the project site. HVJ believes that faulting should not impact the project site; however, it should be noted that unmapped faults that could impact the project site might exist within the project area. A detailed fault study was not within the scope of this study.

4. Recommendations for pavement reconstruction and installation of storm sewers using both open cut and trenchless techniques are presented in this report. Trenchless operations should generally be in accordance with City of Houston Standard Specification, 02447.

5. Details of existing pavement thickness at each boring location are presented in the report, including recommended repair sections.

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 Klotz Associates to provide geotechnical services for the proposed Rampart Street storm sewer improvements along Pine from Renwick west to approximately 500 feet east of Hillcroft, along Valerie and Flack from Rampart west to approximately 500 feet east of Hillcroft, along Rampart from Flack north to Clarewood, along Clarewood from Rampart east to Mullins, and along Mullins from Clarewood north to High Star in Houston, Texas. The project also includes replacement of asphalt and concrete pavement in accordance with City of Houston pavement replacement ordinances. Based on the information provided to us by Klotz Associates, HVJ understands that the invert depth of the proposed storm sewers ranges between 5 and 20.5 feet below the existing grade. A site vicinity map showing the approximate project location is presented on Plate 1 of the report.

The purpose of this study is to provide design and construction recommendations for the proposed pavement reconstruction and storm sewer utilities. The geotechnical investigation, laboratory testing and report preparation was performed in accordance with Chapter 11 of the City of Houston Department of Public Works and Engineering Infrastructure Design Manual, July 2012.

2.2 Geotechnical Investigation Program

The primary objectives of this study were to gather information on subsurface conditions at the site and to provide recommendations for the proposed pavement reconstruction and storm sewer lines. The objectives were accomplished by:

1. Drilling twenty soil borings to depths ranging between 20 to 32 feet below the existing subgrade to determine soil stratigraphy and to obtain samples for laboratory testing;

2. Installing four piezometers at boring locations B-3 (PZ-1), B-8 (PZ-2), B-13 (PZ-3) and B-18 (PZ-4) to gain an understanding of the groundwater conditions at the site and to evaluate the potential need for dewatering during construction;

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

4. Performing engineering analyses to develop design guidelines and recommendations for the proposed storm sewer lines construction.

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 in between January 15, 2013 to January 31, 2013. Subsurface conditions were investigated by drilling twenty soil borings to depths ranging from 20 to 32 feet below the existing grade. The pavement was cored at all the boring locations and pavement thickness information was obtained. All boreholes except the piezometers were backfilled with cement grout by tremie method in accordance with the City guidelines and patched at the surface, where applicable.

3.2 Sampling Methods

Soil samples were obtained continuously to a depth of 20 feet and then at 5-foot intervals. 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.

3.3 Water Level Measurements

Groundwater was encountered at almost all the boring locations except at B-1, B-2, B-15, B-16, B-17 and B-18 during the drilling operations. Four piezometers were installed at boring locations B-3 (PZ-1), B-8 (PZ-2), B-13 (PZ-3) and B-18 (PZ-4). The 24-hour water level readings at four piezometers are provided in Section 5.4. Piezometer installation records and groundwater level data are provided in Appendix D.

4 LABORATORY TESTING

Selected soil samples were tested in the laboratory to determine applicable physical and engineering properties. All tests except pocket penetrometer were performed according to the relevant ASTM Standards. These tests consisted of moisture content measurements, 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 ASTM version of the Unified Soils Classification System, and the unconsolidated undrained tests were performed to obtain the undrained shear strength of the soil. The type and number of tests performed for this investigation are summarized below:

Type of Test	Number of Tests
Moisture Content (ASTM D2216)	228
Atterberg Limits (ASTM D4318)	93
Percent Passing No. 200 Sieve (ASTM D1140 & ASTM 2487)	56
Pocket Penetrometer	184
Unconsolidated Undrained Compression (UU) (ASTM D 2850)	54
Unit Dry Weight (ASTM D 2166/2850)	54

The laboratory test results are presented on the boring logs in Appendix A. A summary of laboratory test results are provided in Appendix B.

5 SITE CHARACTERIZATION

5.1 General Geology

There are two major surface geological formations that exist in the Houston area: 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 area is located in the Beaumont formation.

The Beaumont formation was deposited on land near sea level in flat river deltas and in inter-delta regions. Soil deposition occurred in fresh water streams and in flood plains (as backwater marsh and natural levees). The courses of major streams and deltaic tributaries changed frequently during the period of deposition, generating within the Beaumont clay a complex stratification of sand, silt and clay deposits. Frequently, stream courses were diverted significant distances from a given point in a backwater marsh, and the water overlying the soil would evaporate since it was cut off from a drainage path. Such water, which would be highly alkaline, would precipitate large nodules of calcium carbonate (calcareous nodules) throughout the surface of evaporation. With the coming of the Second Wisconsin Ice Age, the nearby sea withdrew, leaving the formation several hundred feet above sea level and permitting the soil to desiccate. The process of desiccation compressed the clays in the formation such that they became significantly overconsolidated to a large depth. In addition to preconsolidating the soil, the process of desiccation, together with the later rewetting, produced a network of fissures and slickensides that are now closed but which represent potential planes of weakness in the soil.

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 has been 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 was made from published reports. The primary objective of this review was to evaluate available information from published reports and open file reports. Based on our review, no fault was located within two miles radius from the project site. HVJ believes that faulting should not impact the project site; however, it should be noted that unmapped faults that could impact the project site might exist within the project area. A detailed fault study was not within the scope of this study.

5.3 Soil Stratigraphy

Our 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. Soil stratigraphy encountered at different borings and at different depths is detailed below.

Along Mullins Street: At boring B-1, lean clay with sand was observed at the top 6 feet underlain by fat clay to the depth of 10 feet and is followed by lean clay to the termination depth of boring. Fat clay was observed at the top 12 feet followed by sandy lean clay to the termination depth at boring B-2.

Along Clarewood Street: Sandy lean clay was observed at the top 4 feet followed by lean clay to the depth of 12 feet at boring B-3, silty clay was encountered in between 12 to 14 feet underlain by sand with silt and silty sand to the termination depth of boring B-3.

Along Rampart Street: At boring B-4, lean clay with sand was encountered at top 10 feet followed by sandy lean clay to the depth of 16 feet and the boring was terminated with lean clay. Lean clay with sand was observed at the top 8 feet of boring B-5 underlain by sandy lean clay to the termination depth. At boring B-6, sandy lean clay was observed at the top 4 feet followed by lean clay to the depth of 12 feet, silty clay was observed in between 12 to 14 feet underlain by sand with silt to the depth of 23 feet, sandy lean clay was encountered from 23 feet to 28 feet underlain by sand to the termination depth. At boring B-7, sandy lean clay was observed at top 2 feet followed by fat clay up to 4 feet deep, lean clay was observed in between 4 to 8 feet underlain by fat clay to the depth of 14 feet and the boring was terminated with sandy lean clay. Lean clay was observed at the top 10 feet followed by sandy lean clay to the depth of 12 feet at boring B-8. Also, clayey sand was observed from 12 to 18 feet followed by sand with silt to the depth of 28 feet and the boring was terminated with sandy lean clay. At boring B-9, sandy lean clay was encountered at the top 4 feet followed by lean clay to the depth of 8 feet, sandy lean clay was observed from 8 to 14 feet followed by clayey sand to the depth of 18 feet, sand with silt was encountered in between 18 to 28 feet underlain by clayey sand to the termination depth. At boring B-10, sandy lean clay was encountered at top 10 feet underlain by lean clay to the depth of 14 feet, clayey sand was observed from 14 to 18 feet followed by sand with silt to the depth of 30 feet and the boring was terminated with clayey sand. At boring B-11, lean clay was encountered at top 8 feet underlain by sandy lean clay to the depth of 15 feet; sandy silt was encountered from 16 to 23 feet followed by clayey sand to the termination depth of the boring. At boring B-12, fill material comprising of lean clay with shell was encountered at the top 2 feet underlain by fat clay to the depth of 10 feet, silty clay was observed from 10 to 16 feet underlain by sandy lean clay up to 18 feet deep, lean clay was encountered from 18 feet to 28 feet followed by silty sand to the termination depth. At boring B-13, lean clay was observed at top 4 feet underlain by sandy lean clay to the depth of 6 feet, lean clay was observed from 6 to 12 feet followed by sand with silt to the termination depth of the boring. At boring B-14, lean clay was encountered at top 4 feet followed by fat clay to the depth of 16 feet, sandy lean clay was observed from 16 to 23 feet underlain by clayey sand to the depth of 30 feet and the boring was terminated with sandy silt. At boring B-15, fill material comprising of sandy lean clay with shells was observed at top 2 feet followed by lean clay to the depth of 14 feet with a layer of fat clay in between 8 to 10 feet and the boring was terminated with sandy lean clay.

Along Flack Drive: At boring B-16, fat clay was encountered at top 10 feet followed by sandy lean clay to the termination depth with a layer of lean clay between 10 and 12 feet.

Along Valerie Street: Fat clay was observed at the top 12 feet underlain by sandy lean clay to termination depth at boring B-17.

Along Pine Street: At boring B-18, fat clay was encountered at top 12 feet with a layer of lean clay between 4 and 6 feet, sandy lean clay was observed from 12 feet to the termination depth of the boring. At boring B-19, fill material comprising of sandy lean clay with shells was encountered at top 2 feet underlain by sandy lean clay to the depth of 6 feet, lean clay was observed from 6 to 12 feet followed by sandy lean clay to the depth of 23 feet, clayey sand was observed from 23 to 25 feet underlain by silty sand to the termination depth of boring B-19. Sandy lean clay was observed at the top 8 feet underlain by fat clay to the depth of 14 feet at boring B-20, lean clay was encountered from 14 to 23 feet followed by clayey sand up to 30 feet deep and the boring was terminated with sandy lean clay.

Details of the subsurface stratigraphy encountered in the borings are shown on the boring logs presented in Appendix A.

5.4 Groundwater Conditions

Groundwater was encountered at almost all the boring locations except at B-1, B-2, B-15, B-16, B-17 and B-18 during the drilling operations. Four piezometers were installed at boring locations B-3 (PZ-1), B-8 (PZ-2), B-13 (PZ-3) and B-18 (PZ-4). The 24-hours water level readings at four piezometer locations are shown in the table below. The 30-days water level readings, well records and pluggin reports will be provided in the final report. Piezometer installation records and groundwater level data are provided in Appendix D.

Boring Number	Ground Water During Drilling	Water Level Reading After 24 Hours	Water Level Reading After 30 Days
B-3 (PZ-1)	15’	8.0’	N/A
B-8 (PZ-2)	15’	7.5’	N/A
B-13 (PZ-3)	18.0’	15.0’	N/A
B-16 (PZ-4)	Dry	Dry	N/A

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, 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 sewers and/or sanitary sewers.

6 STORM SEWER DESIGN CRITERIA AND RECOMMENDATIONS

6.1 General

The project involves the replacement of storm sewers from Rampart Street along Pine from Renwick west to approximately 500 feet east of Hillcroft, along Valerie and Flack from Rampart west to approximately 500 feet east of Hillcroft, along Rampart from Flack north to Clarewood, along Clarewood from Rampart east to Mullins, and along Mullins from Clarewood north to High Star in Houston, Texas. The project also includes replacement of asphalt and concrete pavement in accordance with City of Houston pavement replacement ordinances. Based on the information provided to us by Klotz Associates, HVJ understands that the invert depth of the proposed storm sewers ranges between 5 and 20.5 feet below the existing grade. Our Analyses and recommendations for the installation of utilities using both augering and open cut techniques are presented below.

6.2 Geotechnical Parameters

Geotechnical design parameters are presented in the following table. Design parameters given in the table are based on field and laboratory test data obtained at boring locations only and at the approximate invert depth. It must be noted that because of the nature of the soil stratigraphy at this site, parameters at locations away from the borings may vary substantially from values reported in the table.

Boring No.	Street Name	Actual Invert Depth (ft)	Soil Description at Invert Depth	Total Unit Weight (pcf)	Undrained Shear Strength (psf) / or Friction Angle (deg)	Allowable Bearing Pressure (psf)	E'n, Long Term (psi)
B-1	Mullins Street	14	Stiff Lean Clay	110	1400	3300	600
B-2	Mullins Street	13	Stiff Lean Clay	111	1500	3400	600
B-3	Clarewood Street	13	Very Stiff Silty Clay	106	2600	5500	1000
B-4	Rampart Street	15.5	Very Stiff Lean Clay	112	3000	6000	1000
B-5	Rampart Street	16.5	Stiff Sandy Lean Clay	106	1600	3800	600
B-6	Rampart Street	19	Medium Dense Sand with Silt	120	30^0	4700	1000
B-7	Rampart Street	19	Soft Sandy Lean Clay	113	400	1500	300
B-8	Rampart Street	19	Medium Dense Sand with Silt	120	30^0	4700	1000
B-9	Rampart Street	20	Medium Dense Sand with Silt	120	30^0	4700	1000

Boring No.	Street Name	Actual Invert Depth (ft)	Soil Description at Invert Depth	Total Unit Weight (pcf)	Undrained Shear Strength (psf) / or Friction Angle (deg)	Allowable Bearing Pressure (psf)	E'n, Long Term (psi)
B-10	Rampart Street	20.5	Medium Dense Sand with Silt	120	30^0	4700	1000
B-11	Rampart Street	20	Medium Dense Sandy Silt	120	30^0	4700	1000
B-12	Rampart Street	19.5	Very Stiff Lean Clay	117	2500	5700	1000
B-13	Pinemont Street	19	Medium Dense Sand with Silt	120	30^0	4700	1000
B-14	Pinemont Street	18	Very Stiff Sandy Lean Clay	111	3000	6000	1000
B-15	Pinemont Street	13.5	Very Stiff Lean Clay	95	2500	5000	1000
B-16	Flack Drive	11.5	Stiff Lean Clay	88	1600	3500	600
B-17	Valerie Street	5	Stiff Fat Clay	92	1400	3000	600
B-18	Pine Street	5	Stiff Lean Clay	91	1500	3000	600
B-19	Pine Street	19	Hard Sandy Lean Clay	114	4200	6000	2000
B-20	Pine Street	20	Very Stiff Lean Clay	121	2000	4500	600

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. The undrained shear strength and allowable bearing pressure 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 pressures include a factor of safety of three.

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 excavation methods, loads due to overburden and traffic can be determined from Plate 3.

The traffic load applied to the 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 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.

The design of flexible pipes requires the modulus of soil reaction of the native soil (E_n') in the trench wall as input. The E_n' values are based on empirical relationships to the soil consistency as defined by unconsolidated undrained compression tests for cohesive soils. E_n' values for the native soils are presented in the above table.

The E_n' values for short-term conditions in cohesive soils may be assumed to be 1.5 times the long-term values. These values are based on the soil data obtained at the boring locations only and may be used for the noted invert depth zone.

Pipe Bedding. The storm sewer may be installed using City of Houston standard bedding details as outlined on Standard Drawing Nos. 02317-02 and 02317-03. If needed, HVJ recommends groundwater control in accordance with Section 01578 of City of Houston Standard Specifications be implemented to achieve stable trench conditions and satisfactory foundation base.

The excavations should be performed with equipment capable of providing a relatively clean bearing area. Stable soils are essential to provide a strong base during construction. In addition, stable soils enhance trench bottom stability, support for bedding compaction, and minimize possible pipe settlement. Whenever soft foundation soils if encountered during trench excavation, HVJ recommends over excavating 3 to 5 feet below the base of the foundation and replacing with on-site soils compacted to at least 95% of maximum dry density in loose lifts not exceeding 8 inches.

Trench Backfill. Trench backfill for storm sewers should be in accordance with Section 02317, Excavation and Backfill for Utilities, of the City of Houston Standard Specifications, January 2011. The water line backfill should be in accordance with Drawing No. 02317-04.

Pipe embedment (bedding, haunching, and initial backfill) for water lines may consist of bank run sand, concrete sand, gem sand, pea gravel, crushed limestone, cement stabilized sand, or Class I, II and III embedment materials as specified in City of Houston Standard Specification Sections 02320 and 02321. For pipes that will be located under streets or within one foot of streets and curbs, pipe embedment should extend to a minimum of 12 inches above the top of pipe and should be compacted to 95% of maximum dry density determined by ASTM D698 as outlined in City of Houston specification 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. Trench zone backfill is that portion of trench backfill that extends vertically from the top of pipe embedment up to pavement subgrade or up to final grade when not beneath pavement. Trench zone backfill for water lines may consist of bank run sand, select fill, or random backfill material as specified in City of Houston Standard Specification Section 02320. Trenches that are located partially within the limit of one foot from streets or curbs should be uniformly backfilled according to the paved area criteria. Backfill material may consist of in-situ soils or imported select fill. Imported select fill should consist of lean sandy clay with a liquid limit less than 40 and a plasticity index between 8 and 20. Excavated material fulfilling these criteria may be used as backfill. 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.

6.3 Pressures on Primary and Permanent Liners

It is customary to place a primary liner immediately after excavation so that the ground is always supported. A permanent liner is then placed some time after the installation of the primary liner. The annular space between the liners is then filled with grout. The tunnel liners should be designed to support not only the ground loads but also the construction loads. Pressures on the liner with an example calculation of liner load due to earth and traffic load are presented on Plate 3.

Deformation of the liner in the horizontal and vertical diameters can be expected due to soil-liner interaction. Experience with liner distortion in the Houston area suggest values in the range of 0.75 percent difference in length of the vertical and horizontal diameters; with shortening of the vertical diameter in most cases. To the extent that the tunnel liner reduces the soil deformation due to the rigidity of the liner, bending moments will be developed in the liner. The lining will be adequate with respect to bending if it can be deformed, without overstress, by an amount equal to the expected change in diameter.

Buckling of the liner can be a problem if non-uniform support of the liner occurs. This sometimes happens if a local overcut situation occurs during tunneling which is not properly backfilled. Buckling can also occur if the liner is used as reaction for the tunneling equipment, and the tunneling equipment unevenly applies thrust loads.

6.4 Thrust Force Design Recommendations

Piping System Thrust Restraint. Unbalanced thrust forces will be developed in water lines due to changes in direction, cross-sectional areas, or when the pipe is terminated. These forces may cause joints to disengage if not adequately restrained. There will be a slight loss of head due to turbulence in bends in the pipes. This loss will cause a pressure change across the bend, but it is usually small enough to be neglected.

The thrust force may require more reaction than is available just from the pipe bearing against the backfill. In order to prevent intolerable movement and overstressing of the pipe, suitable buttressing should be provided. In general, thrust blocks, concrete encasement, restrained joints and tie rods are common methods of providing reaction for the thrust restraint design. The thrust restraint design provisions described in this section are based on the American Water Works Association Manual M9 (2008) Concrete Pressure Pipe.

Various types of thrust restraint systems are used depending on type of pipes and installation conditions. The force diagram shown on Plate 4 illustrates the thrust force generated by flow in a bend in the pipe. The equations for computing this thrust force are also given on this figure. An example computation of a thrust force generated by flow at a bend in a pipe for a surge pressure of 150 psi and a bend angle of 90 degrees is also presented on Plate 5.

Frictional Resistance. The unbalanced force produced by grade and alignment changes can also be resisted by friction on the pipe. The length of pipe will be formed by tying or welding joints together for the distance required to develop adequate capacity or by encasing the pipe in concrete. The resisting frictional force, F_R is computed as

$$F_R = f\,(2W_e + W_w + W_p)$$

Where:

f = Coefficient of friction between pipe and soil

W_e = Weight of soil over pipe in lb/ft

W_w = Weight of contained water in lb/ft

W_p = Weight of pipe in lb/ft

The friction value depends on the material in contact with the pipe and the soil used in the backfill around the pipe. For pipe surrounded by compacted sand or crushed stone, the friction between the pipe and soil may be based on a friction angle of 30 degrees. The allowable coefficient of friction, f, of 0.28, 0.23 and 0.18 can be used for concrete, steel and PVC pipes, respectively.

This value includes a factor of safety of 2.0. The weight of soil above the pipe will depend on the soil unit weight and the pipe depth. For compacted soils used for backfill, a total unit weight of 125 pcf can be used.

Tied joints are used to transmit thrust across joints. These ties may be welded or harnessed joints. Joints may be welded in the field in order to transmit the thrust involved. Information concerning types of harnessed joints available and size and pressure limitations can be obtained from the pipe manufacturers.

6.5 Utilities Installed by Trenchless Technique

We understand that trenchless construction methods may be used to install storm sewers at some locations along the alignment. The results of our soil borings indicate that cohesive soils will be encountered at the pipe invert depth. It should be noted that due to variability in soil deposits any tunneling operations along the projected alignments could result in varying degrees of mixed face tunneling conditions where several types of soil material may be encountered at the tunneling face.

Although the clays are typically stable, face stability problems can occur when soft soils are encountered. Even with dewatering systems operating, unstable flowing situation may occur.

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	88 to 121 pcf
Coefficient of Earth Pressure, K_o	1.0
Undrained Shear Strength	400 to 4200 psf
Poisson's Ratio	0.45
Young's Modulus	3000 to 14000 psi

Pipe Design. For pipes to be installed by tunneling techniques, 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 4A and 4B. Therefore, pipes designed to resist construction loads during tunneling operations should have adequate strength for most long-term overburden and traffic loads.

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 water line and any possible future excavation to be performed near the pipelines.

Influence of Tunneling on Adjacent or Overlying Structures. The construction of every tunnel 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, roads and services located above the 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. While the recommendations HVJ is 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 CONSIDERATIONS

7.1 General

This section is intended to address issues that might arise during construction. Our 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, open-cut construction and augering technique 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 Excavation Considerations

Excavations should satisfy two requirements. First, the soils above final grade must be removed without disturbing the soil below excavation grade, 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 4A and 4B. 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.

Boring No.	Street Name	OSHA Soil Type				
		Depth of Trench (feet)				
		0-10	10-14	14 – 21	21-25	25-32
B-1	Mullins Street	B	B	B	-	-
B-2	Mullins Street	B	B	B	-	-
B-3	Clarewood Street	B	B	C	C	-
B-4	Rampart Street	B	B	B	B	-
B-5	Rampart Street	B	B	B	B	-
B-6	Rampart Street	B	B	C	C	C
B-7	Rampart Street	B	B	B	B	-
B-8	Rampart Street	B	C	C	C	C
B-9	Rampart Street	B	B	C	C	C
B-10	Rampart Street	B	B	C	C	C
B-11	Rampart Street	B	B	C	C	C
B-12	Rampart Street	B	B	B	B	C
B-13	Pinemont Street	B	C	C	C	C
B-14	Pinemont Street	B	B	B	C	C
B-15	Pinemont Street	B	B	B	-	-
B-16	Flack Drive	B	B	B	-	-
B-17	Valerie Street	B	B	B	-	-

Boring No.	Street Name	OSHA Soil Type				
		Depth of Trench (feet)				
		0-10	10-14	14 – 21	21-25	25-32
B-18	Pine Street	B	B	B	-	-
B-19	Pine Street	B	B	B	C	C
B-20	Pine Street	B	B	B	C	C

In general, it is our 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 4A and 4B.

The planned construction will 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. HVJ recommends that the horizontal distance should be 4 feet for excavation depths of up to 10 feet.

7.3 Auger Construction Considerations

In augering, a launch pit is excavated and a horizontal boring rig is used to excavate an unsupported bore distance of up to 300 to 400 feet to a receive pit. Once the bore is excavated, dragging a tool through the bore cleans it, and then the pipe is dragged through the bore. This technique is commonly used in the Houston area for installation of small diameter pipes at depths above the groundwater table. Augering operations should generally be in accordance with City of Houston Standard Specification, 02447.

Bore Stability. In auger construction, where the bore must stand open unsupported for a period of several hours, the structure of the soil is very important. Augering operations have encountered difficulties such as slowed production rates, ground surface settlement above the bore, and bore collapse in some soil conditions in the Houston area. HVJ does not recommend augering in unstable soils or in soils below the water table without providing casing to prevent running ground condition. Firm to very stiff clay soils are generally suitable for augering, however, the secondary structure of the soil is an important consideration. Where a blocky, slickensided, or fissured condition is noted on the boring logs, the clay soil may slough excessively from the bore walls. This will lead to an excessive number of cleaning passes to allow passage of the pipe, and it will result in formations of large voids around the pipe. Collapse of these voids after pipe placement commonly results in noticeable settlement of the ground surface above the bore.

Loss of Ground. A properly designed and controlled augering operation can eliminate or reduce immediate soil movement and subsidence to a tolerable level. Nevertheless, some ground loss should be expected during any tunnel construction operation. With good construction techniques, ground loss can be held to acceptable levels. Generally, tunnels 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 or silts 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 as discussed in a later section.

Ground Control and Improvement. HVJ recommends that tunnels be constructed using techniques that provide positive support to the soil during augering operations. Several measures are available to overcome adverse ground conditions including groundwater lowering and grouting. HVJ expects that groundwater will be encountered in tunnels that are excavated below 13 feet. Groundwater control and dewatering recommendations are provided in Section 7.6 of this report.

7.4 Auger Pit Construction Considerations

It is our understanding that auger pits constructed for augering operations will vary in size depending on whether the pit is a drive or receive pit, the size of machine, and the length of auger 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. HVJ recommends that pressure distribution as shown on Plates 4A and 4B be used, 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 4A and 4B.

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 loss of ground at the ground surface outside the pit and heave of the excavation base inside the pit. Pits for augering operations are typically excavated approximately 4 feet below pipe invert depth. Whenever soft foundation soils are encountered during trench excavation, HVJ recommends over excavating 3 to 5 feet below the base of the foundation and replacing with on-site soils compacted to at least 95% of maximum dry density in loose lifts not exceeding 8 inches.

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.

7.5 Select Fill and General Earthwork Recommendations

Select fill required to raise the grade or backfill should consist of lean 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.

7.6 Groundwater Control

Groundwater seepage may be expected during excavation depending upon the groundwater conditions at the time of construction. 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. Assessment of the need for groundwater control and installation of appropriate dewatering equipment is the contractor's responsibility. 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 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. Based on the subsurface soils encountered, HVJ anticipates groundwater to be controlled using a pump and sump arrangement. In any case, the groundwater control system used must provide a relatively dry, stable base for construction. However, it should be noted that groundwater conditions will change due to rainfall and seasonal changes.

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 to this purpose, the water will be lowered at least 3 feet 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 PAVEMENT REPAIR DESIGN RECOMMENDATIONS

8.1 General

HVJ understands that the project includes repair of the existing pavement in the proposed construction area only. As per the City of Houston Design Manual, pavement restoration design must consider minimum limits and methods required for restoration on City Standard Details. The required pavement repair section was evaluated considering existing pavement sections based on the City of Houston Drawing No. 02951-03 Asphalt Pavement Restoration and Drawing Nos. 02902-01 and 02902-02 Pavement Repair Details for Street Cuts (See details in Appendix C).

8.2 Existing Pavement Thickness

The existing pavement within the project area was cored prior to drilling at all the boring locations. The existing cross sections for Rampart St range from 3" to 6.5" asphalt over 5" to 11" cement stabilized sand base, with the exception of B-5 that also includes 7.5" concrete under the asphalt. The existing cross sections for the remaining streets are generally 1.5" to3.5" asphalt over 4" to 6.5" concrete. The existing pavement structure and thickness are presented in the following table:

8.3 Required Repair Thickness

As per the repair requirements in the City of Houston standard drawing 02951-03, the repair required for the portions of the project limits represented by HMAC over PCC, would include replacement of the concrete for the extent of the excavation to match existing thickness plus two inches.

For Rampart St, the base is replaced to match existing thickness plus two inches for the extent of the excavation. The average existing HMAC surface thickness for Rampart St is 4.5" and the average existing base thickness is 7.5", therefore the recommended repair section for Rampart St based on these averages is 4.5" HMAC over 9.5" base.

The recommended repair sections by street are summarized in the following table.

Street	Pavement Repair Section for Street Cut
Mullins St	2.0" HMAC Surface 7.0" Concrete
Clarewood	1.5" HMAC Surface 8.0" Concrete
Flack Dr	1.0" HMAC Surface 8.5" Concrete
Valerie St	1.75" HMAC Surface 8.25" Concrete

Pine St, north of Rampart St	2.0” HMAC Surface 8.5” Concrete
Pine St, btwn Rampart St and S Renwick Dr	3” HMAC Surface 10” Crushed Concrete Base
Rampart St	4.5” HMAC Surface 9.5” Crushed Concrete Base

The HMAC should meet the COH specification 02741, the concrete should meet the COH specification 02751, and the crushed concrete base should meet the COH specification 02713. If one repair section is desired, the thickest repair section is recommended to meet the minimum requirements for the thickest existing pavement structure.

To expedite construction for the streets with existing HMAC over cement stabilized sand base sections, an HMAC base could be considered in lieu of the crushed concrete base replacement. Assuming a structural coefficient of 0.14 for crushed concrete base and 0.40 for HMAC base, an equivalent structural thickness of HMAC base may be estimated. For Rampart St and the portion of Pine St with existing cement stabilized sand base, the following alternative repair sections may be considered:

Street	Alternative Pavement Repair Street Cut Sections	
Pine St, btwn Rampart St and S Renwick Dr	3” HMAC Surface 4” HMAC Base	2.0” HMAC Surface 5.5” HMAC Base
Rampart St	4.5” HMAC Surface 4” HMAC Base	2.0” HMAC Surface 7.0” HMAC Base

9 PAVEMENT RECONSTRUCTION RECOMMENDATIONS

9.1 General

HVJ understands that a decision as been made following submittal of the draft design report, to reconstruct the streets for the entire alignment of the storm sewer improvements with the exception of street repair at the outfall at Renwick Dr intersection with Rampart St. The desired reconstruction sections are to meet the COH Design Manual Street Paving Design Requirements.

9.2 Pavement Sections for Reconstruction

The summary of pavement sections, based on the COH minimum requirements, is shown in the following table.

Street Classification	Project Street	COH Minimum Pavement Section	Pavement Repair Section for Street Cut
Width Less Than or Equal to 27 Ft Face-to-Face of Curb (Residential)	Mullins St Clarewood Flack Dr Valerie St Pine West of Rampart	6" JRCP 6" Stabilized Subgrade	n/a
Width Greater than 27 Ft Face-to-Face of Curb not Major Thoroughfare	Rampart St Pine East of Rampart	7" JRCP 6" Stabilized Subgrade	n/a
Major Thoroughfare	Bissonet intersection with Rampart St	8" JRCP 8" Stabilized Subgrade	n/a
	Bellaire intersection with Rampart St		
Major Thoroughfare - Repair	Renwick Dr intersection with Rampart St	n/a	10" JRCP*

* Existing concrete thickness assumed to be equal to 8" minimum Thoroughfare section required by COH, which is increased by 2" for repair section; after required depth of concrete removal and excavation, subgrade should be prepared as per COH 02315 Roadway Excavation

9.3 Pavement Alternative for Expedited Reconstruction

For possible situations on Rampart St When expedited construction may be necessary for traffic constraints, cement stabilized sand may be used in lieu of the stabilized subgrade, under a base layer. It is HVJ understands that the practice of using cement stabilized sand has been used routinely in the City of Houston. This material is provides a strength gain progression above the subgrade and provides a depth of non-swelling material, although it does not provide a complete moisture barrier. The addition of an HMAC base placed on the cement stabilized sand will provide the moisture barrier as well as the added benefit of a temporary driving surface, if needed. Therefore, the recommended rigid pavement design alternative for Rampart St that accommodates expedited construction is:

7" PCC (COH Specification 02751)
4" HMAC Base (COH Specification 02711)
6" Cement Stabilized Sand (COH Specification 02321)
Compacted subgrade

10 PREPARATION OF SUBGRADE

The surficial soils mostly consist of fat clays and lean clays. The City of Houston requires stabilizing the top six inches of the subgrade soil beneath the proposed concrete pavement. Stabilization of the subgrade will increase the modulus of subgrade reaction and provide subgrade stability for construction during inclement weather. Based on the soils classifications and Plasticity Indices of these materials in the top few feet under the existing pavements, lime is recommended as the stabilizing agent. The following procedures for subgrade preparation are recommended.

1. Clear the proposed development area of existing pavement and subgrade to the grade required for the proposed pavement section.

2. Subgrade surfaces exposed after excavation should be proof-rolled in accordance with TxDOT Standard Specification Item 216 or equivalent City of Houston specification. If rutting develops, tire pressures should be reduced. The purpose of the proof-rolling operation is to identify any underlying zones or pockets of soft soils and to remove such weak materials.

3. Before stabilizing the subgrade, scarify the upper six inches of exposed surface as required, mix with lime and compact it to 95 percent of standard proctor maximum dry density (ASTM D698). Construction of lime-stabilized subgrade should conform to City of Houston Section 02336.

As per the COH 02336 Lime Stabilized Subgrade specification, the minimum lime content shall be 5 percent of dry unit weight of subgrade as determined by ASTM D 698. Based on HVJ's experience with similar soils a range of 5% to 6% lime may be required to stabilize the subgrade; however, the actual amount of lime should be determined for subgrade soils by conducting laboratory tests on the exposed subgrade material during construction.

11 MONITORING

11.1 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.

11.2 Preconstruction Survey

HVJ recommends that a preconstruction survey be performed prior to any tunneling operations. As part of the survey, a complete visual record should be made of all structures along the tunnel alignment. This survey should be comprised of a combined photographic and video taped documentation of the condition of the surrounding structures. Settlement sensitive structures and structures with pre-existing damage should be of particular concern during the visual record process.

In addition to the visual record, a review of the operating conditions of facilities located within a horizontal distance equal to approximately twice the invert depth from the centerline of the tunnel is recommended. Particular attention should be paid to the conditions of existing utilities near the tunnel bore. Existing leaking utilities need to be identified and repaired prior to tunneling to prevent tunneling difficulties due to infiltration of water or sewage into the bore. The location of settlement sensitive utilities should be established and a monitoring program implemented to determine whether tunneling operations are proceeding without loss of ground prior to the tunnel being driven near the utility.

11.3 Construction Monitoring - Tunneling

HVJ recommends that surface elevations along the tunnel alignment be monitored prior to, at intervals during, and after construction.

Ground surface settlements can be measured by taking precise leveling measurements, by standard surveying methods, on settlement monuments installed in the ground along the centerline of the tunnel. The monuments should be suitably protected against vandalism and accidental damage. Survey benchmarks should be established in close proximity to the alignment but outside the influence of any settlement trough.

11.4 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 these services and would be pleased to do so for this project.

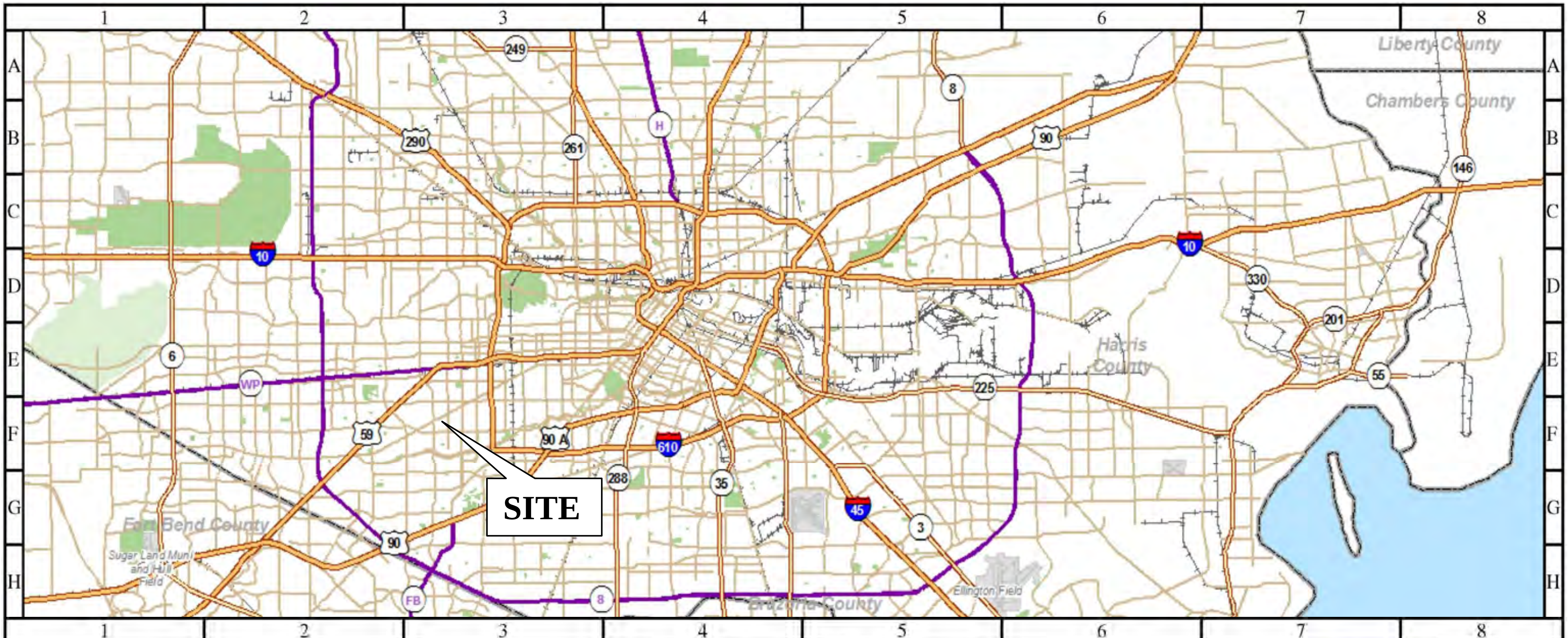
12 DESIGN REVIEW

HVJ should be retained to review the final design plans and specifications for this project. During all excavation, grading and construction phases of this project, HVJ should provide the materials testing verification and observation services so our geotechnical recommendations may be interpreted and implemented correctly.

13 LIMITATIONS

This investigation was performed for the exclusive use of Klotz Associates and the City of Houston for the proposed Rampart Street storm sewer improvements along Pine from Renwick west to approximately 500 feet east of Hillcroft, along Valerie and Flack from Rampart west to approximately 500 feet east of Hillcroft, along Rampart from Flack north to Clarewood, along Clarewood from Rampart east to Mullins, and along Mullins from Clarewood north to High Star in Houston, Texas. HVJ Associates, Inc. has endeavored to comply with generally accepted geotechnical engineering practice common in the local area. HVJ Associates, Inc. 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 HVJ and HVJ's experience with similar soils and site 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 Associates, Inc. should be immediately notified so that further investigation and supplemental recommendations can be provided.

PLATES



CITY OF HOUSTON

Department of Public Works and Engineering

Geographic Information & Management System (GIMS)

1 inch = 23146 feet

DISCLAIMER: THIS MAP REPRESENTS THE BEST INFORMATION AVAILABLE TO THE CITY.
THE CITY DOES NOT WARRANT ITS ACCURACY OR COMPLETENESS.
FIELD VERIFICATIONS SHOULD BE DONE AS NECESSARY.

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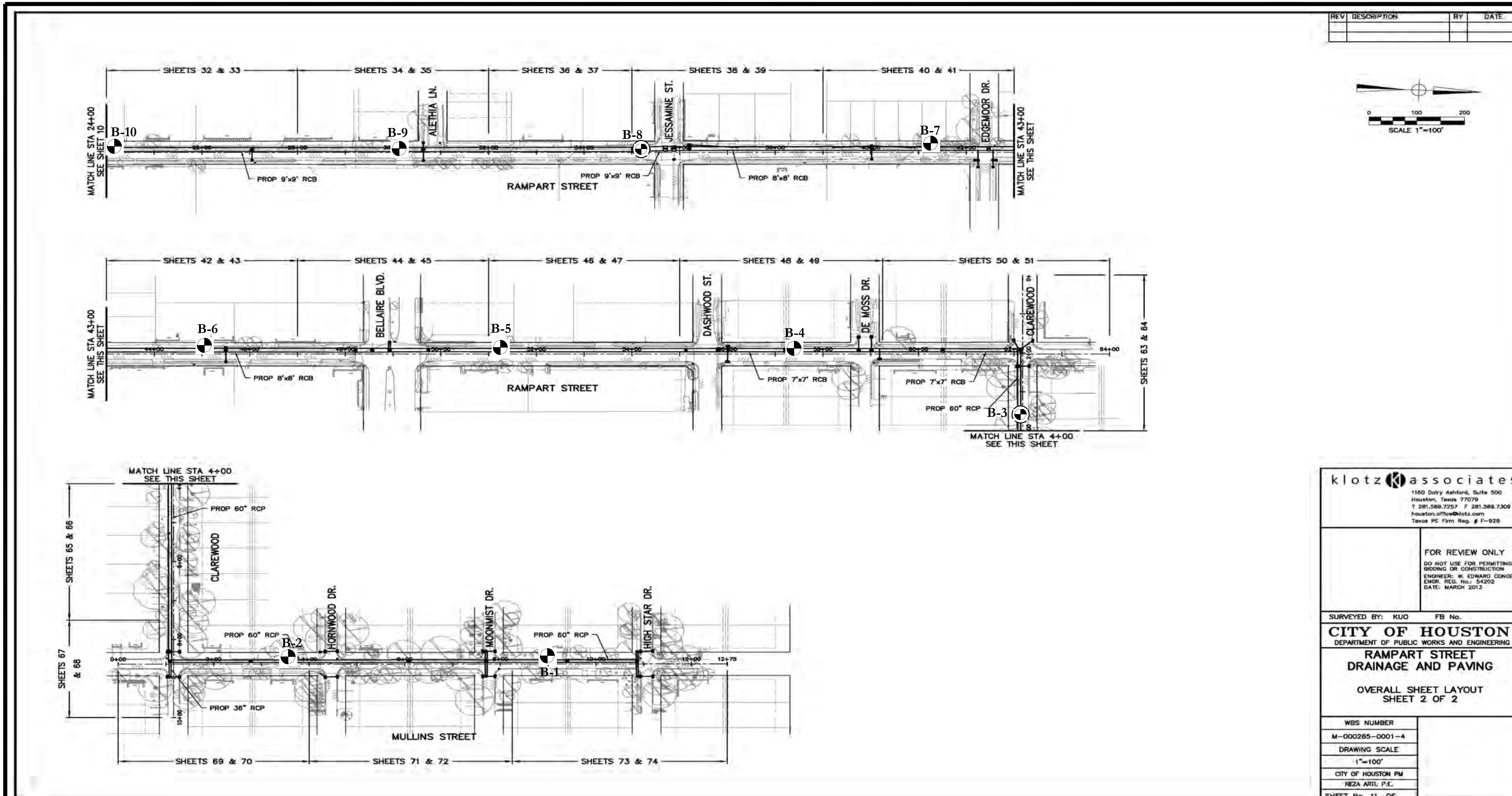
DATE: 2/14/2013	APPROVED BY: JW	PREPARED BY: NL

SITE VICINITY MAP
RAMPART STREET DRAINAGE IMPROVEMENTS
WBS No. M-000267-0001-3

PROJECT NO.: HG1110720	DRAWING NO.: PLATE 1



LEGEND:

- APPROXIMATE BORING LOCATIONS
- APPROXIMATE BORING AND PIEZOMETER LOCATIONS

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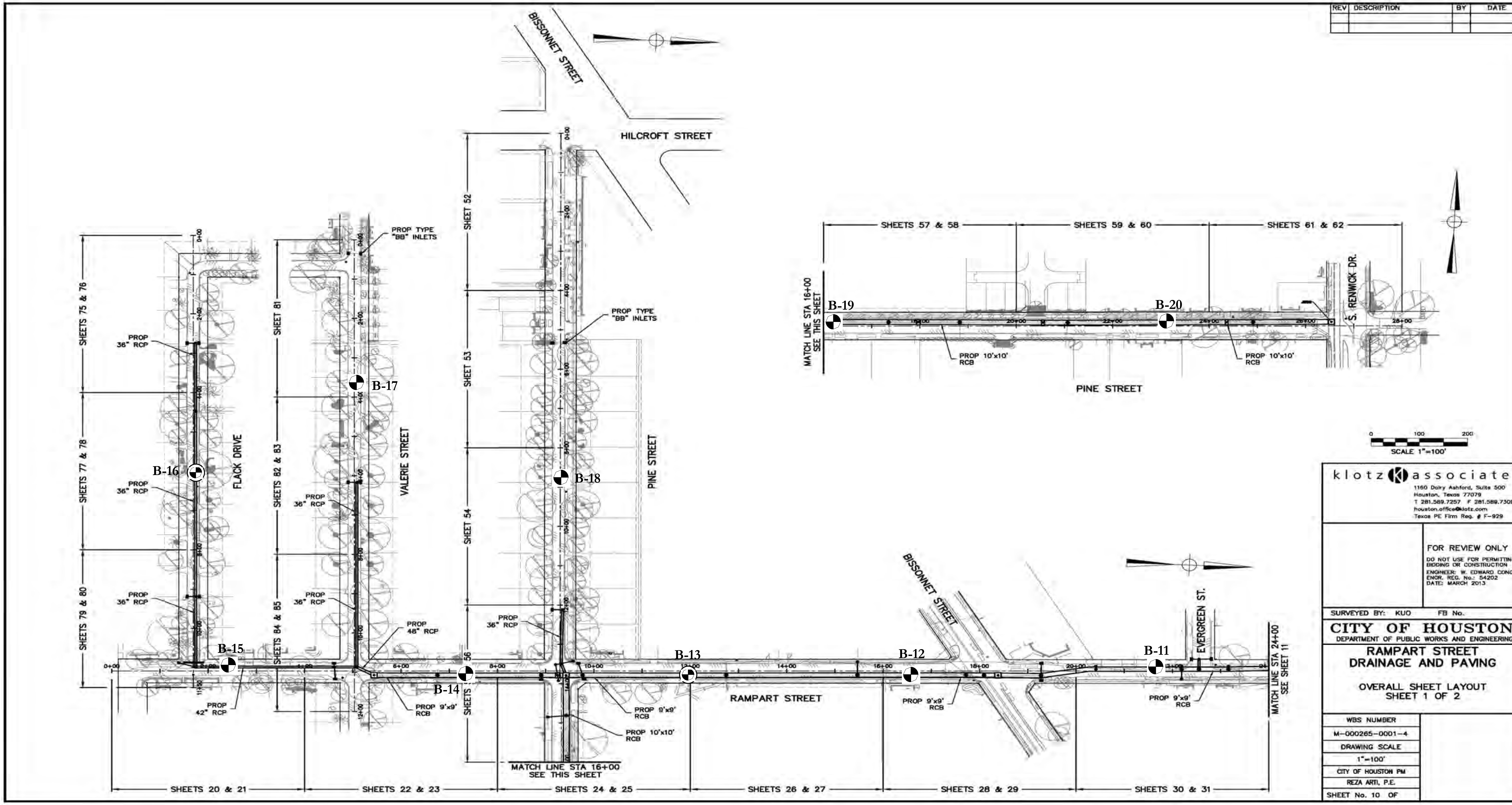
PLAN OF BORINGS
RAMPART STREET DRAINAGE AND PAVING
WBS No. M-000265-0001-3

PROJECT NO.:	DRAWING NO.:
HG1110720	PLATE 2A



LEGEND:

- APPROXIMATE BORING LOCATIONS
- APPROXIMATE BORING AND PIEZOMETER LOCATIONS

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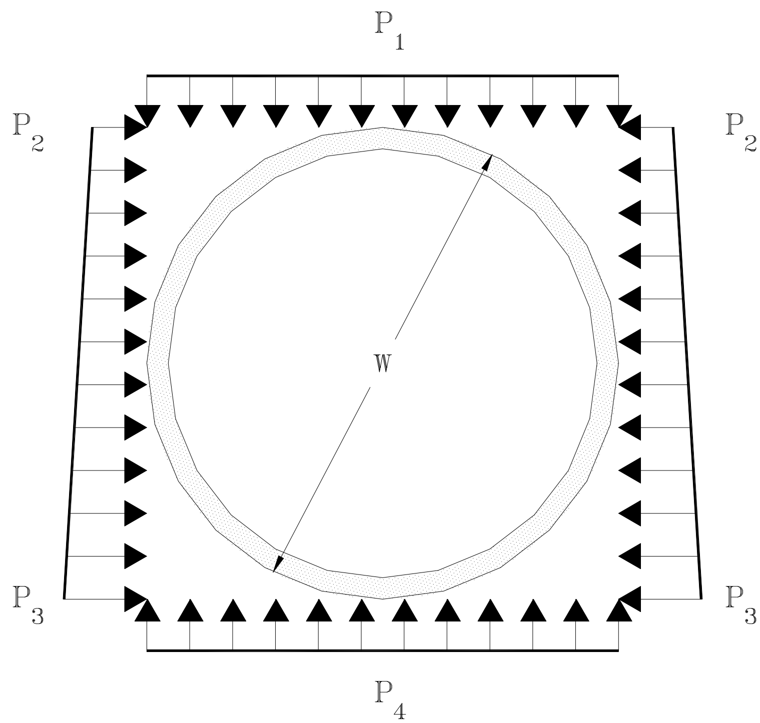
PLAN OF BORINGS
RAMPART STREET DRAINAGE AND PAVING
WBS No. M-000265-0001-3

PROJECT NO.: HG1110720	DRAWING NO.: PLATE 2B



For

$D_w \le H$

$P_1 = \gamma D_w + (H - D_w)(\gamma - \gamma_w) + P_s + (H - D_w)\gamma_w$

$P_2 \equiv [\gamma D_w + (H - D_w)(\gamma - \gamma_w) + P_s]K_o + (H - D_w)\gamma_w$

$P_3 = [\gamma D_w + (H + W - D_w)(\gamma - \gamma_w) + P_s]K_o + (H + W - D_w)\gamma_w$

$P_4 = \gamma D_w + (H + W - D_w)(\gamma - \gamma_w) + P_s + (H + W - D_w)\gamma_w$

For

$H < D_w < H + W$

$P_1 \equiv H\gamma + P_s$

$P_2 = (\gamma H + P_s)K_o$

$P_3 = [\gamma D_w + (H + W - D_w)(\gamma - \gamma_w) + P_s]K_o + (H + W - D_w)\gamma_w$

$P_4 = \gamma D_w + (H + W - D_w)(\gamma - \gamma_w) + P_s + (H + W - D_w)\gamma_w$

For

$D_w \ge (H + W)$

$P_1 \equiv H\gamma + P_s$

$P_2 = (\gamma H + P_s)K_o$

$P_3 = [(H + W)\gamma + P_s]K_o$

$P_4 = (H + W)\gamma + P_s$

Where

P_1, P_2, P_3 = Pressure imposed on pipe, psf
D_w = Depth of groundwater, feet
H = Depth of top of pipe from ground surface, feet
W = Diameter of pipe, feet
γ = Total Unit weight of soil, pcf
γ_w = Unit weight of water, pcf
P_s = Surcharge load, psf
K_o = Coefficient of earth pressure, (1.0 for clays and 0.5 for sands)

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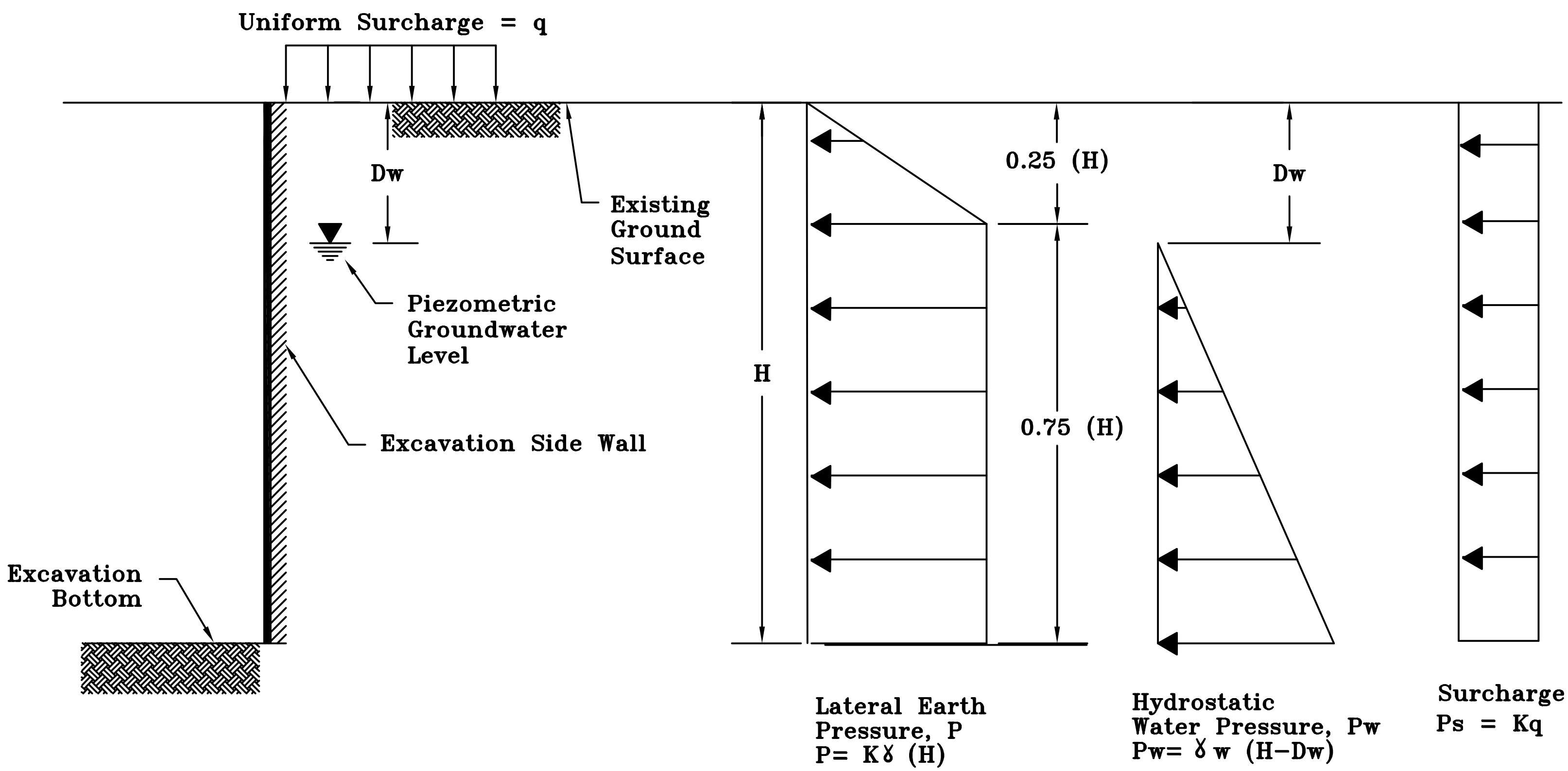
RIGID PIPE AND TUNNEL LINER LOADS

PROJECT NO.: HG1110720	DRAWING NO.: PLATE 3



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

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

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

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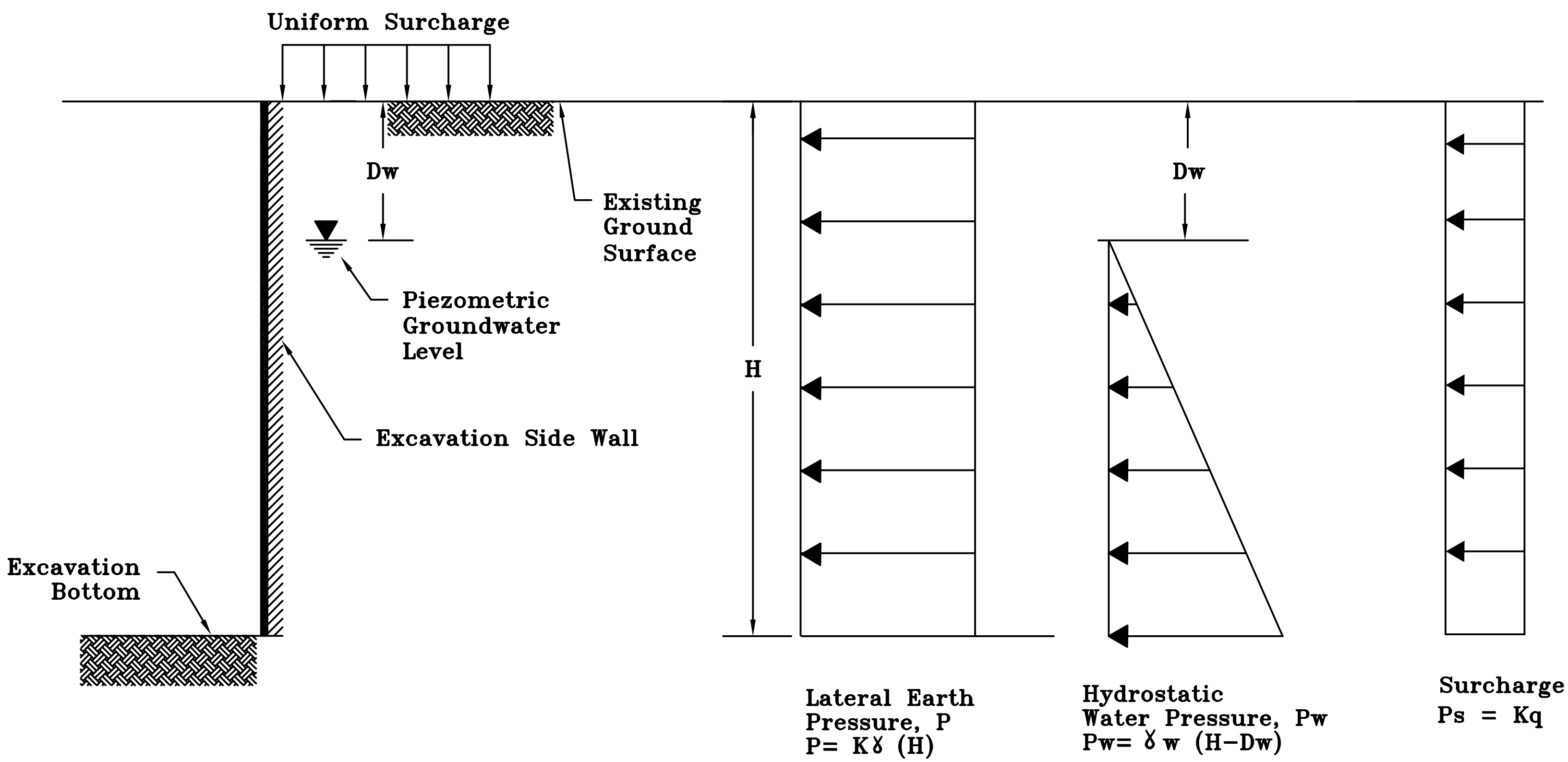
BRACED EXCAVATION
LATERAL EARTH PRESSURE DIAGRAM (CLAY)

PROJECT NO.:	DRAWING NO.:
HG1110720	PLATE 4A



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.

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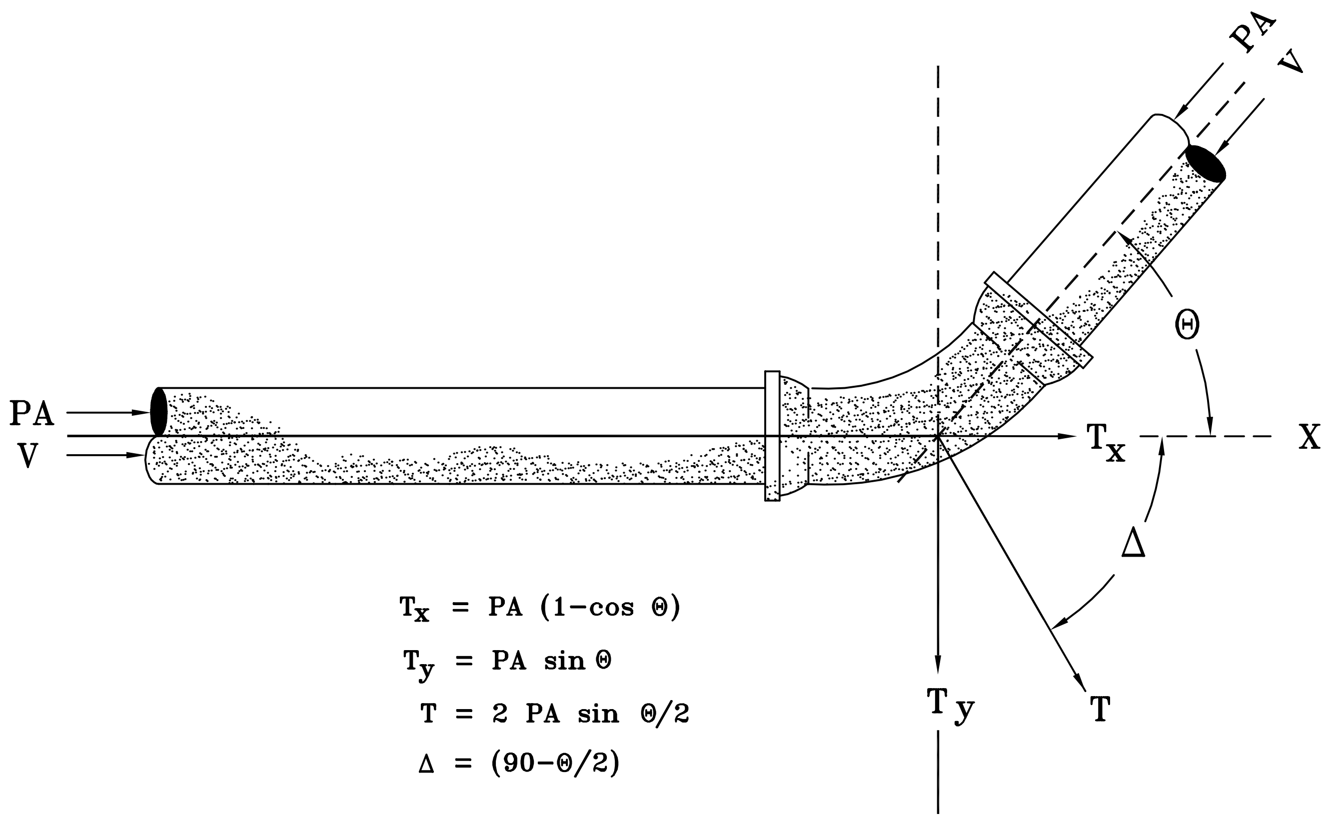
BRACED EXCAVATION
LATERAL EARTH PRESSURE DIAGRAM(SAND/SILT)

PROJECT NO.:	DRAWING NO.:
HG1110720	PLATE 4B



T_x = PA (1−cos Θ)

T_y = PA sin Θ

T = 2 PA sin Θ/2

Δ = (90−Θ/2)

Where:

- T is the resultant force on the bend.
- T_x is the component of thrust force in x−direction.
- T_y is the component of thrust force in y−direction.
- P is the maximum sustained pressure.
- A is the pipe cross−sectional area.
- Θ is the bend deflection angle.
- Δ is the angle between T and X−axis.
- V is the fluid velocity.
- D is the inside diameter of conduit.

Sample Calculation:

Given: P = 150 psi, D = 1.0' = 12" For: $\Theta = 90^\circ$

A = $(\pi D^2)/4$ = 113.1 in^2

Find: T = 2 PA sinΘ/2 = 2 x 150 x 113.1 x sin (90°/2)
= 23,992 lb = 24.0 kips

T_x = PA (1−cos Θ) = 150 x 113.1 x (1−cos 90°)
= 16,969 lb = 17.0 kips

T_y = PA sin Θ = 150 x 113.1 x sin (90°)
= 16,969 lb = 17.0 kips

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THRUST FORCE ACTING ON A BEND

PROJECT NO.:	DRAWING NO.:
HG1110720	PLATE 5

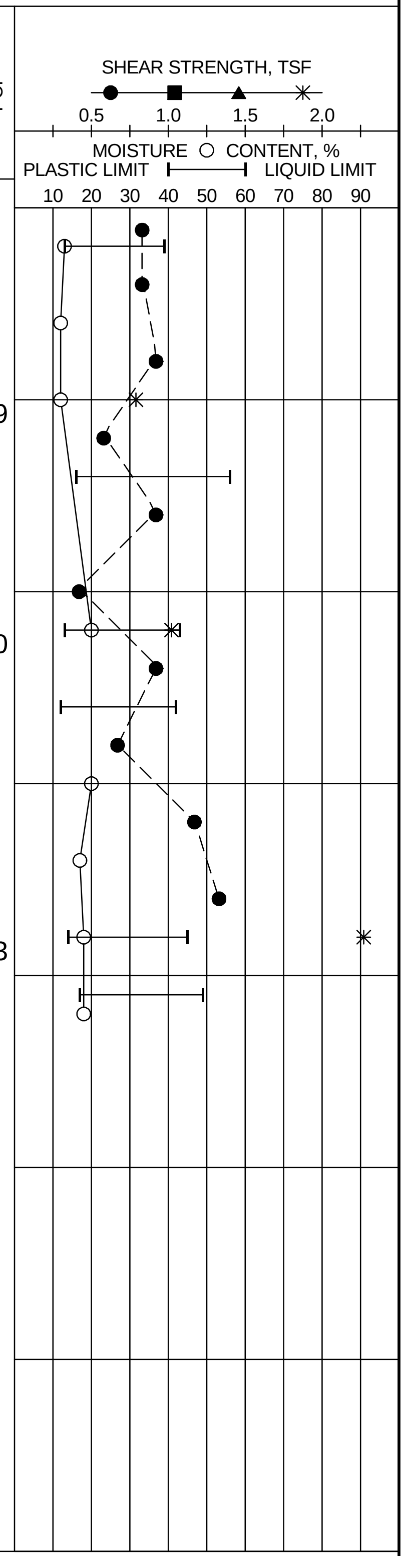
APPENDIX A

BORING LOGS AND KEY TO TERMS & SYMBOLS

LOG OF BORING

Project: Rampart Street Drainage Improvements | Project No.: HG1110720 | WBS No.: M-000265-0001-3
Boring No.: B-1 | Date: 1/15/2013 | Elevation:
Groundwater during drilling: --- | Northing: -- | Station: --
Groundwater after 24hrs: --- | Easting: -- | Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0		Pavement: 1.5" Asphalt, 5.5" Concrete		
		Stiff light brown LEAN CLAY WITH SAND (CL)		
5			77	109
6		Stiff reddish brown FAT CLAY (CH)		
8		-w/ calcareous nodules 8'-10'		
10		Firm to hard reddish brown LEAN CLAY (CL) -w/ calcareous nodules 10'-12'		110
16		-w/ sand 16'-18'		
17			71	
19				113
21				



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

See Plate 2 for boring location.

PLATE A-1

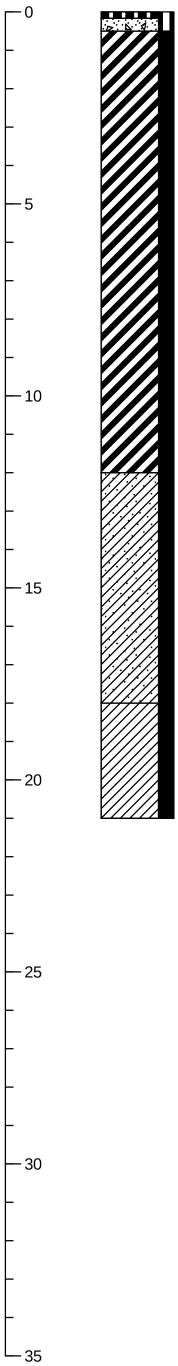
HVJ ASSOCIATES

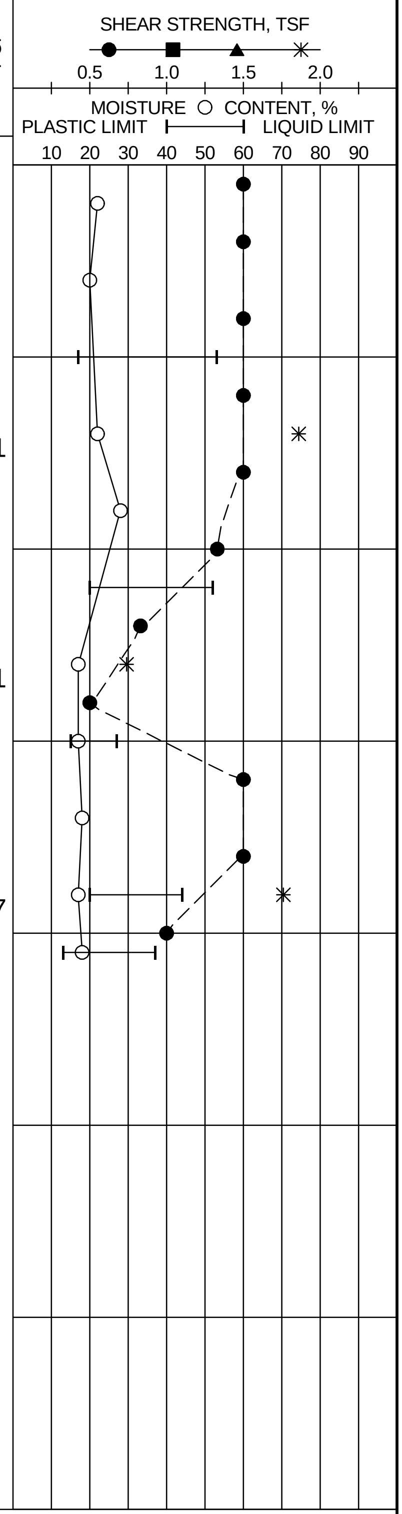
LOG OF SOIL BORING HG-11-10720.GPJ HVJ.GDT 2/14/13

LOG OF BORING

Project: Rampart Street Drainage Improvements | Project No.: HG1110720 | WBS No.: M-000265-0001-3
Boring No.: B-2 | Date: 1/15/2013 | Elevation:
Groundwater during drilling: --- | Northing: -- | Station: --
Groundwater after 24hrs: --- | Easting: -- | Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0		Pavement: 2" Asphalt, 4" Concrete		
		Stiff to very stiff brown and gray FAT CLAY (CH) -w/ sand 0'-2'	82	
		-w/ calcareous nodules 4'-8'		
				111
			90	
12		Stiff to very stiff brown and gray SANDY LEAN CLAY (CL)		111
		-w/ calcareous nodules 16'-21'		
18		Very stiff brown and gray LEAN CLAY (CL)		107
		-w/ calcareous nodules 20'-21'		





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

See Plate 2 for boring location.

PLATE A-2

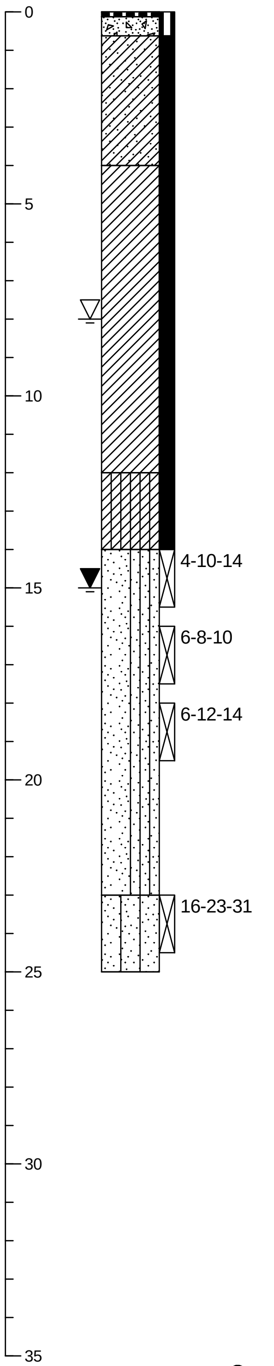
LOG OF SOIL BORING HG-11-10720.GPJ HVJ.GDT 2/14/13

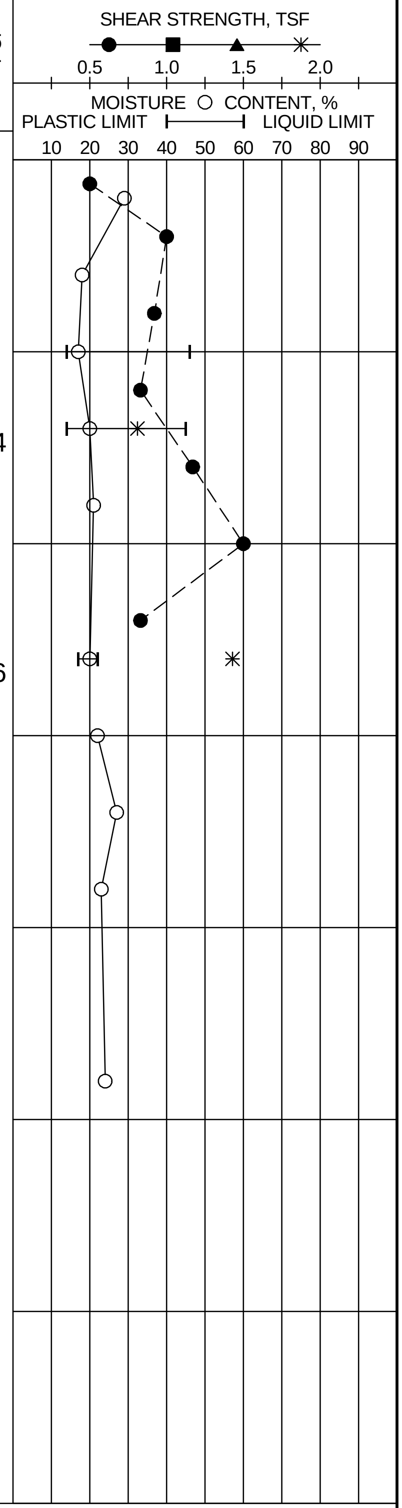
HVJ ASSOCIATES

LOG OF BORING

Project: Rampart Street Drainage Improvements | Project No.: HG1110720 | WBS No.: M-000265-0001-3
Boring No.: B-3 (PZ-1) | Date: 1/31/2013 | Elevation:
Groundwater during drilling: 15 feet | Northing: -- | Station: --
Groundwater after 24hrs: 8 feet | Easting: -- | Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0		Pavement: 1.5" Asphalt, 6" Concrete		
		Stiff dark brown SANDY LEAN CLAY (CL)	67	
		Stiff to very stiff brown and gray LEAN CLAY (CL)		104
		Stiff to very stiff brown and gray SILTY CLAY (CL-ML)		106
	4-10-14	Medium dense light brown SAND WITH SILT (SP-SM)	11	
	6-8-10			
	6-12-14		7	
	16-23-31	Very dense brown SILTY SAND (SM)	15	





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

See Plate 2 for boring location.

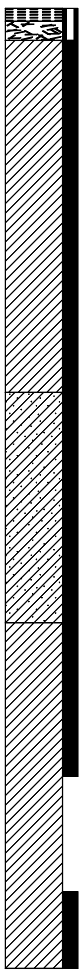
PLATE A-3

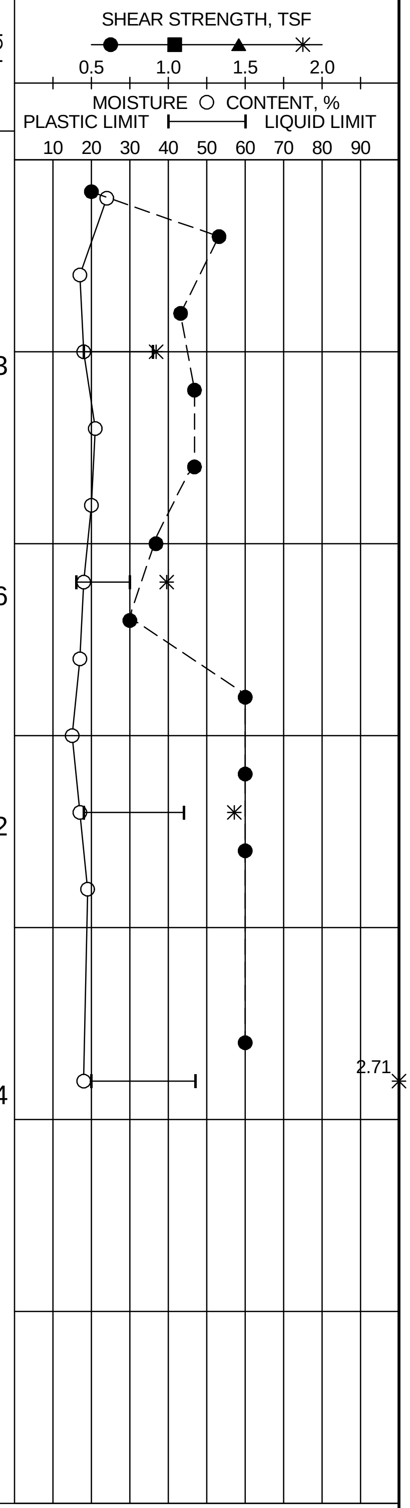
HVJ ASSOCIATES

LOG OF BORING

Project: Rampart Street Drainage Improvements | Project No.: HG1110720 | WBS No.: M-000265-0001-3
Boring No.: B-4 | Date: 1/16/2013 | Elevation:
Groundwater during drilling: --- | Northing: -- | Station: --
Groundwater after 24hrs: --- | Easting: -- | Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0		Pavement: 4" Asphalt, 6" Cement Stabilized Sand		
		Stiff to very stiff brown and gray LEAN CLAY WITH SAND (CL) -w/ calcareous nodules 2'-10'	72	
5				103
			77	
10		Stiff to very stiff reddish brown SANDY LEAN CLAY (CL)		106
15				
		Very stiff to hard reddish brown LEAN CLAY (CL)		112
		-w/ calcareous nodules 18'-20'		
20				
		-w/ calcareous nodules 23'-25'		104
25				
30				
35				





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

See Plate 2 for boring location.

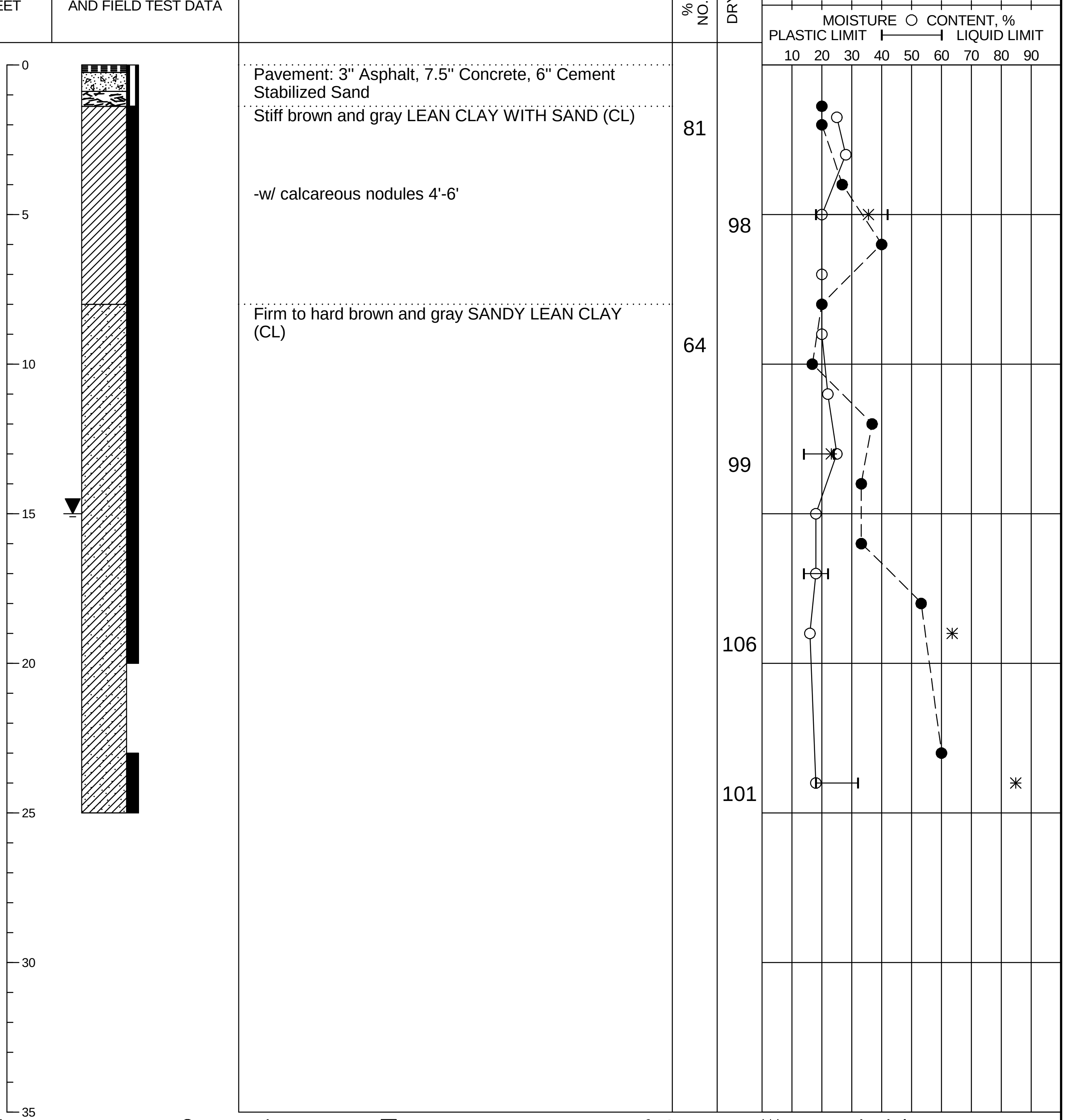
PLATE A-4

HVJ ASSOCIATES

LOG OF BORING

Project: Rampart Street Drainage Improvements | Project No.: HG1110720 | WBS No.: M-000265-0001-3
Boring No.: B-5 | Date: 1/16/2013 | Elevation:
Groundwater during drilling: 15 feet | Northing: -- | Station: --
Groundwater after 24hrs: --- | Easting: -- | Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF	SHEAR STRENGTH, TSF / MOISTURE CONTENT, %
0		Pavement: 3" Asphalt, 7.5" Concrete, 6" Cement Stabilized Sand			
		Stiff brown and gray LEAN CLAY WITH SAND (CL)	81		
		-w/ calcareous nodules 4'-6'			
5				98	
		Firm to hard brown and gray SANDY LEAN CLAY (CL)	64		
10					
				99	
15					
20				106	
25				101	



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

See Plate 2 for boring location.

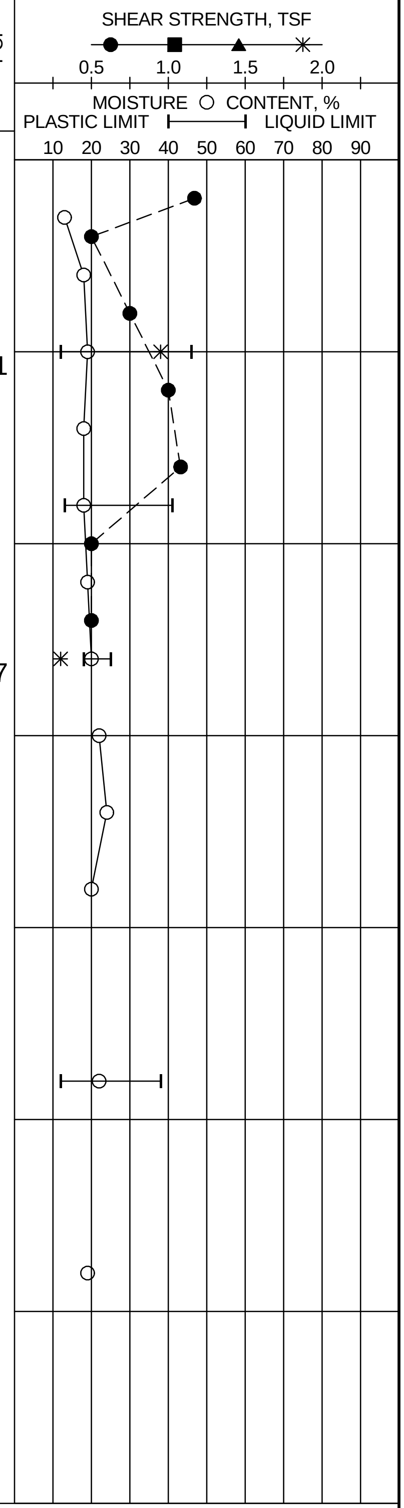
PLATE A-5

HVJ ASSOCIATES

LOG OF BORING

Project: Rampart Street Drainage Improvements | Project No.: HG1110720 | WBS No.: M-000265-0001-3
Boring No.: B-6 | Date: 1/18/2013 | Elevation:
Groundwater during drilling: 14 feet | Northing: -- | Station: --
Groundwater after 24hrs: --- | Easting: -- | Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0		Pavement: 5.5" Asphalt, 6.5" Cement Stabilized Sand		
1		Stiff to very stiff brown and gray SANDY LEAN CLAY (CL)	64	
4		Stiff to very stiff brown and gray LEAN CLAY (CL)		111
12		Firm brown and gray SILTY CLAY (CL-ML)		107
14	4-3-7; 6-9-17; 4-8-12	Medium dense brown SAND WITH SILT (SP-SM)	12; 10	
23	6-10-15	Very stiff brown SANDY LEAN CLAY (CL)		
28	9-11-13	Medium dense brown SAND (SP)	4	



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

See Plate 2 for boring location.

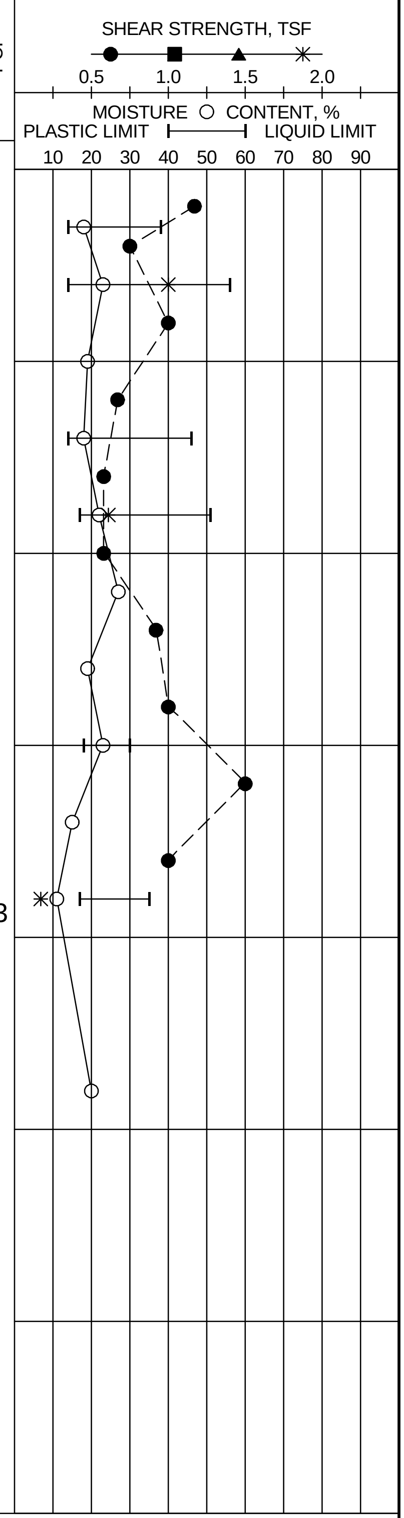
PLATE A-6

HVJ ASSOCIATES

LOG OF BORING

Project: Rampart Street Drainage Improvements | Project No.: HG1110720 | WBS No.: M-000265-0001-3
Boring No.: B-7 | Date: 1/17/2013 | Elevation:
Groundwater during drilling: 18 feet | Northing: -- | Station: --
Groundwater after 24hrs: --- | Easting: -- | Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0		Pavement: 5.5" Asphalt, 6" Cement Stabilized Sand		
		Very stiff dark brown SANDY LEAN CLAY (CL)		
		Stiff brown and gray FAT CLAY (CH)		99
5		Stiff brown and gray LEAN CLAY (CL) -w/ calcareous nodules 4'-8'	78	
		Stiff brown and gray FAT CLAY (CH)		94
10		-w/ calcareous nodules 12'-14'	73	
15		Soft to hard brown and gray SANDY LEAN CLAY (CL)		113
20				
	8-16-22	-w/ calcareous nodules 23'-25'	61	
25				
30				
35				



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

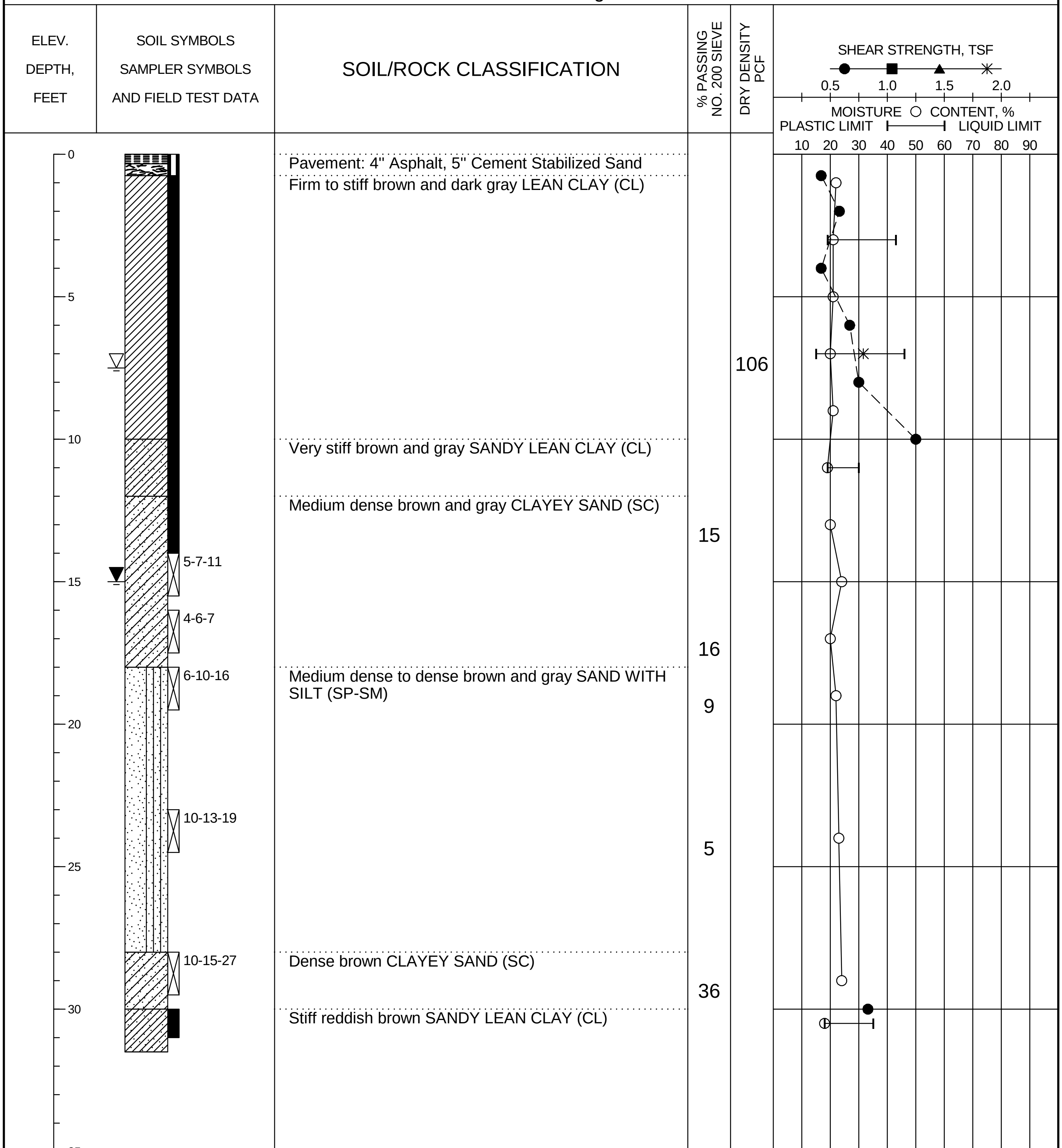
See Plate 2 for boring location.

PLATE A-7

HVJ ASSOCIATES

LOG OF BORING

Project: Rampart Street Drainage Improvements | Project No.: HG1110720 | WBS No.: M-000265-0001-3
Boring No.: B-8 (PZ-2) | Date: 1/16/2013 | Elevation:
Groundwater during drilling: 15 feet | Northing: -- | Station: --
Groundwater after 24hrs: 7.5 feet | Easting: -- | Offset: --



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

See Plate 2 for boring location.

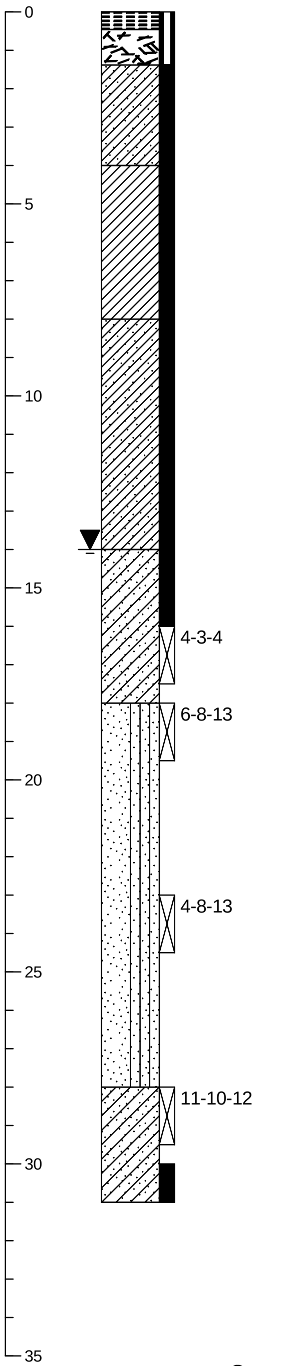
PLATE A-8

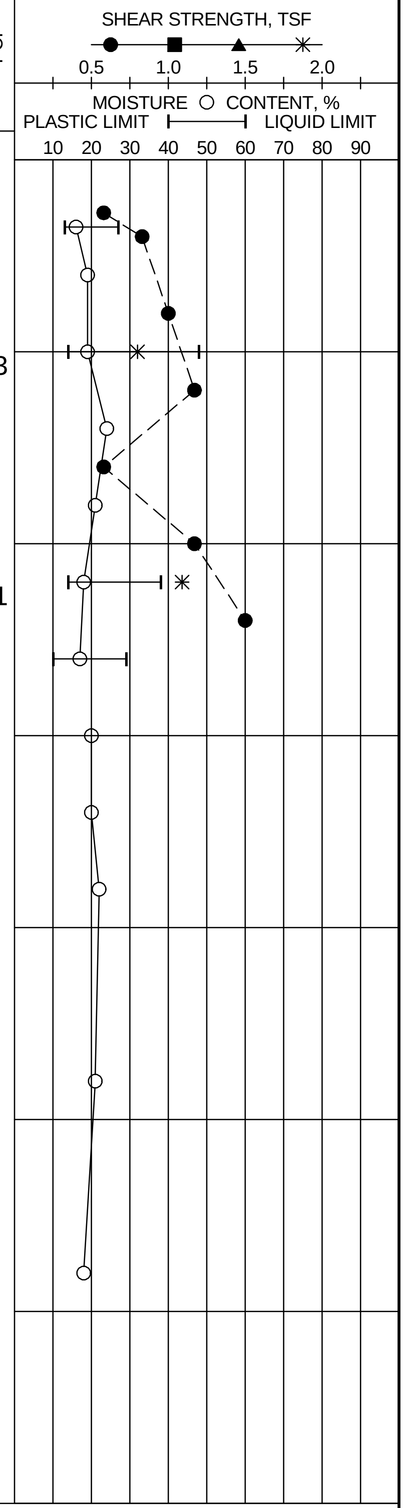
HVJ ASSOCIATES

LOG OF BORING

Project: Rampart Street Drainage Improvements | Project No.: HG1110720 | WBS No.: M-000265-0001-3
Boring No.: B-9 | Date: 1/18/2013 | Elevation:
Groundwater during drilling: 14 feet | Northing: -- | Station: --
Groundwater after 24hrs: --- | Easting: -- | Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0		Pavement: 5.5" Asphalt, 11" Cement Stabilized Sand		
		Stiff dark gray SANDY LEAN CLAY (CL)		
		Stiff to very stiff brown and gray LEAN CLAY (CL)		113
		Stiff to very stiff brown and gray SANDY LEAN CLAY (CL)	68	101
		Loose brown and gray CLAYEY SAND (SC)	25	
	4-3-4			
	6-8-13	Medium dense brown SAND WITH SILT (SP-SM)	9	
	4-8-13		7	
	11-10-12	Medium dense brown CLAYEY SAND (SC)	15	





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

See Plate 2 for boring location.

PLATE A-9

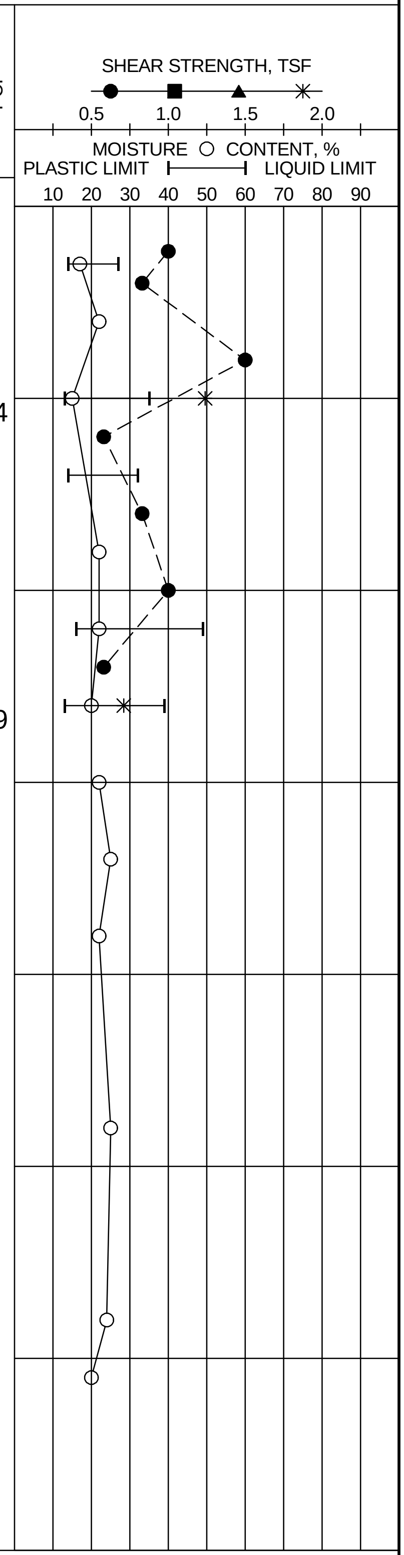
HVJ ASSOCIATES

LOG OF SOIL BORING HG-11-10720.GPJ HVJ.GDT 2/14/13

LOG OF BORING

Project: Rampart Street Drainage Improvements | Project No.: HG1110720 | WBS No.: M-000265-0001-3
Boring No.: B-10 | Date: 1/23/2013 | Elevation:
Groundwater during drilling: 18 feet | Northing: -- | Station: --
Groundwater after 24hrs: --- | Easting: -- | Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0		Pavement: 6" Asphalt, 8" Cement Stabilized Sand		
		Stiff to very stiff brown and gray SANDY LEAN CLAY (CL)		
		-w/ calcareous nodules 4'-10'		
5				114
10		Stiff light brown LEAN CLAY (CL)		
		-w/ sand 12'-14'		109
	4-4-6	Medium dense brown and gray CLAYEY SAND (SC)		
15			26	
	5-6-7			
	▼ (18 ft) 3-3-6	Loose to medium dense brown SAND WITH SILT (SP-SM)	10	
20				
	4-6-10		5	
25				
	4-6-8			
30	10-18-15	Dense brown CLAYEY SAND (SC)	48	
35				



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

See Plate 2 for boring location.

PLATE A-10

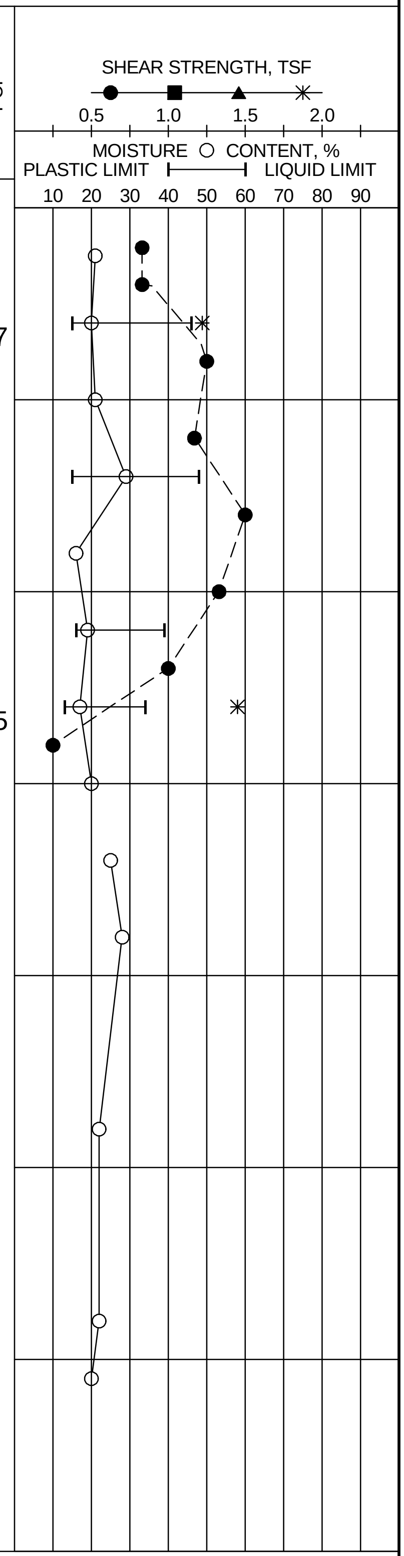
HVJ ASSOCIATES

LOG OF BORING

Project: Rampart Street Drainage Improvements — Project No.: HG1110720 — WBS No.: M-000265-0001-3
Boring No.: B-11 — Date: 1/23/2013 — Elevation:
Groundwater during drilling: Caved in at 17' — Northing: -- — Station: --
Groundwater after 24hrs: --- — Easting: -- — Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0		Pavement: 6.5" Asphalt, 6" Cement Stabilized Sand		
1		Stiff to very stiff gray LEAN CLAY (CL)		
3				107
8		Firm to very stiff brown and gray SANDY LEAN CLAY (CL) -w/ calcareous nodules 8'-12'		
13				105
15			56	
16	2-2-3	Loose to medium dense brown and gray SANDY SILT (ML)		
18	4-5-8			
19			64	
23	2-3-4	Loose to medium dense brown CLAYEY SAND (SC)		
24			26	
28	4-8-10			
30	4-12-16			
31			29	

Depth scale: 0, 5, 10, 15, 20, 25, 30, 35



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

See Plate 2 for boring location.

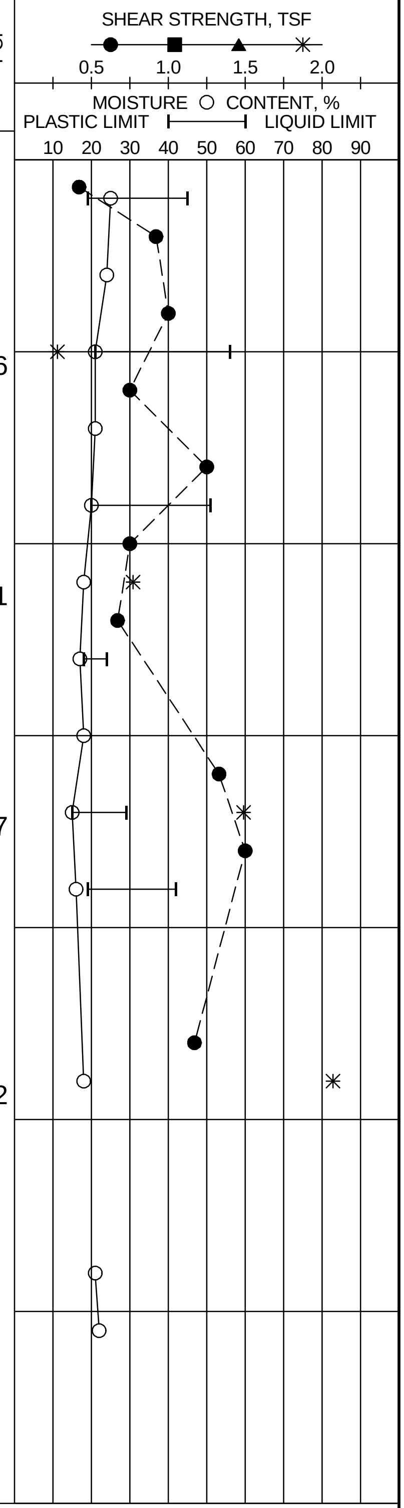
PLATE A-11

HVJ ASSOCIATES

LOG OF BORING

Project: Rampart Street Drainage Improvements
Project No.: HG1110720 WBS No.: M-000265-0001-3
Boring No.: B-12
Date: 1/23/2013
Elevation:
Groundwater during drilling: 28 feet
Northing: --
Station: --
Groundwater after 24hrs: ---
Easting: --
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0		Pavement: 3" Asphalt, 5.5" Cement Stabilized Sand		
		FILL: Dark gray lean clay with shells		
		Firm to very stiff brown and gray FAT CLAY (CH)		
5				106
10		Stiff brown SILTY CLAY (CL-ML)		111
	3-5-8	-w/ sand 14'-16'		
15			76	
		Very stiff brown and gray SANDY LEAN CLAY (CL)		117
		Very stiff to hard gray LEAN CLAY (CL)		
20				
25				102
	5-8-12	Medium dense gray SILTY SAND (SM)		
30	6-9-14		16	
35				



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

See Plate 2 for boring location.

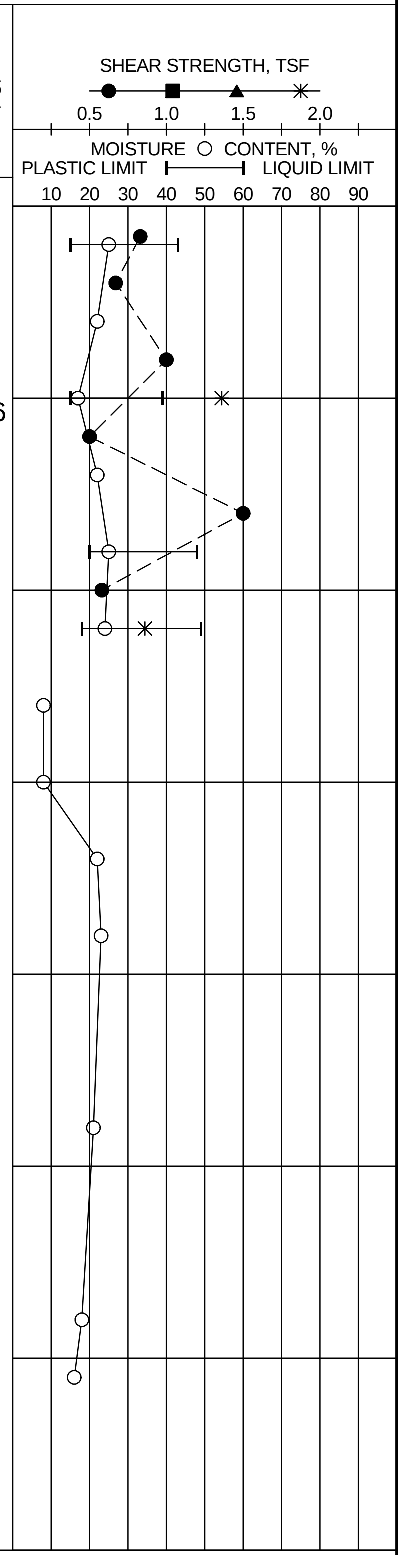
PLATE A-12

HVJ ASSOCIATES

LOG OF BORING

Project: Rampart Street Drainage Improvements | Project No.: HG1110720 | WBS No.: M-000265-0001-3
Boring No.: B-13 (PZ-3) | Date: 1/25/2013 | Elevation:
Groundwater during drilling: 18 feet | Northing: -- | Station: --
Groundwater after 24hrs: 15 feet | Easting: -- | Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0		Pavement: 3" Asphalt, 6.5" Cement Stabilized Sand		
		Stiff gray LEAN CLAY (CL)		
		Very stiff brown and gray SANDY LEAN CLAY (CL)		
5				106
		Stiff to very stiff brown LEAN CLAY (CL)		
10				94
		Loose to dense brown and gray SAND WITH SILT (SP-SM)	9	
15	3-5-9			
	3-3-5			
	6-9-15		8	
20				
	6-8-13		6	
25				
	5-7-10		12	
30	7-11-20		11	
35				



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

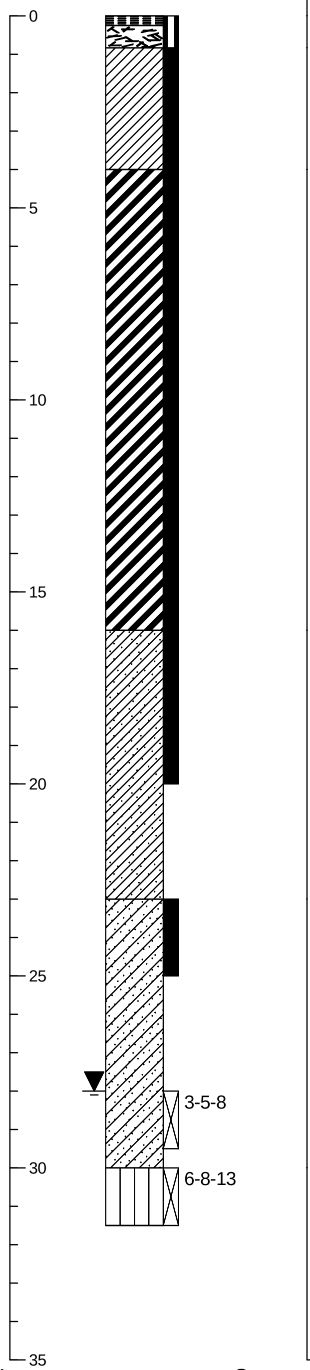
See Plate 2 for boring location.

PLATE A-13

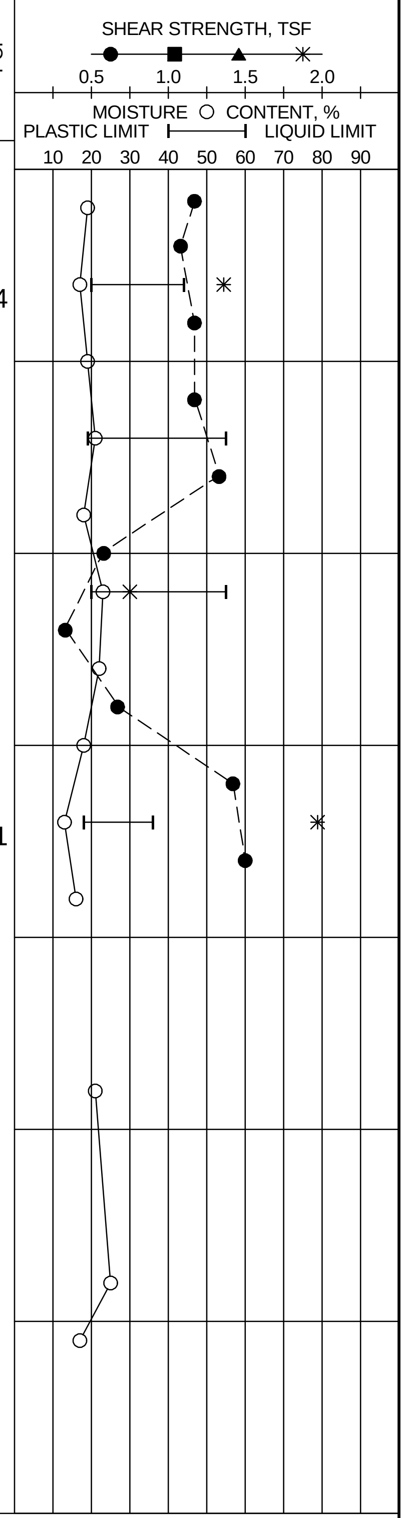
HVJ ASSOCIATES

LOG OF BORING

Project: Rampart Street Drainage Improvements | Project No.: HG1110720 | WBS No.: M-000265-0001-3
Boring No.: B-14 | Date: 1/23/2013 | Elevation:
Groundwater during drilling: 28 feet | Northing: -- | Station: --
Groundwater after 24hrs: --- | Easting: -- | Offset: --



Depth (ft)	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0	Pavement: 3" Asphalt, 7" Cement Stabilized Sand		
0.8	Very stiff brown and gray LEAN CLAY (CL)		104
4	Firm to very stiff brown and gray FAT CLAY (CH)		94
16	Very stiff brown and gray SANDY LEAN CLAY (CL) -w/ calcareous nodules 16'-20'	70	111
23	Medium dense brown CLAYEY SAND (SC)	30	
30	Medium dense brown and gray SANDY SILT (ML)	65	



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

See Plate 2 for boring location.

PLATE A-14

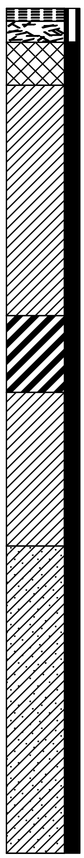
HVJ ASSOCIATES

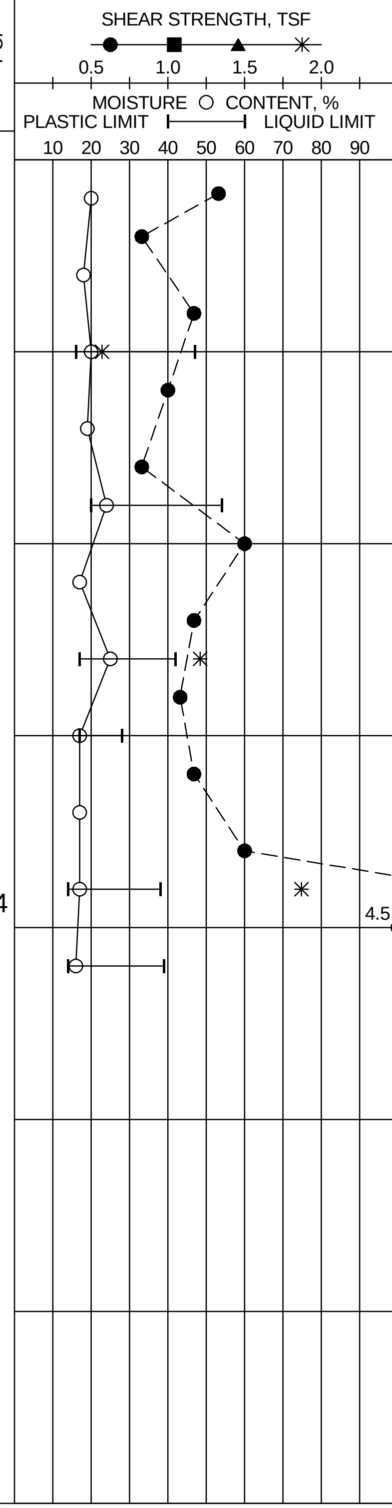
LOG OF SOIL BORING HG-11-10720.GPJ HVJ.GDT 2/14/13

LOG OF BORING

Project: Rampart Street Drainage Improvements | Project No.: HG1110720 | WBS No.: M-000265-0001-3
Boring No.: B-15 | Date: 1/24/2013 | Elevation:
Groundwater during drilling: --- | Northing: -- | Station: --
Groundwater after 24hrs: --- | Easting: -- | Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0		Pavement: 4" Asphalt, 6.5" Cement Stabilized Sand		
		FILL: Dark gray sandy lean clay with shells	50	
		Stiff to very stiff gray LEAN CLAY (CL)		
5				99
		Stiff brown and gray FAT CLAY (CH)		
10		Very stiff brown and gray LEAN CLAY (CL) -w/ calcareous nodules 10'-12'		
				95
		Very stiff reddish brown and gray SANDY LEAN CLAY (CL)		
15		-w/ calcareous nodules 16'-22'		
				114
20				
25				
30				
35				





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

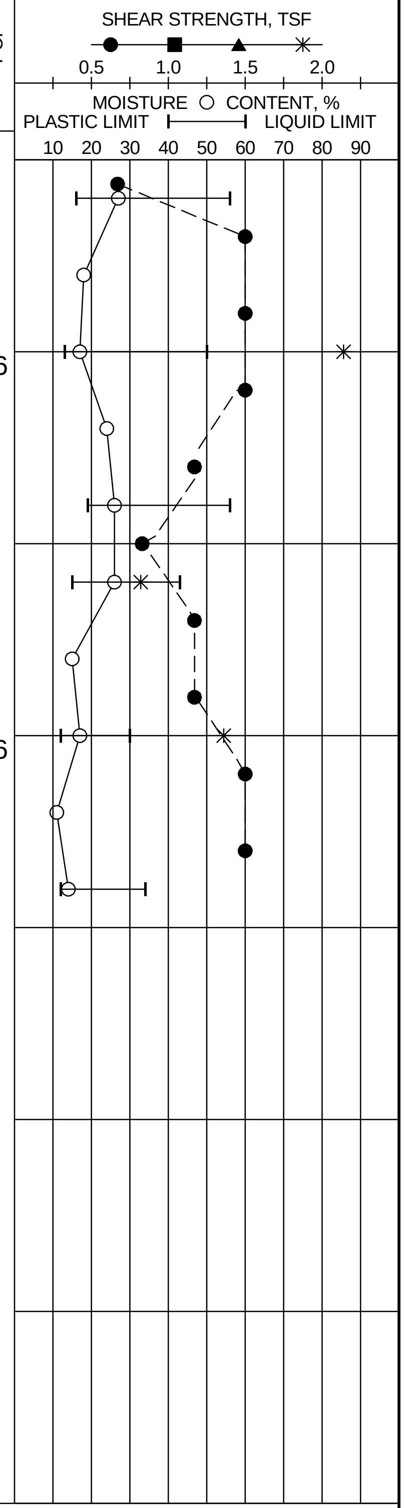
See Plate 2 for boring location.

PLATE A-15

LOG OF BORING

Project: Rampart Street Drainage Improvements | Project No.: HG1110720 | WBS No.: M-000265-0001-3
Boring No.: B-16 (PZ-4) | Date: 1/31/2013 | Elevation:
Groundwater during drilling: --- | Northing: -- | Station: --
Groundwater after 24hrs: Dry | Easting: -- | Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0		Pavement: 1" Asphalt, 6.5" Concrete		
		Stiff to hard brown and gray FAT CLAIY (CH)		
		-w/ calcareous nodules 2'-10'		
5				106
10		Stiff brown LEAN CLAY (CL)		88
		Very stiff brown SANDY LEAN CLAY (CL)		
15				106



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

See Plate 2 for boring location.

PLATE A-16

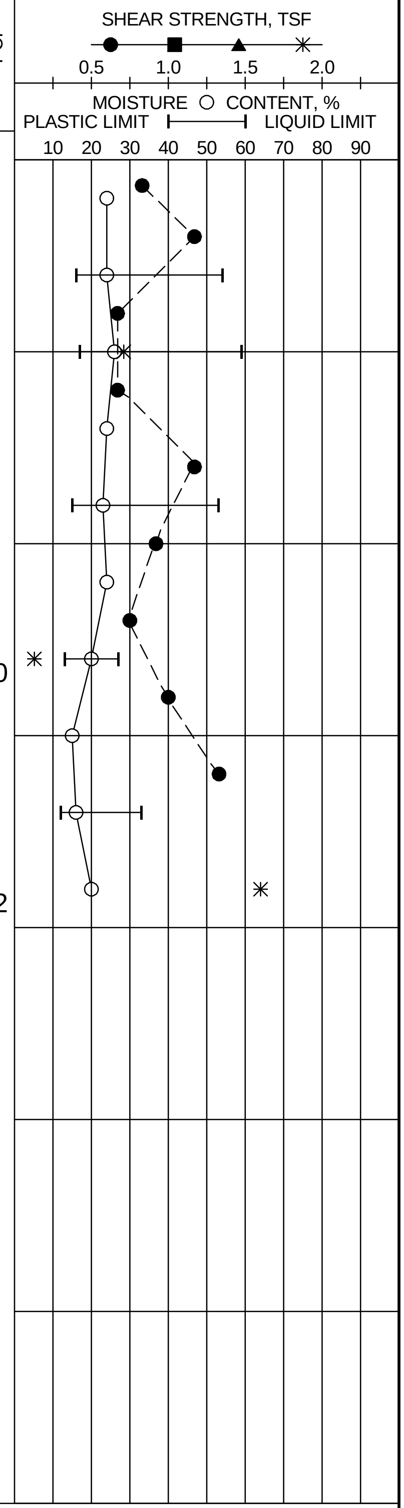
HVJ ASSOCIATES

LOG OF SOIL BORING HG-11-10720.GPJ HVJ.GDT 2/14/13

LOG OF BORING

Project: Rampart Street Drainage Improvements | Project No.: HG1110720 | WBS No.: M-000265-0001-3
Boring No.: B-17 | Date: 1/24/2013 | Elevation:
Groundwater during drilling: --- | Northing: -- | Station: --
Groundwater after 24hrs: --- | Easting: -- | Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0		Pavement: 1.75" Asphalt, 6.25" Concrete		
		Stiff to very stiff brown and dark gray FAT CLAY (CH)		
5				92
12		Soft to very stiff brown and gray SANDY LEAN CLAY (CL)		
13				100
19				102



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

See Plate 2 for boring location.

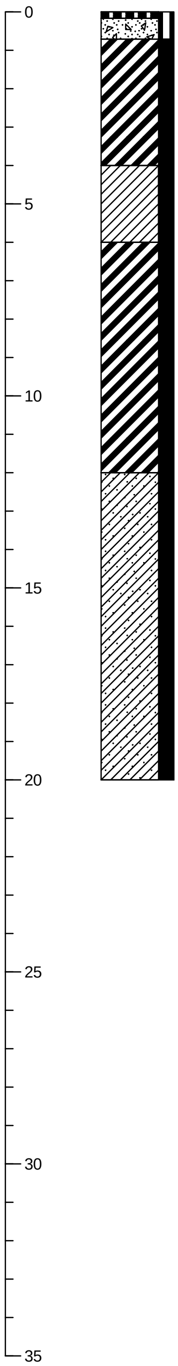
PLATE A-17

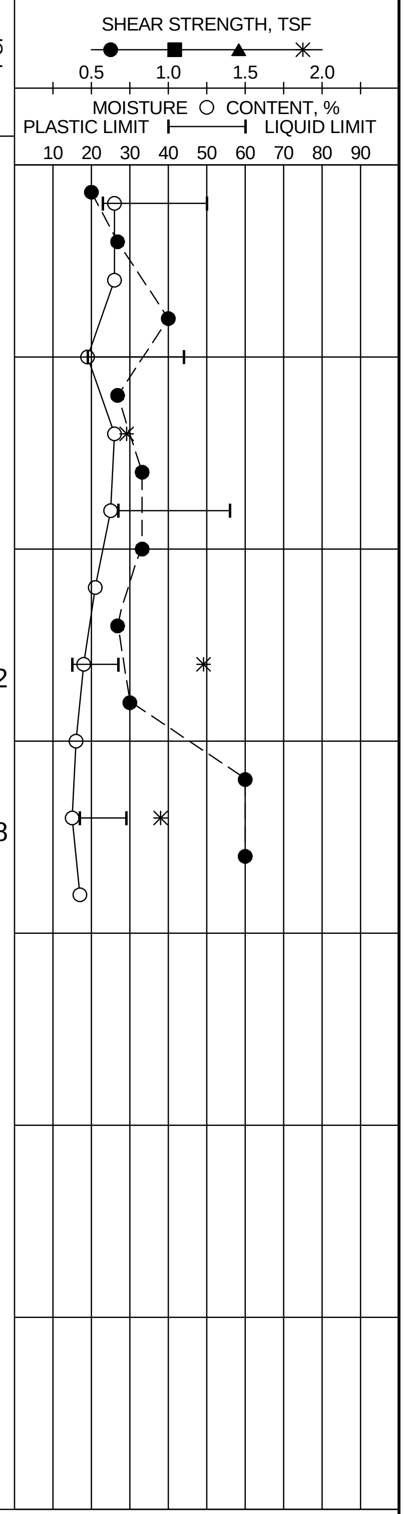
HVJ ASSOCIATES

LOG OF BORING

Project: Rampart Street Drainage Improvements
Project No.: HG1110720
WBS No.: M-000265-0001-3
Boring No.: B-18
Date: 1/24/2013
Elevation:
Groundwater during drilling: ---
Northing: --
Station: --
Groundwater after 24hrs: ---
Easting: --
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0		Pavement: 2" Asphalt, 6.5" Concrete		
		Stiff dark brown FAT CLAY (CH)		
		Stiff gray LEAN CLAY (CL)		
		Stiff brown and gray FAT CLAY (CH) -w/ calcareous nodules 6'-12'		91
		Stiff to very stiff brown and gray SANDY LEAN CLAY (CL)		112
				108





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

See Plate 2 for boring location.

PLATE A-18

HVJ ASSOCIATES

LOG OF SOIL BORING HG-11-10720.GPJ HVJ.GDT 2/14/13

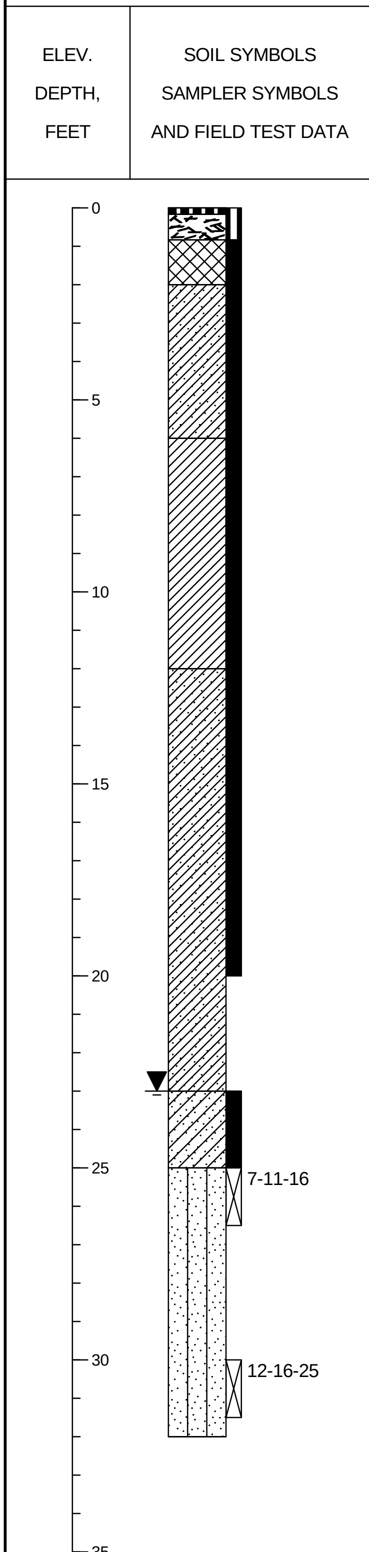
LOG OF BORING

Project: Rampart Street Drainage Improvements | Project No.: HG1110720 | WBS No.: M-000265-0001-3

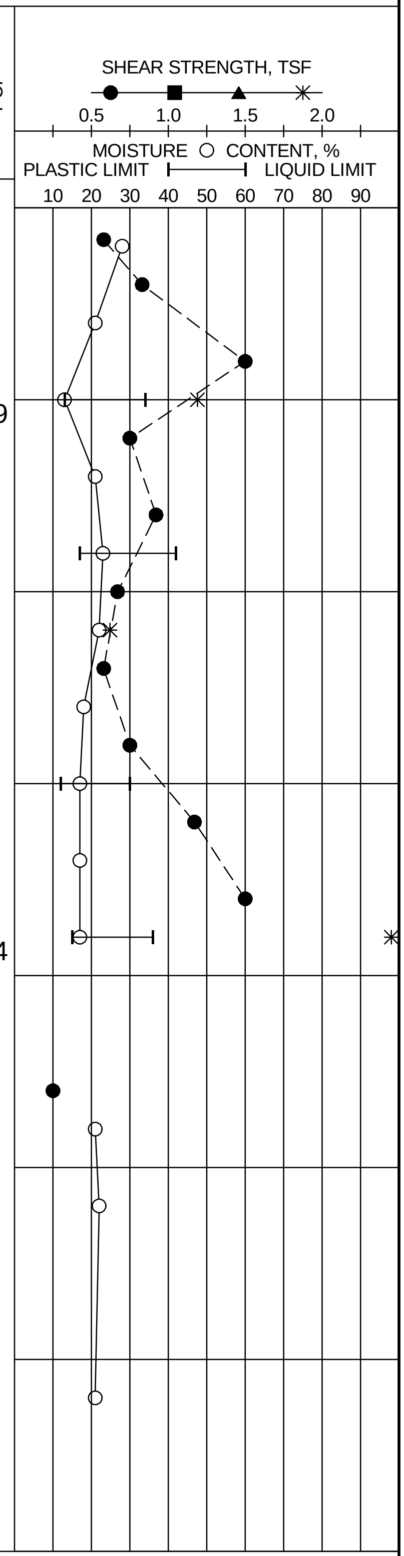
Boring No.: B-19 | Date: 1/24/2013 | Elevation:

Groundwater during drilling: 23 feet | Northing: -- | Station: --

Groundwater after 24hrs: --- | Easting: -- | Offset: --



Field Test Data	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
	Pavement: 2" Asphalt, 8" Cement Stabilized Sand		
	FILL: Dark gray sandy lean clay with shells	66	
	Stiff to very stiff brown and gray SANDY LEAN CLAY (CL)		109
	Stiff brown and gray LEAN CLAY (CL)		96
	Stiff to hard brown and gray SANDY LEAN CLAY (CL) -w/ calcareous nodules 12'-20'		114
	Brown and gray CLAYEY SAND (SC)	21	
7-11-16	Medium dense to dense brown and gray SILTY SAND (SM)	14	
12-16-25		16	



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

See Plate 2 for boring location.

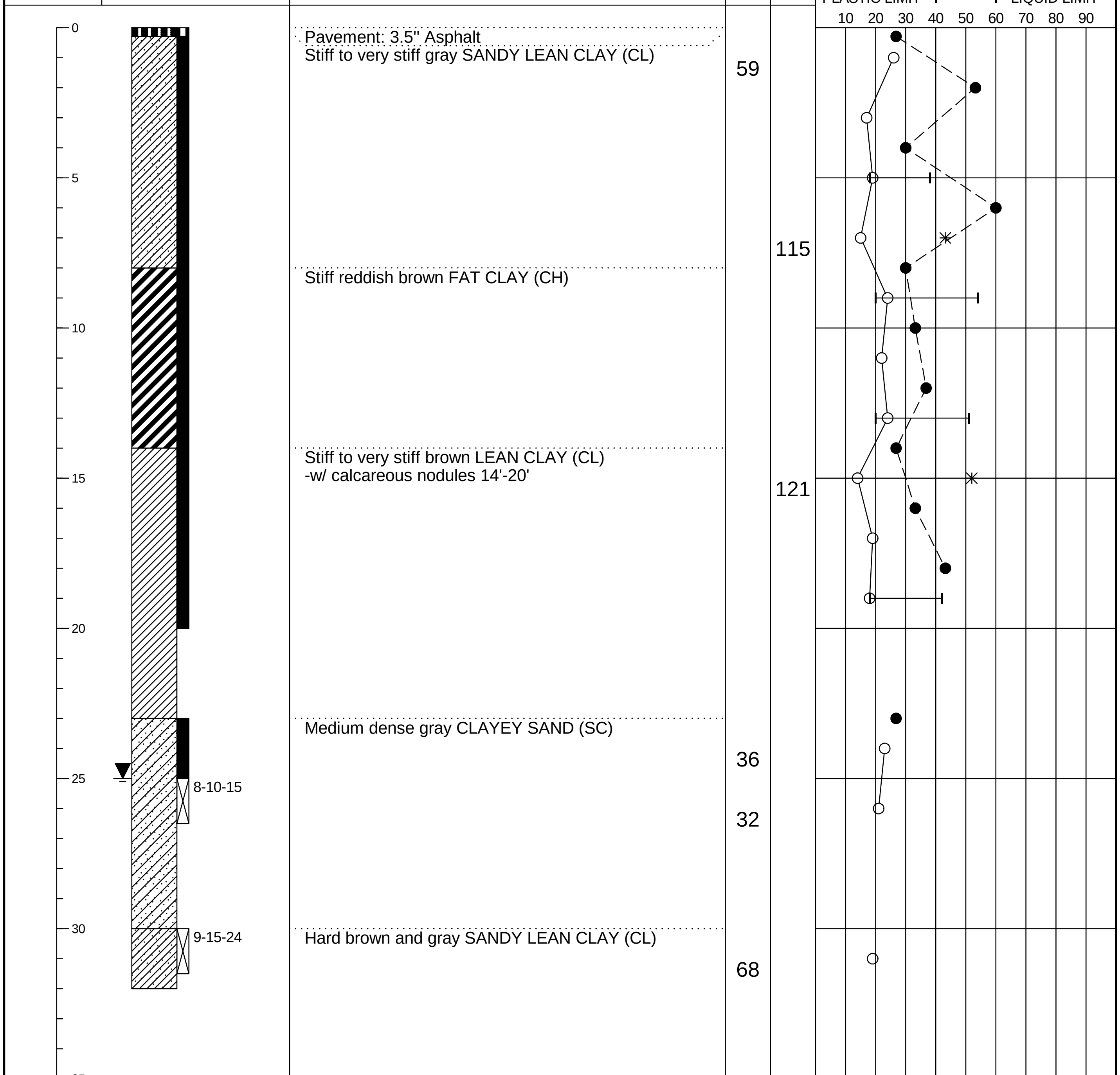
PLATE A-19

HVJ ASSOCIATES

LOG OF BORING

Project: Rampart Street Drainage Improvements | Project No.: HG1110720 | WBS No.: M-000265-0001-3
Boring No.: B-20 | Date: 1/24/2013 | Elevation:
Groundwater during drilling: 25 feet | Northing: -- | Station: --
Groundwater after 24hrs: --- | Easting: -- | Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL/ROCK CLASSIFICATION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0		Pavement: 3.5" Asphalt Stiff to very stiff gray SANDY LEAN CLAY (CL)	59	
				115
8		Stiff reddish brown FAT CLAY (CH)		
14		Stiff to very stiff brown LEAN CLAY (CL) -w/ calcareous nodules 14'-20'		121
23		Medium dense gray CLAYEY SAND (SC)	36	
25	8-10-15		32	
30	9-15-24	Hard brown and gray SANDY LEAN CLAY (CL)	68	



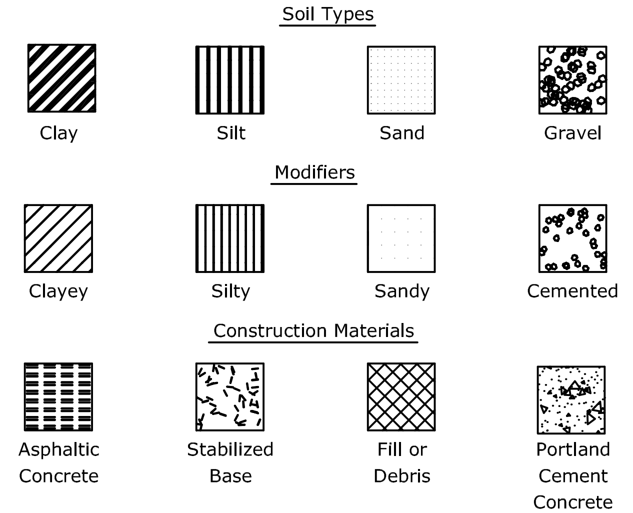
Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 2 for boring location.

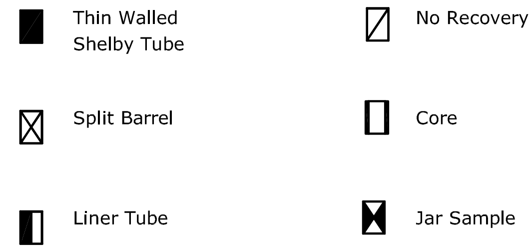
PLATE A-20

HVJ ASSOCIATES

SOIL SYMBOLS



SAMPLER TYPES



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

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KEY TO TERMS AND SYMBOLS USED ON BORING LOGS

PROJECT NO.: HG1110720

DRAWING NO.: PLATE A-21

APPENDIX B

SUMMARY OF LABORATORY TEST RESULTS

Project: Rampart Street Drainage Improvements
Location: Houston, Texas
Number: HG1110720

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Moisture Content (%)	Unit Weight (pcf)	Shear Strength (UU) (tsf)	Shear Strenght (Pocket Pen) (tsf)
B-1	0.6								0.83
B-1	1	39	13	26		13			
B-1	2								0.83
B-1	3					12			
B-1	4								0.92
B-1	5				77	12.3	128.2	0.79	
B-1	6								0.58
B-1	7	56	16	40					
B-1	8								0.92
B-1	10								0.42
B-1	11	43	13	30		19.9	132.9	1.02	
B-1	12								0.92
B-1	13	42	12	30					
B-1	14								0.67
B-1	15					20.3			
B-1	16								1.17
B-1	17				71	17			
B-1	18								1.33
B-1	19	45	14	31		17.9	133.7	2.27	
B-1	20.5	49	17	32					
B-1	21					18.1			
B-2	0.5								1.5
B-2	1				82	22			
B-2	2								1.5
B-2	3					20.2			
B-2	4								1.5
B-2	5	53	17	36					
B-2	6								1.5
B-2	7					22.3	131.4	1.86	
B-2	8								1.5
B-2	9				90	28.2			
B-2	10								1.33
B-2	11	52	20	32					
B-2	12								0.83
B-2	13					17.3	133.9	0.74	
B-2	14								0.5
B-2	15	27	15	12		17.2			
B-2	16								1.5
B-2	17					17.9			
B-2	18								1.5
B-2	19	44	20	24		16.7	124.7	1.76	
B-2	20								1
B-2	20.5	37	13	24		18.3			
B-3 (PZ-1)	0.6								0.5
B-3 (PZ-1)	1				67	28.6			
B-3 (PZ-1)	2								1
B-3 (PZ-1)	3					18			

Project: Rampart Street Drainage Improvements
Location: Houston, Texas
Number: HG1110720

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Moisture Content (%)	Unit Weight (pcf)	Shear Strength (UU) (tsf)	Shear Strenght (Pocket Pen) (tsf)
B-3 (PZ-1)	4								0.92
B-3 (PZ-1)	5	46	14	32		16.5			
B-3 (PZ-1)	6								0.83
B-3 (PZ-1)	7	45	14	31		20.3	125.3	0.81	
B-3 (PZ-1)	8								1.17
B-3 (PZ-1)	9					20.8			
B-3 (PZ-1)	10								1.5
B-3 (PZ-1)	12								0.83
B-3 (PZ-1)	13	22	17	5		19.8	127.3	1.43	
B-3 (PZ-1)	15				11	21.7			
B-3 (PZ-1)	17					26.6			
B-3 (PZ-1)	19				7	23.4			
B-3 (PZ-1)	24				15	24.2			
B-4	0.8								0.5
B-4	1				72	24.3			
B-4	2								1.33
B-4	3					16.9			
B-4	4								1.08
B-4	5	36	18	18		18.3	121.9	0.92	
B-4	6								1.17
B-4	7					20.6			
B-4	8								1.17
B-4	9				77	20.3			
B-4	10								0.92
B-4	11	30	16	14		18	124.9	0.99	
B-4	12								0.75
B-4	13					17.2			
B-4	14								1.5
B-4	15					15.1			
B-4	16								1.5
B-4	17	44	18	26		17.3	131.4	1.43	
B-4	18								1.5
B-4	19					19.2			
B-4	23								1.5
B-4	24	47	20	27		18.5	122.9	2.71	
B-5	1.4								0.5
B-5	1.8				81	25.5			
B-5	2								0.5
B-5	3					28.4			
B-5	4								0.67
B-5	5	42	18	24		20.2	118.2	0.89	
B-5	6								1
B-5	7					19.6			
B-5	8								0.5
B-5	9				64	19.7			
B-5	10								0.42
B-5	11					21.5			

Project: Rampart Street Drainage Improvements
Location: Houston, Texas
Number: HG1110720

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Moisture Content (%)	Unit Weight (pcf)	Shear Strength (UU) (tsf)	Shear Strenght (Pocket Pen) (tsf)
B-5	12								0.92
B-5	13	24	14	10		25.1	123.5	0.58	
B-5	14								0.83
B-5	15					17.8			
B-5	16								0.83
B-5	17	22	14	8		17.9			
B-5	18								1.33
B-5	19					15.5	122.9	1.59	
B-5	23								1.5
B-5	24	32	18	14		18.3	119.2	2.12	
B-6	1								1.17
B-6	1.5				64	12.9			
B-6	2								0.5
B-6	3					18.4			
B-6	4								0.75
B-6	5	46	12	34		19.5	132.1	0.95	
B-6	6								1
B-6	7					18.4			
B-6	8								1.08
B-6	9	41	13	28		18			
B-6	10								0.5
B-6	11					19			
B-6	12								0.5
B-6	13	25	18	7		20.5	128.8	0.3	
B-6	15				12	21.7			
B-6	17					24.4			
B-6	19				10	20.2			
B-6	24	38	12	26		22.2			
B-6	29				4	19.2			
B-7	1								1.17
B-7	1.5	38	14	24		17.5			
B-7	2								0.75
B-7	3	56	14	42		23.5	122.1	1	
B-7	4								1
B-7	5				78	19.1			
B-7	6								0.67
B-7	7	46	14	32		17.8			
B-7	8								0.58
B-7	9	51	17	34		22.1	115	0.61	
B-7	10								0.58
B-7	11					27.5			
B-7	12								0.92
B-7	13				73	19.1			
B-7	14								1
B-7	15	30	18	12		23.1			
B-7	16								1.5
B-7	17					15.3			

Project: Rampart Street Drainage Improvements
Location: Houston, Texas
Number: HG1110720

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Moisture Content (%)	Unit Weight (pcf)	Shear Strength (UU) (tsf)	Shear Strenght (Pocket Pen) (tsf)
B-7	18								1
B-7	19	35	17	18		11	125.3	0.17	
B-7	24				61	19.6			
B-8 (PZ-2)	0.8								0.42
B-8 (PZ-2)	1					22.4			
B-8 (PZ-2)	2								0.58
B-8 (PZ-2)	3	43	19	24		21.3			
B-8 (PZ-2)	4								0.42
B-8 (PZ-2)	5					20.7			
B-8 (PZ-2)	6								0.67
B-8 (PZ-2)	7	46	15	31		19.5	126.5	0.79	
B-8 (PZ-2)	8								0.75
B-8 (PZ-2)	9					20.6			
B-8 (PZ-2)	10								1.25
B-8 (PZ-2)	11	30	19	11		18.6			
B-8 (PZ-2)	13				15	19.7			
B-8 (PZ-2)	15					24.2			
B-8 (PZ-2)	17				16	20			
B-8 (PZ-2)	19				9	21.5			
B-8 (PZ-2)	24				5	23.2			
B-8 (PZ-2)	29				36	23.9			
B-8 (PZ-2)	30								0.83
B-8 (PZ-2)	30.5	35	18	17		18			
B-9	1.4								0.58
B-9	1.8	27	13	14		16.1			
B-9	2								0.83
B-9	3					19.3			
B-9	4								1
B-9	5	48	14	34		18.9	134.4	0.8	
B-9	6								1.17
B-9	7					23.6			
B-9	8								0.58
B-9	9				68	20.8			
B-9	10								1.17
B-9	11	38	14	24		18.3	119	1.09	
B-9	12								1.5
B-9	13	29	10	19		17.5			
B-9	15				25	19.7			
B-9	17					20.5			
B-9	19				9	21.7			
B-9	24				7	20.9			
B-9	29				15	18.3			
B-10	1.2								1
B-10	1.5	27	14	13		16.6			
B-10	2								0.83
B-10	3					21.6			
B-10	4								1.5

Project: Rampart Street Drainage Improvements
Location: Houston, Texas
Number: HG1110720

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Moisture Content (%)	Unit Weight (pcf)	Shear Strength (UU) (tsf)	Shear Strenght (Pocket Pen) (tsf)
B-10	5	35	13	22		15.5	131.3	1.24	
B-10	6								0.58
B-10	7	32	14	18					
B-10	8								0.83
B-10	9					21.5			
B-10	10								1
B-10	11	49	16	33		22.2			
B-10	12								0.58
B-10	13	39	13	26		20.3	130.7	0.71	
B-10	15				26	21.6			
B-10	17					24.6			
B-10	19				10	22.2			
B-10	24				5	24.7			
B-10	29					24.4			
B-10	30.5				48	20.2			
B-11	1								0.83
B-11	1.3					20.7			
B-11	2								0.83
B-11	3	46	15	31		20.1	128.2	1.22	
B-11	4								1.25
B-11	5					20.7			
B-11	6								1.17
B-11	7	48	15	33		29.2			
B-11	8								1.5
B-11	9					15.6			
B-11	10								1.33
B-11	11	39	16	23		19.1			
B-11	12								1
B-11	13	34	13	21		16.9	122.3	1.45	
B-11	14								0.25
B-11	15				56	19.5			
B-11	17					24.6			
B-11	19				64	28			
B-11	24				26	21.6			
B-11	29					21.7			
B-11	30.5				29	20.5			
B-12	0.7								0.42
B-12	1	45	19	26		25			
B-12	2								0.92
B-12	3					24.5			
B-12	4								1
B-12	5	56	21	35		20.8	127.9	0.28	
B-12	6								0.75
B-12	7					21.1			
B-12	8								1.25
B-12	9	51	20	31		19.6			
B-12	10								0.75

Project: Rampart Street Drainage Improvements
Location: Houston, Texas
Number: HG1110720

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Moisture Content (%)	Unit Weight (pcf)	Shear Strength (UU) (tsf)	Shear Strenght (Pocket Pen) (tsf)
B-12	11					17.8	130.6	0.77	
B-12	12								0.67
B-12	13	24	18	6		16.7			
B-12	15				76	18.4			
B-12	16								1.33
B-12	17	29	15	14		15.1	134.3	1.49	
B-12	18								1.5
B-12	19	42	19	23		15.7			
B-12	23								1.17
B-12	24					18	120.7	2.07	
B-12	29				16	21			
B-12	30.5					21.9			
B-13 (PZ-3)	0.8								0.83
B-13 (PZ-3)	1	43	15	28		24.9			
B-13 (PZ-3)	2								0.67
B-13 (PZ-3)	3					22			
B-13 (PZ-3)	4								1
B-13 (PZ-3)	5	39	15	24		17.3	124.2	1.36	
B-13 (PZ-3)	6								0.5
B-13 (PZ-3)	7					22.3			
B-13 (PZ-3)	8								1.5
B-13 (PZ-3)	9	48	20	28		25.4			
B-13 (PZ-3)	10								0.58
B-13 (PZ-3)	11	49	18	31		24.1	116.1	0.86	
B-13 (PZ-3)	13				9	7.5			
B-13 (PZ-3)	15					8.3			
B-13 (PZ-3)	17					21.8			
B-13 (PZ-3)	19				8	22.5			
B-13 (PZ-3)	24				6	21.2			
B-13 (PZ-3)	29				12	18.2			
B-13 (PZ-3)	30.5				11	15.8			
B-14	0.8								1.17
B-14	1					19.4			
B-14	2								1.08
B-14	3	44	20	24		17.4	121.5	1.36	
B-14	4								1.17
B-14	5					18.9			
B-14	6								1.17
B-14	7	55	19	36		20.7			
B-14	8								1.33
B-14	9					17.6			
B-14	10								0.58
B-14	11	55	20	35		22.7	115.2	0.75	
B-14	12								0.33
B-14	13					21.9			
B-14	14								0.67
B-14	15					18.3			

Project: Rampart Street Drainage Improvements
Location: Houston, Texas
Number: HG1110720

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Moisture Content (%)	Unit Weight (pcf)	Shear Strength (UU) (tsf)	Shear Strenght (Pocket Pen) (tsf)
B-14	16								1.42
B-14	17	36	18	18		12.8	125.1	1.97	
B-14	18								1.5
B-14	19				70	16.2			
B-14	24				30	20.6			
B-14	29					24.8			
B-14	30.5				65	16.7			
B-15	0.9								1.33
B-15	1				50	19.5			
B-15	2								0.83
B-15	3					18.1			
B-15	4								1.17
B-15	5	47	16	31		20.2	119	0.57	
B-15	6								1
B-15	7					19			
B-15	8								0.83
B-15	9	54	20	34		23.8			
B-15	10								1.5
B-15	11					17.4			
B-15	12								1.17
B-15	13	42	17	25		25.2	119.5	1.21	
B-15	14								1.08
B-15	15	28	17	11		17.5			
B-15	16								1.17
B-15	17					16.8			
B-15	18								1.5
B-15	19	38	14	24		16.6	133	1.87	
B-15	20								4.5
B-15	21	39	14	25		15.5			
B-16 (PZ-4)	0.6								0.67
B-16 (PZ-4)	1	56	16	40		26.9			
B-16 (PZ-4)	2								1.5
B-16 (PZ-4)	3					17.6			
B-16 (PZ-4)	4								1.5
B-16 (PZ-4)	5	50	13	37		17.4	123.9	2.14	
B-16 (PZ-4)	6								1.5
B-16 (PZ-4)	7					23.8			
B-16 (PZ-4)	8								1.17
B-16 (PZ-4)	9	56	19	37		26.2			
B-16 (PZ-4)	10								0.83
B-16 (PZ-4)	11	43	15	28		26.3	111.3	0.82	
B-16 (PZ-4)	12								1.17
B-16 (PZ-4)	13					15.5			
B-16 (PZ-4)	14								1.17
B-16 (PZ-4)	15	30	12	18		16.6	123.8	1.36	
B-16 (PZ-4)	16								1.5
B-16 (PZ-4)	17					10.9			

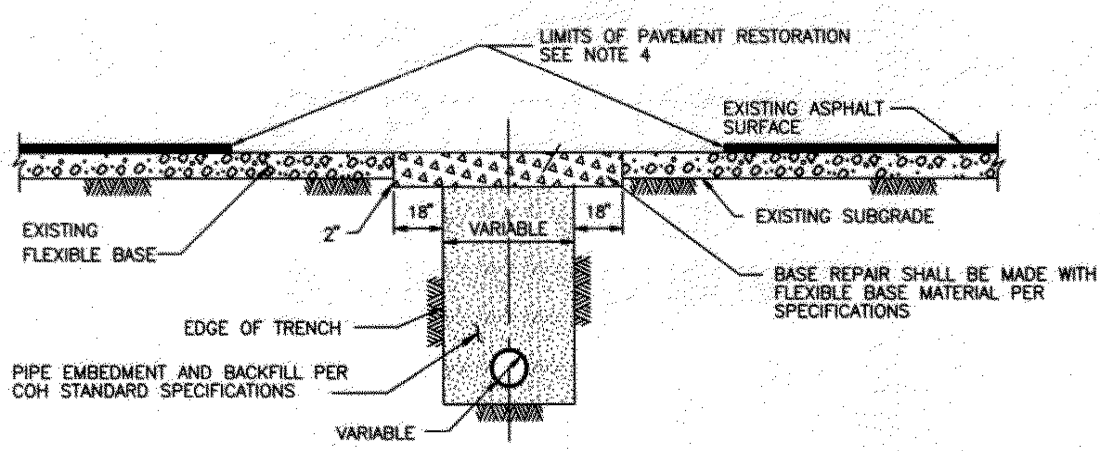
Project: Rampart Street Drainage Improvements
Location: Houston, Texas
Number: HG1110720

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Moisture Content (%)	Unit Weight (pcf)	Shear Strength (UU) (tsf)	Shear Strenght (Pocket Pen) (tsf)
B-16 (PZ-4)	18								1.5
B-16 (PZ-4)	19	34	12	22		13.7			
B-17	0.7								0.83
B-17	1					24.4			
B-17	2								1.17
B-17	3	54	16	38		24.1			
B-17	4								0.67
B-17	5	59	17	42		25.6	115.1	0.71	
B-17	6								0.67
B-17	7					24			
B-17	8								1.17
B-17	9	53	15	38		22.5			
B-17	10								0.92
B-17	11					24.1			
B-17	12								0.75
B-17	13	27	13	14		19.8	119.4	0.13	
B-17	14								1
B-17	15					15			
B-17	16								1.33
B-17	17	33	12	21		15.8			
B-17	19					19.6	122	1.6	
B-18	0.7								0.5
B-18	1	50	23	27		26.4			
B-18	2								0.67
B-18	3					26.2			
B-18	4								1
B-18	5	44	19	25		18.9			
B-18	6								0.67
B-18	7					25.6	114.2	0.73	
B-18	8								0.83
B-18	9	56	27	29		25.3			
B-18	10								0.83
B-18	11					21.3			
B-18	12								0.67
B-18	13	27	15	12		17.5	131.7	1.23	
B-18	14								0.75
B-18	15					15.9			
B-18	16								1.5
B-18	17	29	17	12		15.2	124.8	0.95	
B-18	18								1.5
B-18	19					16.5			
B-19	0.8								0.58
B-19	1				66	27.8			
B-19	2								0.83
B-19	3					21.3			
B-19	4								1.5
B-19	5	34	13	21		13.2	123.7	1.19	

Project: Rampart Street Drainage Improvements
Location: Houston, Texas
Number: HG1110720

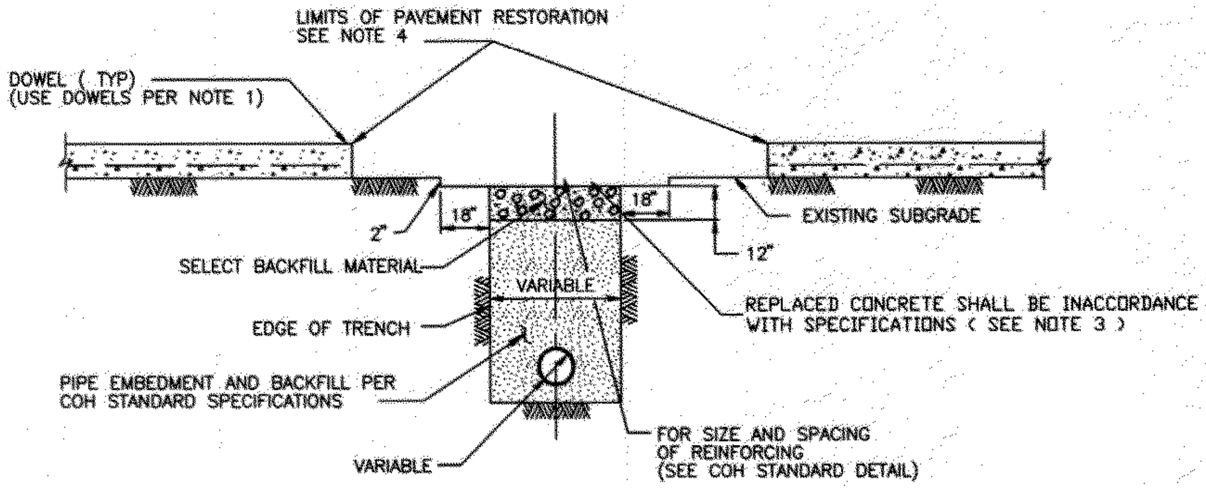
Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Moisture Content (%)	Unit Weight (pcf)	Shear Strength (UU) (tsf)	Shear Strenght (Pocket Pen) (tsf)
B-19	6								0.75
B-19	7					21.2			
B-19	8								0.92
B-19	9	42	17	25		22.7			
B-19	10								0.67
B-19	11					22.1	116.9	0.62	
B-19	12								0.58
B-19	13					18.5			
B-19	14								0.75
B-19	15	30	12	18		16.7			
B-19	16								1.17
B-19	17					16.8			
B-19	18								1.5
B-19	19	36	15	21		17	133	2.45	
B-19	23								0.25
B-19	24				21	21.4			
B-19	26				14	22.4			
B-19	31				16	20.8			
B-20	0.3								0.67
B-20	1				59	26.3			
B-20	2								1.33
B-20	3					16.5			
B-20	4								0.75
B-20	5	38	18	20		18.8			
B-20	6								1.5
B-20	7					14.6	131.2	1.08	
B-20	8								0.75
B-20	9	54	20	34		24			
B-20	10								0.83
B-20	11					21.9			
B-20	12								0.92
B-20	13	51	20	31		23.5			
B-20	14								0.67
B-20	15					14	138.1	1.3	
B-20	16								0.83
B-20	17					19.2			
B-20	18								1.08
B-20	19	42	18	24		18.4			
B-20	23								0.67
B-20	24				36	23			
B-20	26				32	21.3			
B-20	31				68	18.5			
Total		**93**	**93**	**93**	**56**	**228**	**54**	**54**	**184**

APPENDIX C
COH PAVEMENT REPAIR DETAILS



SECTION (A)

REPAIR OF FLEXIBLE BASE PAVEMENT



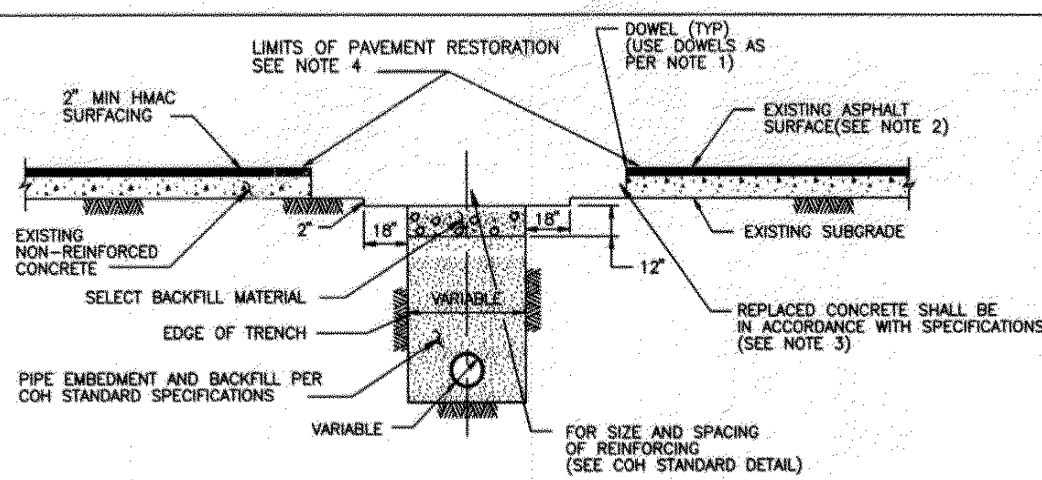
SECTION (B)

REPAIR OF REINFORCED CONCRETE PAVEMENT

NOTE:

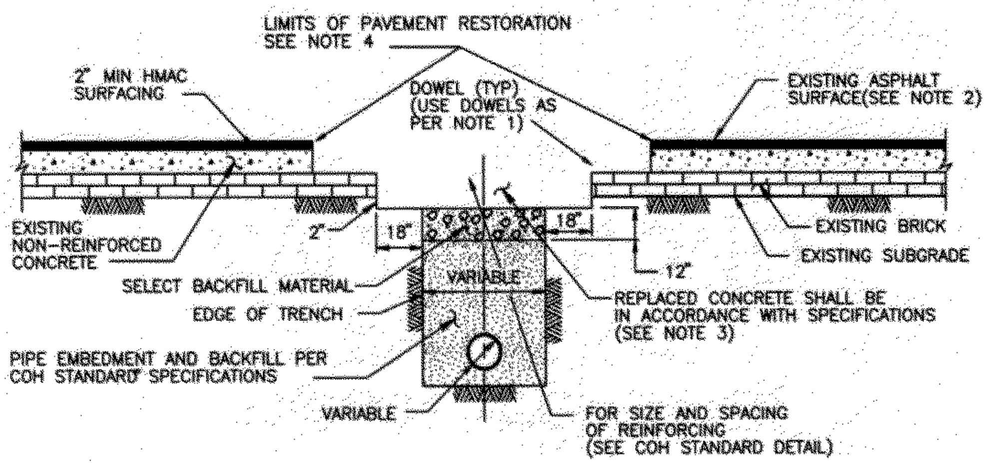
1. EXPOSE 15" OF REINFORCING STEEL AT PROPOSED SAWED JOINT. IF NO REINFORCING STEEL EXISTS, USE HORIZONTAL DOWELS.
   HORIZONTAL DOWELS SHALL BE # 6 BARS, 24" LONG, 24" C-C, DRILLED AND EMBEDDED 8" INTO THE CENTER OF THE EXISTING SLAB. WITH "PO ROC" OR EQUAL.
2. IF REINFORCED CONCRETE IS OVERLAYED WITH ASPHALT, REPLACE WITH 2" MIN HMAC SURFACING.
3. REFER TO STANDARD DETAIL 02751-01 FOR REINFORCING STEEL REQUIREMENTS
4. REFER TO STANDARD DETAIL 02951-01 FOR PAVEMENT RESTORATION LIMITS.

CITY OF HOUSTON DEPARTMENT OF PUBLIC WORKS AND ENGINEERING ENGINEERING, CONSTRUCTION AND REAL ESTATE DIVISION	
PAVEMENT REPAIR DETAILS FOR STREET CUTS (NOT TO SCALE)	
APPROVED BY: CITY ENGINEER	APPROVED BY: DIRECTOR OF PUBLIC WORKS AND ENGINEERING
EFF DATE: OCT-01-2002	DWG NO: 02902-01



SECTION (C)

REPAIR OF NON-REINFORCED CONCRETE PAVEMENT



SECTION (D)

REPAIR OF NON-REINFORCED CONCRETE PAVEMENT WITH BRICK

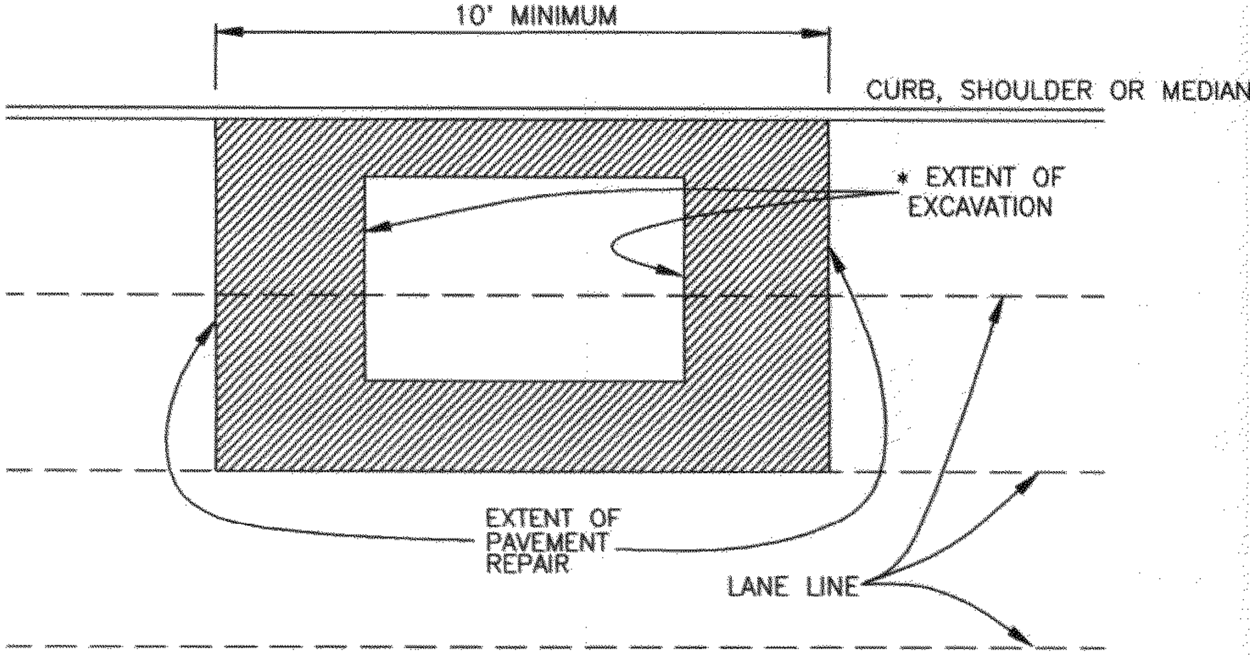
NOTE:

1. EXPOSE 15" OF REINFORCING STEEL AT PROPOSED SAWED JOINT. IF NO REINFORCING STEEL EXISTS, USE HORIZONTAL DOWELS.
   HORIZONTAL DOWELS SHALL BE # 6 BARS, 24" LONG, 24" C-C, DRILLED AND EMBEDDED 8" INTO THE CENTER OF THE EXISTING SLAB. WITH "PO ROC" OR EQUAL.
2. IF REINFORCED CONCRETE IS OVERLAYED REPLACE WITH SAME THICKNESS OF HMAC SURFACING.
3. REFER TO STANDARD DETAIL 02751-01 FOR REINFORCING STEEL REQUIREMENT
4. REFER TO STANDARD DETAIL 02951-01 FOR PAVEMENT RESTORATION LIMITS.

CITY OF HOUSTON DEPARTMENT OF PUBLIC WORKS AND ENGINEERING ENGINEERING, CONSTRUCTION AND REAL ESTATE DIVISION	
PAVEMENT REPAIR DETAILS FOR STREET CUTS NON REINFORCED CONCRETE AND BRICK PAVEMENT (NOT TO SCALE)	
APPROVED BY: CITY ENGINEER	APPROVED BY: DIRECTOR OF PUBLIC WORKS AND ENGINEERING
EFF DATE: OCT-01-2002	DWG NO: 02902-02

ASPHALT PAVEMENT RESTORATION

FOR PAVEMENT OF ALL AGES



NOTES:

1. EXTENT OF PAVEMENT REPAIR SHALL BE PERPENDICULAR AND PARALLEL TO TRAVEL WAY.

2. FLEXIBLE BASE:

   REPLACE BASE TO SAME THICKNESS PLUS TWO INCHES (2") FOR EXTENT OF EXCAVATION. USE APPROVED BASE MATERIAL TYPE. *

3. SURFACE COURSE:

A. WIDTH:
   SURFACE MILL AND OVERLAY FULL WIDTH OF LANE(S) TO NEAREST LANE DIVIDER BEYOND EDGE OF EXCAVATION.

B. LENGTH:
   MINIMUM LENGTH OF SURFACE MILL ALONG TRAVEL WAY IS 10'.

C. REPLACE PAVEMENT MARKINGS IN ACCORDANCE WITH CITY SPECIFICATIONS 02764 & 02767.

ADDITIONAL REQUIREMENTS FOR ASPHALT OVERLAY ON CONCRETE PAVEMENT:

1. REPLACE CONCRETE FOR EXTENT OF EXCAVATION. REPLACE TO SAME THICKNESS PLUS TWO INCHES (2").

2. WIDTH:
   IF EXCAVATION EXTENDS MORE THAN HALF OF A LANE, REPLACE ENTIRE LANE OF CONCRETE. OTHERWISE USE STANDARD DETAIL 02902-01.

3. SAW CUT AND EXPOSE 15" OF REINFORCING STEEL AROUND EDGE OF CONCRETE REPLACEMENT. IF NO REINFORCING STEEL EXISTS, USE HORIZONTAL DOWELS PER SPECIFICATION SECTION 02902.

4. REPLACE CURB WHEN ADJACENT LANE IS REPLACED.

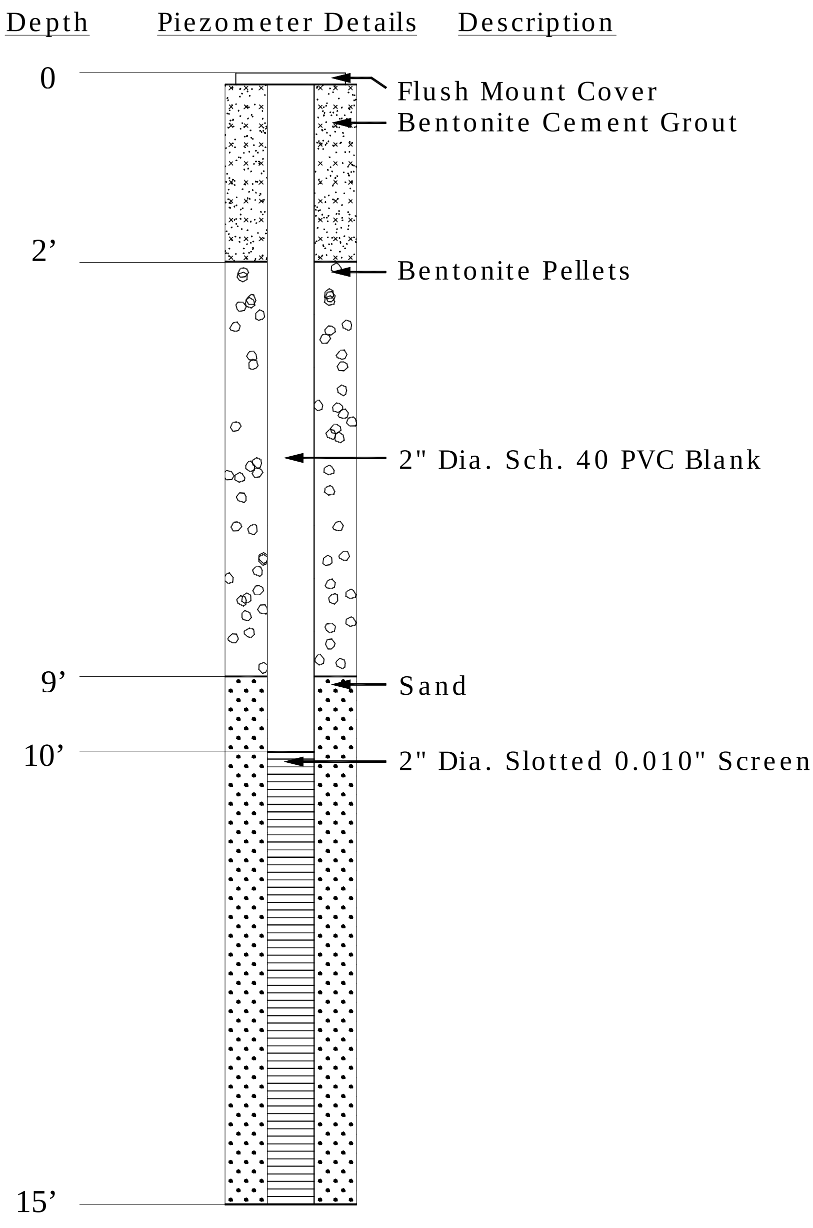
5. MAINTAIN CONCRETE EXPANSION JOINTS AT EXISTING LOCATIONS UNLESS OTHERWISE APPROVED BY CITY ENGINEER.

* EXTENT OF EXCAVATION INCLUDES 18" OVERCUT AS SHOWN ON STANDARD DETAIL 02902-01.

CITY OF HOUSTON DEPARTMENT OF PUBLIC WORKS AND ENGINEERING ENGINEERING, CONSTRUCTION AND REAL ESTATE GROUP	
Street Cut Pavement Replacement ASPHALT PAVEMENT FOR PAVEMENT OF ALL AGES (NOT TO SCALE)	
APPROVED BY: CITY ENGINEER	APPROVED BY: DIRECTOR OF PUBLIC WORKS AND ENGINEERING
EFF DATE: JUNE 2002	DWG NO: 02951-03

APPENDIX D

PIEZOMETER INSTALLATION RECORDS



Water Level Readings

Date	Depth (ft.)	Elev. (ft.)
2/1/13	8.0	N/A
3/2/13	7.5	N/A

NOTES:

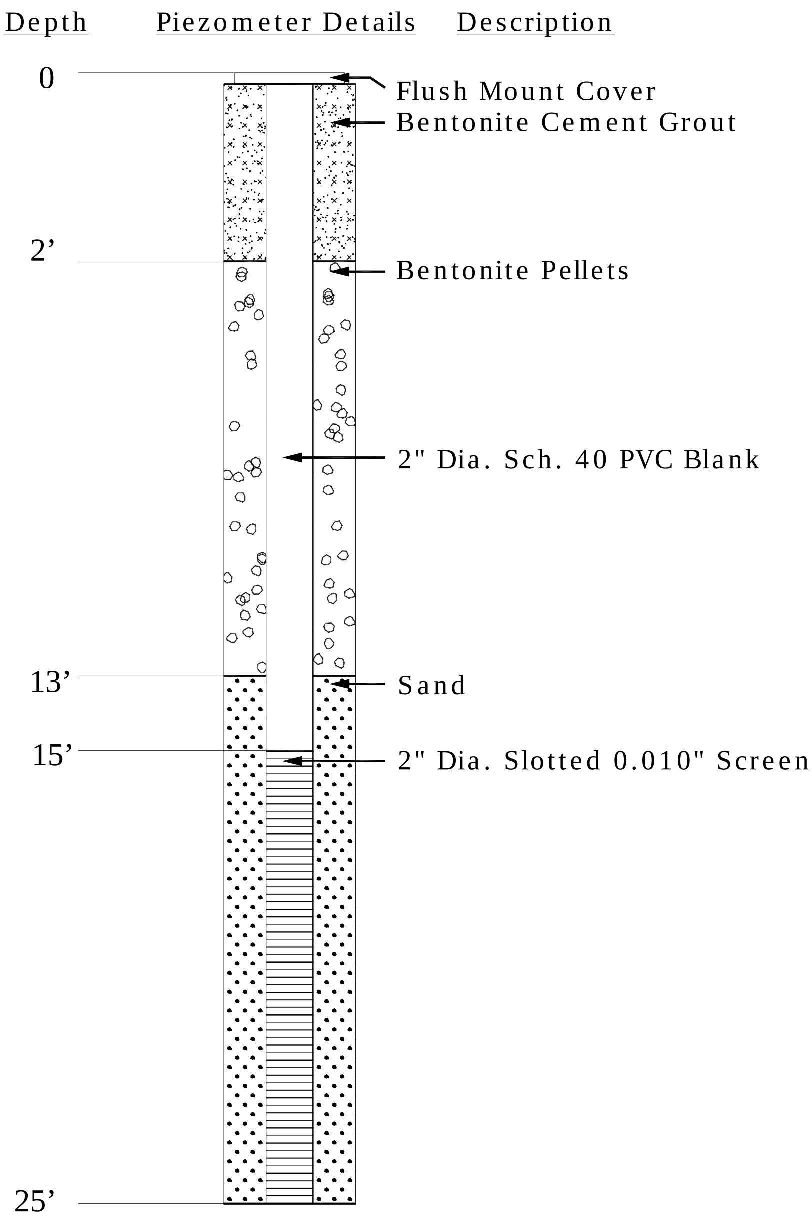
- Piezometer was installed on 1/31/13.
- See Plate 2A for boring location; see Plate A-3 for boring log.

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-3)
WBS No. M-000267-0001-3

PROJECT NO.: HG1110720

DRAWING NO.: PLATE D-1



Water Level Readings

Date	Depth (ft.)	Elev. (ft.)
1/18/13	7.5	N/A
2/16/13	8.5	N/A

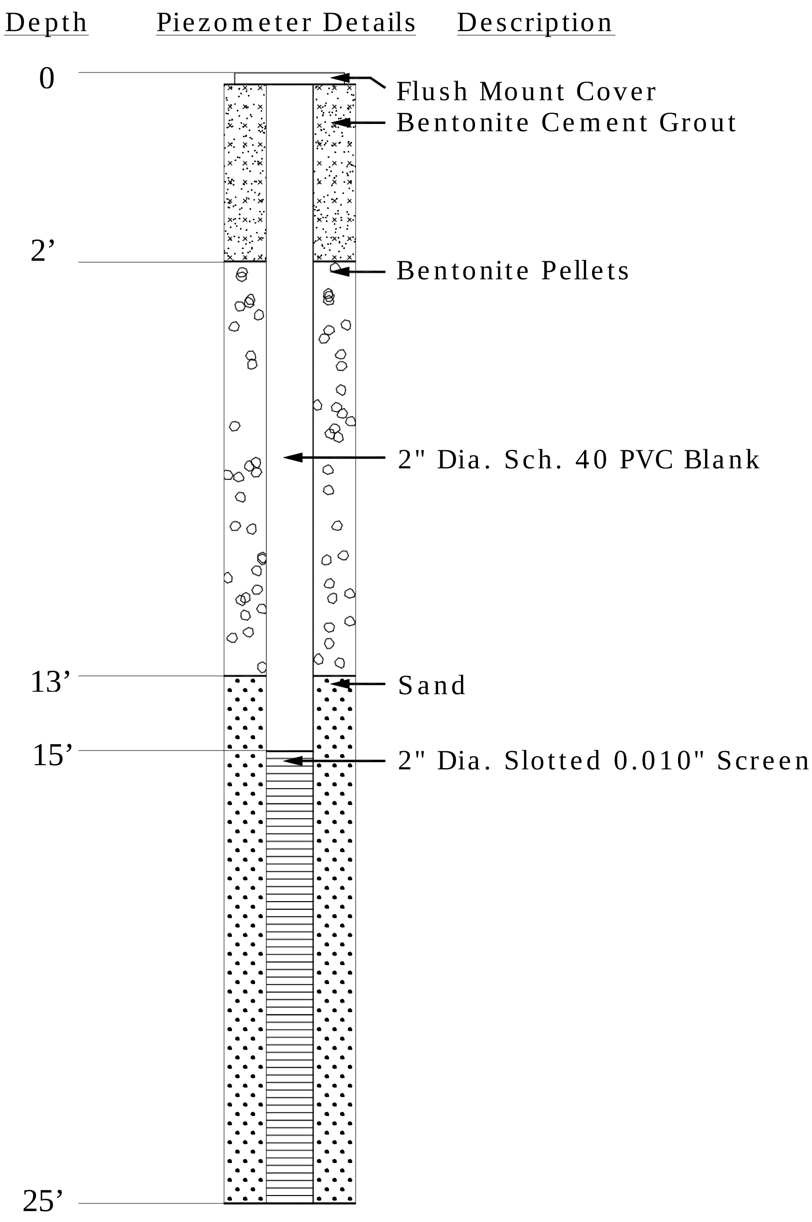
NOTES:

- Piezometer was installed on 1/17/13.
- See Plate 2A for boring location; see Plate A-8 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)
WBS No. M-000267-0001-3

PROJECT NO.:	DRAWING NO.:
HG1110720	PLATE D-2



Water Level Readings

Date	Depth (ft.)	Elev. (ft.)
1/26/13	15.0	N/A
2/25/13	19.3	N/A

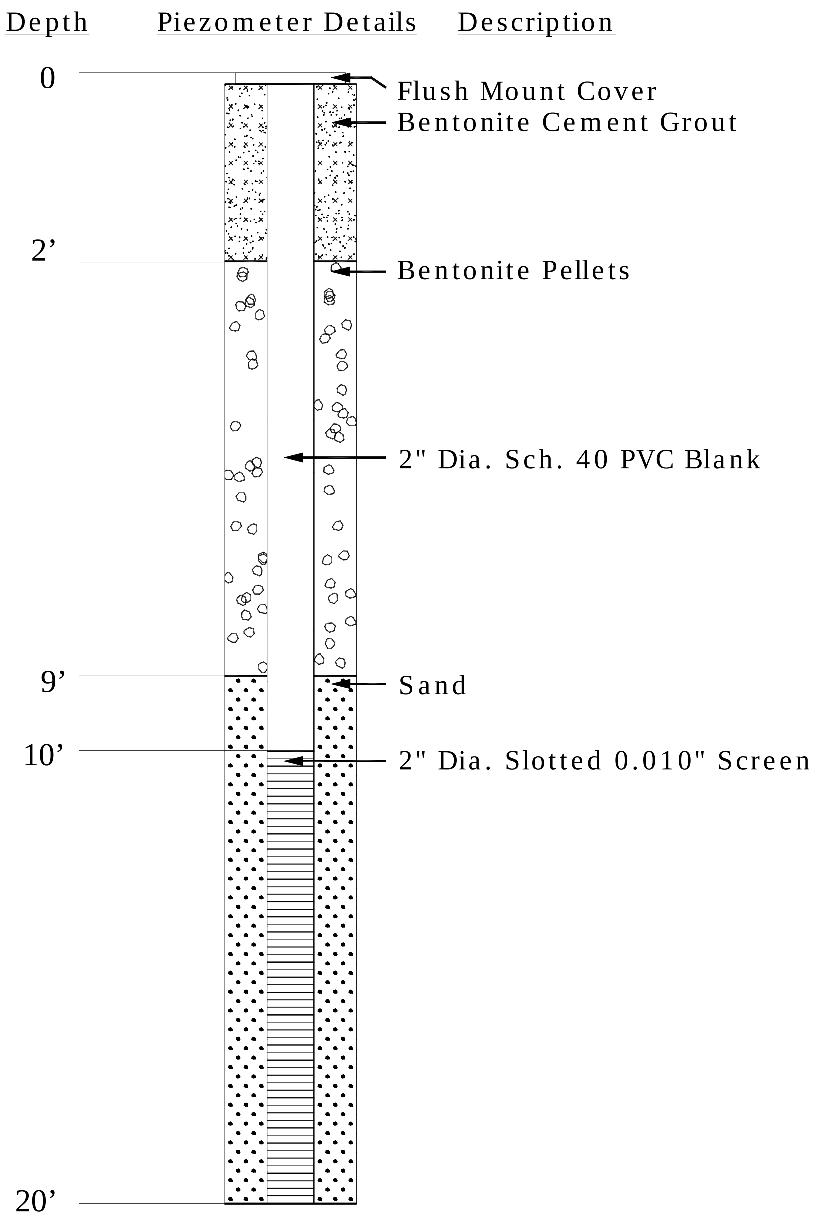
NOTES:

- Piezometer was installed on 1/25/13.
- See Plate 2B for boring location; see Plate A-13 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-3 (B-13)
WBS No. M-000267-0001-3

PROJECT NO.:	DRAWING NO.:
HG1110720	PLATE D-3



Water Level Readings

Date	Depth (ft.)	Elev. (ft.)
2/1/13	Dry	N/A
3/2/13	18.0	N/A

NOTES:

- Piezometer was installed on 1/31/13.
- See Plate 2B for boring location; see Plate A-16 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-4 (B-16)
WBS No. M-000267-0001-3

PROJECT NO.:	DRAWING NO.:
HG1110720	PLATE D-4

STATE OF TEXAS WELL REPORT for Tracking #315432

Owner:	**city of houston**	Owner Well #:	**PZ #2**
Address:	**houston , TX**	Grid #:	**65-21-4**
Well Location:	**6101 jessamine houston , TX**	Latitude:	**29° 42' 12" N**
Well County:	**Harris**	Longitude:	**095° 29' 32" W**
Elevation:	**No Data**	GPS Brand Used:	**No Data**
Type of Work:	**New Well**	Proposed Use:	**Monitor**

Drilling Date:	Started: **1/16/2013** Completed: **1/16/2013**
Diameter of Hole:	Diameter: **8 in From Surface To 25 ft**
Drilling Method:	**Hollow Stem Auger**
Borehole Completion:	Other: **silica**
Annular Seal Data:	1st Interval: **From 0 ft to 5 ft with 2 bags cement (#sacks and material)** 2nd Interval: **No Data** 3rd Interval: **No Data** Method Used: **hand mixed** Cemented By: **tss, inc.** 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:	**Alternative Procedure Used**
Water Level:	Static level: **No Data** Artesian flow: **No Data**
Packers:	**No Data**
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:	**tss, inc.** **3801 capital of texas hwy** **austin , TX 78746**
Driller License Number:	**54611**

Licensed Well Driller Signature:	**brian kern**
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 **#315432**) 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
0-25 ft alternating gray and black clay and sand seams

CASING, BLANK PIPE & WELL SCREEN DATA

Dia. New/Used Type Setting From/To
2 n plastic schedule 40 0-10
2 n screen .010 10-25

STATE OF TEXAS WELL REPORT for Tracking #315431

Owner:	**city of houston**	Owner Well #:	**PZ #1**
Address:	**houston , TX**	Grid #:	**65-21-1**
Well Location:	**6021 clearwood houston , TX**	Latitude:	**29° 42' 54" N**
Well County:	**Harris**	Longitude:	**095° 29' 29" W**
Elevation:	**No Data**	GPS Brand Used:	**No Data**
Type of Work:	**New Well**	Proposed Use:	**Monitor**

Drilling Date:	Started: **1/31/2013** Completed: **1/31/2013**
Diameter of Hole:	Diameter: **8 in From Surface To 25 ft**
Drilling Method:	**Hollow Stem Auger**
Borehole Completion:	Other: **silica**
Annular Seal Data:	1st Interval: **From 0 ft to 5 ft with 2 bags cement (#sacks and material)** 2nd Interval: **No Data** 3rd Interval: **No Data** Method Used: **hand mixed** Cemented By: **tss, inc.** 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:	**Alternative Procedure Used**
Water Level:	Static level: **No Data** Artesian flow: **No Data**
Packers:	**No Data**
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:	**tss, inc.** **3801 capital of texas hwy** **austin , TX 78746**
Driller License Number:	**54611**

Licensed Well Driller Signature: **brian kern**

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 **#315431**) 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
0-25 ft	**alternating gray and black clay and sand seams**

CASING, BLANK PIPE & WELL SCREEN DATA

Dia.	New/Used	Type	Setting From/To
2	**n**	**plastic schedule 40**	**0-10**
2	**n**	**screen .010**	**10-25**

STATE OF TEXAS PLUGGING REPORT for Tracking #86745

Owner:	**city of houston**	Owner Well #:	**pz 4**
Address:	**city of houston , TX**	Grid #:	**65-21-4**
Well Location:	**5616 flack dr.** **houston , TX**	Latitude:	**29° 41' 55" N**
Well County:	**Harris**	Longitude:	**095° 29' 39" W**
		GPS Brand Used:	**No Data**

Well Type: **Monitor**

HISTORICAL DATA ON WELL TO BE PLUGGED

Original Well Driller:	**tss**
Driller's License Number of Original Well Driller:	**54611**
Date Well Drilled:	**1/31/2013**
Well Report Tracking Number:	**No Data**
Diameter of Borehole:	**8 inches**
Total Depth of Borehole:	**25 feet**

Date Well Plugged:	**3/5/2013**
Person Actually Performing Plugging Operation:	**tss, inc.**
License Number of Plugging Operator:	**54611**
Plugging Method:	**Tremmie pipe cement from bottom to top.**
Plugging Variance #:	**No Data**
Casing Left Data:	1st Interval: **No Data** 2nd Interval: **No Data** 3rd Interval: **No Data**
Cement/Bentonite Plugs Placed in Well:	1st Interval: **From 0 ft to 25 ft; Sack(s)/type of cement used: 4 bags cement** 2nd Interval: **No Data** 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:	**tss, inc** **3801 capital of texas hwy** **austin , TX 78746**

Plug Installer License Number:	**54611**
Licensed Plug Installer Signature:	**brian kern**
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 **#86745**) on your written request.

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Austin, TX 78711
(512) 463-7880

STATE OF TEXAS PLUGGING REPORT for Tracking #86744

Owner:	**city of houston**	Owner Well #:	**pz 3**
Address:	**city of houston , TX**	Grid #:	**65-21-4**
Well Location:	**7707 rampart houston , TX**	Latitude:	**29° 41' 42" N**
Well County:	**Harris**	Longitude:	**095° 29' 32" W**
		GPS Brand Used:	**No Data**

Well Type: **Monitor**

HISTORICAL DATA ON WELL TO BE PLUGGED

Original Well Driller:	**tss**
Driller's License Number of Original Well Driller:	**54611**
Date Well Drilled:	**1/25/2013**
Well Report Tracking Number:	**No Data**
Diameter of Borehole:	**8 inches**
Total Depth of Borehole:	**25 feet**

Date Well Plugged:	**3/5/2013**
Person Actually Performing Plugging Operation:	**tss, inc.**
License Number of Plugging Operator:	**54611**
Plugging Method:	**Tremmie pipe cement from bottom to top.**
Plugging Variance #:	**No Data**
Casing Left Data:	1st Interval: **No Data** 2nd Interval: **No Data** 3rd Interval: **No Data**
Cement/Bentonite Plugs Placed in Well:	1st Interval: **From 0 ft to 25 ft; Sack(s)/type of cement used: 4 bags cement** 2nd Interval: **No Data** 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:	**tss, inc** **3801 capital of texas hwy** **austin , TX 78746**

Plug Installer License Number:	**54611**
Licensed Plug Installer Signature:	**brian kern**
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 **#86744**) on your written request.

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STATE OF TEXAS PLUGGING REPORT for Tracking #86743

Owner:	**city of houston**	Owner Well #:	**pz 2**
Address:	**city of houston , TX**	Grid #:	**65-21-4**
Well Location:	**6106 jessamine dallas , TX**	Latitude:	**29° 42' 12" N**
Well County:	**Harris**	Longitude:	**095° 29' 32" W**
		GPS Brand Used:	**No Data**
Well Type:	**Monitor**		

HISTORICAL DATA ON WELL TO BE PLUGGED

Original Well Driller:	**tss**
Driller's License Number of Original Well Driller:	**54611**
Date Well Drilled:	**1/31/2013**
Well Report Tracking Number:	**No Data**
Diameter of Borehole:	**8 inches**
Total Depth of Borehole:	**25 feet**

Date Well Plugged:	**3/5/2013**
Person Actually Performing Plugging Operation:	**tss, inc.**
License Number of Plugging Operator:	**54611**
Plugging Method:	**Tremmie pipe cement from bottom to top.**
Plugging Variance #:	**No Data**
Casing Left Data:	1st Interval: **No Data** 2nd Interval: **No Data** 3rd Interval: **No Data**
Cement/Bentonite Plugs Placed in Well:	1st Interval: **From 0 ft to 25 ft; Sack(s)/type of cement used: 4 bags cement** 2nd Interval: **No Data** 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:	**tss, inc 3801 capital of texas hwy austin , TX 78746**

Plug Installer License Number:	**54611**
Licensed Plug Installer Signature:	**brian kern**
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 **#86743**) on your written request.

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STATE OF TEXAS PLUGGING REPORT for Tracking #86742

Owner:	**city of houston**	Owner Well #:	**pz 1**
Address:	**city of houston , TX**	Grid #:	**65-21-1**
Well Location:	**6021 clearwood houston , TX**	Latitude:	**29° 42' 54" N**
Well County:	**Harris**	Longitude:	**095° 29' 29" W**
		GPS Brand Used:	**No Data**

Well Type: **Monitor**

HISTORICAL DATA ON WELL TO BE PLUGGED

Original Well Driller:	**tss**
Driller's License Number of Original Well Driller:	**54611**
Date Well Drilled:	**1/31/2013**
Well Report Tracking Number:	**No Data**
Diameter of Borehole:	**8 inches**
Total Depth of Borehole:	**25 feet**

Date Well Plugged:	**3/5/2013**
Person Actually Performing Plugging Operation:	**tss, inc.**
License Number of Plugging Operator:	**54611**
Plugging Method:	**Tremmie pipe cement from bottom to top.**
Plugging Variance #:	**No Data**
Casing Left Data:	1st Interval: **No Data** 2nd Interval: **No Data** 3rd Interval: **No Data**
Cement/Bentonite Plugs Placed in Well:	1st Interval: **From 0 ft to 25 ft; Sack(s)/type of cement used: 4 bags cement** 2nd Interval: **No Data** 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:	**tss, inc** **3801 capital of texas hwy** **austin , TX 78746**

Plug Installer License Number:	**54611**
Licensed Plug Installer Signature:	**brian kern**
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 **#86742**) on your written request.

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STATE OF TEXAS WELL REPORT for Tracking #315434

Owner:	**city of houston**	Owner Well #:	**PZ #4**
Address:	**houston , TX**	Grid #:	**65-21-4**
Well Location:	**5616 flack dr.** **houston , TX**	Latitude:	**29° 41' 55" N**
Well County:	**Harris**	Longitude:	**095° 29' 39" W**
Elevation:	**No Data**	GPS Brand Used:	**No Data**
Type of Work:	**New Well**	Proposed Use:	**Monitor**

Drilling Date: Started: **1/25/2013**
Completed: **1/25/2013**

Diameter of Hole: Diameter: **8 in From Surface To 25 ft**

Drilling Method: **Hollow Stem Auger**

Borehole Completion: Other: **silica**

Annular Seal Data: 1st Interval: **From 0 ft to 5 ft with 2 bags cement (#sacks and material)**
2nd Interval: **No Data**
3rd Interval: **No Data**
Method Used: **hand mixed**
Cemented By: **tss, inc.**
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: **Alternative Procedure Used**

Water Level: Static level: **No Data**
Artesian flow: **No Data**

Packers: **No Data**

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: **tss, inc.**
3801 capital of texas hwy
austin , TX 78746

Driller License Number:	**54611**
Licensed Well Driller Signature:	**brian kern**
Registered Driller Apprentice Signature:	**No Data**
Apprentice Registration Number:	**No Data**
Comments:	**No Data**

IMPORTANT NOTICE FOR PERSONS HAVING WELLS DRILLED CONCERNING CONFIDENTIALITY

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Please include the report's Tracking number (Tracking **#315434**) on your written request.

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P.O. Box 12157
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(512) 463-7880

DESC. & COLOR OF FORMATION MATERIAL

From (ft) To (ft) Description
0-25 ft alternating gray and black clay and sand seams

CASING, BLANK PIPE & WELL SCREEN DATA

Dia. New/Used Type Setting From/To
2 n plastic schedule 40 0-10
2 n screen .010 10-25

STATE OF TEXAS WELL REPORT for Tracking #315433

Owner:	**city of houston**	Owner Well #:	**PZ #3**
Address:	**houston , TX**	Grid #:	**65-21-1**
Well Location:	**7707 rampart** **houston , TX**	Latitude:	**29° 42' 32" N**
Well County:	**Harris**	Longitude:	**095° 29' 32" W**
Elevation:	**No Data**	GPS Brand Used:	**No Data**
Type of Work:	**New Well**	Proposed Use:	**Monitor**

Drilling Date:	Started: **1/25/2013** Completed: **1/25/2013**
Diameter of Hole:	Diameter: **8 in From Surface To 25 ft**
Drilling Method:	**Hollow Stem Auger**
Borehole Completion:	Other: **silica**
Annular Seal Data:	1st Interval: **From 0 ft to 5 ft with 2 bags cement (#sacks and material)** 2nd Interval: **No Data** 3rd Interval: **No Data** Method Used: **hand mixed** Cemented By: **tss, inc.** 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:	**Alternative Procedure Used**
Water Level:	Static level: **No Data** Artesian flow: **No Data**
Packers:	**No Data**
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:	**tss, inc.** **3801 capital of texas hwy** **austin , TX 78746**

Driller License Number:	**54611**
Licensed Well Driller Signature:	**brian kern**
Registered Driller Apprentice Signature:	**No Data**
Apprentice Registration Number:	**No Data**
Comments:	**No Data**

IMPORTANT NOTICE FOR PERSONS HAVING WELLS DRILLED CONCERNING CONFIDENTIALITY

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P.O. Box 12157
Austin, TX 78711
(512) 463-7880

DESC. & COLOR OF FORMATION MATERIAL	CASING, BLANK PIPE & WELL SCREEN DATA
From (ft) To (ft) Description	Dia. New/Used Type Setting From/To
0-25 ft alternating gray and black clay and sand seams	**2 n plastic schedule 40 0-10** **2 n screen .010 10-25**