

UPDATED GEOTECHNICAL DATA SUMMARY REPORT

**CHARLESTON NAVAL BASE CONTAINER TERMINAL
NORTH CHARLESTON, SOUTH CAROLINA
S&ME PROJECT NO. 1131-03-264**

Prepared For:

South Carolina State **PORTS AUTHORITY**

Prepared By:



620 Wando Park Boulevard
Mt. Pleasant, South Carolina 29464

May 20, 2005

May 20, 2005

Mr. David N. Smith, P.E.
South Carolina State Ports Authority
P.O. Box 22287
Charleston, SC 29413-2287

Reference: **UPDATED GEOTECHNICAL DATA SUMMARY REPORT**
 Charleston Naval Base Container Terminal
 South Carolina State Ports Authority
 Charleston, South Carolina
 S&ME Job No. 1131-03-264

Dear Mr. Smith:

We have performed 7 cone penetration test soundings in the area that has been incorporated into the proposed Charleston Naval Base Container Terminal subsequent to our original exploration. This report presents an update of our report originally issued September 18, 2003. Our work was performed in general accordance with our Contract for Consulting Engineering Services, dated May 14, 2003. The report describes the scope of our subsurface exploration and presents a summary of the subsurface conditions and laboratory testing. We appreciate the opportunity to be part of the design team for this ambitious project. If you have any questions concerning this updated data summary report, please call.

Sincerely,

S&ME, Inc.

Daniel W. Holley, E.I.T.
Project Professional

Aaron D. Goldberg, P.E.
Project Manager

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1.0 INTRODUCTION

1.1 OBJECTIVES OF EXPLORATION

The objective of this exploration was to characterize the subsurface conditions across the site of the proposed Charleston Naval Base Container Terminal, in order to provide the data necessary for development of site stabilization measures. Our site characterization included profiling the weak and compressible soil layers, more stable soil layers, and incompressible “basement” strata across the site. Based on both field and laboratory testing, we determined pertinent characteristics of certain soil layers, including consolidation parameters and strength, and the degree of on-going consolidation within various areas of the dredge disposal site.

1.2 SITE DESCRIPTION AND PROPOSED DEVELOPMENT

The proposed Charleston Naval Base Container Terminal site consists of approximately 283 acres located along the western bank of the Cooper River, as shown in Figures 1.1 and 1.2. Approximately 206 acres of the site are uplands and approximately 20 acres are wetlands. Filling open waters (or tidelands) and constructing a 3,000-ft long wharf structure will create the remaining area.

A portion of the uplands area is an inactive dredge material disposal basin with elevations varying from about 21 ft Charleston Low Water (CLW) at the northern end of the basin to 12 ft CLW near the southern end of the basin. The southern part of the dredge spoil basin is surrounded by a dike that has crest elevations varying from about 15 ft CLW to 18 ft CLW. The dike is wooded with small to medium sized trees, and the central portion of the spoil basin is covered by thick brush. The northern portion of the site is developed and generally covered by buildings, pavement, and grass fields. The elevations across the developed portions of the site range from about 8 ft CLW to 16 ft CLW.

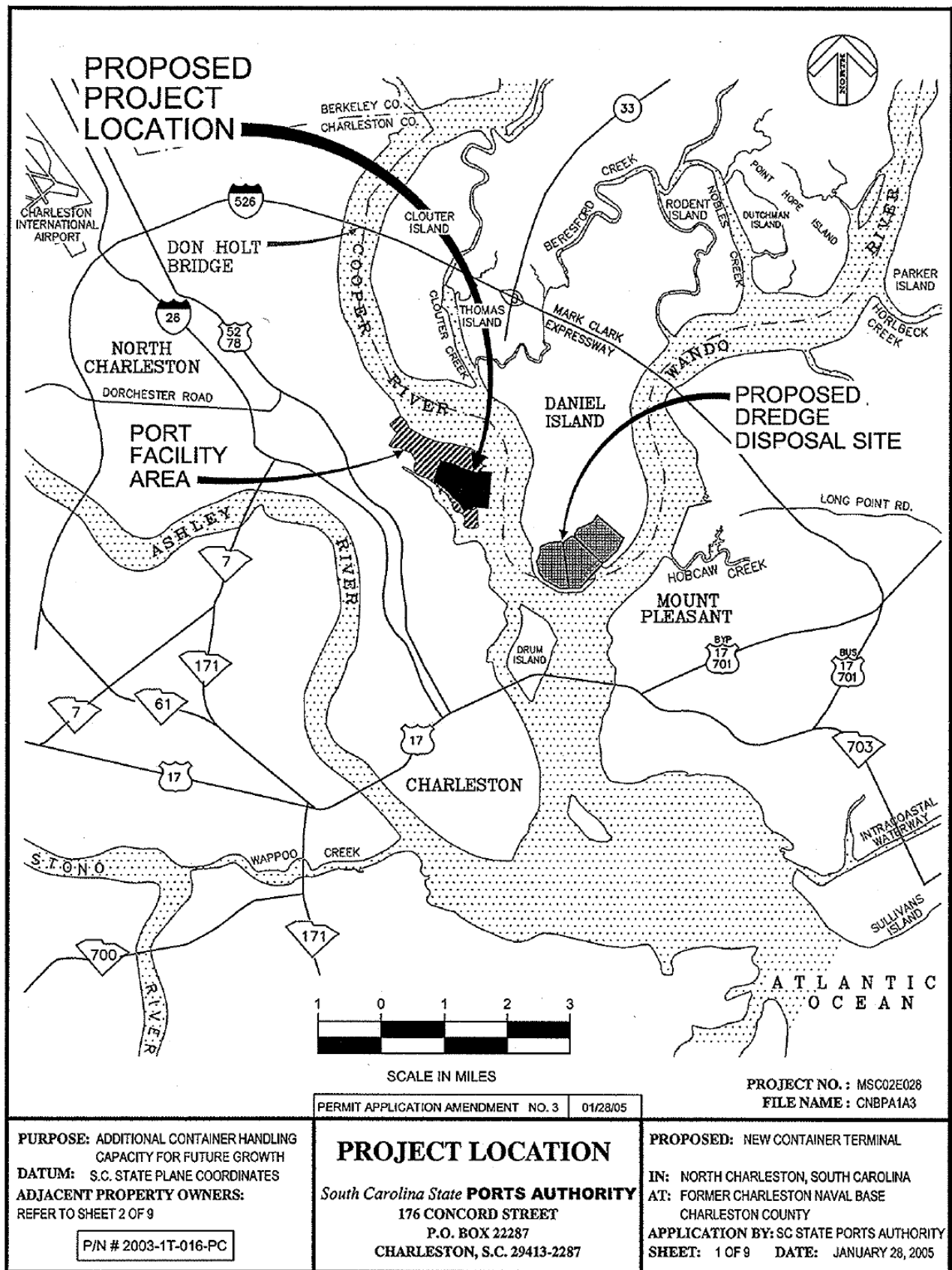
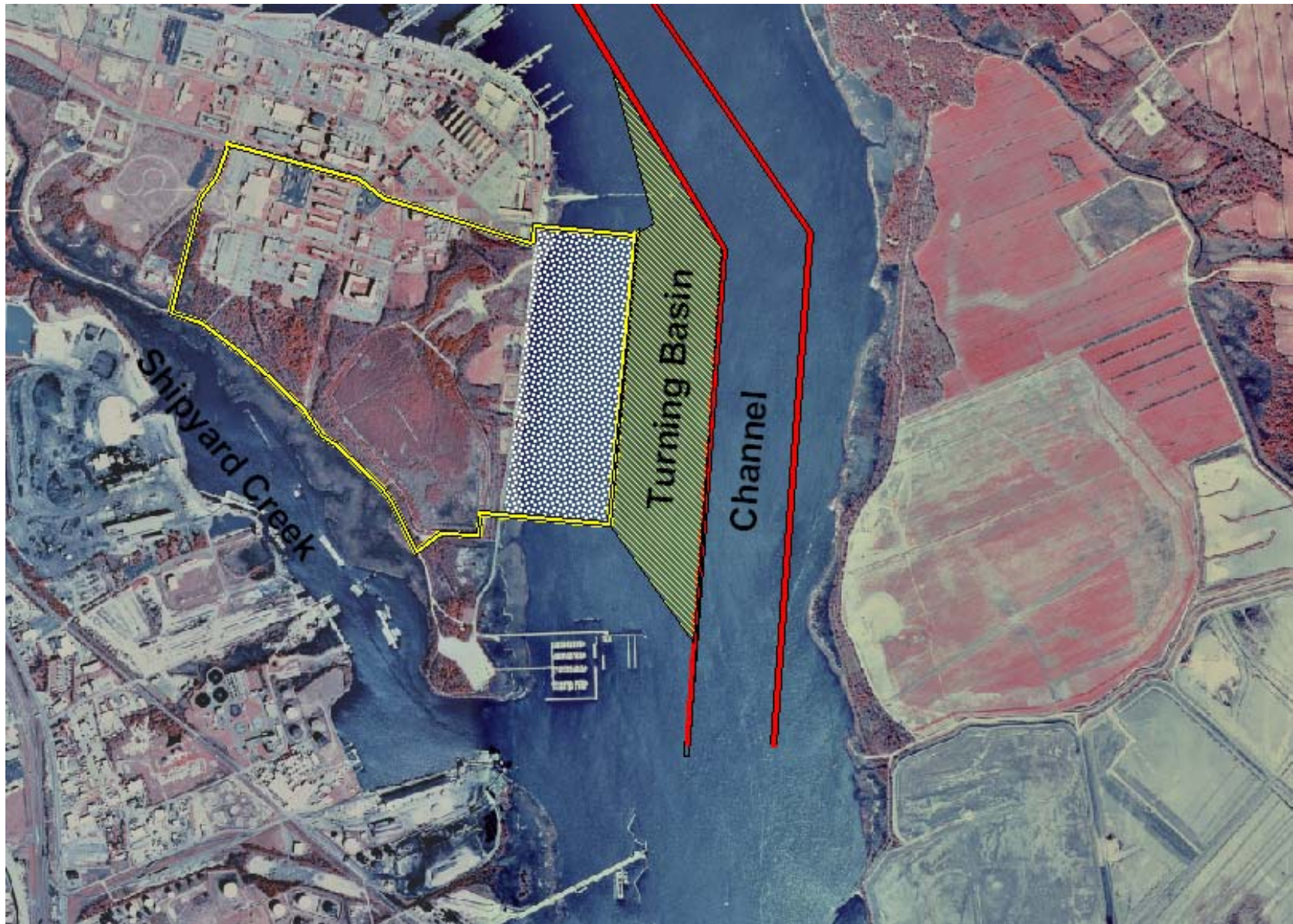


Figure 1.1 Project Location Map from RFP



S&ME Project No.: 1131-03-264

Date: May, 2005



Site of Proposed Charleston Naval Base Container Terminal
North Charleston, SC

Figure 1.2

The site is bounded by adjacent property owners to the north, Shipyard Creek to the southwest, restricted use areas to the northwest, and the Cooper River to the east. The current property owners are shown on Figure 1.3 and the existing (land use) conditions are shown in Figure 1.4. Proposed conditions at the terminal site are shown on Figures 1.5 and 1.6. We understand the expected terminal development includes:

- construction of a storm water detention pond,
- raising the site with engineered fill to subgrade elevations between 14 ft and 16 ft CLW,
- installing support utilities,
- paving the container yard area with asphalt pavement to a finished grade elevation between 16 ft and 18 ft CLW,
- constructing a concrete wharf structure (see Figure 1.7),
- dredging the channel and berth, and
- constructing support buildings and structures.

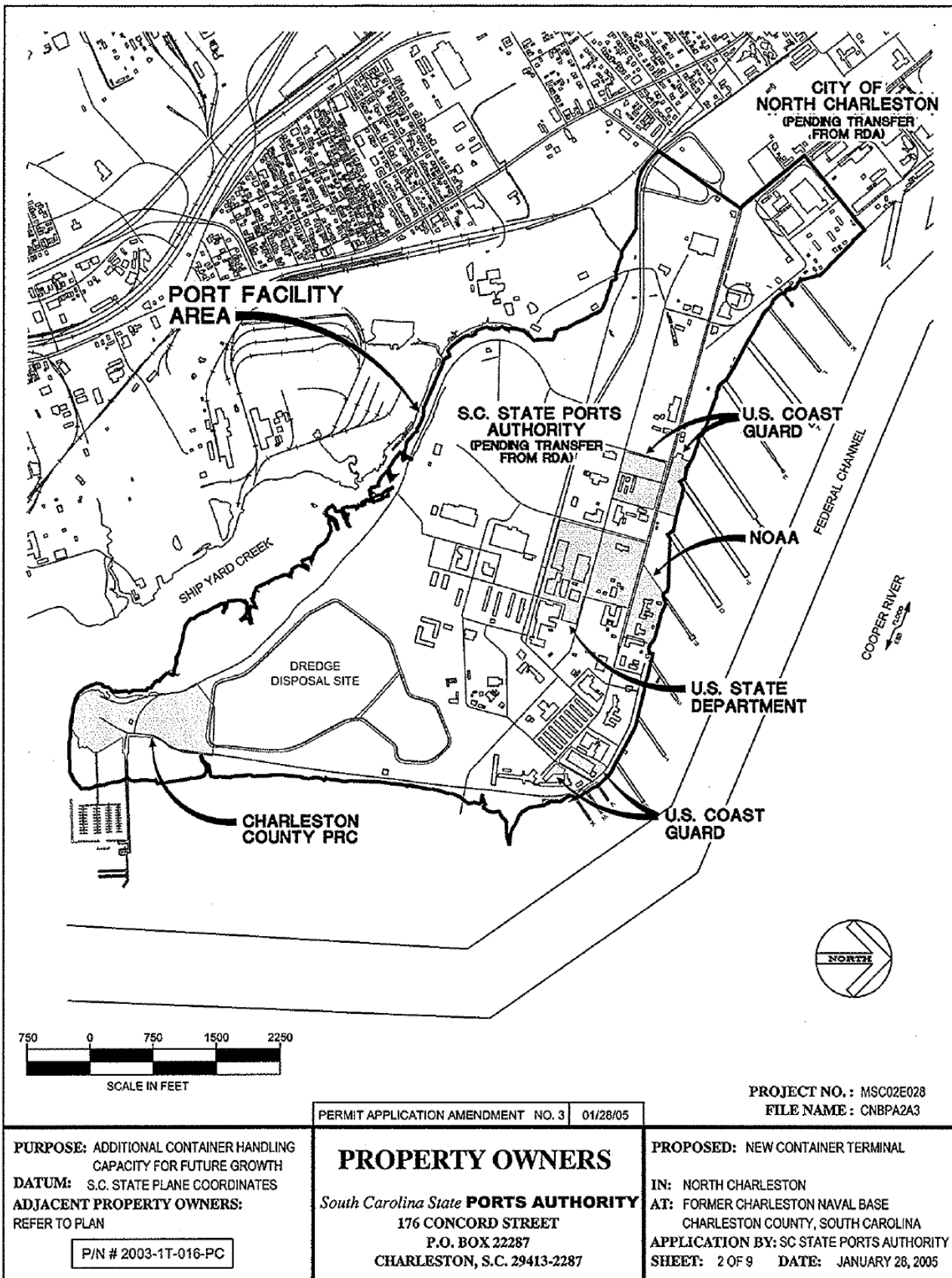


Figure 1.3 Property Owner Map from RFP

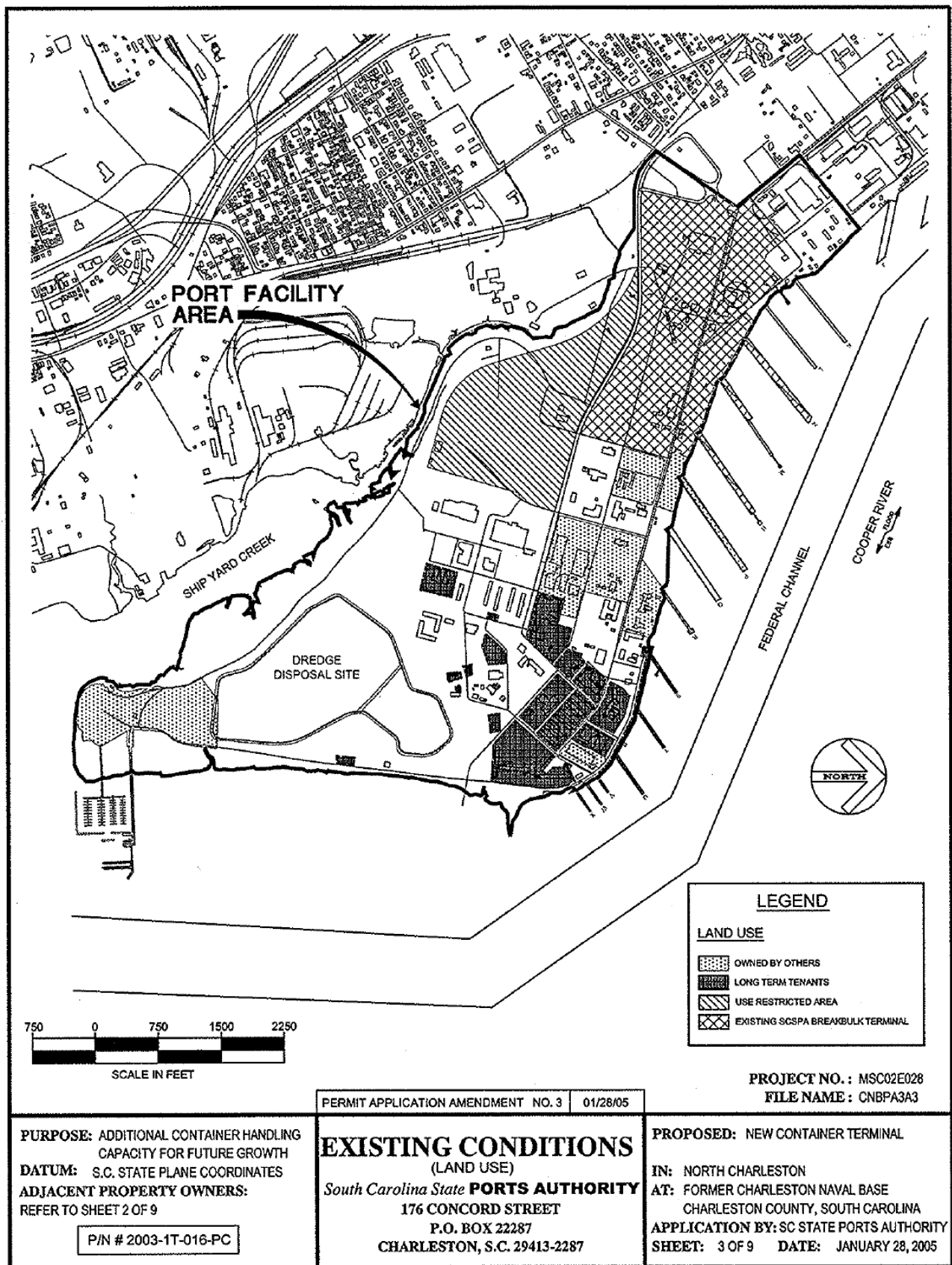


Figure 1.4 Existing Conditions Map from RFP

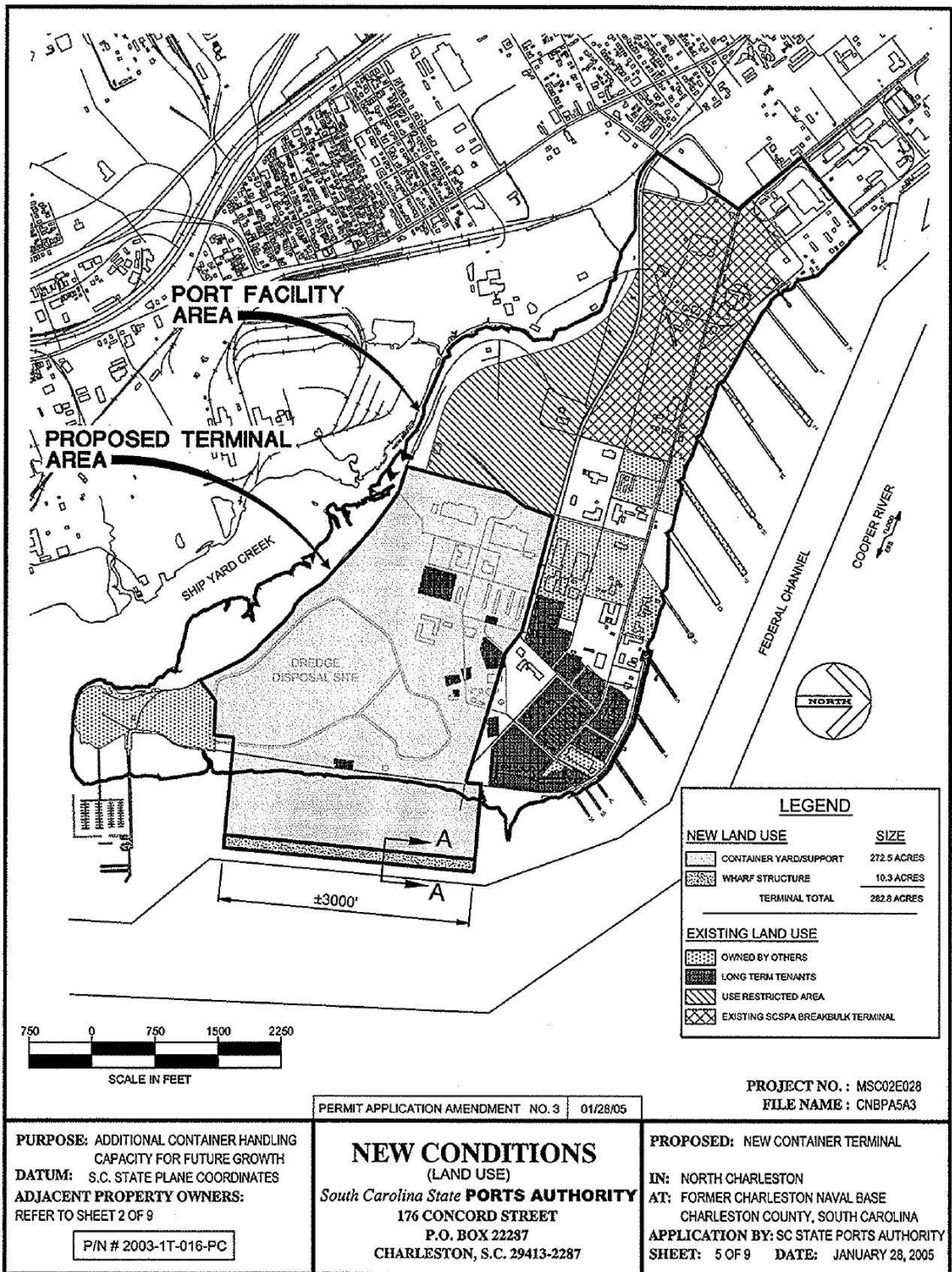


Figure 1.5 New Land Use Plan from RFP

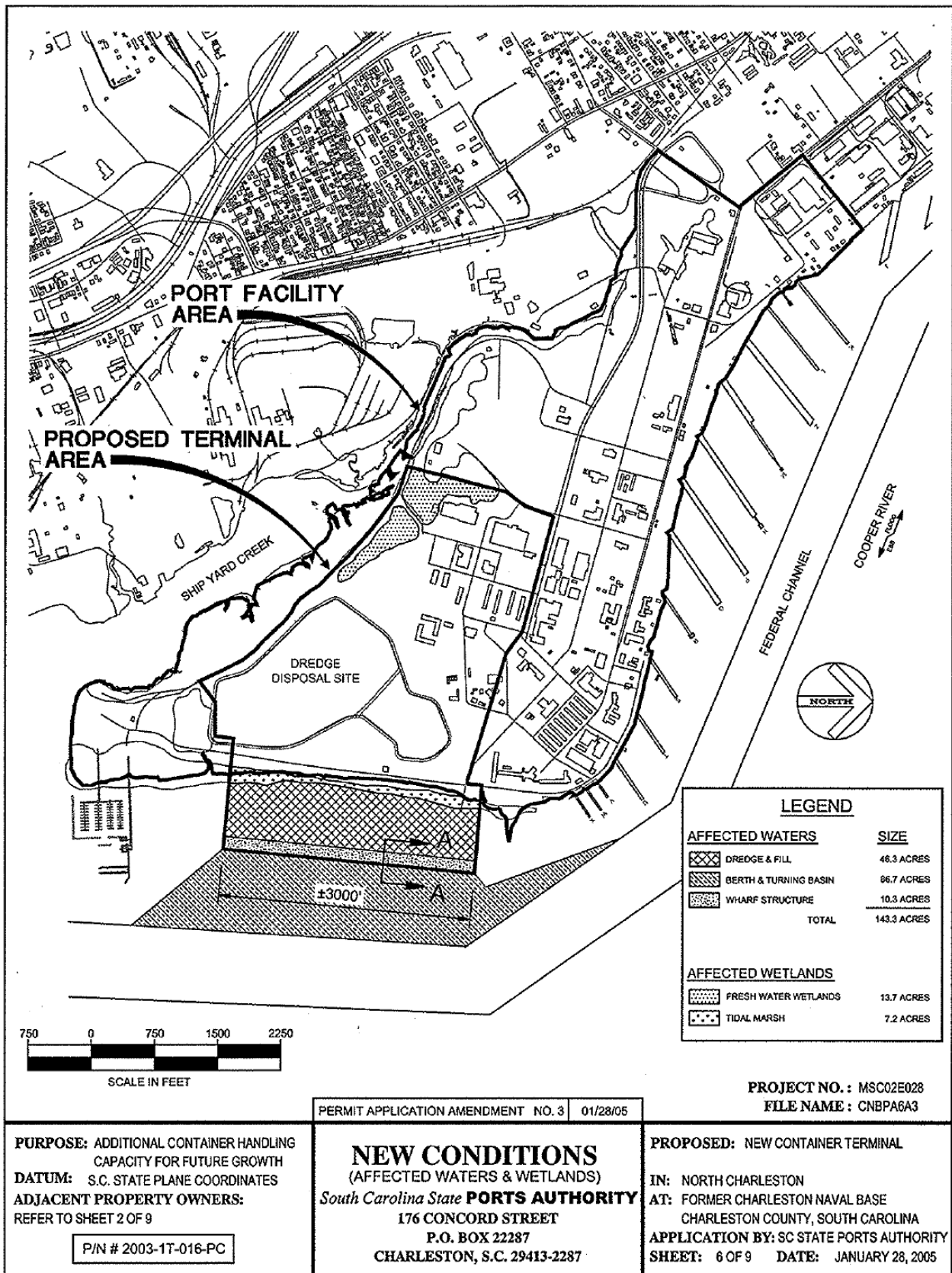
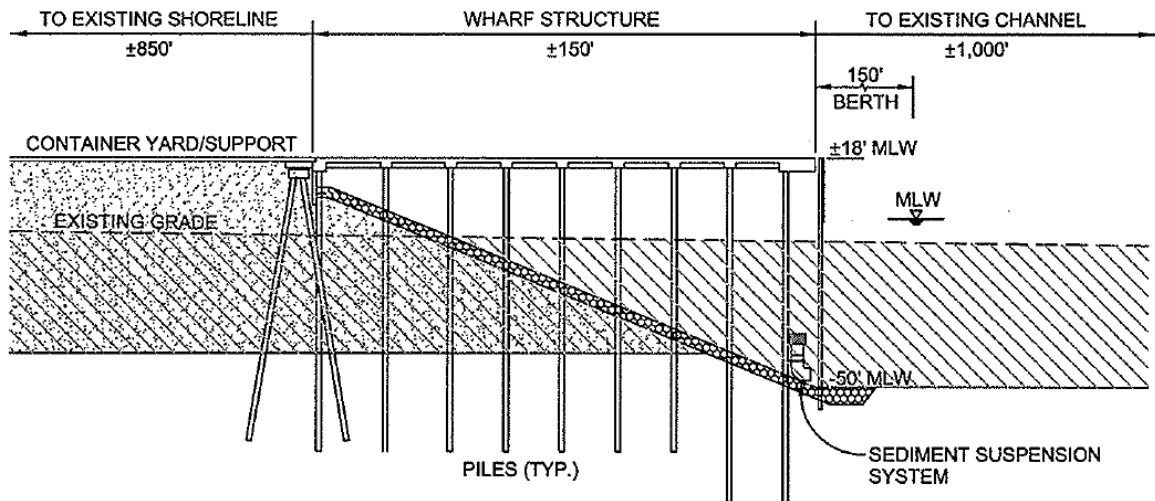


Figure 1.6 New Conditions Affected Waters and Wetlands from RFP



PILE SUPPORTED DECK & BERTH

N.T.S.

LEGEND	
	RIP-RAP
	DREDGE
	FILL
	DREDGE & FILL

PERMIT APPLICATION AMENDMENT NO. 3 01/28/05		PROJECT NO. : MSC02E028 FILE NAME : CNBPA8A3
PURPOSE: ADDITIONAL CONTAINER HANDLING CAPACITY FOR FUTURE GROWTH DATUM: CHARLESTON LOW WATER (MLW) ADJACENT PROPERTY OWNERS: REFER TO SHEET 2 OF 9 P/N # 2003-1T-016-PC	SECTION A - A South Carolina State PORTS AUTHORITY 176 CONCORD STREET P.O. BOX 22287 CHARLESTON, S.C. 29413-2287	PROPOSED: NEW CONTAINER TERMINAL IN: NORTH CHARLESTON AT: FORMER CHARLESTON NAVAL BASE CHARLESTON COUNTY, SOUTH CAROLINA APPLICATION BY: SC STATE PORTS AUTHORITY SHEET: 8 OF 9 DATE: JANUARY 28, 2005



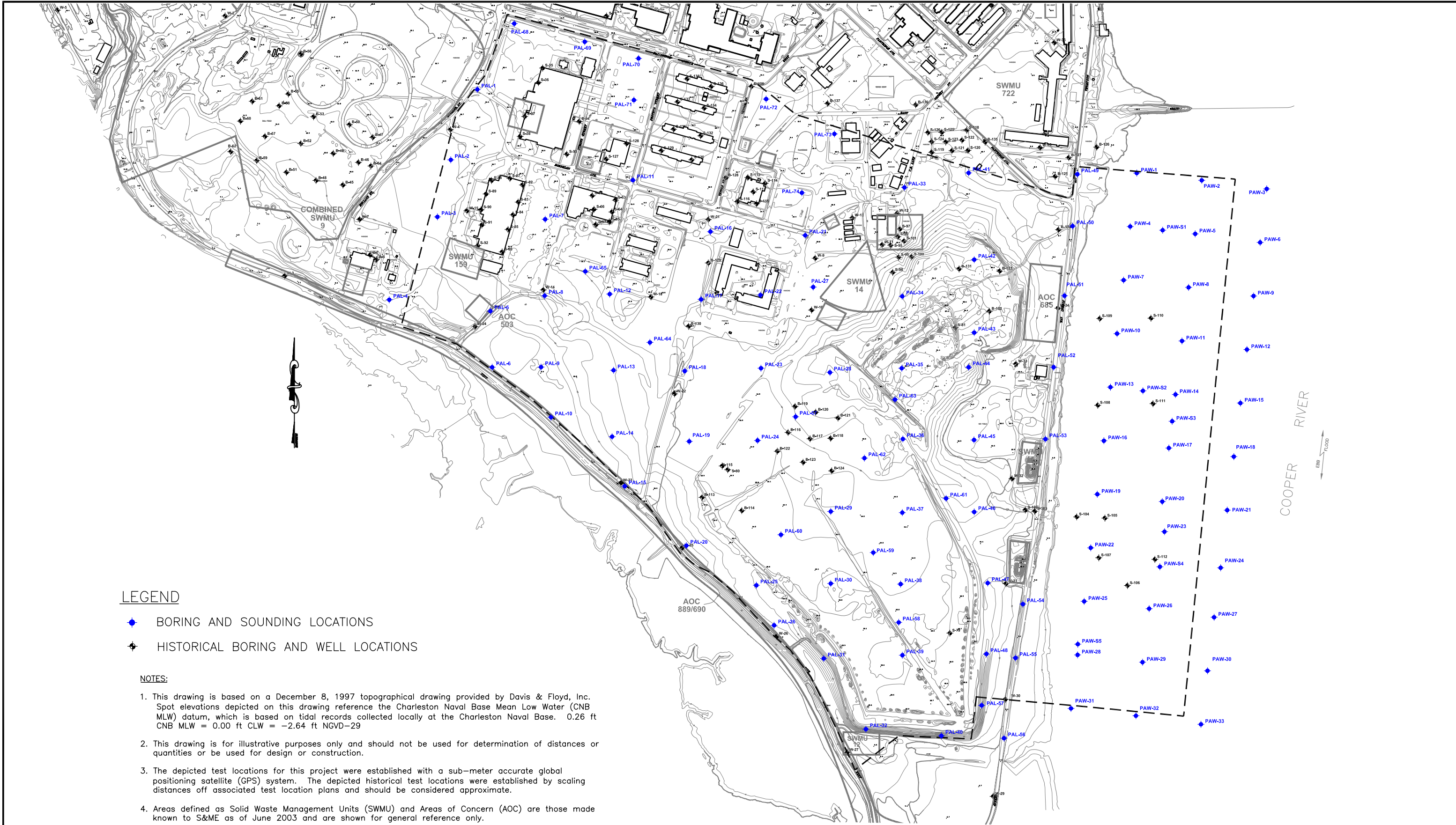
Figure 1.7 Conceptual Wharf Configuration from RFP

2.0 FIELD EXPLORATION

2.1 PREVIOUS SITE EXPLORATIONS

Listed below are 15 previous studies that SCI and S&ME have performed on or near the terminal site. The projects include 108 soil test borings, eight consolidation tests and numerous index tests. The approximate locations of these borings are shown on a reduced size plot of the Test Location Plan presented as Figure 2-1. The Test Location Plan is also presented full size (24-in. by 36-in.) in Appendix I.

1. *Proposed Subsistence Building and Barracks* dated August, 1961 by SCI. Ten soil test borings were performed to depths of 66 to 101 ft in the southeastern quadrant of the intersection of Proteus Street and Bainbridge Avenue and the northwestern quadrant of the intersection of Proteus Street and Bordelon Avenue.
2. *Proposed E.M. Club* dated January, 1967 by SCI. Six soil test borings were performed to depths of 71 to 96 ft in the southwestern quadrant of the intersection of Proteus Street and Bordelon Avenue.
3. *Proposed Commissary* dated October, 1970 by SCI. Eleven soil test borings were performed to depths of 61 to 86 ft south of the west end of Bordelon Avenue.
4. *Proposed Helo-Landing Pad and Sled Ramp* dated July, 1971 by SCI. Five soil test borings were performed (two on land and three in the Cooper River) off Juneau Avenue to depths of 52 to 91 ft.
5. *Proposed Dental Clinic* dated August, 1974 by SCI. Five soil test borings were performed to depths of 48 to 81 ft in the northeastern quadrant of Vesole Street and Bordelon Avenue.
6. *Proposed Petty Officers Club* dated December, 1974 by SCI. Nine soil test borings were performed to depths of 50 to 87 ft between Partridge Avenue and C.B. Lane.
7. *Navy Exchange Addition, Building No. 656* dated October, 1977 by SCI. Four soil test borings were performed to depths of 66 to 106 ft between Bainbridge and Bordelon Avenues.

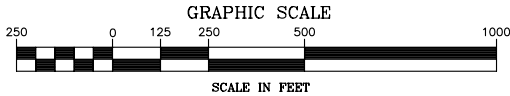


LEGEND

- ◆ BORING AND SOUNDING LOCATIONS
- ✦ HISTORICAL BORING AND WELL LOCATIONS

NOTES:

1. This drawing is based on a December 8, 1997 topographical drawing provided by Davis & Floyd, Inc. Spot elevations depicted on this drawing reference the Charleston Naval Base Mean Low Water (CNB MLW) datum, which is based on tidal records collected locally at the Charleston Naval Base. 0.26 ft CNB MLW = 0.00 ft CLW = -2.64 ft NGVD-29
2. This drawing is for illustrative purposes only and should not be used for determination of distances or quantities or be used for design or construction.
3. The depicted test locations for this project were established with a sub-meter accurate global positioning satellite (GPS) system. The depicted historical test locations were established by scaling distances off associated test location plans and should be considered approximate.
4. Areas defined as Solid Waste Management Units (SWMU) and Areas of Concern (AOC) are those made known to S&ME as of June 2003 and are shown for general reference only.



BORING AND SOUNDING LOCATION PLAN CHARLESTON NAVAL BASE CONTAINER TERMINAL SOUTH CAROLINA STATE PORTS AUTHORITY NORTH CHARLESTON, SOUTH CAROLINA		
SCALE:	AS SHOWN	DRAWN BY: LAJ
PROJECT NO.	1131-03-264	DATE: 5-13-05
		APPROVED BY:
		FIGURE NO. 2-1

8. *Proposed Small Arms Range and Addition* dated March, 1981 and July, 1981 by SCI. Seven soil test borings were performed to depths of 11 to 77 ft at the end of C.B. Lane.
9. *Proposed Addition, Navy Exchange Building 656* dated June, 1983 by SCI. Two soil test borings were performed to depths of 92 to 97 ft on the west side of Strong Street near Building 656.
10. *Proposed Addition, Building 661* dated July, 1987 by S&ME. Two soil test borings were performed to a depth of 65 ft south of existing Building 661.
11. *Advance Fire Fighting Training Facility (Basic Site)* dated September, 1990 by S&ME. Twelve soil test borings were performed to depths of 70 to 90 ft in the existing dredge spoil area between Tidewater road and Juneau Avenue. In addition to field testing, three consolidation tests and numerous index laboratory tests were performed on the soft clays to estimate settlement characteristics.
12. *Advanced Fire-Fighting Training Facility, Alternate Site "B"* dated May, 1991 by S&ME. Eighteen soil test borings were performed to depths of 50 to 80 ft between Bainbridge Avenue and Tidewater Road, west of Holland Street. Seventeen test pits were also excavated at the site to better characterize the shallow subsurface conditions. In addition to field testing, five consolidation tests, two unconfined compression tests, and numerous index laboratory tests were performed on the soft clays to estimate settlement characteristics and strength properties.
13. *Existing Spoil Area between Juneau Avenue and Shipyard Creek* dated June, 1997 by SCI. Three soil test borings were performed to depths of 62 to 82 ft in the existing dredge spoil area.
14. *Boatyard Site* dated June, 2000 by S&ME. Four soil test borings were performed to depths of 17 to 52 ft in the existing dredge spoil area. In addition, several index laboratory tests were performed on the soft clays to estimate settlement characteristics.
15. *North Charleston to Daniel Island Water Main* dated May, 2002 by S&ME. The portion of this project that encompassed the proposed terminal site included 10 soil test borings to depths of 10 to 56 ft. In addition, six test pits were excavated in the proposed terminal site.

As part of previous environmental assessments of the Navy Base, numerous wells were installed by government contractors throughout the site. We have identified 43 deep wells (i.e., wells that extended into the Cooper Marl) on the Navy Base. As shown on the Test Location Plan, 25 of these wells fall within the general area of the proposed terminal. The available "top of marl" elevations from these wells have been included in our contour map of the elevation of top of

marl deposits. However, since construction logs from the wells do not provide detailed information of the overburden soils, we have not included the logs in our report. We note that the depicted deep well locations may not represent all the deep wells installed at the proposed terminal site, and that many other shallow wells are also present at the site.

2.2 SCOPE OF FIELD EXPLORATION

We used a combination of soil test borings, cone penetration test (CPT) soundings and dilatometer soundings to profile the site. Our original field exploration was conducted from June 3, 2003 through July 22, 2003. The additional CPT soundings were performed on April 4 and 5, 2005.

For our original exploration, barge-mounted, track-mounted, truck-mounted and ATV-mounted rigs were used to access the various site conditions encountered. We advanced a total of 31 soil test borings and 7 dilatometer soundings in the water (designated PAW-1 through PAW-33 and PAW-S1 through PAW-S5). On land, we advanced 53 CPT soundings, 7 DMT soundings, and 12 soil borings (designated PAL-1 through PAL-67 and PZ-1 through PZ-6). A total of six piezometers were installed in completed boreholes PZ-1 through PZ-6. For the additional exploration we advanced 7 CPT soundings on land (designated PAL-68 through PAL-74)

The exploration type, location, ground surface elevation, and termination depth of each boring and sounding are tabulated and presented in Appendix I along with a log of each. The locations are also shown on Figure 2-1, and the Boring and Sounding Location Plan in Appendix I. Further details of each type of exploration are presented in the following sections.

2.2.1 Standard Penetration Test Borings

Forty-three soil test borings were drilled by Soil Consultants, Inc. (SCI) using a mud-rotary drilling procedure. Borings located in the water were drilled from a barge using a CME-550 ATV drill rig and borings located on land were drilled using a track-mounted CME-45 drill rig. For Standard Penetration Testing (SPT), the CME-550 and CME-45 drill rigs used a donut

hammer and an automatic trip hammer, respectively. For borings drilled in the water, SPT testing and split-spoon sampling were performed at approximately 5-ft intervals below the mudline. On land, SPT testing and split-spoon sampling were performed every 2½ ft in the upper 10 ft and 5-ft intervals thereafter. The SPT testing and split-spoon sampling was performed in general accordance with ASTM D 1586. Upon completion of the drilling, the soil samples were transported to our Mt. Pleasant laboratory for further classification and testing.

In split-spoon sampling, a standard 2-in. O.D. split steel tube is driven into undisturbed soil at a select depth using a 140-lb hammer falling a distance of 30 in. The number of blows required to advance the sampler the last 12 in. of the standard 18-in. “drive” is recorded as the Standard Penetration Resistance (N-value). The N-values¹ are presented on the boring logs at the test depth, and provide an indication of the relative density of granular materials and the strength of cohesive materials. The results of the SPT borings are graphically presented on the boring logs in Appendix I.

In addition to the split-spoon samples, we obtained 38 undisturbed samples (Shelby-tube) (per ASTM D 1587) in selected cohesive strata. In undisturbed sampling, a thin-walled steel tube (i.e., a Shelby tube) with a sharp leading edge is pushed into undisturbed soil at a select depth in the borehole to obtain relatively undisturbed samples of cohesive soils. The recovered undisturbed samples were cleaned at each end, sealed with wax, capped, taped and transported to our laboratory for testing.

2.2.2 Cone Penetration Test Soundings

We advanced 60 CPT soundings using truck or track-mounted rigs to hydraulically advance an electronically instrumented cone penetrometer. During penetration, the tip resistance, pore-water pressure and sleeve friction were measured and recorded in general accordance with ASTM

¹ The N-values on the boring logs have not been normalized for varying energies of the different type hammers, and thus represent field values

D 5778. The method produces a nearly continuous record of information on subsurface conditions.

Cones with tip areas of 1.55 in.² (10 cm²) and 2.33 in.² (15 cm²) were used for testing. For both cone sizes, pore-water pressure transducers and porous filter elements are located directly behind the cone tip (u_2 position). In addition, the cones used for this exploration were instrumented with seismic sensors for measuring shear-wave velocity. A legend with the CPT soil classification system and the logs of the cone testing are included in Appendix I.

At select elevations, the advance of the cone penetrometer was halted and the rate of pore-water pressure dissipation was measured. This dissipation test data is correlated to the time rate of consolidation for clay soils, and is used to estimate hydrostatic water levels in sands. The results of the dissipation testing, (i.e., pore-water pressures as a function of time), are presented in Appendix I.

2.2.3 Seismic Cone Penetration Test Sounding

We performed shear wave velocity measurements in CPT soundings PAL-8, PAL-29 and PAL-53 using a cone penetrometer instrumented with geophones. The seismic cone penetrometer test (SCPT) measures the travel times of vibrations generated by an impulsive force applied to the ground surface. For each measurement (at a depth interval of about 3 ft), the travel time of the first arrival was determined and corrected for the horizontal offset of the source. Interval velocities were calculated by dividing the distance between adjacent depths by the difference in travel times. The SCPT data, in the form of interval velocity versus depth and travel time versus depth plots, are presented in Appendix I.

2.2.4 Dilatometer Test Sounding

We performed 14 DMT soundings using the barge-mounted drill rig and the CPT rigs to advance a specially designed, instrumented blade (the dilatometer). During the DMT sounding, data (pressure measurements) were collected at 1 to 2-ft intervals. DMT measurements consist of

determining the pressure required to expand a membrane into the surrounding soil. Dilatometer test measurements were performed in general accordance with ASTM D 6635. Soil samples are not collected in a DMT sounding. However, the dilatometer data is correlated to numerous soil properties, including undrained shear strength, friction angle, and a stiffness modulus. The DMT results and a legend of formulas and soil classification are presented in Appendix I.

2.2.5 Piezometer Installations

We installed six vibrating wire piezometers in completed boreholes PZ-1 through PZ-6. The piezometers are model number 4500 DP manufactured by Geokon, Inc. of Lebanon, New Hampshire. The piezometers include a 5-ft stainless steel drive rod with reaction wings to aid installation. The boreholes were advanced to about 5 ft above the desired tip depth of the piezometer and a spilt-spoon sample was obtained. The piezometers were then assembled with the drill string, lowered into the borehole, and pushed about 5 ft beyond the bottom of the boreholes. The drill string was removed and the boreholes were grouted with bentonite grout to seal in the piezometers. Logs of the piezometer installations and calibration sheets are included in Appendix I.

2.3 SITE SURVEY CONTROL

2.3.1 Vertical Datum

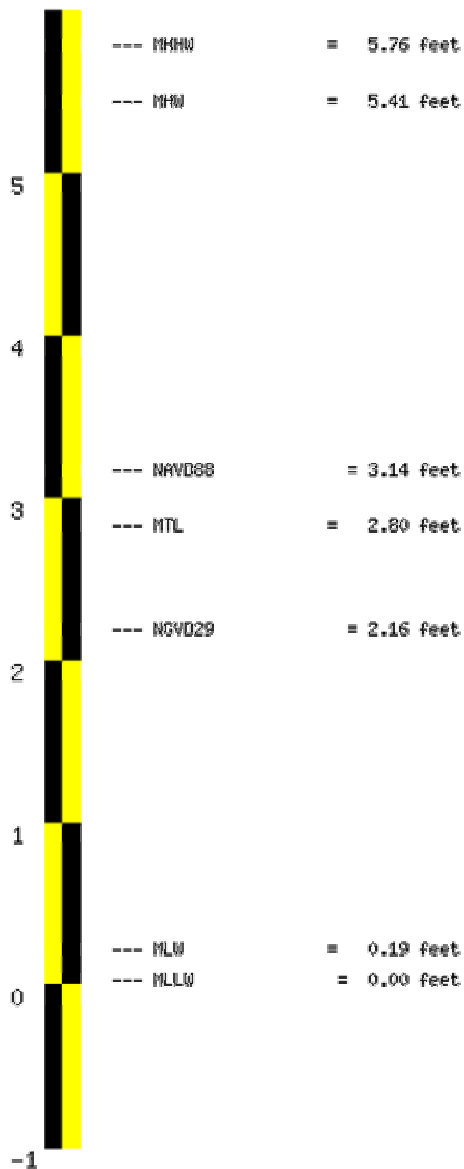
In February 2003, we obtained an electronic copy of a topographical map of the Charleston Navy Base from Davis & Floyd, Inc. Based on information provided by Mr. Milton Muckenfuss and Mr. Albert Heatly of Davis & Floyd, Inc., the controls for the map were set on August 5, 1997, the aerial survey was completed on December 8, 1997 and the final topographical map was completed in late December of 1997. Mr. Muckenfuss informed us that Davis & Floyd, Inc. performed the survey using the National Geodetic Vertical Datum (NGVD) 1929, but at the Navy's request, converted the topographic information into the Charleston Navy Base's Mean Low Water (CNB MLW) datum, which is 2.90 ft below NGVD 1929. The numerical conversion was based on a survey disk located at the end of Juneau Avenue and established by Forsberg

Engineering in June 1991. Mr. Gray Lewis of Forsberg Engineering informed us that the CNB MLW datum was created by the Navy at an undetermined date, and is based on the Navy's locally collected tidal records dating back to 1917.

Following the completion of our field testing, we retained the services of Davis & Floyd, Inc. to perform a survey of the ground surface elevation at each land-based test location. For the water-based test locations, sample elevations were estimated by subtracting the known (i.e., measured) sampling depth below the waterline, from the tide height at the time of the sampling. The tide height was determined by observation of staff gauges Davis and Floyd installed for this project, and tide elevations recorded by NOAA at the Charleston Customs House (and available on the internet) which were corrected for the distance to Naval Base. The tide heights provided by NOAA are referenced to mean lower low water (MLLW), and we researched the current tidal datums maintained by NOAA to convert to CLW. A new MLLW datum has been in effect for the past several years, and datums referenced to the new MLLW epoch (1983-2001) are presented in Figure 2-2. All boring and sounding logs performed for this project reference CLW in feet. However, the historical boring logs included in Appendix IV are presented in their original as-recorded vertical datums.

The State Ports Authority provided us with the difference between NGVD 1929 and CLW as 2.64 ft. Based on the information provided by NOAA, the difference in MLW from the previous epoch (1960-1978) is seen to be 0.27 ft (higher water level presently). For reference purposes, conversions between various datums encountered are presented in Table 2-1 as follows:

Elevation Information for PID = CJ0085, VM = 611
 Station_ID --- 8665530



The NAVD 88 and the NGVD 29 elevations related to MLLW were computed from Bench Mark, 866 5530 TIDAL 13, at the station.

Displayed tidal datums are Mean Higher High Water(MHHW), Mean High Water (MHW), Mean Tide Level(MTL), Mean Low Water(MLW), and Mean Lower Low Water(MLLW)

Source: NOAA website http://www.co-ops.nos.noaa.gov/cgi-bin/station_info.cgi?stn=8665530

Note: 0.26 ft Charleston Navy Base Mean Low Water (CNB MLW) = 0.00 ft Charleston Low Water (CLW) = -2.64 ft NGVD-29

Proj. No. 1131-03-264
 MAY 2005



**TIDAL AND GEODETIC VERTICAL DATUMS
 FOR CHARLESTON PROVIDED BY NOAA
 CHAS. NAVAL BASE CONTAINER TERMINAL
 NORTH CHARLESTON, SC**

**Figure:
 2-2**

Table 2-1 Vertical Datum Conversions

Vertical Datum	Vertical Datum			
	NGVD-29	MLW	CNB MLW	CLW
National Geodetic Vertical Datum, 1929	0.00	1.97	2.90	2.64
Mean Low Water	-1.97	0.00	0.96	0.67
CNB Mean Low Water	-2.90	-0.93	0.00	-0.26
Charleston Low Water	-2.64	-0.67	0.26	0.00

Ex.: 0.00 ft CLW = -2.64 ft NGVD-29

Ex.: 0.00 ft CNB MLW = -0.26 ft CLW

2.3.2 Horizontal Datum

Following the completion of our field testing, we recorded the horizontal coordinates of each test location for this project using a global positioning satellite (GPS) system. Horizontal locations of the historical boring logs were determined by scaling distances and estimating angles from their associated test location plans and should be considered approximate. All boring and sounding logs performed for this project are provided in feet and reference the horizontal North American Datum 1983 (NAD 83).

3.0 LABORATORY TESTING

After completion of the field exploration, we transported the soil samples to our Mt. Pleasant laboratory for visual classification and laboratory testing. We used the Unified Soil Classification System (USCS) for soil identification. In general, the laboratory testing can be divided into two categories; index property testing and engineering property testing. The test results are presented on the Soil Data Summary in Appendix II and the SPT Boring Logs in Appendix I. The grain-size distribution curves, consolidation test results, triaxial strength test results and Laboratory Testing Procedures are also included in Appendix II. Further details on the types and number of test performed are presented in the following sections.

3.1 INDEX TESTING

We used index test data to aid with soil classification, supplement engineering property tests and serve as the basis for various correlations. As described below, the index testing consisted of grain size analyses (including wash-200[#]), Atterberg limits tests and natural moisture content tests.

3.1.1 Atterberg Limits

We performed Atterberg limits tests on 108 samples in general accordance with ASTM standard test method D 4318. The test determined the Liquid Limit (LL), Plastic Limit (PL) and Plasticity Index (PI). The PL and LL represent the moisture content at which a cohesive soil changes from a semi-solid to a plastic state and from a plastic state to a liquid state, respectively. The PI is the difference between the LL and PL. The test data primarily confirmed our visual classifications, but also provided data for empirical correlations to evaluate consolidation and strength characteristics of the clay strata.

3.1.2 Grain Size Analyses

We performed grain size analyses on 143 samples in general accordance with ASTM standard test method D 1140. The samples were sieved to determine the grain size distribution and/or the percentage of material finer than the No. 200 sieve (i.e., silt and clay particles). The tests confirm our visual classifications and provide data that will be used for subsequent liquefaction analyses.

3.1.3 Natural Moisture Content

We performed natural moisture content tests on 181 samples in general accordance with ASTM standard test method D 2216. The natural moisture content is defined as the ratio of the weight of water present in the soil to the dry weight of soil. The test data are used with empirical correlations to evaluate consolidation and strength characteristics of the clay strata.

3.1.4 Organic Content

We performed organic content tests on 13 samples in general accordance with ASTM standard test method D 2974. The organic content is defined as the ratio of the weight of organic material present in the soil to the dry weight of soil (mineral matter). These test data are used to confirm visual classifications and provide a reference for strength and consolidation properties that are affected by organic content.

3.1.5 Unit Weight Determination

We performed unit weight measurements on 30 samples that were extracted from Shelby tubes. Unit weights are determined by simply measuring the volume and weight of undisturbed soil samples. The natural moisture content is also determined so that wet and dry unit weights can be evaluated. Unit weights will be used in our stability and settlement analyses.

3.2 ENGINEERING PROPERTY TESTING

We performed strength and consolidation testing to evaluate how the site soils will react to various loading conditions. These tests are described below.

3.2.1 Consolidation Tests

We performed consolidation tests on 21 undisturbed samples in general accordance with ASTM standard test method D 2435. The test results will be used to evaluate the settlement potential (magnitude and rate) of the soft clay strata. Consolidation testing consist of loading an approximately 1-in. thick soil specimen confined in a rigid ring and measuring the resulting displacement as a function of time.

3.2.2 Consolidated Undrained Triaxial Tests

We performed consolidated-undrained (CU) triaxial shear tests, with pore pressure measurements on 10 undisturbed samples in general accordance with ASTM standard test method D 2850. During the CU test, the sample is back-pressure saturated during the consolidation stage prior to loading. This allows meaningful measurement of the pore pressure response during loading, and thus results in total and effective stress strength parameters. The test series consisted of testing three specimens (from the same Shelby tube) at three different consolidation stresses. However, three of the undisturbed soils samples did not have sufficient material to run the full three-point series due to the presence of sand, shell or organic detritus in the sample. Therefore, two tests were performed with only one consolidation pressure and one test with two consolidation pressures. For the remaining seven samples, we performed testing at three consolidation pressures. The results of the strength testing will be used in our subsequent stability analyses.

4.0 SUBSURFACE CONDITIONS

4.1 SUBSURFACE STRATIGRAPHY

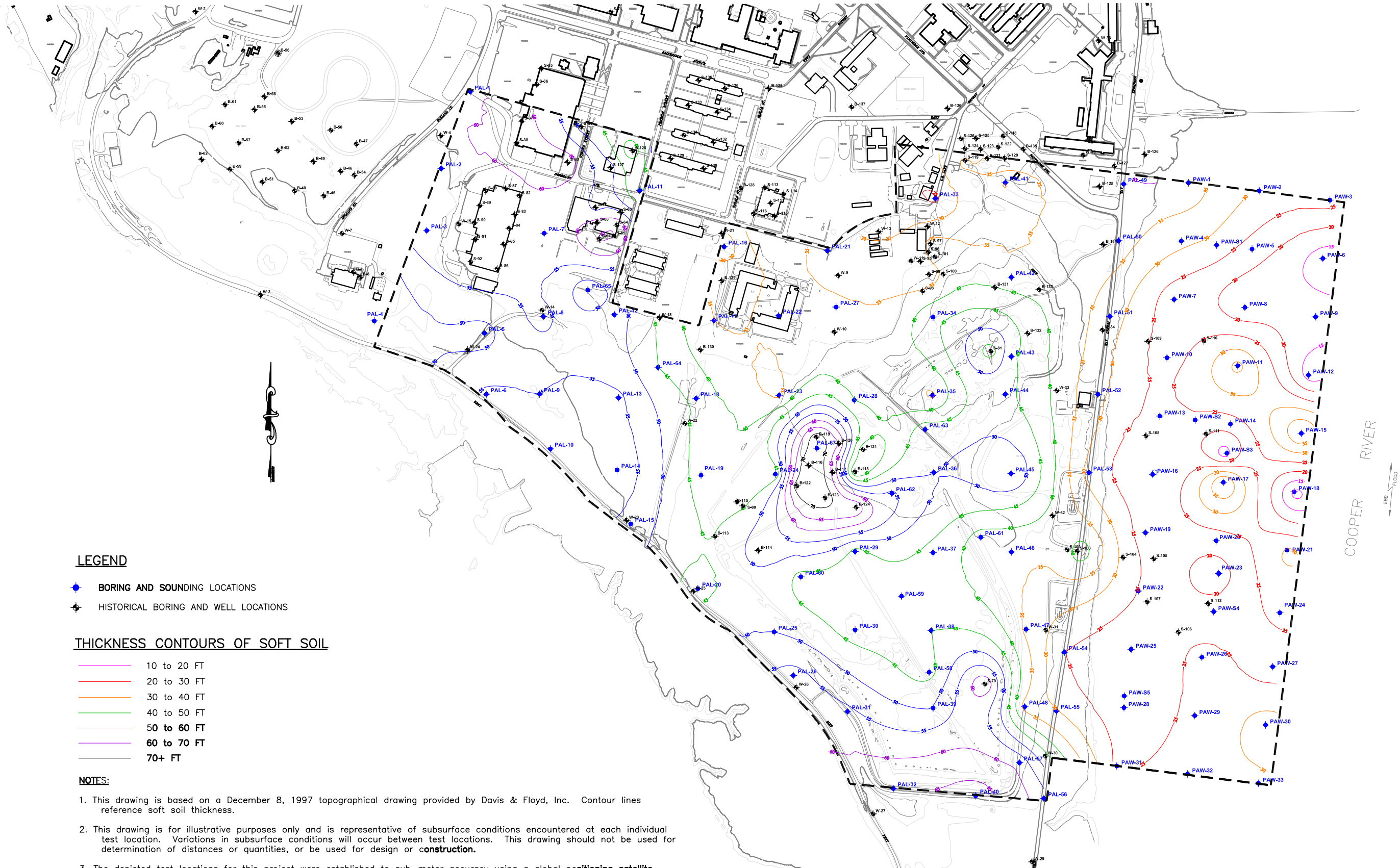
The borings and soundings generally encountered five soil layers that we identified as:

- Cohesive Crust and/or Sands
- Soft Fine-Grained Deposits
- Stiff Fine-Grained Deposits
- Sand Deposits
- Marl Deposits.

The characteristics and distribution of these five layers are discussed in the following sections and graphically depicted in Figures 4-1 through 4-20. These contour plots and subsurface profiles are also presented full size (24-in. by 36-in.) in Appendix III. Stratification lines on the profiles represent approximate boundaries between soil types; however, the actual transition may be gradual and will vary between borings and soundings.

4.1.1 Layer 1: Cohesive Crust and/or Sands

Except within the Cooper River, fill soils (generally consisting of loose to dense sands and interbedded firm to stiff clays) were encountered at the ground surface to an average depth of 8 ft. The thickness of the cohesive crust and/or sands ranged from about 1 to 18 ft. These surface deposits consist of both artificial fill and dredge spoil.



LEGEND

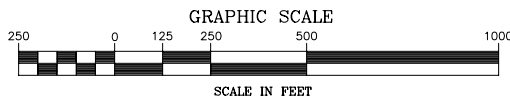
- ◆ BORING AND SOUNDING LOCATIONS
- ✦ HISTORICAL BORING AND WELL LOCATIONS

THICKNESS CONTOURS OF SOFT SOIL

- 10 to 20 FT
- 20 to 30 FT
- 30 to 40 FT
- 40 to 50 FT
- 50 to 60 FT
- 60 to 70 FT
- 70+ FT

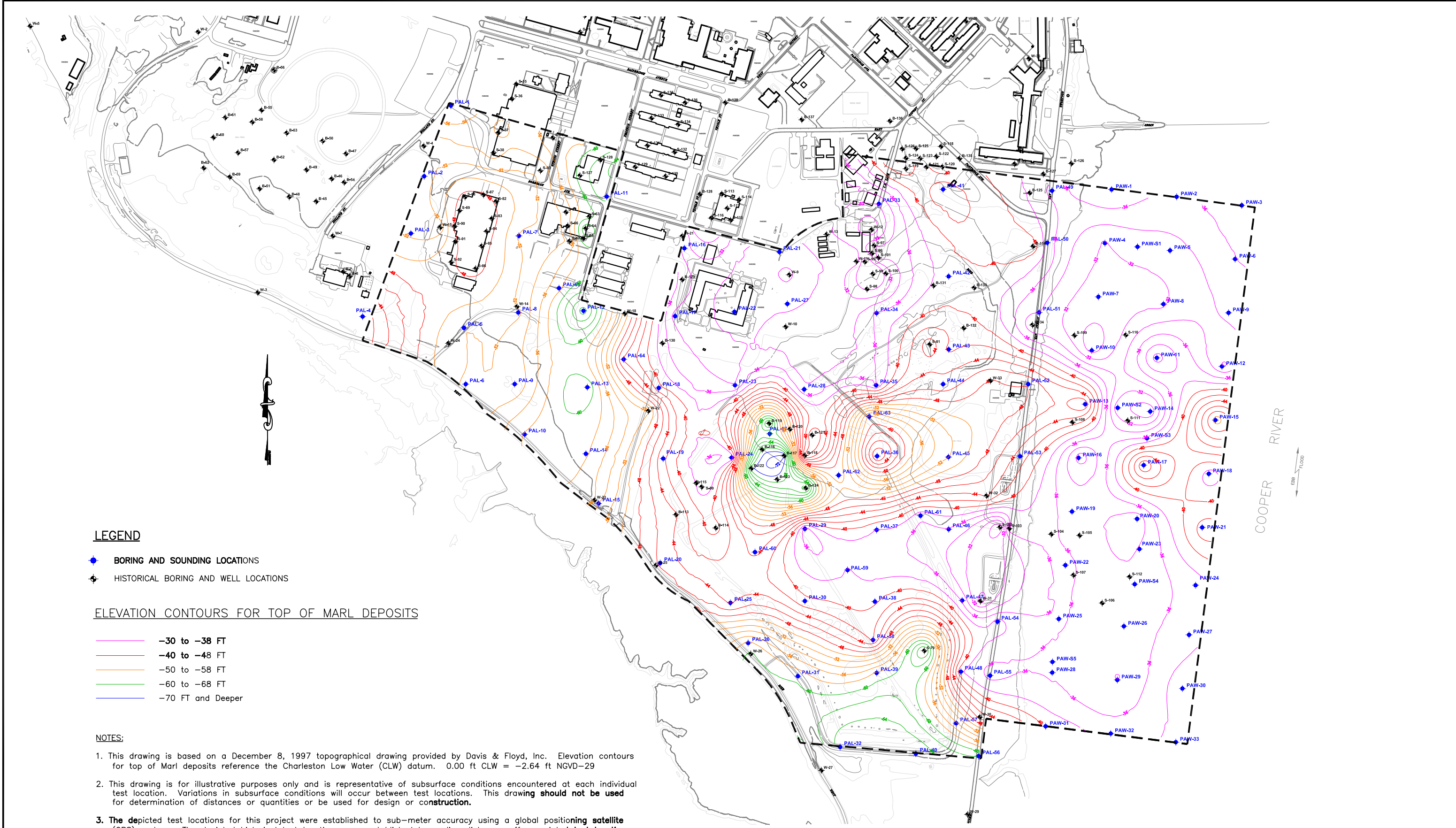
NOTES:

1. This drawing is based on a December 8, 1997 topographical drawing provided by Davis & Floyd, Inc. Contour lines reference soft soil thickness.
2. This drawing is for illustrative purposes only and is representative of subsurface conditions encountered at each individual test location. Variations in subsurface conditions will occur between test locations. This drawing should not be used for determination of distances or quantities, or be used for design or **construction**.
3. The depicted test locations for this project were established to sub-meter accuracy using a global positioning satellite (GPS) system. The depicted historical test locations were established by scaling distances off associated **test location** plans and should be considered approximate.



SOFT SOIL ISOPACH
CHARLESTON NAVAL BASE CONTAINER TERMINAL
NORTH CHARLESTON, SOUTH CAROLINA

SCALE: AS SHOWN	DRAWN BY: LAJ	APPROVED BY:
PROJECT NO. 1131-03-264	DATE: 9-2-03	FIGURE NO. 4-1



LEGEND

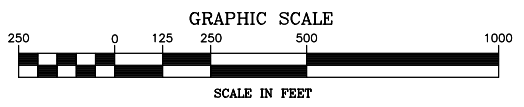
- BORING AND SOUNDING LOCATIONS
- ⊕ HISTORICAL BORING AND WELL LOCATIONS

ELEVATION CONTOURS FOR TOP OF MARL DEPOSITS

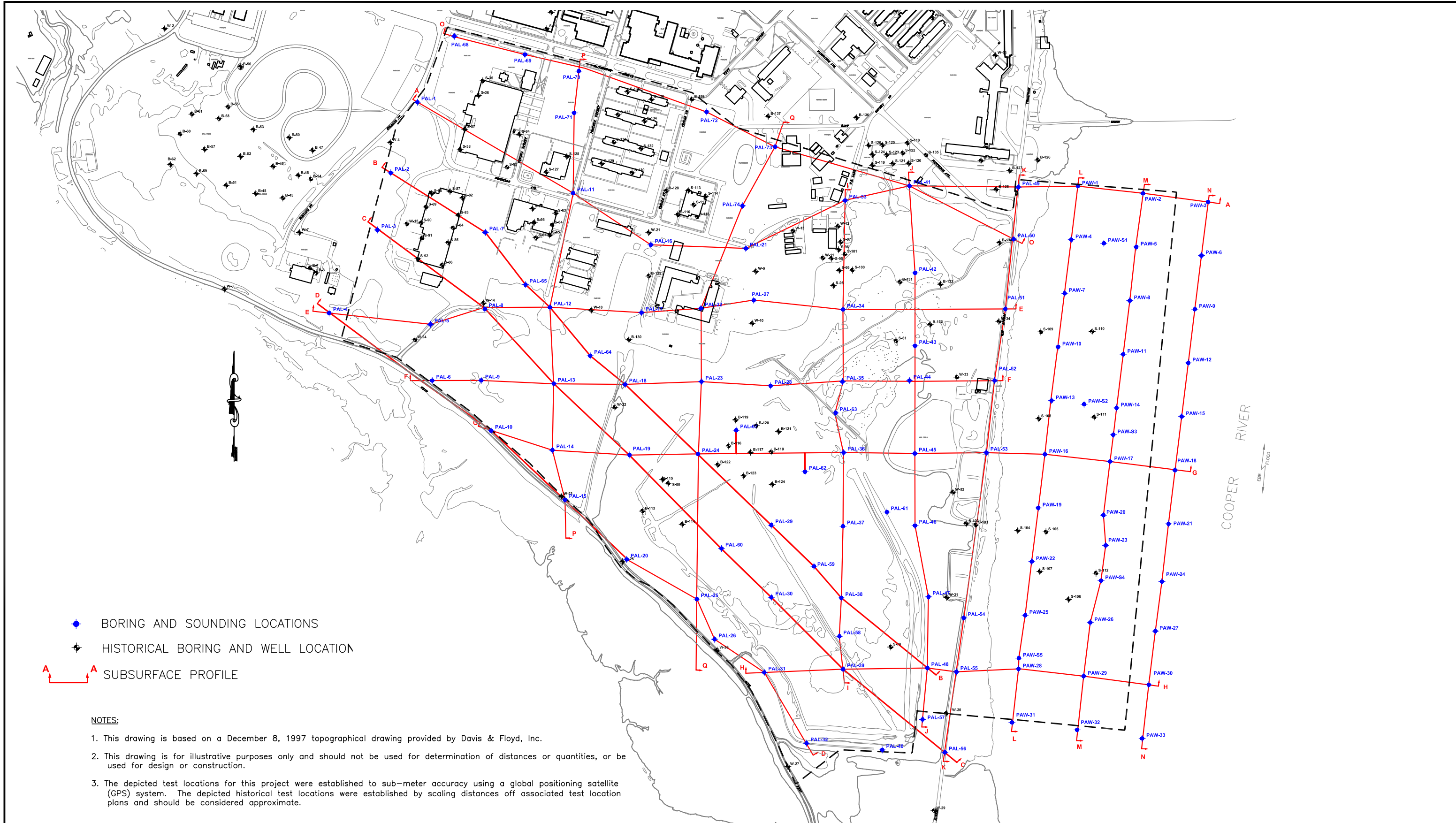
- -30 to -38 FT
- -40 to -48 FT
- -50 to -58 FT
- -60 to -68 FT
- -70 FT and Deeper

NOTES:

1. This drawing is based on a December 8, 1997 topographical drawing provided by Davis & Floyd, Inc. Elevation contours for top of Marl deposits reference the Charleston Low Water (CLW) datum. 0.00 ft CLW = -2.64 ft NGVD-29
2. This drawing is for illustrative purposes only and is representative of subsurface conditions encountered at each individual test location. Variations in subsurface conditions will occur between test locations. This drawing **should not be used** for determination of distances or quantities or be used for design or construction.
3. The depicted test locations for this project were established to sub-meter accuracy using a global positioning satellite (GPS) system. The depicted historical test locations were established by scaling distances off associated test location plans and should be considered **approximate**.



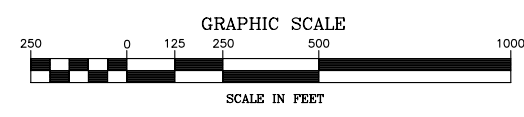
ELEVATION CONTOURS FOR TOP OF MARL DEPOSITS CHARLESTON NAVAL BASE CONTAINER TERMINAL NORTH CHARLESTON, SOUTH CAROLINA		
SCALE: AS SHOWN	DRAWN BY: LAJ	APPROVED BY:
PROJECT NO. 1131-03-264	DATE: 9-2-03	FIGURE NO. 4-2



- ◆ BORING AND SOUNDING LOCATIONS
- ◆ HISTORICAL BORING AND WELL LOCATION
- A A SUBSURFACE PROFILE

NOTES:

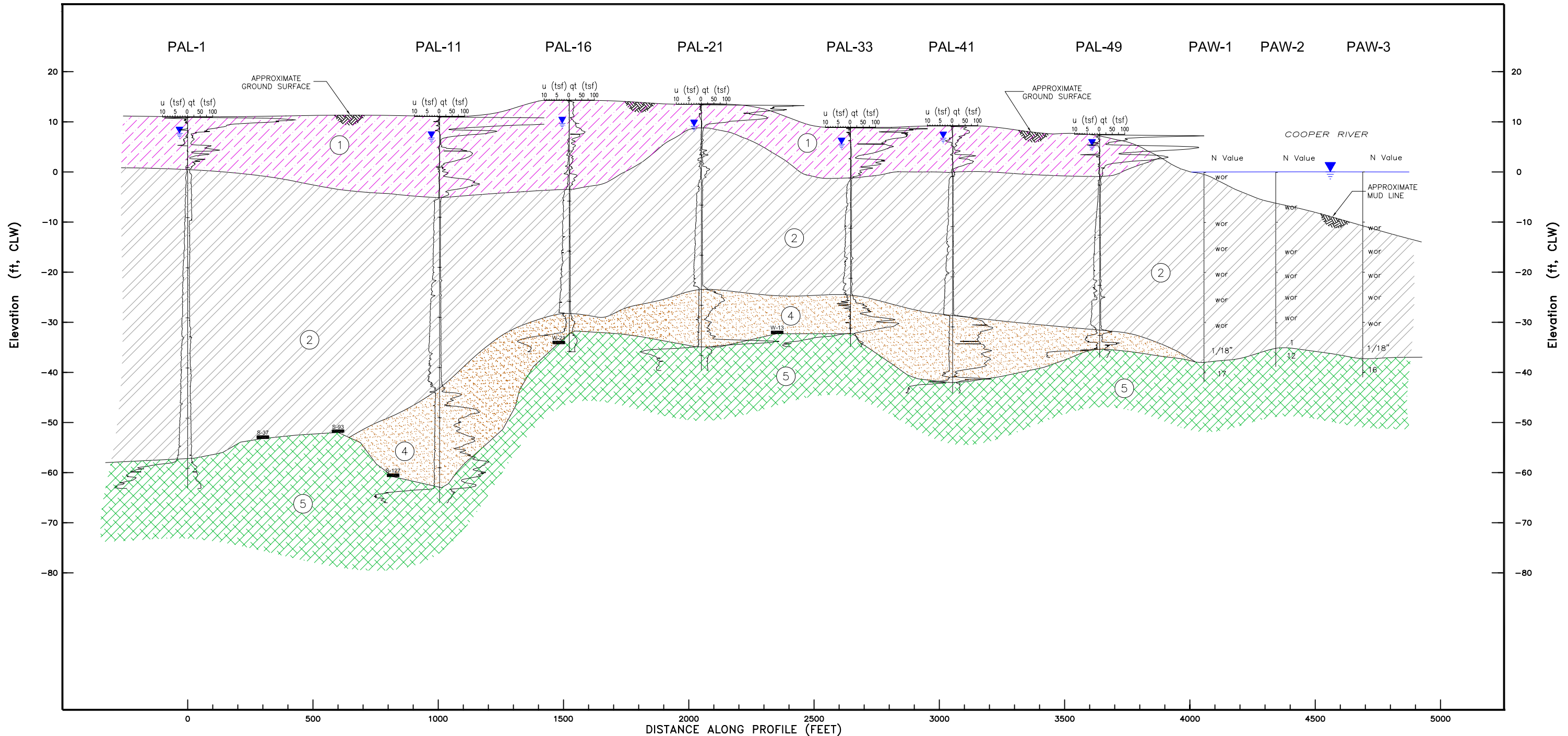
1. This drawing is based on a December 8, 1997 topographical drawing provided by Davis & Floyd, Inc.
2. This drawing is for illustrative purposes only and should not be used for determination of distances or quantities, or be used for design or construction.
3. The depicted test locations for this project were established to sub-meter accuracy using a global positioning satellite (GPS) system. The depicted historical test locations were established by scaling distances off associated test location plans and should be considered approximate.



GENERALIZED SUBSURFACE PROFILE
LOCATION PLAN

CHARLESTON NAVAL BASE CONTAINER TERMINAL
NORTH CHARLESTON, SOUTH CAROLINA

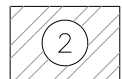
SCALE: AS SHOWN	DRAWN BY: LAJ	APPROVED BY:
PROJECT NO. 1131-03-264	DATE: 5-13-05	FIGURE NO. 4-3



LEGEND



COHESIVE CRUST AND/OR SANDS generally consisting of loose to dense sands and/or firm to stiff clay and silt; artificial fill and dredge spoil



SOFT FINE-GRAINED DEPOSITS generally consisting of compressible clay and silt; dredge spoil and virgin deposits



STIFF FINE-GRAINED DEPOSITS generally consisting of firm to stiff clay and silt with varying sand content; virgin deposits



SAND DEPOSITS generally very loose to dense, with varying fines content; virgin deposits



MARL DEPOSITS generally consisting of calcareous sands and/or elastic clay and silt; virgin deposits including Cooper Group and younger marl deposits

PAL-1

Name and approximate location of soil boring/CPT/DMT

u (tsf)

Cone Penetration Test pore pressure in tons/ft²

qt (tsf)

Cone Penetration Test tip resistance in tons/ft²

Material Index, Id

Dilatometer Material Index

N Value

Location and value of Standard Penetration Test



River water level at 0.0 CLW



Groundwater level at time of exploration



Approximate top of marl deposits location and elevation for historical borings and wells

NOTES:

1. This profile is for illustrative purposes only and is representative of subsurface conditions encountered at each individual test location. Variations in subsurface conditions will occur between test locations. This profile should not be used for determination of distances or quantities or be used for design or construction.
2. Ground surface elevations at actual boring and sounding locations were obtained and provided by Davis & Floyd, Inc. and reference the Charleston Low Water (CLW) datum (0.00 ft CLW = -2.64 ft NGVD-29). Approximate ground surface elevation lines between boring and sounding locations are for illustrative purposes and are included to provide continuity between test locations.



GENERALIZED SUBSURFACE PROFILE A CHARLESTON NAVAL BASE CONTAINER TERMINAL SOUTH CAROLINA STATE PORTS AUTHORITY NORTH CHARLESTON, SOUTH CAROLINA

SCALE:

AS SHOWN

DRAWN BY:

LAJ

APPROVED BY:

PROJECT NO.

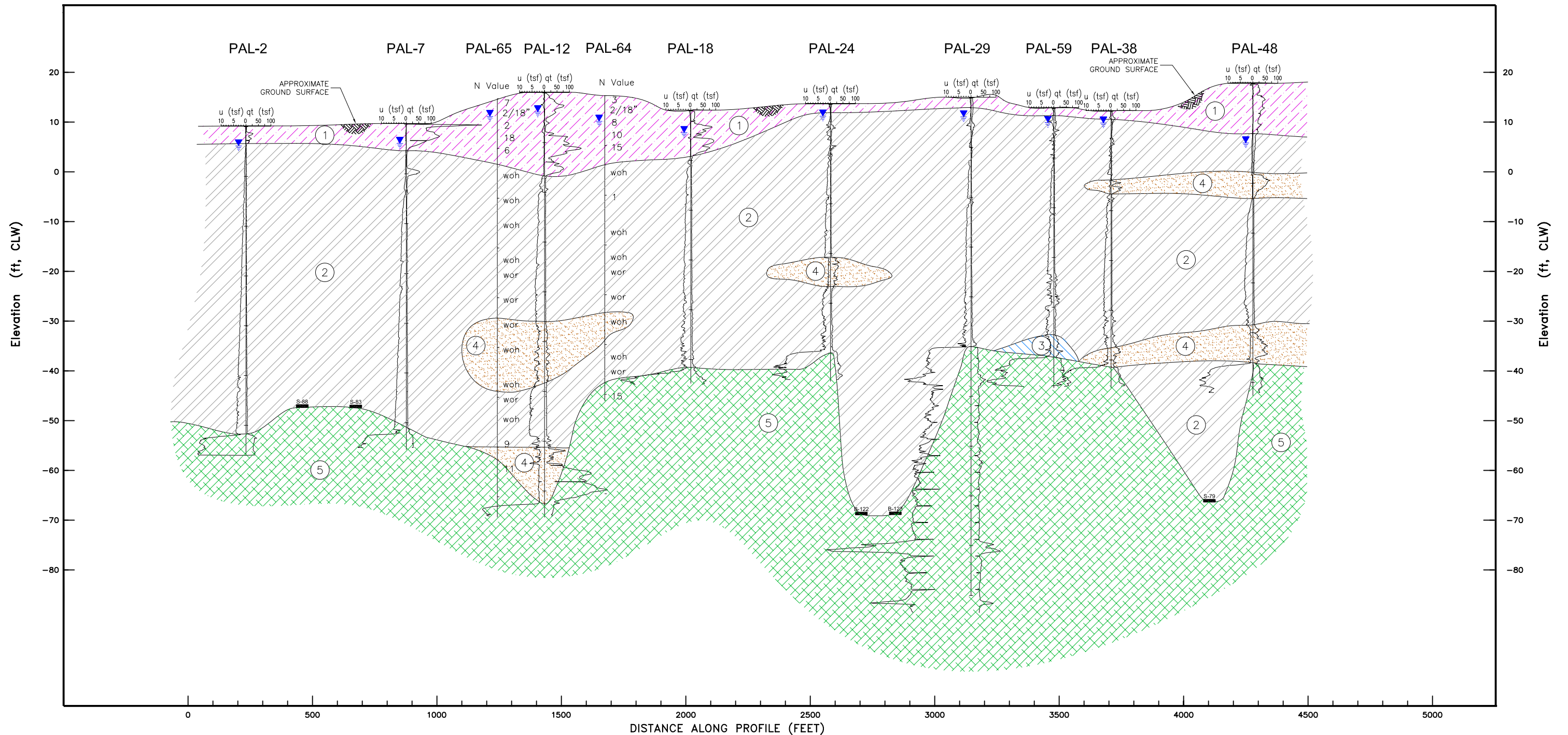
1131-03-264

DATE:

9-12-03

FIGURE

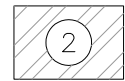
4-4



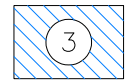
LEGEND



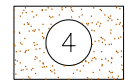
COHESIVE CRUST AND/OR SANDS
generally consisting of loose to dense
sands and/or firm to stiff clay and
silt; artificial fill and dredge spoil



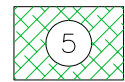
SOFT FINE-GRAINED DEPOSITS
generally consisting of compressible clay
and silt; dredge spoil and virgin deposits



STIFF FINE-GRAINED DEPOSITS generally
consisting of firm to stiff clay and silt
with varying sand content; virgin deposits



SAND DEPOSITS
generally very loose to dense, with varying
fines content; virgin deposits



MARL DEPOSITS
generally consisting of calcareous sands and/or
elastic clay and silt; virgin deposits including
Cooper Group and younger marl deposits

PAL-1

Name and approximate location
of soil boring/CPT/DMT

u (tsf)

Cone Penetration Test pore
pressure in tons/ft²

qt (tsf)

Cone Penetration Test tip
resistance in tons/ft²

Material Index, Id

Dilatometer Material Index

N Value

Location and value of Standard
Penetration Test



River water level at 0.0 CLW



Groundwater level at time of
exploration



Approximate top of marl deposits
location and elevation for
historical borings and wells

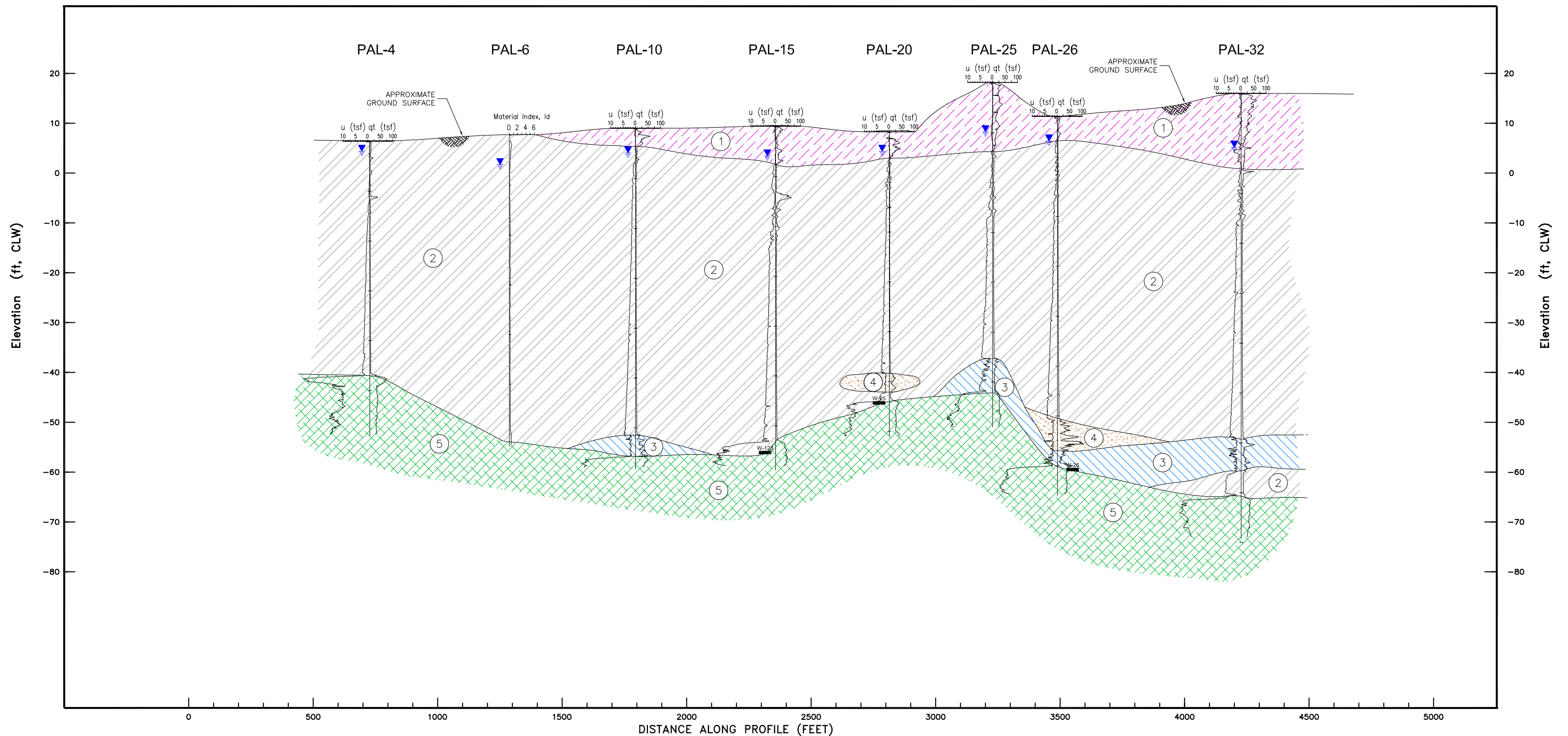
NOTES:

- This profile is for illustrative purposes only and is representative of subsurface conditions encountered at each individual test location. Variations in subsurface conditions will occur between test locations. This profile should not be used for determination of distances or quantities or be used for design or construction.
- Ground surface elevations at actual boring and sounding locations were obtained and provided by Davis & Floyd, Inc. and reference the Charleston Low Water (CLW) datum (0.00 ft CLW = -2.64 ft NGVD-29). Approximate ground surface elevation lines between boring and sounding locations are for illustrative purposes and are included to provide continuity between test locations.



GENERALIZED SUBSURFACE PROFILE B CHARLESTON NAVAL BASE CONTAINER TERMINAL SOUTH CAROLINA STATE PORTS AUTHORITY NORTH CHARLESTON, SOUTH CAROLINA

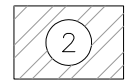
SCALE: AS SHOWN	DRAWN BY: LAJ	APPROVED BY:
PROJECT NO. 1131-03-264	DATE: 9-12-03	FIGURE 4-5



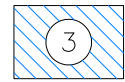
LEGEND



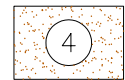
1 COHESIVE CRUST AND/OR SANDS
generally consisting of loose to dense
sands and/or firm to stiff clay and
silt; artificial fill and dredge spoil



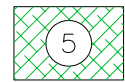
2 SOFT FINE-GRAINED DEPOSITS
generally consisting of compressible clay
and silt; dredge spoil and virgin deposits



3 STIFF FINE-GRAINED DEPOSITS generally
consisting of firm to stiff clay and silt
with varying sand content; virgin deposits



4 SAND DEPOSITS
generally very loose to dense, with varying
fines content; virgin deposits



5 MARL DEPOSITS
generally consisting of calcareous sands and/or
elastic clay and silt; virgin deposits including
Cooper Group and younger marl deposits

PAL-1

Name and approximate location
of soil boring/CPT/DMT

u (tsf)

Cone Penetration Test pore
pressure in tons/ft²

qt (tsf)

Cone Penetration Test tip
resistance in tons/ft²

Material Index, Id

Dilatometer Material Index

N Value

Location and value of Standard
Penetration Test



River water level at 0.0 CLW



Groundwater level at time of
exploration



Approximate top of marl deposits
location and elevation for
historical borings and wells

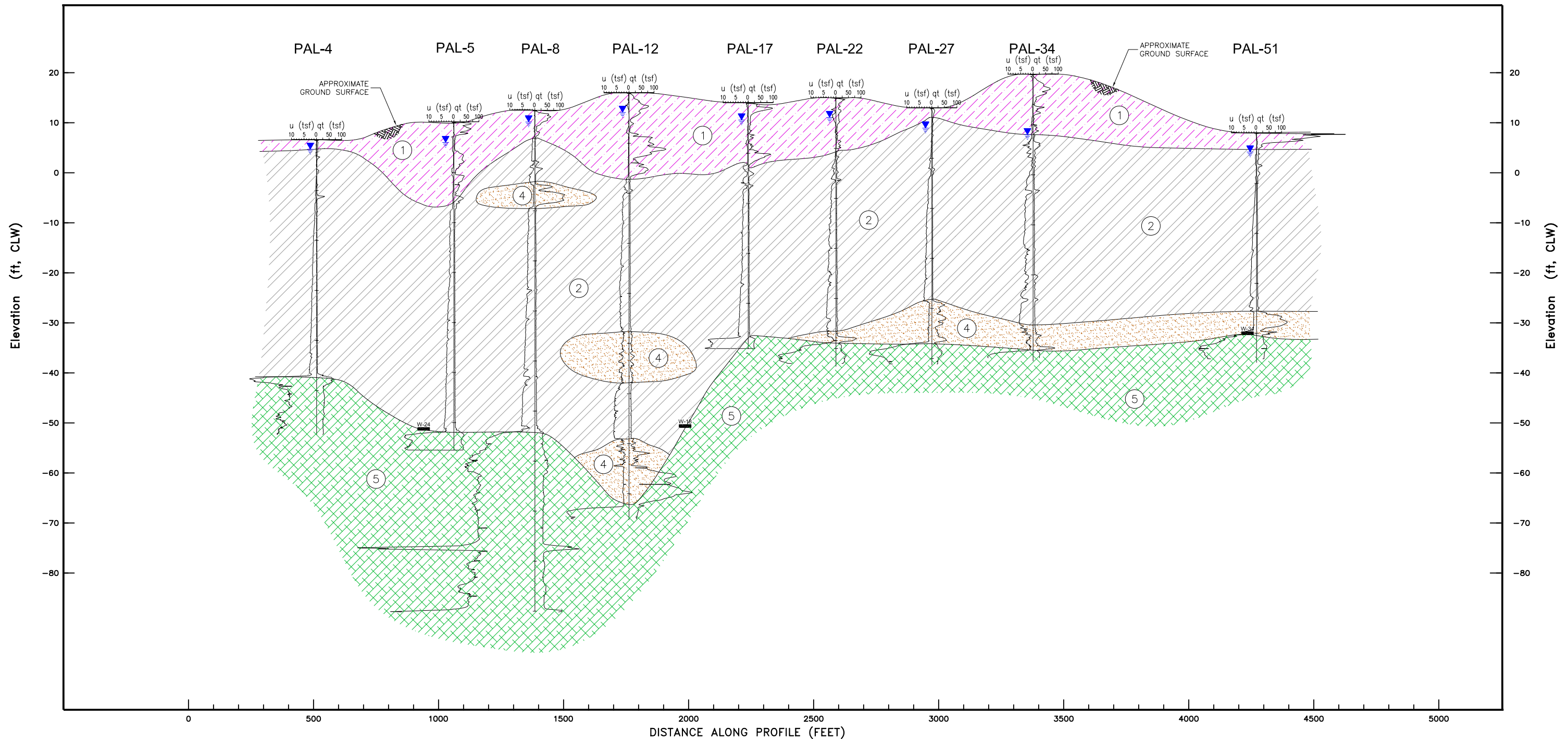
NOTES:

1. This profile is for illustrative purposes only and is representative of subsurface conditions encountered at each individual test location. Variations in subsurface conditions will occur between test locations. This profile should not be used for determination of distances or quantities or be used for design or construction.
2. Ground surface elevations at actual boring and sounding locations were obtained and provided by Davis & Floyd, Inc. and reference the Charleston Low Water (CLW) datum (0.00 ft CLW = -2.64 ft NGVD-29). Approximate ground surface elevation lines between boring and sounding locations are for illustrative purposes and are included to provide continuity between test locations.



GENERALIZED SUBSURFACE PROFILE D CHARLESTON NAVAL BASE CONTAINER TERMINAL SOUTH CAROLINA STATE PORTS AUTHORITY NORTH CHARLESTON, SOUTH CAROLINA

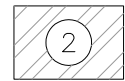
SCALE: AS SHOWN	DRAWN BY: LAJ	APPROVED BY:
PROJECT NO. 1131-03-264	DATE: 9-12-03	FIGURE 4-7



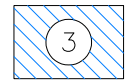
LEGEND



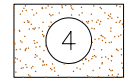
1 COHESIVE CRUST AND/OR SANDS
generally consisting of loose to dense
sands and/or firm to stiff clay and
silt; artificial fill and dredge spoil



2 SOFT FINE-GRAINED DEPOSITS
generally consisting of compressible clay
and silt; dredge spoil and virgin deposits



3 STIFF FINE-GRAINED DEPOSITS generally
consisting of firm to stiff clay and silt
with varying sand content; virgin deposits



4 SAND DEPOSITS
generally very loose to dense, with varying
fines content; virgin deposits



5 MARL DEPOSITS
generally consisting of calcareous sands and/or
elastic clay and silt; virgin deposits including
Cooper Group and younger marl deposits

PAL-1

Name and approximate location
of soil boring/CPT/DMT

u (tsf)

Cone Penetration Test pore
pressure in tons/ft²

qt (tsf)

Cone Penetration Test tip
resistance in tons/ft²

Material Index, Id

Dilatometer Material Index

N Value

Location and value of Standard
Penetration Test



River water level at 0.0 CLW



Groundwater level at time of
exploration



Approximate top of marl deposits
location and elevation for
historical borings and wells

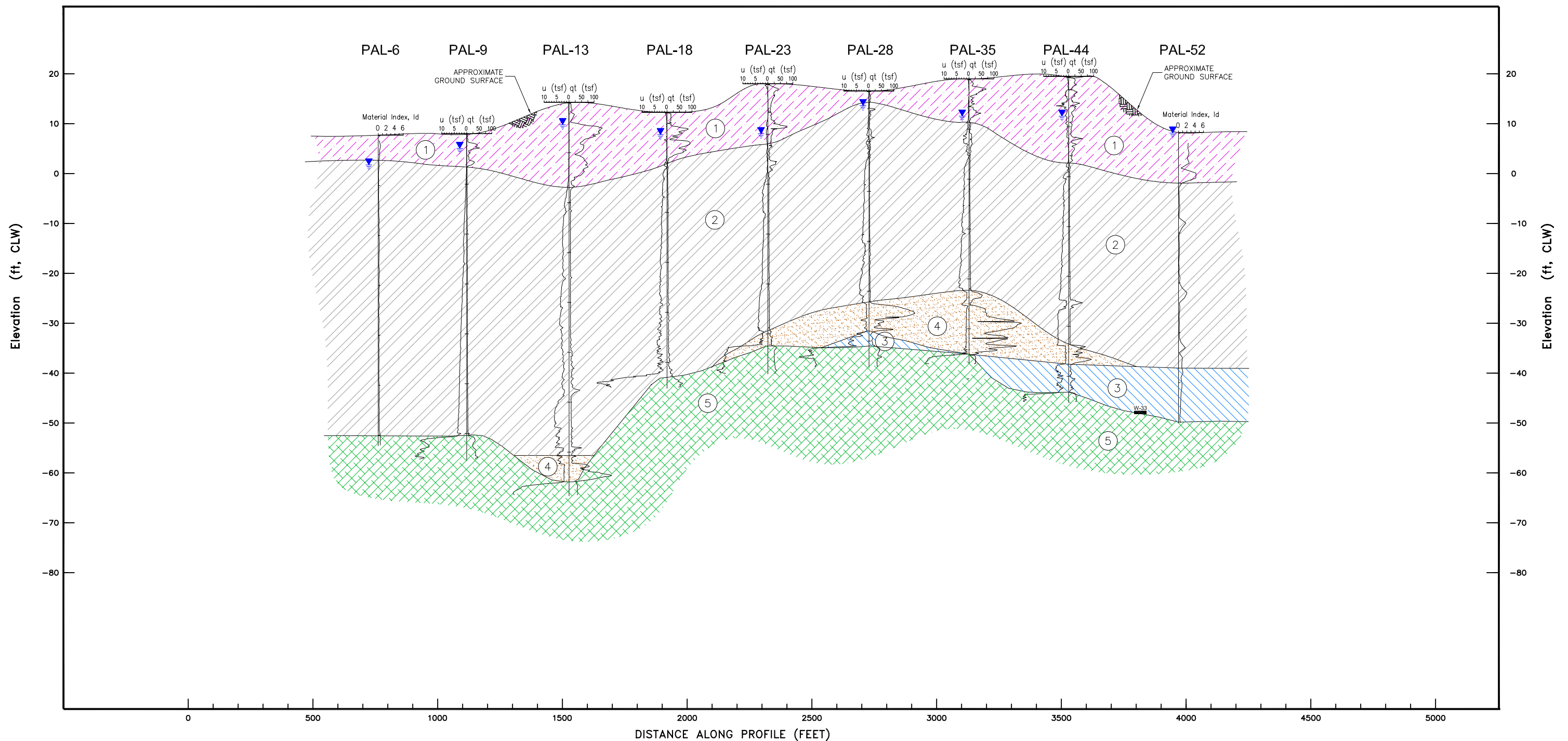
NOTES:

1. This profile is for illustrative purposes only and is representative of subsurface conditions encountered at each individual test location. Variations in subsurface conditions will occur between test locations. This profile should not be used for determination of distances or quantities or be used for design or construction.
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GENERALIZED SUBSURFACE PROFILE E CHARLESTON NAVAL BASE CONTAINER TERMINAL SOUTH CAROLINA STATE PORTS AUTHORITY NORTH CHARLESTON, SOUTH CAROLINA

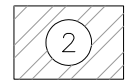
SCALE: AS SHOWN	DRAWN BY: LAJ	APPROVED BY:
PROJECT NO. 1131-03-264	DATE: 9-12-03	FIGURE 4-8



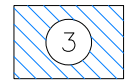
LEGEND



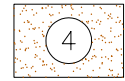
COHESIVE CRUST AND/OR SANDS
generally consisting of loose to dense
sands and/or firm to stiff clay and
silt; artificial fill and dredge spoil



SOFT FINE-GRAINED DEPOSITS
generally consisting of compressible clay
and silt; dredge spoil and virgin deposits



STIFF FINE-GRAINED DEPOSITS generally
consisting of firm to stiff clay and silt
with varying sand content; virgin deposits



SAND DEPOSITS
generally very loose to dense, with varying
fines content; virgin deposits



MARL DEPOSITS
generally consisting of calcareous sands and/or
elastic clay and silt; virgin deposits including
Cooper Group and younger marl deposits

PAL-1

Name and approximate location
of soil boring/CPT/DMT

u (tsf)

Cone Penetration Test pore
pressure in tons/ft²

qt (tsf)

Cone Penetration Test tip
resistance in tons/ft²

Material Index, Id

Dilatometer Material Index

N Value

Location and value of Standard
Penetration Test



River water level at 0.0 CLW



Groundwater level at time of
exploration



Approximate top of marl deposits
location and elevation for
historical borings and wells

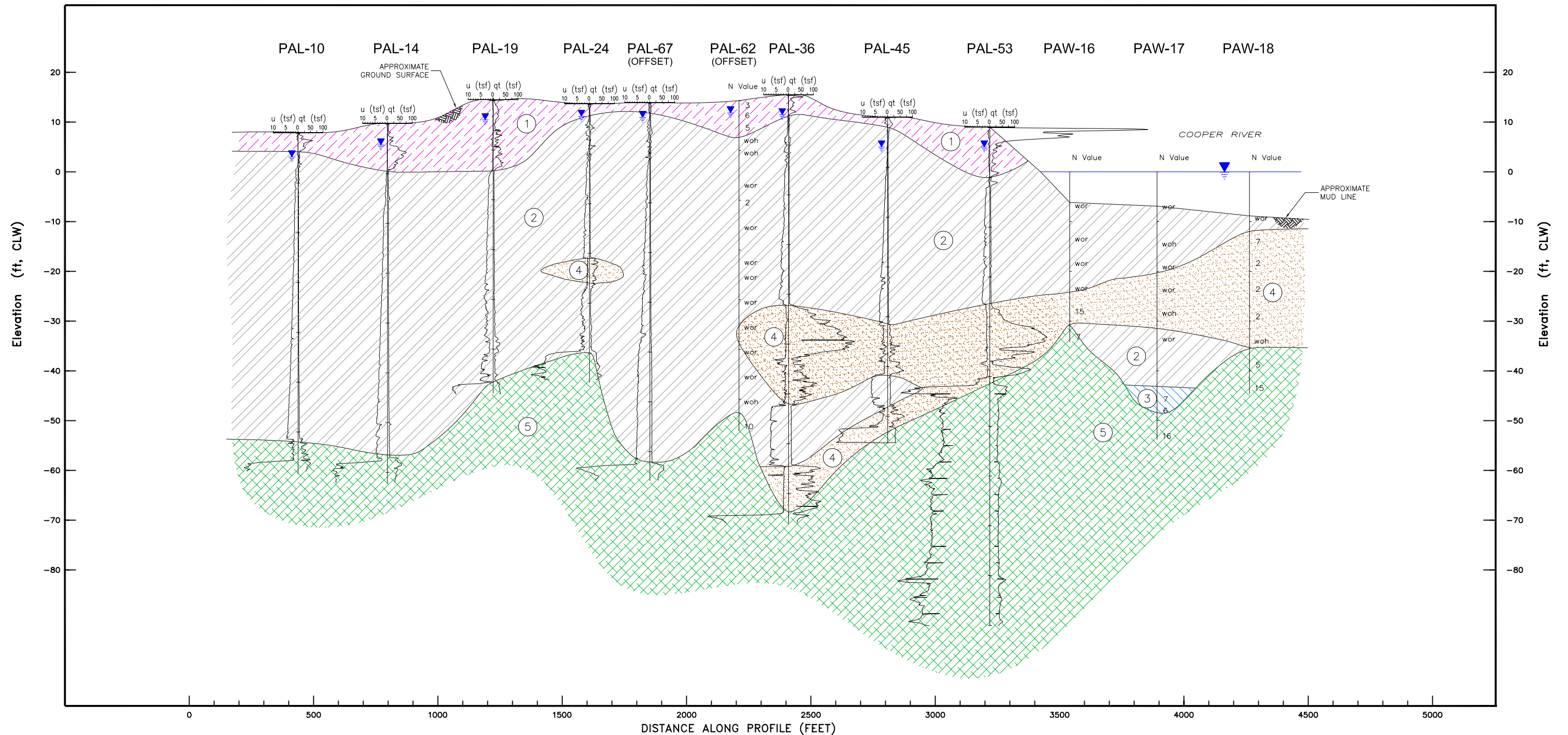
NOTES:

1. This profile is for illustrative purposes only and is representative of subsurface conditions encountered at each individual test location. Variations in subsurface conditions will occur between test locations. This profile should not be used for determination of distances or quantities or be used for design or construction.
2. Ground surface elevations at actual boring and sounding locations were obtained and provided by Davis & Floyd, Inc. and reference the Charleston Low Water (CLW) datum (0.00 ft CLW = -2.64 ft NGVD-29). Approximate ground surface elevation lines between boring and sounding locations are for illustrative purposes and are included to provide continuity between test locations.



GENERALIZED SUBSURFACE PROFILE F CHARLESTON NAVAL BASE CONTAINER TERMINAL SOUTH CAROLINA STATE PORTS AUTHORITY NORTH CHARLESTON, SOUTH CAROLINA

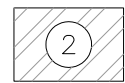
SCALE: AS SHOWN	DRAWN BY: LAJ	APPROVED BY:
PROJECT NO. 1131-03-264	DATE: 9-12-03	FIGURE 4-9



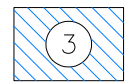
LEGEND



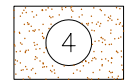
COHESIVE CRUST AND/OR SANDS
generally consisting of loose to dense
sands and/or firm to stiff clay and
silt; artificial fill and dredge spoil



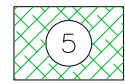
SOFT FINE-GRAINED DEPOSITS
generally consisting of compressible clay
and silt; dredge spoil and virgin deposits



STIFF FINE-GRAINED DEPOSITS generally
consisting of firm to stiff clay and silt
with varying sand content; virgin deposits



SAND DEPOSITS
generally very loose to dense, with varying
fines content; virgin deposits



MARL DEPOSITS
generally consisting of calcareous sands and/or
elastic clay and silt; virgin deposits including
Cooper Group and younger marl deposits

PAL-1

Name and approximate location
of soil boring/CPT/DMT

u (tsf)

Cone Penetration Test pore
pressure in tons/ft²

qt (tsf)

Cone Penetration Test tip
resistance in tons/ft²

Material Index, Id

Dilatometer Material Index

N Value

Location and value of Standard
Penetration Test



River water level at 0.0 CLW



Groundwater level at time of
exploration



Approximate top of marl deposits
location and elevation for
historical borings and wells

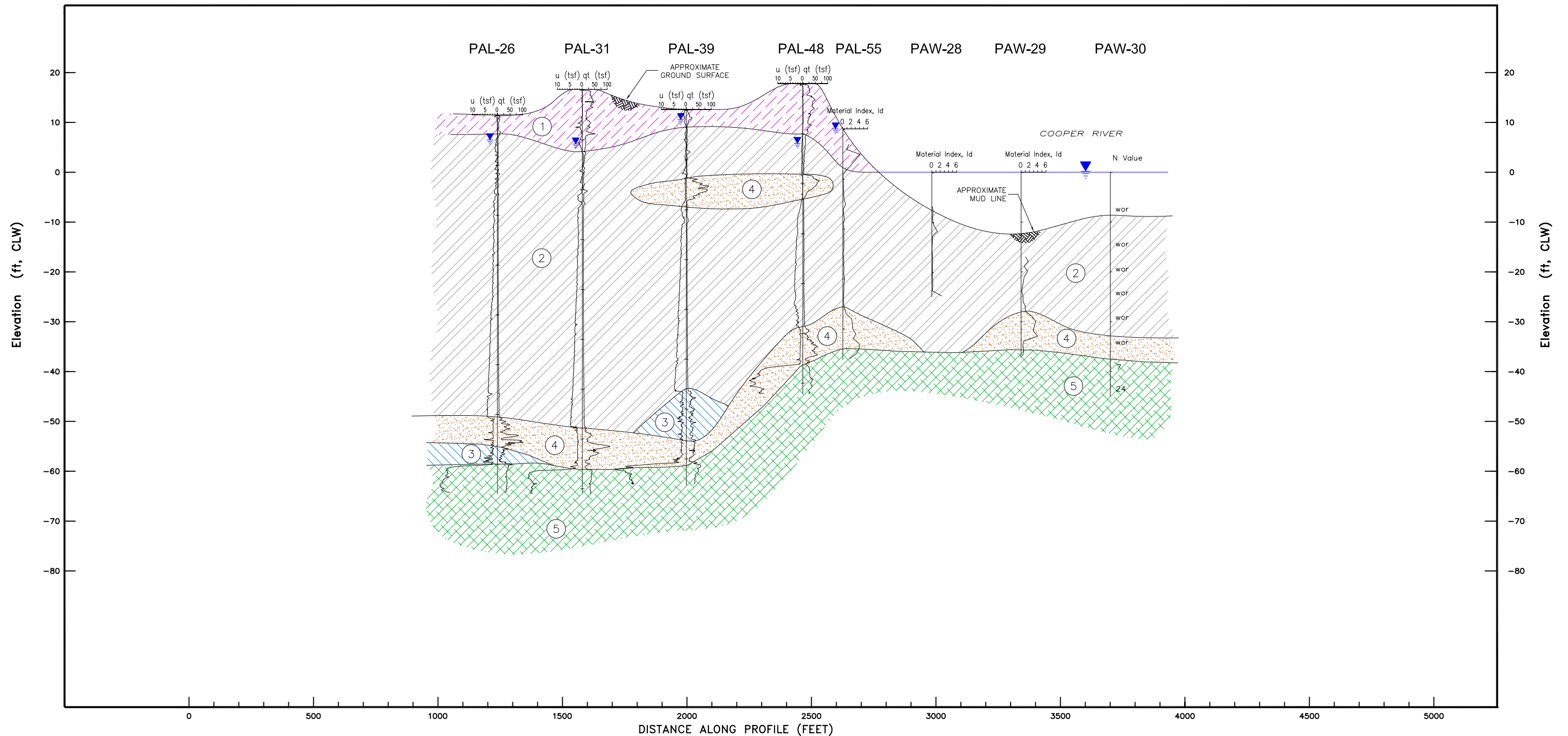
NOTES:

1. This profile is for illustrative purposes only and is representative of subsurface conditions encountered at each individual test location. Variations in subsurface conditions will occur between test locations. This profile should not be used for determination of distances or quantities or be used for design or construction.
2. Ground surface elevations at actual boring and sounding locations were obtained and provided by Davis & Floyd, Inc. and reference the Charleston Low Water (CLW) datum (0.00 ft CLW = -2.64 ft NGVD-29). Approximate ground surface elevation lines between boring and sounding locations are for illustrative purposes and are included to provide continuity between test locations.



GENERALIZED SUBSURFACE PROFILE G CHARLESTON NAVAL BASE CONTAINER TERMINAL SOUTH CAROLINA STATE PORTS AUTHORITY NORTH CHARLESTON, SOUTH CAROLINA

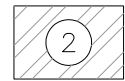
SCALE: AS SHOWN	DRAWN BY: LAJ	APPROVED BY:
PROJECT NO. 1131-03-264	DATE: 9-12-03	FIGURE 4-10



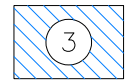
LEGEND



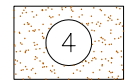
1 COHESIVE CRUST AND/OR SANDS
generally consisting of loose to dense
sands and/or firm to stiff clay and
silt; artificial fill and dredge spoil



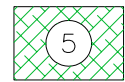
2 SOFT FINE-GRAINED DEPOSITS
generally consisting of compressible clay
and silt; dredge spoil and virgin deposits



3 STIFF FINE-GRAINED DEPOSITS generally
consisting of firm to stiff clay and silt
with varying sand content; virgin deposits



4 SAND DEPOSITS
generally very loose to dense, with varying
fines content; virgin deposits



5 MARL DEPOSITS
generally consisting of calcareous sands and/or
elastic clay and silt; virgin deposits including
Cooper Group and younger marl deposits

PAL-1

Name and approximate location
of soil boring/CPT/DMT

u (tsf)

Cone Penetration Test pore
pressure in tons/ft²

qt (tsf)

Cone Penetration Test tip
resistance in tons/ft²

Material Index, Id

Dilatometer Material Index

N Value

Location and value of Standard
Penetration Test



River water level at 0.0 CLW



Groundwater level at time of
exploration



Approximate top of marl deposits
location and elevation for
historical borings and wells

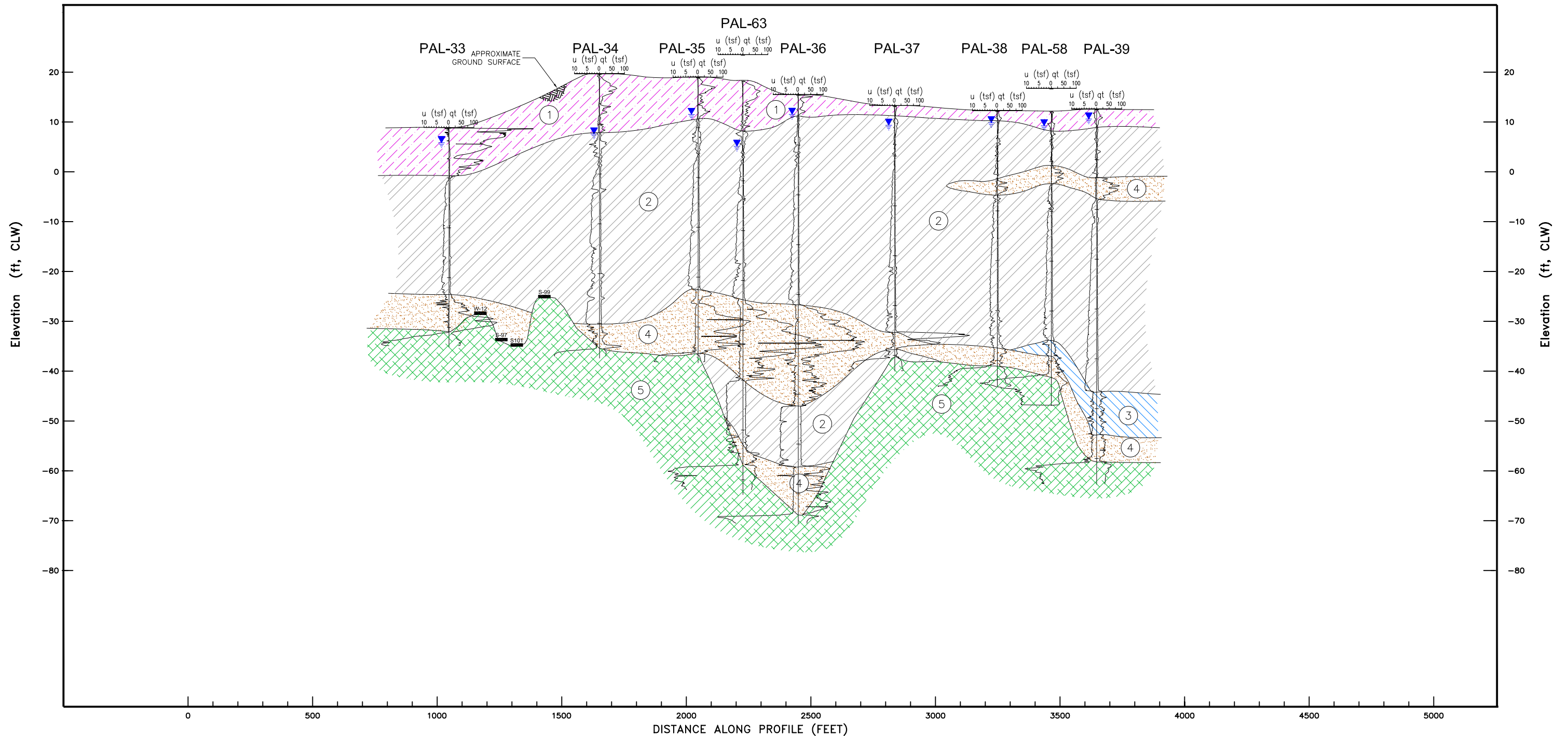
NOTES:

1. This profile is for illustrative purposes only and is representative of subsurface conditions encountered at each individual test location. Variations in subsurface conditions will occur between test locations. This profile should not be used for determination of distances or quantities or be used for design or construction.
2. Ground surface elevations at actual boring and sounding locations were obtained and provided by Davis & Floyd, Inc. and reference the Charleston Low Water (CLW) datum (0.00 ft CLW = -2.64 ft NGVD-29). Approximate ground surface elevation lines between boring and sounding locations are for illustrative purposes and are included to provide continuity between test locations.

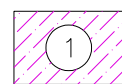


GENERALIZED SUBSURFACE PROFILE H CHARLESTON NAVAL BASE CONTAINER TERMINAL SOUTH CAROLINA STATE PORTS AUTHORITY NORTH CHARLESTON, SOUTH CAROLINA

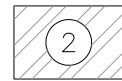
SCALE: AS SHOWN	DRAWN BY: LAJ	APPROVED BY:
PROJECT NO. 1131-03-264	DATE: 9-12-03	FIGURE 4-11



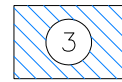
LEGEND



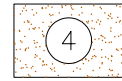
1 COHESIVE CRUST AND/OR SANDS
generally consisting of loose to dense
sands and/or firm to stiff clay and
silt; artificial fill and dredge spoil



2 SOFT FINE-GRAINED DEPOSITS
generally consisting of compressible clay
and silt; dredge spoil and virgin deposits



3 STIFF FINE-GRAINED DEPOSITS generally
consisting of firm to stiff clay and silt
with varying sand content; virgin deposits



4 SAND DEPOSITS
generally very loose to dense, with varying
fines content; virgin deposits



5 MARL DEPOSITS
generally consisting of calcareous sands and/or
elastic clay and silt; virgin deposits including
Cooper Group and younger marl deposits

PAL-1

Name and approximate location
of soil boring/CPT/DMT

u (tsf)

Cone Penetration Test pore
pressure in tons/ft²

qt (tsf)

Cone Penetration Test tip
resistance in tons/ft²

Material Index, Id

Dilatometer Material Index

N Value

Location and value of Standard
Penetration Test



River water level at 0.0 CLW



Groundwater level at time of
exploration



Approximate top of marl deposits
location and elevation for
historical borings and wells

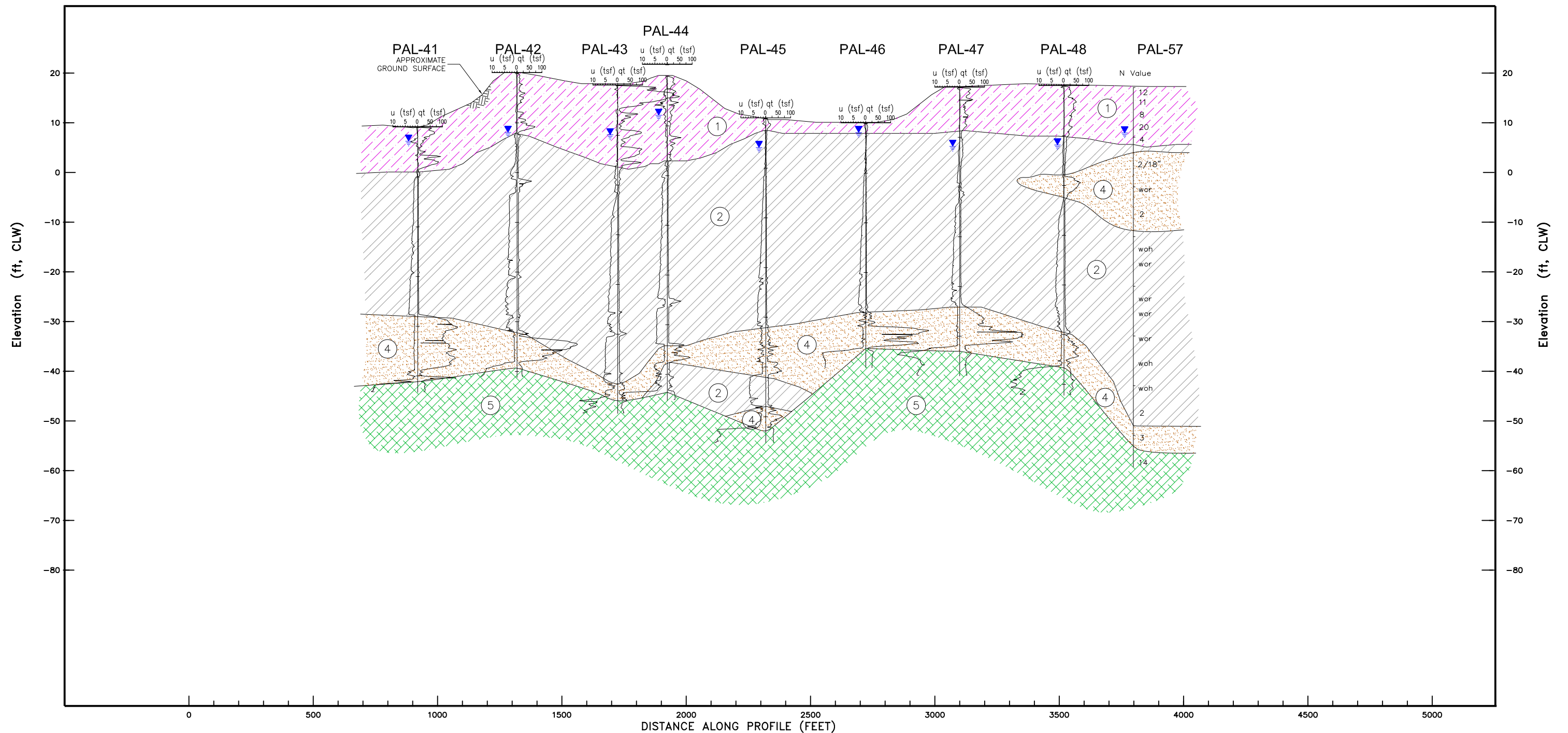
NOTES:

1. This profile is for illustrative purposes only and is representative of subsurface conditions encountered at each individual test location. Variations in subsurface conditions will occur between test locations. This profile should not be used for determination of distances or quantities or be used for design or construction.
2. Ground surface elevations at actual boring and sounding locations were obtained and provided by Davis & Floyd, Inc. and reference the Charleston Low Water (CLW) datum (0.00 ft CLW = -2.64 ft NGVD-29). Approximate ground surface elevation lines between boring and sounding locations are for illustrative purposes and are included to provide continuity between test locations.



GENERALIZED SUBSURFACE PROFILE I CHARLESTON NAVAL BASE CONTAINER TERMINAL SOUTH CAROLINA STATE PORTS AUTHORITY NORTH CHARLESTON, SOUTH CAROLINA

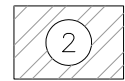
SCALE: AS SHOWN	DRAWN BY: LAJ	APPROVED BY:
PROJECT NO. 1131-03-264	DATE: 9-12-03	FIGURE 4-12



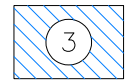
LEGEND



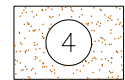
COHESIVE CRUST AND/OR SANDS generally consisting of loose to dense sands and/or firm to stiff clay and silt; artificial fill and dredge spoil



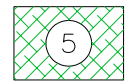
SOFT FINE-GRAINED DEPOSITS generally consisting of compressible clay and silt; dredge spoil and virgin deposits



STIFF FINE-GRAINED DEPOSITS generally consisting of firm to stiff clay and silt with varying sand content; virgin deposits



SAND DEPOSITS generally very loose to dense, with varying fines content; virgin deposits



MARL DEPOSITS generally consisting of calcareous sands and/or elastic clay and silt; virgin deposits including Cooper Group and younger marl deposits

PAL-1

Name and approximate location of soil boring/CPT/DMT

u (tsf)

Cone Penetration Test pore pressure in tons/ft²

qt (tsf)

Cone Penetration Test tip resistance in tons/ft²

Material Index, Id

Dilatometer Material Index

N Value

Location and value of Standard Penetration Test



River water level at 0.0 CLW



Groundwater level at time of exploration



Approximate top of marl deposits location and elevation for historical borings and wells

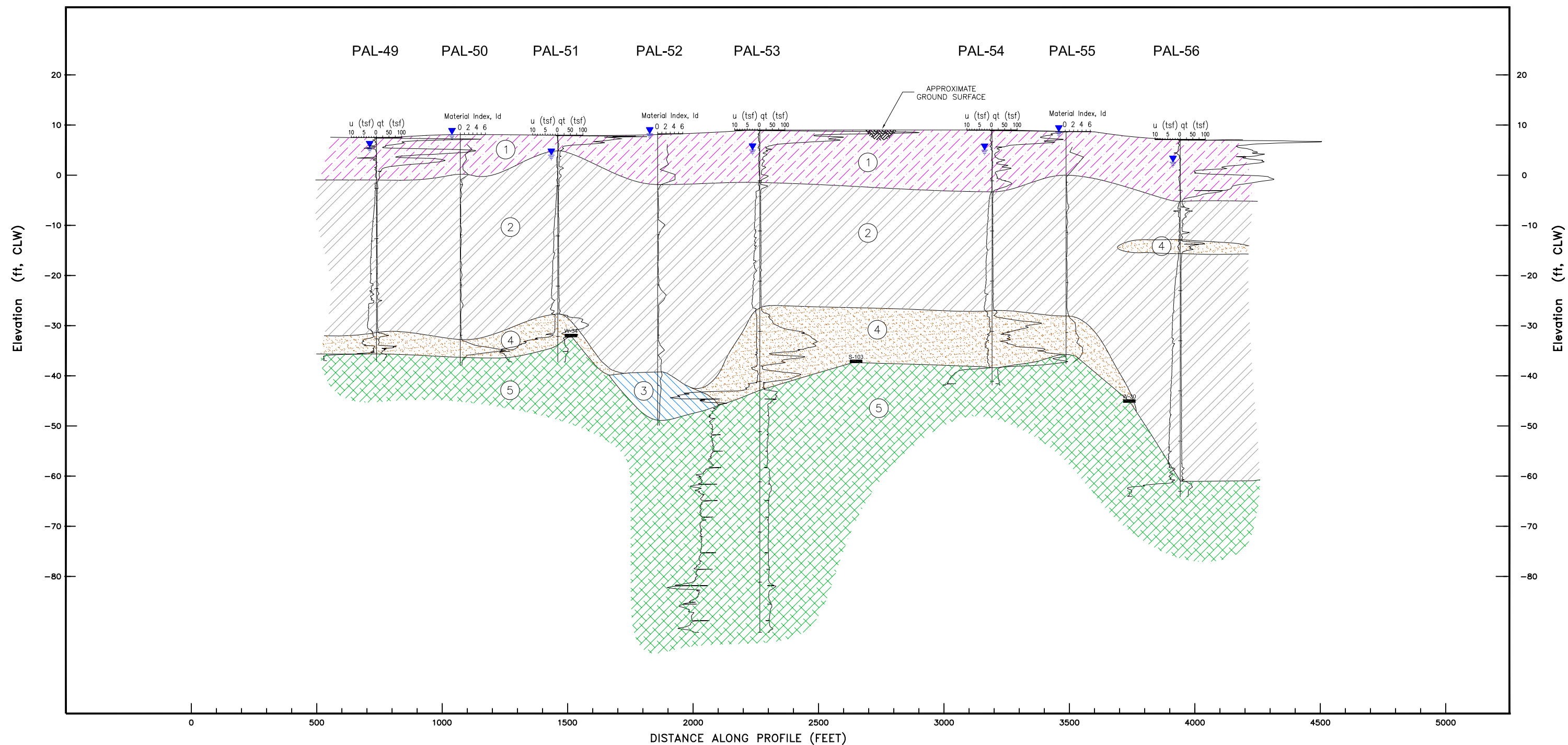
NOTES:

- This profile is for illustrative purposes only and is representative of subsurface conditions encountered at each individual test location. Variations in subsurface conditions will occur between test locations. This profile should not be used for determination of distances or quantities or be used for design or construction.
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GENERALIZED SUBSURFACE PROFILE J CHARLESTON NAVAL BASE CONTAINER TERMINAL SOUTH CAROLINA STATE PORTS AUTHORITY NORTH CHARLESTON, SOUTH CAROLINA

SCALE: AS SHOWN	DRAWN BY: LAJ	APPROVED BY:
PROJECT NO. 1131-03-264	DATE: 9-12-03	FIGURE 4-13



- 1** **COHESIVE CRUST AND/OR SANDS**
generally consisting of loose to dense sands and/or firm to stiff clay and silt; artificial fill and dredge spoil


2 **SOFT FINE-GRAINED DEPOSITS**
generally consisting of compressible clay and silt; dredge spoil and virgin deposits

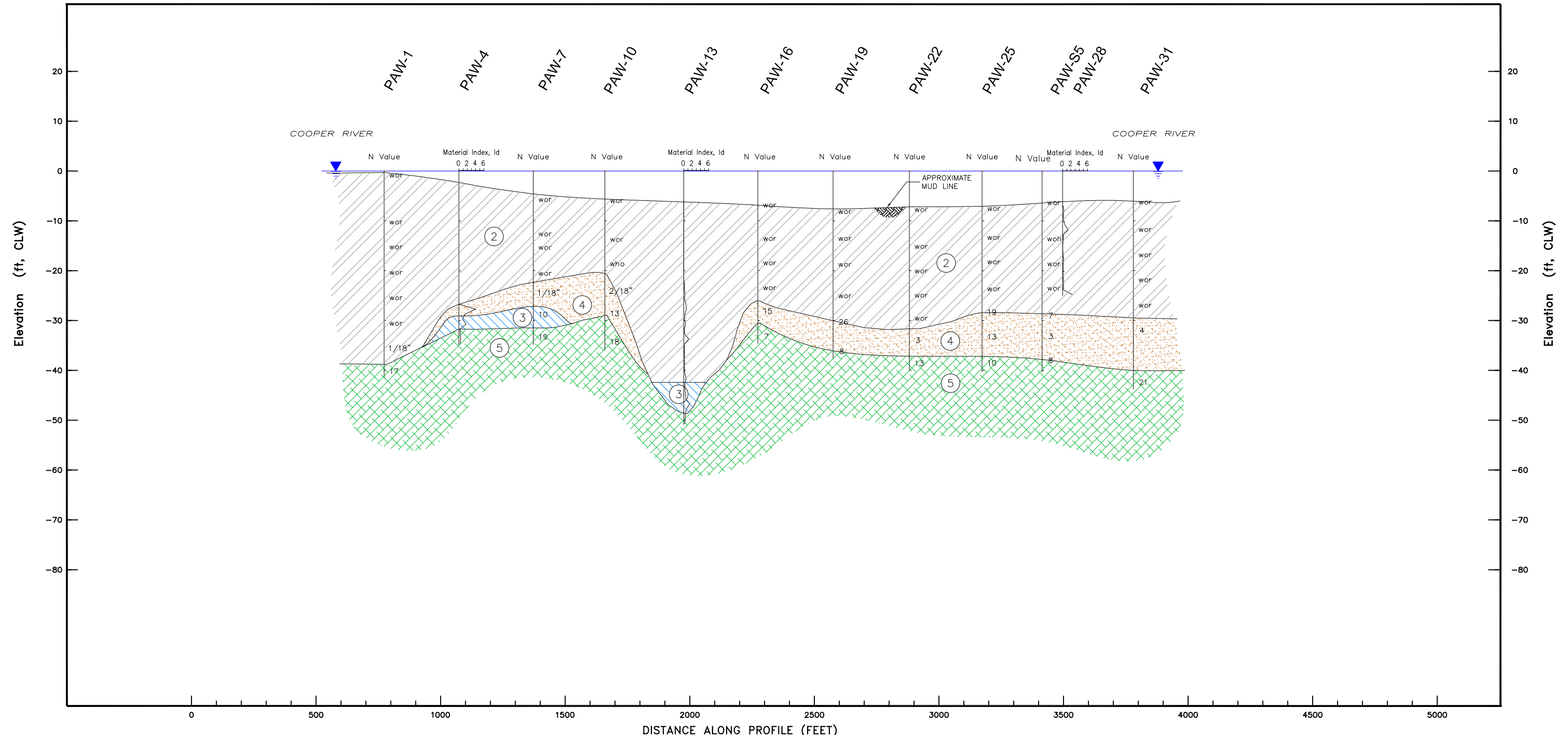
3 **STIFF FINE-GRAINED DEPOSITS** generally consisting of firm to stiff clay and silt with varying sand content; virgin deposits

4 **SAND DEPOSITS**
generally very loose to dense, with varying fines content; virgin deposits

5 **MARL DEPOSITS**
generally consisting of calcareous sands and/or elastic clay and silt; virgin deposits including Cooper Group and younger marl deposits

NOTES:

 <p style="margin: 0;">ENGINEERING · TESTING · ENVIRONMENTAL SERVICES</p>		
<p style="margin: 0;">GENERALIZED SUBSURFACE PROFILE K</p> <p style="margin: 0;">CHARLESTON NAVAL BASE CONTAINER TERMINAL</p> <p style="margin: 0;">SOUTH CAROLINA STATE PORTS AUTHORITY</p> <p style="margin: 0;">NORTH CHARLESTON, SOUTH CAROLINA</p>		
SCALE: <div style="font-size: 1.5em; margin-top: 10px;">AS SHOWN</div>	DRAWN BY: <div style="font-size: 1.5em; margin-top: 10px;">LAJ</div>	APPROVED BY:
PROJECT NO. <div style="font-size: 1.5em; margin-top: 10px;">1131-03-264</div>	DATE: <div style="font-size: 1.5em; margin-top: 10px;">9-12-03</div>	FIGURE <div style="font-size: 1.5em; margin-top: 10px;">4-14</div>



LEGEND

- COHESIVE CRUST AND/OR SANDS generally consisting of loose to dense sands and/or firm to stiff clay and silt; artificial fill and dredge spoil
- SOFT FINE-GRAINED DEPOSITS generally consisting of compressible clay and silt; dredge spoil and virgin deposits
- STIFF FINE-GRAINED DEPOSITS generally consisting of firm to stiff clay and silt with varying sand content; virgin deposits
- SAND DEPOSITS generally very loose to dense, with varying fines content; virgin deposits
- MARL DEPOSITS generally consisting of calcareous sands and/or elastic clay and silt; virgin deposits including Cooper Group and younger marl deposits

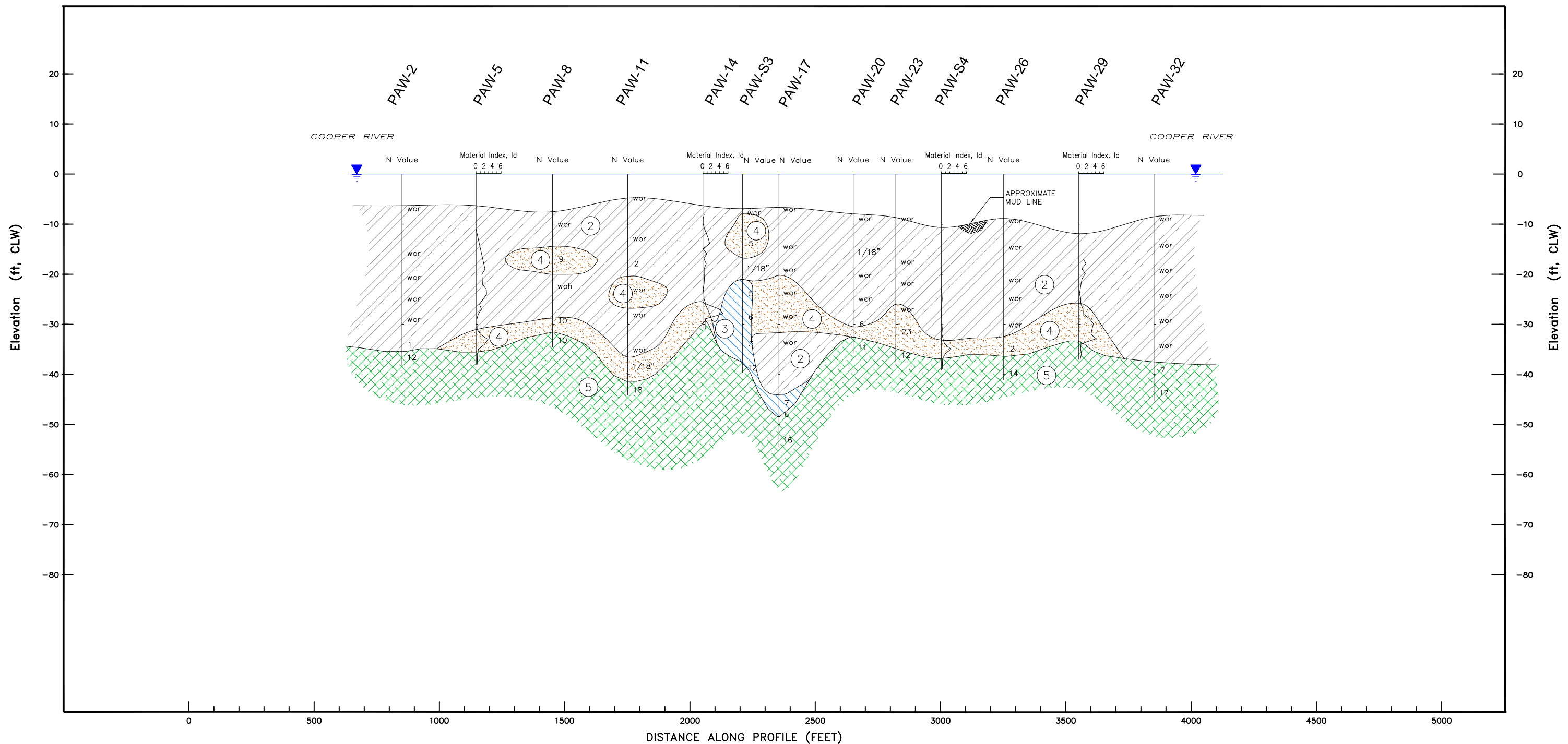
- PAL-1** Name and approximate location of soil boring/CPT/DMT
- u (tsf)** Cone Penetration Test pore pressure in tons/ft²
- qt (tsf)** Cone Penetration Test tip resistance in tons/ft²
- Material Index, Id** Dilatometer Material Index
- N Value** Location and value of Standard Penetration Test
- River water level at 0.0 CLW
- Groundwater level at time of exploration
- Approximate top of marl deposits location and elevation for historical borings and wells

NOTES:

- This profile is for illustrative purposes only and is representative of subsurface conditions encountered at each individual test location. Variations in subsurface conditions will occur between test locations. This profile should not be used for determination of distances or quantities or be used for design or construction.
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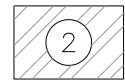
GENERALIZED SUBSURFACE PROFILE L CHARLESTON NAVAL BASE CONTAINER TERMINAL SOUTH CAROLINA STATE PORTS AUTHORITY NORTH CHARLESTON, SOUTH CAROLINA		
SCALE: AS SHOWN	DRAWN BY: LAJ	APPROVED BY:
PROJECT NO. 1131-03-264	DATE: 9-12-03	FIGURE 4-15



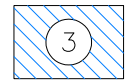
LEGEND



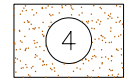
COHESIVE CRUST AND/OR SANDS
generally consisting of loose to dense
sands and/or firm to stiff clay and
silt; artificial fill and dredge spoil



SOFT FINE-GRAINED DEPOSITS
generally consisting of compressible clay
and silt; dredge spoil and virgin deposits



STIFF FINE-GRAINED DEPOSITS generally
consisting of firm to stiff clay and silt
with varying sand content; virgin deposits



SAND DEPOSITS
generally very loose to dense, with varying
fines content; virgin deposits



MARL DEPOSITS
generally consisting of calcareous sands and/or
elastic clay and silt; virgin deposits including
Cooper Group and younger marl deposits

PAL-1

Name and approximate location
of soil boring/CPT/DMT

u (tsf)

Cone Penetration Test pore
pressure in tons/ft²

qt (tsf)

Cone Penetration Test tip
resistance in tons/ft²

Material Index, Id

Dilatometer Material Index

N Value

Location and value of Standard
Penetration Test



River water level at 0.0 CLW



Groundwater level at time of
exploration



Approximate top of marl deposits
location and elevation for
historical borings and wells

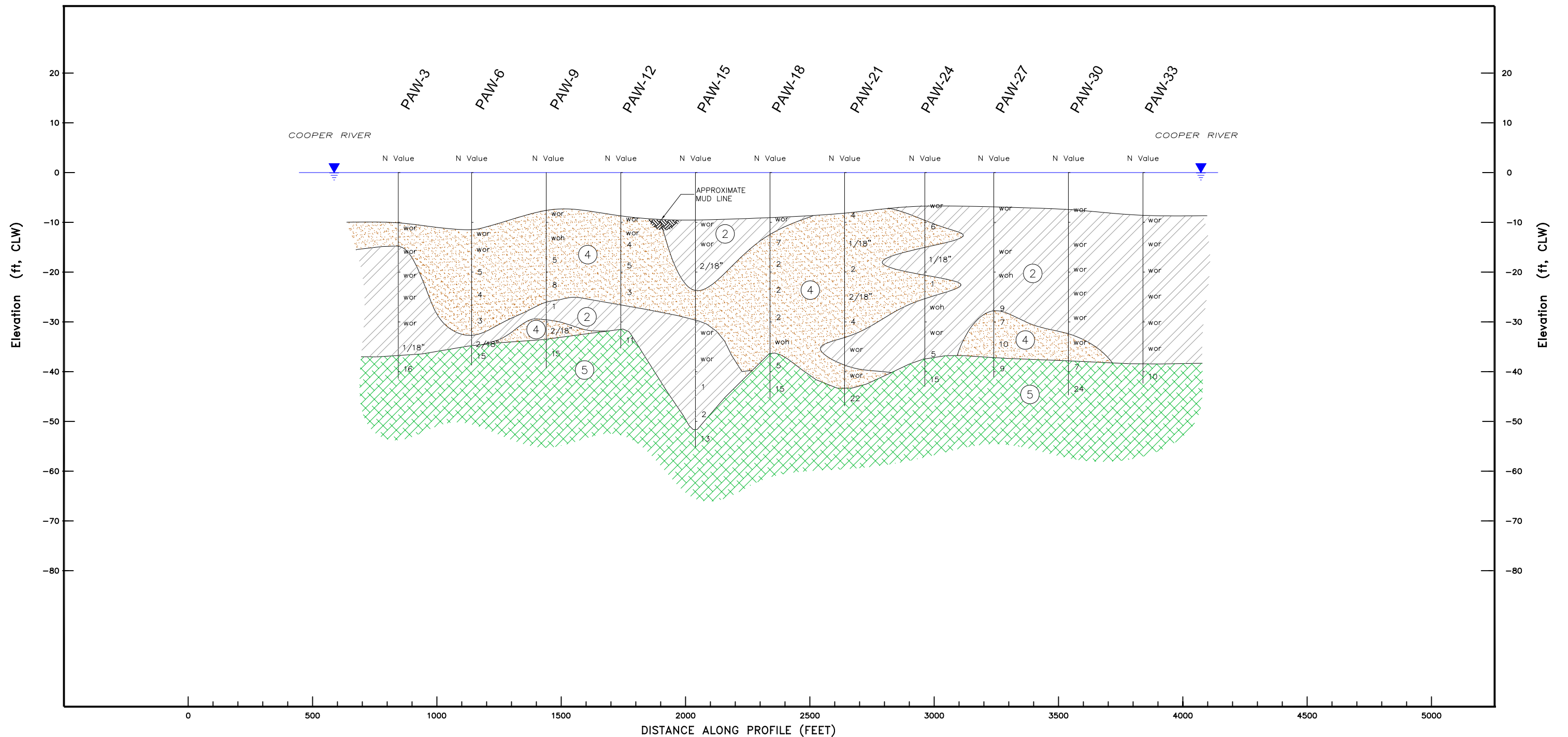
NOTES:

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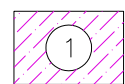


GENERALIZED SUBSURFACE PROFILE M CHARLESTON NAVAL BASE CONTAINER TERMINAL SOUTH CAROLINA STATE PORTS AUTHORITY NORTH CHARLESTON, SOUTH CAROLINA

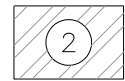
SCALE: AS SHOWN	DRAWN BY: LAJ	APPROVED BY:
PROJECT NO. 1131-03-264	DATE: 9-12-03	FIGURE 4-16



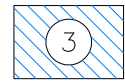
LEGEND



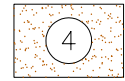
COHESIVE CRUST AND/OR SANDS generally consisting of loose to dense sands and/or firm to stiff clay and silt; artificial fill and dredge spoil



SOFT FINE-GRAINED DEPOSITS generally consisting of compressible clay and silt; dredge spoil and virgin deposits



STIFF FINE-GRAINED DEPOSITS generally consisting of firm to stiff clay and silt with varying sand content; virgin deposits



SAND DEPOSITS generally very loose to dense, with varying fines content; virgin deposits



MARL DEPOSITS generally consisting of calcareous sands and/or elastic clay and silt; virgin deposits including Cooper Group and younger marl deposits

PAL-1

Name and approximate location of soil boring/CPT/DMT

u (tsf)

Cone Penetration Test pore pressure in tons/ft²

qt (tsf)

Cone Penetration Test tip resistance in tons/ft²

Material Index, Id

Dilatometer Material Index

N Value

Location and value of Standard Penetration Test



River water level at 0.0 CLW



Groundwater level at time of exploration



Approximate top of marl deposits location and elevation for historical borings and wells

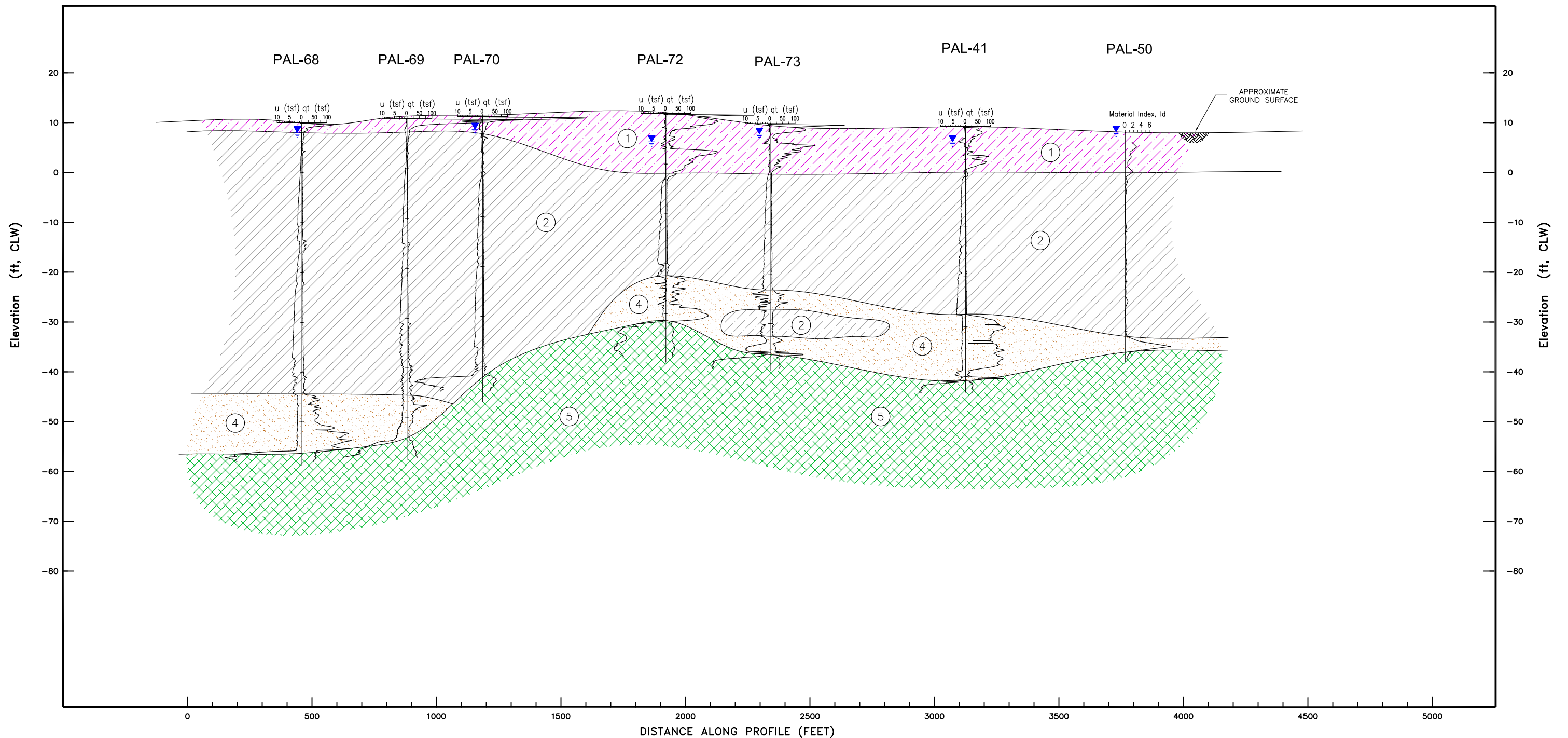
NOTES:

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GENERALIZED SUBSURFACE PROFILE N CHARLESTON NAVAL BASE CONTAINER TERMINAL SOUTH CAROLINA STATE PORTS AUTHORITY NORTH CHARLESTON, SOUTH CAROLINA

SCALE: AS SHOWN	DRAWN BY: LAJ	APPROVED BY:
PROJECT NO. 1131-03-264	DATE: 9-12-03	FIGURE 4-17



LEGEND

- | | | |
|--|---|--|
| | 1 | COHESIVE CRUST AND/OR SANDS
generally consisting of loose to dense
sands and/or firm to stiff clay and
silt; artificial fill and dredge spoil |
| | 2 | SOFT FINE-GRAINED DEPOSITS
generally consisting of compressible clay
and silt; dredge spoil and virgin deposits |
| | 3 | STIFF FINE-GRAINED DEPOSITS generally
consisting of firm to stiff clay and silt
with varying sand content; virgin deposits |
| | 4 | SAND DEPOSITS
generally very loose to dense, with varying
fines content; virgin deposits |
| | 5 | MARL DEPOSITS
generally consisting of calcareous sands and/or
elastic clay and silt; virgin deposits including
Cooper Group and younger marl deposits |

- | | |
|--------------------|--|
| PAL-1 | Name and approximate location
of soil boring/CPT/DMT |
| u (tsf) | Cone Penetration Test pore
pressure in tons/ft ² |
| qt (tsf) | Cone Penetration Test tip
resistance in tons/ft ² |
| Material Index, Id | Dilatometer Material Index |
| N Value | Location and value of Standard
Penetration Test |
| | River water level at 0.0 CLW |
| | Groundwater level at time of
exploration |
| | Approximate top of marl deposits
location and elevation for
historical borings and wells |

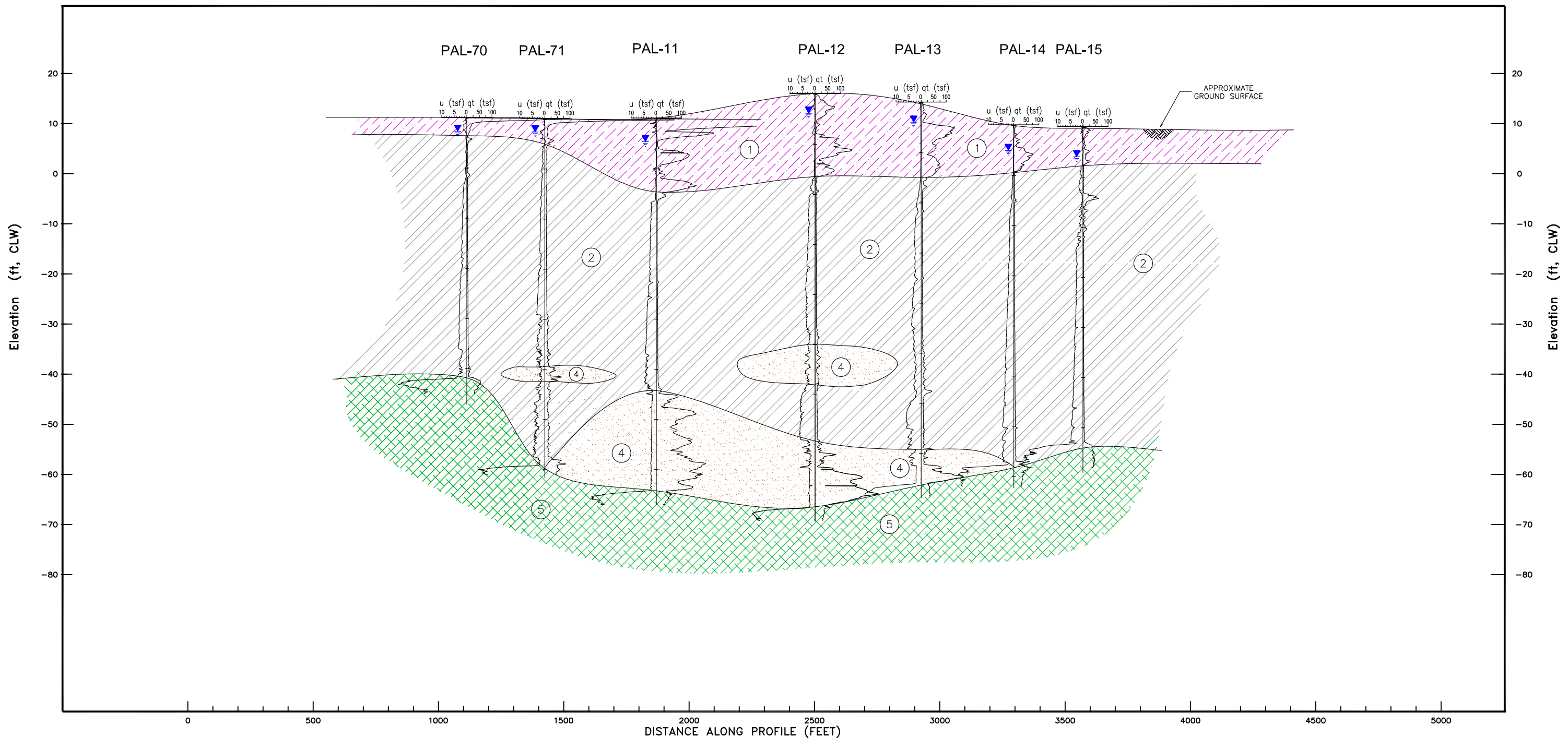
NOTES:

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GENERALIZED SUBSURFACE PROFILE O CHARLESTON NAVAL BASE CONTAINER TERMINAL SOUTH CAROLINA STATE PORTS AUTHORITY NORTH CHARLESTON, SOUTH CAROLINA

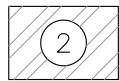
SCALE: AS SHOWN	DRAWN BY: LAJ	APPROVED BY:
PROJECT NO. 1131-03-264	DATE: 5-13-05	FIGURE 4-18



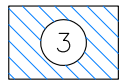
LEGEND



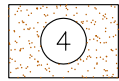
1 COHESIVE CRUST AND/OR SANDS generally consisting of loose to dense sands and/or firm to stiff clay and silt; artificial fill and dredge spoil



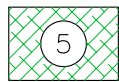
2 SOFT FINE-GRAINED DEPOSITS generally consisting of compressible clay and silt; dredge spoil and virgin deposits



3 STIFF FINE-GRAINED DEPOSITS generally consisting of firm to stiff clay and silt with varying sand content; virgin deposits



4 SAND DEPOSITS generally very loose to dense, with varying fines content; virgin deposits



5 MARL DEPOSITS generally consisting of calcareous sands and/or elastic clay and silt; virgin deposits including Cooper Group and younger marl deposits

PAL-1

Name and approximate location of soil boring/CPT/DMT

u (tsf)

Cone Penetration Test pore pressure in tons/ft²

qt (tsf)

Cone Penetration Test tip resistance in tons/ft²

Material Index, Id

Dilatometer Material Index

N Value

Location and value of Standard Penetration Test



River water level at 0.0 CLW



Groundwater level at time of exploration



Approximate top of marl deposits location and elevation for historical borings and wells

NOTES:

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GENERALIZED SUBSURFACE PROFILE P CHARLESTON NAVAL BASE CONTAINER TERMINAL SOUTH CAROLINA STATE PORTS AUTHORITY NORTH CHARLESTON, SOUTH CAROLINA

SCALE:

AS SHOWN

DRAWN BY:

LAJ

APPROVED BY:

PROJECT NO.

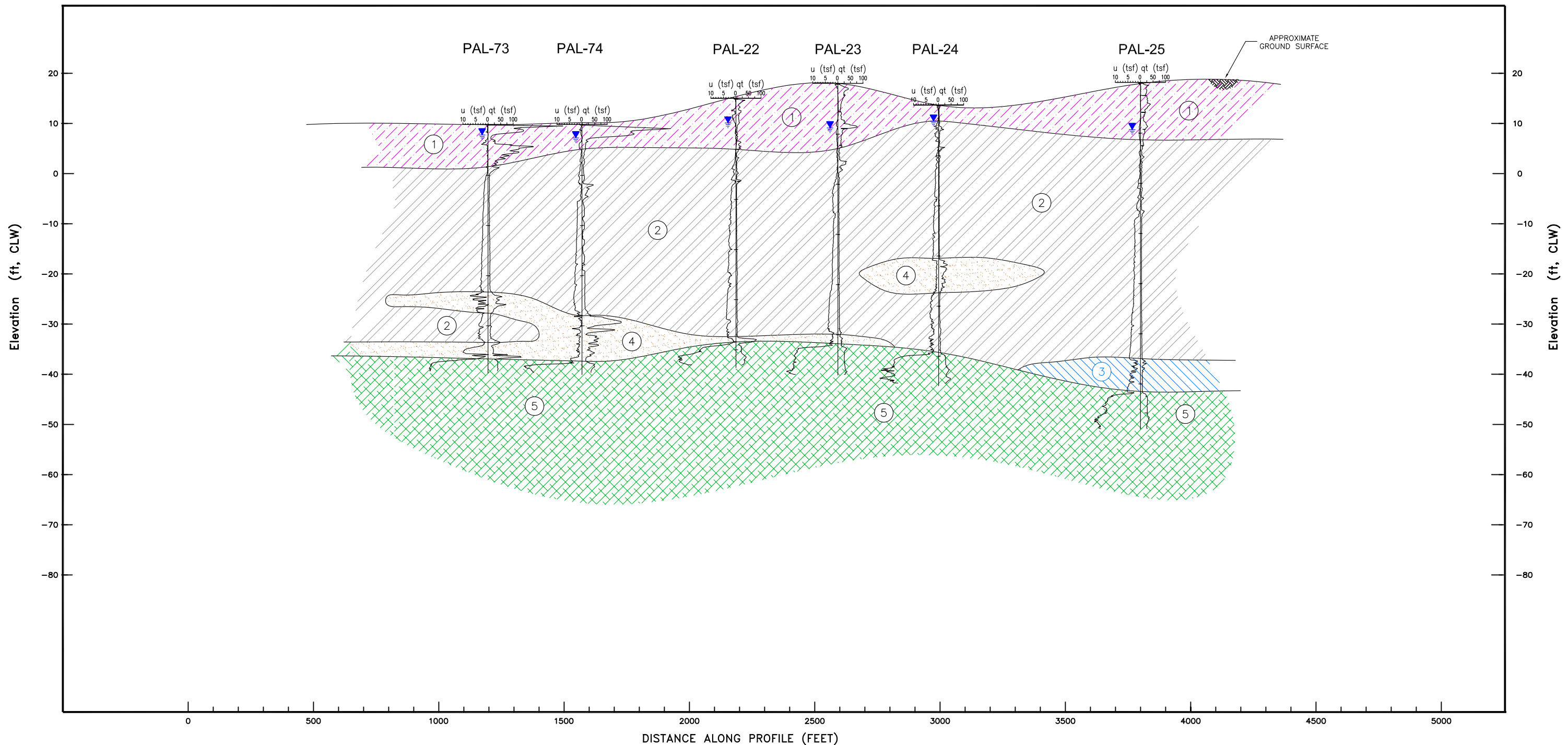
1131-03-264

DATE:

5-13-05

FIGURE

4-19



LEGEND

- 1** COHESIVE CRUST AND/OR SANDS generally consisting of loose to dense sands and/or firm to stiff clay and silt; artificial fill and dredge spoil
- 2** SOFT FINE-GRAINED DEPOSITS generally consisting of compressible clay and silt; dredge spoil and virgin deposits
- 3** STIFF FINE-GRAINED DEPOSITS generally consisting of firm to stiff clay and silt with varying sand content; virgin deposits
- 4** SAND DEPOSITS generally very loose to dense, with varying fines content; virgin deposits
- 5** MARL DEPOSITS generally consisting of calcareous sands and/or elastic clay and silt; virgin deposits including Cooper Group and younger marl deposits

- PAL-1** Name and approximate location of soil boring/CPT/DMT
- u (tsf) Cone Penetration Test pore pressure in tons/ft²
- qt (tsf) Cone Penetration Test tip resistance in tons/ft²
- Material Index, Id Dilatometer Material Index
- N Value Location and value of Standard Penetration Test
- ▼ River water level at 0.0 CLW
- ▼ Groundwater level at time of exploration
- S-37 Approximate top of marl deposits location and elevation for historical borings and wells

NOTES:

- This profile is for illustrative purposes only and is representative of subsurface conditions encountered at each individual test location. Variations in subsurface conditions will occur between test locations. This profile should not be used for determination of distances or quantities or be used for design or construction.
- Ground surface elevations at actual boring and sounding locations were obtained and provided by Davis & Floyd, Inc. and reference the Charleston Low Water (CLW) datum (0.00 ft CLW = -2.64 ft NGVD-29). Approximate ground surface elevation lines between boring and sounding locations are for illustrative purposes and are included to provide continuity between test locations.



GENERALIZED SUBSURFACE PROFILE Q CHARLESTON NAVAL BASE CONTAINER TERMINAL SOUTH CAROLINA STATE PORTS AUTHORITY NORTH CHARLESTON, SOUTH CAROLINA

SCALE: AS SHOWN	DRAWN BY: LAJ	APPROVED BY:
PROJECT NO. 1131-03-264	DATE: 5-13-05	FIGURE 4-20

4.1.2 Layer 2: Soft Fine-Grained Deposits

Soft fine-grained deposits, generally consisting of compressible clay and silt, were encountered in all borings and soundings across the site. These soft deposits consist of both dredge spoil and virgin deposits. The thickness of the soft deposits ranged from about 24 to 72 ft with an average of 45 ft for borings and soundings on land. The thickness of the soft deposits ranged from about 8 to 42 ft with an average of 25 ft for borings and soundings over water. A soft soil isopach map showing the thickness of the soft soils across the site is presented in Figure 4-1 and Appendix III.

4.1.3 Layer 3: Stiff Fine-Grained Deposits

This stratum was encountered below soil Layer 2 in isolated locations, and generally consists of firm to stiff virgin clay and silt. Although also fined-grained soils, this stratum does not present the concerns with compressibility associated with Layer 2.

4.1.4 Layer 4: Sand Deposits

Virgin sand deposits generally consisting of very loose to dense sands with varying fines content was encountered below and interbedded with soil Layer 2 on land. In the water, this layer was encountered above, below and interbedded with Layer 2.

4.1.5 Layer 5: Marl Deposits

We terminated all our borings and soundings in the “basement” stratum of the Ashley Formation of the Cooper Group or younger marl deposits. This layer generally consists of calcareous sands and/or elastic clay and silt. Geologically, the Cooper Group and younger marl deposits are massive formations, probably greater than 200 ft thick at the site. These marls are geologically described as a phosphatic limestone consisting of calcium carbonates, quartz sand, clay, phosphatic sand and pebble, and small amounts of glauconite, shell hash and mica. These deposits are evident in the CPT soundings as the pore pressure measurements increase rapidly to

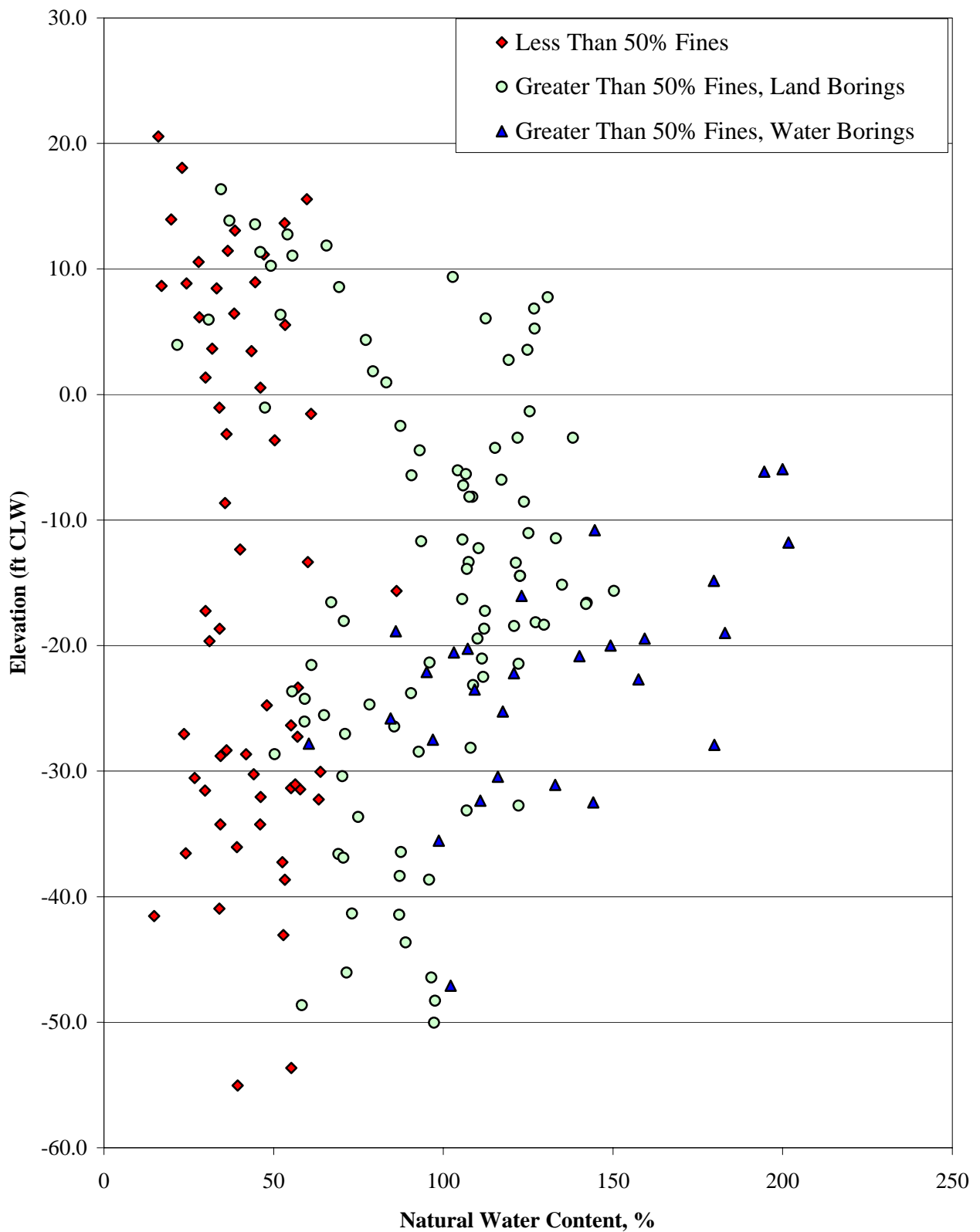
values over 15 to 20 tsf. A contour map showing the top elevation of this layer across the site is presented in Figure 4-2 and Appendix III.

4.2 SOIL INDEX AND ENGINEERING PROPERTIES

The majority of the laboratory testing described previously was conducted on samples obtained from soil Layer 2, the soft fine-grained deposits. Therefore most of the following discussion focuses on Layer 2.

4.2.1 Moisture Content

The moisture content of soil Layer 2 range from 31% to 202%, with an average of 107%. Granular soils (i.e., less than 50% fines) within Layer 1 and Layer 4 have moisture contents ranging from about 15% to 86%, with an average of 41%. A plot of the moisture content as a function of elevation for all sediments above the marl deposits is presented in Figure 4-21. A general trend of decreasing water content with depth is evident for the clay and silt (soils with greater than 50% fines) samples obtained in the water borings. This trend is expected for normally consolidated soils where density (and related properties) generally increase with depth. On land, the clay and silt soils generally increase in water content with depth, and below an elevation of about -10 ft CLW, the water contents then generally decrease. The lower water contents near the ground surface are typically a function of desiccation and overconsolidation, and where these effects are overcome by increasing depth, the water contents begin to again follow the usual trend for normally consolidated soil. Scatter in the general trend of increasing water content with depth for the samples obtained on land may be due to the presence of excess pore pressures described later in Section 4.3.



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NATURAL MOISTURE CONTENT
OF SEDIMENTS ABOVE COOPER MARL
CHAS. NAVAL BASE CONTAINER TERMINAL
NORTH CHARLESTON, SC

Figure:
4-21

4.2.2 Atterberg Limits and Organic Content

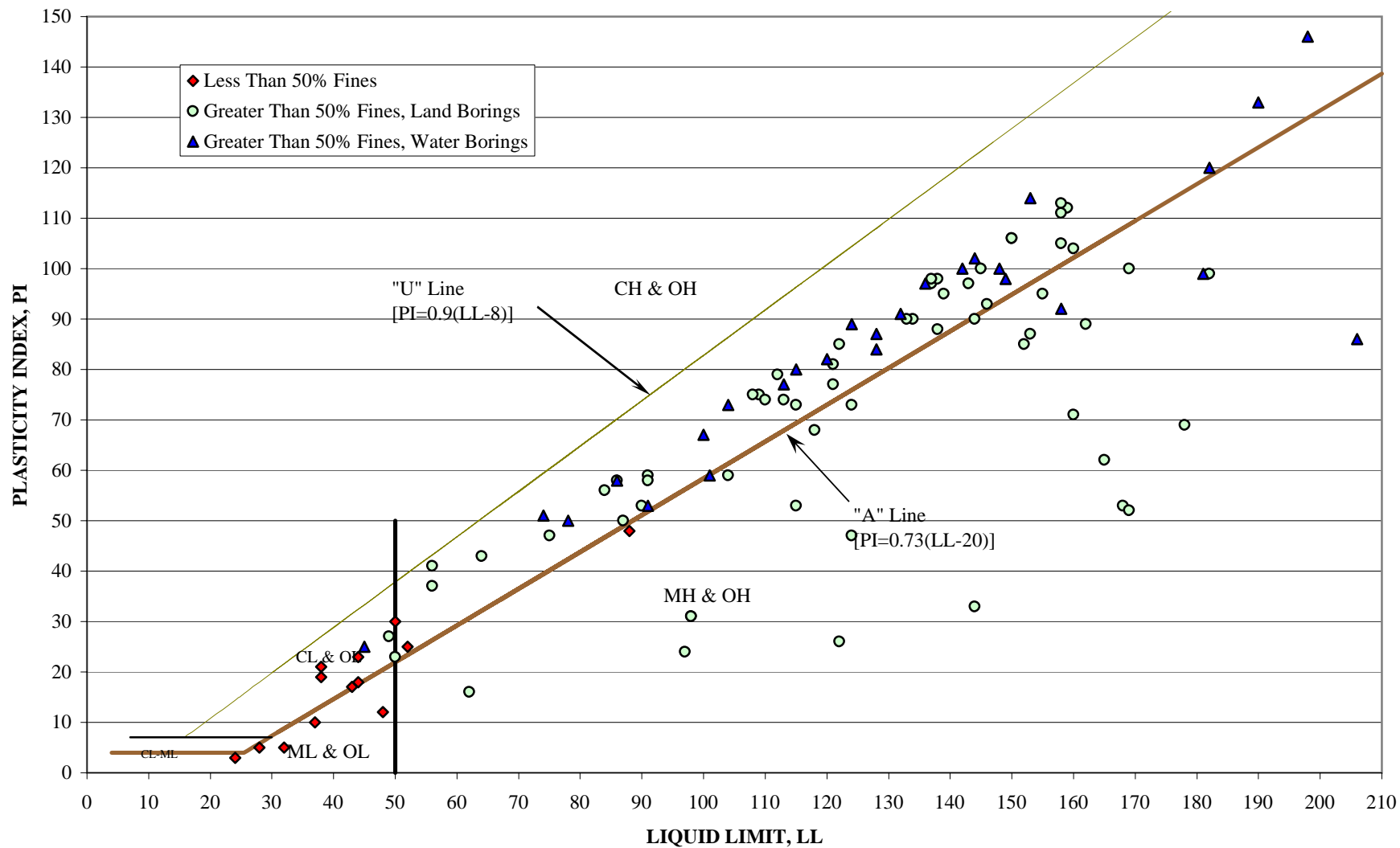
The Atterberg Limits of samples from sediments above the marl deposits are presented on Figure 4-22. The majority of the fine-grained soils are shown to have high plasticity, and generally plot as CH clays. The liquid Limit of soils in Layer 2 range from 45 to 206, with an average of 126. The Plastic Limit of these soils range from 16 to 146, with an average of 76. Although Layer 2 has been identified as CH and MH material on the boring logs and soil data summary, the presence of organic material and odor could appropriately lead to a dual classification of CH/OH and MH/OH. For the sake of a simpler presentation, we have not presented this dual classification. Organic contents range from about 5% to 15% for the 13 samples tested.

The natural water content is plotted with the Atterberg Limits on Figures 4-23 and 4-24 for clays and silts sampled on land and in the water, respectively. It is evident from the plots that the natural water content of soils sampled from within the Cooper River are closer to the Liquid Limit and, therefore, also reflect higher void ratios. Void ratio as a function of elevation is plotted on Figure 4-25.

4.2.3 Consolidation Properties

Strain as a function of applied pressure from consolidation testing on soil samples obtained from soil Layer 2 are presented in Figure 4-26 for land borings and Figure 4-27 for water borings. The average compression ratio (slope of normally consolidated portion of consolidation curve plotted semi-log) for the samples obtained on land is 0.33 and the average compression ratio for the samples obtained in the Cooper River is 0.26. The compression index as a function of Liquid Limit is presented in Figure 4-28, along with the general relationship proposed by Terzaghi and Peck².

² Terzaghi, K. and Peck, R.B., *Soil Mechanics in Engineering Practice*, 2nd ed., John Wiley & Sons, Inc., New York, 1967, p. 73.



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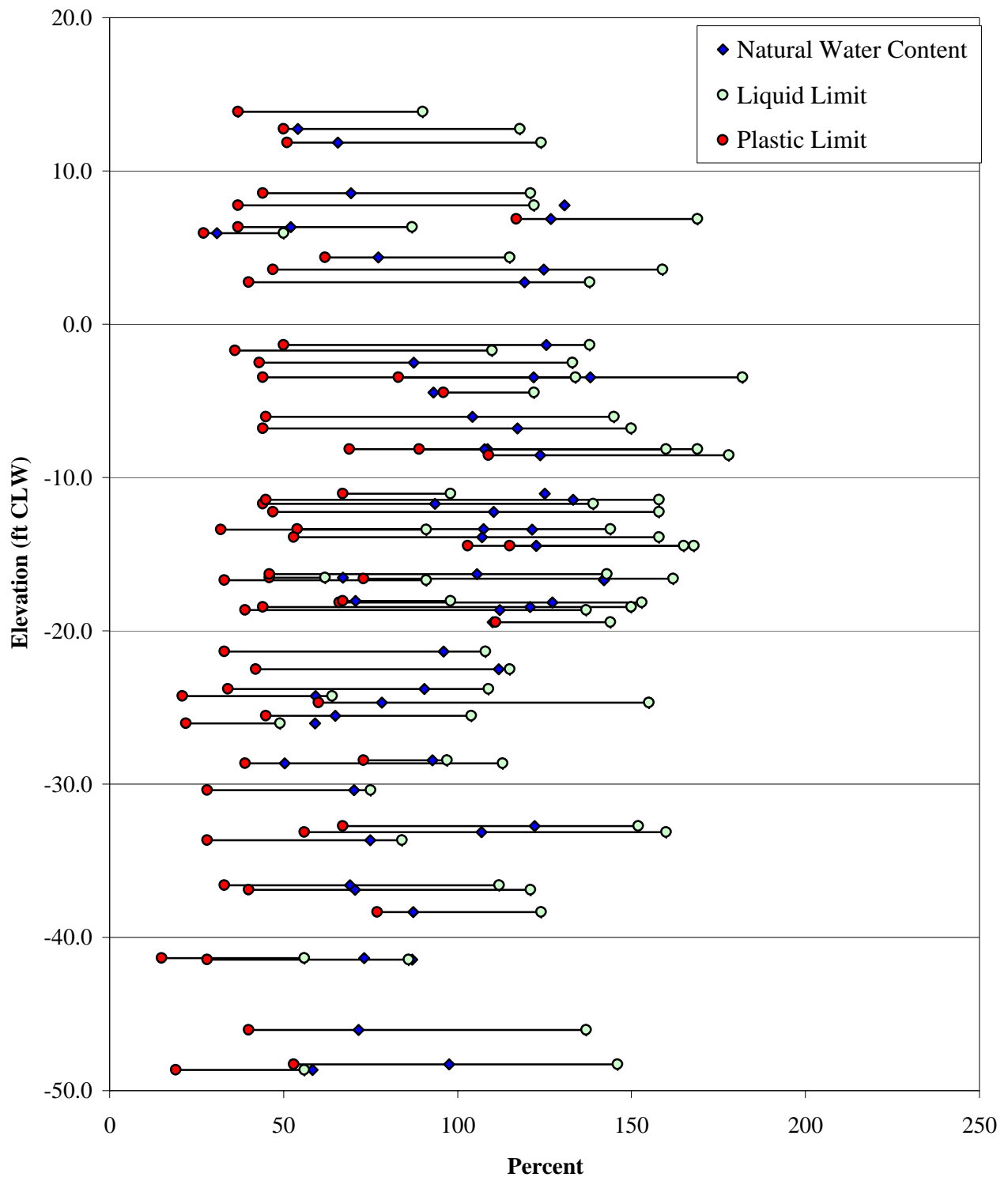
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SOIL PLASTICITY OF SEDIMENTS ABOVE COOPER MARL

CHARLESTON NAVAL BASE CONTAINER TERMINAL
NORTH CHARLESTON, SOUTH CAROLINA

Figure:
4-22



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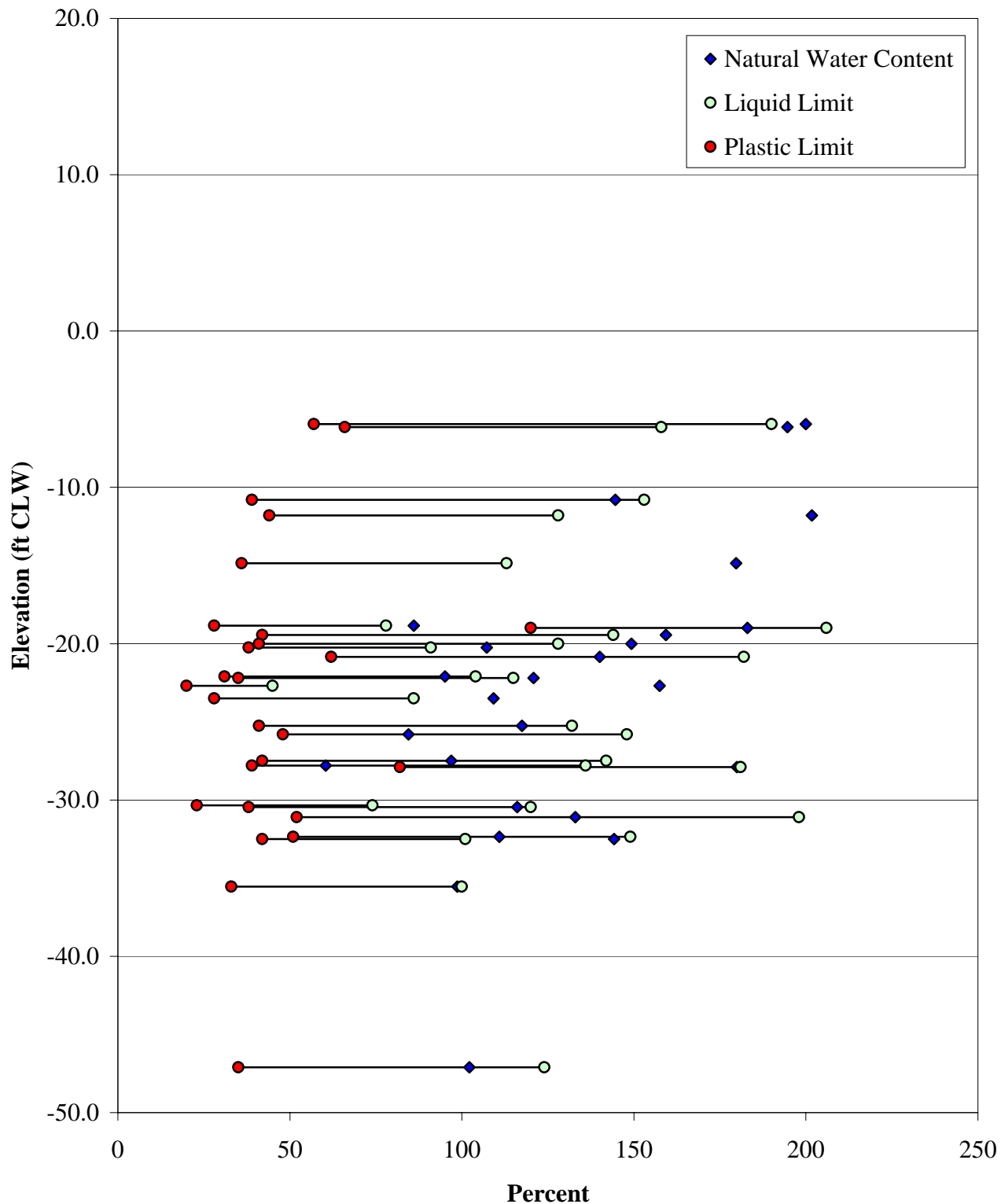
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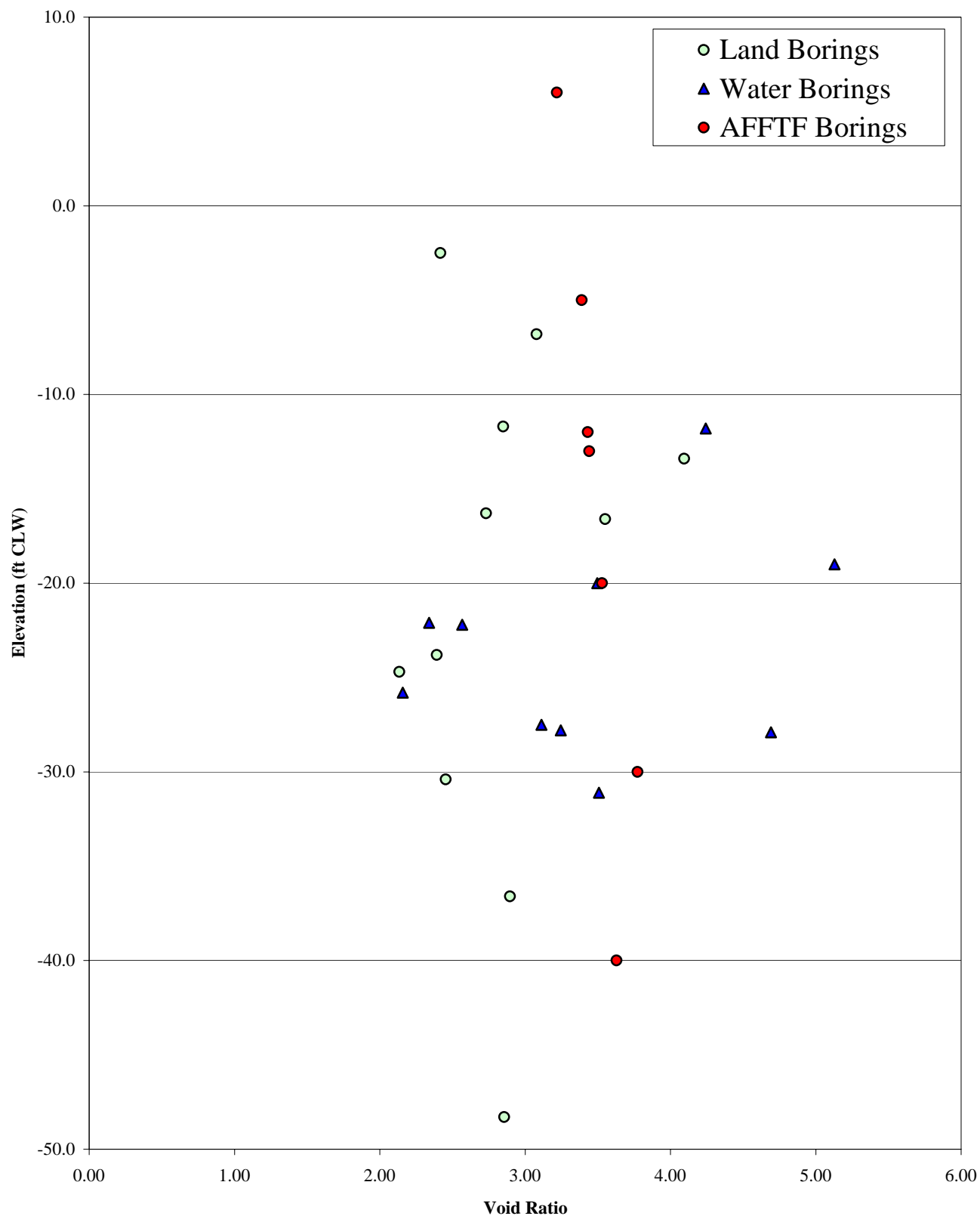


ATTERBERG LIMITS AND
NATURAL MOISTURE CONTENT
COHESIVE SOILS IN LAND BORINGS
CHAS. NAVAL BASE CONTAINER TERMINAL
NORTH CHARLESTON, SC

Figure:

4-23





Note: AFFTF-series samples are from previous site explorations for the Advanced Fire Fighting Training Facility.

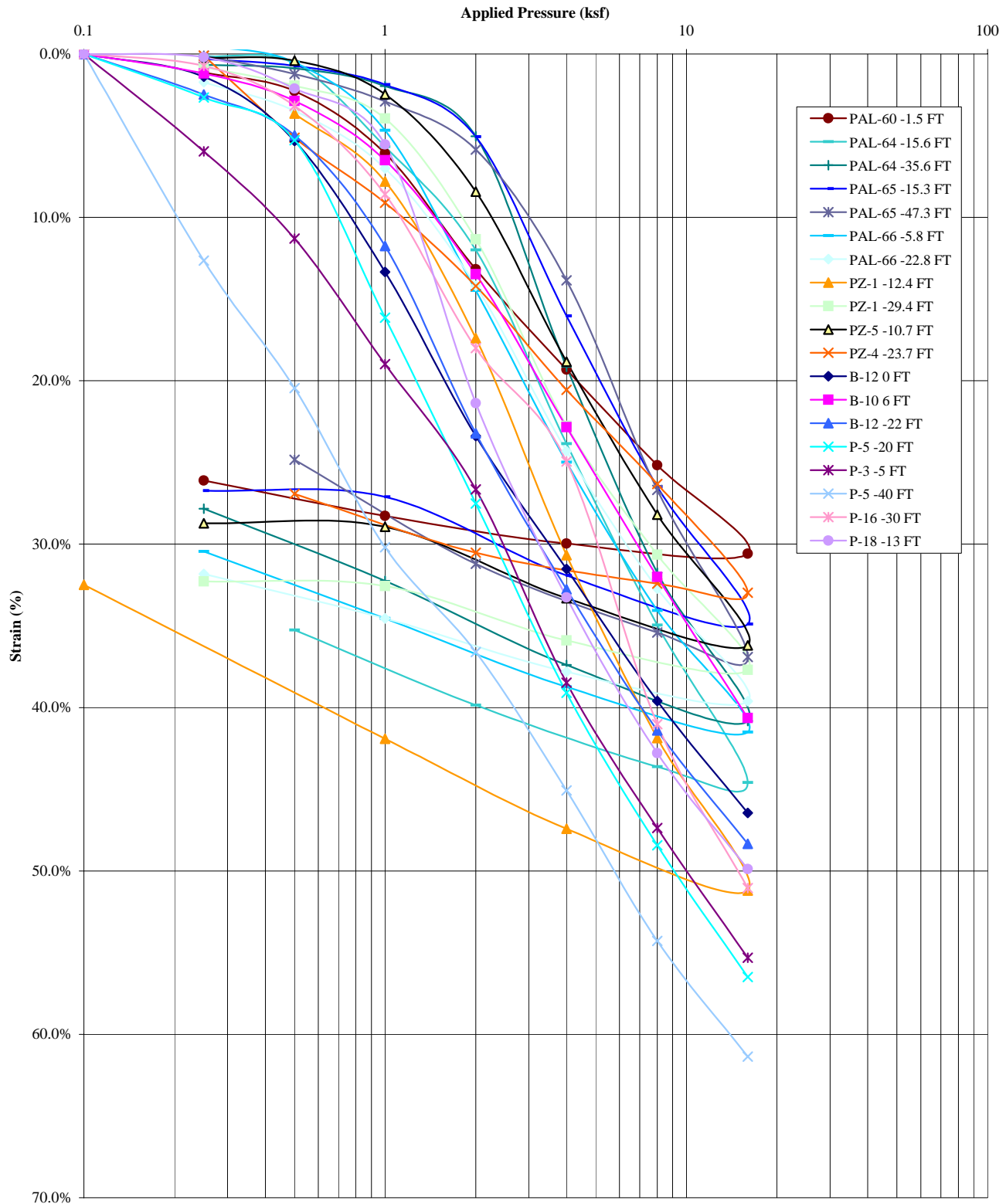
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SOFT FINE-GRAINED DEPOSITS
VOID RATIO AS A FUNCTION OF ELEVATION
CHAS. NAVAL BASE CONTAINER TERMINAL
NORTH CHARLESTON, SC

Figure:
4-25



Note: B-series and P-series samples are from previous site explorations for the Advanced Fire Fighting Training Facility

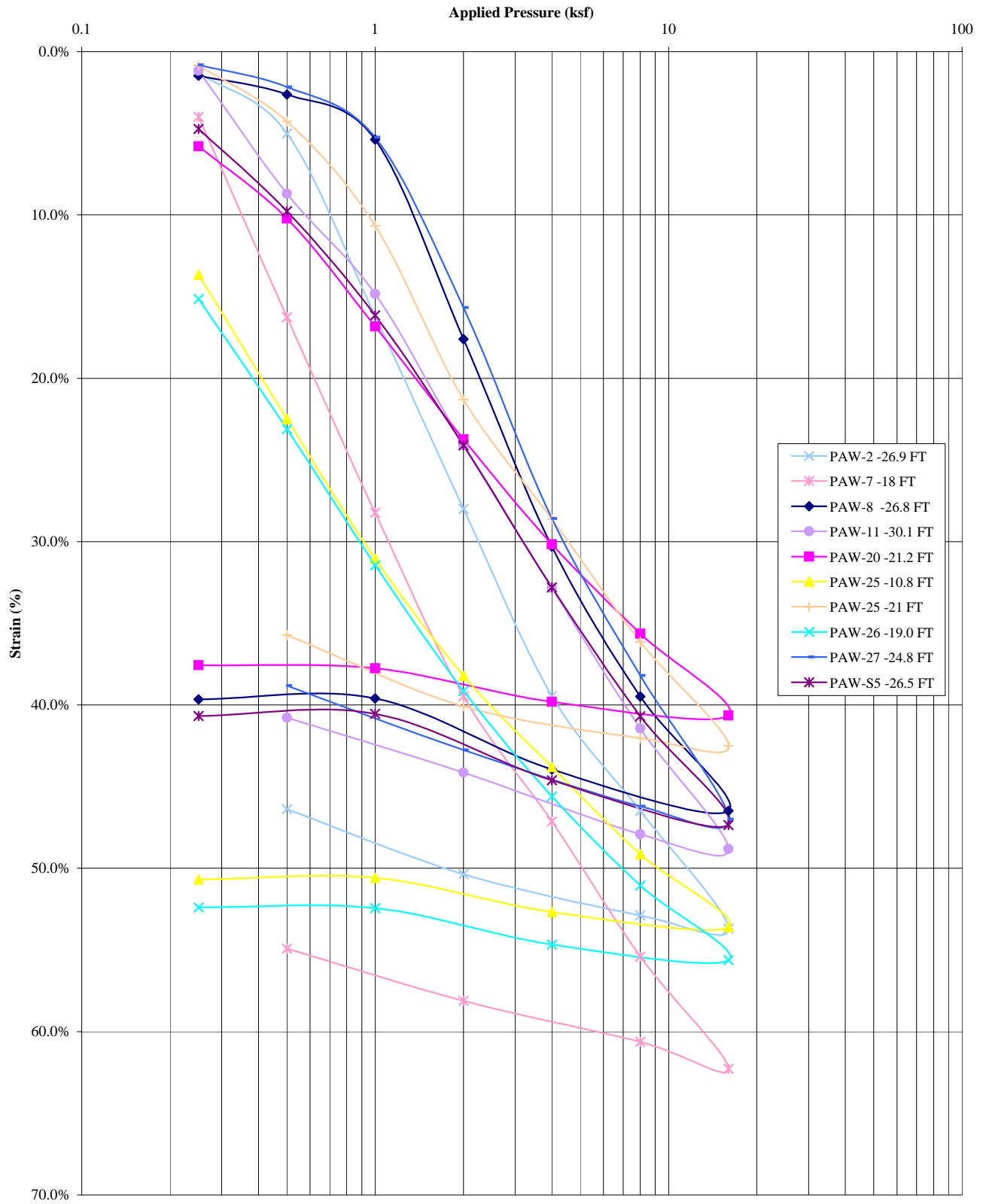
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**CONSOLIDATION TEST RESULTS
SPECIMENS FROM LAND BORINGS
CHAS. NAVAL BASE CONTAINER TERMINAL
NORTH CHARLESTON, SC**

**Figure:
4-26**



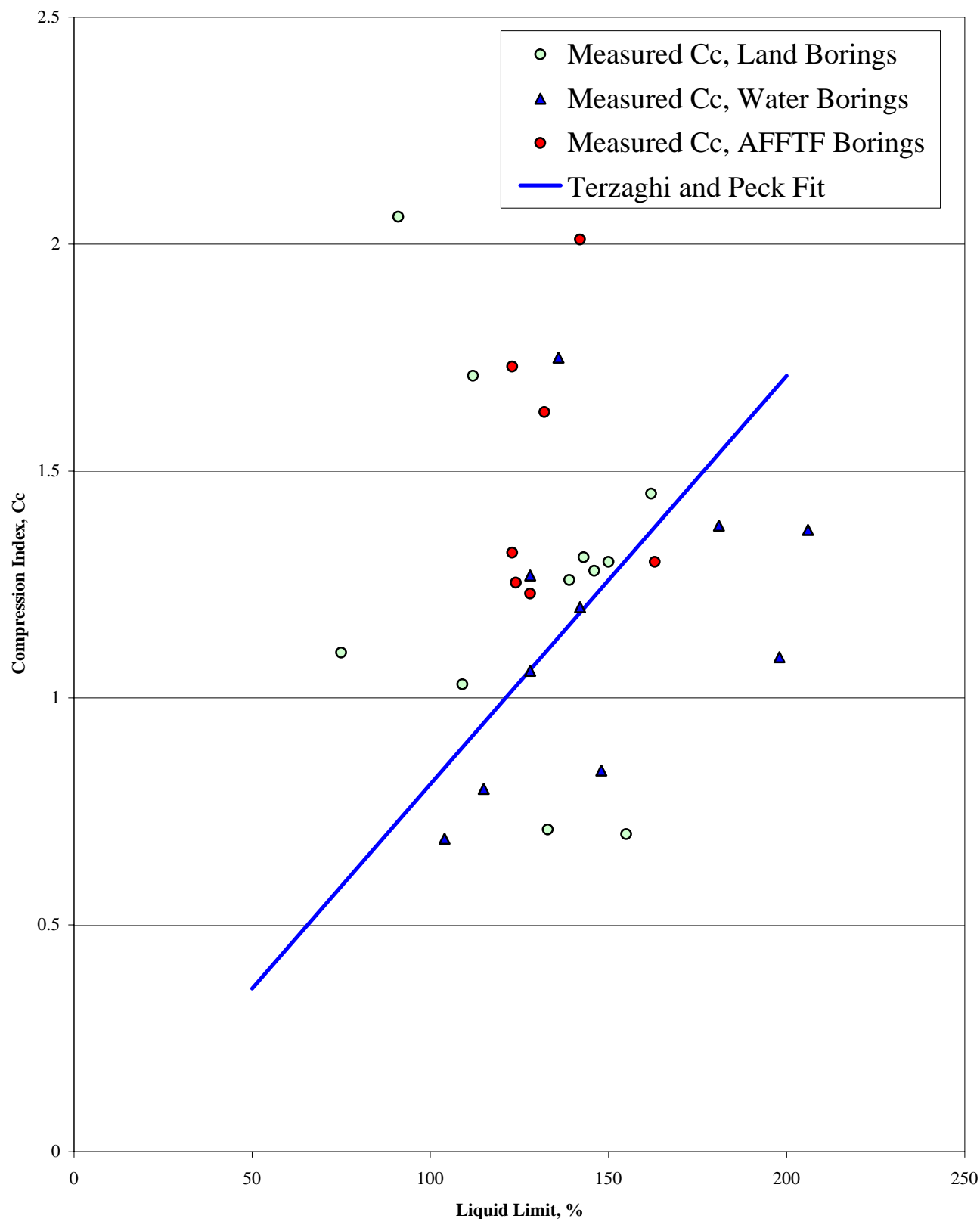
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CONSOLIDATION TEST RESULTS
SPECIMENS FROM WATER BORINGS
CHAS. NAVAL BASE CONTAINER TERMINAL
NORTH CHARLESTON, SC

Figure:
4-27



Note: AFFTF-series samples are from previous site explorations for the Advanced Fire Fighting Training Facility.

The vertical coefficient of consolidation, c_v , averaged about 0.01 ft²/day, and generally ranged between 0.003 and 0.02 ft²/day in the normally consolidated stress range. The horizontal coefficient of consolidation, c_h , averaged about 0.02 ft²/day, and generally ranged between 0.01 and 0.1 ft²/day based on the CPT pore-pressure dissipation test results in clay soil.

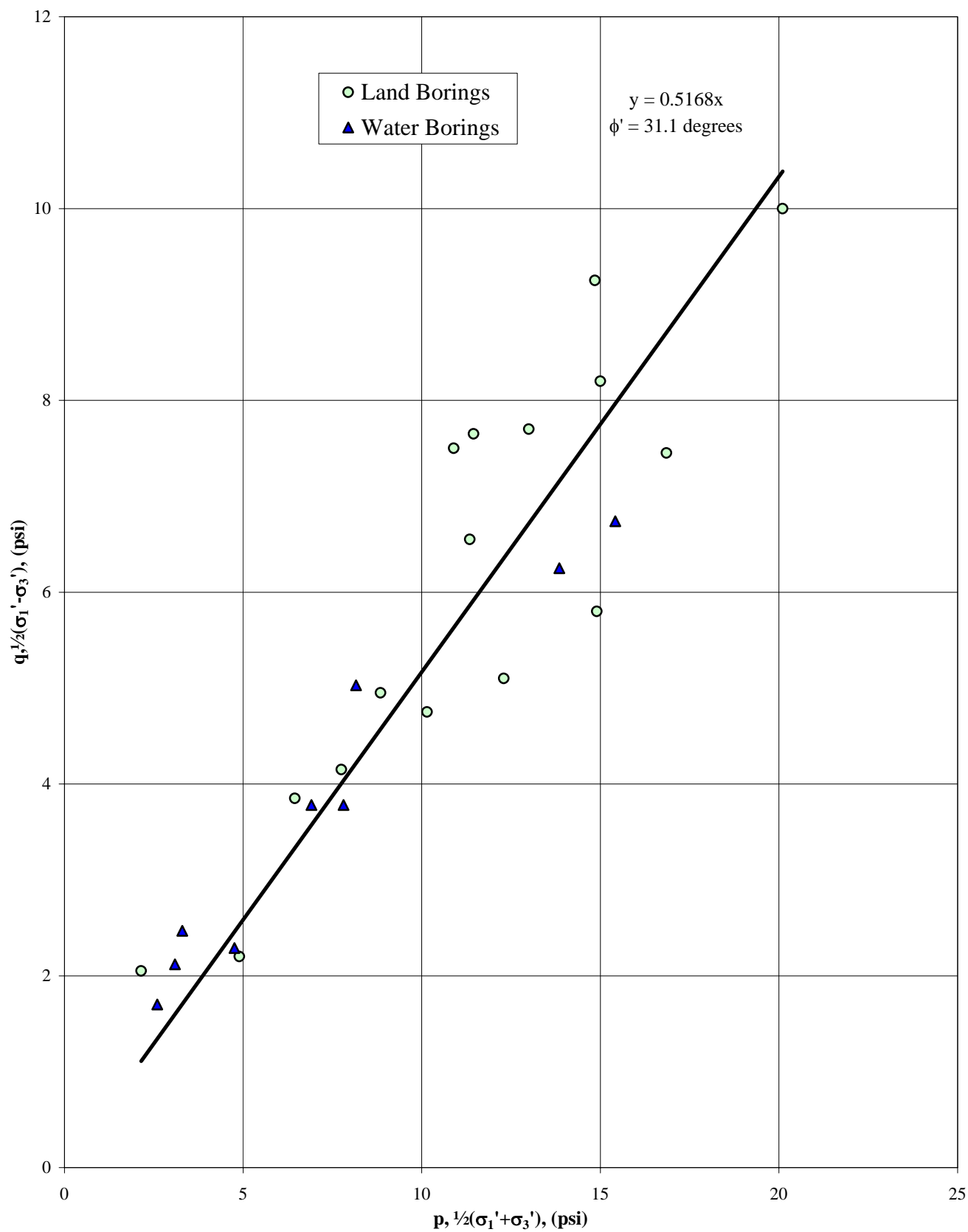
4.2.4 Strength Properties

We have used a modified Mohr-Coulomb plot (p-q plot) to show all of the consolidated-undrained triaxial test results together. This plot, Figure 4-29, shows one-half the peak stress difference ($q, \frac{1}{2}(\sigma_1' - \sigma_3')$) as a function of one-half the peak stress sum ($p, \frac{1}{2}(\sigma_1' + \sigma_3')$). The best fit line corresponds to an effective stress friction angle of 31.1 degrees. A plot of the undrained shear strength as a function of the consolidation pressure is presented in Figure 4-30. The best fit line corresponds to an undrained shear strength ratio of 0.26.

4.3 GROUNDWATER

Groundwater levels were recorded approximately 24 hours after the completion of soil borings, and immediately following the completion of the CPT soundings. The groundwater levels are presented on the soil boring and CPT logs, and the profiles in the Appendices. Groundwater was encountered at a median depth of 4 ft below the ground surface, corresponding to a median groundwater elevation of 8 ft CLW. Groundwater levels are expected to fluctuate with climatic, seasonal and tidal changes, as well as with construction activity at the site.

A time history of the three piezometers installed near CPT sounding PAL-39 (PZ-1 through PZ-3) is shown in Figure 4-31. We measured a groundwater elevation of 10.6 ft in the CPT hole at the time of our field exploration. The piezometric elevations measured by the piezometers range from about 8.1 ft to 10.4 ft CLW. The piezometric elevations lower than the apparent groundwater table may be indicative of vertical flow gradients within the soils, or the groundwater depth measured may not be representative due to the clay soils near the ground



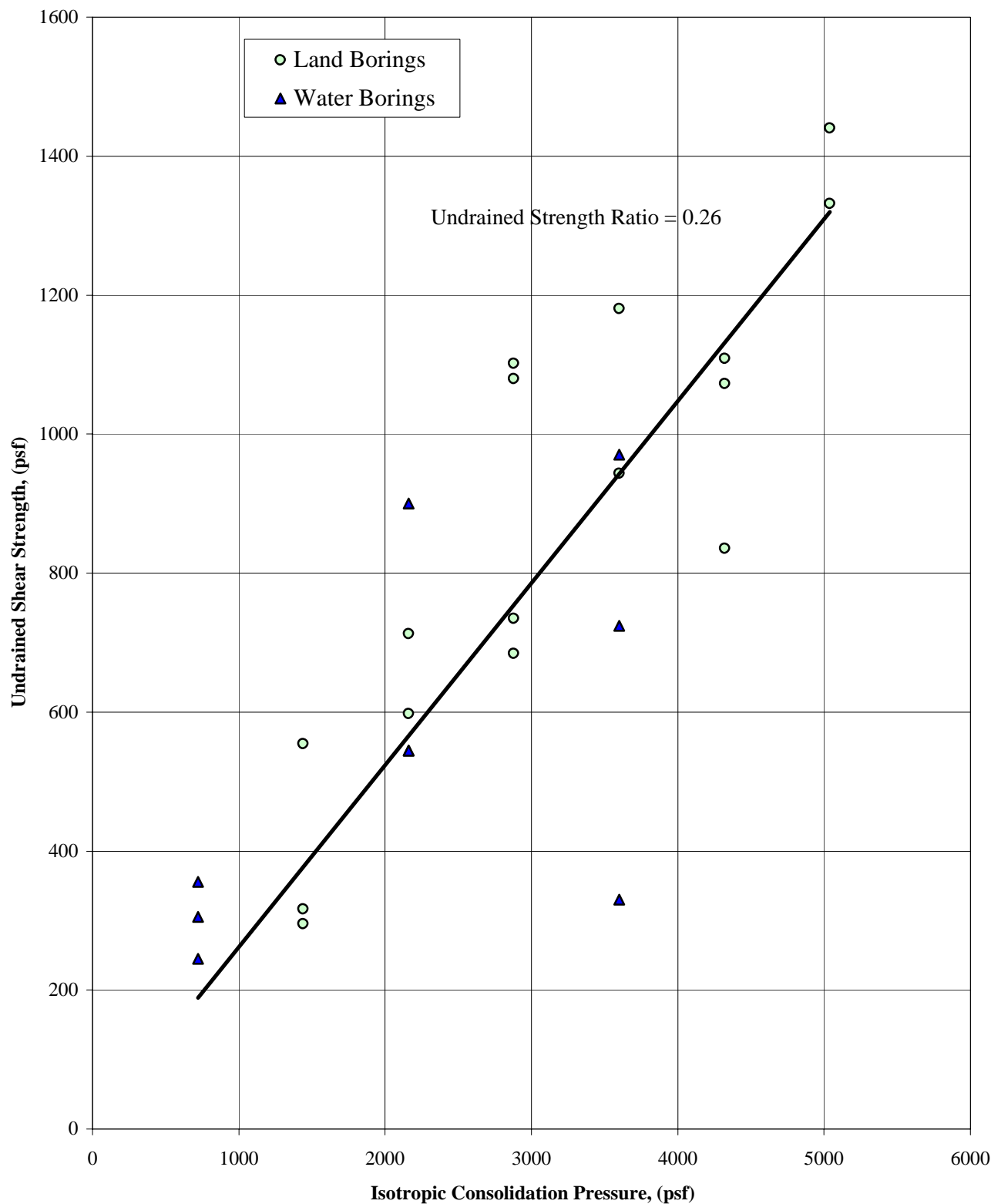
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SOFT FINE-GRAINED DEPOSITS
 TRIAXIAL COMPRESSION p-q PLOT
 CHAS. NAVAL BASE CONTAINER TERMINAL
 NORTH CHARLESTON, SC

Figure:
 4-29



Proj. No. 1131-03-264

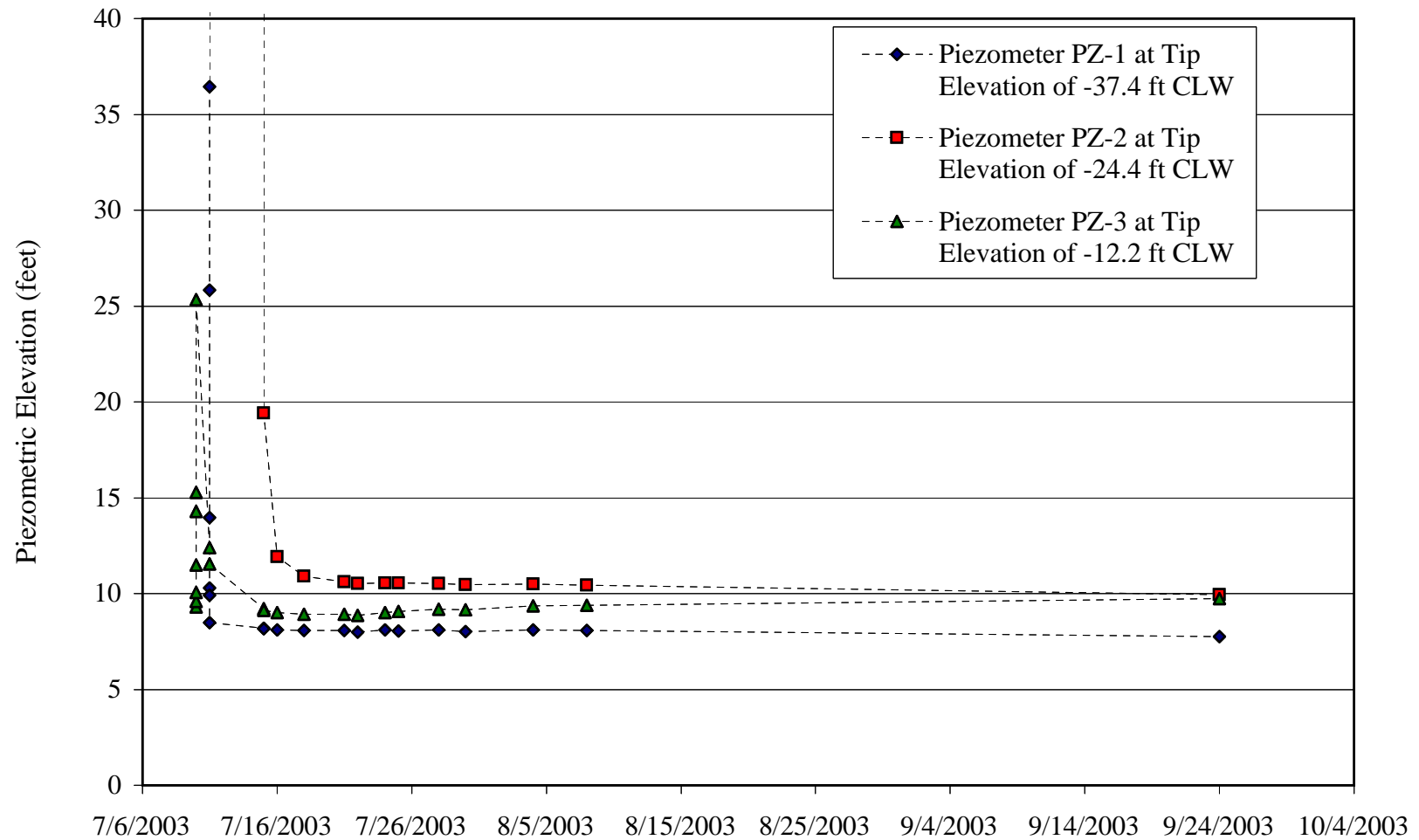
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SOFT FINE-GRAINED DEPOSITS
 TRIAXIAL COMPRESSION
 UNDRAINED STRENGTH RATIO PLOT
 CHAS. NAVAL BASE CONTAINER TERMINAL
 NORTH CHARLESTON, SC

Figure:

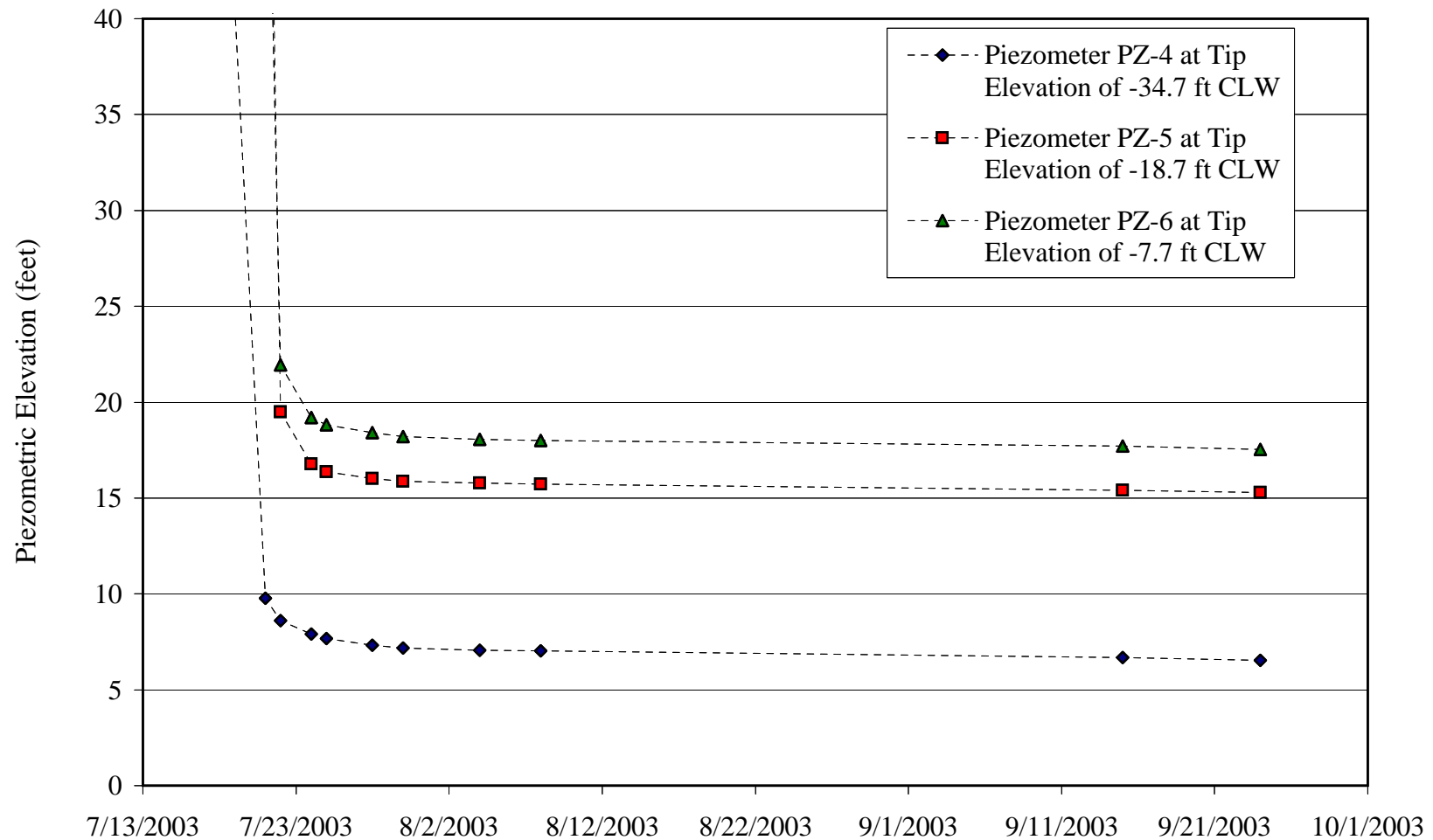
4-30



Proj. No.: 1131-03-264		TIME HISTORY PIEZOMETRIC ELEVATION MEASUREMENTS CHAS. NAVAL BASE CONTAINER TERMINAL NORTH CHARLESTON, SC	Figure: 4-31
SEPTEMBER 2003			

surface. Nonetheless, all measurements are within about 2½ ft of each other, and therefore there do not appear to be large excess pore pressures (in comparison to those that will be induced during site development) in the area near CPT sounding PAL-39. Considering the median ground water elevation of 8 ft CLW, there could be up to about 2½-ft head of excess pore-water pressure. We note that PZ-2, located farthest from drainage boundaries, has a higher piezometric elevation than piezometers located above or below it, also possibly indicating excess pore-water pressure due to the placement of dredge spoil. Assuming an original ground surface elevation of about 8 ft (and not accounting for the effects of fill submergence), there could be about 4 ft of fill in-place. If the fill has a unit weight about twice that of water, the maximum excess pore-water pressure (referenced to the median groundwater level), indicates that the dredge spoil and marsh deposits near PAL-39 may be about 70% consolidated at the present time.

A time history of the three piezometers installed near CPT sounding PAL-43 (PZ-4 through PZ-6) is shown in Figure 4-32. We measured a groundwater elevation of 11.3 ft CLW in the CPT hole at the time of our field exploration. The piezometric elevations measured by the piezometers range from about 7.0 ft to 18.0 ft CLW. The piezometric elevations significantly higher than the apparent groundwater table are indicative of the presence of excess pore-water pressures due the placement of dredge spoil. The portion of the site near PAL-43 has the highest ground surface elevation, and it is apparent from these piezometric elevation measurements that the underlying dredge spoil and marsh deposits have not fully consolidated. Assuming an original ground surface elevation of about 8 ft (and not accounting for the effects of fill submergence), there could be about 13 ft of fill in-place. If the fill has a unit weight about twice that of water, the maximum excess pore-water pressure (referenced to the observed groundwater level), indicates that the dredge spoil and marsh deposits near PAL-43 may be 75% consolidated at the present time. If the median ground water elevation of 8 ft CLW were referenced, then the dredge spoil and marsh deposits near PAL-43 may be only about 60% consolidated at the present time.



Proj. No.: 1131-03-264		TIME HISTORY PIEZOMETRIC ELEVATION MEASUREMENTS CHAS. NAVAL BASE CONTAINER TERMINAL NORTH CHARLESTON, SC	Figure: 4-32
SEPTEMBER 2003			

5.0 GEOGRAPHIC INFORMATION SYSTEM

We have compiled the information presented with this report in an ArcView™ Geographic Information System (GIS). The basis of the GIS is a 1999 satellite photograph obtained from the South Carolina Department of Natural Resources (SCDNR) GIS Clearinghouse. We have added layers to the photograph depicting the proposed terminal limits (shown in yellow), test locations from previous subsurface investigations (orange triangles), test locations from this subsurface investigation (green circles) and profile lines (shown in red) containing the combined data. For ArcView™ users, the test locations and profile lines are “hot-linked” (📌 button) to the boring/sounding logs and profiles and can be accessed by following the instructions enclosed with the CD on the inside back cover. For all other users, we have included ArcExplorer™, which will allow you to view the satellite photographs and layers, but not access the “hot-links.”

6.0 LIMITATIONS

This report has been prepared in accordance with generally accepted geotechnical engineering practice for specific application to this project. The data and conclusions contained in this report are based upon applicable standards of our practice in this geographic area at the time this report was prepared. No other warranty, express or implied, is made.