DRAFT

Design Study

Terminal 3 & 4 Backlands Redevelopment – Gate Complex

Port of Tacoma, Tacoma, Washington

Prepared for

Moffatt & Nichol

September 22, 2017

19308-00

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Prepared by

Hart Crowser, Inc.

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Design Study

Terminal 3 & 4 Backlands Redevelopment – Gate Complex

Port of Tacoma, Tacoma, Washington

PURPOSE, SCOPE, AND USE OF THIS REPORT

The purpose of our work is to provide KPFF Consulting Engineers (KPFF) and its design and construction consultants with subsurface information, along with our interpretation and geotechnical engineering recommendations to support the design for the Pier 4 Reconfiguration Project.

Our scope of work for this project included:

- Assessing subsurface conditions using existing geotechnical data from historical geotechnical reports;
- Provide recommendations for design of new:
    - Shallow foundations,
    - RTG runway grade beams,
    - Underground utilities,
    - Pavement sections,
    - Light poles/luminaires, etc.,
    - Grading and backfilling with structural fill,
    - General dewatering recommendations; and
- Producing a geotechnical engineering design report.

We prepared this report for the exclusive use of Moffatt & Nichol for specific application to this project and site location. We completed the work according to generally accepted geotechnical practices in the same or similar localities, related to the nature of the work accomplished, at the time the services were accomplished. We make no other warranty, express or implied.

PROJECT UNDERSTANDING

The purpose of this project is to construct a new gate complex and reconfigure the backland container handling yard within Terminal 3 and 4 to align with the Pier 4 reconfiguration that is currently under construction.

SITE DESCRIPTION

Terminals 3 and 4 are located in the Port of Tacoma, within the General Central Peninsula (GCP) terminal complex. The site vicinity is shown on Figure 1 and the site location and existing soil boring locations are shown on Figure 2.

Site horizontal datum is Washington State Plane Coordinate System, South Zone, NAD 83/2007. Site vertical datum is Mean Lower Low Water (MLLW) based on Tide 22 Benchmark at the NE corner of 11th Street Bridge and Milwaukee Way at elevation 19.39 feet.

Existing ground surface is paved with asphalt or concrete. The existing ground surface elevation in the vicinity of the project is approximately elevation 17 feet.

SUBSURFACE CONDITIONS

Soil Conditions

The locations of historical borings in the site vicinity are shown on Figure 2. Generally, the site soils include interbedded zones of silt and sand of varying density. The soil density varies typically from loose, near the ground surface, to dense with increasing depth; however, there are zones of less dense and very dense soil scattered throughout the subsurface.

For structures founded within 10 feet below ground surface (bgs) the soil is expected to consist of sand to silty sand with assumed uniform total unit weight of 115 pounds per cubic foot (pcf) and internal angle of friction of 30 degrees.

Groundwater Conditions

Groundwater elevation in the upland area is expected to vary from about elevation 6 to 11 feet MLLW, or about 6 to 11 feet below planned ground surface (elevation 17 feet MLLW).

SEISMIC CONSIDERATIONS

Seismic Setting

The site is in a seismically active area. In this section, we describe the seismic setting at the project site, identify the seismic basis of design, provide our recommended design response spectra based on our site-specific seismic response analysis, and discuss the seismic hazards at the site.

The seismicity of Western Washington is dominated by the Cascadia Subduction Zone, in which the offshore Juan de Fuca Plate subducts beneath the continental North American Plate (Figure 3). Three types of earthquakes are associated with subduction zones: intraslab subduction, interface subduction, and crustal earthquakes.

Subduction Zone Sources are caused by the offshore Juan de Fuca Plate subducting below the North American Plate. This causes two distinct types of events. Large magnitude interface subduction earthquakes occur at shallow depths near the Washington coast at the interface between the two plates (e.g., the 1700 earthquake, with magnitude of approximately 9.0). A deeper zone of seismicity is associated with bending and breaking of the Juan de Fuca Plate below the Puget Sound Region, which produces intraslab subduction earthquakes at depths of 40 to 70 kilometers (e.g., the 1949, 1965, and 2001 earthquakes). The intraslab events can produce earthquakes with magnitudes as large as 7.5. Figure 4 depicts the Cascadia Subduction Zone and the various types of earthquakes it can produce.

Recent fault trenching and seismic records in the Puget Sound area indicate a distinct shallow zone of crustal seismicity (e.g., Seattle and Tacoma Faults), which may have surficial expressions and can extend 25 to 30 kilometers deep. Figure 4 shows the position of the Puget Sound crustal faults in relation to the project site.

Site Class and IBC Response Spectrum

A downhole shear wave velocity survey was previously done in support of the Pier 4 reconfiguration (Hart Crowser 2015). The survey was conducted in Boring HC12-B5 (Hart Crowser 2014). The measured profile had a V_{S30} (weighted average shear wave velocity in the upper 30 meters [100 feet]) of 495 feet per second, which corresponds to Site Class E. However, because the site contains potentially liquefiable soil, the site soils are classified as Site Class F.

The 2012 International Building Code (IBC; International Code Council 2012) requires a site-specific analysis to determine seismic parameters for Site Class F soils if the period of the structure is greater than 0.5 seconds. For structures with periods of vibration less than 0.5 seconds, the following code-based parameters may be used:

- Latitude = 47.27269 degrees;
- Longitude = -122.41085 degrees;
- Site Class: E;
- Mapped MCE_R, site class adjusted peak ground acceleration, PGA_M = 0.45g;
- Mapped MCE_R spectral response acceleration at short periods, S_S = 1.297 g; and
- Mapped MCE_R spectral response acceleration at 1-second periods, S_1 = 0.503 g.

Liquefaction Potential

Liquefaction is a phenomenon caused by a rapid increase in porewater pressure that reduces the effective stress between soil particles, resulting in the sudden loss of shear strength in the soil. Granular soils that rely on inter-particle friction for strength are susceptible to liquefaction until the excess pore pressures can dissipate. Sand boils and flows observed at the ground surface after an earthquake are the result of excess pore pressures dissipating upward, carrying soil particles with the draining water. In general, loose, saturated sandy soils with low silt and clay contents are the most susceptible to liquefaction. Silty soils with low plasticity are moderately susceptible to liquefaction under relatively higher levels of ground shaking. For any soil type, the soil must be saturated for liquefaction to occur. Liquefaction can cause ground surface settlement and lateral spreading.

In general, we anticipate widespread liquefaction between the groundwater table and approximately elevation –30 feet, and limited or localized zones of liquefaction below elevation –30 feet. Some explorations indicate that localized zones of soft or loose liquefiable deposits are present at depths as great as 220 feet bgs. However, the depth of potential liquefaction is often limited to 80 feet bgs, following guidance in WSDOT Geotechnical Design Manual (WSDOT 2014). WSDOT has historically adopted an 80-foot limit because simplified procedures for estimating liquefaction potential, such as Idriss and Boulanger, are only calibrated for depths down to approximately 50 to 60 feet, and observations of liquefaction suggest that the effects of liquefaction become less significant as the depth of the liquefiable layer increases. It is also difficult and expensive to mitigate and design against liquefaction at these great depths.

Post-Liquefaction Vertical Settlement

Post-liquefaction settlement occurs because liquefiable soils are redistributed and become denser after an earthquake. The ground surface settlement is not typically uniform across the area, and can result in significant differential settlement.

A previous study (Hart Crowser 2015) calculated liquefaction induced settlement in the vicinity of the Pier 4 reconfiguration and estimated settlement on the order of 4 to 20 inches across the site. In our opinion, the soil conditions across the site are such that this range of potential settlement is also representative of the breadth of Terminal 3 and 4. Note, this estimate only includes strains in the upper 80 feet of soil. This is a reasonable assumption for ground surface settlement, because research has shown that volumetric contractions at depths greater than 60 feet may not manifest as surface settlement (Cetin et al. 2009).

Because these are broad ranges of settlement, we recommend that structures being designed to withstand the design earthquake be specifically addressed based on the nearest available boring data.

Fault Surface Rupture

Terminals 3 and 4 are approximately 10 miles southeast of the easternmost splay of the east–west Tacoma fault, as mapped by Brocher et al. (2004). Figure 4 is a map of the Tacoma fault and other known faults in the region. The last known rupture of the Tacoma fault occurred approximately 1,000 years ago. Based on current knowledge, the hazard of surface rupture at the site is considered to be very low.

DESIGN RECOMMENDATIONS

Shallow Foundation Soil Capacities

These recommendations are applicable to lightly loaded structures bearing on shallow spread footings including the following structures:

- Radiation Portal Monitor
- Optical Character Recognition system
- Gate arm pedestal

- Intercom pedestal
- Guard platform slab
- Transformer and switchgear pads
- USCBP booth
- Camera bridge
- TWIC booth.

We recommend the following:

- Shallow footings should bear directly on a minimum 2-foot-thick layer of well-compacted structural fill material. This two foot zone can consist of overexcavated and backfilled material or recompaction (as necessary) of the material encountered at the base of the footing excavation.
- Use a maximum allowable bearing pressure of 1.5 kips per square foot (ksf)
- The bottom of foundation should be buried at least 1.5 feet below the lowest adjacent grade.
- The allowable soil bearing pressure may be increased up to one-third for loads of short duration, such as those caused by wind or seismic forces.
- Lateral loads may be resisted by passive earth pressure and base friction; however, we recommend ignoring the upper 2 feet of soil unless that soil is protected from erosion by permanent hardscaping. For foundations placed directly against the existing soil, use an allowable equivalent fluid passive earth pressure of 230 pcf (105 pcf below the water table) and an allowable base sliding coefficient of friction of 0.35. These allowable values include a factor of safety of 1.5.
- Lateral soil loads from adjacent, existing soil may be applied as an active earth pressure with an equivalent fluid unit weight of 38 pcf (18 pcf below the groundwater table). Use of an active earth pressure presumed that the wall is able to laterally deflect at least 0.001H, where H is the buried height of the wall.
- Unless permanently drained, structures should be designed for full hydrostatic groundwater pressure. If permanent drainage is provided, then full hydrostatic ground pressure need only be applied below the bottom of the permanent drainage.
- The bottom of footings should be located outside of an imaginary 45-degree plane projected upward from the bottom edge of any adjacent footings or utility trenches. For footings inside this plane, loads may be transferred through the soil to the deeper footing and the combined load could be in excess of the design allowable bearing capacity and/or an adjacent structure needs to be designed for the lateral load caused by the footing. When footings cannot be located outside of the 45-degree plane, consult with Hart Crowser to assess potential design implications.

Vertical Modulus of Subgrade Reaction for Shallow Foundations

Use a modulus of subgrade reaction based on a 1-foot-by-1-foot square plate [$k_{(1x1)}$] of 200 pounds per cubic inch. Use the equations below to calculate the appropriate modulus of subgrade reaction for different foundation sizes and shapes:

For a square foundation of size B x B:

$$k_{(BxB)} = k_{(1x1)} \frac{(B+1)^2}{4B^2}$$ for footings where B ≤ 20 feet

$$k_{(BxB)} = k_{(1x1)} \frac{(B+1)^2}{2B^2}$$ for footings where B ≥ 40 feet

For footings where 20 < B < 40, perform linear interpolation using the two equations above.

For a rectangular foundation of size B x L:

$$k = k_{(BxB)} \frac{(1+0.5\frac{B}{L})}{1.5}$$

Where:

k = modulus of subgrade reaction of rectangular footing;

$k_{(BxB)}$ = modulus of subgrade reaction of square footing;

$k_{(1x1)}$ = modulus of subgrade reaction of footing with dimensions of 1 foot by 1 foot;

B = footing width; and

L = footing length.

Truck Scale Foundation

We understand that the scale manufacturer requires a minimum 2,500 psf allowable bearing capacity and does not provide a modulus of subgrade reaction requirement. We recommend that the areas under the scale footings be overexcavated at least 3.0 feet and then backfilled as previously recommended in the recommendations for shallow foundations section of this report.

Short Mast Light Poles

Design of short mast light poles may be designed using an allowable equivalent fluid passive earth pressure of 150 pcf above the water table and 65 pcf below the water table. If applicable, a lateral base sliding coefficient of friction of 0.25 may also be used. These allowable values include a factor of safety of 2.0.

Foundation design within 10 feet of sloping ground steeper than 2H:1V should be reviewed by Hart Crowser.

High Mast Luminaire

High mast luminaires are expected to consist of light poles up to 110 feet tall. We understand that these light poles may have approximately 900 kip-ft of moment, 10 kips of shear force, and 9 kips of axial force (unfactored).

The locations of new High Mast Luminaires are not finalized; therefore, for this report, we are providing preliminary design values. Also, for final design, we recommend doing new soil borings at the locations of the new High Mast Luminaires.

Based on our experience and on standard practice for similar projects, we recommend using deep foundations, typically 4-foot-diamter drilled shafts, to support the luminaires. We recommend a minimum shaft embedment of 25 feet bgs. The vertical capacity is well in excess of the anticipated vertical loads; therefore, we do not anticipate that vertical loads will control the design. For lateral capacity design, we preliminarily recommend the LPILE soil parameters in Table 1.

To avoid lateral group effects, drilled shaft center-to-center spacing should be greater than five times the shaft diameter.

Drilled shaft foundation design within 10 feet of sloping ground steeper than 2H:1V should be reviewed by Hart Crowser.

Table 1 – LPILE Soil Profile for High Mast Luminaire Deep Foundations

Elevation in feet (MLLW)	Soil Type	Effective Unit Weight		Friction Angle in degrees	P-multiplier m_p[(a)]	P-Y Modulus (k) in pci
		in pcf	in pci			
18 to 8	API Sand	115	0.067	30	1	43
8 to -20	API Sand	53	0.031	30	1 [0.1]	32

a. For liquefied conditions, the P-multiplier in [ ] should be applied in the LPILE analysis.

Pavement

Pavement Basis of Design

From our review of the Draft Basis of Design document (Moffatt & Nichol 2017), we understand that a formal pavement assessment was not included in the scope of work for this initial effort. Without knowledge of existing pavement conditions, pavement section thicknesses, subgrade conditions, and load magnitude and repetition data, calculations for pavement thickness and estimated service life is possible.

The goal of new paving work in this project will be to restore damaged areas to a serviceable condition. Full depth repairs will be provided with the intent that the repaired pavement have performance characteristics similar to the existing pavement in the vicinity of improvements that require demolition, trenching, minor regrading, or other construction operations. These pavements are expected to perform similar to existing pavements that are remaining in service. We understand that this approach to pavement repair is acceptable to the owner and their tenants.

It should be noted that based on past historical practice in heavy container cargo areas the Port has typically used an asphalt pavement section consisting of 8 inches of asphaltic concrete over 12 inches of crushed base course.

We recommend that, at a minimum, observing the as-built construction of the existing pavement sections and using that information as a basis for the proposed pavement sections.

Pavement Design Recommendations

These recommendations assume a minimum of 2 feet of structural fill or equivalent existing fill subgrade. Recommendations for over-excavation and replacement as previously noted for foundations is also applicable for pavement subgrade.

Asphalt

Asphalt pavement design may assume a subgrade resilient modulus of 10,000 psi.

Concrete

Design for concrete pavement may use a modulus of subgrade reaction of 260 psi, assuming that the concrete will be placed on a compacted structural fill subgrade.

Utilities

In general, we recommend that utility trench cut design be the contractor's responsibility. For shallow trench excavations, less than 4 feet deep, open cutting is not prohibited. Temporary shoring may be necessary if deeper excavation is required for utility placement or if the soils are unstable. The contractor should verify the condition of the side slopes during construction, and lay back trench cuts as necessary to conform to current standards of practice. We can provide additional recommendations as required.

Buried Structures

The following recommendations are for design and construction of proposed stormwater structures, manholes, catch basins, and similar underground structures extending less than 10 feet bgs:

- Lateral active earth pressure of 38 pcf above the gwt and 18 pcf below the gwt
- Lateral at-rest earth pressure of 55 pcf above the gwt and 24 pcf below the gwt
- Lateral allowable passive earth pressure of 230 pcf above the gwt and 105 pcf below the gwt
- Lateral allowable base sliding coefficient of 0.35

- Lateral seismic earth pressure increment of 9·H psf, where H is the buried wall height, applied as a uniform, rectangular pressure distribution.

- For structures bearing above the groundwater table, overexcavation may be required if soft or loose material is encountered during footing excavation. A Hart Crowser field representative should determine the need for, and extents of, overexcavation. If the overexcavated soil is suitable for recompaction, it can be reused.

- For foundation subgrades below the groundwater table, we expect that soft or loose conditions will be encountered when excavations reach planned foundation elevations and may require overexcavation. The need for overexcavation should be determined in the field during construction by a Hart Crowser representative. For planning, assume that overexcavation will extend 3 feet below the design foundation subgrade elevation. The overexcavation should be backfilled with free draining quarry spalls (or similar) and the quarry spalls should be wrapped in a geotextile fabric. The quarry spalls should be compacted by thoroughly tamping with the heel of an excavator bucket or by using a similar procedure. A minimum of 6-inch thickness of crushed surfacing base course (CSBC) should then be placed on top of the quarry spalls up to plan foundation subgrade elevation. The geotextile fabric needs to be of sufficient toughness to withstand quarry spalls being dropped from the height of the max excavation depth.

Dewatering Recommendations

Structures extending below the water table will require dewatering to maintain a safe and workable excavation. To provide a workable subgrade, the dewatering should lower the water at least 2 feet below the bottom of planned excavation (including potential over-excavation).

For planning purposes, assume the groundwater table is located 6 feet below ground surface.

CONSTRUCTION RECOMMENDATIONS

Structural Fill

Soil placed beneath structures, surrounding utilities, or below paved areas should be considered structural fill. In these fill areas, we recommend the following:

- For imported soil to be used as structural fill, use a clean, well-graded sand or sand and gravel with less than 5 percent by weight passing the No. 200 mesh sieve (based on the minus 3/4-inch fraction) for wet-weather grading. Compaction of material containing more than about 5 percent fine material may be difficult if the material is wet or becomes wet during rainy weather. During dry weather grading, the fines content may be increased provided that the soil is compacted near its optimum moisture content.

- For structural fill placed as crushed surfacing base course below pavement and sidewalks, use material that meets the requirements of WSDOT Standard Specification 9-03.9[3].

- Place structural fill only on a dense and non-yielding subgrade.
- Place and compact all structural fill in lifts with a loose thickness no greater than 10 inches. If small, hand-operated compaction equipment is used to compact structural fill, lifts should not exceed 6 inches in loose thickness.
- Control the moisture content of the fill to within 2 percent of the optimum moisture (the moisture content corresponding to the maximum modified Proctor dry density).
- Require compaction of at least 95 percent below all structures, slabs-on-grade, pavement, or sidewalks. The minimum dry densities recommended here are a percentage of the modified Proctor maximum dry density as determined by the ASTM D1557 test procedure.
- If wet subgrade areas are encountered during foundation or pavement section preparation, clean material with a gravel content (material coarser than a US No. 4 sieve) of at least 30 to 35 percent may be necessary.
- Have a Hart Crowser geotechnical engineer or engineering geologist verify the compacted densities of each lift.

Before fill control can begin, the compaction characteristics must be determined from representative samples of the structural and drainage fill. Samples should be obtained as soon as possible. A study of compaction characteristics should include determination of optimum and natural moisture content, maximum dry density, and gradation of the soil.

Use of On-Site Soil as Structural Fill

The suitability of excavated site soil for use as compacted structural fill depends on the gradation and moisture content of the soil when it is placed. As the amount of fines (the portion passing the No. 200 sieve) increases, the soil becomes increasingly sensitive to small changes in moisture content, and adequate compaction becomes more difficult to achieve. Soil containing more than about 5 percent fines cannot be consistently compacted to a dense non-yielding condition when the water content is greater than about 2 percent above or below optimum. To be reusable, soil must also be free of organic and other compressible materials.

Based on our prior experience at the Port of Tacoma, the on-site soil likely has a fines content great enough to make it moisture-sensitive when wet. It is possible that the soil could be used as fill during the drier summer construction season, especially if the material can be aerated using dozers or discs. During periods of wet weather, it will be more difficult to use these materials. Earthwork operations would need to be scheduled for periods of dry weather to keep the moisture content of the material near its optimum level.

Shallow Foundation Construction

- Before placing concrete for footings, subgrade soil should be in a very dense, non-yielding condition. Any disturbed soil should be removed. Also, mud mats may be necessary to protect silty subgrade soil from being disturbed during construction after it is exposed.

- Have our representative observe exposed subgrades before footing construction to verify design assumptions about subsurface conditions and subgrade preparation.

- The exposed subgrade should be carefully prepared and protected before concrete placement. Any loosening of the materials during construction could result in more settlement. It is important that foundation excavations be cleaned of loose or disturbed soil before placing any concrete and that there is no standing water in any foundation excavation. These conditions should be observed by our representative.

- Maintain groundwater levels at least 2 feet below the base grade of the footing excavation at all times to prevent the risk of heave, piping, boiling, and other loss or disturbance of subgrade material. This groundwater level should be maintained until after the footing steel and concrete are placed.

- Any loose to medium dense sand and soft to medium stiff silt that occurs naturally or is disturbed during construction, should be overexcavated and replaced with lean concrete for footings. Any visible organic and other unsuitable material should be removed from the exposed subgrade.

Temporary Cuts

Because of the variables involved, actual slope grades required for stability in temporary cut areas can only be estimated before construction. We recommend that stability of the temporary slopes used for construction be the sole responsibility of the contractor, since the contractor is in control of the construction operation and is continuously at the site to observe the nature and condition of the subsurface. Excavations should be made in accordance with all local, state, and federal safety requirements.

For planning purposes, temporary slopes constructed in fill soils above the water table should be constructed no steeper than 1.5H:1V. Flatter slopes may be necessary where seepage or sloughing is observed or to conform to safety requirements.

The stability and safety of open trenches and cut slopes depend on a number of factors, including:

- Type and density of the soil;

- Presence and amount of any seepage;

- Depth of cut;

- Proximity of the cut to any surcharge loads near the top of the cut, such as stockpiled material, traffic loads, structures, etc.;

- Duration of the open excavation; and
- Care and methods used by the contractor.

Based on these factors, we recommend:

- No traffic, construction equipment, stockpiles or building supplies be allowed within at least 5 feet from the top of the cut.
- Exposed soil should be protected from surface erosion using plastic sheeting, shotcrete, etc.
- Limit the duration of open excavations as much as possible.
- Surface water should be diverted away from exposed soil.
- The condition of soil, slopes, and open cuts should be re-evaluated throughout construction by a Competent Person.

RECOMMENDATIONS FOR CONTINUING GEOTECHNICAL SERVICES

Throughout this report, we have provided recommendations where we believe it is appropriate for Hart Crowser to provide additional geotechnical input to the design and construction process. Many of these recommendations and some additional recommendations are summarized in this section.

Continuing Design and Consultation Services

Before construction begins, we recommend that Hart Crowser:

- Continue to meet with the design team as needed to address geotechnical questions that may arise throughout the remainder of the design process;
- Drill new geotechnical borings at the High Mast Luminaire locations and provide revised geotechnical recommendations for foundation design;
- Review the project plans and specifications to see that the geotechnical engineering recommendations are properly interpreted.

Construction Services

During the construction phase of the project, we recommend retaining Hart Crowser to:

- Review applicable submittals;
- Observe installation of piles and ground improvement;
- Observe shallow foundation subgrade conditions;

- Observe installation of deep foundations;
- Consult with the construction team as needed; and
- Respond to other geotechnical engineering considerations that may arise during construction.

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Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), MapmyIndia, NGCC, © OpenStreetMap contributors, and the GIS

0 0.5 1 2

Scale in Miles

N

Terminal 3 & 4 Backlands Redevelopment - Gate Complex
Tacoma, Washington

Vicinity Map

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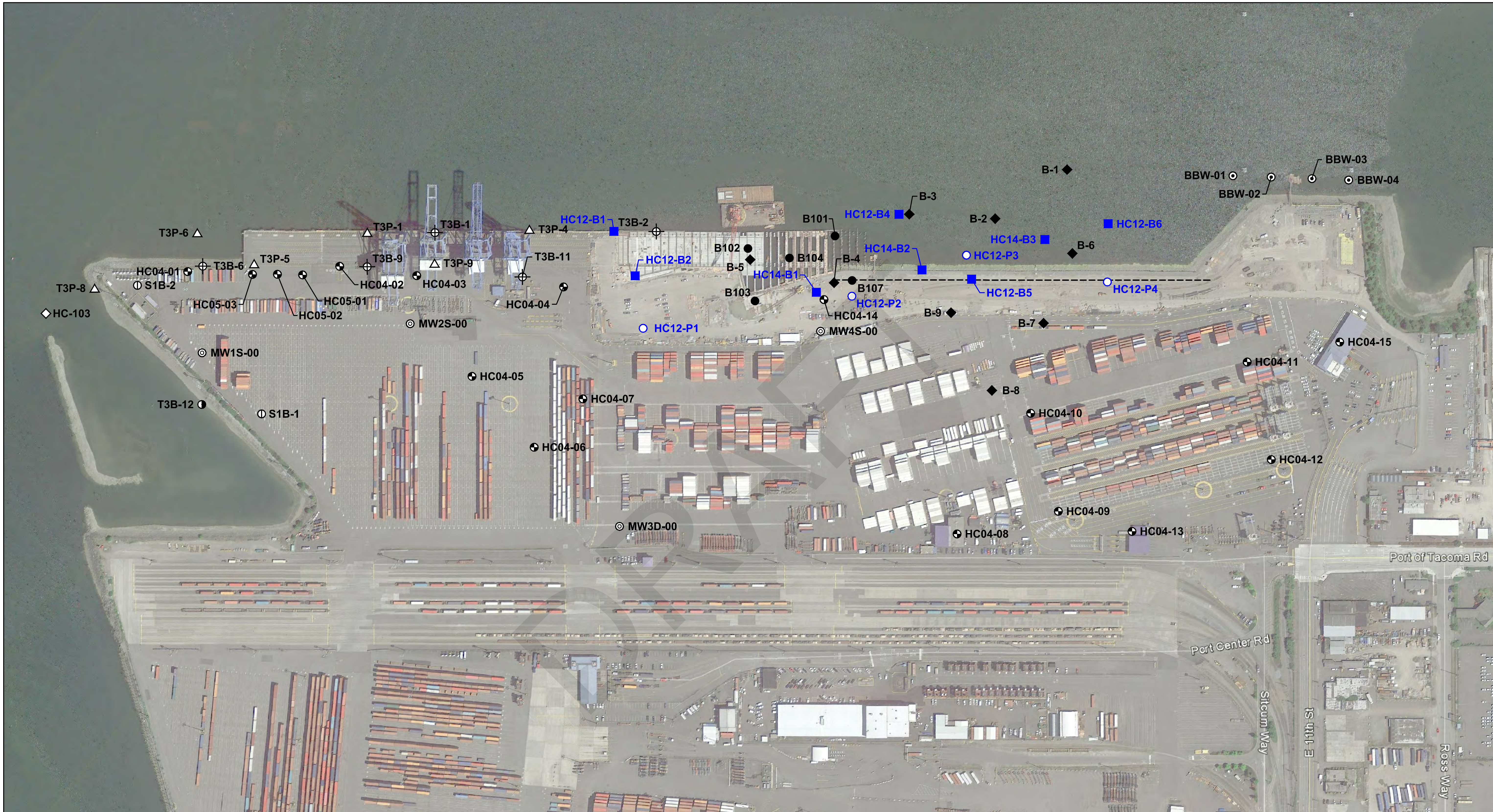
Figure

1

Document Path: L:\Notebooks\1930800_Terminal 3 and 4 Gate Facility\GIS\1930800-AA (VMap).mxd Date: 9/21/2017 User Name: ericlindquist



Legend

HC14-B1 ■	Boring (Hart Crowser 2015)	T3B-12 ◑	Boring (Hart Crowser 1987)	MW1S-00 ◎	Boring (Conestayo-Rovers 2000)
HC12-P3 ○	CPT Probe (Hart Crowser 2015)	T3B-1 ⌖	Boring (Hart Crowser 1986)		
HC05-01	Boring (Hart Crowser 2004-2005)	T3P-1 △	CPT Probe (Hart Crowser 1986)		
S1B-1 ⦶	Boring (Hart Crowser 2003)	B101 ●	Boring (Hart Crowser 1980)		
HC-103 ◇	Boring (Hart Crowser 2000)	B-1 ◆	Boring (Dames & Moore 1967)		

Source: Aerial photo from Google Earth Pro, 2017.

N

0 300 600

Scale in Feet

Terminal 3 & 4 Backlands Redevelopment - Gate Complex
Tacoma, Washington

Site and Exploration Plan

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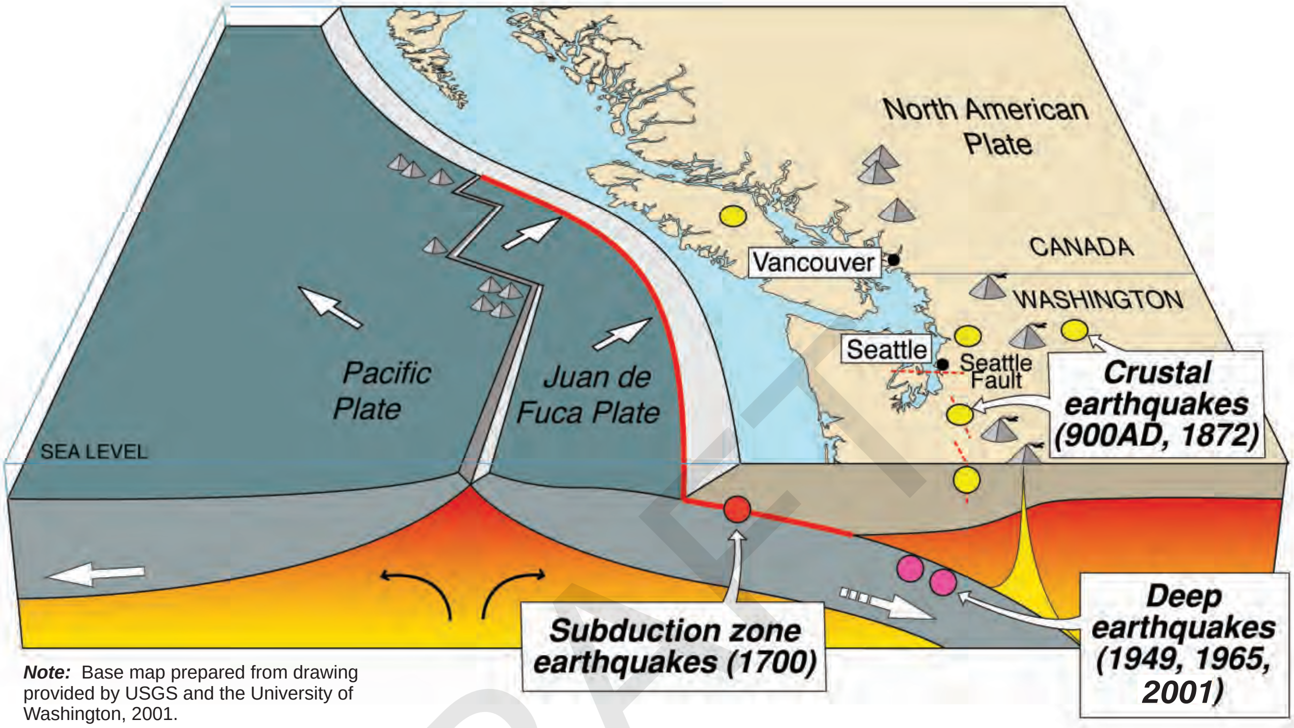
Figure **2**

EAL 09/21/17 1930800-001 (SPlan).dwg



Note: Base map prepared from drawing provided by USGS and the University of Washington, 2001.

Not to Scale

Source	***Maximum Magnitude***
Cascadia Subduction Zone - Interface	9.0
Cascadia Subduction Zone - Intraslab	7.5
Crustal Faults	7.5

Terminal 3 & 4 Backlands Redevelopment - Gate Complex
Tacoma, Washington

Cascadia Subduction Zone Earthquake Sources

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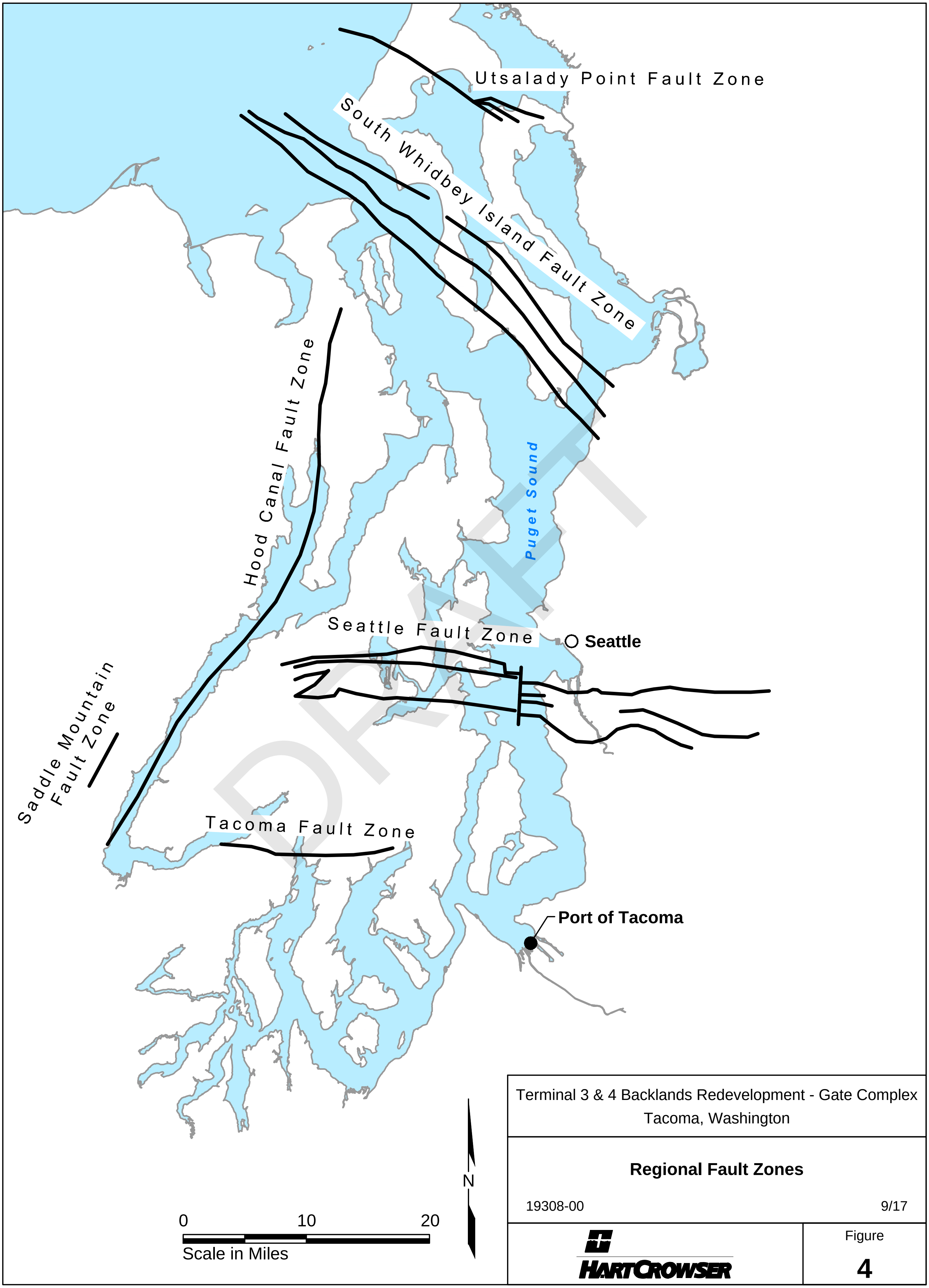
Figure **3**

EAL 09/21/17 1930800-003 (EQSources).ai



Terminal 3 & 4 Backlands Redevelopment - Gate Complex
Tacoma, Washington

Regional Fault Zones

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Figure 4

EAL 09/21/17 1930800-002 (RFZ).dwg

APPENDIX A
Historical Subsurface Data

APPENDIX A

Historical Subsurface Data

We collected historical subsurface data from geotechnical reports completed by Hart Crowser and others for past projects at Terminal 3 and 4. These data are compiled in this appendix. The approximate locations of the boring logs from these data are shown on Figure 2 of the main report, actual locations may differ from those shown.

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Geotechnical Engineering Design Study
Terminals 3 and 4 Redevelopment
Port of Tacoma, Washington

Anchorage

Denver

Prepared for
BERGER/ABAM Engineers

Edmonds

April 27, 2005
17100-00

DRAFT

Prepared by
Hart Crowser, Inc.

Long Beach

GARRY E. HORVITZ
STATE OF WASHINGTON
19478
REGISTERED
PROFESSIONAL ENGINEER
4/28/05
EXPIRES 10/03/05

Philadelphia

Douglas D. Lindquist, P.E.
Sr. Project Geotechnical Engineer

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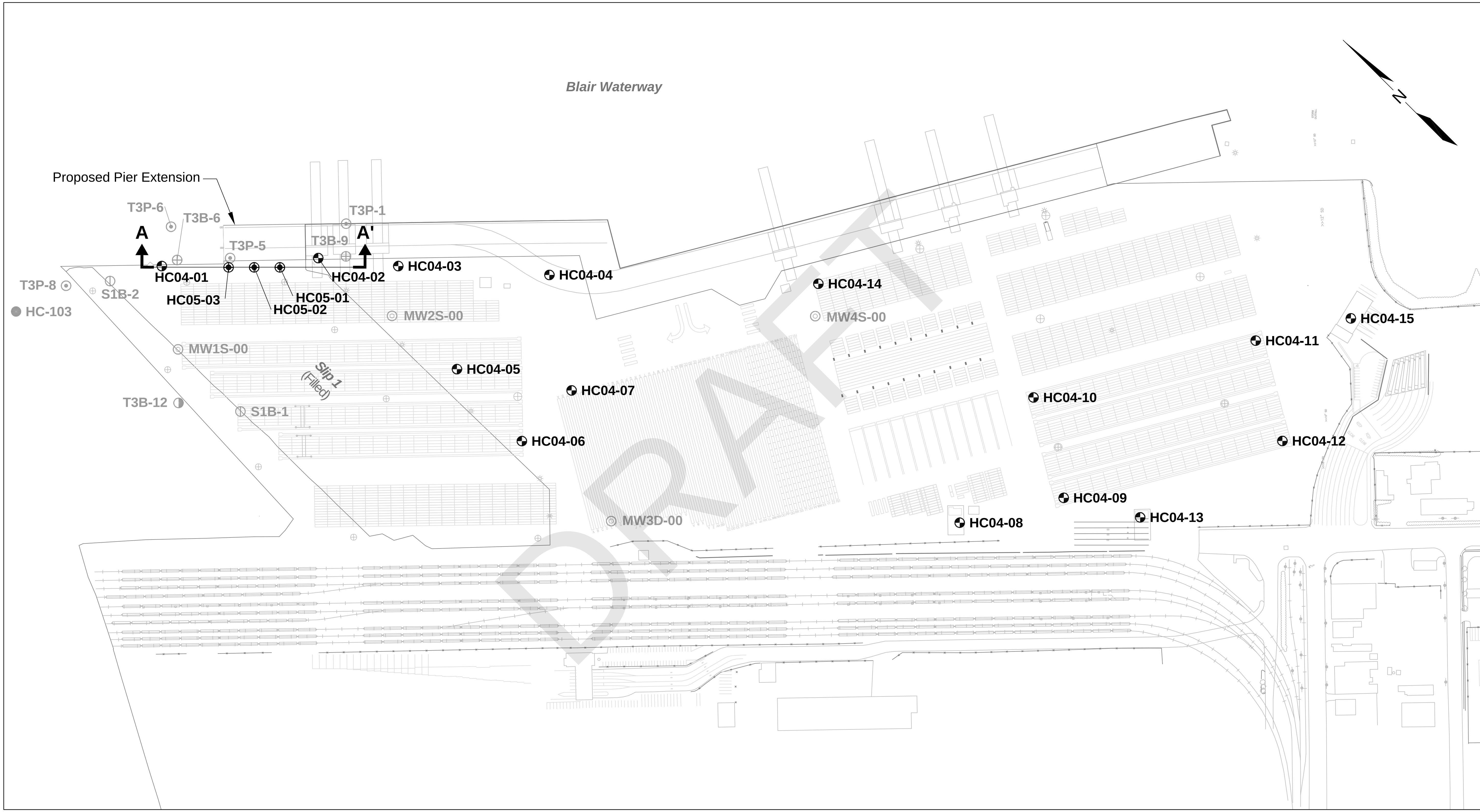
Site and Exploration Plan



HEL 4/21/05 1710000-003.DWG

Exploration Location and Number

HC05-03 Boring (Hart Crowser, 2005)
HC04-02 Boring (Hart Crowser, 2004)
S1B-2 Boring (Hart Crowser, 2003)
HC-103 Boring (Hart Crowser, 2000)

T3B-12 Boring (Hart Crowser, 1987)
T3B-6 Boring (Hart Crowser, 1986)
T3P-6 Probe (Hart Crowser, 1986)
MW1S-00 Boring (Conestayo-Rovers, 2000)

A A'
Cross Section Location and Designation

0 300 600
Scale in Feet

HARTCROWSER
17100-00 *4/05*
Figure 2

APPENDIX A
FIELD EXPLORATIONS METHODS AND ANALYSIS

APPENDIX A
FIELD EXPLORATIONS METHODS AND ANALYSIS

This appendix documents the processes Hart Crowser used in determining the nature of the soils underlying the project site addressed by this report. The discussion includes information on the following subjects:

- Explorations and Their Location;
- The Use of Auger Borings;
- The Use of Mud Rotary Borings;
- Standard Penetration Test (SPT) Procedures;
- Use of Shelby Tubes; and
- The Use of Cone Penetrometer Probes.

Explorations and Their Location

Subsurface explorations for this project include fourteen hollow-stem auger borings and four mud rotary boring. Existing subsurface explorations completed by Hart Crowser in the project area include six hollow-stem auger borings and four cone penetrometer probes. The exploration logs within this appendix show our interpretation of the drilling, sampling, and testing data. They indicate the depth where the soils change. Note that the change may be gradual. In the field, we classified the samples taken from the explorations according to the methods presented on Figure A-1 - Key to Exploration Logs. This figure also provides a legend explaining the symbols and abbreviations used in the logs.

Location of Explorations. Figure 2 shows the location of explorations, located by hand taping or pacing from existing physical features. The ground surface elevations at these locations were estimated from known elevations at adjacent locations. Previous explorations were located in the field by differential Global Positioning System (DGPS) or by hand pacing or taping from existing physical structures. Hydrographic survey techniques were used to estimate the mudline surface elevations for offshore explorations. The method used determines the accuracy of the location and elevation of the explorations.

The Use of Auger Borings

With depths ranging from 11.5 to 100.0 feet below the ground surface, fourteen hollow-stem auger borings (designated HC04-01 and HC04-03 through HC04-15), were drilled from August 19 to August 27, 2004. Borings S1B-1, S1B-2, HC-104, T3B-12, T3B-6, and T3B-9 were drilled during previous studies and have depths ranging from 42.5 to 161.5 feet below the ground surface. The borings used a 3-3/8-inch inside diameter hollow-stem auger and were advanced with a truck-mounted drill rig subcontracted by Hart Crowser. The drilling was continuously observed by an engineering geologist from Hart Crowser. Detailed field logs were prepared of each boring. Using the Standard Penetration Test (SPT), we obtained samples at 2-1/2- to 5-foot-depth intervals.

The boring logs are presented on Figures A-5 and A-7 through A-30 at the end of this appendix.

The Use of Mud Rotary Borings

With a depth of 129.0 to 150.5 feet below the ground surface, four mud rotary borings, designated HC04-02, HC05-01, HC05-02, and HC05-03 were drilled on August 24, 2004, and February 18 through 24, 2005. The boring used a 4-7/8-inch-diameter drag bit and was advanced with a truck-mounted drill rig subcontracted by Hart Crowser. The drilling was continuously observed by a geotechnical engineer from Hart Crowser. A detailed field log was prepared of the boring. Using the SPT, we obtained samples at 2-1/2- to 5-foot-depth intervals.

The boring logs are presented on Figures A-2 through A-4 and A-6 at the end of this appendix.

Standard Penetration Test (SPT) Procedures

This test is an approximate measure of soil density and consistency. To be useful, the results must be used with engineering judgment in conjunction with other tests. The SPT (as described in ASTM D 1586) was used to obtain disturbed samples. This test employs a standard 2-inch outside diameter split-spoon sampler. Using a 140-pound hammer, free-falling 30 inches, the sampler is driven into the soil for 18 inches. The number of blows required to drive the sampler the last 12 inches only is the Standard Penetration Resistance. This resistance, or blow count, measures the relative density of granular soils and the consistency of cohesive soils. The blow counts are plotted on the boring logs at their respective sample depths.

Soil samples are recovered from the split-barrel sampler, field classified, and placed into water-tight jars. They are then taken to Hart Crowser's laboratory for further testing.

In the Event of Hard Driving

Occasionally very dense materials preclude driving the total 18-inch sample. When this happens, the penetration resistance is entered on logs as follows:

Penetration less than 6 inches. The log indicates the total number of blows over the number of inches of penetration.

Penetration greater than 6 inches. The blow count noted on the log is the sum of the total number of blows completed after the first 6 inches of penetration. This sum is expressed over the number of inches driven that exceed the first 6 inches. The number of blows needed to drive the first 6 inches are not reported. For example, a blow count series of 12 blows for 6 inches, 30 blows for 6 inches, and 50 (the maximum number of blows counted within a 6-inch increment for SPT) for 3 inches would be recorded as 80/9.

The Use of Cone Penetrometer Probes

As part of work previously completed for Terminal 3, Hart Crowser used a cone penetrometer to probe the subgrade soils. Completed by Subterranian, Inc., of Gig Harbor, the probes (designated T3P-1, T3P-5, T3P-6 and T3P-8) were advanced to depths ranging from 75 to 105 feet below the ground surface. They used a Begemann type cone (see Figure A-23). The system was mounted on a truck or barge that provided the necessary reaction for the applied loads.

The cone and its sleeve provide information by which we can interpret the density and consistency of the soils. A direct correlation exists between the point of resistance of the cone and the bearing capacity in the soil. Another direct correlation exists between the friction registered on the sleeve and the friction characteristics of the soil. We use the penetrometer results in conjunction with the soil classification chart developed by Schmertmann (1978) (see Figure A-23).

Friction Values and Soil Type. Generally, a friction ratio less than 2 indicates sand; a ratio between 2 and 4 indicates a silt-sand mixture, clayey sand, or silt; and ratios greater than 4 indicate a clayey silt or clay.

Logs of cone penetrometer probes are presented on Figures A-24 through A-27.

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Key to Exploration Logs

Sample Description

Classification of soils in this report is based on visual field and laboratory observations which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field nor laboratory testing unless presented herein. Visual-manual classification methods of ASTM D 2488 were used as an identification guide.

Soil descriptions consist of the following:
Density/consistency, moisture, color, minor constituents, MAJOR CONSTITUENT, additional remarks.

Density/Consistency

Soil density/consistency in borings is related primarily to the Standard Penetration Resistance. Soil density/consistency in test pits is estimated based on visual observation and is presented parenthetically on the test pit logs.

SAND or GRAVEL Density	Standard Penetration Resistance (N) in Blows/Foot	SILT or CLAY Consistency	Standard Penetration Resistance(N) in Blows/Foot	Approximate Shear Strength in TSF
Very loose	0 - 4	Very soft	0 - 2	<0.125
Loose	4 - 10	Soft	2 - 4	0.125 - 0.25
Medium dense	10 - 30	Medium stiff	4 - 8	0.25 - 0.5
Dense	30 - 50	Stiff	8 - 15	0.5 - 1.0
Very dense	>50	Very stiff	15 - 30	1.0 - 2.0
		Hard	>30	>2.0

Moisture

Dry	Little perceptible moisture
Damp	Some perceptible moisture, probably below optimum
Moist	Probably near optimum moisture content
Wet	Much perceptible moisture, probably above optimum

Minor Constituents

Minor Constituents	Estimated Percentage
Not identified in description	0 - 5
Slightly (clayey, silty, etc.)	5 - 12
Clayey, silty, sandy, gravelly	12 - 30
Very (clayey, silty, etc.)	30 - 50

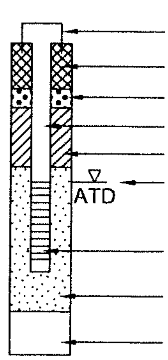
Legends

Sampling Test Symbols

Boring Samples
- Split Spoon
- Shelby Tube
- Cuttings
- Core Run
- * No Sample Recovery
- P Tube Pushed, Not Driven

Test Pit Samples
- Grab (Jar)
- Bag
- Shelby Tube

Groundwater Observation Wells



Monument
Surface Seal
Gravel Backfill
Riser Pipe
Bentonite
Groundwater Level on Date or at Time of Drilling (ATD)
Well Screen
Sand Pack
Native Material
Groundwater Seepage (Test Pits)

Test Symbols

GS	Grain Size Classification
CN	Consolidation
UU	Unconsolidated Undrained Triaxial
CU	Consolidated Undrained Triaxial
CD	Consolidated Drained Triaxial
QU	Unconfined Compression
DS	Direct Shear
K	Permeability
PP	Pocket Penetrometer Approximate Compressive Strength in TSF
TV	Torvane Approximate Shear Strength in TSF
CBR	California Bearing Ratio
MD	Moisture Density Relationship
AL	Atterberg Limits Water Content in Percent Liquid Limit Natural Plastic Limit
PID	Photoionization Detector Reading
CA	Chemical Analysis
WOR	Weight of Rod
WOH	Weight of Hammer

ABJ 3/03/05
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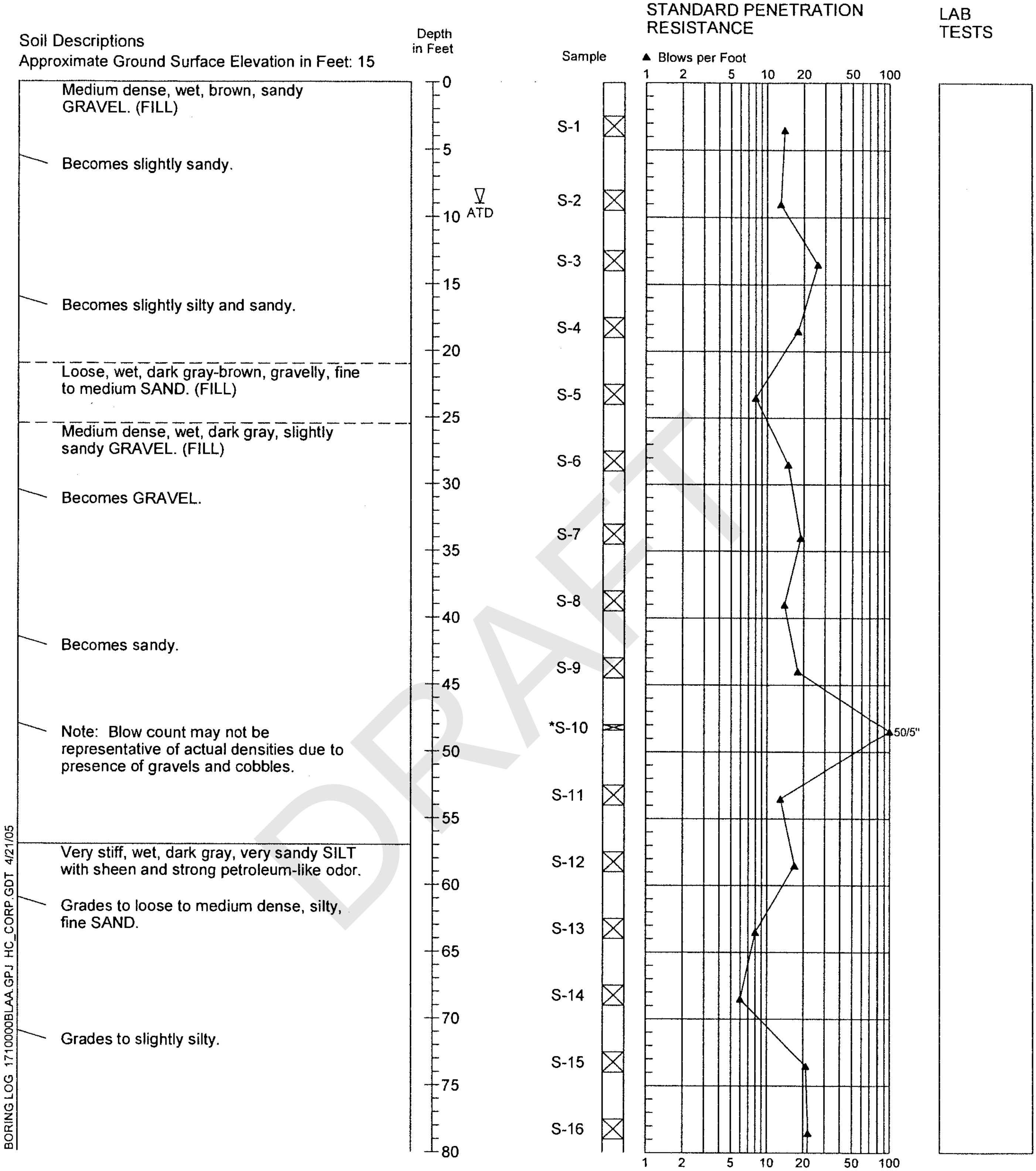
HARTCROWSER
17100-00 3/05
Figure A-1

Boring Log HC05-01

Soil Descriptions
Approximate Ground Surface Elevation in Feet: 15



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

17100-00 02/05

Figure A-2 1/2

Boring Log HC05-01

Soil Descriptions
Approximate Ground Surface Elevation in Feet: 15

Very stiff, wet, dark gray, very sandy SILT with sheen and strong petroleum-like odor.

Loose to medium dense, wet, dark gray, silty, fine SAND.

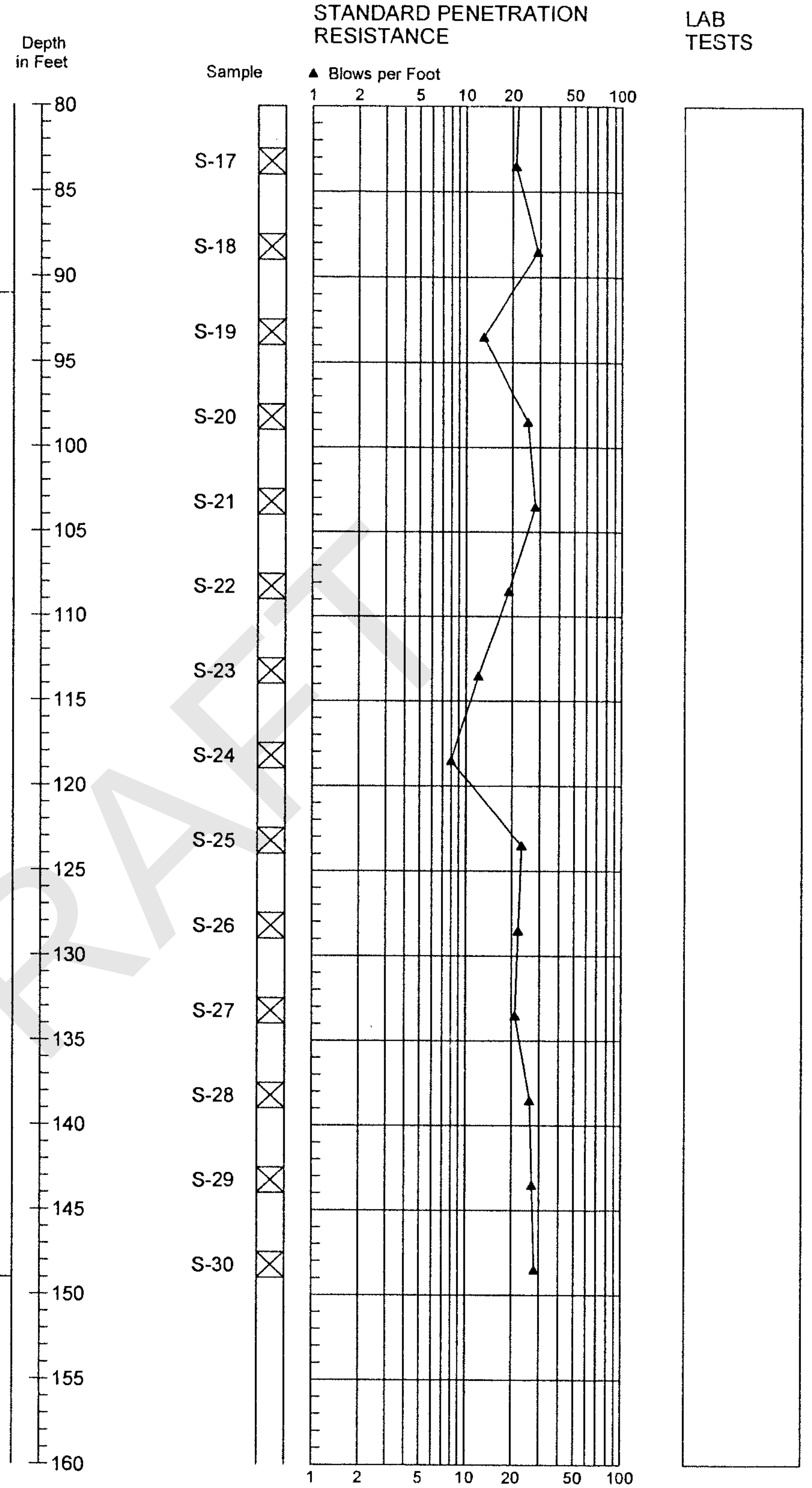
Grades to slightly silty.

Grades to silty.

Grades to very silty.

Becomes slightly silty.

Bottom of Boring at 149.0 Feet.
Completed 02/18/05.



BORING LOG 171000BLAA.GPJ HC_CORP.GDT 4/21/05

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

17100-00 *02/05*

Figure A-2 *2/2*

Boring Log HC05-02

Soil Descriptions
Approximate Ground Surface Elevation in Feet: 15

Depth in Feet: 0–80

Very dense, wet, gray-brown, slightly silty, very sandy GRAVEL. (FILL)

Loose to very dense, wet, brown, gravelly, medium to coarse SAND. (FILL)

ATD

Loose to very dense, wet, brown, very sandy GRAVEL. (FILL)

Becomes sandy.

Becomes slightly silty and very sandy.

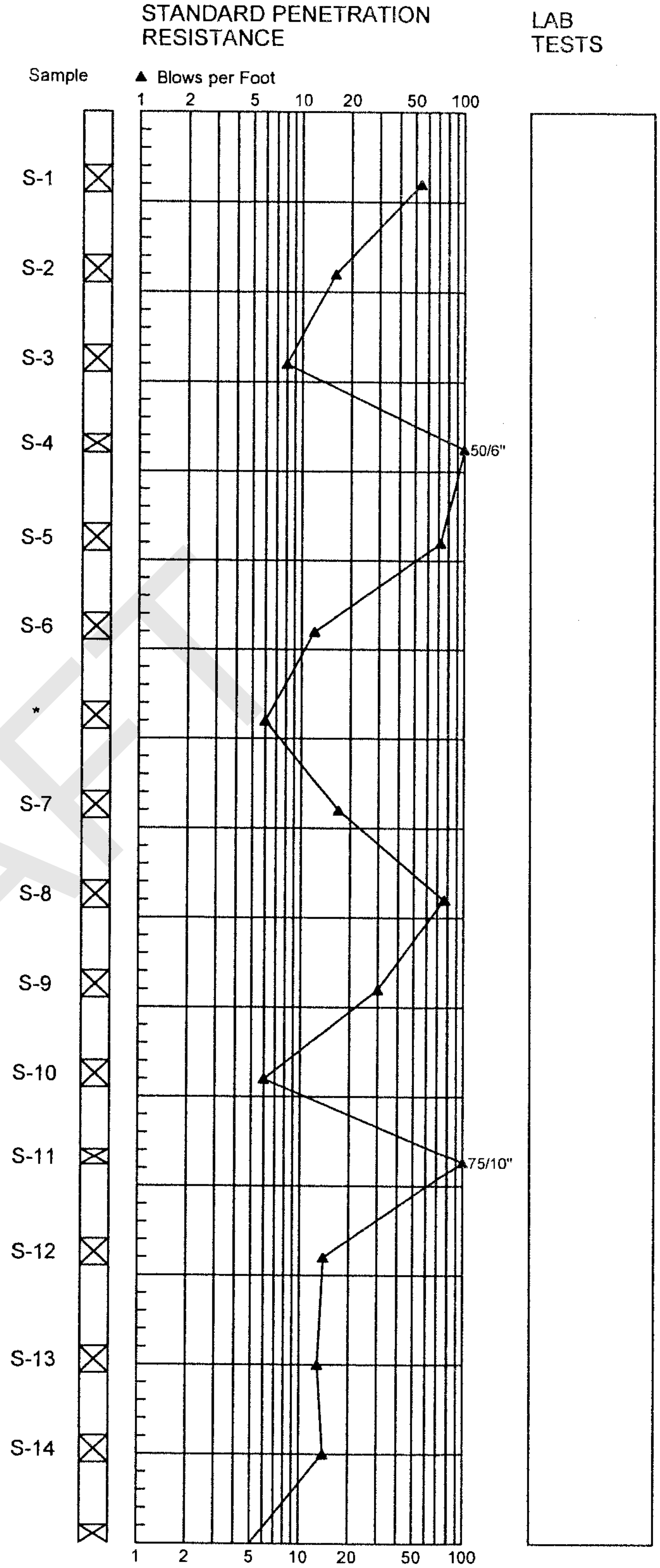
Very dense, wet, brown, fine to medium SAND with trace gravel. (FILL)
Note: Blow count may not be representative of actual densities due to presence of gravels and cobbles.

Stiff, wet, dark gray, slightly sandy SILT.

Grades to very sandy SILT to very silty SAND.

Grades to slightly silty, fine to medium SAND.

Medium stiff to stiff, wet, dark gray, slightly clayey SILT with trace sand.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

17100-00 02/05

Figure A-3 1/2

Boring Log HC05-02

Soil Descriptions
Approximate Ground Surface Elevation in Feet: 15

Medium stiff to stiff, wet, dark gray, slightly clayey SILT with trace sand.
Grades to slightly sandy SILT.

Medium dense, wet, dark gray, slightly silty, fine SAND with trace shell fragments.

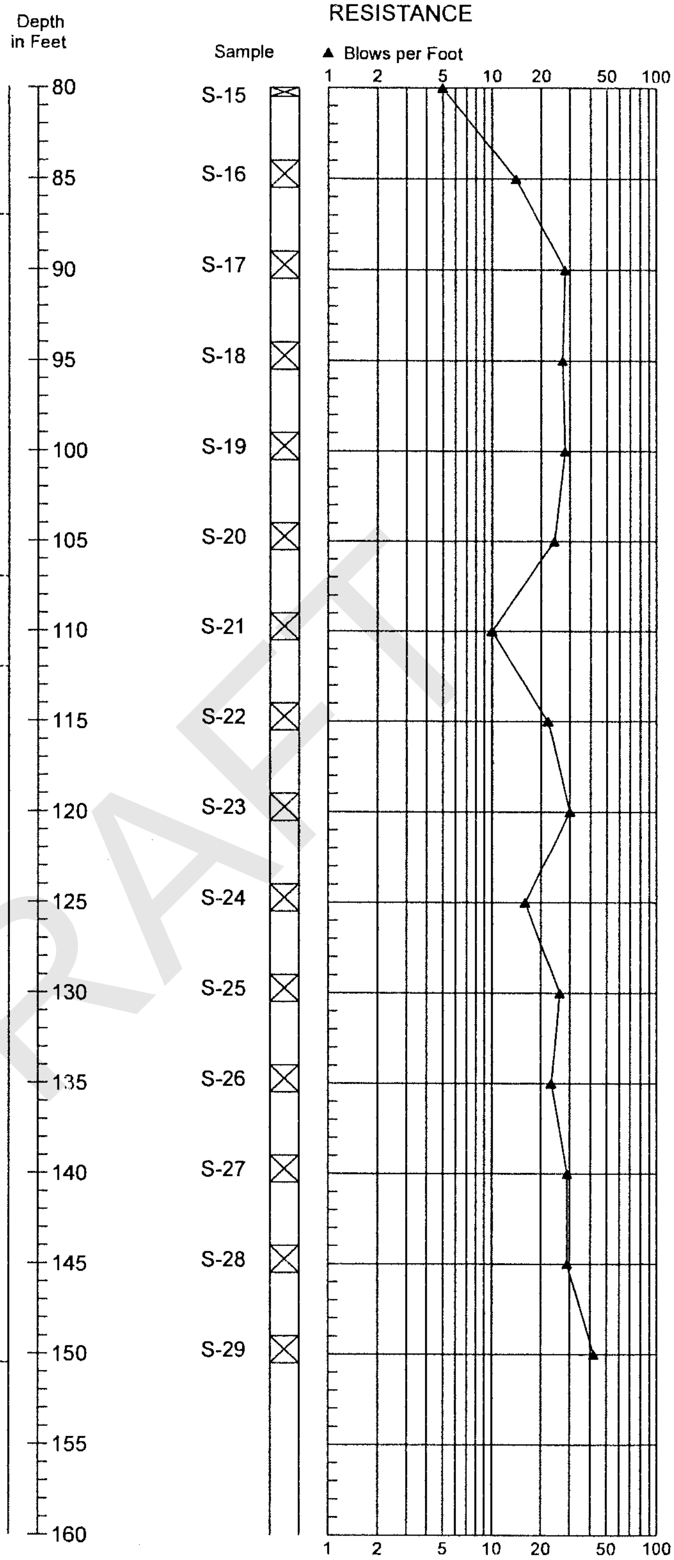
Grades to very silty.

Stiff, wet, dark gray, slightly clayey, sandy SILT.

Medium dense to dense, wet, dark gray, silty, fine SAND.
1-foot seam of slightly clayey, sandy SILT.

Grades to slightly silty.

Trace shell fragments.
Bottom of Boring at 150.5 Feet.
Completed 02/22/05.



LAB TESTS

BORING LOG 17100008LAA.GPJ HC_CORP.GDT 4/21/05

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

17100-00 *02/05*

Figure A-3 *2/2*

Boring Log HC05-03

Soil Descriptions
Approximate Ground Surface Elevation in Feet: 15

Depth in Feet

Loose to very dense, damp, light gray, sandy GRAVEL. (FILL)

Becomes wet, gray-brown, gravelly SAND.

∇ ATD

Becomes very gravelly SAND to very sandy GRAVEL.

Becomes sandy GRAVEL.

Medium dense to dense, wet, brown, slightly gravelly SAND. (FILL)

Becomes slightly sandy GRAVEL.

Becomes slightly gravelly SAND.

Medium dense, wet, dark gray, silty, fine SAND with trace shell fragments.

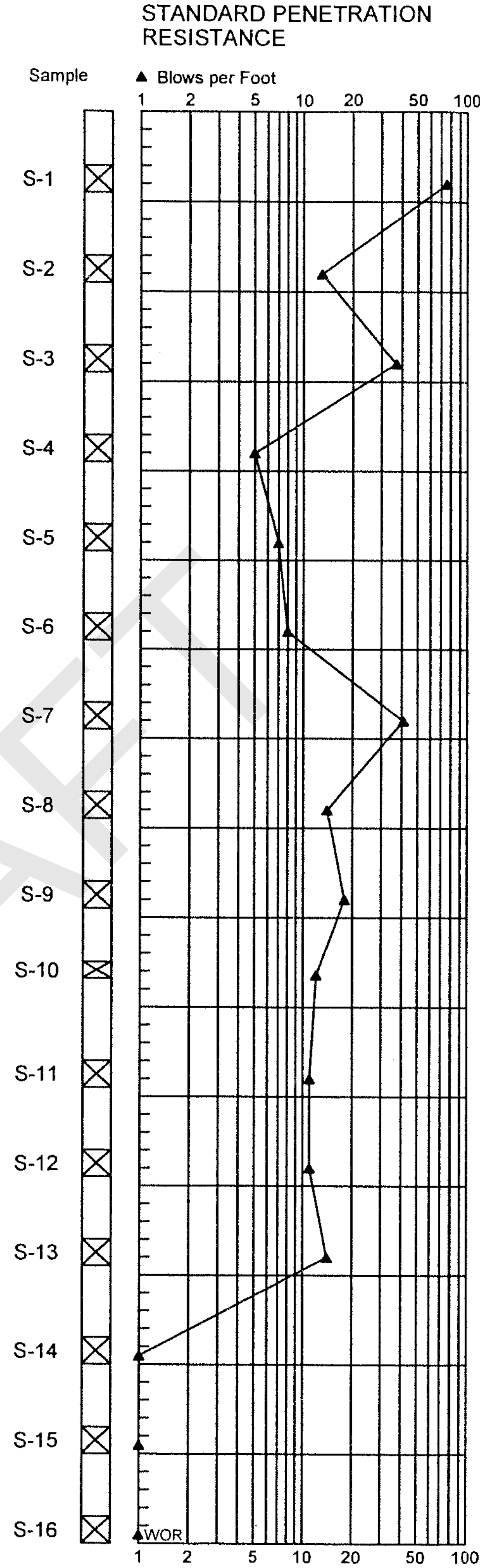
5-inch sandy SILT seam.

Very soft, wet, dark gray SILT with trace sand.

Becomes slightly clayey.

Trace shell fragments.

Becomes slightly sandy.



LAB TESTS

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

17100-00 *02/05*

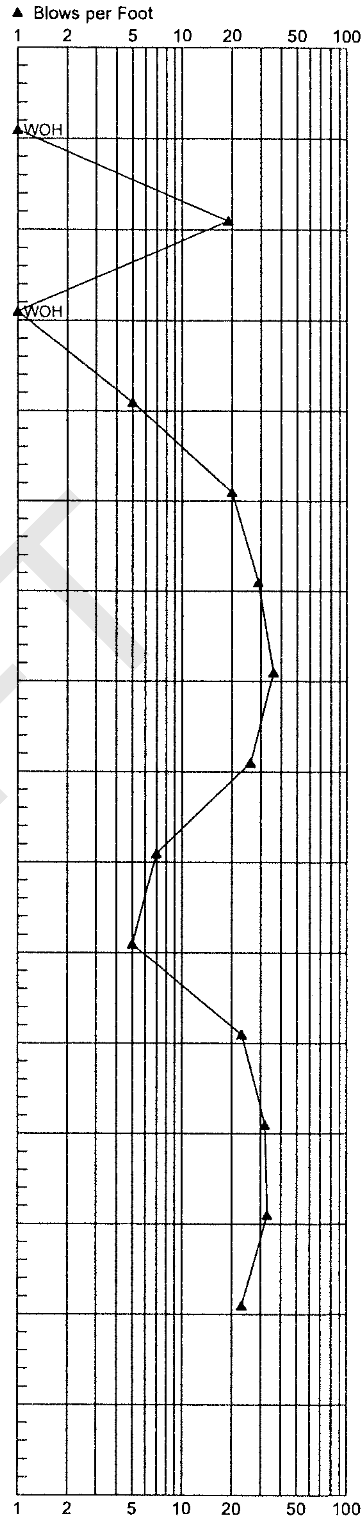
Figure A-4 *1/2*

Boring Log HC05-03

Soil Descriptions
Approximate Ground Surface Elevation in Feet: 15

Depth in Feet	Soil Descriptions	Sample
80	Very soft, wet, dark gray SILT with trace sand.	
85		S-17
87	5-foot zone of very silty SAND to very sandy SILT.	
90		S-18
95		S-19
97	Becomes slightly sandy.	
100		S-20
101.5	Medium dense to dense, wet, dark gray, silty, fine SAND.	
104	2-foot zone of sandy SILT.	
105		S-21
110		S-22
115		*S-23
120		S-24
121	Grades to very silty.	
125		S-25
126.5	Soft, wet, dark gray, slightly clayey, slightly sandy SILT.	
130	Medium dense to dense, wet, dark gray, very silty, fine SAND.	S-26
135		S-27
140		S-28
145		S-29
150	Bottom of Boring at 150.0 Feet. Completed 02/24/05.	S-30
155		
160		

STANDARD PENETRATION RESISTANCE



LAB TESTS

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

17100-00 *02/05*

Figure A-4 *2/2*

Boring Log HC04-01

Soil Descriptions
Approximate Ground Surface Elevation in Feet: 15

Medium dense, moist, brown, slightly silty, gravelly SAND with cobbles

Very loose to medium dense, moist, brown, very gravelly SAND.

Becomes wet.

Grades to gray-brown, very sandy GRAVEL.

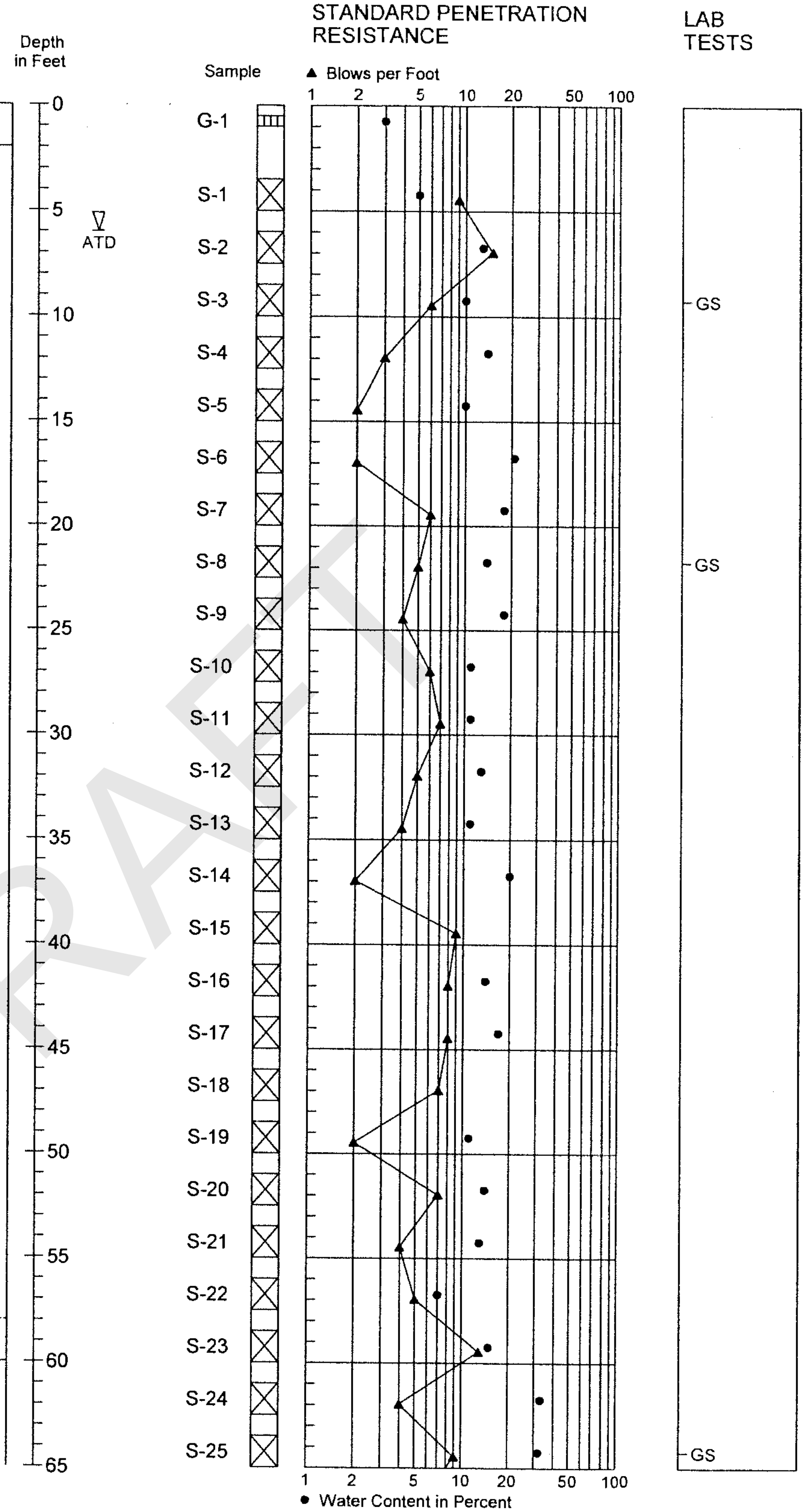
Petroleum odor

Grades to very gravelly SAND.

Grades to very sandy GRAVEL.

Medium dense, wet, brown, gravelly SAND.

Very loose to loose, wet, dark gray, very silty fine SAND.



BORING LOG 1710000BL.GPJ HC_CORP.GDT 4/21/05

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

17100-00 08/04

Figure A-5 1/2

Boring Log HC04-01

Soil Descriptions
Approximate Ground Surface Elevation in Feet: 15

Depth in Feet: 65

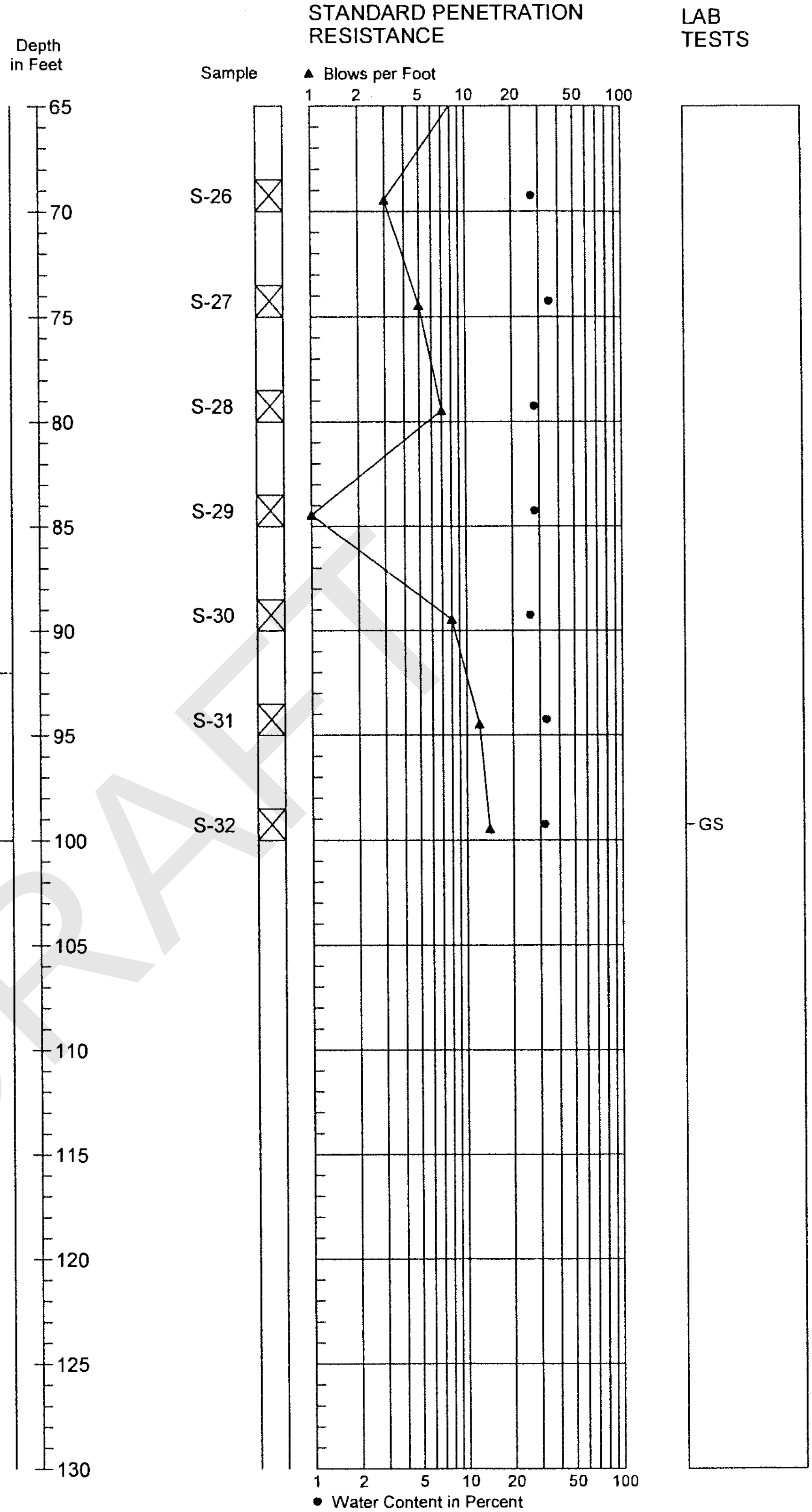
Very loose to loose, wet, dark gray, very silty fine SAND.

Grades to very silty. (approx. 73 ft)

Grades to silty (approx. 78 ft)

Medium dense, wet, dark gray, sandy SILT. (approx. 92 ft)

Bottom of Boring at 100.0 Feet.
Completed 08/19/04.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

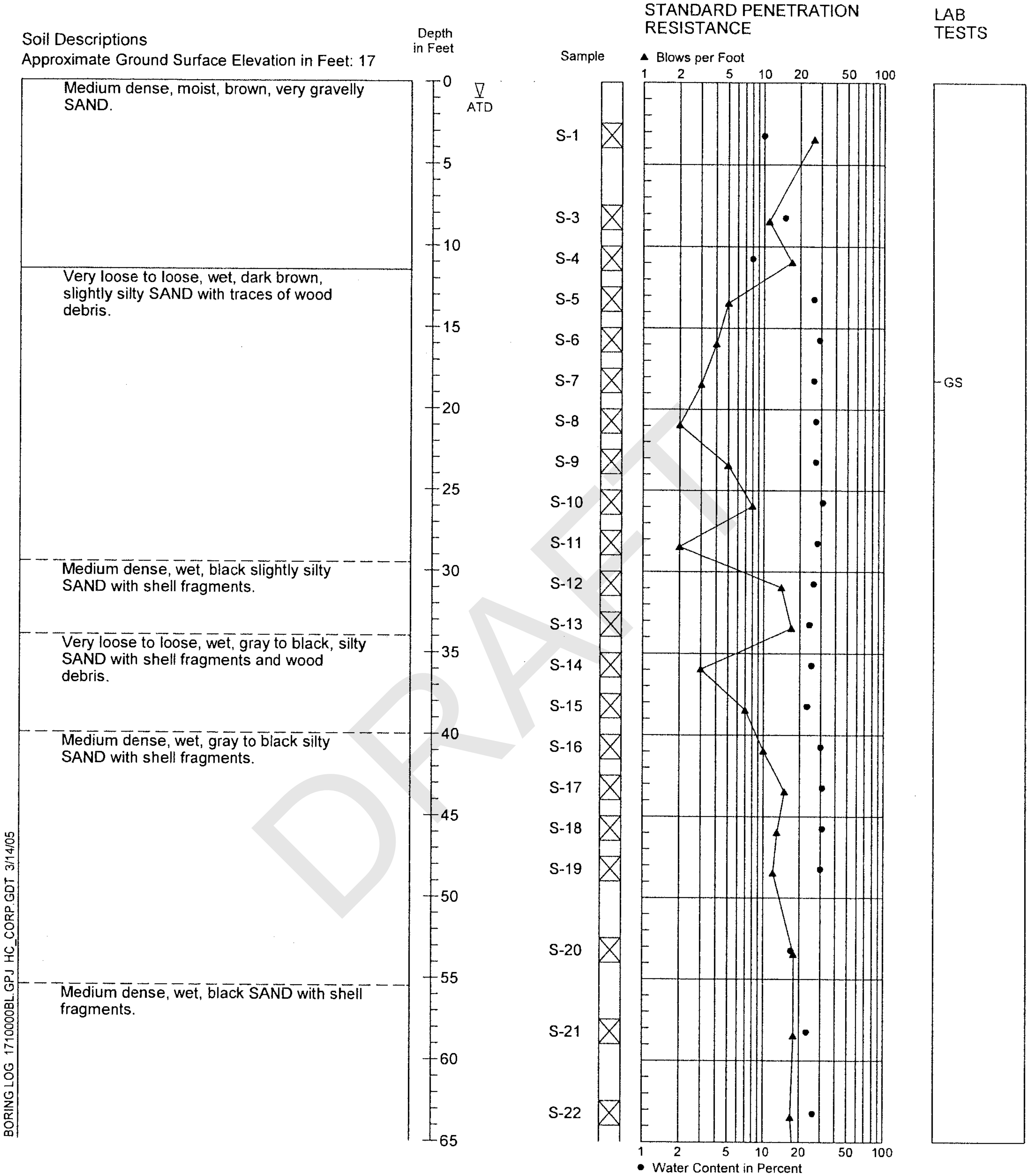
HARTCROWSER

17100-00 08/04

Figure A-5 2/2

Boring Log HC04-02

Soil Descriptions
Approximate Ground Surface Elevation in Feet: 17



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

17100-00 08/04

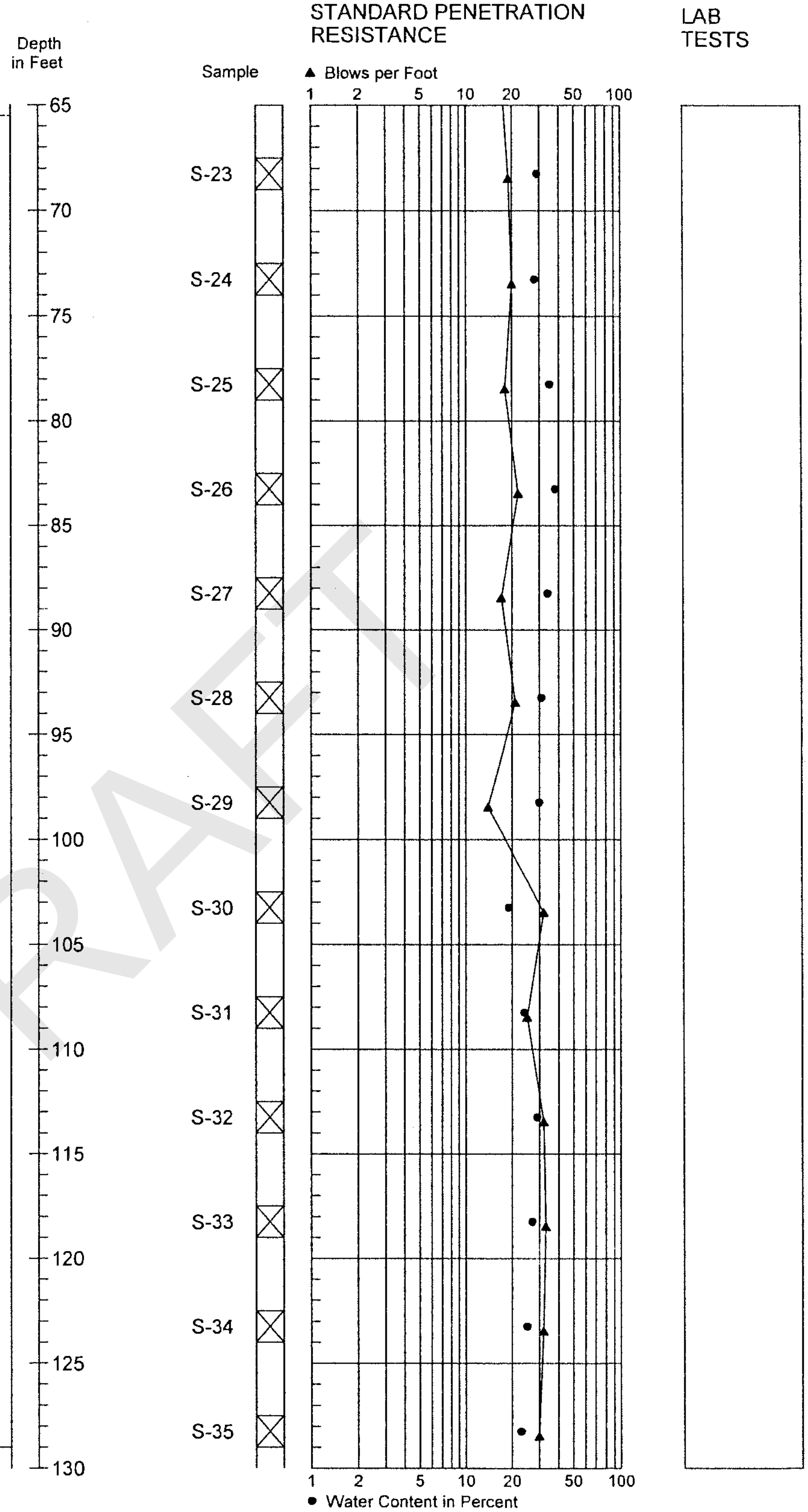
Figure A-6 1/2

Boring Log HC04-02

Soil Descriptions
Approximate Ground Surface Elevation in Feet: 17

Medium dense, wet, dark gray brown, silty to slightly silty SAND with occasional shell fragments.

Bottom of Boring at 129.0 Feet.
Completed 08/24/04.



BORING LOG 171000BL.GPJ HC_CORP.GDT 3/14/05

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

17100-00 08/04
Figure A-6 2/2

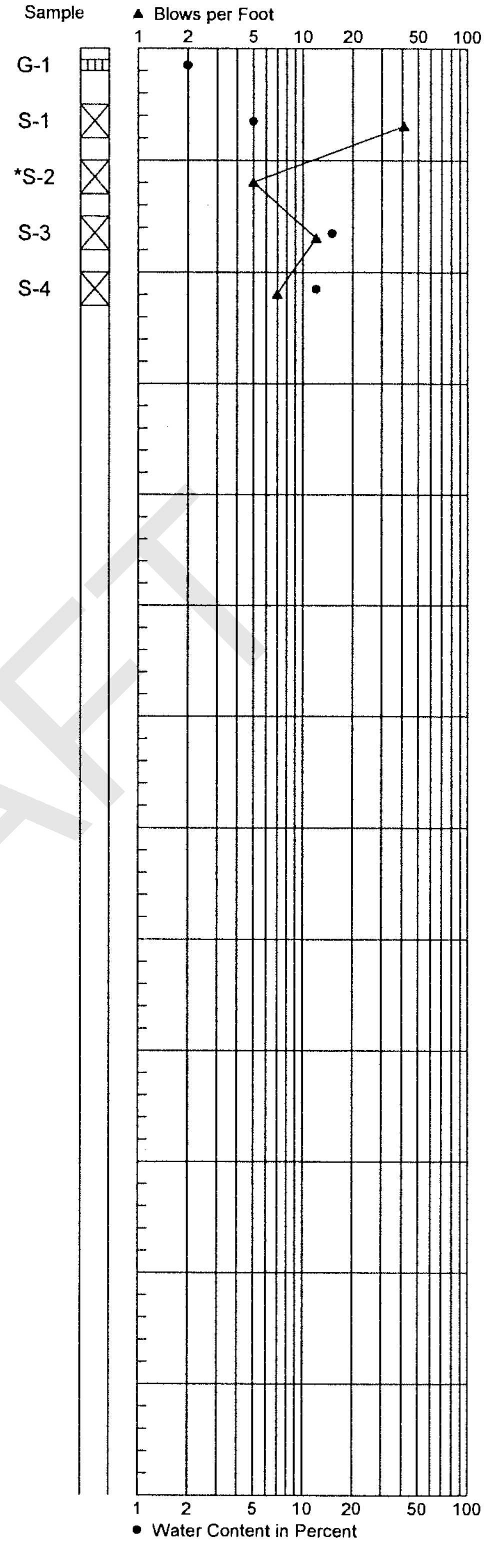
Boring Log HC04-03

Soil Descriptions
Approximate Ground Surface Elevation in Feet: 17

Soil Descriptions	Depth in Feet
Asphalt pavement.	0
Medium dense, damp, brown, slightly silty, gravelly SAND. (ROAD BASE)	
Dense, damp, brown, slightly silty, very gravelly SAND.	5
Medium dense, wet, brown, very gravelly SAND. (Groundwater: ATD)	
Loose, wet, brown, very gravelly SAND.	10
Bottom of Boring at 11.5 Feet. Completed 08/20/04.	

STANDARD PENETRATION RESISTANCE

LAB TESTS



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

17100-00 *08/04*

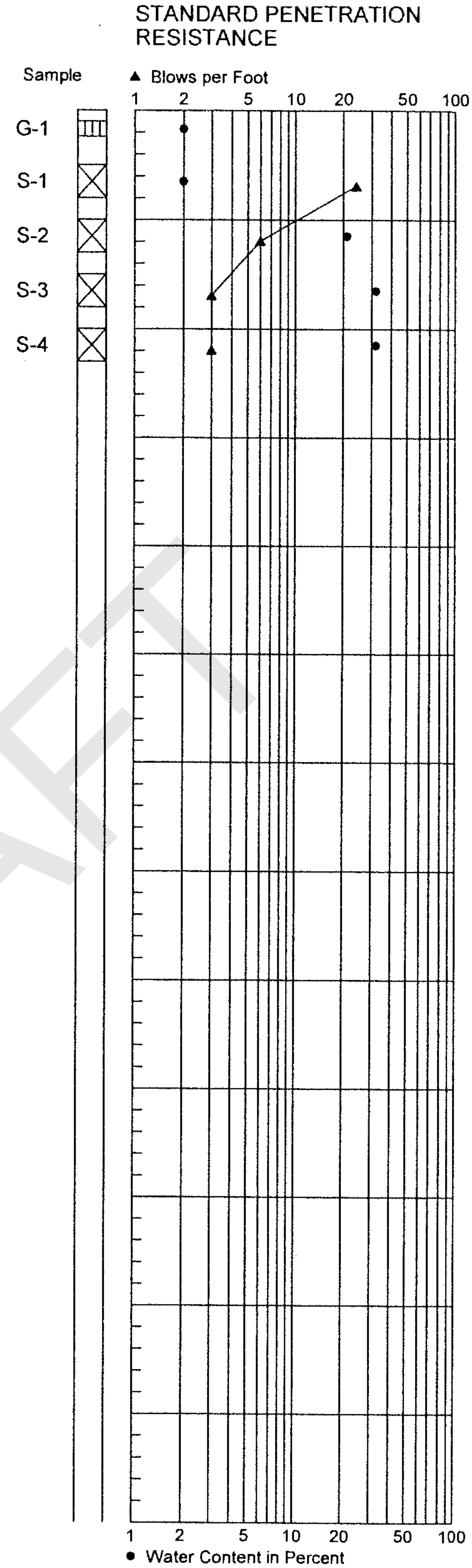
Figure A-7

Boring Log HC04-04

Soil Descriptions
Approximate Ground Surface Elevation in Feet: 17

Soil Descriptions	Depth in Feet
Asphalt pavement.	0
Medium dense, damp, brown, very gravelly SAND. (ROAD BASE)	
Loose, moist to wet, dark brown SAND.	5
Very loose, wet, dark brown SAND with trace wood debris.	ATD
Bottom of Boring at 11.5 Feet. Completed 08/20/04.	10

Depth in Feet: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65



LAB TESTS

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

17100-00 08/04

Figure A-8

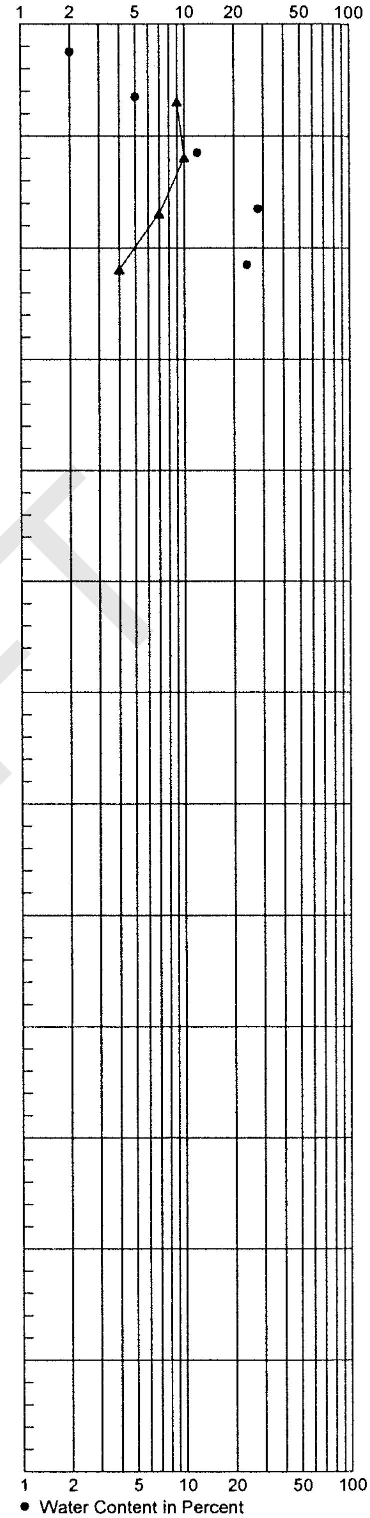
Boring Log HC04-05

Soil Descriptions
Approximate Ground Surface Elevation in Feet: 17

Soil Descriptions	Depth in Feet	Sample
Asphalt pavement.	0	G-1
Medium dense, damp, brown, slightly silty, very gravelly SAND. (ROAD BASE)		S-1
Loose to medium dense, moist, dark brown SAND.	5	S-2
Loose, wet, dark brown, slightly silty SAND.	ATD	S-3
Loose, wet, dark brown, well sorted SAND with shell fragments.	10	S-4
Bottom of Boring at 11.5 Feet. Completed 08/20/04.		

Depth in Feet: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65

STANDARD PENETRATION RESISTANCE



LAB TESTS

GS

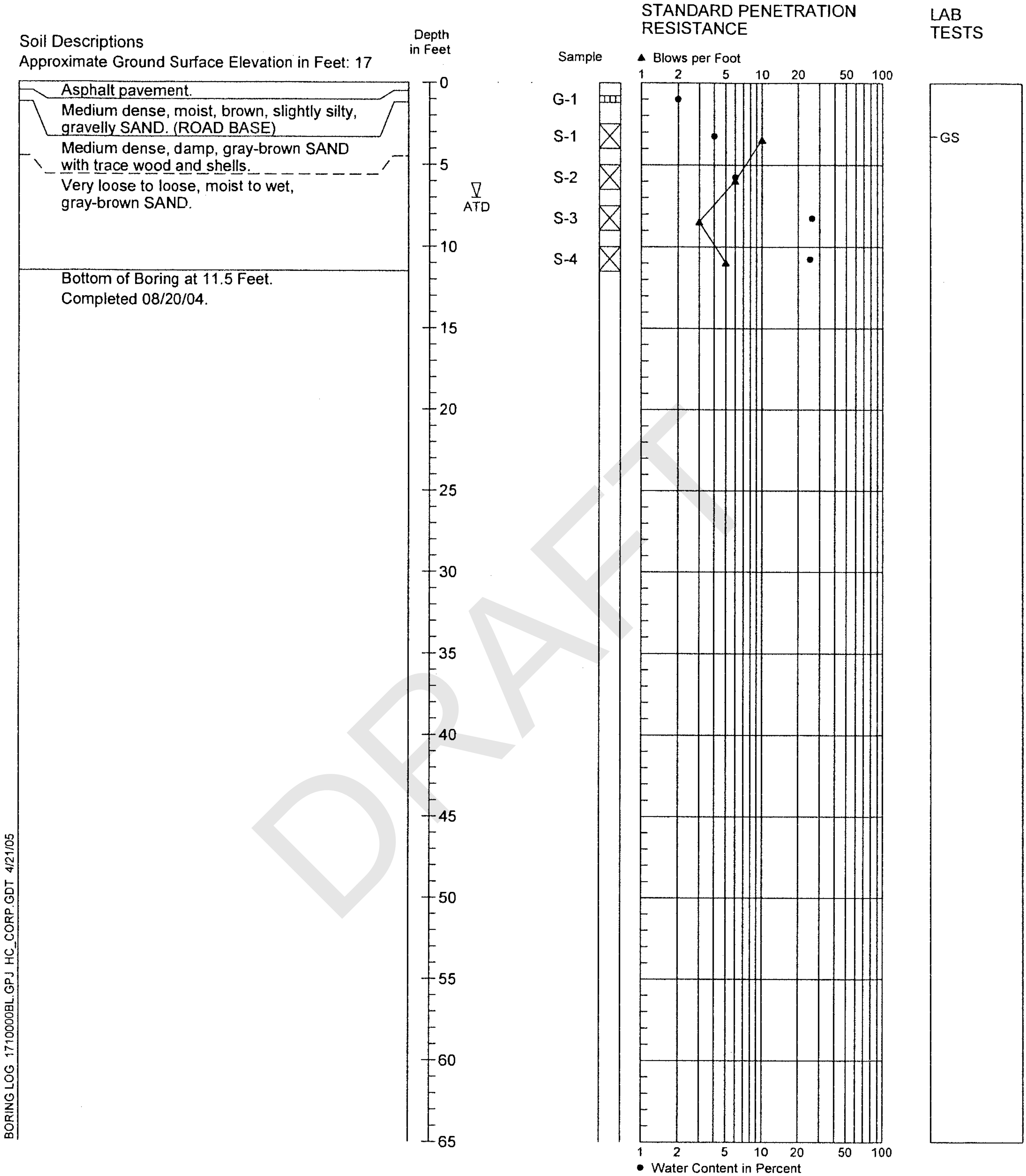
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

17100-00 *08/04*

Figure A-9

Boring Log HC04-06



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

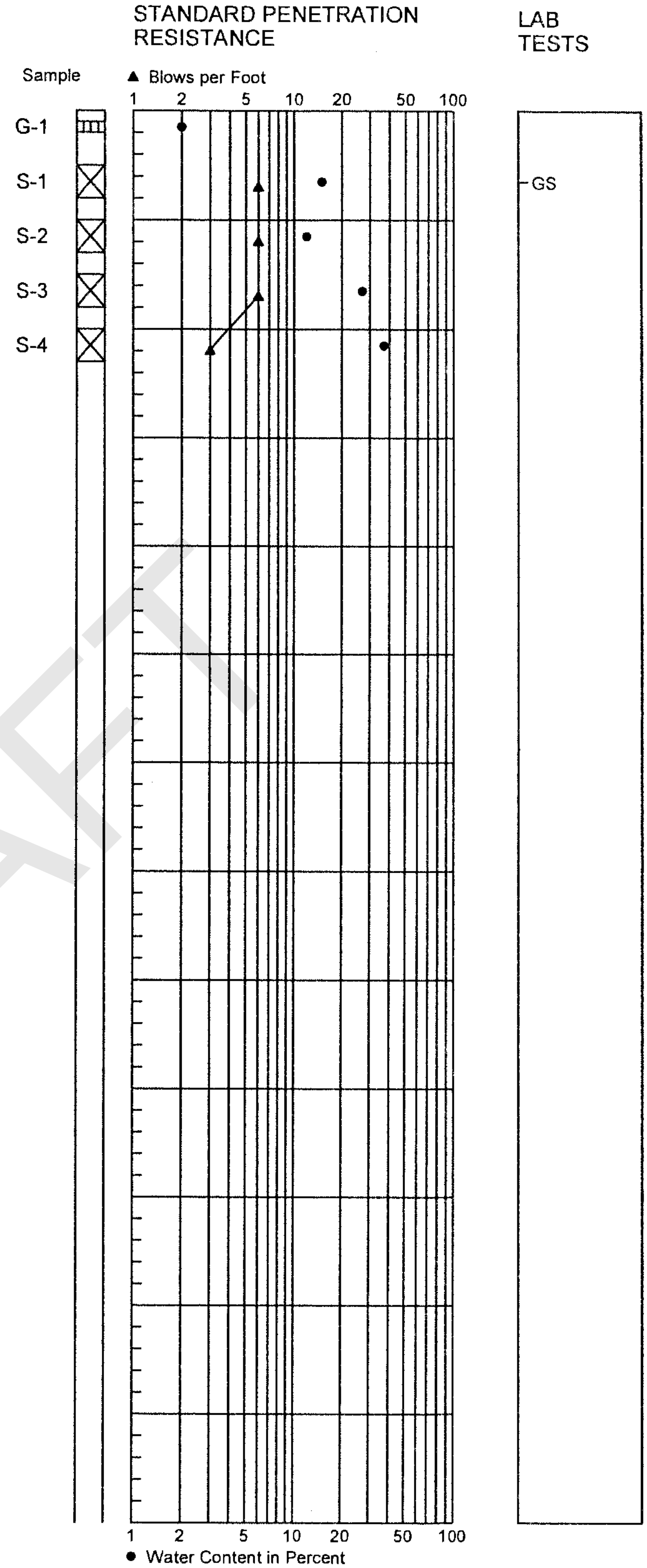
17100-00 08/04

Figure A-10

Boring Log HC04-07

Soil Descriptions
Approximate Ground Surface Elevation in Feet: 17

Soil Descriptions	Depth in Feet
Asphalt pavement.	0
Medium dense, damp, brown, silty, very gravelly SAND. (ROAD BASE)	
Loose, moist to wet, gray-brown, silty SAND.	5
▽ ATD	
Very loose, wet, black, silty SAND.	10
Bottom of Boring at 11.5 Feet. Completed 08/20/04.	



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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17100-00 *08/04*

Figure A-11

Boring Log HC04-08

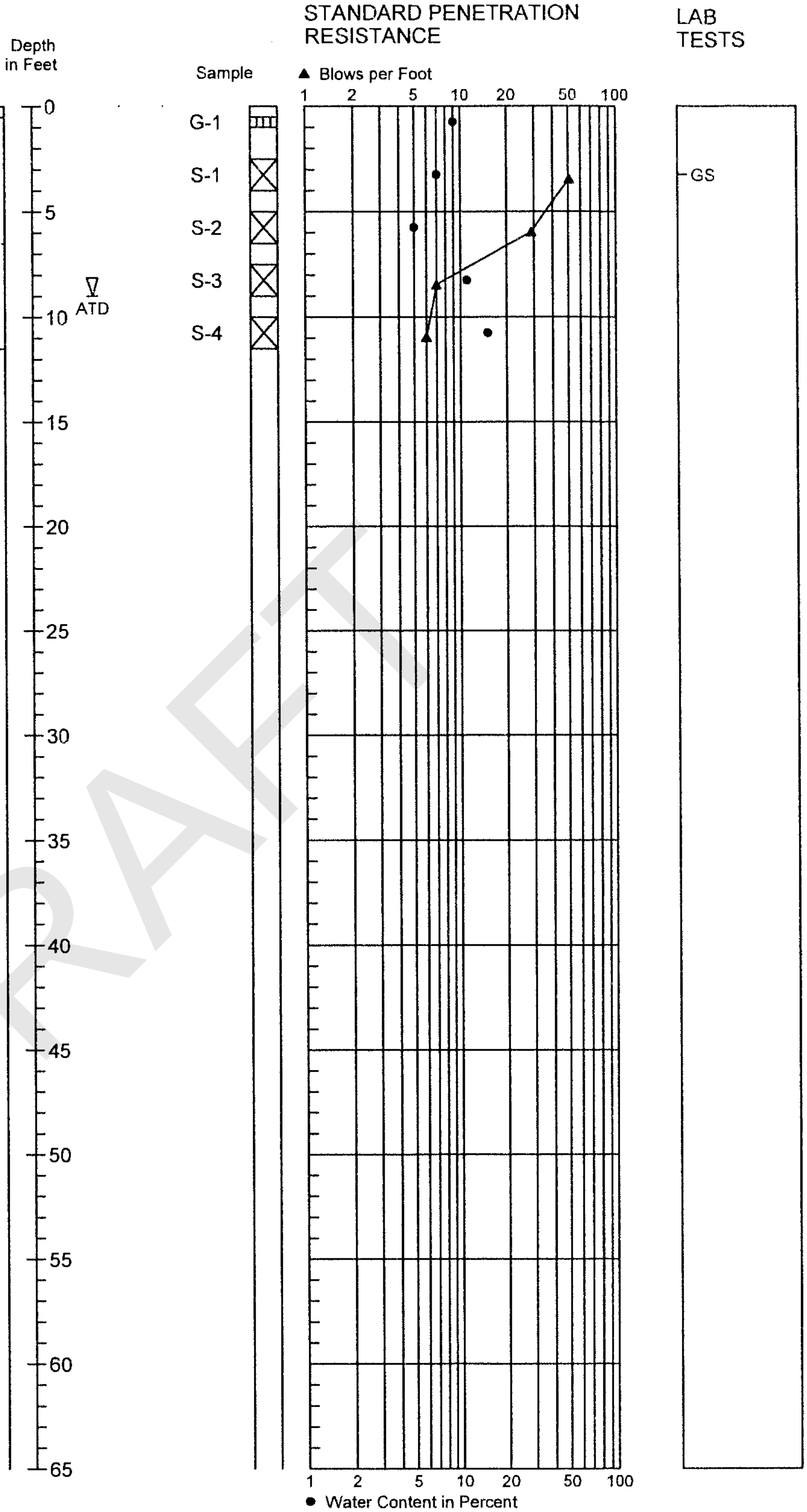
Soil Descriptions
Approximate Ground Surface Elevation in Feet: 17

Asphalt pavement.

Dense to very dense, moist, gray, silty, gravelly SAND. (ROAD BASE)

Loose, wet, light gray, slightly gravelly, silty SAND.

Bottom of Boring at 11.5 Feet.
Completed 08/23/04.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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17100-00 08/04

Figure A-12

Boring Log HC04-09

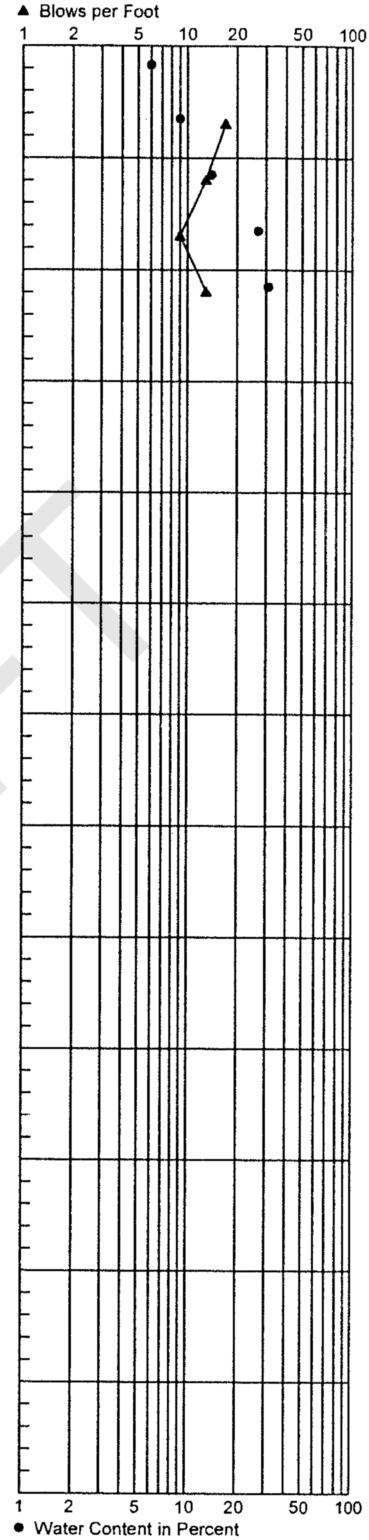
Soil Descriptions
Approximate Ground Surface Elevation in Feet: 17

Depth in Feet

Soil Descriptions	Depth in Feet	Sample
Asphalt pavement.	0	G-1
Medium dense, moist, brown, silty, gravelly SAND. (ROAD BASE)		S-1
Loose to medium dense, moist to wet, gray-brown, SAND to silty SAND.	5	S-2
	∇ ATD	S-3
	10	S-4
Bottom of Boring at 11.5 Feet. Completed 08/23/04.		

Depth scale: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65

STANDARD PENETRATION RESISTANCE



LAB TESTS

GS

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

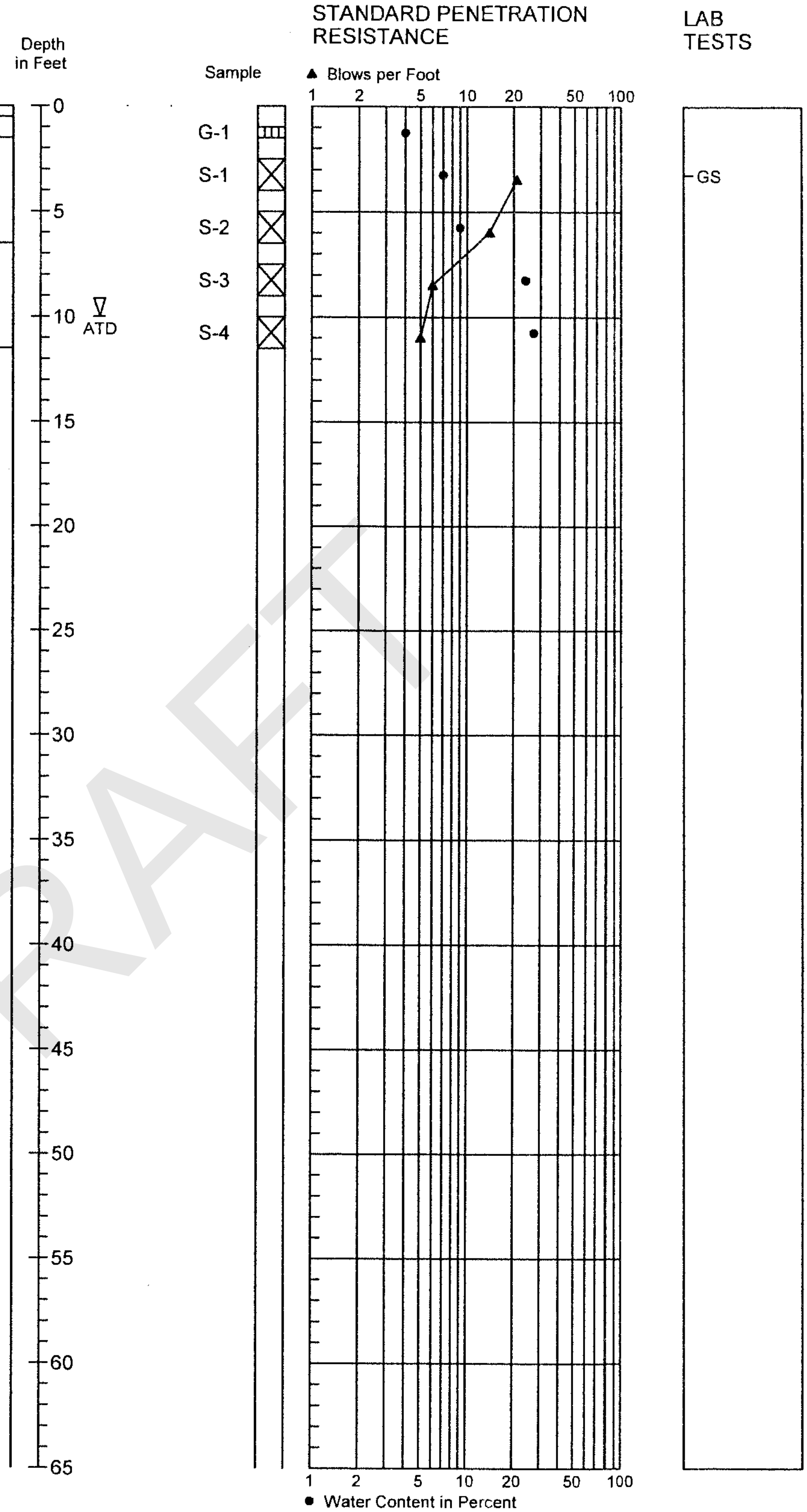
17100-00 08/04

Figure A-13

Boring Log HC04-10

Soil Descriptions
Approximate Ground Surface Elevation in Feet: 17

Soil Descriptions	Depth in Feet	Sample
Asphalt pavement.	0	G-1
Medium dense, damp, brown, slightly silty, gravelly SAND. (ROAD BASE)		
Medium dense, moist, brown SAND.		S-1
Loose, moist to wet, gray-brown SAND.	5	S-2
	10 ATD	S-3, S-4
Bottom of Boring at 11.5 Feet. Completed 08/23/04.	11.5	



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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17100-00 08/04

Figure A-14

Boring Log HC04-11

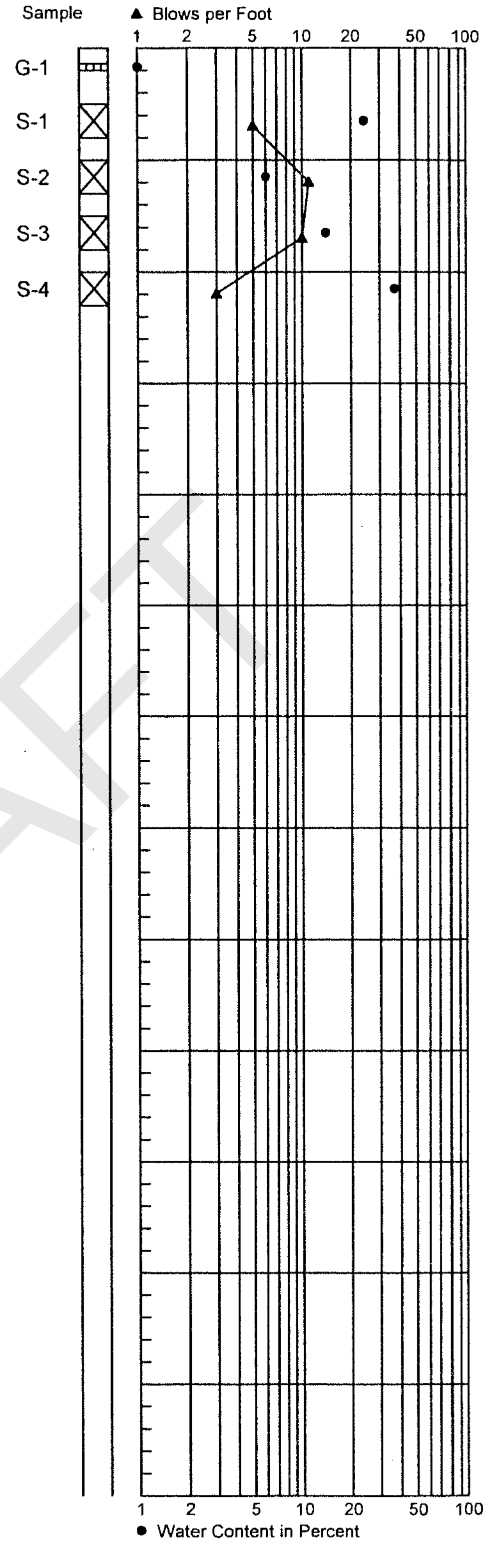
Soil Descriptions
Approximate Ground Surface Elevation in Feet: 18

Depth in Feet

Depth in Feet	Soil Descriptions
0	Asphalt pavement.
	Loose, damp to moist, dark brown with orange stain lenses, very silty SAND.
5	Very loose, wet, dark brown, silty SAND with trace shell fragments.
10 (ATD)	
	Bottom of Boring at 11.5 Feet. Completed 08/23/04.

STANDARD PENETRATION RESISTANCE

LAB TESTS



GS

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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17100-00 08/04

Figure A-15

Boring Log HC04-12

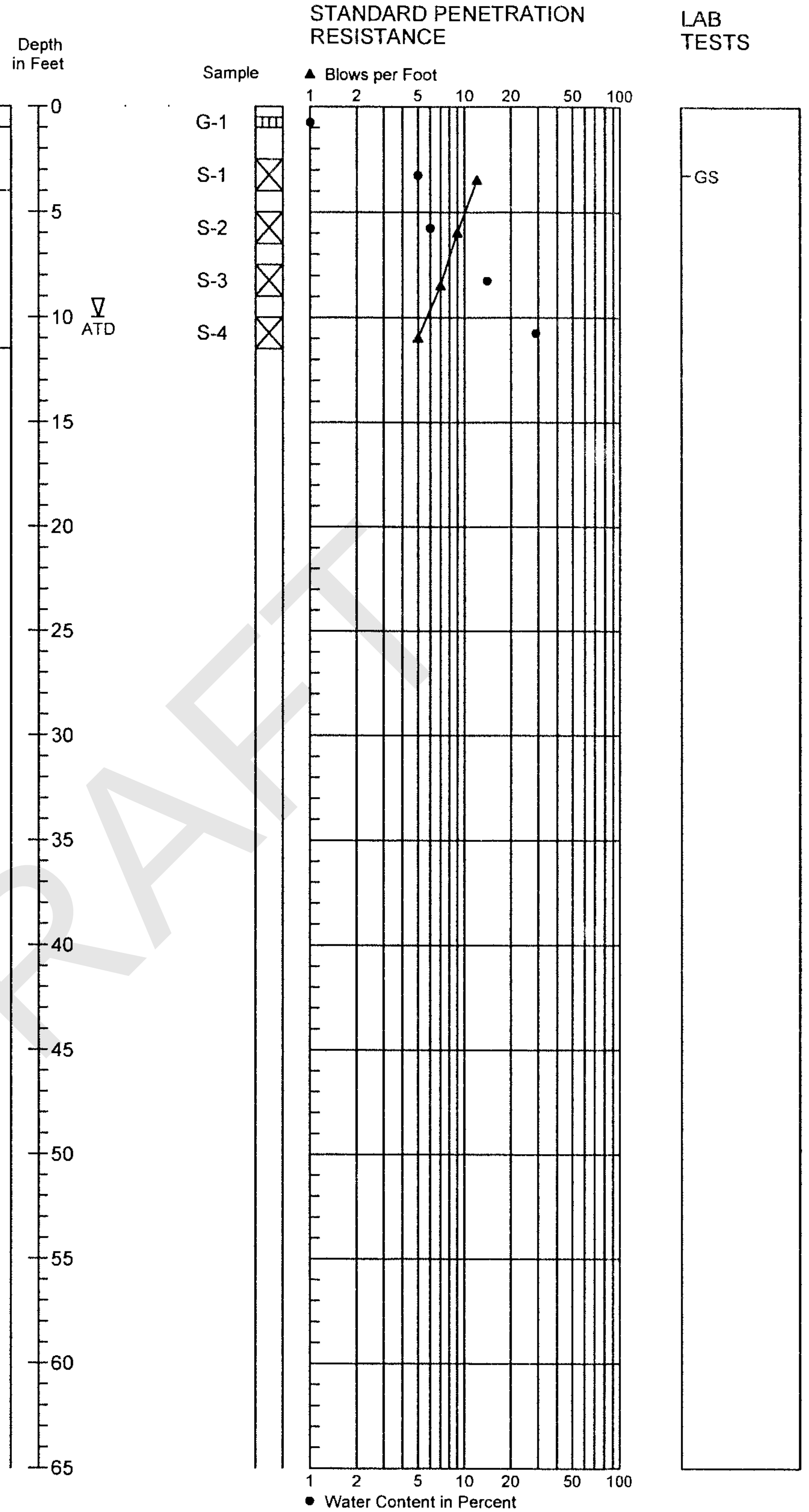
Soil Descriptions
Approximate Ground Surface Elevation in Feet: 17

Asphalt pavement.

Medium dense, damp, gray-brown, slightly silty SAND.

Loose, damp, gray-brown SAND.

Bottom of Boring at 11.5 Feet.
Completed 08/23/04.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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17100-00 08/04

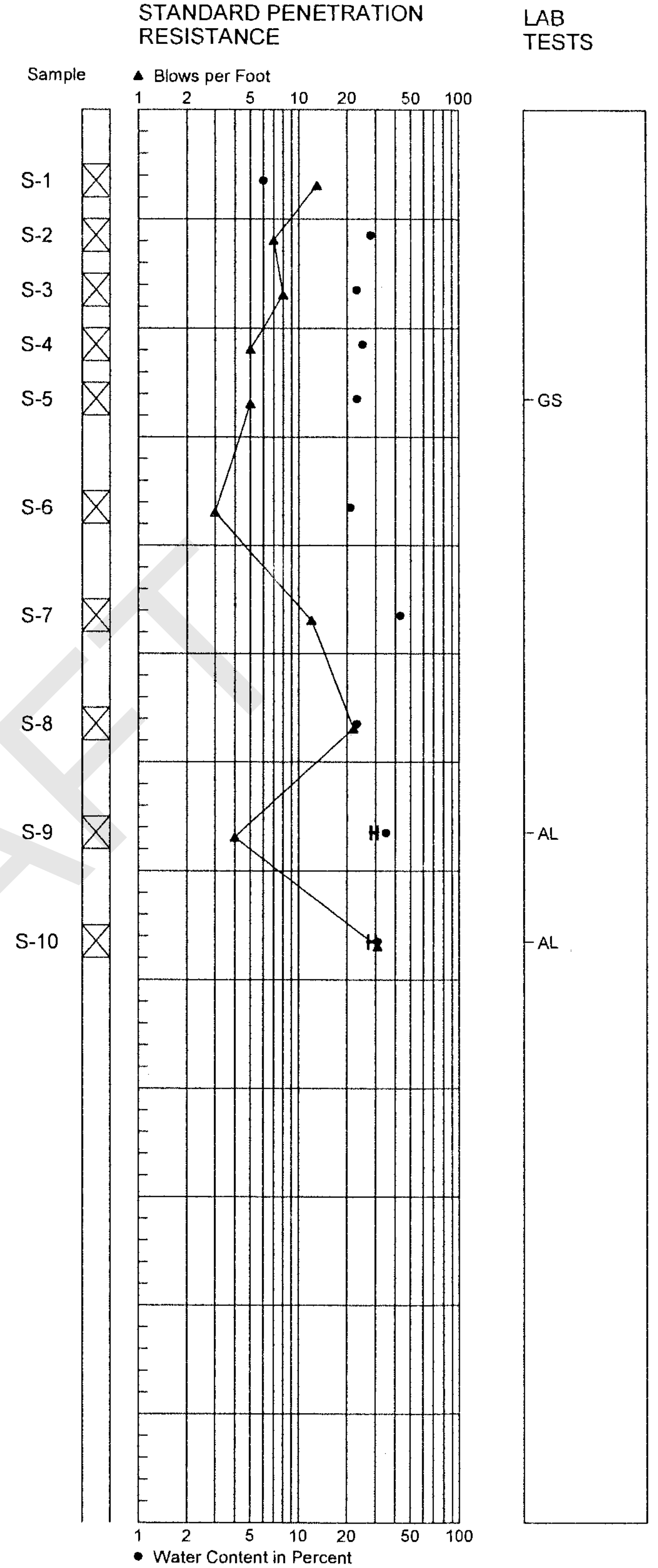
Figure A-16

Boring Log HC04-13

Soil Descriptions
Approximate Ground Surface Elevation in Feet: 16

Soil Descriptions	Depth in Feet
Asphalt pavement.	0
Medium dense, damp, brown SAND.	
Loose, moist, brown, gravelly SAND with organics, petroleum-like odor and lens of light brown clayey silt.	5
Loose, wet, gray to dark brown, slightly silty SAND.	ATD (groundwater)
Medium dense, wet, gray-brown SAND with shell fragments.	20
Medium dense, wet, gray, silty SAND with trace shell fragments and organic material.	25
Medium stiff, moist to wet, slightly sandy, slightly clayey SILT with trace organic material.	30
Dense, wet, gray to dark brown, silty SAND with lenses of slightly sandy, slightly clayey SILT.	35
Bottom of Boring at 39.0 Feet. Completed 08/23/04.	40

Depth in Feet: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65



BORING LOG 1710000BL.GPJ HC_CORP.GDT 3/14/05

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

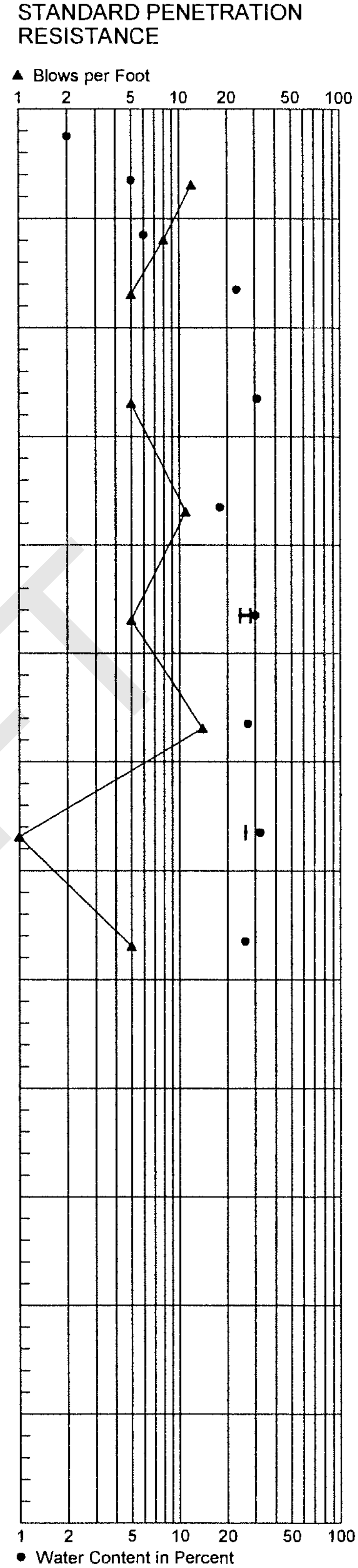
17100-00 08/04

Figure A-17

Boring Log HC04-14

Soil Descriptions
Approximate Ground Surface Elevation in Feet: 17

Soil Descriptions	Depth in Feet	Sample	Lab Tests
Asphalt pavement.	0		
Medium dense, damp, gray, silty, very sandy GRAVEL. (ROAD BASE)		G-1	
Medium dense, damp, gray-brown SAND with shell fragments.		S-1	
Loose, wet, dark brown, slightly silty SAND with shell fragments.	5	S-2	
	▽ ATD	S-3	GS
	10	S-4	
Medium dense, wet, dark brown, slightly silty SAND with shell fragments.	15	S-5	
Medium stiff, moist to wet, gray, clayey, very sandy SILT with shell fragments.	20	S-6	AL, GS
Medium dense, wet, dark brown, slightly silty SAND with shell fragments.	25	S-7	
Very loose to loose, moist to wet, gray to brown, silty SAND.	30	S-8	AL, GS
	35	S-9	
Bottom of Boring at 39.0 Feet. Completed 08/26/04.	40		



BORING LOG 17100000BL.GPJ HC_CORP.GDT 4/21/05

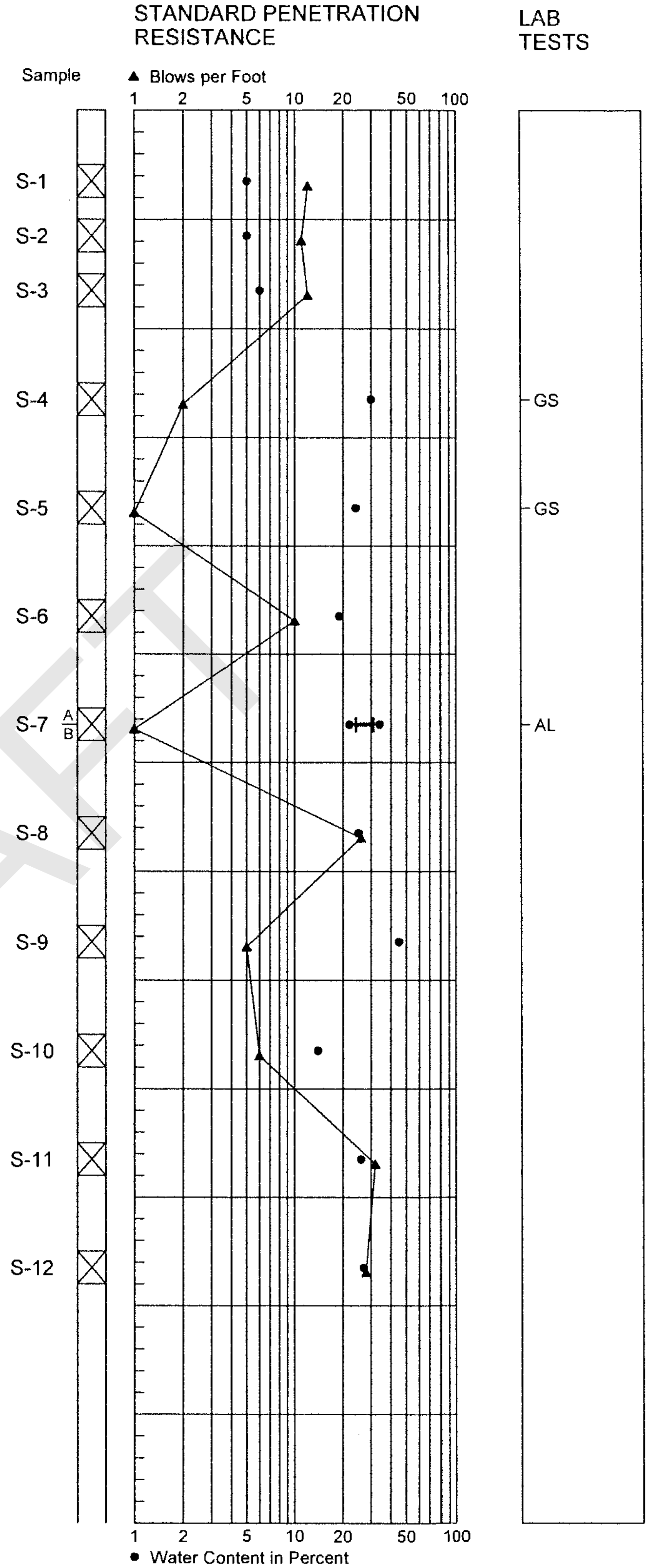
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER
17100-00 08/04
Figure A-18

Boring Log HC04-15

Soil Descriptions
Approximate Ground Surface Elevation in Feet: 19

Soil Descriptions	Depth in Feet
Asphalt pavement.	0
Medium dense, damp, brown, SAND with shell fragments.	
Very loose, wet, gray, silty, SAND with shell and wood fragments.	11 (▽ ATD)
Loose, wet, gray, silty, SAND with shell fragments.	
Very loose, wet, gray, silty, SAND.	
Very soft, wet, gray, slightly sandy, clayey SILT with shell fragments.	
Medium dense, gray, silty SAND.	
Loose, wet, gray, silty SAND with clayey silt lenses.	
Dense, wet, gray, silty SAND with clay and silt lenses.	
Medium dense, wet, gray, SAND with clay and silt lenses.	
Bottom of Boring at 54.0 Feet. Completed 08/27/04.	54



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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17100-00 08/04

Figure A-19

Boring Log S1B-1

Soil Descriptions

Approx. Ground Surface Elevation in Feet: 18

3 inches of Asphalt over cobbly, gravelly SAND over dense, damp, brown, gravelly, fine SAND.

Very loose to medium dense, damp to wet, dark brown to dark gray, fine to medium SAND.

Very loose, wet, gray, silty to very silty, fine SAND.

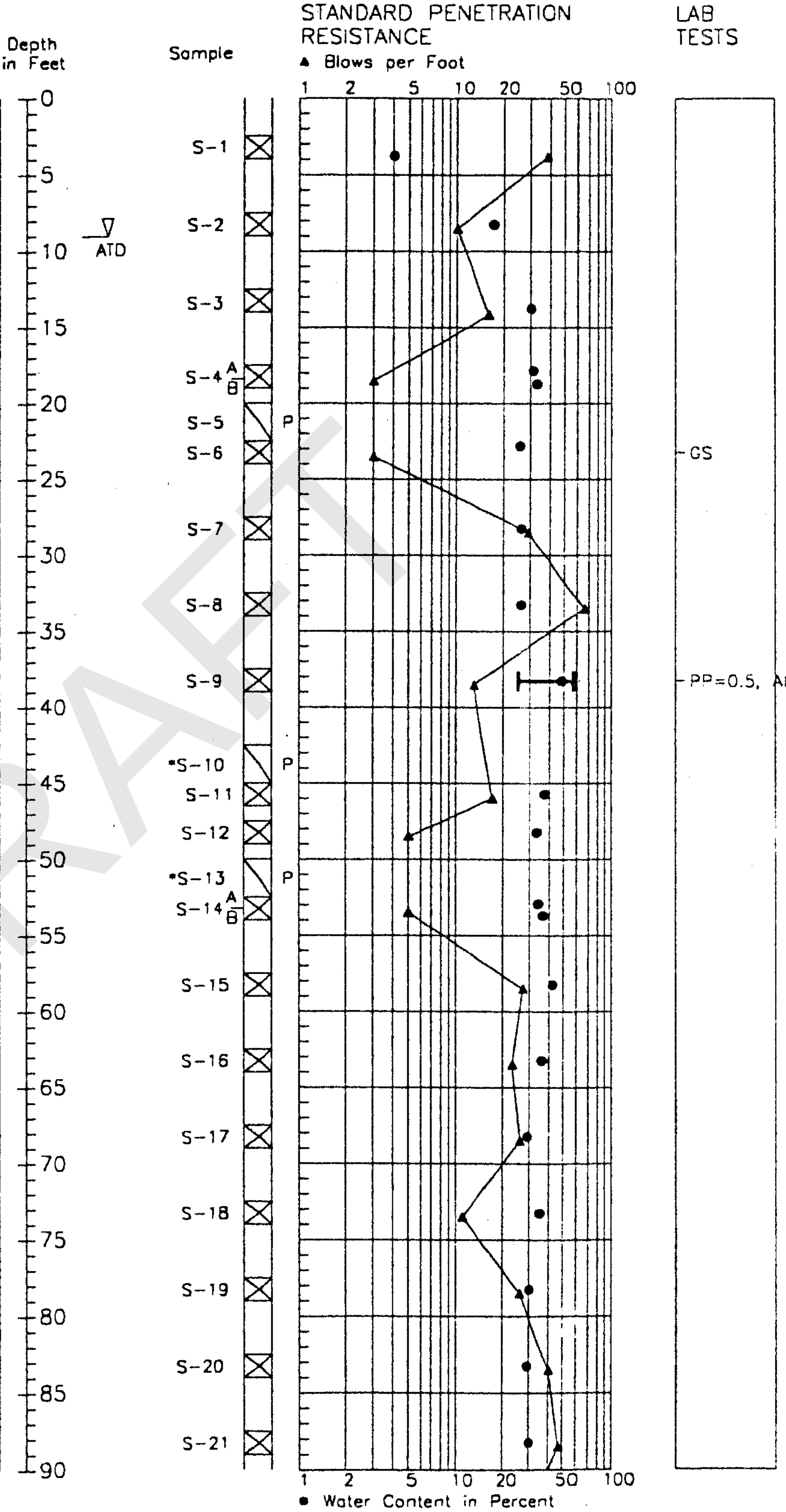
Medium dense to very dense, wet, dark gray, fine to medium SAND with trace shell fragments.

Stiff, moist, light gray, silty CLAY with trace sand.

Loose to medium dense, wet, gray, silty to very silty, fine SAND with interbeds of sandy Silt.

Medium dense to dense, wet, gray, slightly silty to silty, fine SAND.

Trace wood debris and shell fragments.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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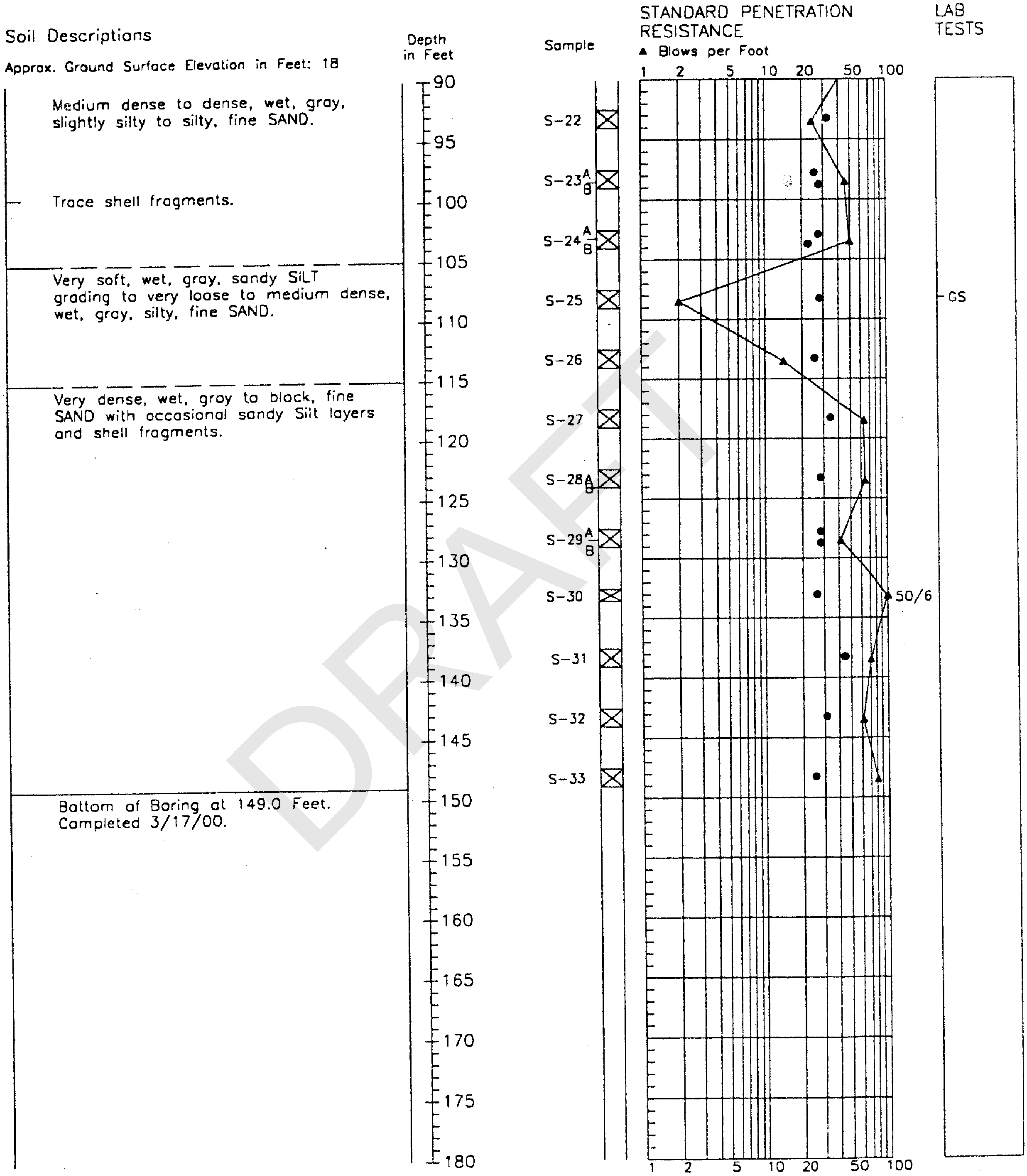
J-7278-03 5/01

Figure A-20

DTN 5/17/01 1=1 LOGS

...rlie-8.pc2

Boring Log S1B-1



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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J-7278-03 *5/01*

Figure A-20

DTN 5/17/01 1=1 charlie-8.pc2 LOGS

Boring Log S1B-2

Soil Descriptions

Approx. Ground Surface Elevation in Feet: 18

Cobbly, gravelly SAND inferred from drill action and cuttings over medium dense, wet, dark gray, sandy GRAVEL.

Very loose to medium dense, wet, gray, slightly silty, fine SAND.

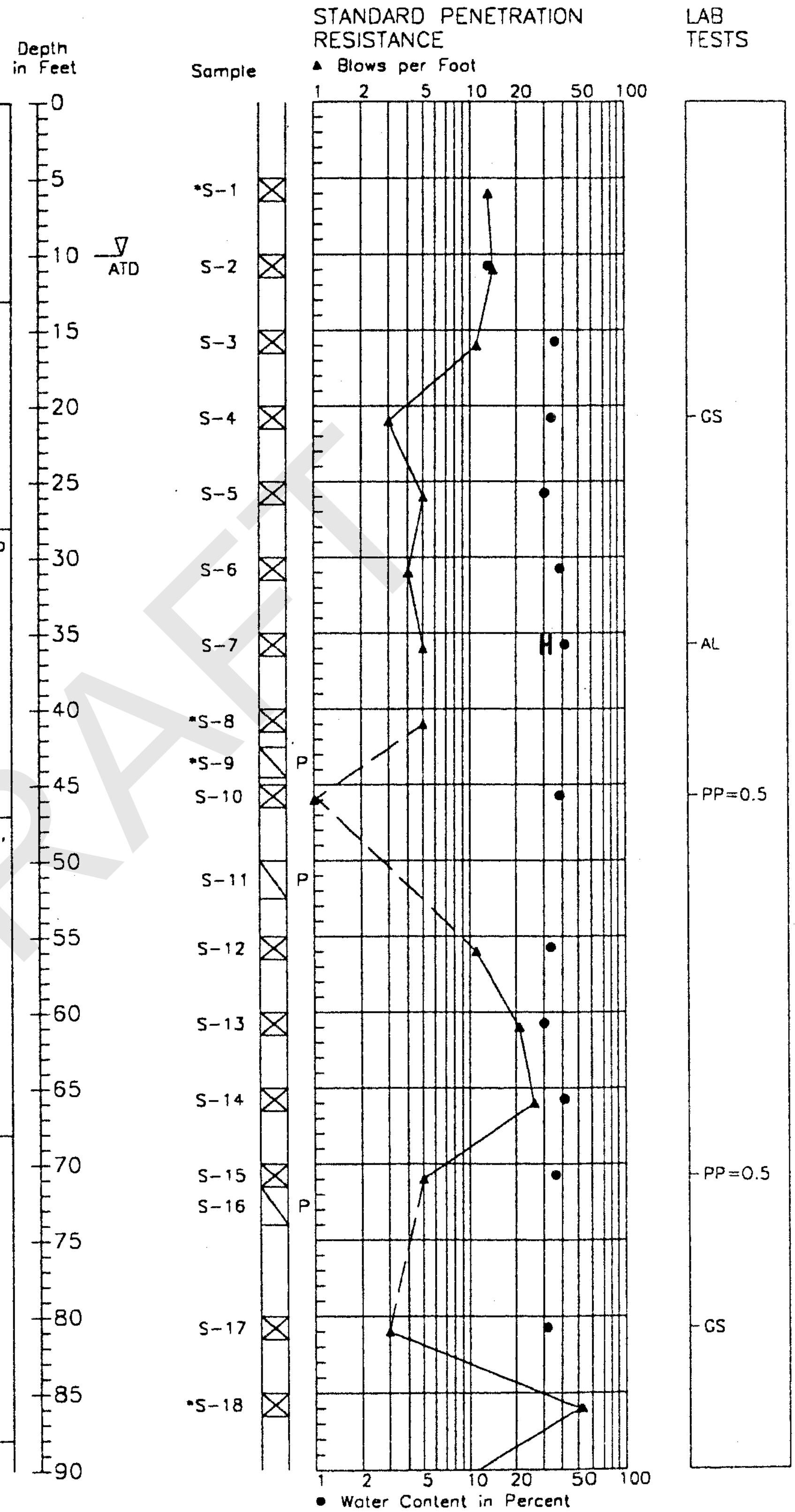
Trace shell fragments.

Very soft to medium stiff, moist, gray to black, sandy SILT.

Medium dense wet, dark gray and brown, silty, fine SAND.

Very loose to medium dense, wet, silty to very silty, fine SAND with Silt interbeds.

Very soft to (medium stiff), wet, dark gray SILT.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-7278-03 5/01

Figure A-21

OTN 5/17/01 1=1 charlie-8.pc2
LOGS

Boring Log S1B-2

Soil Descriptions

Approx. Ground Surface Elevation in Feet: 18

Very soft to (medium stiff), wet, dark gray SILT.

Medium dense to dense, wet, dark gray, slightly silty to silty, fine SAND with trace shell fragments.

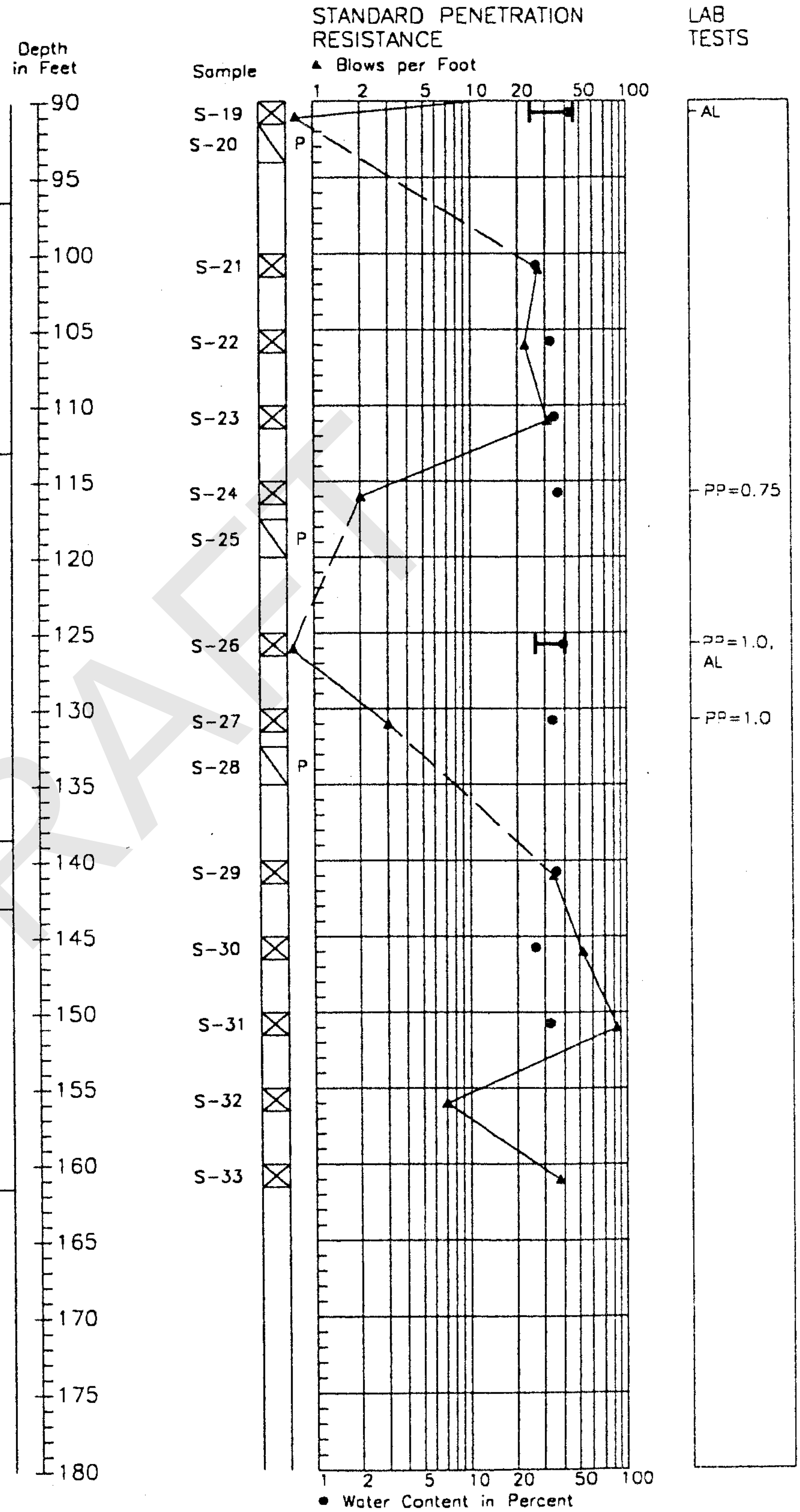
Very soft, moist, dark gray SILT.

Hard, wet, dark gray, slightly sandy SILT.

Dense to very dense, moist to wet, black, slightly silty to silty, fine SAND.

Loose, moist, dark gray SILT layer.

Bottom of Boring at 161.5 Feet.
Completed 3/30/00.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER
J-7278-03 5/01
Figure A-21

DTN 5/17/01 1=1 LOGS aria-8.pc2

Boring Log HC-103

Soil Descriptions

Approx. Ground Surface Elevation in Feet: −44.7

Very soft, wet, gray, sandy SILT with Sand interbeds.

Very loose to loose, wet, dark gray, slightly silty to silty SAND with sandy Silt interbeds and occasional scattered shell fragments.

— 1 foot of heave.

Medium stiff to very stiff, wet, dark gray, very sandy SILT.

Stiff to medium stiff, dark gray, sandy SILT with interbedded Sand layers.

Loose, wet, gray, silty, fine SAND.

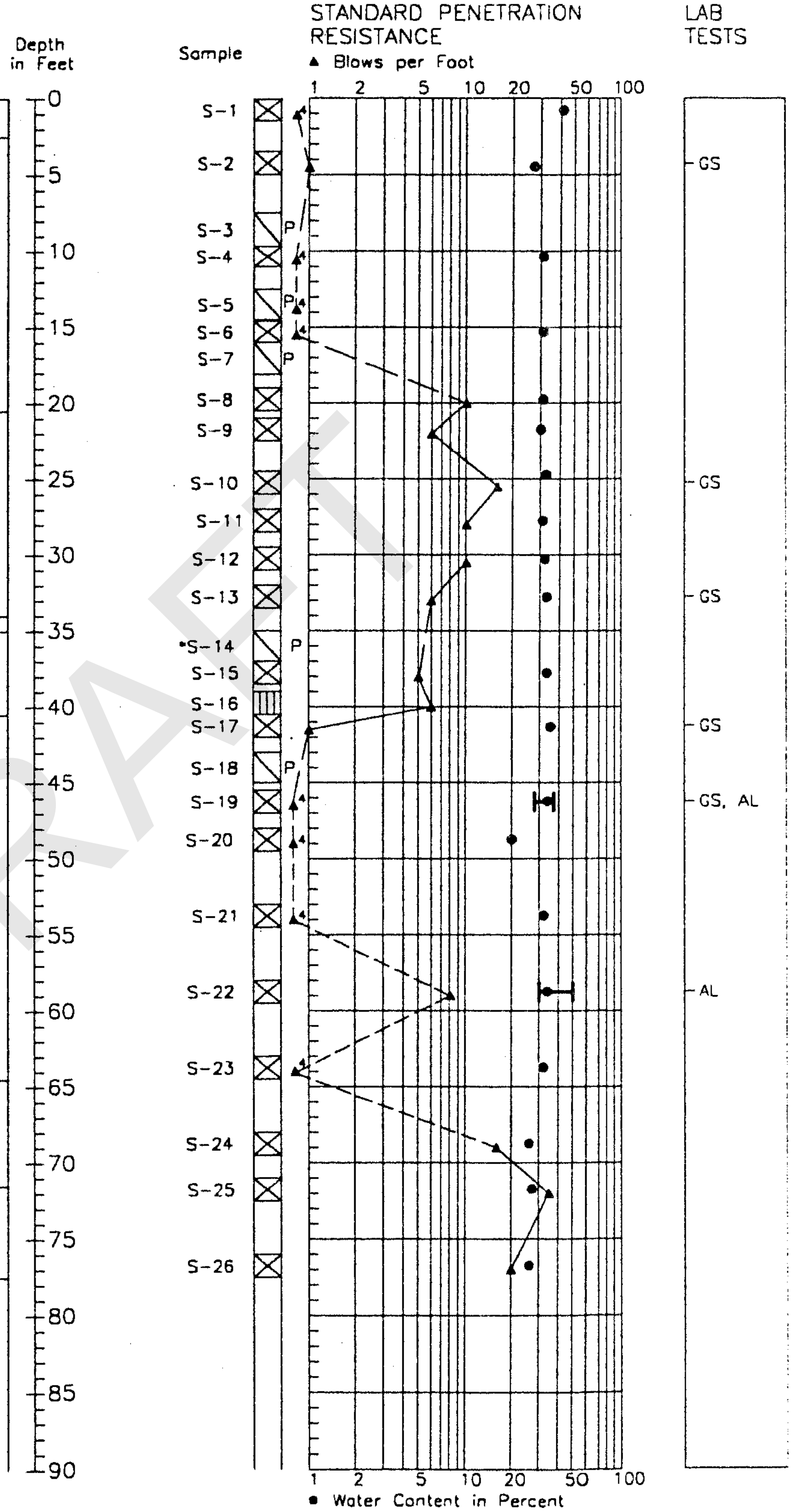
Very soft to soft, wet, gray, slightly sandy SILT with silty Sand interbeds.

Medium dense, wet, slightly silty to very silty SAND with medium Sand interbeds.

Very stiff, wet, dark gray, slightly sandy SILT.

Dense to medium dense, wet, dark gray, slightly silty SAND.

Bottom of Boring 77.5 Feet.
Completed 5/4/00.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Penetrated under weight of rods.

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J-4965-01 5/01

Figure A-22

Boring Log T3B-12

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet -22 (MLLW)

Strong chemical odor noted in samples from mudline to bottom of boring.

Very soft, wet, black, clayey SILT with shells and slag debris. Wire rope noted throughout zone.

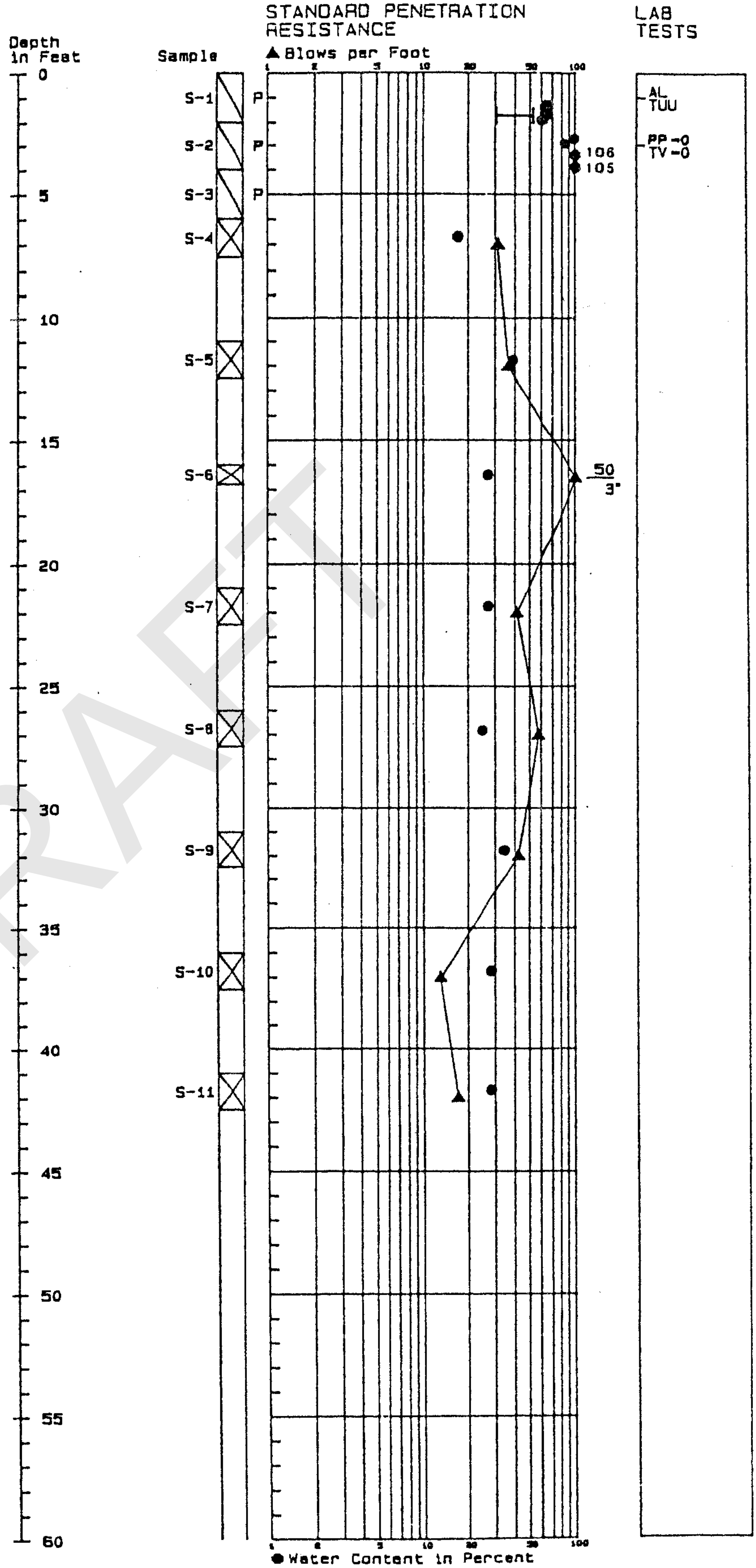
Dense, wet, dark gray, slightly silty SAND with some gravel. (FILL?)

Hard, wet, dark gray, sandy SILT. (FILL?)

Dense, wet, dark gray, slightly silty to silty, fine SAND with occasional wood fragments, roots and wire fragments. (FILL?)

Medium dense, wet, gray, slightly silty SAND.

Bottom of Boring at 42.5 Feet. Completed 2/21/87.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

J-1682-01 February 1987

HART-CROWSER & associates, inc.

Figure A-23

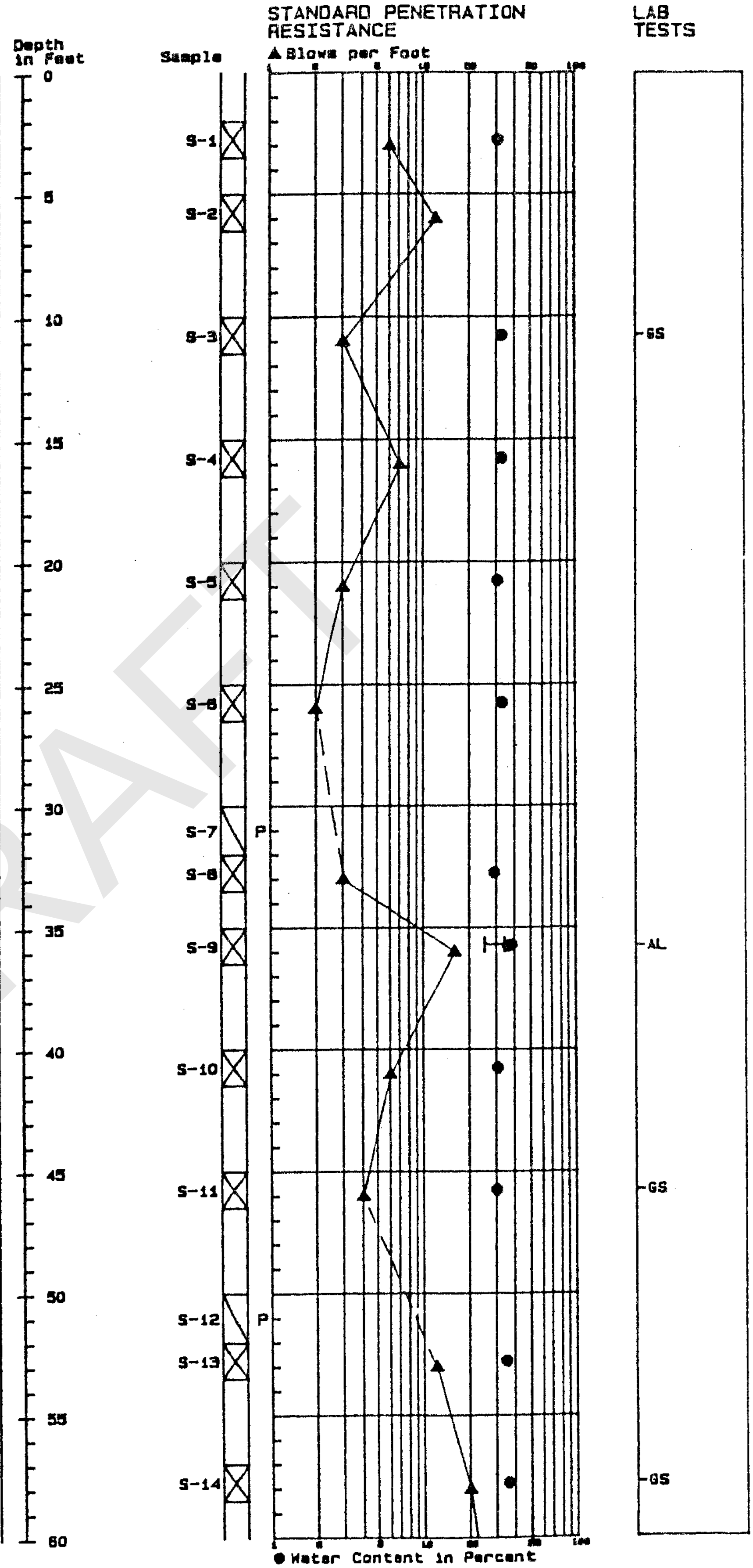
Boring Log T3B-6

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet -37.6

Soft to stiff, wet, black to gray, slightly sandy SILT with sandy SILT and clayey SILT interbeds.

Stiff to hard, wet, gray, very sandy SILT with very silty SAND interbeds.



J-1681 March 1986

HART-CROWSER & associates, inc.

Sheet 1 of 2

Figure A-24

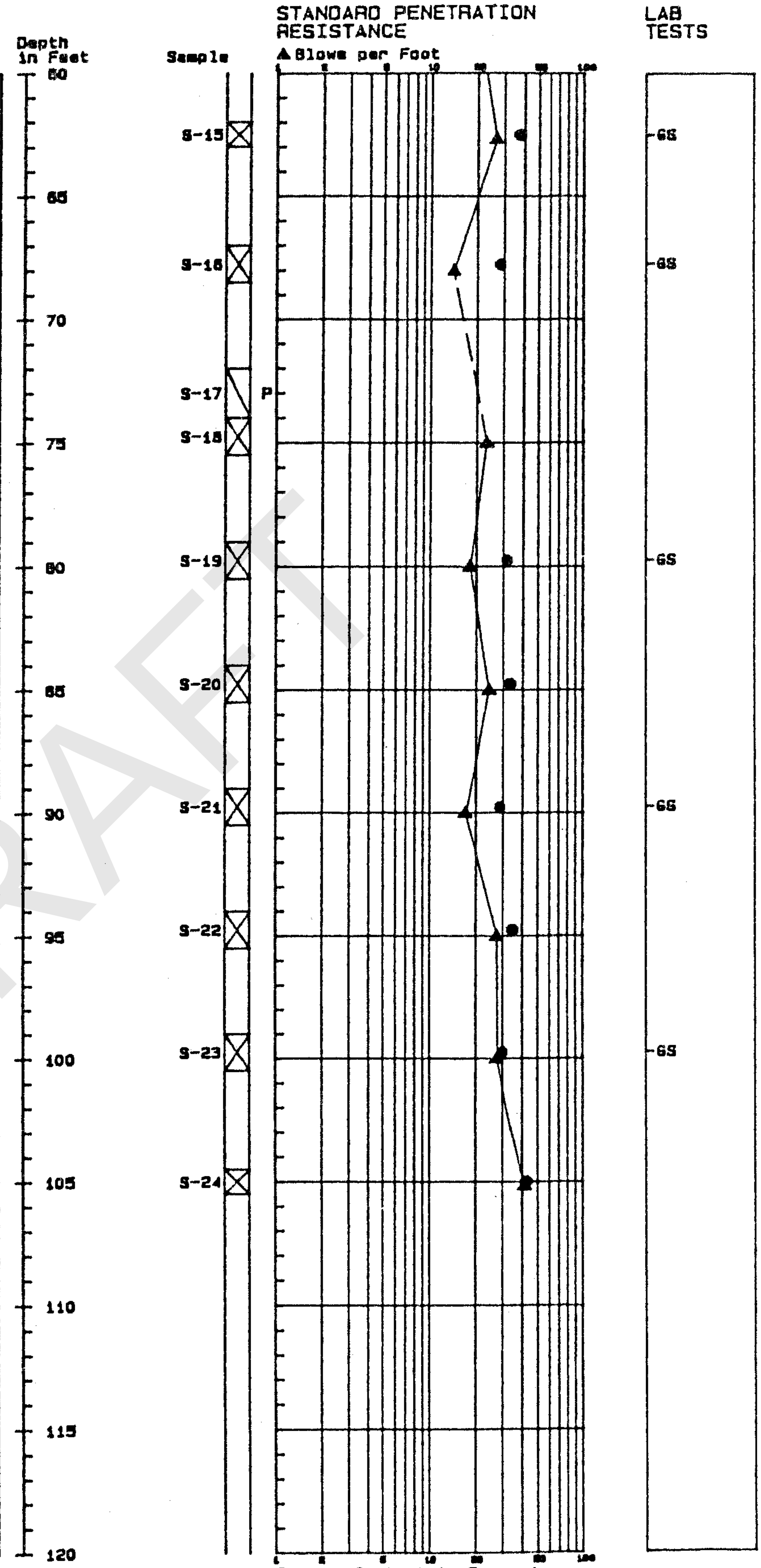
Boring Log T3B-6

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet -37.6

Stiff to hard, wet, gray, very sandy SILT with very silty SAND interbeds.

Bottom of Boring at 105.5 Feet.
Completed 3/15/86.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

J-1681 March 1986

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Sheet 2 of 2 *Figure A-24*

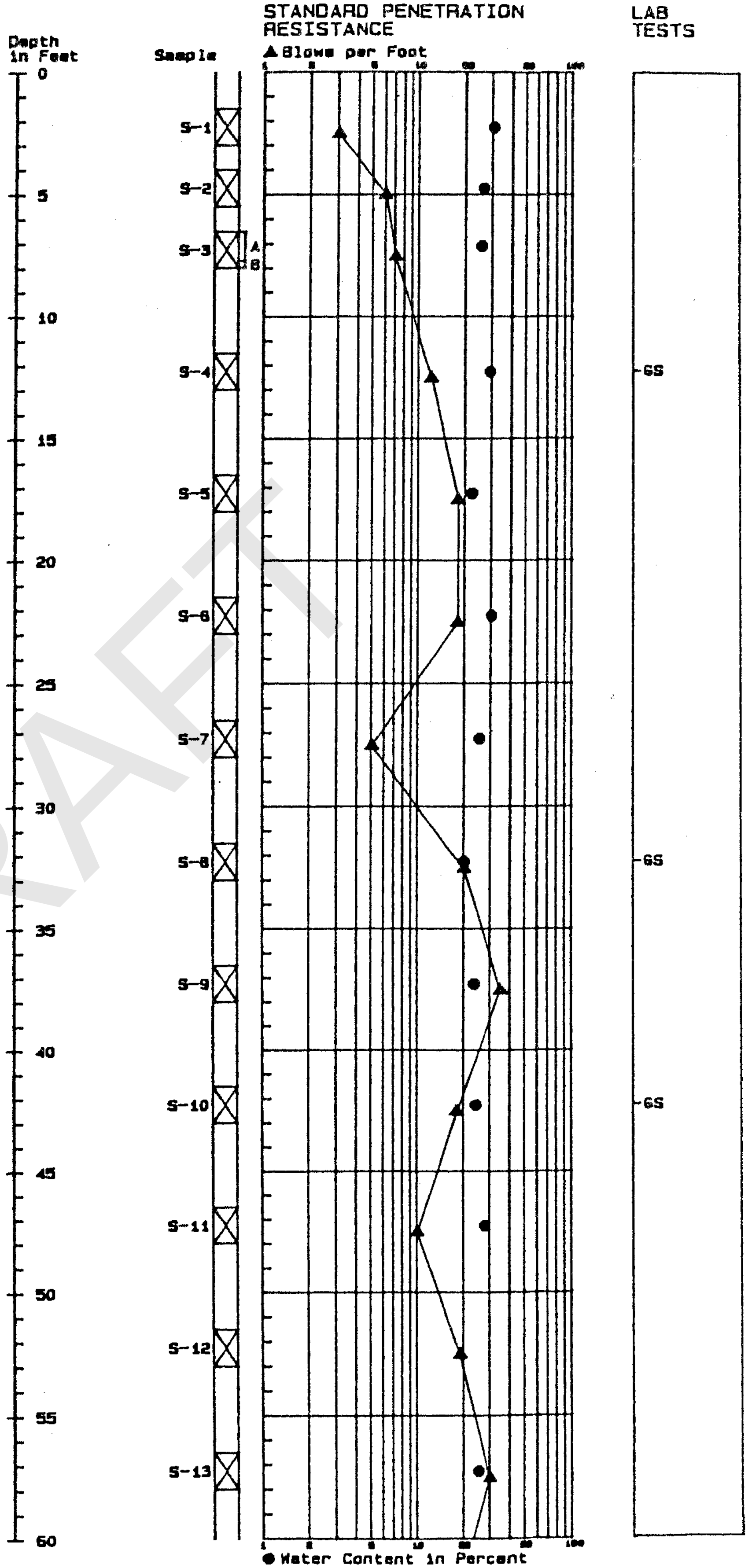
Boring Log T3B-9

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet -3

Very loose to loose, wet, dark gray, slightly silty, medium to fine SAND.

Medium dense, wet, gray, silty, medium to fine SAND with scattered very silty SAND interbeds and shell fragments.



J-1680 March 1986

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Sheet 1 of 2 *Figure A-25*

Boring Log T3B-9

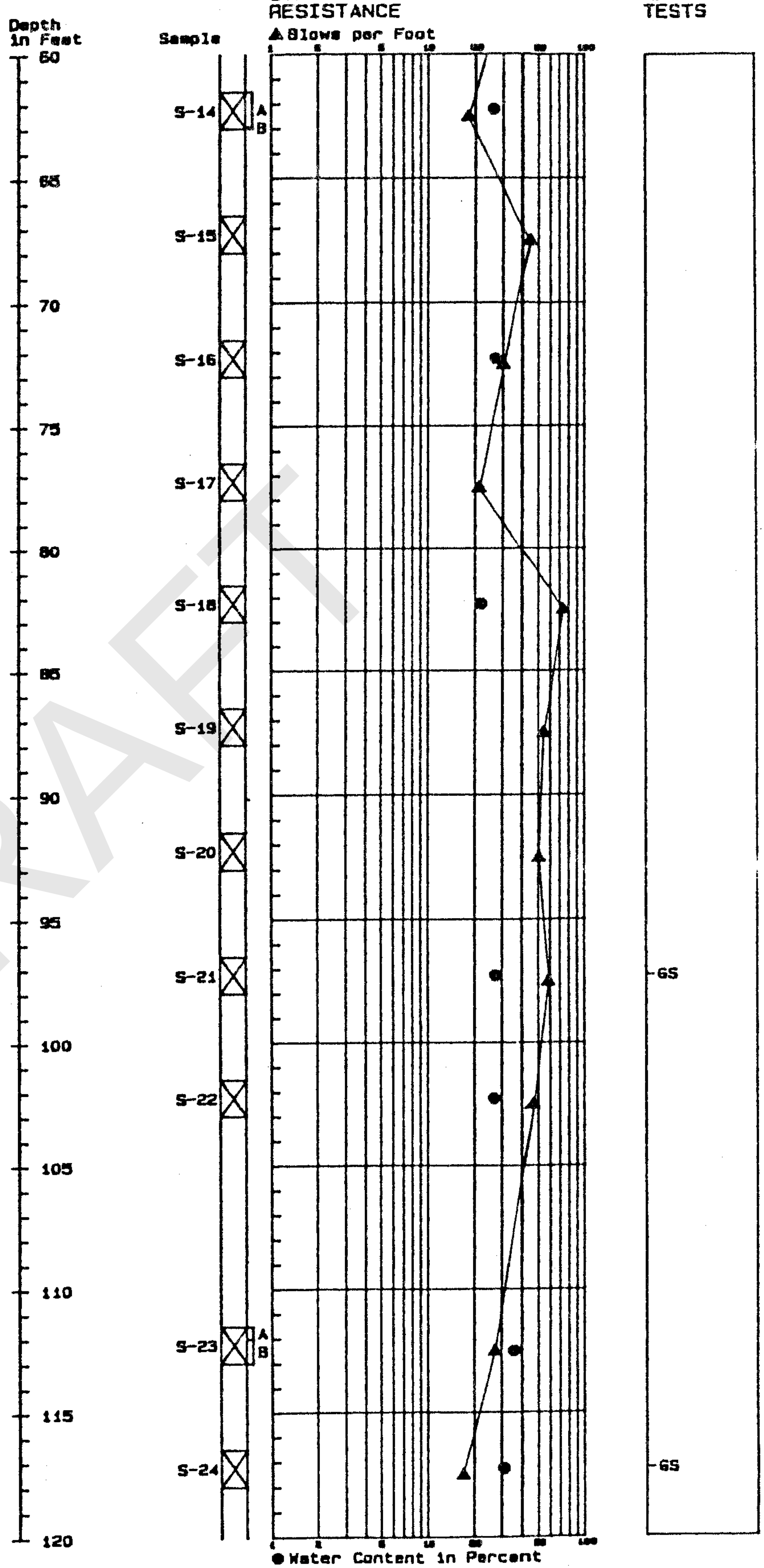
SOIL DESCRIPTIONS

Ground Surface Elevation in Feet -3

Medium dense to dense, wet, gray, silty, medium to fine SAND with sandy SILT interbeds.

Very stiff, wet, gray, slightly clayey, sandy SILT.

Bottom of Boring at 118.0 Feet.
Completed 3/1/86.



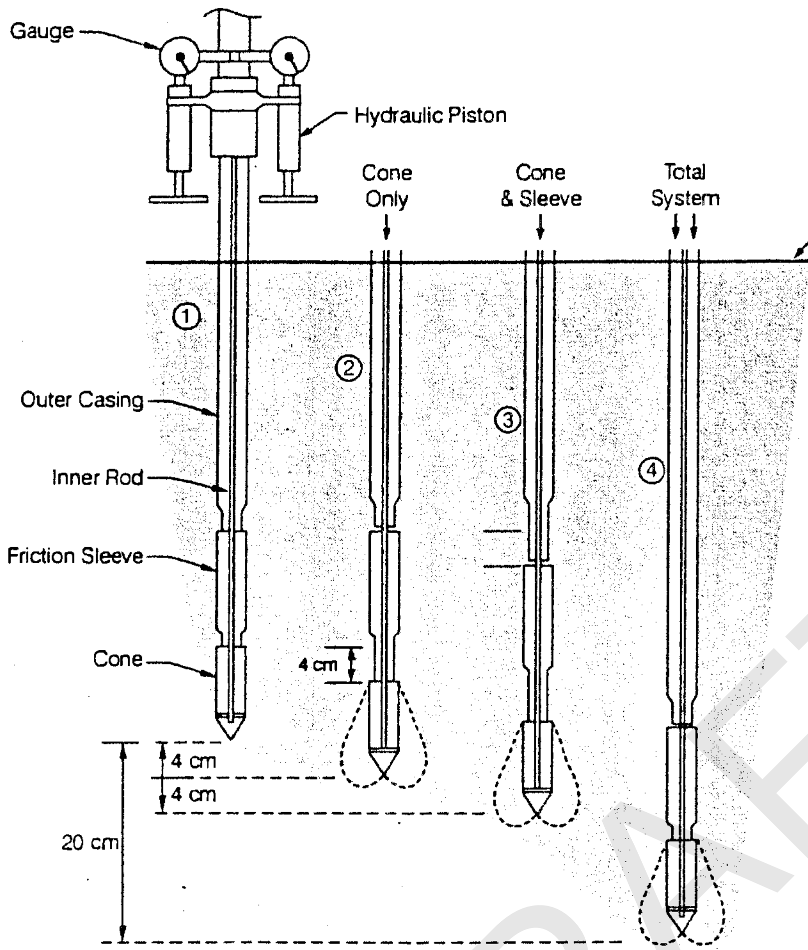
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

J-1680 March 1986

HART-CROWSER & associates, inc.

Sheet 2 of 2 *Figure A-25*

Principle of Cone Penetrometer

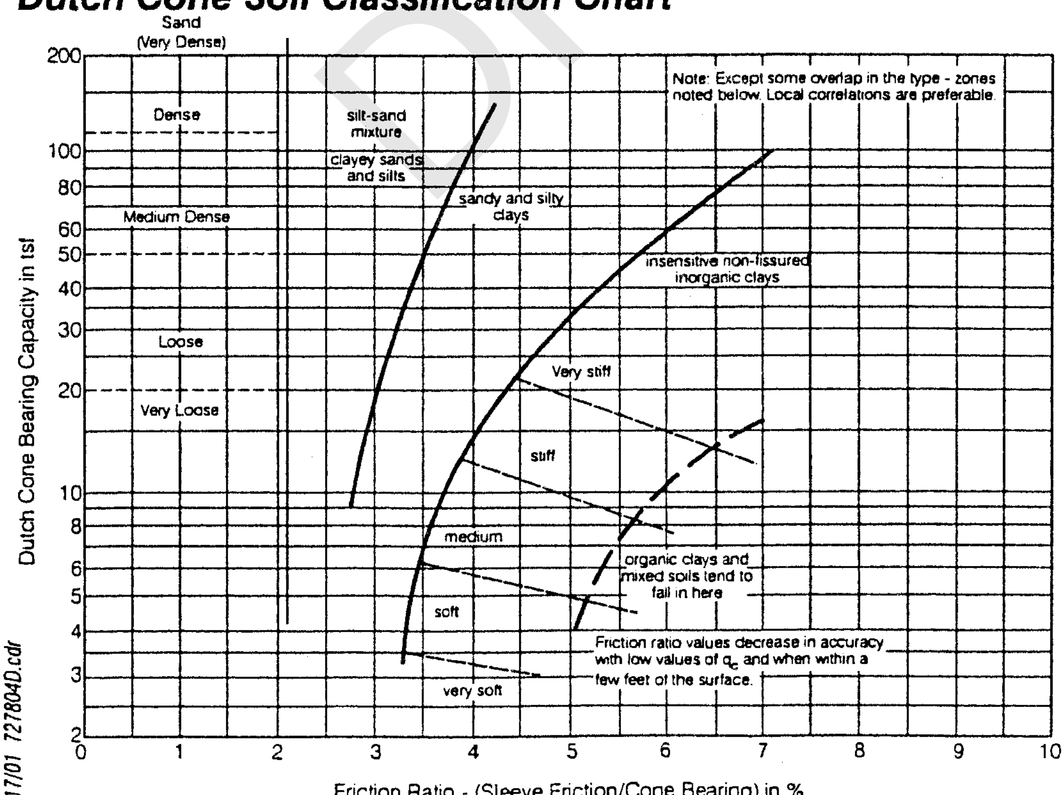


Procedure

1. The cone as shown in position 1 is pushed down by the inner rod for a depth of 4 cm and the point resistance measured.
2. From position 2 the point is again pushed 4 cm and the combined point resistance and side friction is measured by causing the sleeve to be lowered as shown in position 3.
3. The total system is then advanced 20 cm by pushing the outer casing to position 4 from which the next test is accomplished.

Notes: 1. The cone apex angle = 60°
Section area = 10 cm
2. Length of friction sleeve = 13 cm
Diameter = 36 mm

Dutch Cone Soil Classification Chart



DTN 5/17/01 727804D.cdr

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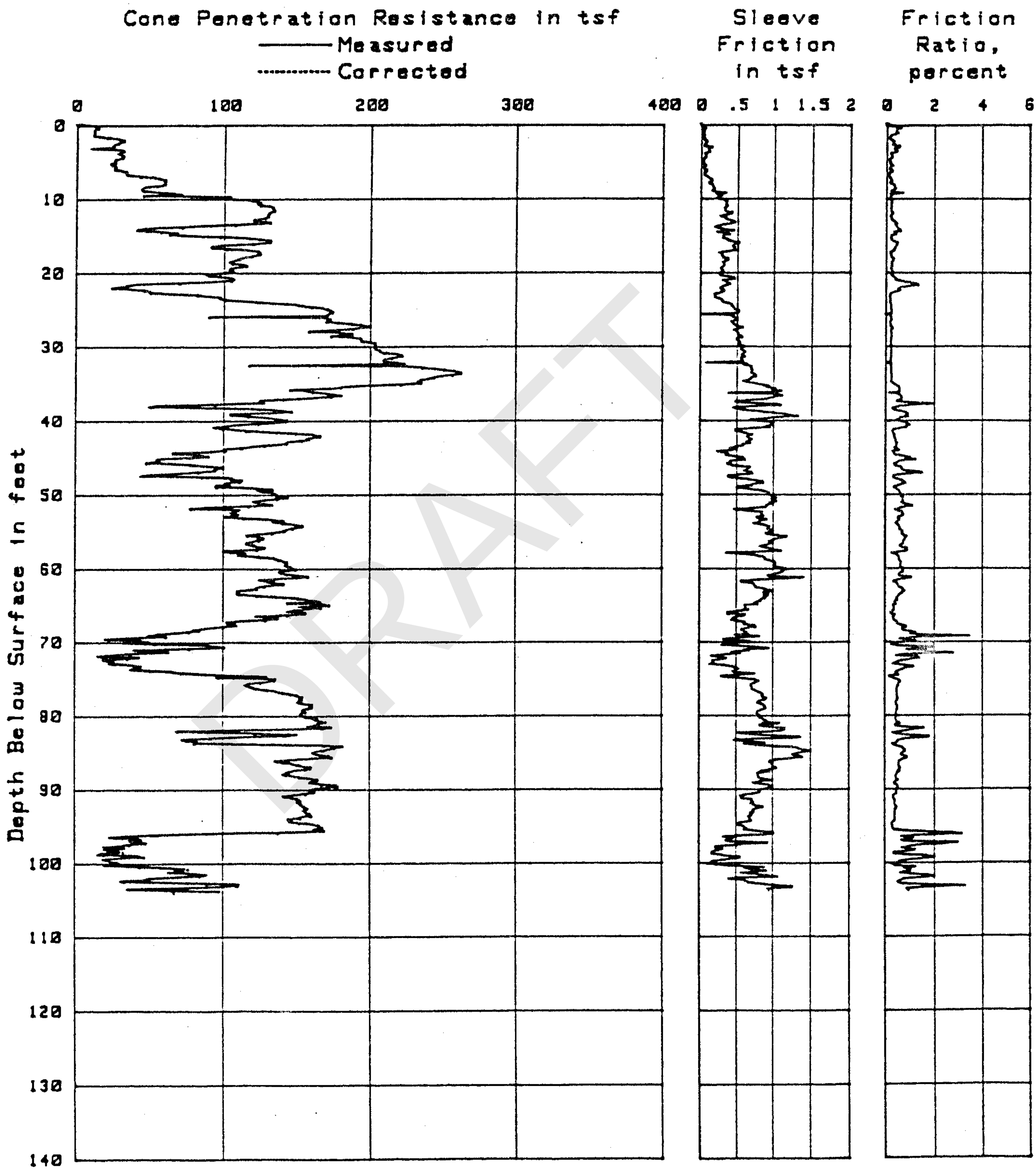
J-7278-04 5/01

Figure A-26

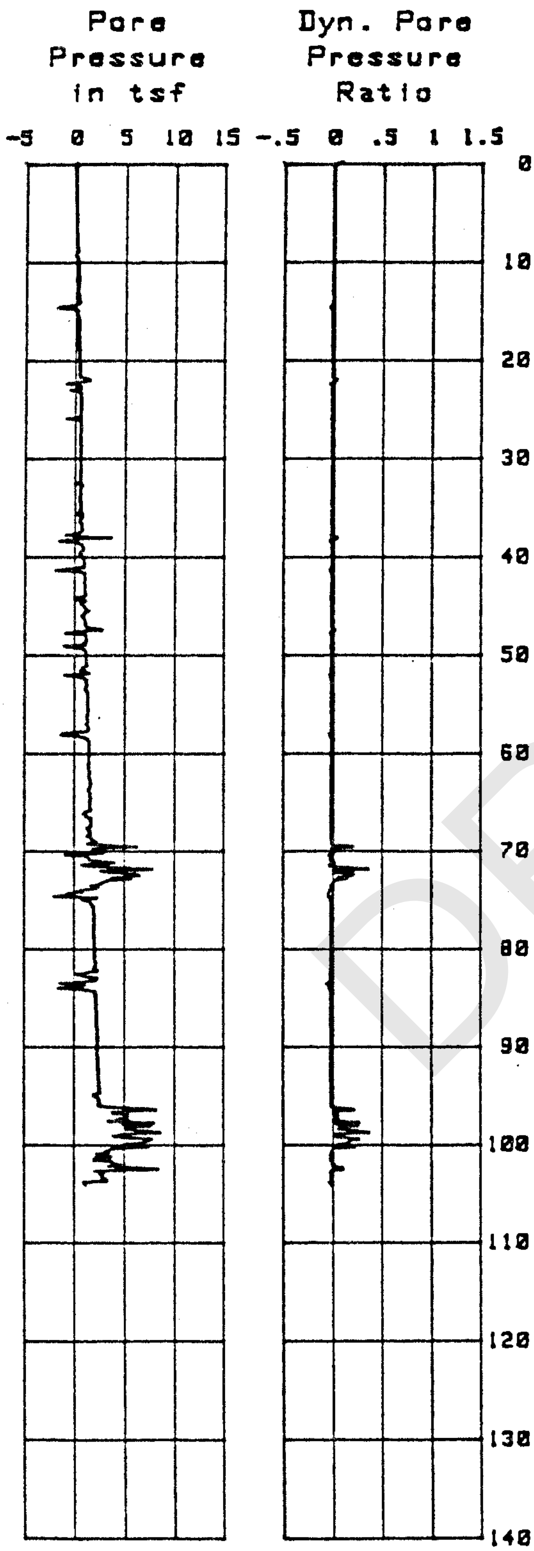
Probe Log T3P-1

Approximate Surface Elevation in Feet -35
(MLLW=0)



J-1680 October 1986
HART-CROWSER & associates inc.
Sheet 1 of 2 *Figure A-27*

Probe Log T3P-1



Soil Interpretation

Soft to stiff, clayey, sandy SILT.

Medium dense, silty SAND.

Medium dense to very dense, silty SAND.

Loose to medium dense, silty SAND.

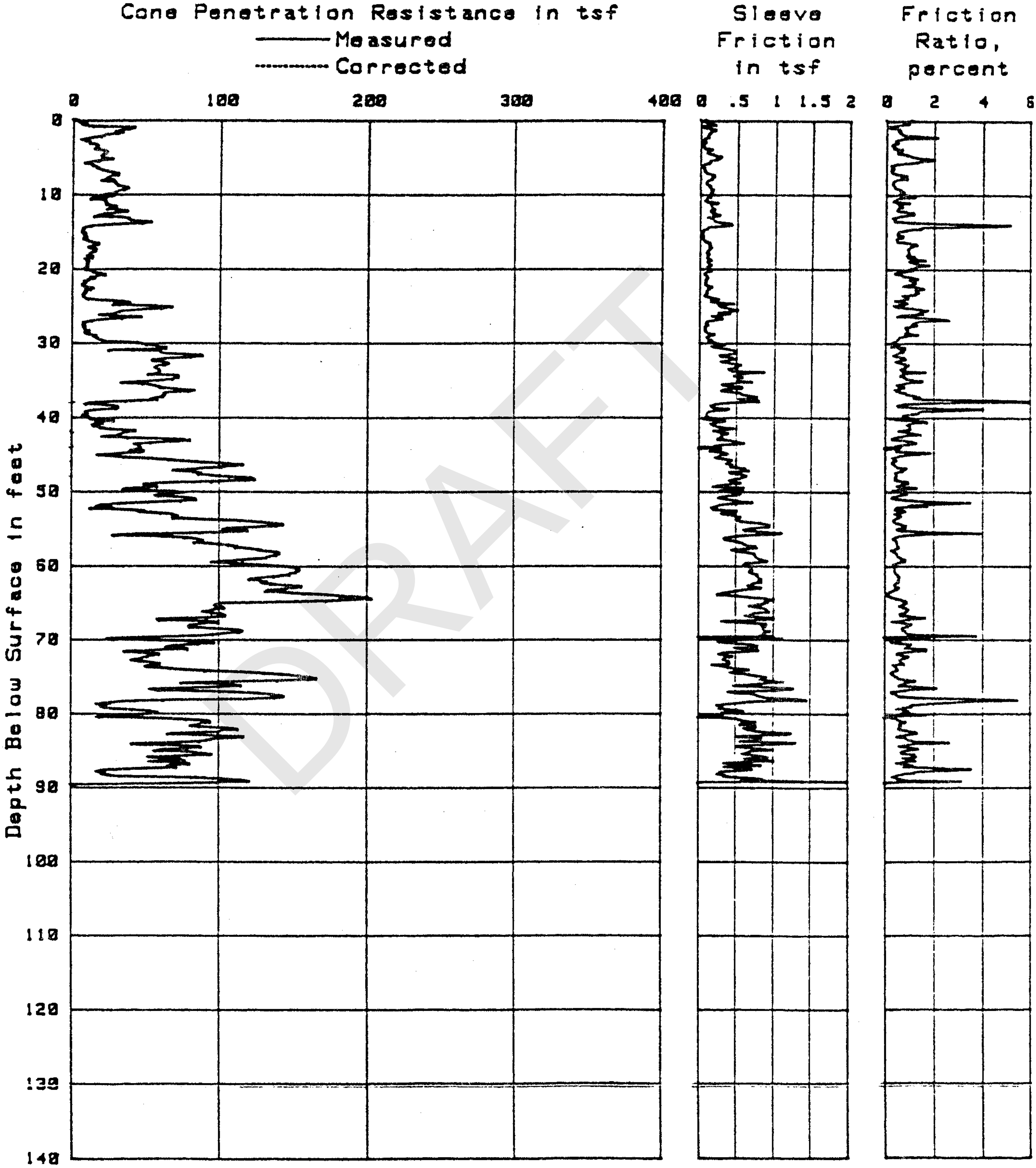
Medium dense to dense, very silty SAND.

Stiff to very stiff, sandy SILT.

Bottom of Probe at 101.4 Feet.
Completed 4/11/86.

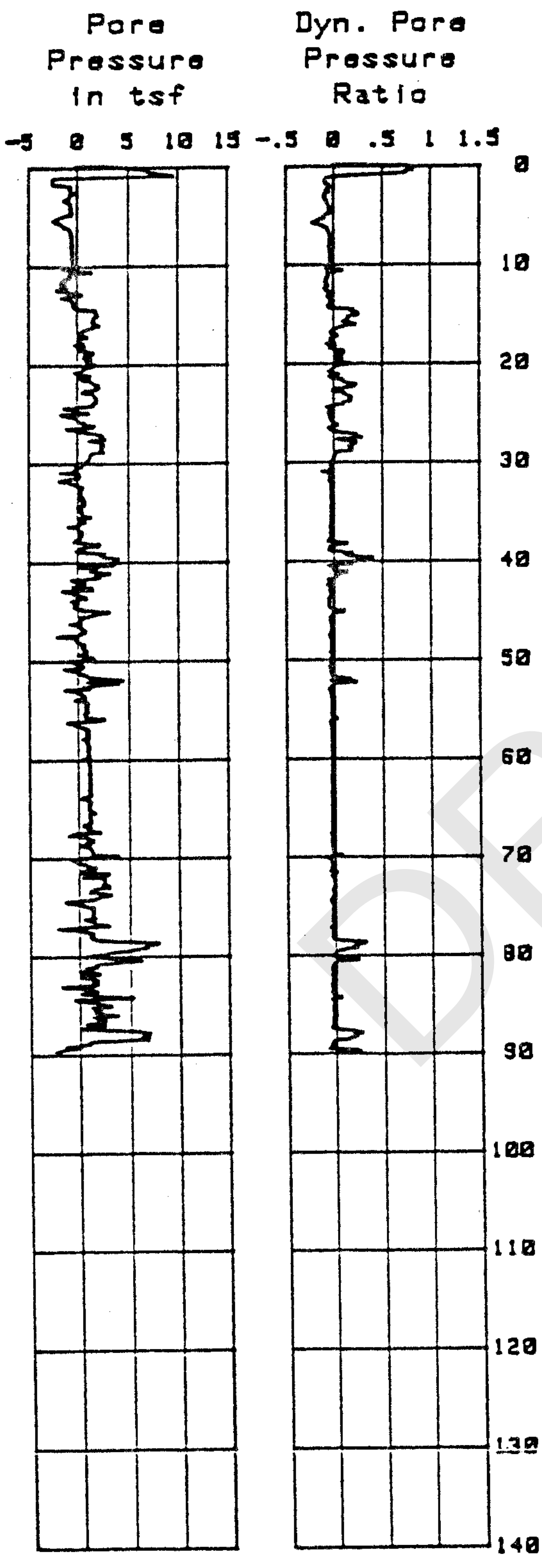
Probe Log T3P-5

Approximate Surface Elevation in Feet -37
(MLLW=0)



J-1681 August 1986
HART-CROWSER & associates inc.
Sheet 1 of 2 *Figure A-28*

Probe Log T3P-5



Soil Interpretation

Medium stiff to stiff, sandy SILT with silty SAND interbeds.

Medium dense, silty SAND.

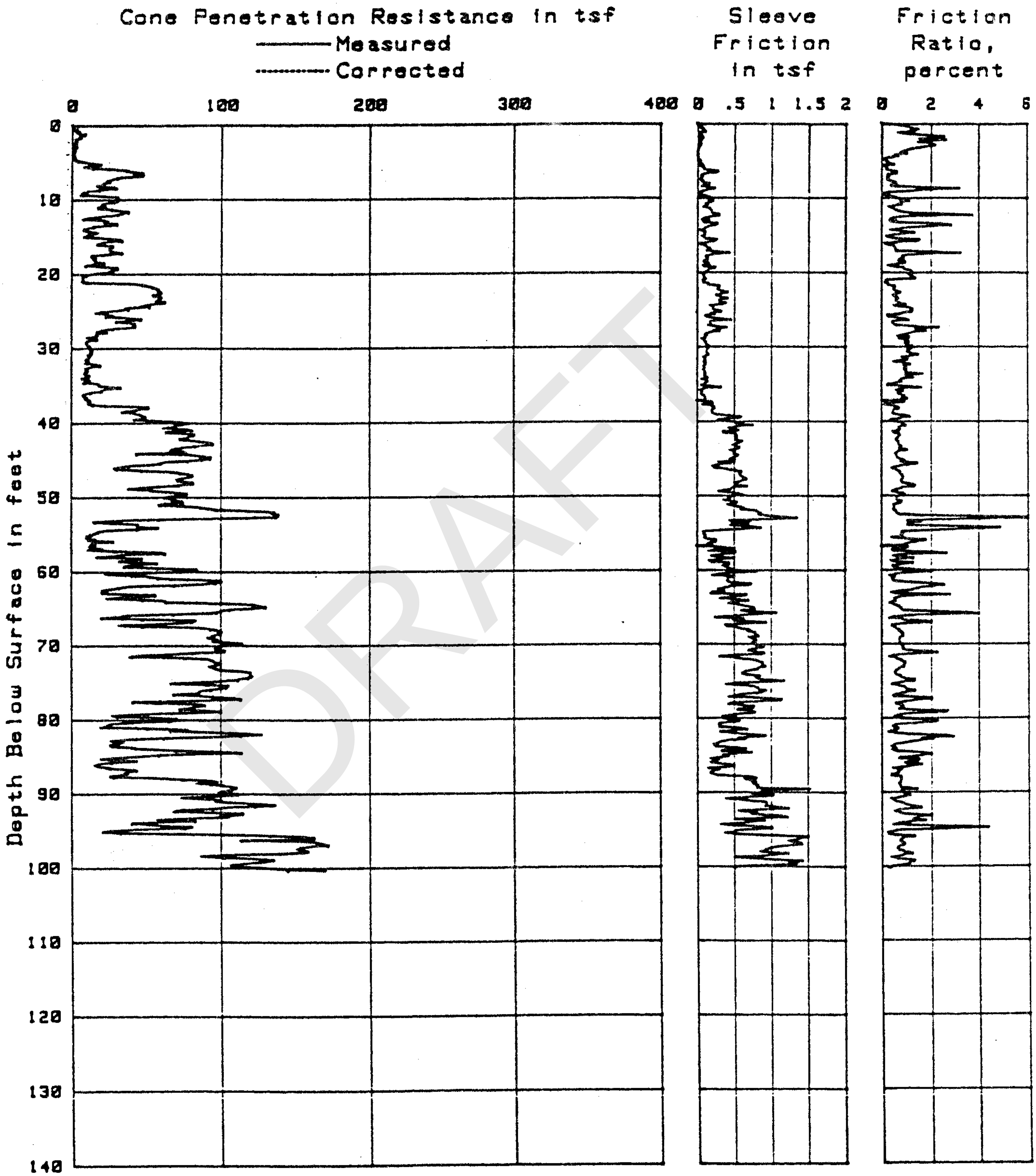
Medium stiff to stiff, sandy SILT.

Medium dense to dense, silty SAND with scattered sandy SILT interbeds.

Bottom of Probe at 90.0 Feet.
Completed 3/15/86.

Probe Log T3P-6

Approximate Surface Elevation in Feet -39
(MLLW=0)



J-1681 August 1986
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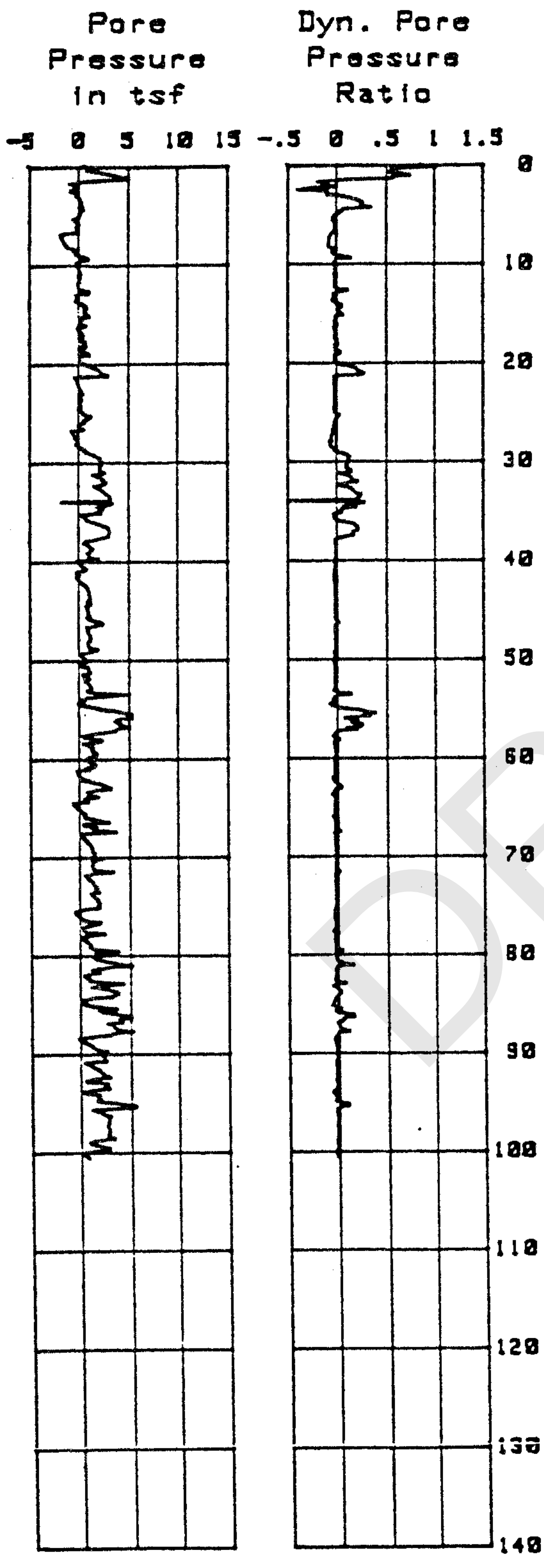
Sheet 1 of 2 *Figure A-29*

Probe Log T3P-6



Soil Interpretation

Soft to stiff, sandy SILT.

Medium stiff to stiff, sandy SILT with scattered SILT interbeds.

Medium dense, silty SAND.

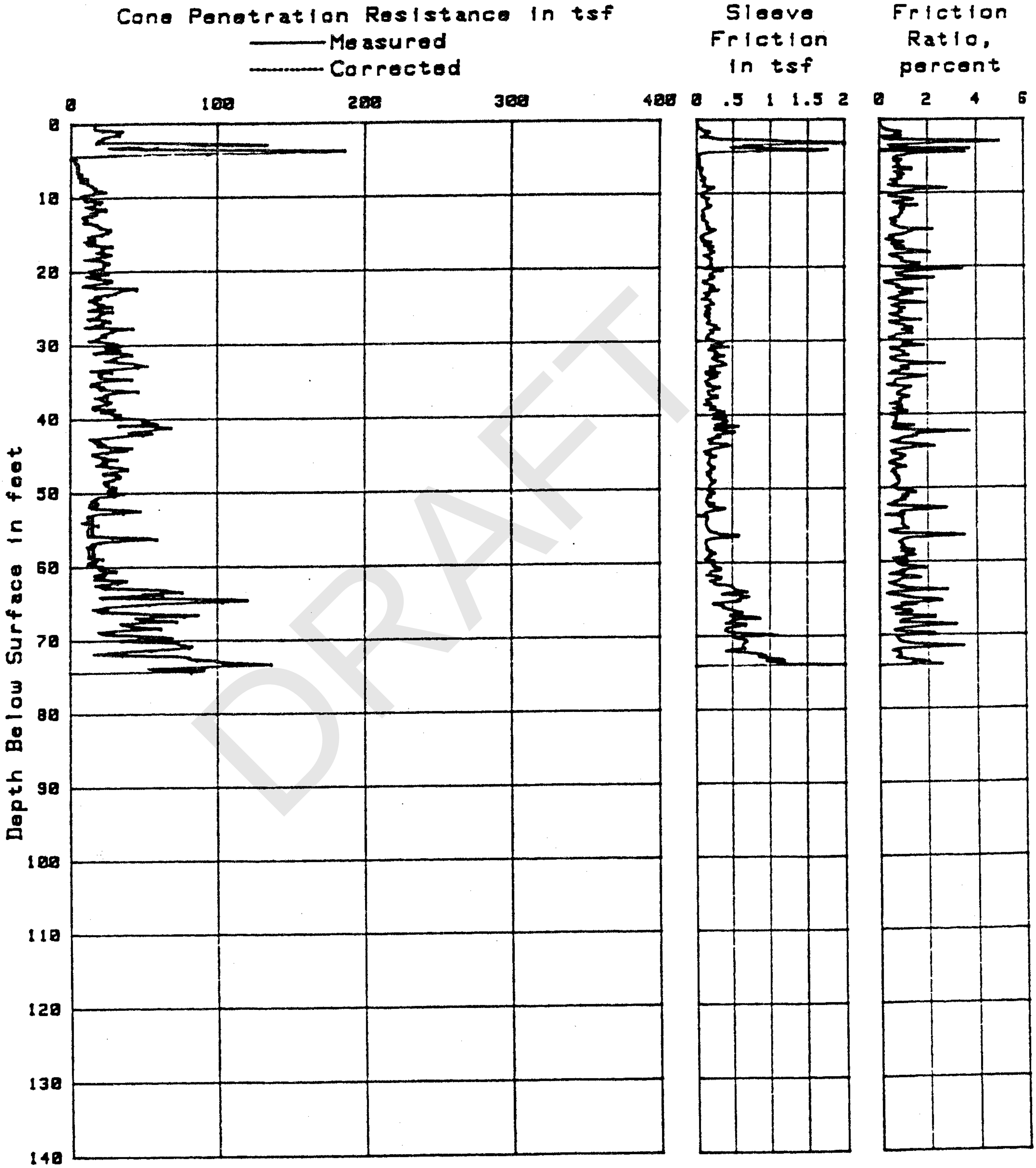
Medium stiff to stiff, sandy SILT.

Medium dense to dense, silty SAND with sandy SILT interbeds.

Bottom of Probe at 101.5 Feet.
Completed 3/15/86.

Probe Log T3P-8

Approximate Surface Elevation in Feet -33 (MLLW=0)



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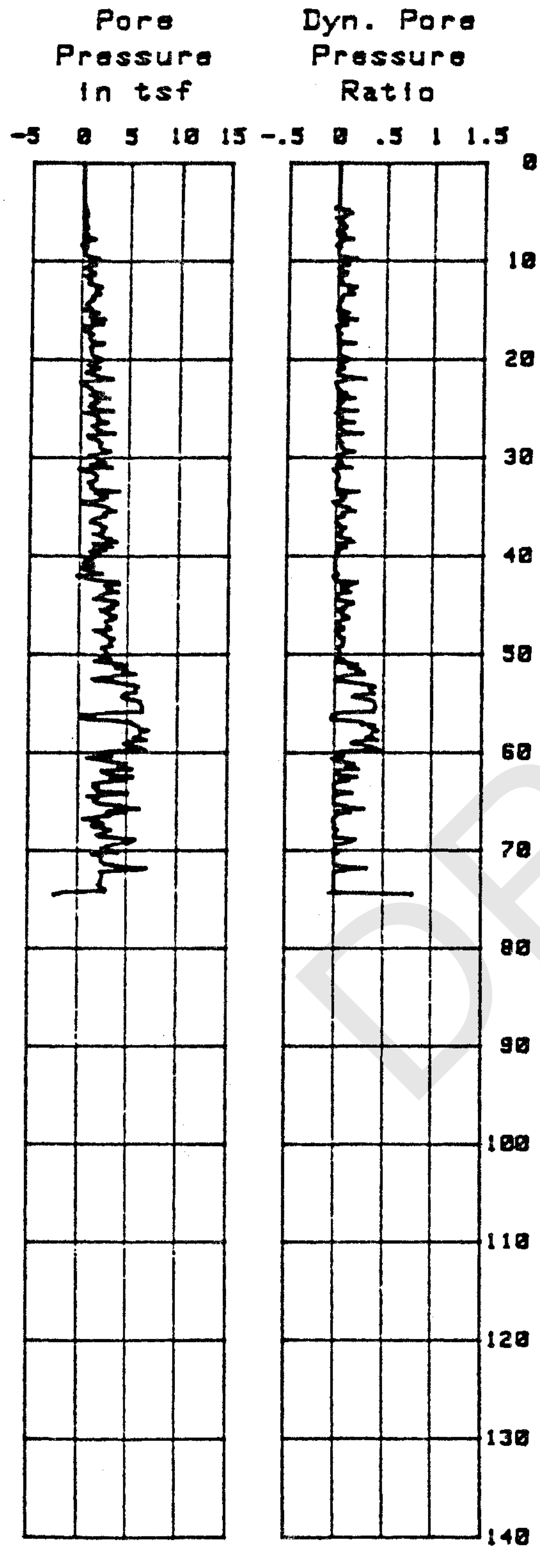
J-1681 August 1986
HART-CROWSER & associates inc.
Sheet 1 of 2 *Figure A-30*

Probe Log T3P-8



Soil Interpretation

Medium dense to dense, silty SAND.

Medium stiff to stiff, sandy SILT with numerous silty SAND interbeds.

Medium dense to dense, silty SAND with sandy SILT interbeds.

Bottom of Probe at 75.1 Feet.
Completed 3/16/86.

APPENDIX B
LABORATORY TESTING PROGRAM

APPENDIX B
LABORATORY TESTING PROGRAM

A laboratory testing program was performed for this study to evaluate the basic index and geotechnical engineering properties of the site soils. Disturbed samples were tested. The tests performed and the procedures followed are outlined below.

Soil Classification

Field Observation and Laboratory Analysis. Soil samples from the explorations were visually classified in the field and then taken to our laboratory where the classifications were verified in a relatively controlled laboratory environment. Field and laboratory observations include density/consistency, moisture condition, and grain size and plasticity estimates.

The classifications of selected samples were checked by laboratory tests such as Atterberg limits determinations and grain size analyses. Classifications were made in general accordance with the Unified Soil Classification (USC) System, ASTM D 2487, as presented on Figure B-1.

Water Content Determinations

Water contents were determined for most samples recovered in the explorations in general accordance with ASTM D 2216, as soon as possible following their arrival in our laboratory. Water contents were not determined for very small samples nor samples where large gravel contents would result in values considered unrepresentative. The results of these tests are plotted at the respective sample depth on the exploration logs. In addition, water contents are routinely determined for samples subjected to other testing. These are also presented on the exploration logs.

Atterberg Limits (AL)

We determined Atterberg limits for selected fine-grained soil samples. The liquid limit and plastic limit were determined in general accordance with ASTM D 4318-84. The results of the Atterberg limits analyses and the plasticity characteristics are summarized in the Liquid and Plastic Limits Test Report, Figure B-2. This relates the plasticity index (liquid limit minus the plastic limit) to the liquid limit. The results of the Atterberg limits tests are shown graphically on the boring logs as well as where applicable on figures presenting various other test results.

Grain Size Analysis (GS)

Grain size distribution was analyzed on representative samples in general accordance with ASTM D 422. Wet sieve analysis was used to determine the size distribution greater than the U.S. No. 200 mesh sieve. The size distribution for particles smaller than the No. 200 mesh sieve was determined by the hydrometer method for a selected number of samples. The results of the tests are presented as curves on Figures B-3 through B-8 plotting percent finer by weight versus grain size.

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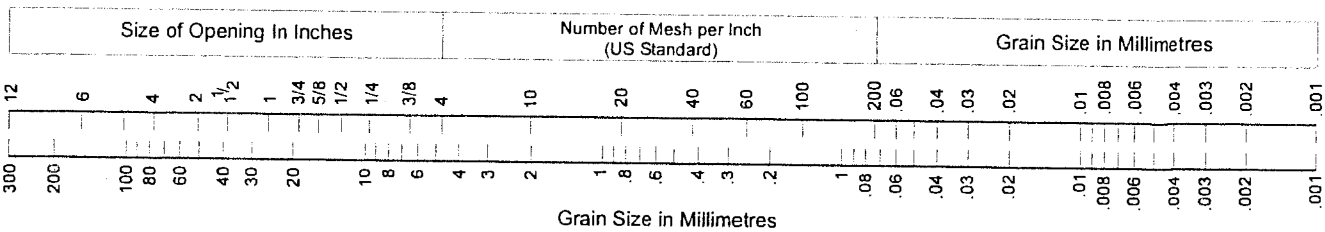
Unified Soil Classification (USC) System
Soil Grain Size



COBBLES	GRAVEL	SAND	SILT and CLAY
Coarse-Grained Soils			Fine-Grained Soils

Coarse-Grained Soils

G W	G P	G M	G C	S W	S P	S M	S C
Clean GRAVEL <5% fines		GRAVEL with >12% fines		Clean SAND <5% fines		SAND with >12% fines	
GRAVEL >50% coarse fraction larger than No. 4				SAND >50% coarse fraction smaller than No. 4			
Coarse-Grained Soils >50% larger than No. 200 sieve							

G W and S W $\left(\frac{D_{60}}{D_{10}}\right)$ >4 for G W, >6 for S W & $1 \leq \left(\frac{(D_{30})^2}{D_{10} \times D_{60}}\right) \leq 3$

G P and S P Clean GRAVEL or SAND not meeting requirements for G W and S W

G M and S M Atterberg limits below A line with PI <4

G C and S C Atterberg limits above A Line with PI >7

* Coarse-grained soils with percentage of fines between 5 and 12 are considered borderline cases requiring use of dual symbols.

D_{10}, D_{30}, and D_{60} are the particles diameter of which 10, 30, and 60 percent, respectively, of the soil weight are finer.

Fine-Grained Soils

M L	C L	O L	M H	C H	O H	Pt
SILT	CLAY	Organic	SILT	CLAY	Organic	Highly Organic Soils
Soils with Liquid Limit <50%			Soils with Liquid Limit >50%			
Fine-Grained Soils >50% smaller than No. 200 sieve						

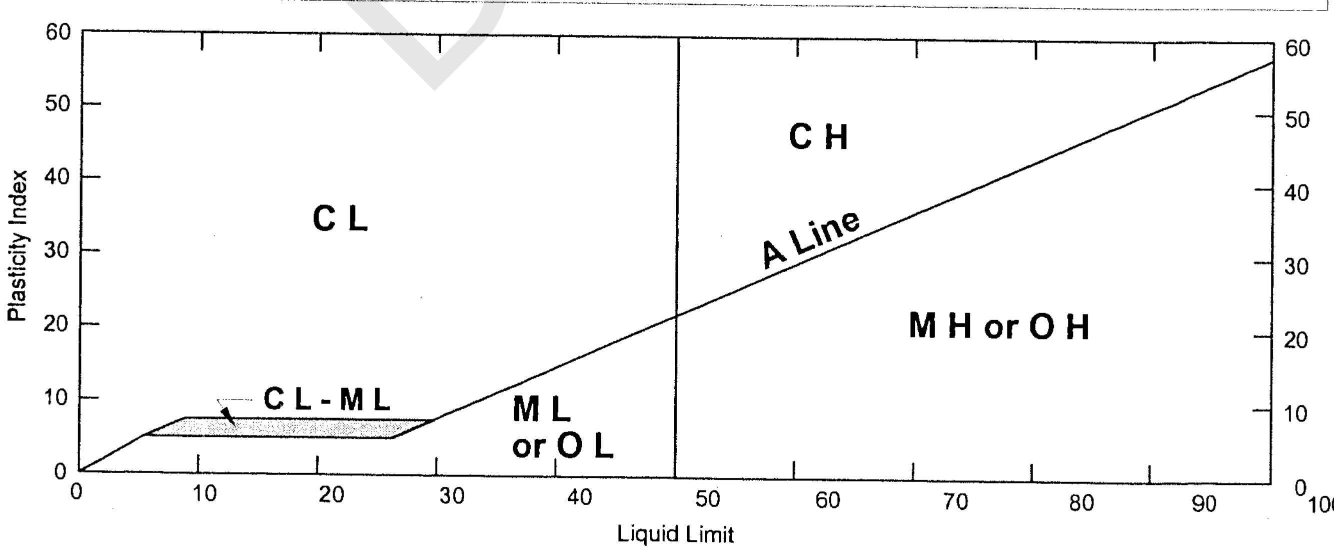


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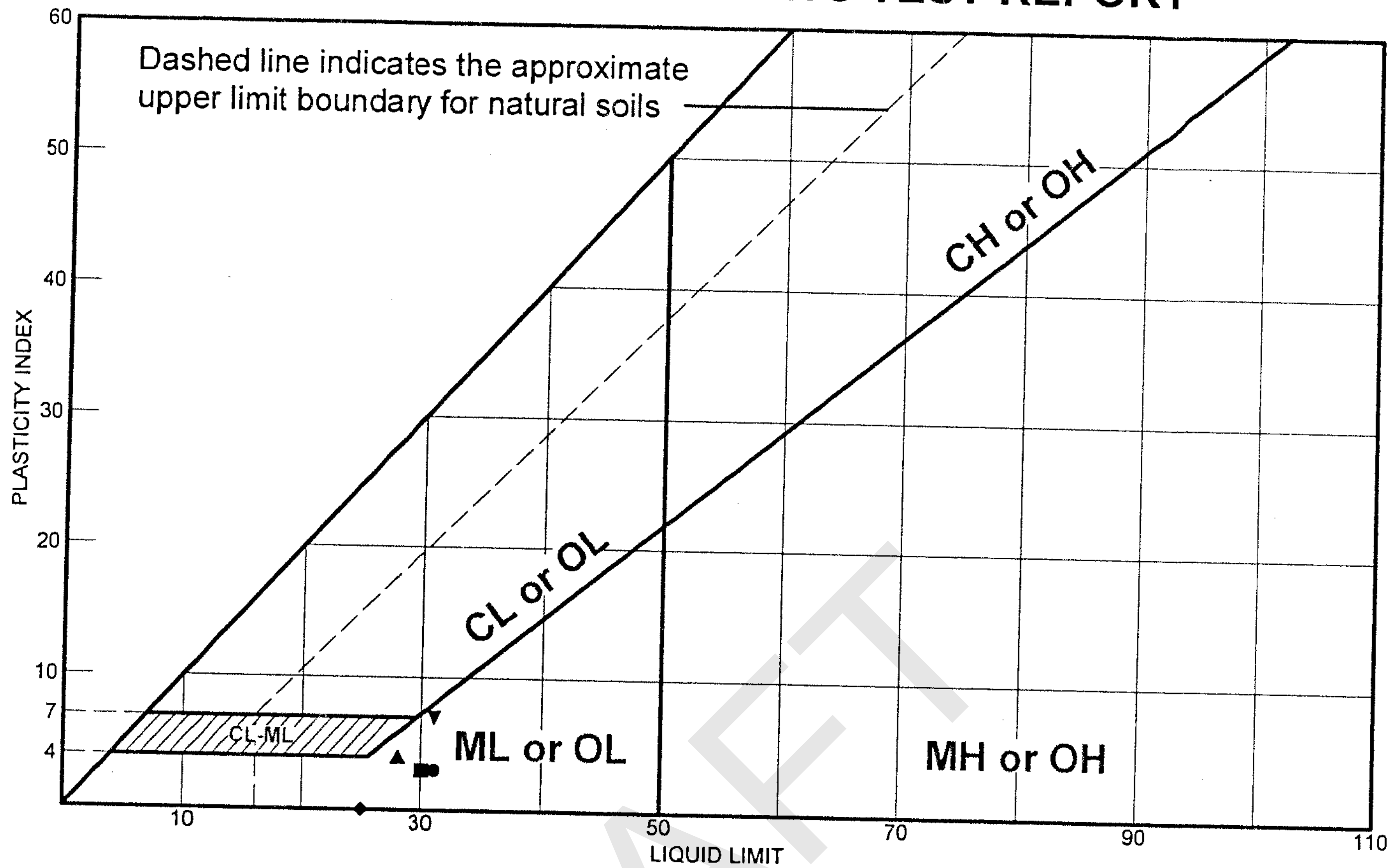
Figure B-1

Grain Size (B-1).cdr

LIQUID AND PLASTIC LIMITS TEST REPORT



Location + Description	LL	PL	PI	-200	USCS
● Source: HC04-13 Sample No.: S-9 Elev./Depth: 32.5' SILT	31	28	3		ML
■ Source: HC04-13 Sample No.: S-10 Elev./Depth: 37.5 SILT	30	27	3		ML
▲ Source: HC04-14 Sample No.: S-6 Elev./Depth: 22.5' Sandy SILT	28	24	4	62.7	ML
◆ Source: HC04-14 Sample No.: S-8 Elev./Depth: 32.5' Sandy SILT	25	26	NP		ML
▼ Source: HC04-15 Sample No.: S-7B Elev./Depth: 28.5'	31	24	7		ML

Remarks:

●
■
▲
◆
▼

Project: Terminal 3 and Terminal 4 Redevelopment

Client: BERGER/ABAM Engineers, Inc.

Location: Tacoma, WA

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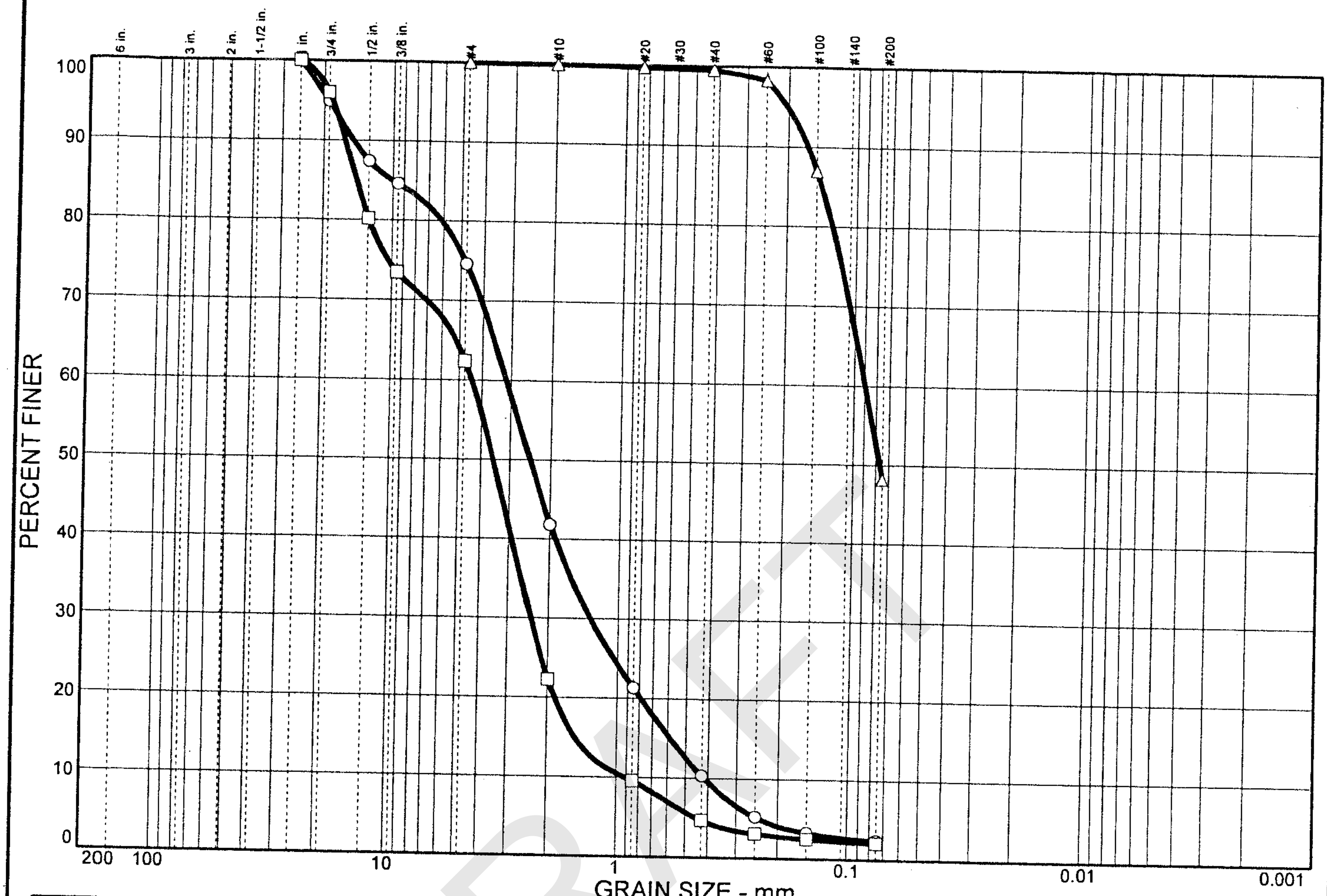
Figure No. B-2

Particle Size Distribution Report



	% COBBLES	% GRAVEL CRS.	% GRAVEL FINE	% SAND CRS.	% SAND MEDIUM	% SAND FINE	% FINES SILT	% FINES CLAY
○	0.0	5.1	20.3	32.8	31.5	7.9	2.4	
□	0.0	4.0	33.6	40.1	17.6	2.6	2.1	
△	0.0	0.0	0.0	0.1	0.4	51.3	48.2	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			10.0	3.16	2.48	1.32	0.587	0.415	1.33	7.60
□			14.3	4.44	3.55	2.40	1.52	0.909	1.43	4.88
△			0.142	0.0899	0.0771					

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
○ Gravelly SAND	SW	10%
□ Very gravelly, medium to coarse SAND	SP	14%
△ Very silty, fine SAND	SM	32%

Remarks:

○ Small sample size

□ Small sample size

△

Project: Terminal 3 and Terminal 4 Redevelopment

Client: BERGER/ABAM Engineers, Inc.

○ **Source:** HC04-01 **Sample No.:** S-3 **Elev./Depth:** 8.5'

□ **Source:** HC04-01 **Sample No.:** S-8 **Elev./Depth:** 21.0'

△ **Source:** HC04-01 **Sample No.:** S-25 **Elev./Depth:** 68.5'

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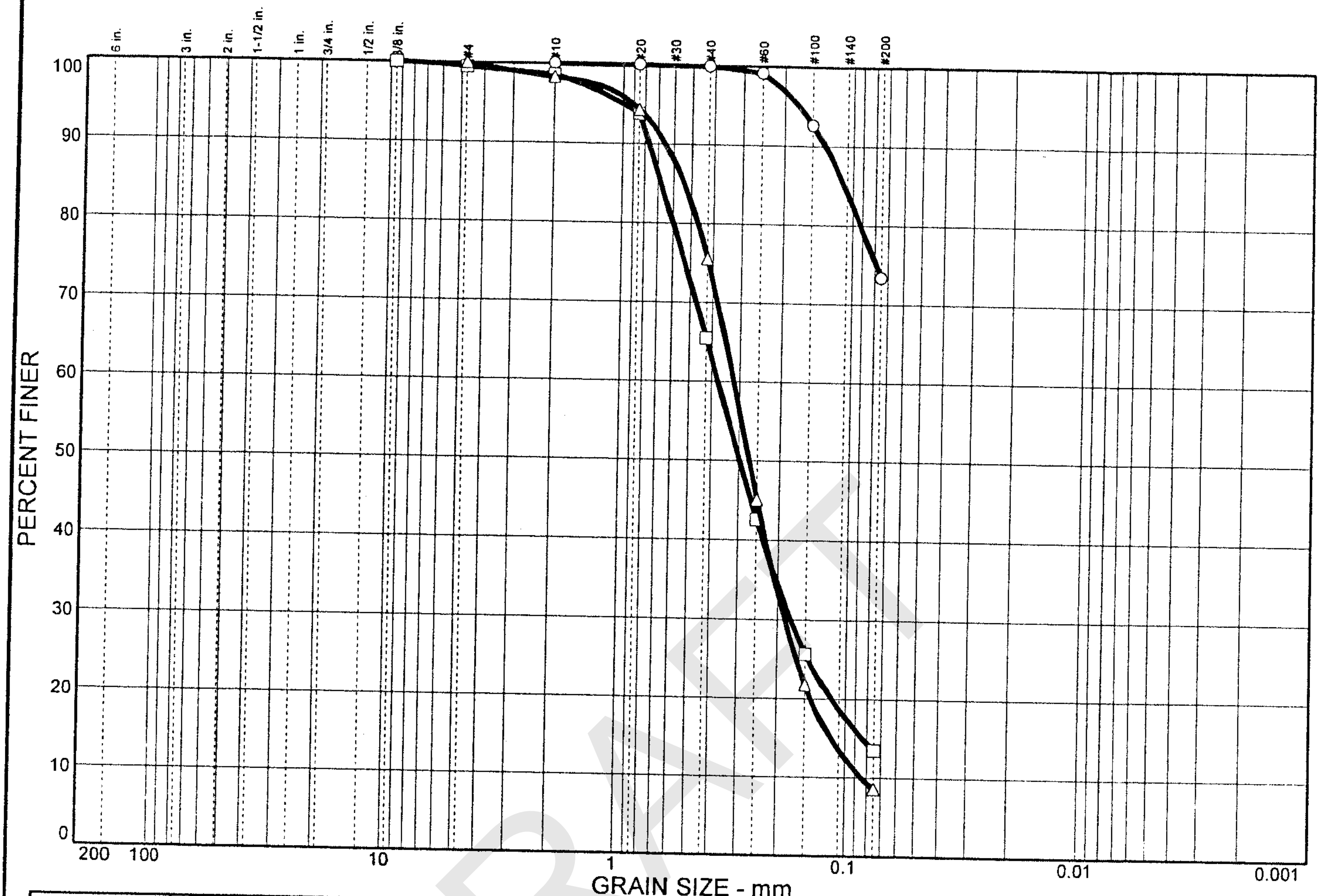
Figure No. B-3

Particle Size Distribution Report



	% COBBLES	% GRAVEL CRS.	% GRAVEL FINE	% SAND CRS.	% SAND MEDIUM	% SAND FINE	% FINES SILT	% FINES CLAY
○	0.0	0.0	0.0	0.0	0.1	26.5	73.4	
□	0.0	0.0	0.5	0.9	33.1	52.0	13.5	
△	0.0	0.0	0.0	1.7	22.7	67.0	8.6	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.109							
□			0.679	0.375	0.299	0.175	0.0836			
△			0.540	0.321	0.272	0.186	0.115	0.0839	1.28	3.82

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
○ Sandy SILT	ML	32%
□ Silty, medium to fine SAND	SM	26%
△ Slightly silty, medium to fine SAND	SP-SM	5%

Remarks:
○
□
△

Project: Terminal 3 and Terminal 4 Redevelopment

Client: BERGER/ABAM Engineers, Inc.

○ **Source:** HC04-01 **Sample No.:** S-32 **Elev./Depth:** 98.5'
□ **Source:** HC04-02 **Sample No.:** S-7 **Elev./Depth:** 17.5'
△ **Source:** HC04-05 **Sample No.:** S-1 **Elev./Depth:** 2.5'

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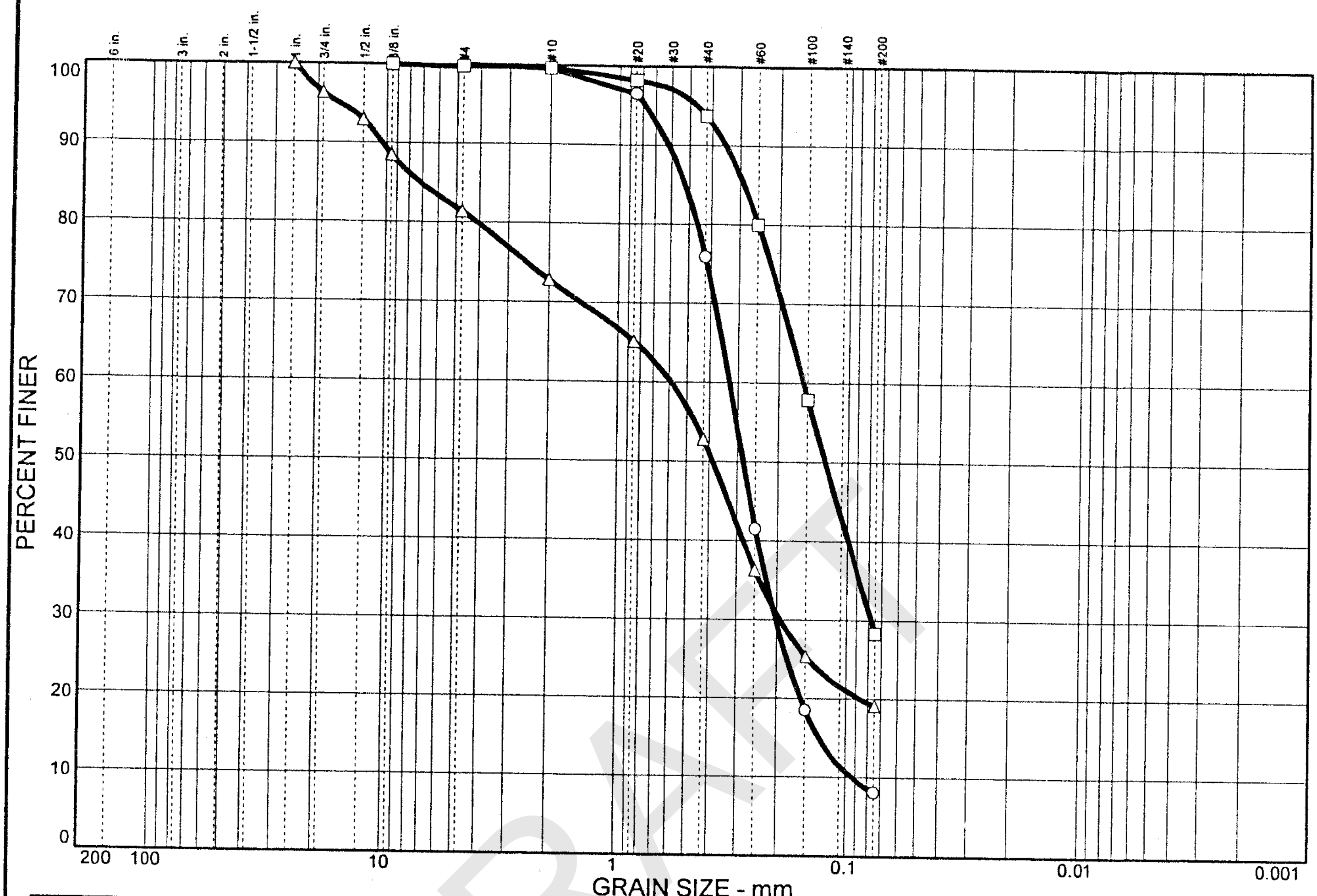
Figure No. B-4

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	0.4	23.7	67.8	8.1	
□	0.0	0.0	0.2	0.2	5.9	65.4	28.3	
△	0.0	3.7	14.9	8.6	20.0	33.7	19.1	

☒	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.524	0.329	0.285	0.203	0.130	0.0933	1.34	3.53
□			0.290	0.157	0.125	0.0781				
△			7.15	0.589	0.386	0.194				

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
○ Slightly silty, medium to fine SAND	SP-SM	4%
□ Silty, medium to fine SAND	SM	15%
△ Gravelly, silty SAND	SM	7%

Remarks:

○

□

△ Small sample size

Project: Terminal 3 and Terminal 4 Redevelopment

Client: BERGER/ABAM Engineers, Inc.

○ **Source:** HC04-06 **Sample No.:** S-1 **Elev./Depth:** 2.5'

□ **Source:** HC04-07 **Sample No.:** S-1 **Elev./Depth:** 2.5'

△ **Source:** HC04-08 **Sample No.:** S-1 **Elev./Depth:** 2.5'

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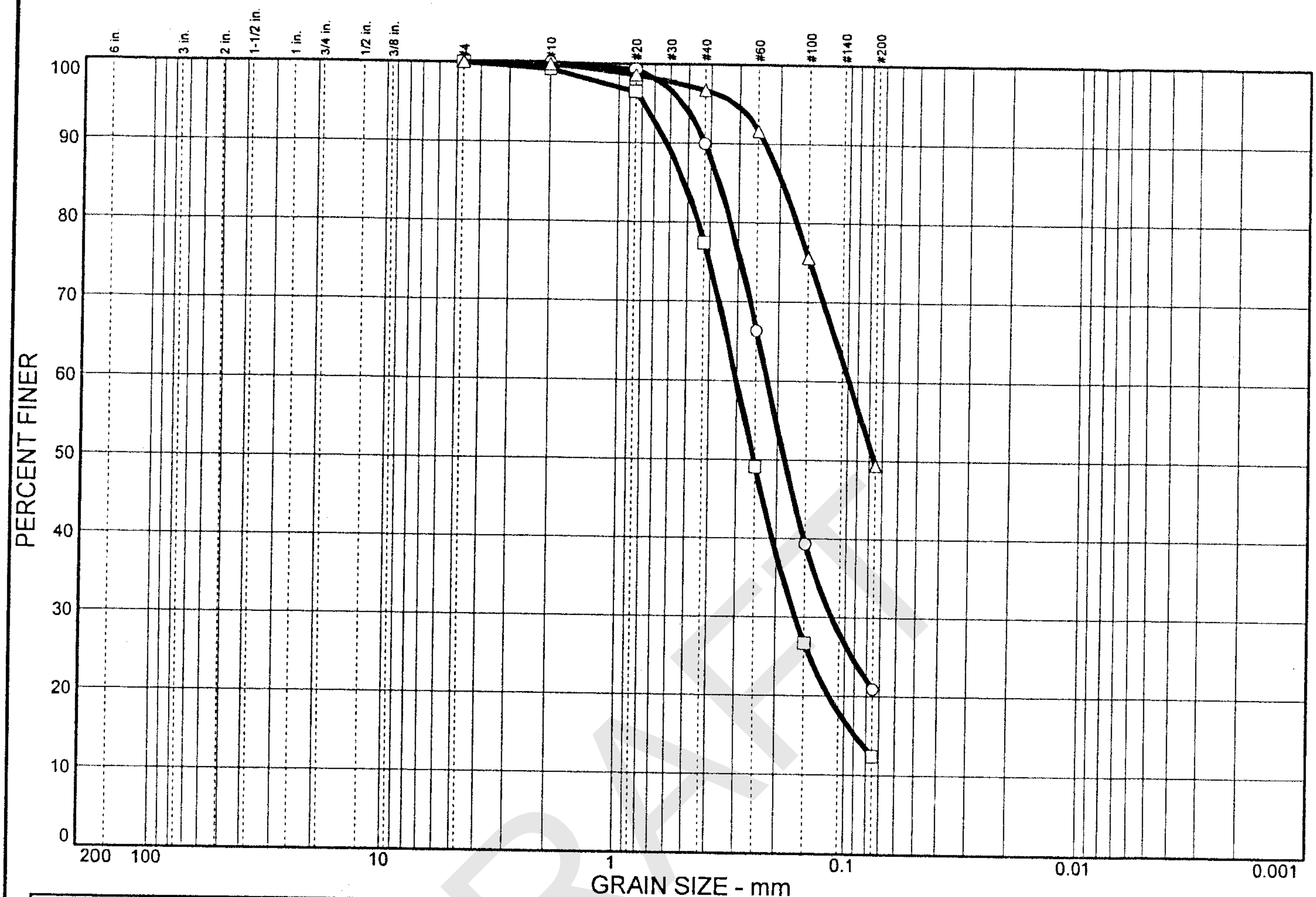
Figure No. B-5

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	0.0	10.1	69.0	20.9	
□	0.0	0.0	0.0	0.8	21.8	65.0	12.4	
△	0.0	0.0	0.0	0.2	3.1	47.3	49.4	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.369	0.223	0.187	0.115				
□			0.521	0.304	0.254	0.165	0.0891			
△			0.196	0.0991	0.0762					

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
○ Silty, medium to fine SAND	SM	9%
□ Silty, medium to fine SAND	SM	7%
△ Very silty, fine SAND	SM	24%

Remarks:

○

□

△

Project: Terminal 3 and Terminal 4 Redevelopment

Client: BERGER/ABAM Engineers, Inc.

○ **Source:** HC04-09 **Sample No.:** S-1 **Elev./Depth:** 2.5'

□ **Source:** HC04-10 **Sample No.:** S-1 **Elev./Depth:** 2.5'

△ **Source:** HC04-11 **Sample No.:** S-1 **Elev./Depth:** 2.5'

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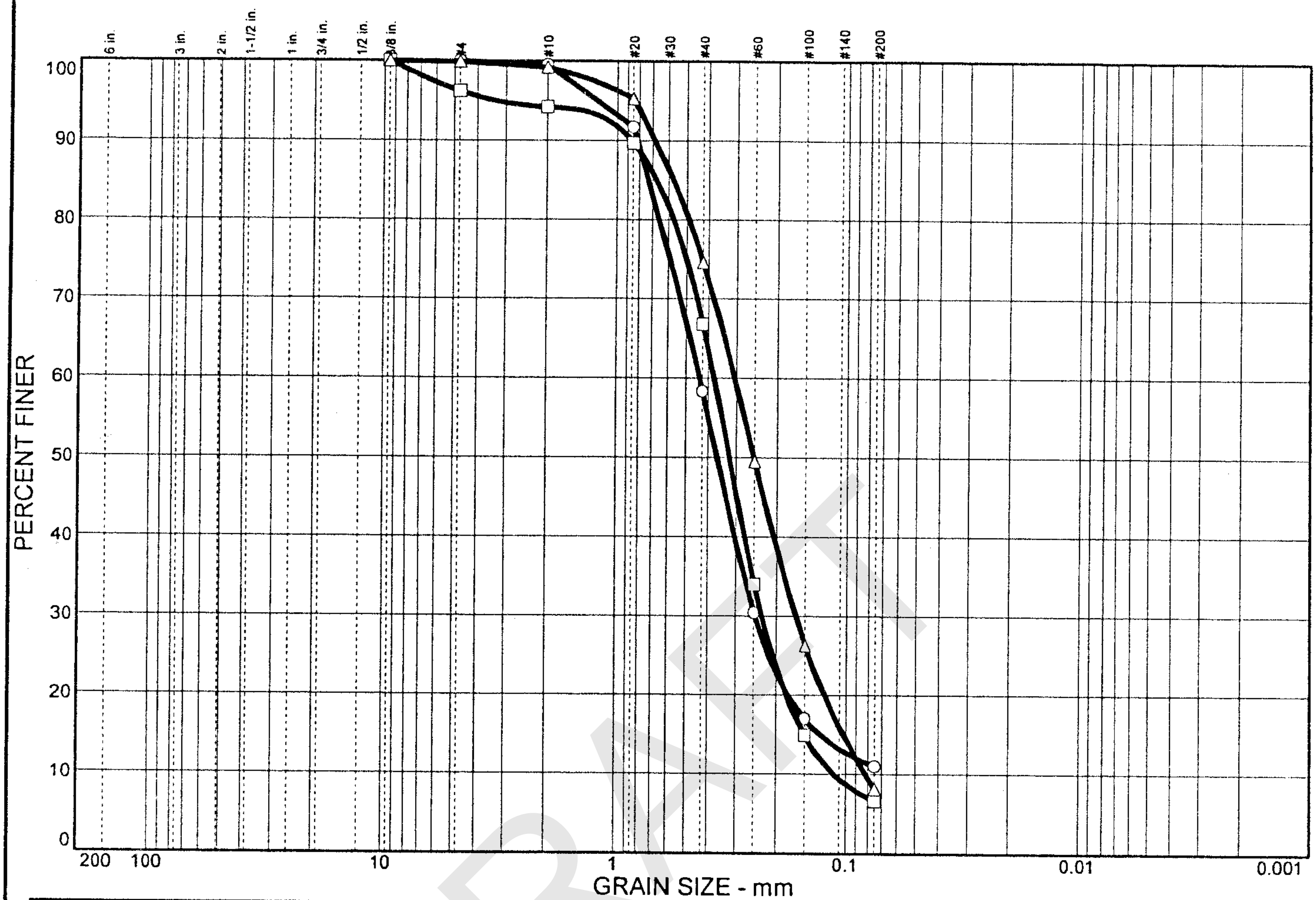
Figure No. B-6

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	0.5	41.2	47.3	11.0	
□	0.0	0.0	3.8	2.0	27.4	60.2	6.6	
△	0.0	0.0	0.1	0.7	24.6	66.5	8.1	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.733	0.439	0.366	0.248	0.129			
□			0.675	0.379	0.324	0.231	0.151	0.112	1.26	3.37
△			0.574	0.308	0.253	0.165	0.103	0.0821	1.07	3.75

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
○ Slightly silty, medium to fine SAND	SP-SM	5%
□ Slightly silty, medium to fine SAND	SP-SM	23%
△ Slightly silty, medium to fine SAND	SP-SM	23%

Remarks:

○

□

△

Project: Terminal 3 and Terminal 4 Redevelopment

Client: BERGER/ABAM Engineers, Inc.

	Source	Sample No.	Elev./Depth
○	HC04-12	S-1	2.5'
□	HC04-13	S-5	12.5'
△	HC04-14	S-3	7.5'

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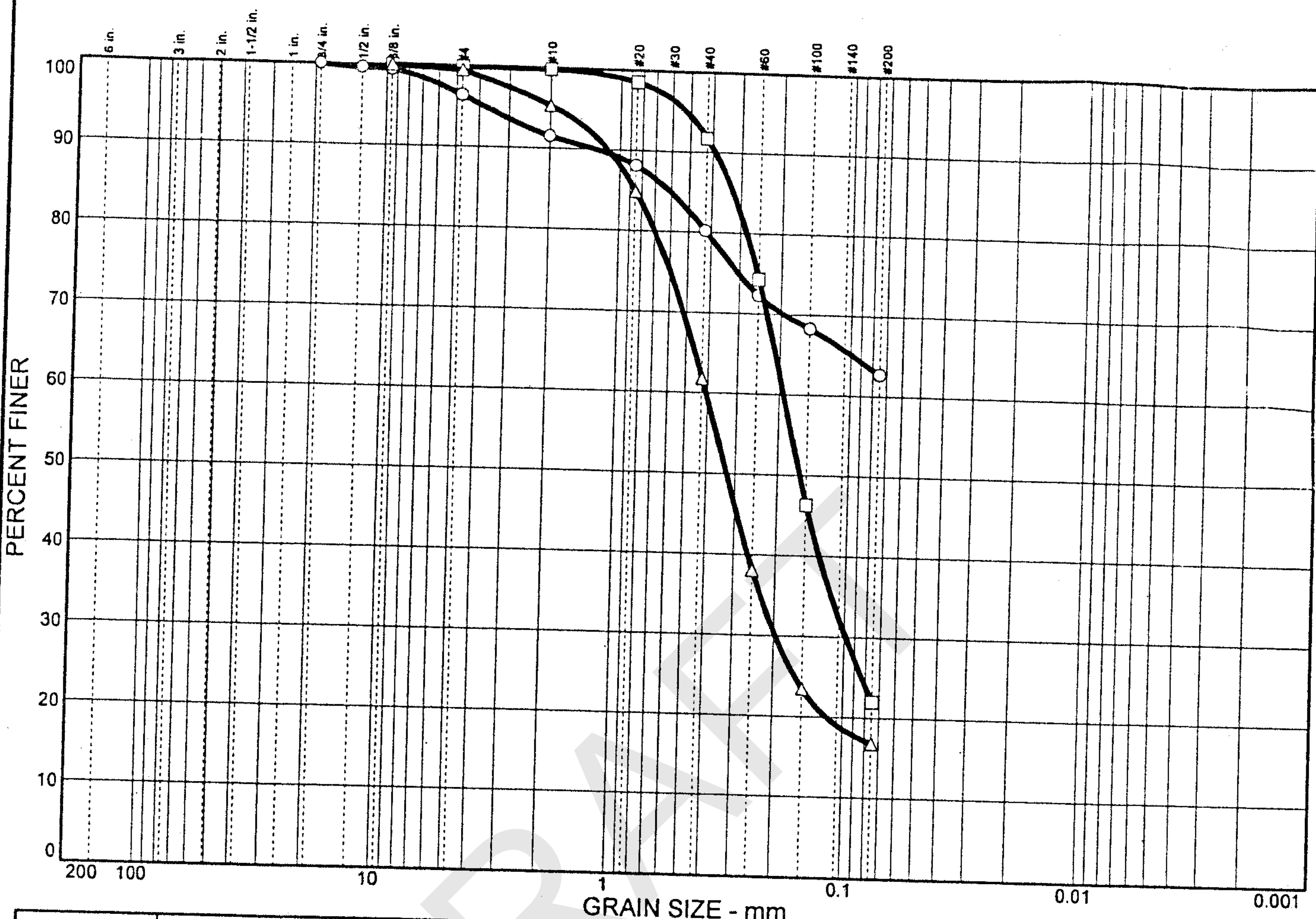
Figure No. B-7

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	3.6	4.9	11.3	17.5	62.7	
□	0.0	0.0	0.1	0.1	8.1	69.7	22.0	
△	0.0	0.0	0.5	4.2	33.5	45.0	16.8	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	28	4	0.608							
□			0.327	0.192	0.161	0.0990				
△			0.854	0.408	0.328	0.197				

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
○ Sandy SILT	ML	30%
□ Silty, medium to fine SAND	SM	30%
△ Silty, medium to fine SAND	SM	24%

Remarks:

○ +# 40 material mostly shells

□

△

Project: Terminal 3 and Terminal 4 Redevelopment

Client: BERGER/ABAM Engineers, Inc.

○ **Source:** HC04-14 **Sample No.:** S-6 **Elev./Depth:** 22.5'

□ **Source:** HC04-15 **Sample No.:** S-4 **Elev./Depth:** 12.5'

△ **Source:** HC04-15 **Sample No.:** S-5 **Elev./Depth:** 17.5'

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Figure No. B-8

APPENDIX C
EXPLORATIONS BY OTHERS

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

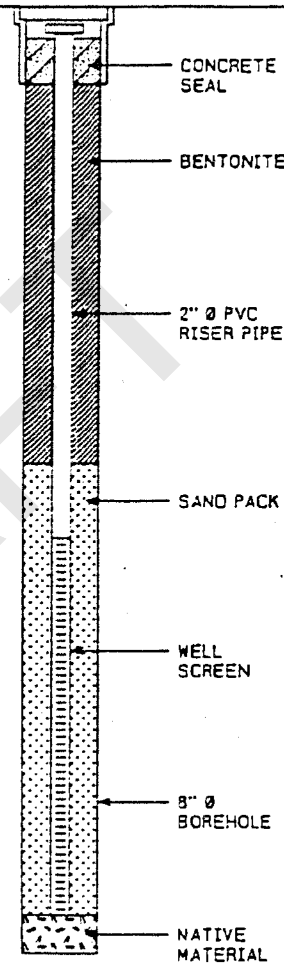
(WL-01)

PROJECT NAME: PORT OF TACOMA - SLIP 1
PROJECT NUMBER: 15403-20
CLIENT: PORT OF TACOMA/OCC
LOCATION: TACOMA, WA

HOLE DESIGNATION: MW1S-00
DATE COMPLETED: FEBRUARY 7, 2000
DRILLING METHOD: HSA
CRA SUPERVISOR: J. VANDER LINDEN

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. MLLW	SAMPLE NUMBER	STATE	'N' VALUE	PID (ppm)
	GROUND SURFACE REFERENCE POINT (Top of Riser)	18.8 18.48				
	ASPHALT	18.3				
	FILL-COARSE GRAVEL					
2.5	FILL-SAND, brown, dry	16.3				
5.0						
7.5						
10.0						
12.5						
15.0	SW-SAND (NATIVE), fine to medium grained, black, trace red and white grains, wet	3.8	1SS	X		
17.5						
20.0	- trace shells		2SS	X		
22.5						
	ML/SW-SILT and SAND, fine grained, gray, wet	-5.2	3SS	X		
25.0	END OF HOLE @ 25.0ft BGS	-6.2				
27.5						
30.0						
32.5						

MONITOR INSTALLATION



SCREEN DETAILS
Screened interval:
14.0 to 24.0ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
12.0 to 24.0ft BGS
Material: #20 Silica Sand

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▽ STATIC WATER LEVEL ▼

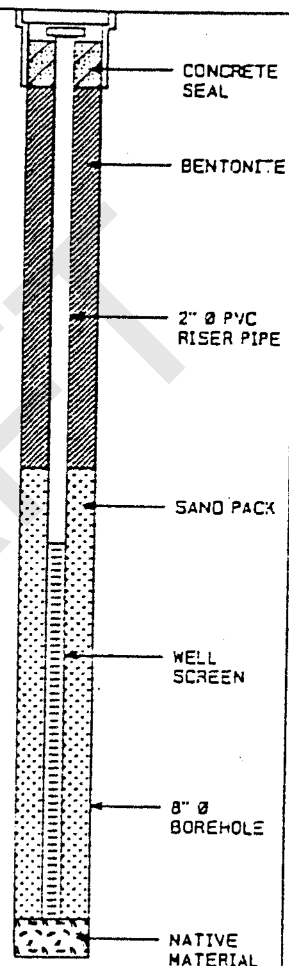
STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: PORT OF TACOMA - SLIP 1
PROJECT NUMBER: 15403-20
CLIENT: PORT OF TACOMA/OCC
LOCATION: TACOMA, WA

HOLE DESIGNATION: MW2S-00
DATE COMPLETED: FEBRUARY 8, 2000
DRILLING METHOD: HSA
CRA SUPERVISOR: J. VANDER LINDEN

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. MLLW
	GROUND SURFACE REFERENCE POINT (Top of Riser)	17.6 17.30
	ASPHALT	17.1
	FILL-SAND, brown	
-2.5		
-5.0		12.1
	ML-SILT, gray, laminated	11.6
	SW-SAND, medium grained, brown, moist	10.5
-7.5	SW/ML-SILT and SAND (NATIVE), fine grained, gray, trace red and white sand grains, wet	
-10.0		
-12.5		3.6
-15.0	SW-SAND, little silt, fine grained, black, trace red and white sand grains, wet	
-17.5	ML-SILT, trace fine sand, trace shells, gray, wet	.5
	SW/ML-SILT and SAND, fine grained, gray, wet	-.4
-20.0	SW-SAND, medium grained, black, trace red and white sand grains, wet	-2.9
-22.5	ML-SILT, trace fine sand, trace shells, gray	-6.0
-25.0	END OF HOLE @ 25.0ft BGS	-7.4
-27.5		
-30.0		
-32.5		

MONITOR INSTALLATION



SCREEN DETAILS
Screened interval:
14.0 to 24.0ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
12.0 to 24.0ft BGS
Material: #20 Silica Sand

SAMPLE

NUMBER	STATE	'N' VALUE	PID (ppm)
1SS	X	>83	
2SS	X	34	
3SS	X	33	
4SS	X	34	
5SS	X	37	
6SS	X	16	
7SS	X	16	
8SS	X	39	
9SS	X	26	

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE. REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

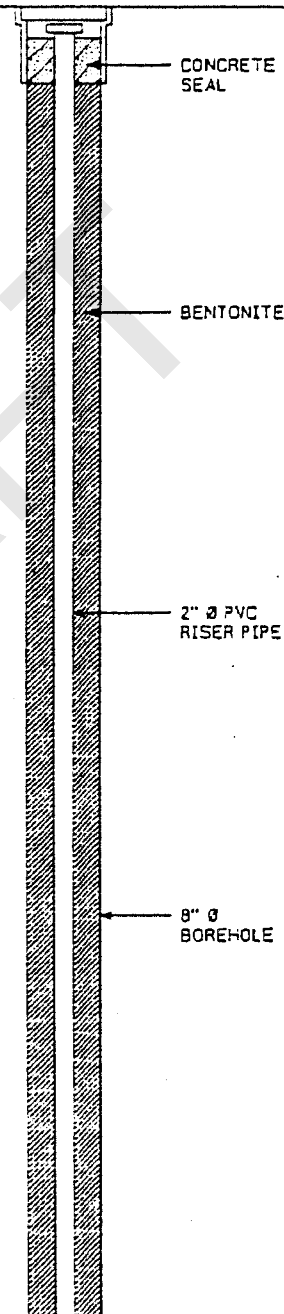
PROJECT NAME: PORT OF TACOMA – SLIP I
PROJECT NUMBER: 15403-20
CLIENT: PORT OF TACOMA/OCC
LOCATION: TACOMA, WA

HOLE DESIGNATION: MW3D-00
DATE COMPLETED: FEBRUARY 9, 2000
DRILLING METHOD: HSA
CRA SUPERVISOR: J. VANDER LINDEN

DEPTH ft. BGS: -2.5, -5.0, -7.5, -10.0, -12.5, -15.0, -17.5, -20.0, -22.5, -25.0, -27.5, -30.0, -32.5

STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. MLLW
GROUND SURFACE REFERENCE POINT (Top of Riser)	18.4 18.16
ASPHALT	17.9
FILL-GRAVEL, coarse grained, dry	17.4
FILL-SAND, trace gravel, brown, dry	
SW-SAND (NATIVE), medium grained, brown, trace red and white grains, trace shells, dry – moist	14.4
ML-SILT, gray, laminated – wet – trace shells, black	12.0
SW-SAND, trace shells, medium grained, black, trace red and white grains, wet	2.6
ML/SW-SILT and SAND, fine grained, gray/black	1.4
SW-SAND, black, trace red and white grains, wet	-2.8
ML-SILT, little fine sand, gray, wet	-4.4
SW-SAND, medium to coarse grained, black, trace red and white grains, wet	-7.6
SP-SAND, trace shells, fine to medium grained, black, trace red and white grains, wet	-8.1
SP/ML-SILT and SAND, trace shells and wood pieces, fine grained, gray	-12.1
SP-SAND, little silt, trace wood pieces, fine grained, black/gray, trace red and white grains, wet	-13.6

MONITOR INSTALLATION



SAMPLE NUMBER	STATE	'N' VALUE	PID (ppm)
1SS		35	
2SS		28	
3SS		30	
4SS		28	
5SS		38	
6SS		25	
7SS		22	
8SS		32	
9SS		8	
10SS		13	
11SS		21	
12SS		26	
13SS		20	
14SS		12	
15SS		42	
16SS		47	
17SS		68	
18SS		>50	
19SS		>83	
20SS		58	

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ⊻ STATIC WATER LEVEL ▼

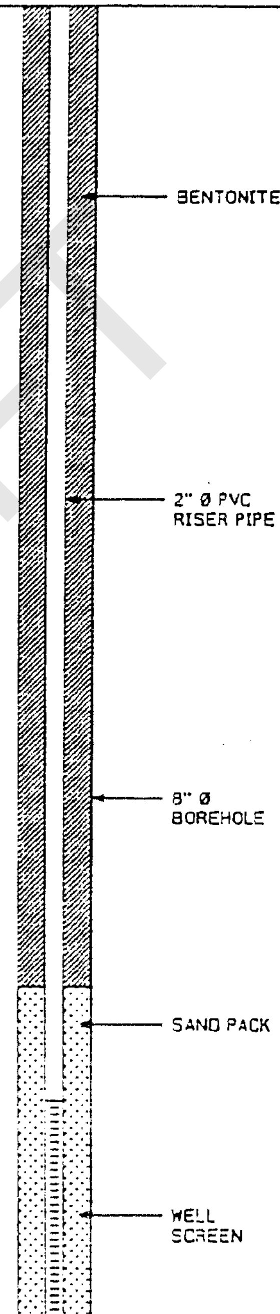
STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: PORT OF TACOMA - SLIP 1
PROJECT NUMBER: 15403-20
CLIENT: PORT OF TACOMA/OCC
LOCATION: TACOMA, WA

HOLE DESIGNATION: MW3D-00
DATE COMPLETED: FEBRUARY 9, 2000
DRILLING METHOD: HSA
CRA SUPERVISOR: J. VANDER LINDEN

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. MLLW	SAMPLE NUMBER	STATE	'N' VALUE	PID (ppm)
			21SS		82	
-37.5			22SS		>50	
			23SS		23	
-40.0	- more silt		24SS		14	
	- trace shells		25SS		>50	
-42.5			26SS		>50	
-45.0						
-47.5						
-50.0	SW-SAND, medium to fine grained, black, trace red and white grains, wet	-30.6	27SS		>50	
-52.5						
-55.0			28SS		>50	
-57.5						
-60.0			29SS		31	
-62.5						
-65.0						
	ML-SILT, gray, wet	-47.4 / -47.5	30SS		>76	
-67.5	SW-SAND, medium to fine grained, black, trace red and white grains, wet	-48.6 / -48.9	31SS		60	
	ML-SILT, gray, wet		32SS		37	
			33SS		20	

MONITOR INSTALLATION



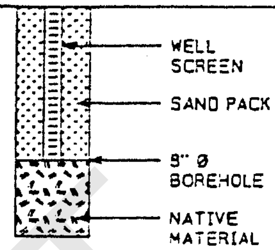
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE, REFER TO CURRENT ELEVATION TABLE
WATER FOUND ⊻ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: PORT OF TACOMA - SLIP 1
PROJECT NUMBER: 15403-20
CLIENT: PORT OF TACOMA/OCC
LOCATION: TACOMA, WA

HOLE DESIGNATION: MW3D-00
DATE COMPLETED: FEBRUARY 9, 2000
DRILLING METHOD: HSA
CRA SUPERVISOR: J. VANDER LINDEN

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. MLLW	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	SW-SAND, medium to fine grained, black, trace red and white grains, wet			33SS	X	20	
72.5				34SS	X	28	
		-55.7		35SS	X	18	
75.0	ML-SILT, gray, wet	-56.1		36SS	X	76	
	SW/ML-SILT and SAND, fine grained, gray, wet	-57.6					
	END OF HOLE @ 76.0ft BGS						
77.5							
80.0							
82.5							
85.0							
87.5							
90.0							
92.5							
95.0							
97.5							
100.0							
102.5							



SCREEN DETAILS
Screened interval:
64.0 to 74.0ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
61.0 to 74.0ft BGS
Material: #20 Silica Sand

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

(WL-04)
Page 1 of 1

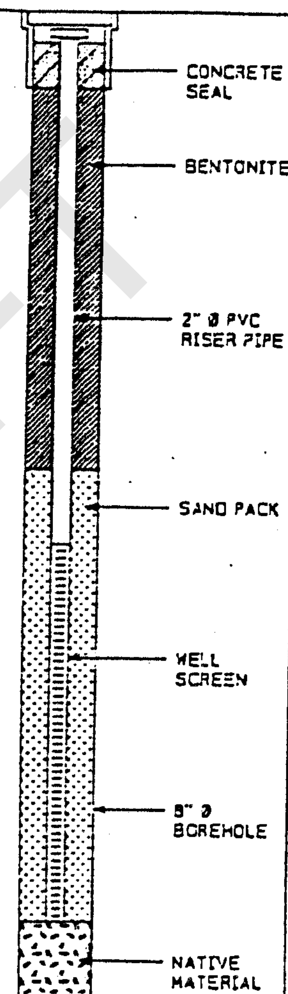
PROJECT NAME: PORT OF TACOMA - SLIP 1
PROJECT NUMBER: 15403-20
CLIENT: PORT OF TACOMA/OCC
LOCATION: TACOMA, WA

HOLE DESIGNATION: MW4S-00
DATE COMPLETED: FEBRUARY 8, 2000
DRILLING METHOD: HSA
CRA SUPERVISOR: J. VANDER LINDEN

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. MLLW
	GROUND SURFACE REFERENCE POINT (Top of Riser)	17.9 17.63
	ASPHALT	17.4
	FILL-SAND and GRAVEL, coarse grained, dry	
	FILL-SAND and GRAVEL, brown, dry	13.9
	FILL-SAND, some fine gravel, coarse grained, black, wet	10.9
	SP-SAND (NATIVE), trace wood pieces, coarse to medium grained, black, trace red and white grains, wet - trace shells, medium to fine grained - trace silt	4.0
	ML-SILT, trace to little fine sand, gray	-7.7
	END OF HOLE @ 26.0ft BGS	-8.1

Depth scale (ft. BGS): 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0, 22.5, 25.0, 27.5, 30.0, 32.5

MONITOR INSTALLATION



SCREEN DETAILS
Screened interval:
14.0 to 24.0ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
12.0 to 24.0ft BGS
Material: #20 Silica Sand

SAMPLE

NUMBER	STATE	'N' VALUE	PID (ppm)
1SS		30	
2SS		33	
3SS		49	
4SS		41	
5SS		24	
6SS		25	
7SS		10	
8SS		12	
9SS		22	
10SS		24	
11SS		38	
12SS		18	
13SS		27	
14SS		12	

DRAFT

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE, REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▽ STATIC WATER LEVEL ▼

www.hartcrowser.com

Geotechnical Data Report

Port of Tacoma: Pier 4 Reconfiguration

Tacoma, Washington

Prepared for

KPFF Consulting Engineers

September 18, 2014
17916-01

Prepared by

Hart Crowser, Inc.

Garry E. Horvitz, PE, LEG
Senior Principal
Geotechnical Engineer

Douglas D. Lindquist, PE, LEED AP
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Geotechnical Engineer

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Project
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1700 Westlake Avenue North, Suite 200
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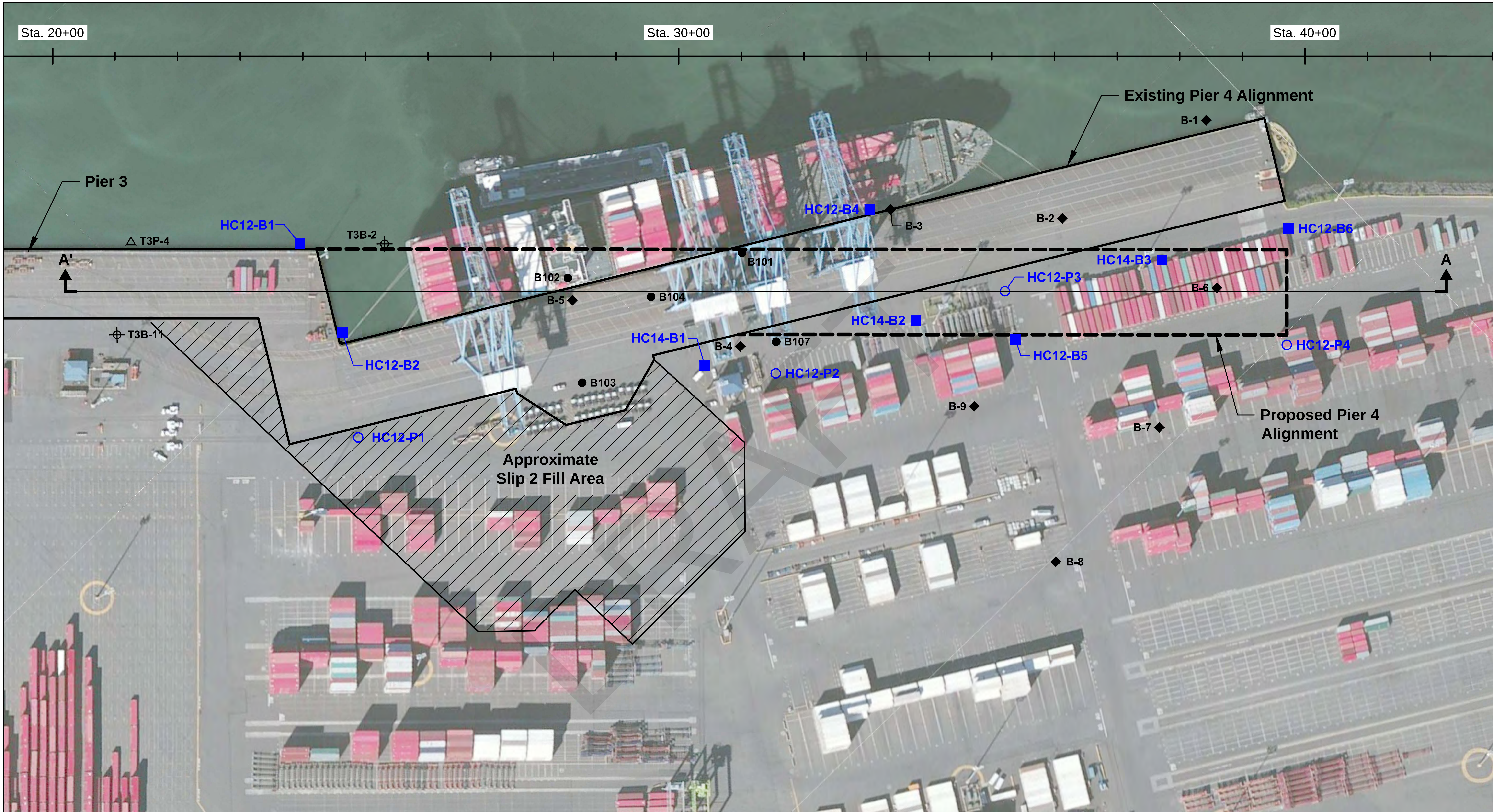

Exploration Location and Number

HC14-B1 ■ Boring (Current Study)

HC12-P3 ○ CPT Probe (Current Study)

HC05-01 Boring (Hart Crowser 2004-2005)

T3B-1 Boring (Hart Crowser 1986)

T3P-1 △ CPT Probe (Hart Crowser 1986)

B101 ● Boring (Hart Crowser 1980)

B-1 ◆ Boring (Dames & Moore 1967)

Project North

0 150 300

Scale in Feet

Port of Tacoma Pier 4

Tacoma, Washington

Site and Exploration Plan

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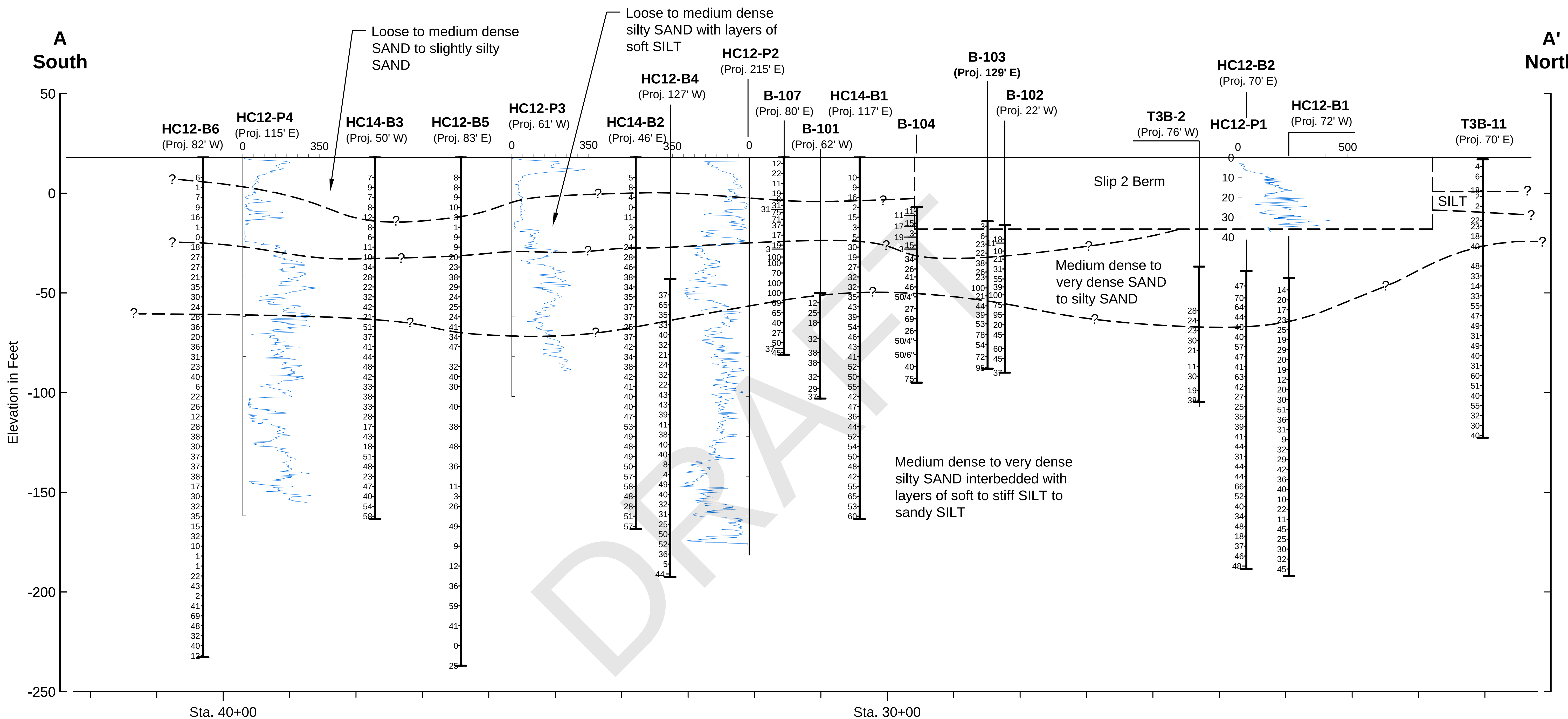
Figure

2

EAL 09/18/14 179161-002.dwg



HC12-P1 Exploration Number
(83' East) (Offset Distance and Direction)

CPT Tip Resistance in Tons per Square Foot

B-102 Exploration Number
(83' East) (Offset Distance and Direction)

9

Standard Penetration Resistance in Blows per Foot

Horizontal Scale in Feet
0 150 300

0 50 100
Vertical Scale in Feet
Vertical Exaggeration x 3

Port of Tacoma Pier 4
Tacoma, Washington

Generalized Subsurface Profile

17916-01 9/14

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Figure
3

EAL 09/18/14 1791601-003.dwg

ATTACHMENT 2
Shear Wave Velocity Test Report

Global Geophysics
P. O. Box 2229
Redmond, WA 98073-2229
Tel: 425-890-4321
Fax: 360-805-0259

September 15, 2014 Our Ref.: 103-0108.000

Hart Crowser, Inc.
1700 Westlake Avenue North, Suite 200
Seattle, WA 98109-3056

Attention: Mr. Doug Lindquist

RE: REPORT ON THE SUSPENSION LOGGING FOR PORT OF TACOMA PIER 4

Dear Mr. Lindquist:

Global Geophysics conducted borehole suspension loggings in boreholes B5 at Port of Tacoma in January, 2013. This boring is 250 ft in depth, which were drilled with mud rotary and cased with 3 inch PVC pipes.

The objective of the geophysical investigation is to calculate the s-wave velocities using the suspension logging.

METHODOLOGY AND INSTRUMENTATION

Suspension soil velocity measurements were performed using the suspension PS logging system, manufactured by OYO Corporation, and their subsidiary, Robertson Geologging. This system directly determines the average velocity of a 3.3 feet high segment of the soil column surrounding the boring of interest by measuring the elapsed time between arrivals of a wave propagating upward through the soil column. The receivers that detect the wave, and the source that generates the wave, are moved as a unit in the boring producing relatively constant amplitude signals at all depths.

The suspension system probe consists of a combined reversible polarity solenoid horizontal shear wave source (SH) and compressional-wave source (P), joined to two biaxial receivers by a flexible isolation cylinder. The separation of the two receivers is 3.28 feet, allowing average wave velocity in the region between the receivers to be determined by inversion of the wave travel time between the two receivers. The total length of the probe as used in these surveys is 21 feet. The probe receives control signals from, and sends the receiver signals to, instrumentation on the surface via an armored 4-conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 1.3-foot circumference sheave fitted with a digital rotary encoder.

The entire probe is suspended in the boring by the cable, therefore, source motion is not coupled directly to the boring walls; rather, the source motion creates a horizontally propagating impulsive pressure wave in the fluid filling the boring and surrounding the source. This pressure wave is converted to P and SH-waves in the surrounding soil and rock as it passes through the casing and grout annulus and impinges upon the wall of the boring. These waves propagate through the soil and rock surrounding the boring, in turn causing a pressure wave to be generated in the fluid surrounding the receivers as the soil waves pass their location.

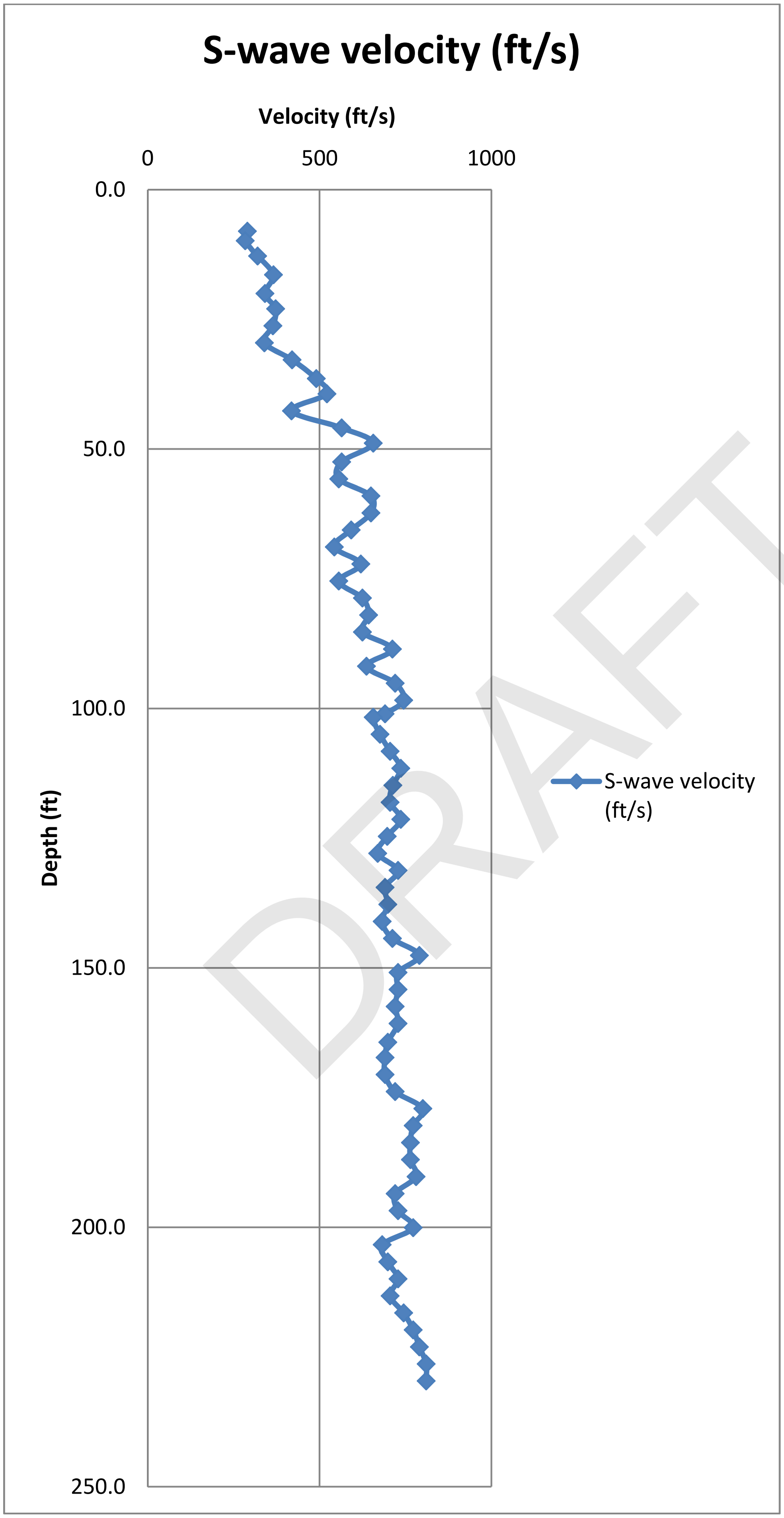
In operation, a distinct, repeatable pattern of impulses is generated at each depth as follows:
1. The source is fired in one direction producing dominantly horizontal shear with some vertical compression, and the signals from the horizontal receivers situated parallel to the axis of motion of the source are recorded.
2. The source is fired again in the opposite direction and the horizontal receiver signals are recorded.
3. The source is fired again and the vertical receiver signals are recorded. The repeated source pattern facilitates the picking of the P and SH-wave arrivals; reversal of the source changes the polarity of the SH-wave pattern but not the P-wave pattern.

RESULTS

The compressional and shear wave velocities are presented in the table below.

Depth (ft)	S-wave velocity (ft/s)	p-wave velocity (ft/s)
8.0	290	
9.8	284	
12.8	320	
16.4	366	
20.0	341	
23.0	372	
26.2	364	
29.5	339	
32.8	420	
36.4	490	
39.4	522	5127
42.6	418	5127
45.9	564	5376
48.9	656	5468
52.5	564	5376
55.8	556	5560
59.0	649	5655
62.3	649	5468
65.6	592	5753
68.9	543	5376
72.2	620	5376
75.4	556	5291
78.7	625	5468
82.0	643	5560
85.3	625	5291
88.6	712	5291
91.8	636	5468

95.1	720	5468
98.4	745	5560
101.0	690	5376
101.7	656	5468
105.0	676	5560
108.2	705	5560
111.5	736	5655
114.8	713	5468
118.1	705	5468
121.4	736	5560
124.6	697	5753
127.9	669	5468
131.2	728	5468
134.5	690	5560
137.8	699	5468
141.0	682	5376
144.3	712	5468
147.6	790	5376
150.9	728	5291
154.2	728	5376
157.4	720	5205
160.7	728	5291
164.3	699	5291
167.3	690	5291
170.6	690	5291
173.8	720	5291
177.1	800	5376
180.4	772	5376
183.7	764	5205
187.0	764	5376
190.2	781	5468
193.5	720	5291
196.8	728	5468
200.1	772	5291
203.4	682	5291
206.6	699	5127
209.9	728	5127
213.2	705	5127
216.5	745	5291
219.8	772	5291
223.0	790	5205
226.3	810	5376
229.6	810	5753


S-wave velocity (ft/s)
Velocity (ft/s)
0
500
1000
0.0
50.0
100.0
150.0
200.0
250.0
Depth (ft)
S-wave velocity (ft/s)
DRAFT

LIMITATIONS OF THE GEOPHYSICAL METHODS

Global geophysics services are conducted in a manner consistent with the level of care and skill ordinarily exercised by other members of the geophysical community currently practicing under similar conditions subject to the time limits and financial and physical constraints applicable to the services. Suspension logging is a remote sensing geophysical method that may not detect all subsurface layer changes.

Sincerely,

Global Geophysics

John Liu, Ph.D., R.G.
Principal Geophysicist

APPENDIX A
Boring Logs – Current Study

Key to Exploration Logs

Sample Description

Classification of soils in this report is based on visual field and laboratory observations which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field nor laboratory testing unless presented herein. Visual-manual classification methods of ASTM D 2488 were used as an identification guide.

Soil descriptions consist of the following:
Density/consistency, moisture, color, minor constituents, MAJOR CONSTITUENT, additional remarks.

Density/Consistency

Soil density/consistency in borings is related primarily to the Standard Penetration Resistance. Soil density/consistency in test pits and probes is estimated based on visual observation and is presented parenthetically on the logs.

SAND or GRAVEL Density	Standard Penetration Resistance (N) in Blows/Foot	SILT or CLAY Consistency	Standard Penetration Resistance (N) in Blows/Foot	Approximate Shear Strength in TSF
Very loose	0 to 4	Very soft	0 to 2	<0.125
Loose	4 to 10	Soft	2 to 4	0.125 to 0.25
Medium dense	10 to 30	Medium stiff	4 to 8	0.25 to 0.5
Dense	30 to 50	Stiff	8 to 15	0.5 to 1.0
Very dense	>50	Very stiff	15 to 30	1.0 to 2.0
		Hard	>30	>2.0

Sampling Test Symbols

- 1.5" I.D. Split Spoon
- Grab (Jar)
- 3.0" I.D. Split Spoon
- Shelby Tube (Pushed)
- Bag
- Cuttings
- Core Run

Moisture

Dry	Little perceptible moisture
Damp	Some perceptible moisture, likely below optimum
Moist	Likely near optimum moisture content
Wet	Much perceptible moisture, likely above optimum

Minor Constituents

Minor Constituents	Estimated Percentage
Trace	<5
Slightly (clayey, silty, etc.)	5 - 12
Clayey, silty, sandy, gravelly	12 - 30
Very (clayey, silty, etc.)	30 - 50

Laboratory Test Symbols

GS	Grain Size Classification
CN	Consolidation
UU	Unconsolidated Undrained Triaxial
CU	Consolidated Undrained Triaxial
CD	Consolidated Drained Triaxial
QU	Unconfined Compression
DS	Direct Shear
K	Permeability
PP	Pocket Penetrometer Approximate Compressive Strength in TSF
TV	Torvane Approximate Shear Strength in TSF
CBR	California Bearing Ratio
MD	Moisture Density Relationship
AL	Atterberg Limits Water Content in Percent Liquid Limit Natural Plastic Limit
PID	Photoionization Detector Reading
CA	Chemical Analysis
DT	In Situ Density in PCF
OT	Tests by Others

SOIL CLASSIFICATION CHART

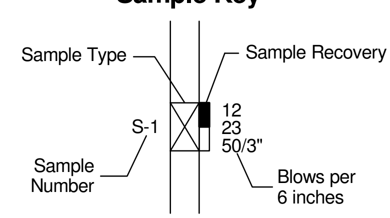
MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

Groundwater Indicators

- Groundwater Level on Date or (ATD) At Time of Drilling
- Groundwater Seepage (Test Pits)

Sample Key



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17916-01 *6/14*

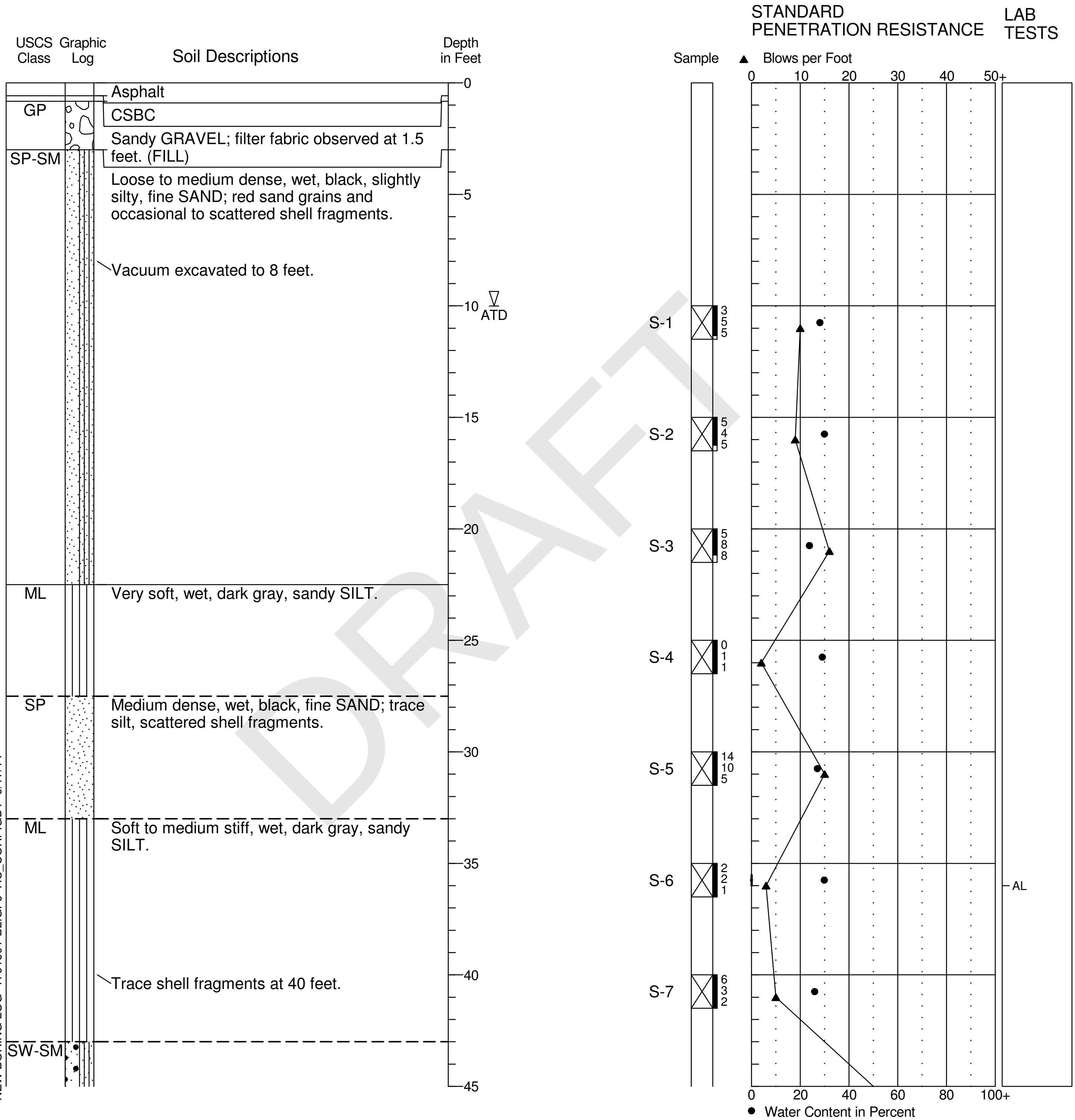
Figure A-1

KEY SHEET 1791601-BL.GPJ HC_CORP.GDT 9/17/14

Boring Log HC14-B1

Location: N 103673.45 E 1249275.92
Approximate Ground Surface Elevation: 18 Feet
Horizontal Datum: Washington State Plane
Vertical Datum: MLLW

Drill Equipment: Mobile B-29/Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: W. McDonald   Reviewed By: B. Cook



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

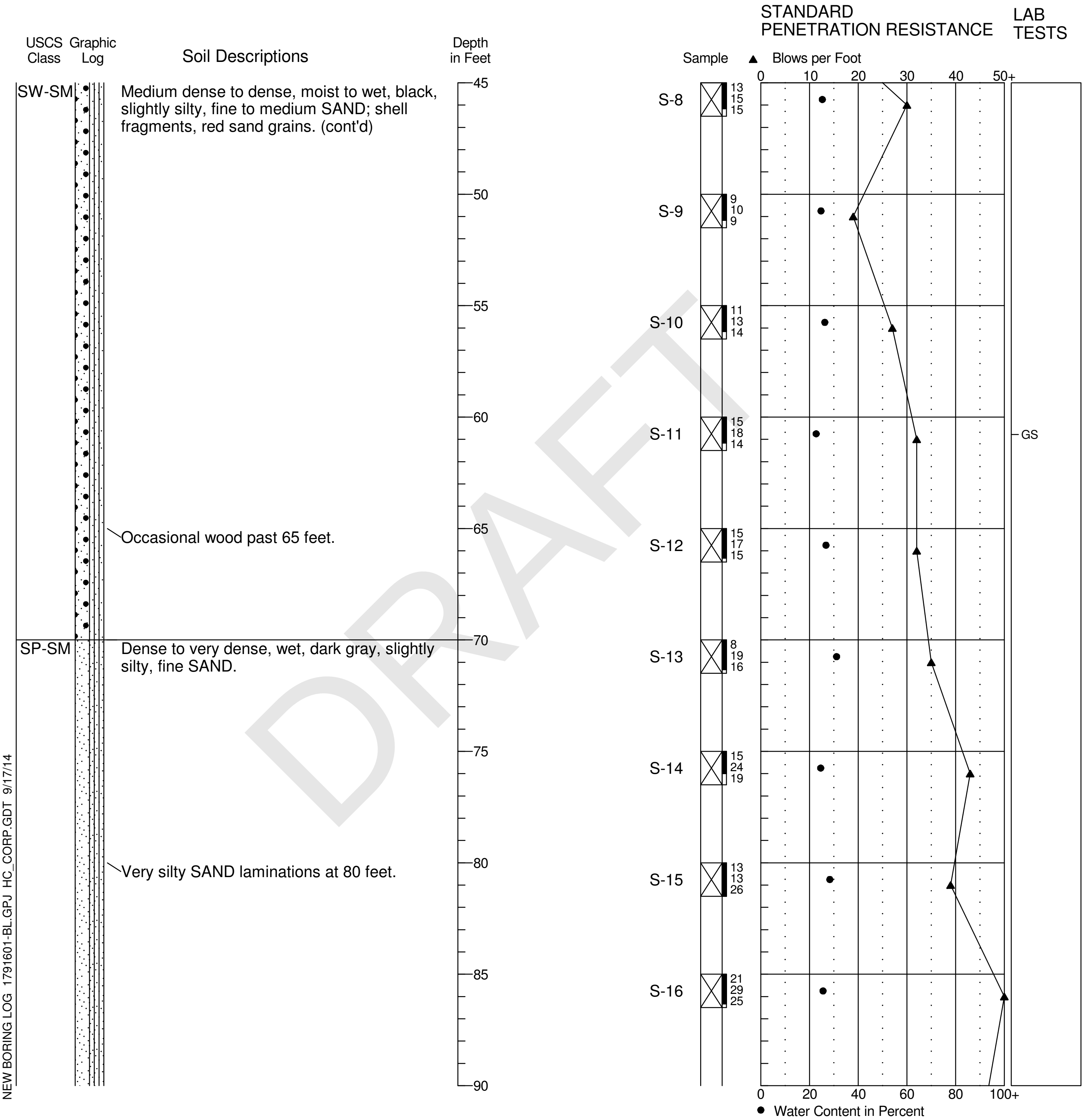
17916-01 **6/14**

Figure A-2 **1/5**

Boring Log HC14-B1

Location: N 103673.45 E 1249275.92
Approximate Ground Surface Elevation: 18 Feet
Horizontal Datum: Washington State Plane
Vertical Datum: MLLW

Drill Equipment: Mobile B-29/Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: W. McDonald   Reviewed By: B. Cook



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

17916-01   6/14
Figure A-2   2/5

Boring Log HC14-B1

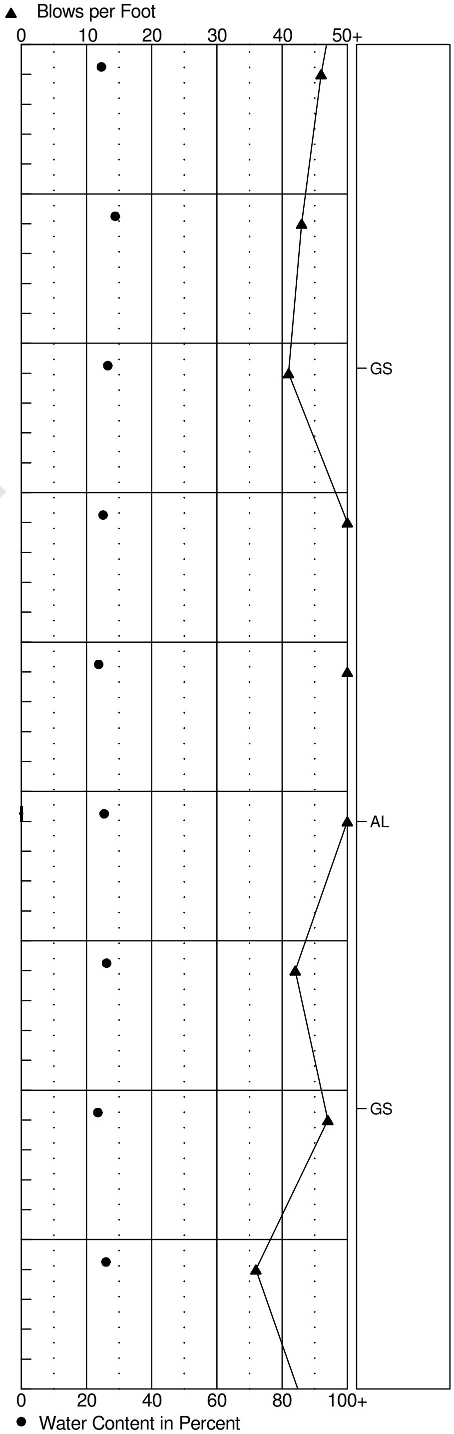
Location: N 103673.45 E 1249275.92
Approximate Ground Surface Elevation: 18 Feet
Horizontal Datum: Washington State Plane
Vertical Datum: MLLW

Drill Equipment: Mobile B-29/Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: W. McDonald   Reviewed By: B. Cook

USCS Class	Soil Descriptions	Depth in Feet
SP-SM	Dense to very dense, wet, dark gray, slightly silty, fine SAND. (cont'd)	90
	Silt partings observed at 95 feet.	95
	Occasional wood past 110 feet.	110
ML	Hard, moist to wet, gray-brown, sandy SILT.	115
SP ML	Dense, moist to wet, black, fine to medium SAND; trace silt and red sand grains.	120
	Occasional 1/2-inch silt seams past 125 feet.	125
	Interbedded silt layers past 130 feet.	130
SM SP-SM		133
		135

Sample	Blows	Lab Tests
S-17	21 24 22	
S-18	10 22 21	
S-19	13 19 22	GS
S-20	20 28 24	
S-21	17 24 26	
S-22	18 27 28	AL
S-23	15 20 22	
S-24	19 20 27	GS
S-25	14 15 21	

STANDARD PENETRATION RESISTANCE



LAB TESTS

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

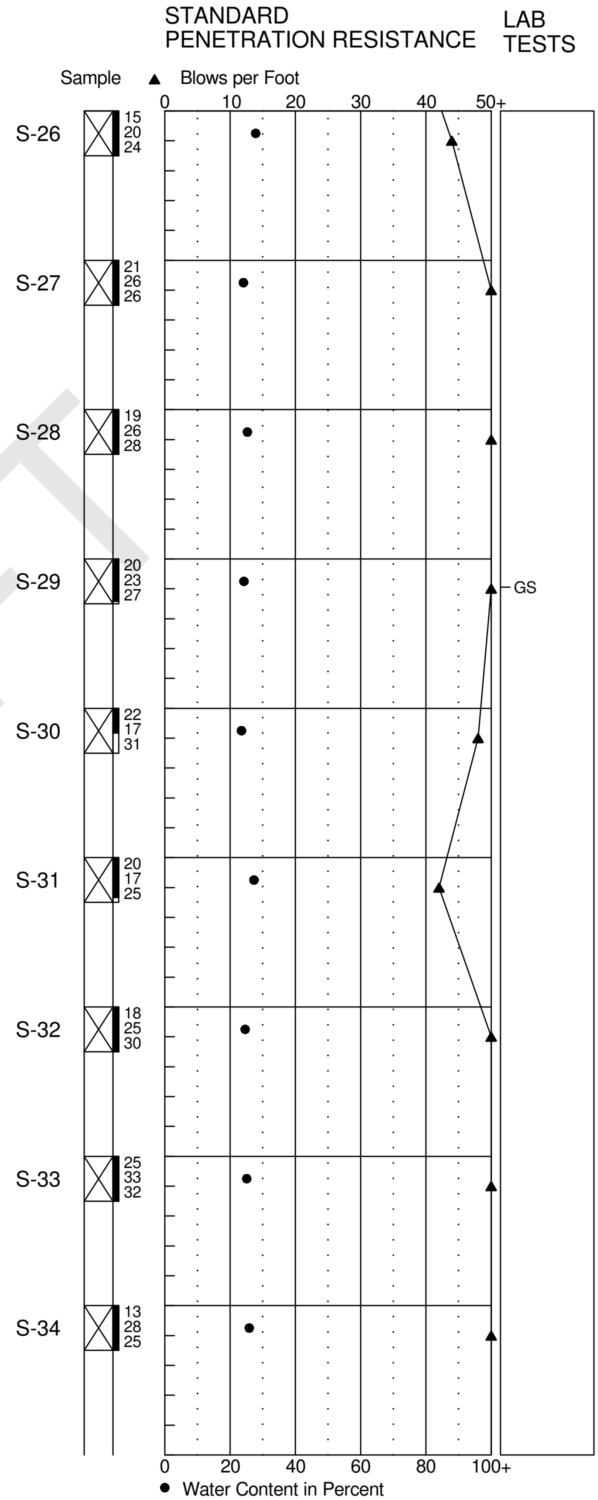
Boring Log HC14-B1

Location: N 103673.45 E 1249275.92
Approximate Ground Surface Elevation: 18 Feet
Horizontal Datum: Washington State Plane
Vertical Datum: MLLW

Drill Equipment: Mobile B-29/Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: W. McDonald   Reviewed By: B. Cook

USCS Class	Graphic Log	Soil Descriptions	Depth in Feet
SM SP-SM		Interbedded layers of dense to very dense, wet, black to dark gray, silty, fine SAND and slightly silty, fine SAND; trace silt. (cont'd)	135
		Silt seams at 170 feet.	170
ML		Hard, moist, gray-brown, slightly sandy SILT; grades to a very sandy SILT.	172

Depth scale: 135, 140, 145, 150, 155, 160, 165, 170, 175, 180



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

17916-01 *6/14*

Figure A-2 *4/5*

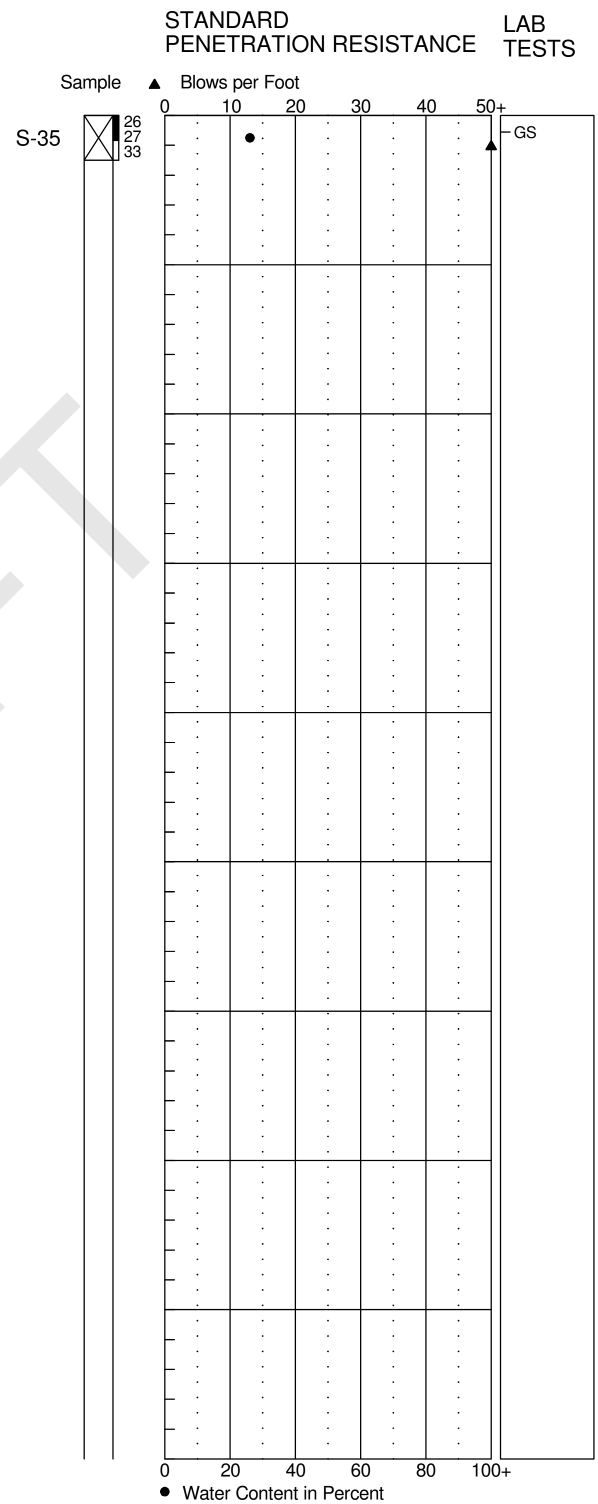
Boring Log HC14-B1

Location: N 103673.45 E 1249275.92
Approximate Ground Surface Elevation: 18 Feet
Horizontal Datum: Washington State Plane
Vertical Datum: MLLW

Drill Equipment: Mobile B-29/Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: W. McDonald   Reviewed By: B. Cook

USCS Class	Graphic Log	Soil Descriptions	Depth in Feet
ML			180
		Bottom of Boring at 181.5 Feet. Started 06/20/14. Completed 06/27/14.	

Depth in Feet: 180, 185, 190, 195, 200, 205, 210, 215, 220, 225



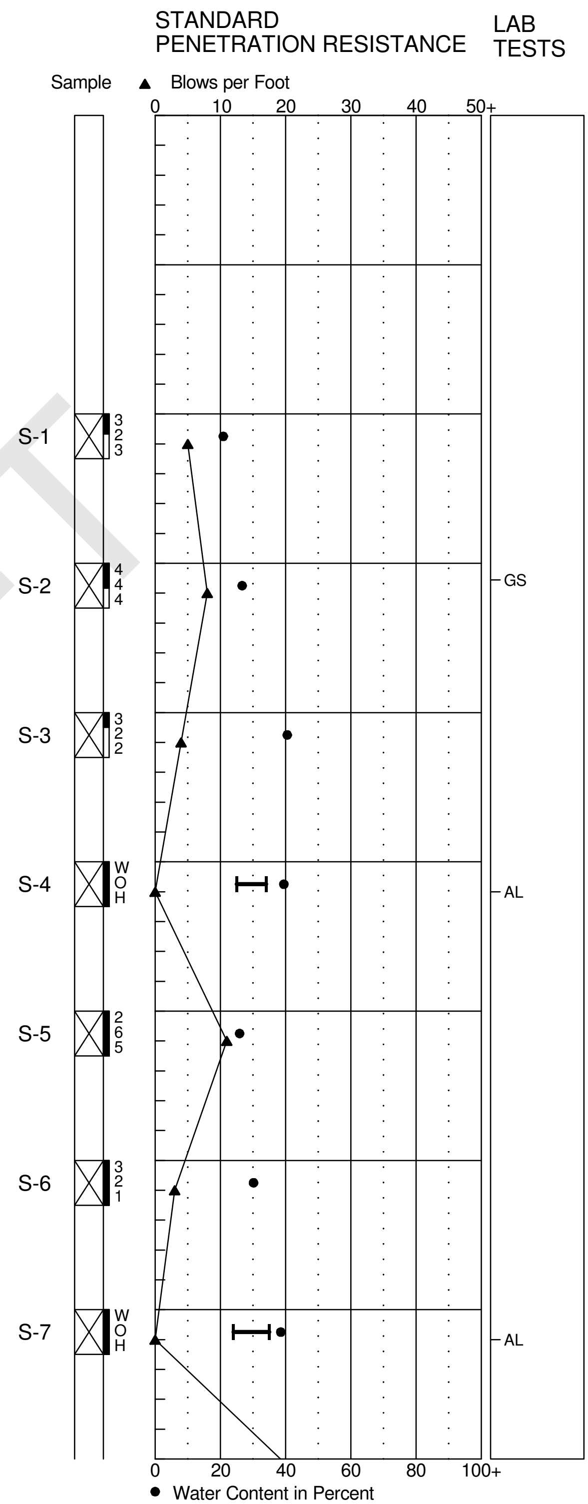
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

Boring Log HC14-B2

Location: N 103491.36 E 1249568.71
Approximate Ground Surface Elevation: 17 Feet
Horizontal Datum: Washington State Plane
Vertical Datum: MLLW

Drill Equipment: Mobile B-59/Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: W. McDonald   Reviewed By: C. de la Torre

USCS Class	Soil Descriptions	Depth in Feet
	Asphalt	0
SP	Loose, moist to wet, black, fine to medium SAND with red sand grains and occasional shell fragments. Vacuum excavated to 8 feet. (∇ ATD)	1 – 18
ML	Soft to very soft, wet, dark gray, trace to slightly sandy SILT with occasional shell and wood fragments (<1/2 inch).	18 – 28
SM	Medium dense, moist, dark gray, silty, fine SAND with occasional shell fragments.	28 – 32
ML	Very soft to soft, moist to wet, gray-brown, fine sandy to clayey SILT with occasional shell and wood fragments.	32 – 42
SP SP-SM		42 – 45

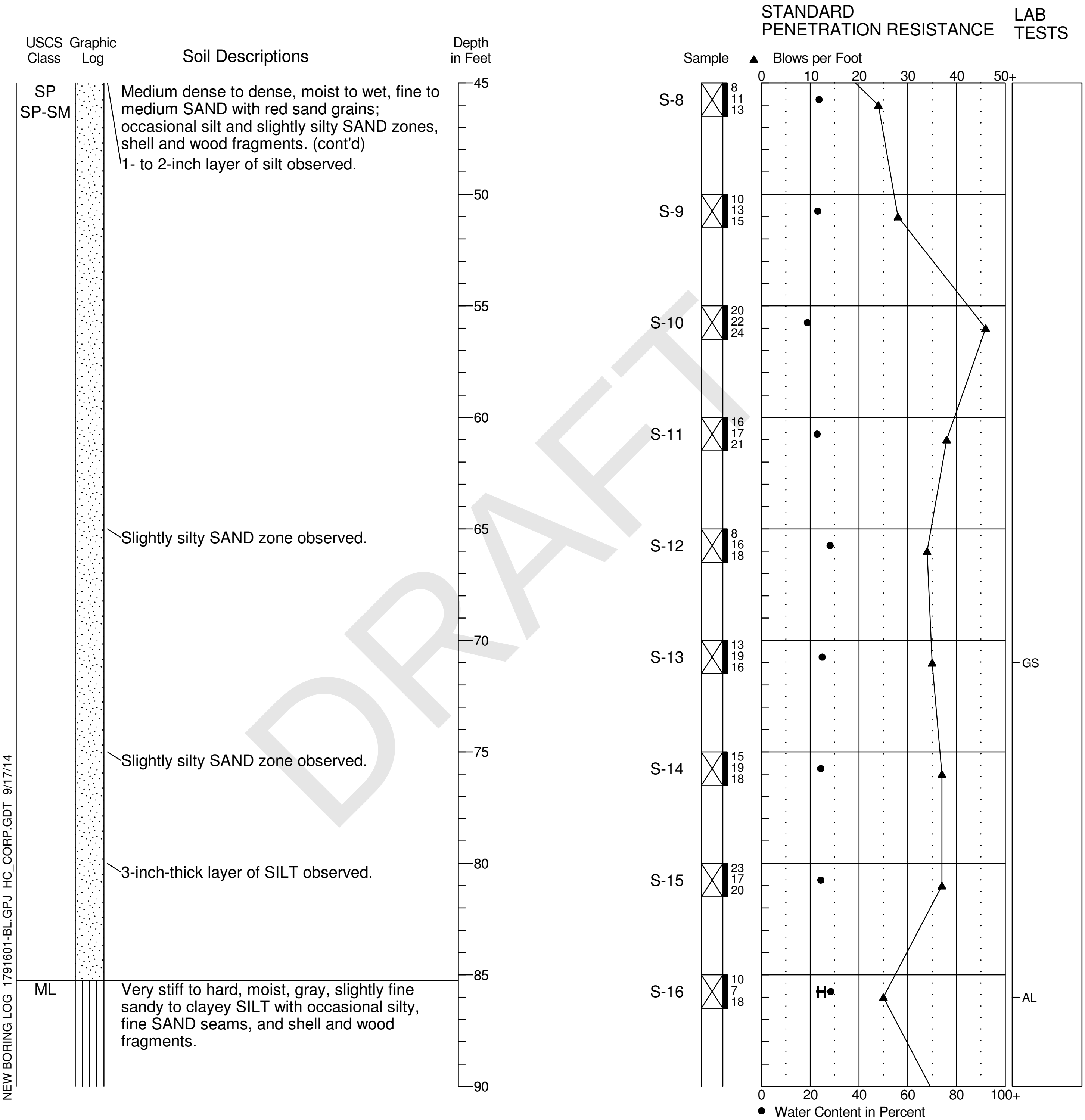


1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

Boring Log HC14-B2

Location: N 103491.36 E 1249568.71
Approximate Ground Surface Elevation: 17 Feet
Horizontal Datum: Washington State Plane
Vertical Datum: MLLW

Drill Equipment: Mobile B-59/Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: W. McDonald   Reviewed By: C. de la Torre



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

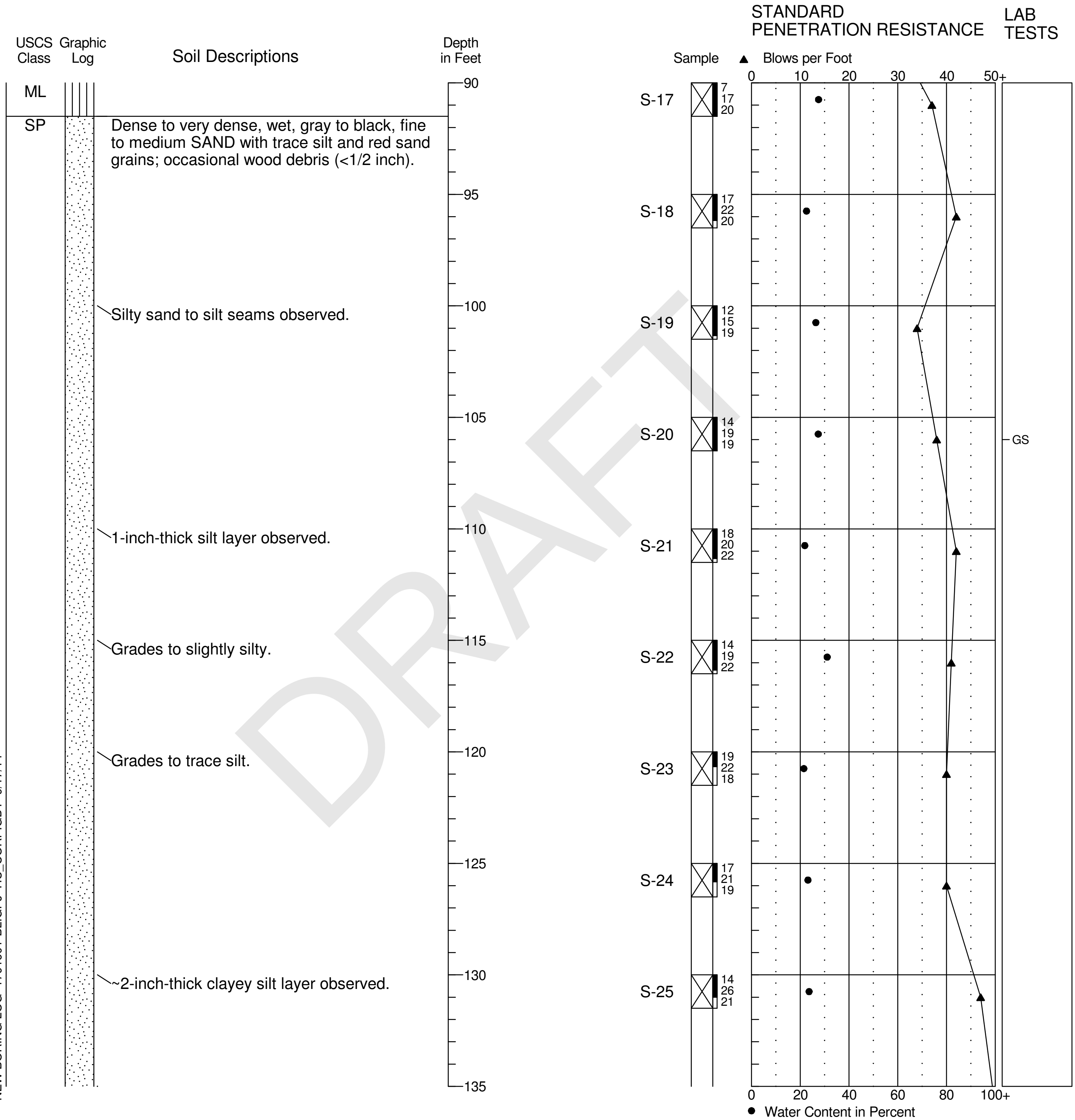
17916-01 *6/14*

Figure A-3 *2/5*

Boring Log HC14-B2

Location: N 103491.36 E 1249568.71
Approximate Ground Surface Elevation: 17 Feet
Horizontal Datum: Washington State Plane
Vertical Datum: MLLW

Drill Equipment: Mobile B-59/Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: W. McDonald   Reviewed By: C. de la Torre



NEW BORING LOG 1791601-BL.GPJ HC_CORP.GDT 9/17/14

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

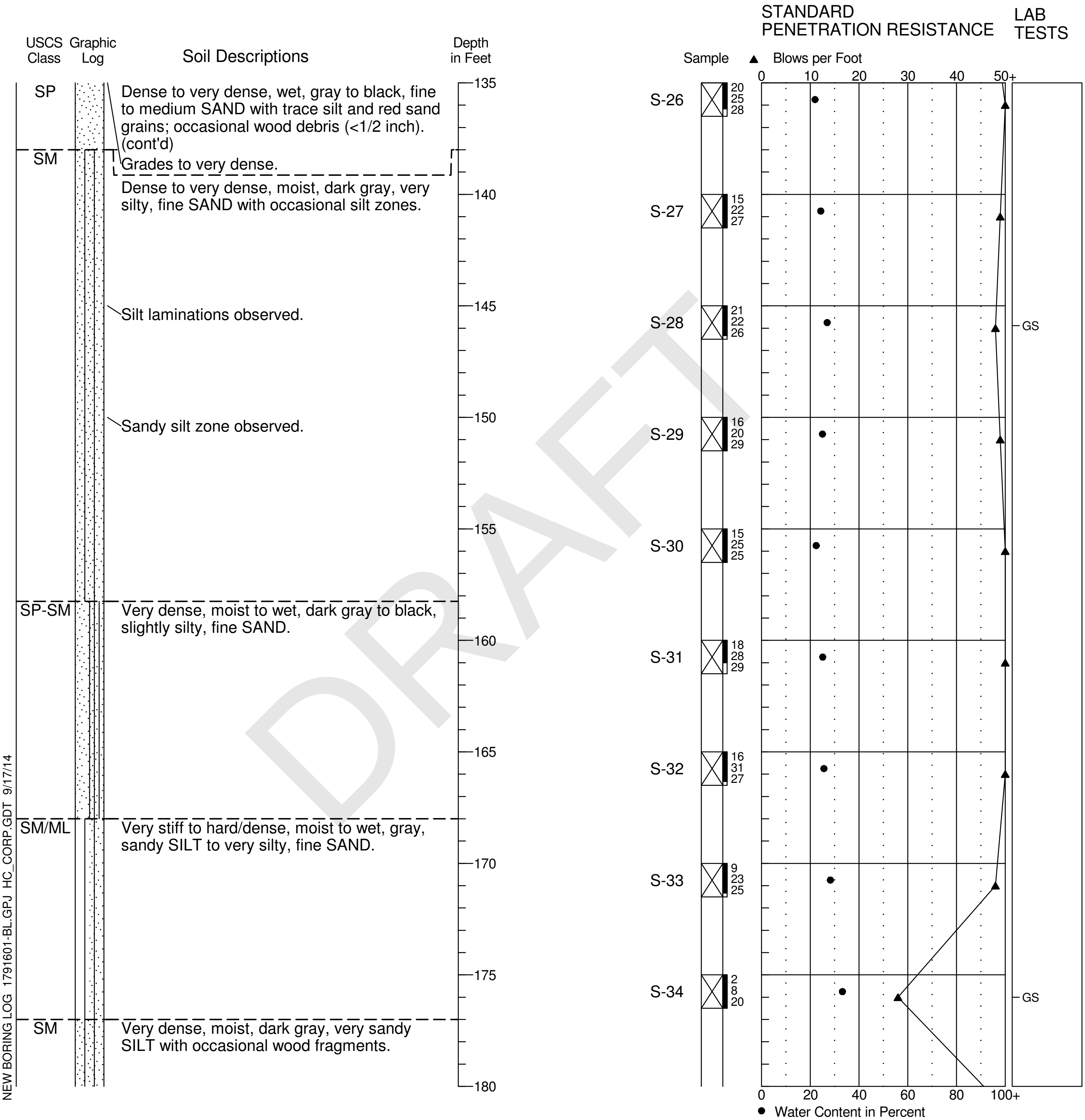
17916-01 **6/14**

Figure A-3 **3/5**

Boring Log HC14-B2

Location: N 103491.36 E 1249568.71
Approximate Ground Surface Elevation: 17 Feet
Horizontal Datum: Washington State Plane
Vertical Datum: MLLW

Drill Equipment: Mobile B-59/Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: W. McDonald   Reviewed By: C. de la Torre



NEW BORING LOG 1791601-BL.GPJ HC_CORP.GDT 9/17/14

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

17916-01 *6/14*

Boring Log HC14-B2

Location: N 103491.36 E 1249568.71
Approximate Ground Surface Elevation: 17 Feet
Horizontal Datum: Washington State Plane
Vertical Datum: MLLW

Drill Equipment: Mobile B-59/Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: W. McDonald   Reviewed By: C. de la Torre

USCS Class	Graphic Log	Soil Descriptions	Depth in Feet
SM		Very dense, moist, dark gray, very sandy SILT with occasional wood fragments. (cont'd)	180
		Bottom of Boring at 186.5 Feet. Started 06/20/14. Completed 06/25/14.	

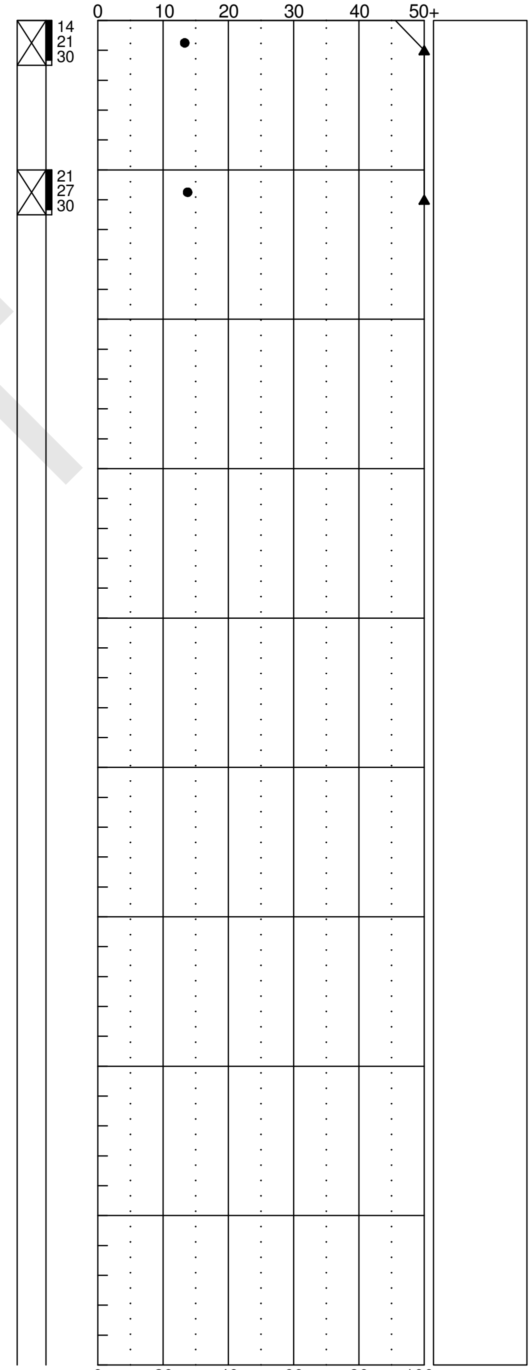
Depth in Feet: 180, 185, 190, 195, 200, 205, 210, 215, 220, 225

STANDARD PENETRATION RESISTANCE

LAB TESTS

Sample ▲ Blows per Foot

Sample	Blows
S-35	14 21 30
S-36	21 27 30



● Water Content in Percent

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

17916-01 *6/14*

Figure A-3 *5/5*

Boring Log HC14-B3

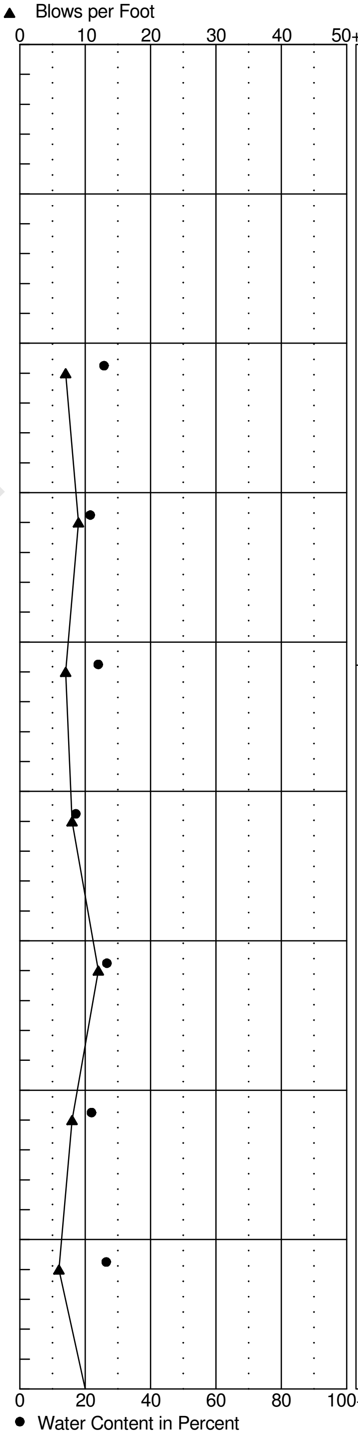
Location: N 103288.78 E 1249918.83
Approximate Ground Surface Elevation: 18 Feet
Horizontal Datum: Washington State Plane
Vertical Datum: MLLW

Drill Equipment: Mobile B-59/Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: W. McDonald   Reviewed By: C. Valdez

USCS Class	Soil Descriptions	Depth in Feet
	Asphalt	0
SP-SM	Brown, gravelly, slightly silty SAND with cobbles. (FILL)	
SP-SM	Loose to medium dense, wet, gray-brown to black, slightly silty, fine to medium SAND; red sand grains, and occasional shell fragments.	5
	Vacuum excavated to 9 feet.	10 ATD
		15
		20
		25
		30
		35
	Frequent sandy SILT layers observed.	40
		45

Sample	Blows	Lab Tests
S-1	3 3 4	
S-2	4 5 4	
S-3	4 3 4	GS
S-4	4 4 4	
S-5	5 5 7	
S-6	4 4 4	
S-7	4 3 3	

STANDARD PENETRATION RESISTANCE



LAB TESTS

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

Boring Log HC14-B3

Location: N 103288.78 E 1249918.83
Approximate Ground Surface Elevation: 18 Feet
Horizontal Datum: Washington State Plane
Vertical Datum: MLLW

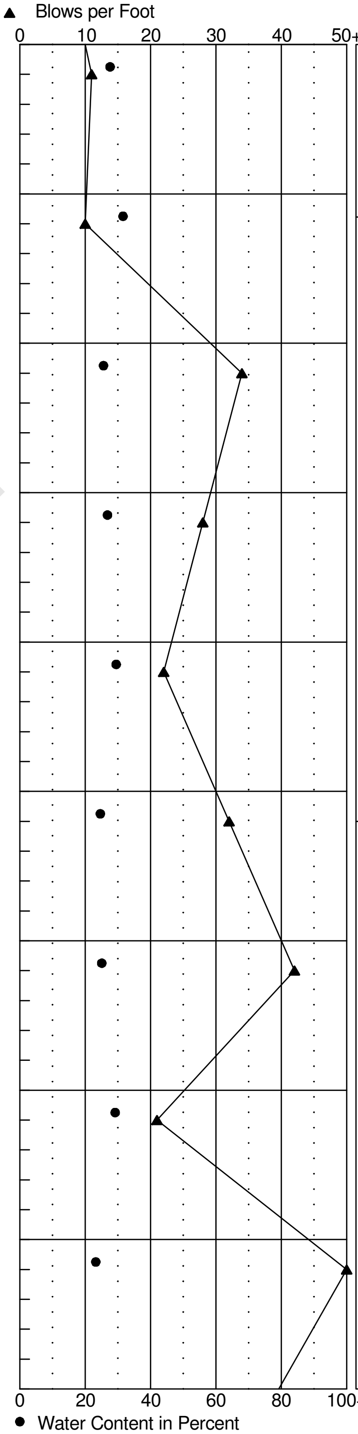
Drill Equipment: Mobile B-59/Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: W. McDonald   Reviewed By: C. Valdez

USCS Class	Soil Descriptions	Depth in Feet
SP-SM	Loose to medium dense, wet, gray-brown to black, slightly silty, fine to medium SAND; red sand grains, and occasional shell fragments. (cont'd)	45
	Grades to silty.	50
SP-SM	Medium dense to dense, black, fine SAND with trace silt to slightly silty, fine SAND with occasional silt lenses.	55
SP-SM	Medium dense, wet, dark gray, fine SAND to very silty, fine SAND with silt seams, occasional shell fragments and trace wood.	80
SP	Dense to very dense, wet, black, fine to medium SAND with red sand grains and shell fragments.	85

Sample	Blows	Lab Tests
S-8	3, 4, 7	
S-9	6, 6, 4	GS
S-10	12, 14, 20	
S-11	10, 12, 16	
S-12	9, 11, 11	
S-13	13, 15, 17	GS
S-14	12, 18, 24	
S-15	5, 11, 10	
S-16	15, 25, 26	

STANDARD PENETRATION RESISTANCE

LAB TESTS



NEW BORING LOG 1791601-BL.GPJ HC_CORP.GDT 9/17/14

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

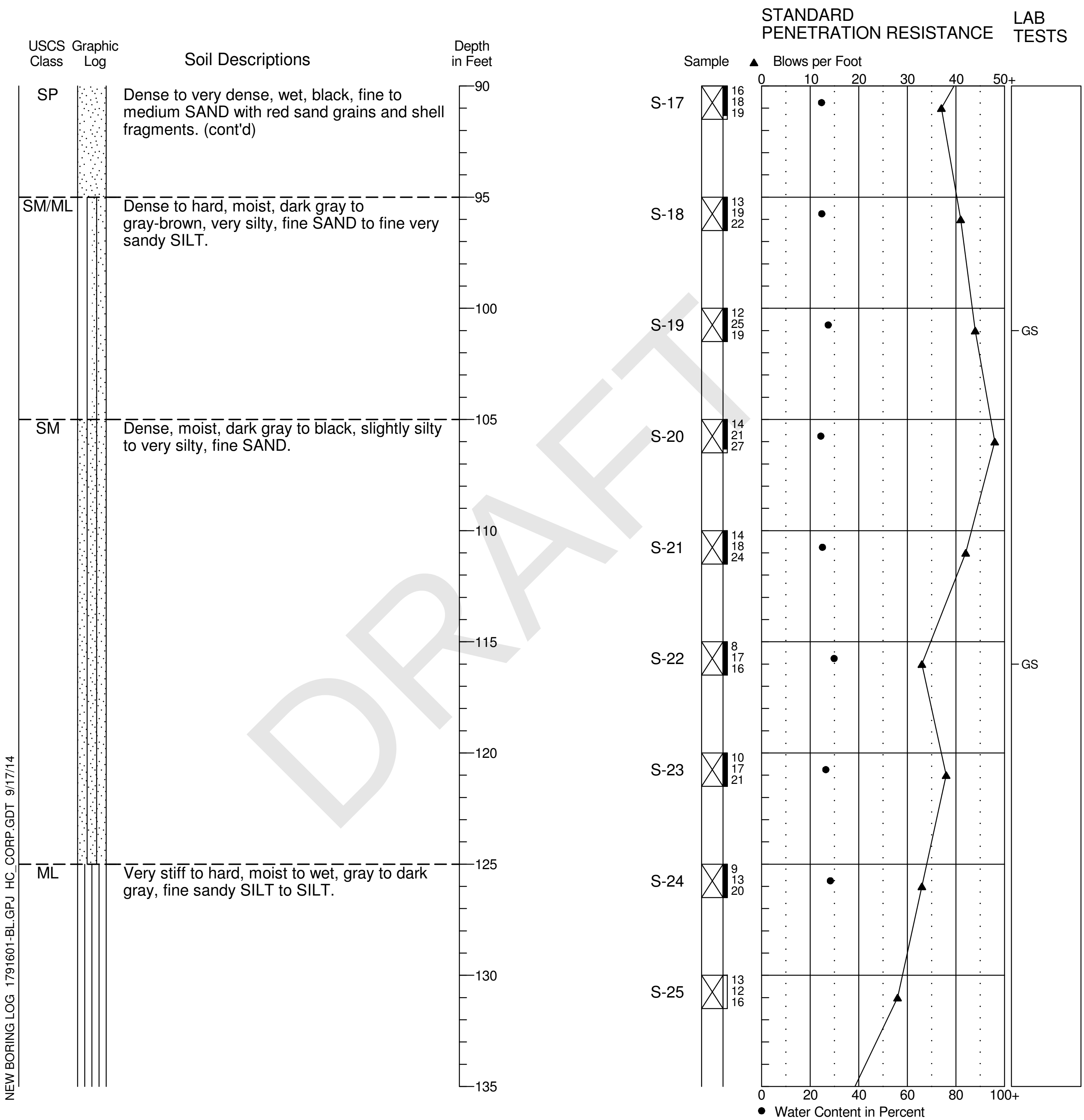
HARTCROWSER

17916-01 *7/14*

Boring Log HC14-B3

Location: N 103288.78 E 1249918.83
Approximate Ground Surface Elevation: 18 Feet
Horizontal Datum: Washington State Plane
Vertical Datum: MLLW

Drill Equipment: Mobile B-59/Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: W. McDonald   Reviewed By: C. Valdez



1. Refer to Figure A-1 for explanation of descriptions and symbols.
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3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

17916-01 **7/14**
Figure A-4 **3/5**

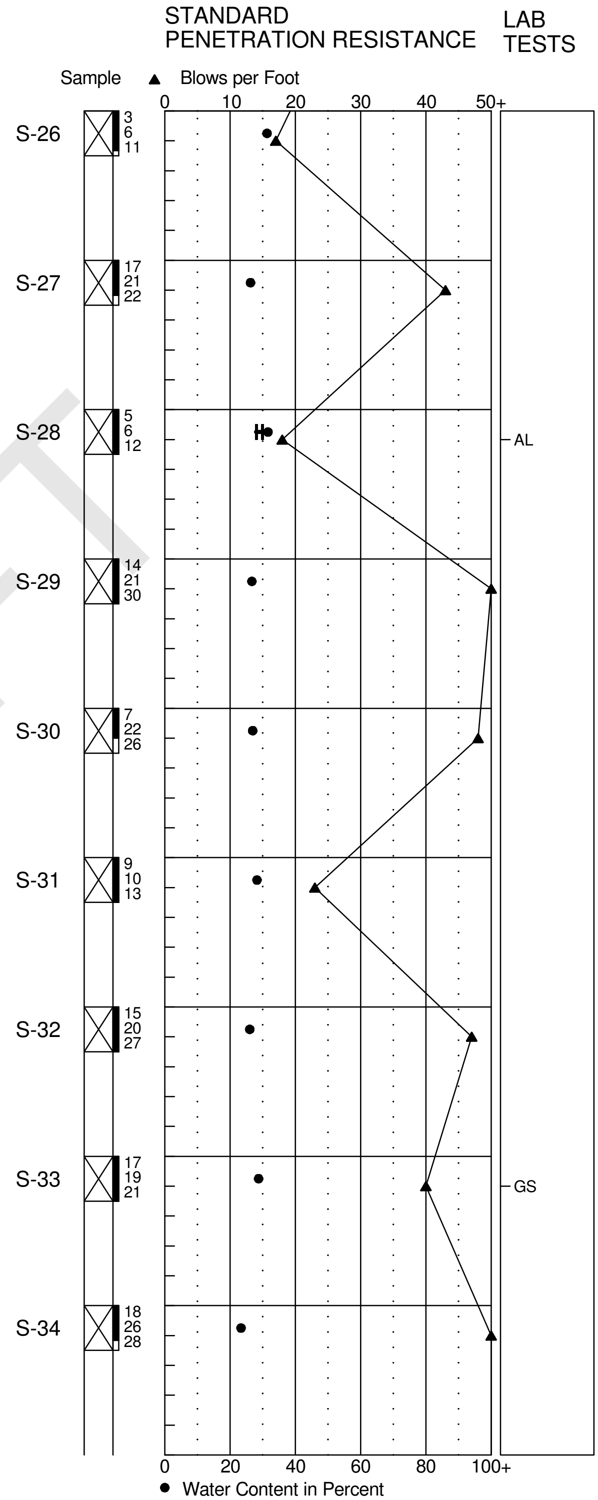
Boring Log HC14-B3

Location: N 103288.78 E 1249918.83
Approximate Ground Surface Elevation: 18 Feet
Horizontal Datum: Washington State Plane
Vertical Datum: MLLW

Drill Equipment: Mobile B-59/Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: W. McDonald   Reviewed By: C. Valdez

USCS Class	Soil Descriptions	Depth in Feet
ML	Very stiff to hard, moist to wet, gray to dark gray, fine sandy SILT to SILT. (cont'd)	135
SP	Dense, moist to wet, dark gray, slightly silty to silty SAND.	
ML	Very stiff, moist to wet, dark gray, fine slightly sandy SILT.	
SP-SM	Dense to very dense, moist, dark gray, fine SAND to silty fine SAND with occasional silt lens.	150
ML	Very stiff, moist, gray SILT with trace fine sand.	
SP-SM	Dense to very dense, moist to wet, dark gray, slightly silty, fine SAND with frequent silt lenses.	

Depth scale: 135, 140, 145, 150, 155, 160, 165, 170, 175, 180



NEW BORING LOG 1791601-BL.GPJ HC_CORP.GDT 9/17/14

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
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4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

Boring Log HC14-B3

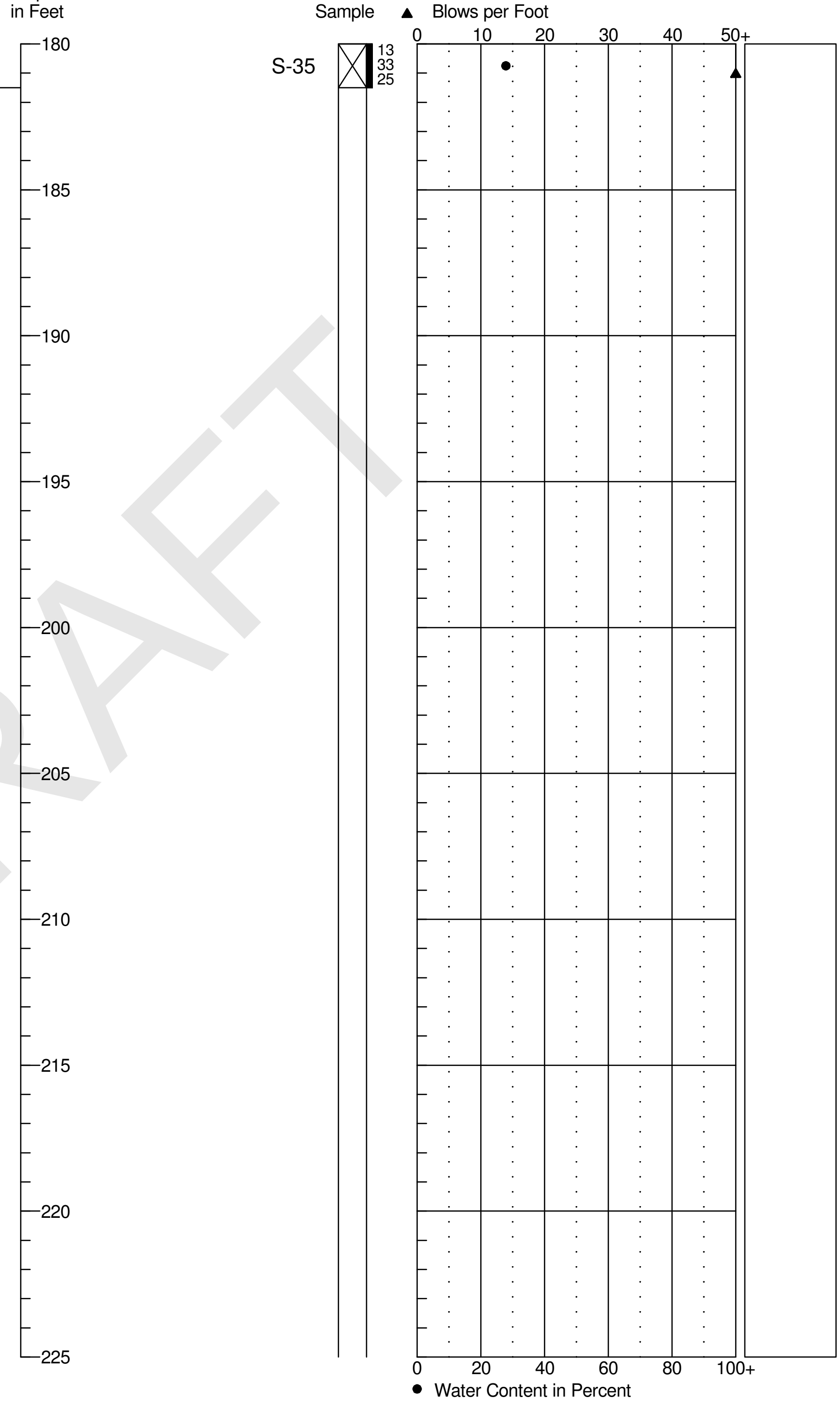
Location: N 103288.78 E 1249918.83
Approximate Ground Surface Elevation: 18 Feet
Horizontal Datum: Washington State Plane
Vertical Datum: MLLW

Drill Equipment: Mobile B-59/Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: W. McDonald   Reviewed By: C. Valdez

USCS Class	Graphic Log	Soil Descriptions	Depth in Feet
SP-SM			180
		Bottom of Boring at 181.5 Feet. Started 06/20/14. Completed 07/01/14.	

Sample S-35: 13 / 33 / 25

STANDARD PENETRATION RESISTANCE   LAB TESTS



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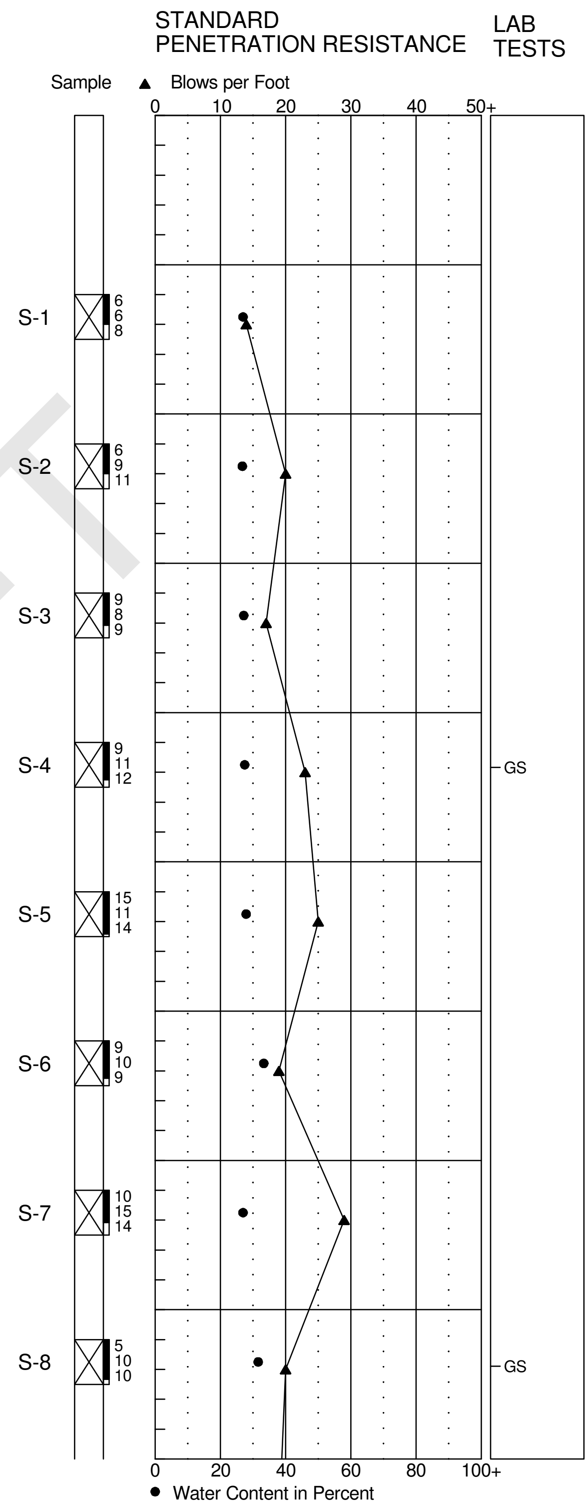
Boring Log HC12-B1

Location: See Figure 2.
Approximate Ground Surface Elevation: -42 Feet
Horizontal Datum:
Vertical Datum: MLLW

Drill Equipment: Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald Reviewed By: B. Cook

USCS Class	Soil Descriptions	Depth in Feet
GP-GM SP-SM	(Very loose), sandy GRAVEL and gravelly SAND inferred from drill action. (FILL)	0
SP	Medium dense, wet, dark gray, fine to medium SAND with trace silt.	6
GP-GM SP-SM	Loose, sandy GRAVEL to gravelly SAND inferred from drill action.	24
SM	Medium dense, wet, dark gray, silty, fine SAND.	26
SP SP-SM	Medium dense, wet, dark gray, fine to medium SAND with trace silt, grades to slightly silty, fine to medium SAND.	35
SM		44



NEW BORING LOG 1791601-BL.GPJ HC_CORP.GDT 9/17/14

DRAFT

1. Refer to Figure A-1 for explanation of descriptions and symbols.
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HARTCROWSER

17916-01 2/13
Figure A-5 1/4

Boring Log HC12-B1

Location: See Figure 2.
Approximate Ground Surface Elevation: -42 Feet
Horizontal Datum:
Vertical Datum: MLLW

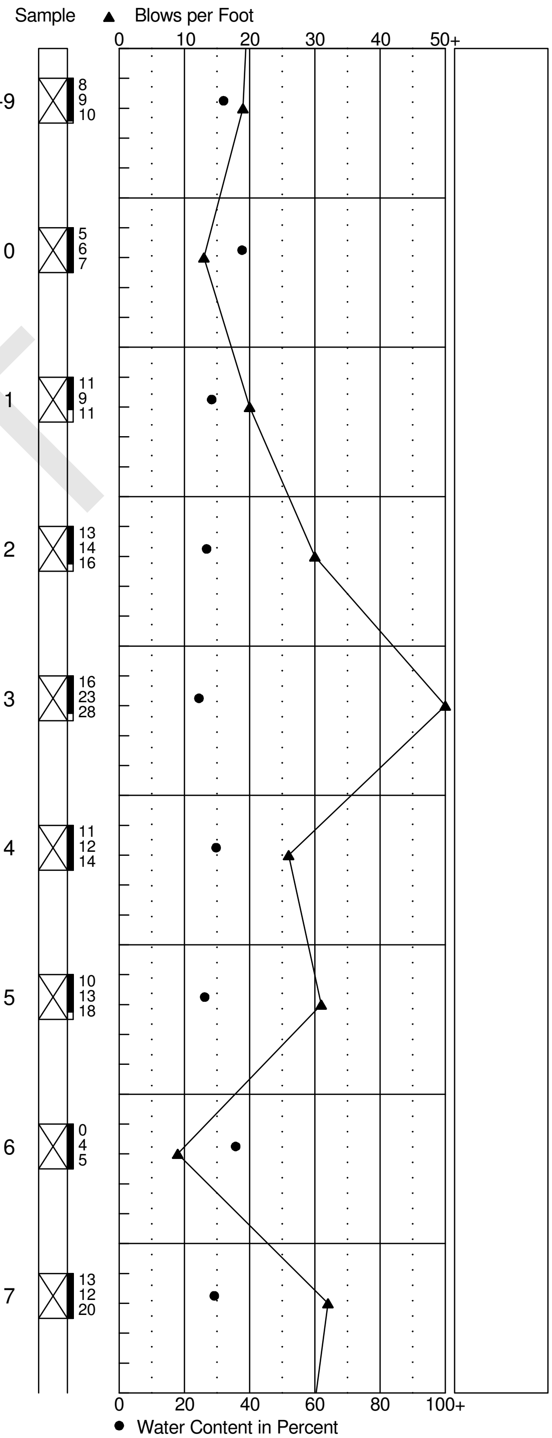
Drill Equipment: Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald   Reviewed By: B. Cook

USCS Class	Soil Descriptions	Depth in Feet
SM	Medium dense, wet, dark gray, silty, fine SAND with sandy silt laminations and partings. (cont'd)	45
	Scattered organic material, and wood debris at 51 feet.	50
SP	Medium dense to to very dense, wet, dark gray, fine to medium SAND with trace silt.	55
	Scattered silt partings and sandy silt zones between 66 and 73 feet.	65
ML	Stiff, wet, gray SILT with interbedded dark gray, fine to medium SAND layers and fine sandy SILT laminations.	80
SP	Dense, wet, dark gray, slightly silty, fine to medium SAND with silt seams.	84
SP		88

Sample	Blows
S-9	8 / 9 / 10
S-10	5 / 6 / 7
S-11	11 / 9 / 11
S-12	13 / 14 / 16
S-13	16 / 23 / 28
S-14	11 / 12 / 14
S-15	10 / 13 / 18
S-16	0 / 4 / 5
S-17	13 / 12 / 20

STANDARD PENETRATION RESISTANCE

LAB TESTS



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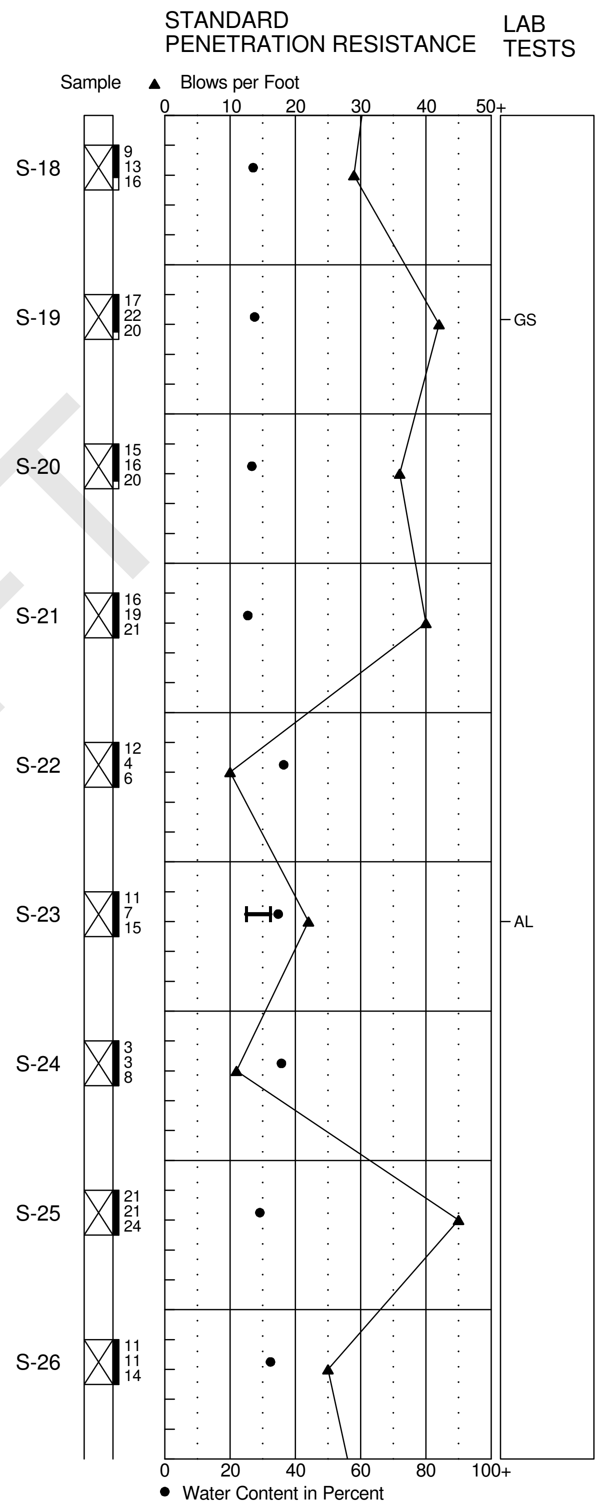
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

Boring Log HC12-B1

Location: See Figure 2.
Approximate Ground Surface Elevation: -42 Feet
Horizontal Datum:
Vertical Datum: MLLW

Drill Equipment: Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald   Reviewed By: B. Cook

USCS Class	Soil Descriptions	Depth in Feet
SP	Medium dense to dense, wet, dark gray, fine to medium SAND with trace silt. (cont'd)	90
	Scattered silt seams past 106 feet.	
ML	Stiff to very stiff, wet, gray SILT with fine sandy silt zones and occasional fine sand seams.	110
	Silt has blocky texture at 116 feet.	
	Numerous pores within soil matrix at 121 feet.	
SM	Dense, wet, dark gray, slightly silty to silty, fine SAND with scattered silt seams.	
ML SM	Very stiff, wet, dark gray SILT and fine sandy SILT with zones of very silty, fine SAND.	135



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3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

17916-01   2/13
Figure A-5   3/4

Boring Log HC12-B1

Location: See Figure 2.
Approximate Ground Surface Elevation: -42 Feet
Horizontal Datum:
Vertical Datum: MLLW

Drill Equipment: Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald   Reviewed By: B. Cook

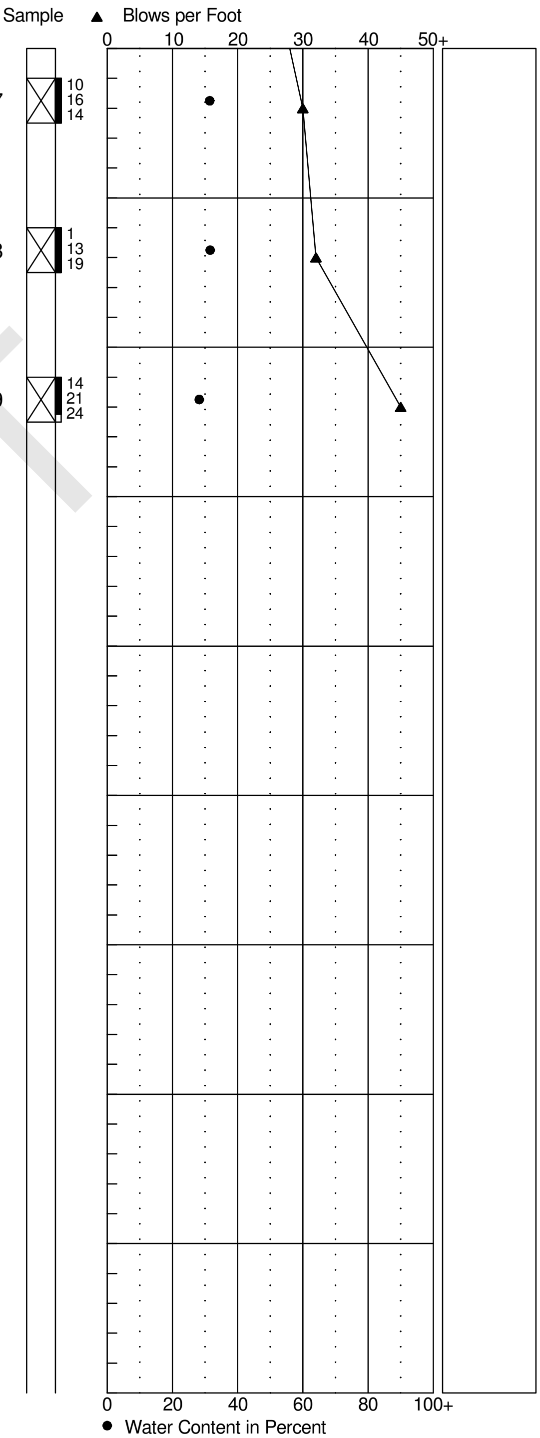
USCS Class	Soil Descriptions	Depth in Feet
ML SM	Very stiff, wet, dark gray SILT and fine sandy SILT with zones of very silty, fine SAND. (cont'd)	135
SM	Dense, wet, dark gray, silty, fine SAND with fine sandy silt zones and laminations.	
SP-SM	Dense, wet, dark gray, slightly silty, fine to medium SAND.	
	Bottom of Boring at 147.5 Feet. Started 02/19/13. Completed 02/20/13.	

Depth scale: 135, 140, 145, 150, 155, 160, 165, 170, 175, 180

STANDARD PENETRATION RESISTANCE

LAB TESTS

Sample	Blows
S-27	10 16 14
S-28	1 13 19
S-29	14 21 24



NEW BORING LOG 1791601-BL.GPJ HC_CORP.GDT 9/17/14

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

17916-01 *2/13*

Figure A-5 *4/4*

Boring Log HC12-B2

Location: See Figure 2.
Approximate Ground Surface Elevation: -39 Feet
Horizontal Datum:
Vertical Datum: MLLW

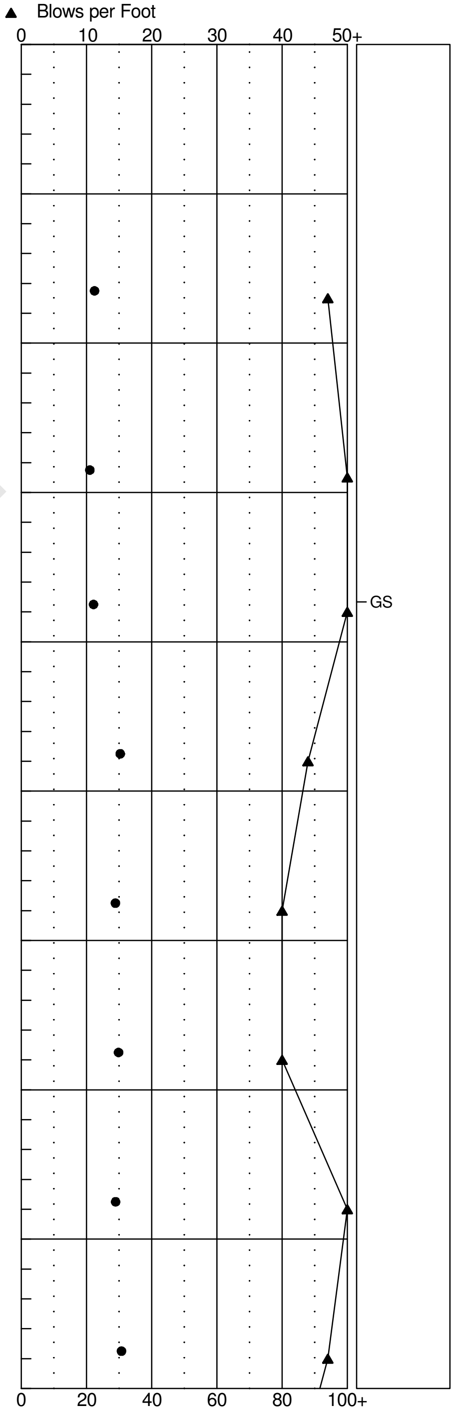
Drill Equipment: Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald   Reviewed By: B. Cook

USCS Class	Soil Descriptions	Depth in Feet
	Very loose, wet, very dark gray, silty fine SAND to fine sandy SILT. (FILL)	0
	Trace to scattered shell fragments and gravels from 5.5 to 15 feet.	
SP-SM	Dense to very dense, wet, dark gray, trace to slightly silty, fine to medium SAND.	10
	Scattered organic zones at 23 feet.	
SM	Dense to very dense, wet, dark gray, silty, fine SAND with silt and fine sandy silt seams.	30
	Trace shell fragments at 38 feet.	
		45

Sample	Blows
S-1	10 22 25
S-2	25 31 39
S-3	24 31 33
S-4	12 20 24
S-5	13 19 21
S-6	13 21 19
S-7	18 28 29
S-8	16 23 24

STANDARD PENETRATION RESISTANCE

LAB TESTS



DRAFT

NEW BORING LOG 1791601-BL.GPJ HC_CORP.GDT 9/17/14

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

17916-01   2/13
Figure A-6   1/4

Boring Log HC12-B2

Location: See Figure 2.
Approximate Ground Surface Elevation: -39 Feet
Horizontal Datum:
Vertical Datum: MLLW

Drill Equipment: Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald Reviewed By: B. Cook

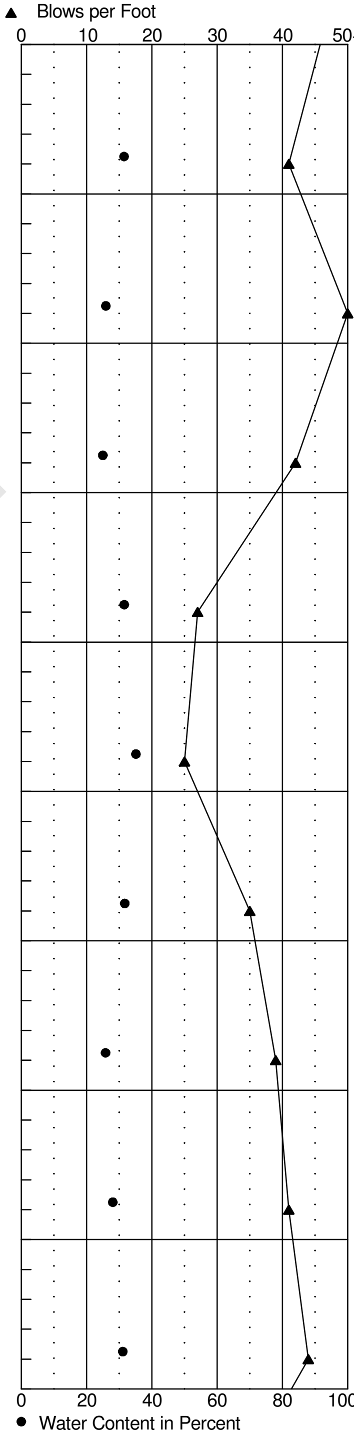
USCS Class	Soil Descriptions
SM	Dense to very dense, wet, dark gray, silty, fine SAND with silt and fine sandy silt seams. (cont'd) Interbedded fine sandy SILT layers at 48 feet.
SP	Dense to very dense, wet, dark gray, fine to medium SAND with occasional silt seams.
SM	Medium dense, wet, dark gray, silty, fine to medium SAND with occasional fine sandy silt zones.
ML SM	Very stiff, wet, gray, fine sandy SILT and SILT with zones of silty, fine SAND.
SP-SM	Dense, wet, dark gray, slightly silty, fine to medium SAND. Scattered silt seams at 83 feet.
SM	Dense, wet, dark gray, silty, fine to medium SAND with interbedded silt and fine sandy silt layers.

Depth in Feet: 45, 50, 55, 60, 65, 70, 75, 80, 85, 90

STANDARD PENETRATION RESISTANCE

LAB TESTS

Sample	Blows	Lab Tests
S-9	12 16 25	
S-10	20 29 34	
S-11	17 21 21	
S-12	8 16 11	GS
S-13	8 13 12	
S-14	11 18 17	
S-15	13 18 21	
S-16	16 19 22	
S-17	23 24 20	



NEW BORING LOG 1791601-BL.GPJ HC_CORP.GDT 9/17/14

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

17916-01 *2/13*

Figure A-6 *2/4*

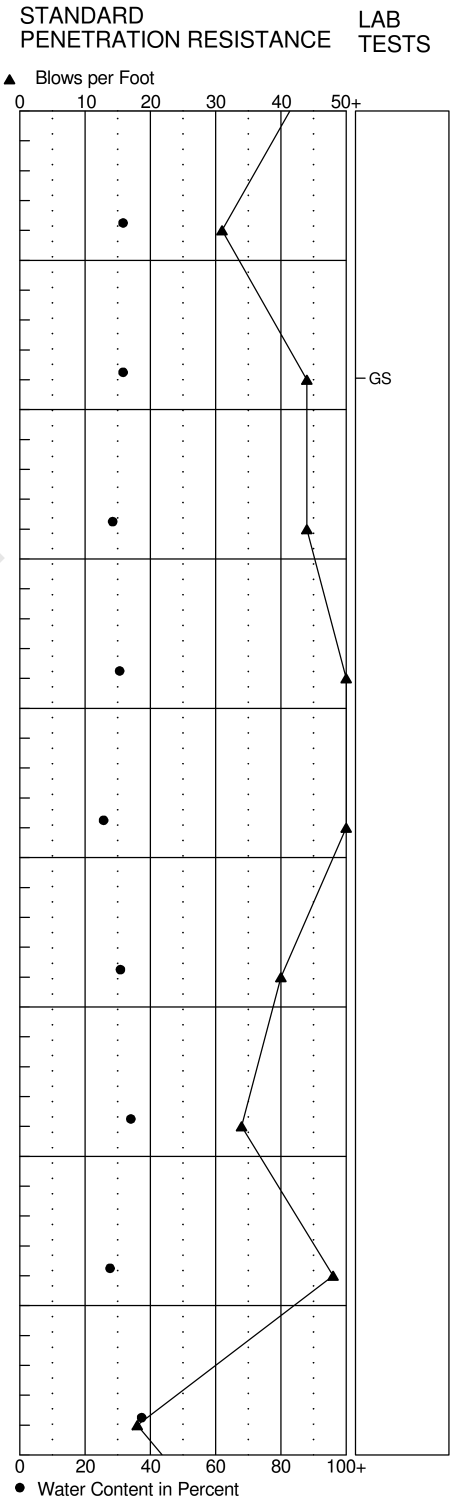
Boring Log HC12-B2

Location: See Figure 2.
Approximate Ground Surface Elevation: -39 Feet
Horizontal Datum:
Vertical Datum: MLLW

Drill Equipment: Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald   Reviewed By: B. Cook

USCS Class	Soil Descriptions	Depth in Feet
SM		90
ML	Hard, wet, brownish gray SILT and fine sandy SILT with interbedded silty, fine sand layers.	
SM	Dense, wet, dark gray, silty, fine to medium SAND with interbedded fine sandy silt layers and scattered organic material.	95
SP-SM	Very dense, wet, dark gray, trace to slightly silty, fine to medium SAND.	105
ML	Stiff, wet, gray SILT and fine sandy SILT.	115
SM	Dense, wet, dark gray, silty, fine SAND.	
ML SM	Hard, wet, gray SILT to silty, fine SAND.	120
SM	Dense, very moist, dark gray, very silty, fine SAND with occasional silt laminations.	125
ML	Very stiff, wet, gray, fine sandy SILT with blocky texture.	130
		135

Sample	Blows	Lab Tests
S-18	11 15 16	
S-19	18 22 22	GS
S-20	14 21 23	
S-21	21 34 32	
S-22	22 26 26	
S-23	3 18 22	
S-24	6 15 19	
S-25	21 21 27	
S-26	7 8 10	



1. Refer to Figure A-1 for explanation of descriptions and symbols.
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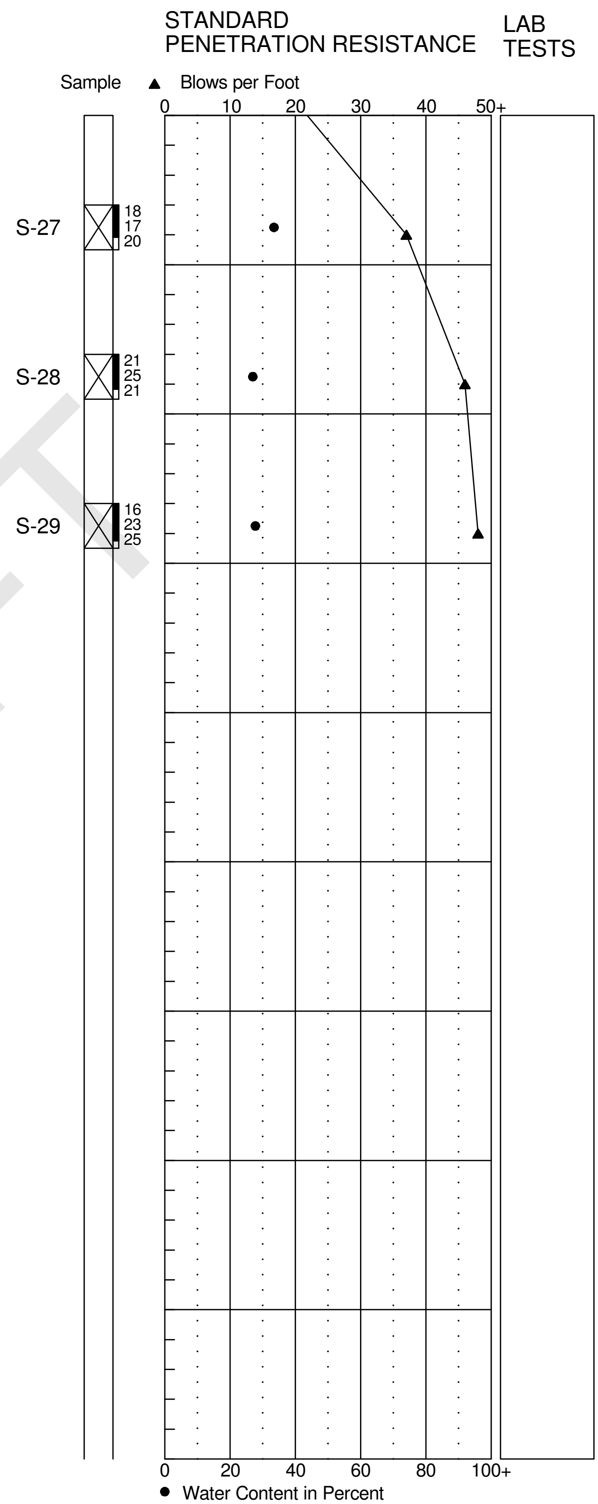
Boring Log HC12-B2

Location: See Figure 2.
Approximate Ground Surface Elevation: -39 Feet
Horizontal Datum:
Vertical Datum: MLLW

Drill Equipment: Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald Reviewed By: B. Cook

USCS Class	Graphic Log	Soil Descriptions	Depth in Feet
ML			135
SM		Dense, wet, gray, very silty, fine SAND with scattered silt laminations.	
SP-SM		Dense, very moist, dark gray, slightly silty, fine SAND.	140
		Bottom of Boring at 149.5 Feet. Started 02/11/13. Completed 02/13/13.	149.5



NEW BORING LOG 1791601-BL.GPJ HC_CORP.GDT 9/17/14

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
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HARTCROWSER

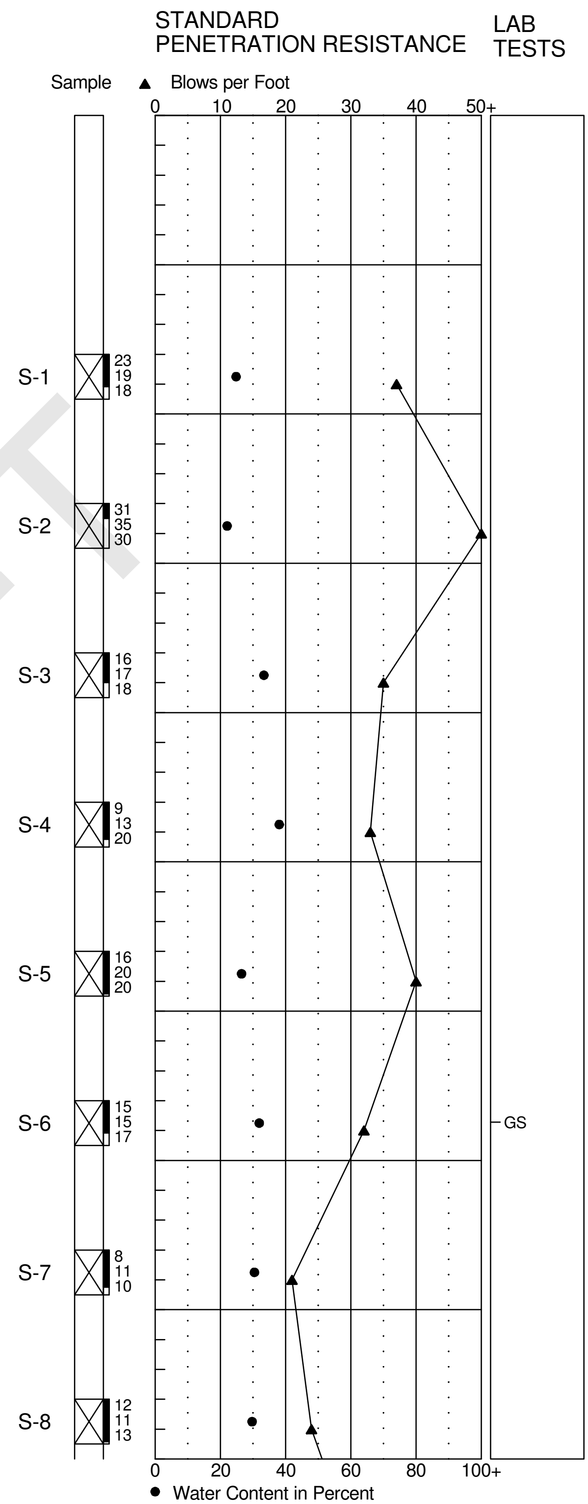
17916-01 *2/13*

Boring Log HC12-B4

Location: See Figure 2.
Approximate Ground Surface Elevation: -43 Feet
Horizontal Datum:
Vertical Datum: MLLW

Drill Equipment: Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald   Reviewed By: B. Cook

USCS Class	Soil Descriptions	Depth in Feet
SM	(Very loose), silty, fine SAND inferred. (FILL)	0
	Drilling action and drilling mud return interpreted as Wood with possible Rip Rap, Gravel and/or Concrete. (FILL)	
SM	Dense, very moist to wet, dark gray, silty, fine to medium SAND with scattered shell fragments in upper 10 feet.	5
	Scattered fine sandy SILT and SILT laminations and layers with trace organic material past 23 feet.	
SP-SM	Medium dense, wet, dark gray, slightly silty to silty, fine to medium SAND.	36



NEW BORING LOG 1791601-BL.GPJ HC_CORP.GDT 9/17/14

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2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
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4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

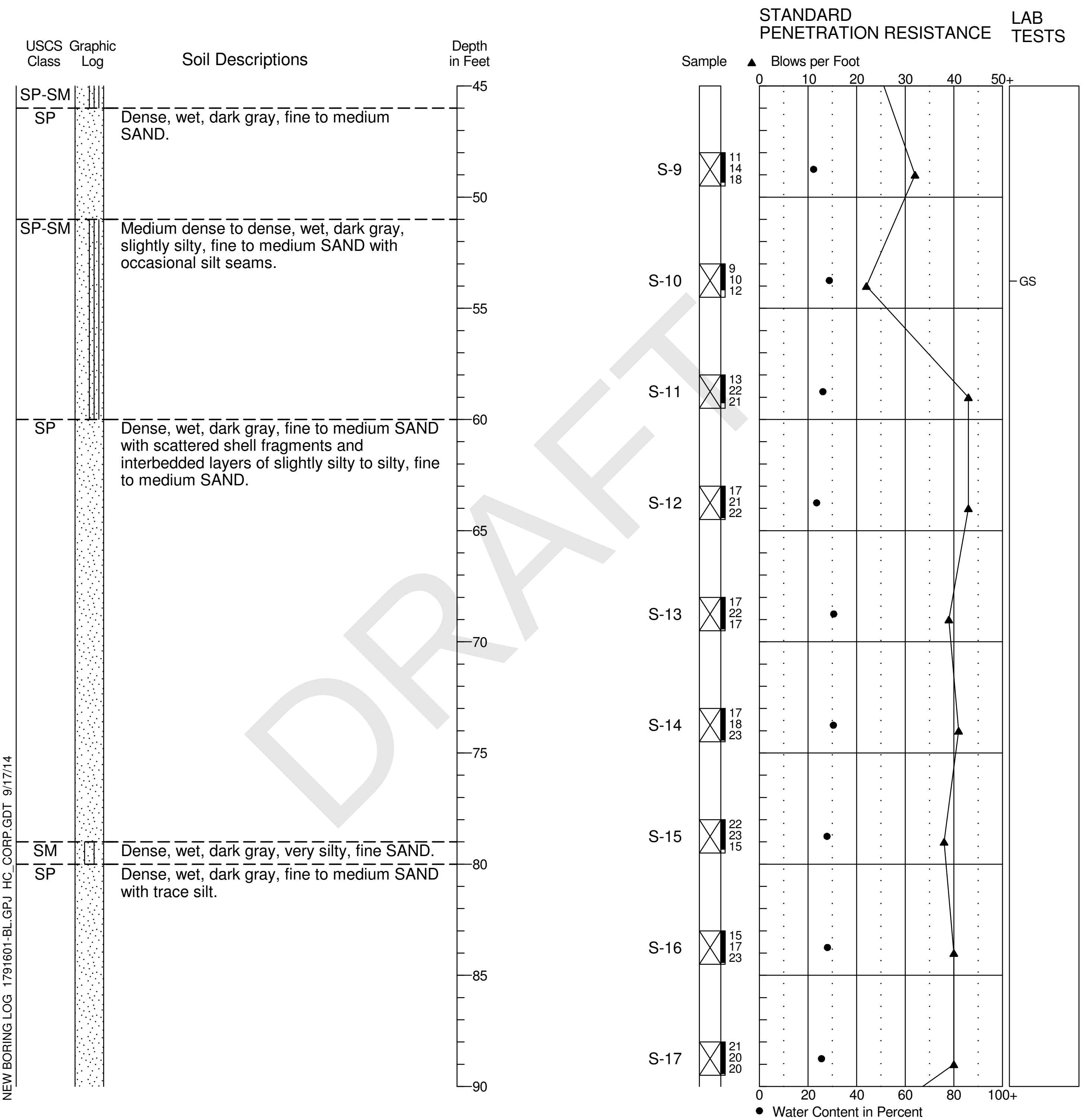
HARTCROWSER

17916-01 *2/13*

Boring Log HC12-B4

Location: See Figure 2.
Approximate Ground Surface Elevation: -43 Feet
Horizontal Datum:
Vertical Datum: MLLW

Drill Equipment: Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald Reviewed By: B. Cook



1. Refer to Figure A-1 for explanation of descriptions and symbols.
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4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

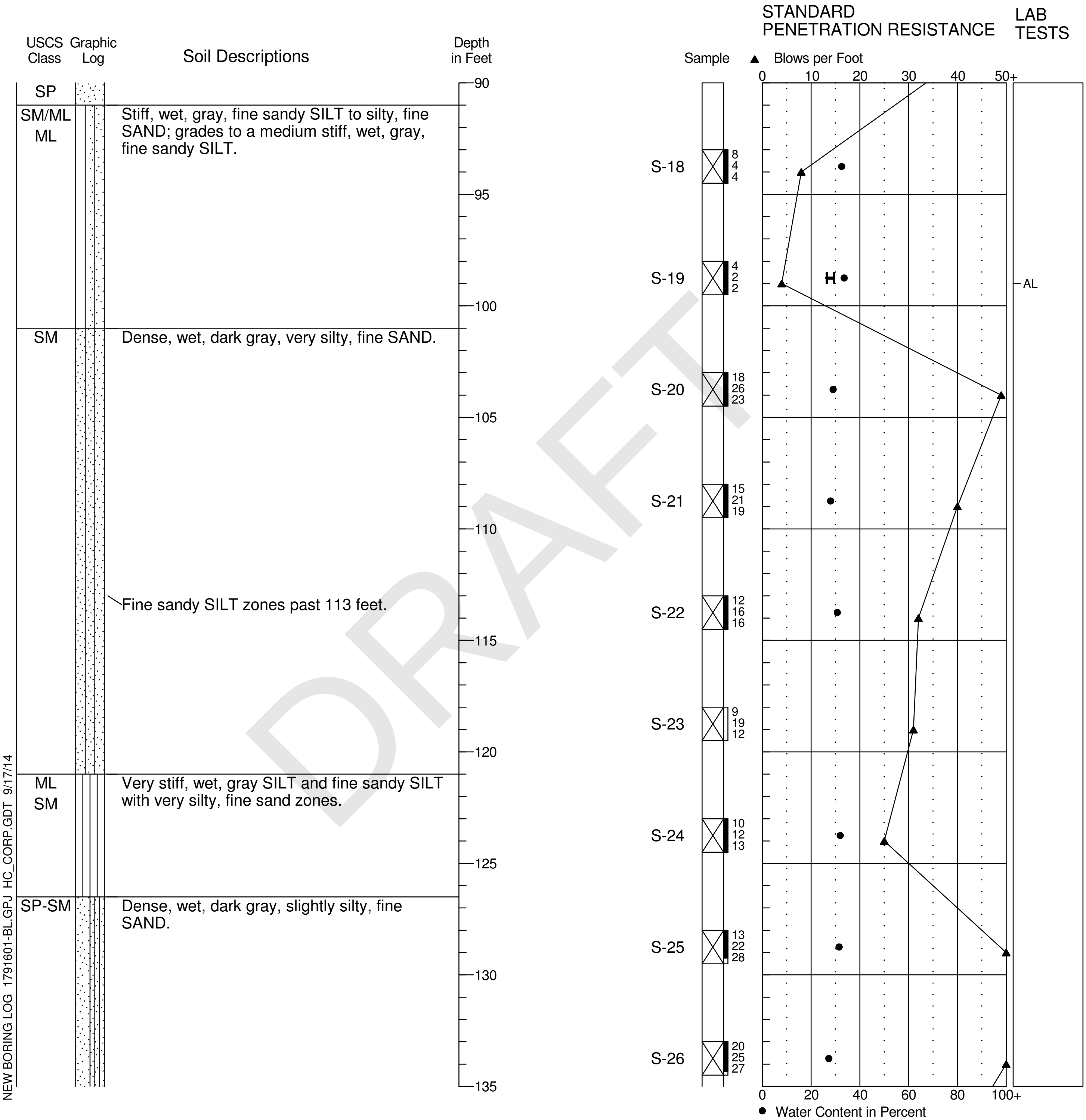
17916-01 *2/13*

Figure A-7 *2/4*

Boring Log HC12-B4

Location: See Figure 2.
Approximate Ground Surface Elevation: -43 Feet
Horizontal Datum:
Vertical Datum: MLLW

Drill Equipment: Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald Reviewed By: B. Cook



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
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4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

17916-01 2/13

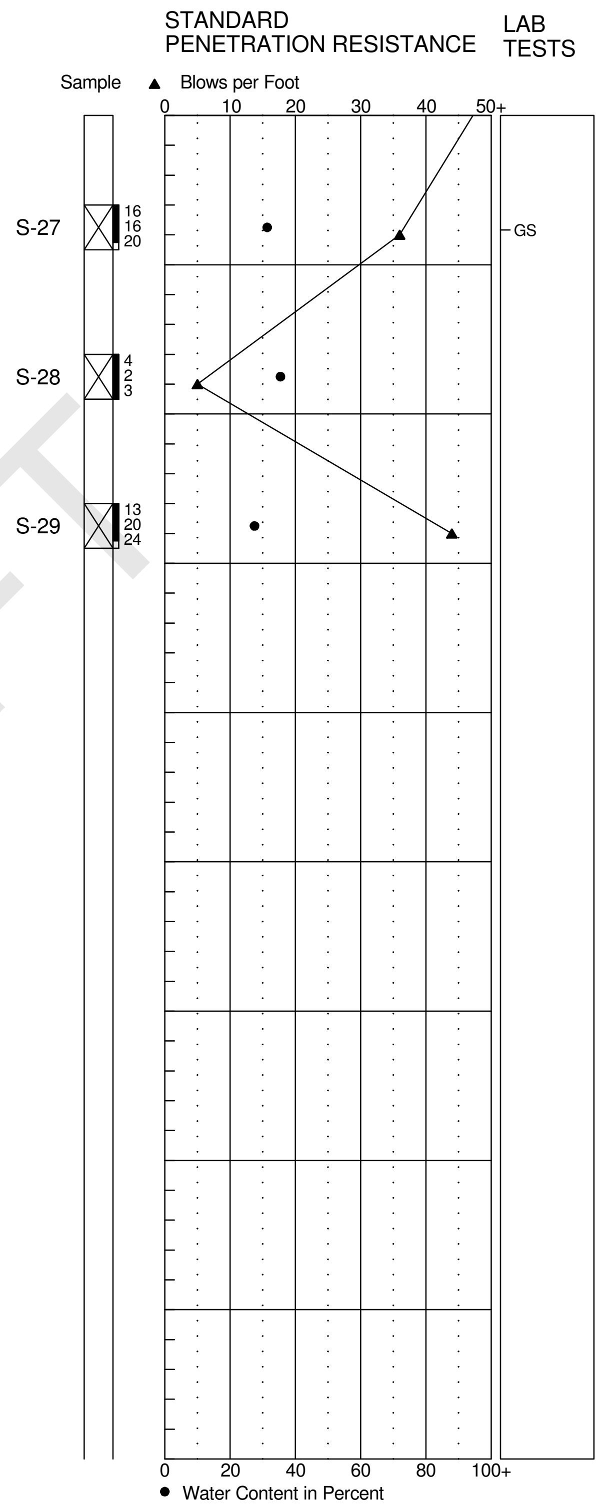
Figure A-7 3/4

Boring Log HC12-B4

Location: See Figure 2.
Approximate Ground Surface Elevation: -43 Feet
Horizontal Datum:
Vertical Datum: MLLW

Drill Equipment: Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald   Reviewed By: B. Cook

USCS Class	Soil Descriptions	Depth in Feet
SP-SM		135
SM	Dense, wet, dark gray, silty, fine SAND with occasional fine sandy silt seams.	
ML	Medium stiff, wet, gray SILT with trace sand.	140
SM	Dense, very moist, dark gray, very silty, fine SAND.	145
	Bottom of Boring at 149.5 Feet. Started 02/14/13. Completed 02/15/13.	150



1. Refer to Figure A-1 for explanation of descriptions and symbols.
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4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

17916-01 *2/13*

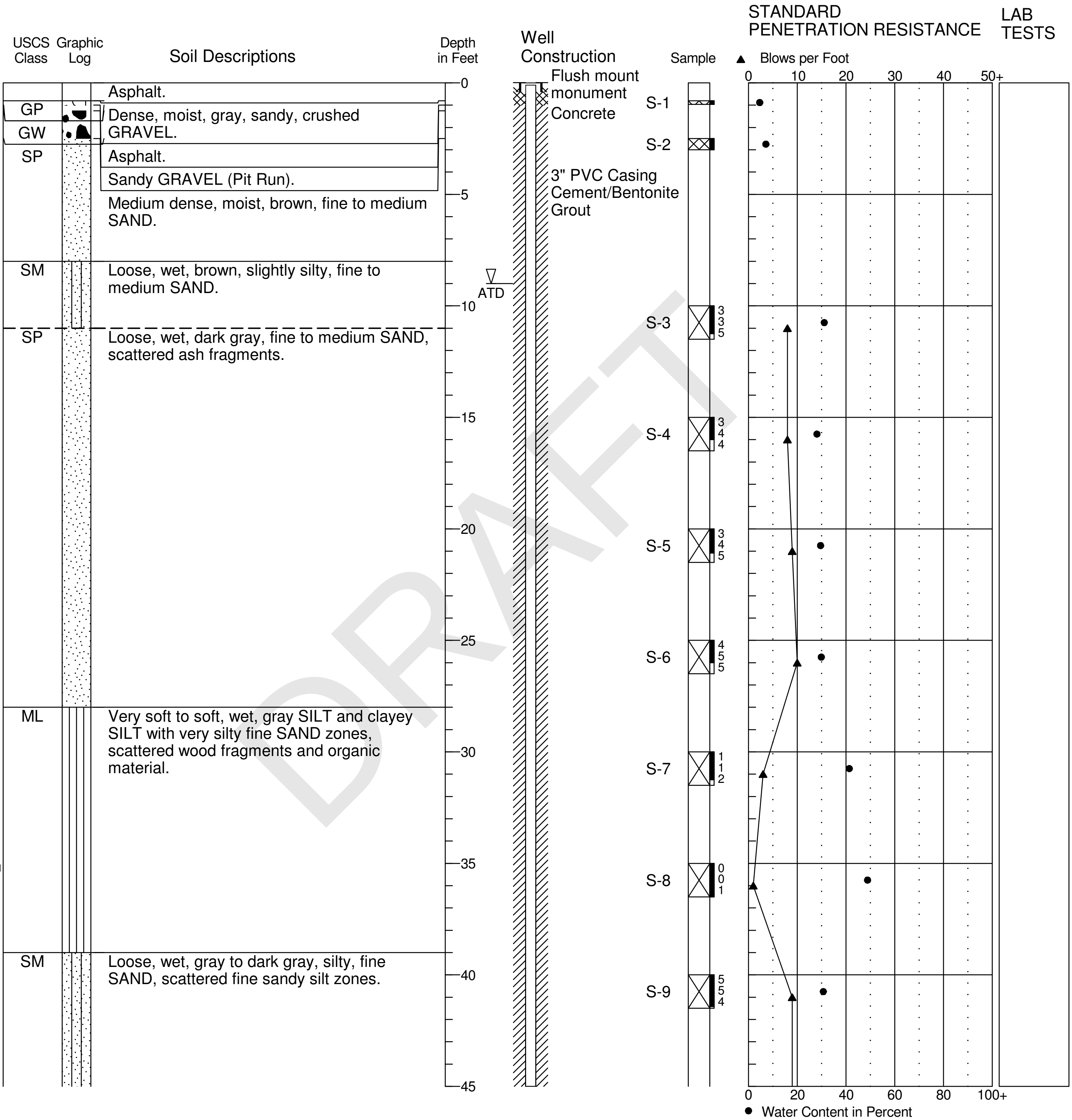
Figure A-7 *4/4*

Boring Log/Construction Data for Shear Wave Well HC12-B5

Location: See Figure 2.
Approximate Ground Surface Elevation: 17 Feet
Horizontal Datum:
Vertical Datum: MLLW

Drill Equipment: Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald   Reviewed By: B. Cook

USCS Class	Soil Descriptions
	Asphalt.
GP	Dense, moist, gray, sandy, crushed
GW	GRAVEL.
SP	Asphalt.
	Sandy GRAVEL (Pit Run).
	Medium dense, moist, brown, fine to medium SAND.
SM	Loose, wet, brown, slightly silty, fine to medium SAND.
SP	Loose, wet, dark gray, fine to medium SAND, scattered ash fragments.
ML	Very soft to soft, wet, gray SILT and clayey SILT with very silty fine SAND zones, scattered wood fragments and organic material.
SM	Loose, wet, gray to dark gray, silty, fine SAND, scattered fine sandy silt zones.



NEW BORING LOG 1791601-BL.GPJ HC_CORP.GDT 9/17/14

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

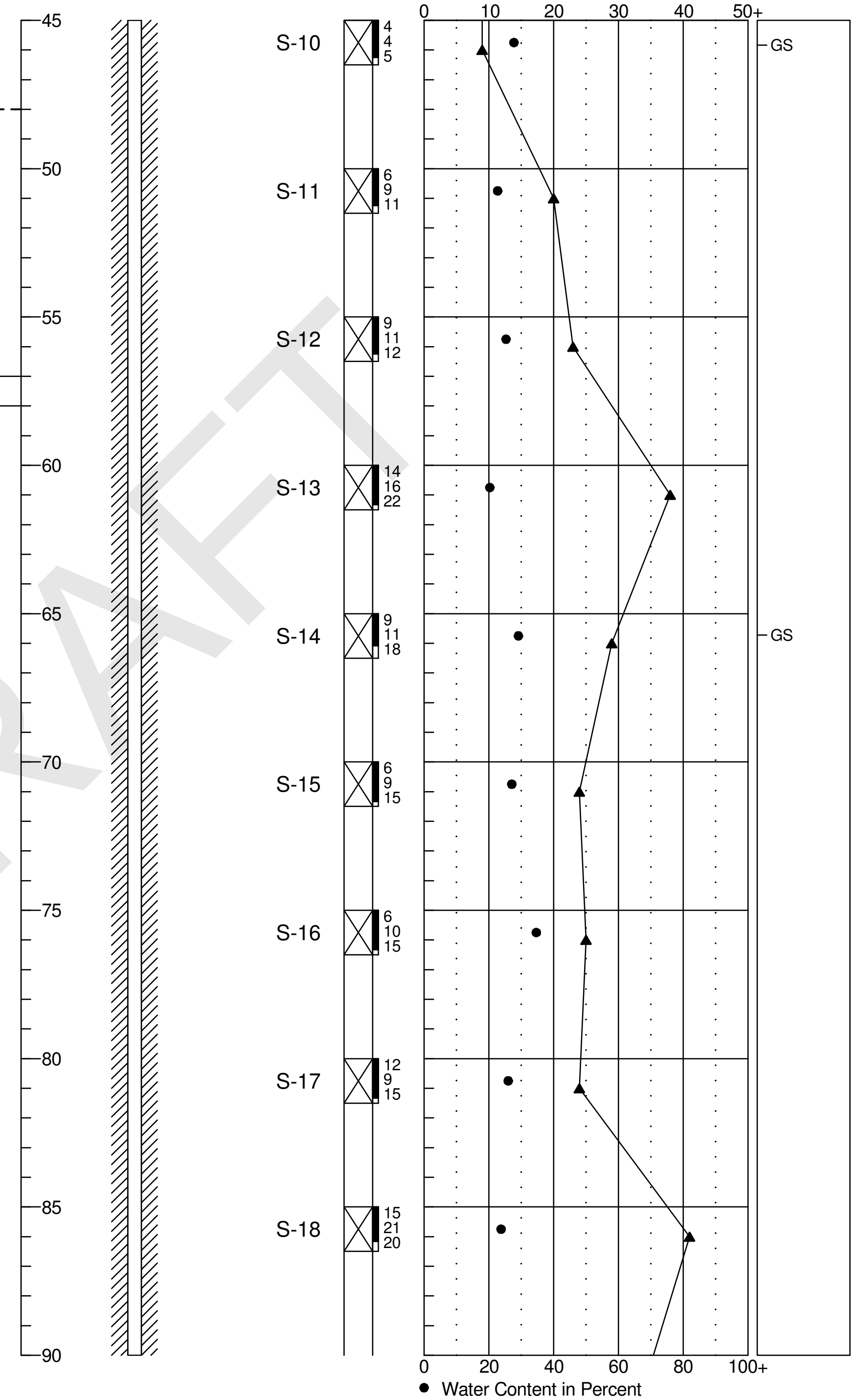
17916-01   12/12
Figure A-8   1/6

Boring Log/Construction Data for Shear Wave Well HC12-B5

Location: See Figure 2.
Approximate Ground Surface Elevation: 17 Feet
Horizontal Datum:
Vertical Datum: MLLW

Drill Equipment: Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald Reviewed By: B. Cook

USCS Class	Soil Descriptions
SM	Loose, wet, gray to dark gray, silty, fine SAND, scattered fine sandy silt zones. (cont'd)
SP	Medium dense, wet, dark gray, fine to medium SAND.
GP	Sandy, fine GRAVEL.
SP	Medium dense to dense, wet, gray to dark gray, fine to medium SAND with silty, fine SAND and sandy SILT zones/seams, trace shell and ash fragments.



NEW BORING LOG 1791601-BL.GPJ HC_CORP.GDT 9/17/14

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HARTCROWSER

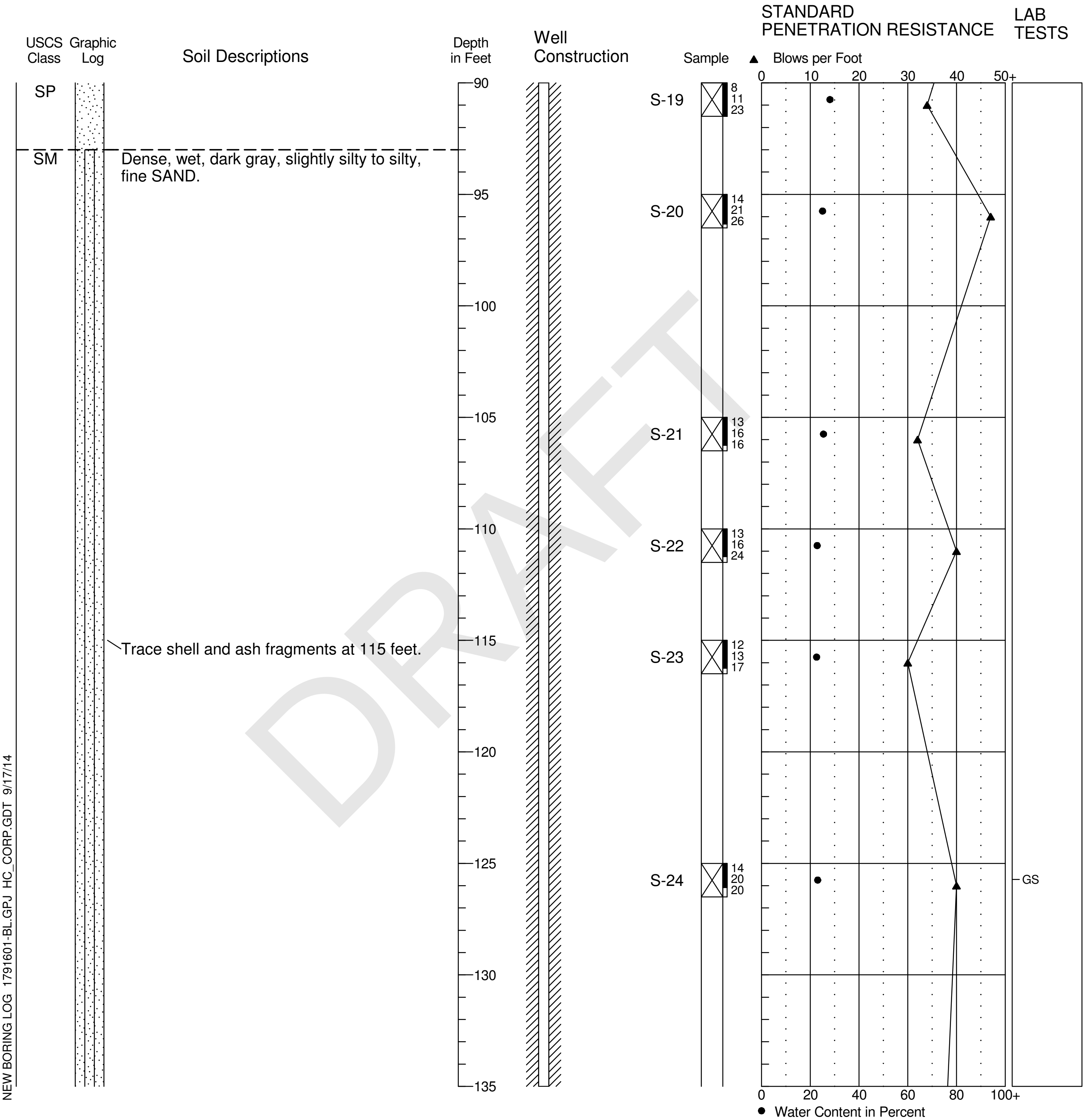
17916-01 *12/12*

Figure A-8 *2/6*

Boring Log/Construction Data for Shear Wave Well HC12-B5

Location: See Figure 2.
Approximate Ground Surface Elevation: 17 Feet
Horizontal Datum:
Vertical Datum: MLLW

Drill Equipment: Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald   Reviewed By: B. Cook



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HARTCROWSER

17916-01 *12/12*

Figure A-8 *3/6*

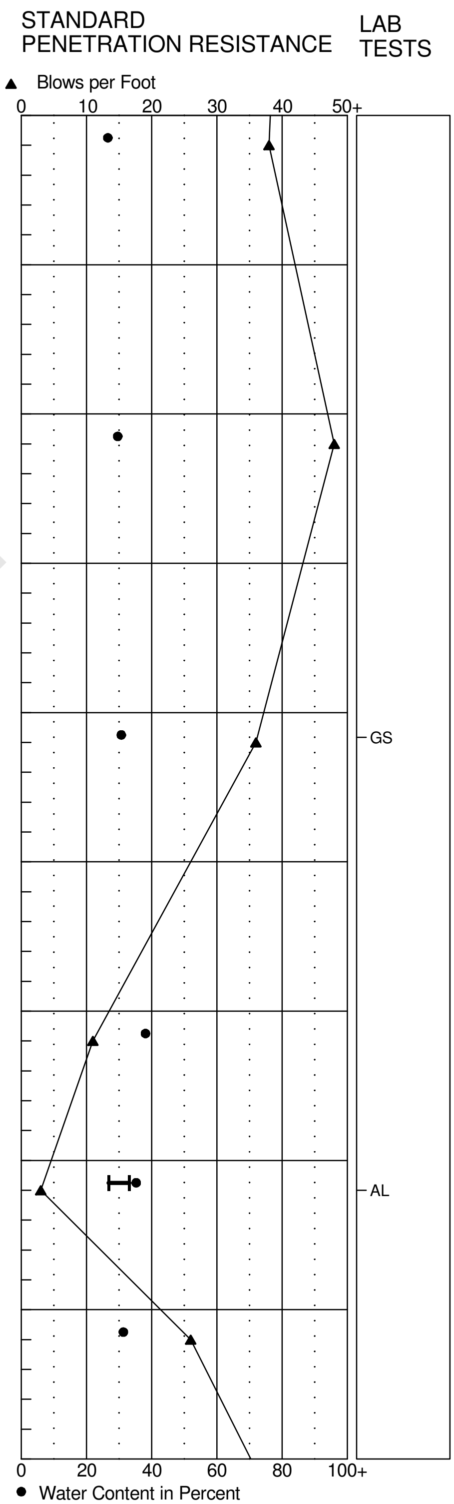
Boring Log/Construction Data for Shear Wave Well HC12-B5

Location: See Figure 2.
Approximate Ground Surface Elevation: 17 Feet
Horizontal Datum:
Vertical Datum: MLLW

Drill Equipment: Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald   Reviewed By: B. Cook

USCS Class	Depth in Feet	Soil Descriptions
SM	135	Dense, wet, dark gray, slightly silty to silty, fine SAND. (cont'd)
SM	140	Dense, wet, gray, silty to very silty, fine SAND with fine sandy SILT and clayey SILT laminations, scattered organic material.
ML	165	Soft, wet, gray SILT and clayey SILT.
SM	175	Dense, wet, gray, silty to very silty, fine SAND, interbedded fine sandy SILT and clayey SILT.

Sample	Blows	Lab Tests
S-25	11, 16, 22	
S-26	16, 25, 23	
S-27	5, 16, 20	GS
S-28	11, 5, 6	
S-29		
S-30	5, 1, 2	AL
S-31	12, 8, 18	



NEW BORING LOG 1791601-BL.GPJ HC_CORP.GDT 9/17/14

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HARTCROWSER

17916-01 *12/12*

Figure A-8 *4/6*

Boring Log/Construction Data for Shear Wave Well HC12-B5

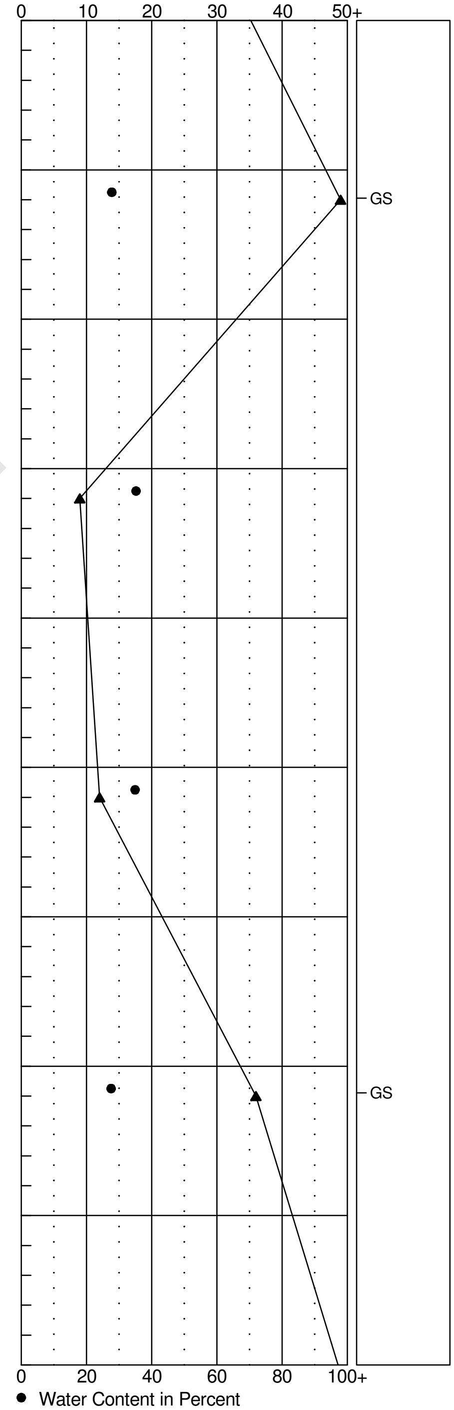
Location: See Figure 2.
Approximate Ground Surface Elevation: 17 Feet
Horizontal Datum:
Vertical Datum: MLLW

Drill Equipment: Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald Reviewed By: B. Cook

USCS Class	Soil Descriptions	Depth in Feet
SM	Dense, wet, gray, silty to very silty, fine SAND, interbedded fine sandy SILT and clayey SILT. (cont'd)	180
	Stiff, wet, gray SILT and clayey SILT, occasional fine sandy silt zones.	195
SM	Dense to very dense, wet, dark gray, silty fine SAND with interbedded SILT and fine sandy SILT layers/partings.	210

Well Construction

Sample	Blows	Depth (approx., ft)	Lab Tests
S-32	7 17 32	185	GS
S-33	0 4 5	195	
S-34	0 6 6	205	
S-35	15 17 19	215	GS



DRAFT

NEW BORING LOG 1791601-BL.GPJ HC_CORP.GDT 9/17/14

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4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

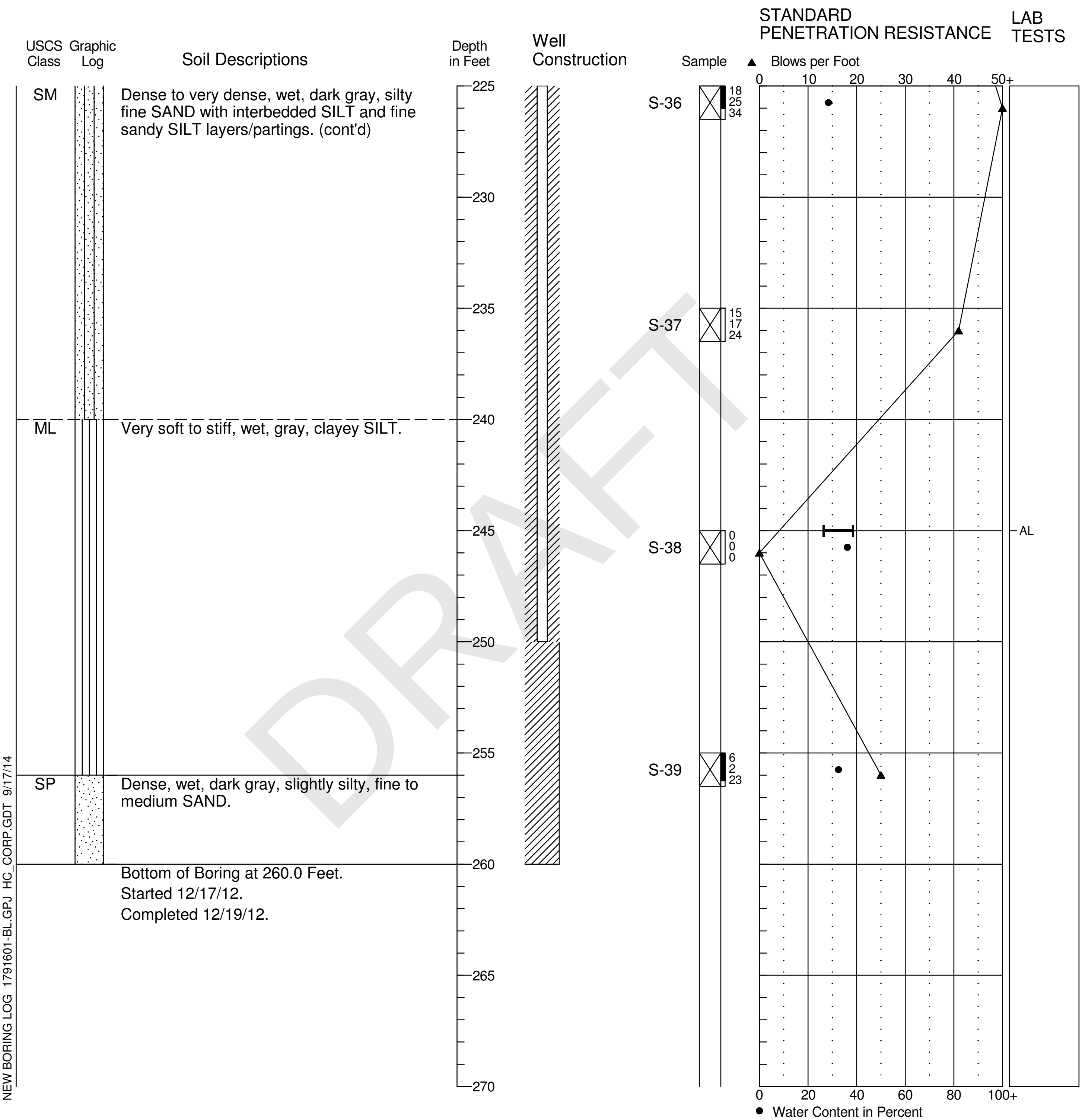
17916-01 *12/12*

Figure A-8 *5/6*

Boring Log/Construction Data for Shear Wave Well HC12-B5

Location: See Figure 2.
Approximate Ground Surface Elevation: 17 Feet
Horizontal Datum:
Vertical Datum: MLLW

Drill Equipment: Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald Reviewed By: B. Cook



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HARTCROWSER

17916-01 *12/12*

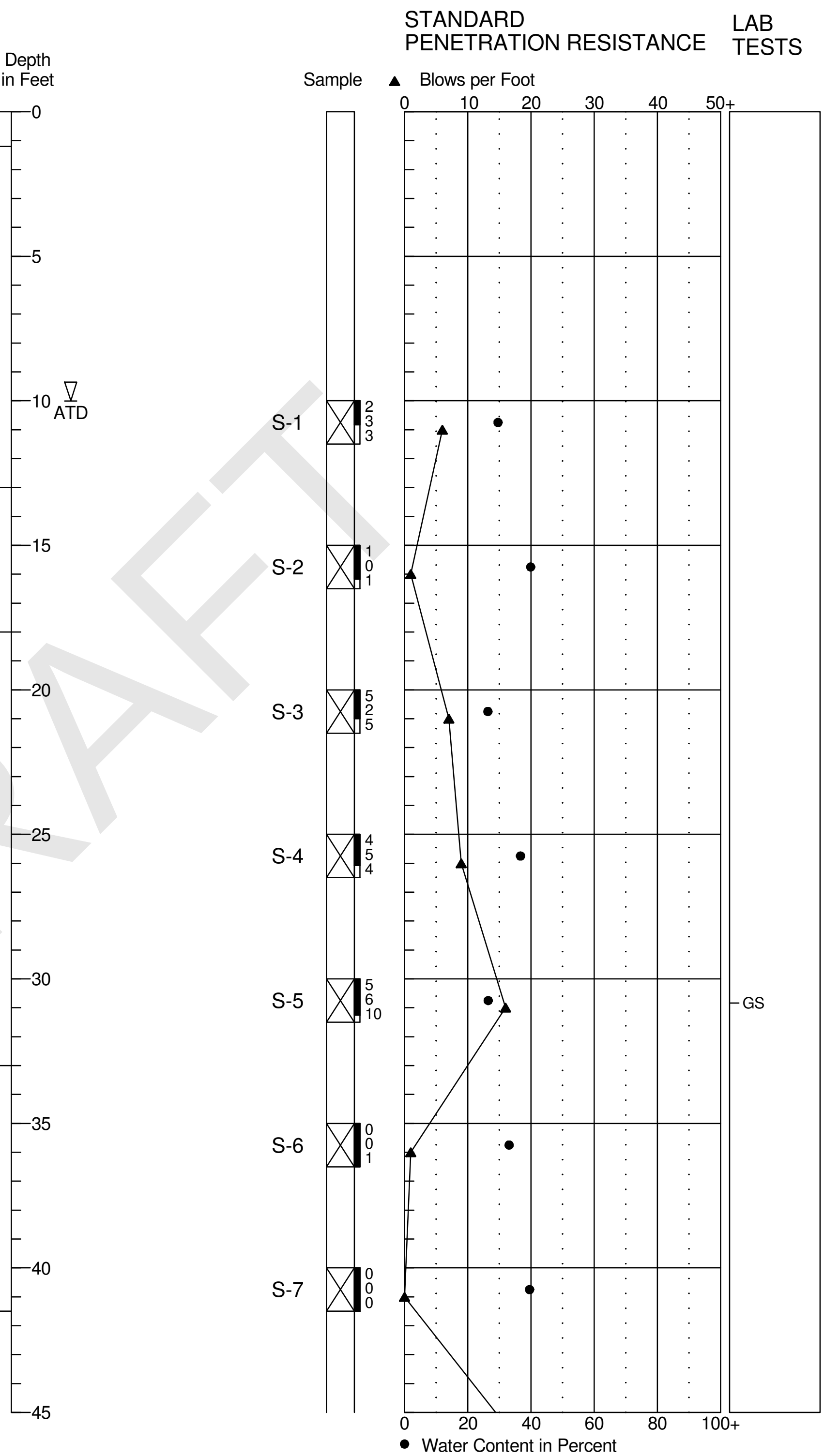
Figure A-8 *6/6*

Boring Log HC12-B6

Location: See Figure 2.
Approximate Ground Surface Elevation: 19 Feet
Horizontal Datum:
Vertical Datum: MLLW

Drill Equipment: Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald   Reviewed By: B. Cook

USCS Class	Graphic Log	Soil Descriptions	Depth in Feet
		Asphalt.	0
SP		Medium dense to loose, moist, brown, fine to medium SAND, trace shell fragments.	
ML		Very soft, wet, gray SILT.	
SP		Loose, wet, gray to dark gray, fine to medium SAND with slightly silty zones, becomes medium dense past 30 feet with scattered shell fragments.	
ML		Very soft, wet, gray SILT and clayey SILT.	
SP		Medium dense to dense, wet, dark gray, fine to medium SAND, zones of scattered shell fragments.	45



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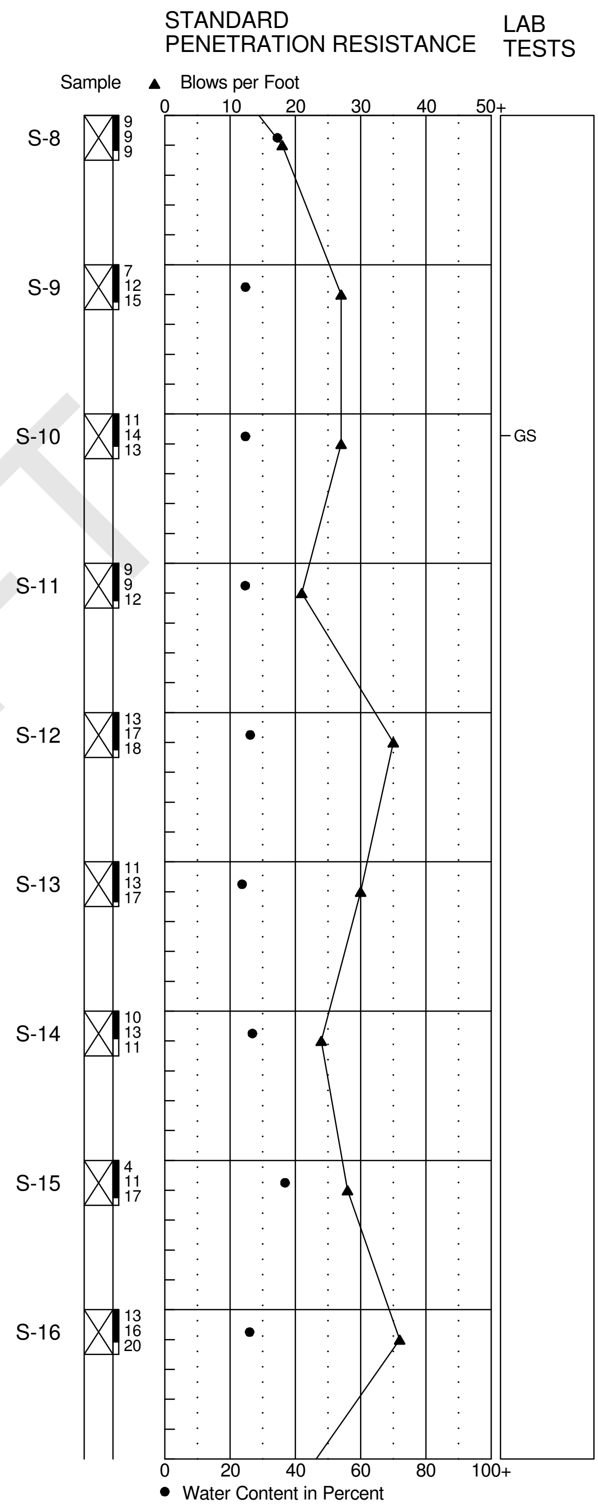
Boring Log HC12-B6

Location: See Figure 2.
Approximate Ground Surface Elevation: 19 Feet
Horizontal Datum:
Vertical Datum: MLLW

Drill Equipment: Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald   Reviewed By: B. Cook

USCS Class	Graphic Log	Soil Descriptions	Depth in Feet
SP		Medium dense to dense, wet, dark gray, fine to medium SAND, zones of scattered shell fragments. (cont'd)	45
SM		Medium dense to dense, wet, gray, silty to very silty, fine SAND with fine sandy SILT zones.	78 (approx.) to 90

Depth scale: 45, 50, 55, 60, 65, 70, 75, 80, 85, 90



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HARTCROWSER

17916-01 *12/12*

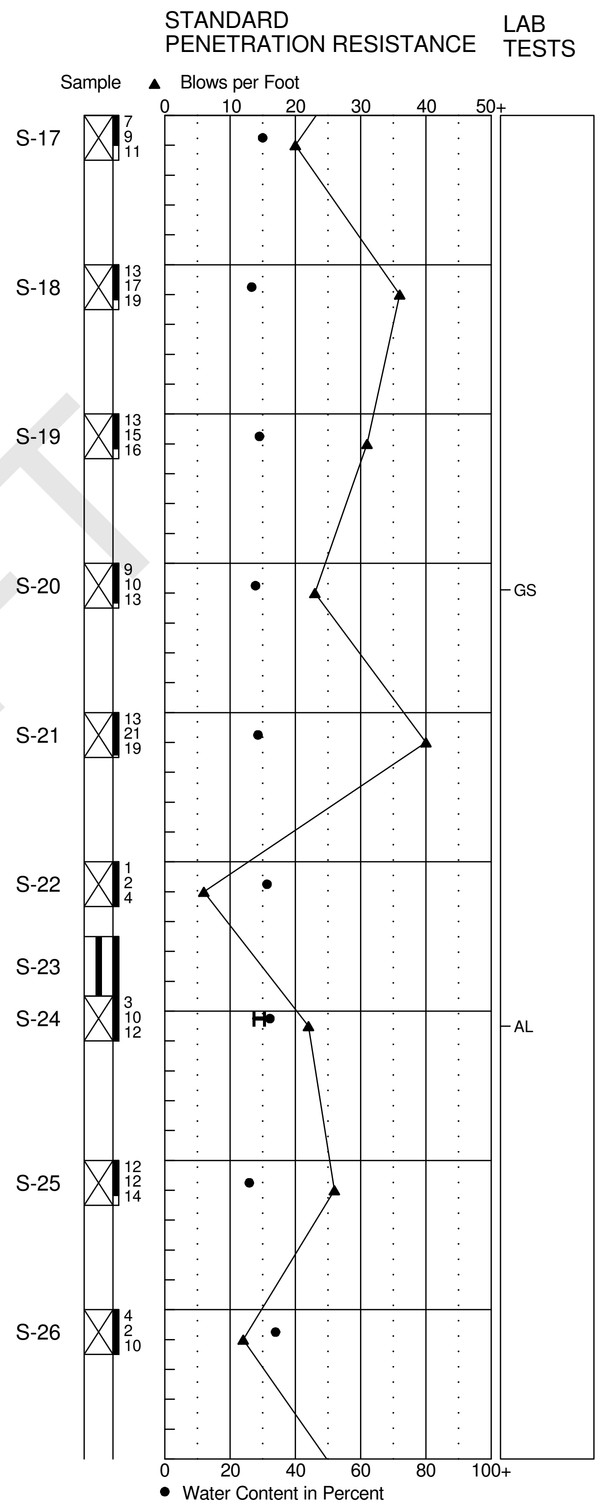
Figure A-9 *2/6*

Boring Log HC12-B6

Location: See Figure 2.
Approximate Ground Surface Elevation: 19 Feet
Horizontal Datum:
Vertical Datum: MLLW

Drill Equipment: Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald   Reviewed By: B. Cook

USCS Class	Soil Descriptions	Depth in Feet
SM	Medium dense to dense, wet, gray, silty to very silty, fine SAND with fine sandy SILT zones. (cont'd)	90
SP	Dense, wet, gray to dark gray, fine to medium SAND, scattered shell fragments.	95
SM	Medium dense to dense, wet, gray, slightly silty to silty, fine SAND with very silty, fine SAND zones.	100–110
ML	Medium stiff to very stiff, wet, gray SILT and clayey SILT with fine sandy SILT zones.	115–120
SM	Medium dense, wet, gray, silty, fine SAND with fine sandy SILT zones.	125
ML	Stiff, wet, gray SILT with clayey SILT zones.	130
SM		135



NEW BORING LOG 1791601-BL.GPJ HC_CORP.GDT 9/17/14

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2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
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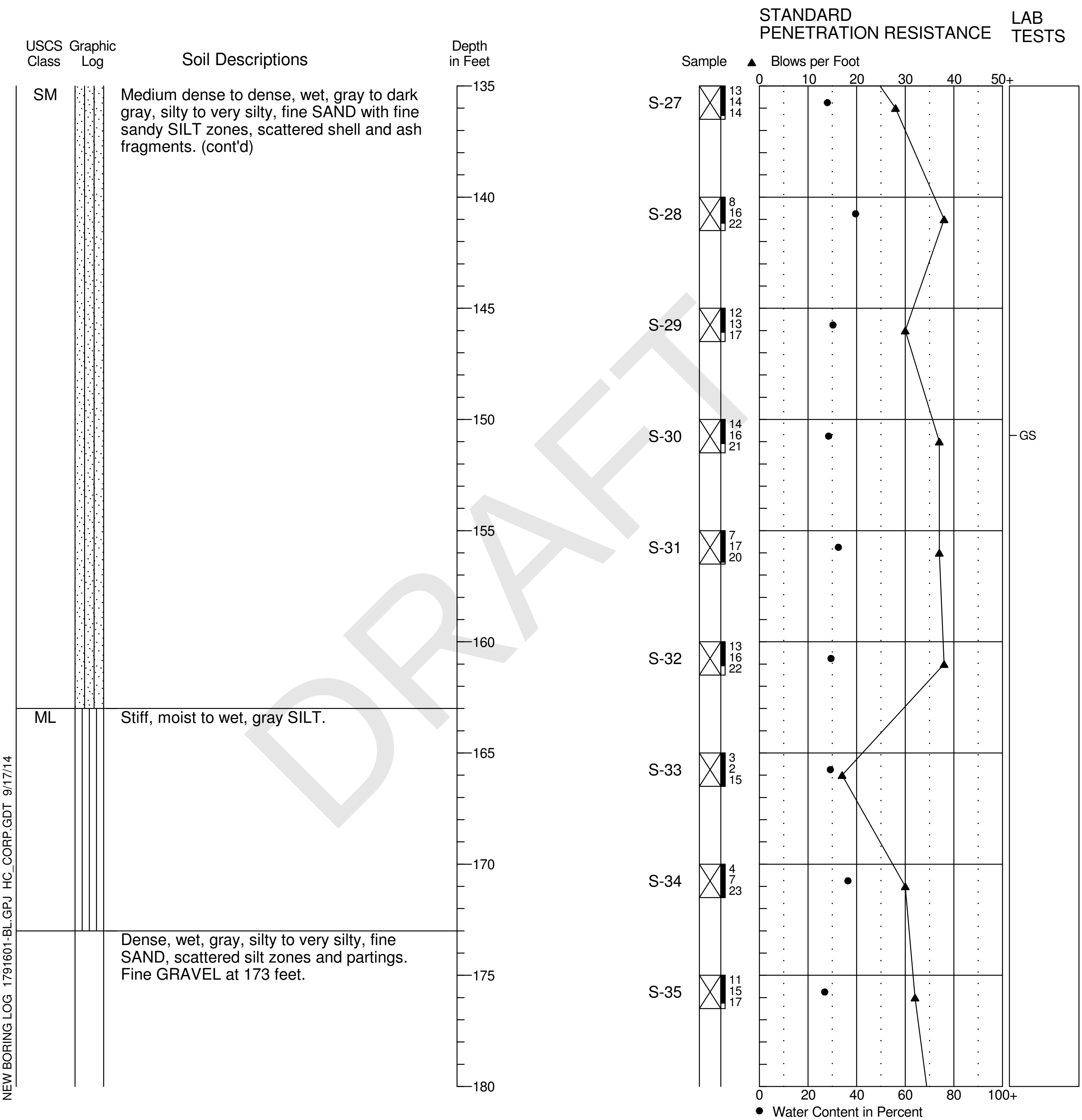
HARTCROWSER

17916-01 **12/12**
Figure A-9 **3/6**

Boring Log HC12-B6

Location: See Figure 2.
Approximate Ground Surface Elevation: 19 Feet
Horizontal Datum:
Vertical Datum: MLLW

Drill Equipment: Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald   Reviewed By: B. Cook



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3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
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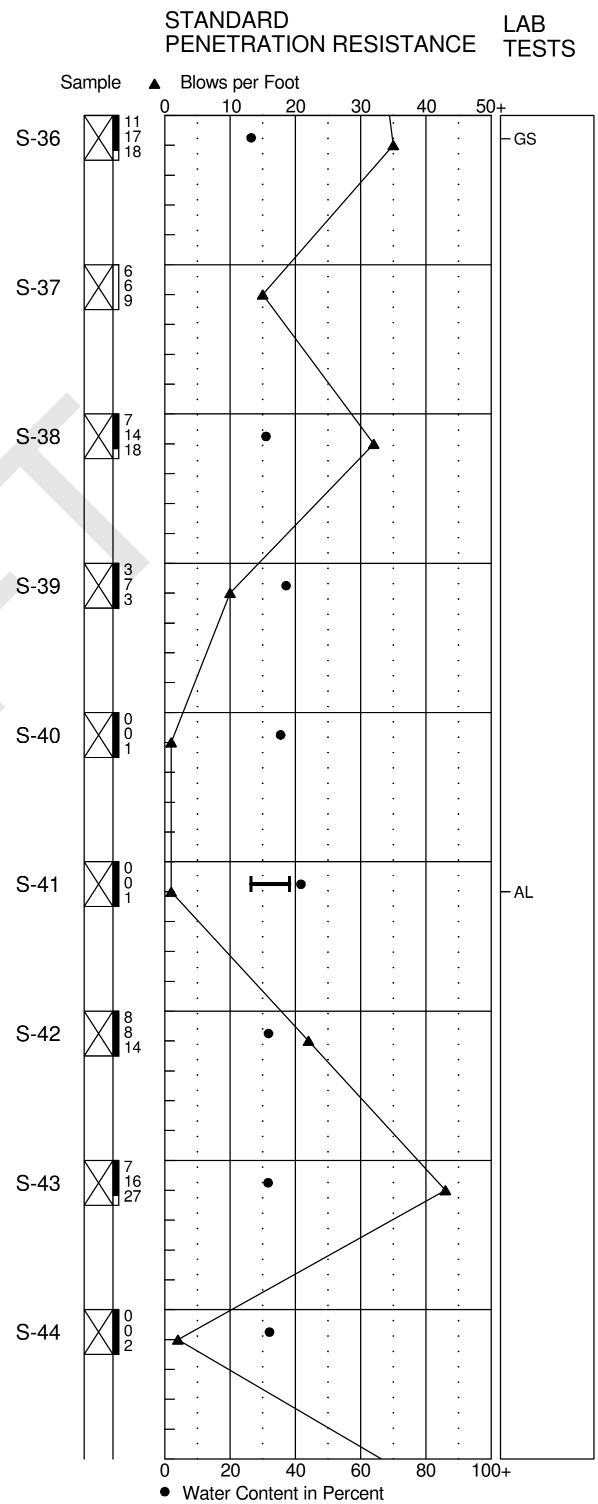
Boring Log HC12-B6

Location: See Figure 2.
Approximate Ground Surface Elevation: 19 Feet
Horizontal Datum:
Vertical Datum: MLLW

Drill Equipment: Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald   Reviewed By: B. Cook

USCS Class	Graphic Log	Soil Descriptions	Depth in Feet
		Dense, wet, gray, silty to very silty, fine SAND, scattered silt zones and partings. Fine GRAVEL at 173 feet. (cont'd)	180
ML		Stiff, wet, gray, clayey SILT with fine sandy SILT zones, scattered organic material.	
ML		Very soft, wet, gray, clayey SILT. Becomes very stiff past 209 feet.	
SM		Dense, wet, gray, very silty, fine SAND with SILT and clayey SILT zones.	
ML		Very soft, wet, gray, clayey SILT, very stiff with silty fine SAND partings past 223 feet.	225



DRAFT

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

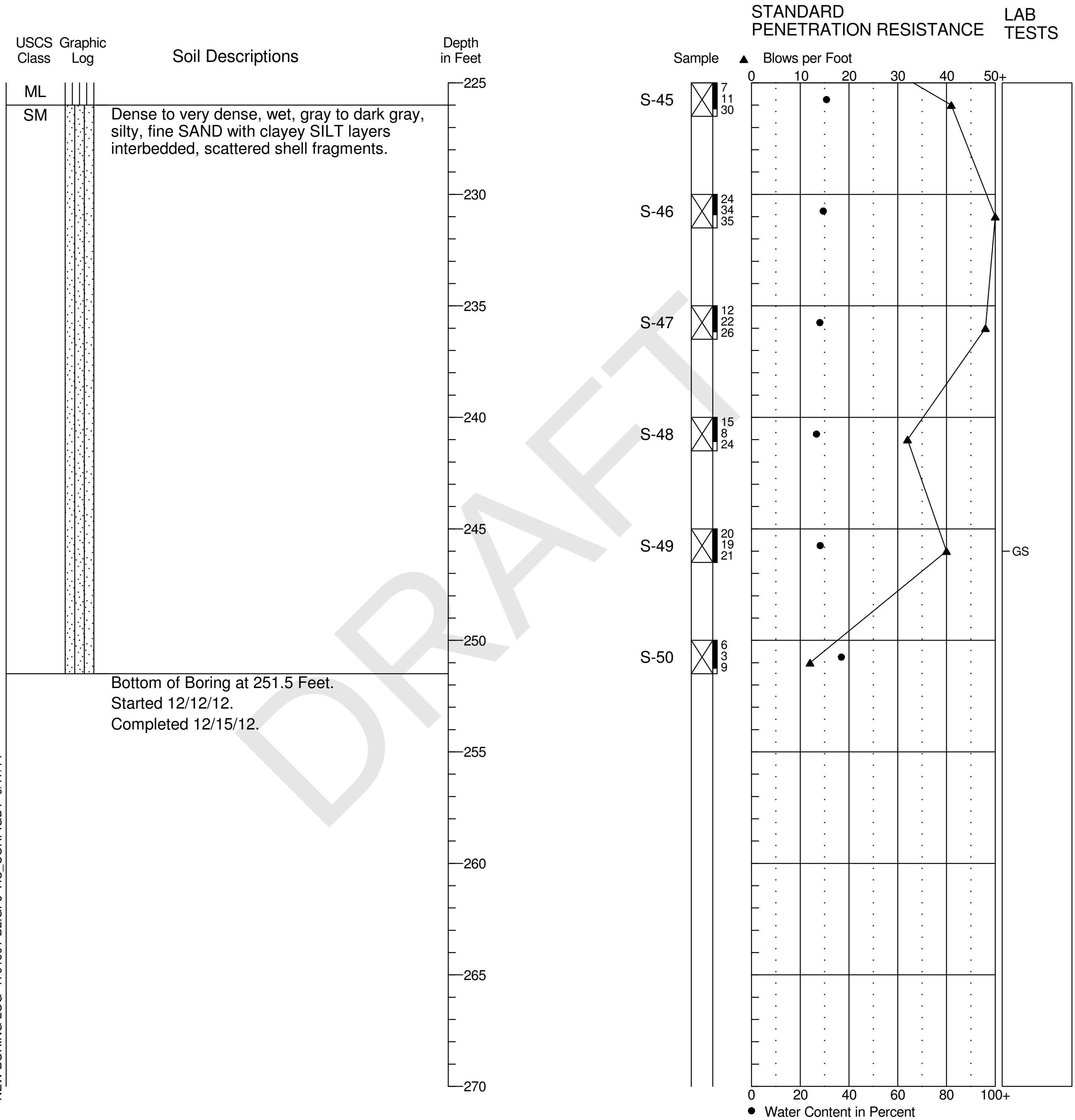
17916-01   12/12
Figure A-9   5/6

NEW BORING LOG 1791601-BL.GPJ HC_CORP.GDT 9/17/14

Boring Log HC12-B6

Location: See Figure 2.
Approximate Ground Surface Elevation: 19 Feet
Horizontal Datum:
Vertical Datum: MLLW

Drill Equipment: Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald   Reviewed By: B. Cook



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

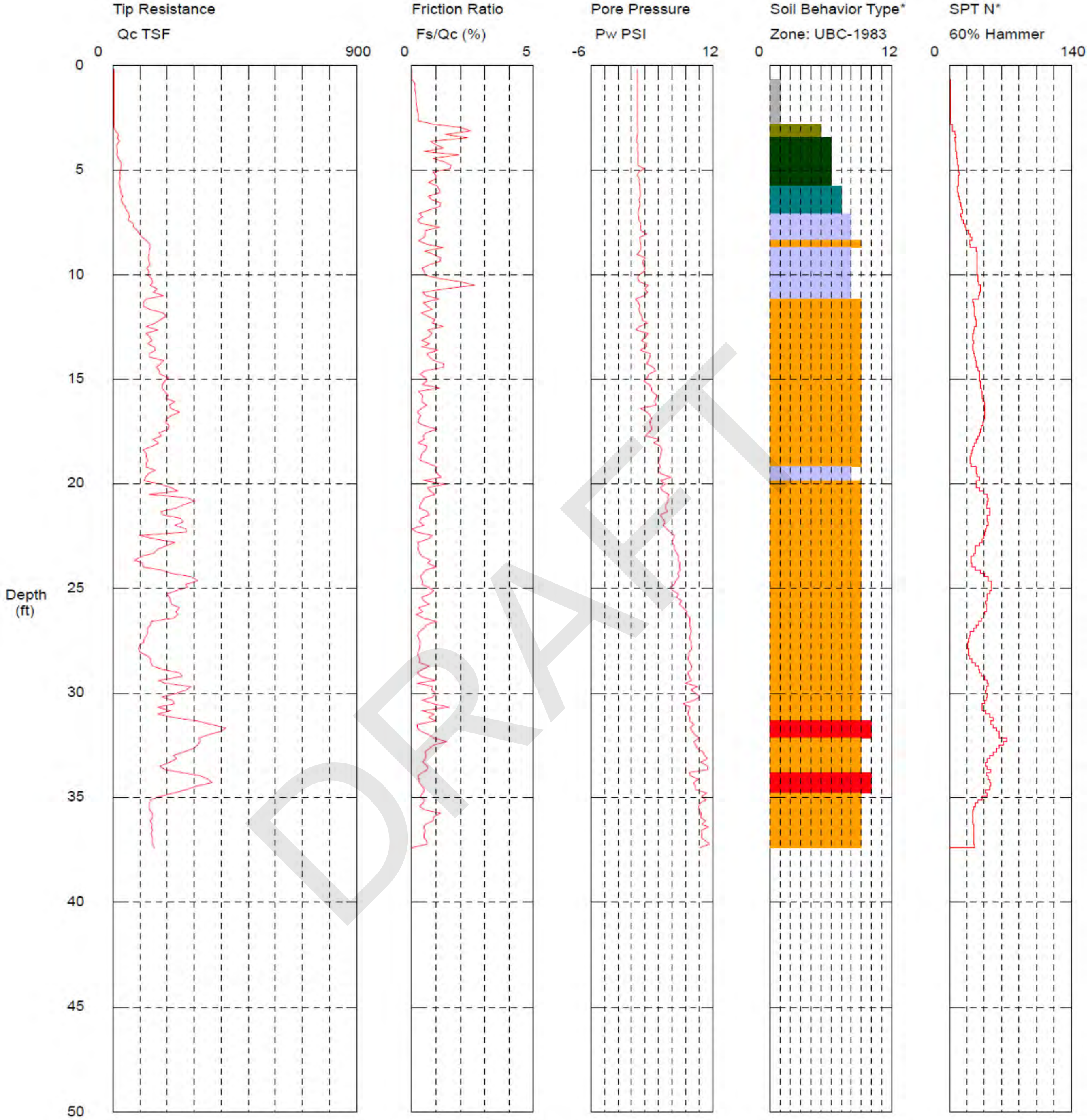
HARTCROWSER

17916-01 *12/12*

Figure A-9 *6/6*

Operator: Gerdes
Sounding: HC 12 - P1
Cone Used: DDG1238

CPT Date/Time: 1/25/2013 10:17:31 AM
Location: Port of Tacoma
Job Number:



Maximum Depth = 37.40 feet

Depth Increment = 0.164 feet

1 sensitive fine grained	4 silty clay to clay	7 silty sand to sandy silt	10 gravelly sand to sand
2 organic material	5 clayey silt to silty clay	8 sand to silty sand	11 very stiff fine grained (*)
3 clay	6 sandy silt to clayey silt	9 sand	12 sand to clayey sand (*)

InSitu Engineering

Pre-Drilled 3ft

Soil behavior type and SPT based on data from UBC-1983

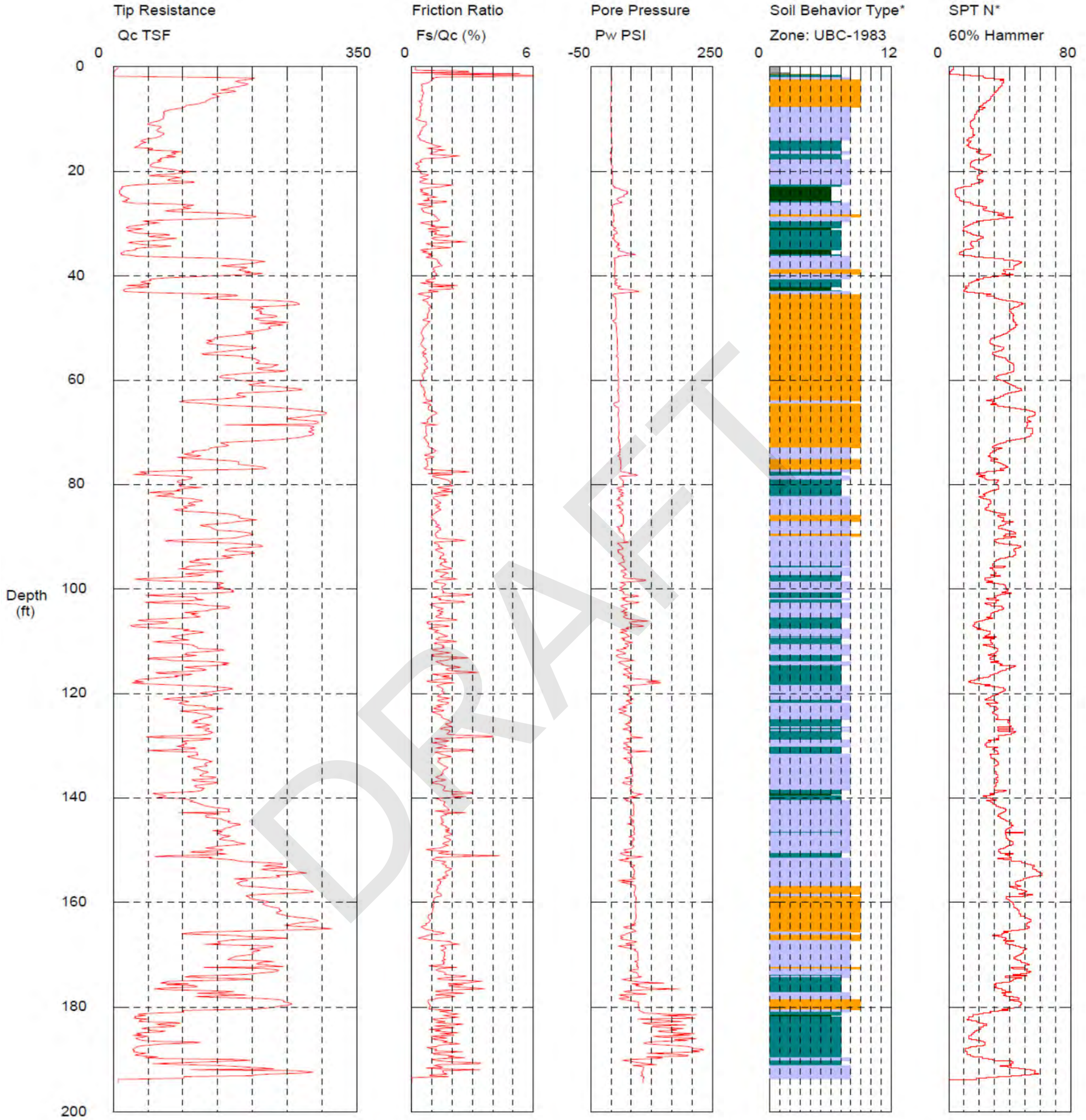
HARTCROWSER

17916-00 3/13

Figure A-10 1/1

MKH 3/27/2013 U:\SPU\time\7_4_2014 to 7_4_2015\[Time and expense sheets 9_1.xls]daytimer

Operator: Gerdes	CPT Date/Time: 1/30/2013 11:15:05 AM
Sounding: HC 12 - P2	Location: Port of Tacoma
Cone Used: DDG1238	Job Number:



Maximum Depth = 194.39 feet

Depth Increment = 0.164 feet

1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

InSitu Engineering

Pre-Drilled 2ft

Soil behavior type and SPT based on data from UBC-1983

MKH 3/27/2013 U:\SPU\time\7_4_2014 to 7_4_2015\[Time and expense sheets 9_1.xls]daytimer

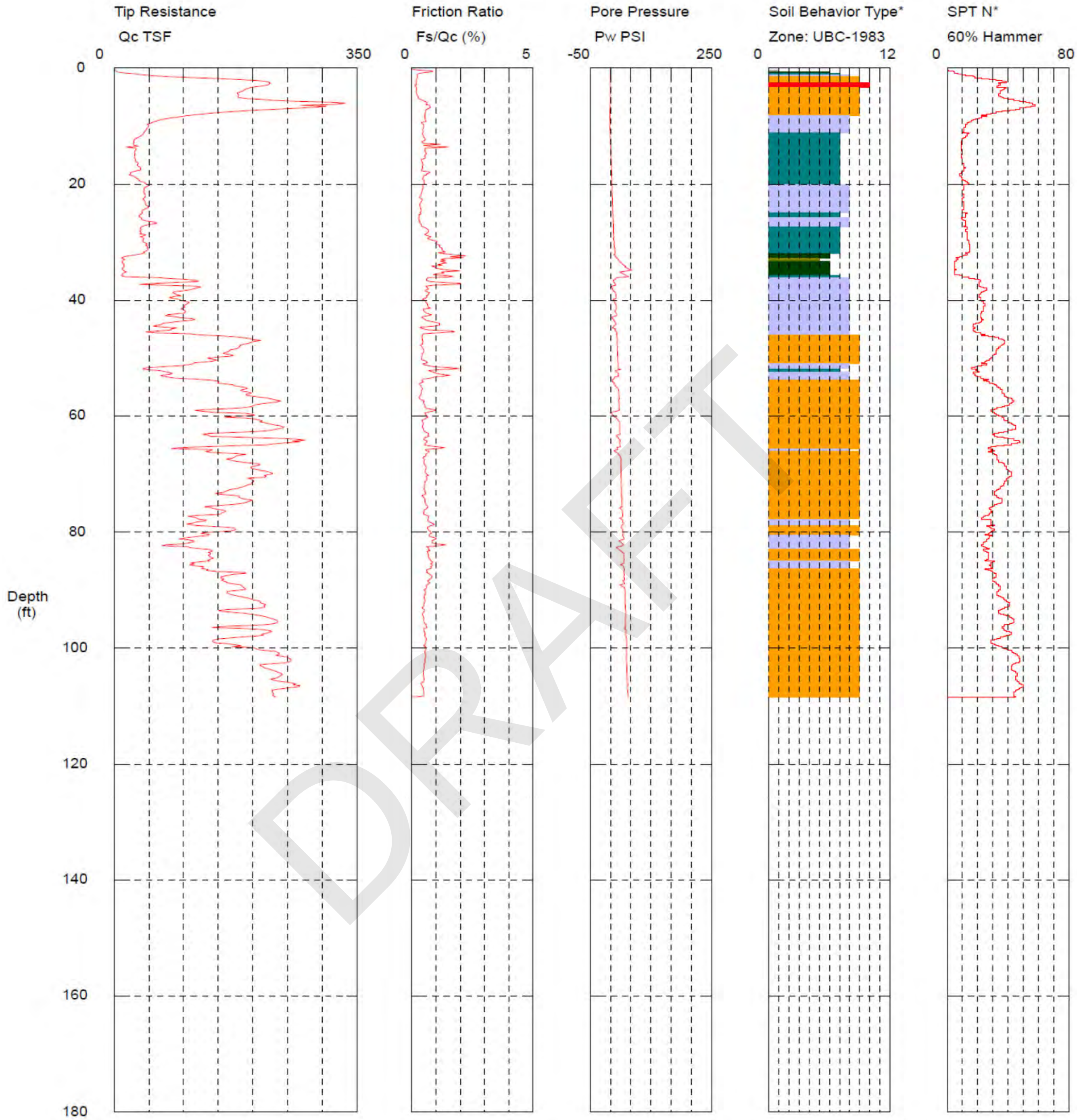
HARTCROWSER

17916-00 3/13

Figure A-11 1/1

Operator: Gerdes
Sounding: HC 12-P3
Cone Used: DDG1220

CPT Date/Time: 12/19/2012 8:20:35 AM
Location: Port of Tacoma
Job Number:



Maximum Depth = 108.43 feet

Depth Increment = 0.164 feet

- 1 sensitive fine grained
- 2 organic material
- 3 clay
- 4 silty clay to clay
- 5 clayey silt to silty clay
- 6 sandy silt to clayey silt
- 7 silty sand to sandy silt
- 8 sand to silty sand
- 9 sand
- 10 gravelly sand to sand
- 11 very stiff fine grained (*)
- 12 sand to clayey sand (*)

InSitu Engineering

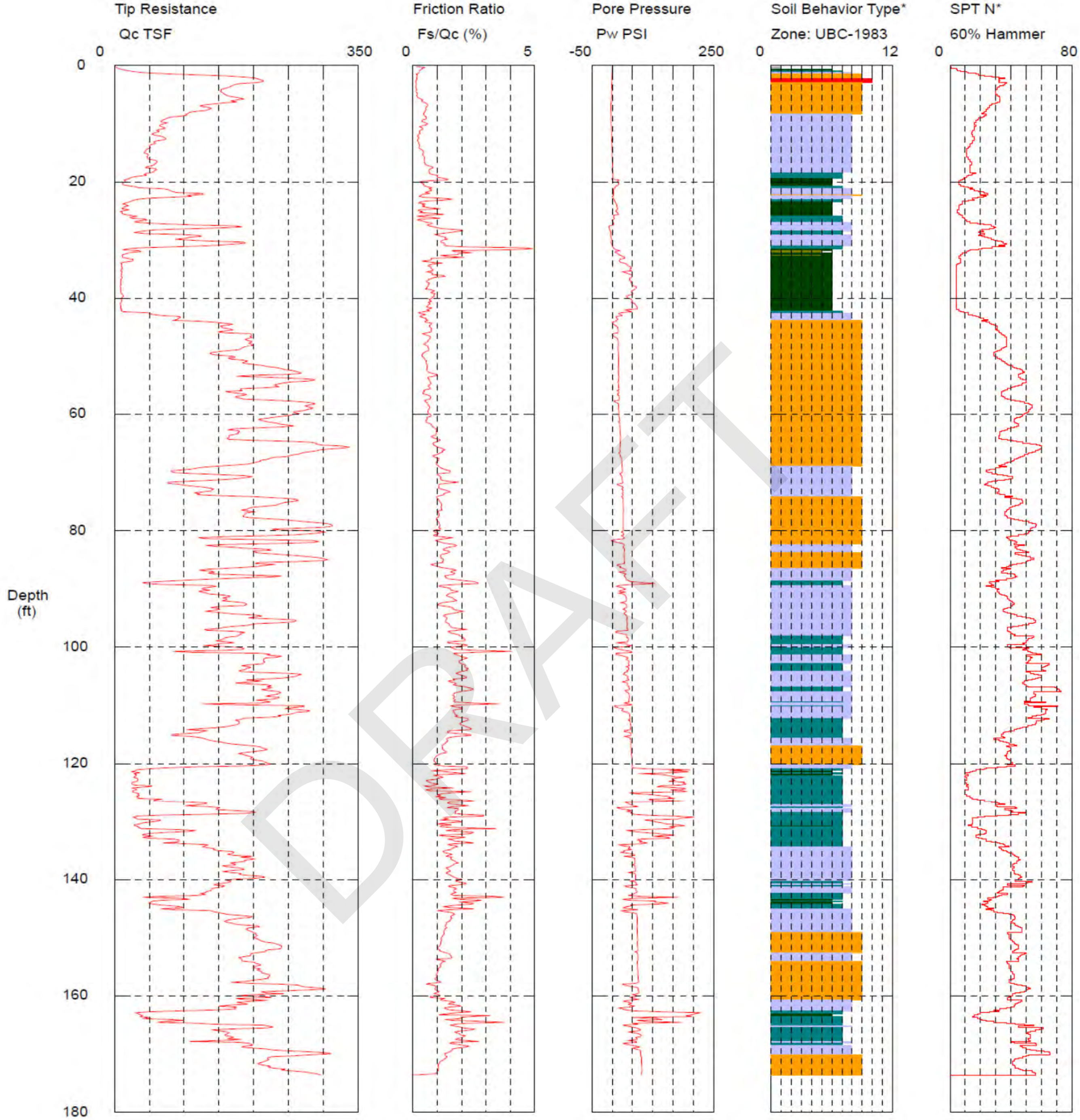
Predrilled 6ft

*Soil behavior type and SPT based on data from UBC-1983

HARTCROWSER
17916-00 3/13
Figure A-12 1/1

Operator: Gerdes
Sounding: HC 12-P4
Cone Used: DPG1186

CPT Date/Time: 12/12/2012 11:25:55 AM
Location: Port of Tacoma
Job Number:



Maximum Depth = 173.59 feet

Depth Increment = 0.164 feet

1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

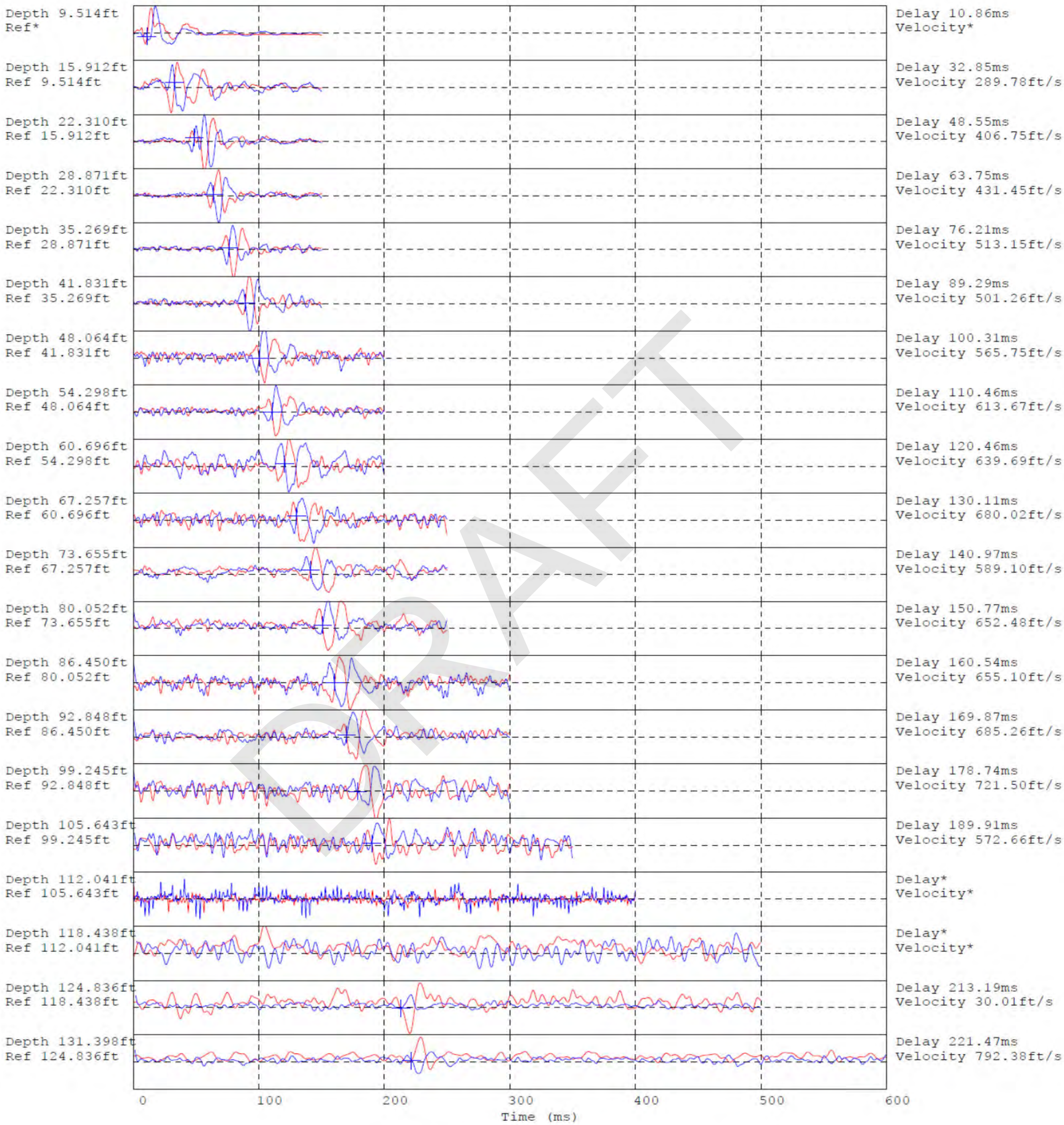
InSitu Engineering

*Soil behavior type and SPT based on data from UBC-1983

HARTCROWSER
17916-00 3/13
Figure A-13 1/1

MKH 3/27/2013 U:\SPU\time\7_4_2014 to 7_4_2015\[Time and expense sheets 9_1.xls]daytimer

Terminal 4 - HC12-P4
Shear Wave



Hammer to Rod String Distance 0.333(m)
* = Not Determined

Red - Right Shear Wave
Blue - Left Shear Wave

Green - Compression Wave

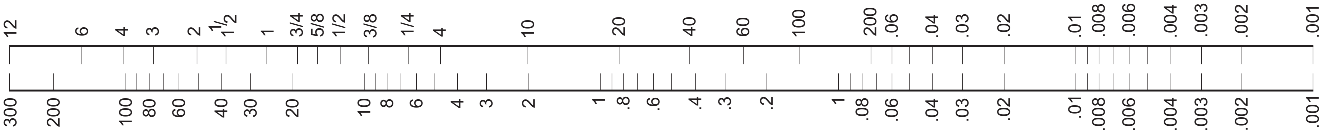
HARTCROWSER
17916-00 3/13
Figure A-14 1/1

MKH 3/27/2013 U:\SPU\time\7_4_2014 to 7_4_2015\[Time and expense sheets 9_1.xls]daytimer

APPENDIX B
Laboratory Test Results

Unified Soil Classification (USC) System
Soil Grain Size

Size of Opening In Inches	Number of Mesh per Inch (US Standard)	Grain Size in Millimetres



COBBLES	GRAVEL	SAND	SILT and CLAY
Coarse-Grained Soils			Fine-Grained Soils

Coarse-Grained Soils

G W	G P	G M	G C	S W	S P	S M	S C
Clean GRAVEL <5% fines		* GRAVEL with >12% fines		Clean SAND <5% fines		* SAND with >12% fines	
GRAVEL >50% coarse fraction larger than No. 4				SAND >50% coarse fraction smaller than No. 4			
Coarse-Grained Soils >50% larger than No. 200 sieve							

G W and S W $\left(\frac{D_{60}}{D_{10}}\right)$ >4 for G W, >6 for S W & $1 \leq \left(\frac{(D_{30})^2}{D_{10} \times D_{60}}\right) \leq 3$

G P and S P Clean GRAVEL or SAND not meeting requirements for G W and S W

G M and S M Atterberg limits below A line with PI <4

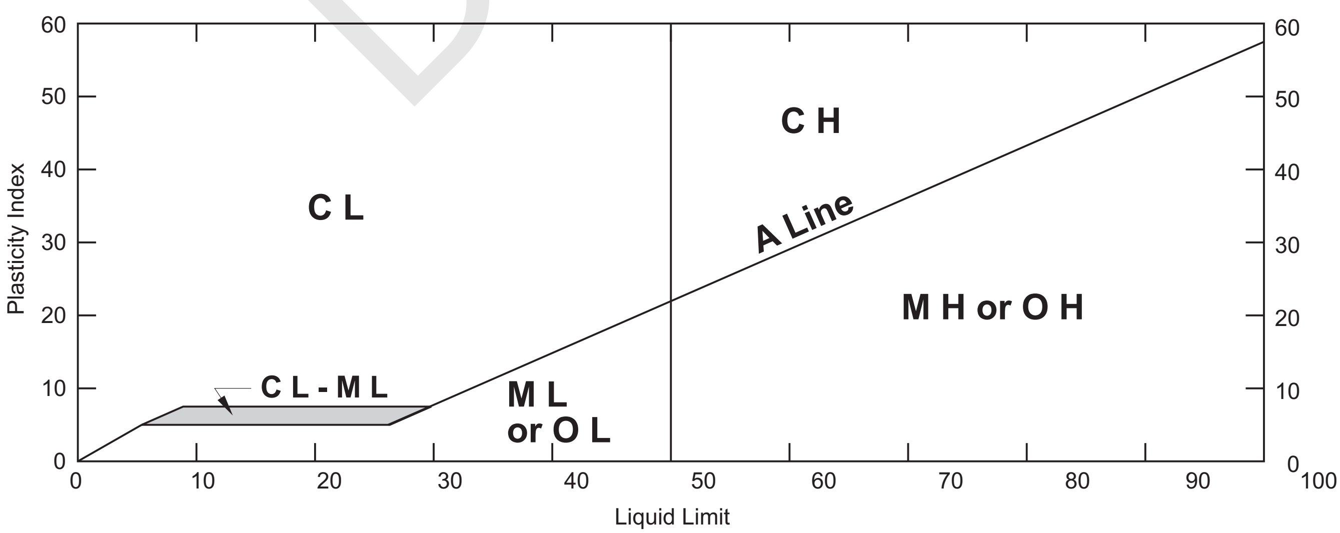
G C and S C Atterberg limits above A Line with PI >7

* Coarse-grained soils with percentage of fines between 5 and 12 are considered borderline cases requiring use of dual symbols.

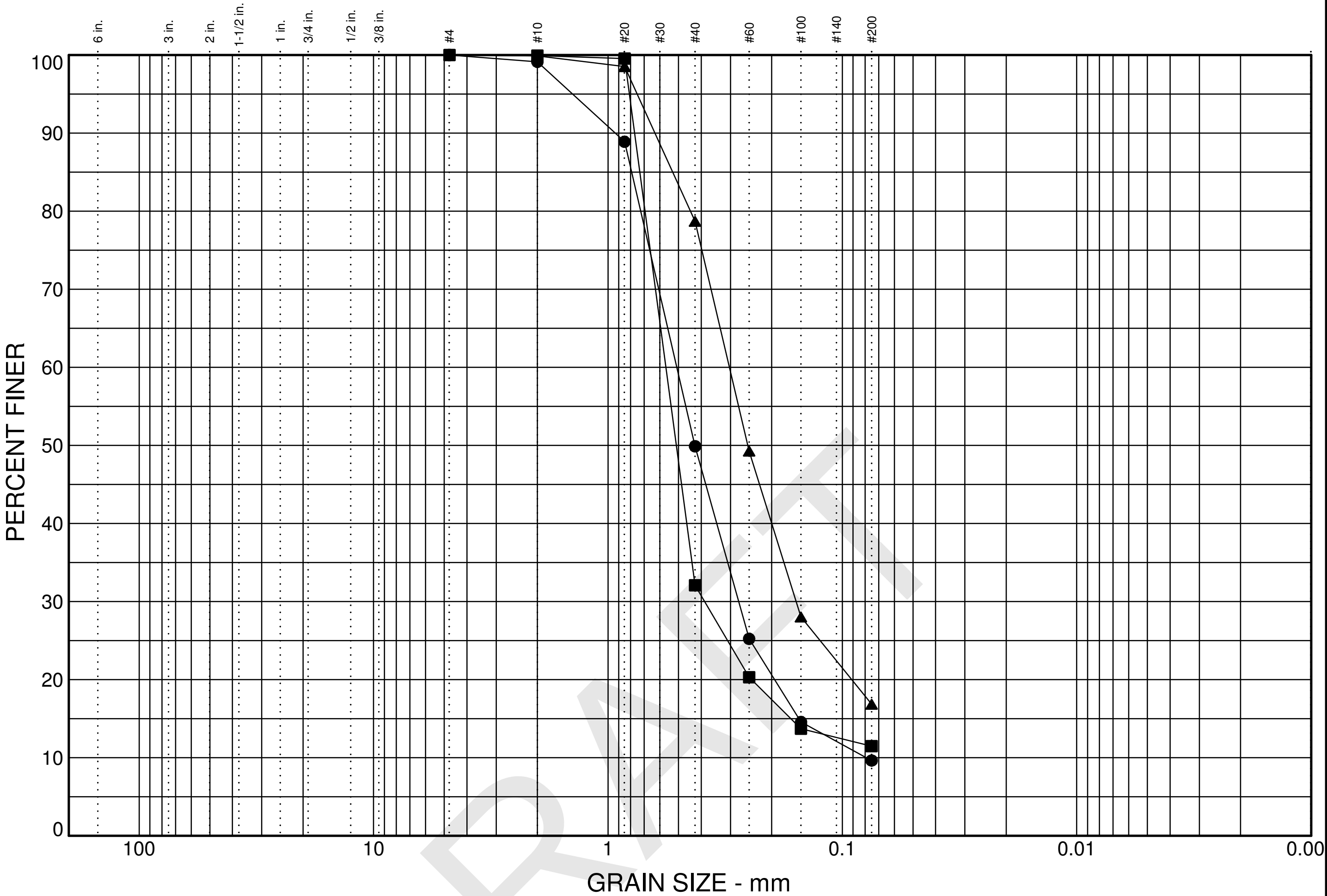
D_{10}, D_{30}, and D_{60} are the particles diameter of which 10, 30, and 60 percent, respectively, of the soil weight are finer.

Fine-Grained Soils

M L	C L	O L	M H	C H	O H	Pt
SILT	CLAY	Organic	SILT	CLAY	Organic	Highly Organic Soils
Soils with Liquid Limit <50%			Soils with Liquid Limit >50%			
Fine-Grained Soils >50% smaller than No. 200 sieve						



Particle Size Distribution Test Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.0	90.4	9.6	
■	0.0	0.0	88.5	11.5	
▲	0.0	0.0	83.1	16.9	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.793	0.509	0.426	0.277	0.153	0.079	1.91	6.45
■			0.732	0.566	0.511	0.387	0.166		5.55	11.91
▲			0.53	0.303	0.253	0.157				

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
● slightly silty SAND	SW-SM	22.7%
■ slightly silty SAND	SP-SM	26.5%
▲ silty SAND	SM	23.5%

Remarks:
●

■

▲

Project: Port of Tacoma Pier 4 Reconfiguration

Client:

● Source: HC14-B1	Sample No.: S-11	Depth: 60.0 to 61.5
■ Source: HC14-B1	Sample No.: S-19	Depth: 100.0 to 101.5
▲ Source: HC14-B1	Sample No.: S-24	Depth: 125.0 to 126.5

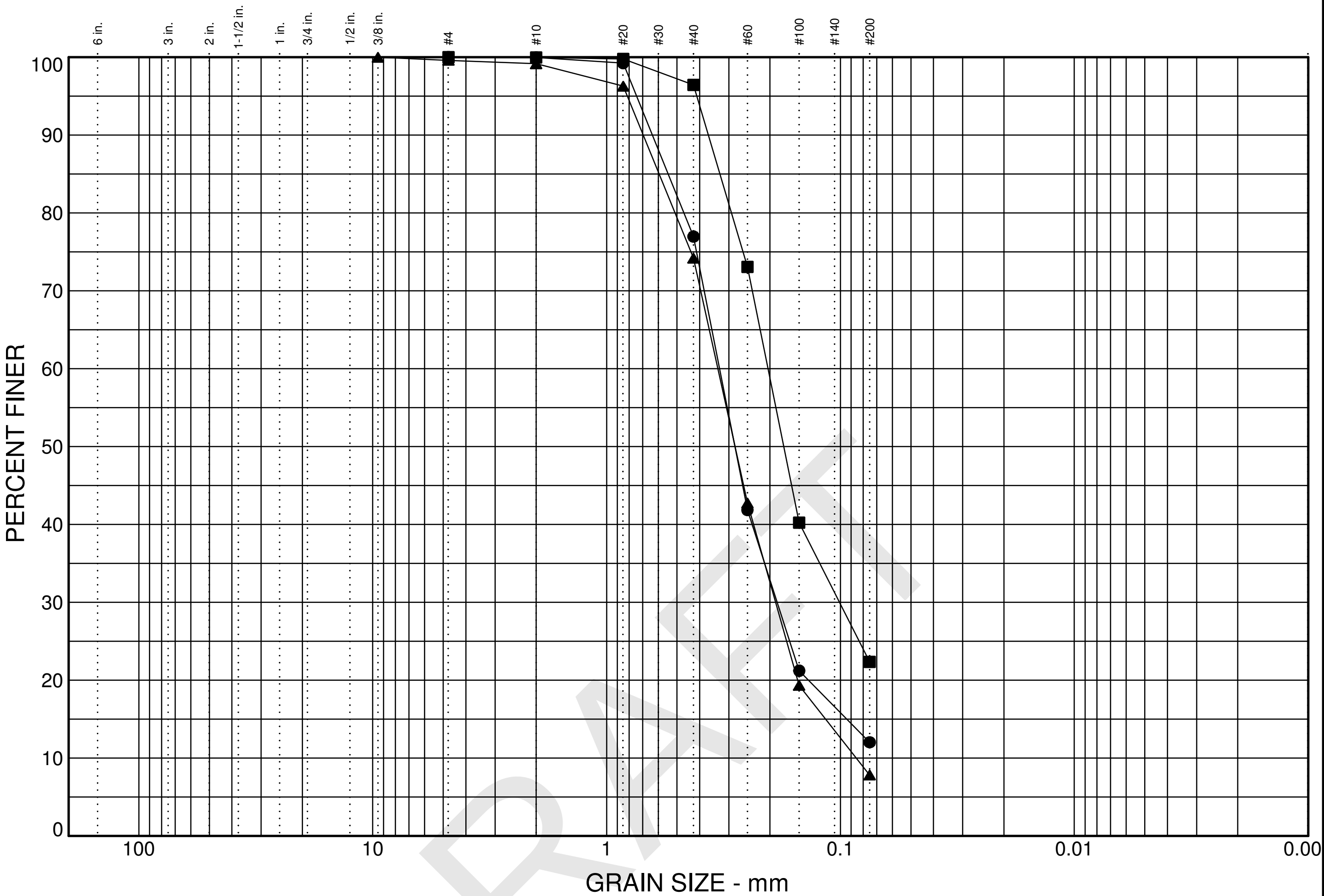
HARTCROWSER

17916-01 *6/14*

Figure B-2

GRAIN SIZE 1791601-BL.GPJ HC_CORP.GDT 9/3/14

Particle Size Distribution Test Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.0	88.0	12.0	
■	0.0	0.0	77.7	22.3	
▲	0.0	0.4	91.8	7.8	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.546	0.329	0.283	0.186	0.094		1.64	5.11
■			0.328	0.204	0.175	0.101				
▲			0.596	0.334	0.282	0.189	0.116	0.085	1.25	3.91

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
● slightly silty SAND	SP-SM	24.3%
■ silty SAND	SM	26.1%
▲ slightly silty SAND	SP-SM	26.7%

Remarks:

●

■

▲

Project: Port of Tacoma Pier 4 Reconfiguration

Client:

● Source: HC14-B1 Sample No.: S-29 Depth: 150.0 to 151.5
■ Source: HC14-B1 Sample No.: S-35 Depth: 180.0 to 181.5
▲ Source: HC14-B2 Sample No.: S-2 Depth: 15.0 to 16.5

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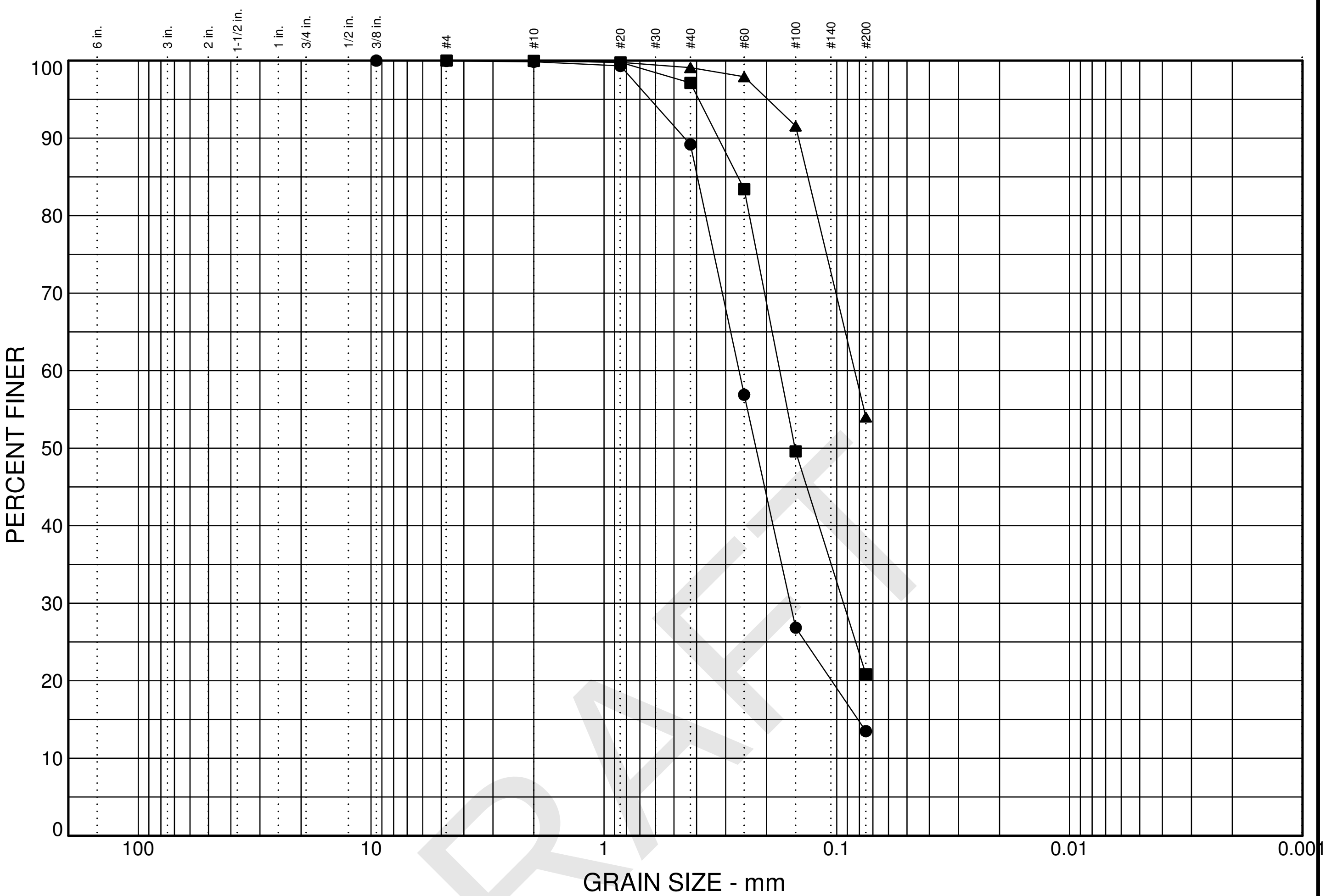
17916-01 *6/14*

Figure B-3

GRAIN SIZE 1791601-BL.GPJ HC_CORP.GDT 9/3/14

Particle Size Distribution Test Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.0	86.5	13.5	
■	0.0	0.0	79.2	20.8	
▲	0.0	0.0	46.0	54.0	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.397	0.263	0.222	0.158	0.081			
■			0.266	0.176	0.151	0.094				
▲			0.133	0.084						

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
● silty SAND	SM	24.9%
■ silty SAND	SM	27.4%
▲ very sandy SILT	ML	26.9%

Remarks:
●
■
▲

Project: Port of Tacoma Pier 4 Reconfiguration

Client:

● Source: HC14-B2	Sample No.: S-13	Depth: 70.0 to 71.5
■ Source: HC14-B2	Sample No.: S-20	Depth: 105.0 to 106.5
▲ Source: HC14-B2	Sample No.: S-28	Depth: 145.0 to 146.5

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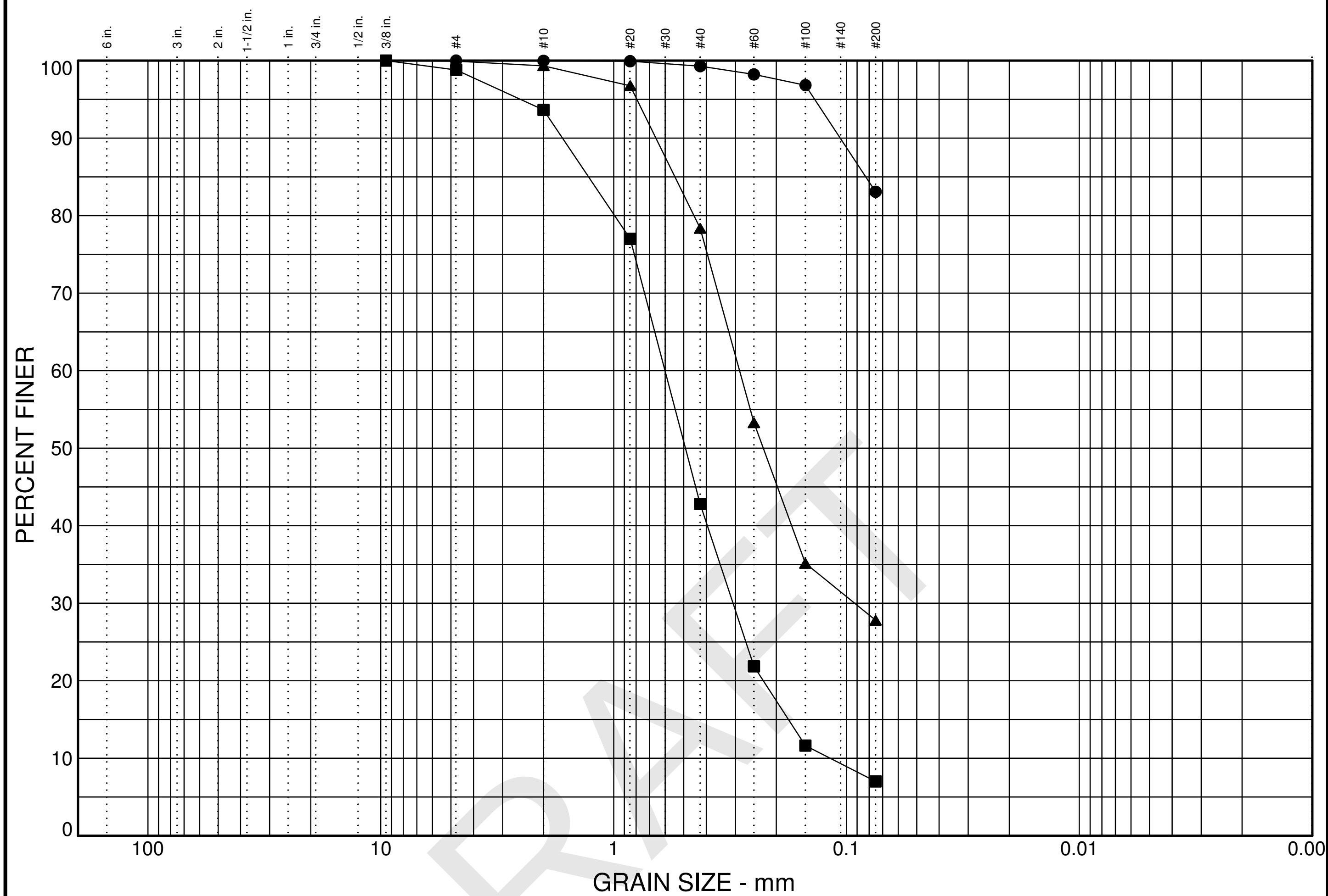
17916-01 *6/14*

Figure B-4

Particle Size Distribution Test Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.0	16.9	83.1	
■	0.0	1.2	91.8	7.0	
▲	0.0	0.1	72.1	27.8	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.083							
■			1.282	0.602	0.492	0.307	0.177	0.117	1.34	5.13
▲			0.546	0.288	0.228	0.092				

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
● sandy SILT	ML	33.2%
■ slightly silty SAND, trace gravel	SP-SM	24.0%
▲ silty SAND	SM	31.6%

Remarks:
●

■

▲

Project: Port of Tacoma Pier 4 Reconfiguration

Client:

● Source: HC14-B2 Sample No.: S-34 Depth: 175.0 to 176.5
■ Source: HC14-B3 Sample No.: S-3 Depth: 20.0 to 21.5
▲ Source: HC14-B3 Sample No.: S-9 Depth: 50.0 to 51.5

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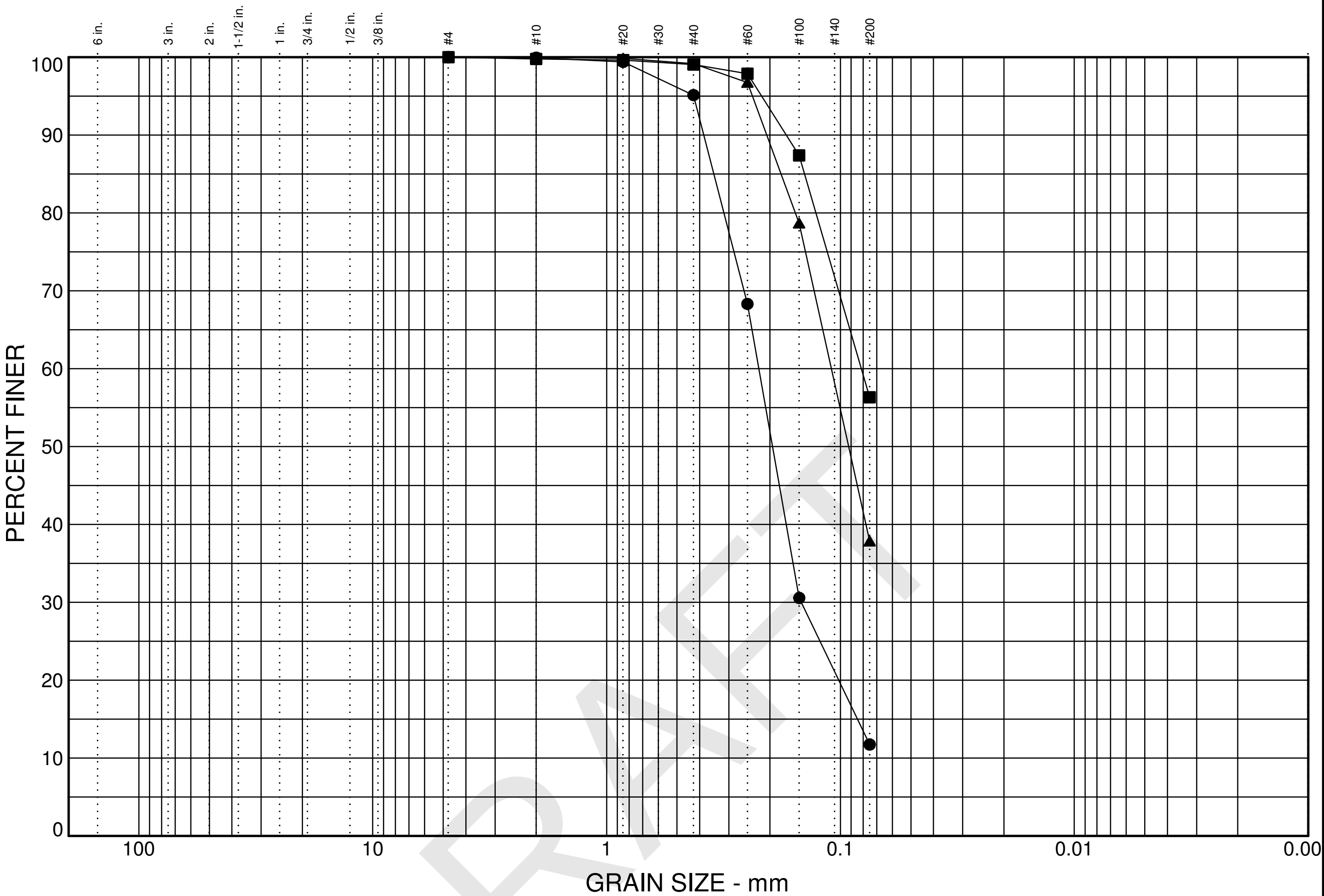
17916-01 *6/14*

Figure B-5

GRAIN SIZE 1791601-BL.GPJ HC_CORP.GDT 9/3/14

Particle Size Distribution Test Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.0	88.3	11.7	
■	0.0	0.0	43.7	56.3	
▲	0.0	0.0	62.1	37.9	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.348	0.223	0.195	0.147	0.085		1.37	3.18
■			0.142	0.081						
▲			0.179	0.109	0.092					

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
● slightly silty SAND	SP-SM	24.6%
■ very sandy SILT	ML	27.4%
▲ very silty SAND	SM	29.9%

Remarks:
●

■

▲

Project: Port of Tacoma Pier 4 Reconfiguration

Client:

● Source: HC14-B3 Sample No.: S-13 Depth: 70.0 to 71.5
■ Source: HC14-B3 Sample No.: S-19 Depth: 100.0 to 101.5
▲ Source: HC14-B3 Sample No.: S-22 Depth: 115.0 to 116.5

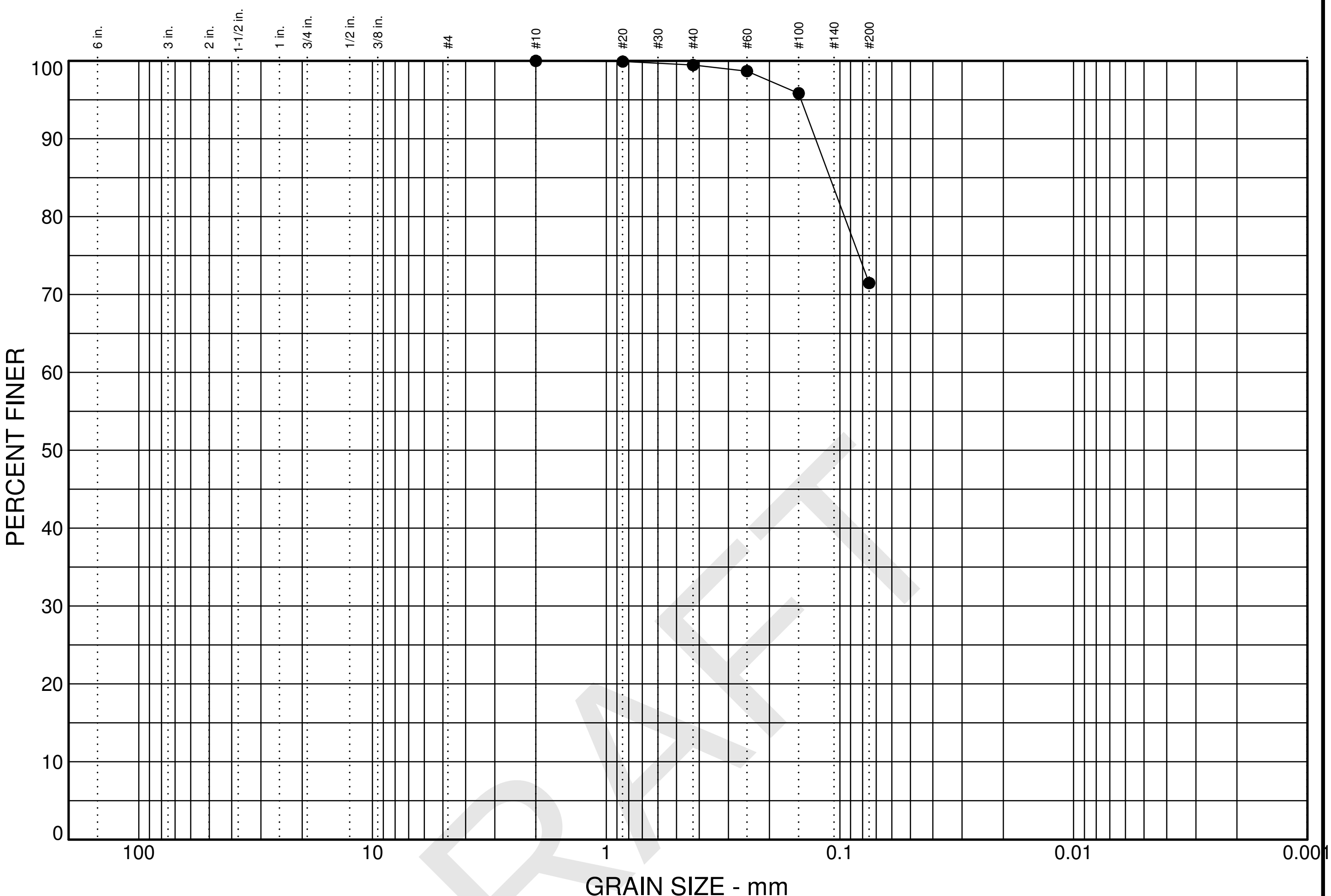
HARTCROWSER

17916-01 *6/14*

Figure B-6

GRAIN SIZE 1791601-BL.GPJ HC_CORP.GDT 9/3/14

Particle Size Distribution Test Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.0	28.5	71.5	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.11							

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
● sandy SILT	ML	28.7%

Remarks:
●

Project: Port of Tacoma Pier 4 Reconfiguration

Client:
● Source: HC14-B3 Sample No.: S-33 Depth: 170.0 to 171.5

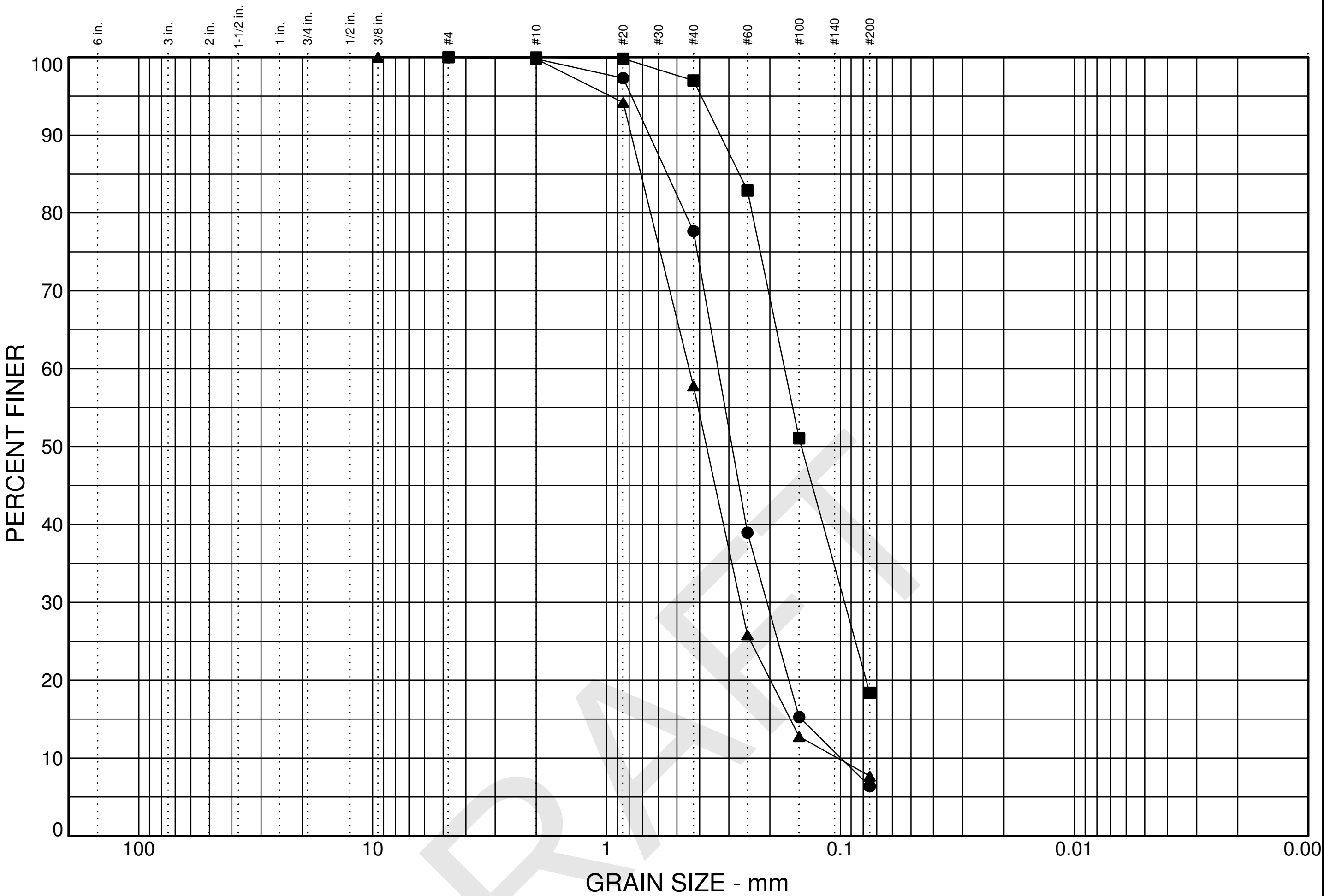
HARTCROWSER

17916-01 *6/14*

Figure B-7

GRAIN SIZE 1791601-BL.GPJ HC_CORP.GDT 9/3/14

Particle Size Distribution Test Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.0	93.6	6.4	
■	0.0	0.0	81.6	18.4	
▲	0.0	0.0	92.3	7.7	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.55	0.334	0.291	0.206	0.147	0.099	1.28	3.35
■			0.271	0.173	0.147	0.096				
▲			0.714	0.443	0.373	0.268	0.164	0.103	1.58	4.31

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
● slightly silty SAND	SP-SM	27.5%
■ silty SAND	SM	31.6%
▲ slightly silty SAND	SP-SM	27.5%

Remarks:
●
■
▲

Project: Port of Tacoma Pier 4 Reconfiguration

Client:

● Source: HC12-B1	Sample No.: S-4	Depth: 21.0 to 22.5
■ Source: HC12-B1	Sample No.: S-8	Depth: 41.0 to 42.5
▲ Source: HC12-B1	Sample No.: S-19	Depth: 96.0 to 97.5

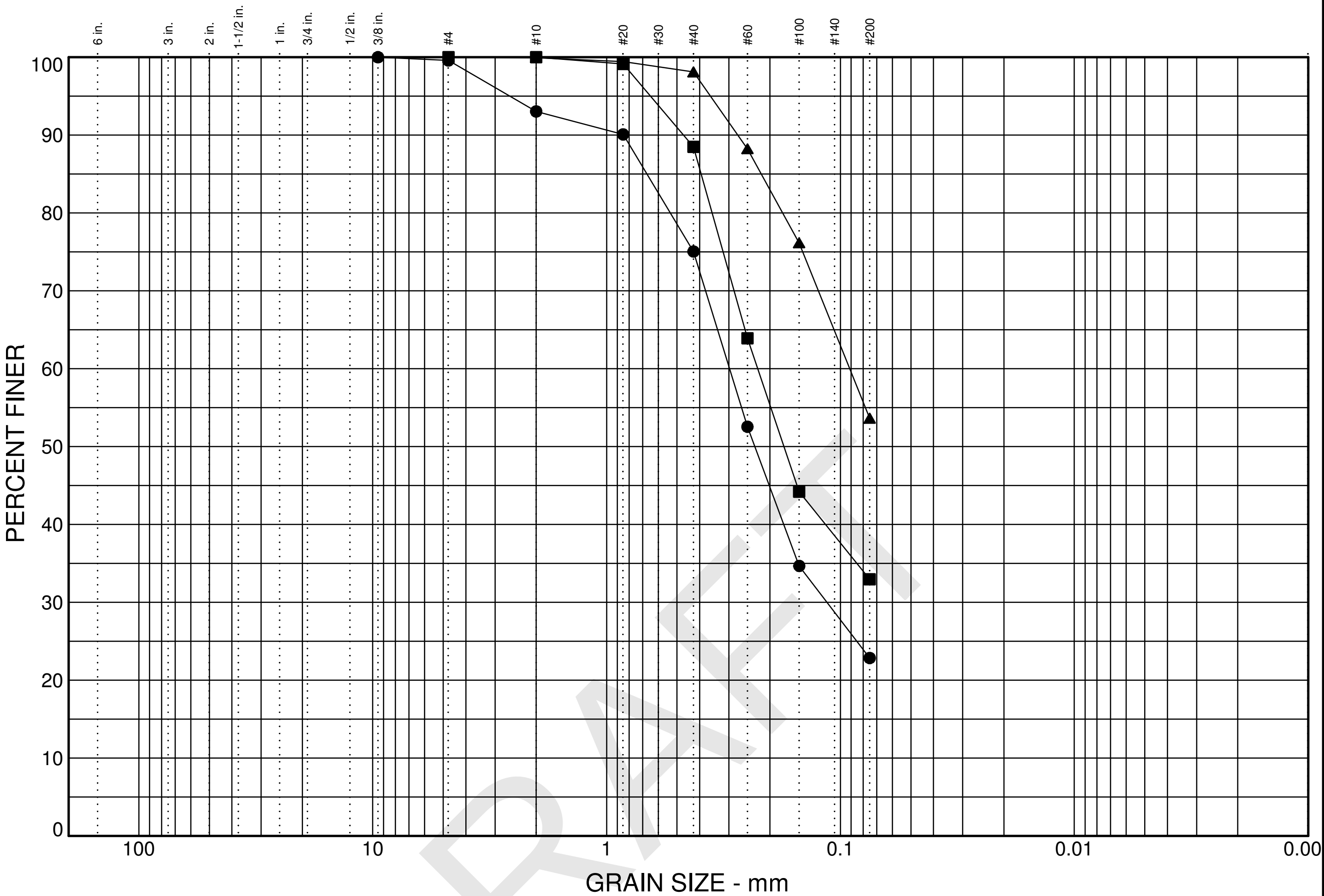
HARTCROWSER

17916-01 ***6/14***

Figure B-8

GRAIN SIZE 1791601-BL.GPJ HC_CORP.GDT 9/3/14

Particle Size Distribution Test Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.4	76.7	22.9	
■	0.0	0.0	67.0	33.0	
▲	0.0	0.0	46.4	53.6	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.672	0.298	0.232	0.114				
■			0.394	0.226	0.174					
▲			0.218	0.091						

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
● silty SAND	SM	22.2%
■ very silty SAND	SM	31.5%
▲ very sandy SILT	ML	31.6%

Remarks:
●

■

▲

Project: Port of Tacoma Pier 4 Reconfiguration

Client:

● Source: HC12-B2 Sample No.: S-3 Depth: 18.0 to 19.5
■ Source: HC12-B2 Sample No.: S-12 Depth: 63.0 to 64.5
▲ Source: HC12-B2 Sample No.: S-19 Depth: 98.0 to 99.5

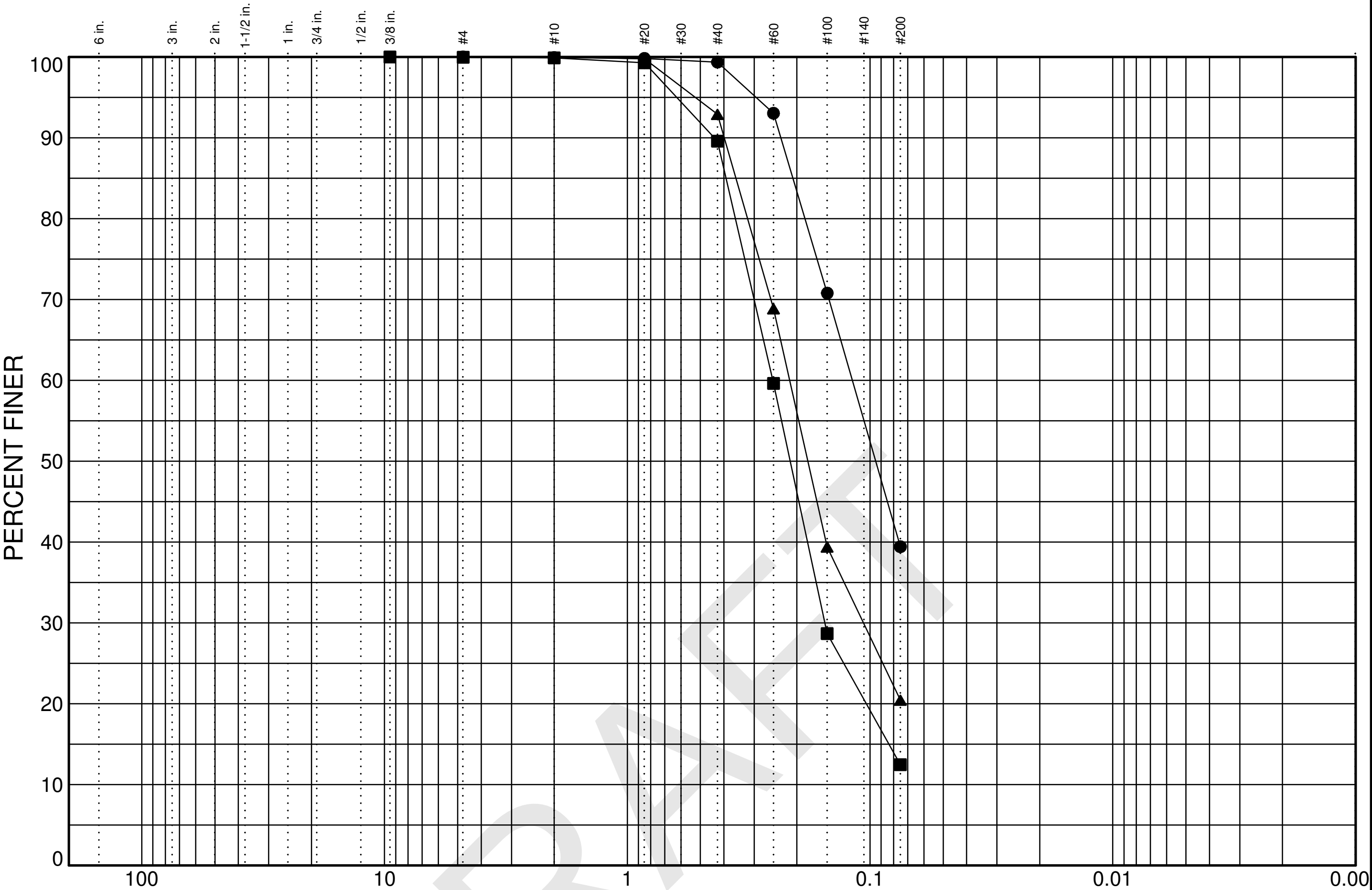
HARTCROWSER

17916-01 6/14

Figure B-9

GRAIN SIZE 1791601-BL.GPJ HC_CORP.GDT 9/3/14

Particle Size Distribution Test Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.0	60.6	39.4	
■	0.0	0.0	87.5	12.5	
▲	0.0	0.0	79.6	20.4	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.208	0.118	0.095					
■			0.392	0.252	0.213	0.153	0.084		1.38	3.73
▲			0.357	0.214	0.18	0.106				

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
● very silty SAND	SM	31.9%
■ slightly silty SAND	SP-SM	28.8%
▲ silty SAND	SM	31.4%

Remarks:
●
■
▲

Project: Port of Tacoma Pier 4 Reconfiguration

Client:

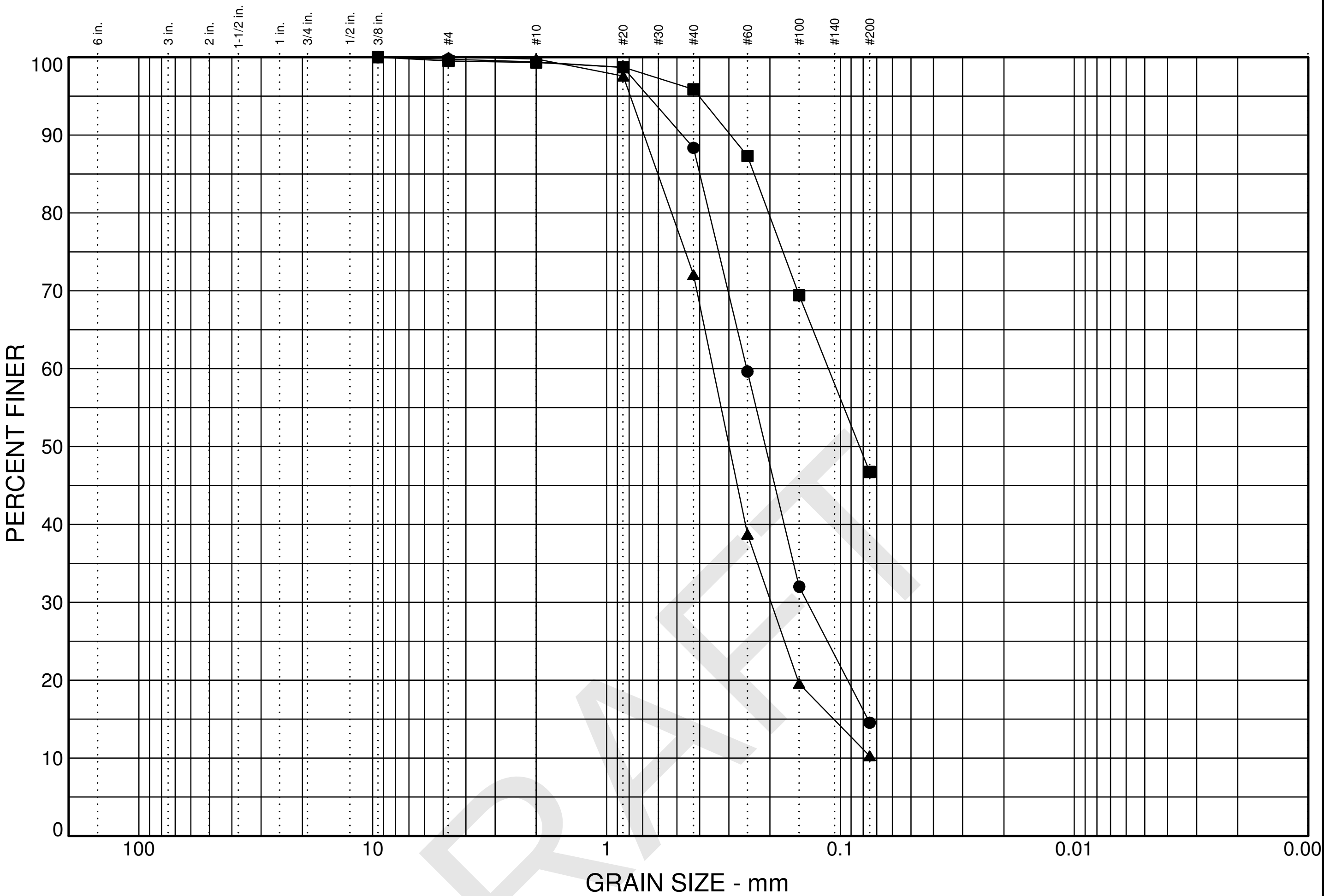
● Source: HC12-B4 Sample No.: S-6 Depth: 33.0 to 34.5
■ Source: HC12-B4 Sample No.: S-10 Depth: 53.0 to 54.5
▲ Source: HC12-B4 Sample No.: S-27 Depth: 138.0 to 139.5

HARTCROWSER

17916-01 *6/14*

Figure B-10

Particle Size Distribution Test Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.3	85.2	14.5	
■	0.0	0.5	52.8	46.7	
▲	0.0	0.0	89.7	10.3	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.399	0.252	0.209	0.138	0.076			
■			0.234	0.112	0.083					
▲			0.604	0.351	0.299	0.198	0.107		1.52	4.78

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
● silty SAND	SP-SM	27.7%
■ very silty SAND	SM	29.1%
▲ slightly silty SAND	SP-SM	23.0%

Remarks:
●

■

▲

Project: Port of Tacoma Pier 4 Reconfiguration

Client:

● Source: HC12-B5 Sample No.: S-10 Depth: 45.0 to 46.5
■ Source: HC12-B5 Sample No.: S-14 Depth: 65.0 to 66.5
▲ Source: HC12-B5 Sample No.: S-24 Depth: 125.0 to 126.5

HARTCROWSER

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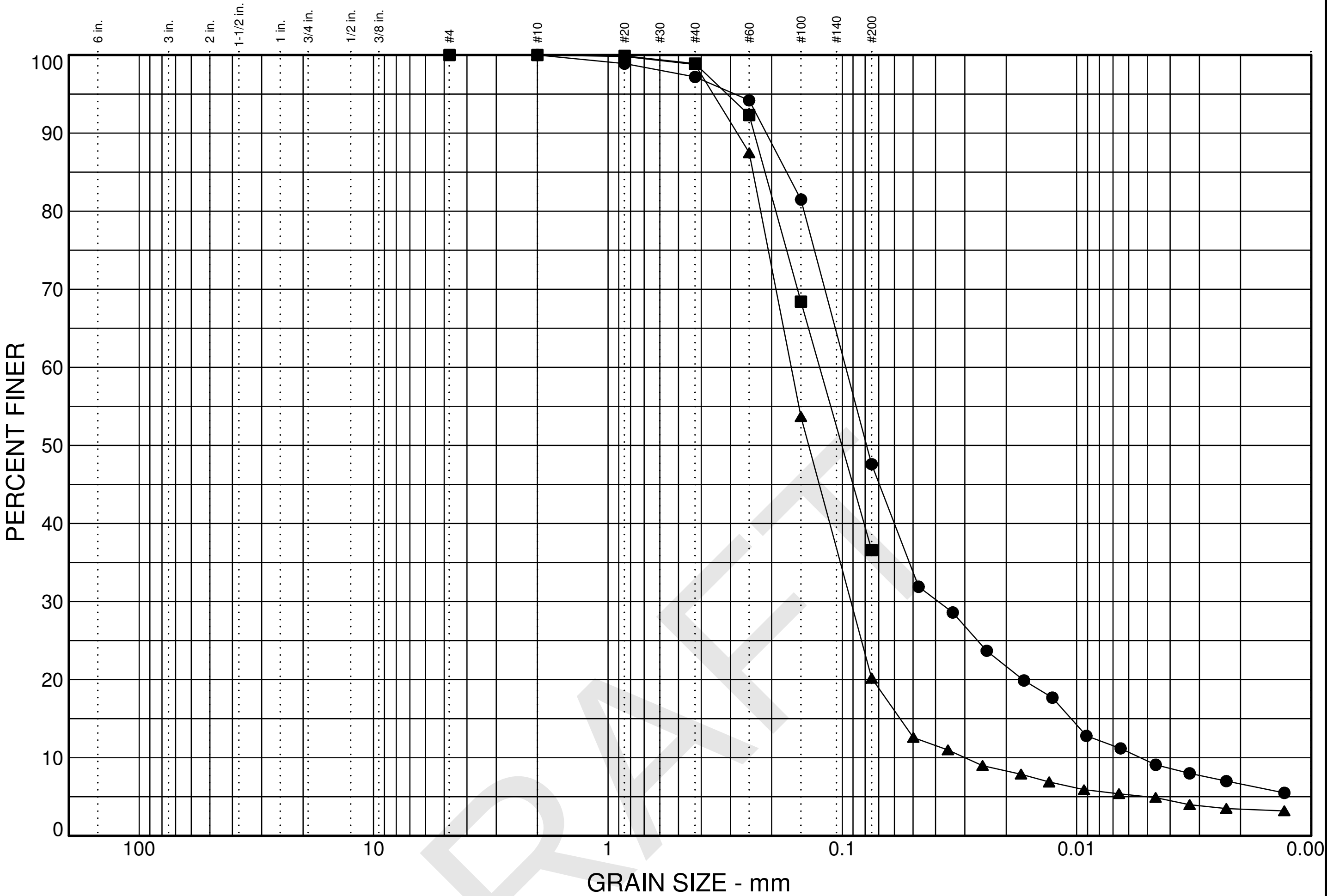
Figure B-11

GRAIN SIZE 1791601-BL.GPJ HC_CORP.GDT 9/3/14

Particle Size Distribution Test Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.0	52.4	47.6	
■	0.0	0.0	63.4	36.6	
▲	0.0	0.0	79.8	20.2	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.173	0.097	0.079	0.039	0.011	0.005	2.95	18.12
■			0.214	0.125	0.1					
▲			0.241	0.165	0.139	0.092	0.057	0.03	1.71	5.52

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
● very silty SAND	SM	30.7%
■ very silty SAND	SM	27.8%
▲ silty SAND	SM	27.6%

Remarks:
●

■

▲

Project: Port of Tacoma Pier 4 Reconfiguration

Client:

● Source: HC12-B5 Sample No.: S-27 Depth: 155.0 to 156.5
■ Source: HC12-B5 Sample No.: S-32 Depth: 185.0 to 186.5
▲ Source: HC12-B5 Sample No.: S-35 Depth: 215.0 to 216.5

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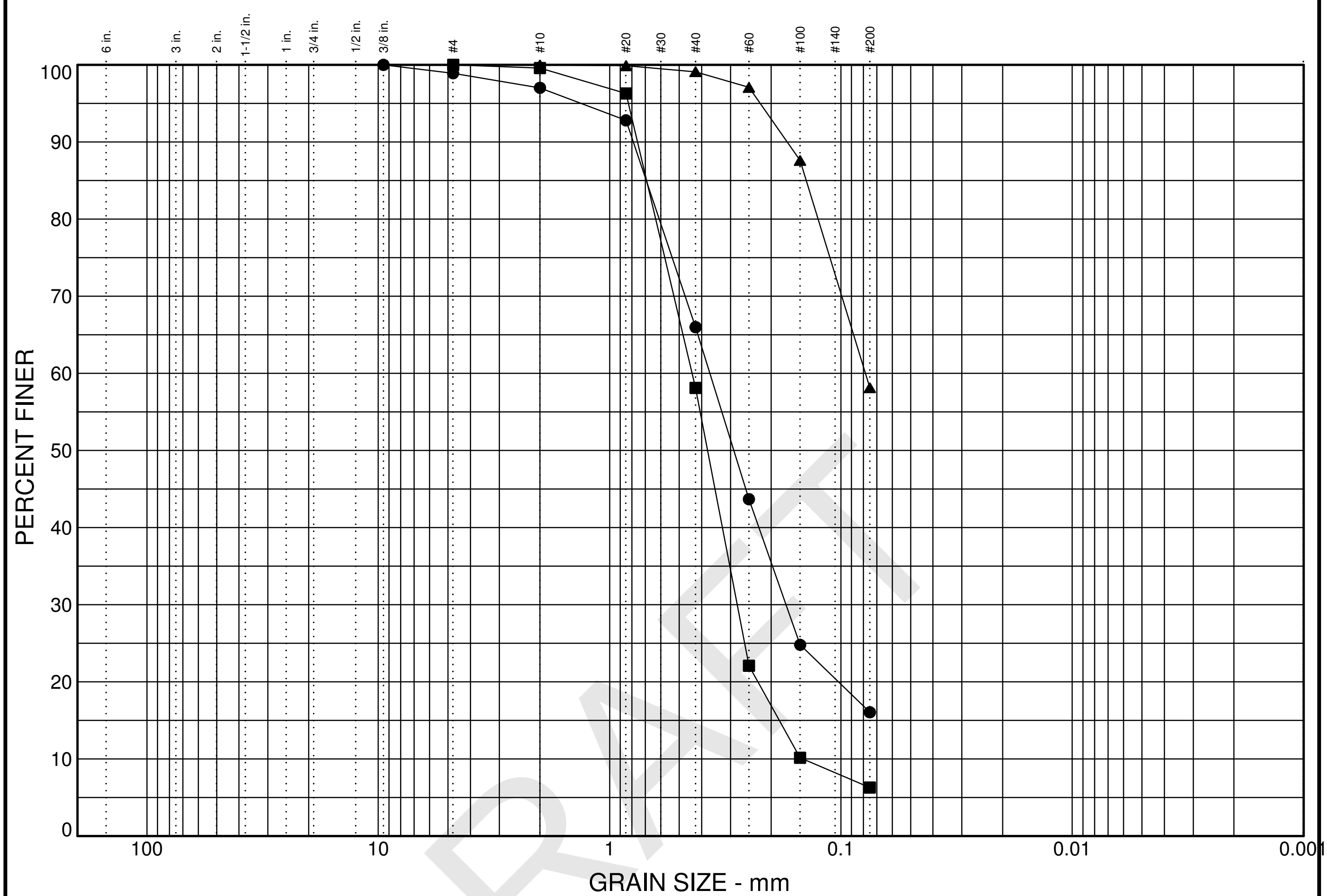
Figure B-12

GRAIN SIZE 1791601-BL.GPJ HC_CORP.GDT 9/3/14

Particle Size Distribution Test Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	1.1	82.9	16.1	
■	0.0	0.0	93.7	6.3	
▲	0.0	0.0	41.9	58.1	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.695	0.369	0.291	0.173				
■			0.692	0.44	0.377	0.281	0.184	0.145	1.23	3.03
▲			0.141	0.078						

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
● silty SAND, trace gravel	ML	26.5%
■ slightly silty SAND	SP	24.7%
▲ very sandy SILT	ML	27.8%

Remarks:
●
■
▲

Project: Port of Tacoma Pier 4 Reconfiguration

Client:

● Source: HC12-B6 Sample No.: S-5 Depth: 30.0 to 31.5
■ Source: HC12-B6 Sample No.: S-10 Depth: 55.0 to 56.5
▲ Source: HC12-B6 Sample No.: S-20 Depth: 105.0 to 106.5

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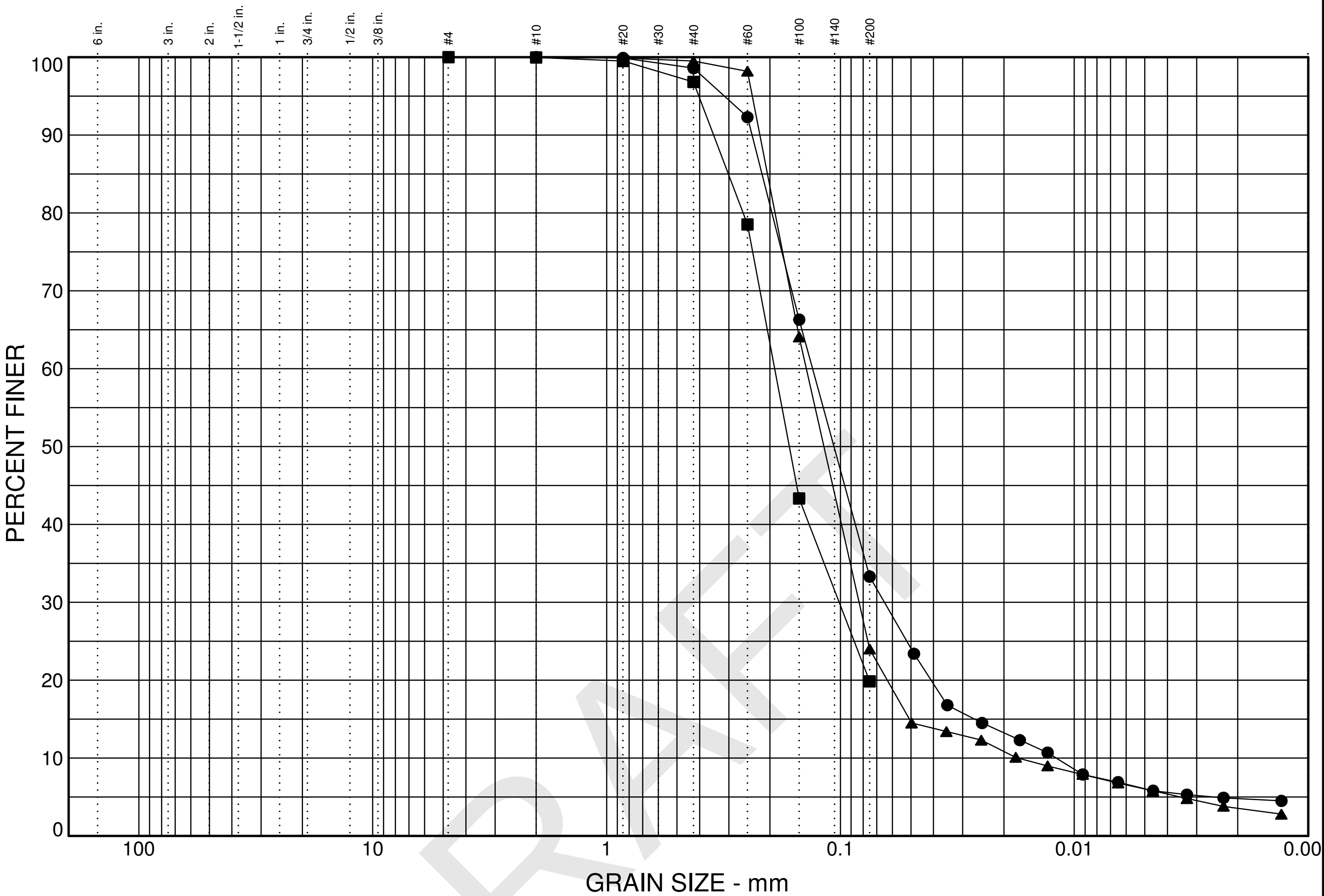
Figure B-13

GRAIN SIZE 1791601-BL.GPJ HC_CORP.GDT 9/3/14

Particle Size Distribution Test Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.0	66.7	33.3	
■	0.0	0.0	80.2	19.8	
▲	0.0	0.0	76.0	24.0	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.217	0.131	0.107	0.065	0.027	0.012	2.68	11.02
■			0.302	0.191	0.165	0.101				
▲			0.205	0.14	0.118	0.083	0.051	0.017	2.86	8.08

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
● very silty SAND	SM	28.5%
■ silty SAND	SM	26.5%
▲ silty SAND	SM	28.2%

Remarks:
●

■

▲

Project: Port of Tacoma Pier 4 Reconfiguration

Client:

● Source: HC12-B6 Sample No.: S-30 Depth: 150.0 to 151.5
■ Source: HC12-B6 Sample No.: S-36 Depth: 180.0 to 181.5
▲ Source: HC12-B6 Sample No.: S-49 Depth: 245.0 to 246.5

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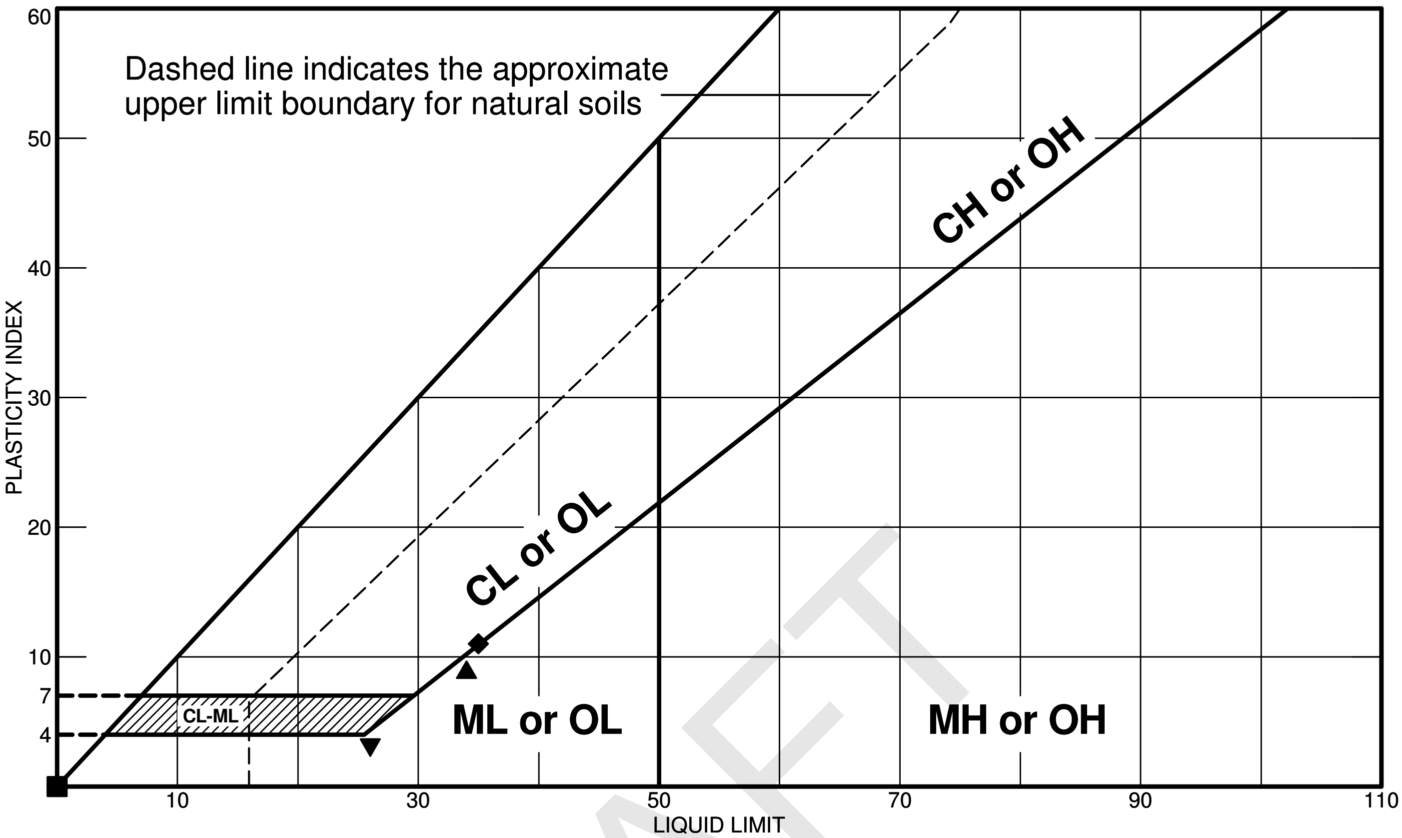
Figure B-14

Liquid and Plastic Limits Test Report



	Location + Description	LL	PL	PI	-200	USCS
●	Source: HC14-B1 Sample No.: S-6 Depth: 35 sandy SILT	NP	NP	NP		ML
■	Source: HC14-B1 Sample No.: S-22 Depth: 115 sandy SILT	NP	NP	NP		ML
▲	Source: HC14-B2 Sample No.: S-4 Depth: 25 SILT	34	25	9		ML
◆	Source: HC14-B2 Sample No.: S-7 Depth: 40 CLAY	35	24	11		CL
▼	Source: HC14-B2 Sample No.: S-16 Depth: 85 SILT	26	23	3		ML

Remarks:

● granular, non-plastic

■ granular, non-plastic

▲

◆

▼

Project: Port of Tacoma Pier 4 Reconfiguration

Client:

Location:

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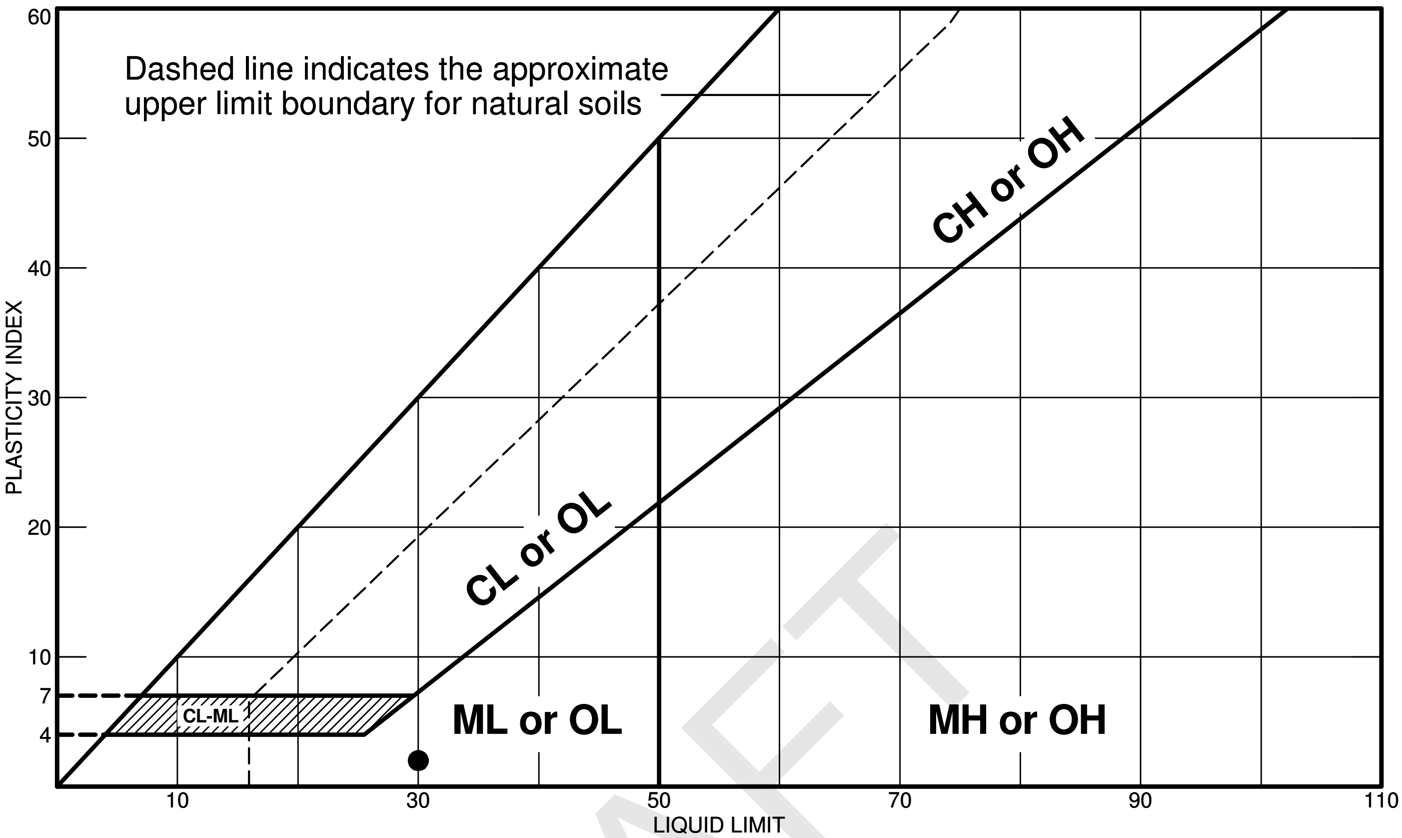
Figure B- 15

Liquid and Plastic Limits Test Report



Location + Description	LL	PL	PI	-200	USCS
● Source: HC14-B3 Sample No.: S-28 Depth: 145 SILT	30	28	2		ML

Remarks:

●

Project: Port of Tacoma Pier 4 Reconfiguration

Client:

Location:

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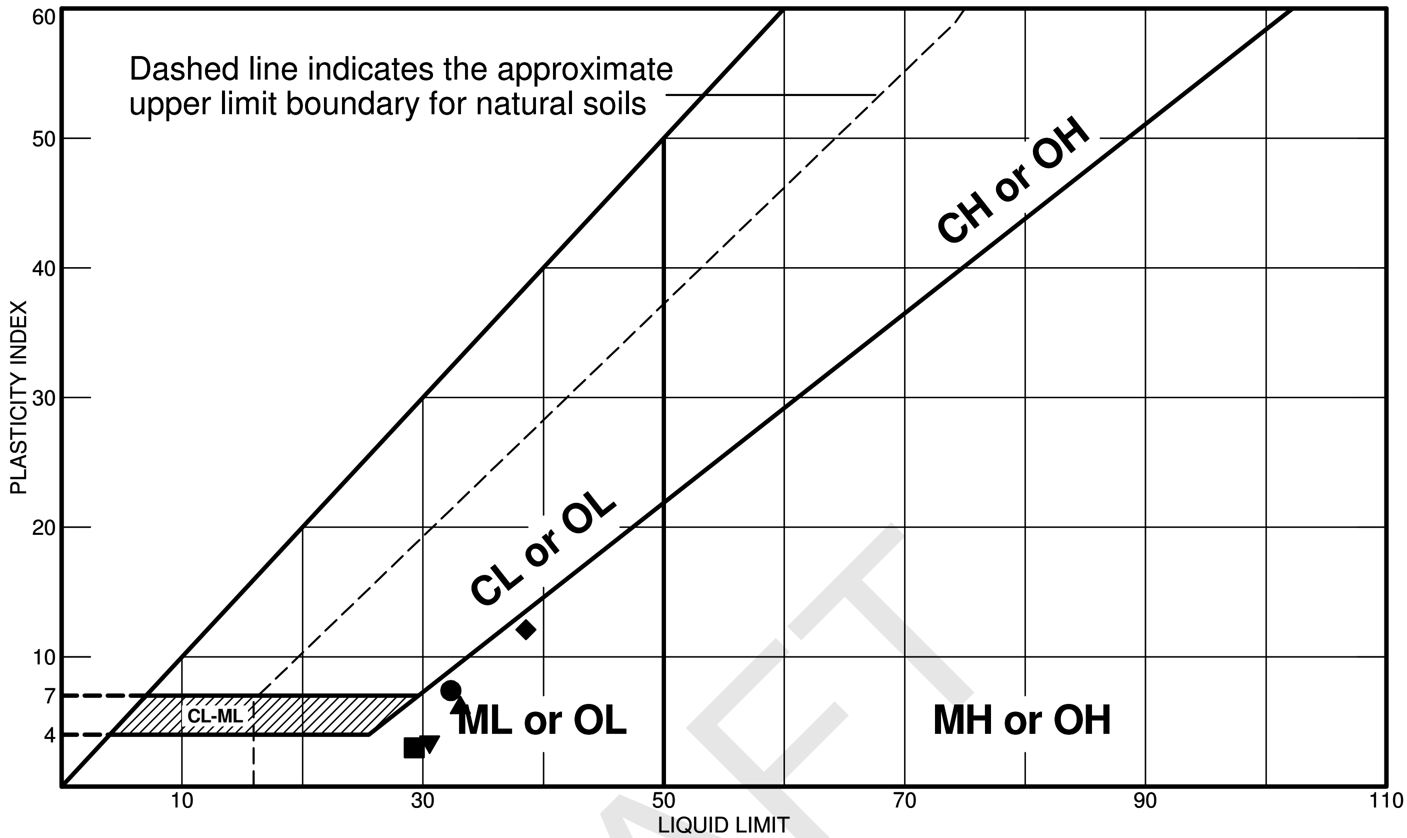
Figure B- 16

Liquid and Plastic Limits Test Report



Location + Description	LL	PL	PI	-200	USCS
● Source: HC12-B1 Sample No.: S-23 Depth: 116 SILT	32	25	7		ML
■ Source: HC12-B4 Sample No.: S-19 Depth: 98 SILT	29	26	3		ML
▲ Source: HC12-B5 Sample No.: S-30 Depth: 170 SILT	33	27	6		ML
◆ Source: HC12-B5 Sample No.: S-38 Depth: 245 SILT	39	26	13		ML
▼ Source: HC12-B6 Sample No.: S-24 Depth: 119.5 SILT	31	27	4		ML

Remarks:

● Description and Classification based on Atterberg LImit test results only.

■ Description and Classification based on Atterberg LImit test results only.

▲

◆

▼

Project: Port of Tacoma Pier 4 Reconfiguration

Client:

Location:

HARTCROWSER

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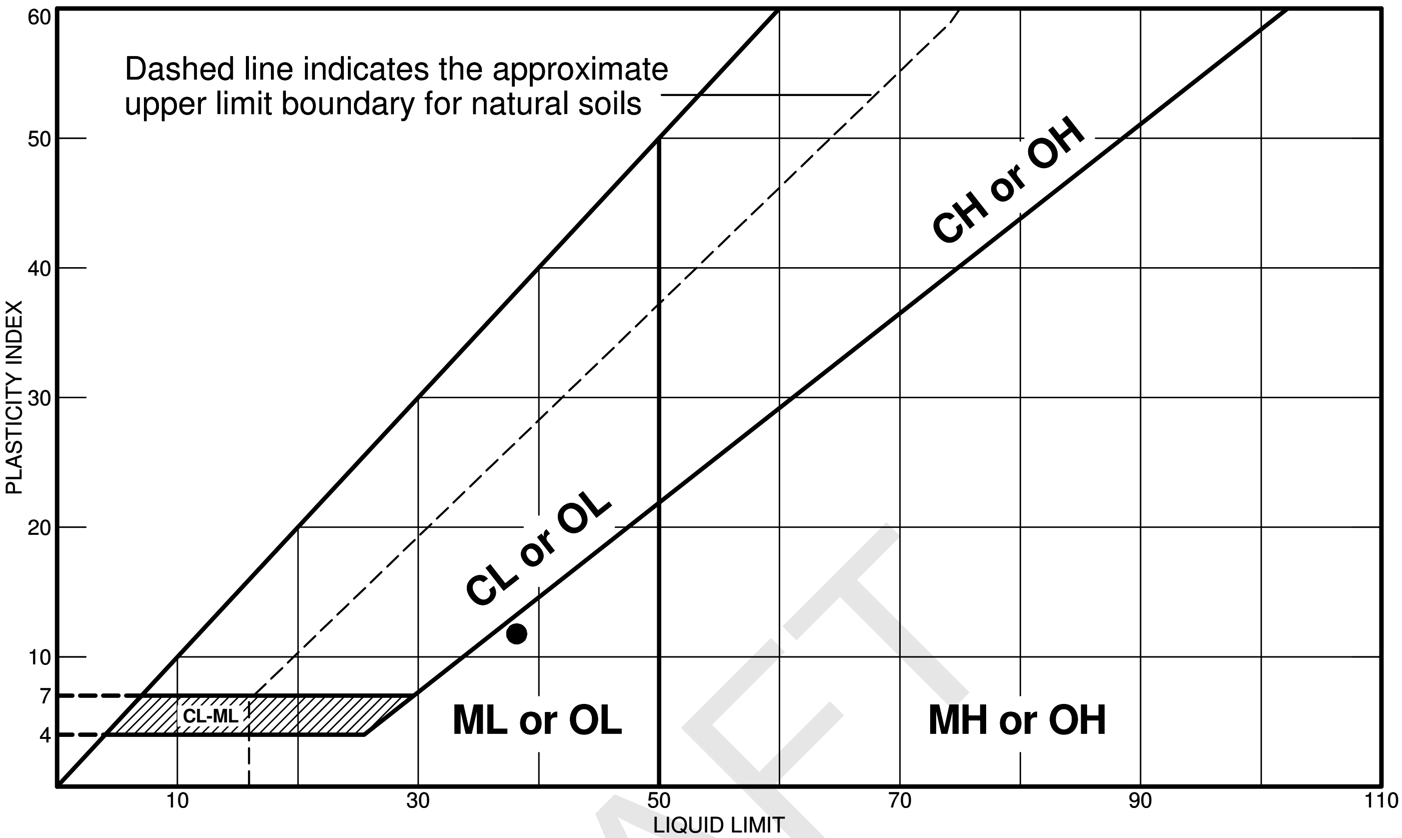
Figure B- 17

Liquid and Plastic Limits Test Report



Location + Description	LL	PL	PI	-200	USCS
● Source: HC12-B6 Sample No.: S-41 Depth: 205 SILT	38	26	12		ML

Remarks:
●

Project: Port of Tacoma Pier 4 Reconfiguration

Client:

Location:

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Figure B- 18