



**DRAFT**

Design Report

**Thorne Road Container Yard**  
**Port of Tacoma**  
**Tacoma, Washington**

Prepared for  
**Moffatt & Nichol**

April 24, 2020  
19398-00



**HARTCROWSER**

# **DRAFT**

**Design Report**

## **Thorne Road Container Yard Port of Tacoma, Tacoma, Washington**

Prepared for  
**Moffatt & Nichol**

April 24, 2020  
19398-00

Prepared by  
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# Contents

<b>INTRODUCTION</b>	<b>1</b>
<b>PURPOSE, SCOPE, AND USE OF THIS REPORT</b>	<b>1</b>
Purpose	1
Scope	1
Use of this Report	2
<b>PROJECT UNDERSTANDING</b>	<b>2</b>
<b>SUBSURFACE CONDITIONS</b>	<b>2</b>
Soil Conditions	2
Soil Unit 1 – Sandy Gravel, with Occasionally Concrete, Asphalt and Roots (Fill)	2
Soil Unit 2 – Loose to Medium Dense Silty Sand (Dredge Fill)	3
Soil Unit 3 – Silt and Organic Soil (Delta Plain Deposits)	3
Soil Unit 4 – Loose to Medium Dense Sand and Silt (Delta Plain Deposits)	3
Groundwater Conditions	3
<b>DESIGN RECOMMENDATIONS</b>	<b>3</b>
Fill-Induced Settlement	3
Pavement Design Recommendations	3
Shallow Foundation Soil Capacities	4
Pole and Sign Foundations	5
Utilities	6
Buried Structures	6
Dewatering Recommendations	7
<b>CONSTRUCTION RECOMMENDATIONS</b>	<b>7</b>
<b>SITE PREPARATION</b>	<b>7</b>
Clearing Vegetation	7
Subgrade Preparation	7
Structural Fill	8
Use of On-Site Soil as Structural Fill	9
Shallow Foundation Construction	9
Temporary Cuts	10

## **RECOMMENDATIONS FOR CONTINUING GEOTECHNICAL SERVICES**11

Continuing Design and Consultation Services 11

Construction Services 11

## **REFERENCES** 12

### **FIGURES**

Figure 1 – Site Vicinity

Figure 2 – Site Location

Figure 3 – Cross Section AA'

Figure 4 – Cross Section BB'

Figure 5 – Cross Section CC'

### **APPENDIX A**

HC Borings

### **APPENDIX B**

Lab Test Results

### **APPENDIX C**

Historical Subsurface Data

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## Design Report

# Thorne Road Container Yard Port of Tacoma, Tacoma, Washington

## INTRODUCTION

This report presents our geotechnical engineering design study for the Thorne Road Container Yard in Tacoma, Washington.

This report contains the following sections:

- Introduction;
- Purpose, Scope, and Use of This Report;
- Project Understanding;
- Subsurface Conditions;
- Design Recommendations; and
- Construction Recommendations.

Tables are presented in the text and figures follow the text to illustrate the project area, exploration locations, and geotechnical design recommendations. Appendix A presents field exploration logs for the current study and previous studies by Hart Crowser. Appendix B presents the laboratory test methods and results. Appendix C presents historical exploration logs by others.

## PURPOSE, SCOPE, AND USE OF THIS REPORT

### Purpose

The purpose of our work is to provide Moffatt & Nichol and its design and construction consultants with subsurface information, along with our interpretation and geotechnical engineering recommendations to support the design of the Thorne Road Container Yard Project.

### Scope

Our scope of work for this project included:

- Collect and evaluate existing information provided by the Port of Tacoma;
- Conduct site explorations including test pits, hand augers, and Cone Penetration Tests (CPTs);
- Provide a summary of subsurface conditions and the influence of those conditions on project development;
- Provide recommendations for:
  - Grading, including recommendations for overexcavation of unsuitable pavement and upper fill soils,

- Design of shallow foundations,
  - Design of underground utilities,
  - Foundations for portable buildings, light poles, luminaires, etc.
  - Estimated resilient modulus for pavement design,
  - Structural fill placement and suitability of existing site soils for use as structural fill,
  - General dewatering recommendations.
- Producing a geotechnical engineering design report.

### Use of this 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

Our understanding of the project is based on our review of the draft Basis of Design (Moffatt & Nichol 2018). The purpose of this project is to provide off-dock terminal support primarily consisting of empty container and reefer storage. The project location includes three adjacent Port-owned properties (1451 Thorne Road, 1721 Thorne Road, and 1702 Port of Tacoma Road) in Tacoma, Washington. The project location is shown on Figure 1 – Vicinity Map. The project layout and explorations are shown on Figure 2 – Site and Exploration Plan.

We understand the average existing site elevation is approximately 17 feet mean lower low water (MLLW) and that preliminary estimates of finish grade elevations (including pavement section) are approximately 20 feet MLLW.

### SUBSURFACE CONDITIONS

#### Soil Conditions

Current and historical borings indicate the following soil units in descending order from the ground surface:

#### ***Soil Unit 1 – Sandy Gravel, with Occasionally Concrete, Asphalt and Roots (Fill)***

Explorations indicate near surface soils as fill consisting of clean to slightly silty, sandy gravel to variable depths below existing ground surface, with occasional roots, recycle concrete, and asphalt. Soil Unit 1 was not identified in all explorations and was generally noted to be less than about 1.5 feet where observed at boring locations.



### ***Soil Unit 2 – Loose to Medium Dense Silty Sand (Dredge Fill)***

Below Unit 1 (where present) or from the ground surface, the explorations indicated loose to medium dense, moist to wet, silty sand with occasional gravel. This unit is dredge fill material that appears to have been filled over the years. The bottom of Unit 2 generally sits at about 2 feet below ground surface (bgs) towards the Thorne Road side of the site and dips gently down to about 8 feet bgs on the Port of Tacoma Road side.

### ***Soil Unit 3 – Silt and Organic Soil (Delta Plain Deposits)***

Below Unit 2, explorations encountered wet silt, occasional sand, underlain silt with organics or peat. Unit 3 appears to extend down to about 14 feet bgs.

### ***Soil Unit 4 – Loose to Medium Dense Sand and Silt (Delta Plain Deposits)***

Below Unit 3, CPT probes encountered wet, sand, occasional silt, underlain silt with organics or peat. Unit 4 was the deepest soil unit encountered in our explorations.

## **Groundwater Conditions**

Our understanding of groundwater conditions at the site is based on observations during our explorations, and conditions described in existing historical borings around the site (Appendix A and C).

Observations indicate that groundwater encounters within Soil Unit 2 under unconfined conditions. The depth to water in this layer ranged from 2 to 6 feet bgs in most of the test pit locations. Surface ground water was observed in the three hand-auger boring locations in the wetlands.

## **DESIGN RECOMMENDATIONS**

### **Fill-Induced Settlement**

We used the computer software CPeT-IT to estimate the settlement of approximately 2 to 3 feet of grade fill material on top of the current ground surface based on data from CONETEC's four CPTs. We analyzed the settlement for two scenarios: primary settlement and secondary (creep) settlement.

Based on this analysis, we estimated the total settlement from the various CPT results to be generally between 0.5 to 1.0 inch. Additionally, the estimated settlements generally occur in the depth of 7 to 17 feet bgs and happen mostly as a result of primary consolidation settlement. We estimate that the primary consolidation settlement will take place within three to four weeks of fill.

### **Pavement Design Recommendations**

These recommendations assume a minimum of 2 feet of structural fill or equivalent placed over existing fill subgrade.

- Well-compacted fill soils (to a minimum depth of 2 feet below final subgrade elevation) will provide a subgrade-resilient modulus of 9,000 to 10,000 pounds per square inch (psi).

- We assume that “well-compacted fills” are compacted to 95 percent of the maximum dry density in the top 2 feet and to 90 percent maximum dry density below that (see Washington State Department of Transportation [WSDOT] Standard Spec 2-03-.3(14)C Method B).
- Based on the soils present at the site, we estimate that a resilient modulus value of approximately 8,000 psi will be achievable for existing soils with in-place compaction where the groundwater is at least 2 feet below the compacted surface. At the time of exploration (January 2020), the groundwater in test pits was generally observed to be about 2.5 to 3 feet bgs, except in the wetland areas.
- Where less than 2 feet of fill is required, we estimate that the composite subgrade resilient modulus of well-compacted fill and existing soils compacted in-place as described above will provide a subgrade modulus of approximately 9,000 psi.

### **Asphalt**

Asphalt pavement design may assume a subgrade resilient modulus of 9,000 psi.

### **Concrete**

Design for concrete pavement may use a modulus of subgrade reaction of 150 psi, assuming the concrete will be placed on at least 2 feet of compacted structural fill subgrade. Where less than 2 feet of compacted structural fill subgrade is placed, use a modulus of subgrade reaction of 120 psi.

## **Shallow Foundation Soil Capacities**

These recommendations are applicable to lightly loaded structures bearing on shallow spread footings.

- Shallow footings should bear directly on a minimum 2-foot-thick layer of well-compacted structural fill material. This 2-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 foundations 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 pounds per cubic foot (pcf) (105 pcf below the water table) and an allowable base sliding coefficient of friction of 0.25. 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 50 pcf (25 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.
- Where overexcavation and replacement with structural fill is needed, the base of the overexcavation must extend laterally beyond the outside edge of footings to the same distance as the depth of overexcavation.

## Pole and Sign Foundations

Design recommendations for short mast and high mast poles are provided below. We generally consider short mast poles to be less than 90 feet in height and high mast poles to be greater than 90 feet in height. However, the required foundations will be dependent on the design loading. Therefore, we recommend using the “short mast” recommendations for foundations up to 10 feet deep and the “high mast” recommendations for foundations deeper than 10 feet.

### **Short Mast Poles**

Design of short mast poles (with foundations limited to 10 feet in depth) 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 Poles**

Based on our experience and on standard practice for similar projects, we recommend using deep foundations, typically 4-foot-diameter drilled shafts, to support high mast poles. 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**

Soil Unit	Soil Type	Effective Unit Weight (pcf)	Friction Angle (degrees)	Cohesion (psf)	P-Y Modulus or E50
New Fill and Unit 1	API Sand	120	34	N/A	default
Unit 2 (above groundwater)	API Sand	115	30	N/A	default
Unit 2 (below groundwater)	API Sand	53	30	N/A	default
Unit 3 (below groundwater)	Soft Clay	48	N/A	400	default
Unit 4 (below groundwater)	API Sand	53	30	N/A	default

Notes:

For liquefied conditions, a P-multiplier of 0.1 should be applied in the LPILE analysis for soils below groundwater.

## 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 underground structures extending less than 10 feet bgs:

- Lateral active earth pressure of 50 pcf above the groundwater table (gwt) and 25 pcf below the gwt.
- Lateral at-rest earth pressure of 70 pcf above the gwt and 35 pcf below the gwt.
- Lateral allowable passive earth pressure of 215 pcf above the gwt and 105 pcf below the gwt.
- Lateral allowable base sliding coefficient of 0.25.
- Lateral seismic earth pressure increment of 9H 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 the planned excavation (including potential overexcavation).

For planning purposes, assume the groundwater table is located at an elevation of 15 feet MLLW.

## CONSTRUCTION RECOMMENDATIONS

### SITE PREPARATION

#### *Clearing Vegetation*

In the wetland areas, the groundwater was observed to be within inches of the ground surface. The root zone in the wetlands was generally about 6 inches deep. We recommend leaving the wetland soils and the root zone as undisturbed as possible (i.e., cutting trees and shrubs and mowing grasses, but leaving roots in place). The vegetation and roots can act as a stabilizing layer. However, vegetation can also interfere with compaction of fill placed above. Therefore, we recommend that fill thicknesses above the wetland areas be around 2 feet or greater. And the material used to fill the wetland areas should be a well-graded aggregate with less than 5 percent fines (material passing a U.S. No. 200 mesh sieve) by weight based on the minus 3/4-inch fraction. The material should contain a minimum of 40 percent gravel (material coarser than a U.S. No. 4 sieve). Specifications should be prepared in such a manner as to allow the decision about stripping depth to be determined in the field during construction whereby we can observe the conditions and make the appropriate decisions.

#### *Subgrade Preparation*

Cut areas and areas of less than 12 inches of fill should receive in-place vibratory compaction with a vibratory roller. The effectiveness of in-place vibratory compaction is highly dependent on moisture content. If construction occurs during wet weather conditions, the assumed improvements from

compaction and the ability to place well-compacted fill may be compromised. Other subgrade treatment/fill placement options (such as cement stabilization) may be needed for wet weather construction.

Following site stripping and compaction, the suitability of the subgrade should be evaluated by proof rolling with a fully loaded dump truck or similar heavy rubber-tired construction equipment to identify any remaining soft, loose, or unsuitable areas. The proof roll should be conducted prior to placing fill. The proof rolling should be observed by a representative of Hart Crowser who should evaluate the suitability of the subgrade and identify areas of yielding that are indicative of soft or loose soil.

It should be noted that much of the expected subgrade is moisture sensitive and may be wet of the optimum moisture for compaction. In these cases, it will be necessary to moisture condition the subgrade during dry weather periods using an agricultural disc or other methods to lower the moisture content to within two percent of optimum moisture.

## 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 U.S. 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.
- Quarry spalls and/or railroad ballast over a geotextile separation fabric may be used as structural fill to backfill areas of overexcavation. Material should be placed in lifts not exceeding 12 inches and tamped into place with a large excavator bucket, or similar. Material placement should be monitored by a Hart Crowser representative.
- 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 U.S. 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 U.S. No. 200 mesh 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;
- 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 shallow foundation subgrade conditions;
- Consult with the construction team as needed; and
- Respond to other geotechnical engineering considerations that may arise during construction.

## REFERENCES

Hart Crowser 2017. Geotechnical Data Report, Lot F Redevelopment, Port of Tacoma:, Tacoma, Washington, November 6, 2017, 19322-00.

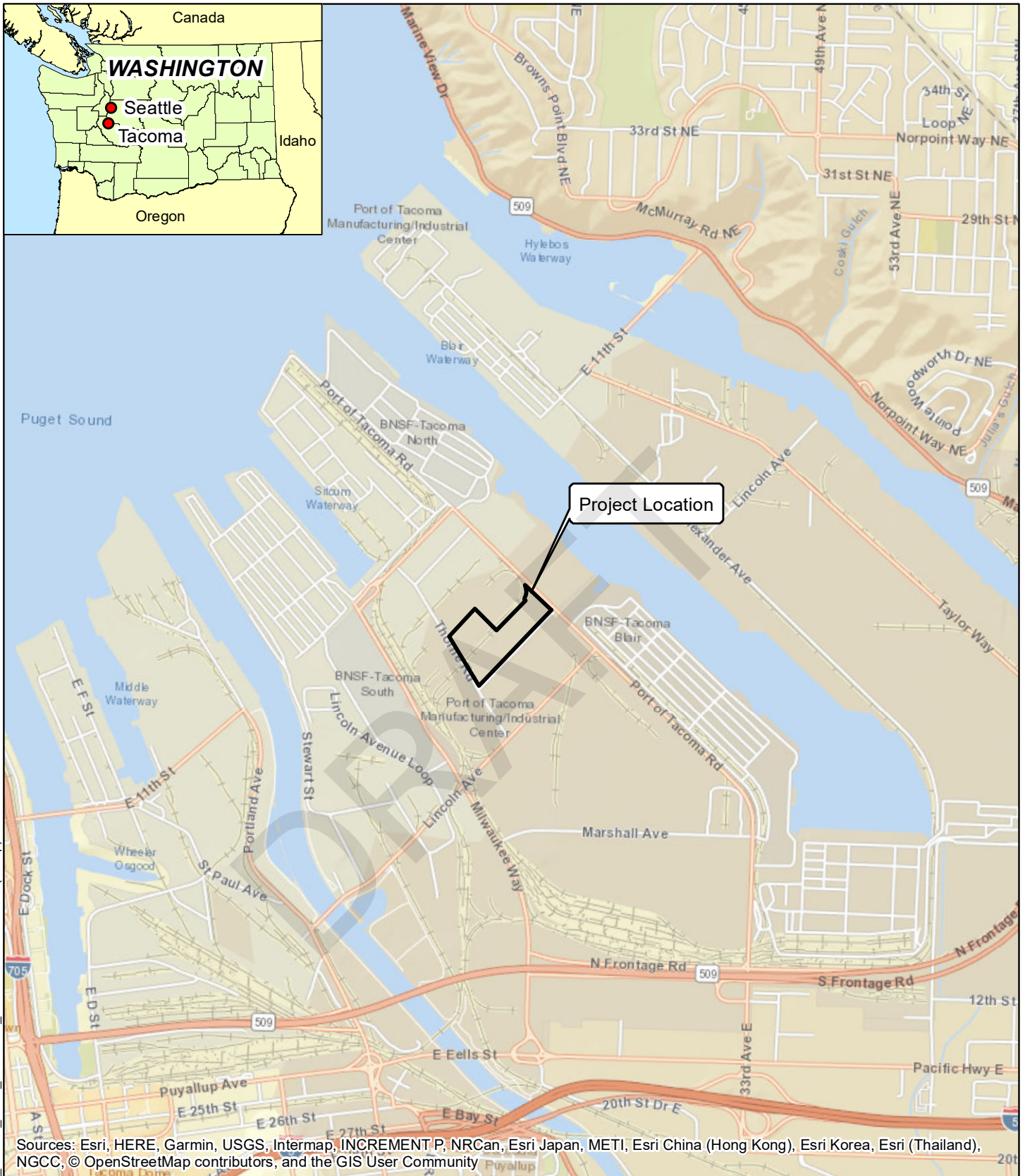
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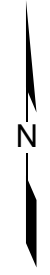
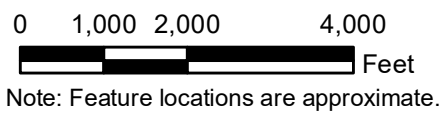
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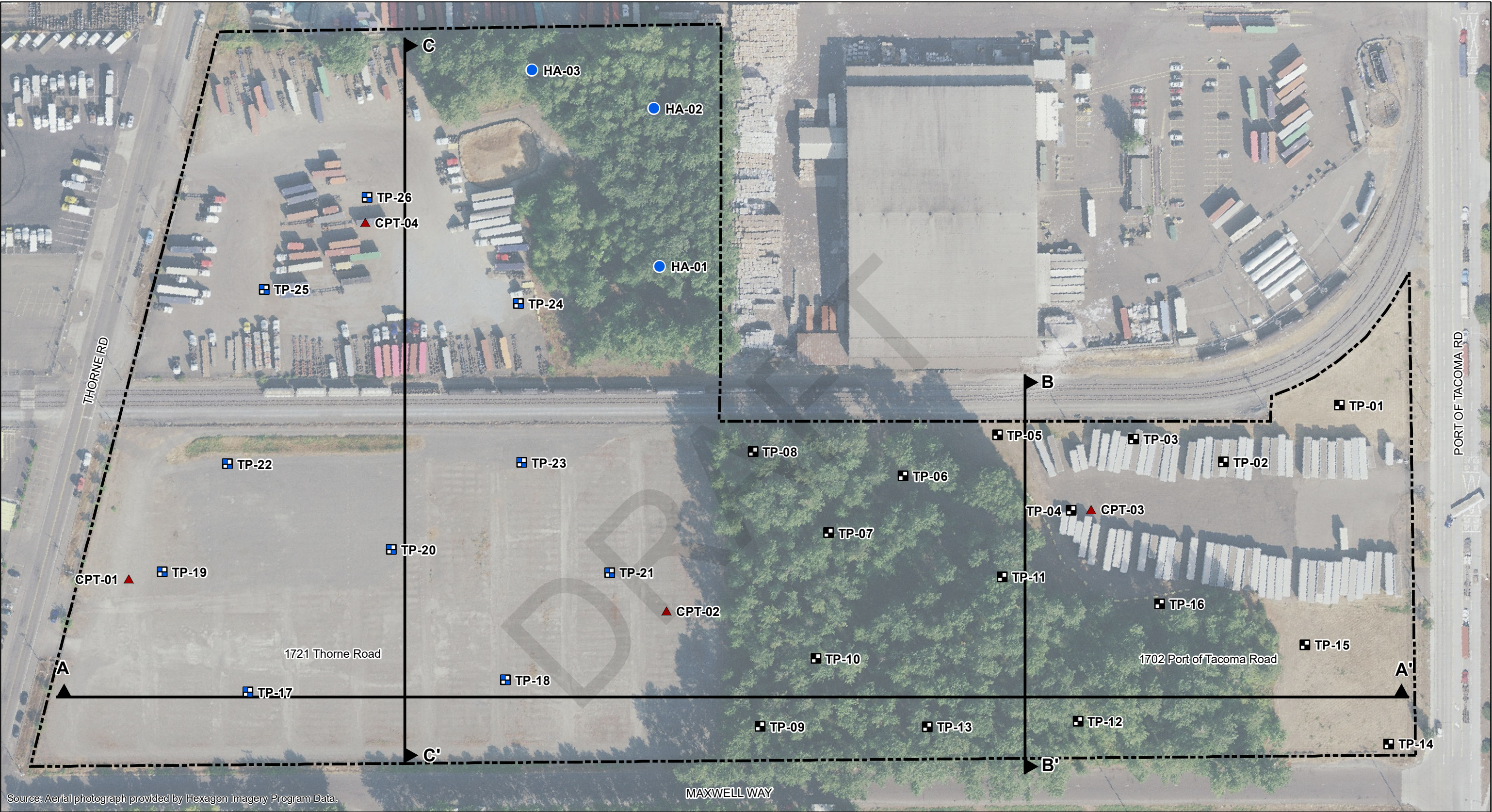
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Thorne Road Container Yard Tacoma, Washington	
Vicinity Map	
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	Figure <b>1</b>

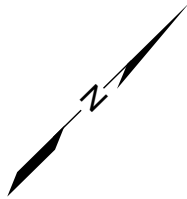
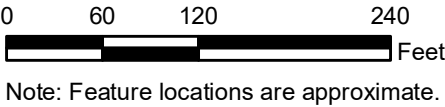


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Legend

- Test Pit (Hart Crowser 2020)
- Hand Auger (Hart Crowser 2020)
- Cone Penetration Test (Hart Crowser 2020)
- Test Pit (GeoEngineers 2005)
- Cross Section
- Property Boundary



Thorne Road Container Yard  
Tacoma, Washington

Site and Exploration Plan

19398-00

02/20

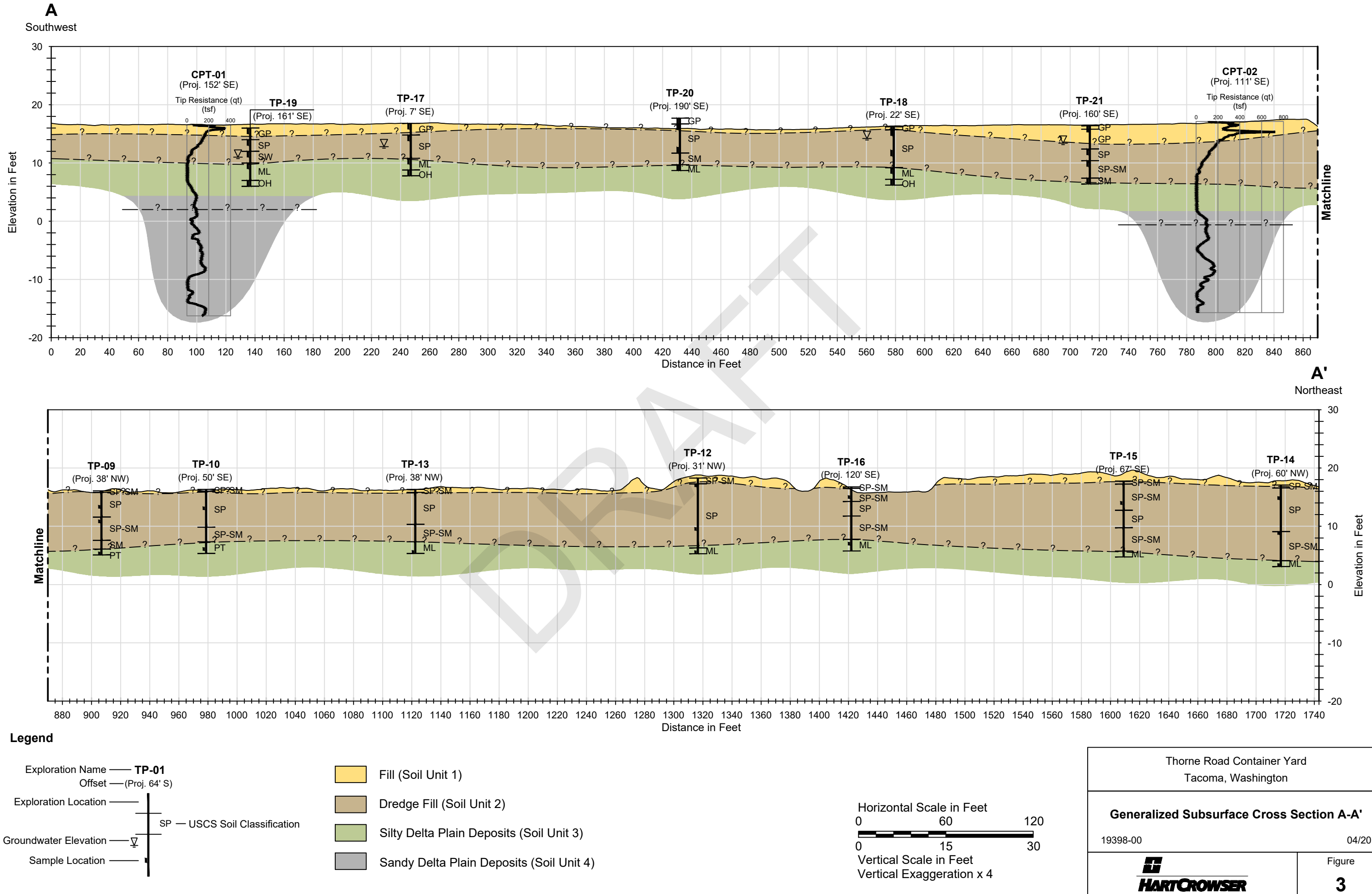


Figure

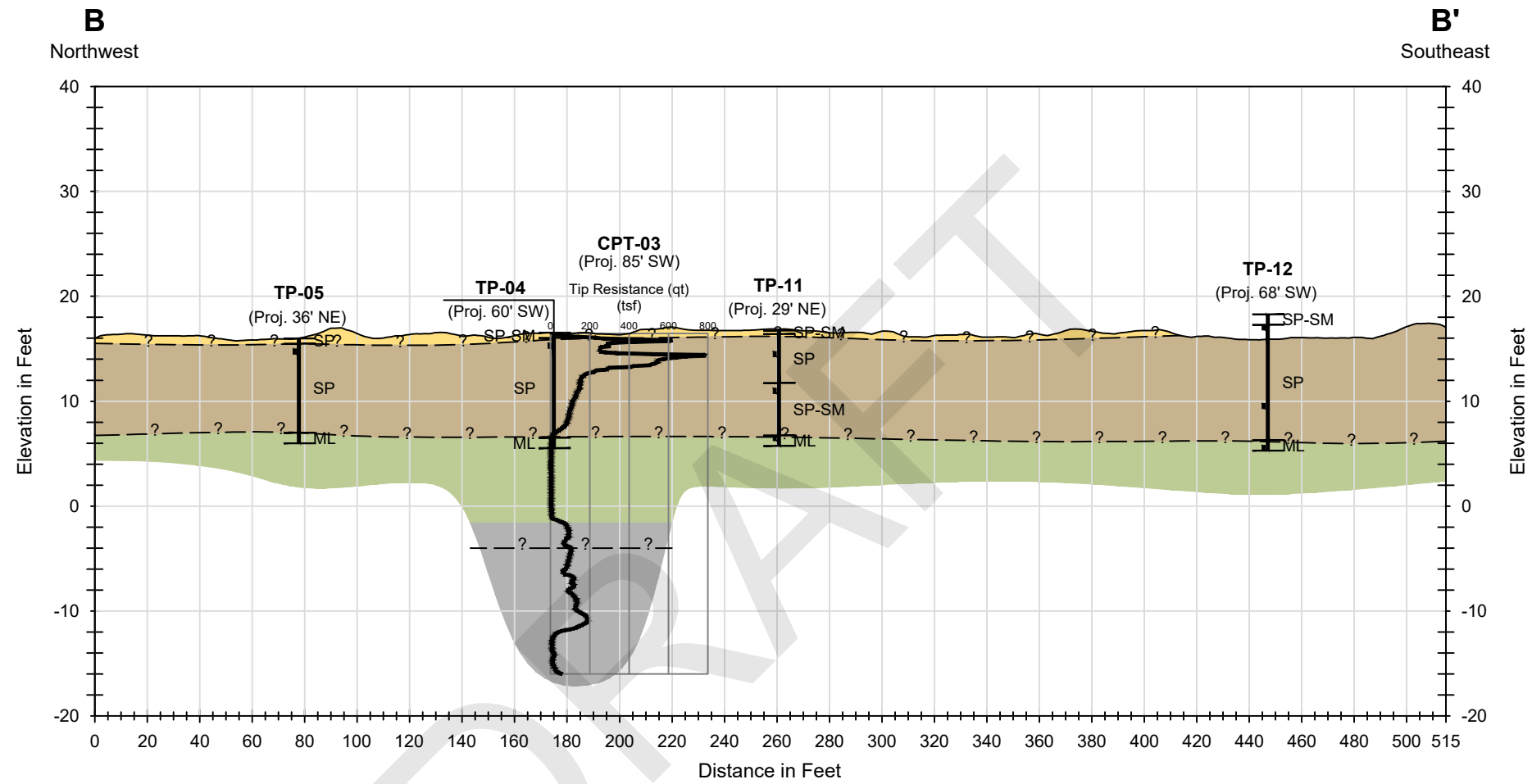
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**Legend**

- Exploration Name — **TP-01**
- Offset — (Proj. 64' S)
- Exploration Location —
- Groundwater Elevation — ▽
- Sample Location —
- SP — USCS Soil Classification

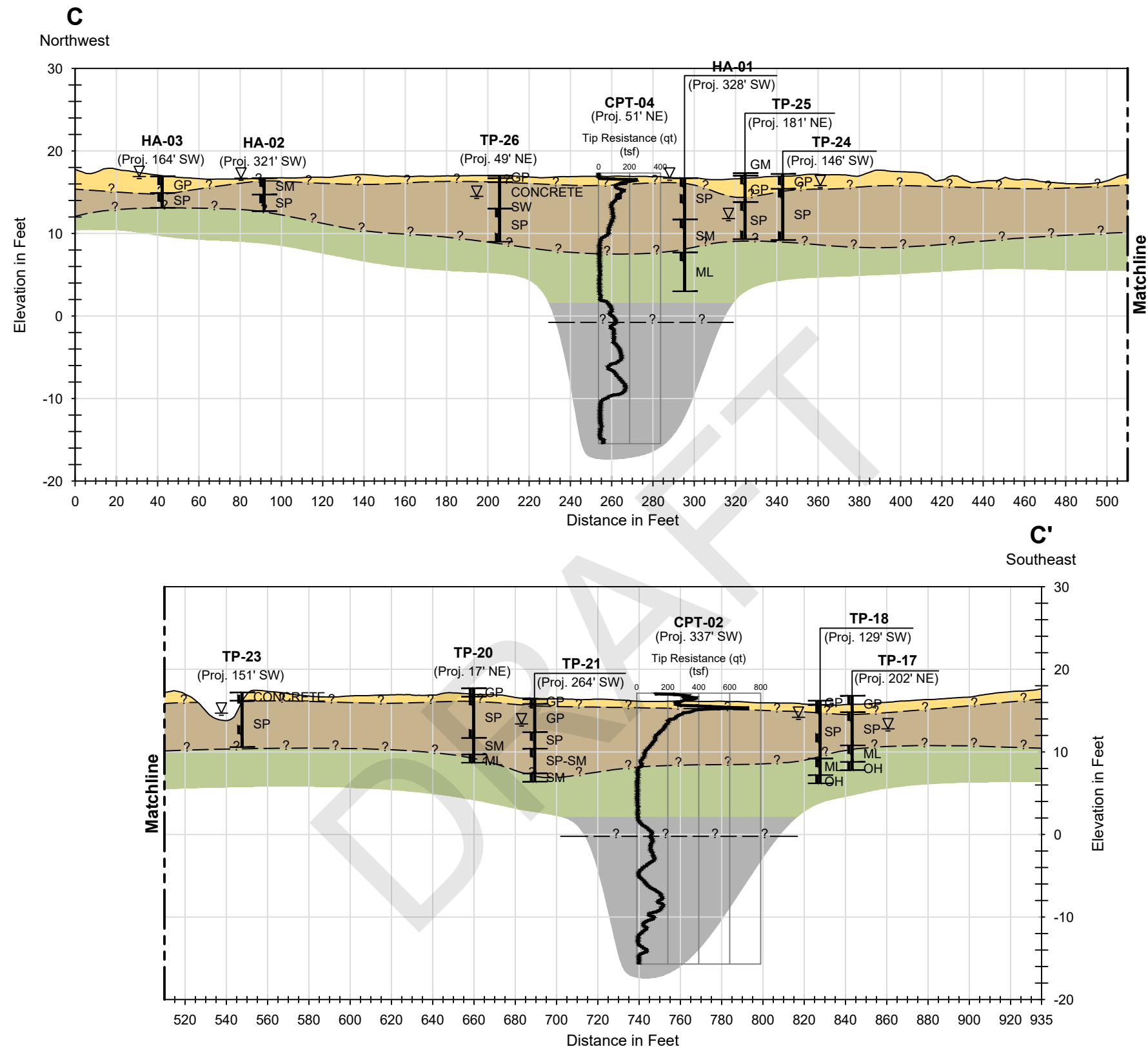
- Fill (Soil Unit 1)
- Dredge Fill (Soil Unit 2)
- Silty Delta Plain Deposits (Soil Unit 3)
- Sandy Delta Plain Deposits (Soil Unit 4)

Horizontal Scale in Feet  
0 60 120  
Vertical Scale in Feet  
0 15 30  
Vertical Exaggeration x 4

Thorne Road Container Yard Tacoma, Washington	
<b>Generalized Subsurface Cross Section B-B'</b>	
19398-00	04/20
	Figure <b>4</b>



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### Legend

- Exploration Name — **TP-01**  
Offset — (Proj. 64' S)  
Exploration Location —  
Groundwater Elevation — ▽  
Sample Location —
- SP — USCS Soil Classification

- Fill (Soil Unit 1)  
Dredge Fill (Soil Unit 2)  
Silty Delta Plain Deposits (Soil Unit 3)  
Sandy Delta Plain Deposits (Soil Unit 4)

Horizontal Scale in Feet  
0 60 120  
Vertical Scale in Feet  
0 15 30  
Vertical Exaggeration x 4

Thorne Road Container Yard  
Tacoma, Washington

### Generalized Subsurface Cross Section C-C'

19398-00

04/20



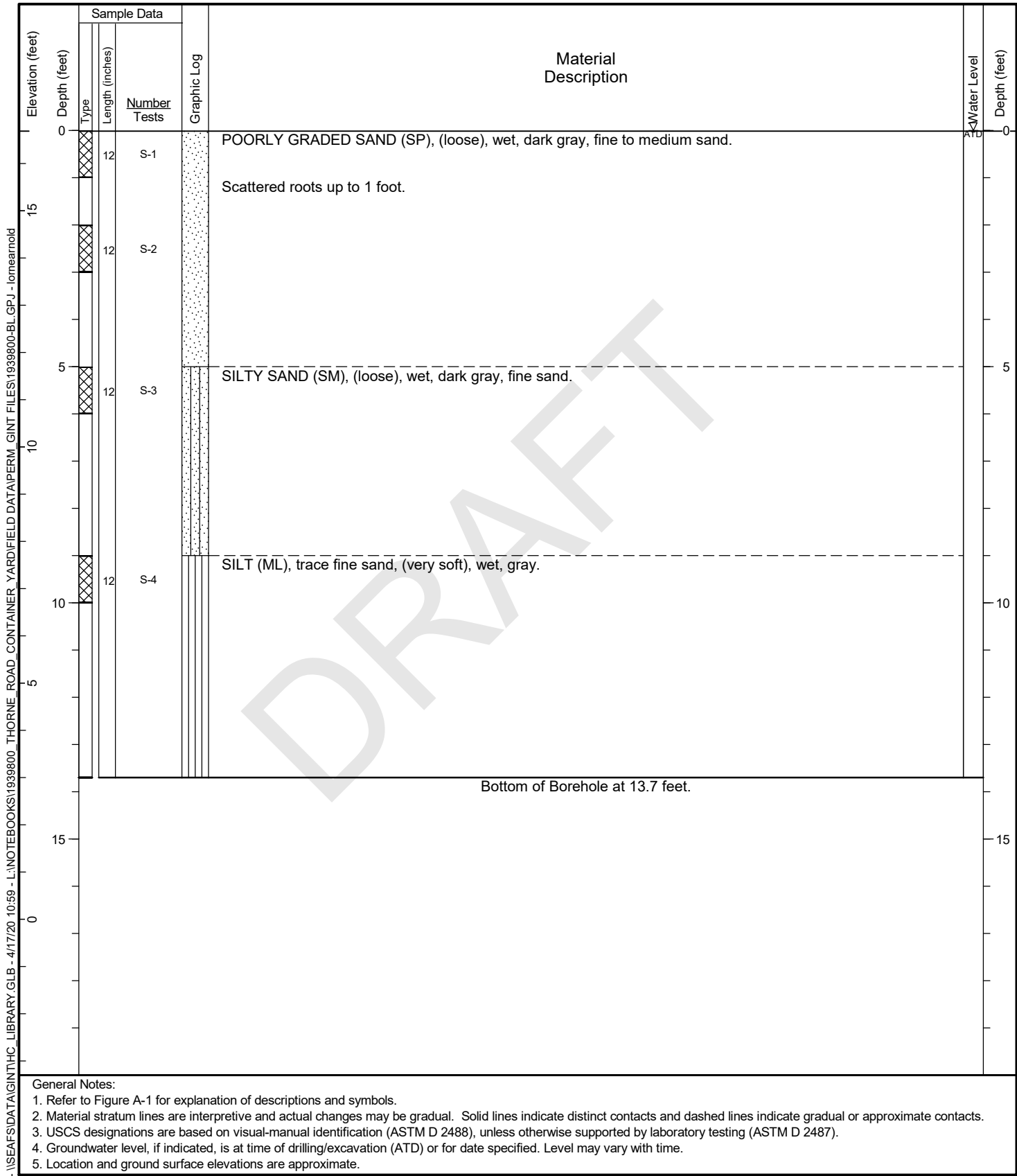
Figure

5

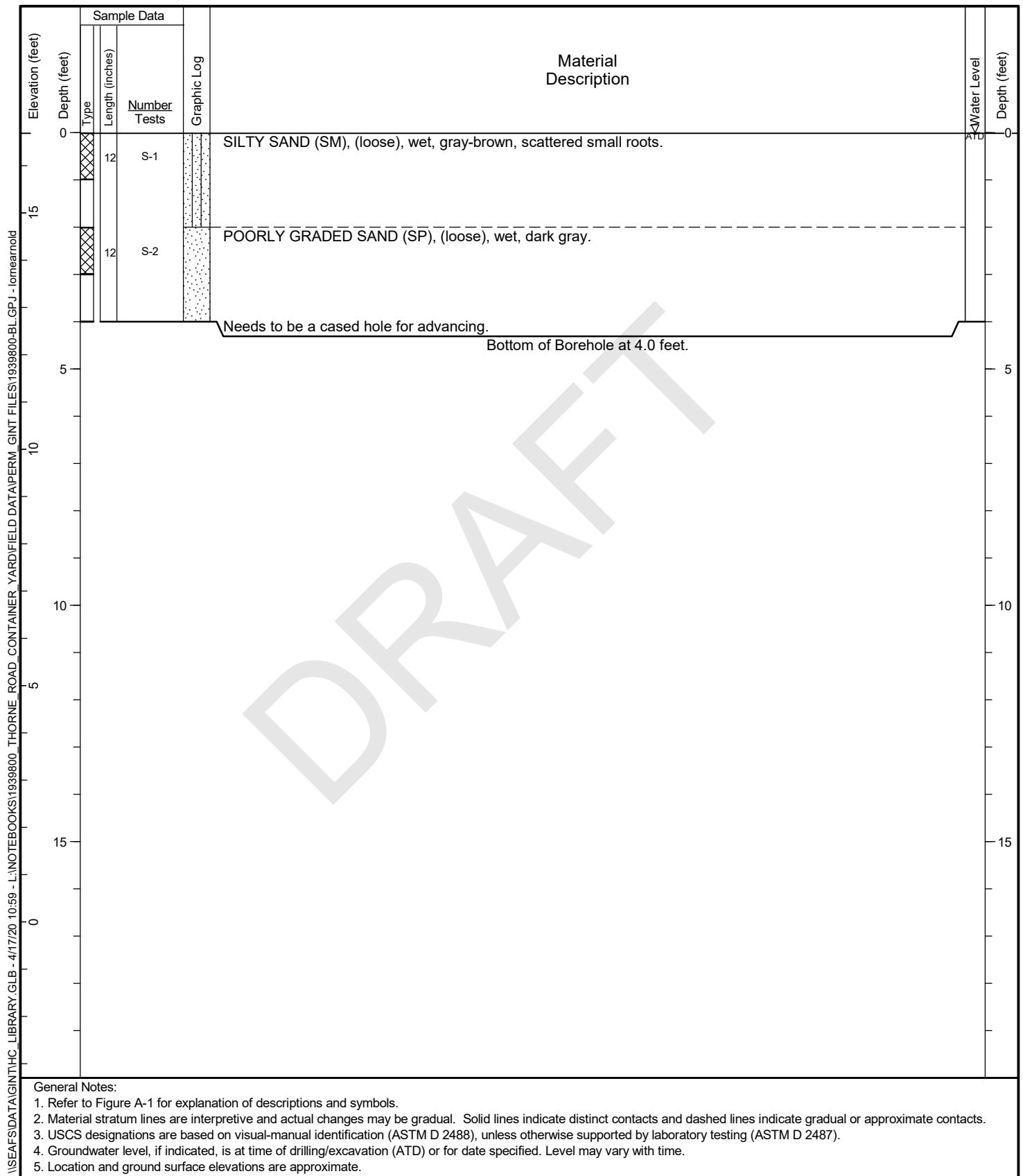
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## **APPENDIX A HC Borings**

Date Started: <u>1/16/20</u>	Date Completed: <u>1/17/20</u>	Contractor/Crew: <u>Hart Crowser</u>
Logged by: <u>B. McDonald</u>	Checked by: <u>M. Liu</u>	Rig Model/Type: <u>NA</u>
Location: <u>Lat: 47.263243 Long: -122.404170 (WGS 84)</u>		Total Depth: <u>13.7 feet</u> Depth to Seepage: <u>0 feet</u>
Ground Surface Elevation: <u>16.7 feet (MLLW)</u>		
Comments: <u>1451 Thorne Rd., Tacoma WA</u>		

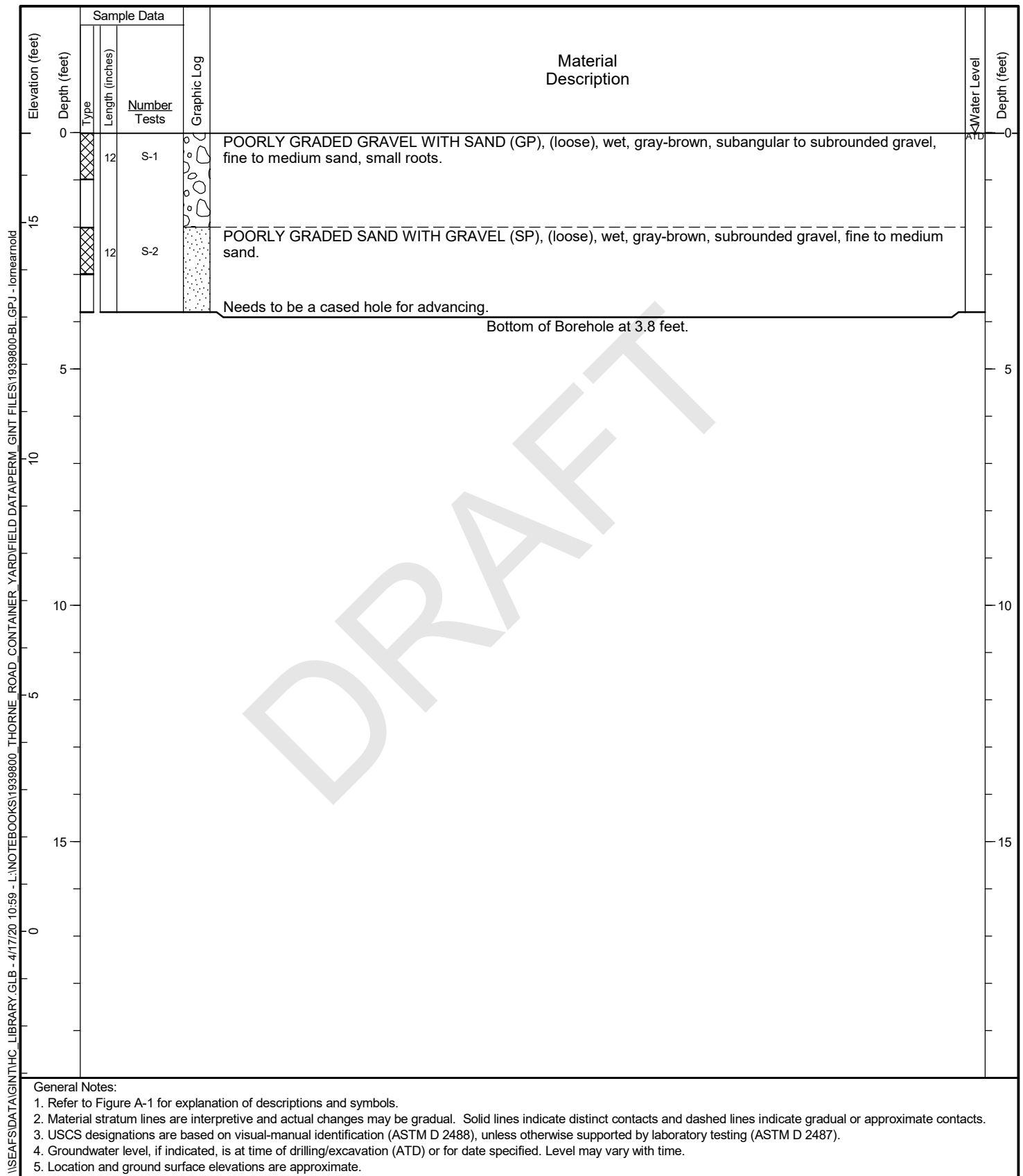


Date Started: <u>1/16/20</u>		Date Completed: <u>1/16/20</u>		Contractor/Crew: <u>Hart Crowser</u>	
Logged by: <u>B. McDonald</u>		Checked by: <u>M. Liu</u>		Rig Model/Type: <u>NA</u>	
Location: <u>Lat: 47.263610 Long: -122.404789 (WGS 84)</u>				Total Depth: <u>4 feet</u> Depth to Seepage: <u>0 feet</u>	
Ground Surface Elevation: <u>16.7 feet (MLLW)</u>					
Comments: <u>1451 Thorne Rd., Tacoma WA</u>					

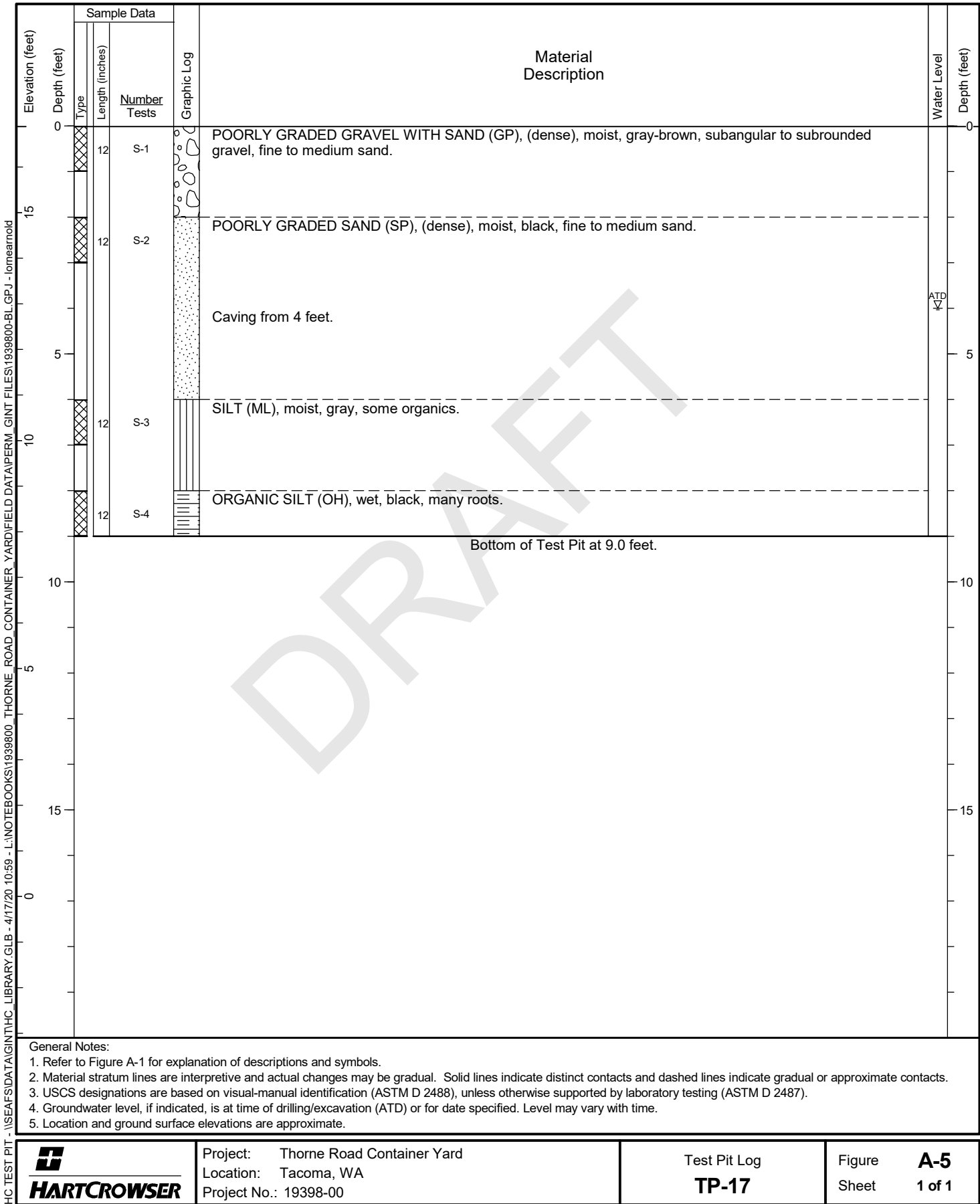


HC TEST PIT - I:\SEAFSDATA\GINT\HC\_LIBRARY.GLB - 4/17/20 10:59 - L:\NOTEBOOKS\1939800\_THORNE\_ROAD\_CONTAINER\_YARD\FIELD DATA\PERM\_GINT FILES\1939800-BL.GPJ - lornearnold

Date Started: <u>1/16/20</u>	Date Completed: <u>1/16/20</u>	Contractor/Crew: <u>Hart Crowser</u>
Logged by: <u>B. McDonald</u>	Checked by: <u>M. Liu</u>	Rig Model/Type: <u>NA</u>
Location: <u>Lat: 47.263388 Long: -122.405366 (WGS 84)</u>		Total Depth: <u>3.8 feet</u> Depth to Seepage: <u>0 feet</u>
Ground Surface Elevation: <u>16.9 feet (MLLW)</u>		
Comments: <u>1451 Thorne Rd., Tacoma WA</u>		

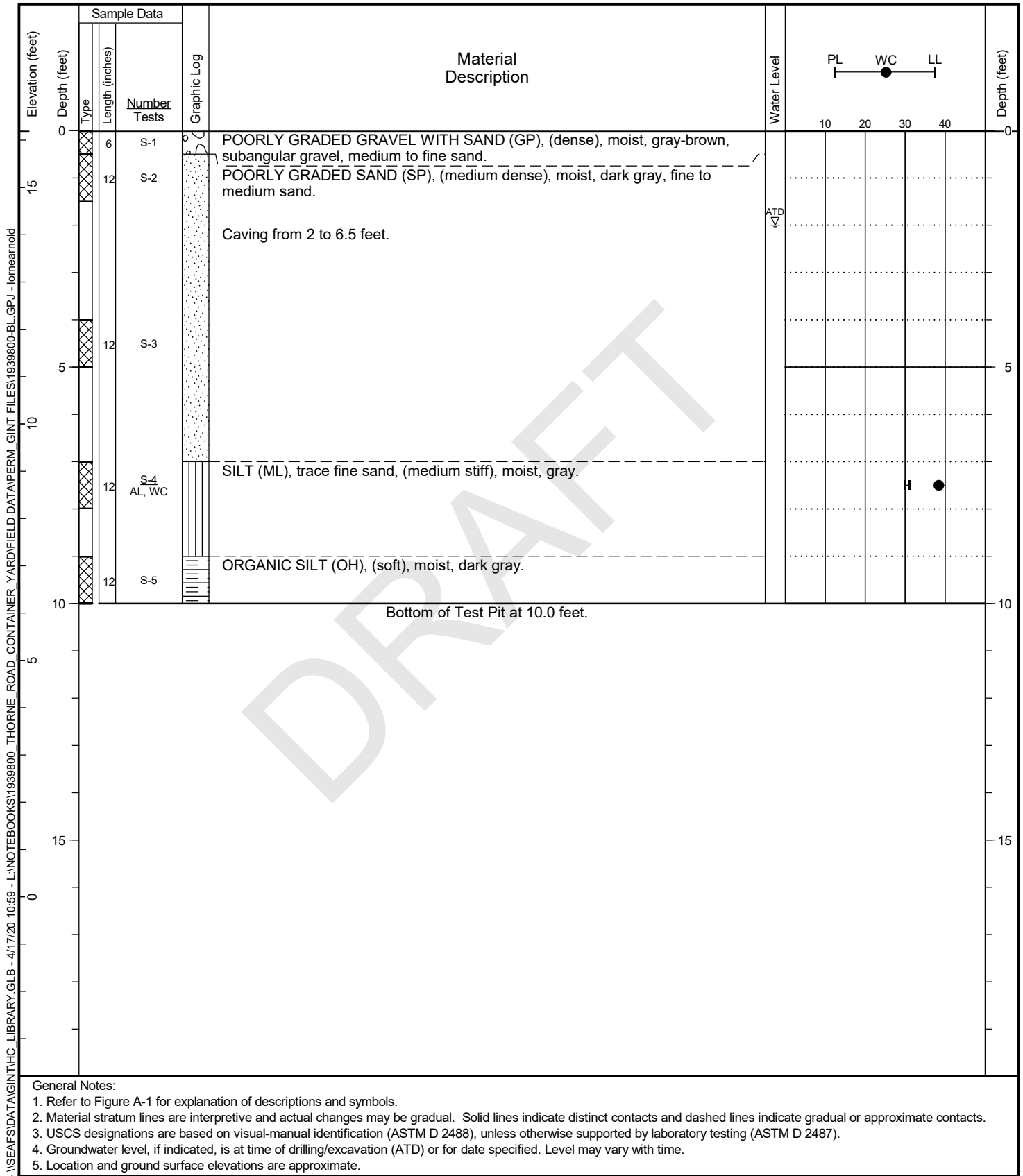


Date Started: 1/15/20	Date Completed: 1/15/20	Contractor/Crew: Holt Services, Inc.
Logged by: B. McDonald	Checked by: M. Liu	Rig Model/Type: Mini excavator
Location: Lat: 47.261155 Long: -122.404018 (WGS 84)		Total Depth: 9 feet
Ground Surface Elevation: 16.9 feet (MLLW)		Depth to Seepage: 4 feet
Comments: 1721 Thorne Rd., Tacoma WA		

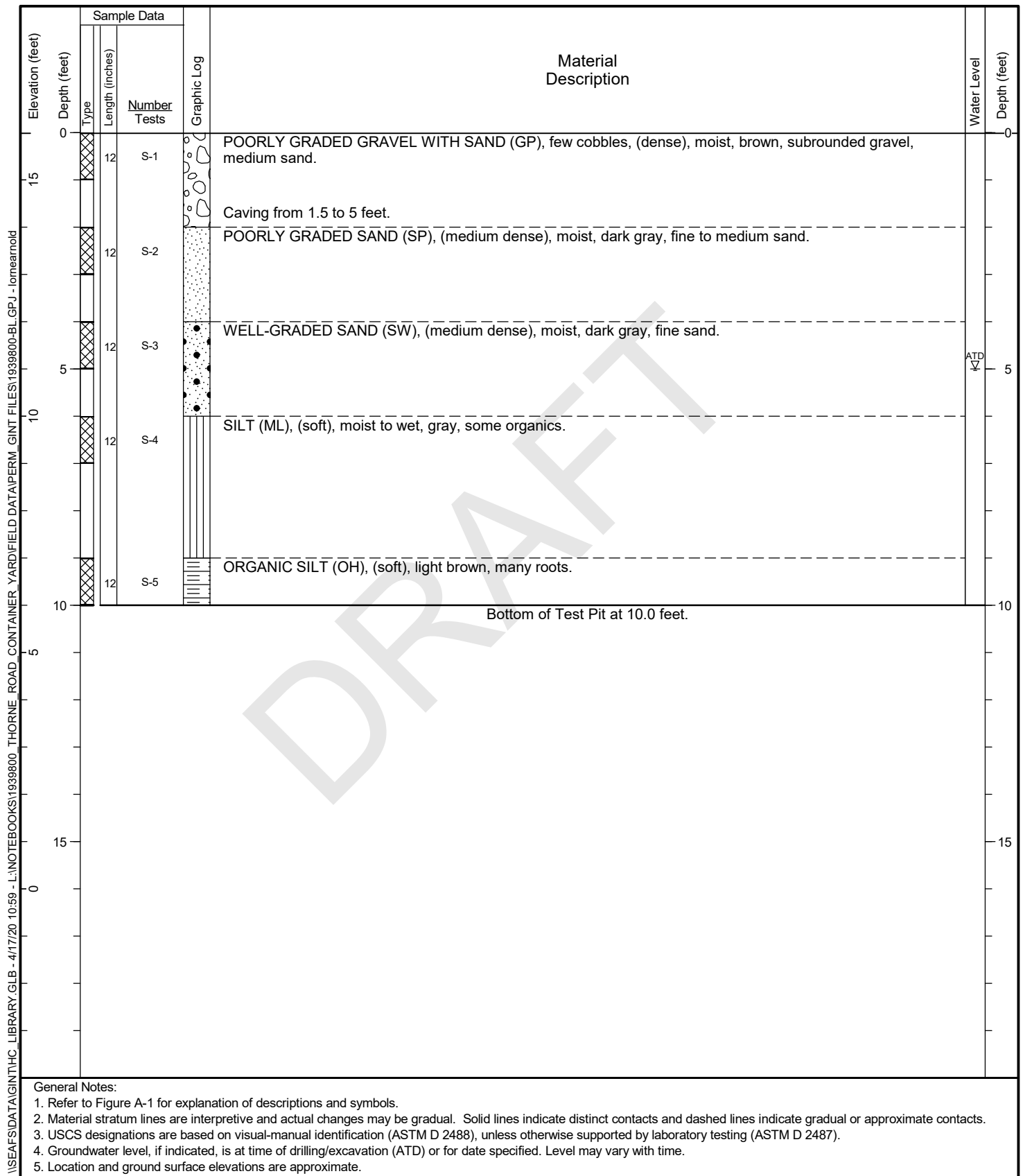




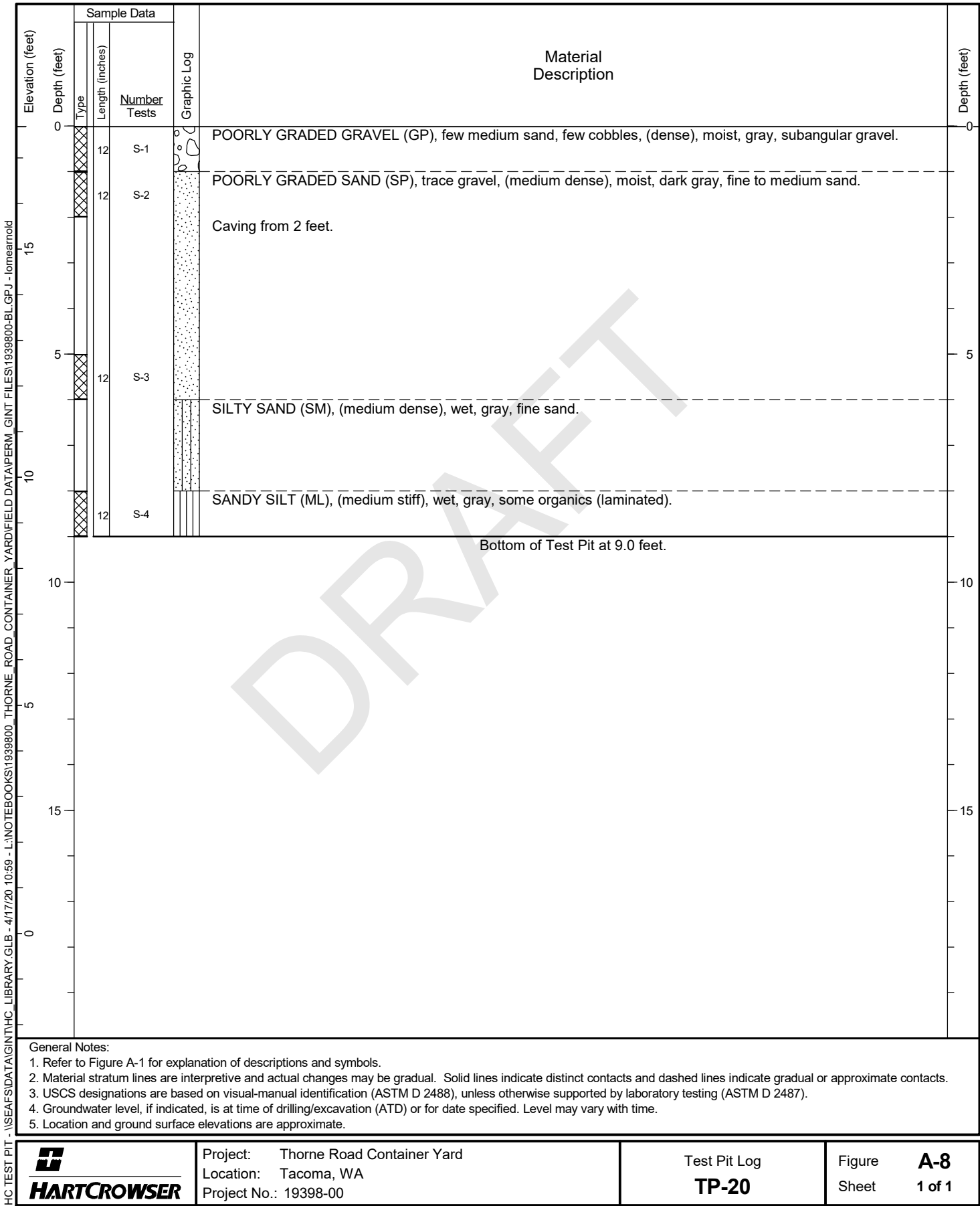
Date Started: <u>1/15/20</u>	Date Completed: <u>1/15/20</u>	Contractor/Crew: <u>Holt Services, Inc.</u>
Logged by: <u>B. McDonald</u>	Checked by: <u>M. Liu</u>	Rig Model/Type: <u>Mini excavator</u>
Location: <u>Lat: 47.261848 Long: -122.403151 (WGS 84)</u>		Total Depth: <u>10 feet</u> Depth to Seepage: <u>2 feet</u>
Ground Surface Elevation: <u>16.2 feet (MLLW)</u>		
Comments: <u>1721 Thorne Rd., Tacoma WA</u>		



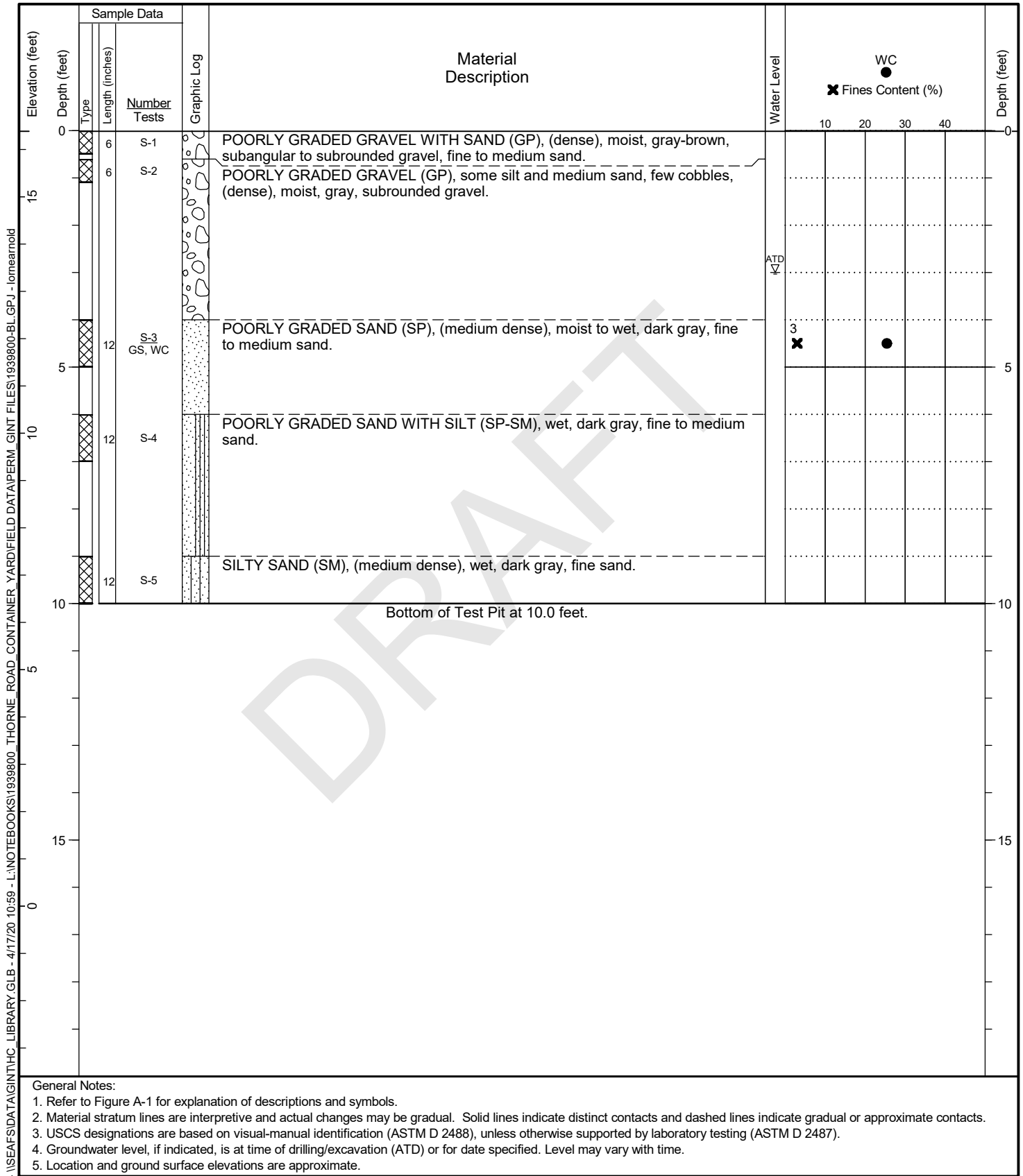
Date Started: <u>1/15/20</u>	Date Completed: <u>1/15/20</u>	Contractor/Crew: <u>Holt Services, Inc.</u>
Logged by: <u>B. McDonald</u>	Checked by: <u>M. Liu</u>	Rig Model/Type: <u>Mini excavator</u>
Location: <u>Lat: 47.261223 Long: -122.404776 (WGS 84)</u>		Total Depth: <u>10 feet</u> Depth to Seepage: <u>5 feet</u>
Ground Surface Elevation: <u>16 feet (MLLW)</u>		
Comments: <u>1721 Thorne Rd., Tacoma WA</u>		



Date Started: 1/15/20	Date Completed: 1/15/20	Contractor/Crew: Holt Services, Inc.
Logged by: B. McDonald	Checked by: M. Liu	Rig Model/Type: Mini excavator
Location: Lat: 47.261869 Long: -122.404049 (WGS 84)		Total Depth: 9 feet
Ground Surface Elevation: 17.7 feet (MLLW)		Depth to Seepage: Not Encountered
Comments: 1721 Thorne Rd., Tacoma WA		



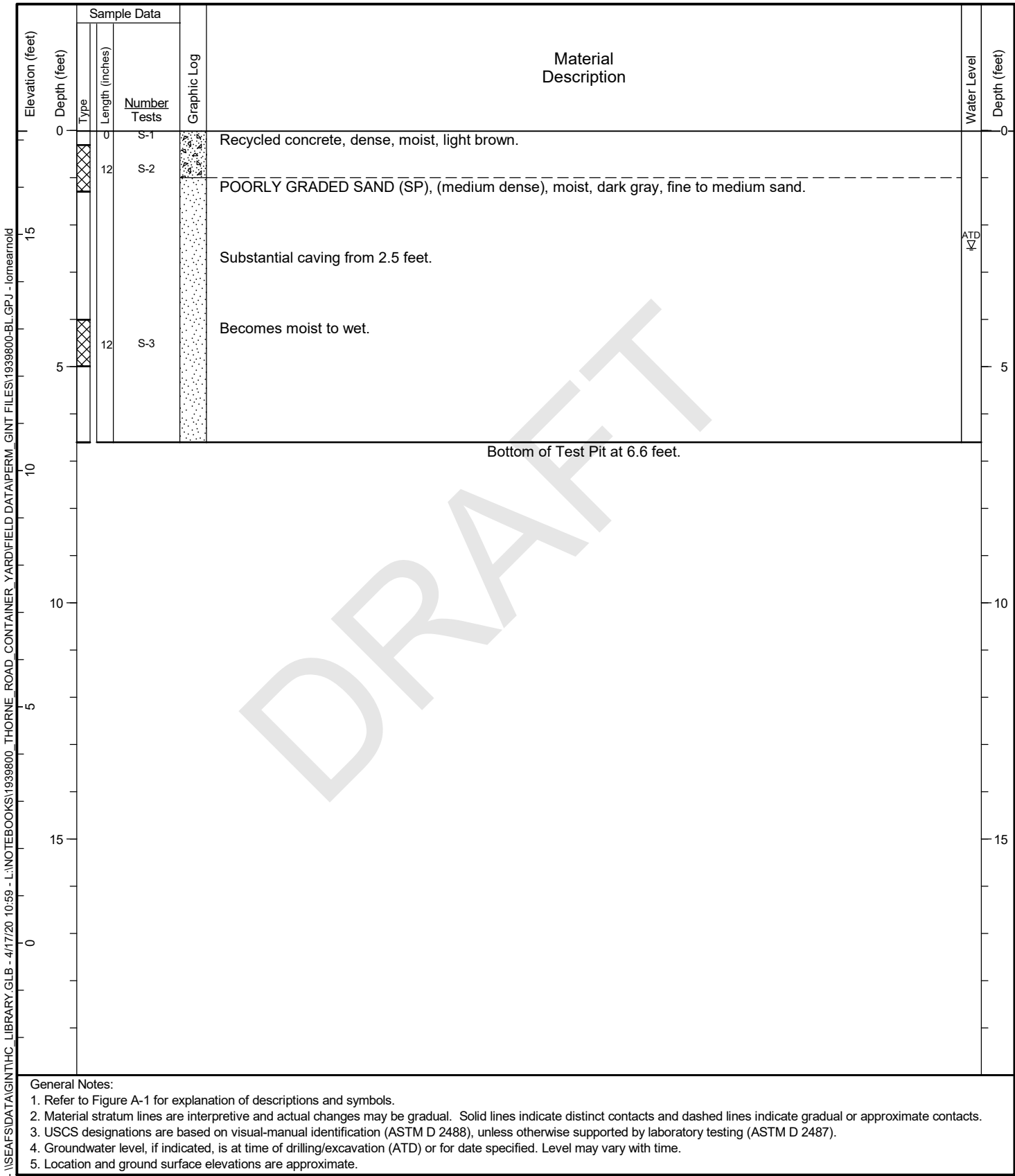
Date Started: <u>1/14/20</u>	Date Completed: <u>1/14/20</u>	Contractor/Crew: <u>Holt Services, Inc.</u>
Logged by: <u>B. McDonald</u>	Checked by: <u>M. Liu</u>	Rig Model/Type: <u>Mini excavator</u>
Location: <u>Lat: 47.262377 Long: -122.403187 (WGS 84)</u>		Total Depth: <u>10 feet</u> Depth to Seepage: <u>3 feet</u>
Ground Surface Elevation: <u>16.4 feet (MLLW)</u>		
Comments: <u>1721 Thorne Rd., Tacoma WA</u>		



Contractor/Crew: Holt Services, Inc.  
Rig Model/Type: Mini excavator  
Total Depth: 9 feet Depth to Seepage: 3 feet



Date Started: 1/14/20	Date Completed: 1/14/20	Contractor/Crew: Holt Services, Inc.
Logged by: B. McDonald	Checked by: M. Liu	Rig Model/Type: Mini excavator
Location: Lat: 47.262415 Long: -122.403916 (WGS 84)		Total Depth: 6.6 feet Depth to Seepage: 2.5 feet
Ground Surface Elevation: 17.2 feet (MLLW)		
Comments: 1721 Thorne Rd., Tacoma WA		



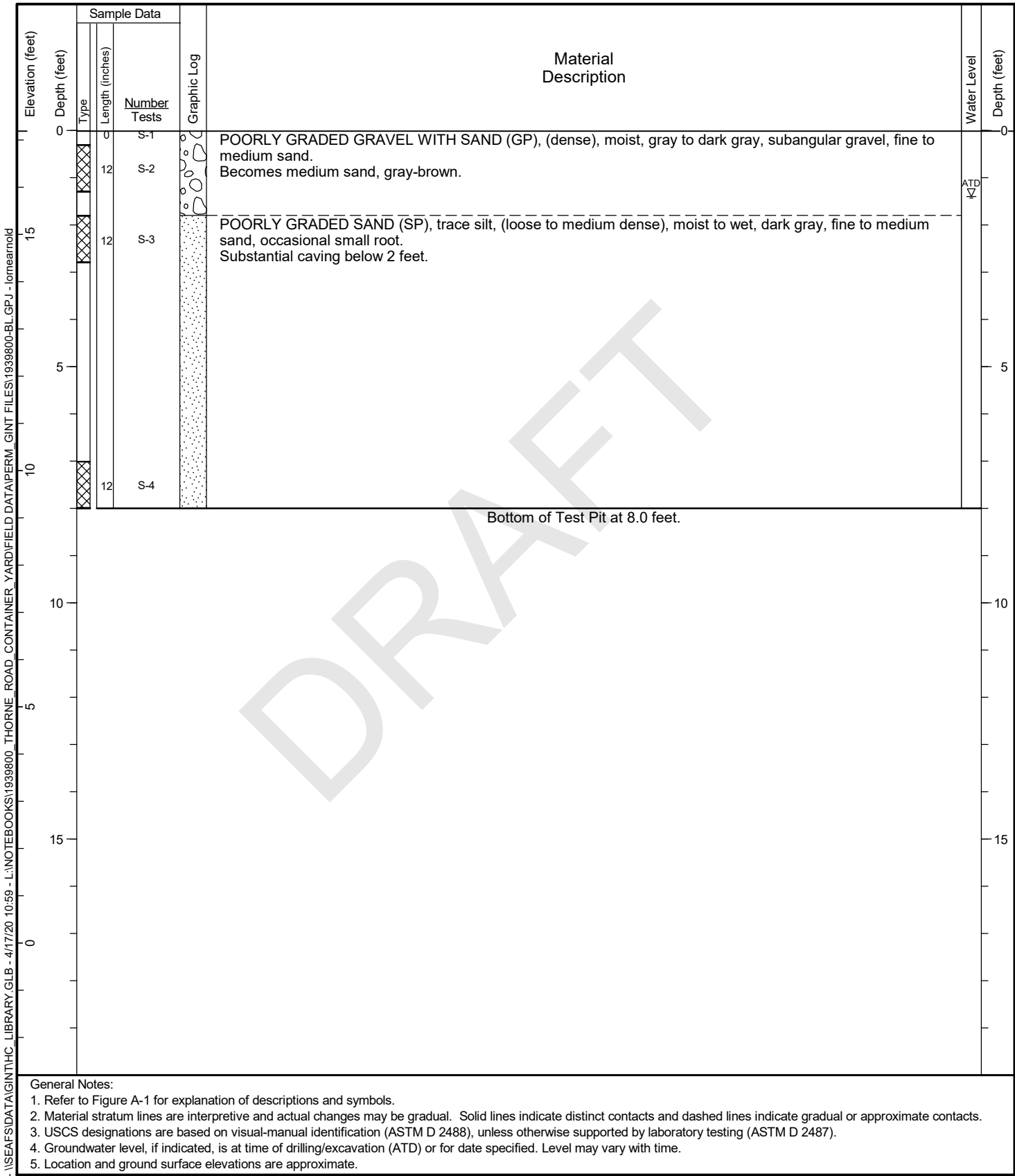
Project: Thorne Road Container Yard  
Location: Tacoma, WA  
Project No.: 19398-00

Test Pit Log  
**TP-23**

Figure **A-11**  
Sheet **1 of 1**



Date Started: 1/14/20	Date Completed: 1/14/20	Contractor/Crew: Holt Services, Inc.
Logged by: B. McDonald	Checked by: M. Liu	Rig Model/Type: Mini excavator
Location: Lat: 47.262790 Long: -122.404530 (WGS 84)		Total Depth: 8 feet
Ground Surface Elevation: 17.2 feet (MLLW)		Depth to Seepage: 1.4 feet
Comments: 1451 Thorne Rd., Tacoma WA		

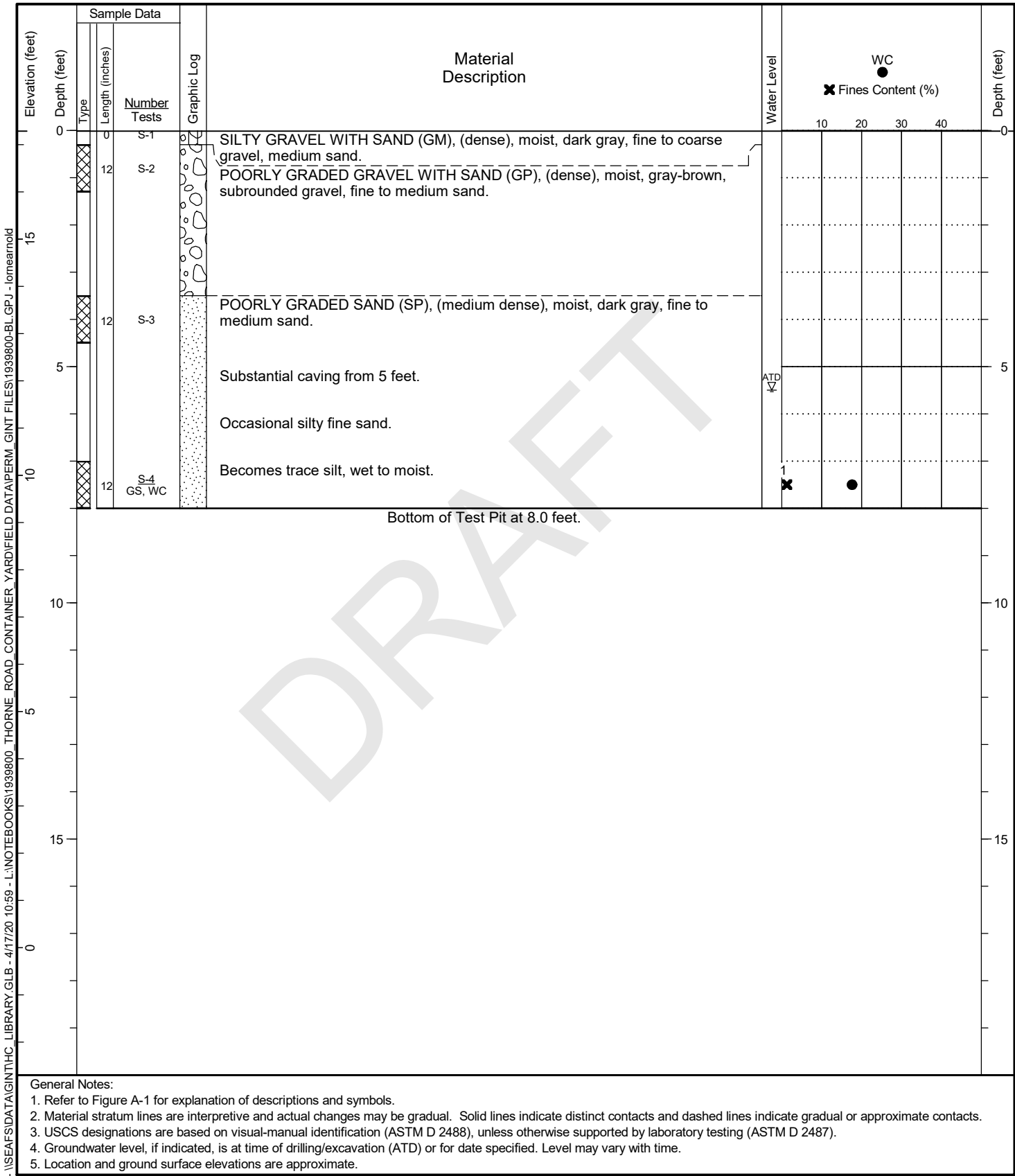


Project: Thorne Road Container Yard  
 Location: Tacoma, WA  
 Project No.: 19398-00

Test Pit Log  
**TP-24**

Figure **A-12**  
 Sheet **1 of 1**

Date Started: 1/14/20	Date Completed: 1/14/20	Contractor/Crew: Holt Services, Inc.
Logged by: B. McDonald	Checked by: M. Liu	Rig Model/Type: Mini excavator
Location: Lat: 47.262168 Long: -122.405485 (WGS 84)	Total Depth: 8 feet	Depth to Seepage: 5.5 feet
Ground Surface Elevation: 17.3 feet (MLLW)		
Comments: 1451 Thorne Rd., Tacoma WA		

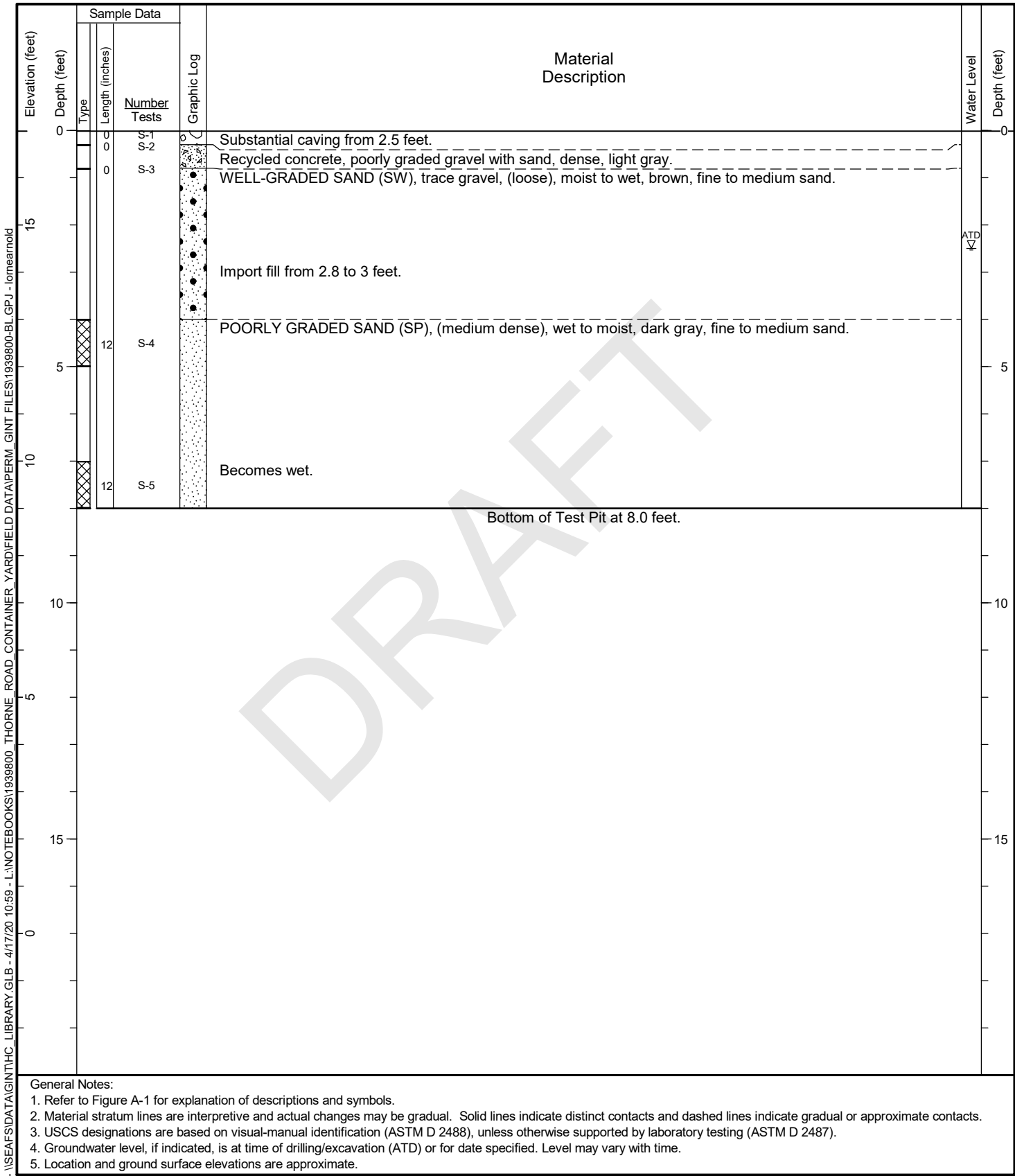


Project: Thorne Road Container Yard  
Location: Tacoma, WA  
Project No.: 19398-00

Test Pit Log  
TP-25

Figure A-13  
Sheet 1 of 1

Date Started: 1/14/20	Date Completed: 1/14/20	Contractor/Crew: Holt Services, Inc.
Logged by: B. McDonald	Checked by: M. Liu	Rig Model/Type: Mini excavator
Location: Lat: 47.262657 Long: -122.405470 (WGS 84)	Total Depth: 8 feet	Depth to Seepage: 2.5 feet
Ground Surface Elevation: 17 feet (MLLW)		
Comments: 1451 Thorne Rd., Tacoma WA		



## **APPENDIX B**

### **Lab Test Results**

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## Soil Grain Size

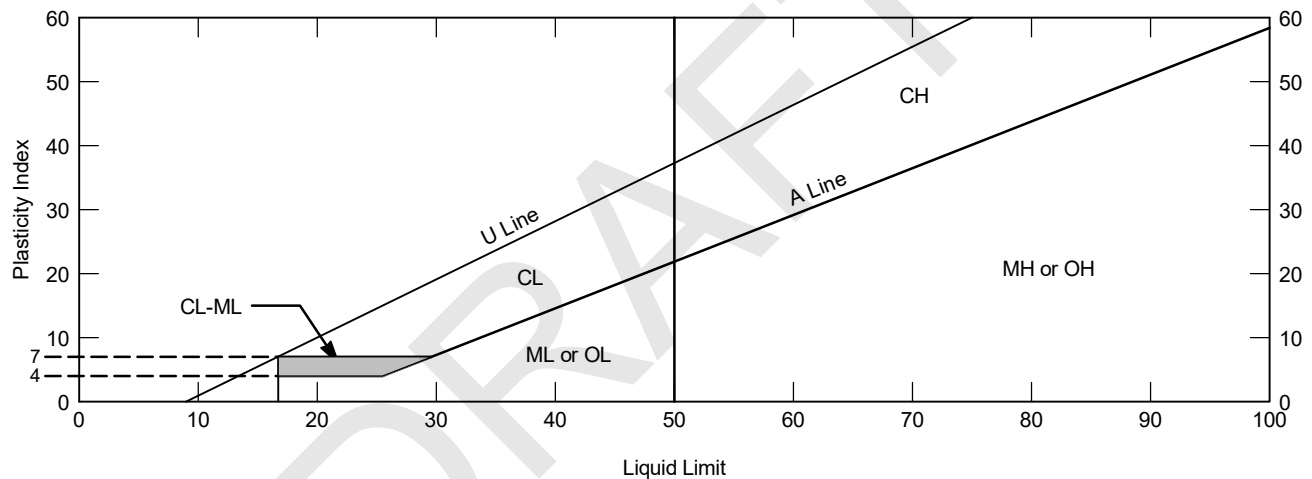
Size of Opening in Inches	Number of Mesh per Inch (US Standard)	Grain Size in Millimeters
12 300	6 200	4 100
4 100	3 60	3 75
3 80	2 40	2 50
1-1/2 30	1 20	1-1/2 40
1 20	3/4 10	1 25
3/4 20	5/8 10	3/4 19
1/2 10	1/2 10	1/2 12.5
3/8 10	3/8 10	3/8 9.5
1/4 10	1/4 10	1/4 6.3
4 10	4 10	4 4.75
10 10	10 10	10 2.5
20 10	20 10	20 1.18
40 10	40 10	40 0.85
60 10	60 10	60 0.60
100 10	100 10	100 0.425
200 10	200 10	200 0.25
400 10	400 10	400 0.15
600 10	600 10	600 0.106
800 10	800 10	800 0.075
1000 10	1000 10	1000 0.053
		0.0475
		0.0375
		0.025
		0.0175
		0.015
		0.0106
		0.0075
		0.006
		0.00425
		0.003
		0.002
		0.001

Grain Size in Millimeters

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

## Fine-Grained Soils

Fine-Grained Soils > 50% smaller than No. 200 Sieve						
Soils with Liquid Limit < 50%			Soils with Liquid Limit > 50%			
SILT	CLAY	ORGANIC	SILT	CLAY	ORGANIC	PEAT
ML	CL	OL	MH	CH	OH	PT



## Coarse-Grained Soils

Coarse-Grained Soils > 50% Larger than No. 200 Sieve									
GRAVEL > 50% Coarse Fraction Larger than No. 4 Sieve					SAND > 50% Coarse Fraction Smaller than No. 4 Sieve				
GRAVEL with 5% Fines	GW	GP	GP	GP	SAND with 5% Fines	SW	SP	SP	SP
GRAVEL with >12% Fines	GM	GC	GC	GC	SAND with > 12% Fines	SM	SC	SC	SC
GRAVEL with 5% < Fines <12%	GW-GM	GW-GC	GP-GM	GP-GC	SAND with 5% < Fines <12%	SW-SM	SW-SC	SP-SM	SP-SC

For clean sands and gravels:

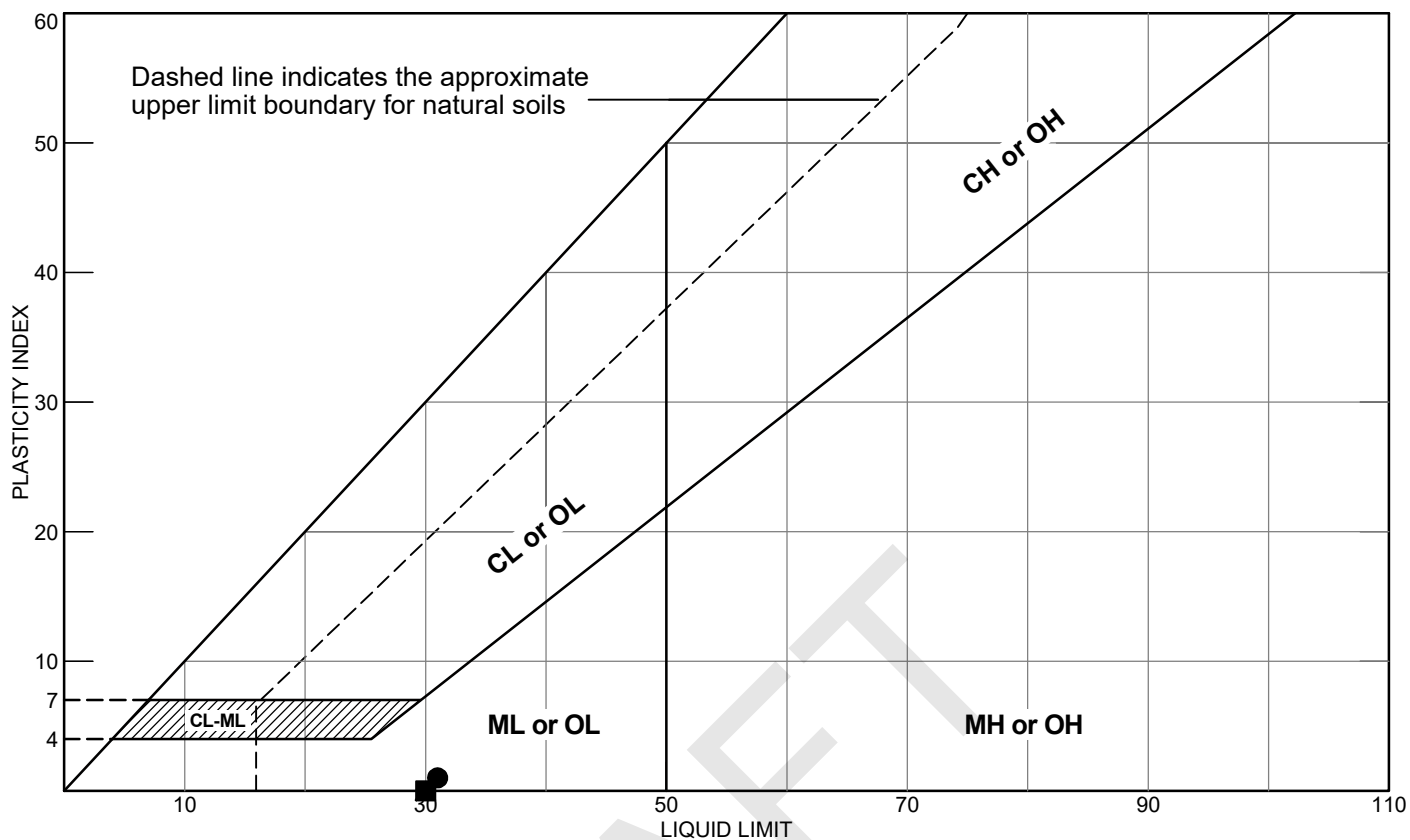
$$1 \leq \frac{(D_{30})^2}{D_{10} \times D_{60}} \leq 3 \quad \& \quad \frac{D_{60}}{D_{10}} \quad \text{where} \quad \begin{matrix} > 4 \text{ for GW} \\ > 6 \text{ for SW} \end{matrix} \quad \text{otherwise GP or SP}$$

$$C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} \quad C_u = \frac{D_{60}}{D_{10}}$$

$D_{10}$ ,  $D_{30}$ ,  $D_{60}$  are particle diameters for which 10, 30, and 60 percent, respectively, of the soil mass are finer.

For sands and gravels with fines:

GM and SM Atterberg limits below A line with  $PI < 4$ GC and SC Atterberg limits above A line with  $PI > 7$



Location and Description			LL	PL	PI	#200	MC%	USCS
● Source: TP-18	Sample No.: S-4	Depth: 7.0 to 8.0	31	30	1	NT	38	ML
SILT								
■ Source: TP-22	Sample No.: S-5	Depth: 6.0 to 7.0	30	31	NP	NT	35	ML
SILT								

**Remarks:**

- 
- Non Plastic



## **APPENDIX C**

### **Historical Subsurface Data**

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## **APPENDIX C**

### **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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Logged by: \_\_\_\_\_ GRL

Surface Elevation (ft): 10

[illegible]

## LOG OF TEST PIT 01



Project:	Parcel "O" - Phase B
Project Location:	Tacoma, Washington
Project Number:	0454-097-00

Figure A-2  
Sheet 1 of 1

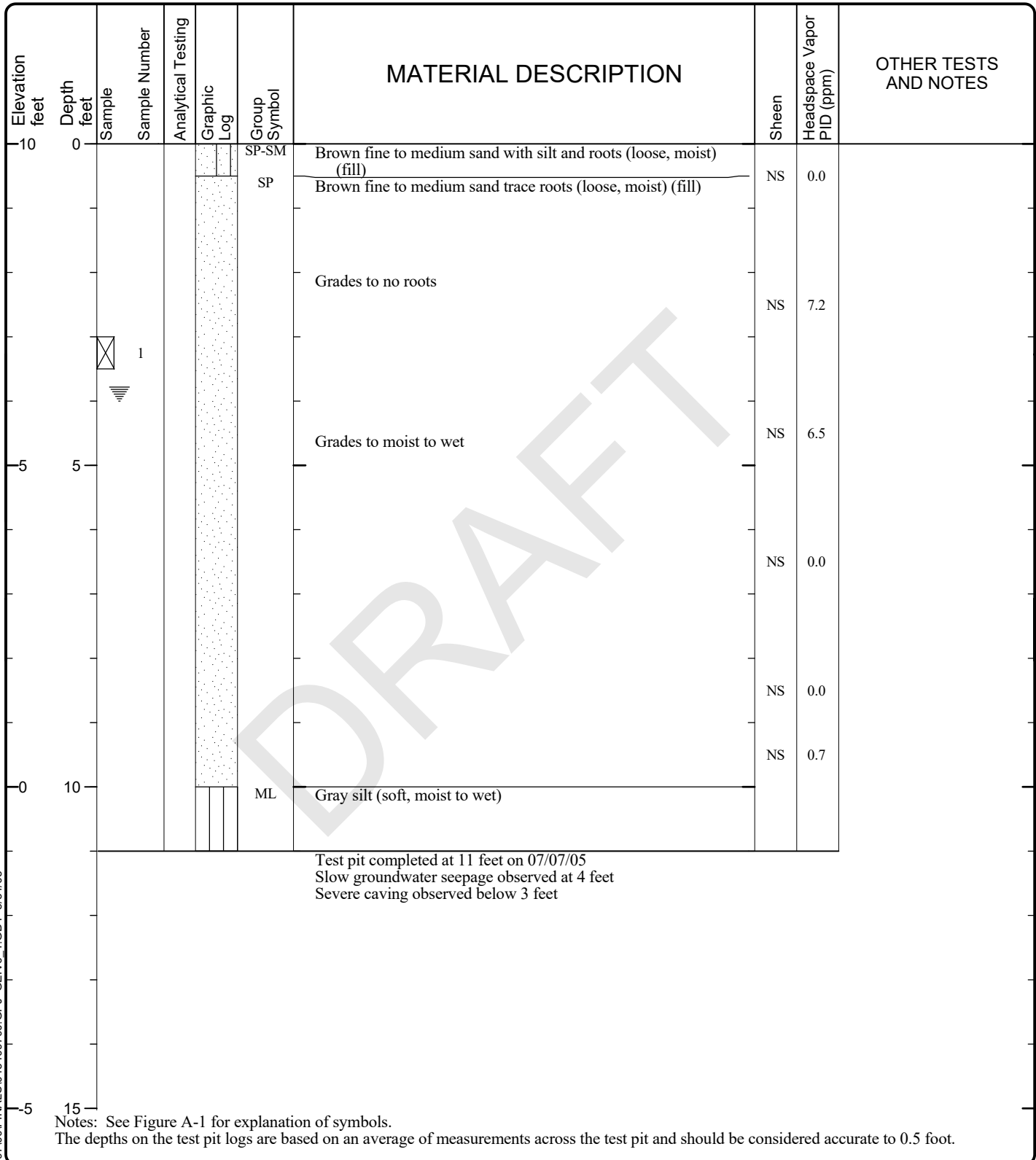
v6 ENVTPIT P:\0\0454097\00\FINALS\045409700.GPJ GEIV6 1.GDT 8/31/05

Date Excavated: 07/07/05

Logged by: GRL

Equipment: Case 580 Rubber Tired  
Backhoe

Surface Elevation (ft): 10



## LOG OF TEST PIT 02

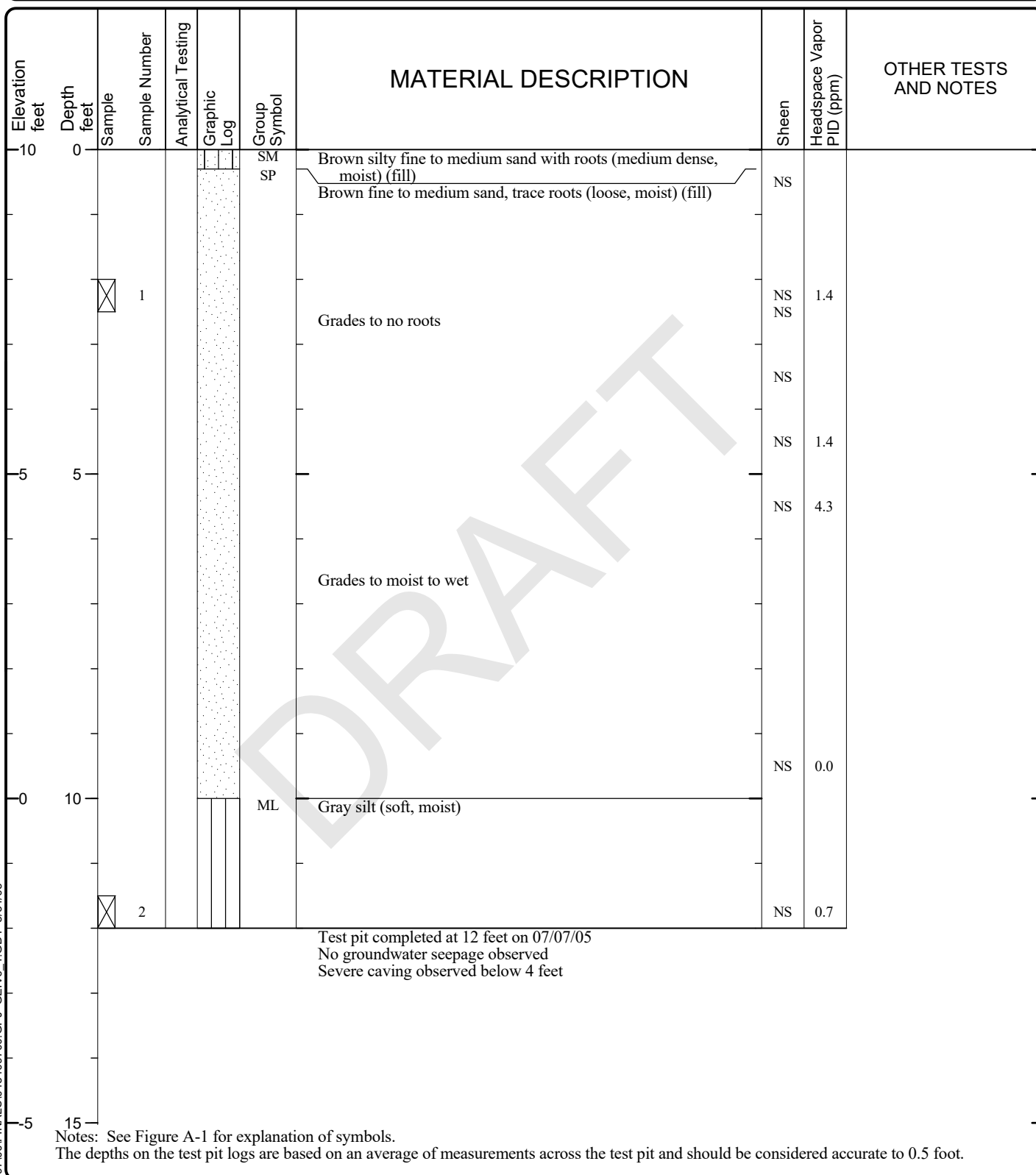


Project: Parcel "O" - Phase B  
 Project Location: Tacoma, Washington  
 Project Number: 0454-097-00

Figure A-3  
 Sheet 1 of 1

Logged by: \_\_\_\_\_ GRL

Surface Elevation (ft): 10



## LOG OF TEST PIT 03



Project:	Parcel "O" - Phase B
Project Location:	Tacoma, Washington
Project Number:	0454-097-00

Figure A-4  
Sheet 1 of 1

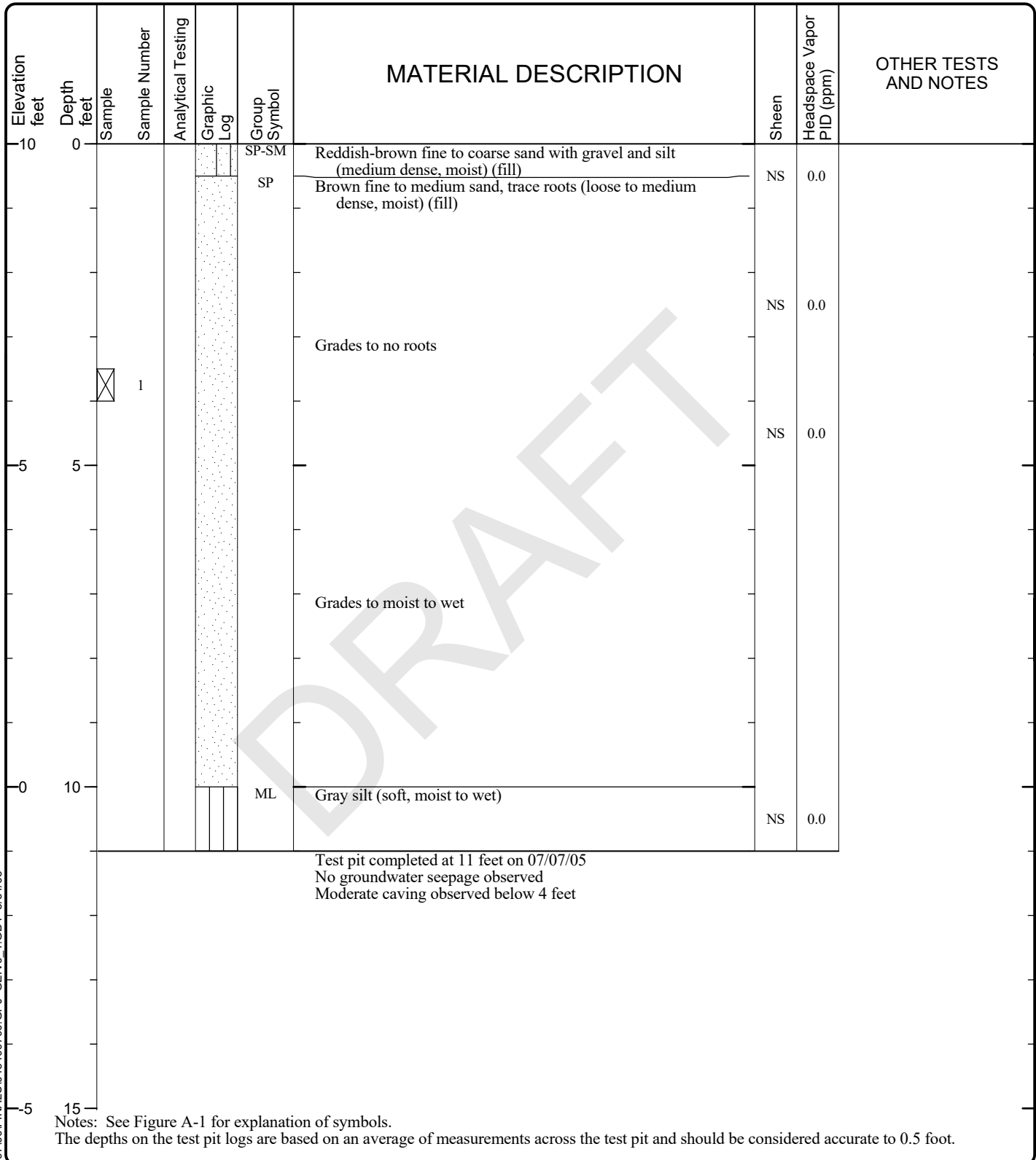
v6 ENVTPIT P:\0\0454097\00\FINALS\045409700.GPJ GEIV6 1.GDT 8/31/05

Date Excavated: 07/07/05

Logged by: GRL

Equipment: Case 580 Rubber Tired  
Backhoe

Surface Elevation (ft): 10



## LOG OF TEST PIT 04



Project: Parcel "O" - Phase B  
 Project Location: Tacoma, Washington  
 Project Number: 0454-097-00

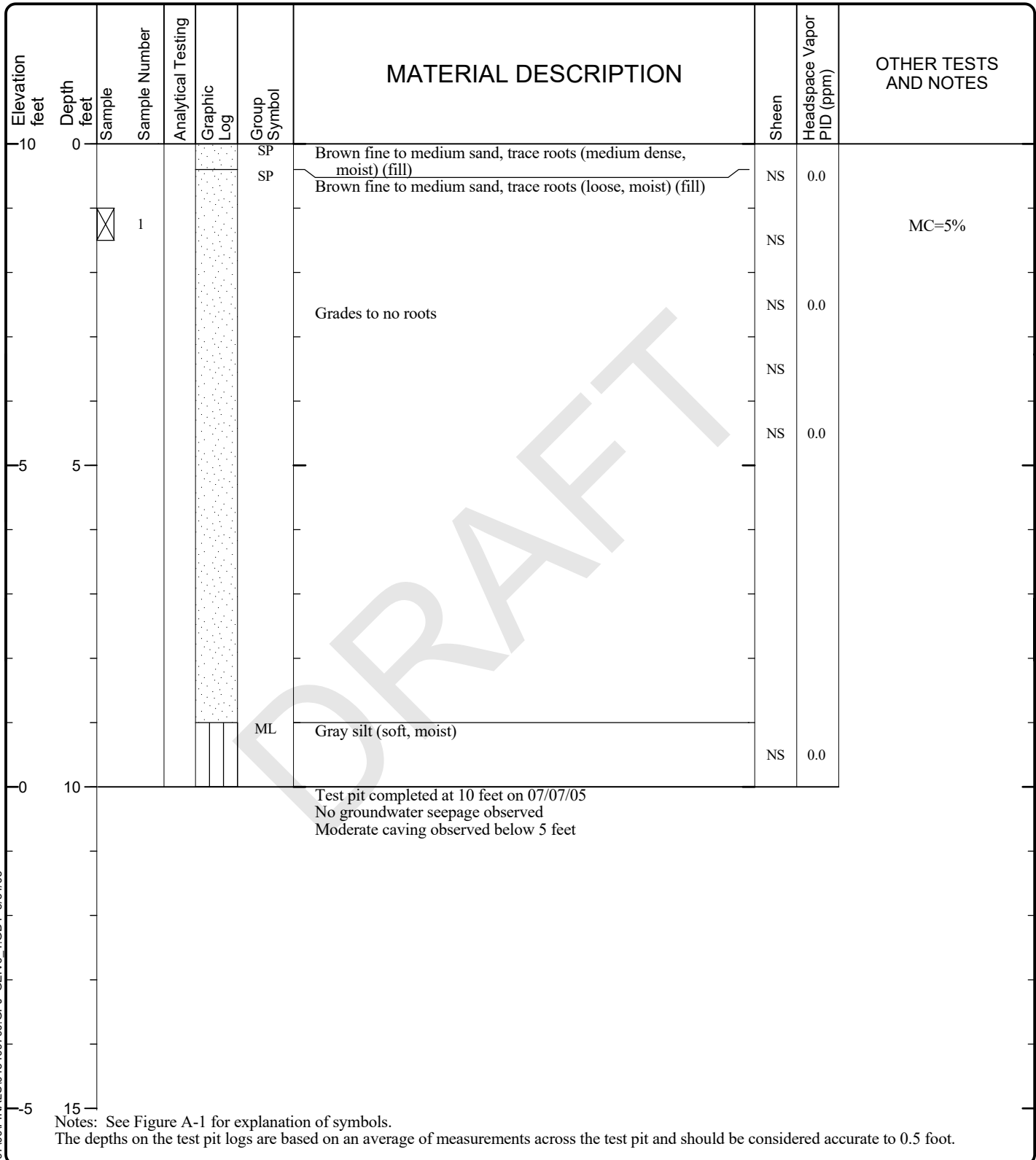
Figure A-5  
 Sheet 1 of 1

Date Excavated: 07/07/05

Logged by: GRL

Equipment: Case 580 Rubber Tired  
Backhoe

Surface Elevation (ft): 10



## LOG OF TEST PIT 05

Project: Parcel "O" - Phase B  
Project Location: Tacoma, Washington  
Project Number: 0454-097-00Figure A-6  
Sheet 1 of 1

Logged by: \_\_\_\_\_ GRL

Surface Elevation (ft): 10

Elevation feet	Depth feet	Sample	Sample Number	Analytical Testing	Graphic Log	Group Symbol	MATERIAL DESCRIPTION	Sheen	Headspace Vapor PID (ppm)	OTHER TESTS AND NOTES
10	0					SP-SM SP	Brown fine to medium sand with silt, roots (medium dense, moist) (fill) Brown fine to medium sand, trace roots (loose to medium dense, moist) (fill)	NS	0.0	
		⊗	1					NS	0.0	
								NS	0.0	
5	5					ML	Gray silt, trace sand (soft, moist to wet) (fill?)			
		⊗	2					NS	4.3	
0	10									
		⊗	3			ML	Gray silt, trace organics (medium stiff, moist)			
-5	15						Test pit completed at 14 feet on 07/07/05 No groundwater seepage observed Moderate caving observed below 4 feet			

Notes: See Figure A-1 for explanation of symbols.  
The depths on the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

## LOG OF TEST PIT 06



Project:	Parcel "O" - Phase B
Project Location:	Tacoma, Washington
Project Number:	0454-097-00

Figure A-7  
Sheet 1 of 1

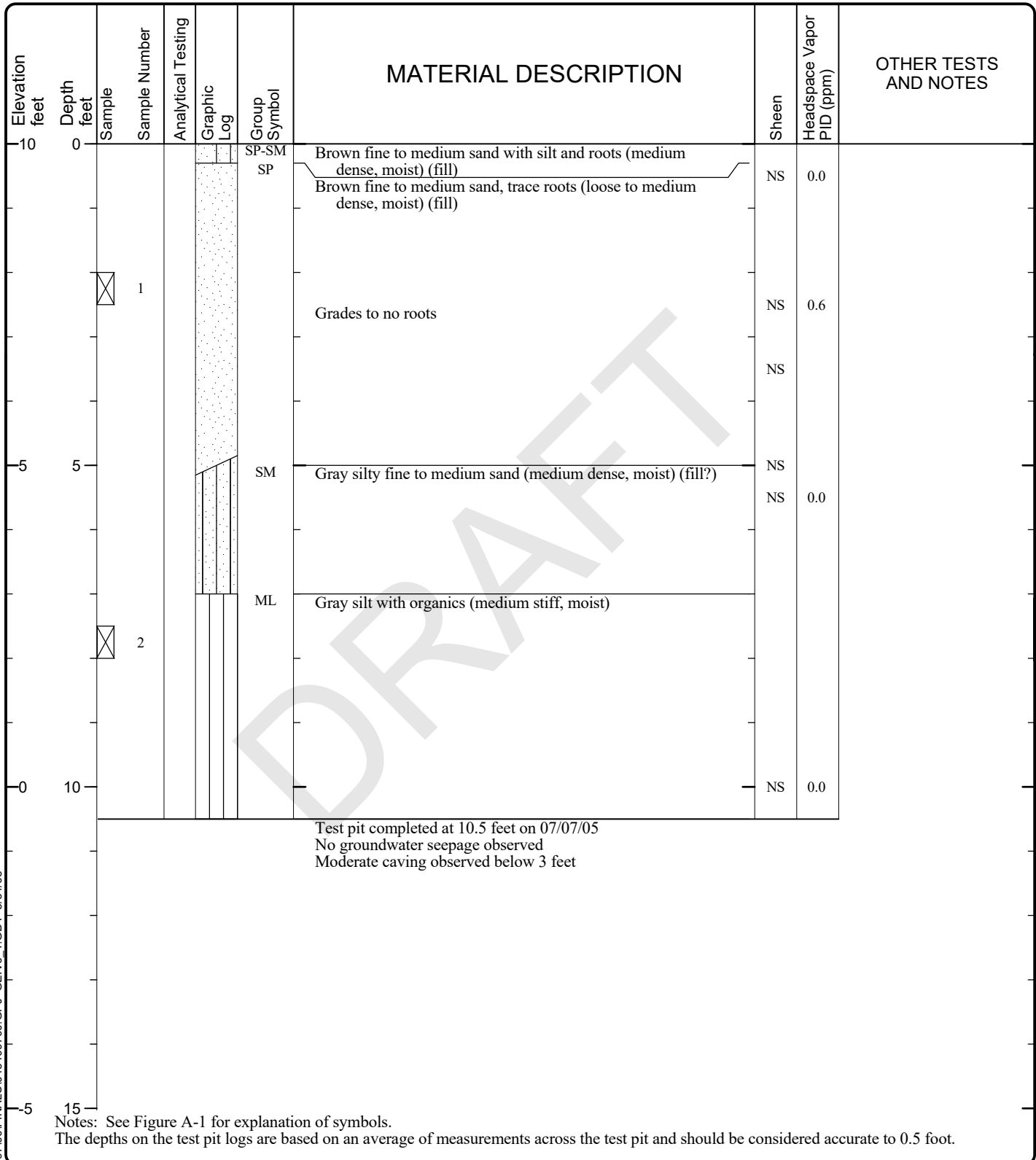
v6 ENVTPIT P:\0\0454097\00\FINALS\045409700.GPJ GEIV6 1.GDT 8/31/05

Date Excavated: 07/07/05

Logged by: GRL

Equipment: Case 580 Rubber Tired  
Backhoe

Surface Elevation (ft): 10



## LOG OF TEST PIT 07



Project: Parcel "O" - Phase B  
 Project Location: Tacoma, Washington  
 Project Number: 0454-097-00

Figure A-8  
 Sheet 1 of 1

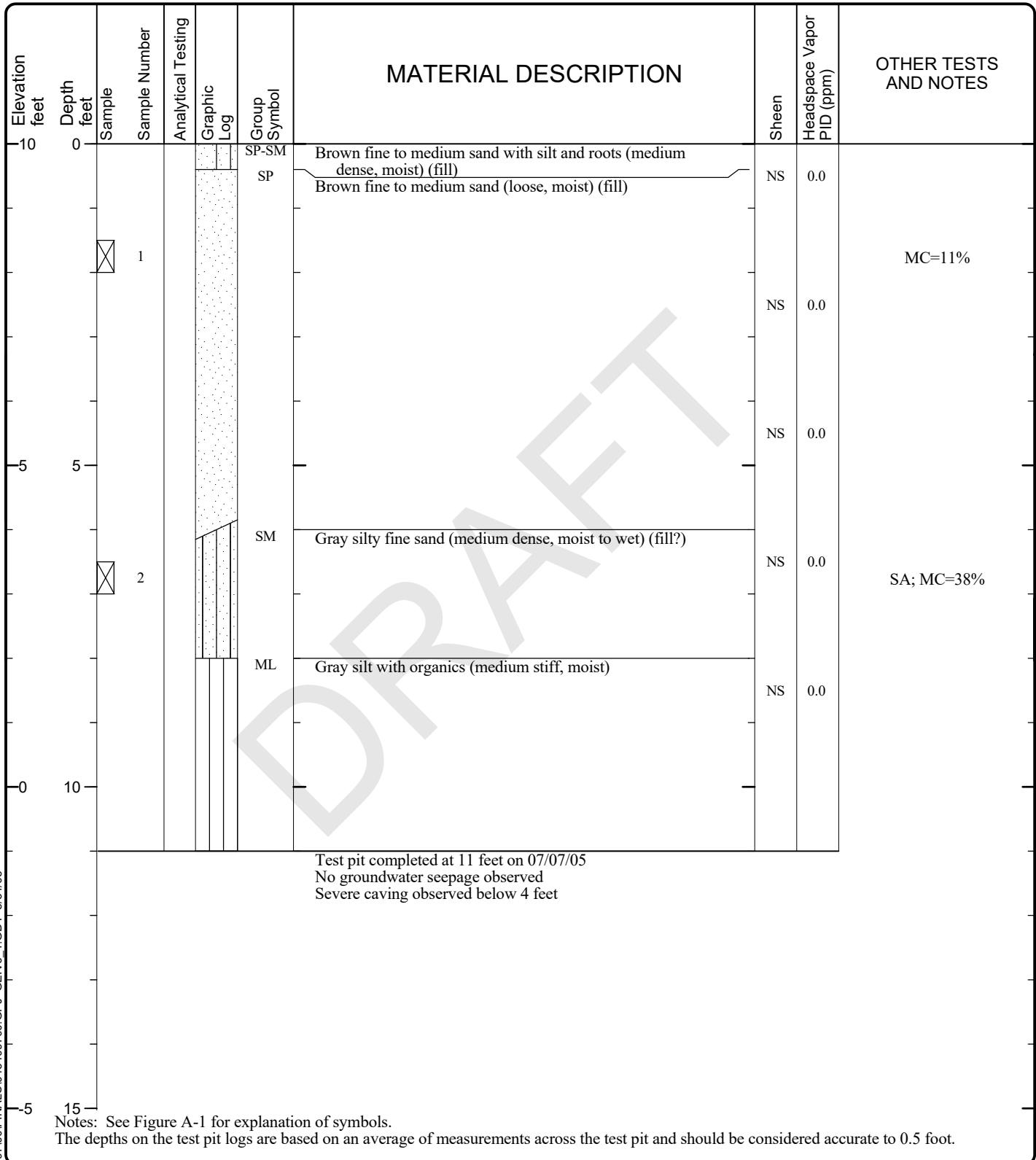


Date Excavated: 07/07/05

Logged by: GRL

Equipment: Case 580 Rubber Tired  
Backhoe

Surface Elevation (ft): 10



## LOG OF TEST PIT 08



Project: Parcel "O" - Phase B  
 Project Location: Tacoma, Washington  
 Project Number: 0454-097-00

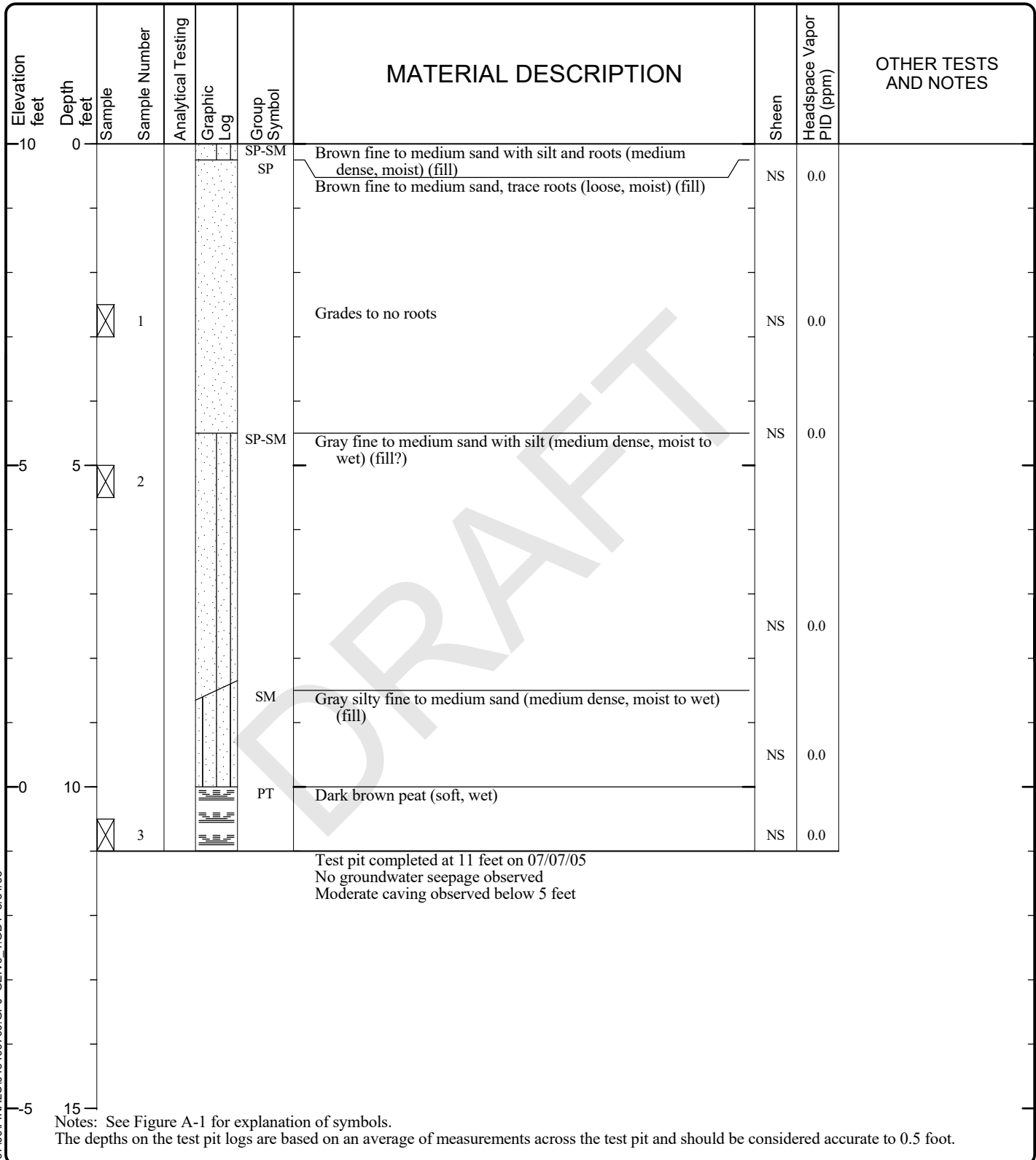
Figure A-9  
 Sheet 1 of 1

Date Excavated: 07/07/05

Logged by: GRL

Equipment: Case 580 Rubber Tired  
Backhoe

Surface Elevation (ft): 10



## LOG OF TEST PIT 09



Project: Parcel "O" - Phase B  
 Project Location: Tacoma, Washington  
 Project Number: 0454-097-00

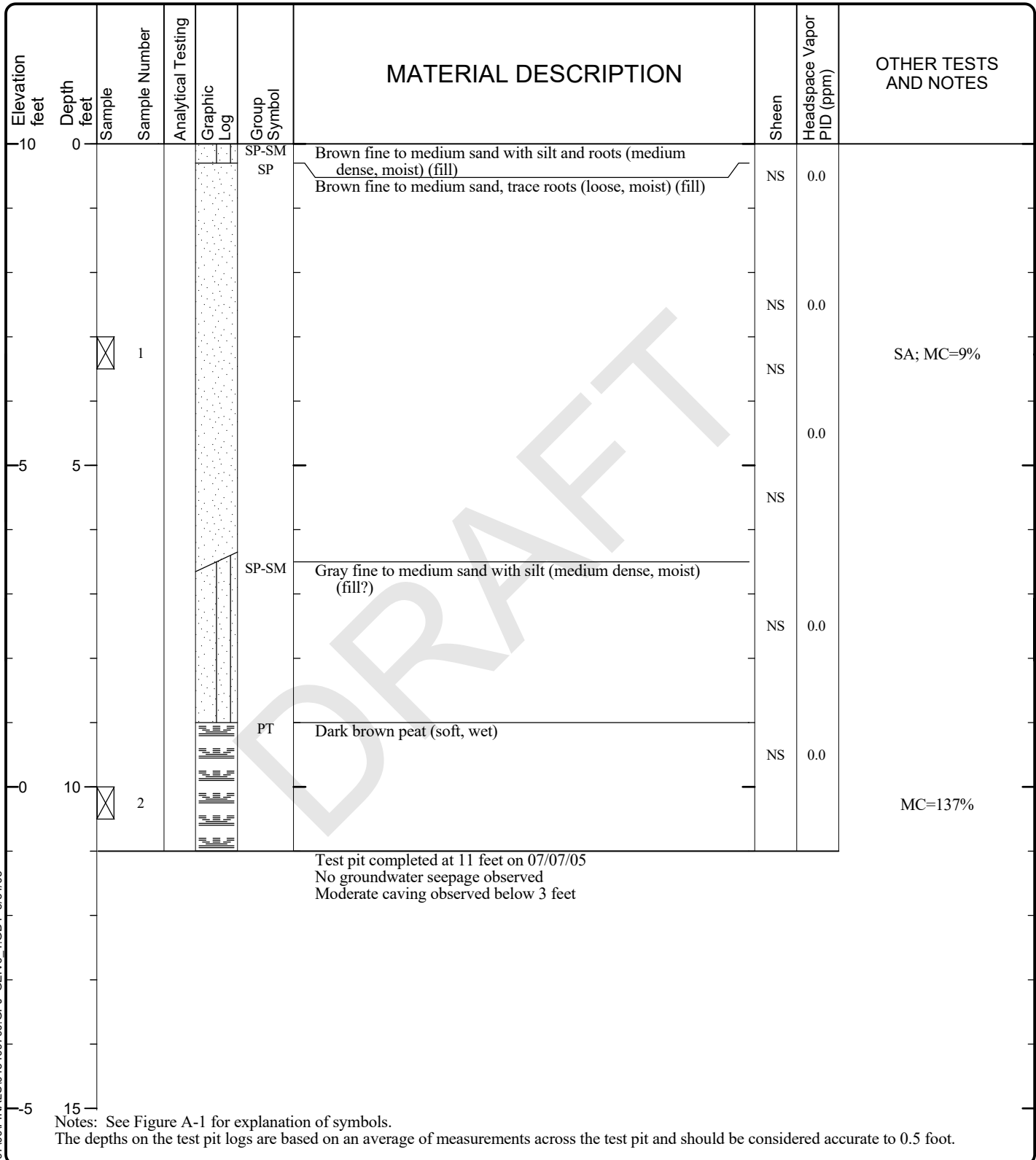
Figure A-10  
 Sheet 1 of 1

Date Excavated: 07/07/05

Logged by: GRL

Equipment: Case 580 Rubber Tired  
Backhoe

Surface Elevation (ft): 10



## LOG OF TEST PIT 10



Project: Parcel "O" - Phase B  
 Project Location: Tacoma, Washington  
 Project Number: 0454-097-00

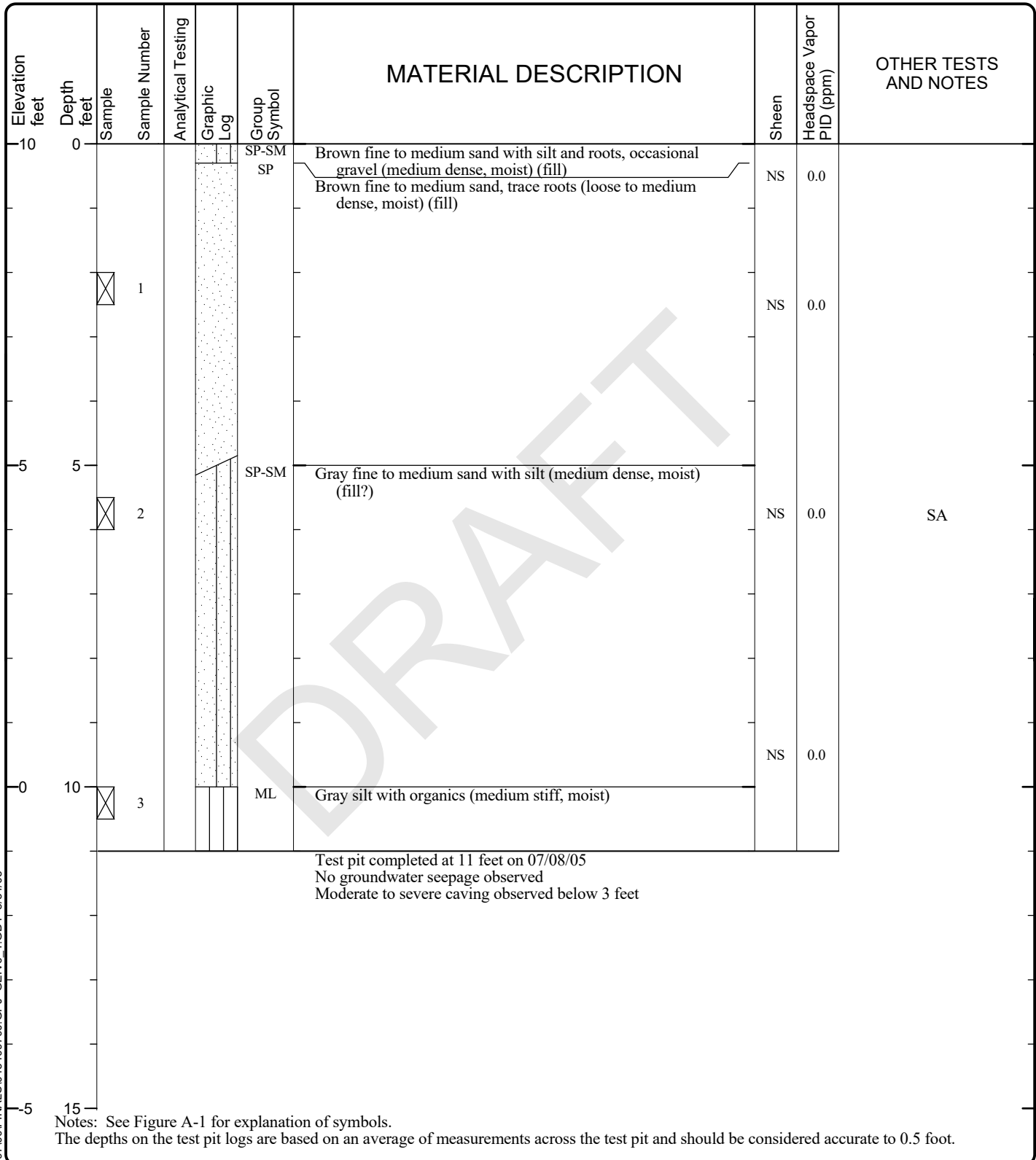
Figure A-11  
 Sheet 1 of 1

Date Excavated: 07/08/05

Logged by: GRL

Equipment: Case 580 Rubber Tired  
Backhoe

Surface Elevation (ft): 10



## LOG OF TEST PIT 11



Project: Parcel "O" - Phase B  
 Project Location: Tacoma, Washington  
 Project Number: 0454-097-00

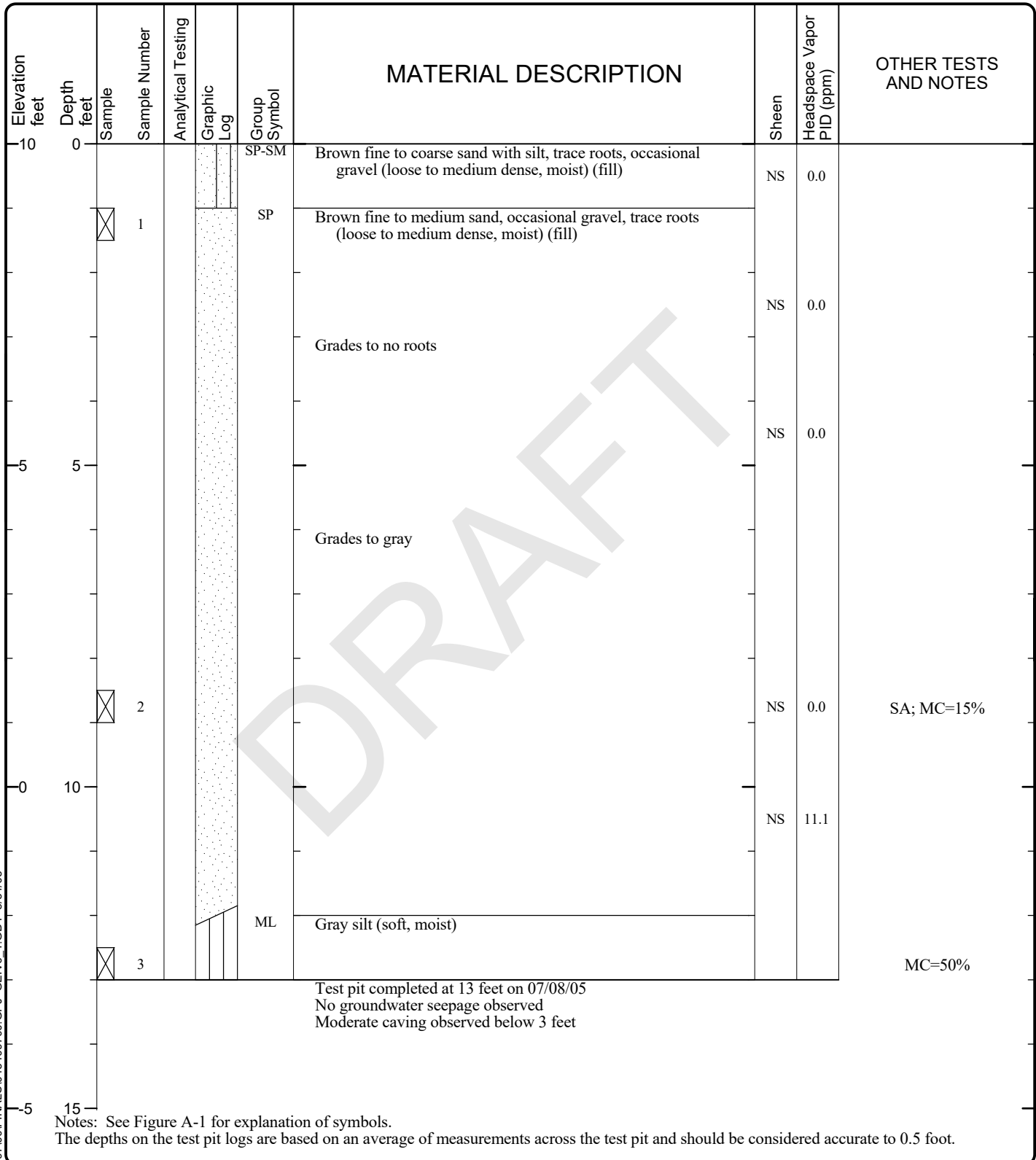
Figure A-12  
 Sheet 1 of 1

Date Excavated: 07/08/05

Logged by: GRL

Equipment: Case 580 Rubber Tired  
Backhoe

Surface Elevation (ft): 10



## LOG OF TEST PIT 12



Project: Parcel "O" - Phase B  
 Project Location: Tacoma, Washington  
 Project Number: 0454-097-00

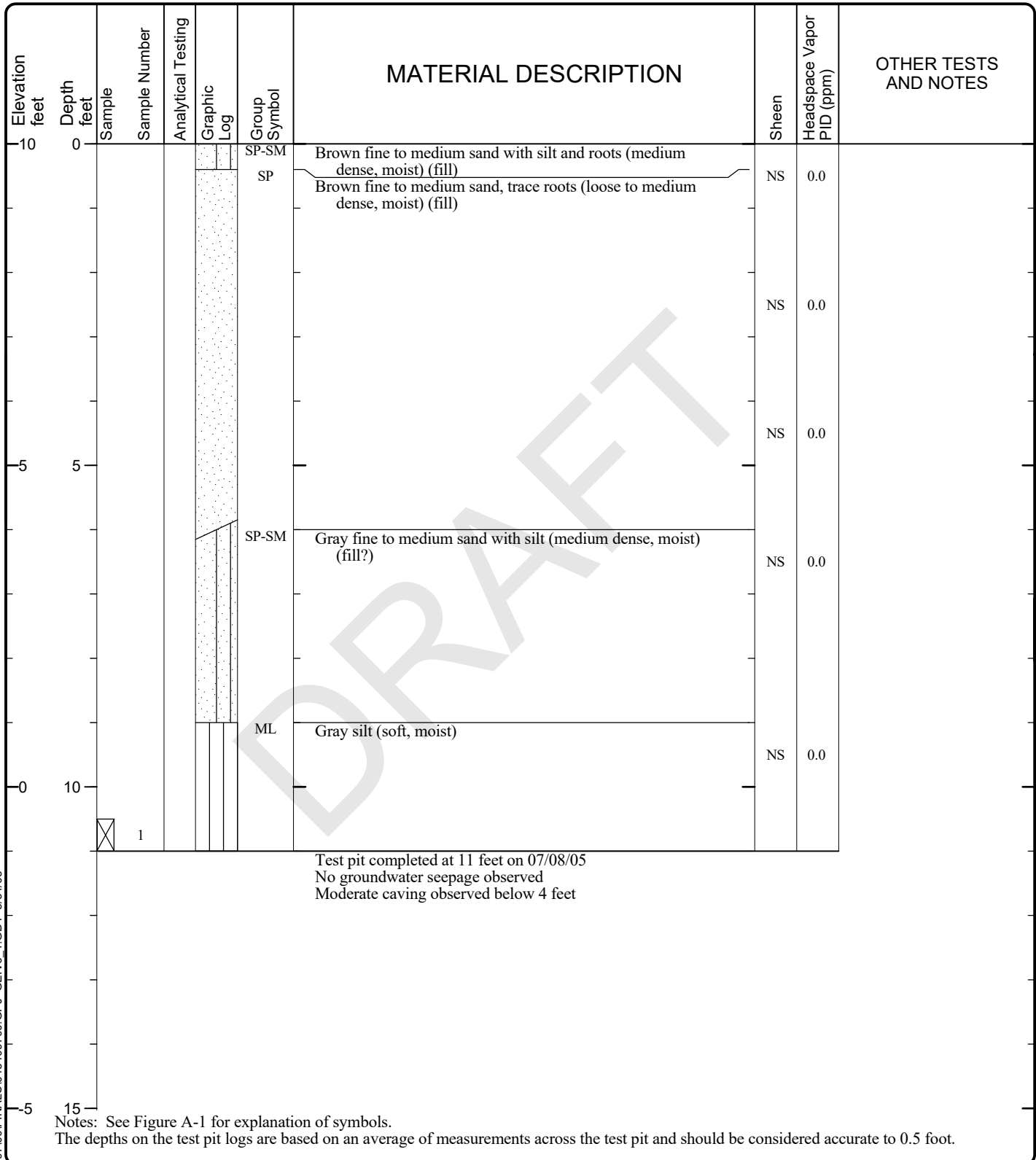
Figure A-13  
 Sheet 1 of 1

Date Excavated: 07/08/05

Logged by: GRL

Equipment: Case 580 Rubber Tired  
Backhoe

Surface Elevation (ft): 10



## LOG OF TEST PIT 13



Project: Parcel "O" - Phase B  
 Project Location: Tacoma, Washington  
 Project Number: 0454-097-00

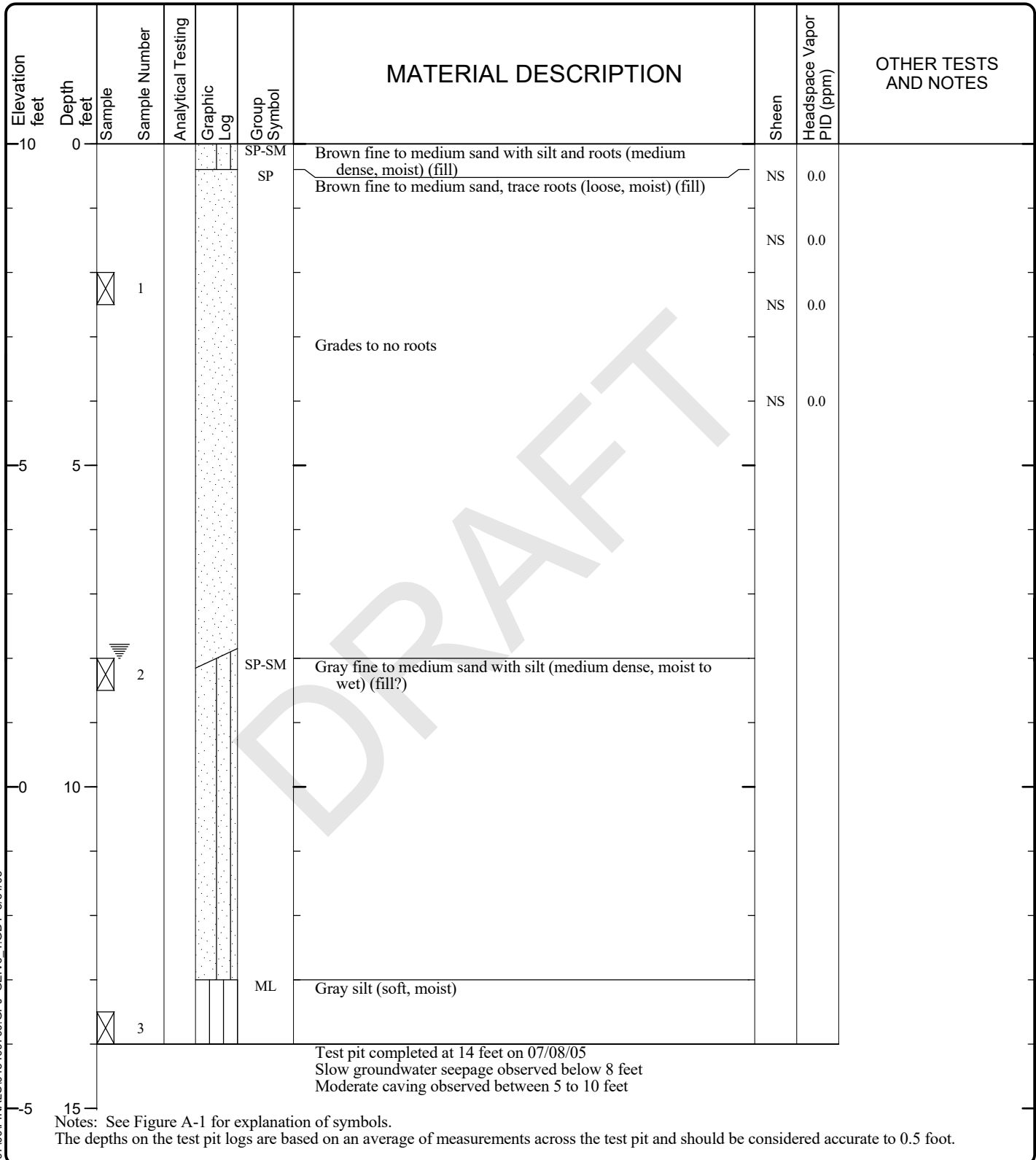
Figure A-14  
 Sheet 1 of 1

Date Excavated: 07/08/05

Logged by: GRL

Equipment: Case 580 Rubber Tired  
Backhoe

Surface Elevation (ft): 10



## LOG OF TEST PIT 14



Project: Parcel "O" - Phase B  
 Project Location: Tacoma, Washington  
 Project Number: 0454-097-00

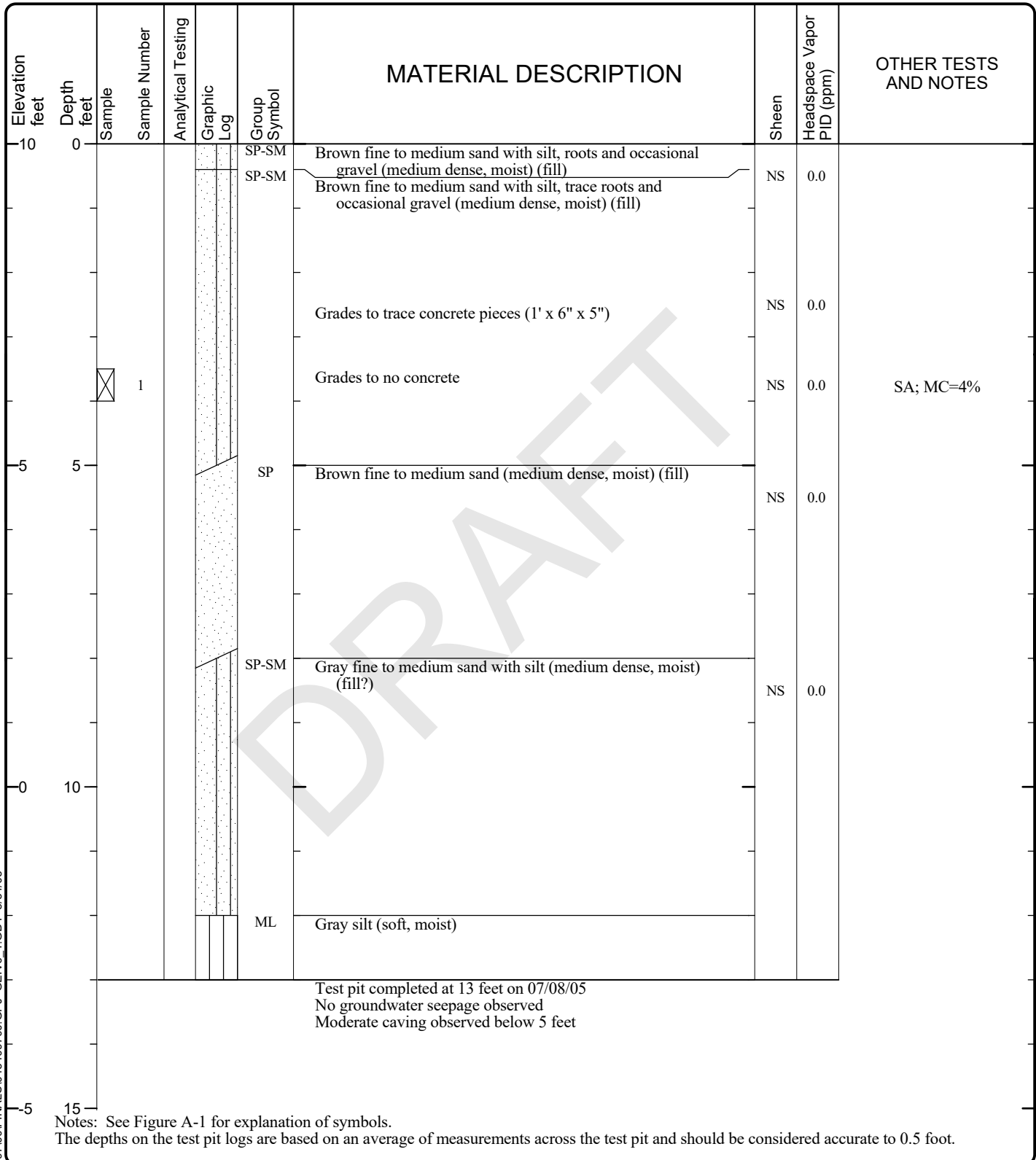
Figure A-15  
 Sheet 1 of 1

Date Excavated: 07/08/05

Logged by: GRL

Equipment: Case 580 Rubber Tired  
Backhoe

Surface Elevation (ft): 10



## LOG OF TEST PIT 15



Project: Parcel "O" - Phase B  
 Project Location: Tacoma, Washington  
 Project Number: 0454-097-00

Figure A-16  
 Sheet 1 of 1

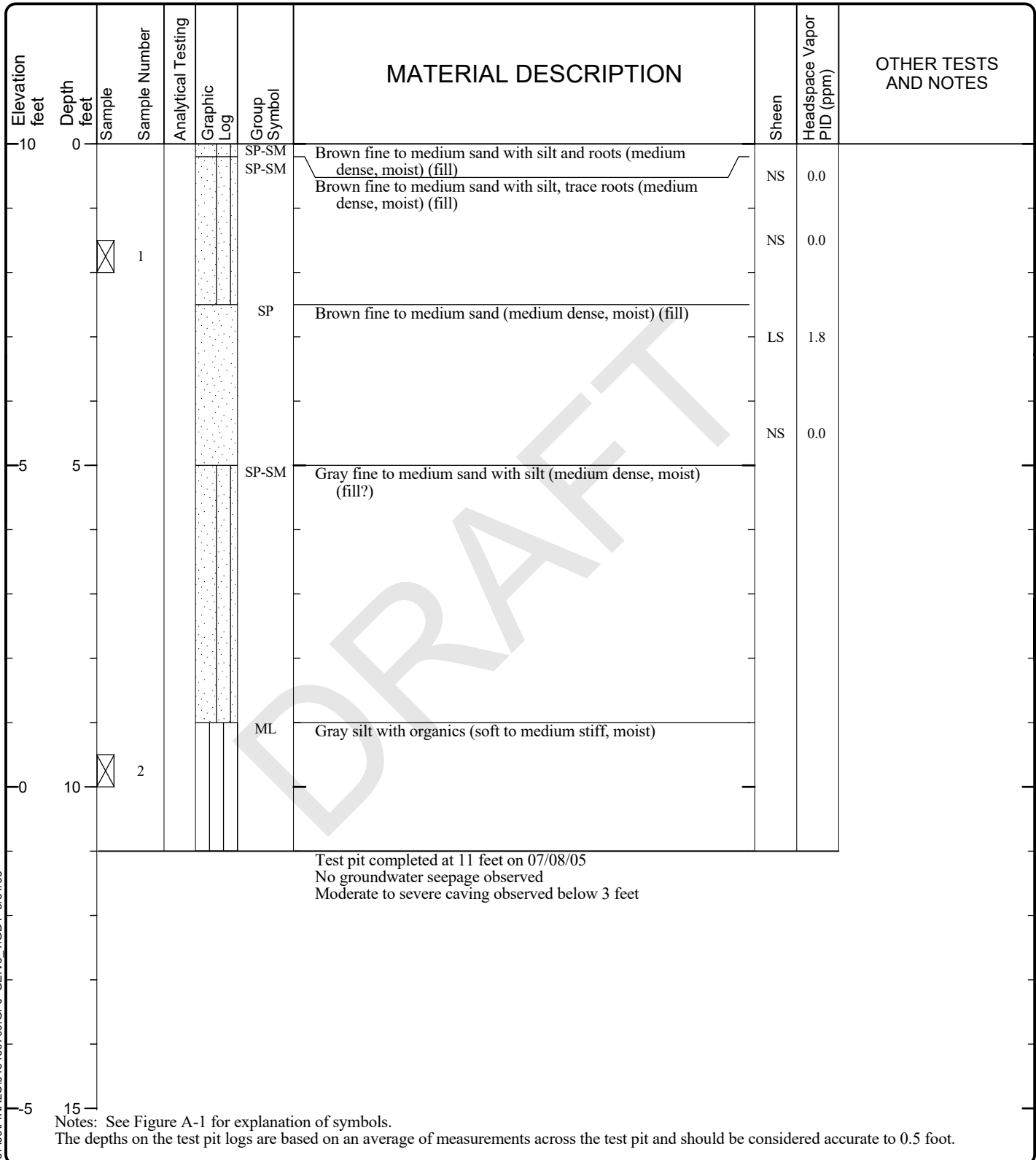


Date Excavated: 07/08/05

Logged by: GRL

Equipment: Case 580 Rubber Tired  
Backhoe

Surface Elevation (ft): 10



## LOG OF TEST PIT 16



Project: Parcel "O" - Phase B  
 Project Location: Tacoma, Washington  
 Project Number: 0454-097-00

Figure A-17  
 Sheet 1 of 1