APPENDIX A
ENGINEERING APPENDIX

MT. SINAI MEDICAL CENTER, CONTINUTING AUTHORITIES PROGRAM (CAP) SECTION 14, PROJECT

DRAFT INTEGRATED FEASIBILITY REPORT AND ENVIRONMENTAL ASSESSMENT

September 2016

US Army Corps
of Engineers®
Jacksonville District

Continuing Authorities Program
Section 14 Project

Engineering Appendix

For

Mount Sinai Medical Center

Miami Beach, Florida

Draft Integrated Feasibility Report
and Environmental Assessment

September 2016

US Army Corps
of Engineers ®
Jacksonville District

Engineering Division

Table of Contents

ATTACHMENTS

- Attachment A - Geotechnical Addendum
- Attachment B - Structural Addendum
- Attachment C – Vertical Road Relocation

1.0 Purpose

The Purpose of this Engineering appendix is to discuss possible solutions to the seawall repair and overtopping conditions at Mount Sinai Medical Center, located in Miami Beach, Florida. This project was authorized under Section 14 of the Continuing Authorities Program (CAP). This appendix will include project background, geotechnical evaluations, coastal analysis, cost analysis, initial designs, and recommendations.

2.0 Project Background

2.1 Location

The project area is located in the City of Miami Beach, Florida, on a barrier island bordered to the east by the Atlantic Ocean and to the west by Biscayne Bay. The study area is the property of Mount Sinai Medical Center, located directly north of Julia Tuttle Causeway and extending approximately 0.57 miles along the bayside of the island, as shown in Figure 2.1.

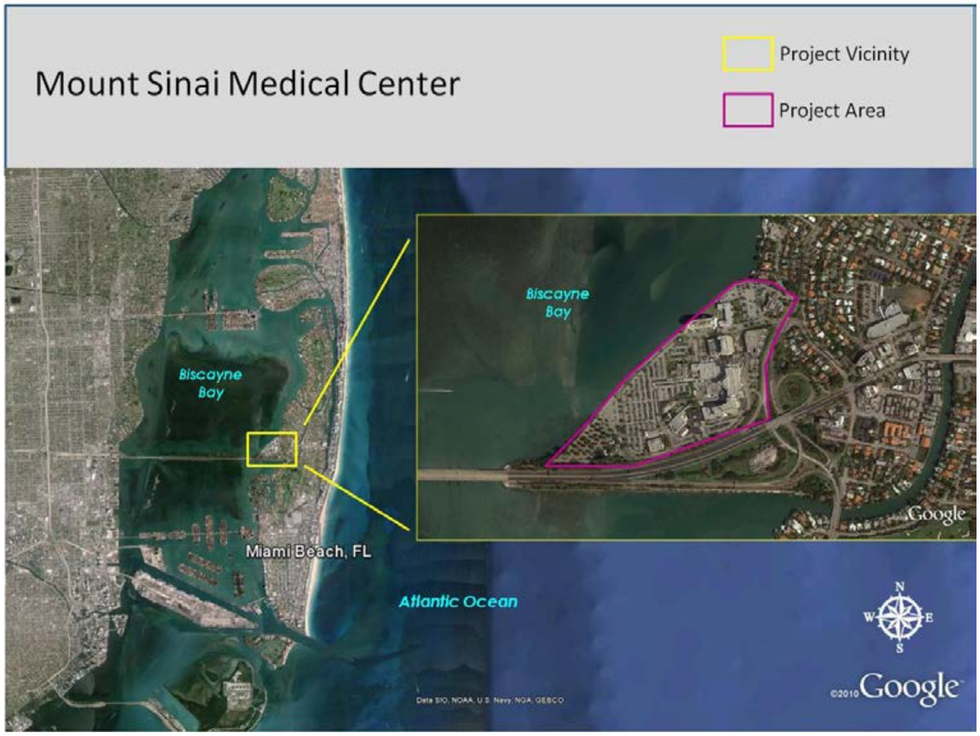

Figure 2.1 Project Location

2.2 Existing Conditions

The existing conditions of the project area include a parking lot, a perimeter road, and a perimeter seawall surrounding the seaward edge of the property. Mount Sinai Medical Center (MSMC) is the only hospital facility on the barrier island, making it a vital facility to the community as well as a critical staging area during disasters. A report entitled *Bulkhead Assessment, Mount Sinai Medical Complex, Miami Beach, Florida (2009, Bureau Veratis, Inc.)* found the existing seawall to be roughly 50 years old. The report indicated that portions of the seawall were in critical condition and would require immediate replacement. This facility is a private non-profit hospital and is considered eligible for this CAP Section 14 Emergency Streambank and Shoreline Erosion study in accordance with ER 1105-2-100 Planning Guidance Notebook published 22 April 2000.

The existing condition of the seawall is at risk of failure. Portions of the seawall have partially deteriorated from exposure (See Figure 2.2), and the supporting bank has eroded away due to rainfall, wave overtopping, loose geotechnical conditions, and tidal Inundation. The current state of the seawall is prone to inundation during extreme storm and high tide events. Inundation is the main driver of erosion, causing material to be transported through the existing seawall, leaving utilities, parking, roads and other critical facilities directly landward vulnerable to flooding and erosion. Overtopping is expected to increase with the current rate of sea level rise (See Figure 2.3 below). Most of the primary medical facilities of the MSMC are located away from the bayfront on higher ground with the exception of the Golden and Lowenstein buildings, which located in close proximity to the seawall. A limited repair to the seawall was performed in front of these two buildings in 2009. A two-lane paved road and parking facilities extend along most of the remaining length of the existing seawall. A grassy area from 8 to 15 feet wide extends along much of the area between the seawall and the road/parking lot. Trees and other vegetation exist along this grassy area, and there is evidence of steel tiebacks and possibly some underground utilities in this area. Areas of scouring damage are evident at many locations adjacent to the seawall, as a result of overtopping and/or wave action. In some areas gravel has been placed in the scour holes to restore surface elevations and prevent further damage.

Figure 2.2 Overtopping Conditions

Figure 2.3 Deteriorated Seawall

2.3 Proposed Alternatives

The main report describes objectives and constraints for the project. An evaluation of the current conditions led to the design of two alternatives and relocation option to prevent erosion during critical tide events.

Alternative 1 includes the placement of sheet pile seawall along the seaward edge of the property with a T-wall constructed along the northern edge of the property line (See Figure 2.4). The sheet pile seawall will be designed at elevation El 4.0 (NAVD88) and would be placed 3 feet in front (seaward) of the existing seawall. Material would be placed between the existing seawall and the new sheet pile wall to reduce the load on the existing wall. The structure will transition from a sheet pile seawall to a T-wall on the north end. The T-wall will tie into 3.5 feet (NAVD88) landward on the north end. On the southern end, the sheet pile seawall will directly tie into the Julia Tuttle Causeway embankment at 4.0 feet (NAVD88) and will require an easement from the FDOT. The sheet pile will be partially coated with coal tar epoxy to prevent corrosion. The design of the seawall is anticipating a 50-year design life. Information on the design of the sheet pile seawall can be found within Attachment B. No easement is required for the T-wall at the northern end of the medical center.

Alternative 2 would include a 300 foot T-wall constructed along the northern edge of the property line. A sheet pile seawall will be placed along the seaward edge of the property and the addition of a 1.5-foot concrete lift added to 130-foot newer existing seawall segment. (See Figure 2.5)

Figure 2.4 Alternative 1 (Sheet Pile Wall with T-Wall)

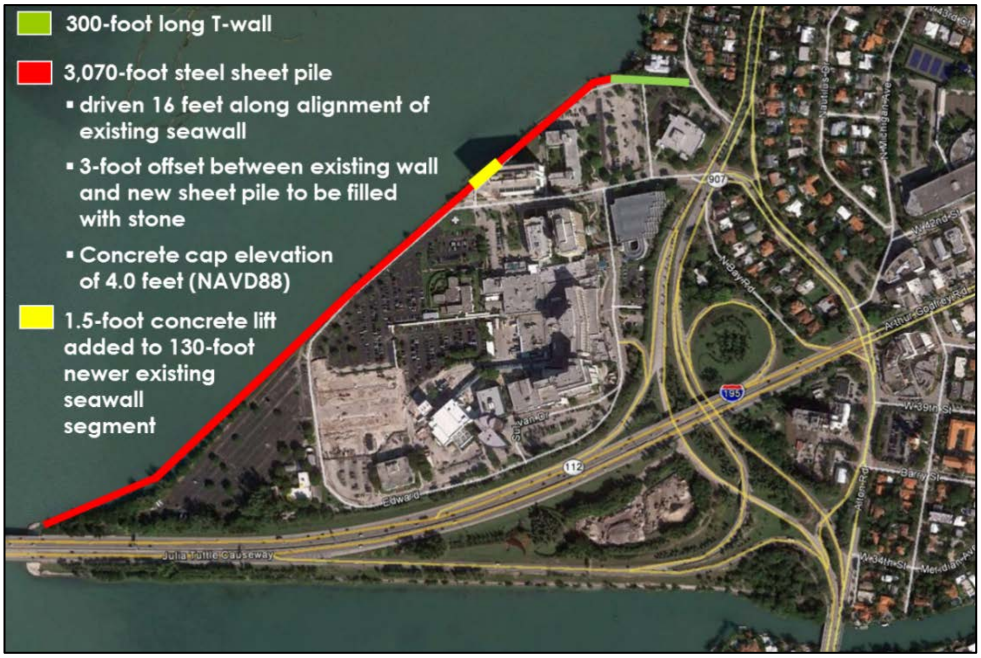

Figure 2.5 Alternative 2 (Sheet Pile with T-wall and Concrete lift)

Relocation was considered in conjunction with the alternatives proposed above. The Relocation plan therefore consists of vertical relocation of the perimeter road adjacent to Biscayne Bay with constructed support for the portion of the existing seawall adjacent to the elevated road. Relocation also includes relocation of vulnerable parking to a new parking garage constructed on the medical center property.

2.4 Recommended Plan

Analyzing the proposed alternatives led to Alternative 2 (See Figure 2.5) to be the most feasible plan of action. The plan includes the construction of a 300-foot long T-wall along the northern edge of the property, a 1.5-foot concrete lift added to 130-foot newer existing seawall segment and the construction of a sheet pile seawall along the entire seaward edge of the property excluding the 130-foot newer existing segment. This alternative was selected per ER 1105-2-100 Appendix F, Section lll, F-23, “the least cost alternative plan is considered to be justified if the total cost of the proposed alternative is less than the cost to relocate the threatened facility”.

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3.0 GEOTECHNICAL

3.1 HISTORY OF EXISTING SEA WALL

The general plans for Bulkhead – Dredging & Fill, dated 1966, indicate that Mount Sinai Hospital expanded its facilities during that time period, with part of that effort including construction of the existing seawall, as shown in Figure 3.1. The 1960s wall expanded a pre-existing (pre-1966) bulkhead by about 500 feet, from 2,622 feet to the current 3,150 foot long wall. This project was established by the City of Miami Beach Resolution # 11923.

The post-1966 added section of wall was composed of 14 inch diameter precast concrete piles, spaced 8 feet center to center, with a 6 inch thick concrete panel between them. The wall was anchored to wood piles through 1-1/4 inch metal rods. The concrete piles were driven to elevation -15 feet (1966 Mean Low Water or MLW), which was approximately equivalent to the top of a limestone layer.

Based on existing data from Bulkhead – Dredging & Fill (1966), the bayfront area of Mount Sinai was filled and raised from elevation -15 feet MLW to -2 feet or -3 MLW. The area was raised with fill from a nearby borrow source located within the bay, as shown in Figure 3.1.

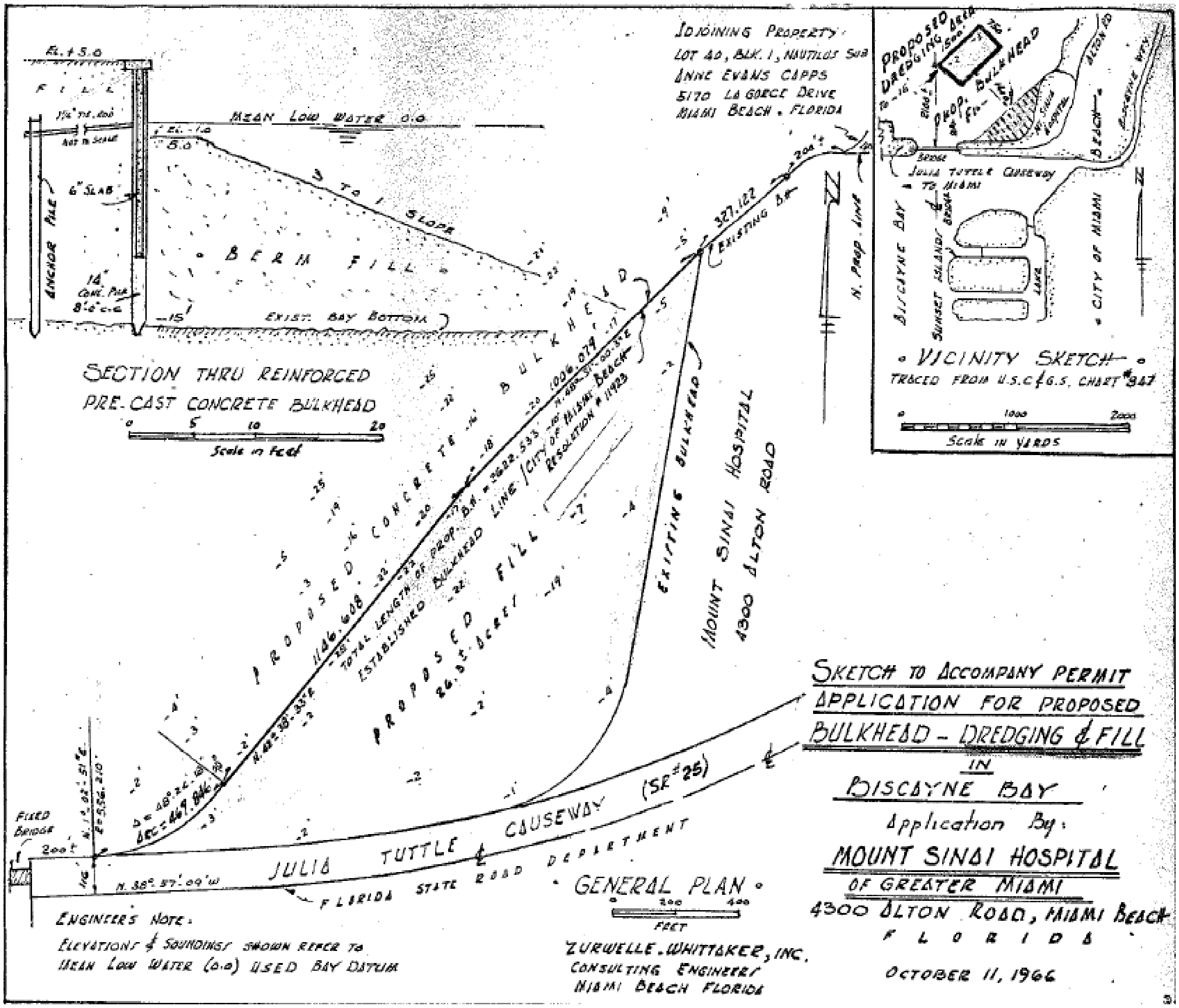


Figure 3.1 Copy of 1966 permit drawing for new bulkhead, dredging and filling.

3.2 HISTORICAL BORING DATA

The only historical boring data presented herein was from a development of a building inside the Mount Sinai area. The Standard Penetration Test (SPT) borings, B-1 and B-2, were performed by Vertical V-Southeast, Inc. and NV5, Inc. (Vertical V-Southeast became New Vertical 5 or NV5), as part of a geotechnical exploration and evaluation for the project titled Warner Building Entrance Canopy, in 2012. The borings (B-1 and B-2) were located within the footprint of a canopy structure project, the objective B-1 and B-2 is to observe the nature, relative compactness and variability of the soil, rock and immediate groundwater levels underlying the project site. The geotechnical report indicates that a limestone layer, approximately 8 feet to 15 feet thick, was typically found starting at depth of 21 feet and 23 feet. The boring location and the soil condition in borings encountered B-1 and B-2 are included in Addendum A.

3.3 Geology

3.3.1 Regional Geology

The landforms of the coastal area of Miami Dade County include barrier islands, lagoons, estuaries, and coastal ridges. The project site is a barrier island located along Eastern Biscayne Bay and north of Key Biscayne, on the Atlantic coast of Miami Dade County. Holocene sands that make up the island are underlain by the limestone units of the Miami Limestone Formation. The Miami Limestone consists of two facies, an oolitic facies and a bryozoan facies. The oolitic facies consists of white to orangish gray, poorly to moderately indurated, sandy, oolitic limestone (grainstone) with scattered concentrations of fossils. The bryozoan facies consists of white to orangish gray, poorly to well indurated, sandy, fossiliferous limestone (grainstone and packstone). Beds of quartz sand are also present as unindurated sediments and indurated limey sandstones. Broken shell is present in most samples.

3.4 PROJECT SPECIFIC GEOTECHNICAL DATA

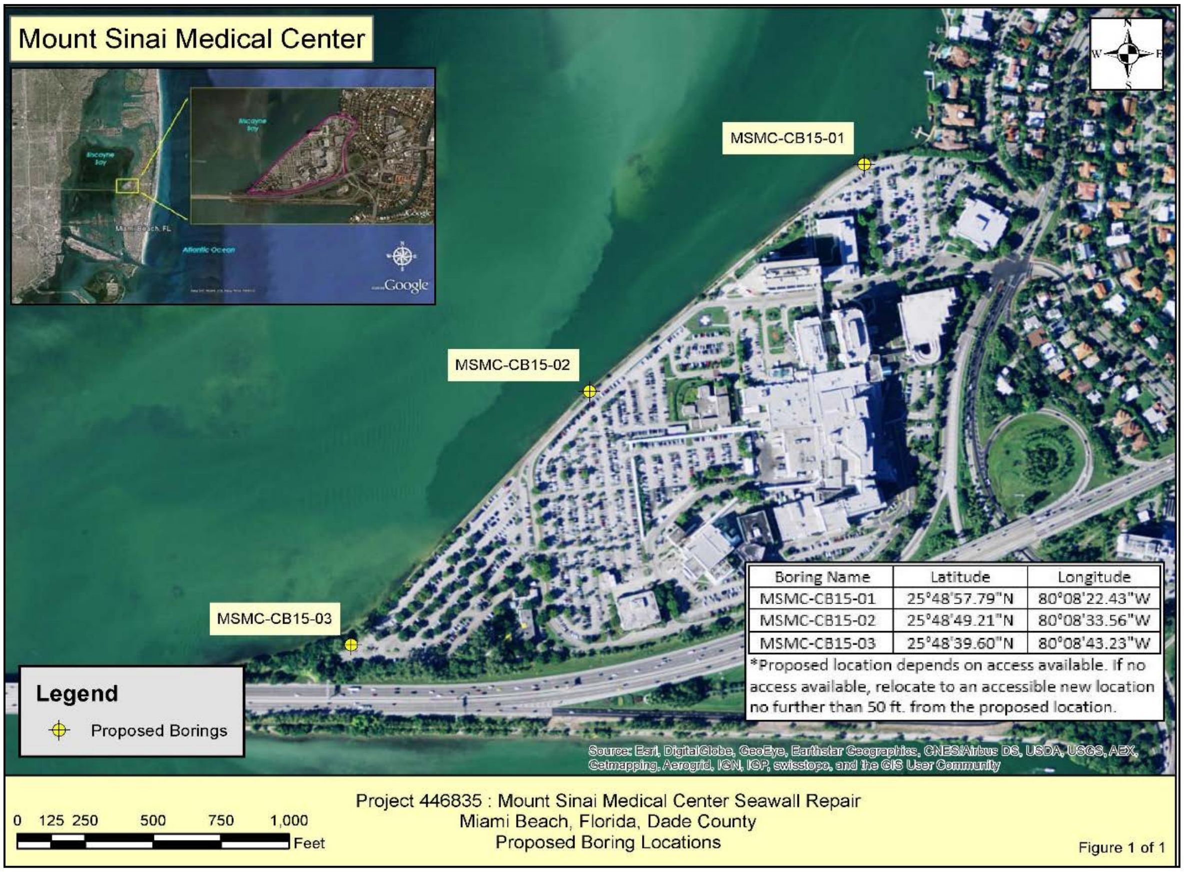
3.4.1 Site-Specific Subsurface Conditions (Materials Encountered)

Project specific geotechnical data was obtained via three SPT borings, MSMC-CB15-01, MSMC-CB15-02 and MSMC-CB15-03 performed at the approximate locations shown on the site plan in Figure 3.2. Boring coordinate's data is shown in Table 3.1. USACE Mobile District's (SAM) drill unit performed drilling of borings. Borings were drilled from the existing ground surface to depths ranging between 30 feet and. 34.5 feet. See Figure 3.3 for the Boring Log Profile Fence. The boring logs are included in the Attachment A – Geotechnical Addendum, of this report.

Table 3.1 Available USACE Boring Data.

Designation	State Plane, FL-East, NAD83		Project Location
	X	Y	
MSMC-CB15-01	539750	939212	Northern Area of Seawall
MSMC-CB15-02	538922	938259	Middle Area of Seawall
MSMC-CB15-03	537910	937331	Southern Area of Seawall

As shown in Figure 3.1, the circa 1966 structure was built into the bay, where site conditions, varied. The figure indicates that toward the center of the alignment of the wall, the bay bottom was approximately at elevation -22 feet. (MLW), rising to both the northeastern & southwestern ends to elevations -5 feet. and -3 feet., respectively. The depressed area toward the center would have required a significant amount of fill to bring it to the final grade, the fill consisting of excavated material from the nearby borrow pit shown in Figure 3.1. It appeared that the materials encountered at ground surface at the boring locations consist of fill material overlying sands, silty-sands, lean clays and silts. Silt and clay N-Value's ranged from 1 to 5 blow per foot (bpf). Sand or silty-sand N-Value's ranged from 2 to 52 bpf. The sand, silty-sand, and silt typically contained a trace of shell and rock fragments. The sands, silty-sands, clays, and silts are underlain by a greenish gray to white oolitic limestone of the Miami Formation. The oolitic limestone was encountered at all boring locations between elevations of -11.8 feet to -23.7 feet NAVD88. The oolitic limestone is described as porous to pitted and contains various percentages of interbedded sand, silt, and fossils and was easily sampled using the SPT method with the rock broken by the spoon advancement. The oolitic limestone matrix (rock fragments recovered) consisted mostly of fine-grained sand size quartz (grainstone), was highly to moderately weathered, and ranged in strength from soft to moderately hard. Sand or silty sand was generally encountered beneath the oolitic limestone. In boring MSMC-CB15-02, a weakly cemented sandstone was encountered below the limestone at elevation -33 feet NAVD88. In boring MSMC-CB15-01, three feet of limestone was cored from a depth of -25.3 to -28.3 feet NAD88. The cored limestone is described as pitted, moderately fractured, very fine mostly quartz sand, indurated (packstone) and soft and can easily be scratched by knife. An Unconfined Compressive Strength (ASTM C-617) test yielded a value of 191 psi on a tested sample selected from the drilled core.



Boring Name	Latitude	Longitude
MSMC-CB15-01	25°48'57.79"N	80°08'22.43"W
MSMC-CB15-02	25°48'49.21"N	80°08'33.56"W
MSMC-CB15-03	25°48'39.60"N	80°08'43.23"W

*Proposed location depends on access available. If no access available, relocate to an accessible new location no further than 50 ft. from the proposed location.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Project 446835 : Mount Sinai Medical Center Seawall Repair
Miami Beach, Florida, Dade County
Proposed Boring Locations

Figure 3.2 Boring Log locations Mount Sinai Seawall Repair

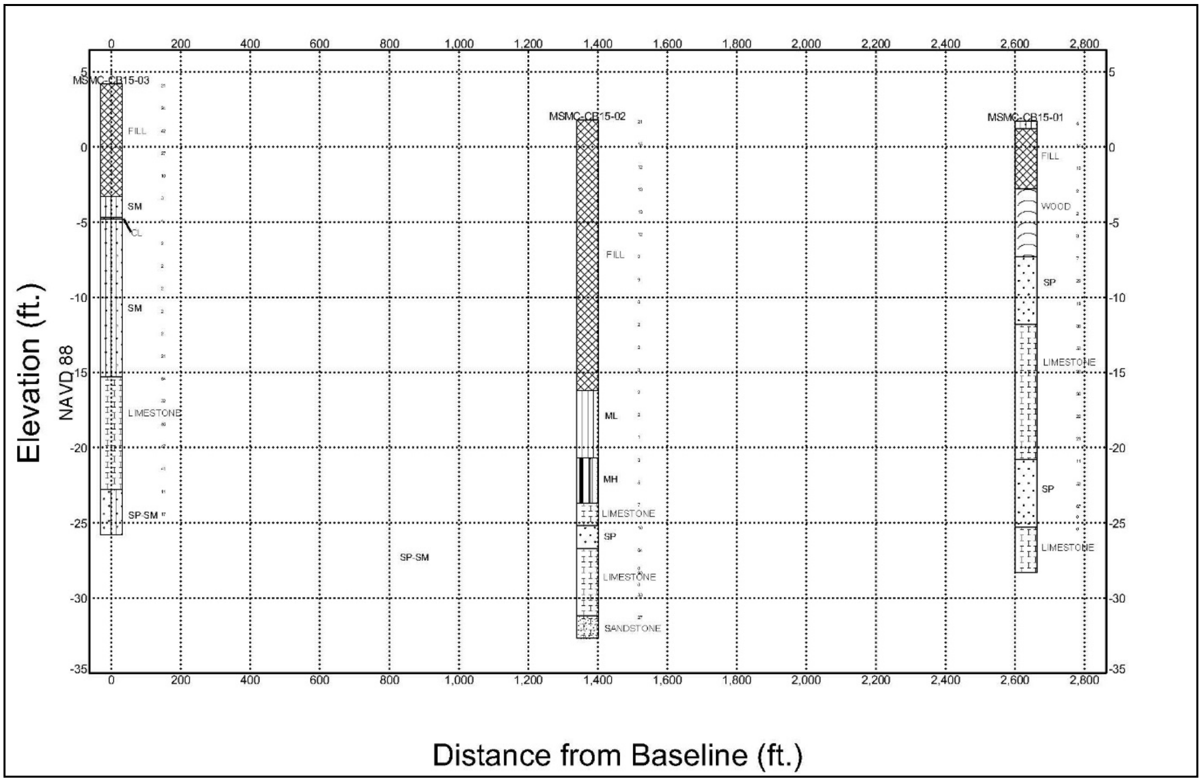


Figure 3.3 Borings Log Profile Fence

The subsurface conditions shown on the boring logs represent the conditions at the boring locations. Subsurface variations between borings should be anticipated. The Unified Soil Classification shown on the borings logs is based on visual classifications and laboratory testing. The limestone encountered corresponds to a rock formation that typically offers high resistance to excavation, hence, special equipment and breaking tools may be required to excavate this limestone. The limestone is also difficult to dewater due to its high porosity and permeability. Limestone content provided for non-limestone material (e.g. SAND w/ little limestone fragments) is descriptive of the materials within the retrieved SPT sampler. The cohesionless/granular soils encountered during this investigation may cave during excavation or drilling, thus stabilization measures may be required.

3.4.2 Boring procedures notes

Borings MSMC-CB15-01 through MSMC-CB-03 were sampled using the Standard Penetration Test (SPT) procedure consisting of a 140 lb. hammer and a 30-inch drop using a 2.0-foot split spoon (1 3/8-inch I.D. and 2-inch O.D.) until refusal was encountered or until the spoon was advanced 18 inches. Refusal is defined as a total of 50 blows of the hammer within any 6-inch increment, a total of 100 blows of the hammer within any 1-foot increment, or no observed advancement of the sampler after 10 successive blows of the hammer. When refusal was encountered, the borings were continued with a 4-inch x 5 1/2-inch diameter core barrel.

3.4.3 Geotechnical Engineering data

According to the previous section, the simplified soil profile of the project is defined by the soil conditions in boring MSMC-CB15-02, since the soil conditions at this boring were considered to be the least favorable from a geotechnical perspective.

Layer I: Fill – This layer consists of mostly fine gravel and coarse-grained sand-sized quartz and was encountered from elevation 1.8 to -5.7 (NAVD88). The fill is medium dense with SPT N-values between 13 and 21 bpf.

Layer II: Fill – This layer consists of gray, poorly graded sand, with some gravel and was encountered from elevation -5.7 to -16.2 (NAVD88). The SPT N-values varies from 2 to 12 bpf. The classification of the layer has been changed based on existing data from a project in 1966.

Layer III: ML\MH – This layer consists primarily of gray, inorganic sandy silt of varying plasticity and sand content with few organics, typically less than 5%, with SPT N values between 1 and 5 bpf. This layer was encountered from -16.2 to -23.7 (NAVD88).

Layer IV: SP – This layer consists of primarily gray, poorly graded sand, with SPT N-values between 7 and 10 bpf. This layer was encountered from -23.7 to -26.7 (NAVD88).

Layer V: Limestone – This layer consist of grey sandy, sparsely fossiliferous moderately hard, limestone, with SPT N-values between 64 and 88 bpf. This layer was encountered from -26.7 to -32.7 (NAVD88).

3.4.4 Laboratory testing

Laboratory testing was performed on the soil and rock samples recovered from the three USACE borings to determine material classification and engineering properties. Laboratory physical testing consisted primarily of determination of the following:

Water Content – ASTM D2216
Organic Content – ASTM D2974 Method C
Sieve Analysis – ASTM D422

Classification of Soils – Standard Practice for Classification of Soils for Engineering Purposes (United Soil Classification System) ASTM D2487

1. Atterberg Limits Multi Point – ASTM D4318.
2. Unconfined Compression Strength (Rock) – Unconfined Compression Tests of Rock Cores, ASTM D2938.

The physical laboratory test results are summarized in Table 3.2 and the interpretation of these results are included in the following sections.

Table 3.2 Summary of laboratory testing

Boring Designation	Sample Number	Soil Classification (USCS)	Limit Liquid, LL (%)	Plastic Index, PI (%)	Organic Content, OC (%)	Visual Shell (%)	Water content, W_n (%)	Munsell Color	Approximately Fines content (%)
MSMC-CB15-01	2	SP-SM	-	-	3.7	-	17.0	10YR 7/3	9
MSMC-CB15-01	7	SP	-	-	-	-	42.7	5YR 3/1	4
MSMC-CB15-01	8	SP	-	-	-	-	20.7	5YR 3/1	3
MSMC-CB15-01	11	SM	-	-	-	-	23.6	10YR 6/3	19
MSMC-CB15-01	15	SP-SM	-	-	-	-	19.6	10YR 7/2	7.5
MSMC-CB15-02	3	(SP-SM)g	-	-	-	-	18.9	-	6
MSMC-CB15-02	8	(SP)g	-	-	-	-	18.1	10YR 6/1	5
MSMC-CB15-02	14	ML	NP	NP	3.1	-	47.6	10Y 5/1	50
MSMC-CB15-02	16	MH	60	24	5.9	2	44.6	N 5	86
MSMC-CB15-02	22	SP-SM	-	-	-	13	13.7	N 7	8
MSMC-CB15-03	3	SP-SM	-	-	-	-	11.3	10YR 7/3	9
MSMC-CB15-03	7	SM	NP	NP	2.6	-	39.9	10Y 5/2	34.5
MSMC-CB15-03	11	SM	-	-	-	-	42.0	10Y 5/1	17.5
MSMC-CB15-03	15	GP-GM	-	-	-	-	28.4	N 9	15
MSMC-CB15-03	20	SP-SM	-	-	0.3	-	20.3	10YR 7/1	5
USCS: Unified Soil Classification System;									

3.5 PRELIMINARY GEOTECHNICAL ANALYSES

3.5.1 Geotechnical Results - Engineering Parameters

The following soil parameters are provided for the lateral design of a steel sheet pile wall. It is noted that the short-term and long-term condition should both be analyzed, and the most critical condition used for design purposes. The parameters provided for limestone strata assume that the intact rock has been pulverized into a sandy gravel, whether by the sheetpile installation, or by chisel-beam or other pre-cutting methods before sheet installation.

The following parameters have been developed using the soil conditions from SPT boring MSMC-CB15-02. In order to develop the table below, an average of the N-values were performed for simplicity of calculations, in addition, some engineering judgment were implement for considerations of the internal friction angle and cohesion of the soil.

Table 3.3 Soil Parameters (Undrained Condition or Q-Case)

Mount Sinai (Undrained condition)										
Elevation Range (NAVD 88)	Soil Classification(1)	Saturated Unit Weight (γ_{sat}) (lb/ft^3)	Moist Unit Weight (γ_{moist}) (lb/ft^3)	Effective unit Weight (γ') (lb/ft^3)	Angle of Internal Friction (ϕ)	At Rest Earth Pressure coefficient K_o	At Active Earth Pressure coefficient K_a	At Passive Earth Pressure coefficient K_p	Cohesion	Soil Steel Interface Wall Friction Angle (Delta)
									Undrained (psf)	
1.8 to -5.7	Fill	120	115	57.6	30	0.50	0.33	3	0	16
-5.7 to -16.2	Fill	110	106	47.6	30	0.52	0.35	2.9	0	16
-16.2 to -23.7	ML/MH	105	100	42.6	0	1	1	1	250	0
-23.7 to -26.7	SP	115	110	52.6	31	0.48	0.32	3.12	0	17
-26.7 to -32.7	Limestone	132	126	69.6	34	0.44	0.28	3.54	0	18

(1) USCS :Unified Soil Classification System

Table 3.4 Soil Parameters (Drained Condition or S-Case)

Mount Sinai (Drained condition)										
Elevation (NAVD 88)	Soil Classification[(1)]	Saturated Unit Weight (γ_{sat}) (lb/ft^3)	Moist Unit Weight (γ_{moist}) (lb/ft^3)	Effective unit Weight (γ') (lb/ft^3)	Angle of Internal Friction (ϕ)	At Rest Earth Pressure coefficient K_o	At Active Earth Pressure coefficient K_a	At Passive Earth Pressure coefficient K_p	Cohesion	Soil Steel Interface Wall Friction Angle (Delta)
									Drained (psf)	
1.8 to -5.7	Fill	120	115	57.6	30	0.50	0.33	3	0	16
-5.7 to -16.2	Fill	110	106	47.6	29	0.52	0.35	2.9	0	16
-16.2 to -23.7	ML/MH	105	100	47.6	26	0.56	0.39	2.56	0	14
-23.7 to -26.7	SP	115	110	52.6	31	0.48	0.32	3.12	0	17
-26.7 to -32.7	Limestone	132	126	69.6	34	0.44	0.28	3.54	0	18
(1) USCS: Unified Soil Classification System										

3.5.2 Recommendations

Additional geotechnical analyses and design work is required to verify the preliminary subsurface conditions and their strength properties to further develop structural features of the Recommended Plan using project-specific geotechnical data. Additional geotechnical investigation, analyses and design work include:

Additional SPT borings logs to refine site characterization.

Refine CWALSHT analysis for internal stability, based on additional data.

Global slope stability analyses of the seawall using GeoSlope software or similar stability analysis.

Lateral analysis of sheetpile seawall using the L-pile software.

Documentation

Preparation of construction level plans and specification.

4.0 Coastal Report

4.1 Site Conditions

Biscayne Bay is approximately 2.25 miles wide at this location, so the seawall is subject to wind-generated waves. However, a large shallow seagrass-covered shoal area is located directly offshore of the MSMC, covering a large amount of the surface area of the bay in this region. This shoal tends to greatly dissipate wave formation and propagation under normal water level conditions, but during periods of elevated water levels damaging wind-generated waves may still pass over this shoal with little effect. In addition to wind-generated waves, boat wakes are an additional design consideration. A boat channel is offset approximately 200 feet seaward of the seawall, and frequent use of this channel by large and/or high-speed vessels has been observed on numerous occasions. The transit of these vessels subjects the seawall to frequent boat wakes that can overtop the seawall as well.

The upper region of Biscayne Bay fronting the MSMC is connected to the Atlantic Ocean at Bakers Haulover Inlet, Government Cut/Miami Harbor, and the Intracoastal Waterway near downtown Miami. The upper bay is therefore readily influenced by water-level fluctuations in the open Atlantic Ocean caused by tides, storm surges, and sea level rise. The presence of numerous man-made islands and causeways constricts tidal flow and may tend to dampen short-period water level fluctuations to some degree, but longer period events can still directly affect water levels at MSMC.

4.2 Description of Problem

An existing seawall was constructed in several phases to prevent erosion of land. The existing seawall has been repaired in various locations but the majority of the wall is in imminent threat of damage by natural erosion processes. Loss of portions of the seawall will result in sudden, extreme erosion impacting existing infrastructure. The primary driver for current erosion problems is overtopping of the wall during extreme high tide events. Overtopping allows material to migrate through cracks in the existing compromised seawall and be carried over the wall as the water recedes. Erosion also contributes to subsidence of land behind the wall. After extreme high tide events, standing water remains in subsided areas complicating and compromising hospital operations and patient health (life risk.) These complications would be exacerbated during disaster events (storms, hurricanes, etc.) where conditions would be worsened by the natural event and increased use of hospital facilities as both an emergency care facility and a disaster staging area.

The primary cause of this erosion and subsequent periodic flooding is the low crest elevation of the existing seawall and the adjacent terrain. The crest elevation of the existing structure is at approximately 2.0 to 2.5 feet NAVD88 and average elevations along the adjacent roadway and parking lot are about 2.5 to 3.5 feet NAVD88. Although possibly adequate to prevent most overtopping when it was constructed in the 1960's, applying the historic rate of sea level rise (+2.3 mm/yr) results in present-day water levels that are about 4 to 5 inches higher than at the time of seawall construction. Given the relatively low elevation of the seawall even at the time of construction, this increased average water surface elevation results in greater overtopping during high tides and storm events.

4.3 Water Levels

All water levels and land surface elevations in this report will be referenced to North American Vertical Datum of 1988 (NAVD88), unless otherwise specified. References to other datums will be provided as necessary.

4.3.1 Tides

Tidal datums are provided for several gages throughout the region. The closest gages to the project site were located at Biscayne Creek (Station # 8723089), located 4.7 miles NNE of MSMC, and the Biscayne Bay gage (Station #8723165), located near downtown Miami, approximately 3.5 miles SW of the MSMC. These gages have periods of record of 29 and 22 months, respectively.

The longest-recording gage in the area is located at Virginia Key (Station 8723214). This gage was installed in January 1994 and remains operational to this day. The resulting period of record is therefore nearly 22 years. This gage is located 5.7 miles south of the MSMC at the confluence of Biscayne Bay and the Atlantic Ocean.

Tidal datums from each of the three references tidal stations are summarized in Table 4.1 below. These three gages span much of the extent of the tidally influenced portions of northern and central Biscayne Bay. As readily seen in this table, the tidal characteristics are relatively similar in spite of the variety of locations.

Datum	Biscayne Creek #8723089	Biscayne Bay #8723165	Virginia Key #8723214
Highest Obs.	1.24	1.51	2.79
MHHW	0.24	0.26	0.22
MHW	0.18	0.2	0.16
NAVD88	0	0	0
MTL	-0.9	-0.89	-0.85
MSL	-0.91	-0.89	-0.87
DTL	-0.93	-0.92	-0.88
MLW	-1.98	-1.98	-1.86
MLLW	-2.11	-2.11	-1.97
Lowest Obs.	-2.92	-3.24	-3.28

Table 4.1 Tidal datums near the project area. NOAA Stations # 8723089, 8723165, and 8723214.

Although the differences between these gages are relatively small, these tidal datums will provide the foundation for the water level analysis that follows. Selection of representative tidal conditions at the MSMC site is therefore important. The Biscayne Bay and Virginia Key gages are both located in, or adjacent to, tidal inlets and therefore do not experience the level tidal dampening that could be expected deeper inside the bay. Of the three gages, only Biscayne Creek was located well within the confined area of Biscayne Bay, and thus experienced similar tidal forcing characteristics as are presently experienced at the MSMC site. Use of the Biscayne Creek gage (station # 8723089) is based on a 2.5-year record, and due to its location should more accurately represent tidal conditions at the project site. Tidal datums from this gage will therefore be used in project formulation and design with the exception of highest observed water level which will be conservatively obtained from the Virginia Key gage due to the longer record at that location.

The highest water level on record was examined at Biscayne Creek and Virginia Key gauges. At Biscayne Creek the maximum level was +1.24 feet NAVD88, but this low value may be due to the relatively short (<2 year) period of record in addition to the causeway effects. The Virginia Key gage recorded a maximum value of +2.79 feet NAVD88. This water level would overtop most of the length of the MSMC seawall and could lead to the level of flooding that is currently observed at the facility.

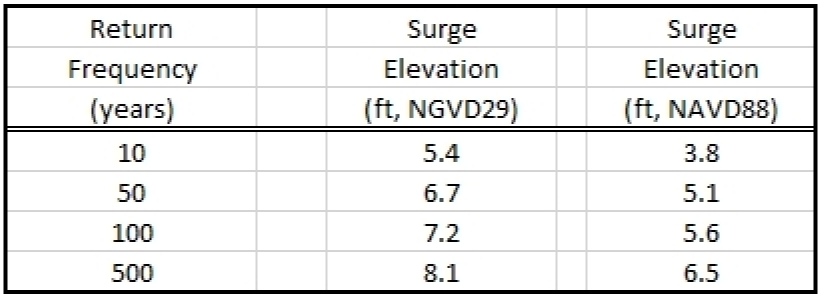
4.3.2 DATUM CONVERSIONS

Two primary vertical survey datums have been used: NAVD88 as described above, and the older National Geodetic Vertical Datum of 1929 (NGVD29). NGVD29 has been superseded by NAVD88, but is typically the reference datum for older elevation data. The conversion between these two datums varies by geographic location, but throughout this project area NGVD29 lies 1.56 feet below NAVD88. This conversion value will be used throughout the report.

Other common elevations of interest are mean lower low water and mean higher high water, which define the limits of the spring tidal range. These values are particularly important in defining the locations of tidally influenced water levels used in this report. Using the values shown for Station 8723089, MLLW lies at -2.11 feet NAVD88, and MHHW lies at 0.24 feet NAVD88.

4.3.3 SURGE

Surge levels are provided by FEMA's 2009 Flood Insurance Study (FIS). These values were originally referenced to the National Geodetic Vertical Datum of 1929 (NGVD29), but are converted to NAVD88 in Table 2 in order to be consistent with other vertical measurements.



Return Frequency (years)	Surge Elevation (ft, NGVD29)	Surge Elevation (ft, NAVD88)
10	5.4	3.8
50	6.7	5.1
100	7.2	5.6
500	8.1	6.5

Table 4.2 Surge levels, from FEMA 2009 FIS.

4.3.4 SEA LEVEL RISE

General Information. Eustatic sea level change is defined as a global change in the water surface elevations of the world's oceans. The total relative sea level change is the combination of eustatic sea level change and changes in local land surface elevations. The eustatic sea level has varied widely over geologic time, and evidence suggests that sea levels in the past have been both much higher - and much lower - than present levels. Sea level rise is a very important issue for future project consideration, however due to the emergency nature of this project, funding limitations, and the objective of preventing current erosion the Recommended Plan considers current day extreme water levels. Future sea level rise was considered, in order to recommend an alternative that can be adapted to future sea level change by the sponsor if necessary.

4.3.5 CALCULATION OF SLR RATES

Sea levels have been rising gradually throughout the study area during the entire period of record. The longest water-level record in the Miami Beach area was measured by NOAA gage #8723170. Recorded water levels from this gage span 50 years, extending from 1931 to 1981. During this period the average annual rate of sea level rise was 2.39 mm per year, +/- 0.43 mm/yr. Note that the gage used to establish the tidal datum used throughout this study (Biscayne Creek, station #8723089) was not used in this computation of sea level change rates due to its short period of record.

It is generally accepted that sea level will continue to rise and that the rate of rise may accelerate due to climatic changes. The Corps of Engineers provides guidance on the calculation of sea level rise and on its application to the design process. The Corps of Engineers' Engineering Regulation (ER) 1100-2-8162 was issued in December 2013 to establish procedures for projecting sea level rise into the future based on global sea level change rates, local historic sea level change rate, base year of project analysis, and number of years in the period of analysis. This ER requires that three scenarios be examined, which result in low, intermediate, and high predictions of sea level rise. The low value is based on an extrapolation of the local historic sea level rise rate. The intermediate and high values are based on the National Research Council (NRC) sea level rise predictive Curves I and III, respectively.

All three curves are based on the following basic equation for prediction of eustatic sea level rise due to ongoing glacial melting and thermal expansion of ocean water:

$E(t) = 0.0017t + bt2$

In this equation E(t) is the eustatic sea level rise (in meters); t is the time of the projection into the future using 1992 as a baseline year. 1992 is used as the baseline because it is the midpoint of the previous tidal epoch (1983-2001). The value b is a coefficient that varies for each of the three NRC curves (note that only curves I and III are used in this analysis). The coefficient b is equal to 2.71E-5 for Curve I; 7.00E-5 for Curve II, and 1.13E-4 for Curve III. This equation assumes a global mean sea level change rate of +1.7 mm/yr. The local sea level change rate for this location includes land subsidence and is +2.39 mm/yr. These parameters were used to calculate the three sea level rise prediction curves as required in ER 1100-2-8162. In Figure 4.1 the extrapolated historic rate is represented by the green line; the NRC Curves I and III predicted rates are represented by the blue and red lines, respectively. These three curves correspond to the low, intermediate, and high predictions of sea level rise required by ER 1100-2-8162, referenced to the base year of 1992.

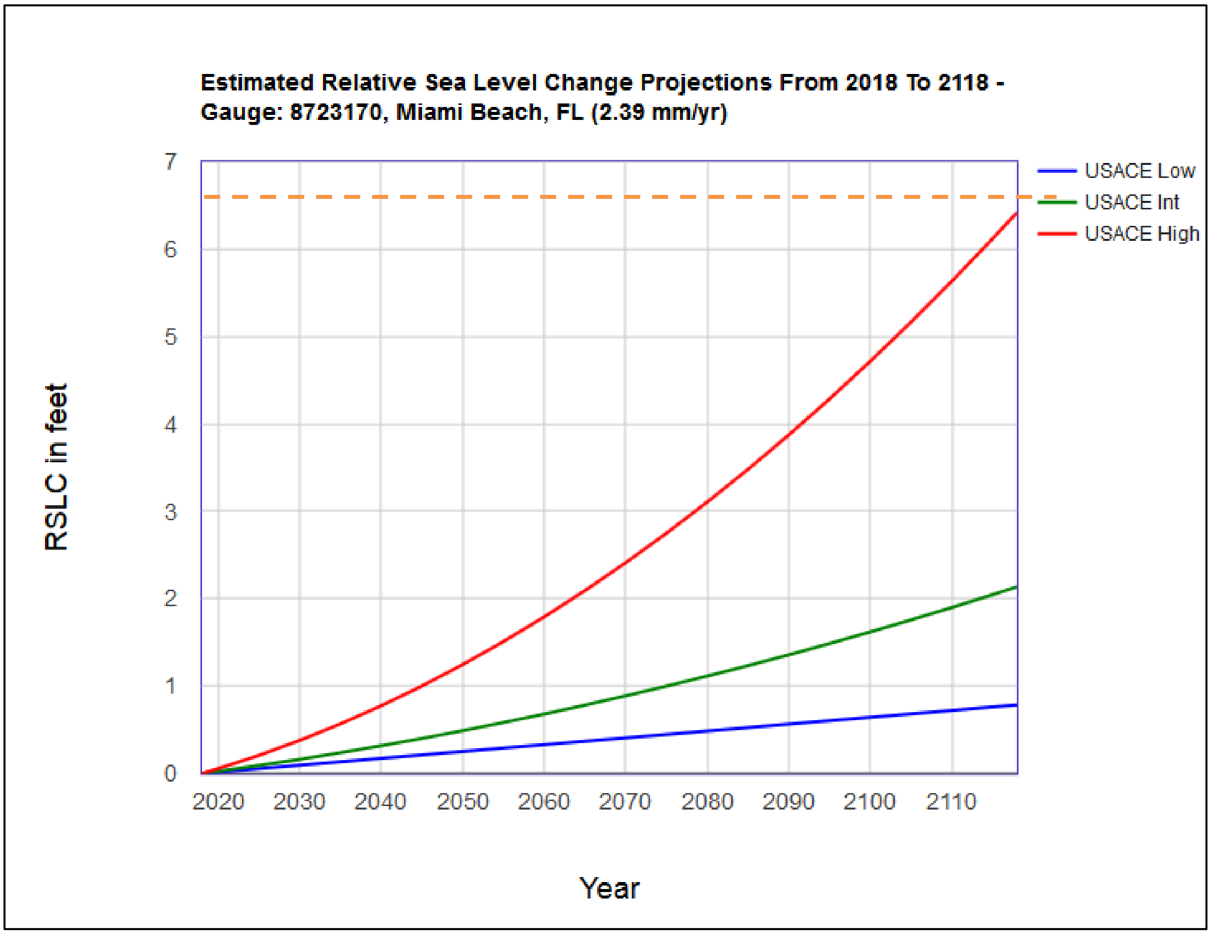


Figure 4.1 Summary of predicted relative sea level rise in Miami Beach by the year 2118.

In accordance with the methodology established in ER1100-2-8162, the year 1992 was chosen as the base year for calculations of sea level change rates for the Miami Beach area. The difference between the base year (1992) and the present (2018) is 26 years, and based on the calculations of RSLC values presented in Figure 4.1, water levels at year 2018 vary from +0.20 to +0.45 feet over the value in 1992. Since the increase in water levels as measured from the present time (2018) is of greater interest in project design than water levels measured from 1992, the values from Figure 4.1 were normalized to 2018 water levels. Table 4.3 presents these values, referenced to the year 2018. The RSLC values provided in Table 4.3 are projected over a 100-year interval, to the year 2118. The 50-year (2068) and 100-year (2118) projections are highlighted in gray.

Estimated Relative Sea Level Change in Feet from 2018 To 2118 Mt. Sinai Medical Center CAP (14) 8723170, Miami Beach, FL NOAA's Published Rate: 0.00784 feet/yr										
SLR Curve	2018	2028	2038	2048	2058	2068	2078	2088	2098	2108	2118
USACE-Low	0	0.08	0.16	0.24	0.31	0.39	0.47	0.55	0.63	0.71	0.78
USACE-Intermediate	0	0.13	0.28	0.45	0.64	0.85	1.07	1.31	1.57	1.84	2.14
USACE-High	0	0.31	0.69	1.15	1.68	2.28	2.96	3.72	4.54	5.44	6.42

Table 4.3 Sea level rise rates referenced to 2018 levels.

4.3.6 BATHYMETRIC/TOPOGRAPHIC DATA

In general, two recent surveys were used for most of the design formulation for this project. Older surveys were utilized to provide historical trends, as-built project conditions for original construction, and other relevant information. The two primary surveys used in this study were performed in 2007 and 2015, and are described below.

A large-scale Lidar (Light Detection and Ranging) survey was performed in 2007 by FDEM (FL Division of Emergency Management. This survey covered the entire barrier island region, including the full extent of the MSMC. This survey produced elevation data at approximately 4-foot intervals across the entire MSMC property, and was used to define elevations for planning and design purposes. Excess elevation data beyond the boundaries of the study area were truncated in the interest of reducing file size and processing time; the limits of the truncated survey are shown in Figure 4.2.

Figure 4.2: 2007 Lidar Survey Boundary

A more limited, but project-specific profile survey was commissioned by Corps of Engineers following approval of the Federal Interest Determination (FID) in 2015. This survey was performed in order to define elevations along the waterfront in greater detail for project design purposes. The contractor was Whidden Surveying & Mapping, Inc., and field work was performed on 10 July 2015. The survey consisted of eight profiles crossing the shoreline, and two upland transects to define elevations along the north and south boundaries of the MSMC property. These profiles and transect lines are shown in Figure 4.2.

Comparisons of these two surveys were performed to determine the consistency of the elevation data which was gathered using two very different survey techniques. Both surveys were in very close agreement in areas where they overlapped, with maximum elevation differences on the order of a few inches or less. This provided a high level of confidence in both site condition surveys. In general, ground-surface elevations throughout the MSMC facility are very low and flat. The crest of the existing seawall varies from about 2 to 2.5 feet NAVD88. Ground elevations landward of the seawall vary from about 2 to 4 feet in most areas. Elevations along both transects are equally low, ranging from the waterline up to maximum elevations of about 4 feet NAVD even at the farthest upland extent of the transects. This creates a potential problem with anchoring any erosion control structures into higher ground to protect against flanking. Initial indications are that any measures will have to wrap around most of the perimeter of the MSMC property to adequately protect the facility against elevated water levels and resulting erosion.

Example 1: FEMA BFE. Using the FEMA base flood elevation (BFE - 1 percent annual chance of exceedance) of 5.6 feet (with no allowance for wave overtopping or sea level rise), the existing bayfront seawall would require raising by up to 3.6 feet. Examination of the transect survey data shows that no surface elevations of +5.6 feet NAVD88 exist along either alignment, so this structure would be vulnerable to flanking. The flood-prevention structure could be anchored into the Julia Tuttle causeway embankment along the south side, but proper real estate easements would likely be required. No suitably high elevations exist along the northern MSMC property boundary to prevent flanking, and much of the MSMC would have to be encircled by flood control structures to prevent erosion by the 100-year event.

Based on elevations provided by the 2007 Lidar survey, the added distance required to anchor the south end of the protective structure into the +5.6-feet elevation contour is 55 feet. This wing wall would extend from the southern terminus of the seawall, southward to the +5.6-feet elevation contour along the Julia Tuttle Causeway embankment. The length of the wing wall required to prevent flanking around the north end of the seawall is much longer, due to extensive areas of low existing ground elevations in that area. To extend from the northern terminus of the existing seawall landward to the +5.6-feet contour would require an additional 1,150 feet of structure. The alignment of this structure would extend eastward along the northern perimeter of the MSMC property, then parallel to Alton Road, past the main entrance to the facility, and anchoring into the +5.6-feet contour in front of the south end of the existing parking garage. This wing wall extends along developed and/or constricted areas, and extends across the main entrance into the MSMC facility.

Example 2: FEMA+1. This alternative uses the FEMA base flood (1 percent chance of exceedance) elevation of 5.6 feet of elevation, plus a 1-foot allowance for wave overtopping and sea level rise effects. This alternative was suggested for future protective structures constructed throughout the northeast US in response to Hurricane Sandy. Using FEMA+1 the design flood-control structure elevation becomes 5.6 feet + 1.0 feet = 6.6 feet NAVD88. This alternative would require raising the existing seawall by up to 4.6 feet. The same problem exists with the lack of sufficiently high upland elevations to anchor the flanks of the structure into. As with the “FEMA BFE” option, the resulting structure would have to encircle most of the MSMC in order to prevent flanking.

The alignments of the wing walls required to properly anchor the reconstructed seawall into the +6.6-foot contour would be the same as for the previous option. The lengths of each wing wall would increase however, since they tie into slightly higher elevations. The total length of the south wing wall would be 60 feet, while the north wing wall length would increase to about 1,350 feet. As with the “FEMA BFE” option, this wing wall extends along developed and/or constricted areas, and extends across the main entrance into the MSMC facility.

Example 3: FEMA+3. This alternative uses the FEMA base flood (1 percent chance of exceedance) elevation of 5.6 feet of elevation, plus a 3-foot allowance for wave overtopping and sea level rise effects. This alternative is consistent with the City of Miami Beach’s requirement for construction of flood control measures. Using FEMA+3 the design flood-control structure elevation becomes 5.6 feet + 3.0 feet = 8.6 feet NAVD88. This alternative would require raising the existing seawall by up to 6.6 feet above its present crest elevation. The problem created by the lack of sufficiently high upland elevations in which to anchor the flanks of the structure is exacerbated with this alternative.

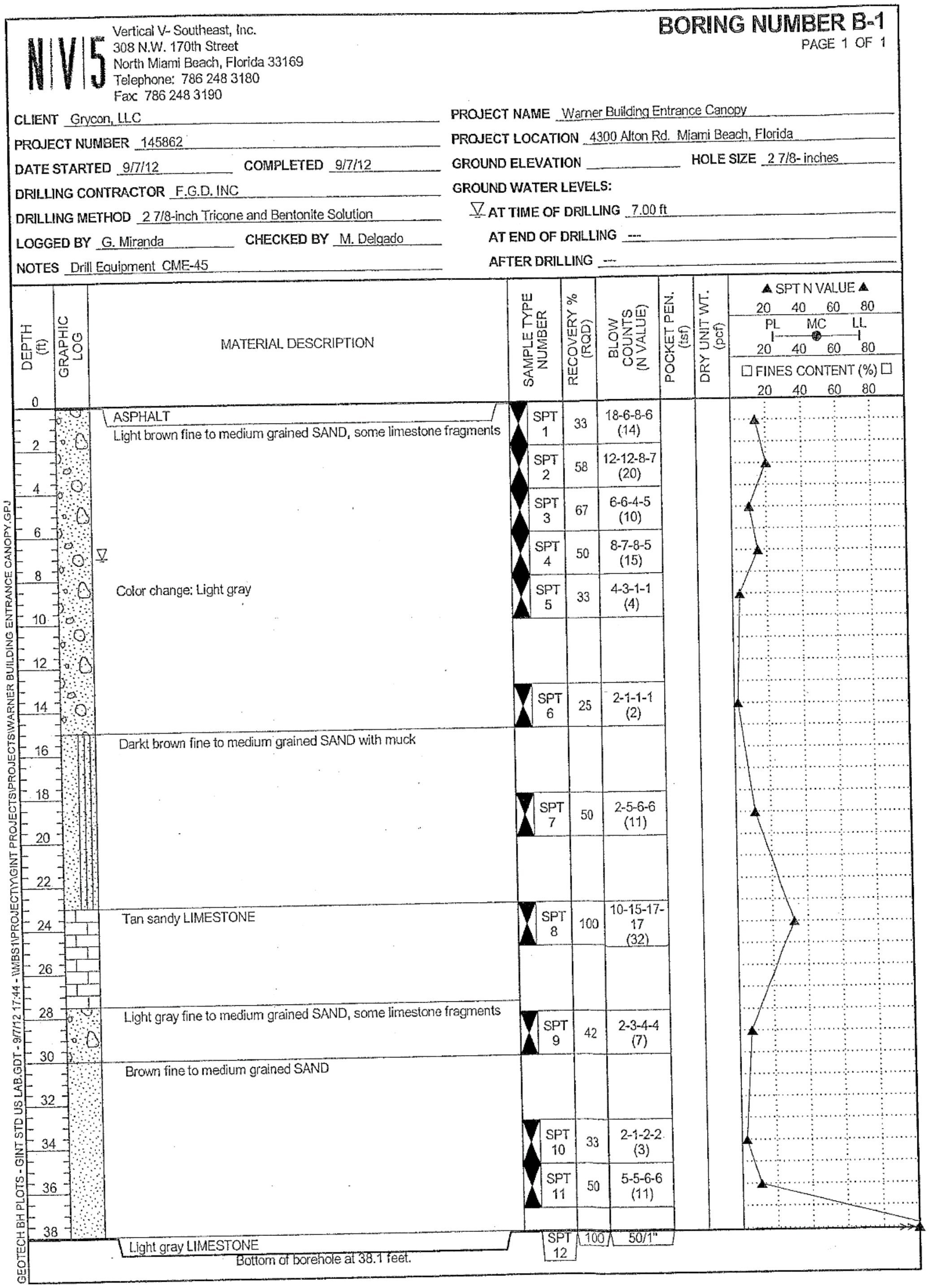
Analysis of the 2007 Lidar survey shows that there are no ground elevations around the perimeter of the MSMC that are high enough to anchor wing walls into, to prevent flanking of the seawall. The protective structure would therefore have to encircle the entire facility. Such a structure would extend from one end of the seawall, around the outermost perimeter of the facility, and tie onto the other end of the seawall. The total length of such a structure (in addition to the 2,950-feet length of the seawall) is 4,100 feet. Much of this alignment extends along the Tuttle Causeway and Alton Road. This structure would also extend across both entrances to the MSMC facility.

Example 4: Local Observations. Anecdotal and photographic evidence provided by MSMC shows that water levels presently overtop the existing seawall by a foot or less during the annual “king tide” events that cause the inundation/erosion that is the basis for this study. The level of overtopping will certainly increase over time due to sea level rise, but at this time there is no evidence to suggest that water levels rise to more than a foot over the existing seawall elevation. Taking the upper limit of the existing seawall heights to be +2.5 feet NAVD88, this results in a maximum design water level during “king tide” events of +3.5 feet NAVD88. Based upon photo documentation provided by MSMC and the maximum recorded water level of +2.79 NAVD88 at the Virginia Key gage, it is rational to assume that a crest elevation of +3.5 will provide robust if not complete protection against the high water events which are resulting in the documented erosion along the MSMC bayfront.

A 3.5-feet elevation is coincident with the maximum existing ground elevations along the northern perimeter of the MSMC property, and would allow the structure to be tied into existing ground within a relatively short distance (about 50 feet) of the bayfront, versus some the higher design elevations that required much longer tieback lengths – some nearly encircling the entire MSMC facility. Based on the Virginia Key gage data, a crest elevation of +3.5 feet would prevent flooding from the maximum measured water level event at that gage, would address the level of flooding observed at MSMC during “king tide” events, and would tie in more easily to the existing topography than previous alternatives and therefore would be more constructible.

The majority of the proposed structure lies along the exposed bayfront of MSMC and is subject to overtopping from wind-generated waves and from boat wakes. In order to minimize overtopping and protect against erosion an additional 0.5 feet can be added to the design crest elevation of the protective structure in order to reduce the amount of overtopping due to wave action. This would result in a crest elevation of +4.0 feet NAVD88. Since wind-generated waves and boat wakes will not propagate inland to the tie-in point, the structure can terminate at the +3.5-feet elevation contour at the northern end.

ATTACHMENT A – (GEOTECHNICAL ADDEDUM)



NV5
Vertical V- Southeast, Inc.
308 N.W. 170th Street
North Miami Beach, Florida 33169
Telephone: 786 248 3180
Fax: 786 248 3190

BORING NUMBER B-1
PAGE 1 OF 1

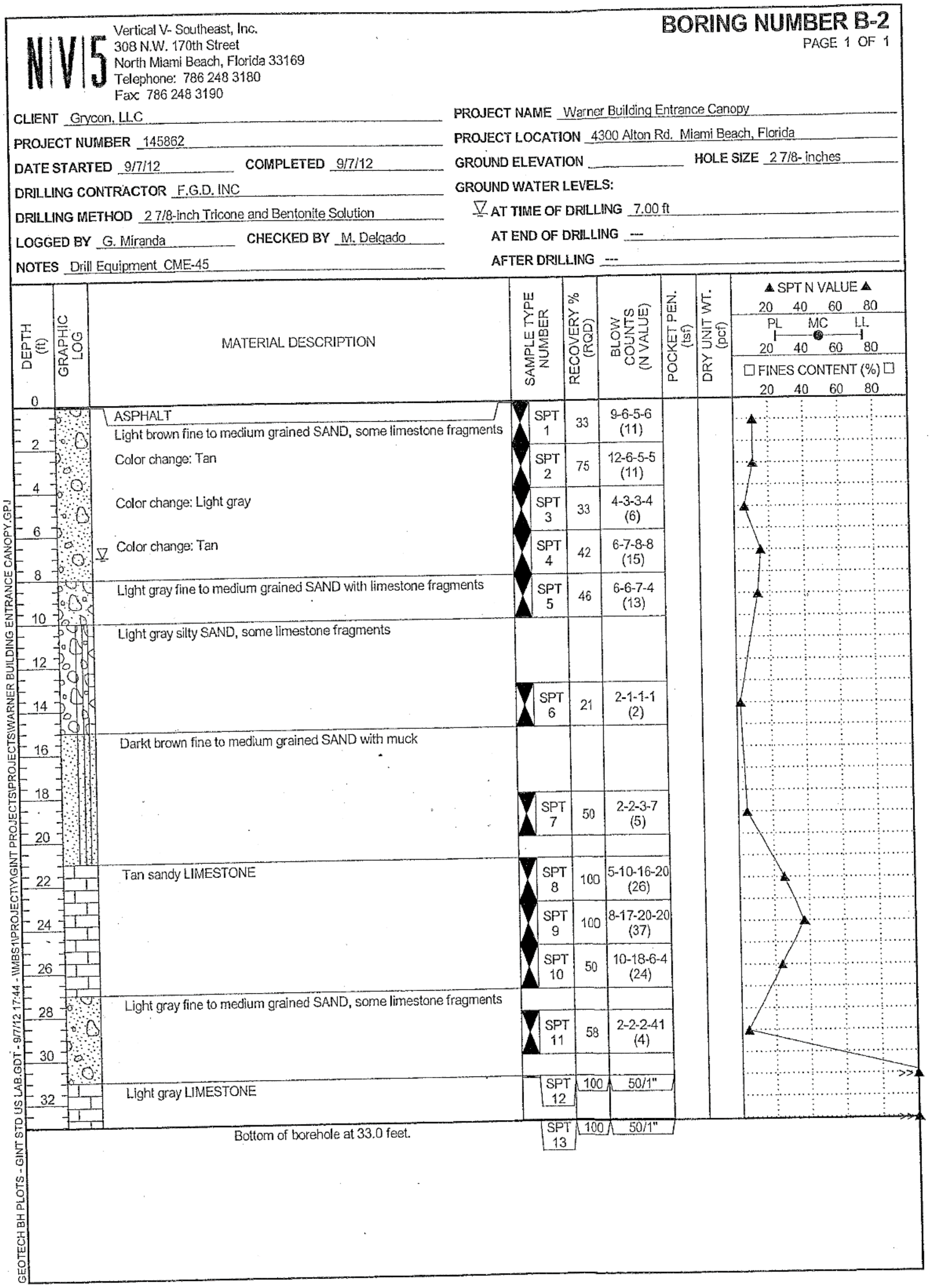
CLIENT Grycon, LLC
PROJECT NUMBER 145862
DATE STARTED 9/7/12 **COMPLETED** 9/7/12
DRILLING CONTRACTOR F.G.D. INC
DRILLING METHOD 2 7/8-inch Tricone and Bentonite Solution
LOGGED BY G. Miranda **CHECKED BY** M. Delgado
NOTES Drill Equipment CME-45

PROJECT NAME Warner Building Entrance Canopy
PROJECT LOCATION 4300 Alton Rd. Miami Beach, Florida
GROUND ELEVATION ______ **HOLE SIZE** 2 7/8- inches
GROUND WATER LEVELS:
∇ **AT TIME OF DRILLING** 7.00 ft
AT END OF DRILLING ---
AFTER DRILLING ---

MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)
ASPHALT Light brown fine to medium grained SAND, some limestone fragments	SPT 1	33	18-6-8-6 (14)		
	SPT 2	58	12-12-8-7 (20)		
	SPT 3	67	6-6-4-5 (10)		
∇	SPT 4	50	8-7-8-5 (15)		
Color change: Light gray	SPT 5	33	4-3-1-1 (4)		
	SPT 6	25	2-1-1-1 (2)		
Darkt brown fine to medium grained SAND with muck	SPT 7	50	2-5-6-6 (11)		
Tan sandy LIMESTONE	SPT 8	100	10-15-17-17 (32)		
Light gray fine to medium grained SAND, some limestone fragments	SPT 9	42	2-3-4-4 (7)		
Brown fine to medium grained SAND	SPT 10	33	2-1-2-2 (3)		
	SPT 11	50	5-5-6-6 (11)		
Light gray LIMESTONE	SPT 12	100	50/1"		

Bottom of borehole at 38.1 feet.

GEOTECH BH PLOTS - GINT STD US LAB.GDT - 9/7/12 17:44 - \\MBS1\PROJECTY\GINT PROJECTS\PROJECTS\WARNER BUILDING ENTRANCE CANOPY.GPJ



NV5
Vertical V- Southeast, Inc.
308 N.W. 170th Street
North Miami Beach, Florida 33169
Telephone: 786 248 3180
Fax 786 248 3190

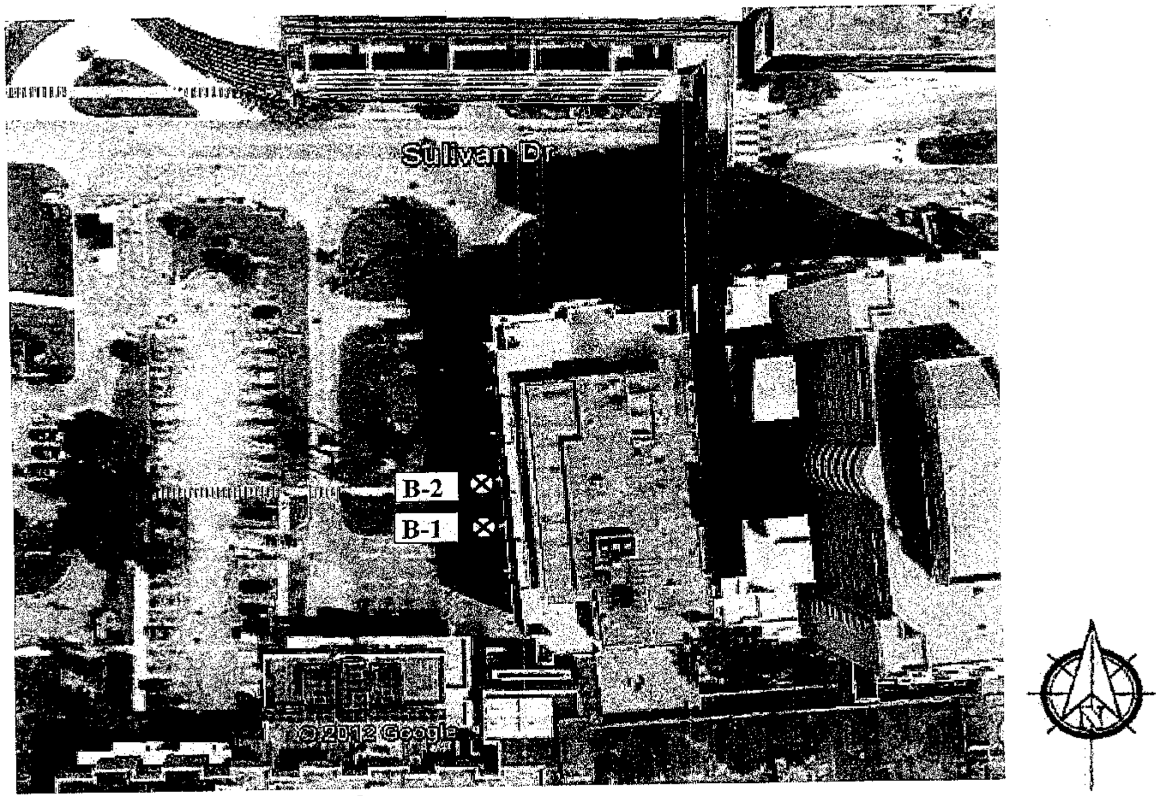
BORING NUMBER B-2
PAGE 1 OF 1

CLIENT Grycon, LLC
PROJECT NUMBER 145862
DATE STARTED 9/7/12 COMPLETED 9/7/12
DRILLING CONTRACTOR F.G.D. INC
DRILLING METHOD 2 7/8-inch Tricone and Bentonite Solution
LOGGED BY G. Miranda CHECKED BY M. Delgado
NOTES Drill Equipment CME-45

PROJECT NAME Warner Building Entrance Canopy
PROJECT LOCATION 4300 Alton Rd. Miami Beach, Florida
GROUND ELEVATION ___ HOLE SIZE 2 7/8- inches
GROUND WATER LEVELS:
∇ AT TIME OF DRILLING 7.00 ft
AT END OF DRILLING ---
AFTER DRILLING ---

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)
0	ASPHALT Light brown fine to medium grained SAND, some limestone fragments	SPT 1	33	9-6-5-6 (11)		
2	Color change: Tan	SPT 2	75	12-6-5-5 (11)		
4	Color change: Light gray	SPT 3	33	4-3-3-4 (6)		
6	∇ Color change: Tan	SPT 4	42	6-7-8-8 (15)		
8	Light gray fine to medium grained SAND with limestone fragments	SPT 5	46	6-6-7-4 (13)		
10	Light gray silty SAND, some limestone fragments					
14		SPT 6	21	2-1-1-1 (2)		
16	Darkt brown fine to medium grained SAND with muck					
18		SPT 7	50	2-2-3-7 (5)		
22	Tan sandy LIMESTONE	SPT 8	100	5-10-16-20 (26)		
24		SPT 9	100	8-17-20-20 (37)		
26		SPT 10	50	10-18-6-4 (24)		
28	Light gray fine to medium grained SAND, some limestone fragments	SPT 11	58	2-2-2-41 (4)		
31	Light gray LIMESTONE	SPT 12	100	50/1"		
33	Bottom of borehole at 33.0 feet.	SPT 13	100	50/1"		

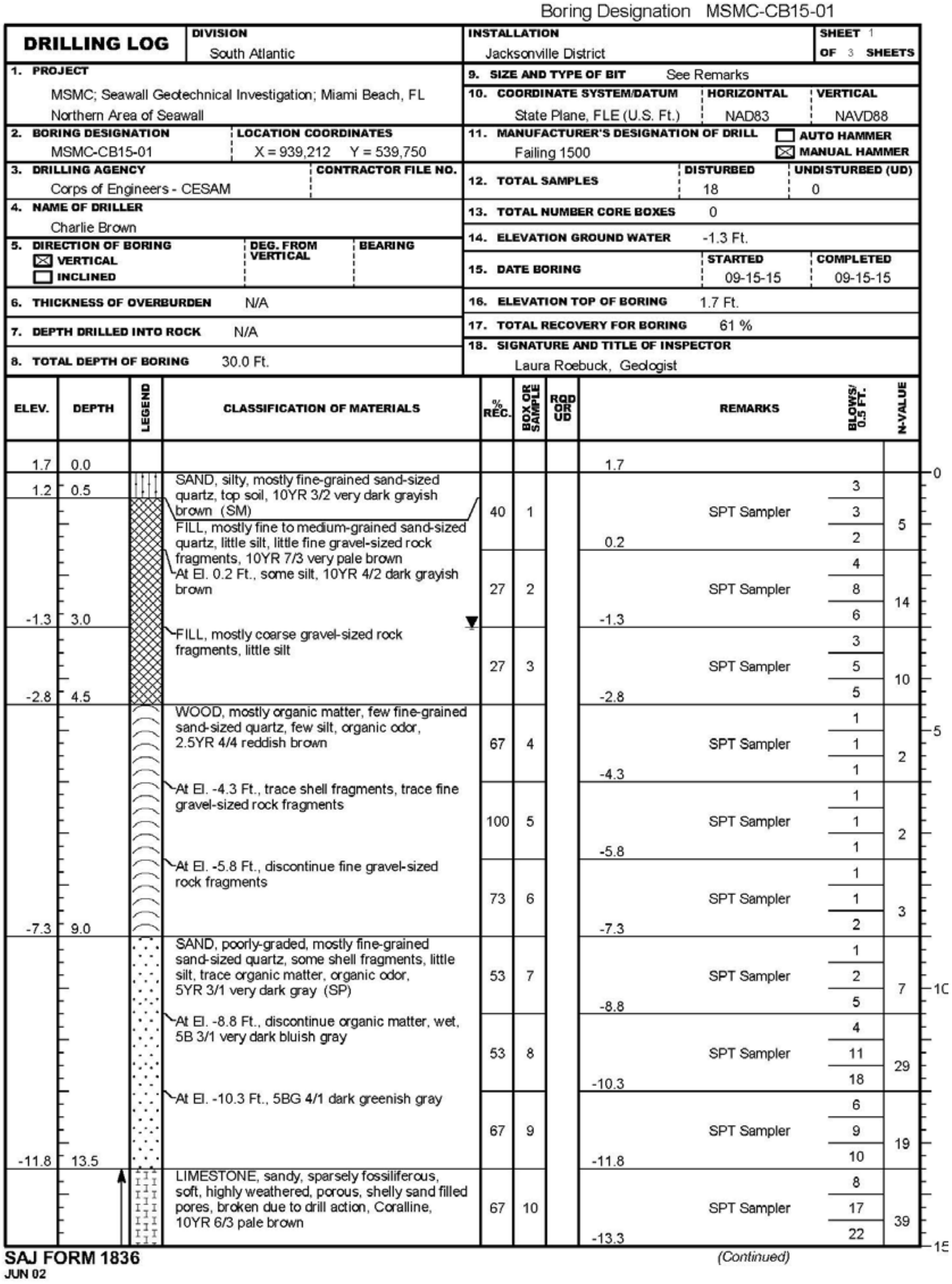
GEOTECH BH PLOTS - GINT STD US LAB.GDT - 9/7/12 17:44 - \\MBS1\PROJECT\GINT PROJECTS\PROJECTS\WARNER BUILDING ENTRANCE CANOPY.GPJ



Projet: Warner Building Entrance Canopy
Location: 4300 Alton Rd. Miami Beach, Florida
Vertical-V Project No. 145862

⊗ **Approximate Boring Test Location (not to scale)**

NV5



Boring Designation MSMC-CB15-01

DRILLING LOG

DIVISION South Atlantic
INSTALLATION Jacksonville District
SHEET 1 **OF** 3 **SHEETS**

1. PROJECT MSMC; Seawall Geotechnical Investigation; Miami Beach, FL
Northern Area of Seawall

2. BORING DESIGNATION MSMC-CB15-01
LOCATION COORDINATES X = 939,212 Y = 539,750

3. DRILLING AGENCY Corps of Engineers - CESAM
CONTRACTOR FILE NO.

4. NAME OF DRILLER Charlie Brown

5. DIRECTION OF BORING ☒ **VERTICAL** ☐ **INCLINED**
DEG. FROM VERTICAL
BEARING

6. THICKNESS OF OVERBURDEN N/A

7. DEPTH DRILLED INTO ROCK N/A

8. TOTAL DEPTH OF BORING 30.0 Ft.

9. SIZE AND TYPE OF BIT See Remarks

10. COORDINATE SYSTEM/DATUM State Plane, FLE (U.S. Ft.) **HORIZONTAL** NAD83 **VERTICAL** NAVD88

11. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500 ☐ **AUTO HAMMER** ☒ **MANUAL HAMMER**

12. TOTAL SAMPLES **DISTURBED** 18 **UNDISTURBED (UD)** 0

13. TOTAL NUMBER CORE BOXES 0

14. ELEVATION GROUND WATER -1.3 Ft.

15. DATE BORING **STARTED** 09-15-15 **COMPLETED** 09-15-15

16. ELEVATION TOP OF BORING 1.7 Ft.

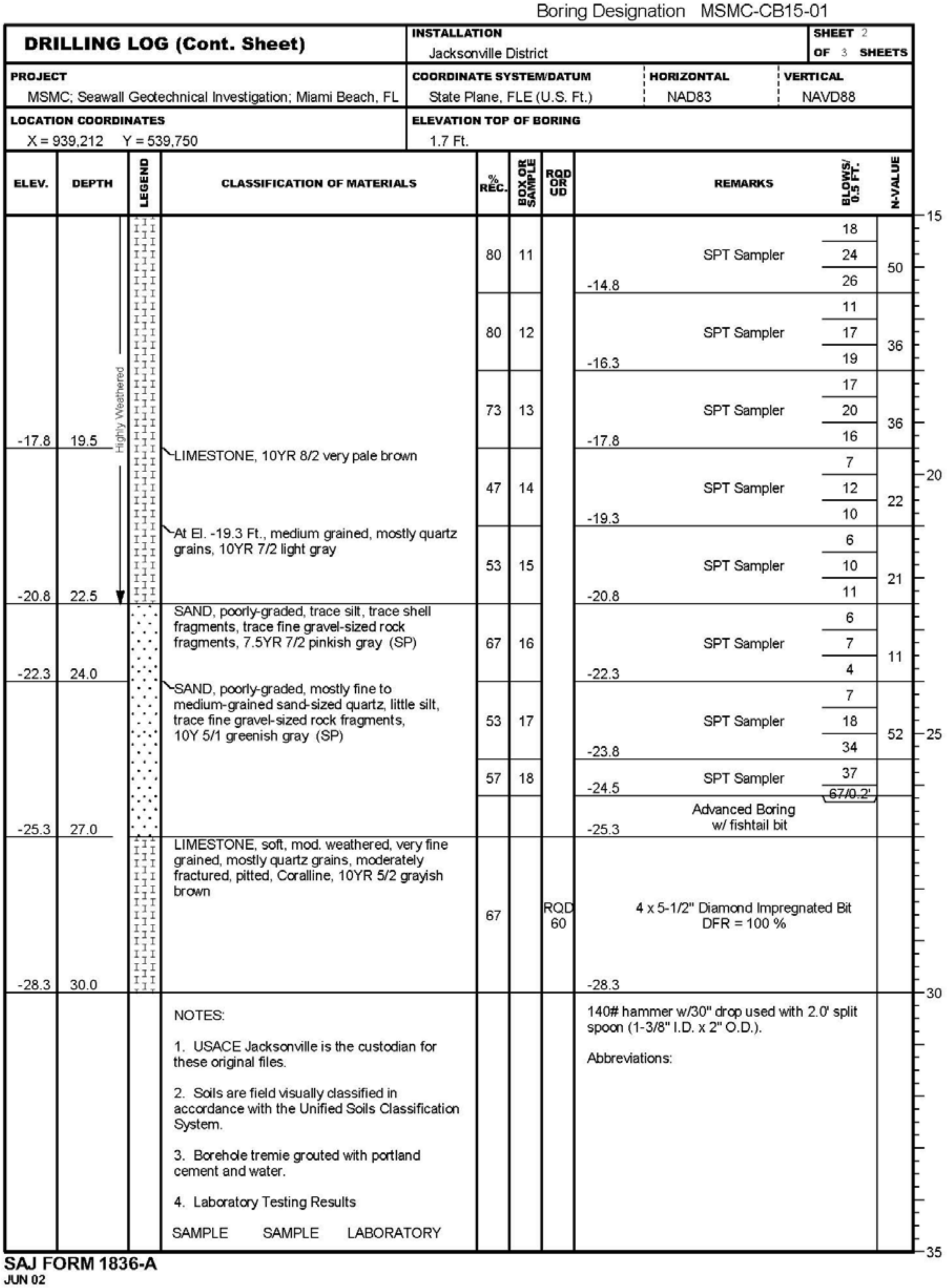
17. TOTAL RECOVERY FOR BORING 61 %

18. SIGNATURE AND TITLE OF INSPECTOR Laura Roebuck, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
1.7	0.0						1.7		
1.2	0.5		SAND, silty, mostly fine-grained sand-sized quartz, top soil, 10YR 3/2 very dark grayish brown (SM) FILL, mostly fine to medium-grained sand-sized quartz, little silt, little fine gravel-sized rock fragments, 10YR 7/3 very pale brown	40	1		SPT Sampler 0.2	3 3 2	5
-1.3	3.0		At El. 0.2 Ft., some silt, 10YR 4/2 dark grayish brown ▼	27	2		SPT Sampler -1.3	4 8 6	14
-2.8	4.5		FILL, mostly coarse gravel-sized rock fragments, little silt	27	3		SPT Sampler -2.8	3 5 5	10
			WOOD, mostly organic matter, few fine-grained sand-sized quartz, few silt, organic odor, 2.5YR 4/4 reddish brown	67	4		SPT Sampler -4.3	1 1 1	2
			At El. -4.3 Ft., trace shell fragments, trace fine gravel-sized rock fragments	100	5		SPT Sampler -5.8	1 1 1	2
-7.3	9.0		At El. -5.8 Ft., discontinue fine gravel-sized rock fragments	73	6		SPT Sampler -7.3	1 1 2	3
			SAND, poorly-graded, mostly fine-grained sand-sized quartz, some shell fragments, little silt, trace organic matter, organic odor, 5YR 3/1 very dark gray (SP)	53	7		SPT Sampler -8.8	1 2 5	7
			At El. -8.8 Ft., discontinue organic matter, wet, 5B 3/1 very dark bluish gray	53	8		SPT Sampler -10.3	4 11 18	29
-11.8	13.5		At El. -10.3 Ft., 5BG 4/1 dark greenish gray	67	9		SPT Sampler -11.8	6 9 10	19
			LIMESTONE, sandy, sparsely fossiliferous, soft, highly weathered, porous, shelly sand filled pores, broken due to drill action, Coralline, 10YR 6/3 pale brown	67	10		SPT Sampler -13.3	8 17 22	39

(Continued)

SAJ FORM 1836
JUN 02



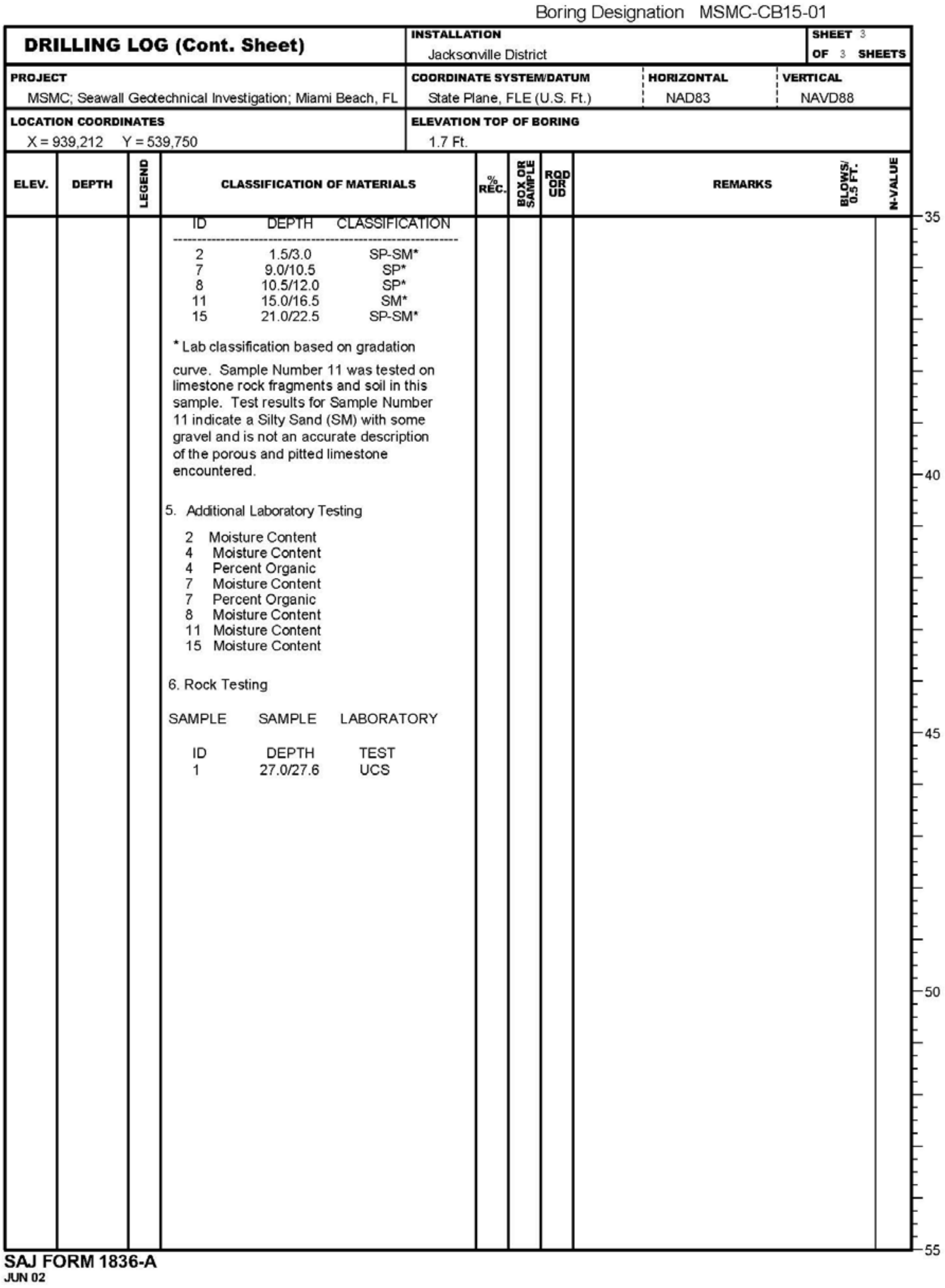
Boring Designation MSMC-CB15-01

DRILLING LOG (Cont. Sheet)	**INSTALLATION** Jacksonville District	**SHEET** 2 **OF** 3 **SHEETS**

PROJECT MSMC; Seawall Geotechnical Investigation; Miami Beach, FL	**COORDINATE SYSTEM/DATUM** State Plane, FLE (U.S. Ft.)	**HORIZONTAL** NAD83	**VERTICAL** NAVD88
LOCATION COORDINATES X = 939,212 Y = 539,750	**ELEVATION TOP OF BORING** 1.7 Ft.		

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
				80	11		SPT Sampler -14.8	18 24 26	50
				80	12		SPT Sampler -16.3	11 17 19	36
-17.8	19.5			73	13		SPT Sampler -17.8	17 20 16	36
			LIMESTONE, 10YR 8/2 very pale brown	47	14		SPT Sampler -19.3	7 12 10	22
-20.8	22.5		At El. -19.3 Ft., medium grained, mostly quartz grains, 10YR 7/2 light gray	53	15		SPT Sampler -20.8	6 10 11	21
-22.3	24.0		SAND, poorly-graded, trace silt, trace shell fragments, trace fine gravel-sized rock fragments, 7.5YR 7/2 pinkish gray (SP)	67	16		SPT Sampler -22.3	6 7 4	11
			SAND, poorly-graded, mostly fine to medium-grained sand-sized quartz, little silt, trace fine gravel-sized rock fragments, 10Y 5/1 greenish gray (SP)	53	17		SPT Sampler -23.8	7 18 34	52
				57	18		SPT Sampler -24.5	37 67/0.2'	
-25.3	27.0						Advanced Boring w/ fishtail bit -25.3		
-28.3	30.0		LIMESTONE, soft, mod. weathered, very fine grained, mostly quartz grains, moderately fractured, pitted, Coralline, 10YR 5/2 grayish brown	67		RQD 60	4 x 5-1/2" Diamond Impregnated Bit DFR = 100 % -28.3		
			NOTES: 1. USACE Jacksonville is the custodian for these original files. 2. Soils are field visually classified in accordance with the Unified Soils Classification System. 3. Borehole tremie grouted with portland cement and water. 4. Laboratory Testing Results SAMPLE SAMPLE LABORATORY				140# hammer w/30" drop used with 2.0' split spoon (1-3/8" I.D. x 2" O.D.). Abbreviations:		

SAJ FORM 1836-A
JUN 02



Boring Designation MSMC-CB15-01

DRILLING LOG (Cont. Sheet)

INSTALLATION Jacksonville District

SHEET 3 **OF** 3 **SHEETS**

PROJECT MSMC; Seawall Geotechnical Investigation; Miami Beach, FL

COORDINATE SYSTEM/DATUM State Plane, FLE (U.S. Ft.)

HORIZONTAL NAD83

VERTICAL NAVD88

LOCATION COORDINATES X = 939,212 Y = 539,750

ELEVATION TOP OF BORING 1.7 Ft.

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE

ID	DEPTH	CLASSIFICATION
2	1.5/3.0	SP-SM*
7	9.0/10.5	SP*
8	10.5/12.0	SP*
11	15.0/16.5	SM*
15	21.0/22.5	SP-SM*

* Lab classification based on gradation curve. Sample Number 11 was tested on limestone rock fragments and soil in this sample. Test results for Sample Number 11 indicate a Silty Sand (SM) with some gravel and is not an accurate description of the porous and pitted limestone encountered.

5. Additional Laboratory Testing

2	Moisture Content
4	Moisture Content
4	Percent Organic
7	Moisture Content
7	Percent Organic
8	Moisture Content
11	Moisture Content
15	Moisture Content

6. Rock Testing

SAMPLE ID	SAMPLE DEPTH	LABORATORY TEST
1	27.0/27.6	UCS

SAJ FORM 1836-A
JUN 02

Boring Designation MSMC-CB15-02

DRILLING LOG

DIVISION South Atlantic

INSTALLATION Jacksonville District

SHEET 1 **OF** 3 **SHEETS**

1. PROJECT
MSMC; Seawall Geotechnical Investigation; Miami Beach, FL
Middle Area of Seawall

2. BORING DESIGNATION MSMC-CB15-02

LOCATION COORDINATES X = 938,259 Y = 538,922

3. DRILLING AGENCY Corps of Engineers - CESAM

CONTRACTOR FILE NO.

4. NAME OF DRILLER Charlie Brown

5. DIRECTION OF BORING
☒ **VERTICAL**
☐ **INCLINED**

DEG. FROM VERTICAL

BEARING

6. THICKNESS OF OVERBURDEN N/A

7. DEPTH DRILLED INTO ROCK N/A

8. TOTAL DEPTH OF BORING 34.5 Ft.

9. SIZE AND TYPE OF BIT See Remarks

10. COORDINATE SYSTEM/DATUM State Plane, FLE (U.S. Ft.) **HORIZONTAL** NAD83 **VERTICAL** NAVD88

11. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500
☐ **AUTO HAMMER**
☒ **MANUAL HAMMER**

12. TOTAL SAMPLES **DISTURBED** 23 **UNDISTURBED (UD)** 0

13. TOTAL NUMBER CORE BOXES 0

14. ELEVATION GROUND WATER -0.1 Ft.

15. DATE BORING **STARTED** 09-16-15 **COMPLETED** 09-17-15

16. ELEVATION TOP OF BORING 1.8 Ft.

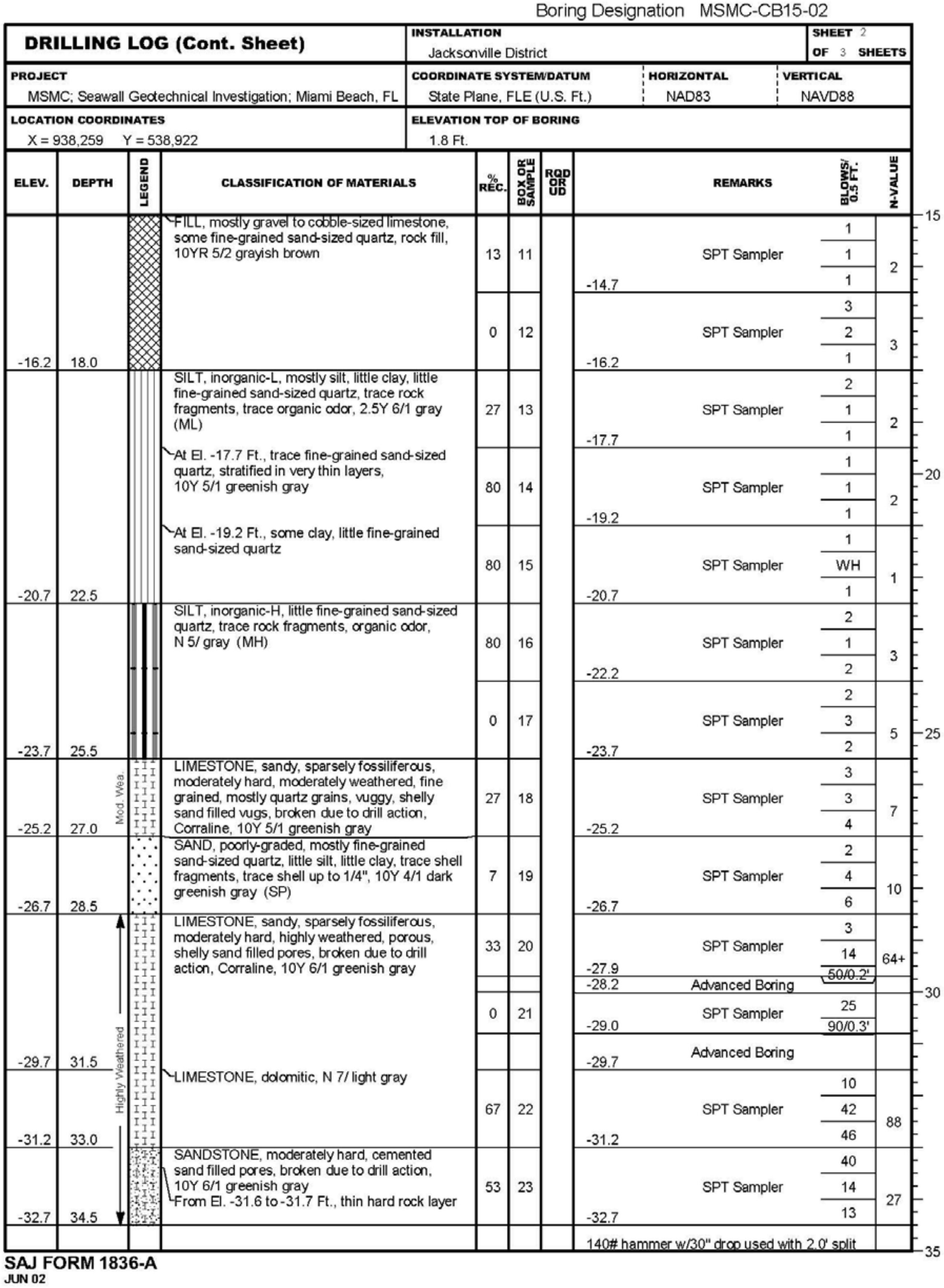
17. TOTAL RECOVERY FOR BORING 34 %

18. SIGNATURE AND TITLE OF INSPECTOR Laura Roebuck, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
1.8	0.0						1.8		
		▨	FILL, mostly fine gravel-sized rock fragments, some fine to coarse-grained sand-sized quartz, trace shell fragments, dry	47	1		SPT Sampler 0.3	3 8 13	21
0.3	1.5	▨	FILL, mostly fine to coarse-grained sand-sized quartz, some coarse gravel-sized rock fragments, wet ▼	47	2		SPT Sampler -1.2	8 8 7	15
		▨		60	3		SPT Sampler -2.7	4 6 6	12
		▨	At El. -2.7 Ft., little shell fragments, 10YR 6/1 gray	47	4		SPT Sampler -4.2	5 6 7	13
		▨	At El. -4.2 Ft., some fine to medium-grained sand-sized quartz, trace silt, 10YR 5/1 gray	53	5		SPT Sampler -5.7	6 6 7	13
		▨	At El. -5.7 Ft., mostly fine to medium-grained sand-sized quartz, some fine gravel-sized rock fragments, 10YR 6/1 gray	13	6		SPT Sampler -7.2	7 6 6	12
		▨		0	7		SPT Sampler -8.7	3 1 1	2
		▨	At El. -8.7 Ft., trace rock fragments, Low Recovery	27	8		SPT Sampler -10.2	3 5 4	9
		▨		0	9		SPT Sampler -11.7	6 4 2	6
-13.2	15.0	▨		0	10		SPT Sampler -13.2	3 1 1	2

SAJ FORM 1836
JUN 02

(Continued)



Boring Designation MSMC-CB15-02

DRILLING LOG (Cont. Sheet)

INSTALLATION Jacksonville District

SHEET 2 **OF** 3 **SHEETS**

PROJECT MSMC; Seawall Geotechnical Investigation; Miami Beach, FL

COORDINATE SYSTEM/DATUM State Plane, FLE (U.S. Ft.)

HORIZONTAL NAD83

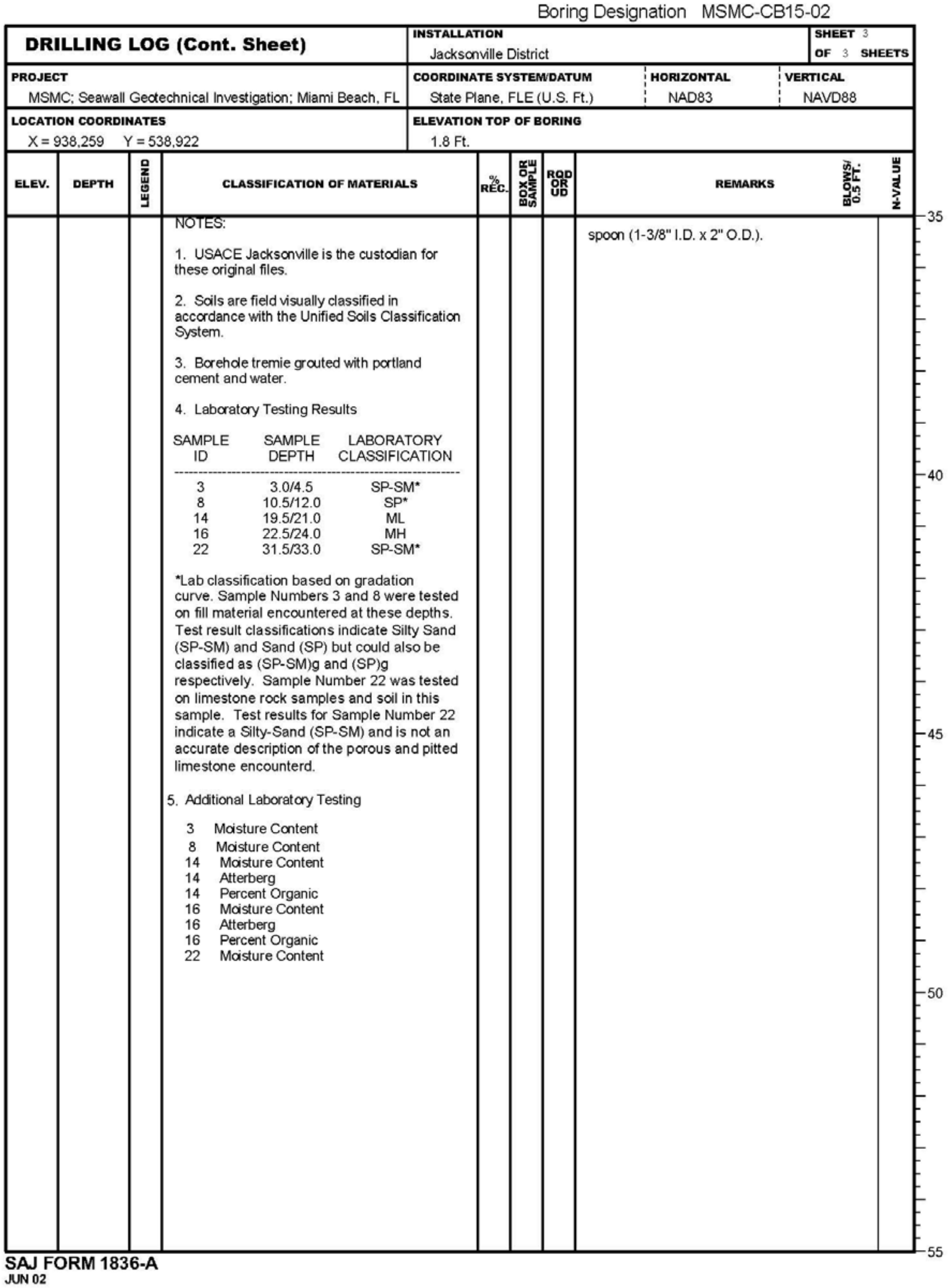
VERTICAL NAVD88

LOCATION COORDINATES X = 938,259 Y = 538,922

ELEVATION TOP OF BORING 1.8 Ft.

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
			FILL, mostly gravel to cobble-sized limestone, some fine-grained sand-sized quartz, rock fill, 10YR 5/2 grayish brown	13	11		SPT Sampler -14.7	1 1 1	2
-16.2	18.0			0	12		SPT Sampler -16.2	3 2 1	3
			SILT, inorganic-L, mostly silt, little clay, little fine-grained sand-sized quartz, trace rock fragments, trace organic odor, 2.5Y 6/1 gray (ML)	27	13		SPT Sampler -17.7	2 1 1	2
			At El. -17.7 Ft., trace fine-grained sand-sized quartz, stratified in very thin layers, 10Y 5/1 greenish gray	80	14		SPT Sampler -19.2	1 1 1	2
-20.7	22.5		At El. -19.2 Ft., some clay, little fine-grained sand-sized quartz	80	15		SPT Sampler -20.7	1 WH 1	1
			SILT, inorganic-H, little fine-grained sand-sized quartz, trace rock fragments, organic odor, N 5/ gray (MH)	80	16		SPT Sampler -22.2	2 1 2	3
-23.7	25.5			0	17		SPT Sampler -23.7	2 3 2	5
-25.2	27.0	Mod. Wea.	LIMESTONE, sandy, sparsely fossiliferous, moderately hard, moderately weathered, fine grained, mostly quartz grains, vuggy, shelly sand filled vugs, broken due to drill action, Corraline, 10Y 5/1 greenish gray	27	18		SPT Sampler -25.2	3 3 4	7
-26.7	28.5		SAND, poorly-graded, mostly fine-grained sand-sized quartz, little silt, little clay, trace shell fragments, trace shell up to 1/4", 10Y 4/1 dark greenish gray (SP)	7	19		SPT Sampler -26.7	2 4 6	10
		Highly Weathered	LIMESTONE, sandy, sparsely fossiliferous, moderately hard, highly weathered, porous, shelly sand filled pores, broken due to drill action, Corraline, 10Y 6/1 greenish gray	33	20		SPT Sampler -27.9	3 14 50/0.2'	64+
							Advanced Boring -28.2		
				0	21		SPT Sampler -29.0	25 90/0.3'	
-29.7	31.5						Advanced Boring -29.7		
-31.2	33.0		LIMESTONE, dolomitic, N 7/ light gray	67	22		SPT Sampler -31.2	10 42 46	88
-32.7	34.5		SANDSTONE, moderately hard, cemented sand filled pores, broken due to drill action, 10Y 6/1 greenish gray From El. -31.6 to -31.7 Ft., thin hard rock layer	53	23		SPT Sampler -32.7	40 14 13	27
							140# hammer w/30" drop used with 2.0' split		

SAJ FORM 1836-A
JUN 02



Boring Designation MSMC-CB15-02

DRILLING LOG (Cont. Sheet)

INSTALLATION Jacksonville District

SHEET 3 **OF** 3 **SHEETS**

PROJECT MSMC; Seawall Geotechnical Investigation; Miami Beach, FL

COORDINATE SYSTEM/DATUM State Plane, FLE (U.S. Ft.)

HORIZONTAL NAD83

VERTICAL NAVD88

LOCATION COORDINATES X = 938,259 Y = 538,922

ELEVATION TOP OF BORING 1.8 Ft.

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
			NOTES:				spoon (1-3/8" I.D. x 2" O.D.).		

NOTES:

1. USACE Jacksonville is the custodian for these original files.

2. Soils are field visually classified in accordance with the Unified Soils Classification System.

3. Borehole tremie grouted with portland cement and water.

4. Laboratory Testing Results

SAMPLE ID	SAMPLE DEPTH	LABORATORY CLASSIFICATION
3	3.0/4.5	SP-SM*
8	10.5/12.0	SP*
14	19.5/21.0	ML
16	22.5/24.0	MH
22	31.5/33.0	SP-SM*

*Lab classification based on gradation curve. Sample Numbers 3 and 8 were tested on fill material encountered at these depths. Test result classifications indicate Silty Sand (SP-SM) and Sand (SP) but could also be classified as (SP-SM)g and (SP)g respectively. Sample Number 22 was tested on limestone rock samples and soil in this sample. Test results for Sample Number 22 indicate a Silty-Sand (SP-SM) and is not an accurate description of the porous and pitted limestone encounterd.

5. Additional Laboratory Testing

3	Moisture Content
8	Moisture Content
14	Moisture Content
14	Atterberg
14	Percent Organic
16	Moisture Content
16	Atterberg
16	Percent Organic
22	Moisture Content

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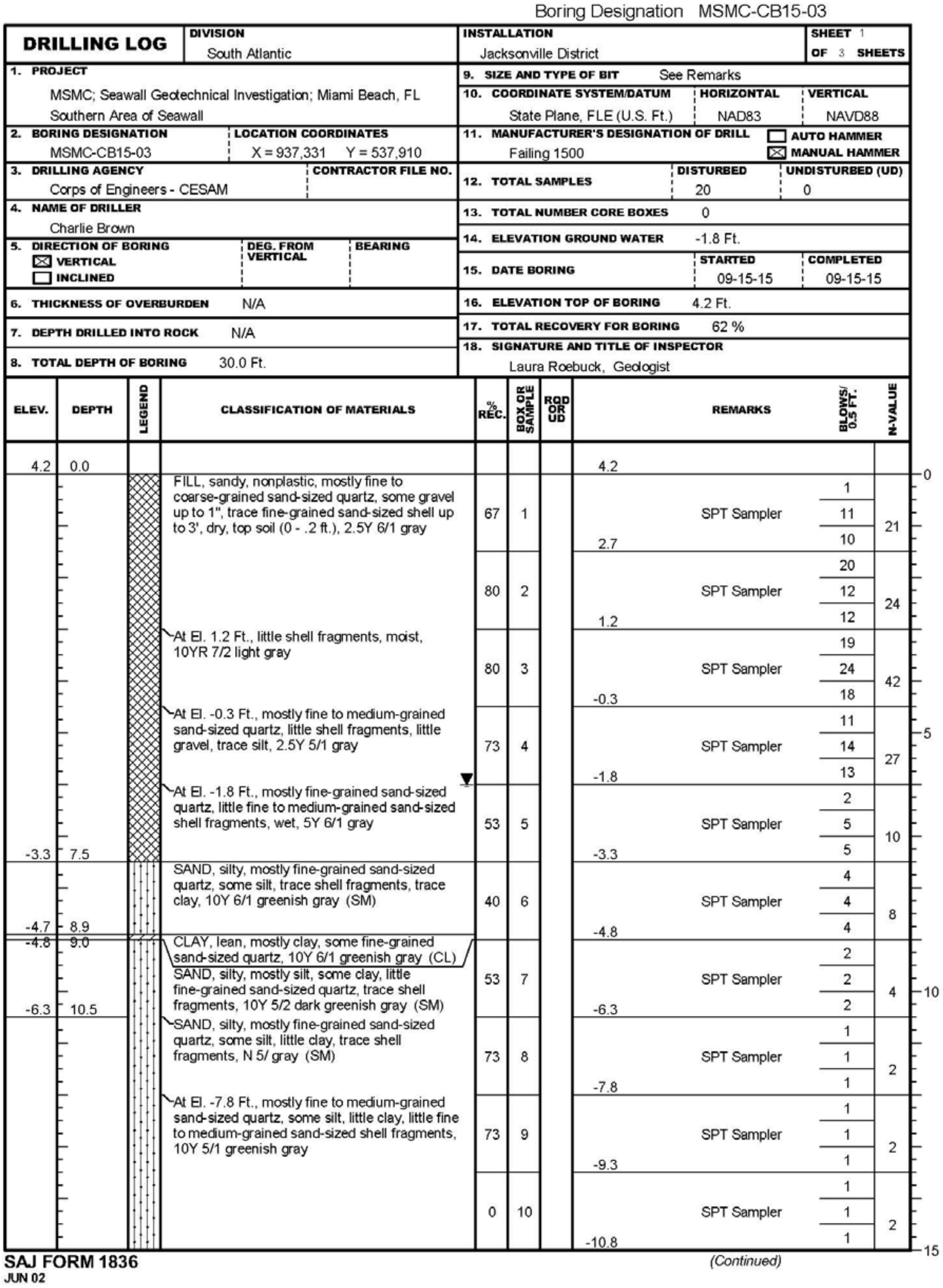
JUN 02



Boring Designation MSMC-CB15-03

DRILLING LOG

DIVISION South Atlantic

INSTALLATION Jacksonville District

SHEET 1 OF 3 SHEETS

1. PROJECT MSMC; Seawall Geotechnical Investigation; Miami Beach, FL Southern Area of Seawall
2. BORING DESIGNATION MSMC-CB15-03 | LOCATION COORDINATES X = 937,331 Y = 537,910
3. DRILLING AGENCY Corps of Engineers - CESAM | CONTRACTOR FILE NO.
4. NAME OF DRILLER Charlie Brown
5. DIRECTION OF BORING ☒ VERTICAL ☐ INCLINED | DEG. FROM VERTICAL | BEARING
6. THICKNESS OF OVERBURDEN N/A
7. DEPTH DRILLED INTO ROCK N/A
8. TOTAL DEPTH OF BORING 30.0 Ft.
9. SIZE AND TYPE OF BIT See Remarks
10. COORDINATE SYSTEM/DATUM State Plane, FLE (U.S. Ft.) | HORIZONTAL NAD83 | VERTICAL NAVD88
11. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500 ☐ AUTO HAMMER ☒ MANUAL HAMMER
12. TOTAL SAMPLES | DISTURBED 20 | UNDISTURBED (UD) 0
13. TOTAL NUMBER CORE BOXES 0
14. ELEVATION GROUND WATER -1.8 Ft.
15. DATE BORING | STARTED 09-15-15 | COMPLETED 09-15-15
16. ELEVATION TOP OF BORING 4.2 Ft.
17. TOTAL RECOVERY FOR BORING 62 %
18. SIGNATURE AND TITLE OF INSPECTOR Laura Roebuck, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
4.2	0.0						4.2		
			FILL, sandy, nonplastic, mostly fine to coarse-grained sand-sized quartz, some gravel up to 1", trace fine-grained sand-sized shell up to 3', dry, top soil (0 - .2 ft.), 2.5Y 6/1 gray	67	1		SPT Sampler 2.7	1 11 10	21
				80	2		SPT Sampler 1.2	20 12 12	24
			At El. 1.2 Ft., little shell fragments, moist, 10YR 7/2 light gray	80	3		SPT Sampler -0.3	19 24 18	42
			At El. -0.3 Ft., mostly fine to medium-grained sand-sized quartz, little shell fragments, little gravel, trace silt, 2.5Y 5/1 gray	73	4		SPT Sampler -1.8	11 14 13	27
			▼ At El. -1.8 Ft., mostly fine-grained sand-sized quartz, little fine to medium-grained sand-sized shell fragments, wet, 5Y 6/1 gray	53	5		SPT Sampler -3.3	2 5 5	10
-3.3	7.5		SAND, silty, mostly fine-grained sand-sized quartz, some silt, trace shell fragments, trace clay, 10Y 6/1 greenish gray (SM)	40	6		SPT Sampler -4.8	4 4 4	8
-4.7 -4.8	8.9 9.0		CLAY, lean, mostly clay, some fine-grained sand-sized quartz, 10Y 6/1 greenish gray (CL) SAND, silty, mostly silt, some clay, little fine-grained sand-sized quartz, trace shell fragments, 10Y 5/2 dark greenish gray (SM)	53	7		SPT Sampler -6.3	2 2 2	4
-6.3	10.5		SAND, silty, mostly fine-grained sand-sized quartz, some silt, little clay, trace shell fragments, N 5/ gray (SM)	73	8		SPT Sampler -7.8	1 1 1	2
			At El. -7.8 Ft., mostly fine to medium-grained sand-sized quartz, some silt, little clay, little fine to medium-grained sand-sized shell fragments, 10Y 5/1 greenish gray	73	9		SPT Sampler -9.3	1 1 1	2
				0	10		SPT Sampler -10.8	1 1 1	2

SAJ FORM 1836
JUN 02

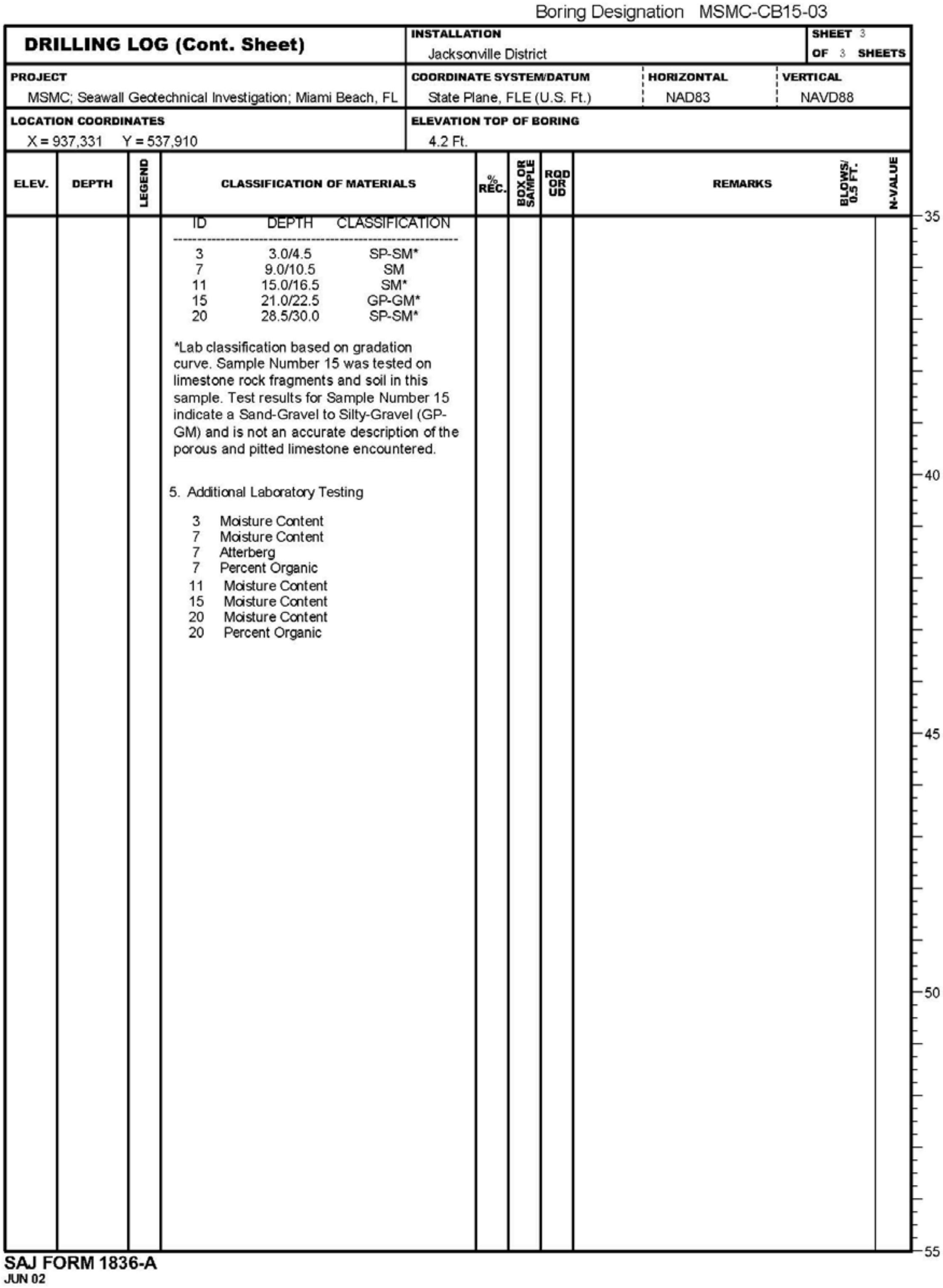
(Continued)

Boring Designation MSMC-CB15-03

DRILLING LOG (Cont. Sheet)	**INSTALLATION** Jacksonville District		**SHEET** 2 **OF** 3 **SHEETS**
PROJECT MSMC; Seawall Geotechnical Investigation; Miami Beach, FL	**COORDINATE SYSTEM/DATUM** State Plane, FLE (U.S. Ft.)	**HORIZONTAL** NAD83	**VERTICAL** NAVD88
LOCATION COORDINATES X = 937,331 Y = 537,910	**ELEVATION TOP OF BORING** 4.2 Ft.		

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE	
			At El. -10.8 Ft., mostly fine-grained sand-sized quartz, some silt, little fine to coarse-grained sand-sized shell fragments, trace clay	73	11		SPT Sampler -12.3	1 1 1	2	15
				60	12		SPT Sampler -13.8	1 1 1	2	
-15.3	19.5		At El. -13.8 Ft., some fine to coarse-grained sand-sized shell fragments, trace rock fragments up to 1-1/2", trace fine gravel-sized coral	60	13		SPT Sampler -15.3	3 10 11	21	
		Highly Weathered	LIMESTONE, sandy, sparsely fossiliferous, soft, highly weathered, mostly quartz grains, porous, sand filled pores, broken due to drill action, Corraline, N 9/ white	73	14		SPT Sampler -16.8	22 38 26	64	20
				100	15		SPT Sampler -18.3	14 25 27	52	
				87	16		SPT Sampler -19.8	20 26 30	56	
-21.3	25.5		At El. -19.8 Ft.	67	17		SPT Sampler -21.3	21 26 21	47	25
-22.8	27.0		LIMESTONE	67	18		SPT Sampler -22.8	16 22 19	41	
			SAND, poorly-graded with silt, mostly fine-grained sand-sized carbonate, some rock fragments up to 1", little silt (SP-SM)	27	19		SPT Sampler -24.3	6 6 5	11	
-25.8	30.0		At El. -24.3 Ft., trace shell fragments, trace rock fragments up to 1", trace silt, 10YR 7/1 light gray	33	20		SPT Sampler -25.8	11 11 6	17	30
			NOTES: 1. USACE Jacksonville is the custodian for these original files. 2. Soils are field visually classified in accordance with the Unified Soils Classification System. 3. Borehole tremie grouted with portland cement and water. 4. Laboratory Testing Results SAMPLE SAMPLE LABORATORY				140# hammer w/30" drop used with 2.0' split spoon (1-3/8" I.D. x 2" O.D.).			35

SAJ FORM 1836-A
JUN 02



Boring Designation MSMC-CB15-03

DRILLING LOG (Cont. Sheet)

INSTALLATION Jacksonville District

SHEET 3 **OF** 3 **SHEETS**

PROJECT MSMC; Seawall Geotechnical Investigation; Miami Beach, FL

COORDINATE SYSTEM/DATUM State Plane, FLE (U.S. Ft.)

HORIZONTAL NAD83

VERTICAL NAVD88

LOCATION COORDINATES X = 937,331 Y = 537,910

ELEVATION TOP OF BORING 4.2 Ft.

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE

ID	DEPTH	CLASSIFICATION
3	3.0/4.5	SP-SM*
7	9.0/10.5	SM
11	15.0/16.5	SM*
15	21.0/22.5	GP-GM*
20	28.5/30.0	SP-SM*

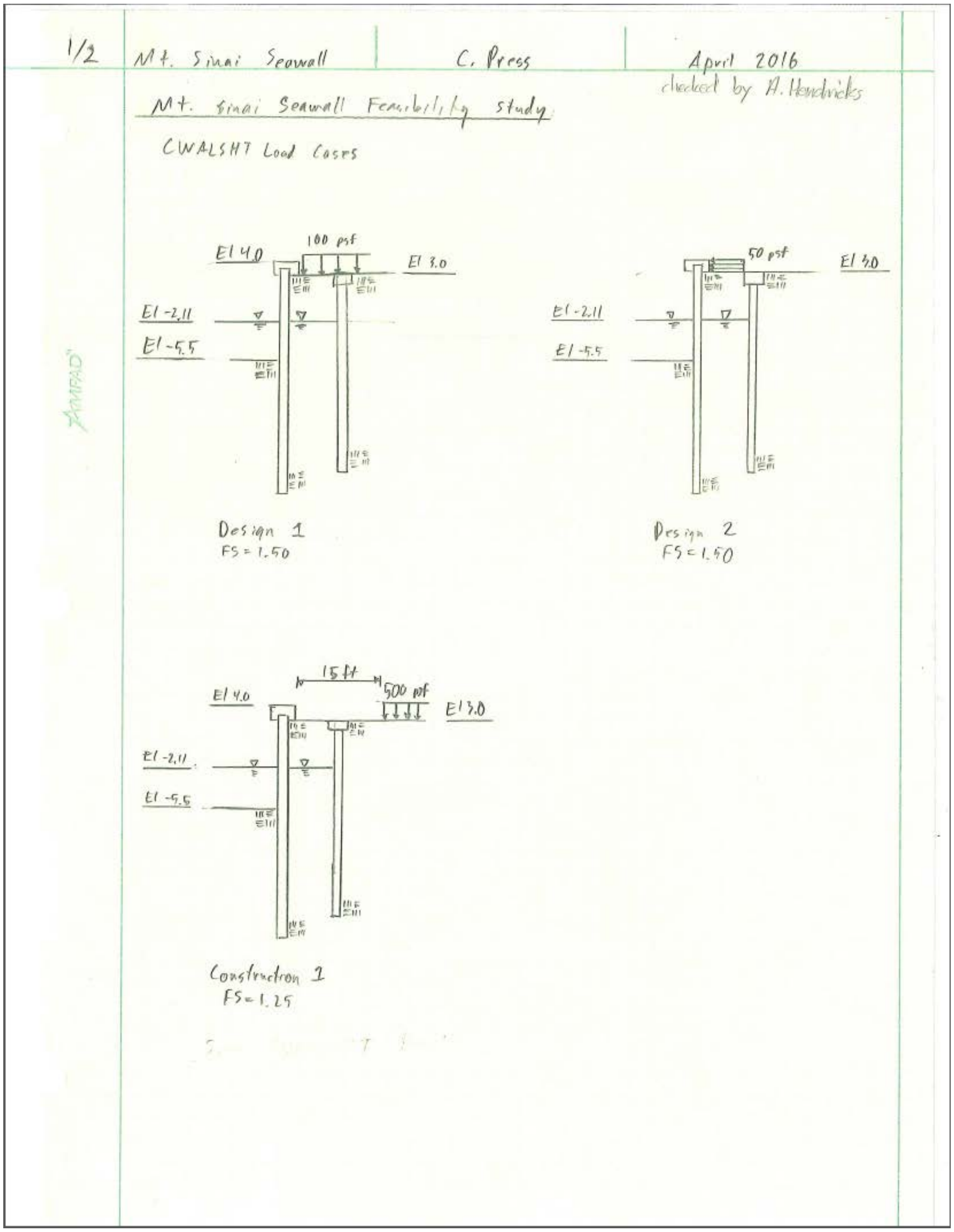
*Lab classification based on gradation curve. Sample Number 15 was tested on limestone rock fragments and soil in this sample. Test results for Sample Number 15 indicate a Sand-Gravel to Silty-Gravel (GP-GM) and is not an accurate description of the porous and pitted limestone encountered.

5. Additional Laboratory Testing

3	Moisture Content
7	Moisture Content
7	Atterberg
7	Percent Organic
11	Moisture Content
15	Moisture Content
20	Moisture Content
20	Percent Organic

SAJ FORM 1836-A
JUN 02

ATTACHMENT B – (STRUCTURAL ADDEDUM)



1/2 Mt. Sinai Seawall C. Press April 2016
checked by A. Hendricks

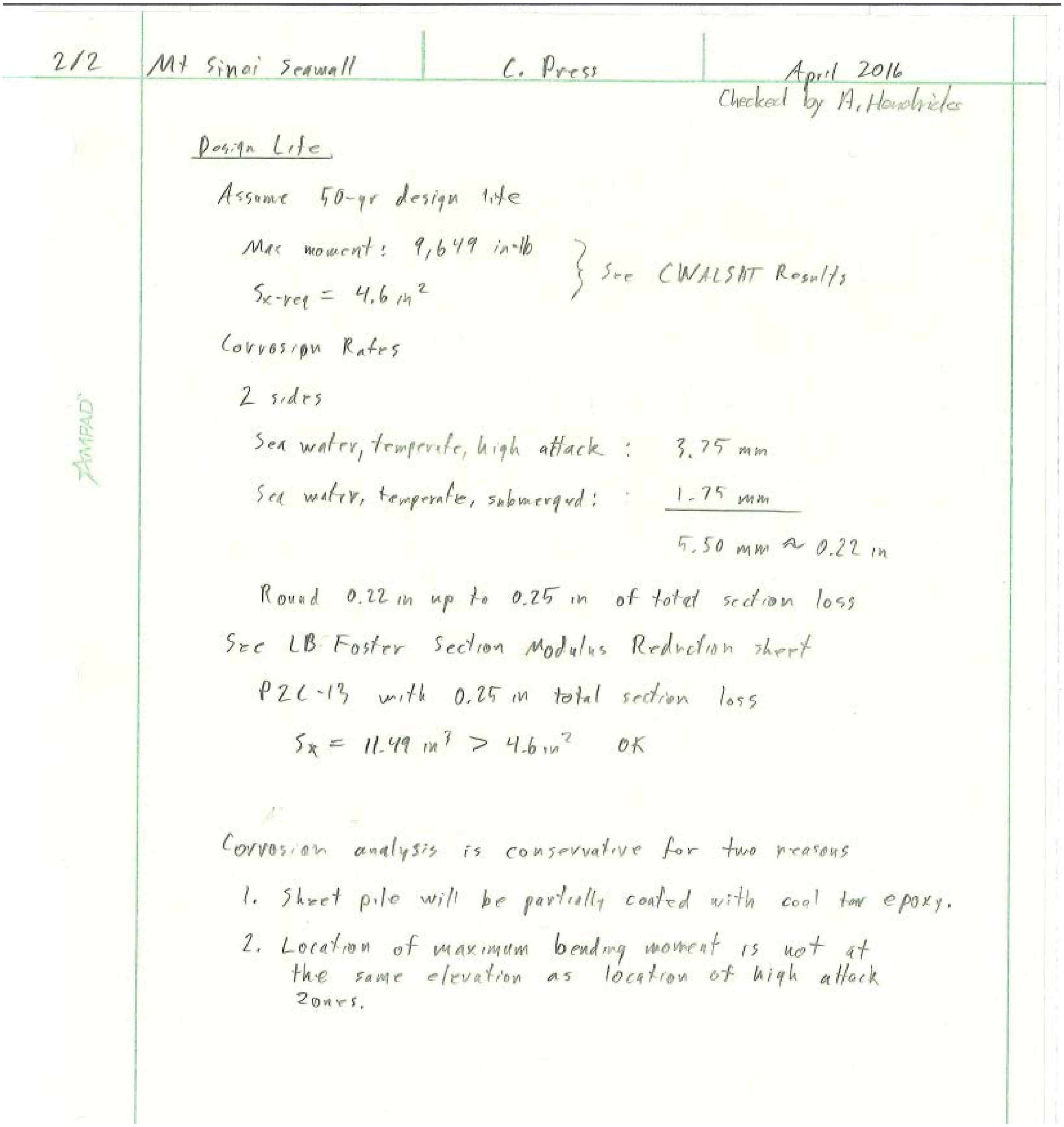
Mt. Sinai Seawall Feasibility study

CWALSHT Load Cases

Design 1
FS = 1.50

Design 2
FS = 1.50

Construction 1
FS = 1.25



2/2 | Mt Sinai Seawall | C. Press | April 2016

Checked by A. Hendricks

Design Life

Assume 50-yr design life

Max moment: 9,649 in-lb
$S_{x\text{-}req} = 4.6\ in^2$
} See CWALSHT Results

Corrosion Rates

2 sides

Sea water, temperate, high attack : 3.75 mm

Sea water, temperate, submerged : 1.75 mm

5.50 mm ≈ 0.22 in

Round 0.22 in up to 0.25 in of total section loss

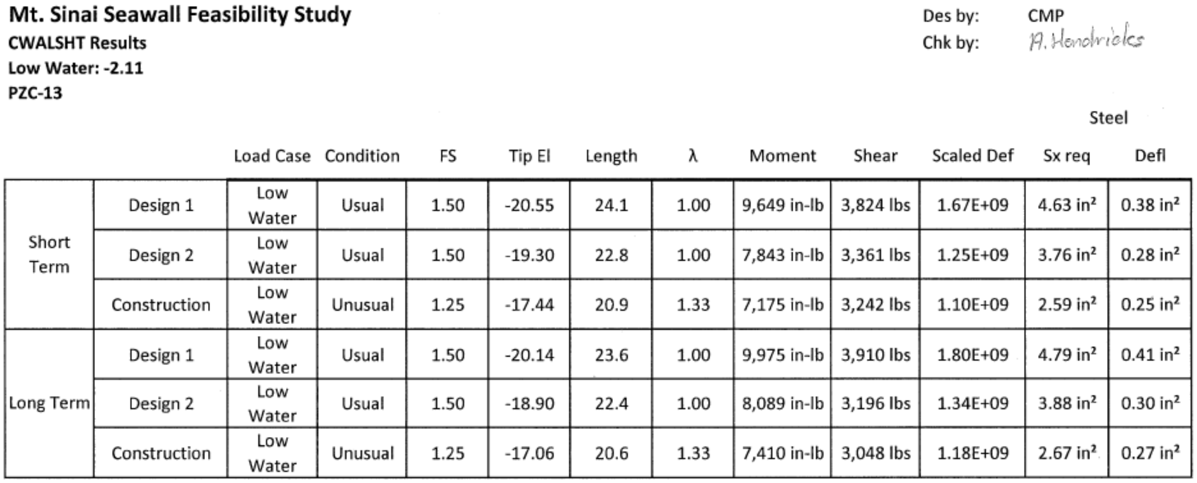
See LB Foster Section Modulus Reduction sheet

PZC-13 with 0.25 in total section loss

$S_x = 11.49\ in^3 > 4.6\ in^2$ OK

Corrosion analysis is conservative for two reasons

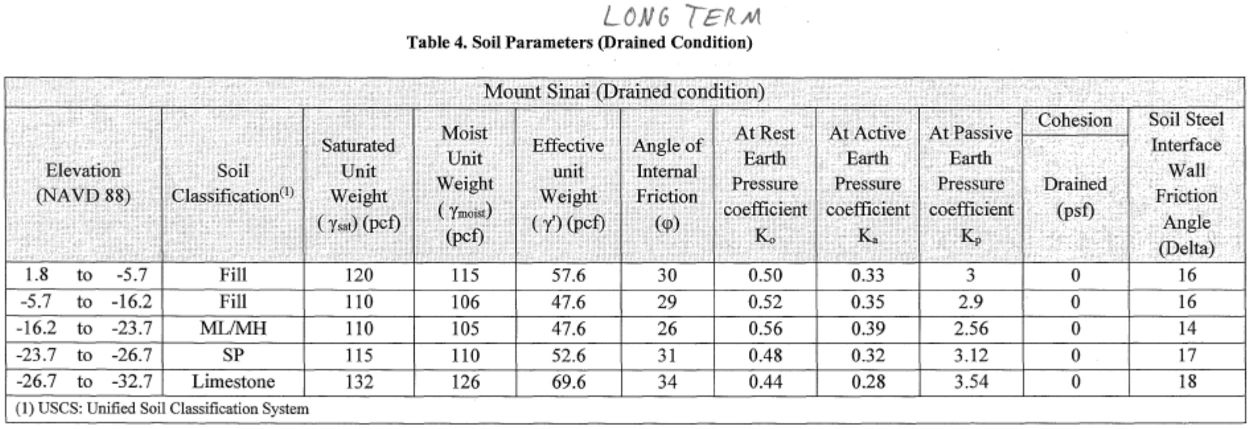
1. Sheet pile will be partially coated with coal tar epoxy.
2. Location of maximum bending moment is not at the same elevation as location of high attack zones.



Mt. Sinai Seawall Feasibility Study
CWALSHT Results
Low Water: -2.11
PZC-13

Des by: CMP
Chk by: A. Hendricks

											Steel	
		Load Case	Condition	FS	Tip El	Length	λ	Moment	Shear	Scaled Def	Sx req	Defl
Short Term	Design 1	Low Water	Usual	1.50	-20.55	24.1	1.00	9,649 in-lb	3,824 lbs	1.67E+09	4.63 in^2	0.38 in^2
	Design 2	Low Water	Usual	1.50	-19.30	22.8	1.00	7,843 in-lb	3,361 lbs	1.25E+09	3.76 in^2	0.28 in^2
	Construction	Low Water	Unusual	1.25	-17.44	20.9	1.33	7,175 in-lb	3,242 lbs	1.10E+09	2.59 in^2	0.25 in^2
Long Term	Design 1	Low Water	Usual	1.50	-20.14	23.6	1.00	9,975 in-lb	3,910 lbs	1.80E+09	4.79 in^2	0.41 in^2
	Design 2	Low Water	Usual	1.50	-18.90	22.4	1.00	8,089 in-lb	3,196 lbs	1.34E+09	3.88 in^2	0.30 in^2
	Construction	Low Water	Unusual	1.25	-17.06	20.6	1.33	7,410 in-lb	3,048 lbs	1.18E+09	2.67 in^2	0.27 in^2

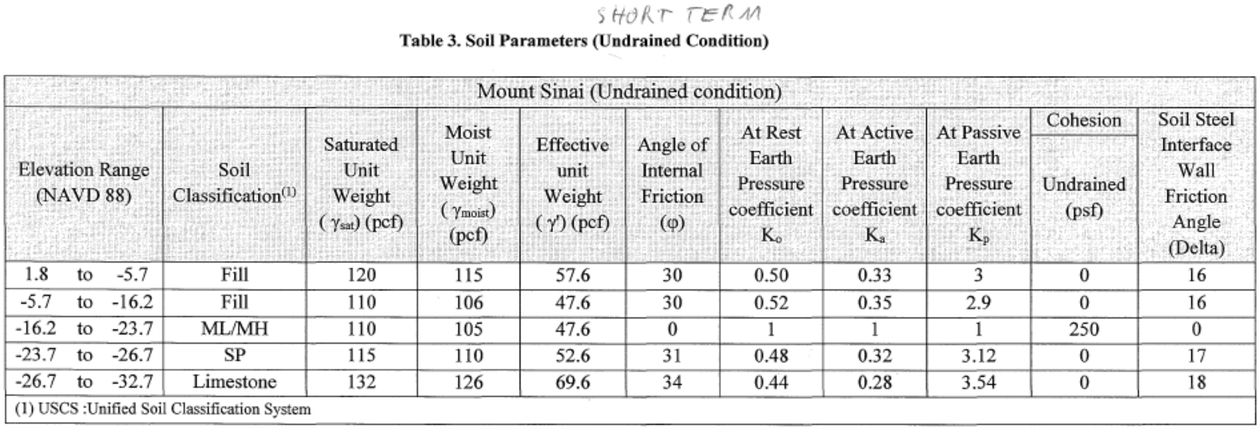


LONG TERM

Table 4. Soil Parameters (Drained Condition)

Mount Sinai (Drained condition)											
Elevation (NAVD 88)			Soil Classification[(1)]	Saturated Unit Weight (γ_{sat}) (pcf)	Moist Unit Weight (γ_{moist}) (pcf)	Effective unit Weight (γ') (pcf)	Angle of Internal Friction (φ)	At Rest Earth Pressure coefficient K_o	At Active Earth Pressure coefficient K_a	At Passive Earth Pressure coefficient K_p	Cohesion Drained (psf)	Soil Steel Interface Wall Friction Angle (Delta)
1.8	to	-5.7	Fill	120	115	57.6	30	0.50	0.33	3	0	16
-5.7	to	-16.2	Fill	110	106	47.6	29	0.52	0.35	2.9	0	16
-16.2	to	-23.7	ML/MH	110	105	47.6	26	0.56	0.39	2.56	0	14
-23.7	to	-26.7	SP	115	110	52.6	31	0.48	0.32	3.12	0	17
-26.7	to	-32.7	Limestone	132	126	69.6	34	0.44	0.28	3.54	0	18

(1) USCS: Unified Soil Classification System

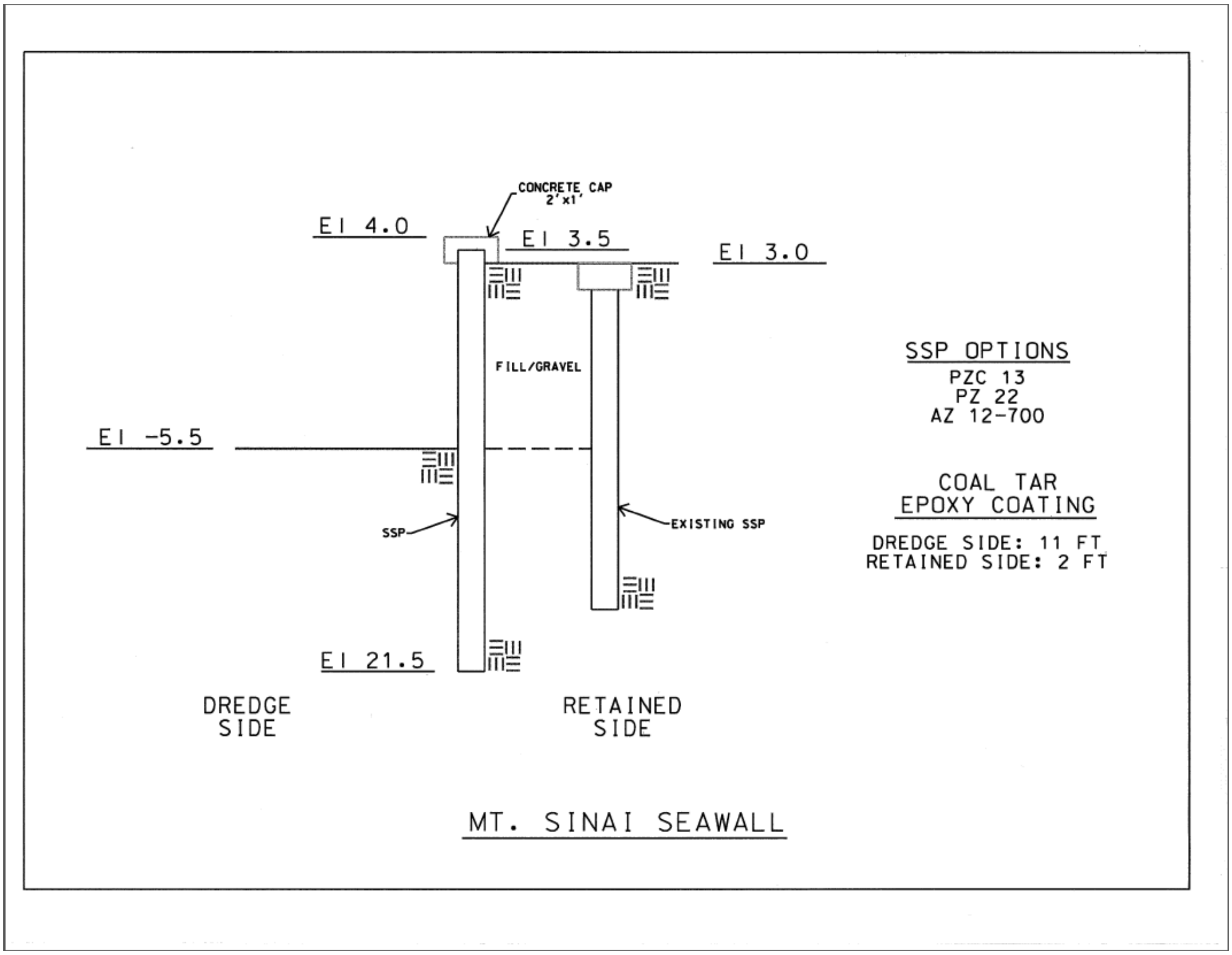


SHORT TERM

Table 3. Soil Parameters (Undrained Condition)

Mount Sinai (Undrained condition)												
Elevation Range (NAVD 88)			Soil Classification[(1)]	Saturated Unit Weight (γ_{sat}) (pcf)	Moist Unit Weight (γ_{moist}) (pcf)	Effective unit Weight (γ') (pcf)	Angle of Internal Friction (φ)	At Rest Earth Pressure coefficient K_o	At Active Earth Pressure coefficient K_a	At Passive Earth Pressure coefficient K_p	Cohesion Undrained (psf)	Soil Steel Interface Wall Friction Angle (Delta)
1.8	to	-5.7	Fill	120	115	57.6	30	0.50	0.33	3	0	16
-5.7	to	-16.2	Fill	110	106	47.6	30	0.52	0.35	2.9	0	16
-16.2	to	-23.7	ML/MH	110	105	47.6	0	1	1	1	250	0
-23.7	to	-26.7	SP	115	110	52.6	31	0.48	0.32	3.12	0	17
-26.7	to	-32.7	Limestone	132	126	69.6	34	0.44	0.28	3.54	0	18

(1) USCS :Unified Soil Classification System


CONCRETE CAP
2'x1'
El 4.0
El 3.5
El 3.0
FILL/GRAVEL
SSP OPTIONS
PZC 13
PZ 22
AZ 12-700
El -5.5
COAL TAR
EPOXY COATING
DREDGE SIDE: 11 FT
RETAINED SIDE: 2 FT
SSP
EXISTING SSP
El 21.5
DREDGE
SIDE
RETAINED
SIDE
MT. SINAI SEAWALL

PZC SHEET PILING PROPERTIES

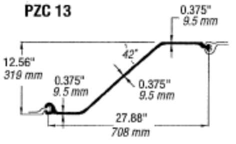
PZC sections are the "latest generation" of sheet piling profiles and were developed to be lighter, wider, and stronger than the older traditional PZ sections. PZC profiles are named for their strength in metric designations. For example, PZC 18 has a Section Modulus of 1,800 cm³/meter. **PZC profiles should always be the designer's first choice in order to provide the end user the most efficient retention wall with the most efficient ratio of section modulus to weight.**

					Per Single Section						Per Unit of Wall			
Section	Nominal Width in. *(mm)*	Wall Depth (Height) in. *(mm)*	Web Thickness in. *(mm)*	Flange Thickness in. *(mm)*	Area in.² *(cm²)*	Weight lbs/ft *(kg/m)*	Moment of Inertia in.⁴ *(cm⁴)*	Section Modulus in.³ *(cm³)*	Total Surface Area ft²/ft *(m²/m)*	Nominal Coating Area* ft²/ft *(m²/m)*	Area in.²/ft *(cm²/m)*	Weight lbs/ft² *(kg/m²)*	Moment of Inertia in.⁴/ft *(cm⁴/m)*	Section Modulus in.³/ft *(cm³/m)*
PZC 13	27.88	12.56	0.375	0.375	14.82	50.4	353.0	56.2	6.10	5.60	6.38	21.7	152.0	24.2
	708	*319*	*9.5*	*9.5*	*95.6*	*75.1*	*14,690*	*920*	*1.86*	*1.71*	*135.1*	*106.0*	*20,760*	*1,300*
PZC 14	27.88	12.60	0.420	0.420	16.15	55.0	381.6	60.5	6.10	5.60	6.95	23.7	164.3	26.0
	708	*320*	*10.7*	*10.7*	*104.2*	*81.8*	*15,890*	*990*	*1.86*	*1.71*	*147.2*	*115.5*	*22,440*	*1,400*
PZC 18	25.00	15.25	0.375	0.375	14.82	50.4	532.2	69.8	6.10	5.60	7.12	24.2	255.5	33.5
	635	*387*	*9.5*	*9.5*	*95.6*	*75.1*	*22,150*	*1,145*	*1.86*	*1.71*	*150.6*	*118.2*	*34,890*	*1,800*
PZC 19	25.00	15.30	0.420	0.420	16.16	55.0	576.3	75.3	6.10	5.60	7.75	26.4	276.6	36.1
	635	*388*	*10.7*	*10.7*	*104.2*	*81.8*	*23,990*	*1,235*	*1.86*	*1.71*	*164.1*	*128.8*	*37,780*	*1,945*
PZC 25	27.88	17.66	0.485	0.560	20.40	69.4	938.7	106.3	6.65	6.15	8.78	29.9	404.1	45.7
	708	*449*	*12.3*	*14.2*	*131.6*	*103.3*	*39,070*	*1,740*	*2.03*	*1.87*	*185.9*	*145.9*	*55,190*	*2,455*
PZC 26	27.88	17.70	0.525	0.600	21.72	73.9	994.3	112.4	6.65	6.15	9.35	31.8	428.1	48.4
	708	*450*	*13.3*	*15.2*	*140.1*	*110.0*	*41,390*	*1,840*	*2.03*	*1.87*	*197.9*	*155.4*	*58,460*	*2,600*
PZC 28	27.88	17.75	0.570	0.645	23.22	79.0	1,057	119.1	6.65	6.15	10.00	34.0	455.1	51.3
	708	*451*	*14.5*	*16.4*	*149.8*	*117.6*	*44,000*	*1,950*	*2.03*	*1.87*	*211.6*	*166.1*	*62,150*	*2,755*
PZC 37	22.50	21.02	0.488	0.563	20.45	69.6	1,349	128.4	6.65	6.15	10.91	37.1	719.6	68.5
	572	*534*	*12.4*	*14.3*	*132.0*	*103.6*	*56,160*	*2,100*	*2.03*	*1.87*	*230.9*	*181.2*	*98,270*	*3,680*
PZC 39	22.50	21.05	0.525	0.600	21.76	74.0	1,429	135.6	6.65	6.15	11.61	39.5	762.1	72.3
	572	*535*	*13.3*	*15.2*	*140.4*	*110.2*	*59,480*	*2,220*	*2.03*	*1.87*	*245.6*	*192.8*	*104,100*	*3,890*
PZC 41	22.50	21.09	0.561	0.636	23.03	78.4	1,507	142.7	6.65	6.15	12.28	41.8	803.6	76.1
	572	*536*	*14.2*	*16.2*	*148.6*	*116.6*	*62,720*	*2,340*	*2.03*	*1.87*	*260.0*	*204.1*	*109,700*	*4,090*

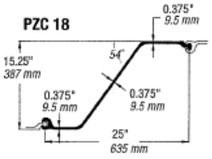
*Both sides of sheet; excludes socket interior and ball of interlock.

All dimensions given are nominal. Actual flange and web thicknesses vary due to mill rolling practices; however, permitted variations for such dimensions are not addressed.

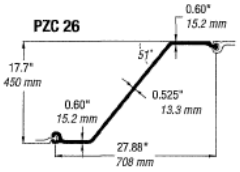
PZC 13



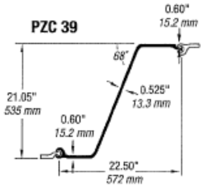
PZC 18

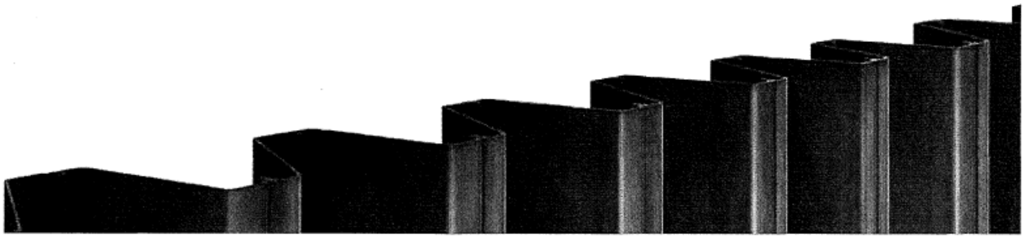


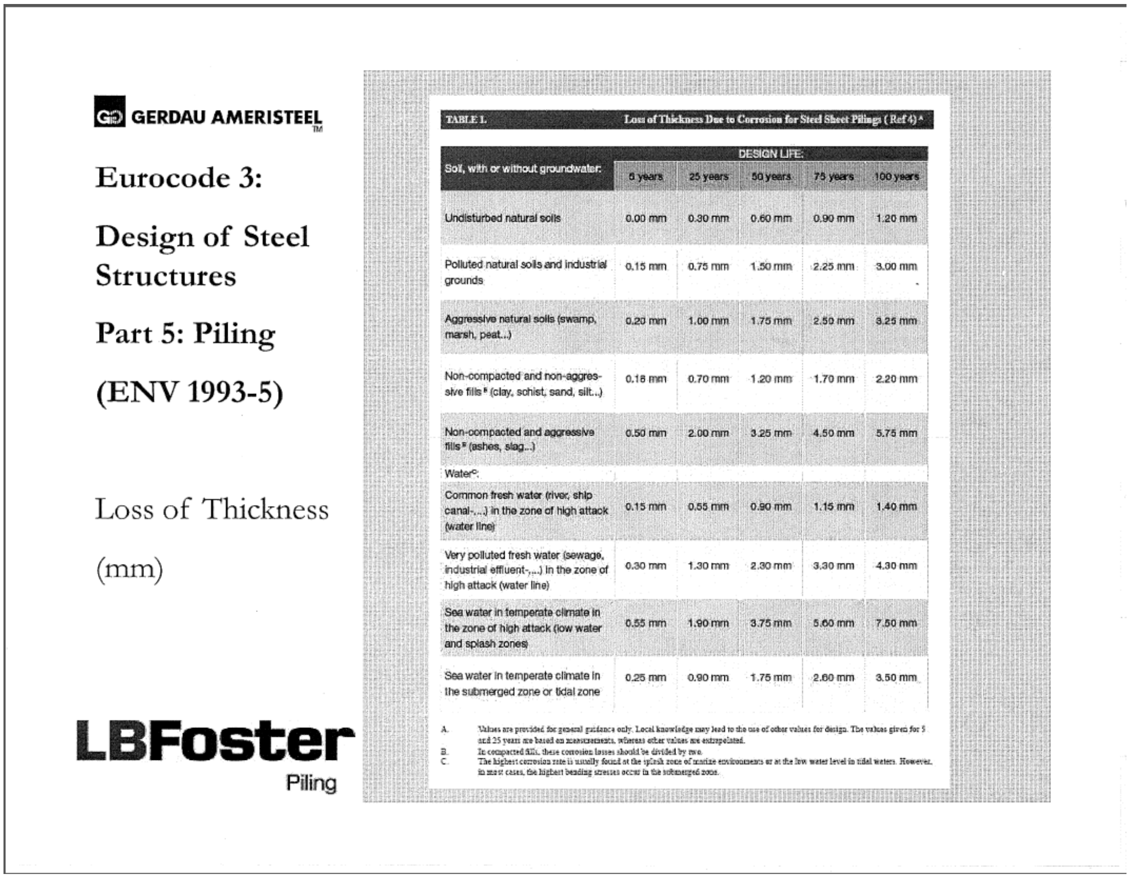
PZC 26



PZC 39







GERDAU AMERISTEEL

Eurocode 3:

Design of Steel Structures

Part 5: Piling

(ENV 1993-5)

Loss of Thickness

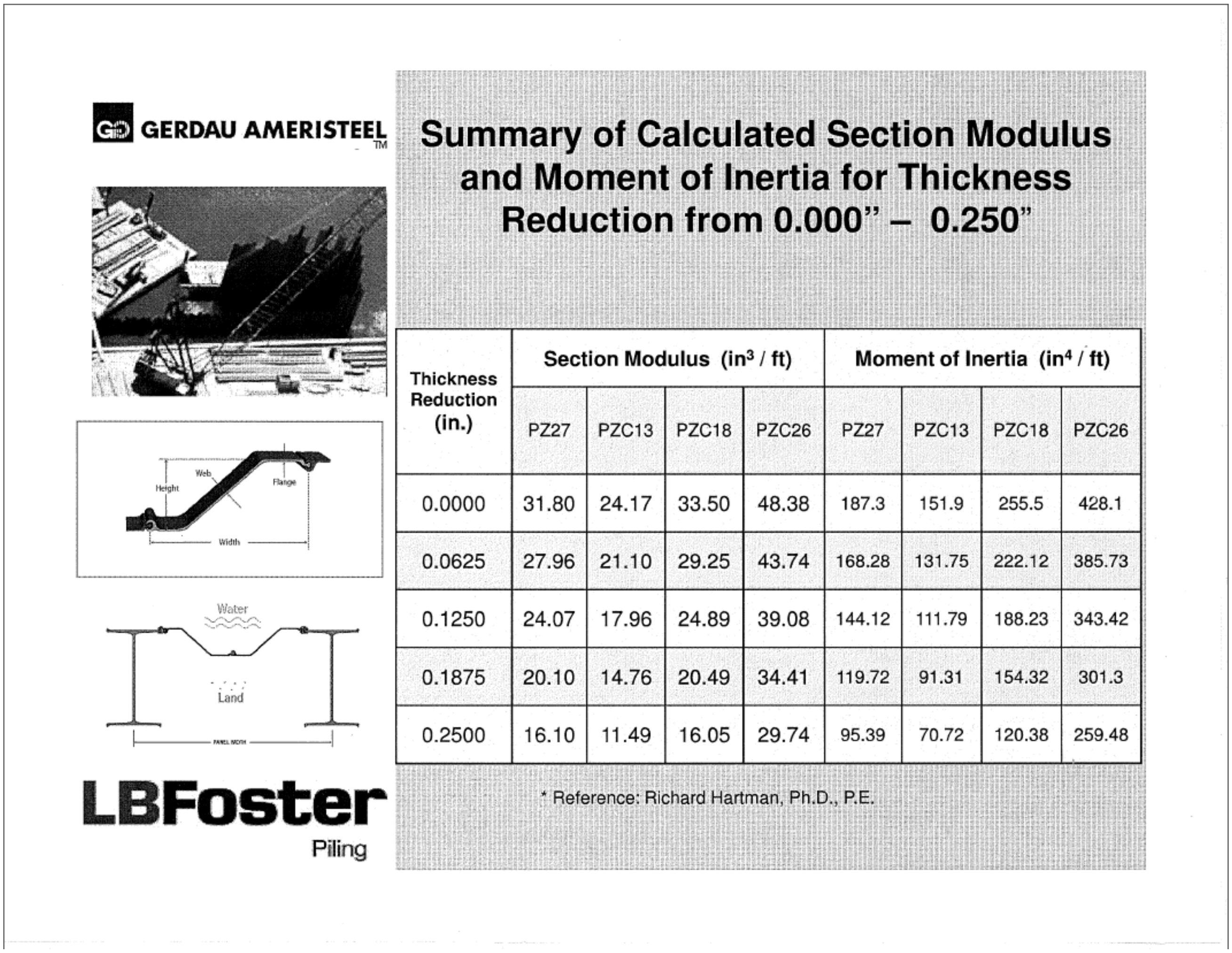
(mm)

LBFoster
Piling

TABLE 1. Loss of Thickness Due to Corrosion for Steel Sheet Pilings (Ref 4)[A]

Soil, with or without groundwater:	DESIGN LIFE:				
	5 years	25 years	50 years	75 years	100 years
Undisturbed natural soils	0.00 mm	0.30 mm	0.60 mm	0.90 mm	1.20 mm
Polluted natural soils and industrial grounds	0.15 mm	0.75 mm	1.50 mm	2.25 mm	3.00 mm
Aggressive natural soils (swamp, marsh, peat...)	0.20 mm	1.00 mm	1.75 mm	2.50 mm	3.25 mm
Non-compacted and non-aggressive fills[B] (clay, schist, sand, silt...)	0.18 mm	0.70 mm	1.20 mm	1.70 mm	2.20 mm
Non-compacted and aggressive fills[B] (ashes, slag...)	0.50 mm	2.00 mm	3.25 mm	4.50 mm	5.75 mm
Water[C]:					
Common fresh water (river, ship canal-,...) in the zone of high attack (water line)	0.15 mm	0.55 mm	0.90 mm	1.15 mm	1.40 mm
Very polluted fresh water (sewage, industrial effluent-,...) in the zone of high attack (water line)	0.30 mm	1.30 mm	2.30 mm	3.30 mm	4.30 mm
Sea water in temperate climate in the zone of high attack (low water and splash zones)	0.55 mm	1.90 mm	3.75 mm	5.60 mm	7.50 mm
Sea water in temperate climate in the submerged zone or tidal zone	0.25 mm	0.90 mm	1.75 mm	2.60 mm	3.50 mm

A. Values are provided for general guidance only. Local knowledge may lead to the use of other values for design. The values given for 5 and 25 years are based on measurements, whereas other values are extrapolated.
B. In compacted fills, these corrosion losses should be divided by two.
C. The highest corrosion rate is usually found at the splash zone of marine environments or at the low water level in tidal waters. However, in most cases, the highest bending stresses occur in the submerged zone.



Summary of Calculated Section Modulus and Moment of Inertia for Thickness Reduction from 0.000" – 0.250"

Thickness Reduction (in.)	Section Modulus (in³ / ft)				Moment of Inertia (in⁴ / ft)			
	PZ27	PZC13	PZC18	PZC26	PZ27	PZC13	PZC18	PZC26
0.0000	31.80	24.17	33.50	48.38	187.3	151.9	255.5	428.1
0.0625	27.96	21.10	29.25	43.74	168.28	131.75	222.12	385.73
0.1250	24.07	17.96	24.89	39.08	144.12	111.79	188.23	343.42
0.1875	20.10	14.76	20.49	34.41	119.72	91.31	154.32	301.3
0.2500	16.10	11.49	16.05	29.74	95.39	70.72	120.38	259.48

* Reference: Richard Hartman, Ph.D., P.E.

ATTACHMENT C – (VERTICAL ROAD RELOCATION)

MT. SINAI – VERTICAL ROAD RELOCATION ALTERNATIVE

CAP Project – Mount Sinai - Vertical Road Relocation Simplified Quantity Estimate			
General Road Properties	**Quantity**	**Unit of Measure**	**Assumptions**
Road Length	1310	FT	1230 ft of new road construction. 4*20' of road transition to existing roads
Road Width - Finish Pavement	20	FT	
Road Width - Subgrade	25	FT	
Sidewalk Length	1000	FT	Sidewalk is constructed between raised road and existing seawall to help control erosion
Sidewalk Width - Finish Pavement	8	FT	
Sidewalk Width - Subgrade	10	FT	
Existing infrastructure	NA		Existing infrastructure (lights, electric lines, gates, gatehouses, etc) will not be impacted by construction
Items to Cost	**Quantity**	**Unit of Measure**	**Assumptions**
Demolition - Existing Pavement	2910	SY	
Demolition - Existing Curb and Gutter	2620	LF	
Demolition - Existing Storm Grates	2	EA	
Demolition - Existing Culverts	100	LF	
Imported Fill Material - Aggregate Base - Road	3640	Tons	
Imported Fill Material - Aggregate Base - Sidewalk	1110	Tons	
Pavement - Road - Asphalt - 2" thick	2910	SY	
Pavement - Curb and Gutter - Concrete	2620	LF	
Pavement - Sidewalk - Concrete	8000	SF	
Storm Grates - 2' x 20'	2	EA	
Storm Grates - 3' x 3'	8	EA	
Culvert Junction Box - Concrete - 3' Diameter, 2' Height	2	EA	
Culvert - 15" RCP	760	LF	
Traffic Control	1	EA	
Erosion Control	1	EA	