SUBSURFACE SOIL EXPLORATION AND RECOMMENDATIONS FOR KINGFISH BOAT RAMP AND PARKING LOT IMPROVEMENTS MANATEE AVENUE WEST, HOLMES BEACH, MANATEE COUNTY, FLORIDA

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Geotechnical, Environmental and
Materials Consultants

June 3, 2020
File No. 11-7511

TO: CPH Engineers, Inc.
501 Mariner Street, Suite 5
Tampa, FL 33609

Attention: Jeffrey Satfield
Email: jsatfield@cphengineers.com

SUBJECT: Subsurface Soil Exploration and Recommendations for
Kingfish Boat Ramp and Parking Lot Improvements
Manatee Avenue West, Holmes Beach, Manatee County, Florida

Dear Mr. Satfield:

As requested, our firm has completed a subsurface soil exploration program at the above-referenced site. Our services were provided in general accordance with those outlined in our proposal dated March 11, 2020. We understand the project involves a sheet pile seawall, stormwater retention/infiltration ponds, and parking lot improvements. The purpose of this program was to determine the nature and condition of the subsurface soils at the site, estimate the seasonal high groundwater table, provide soil parameters for use (by others) in the design of the proposed seawall, and provide soil and pavement subgrade preparation recommendations.

This report documents our findings and conclusions. It has been prepared for the exclusive use of CPH Engineers, Inc. and their consultants for specific application to the subject project, in accordance with generally-accepted geotechnical engineering practices.

SITE LOCATION AND CONDITIONS

The subject site is located in Holmes Beach, Manatee County, Florida. More specifically, the site is located on the north side of Manatee Avenue (SR-64), approximately 500 to 2,500 feet east of its intersection with East Bay Drive.

The USGS topographic survey map for the site vicinity (Bradenton Beach, Florida Quadrangle, with 5-foot contour interval, dated 1964, photo-revised 1987) was reviewed for ground surface features at the proposed project location (see attached Figure 1A). Based on this review, the natural ground surface elevation is in the range of +0 to +5 feet National Geodetic Vertical Datum of 1929 (NGVD). The map does not indicate any significant topographic features at the site, other than it is bordered by Anna Maria Sound.

REVIEW OF SOIL SURVEY MAPS

Based on the U.S. Department of Agriculture, Soil Conservation Service (now the Natural Resources Conservation Service) “Soil Survey of Manatee County, Florida,” the site is located in an area mapped primarily as the "Canaveral sand, filled" soil series, with a small area of the “Canaveral sand, organic substratum” soil series near the west end of the site. The approximate site location on the soils map from the NRCS “Web Soil Survey” is included as Figure 2A of this report.

The “Canaveral sand, filled” soil series consists of a nearly level, moderately well drained to somewhat poorly drained soil that consists of sand and shell that have been dredged or excavated from water areas and then leveled and smoothed, mainly for urban use. The fill material varies but generally ranges from about 20 inches to more than 80 inches in thickness, and consists primarily of sand and shell. In some places there may be balls of clayey or loamy soils in the fill. The underlying material is mostly mineral, but in some areas may be organic. According to the Soil Survey, in the wet season the water table is at a depth of about 40 to 60 inches, but varies depending upon the thickness of the fill material.

The “Canaveral sand, organic substratum” soil series consists of a nearly level, moderately well drained to somewhat poorly drained soil consisting of sand and shell fill overlying organic material. The sand and shell have been dredged or excavated and deposited on tidal swamps or marshes. The thickness of the deposited fill varies within short distances, but generally ranges from approximately 40 to 70 inches and is usually about 45 inches. According to the Soil Survey, the wet season water table is within 30 to 60 inches of the ground surface.

Selected other properties are included in the following table.

Map Symbol	Hydrologic Group	High Water Table (feet)	Depth (inch)	Unified Soil Classification	Percent Passing No. 200 Sieve	Percent Clay	Permeability (feet/day)
9	C	1.0 - 3.0	0 - 80	SP	1 - 4	<2	>40
10			0 - 45	SP	1 - 4	2 - 8	>40
	C	2.5 - 5	45 - 70	PT	---	---	4 - 12
			70 - 80	SP	1 - 3	1 - 8	12 - 40
MAP SYMBOL LEGEND				UNIFIED SOIL CLASSIFICATION LEGEND			
9 - Canaveral sand, filled				SP	- Poorly graded sand		
10 - Canaveral sand, organic substratum				PT	- Peat (muck)		
* More than one soil designated to this map symbol.							
Source: Natural Resources Conservation Service (1983)							

FIELD EXPLORATION PROGRAM

Our field exploration program consisted of conducting two (2) Standard Penetration Test (SPT) borings, four (4) pavement cores, four (4) double-ring infiltrometer (DRI) tests, with a hand auger boring at each of the DRI test locations. The approximate locations are shown on the attached Figure 3A. The equipment and procedures used in the borings are described in Appendix I of this report.

Test borings were located in the field utilizing an aerial photograph of the site and visual reckoning to available landmarks. The locations should be considered accurate only to the degree implied by the method used. Should more accurate locations be required, a registered land surveyor should be retained.

Standard Penetration Tests

The SPT borings are identified as SPT-1 to SPT-2 and were performed to determine the nature and condition of the subsurface soils to a depth of 40 feet below the existing ground surface. The SPT soil borings were initially drilled to a depth of 4½ feet with a hand auger in order to avoid damaging possible underground utilities. The soil conditions encountered at these borings are shown on the graphic soil profiles (boring logs) on Figure 3A of this report.

Pavement Cores

The pavement cores are identified as C-1 to C-4 and were performed to determine the nature and condition of the pavement and subsurface soils to a depth of approximately 5 feet below the existing ground surface. The soil conditions encountered at these borings are shown on the graphic soil profiles (boring logs) on Figure 4A of this report.

The pavement "cores" were performed with a hand auger, rather than with an asphalt/concrete core barrel, since a "shell" pavement was present at these locations, instead of an asphalt or concrete pavement.

Double-Ring Infiltrometer Test (DRI)

The double-ring infiltrometer tests are identified as DRI-1 to DRI-4. The test results are summarized on Plates 1 to 4 of Appendix II of this report. The test results indicate a vertical infiltration rate between 0.45 to 7.0 inch/hour (0.9 to 14 feet/day).

The depth (below existing ground) at which the test was performed was based upon the soil conditions and existing groundwater table depth encountered at each location. The test depths varied from 3 inches to 24 inches below the ground surface.

The test procedure is based upon the procedures of ASTM D-3385. Additional information on the test procedure and interpretation of the test results are included in Appendix I of this report. Estimated hydraulic conductivity (k) values based upon the test results will be presented later in this report.

GENERAL SUBSURFACE CONDITIONS

The general subsurface conditions encountered during the field exploration program are shown on the soil boring logs on Figures 3A to 4A of this report. Soil stratification is based on examination of recovered soil samples and interpretation of field boring logs. The stratification lines represent the approximate boundaries between the soil types, while the actual transitions may be gradual.

A generalization of the subsurface soil conditions encountered in the borings is described below:

DEPTH (feet)		
From	**To**	**SOIL DESCRIPTION**
0	4½	Fine sand (SP), fine sand with silt (SP-SM) and sandy shell (SW). Varying amount of shell.
4½	27	Loose to medium dense fine sand (SP), fine sand with silt (SP-SM) and silty fine sand (SM). Varying amount of shell.
27	40	Dense to very dense fine sand (SP) and fine sand with silt (SP-SM). Varying amount of shell.

On the dates of our field exploration program the water table was encountered at a depth of approximately 2.3 to 3.9 feet below existing grade, except that groundwater was not encountered within the boring depth of 6 feet at boring DRI-4. The water table level is anticipated to fluctuate due to seasonal rainfall variations, the tides and other factors.

LABORATORY TESTING PROGRAM

Representative soil samples obtained from the SPT and hand auger borings were packaged and transferred to our office and, thereafter, examined by a geotechnical engineer. The soil descriptions shown on the soil boring log are based on a visual classification procedure in general accordance with the Unified Soil Classification System (ASTM D-2488-84) and standard practice.

ENGINEERING EVALUATION AND RECOMMENDATIONS

Soil Parameters for Seawall Design

This section includes recommended soil parameters for use by others in design of a seawall. The design should consider that layers of dense to very dense sands were encountered below a depth of approximately 27 feet.

Based upon the soil classifications and SPT “N” values, the internal friction angle, cohesion, unit weights and lateral earth pressure coefficients have been estimated for the soils encountered at borings SP-1 and SP-2. These are listed in the following tables.

Boring SP-1

Depth (feet)	Unified Soil Classification	Saturated Weight (pcf)	Moist Unit Weight (pcf)	Internal Friction Angle (degrees)	Cohesion (ksf)	Active Earth Pressure Coef.	Passive Earth Pressure Coef.	At-Rest Earth Pressure Coef.
BP - 4.5	SP-SM	125	110	32	0	0.31	3.3	0.47
4.5 - 27	SP/SM/SP-SM	116	---	29	0	0.35	2.9	0.52
27 - 40	SP/SP-SM	126	---	37	0	0.25	4.0	0.40

Boring SP-2

Depth (feet)	Unified Soil Classification	Saturated Weight (pcf)	Moist Unit Weight (pcf)	Internal Friction Angle (degrees)	Cohesion (ksf)	Active Earth Pressure Coef.	Passive Earth Pressure Coef.	At-Rest Earth Pressure Coef.
BP - 4.5	SP-SM/SP	125	110	32	0	0.31	3.3	0.47
4.5 - 20	SP	115	---	28	0	0.36	2.8	0.53
20 - 40	SP-SM/SP	124	---	37	0	0.25	4.0	0.40

NOTES
(1) These values in this table are intended for design (stability) analysis, only, and should not be used to determine constructability.
(2) Bouyant unit weight = (saturated unit weight) - (unit weight of water)
(3) Moist unit weight applies only above the groundwater table.

The values listed in the table are for the soils in their in-situ condition. If backfill is to be placed next to the seawall, these values may not be relevant. For a clean, well compacted, granular (sand) backfill, we recommend an internal friction angle of 32°, a moist unit weight of 110 pcf and a saturated unit weight of 125 pcf. The active (0.31), passive (3.3) and at rest (0.47) earth pressure coefficients corresponding to this friction angle should, therefore, also be used for this backfill.

The values in the above table are for geotechnical design (lateral and rotational stability) analysis of the seawall, only. They should not be used to determine the constructability.

The seawall may be designed using active, passive, and/or at rest pressure distributions, supplemented with the lateral pressures induced by groundwater (hydrostatic forces) and by compaction of the backfill. Compaction induced stresses vary with the type and weight of the compactor used during construction, as well as how near the compactor is permitted to the structure.

In general, a drain should be used on the landward side of the seawall structure, to minimize hydrostatic pressures acting on the structure.

Seasonal High Groundwater Table

The groundwater table in the surficial aquifer generally occurs within a few to several feet below the ground surface. Seasonal variations in rainfall and evapotranspiration cause the groundwater table to fluctuate. The seasonal high groundwater table is the highest level that is reached during the year, but it varies from year to year, primarily due to rainfall variations.

For a typical year in Manatee County, over 60% of the annual rainfall occurs during the four months of June through September. During this period, the groundwater table rises to its highest level, which typically occurs in August to September. During the relatively dry portion of the year (from October to May), the groundwater table recedes to lower levels.

The ground surface elevation at each of the hand auger boring locations was estimated by plotting the approximate boring locations onto a topographic survey of the site provided by CPH Engineering (CPH Job No. M13112, Sheets 1 to 4 of 4, dated 5/6/20). The groundwater table elevations were then referenced to the estimated ground surface elevation. These elevations should be considered accurate only to the degree implied.

The seasonal high groundwater table was estimated at each of our hand auger boring locations, based upon our review of the NRCS Soil Survey and our field explorations. The depth (below the existing ground surface) of the groundwater table at the time of our field explorations and our estimate of the seasonal high groundwater table for each location are summarized in the following table.

Boring Number	Existing Ground Surface Elevation (feet, NAVD88)	Existing Groundwater Table			Seasonal High Groundwater Table	
		Depth (feet)	Elevation (feet, NAVD88)	Date (Day-Mo-Yr)	Depth (feet)	Elevation (feet, NAVD88)
C-1	4.2	3.0	1.2	18-May-20	2.4	1.8
C-2	3.4	2.9	0.5	18-May-20	1.6	1.8
C-3	5.2	4.0	1.2	18-May-20	3.4	1.8
C-4	2.8	2.1	0.7	18-May-20	1.5	1.3
DRI-1	2.8	1.2	1.6	18-May-20	0.8	2.0
DRI-2	2.7	1.2	1.5	18-May-20	0.7	2.0
DRI-3	3.0	2.8	0.3	18-May-20	1.0	2.0
DRI-4	6.0	>6.0	---	18-May-20	4.0	2.0

Soil Hydraulic Conductivity

The double-ring infiltrometer (DRI) test measures the vertical infiltration rate under the test conditions (test depth, size of the infiltration surface, etc.). This may not represent the infiltration rate from a full-size infiltration basin and is not a direct measurement of the vertical hydraulic conductivity (k_v) of soils. In general, however, the infiltration rate near the end of the test is no greater than the unsaturated vertical hydraulic conductivity (k_{vu}), since a saturated condition is generally not achieved by tests of this type and the hydraulic gradient near the end of the test is generally equal to or less than 1.0. Therefore, the infiltration rate near the end of the test can generally be used as a reasonable, and probably somewhat conservative estimate of k_{vu}.

In the generally horizontally stratified sandy soil deposits typical of southwest Florida, the saturated horizontal hydraulic conductivity (k_{HS}) is greater than k_{VU}, usually by a factor of approximately 2.25. Considering that the shallow soils at the site are probably fill materials instead of naturally stratified sediments, multiplying the k_{VU} by a factor of 2.25 may yield a non-conservatively high estimate of k_{HS}. We, therefore, recommend the assumption that k_{HS} = 1.5 x k_{VU}.

Based upon the above, we recommend the following values for the shallow sandy soils at the site, based upon the DRI test results.

Location	Test Infiltration Rate (feet/day)	k_{VU} (feet/day)	k_{HS} (feet/day)
DRI-1	8.8	8.8	13
DRI-2	0.9	0.9	---
DRI-3	12	12	18
DRI-4	14	14	21

The relatively low infiltration rate at DRI-2 is considered to be primarily representative of the surficial layers of dark brown to brown fine sands encountered at this location. The underlying layers of “gray fine sand” and “gray fine sand & shell” likely have a significantly greater permeability, so no value of k_{HS} is listed for this location. The k_{HS} value at DRI-2 is probably similar to the k_{HS} values at the other DRI locations.

No factor of safety has been applied to the above values. The design engineer should decide if application of a factor of safety is appropriate.

Pavement Subgrade Preparation Recommendations

The existing soils encountered at the site would generally be considered an excellent to good subgrade for either a flexible (asphalt) or rigid (concrete) pavement, if the soils are adequately prepared and compacted prior to placement of additional fill, stabilization of the pavement subgrade and pavement construction. The recommended soil preparation procedure is summarized below:

1. The parking/drive areas to be paved should be cleared (stripped) of all surface vegetation and organic debris. After stripping, this area should be grubbed or root-raked to completely remove roots with a diameter greater than ½ inch, stumps, or smaller roots in a concentrated state. The actual depths of stripping and grubbing must be determined by visual observation and judgment during the earthwork operation.

2. Following the clearing operations, the exposed subgrade should be evaluated and proof-rolled to confirm that all unsuitable materials have been removed. The proof-rolling should consist of compaction with equipment capable of providing the densities required below. Careful observations should be made during proof-rolling to help identify any areas of soft yielding soils that may require over-excavation and replacement. Care should be used when operating vibratory compactors near existing structures (within 75 feet) to avoid transmission of vibrations that could cause settlement damage. Areas close to existing structures should be compacted using static (non-vibratory) compaction methods.

3. After proof-rolling and remediation of any yielding areas noted, the parking/drive areas should be compacted with at least 6 passes with equipment capable of achieving the compaction requirements. Each pass should overlap the preceding pass by at least 30 percent (%). Sufficient passes should be made over the parking/drive areas to produce a density of at least 95% of Modified Proctor (ASTM D-1557) maximum density to a depth of 1 foot below the compacted surface.

4. After compaction and testing to verify that the desired compaction has been achieved at this elevation, fill (if required) consisting of clean fine sands containing no more than 12% passing the No. 200 sieve, and having a Unified Soil Classification (ASTM D-2487) of “SP” or “SP-SM,” can be placed in level lifts not exceeding 12 inches loose thickness and compacted with the equipment described above. Each lift should be compacted to at least 95% of Modified Proctor maximum density prior to the placement of subsequent lifts and density tests shall be performed to confirm compaction in each fill lift before the next lift is placed.

5. A geotechnical engineer or his representative from Ardaman & Associates, Inc., Sarasota office, should inspect and test the compacted cleared and grubbed elevation and each layer of fill to verify compliance with the above recommendations.

If a stabilized sub-base having a minimum LBR of 40 is required for the pavement, stabilization of the existing soils likely be necessary. The “natural” sandy soils (i.e. the soils outside of or underlying the existing “shell” surface) will likely need to be stabilized with coarse aggregate (crushed concrete, gravel or coarse washed shell) in order to achieve the required LBR value. Silty or clayey materials should not be used as stabilizer. The stabilized subbase should be compacted to at least 98 percent of the modified Proctor maximum dry density (ASTM D-1557, AASHTO T-180).

Based upon the test borings at locations C-1 to C-4, the existing “shell” surface consists of fine sand to fine sand with shell mixed with shell and shell fragments. The borings indicate this layer to be approximately 3 to 4 inches thick at C-1 to C-3 and 8 inches thick at C-4. This layer could likely be mixed into the underlying sandy soils to construct a stabilized sub-base as described in the preceding paragraph.

If the proposed pavement design includes a shell base, the existing “shell” surface could also likely be reused as a pavement base by mixing with additional coarse aggregate (coarse shell of gravel) in order to achieve a minimum LBR value of 100 (or greater if required for the pavement design).

GENERAL COMMENTS

The analysis and recommendations submitted in this report are based upon the data obtained from test borings performed at the locations indicated on the attached Figure 3A. This report does not reflect any variations which may occur outside of or between the boring locations. While the borings are representative of the subsurface conditions at their respective locations and within their respective vertical reaches, local variations characteristic of the subsurface materials of the region are anticipated and may be encountered. The nature and extent of variations may not become evident until during the course of a ground improvement program, if such a program is undertaken. If variations then appear evident, it will be necessary to reevaluate the recommendations of this report, after performing on-site observations during the construction period and noting the characteristics of any variations. The boring logs and related information are based upon the driller's logs and visual examination of selected samples in the laboratory. The delineation between soil types shown on the logs is approximate, and the description represents our interpretation of the subsurface conditions at the designated boring location on the particular date drilled.

The groundwater table depths shown on the boring logs represent the groundwater surfaces encountered on the dates shown. Fluctuation of the groundwater table should be anticipated throughout the year.

It has been a pleasure to be of assistance to you with this project. Please contact us when we may be of further service to you, or should you have any questions concerning this report.

Very truly yours,

ARDAMAN & ASSOCIATES, INC.
Fl. Registry No. 5950

JERRY H. KUEHN
LICENSE
No. 35557
STATE OF
FLORIDA
PROFESSIONAL ENGINEER

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APPENDIX I

Soil Boring, Sampling and Test Methods

SOIL BORING, SAMPLING AND TESTING METHODS

Standard Penetration Test

The Standard Penetration Test (SPT) is a widely accepted method of in situ testing of foundation soils (ASTM D-1586). A 2-foot long, 2-inch O.D. split-barrel sampler attached to the end of a string of drilling rods is driven 18 inches into the ground by successive blows of a 140-pound hammer freely dropping 30 inches. The number of blows needed for each 6 inches of penetration is recorded. The sum of the blows required for penetration of the second and third 6-inch increments of penetration constitutes the test result or N-value. After the test, the sampler is extracted from the ground and opened to allow visual examination and classification of the retained soil sample. The N-value has been empirically correlated with various soil properties allowing a conservative estimate of the behavior of soils under load. The following tables relate N-values to a qualitative description of soil density and, for cohesive soils, an approximate unconfined compressive strength (Qu):

Cohesionless Soils:

N-Value	Description
0 to 4	Very loose
4 to 10	Loose
10 to 30	Medium dense
30 to 50	Dense
Above 50	Very dense

Cohesive Soils:

N-Value	Description	Qu (ton/ft^2)
0 to 2	Very soft	Below 1/4
2 to 4	Soft	1/4 to 1/2
4 to 8	Medium stiff	1/2 to 1
8 to 15	Stiff	1 to 2
15 to 30	Very stiff	2 to 4
Above 30	Hard	Above 4

The tests are usually performed at 5-foot intervals. However, more frequent or continuous testing is done by our firm through depths where a more accurate definition of the soils is required. The test holes are advanced to the test elevations by rotary drilling with a cutting bit, using circulating fluid to remove the cuttings and hold the fine grains in suspension. The circulating fluid, which is a bentonitic drilling mud, is also used to keep the hole open below the water table by maintaining an excess hydrostatic pressure inside the hole. In some soil deposits, particularly highly pervious ones, NX-size flush-coupled casing must be driven to just above the testing depth to keep the hole open and/or prevent the loss of circulating fluid.

Representative split-spoon samples from each sampling interval and from every different stratum are brought to our laboratory in air-tight jars for further evaluation and testing, if necessary. After thorough examination and testing of the samples, the samples are discarded unless prior arrangements have been made. After completion of a test boring, the hole is kept open until a steady state groundwater level is recorded. The hole is then sealed, if necessary, and backfilled.

A hammer with an automatic drop release (auto-hammer) is sometimes used. In this case, a correction factor is applied to the raw blow counts, since the energy efficiency of the auto-hammer is greater than that of the safety hammer. Based upon calibration of the auto-hammer (per ASTM D4633) and standard practice, we use a multiplier of 1.24 to correct the auto-hammer blow counts to equivalent safety hammer "N" values.

Hand Auger Borings

Hand auger borings are used, if soil conditions are favorable, when the soil strata are to be determined within a shallow (approximately 5 to 9 feet) depth or when access is not available to power drilling equipment. A 3-inch diameter, hand bucket auger with a cutting head is simultaneously turned and pressed into the ground. The bucket auger is retrieved to the surface at approximately 6-inch intervals and its contents emptied for inspection. The soil sample so obtained is classified and representative samples put in bags or jars and transported to the laboratory for further classification and testing.

Laboratory Test Methods

Soil samples returned to our laboratory are examined by a geotechnical engineer or geotechnician to obtain more accurate descriptions of the soil strata. Laboratory testing is performed on selected samples as deemed necessary to aid in soil classification and to further define engineering properties of the soils. The test results are presented on the soil boring logs at the depths at which the respective sample was recovered, except that grain size distributions or selected other test results may be presented on separate tables, figures or plates as described in this report. The soil descriptions shown on the logs are based upon a visual-manual classification procedure in general accordance with the Unified Soil Classification System (ASTM D-2488-84) and standard practice. Following is a list of abbreviations which may be used on the boring logs or elsewhere in this report.

-200	- Fines Content (percent passing the No. 200 sieve); ASTM D1140
DD	- Dry Density of Undisturbed Sample; ASTM D2937
Gs	- Specific Gravity of Soil; ASTM D854
k	- Hydraulic Conductivity (Coefficient of Permeability)
LL	- Liquid Limit; ASTM D423
OC	- Organic Content; ASTM D2974
pH	- pH of Soil; ASTM D2976
PI	- Plasticity Index (LL-PL); ASTM D424
PL	- Plastic Limit; ASTM D424
Qp	- Unconfined Compressive Strength by Pocket Penetrometer;
Qu	- Unconfined Compressive Strength; ASTM D2166 (soil), D7012 (rock)
SL	- Shrinkage Limit; ASTM D427
ST	- Splitting Tensile Strength; ASTM D3967 (rock)
USCS	- Unified Soil Classification System; ASTM D2487, D2488
w	- Water (Moisture) Content; ASTM D2216

Soil Classifications

The soil descriptions presented on the soil boring logs are based upon the Unified Soil Classification System (USCS), which is the generally accepted method (ASTM D-2487 and D-2488) for classifying soils for engineering purposes. The following modifiers are the most commonly used in the descriptions.

For Sands:	Modifier	Fines, Sand or Gravel Content*
	with silt or with clay	5% to 12% fines
	silty or clayey	12% to 50% fines
	with gravel or with shell	15% to 50% gravel or shell

For Silts or Clays:	Modifier	Fines, Sand or Gravel Content*
	with sand	15% to 30% sand and gravel; and % sand > % gravel
	sandy	30% to 50% sand and gravel; and % sand > % gravel
	with gravel	15% to 30% sand and gravel; and % sand < % gravel
	gravelly	30% to 50% sand and gravel; and % sand < % gravel

* may be determined by laboratory testing or estimated by visual/manual procedures. Fines content is the combined silt and clay content, or the percent passing the No. 200 sieve.

The USCS also uses a set of Group Symbols, which may also be listed on the soil boring logs. The following is a summary of these.

Group Symbol	General Group Name*	Group Symbol	General Group Name*
GW	Well-graded gravel	SW	Well-graded sand
GP	Poorly graded gravel	SP	Poorly graded sand
GW-GM	Well-graded gravel with silt	SW-SM	Well-graded sand with silt
GW-GC	Well-graded gravel with clay	SW-SC	Well-graded sand with clay
GP-GM	Poorly graded gravel with silt	SP-SM	Poorly graded sand with silt
GP-GC	Poorly graded gravel with clay	SP-SC	Poorly graded sand with clay
GM	Silty gravel	SM	Silty sand
GC	Clayey gravel	SC	Clayey sand
GC-GM	Silty, clayey gravel	SC-SM	Silty, clayey sand
CL	Lean clay	ML	Silt
CL-ML	Silty clay	MH	Elastic silt
CH	Fat clay	OL or OH	Organic silt or organic clay

* Group names may also include other modifiers, per standard or local practice.

Other soil classification standards may be used, depending on the project requirements. The AASHTO classification system is commonly used for highway design purposes and the USDA soil textural classifications are commonly used for septic (on-site sewage disposal) system design purposes.

Double-Ring Infiltrometer Test

The double-ring infiltrometer test is used to determine the vertical infiltration rate of in situ soils above the water table. The test procedure is based upon ASTM D-3385.

The test uses two open-ended cylinders (rings), driven concentrically into the soil to a depth of a few inches. The radius of the outer ring is approximately twice that of the inner ring. Both the inner ring and the outer ring are partially filled with water (or other liquid, when appropriate) and the liquid is maintained at a constant level. The volume of liquid added to the inner ring, to maintain the liquid level constant during timed intervals, is used to calculate the incremental infiltration velocity. The maximum steady-state or average incremental infiltration velocity, depending upon the purpose/application of the test, for the inner ring is equivalent to the infiltration rate.

The purpose of the outer ring is to promote one-dimensional, vertical flow beneath the inner ring. The infiltration velocity for the outer ring may also be measured, as a check on the test integrity, but is not used to determine the infiltration rate.

Application of Double-Ring Infiltrometer Test Results

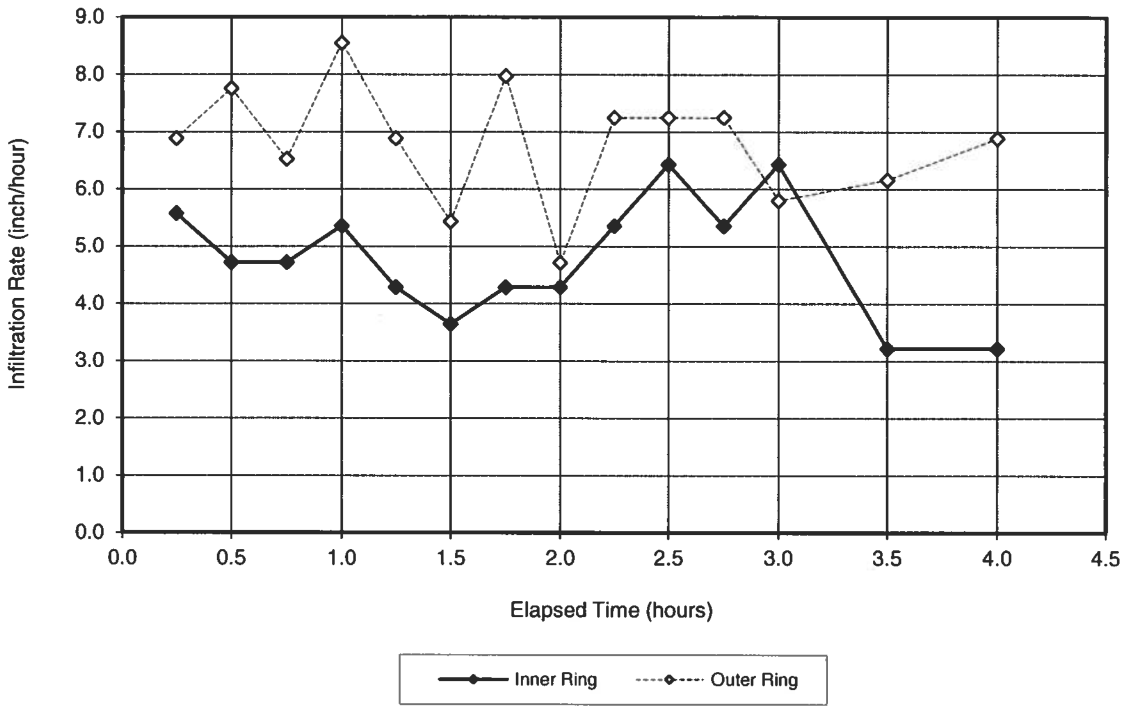
Although the units of the infiltration rate and hydraulic conductivity (k) of soils are similar, there is a distinct difference between these two quantities. They cannot be directly related unless the hydraulic boundary conditions (hydraulic gradient, extent of lateral flow of water, etc.) are known, or can be reliably estimated. In general, however, the infiltration rate near the end of the test is less than the saturated vertical hydraulic conductivity, since a fully saturated condition is generally not achieved by tests of this type and the hydraulic gradient near the end of the test is generally equal to or less than 1.0.

The test results represent a vertical infiltration rate for the conditions under which the test was performed and do not necessarily represent the infiltration rate for other conditions, such as the size of the infiltration basin and the depth of the water table. Some publications, such as EPA 65/1-81-013, recommend using a design infiltration rate that is a small percentage (typically 2% to 10%) of the infiltration rate measured by cylinder (ring) infiltrometers, to compensate for potential clogging of the infiltration surface and to correct for a larger proportion of horizontal flow (relative to vertical flow) that occurs from a small test area relative to a full-size infiltration basin area. This assumes, however, that the vertical infiltration rate (or vertical hydraulic conductivity) is the limiting factor in the basin's infiltration capacity. At sites where there is a shallow water table or shallow restrictive layer, the infiltration capacity of the full-size basin may be most limited by groundwater mounding, and not by the vertical hydraulic conductivity of the soil at or near the basin bottom. In this case, applying a percentage to a measured vertical infiltration rate or vertical hydraulic conductivity may over-estimate the actual infiltration capacity of the full-size basin, and groundwater mounding analyses should be performed by a professional engineer or geologist with expertise in groundwater hydrology.

APPENDIX II

Double-Ring Infiltrometer Test Results

Double-Ring Infiltrometer



GRAPH DATA:

Elapsed Time (hr:min)	Infiltration Rates: Inner Ring (inch/hour)	Infiltration Rates: Outer Ring (inch/hour)
0:15	5.6	6.9
0:30	4.7	7.8
0:45	4.7	6.5
1:00	5.4	8.6
1:15	4.3	6.9
1:30	3.6	5.4
1:45	4.3	8.0
2:00	4.3	4.7
2:15	5.4	7.2
2:30	6.4	7.2
2:45	5.4	7.2
3:00	6.4	5.8
3:30	3.2	6.2
4:00	3.2	6.9

TEST NUMBER: **DRI-1**

Test Location:		DRI-1 (see Figure 3A)
Test Date:		26-May-20
Test Depth (inch, below grade):		3
Inner Ring	- Outside Dia. (inch):	12.4
	- Inside Dia. (inch):	12.0
	- Water Depth (inch):	6
Outer Ring	- Inside Dia. (inch):	24.1
	- Water Depth (inch):	6

SOIL PROFILE:

Depth (ft) From	Depth (ft) To	Soil Description
		(see DRI-1, Figure 4A)

Test Infiltration Rate = 4.4 inch/hour
= 8.8 feet/day

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Kingfish Boatramp
Holmes Beach
Manatee County, Florida

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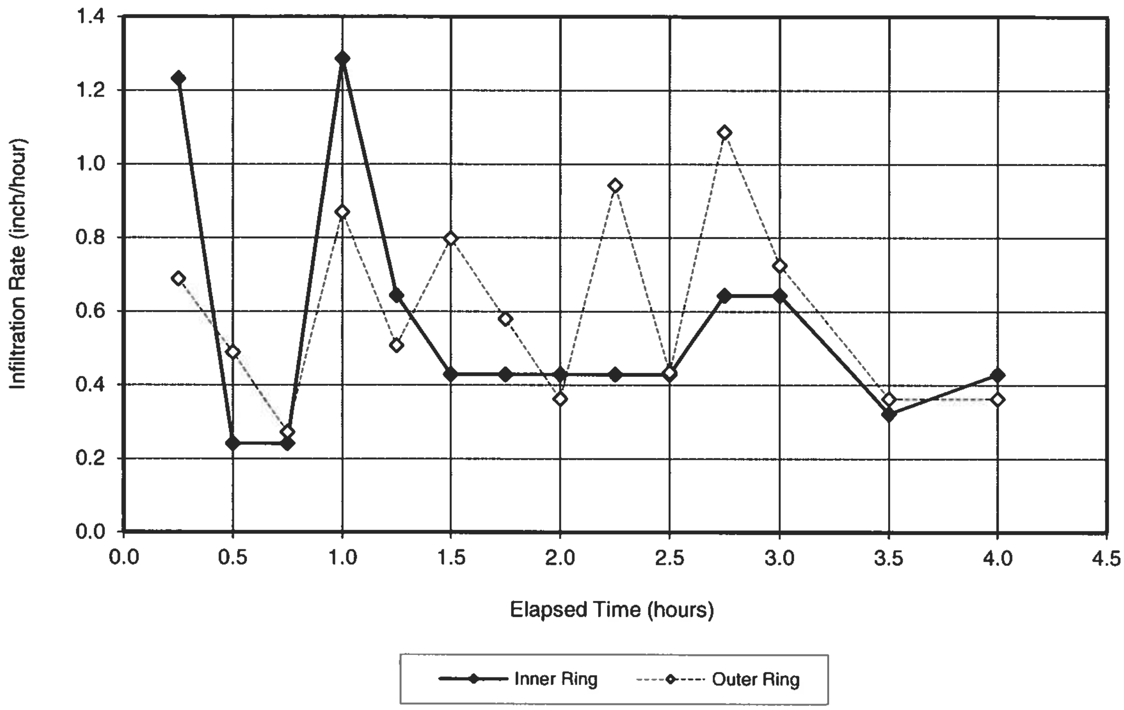
Double-Ring Infiltrometer



GRAPH DATA:

Elapsed Time (hr:min)	Infiltration Rates Inner Ring (inch/hour)	Outer Ring (inch/hour)
0:15	1.2	0.7
0:30	0.2	0.5
0:45	0.2	0.3
1:00	1.3	0.9
1:15	0.6	0.5
1:30	0.4	0.8
1:45	0.4	0.6
2:00	0.4	0.4
2:15	0.4	0.9
2:30	0.4	0.4
2:45	0.6	1.1
3:00	0.6	0.7
3:30	0.3	0.4
4:00	0.4	0.4

TEST NUMBER: **DRI-2**

Test Location:	DRI-2 (see Figure 3A)
Test Date:	21-May-20
Test Depth (inch, below grade):	3
Inner Ring - Outside Dia. (inch):	12.4
- Inside Dia. (inch):	12.0
- Water Depth (inch):	6
Outer Ring - Inside Dia. (inch):	24.1
- Water Depth (inch):	6

SOIL PROFILE:

Depth (ft) From	To	Soil Description
		(see DRI-2, Figure 4A)

Test Infiltration Rate = 0.45 inch/hour

= 0.90 feet/day

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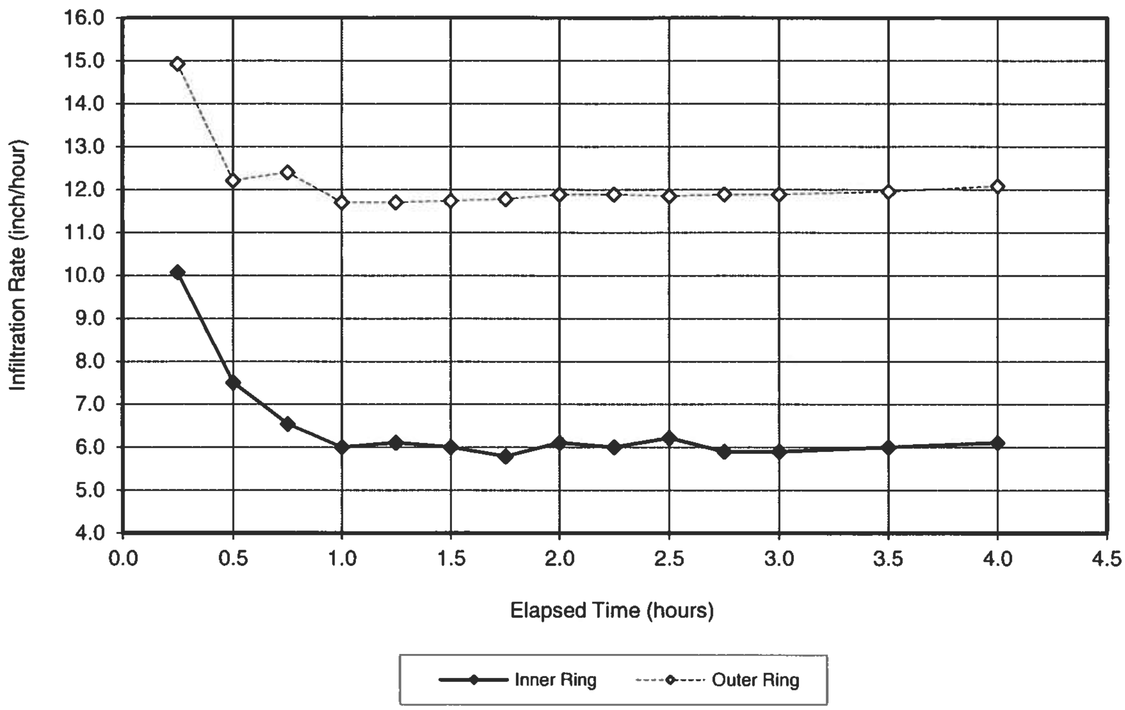
Double-Ring Infiltrometer



GRAPH DATA:

Elapsed Time (hr:min)	Infiltration Rates Inner Ring (inch/hour)	Outer Ring (inch/hour)
0:15	10.1	14.9
0:30	7.5	12.2
0:45	6.5	12.4
1:00	6.0	11.7
1:15	6.1	11.7
1:30	6.0	11.7
1:45	5.8	11.8
2:00	6.1	11.9
2:15	6.0	11.9
2:30	6.2	11.8
2:45	5.9	11.9
3:00	5.9	11.9
3:30	6.0	12.0
4:00	6.1	12.1

TEST NUMBER: **DRI-3**

Test Location: DRI-3 (see Figure 3A)
Test Date: 19-May-20
Test Depth (inch, below grade): 6
Inner Ring - Outside Dia. (inch): 12.4
- Inside Dia. (inch): 12.0
- Water Depth (inch): 6
Outer Ring - Inside Dia. (inch): 24.1
- Water Depth (inch): 6

SOIL PROFILE:

Depth (ft) From	To	Soil Description
		(see DRI-3, Figure 4A)

Test Infiltration Rate = 6.0 inch/hour
= 12 feet/day

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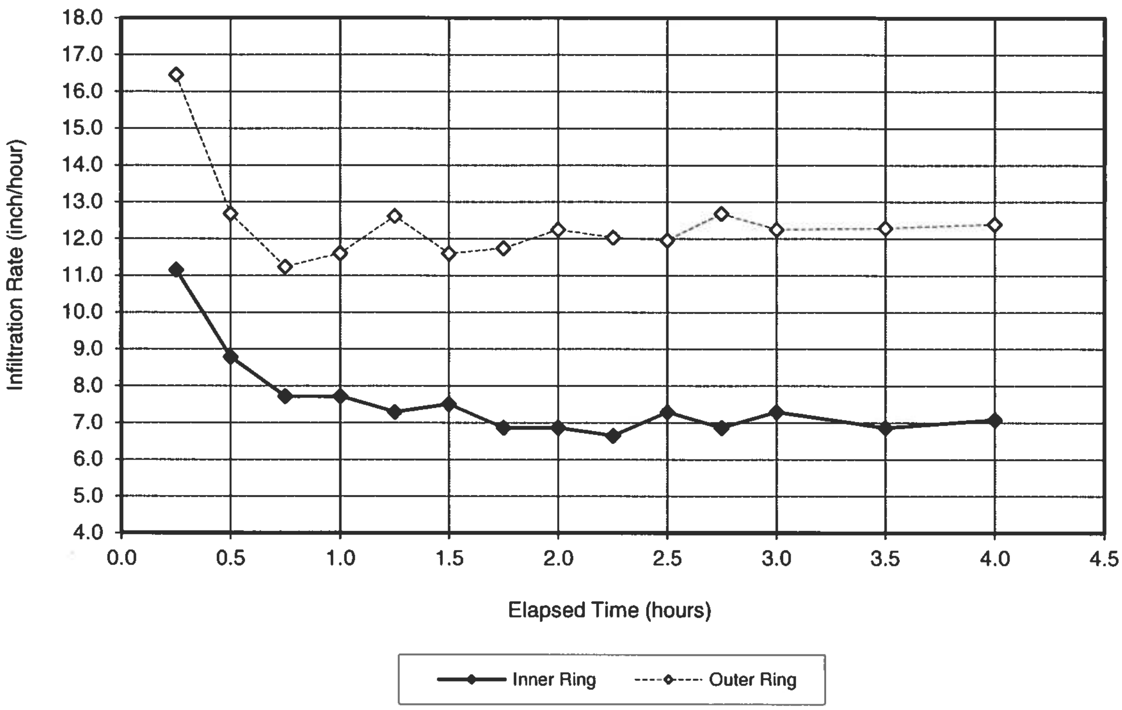
Double-Ring Infiltrometer



GRAPH DATA:

Elapsed Time (hr:min)	Infiltration Rates Inner Ring (inch/hour)	Outer Ring (inch/hour)
0:15	11.1	16.5
0:30	8.8	12.7
0:45	7.7	11.2
1:00	7.7	11.6
1:15	7.3	12.6
1:30	7.5	11.6
1:45	6.9	11.7
2:00	6.9	12.2
2:15	6.6	12.0
2:30	7.3	12.0
2:45	6.9	12.7
3:00	7.3	12.2
3:30	6.9	12.3
4:00	7.1	12.4

TEST NUMBER: **DRI-4**

Test Location: DRI-4 (see Figure 3A)
Test Date: 11-May-20
Test Depth (inch, below grade): 24
Inner Ring - Outside Dia. (inch): 12.4
- Inside Dia. (inch): 12.0
- Water Depth (inch): 6
Outer Ring - Inside Dia. (inch): 24.1
- Water Depth (inch): 6

SOIL PROFILE:

Depth (ft) From	To	Soil Description
		(see DRI-4, Figure 4A)

Test Infiltration Rate = 7.0 inch/hour
= 14 feet/day

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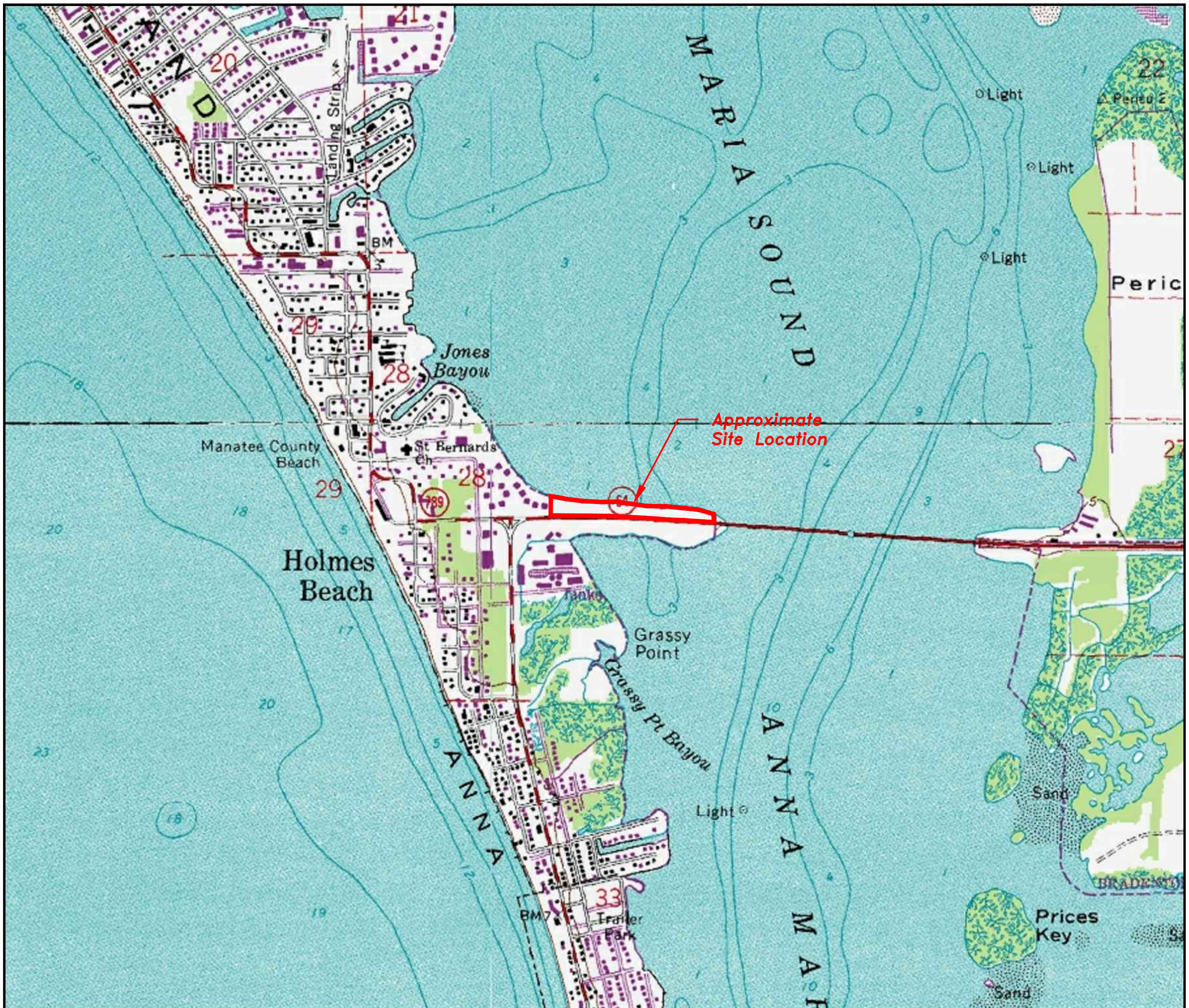
FILE NO.: 11-7511	APPROVED BY:	PLATE: 4



SCALE: 1"=2000'

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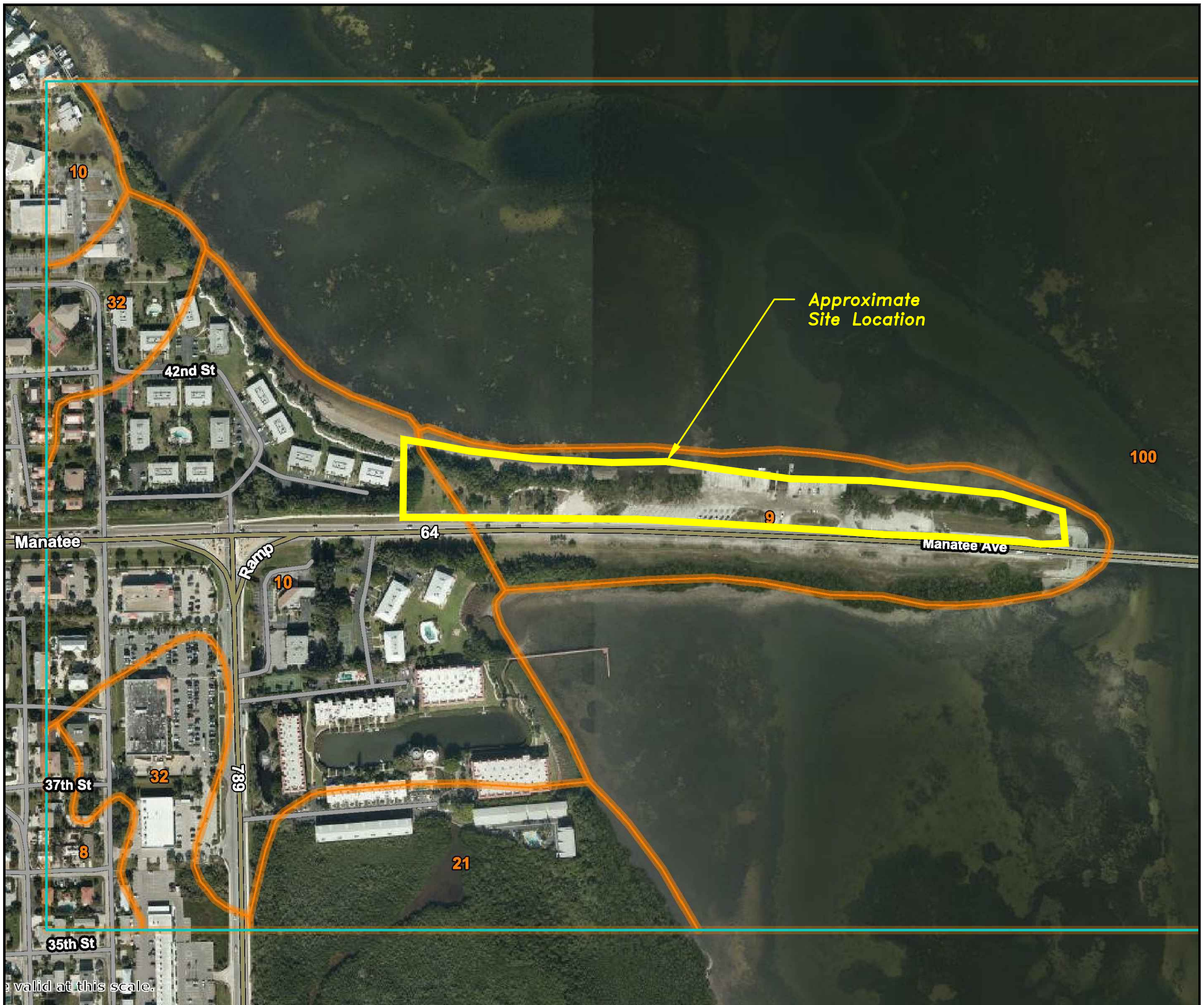
Location of Site on USGS Map
Kingfish Boat Ramp
Manatee Ave. W., Anna Maria
Manatee County, Florida

DRAWN BY: KGS	CHECKED BY:	DATE: 6/2/20
FILE NO. 11-7511	APPROVED BY:	FIGURE: 1A

Base USGS Map From Delorme XMap



SOILS MAP LEGEND

9 Canaveral sand, filled
10 Canaveral sand, organic substratum

SCALE: 1"=500'

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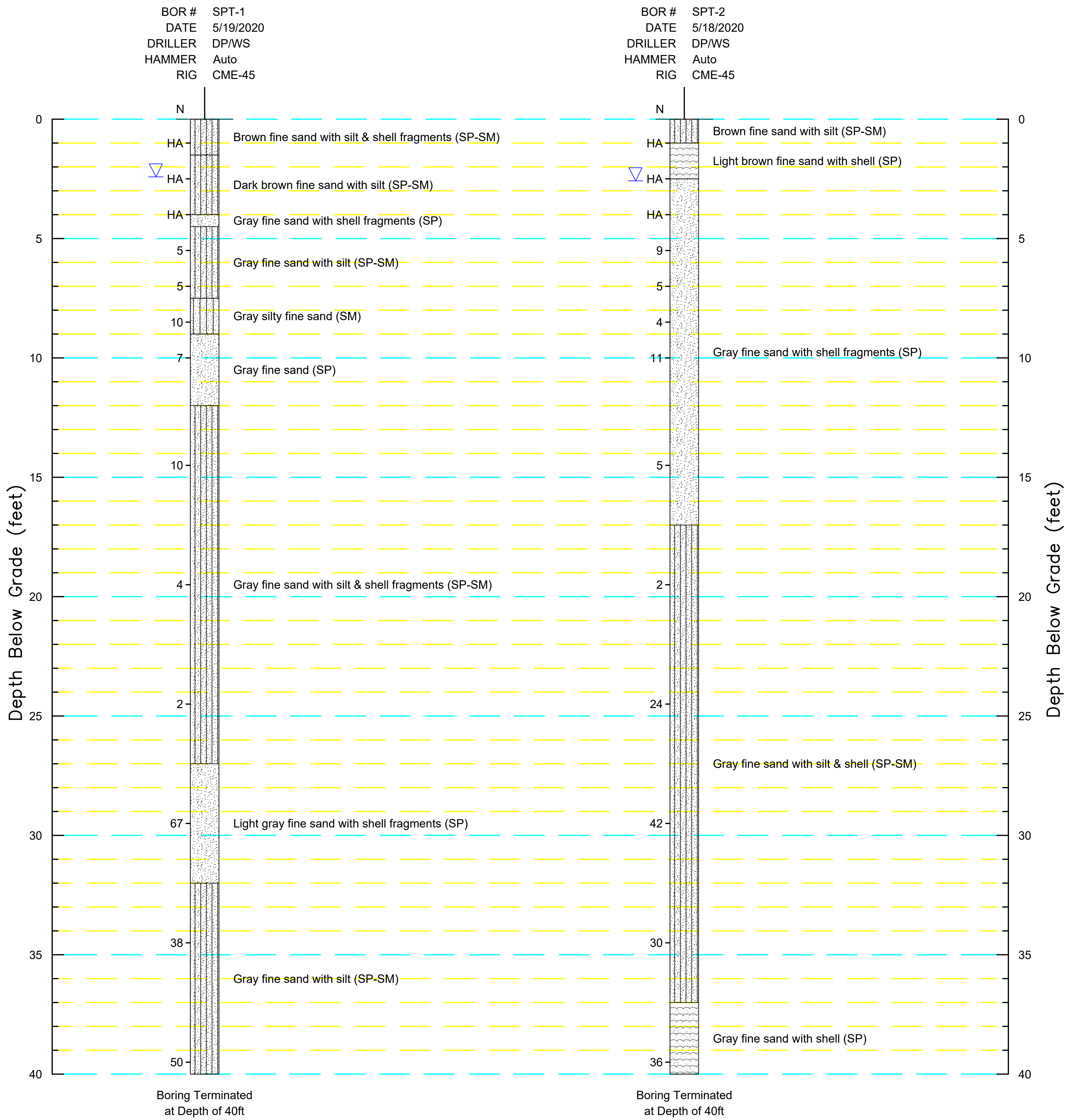
Location of Site on USDA Soils Map
Kingfish Boat Ramp
Manatee Ave. W., Anna Maria
Manatee County, Florida

DRAWN BY: KGS	CHECKED BY:	DATE: 6/2/20
FILE NO. 11-7511	APPROVED BY:	FIGURE: 2A

Base Soils Map From Web Soil Survey



Base Aerial From Google Earth Pro

TEST BORING LOCATIONS

LEGEND

∇ GROUNDWATER LEVEL MEASURED ON DATE DRILLED

N SPT N-VALUE IN BLOWS PER FOOT (UNLESS OTHERWISE NOTED)

SPT N VALUES CONVERTED TO EQUIVALENT SAFETY HAMMER

HA HAND AUGER

GRANULAR MATERIALS– RELATIVE DENSITY	SPT (BLOWS/FOOT)
VERY LOOSE	LESS THAN 4
LOOSE	4–10
MEDIUM DENSE	10–30
DENSE	30–50
VERY DENSE	GREATER THAN 50

SILTS AND CLAYS CONSISTENCY	SPT (BLOWS/FOOT)
VERY SOFT	LESS THAN 2
SOFT	2–4
FIRM	4–8
STIFF	8–15
VERY STIFF	15–30
HARD	GREATER THAN 30

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Test Locations/Soil Boring Logs
Kingfish Boat Ramp
Manatee Ave. W., Anna Maria
Manatee County, Florida

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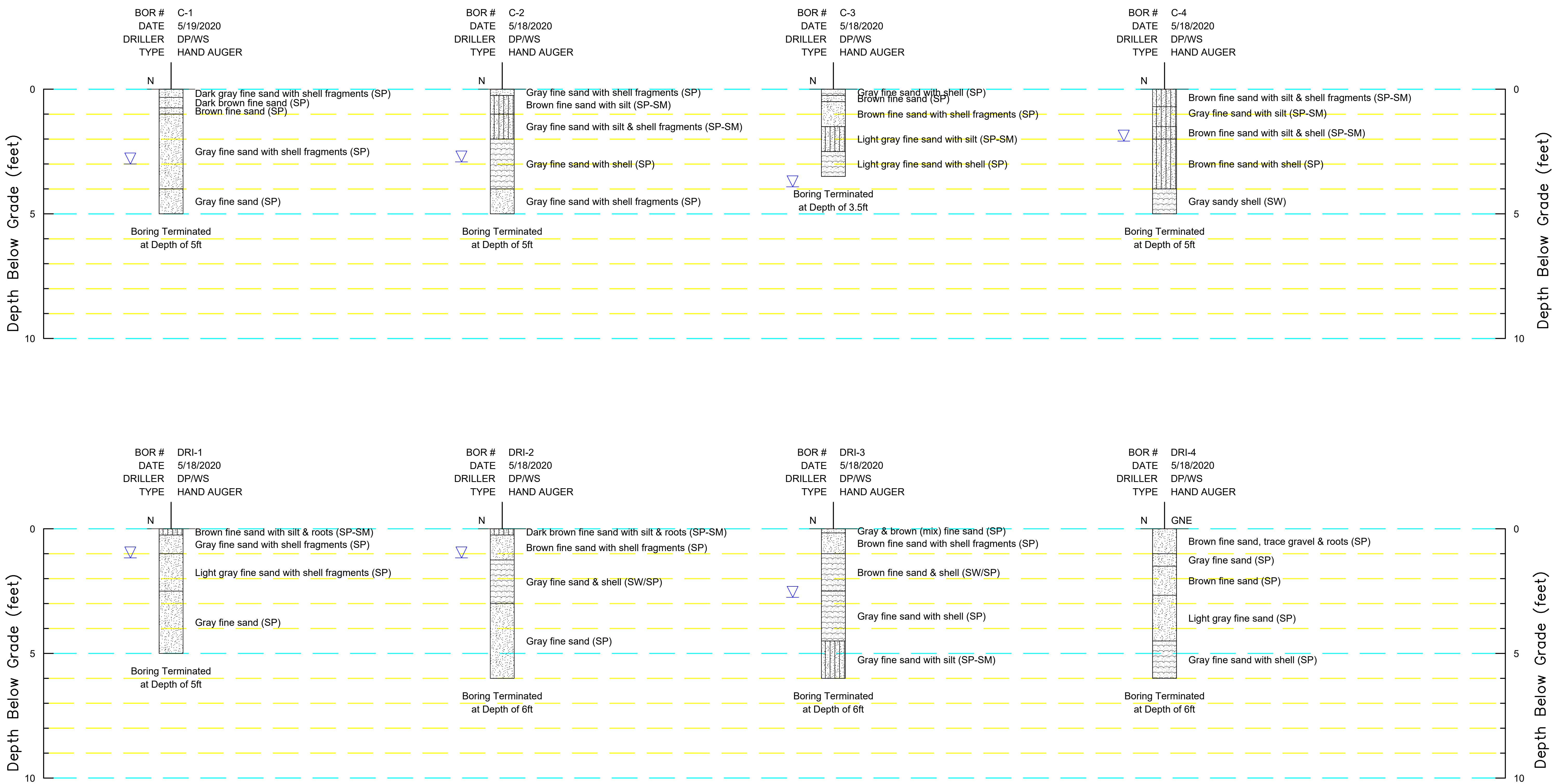
FILE NO. 11-7511	APPROVED BY:	FIGURE: 3A



LEGEND

▽ GROUNDWATER LEVEL MEASURED ON DATE DRILLED

GNE GROUND WATER NOT ENCOUNTERED

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Test Locations/Soil Boring Logs
Kingfish Boat Ramp
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Manatee County, Florida

DRAWN BY: KGS	CHECKED BY:	DATE: 5/29/20
FILE NO. 11-7511	APPROVED BY:	FIGURE: 4A