2018

CITY OF KEY WEST
PORT AND MARINE SERVICES

KEY WEST BIGHT SEAWALL INVESTIGATION
PHASE III
SCHOONER WHARF TO CONCH REPUBLIC

SUBMITTED: February 5, 2018
REVISED: May 10, 2018

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TETRA TECH

February 5, 2017

Submitted via email:
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Karen Olson
Deputy Director
City of Key West - Port and Marine Services
201 William Street
Key West, FL 33040

Subject: Key West Bight Seawall Investigation - Phase III
Schooner Wharf to Conch Republic

Dear Ms. Olson:

Tetra Tech is pleased to submit this seawall investigation summary report for your review. The report discusses the condition of the seawall along the South and West reaches of the Key West Bight adjacent to the Schooner Wharf and Conch Republic restaurants and provides recommendations for repairs.

This report includes a copy of the project topographic survey, geotechnical report, benthic resource survey, and catalog of deficiencies found, which will serve as a basis for permitting in the future. If you have any questions or need any additional information, please feel free to contact me.

Sincerely,

Dave Frodsham PE
Project Engineer
FL PE No. 75507

cc: Doug Bradshaw, Director of Port & Marine Services
Shauna Stotler-Hardy, Tetra Tech
Stuart McGahee, Tetra Tech

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1.0 REPORT/INSPECTION TERMINOLOGY

Abrasion: The process of eroding, rubbing or wearing away a surface by friction.
Active cracks: Those cracks which the mechanism causing the cracking is still at work.
Aggregate: Granular material such as crushed stone in the concrete mix.
Bugholes: (slang) Industry term used to describe small cavities resulting from entrapment of air bubbles in the surface of concrete.
Concrete cover: The distance between the surface of embedded reinforcement and the surface of the concrete.
Corrosion: Destruction of metal by chemical, electrochemical or electrolytic reaction within its environment.
Crack: A complete or incomplete separation of concrete into two or more parts produced by breaking or fracturing.
Damage: Impairment to the value or usefulness of an element or component.
Deformation: A change in dimension or shape, see distortion.
Deflection: A movement of a structural element measured as linear displacement.
Delamination: A horizontal or planar separation of the surfaces of concrete.
Depression: A lowering of the surrounding surfaces
Deterioration: The decomposition of material during exposure to service.
Diagonal crack: A crack forming an angle other than 90 degrees with the centerline of the concrete member.
Discoloration: A departure of color from what is normal.
Disintegration: The deterioration into small fragments or particles due to any cause.
Dislodged: The movement of an object due to impact or force.
Distortion: A change in alignment of the components of a structure, see deformation.
Distress: The cracking or distortion in a concrete structure as the result of stress.
Dormant cracks: Cracks which are not currently moving.
Efflorescence: A white deposit on concrete caused by crystallization of soluble salts brought to the surface by moisture in the concrete due to capillary action.
Fissure: A long, narrow opening or line of breakage made by cracking or splitting.
FRP: Fiber reinforced plastic composites rebar
Galvanic corrosion: An electrochemical process in which one metal corrodes preferentially to another when both metals are in electrical contact and immersed in an electrolyte (seawater).
Gouges: A groove or hole caused by the impact or action of a hard object.
Hairline crack: A crack not greater than 0.003 inch in width or barely perceptible.
High tide: The highest level of the tide or the time at which the tide is highest.
Hollow area: An area of concrete which when struck with a hammer gives off a hollow sound indicating the existence of a horizontal fracture below the surface.
Honeycomb: Voids in concrete due to failure of the mortar to effectively fill the spaces between coarse aggregate. Often the result of insufficient vibration.
Incrustation: A crust of coating, generally hard, formed on the surface of concrete.
Life safety: An act to protect people based on occupancy features and conditions.
Low tide: The lowest level of the tide or the time at which the tide is lowest.
Map crack: An interconnected crack forming networks of any size and similar to those see in dried mud flats.
Mudline: The waterside ground elevation of a seawall.
Pile: A slender structural element that is embedded on end in the ground to support a load.
Pile batter: A pile installed at an angle to the vertical.

Pile bent: A row of bearing piles with a continuous concrete cap.
Pile cap: A structural element that transfers load to the top of one or more supporting piles.
Pile jacket: A prefabricated protective covering placed around the circumference of a pile for the purpose of preservation.
Pitting: Relatively small cavities in concrete or localized corrosion evident as minute cavities in steel.
Popouts: Shallow typical conical depressions in a concrete surface.
Preservation: The process of maintaining a structure in its present condition of arresting further deterioration.
PVC: Polyvinyl chloride used in the manufacture of conduit.
Random crack: A crack that meanders irregularly on the surface of concrete having no particular form.
Raveling: The wearing away of the concrete surface caused by the dislodging of aggregate particles.
Reflective cracks: A propagation of stresses in a concrete topping slab or asphalt layer due to traffic loads
Rehabilitation: The process of modifying a structure to a desired useful condition.
Repair: To replace or correct deteriorated or damaged components or elements of a structure.
Scaling: The local flaking or peeling away of the near-surface of hardened concrete.
Settlement: The lowering in elevation of pavement or structures.
Shrinkage crack: Cracking of a structure due to failure in tension caused by reduction on moisture content.
Sound: The absence of deficiencies or defects which would lessen the structural integrity or performance of the structural element.
Spall: A chip of concrete broken from the surface of a concrete member.
Small spall: A spall not larger than 0.8 depth or than 6 inches in any dimension
Large spall: A spall deeper that 0.8 and/or 6 inches in any dimension.
Splash zone: The area on an offshore structure that is regularly wetted by seawater but is not continuously submerged.
Substrate: Any material on the surface of which another material is placed.
Substructure: All of that part of a marine structure below the deck elevation.
Toe-out: A mode of failure in seawalls where the bottom of the wall pushes forward, indicative of insufficient penetration of sheet pile.
Tidal range: The difference between high and low tide elevations.
Urgency: Priority or a pressing necessity of importance
Void: Volume of concrete that is missing. Term is used to describe an area near the toe of the wall where a considerable amount of concrete is missing.

2.0 EXECUTIVE SUMMARY

From November 28th through 30th of 2017, Tetra Tech, Inc. (Tt) performed a structural condition survey of the municipally-owned portions of the seawall along the South and West reaches of the Key West Bight adjacent to and extending between the Schooner Wharf and Conch Republic restaurants. The subject seawall measures approximately 700 LF in length, and is predominantly a steel sheet pile system with a concrete cap of varying height.

The survey was performed by qualified divers in the presence of a Florida licensed professional engineer with experience in seawall engineering evaluation, design, permitting, and construction. Observations and measurements were recorded underwater via photographs, videos, and notes. Pertinent discoveries made by the divers were also relayed via real-time communication to the engineer on the surface.

The purpose of the inspection was to observe and evaluate the condition of the seawall and record any signs of degradation &/or damage present. Observations were limited to those readily apparent to the naked eye. Recommendations contained within this report are made based upon engineering judgement and standard industry practices. Data collected during the inspection included the following:

- Location of all buildings, boardwalks and docks along or adjacent to the seawall
- Dimensions of seawall features, including:
    a. Height of exposed sheet pile
    b. Height of the concrete cap
    c. Depth of silted sediment at the mudline of the sheet pile
    d. General dimensions of individual sheet pile sections
    e. Relative depth of water from MHW along the mudline
- Presence or absence of any signs of lateral support systems (i.e. tie backs, waler, etc)
- Conversations/correspondence with City Staff & adjacent leaseholders to gather information about their facilities as related to the seawall
- Locations of seawall penetrations for drainage and other utilities
- Composition of seawall construction materials
- Overall seawall condition and areas of localized deficiencies
- Locations and details of benthic resources

A topographic survey (NGVD 1929 Datum) was performed by Avirom & Associates, Inc. in November 2017 to locate and identify site features within the project limits, and provide a basis upon which to establish engineering drawings (See Appendix 4). Geotechnical investigation was conducted by Ardaman & Associates in December 2017 to identify soil strata at five (5) locations along the seawall, establish typical soil properties within the project limits, and provide additional geotechnical considerations for incorporation into engineering analysis and design (See Appendix 5).

For organization, clarity of presentation, and in order to best facilitate future location of a given condition observed, the investigation and this summary report have divided the seawall into four logical baselines along each of the four linear runs of the seawall. These baselines are identified as Baseline A, B, C, & D as shown on Figure 1 below and on the Existing Conditions plans (See Appendix 1). Each baseline is further organized into stations, formatted as 1+75 to indicate 175 LF from beginning station 0+00 (typically a corner), so that a given defect may be more readily found for future monitoring or repairs. The following Figures 1 & 2 are intended to show how the inspection transect was configured and referenced to catalog the wall conditions.

Figure 1: Baseline Layout of Project Limits

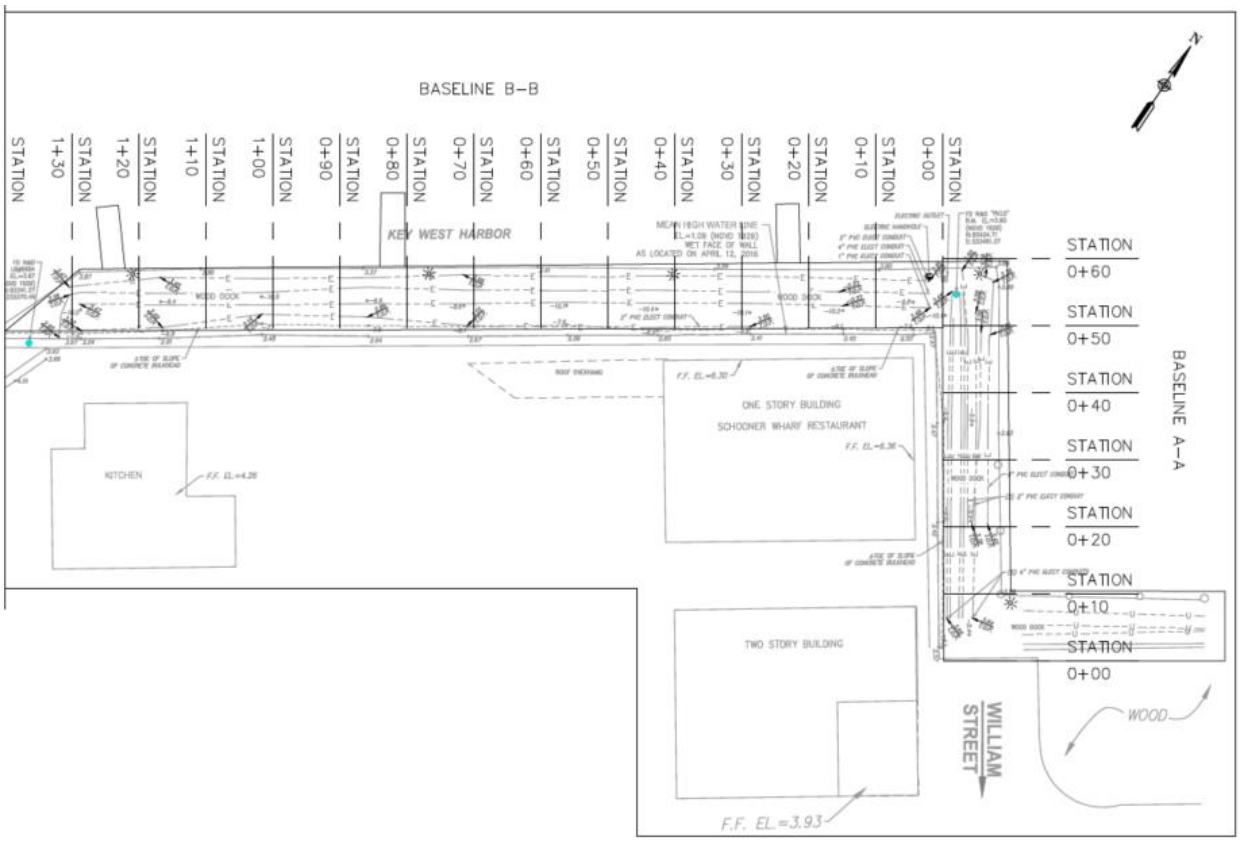


Figure 2: Example of Stationing along Baseline A and the Eastern portion of Baseline B

Tape measurement wheels were used by the divers to station the seawall along the toe of the wall for each baseline. Measurements were then taken as needed perpendicular to the tape-marker to the points of interest so that each deficiency could be cataloged. In the case of a hole in the sheet pile or other penetration through the wall, the diver was instructed to probe with a measuring stick to approximate the depth of a void behind the wall.

The inspection included both a structural and a benthic resource component sufficient to determine existing conditions, develop preliminary remedial measures, and to satisfy permitting requirements associated with any additional monitoring, proposed repair, or proposed repair or replacement of the seawall. The purpose of the benthic resource survey was to determine and quantify the stony corals, spatial extent, size-class, relocation candidates, and total coral tissue area within the project area. Additionally, the survey identified any other biological resources within the project area. This survey will supply the regulatory agencies with the most up-to-date resource data for the project site. Further, data collected from this survey may be used during the planning phase of the project to minimize and avoid impacts to stony corals and/or other resources within the project.

The seawall within the subject area is homogenously comprised of interlocking steel sheet piles with a concrete cap of varying height, and tie-back systems for lateral support. Evidence of these tie-backs was not readily available at the time of inspection, as they are likely embedded within the cap. However, photos and plans used in 1996 for a related project in the area were made available by City Staff and corroborated their existence. The spacing, gauge, length, age, distribution, and level of corrosion of the tie-backs is unknown. Likewise, the embedment depth of the sheet piles is unknown. What can be confirmed is that the steel sheet piles and tie back systems were in place as of 1996. Apart from a newly poured cap along much of Baseline C, all of the remaining structural elements of the seawall appear to be as they had been then, making them in excess of 22 years old, and likely less than 40 years old. Modifications have been made over time to allow for outfall pipes, sewer pump-outs, dock connections and assorted repairs.

Typically steel sheet pile seawalls, when installed in highly aggressive salt water environments like the Key West Bight, typically have a service life on the order of 25-35 years, provided they are properly constructed, coated, and maintained. Generally, the seawall along Baselines A & B is in good condition with some isolated areas of poor condition that should be repaired or monitored. The seawall along Baselines C & D is in poor overall condition with significant and widespread corrosion and metal loss to the sheets themselves, indicating a loss of structural integrity to those segments as a whole. The state of disrepair and omnipresence of corrosion along the edges of the sheets indicates the City should seek to replace Baselines C & D of the seawall in the next two years.

3.0 INTRODUCTION

The project area is located along the South and West boundary of the Key West Bight, adjacent to and extending between the Schooner Wharf and Conch Republic restaurants. Global Positioning System (GPS) coordinates for the center of the project site, at the juncture of Baselines B & C, are as follows: Latitude 24° 33.640' North, Longitude 81°48.152' West.

Figure 3: Project Limits and Surrounding Area

4.0 SITE DESCRIPTION

The survey area is an approximately 700 linear feet of bulkhead along the Southern and Western reaches of the Key West Bight. The seawall is a hardened shoreline surrounding the basin that supports a variety of amenities. Water depths ranged from 5 feet at the shallowest (at Baseline A, STA 0+00) to 13 feet at several locations, as measured from the MHW level of 1.09 NGVD29. The deepest portion of the wall is along Baseline C from STA 0+70 to 2+20, where it is generally between 10-13 feet deep as measured from MHW. Generally, the top of cap and walking surface above the water line may be found between 4.0 and 5.0 NGVD, or 3 to 4 feet above MHW. Sediment composition along the base of the wall is predominantly biogenic mud and fine sand mixed with debris (concrete, rubble, pipes, etc.) Underwater visibility was approximately 2-5 feet; water temperature was 76° Fahrenheit with no noticeable current detected during the survey.

The shoreline of the Key West Bight in the project area is known locally as the "Harbor Walk" and is frequented by tourists and patrons visiting the many shops, sightseeing tours, and restaurants located along the seawall overlooking the marina. The Harbor Walk itself is composed of a winding walkway located on the seawall and boardwalks over the water running parallel to the bulkhead along Baseline A, and the first 135 feet of Baseline B. The area is highly trafficked by pedestrians and bicyclists. Several vessels are moored to the seawall, boardwalk, and piers extending from the seawalls, which service

mostly commercial vessels that service the local tourist industry. Utility services are available beneath the docks and affixed to the cap of the seawall, including electric, water, as well as a sewer pump-out station along Baseline C, roughly 30 feet south of H2 Dock, around STA 1+15.

5.0 INSPECTION METHODS

Field activities were performed from November 28th through 30th of 2017 using a 19-ft. catamaran in order to safely access the survey area. A three man dive team (including two divers and a tender) as well as a professional engineer and a junior engineer (EI) were on site during the inspection. Tetra Tech divers used scuba to visually inspect the wall underwater and cataloged structural deficiencies in real time with the professional engineer topside. The topside structural inspection was conducted by the professional engineer. Tetra Tech certified scientific divers trained in marine biological resource identification used scuba to visually inspect and catalog all stony corals and noted other marine benthic flora and fauna along the face of the approximately 7,000 square-foot bulkhead face and a 10-ft buffer on each end of the bulkhead and along the seafloor apron. Data for the structural inspection and the marine benthic inspection were collected along a single transect positioned from Baseline A STA 0+00 to Baseline D STA 0+50 (700 ft.) along the base of the bulkhead as shown on Figure 1.

The transect tape was used by divers to mark and record the location of each seawall deficiency and coral colony along the bulkhead and buffer area by first marking the location of the observation linearly and then its location vertically from the mudline. Videos of the bulkhead and upland facilities were taken above and below the waterline and include the interspatial area between the waterline and the underside of the docks and boardwalks. Still images were collected from these video feeds and combined with underwater photography which were used together to record specific and representative images of wall condition and benthic resources present within the survey area. Divers followed a systematic approach measuring all deficiencies along the wall using the tape measure and distances from the bottom. This information was then combined with the previously collected georeferenced surveyed data provided by Avirom & Associates, Inc. (Appendix 4)

During the scientific portion of the inspection, the divers also followed the National Oceanic and Atmospheric Administration (NOAA) Protocol for Benthic Surveys of Coral Resources in Florida Keys National Marine Sanctuary (FKNMS) for seawalls and shoreline structures (rip rap, bulkheads, boat ramps, bridges) dated April 29, 2011. The results of the Benthic and Coral Survey is attached to this report as Appendix 3 (Coral Inventory and Benthic Resource Survey for Conch Republic and Schooner Wharf, Key West, FL).

6.0 TYPICAL SEAWALL ASSESSMENT SUMMARIES

The following summary assessment sheets describe the general conditions as well as isolated defects of significance for seawall segments and provide recommended remedial measures. Isolated defects are shown by their Baseline and Station location, while widespread defects are noted within ranges of the same. The wall segments were grouped together in sequence and may be followed along in conjunction with the Existing Conditions Plans found in Appendix 1. All seawall segments were steel sheet pile with a concrete cap that exhibited at least minor spall and corrosion of the steel sheets with some swelling at the knuckle joints and pitting of the concrete cap, as is typical for these materials of this age and environment. These conditions may be considered to be present throughout unless otherwise noted.

Area 1 – Baseline A from Station 0+00 to 0+47

East of Schooner Wharf, North of William Street

Date of Inspection: November 28, 2017

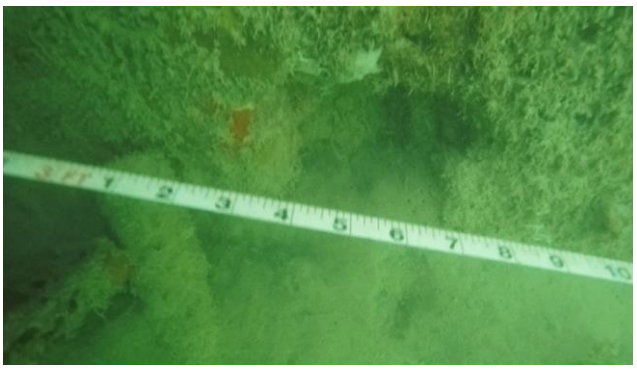


Figure 4: A-A, STA 0+03, 8” Hole (View 1)

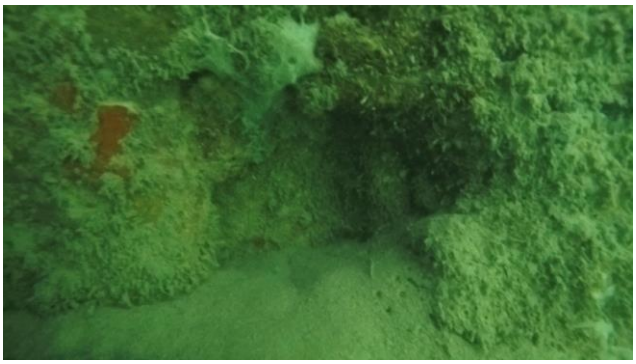


Figure 5: A-A, STA 0+03, 8” Hole (View 2)

Figure 6: A-A, STA 0+35, Typical Sheet Embedment

Figure 7: A-A, STA 0+47, Submerged Conduits

Condition: There is an 8” diameter, 6” deep hole in the concrete cap at STA 0+03, which should be grouted to prevent soil loss. Most of the sheets appear to be intact, although they are covered with marine growth, and due to the suspected age exhibit some minor corrosion and swelling at the knuckle joints. Some pitting is evident in the cap, typically 1/4”-1/2” diameter, and 1/2” deep on 50% of the surface. The overall condition of the wall is good, but most concerning in this area are the submerged utilities at the corner with Baseline B. These utilities should be re-connected to the dock walkway overhead to prevent breaks in the PVC housing conduits and exposure of utilities to salt water.

Location	Item	Condition Index	Recommendation
Baseline A STA 0+00 to 0+47	Overall Wall Condition	Good	Monitor Every 2-3 Years for signs of degradation to sheet piles/cap
STA 0+03	Isolated Hole (8” Dia)	Poor	Fill with Tremie or Pressure Grout
STA 0+47	Submerged Conduits	Poor	Install new hanger hardware

Area 2 – Baseline B from Station 0+00 to 0+80

Northeast of Schooner Wharf Restaurant

Date of Inspection: November 28, 2017

Figure 8: B-B, STA 0+00, Representative example of pitting

Figure 9: B-B, STA 0+35, 14”x14”x39” Void

Figure 10: B-B, STA 0+50, Degraded Cold Joint

Figure 11: B-B, STA 0+50, Degraded Cold Joint

Condition: There is a man-made 14” x 14” hole 4 in deep penetration in the top of the sheet pile, immediately beneath the cap. It appears the sheet was cut off at this location. Unless there is a reason for this defect (for drainage or other purposes) it should be pressure grouted to prevent soil loss from behind the wall. A cold joint is present at STA 0+50, which had previously been epoxy coated, but it appears to be degrading. This area should be epoxy coated again. The remaining sheets appear to be intact. The cap exhibits moderate pitting (>1/4” deep). The overall condition of the wall is good, but as with the prior note, there are submerged utilities at the corner with Baseline A. These utilities should be re-connected to the dock walkway overhead to prevent breaks in the PVC housing conduits and exposure of utilities to salt water.

Location	Item	Condition Index	Recommendation
Baseline B STA 0+00 to 0+80	Overall Wall Condition	Good	Monitor Every 2-3 Years for signs of degradation to sheet piles/cap
STA 0+35	Isolated Hole (14”x14”)	Poor	Fill with Tremie or Pressure Grout
STA 0+50	Isolated Cold Joint	Poor	Epoxy coat

Area 3 – Baseline B from Station 0+80 to 1+60

North of Schooner Wharf Restaurant

Date of Inspection: November 28, 2017

Figure 12: B-B, STA 0+87, Pipe Penetration w/ Cracking

Figure 13: B-B, STA 0+87, Crack running below pipe

Figure 14: B-B, STA 0+87, Split, spalled joint beneath pipe

Figure 15: B-B, STA 1+00, Ficus roots overhang wall

Figure 16: B-B, STA 1+22, Roots overhang wall

Figure 17: B-B, STA 1+26, 3” Dia Hole in sheet pile

Condition: A 12” diameter drainage pipe exits the wall at STA 0+87. Emanating from that penetration are a number of significant cracks, each measuring several feet in length, and approximately 1/2" wide. The steel sheets beneath appear to be separating due to section loss at the joint. A ficus tree at STA 1+00 (the entrance to Schooner Wharf) has roots overhanging the seawall, and while no notable damage appears to be present, ficus roots can be notoriously harmful to infrastructure. The relative significance of this tree to the establishment should be taken into consideration, but in terms of impacts to the seawall, it would be better to remove it, or at least trim the roots back periodically. A second set of roots is found overhanging the wall at STA 1+22. There is a 3” diameter punctured penetration in the sheet pile at 1+26, which is minor but should be patched. A disconnected utility line appears to be present at STA 1+30, although it appears to be devoid of any cable connections.

The overall condition of the wall is fair, and there is increased concern about the structural integrity of the wall due to the corroded sheet pile joints beneath the pipe.

Location	Item	Condition Index	Recommendation
Baseline B STA 0+80 to 1+60	Overall Wall Condition	Fair	Consider replacement. At a minimum, monitor Every 2-3 Years for full replacement.
STA 0+87	Cracks from Pipe Penetration	Poor	Epoxy coat all cracks, monitor for signs of joint degradation at 1 year intervals.
STA 1+00 and 1+22	Roots overgrowing seawall	Poor	Consider removing vegetation or trimming roots periodically
STA 1+26	Puncture Hole	Poor - Minor	Grout or epoxy-fill

Area 4 – Baseline B from Station 1+60 to 3+36

West of Schooner Wharf Restaurant

Date of Inspection: November 28, 2017

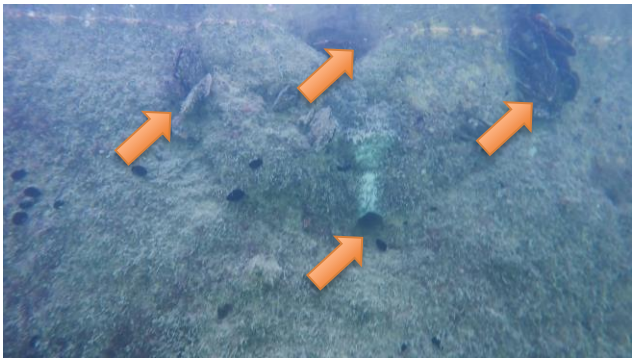


Figure 18: B-B, STA 1+71, Several 3" Dia. holes in cap

Figure 19: B-B, STA 1+71, 36" deep void in cap

Figure 20: B-B, STA 1+84, Broken Concrete Cap

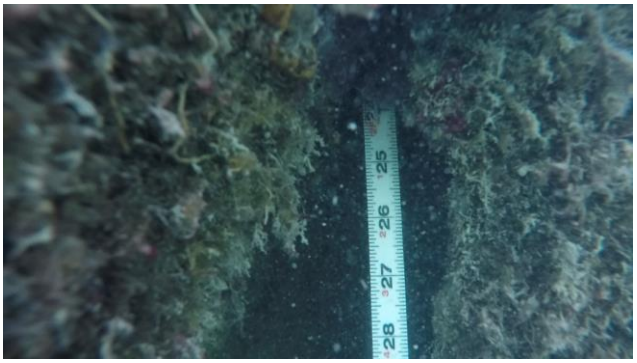


Figure 21: B-B, STA 2+86, Hole in sheet pile, 26" void

Condition: This section of wall is in overall good condition. There are a few isolated areas of concern. At STA 1+71, there are three to four small penetrations in the cap that appear to be drain lines. The cap along this section is broken and cracked from approximately STA 1+60 to STA 2+10, contributing to a potential trip hazard. Some exposed rebar can be found in the spalled portions. At STA 2+81 there is a large piece of concrete debris and nearby at STA 2+86 there is a 4 in diameter hole in the sheet pile with a void extending approximately 25" behind it.

Location	Item	Condition Index	Recommendation
Baseline B STA 1+60 to 3+36	Overall Wall Condition	Good	Monitor Every 2-3 Years for signs of degradation to sheet piles/cap
STA 1+71	Isolated Holes (3-4 @ 3" Dia)	Fair - Minor	Determine if functional outfalls. If not, fill with Tremie or Pressure Grout
STA 1+60 to 2+10	Broken Concrete Cap	Poor	Demolish cap and reconstruct
STA 2+86	Hole in sheet with void	Poor	Fill with Tremie or Pressure Grout

Area 5 – Baseline C from Station 0+00 to 0+80

South of Conch Republic Restaurant

Date of Inspection: November 29, 2017

Figure 22: C-C, STA 0+07, Begin steel sheet piling

Figure 23: C-C, STA 0+57, Spalling cap

Figure 24: C-C, STA 0+57, Severely corroded sheets

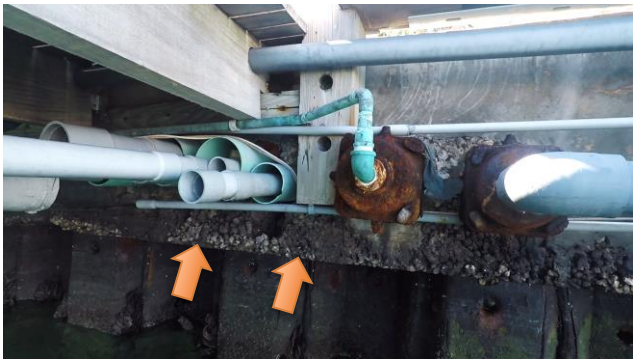


Figure 25: C-C, STA 0+65, Honeycombing in cap

Condition: This section of wall is in overall poor condition. The most apparent change in the transition from Baseline B-B to Baseline C-C is the emergence of a more severely corroded sheet pile throughout the limits of C-C. The sheets are corroded and swollen at the corners and along the joints, indicating a higher degree of corrosion. In many cases, these corroded locations have become long fissures. Isolated cases of defects are distributed throughout, but on account of the loss of structural integrity to the sheets, this wall must be considered to be in poor condition and is a candidate for replacement.

Location	Item	Condition Index	Recommendation
Baseline C STA 0+00 to 0+80	Overall Wall Condition	Poor	Replacement
STA 0+57	Broken cap sections	Poor	Replacement due to overall condition
STA 0+57	High degree of spall	Poor	Representative example; prevalent throughout. Replacement required.
STA 0+65	Honeycombing in cap	Poor	Replacement due to overall condition

Area 6 – Baseline C from Station 0+80 to 1+60

South of Conch Republic Restaurant

Date of Inspection: November 29, 2017

Figure 26: C-C, STA 1+36, Separation of sheets (View 1)

Figure 27: C-C, STA 1+36, (View 2)

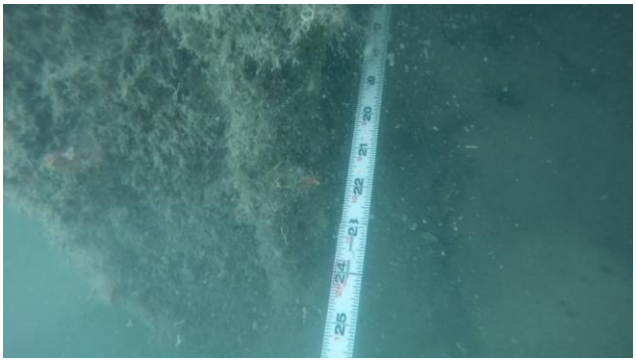


Figure 28: C-C, STA 1+36, Void space of 20”

Figure 29: C-C, STA 1+57, Spalled cap

Condition: This section of wall is in overall poor condition. Consistent with the first segment of Section C-C, this wall also exhibits signs of severe corrosion of the sheet piles. In one instance, at STA 1+36, the sheets have separated and a void space of 20” may be found behind the wall. This sheet appears to have “toed out”, a mode of failure indicative of insufficient penetration of the sheet pile.

Location	Item	Condition Index	Recommendation
Baseline C STA 0+80 to 1+60	Overall Wall Condition	Poor	Replacement
STA 1+36	Separation of sheets	Poor	Replacement due to overall condition
STA 1+57	Cracked cap	Poor	Replacement due to overall condition

Area 7 – Baseline C from Station 1+60 to 2+55

East of Conch Republic Restaurant

Date of Inspection: November 29, 2017

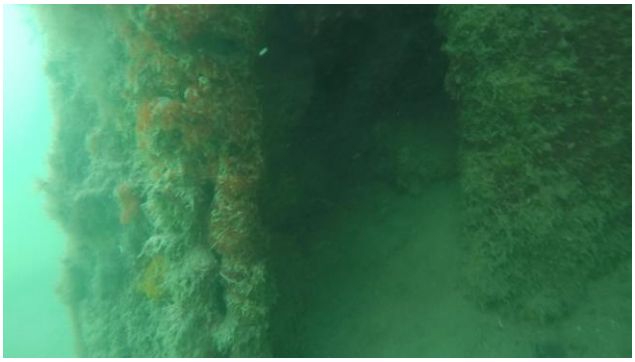


Figure 30: C-C, STA 1+69, Separation of sheets (View 1)

Figure 31: C-C, STA 1+69, (View 2)

Figure 32: C-C, STA 1+90, Severely corroded cap

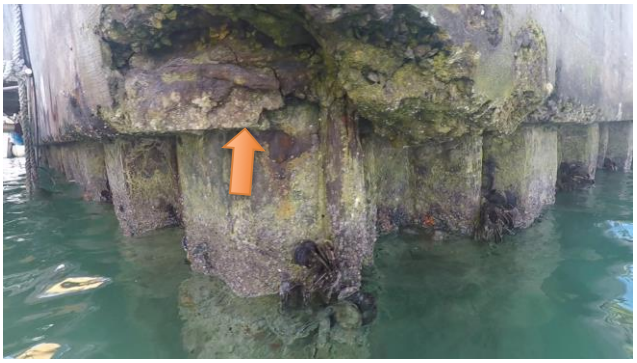


Figure 33: C-C, STA 2+55, Large spalling area

Condition: This section of wall is in overall poor condition. Consistent with the prior two segment of Section C-C, this wall also exhibits signs of severe corrosion of the sheet piles. As had been the case at STA 1+36, the sheets have separated again at STA 1+69, with a "toe-out" failure mode present, indicating insufficient penetration of the sheet pile. In Figures 32 & 33, there are large spall areas with exposed rebar.

Location	Item	Condition Index	Recommendation
Baseline C STA 1+60 to 2+55	Overall Wall Condition	Poor	Replacement
STA 1+69	Separation of sheets	Poor	Replacement due to overall condition
STA 1+90 & 2+55	Cracked/Spalled cap	Poor	Replacement due to overall condition

Area 8 – Baseline D from Station 0+00 to 0+50

North of Conch Republic Restaurant

Date of Inspection: November 29, 2017

Figure 34: D-D, STA 0+00, Spalled cap at corner

Figure 35: D-D, STA 0+10, Honeycomb with cracks

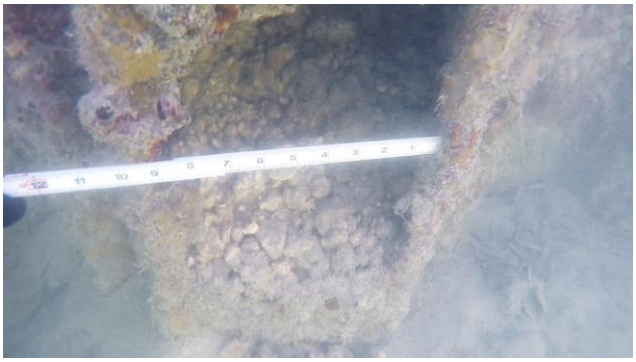


Figure 36: D-D, STA 0+19, 9”x12” hole in sheet pile

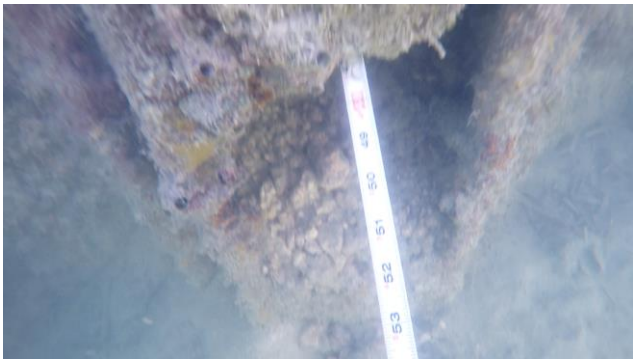


Figure 37: D-D, STA 0+19, 48” penetration into hole

Condition: This section of wall is in overall poor condition. Consistent with Baseline C, the wall exhibits similar levels of corrosion on the sheets. Although this is a shorter run of wall, the need to replace Baseline C should incorporate Baseline D to provide a homogenous interlocking wall for increased stability to the adjacent uplands.

Location	Item	Condition Index	Recommendation
Baseline D STA 0+00 to 0+50	Overall Wall Condition	Poor	Replacement
STA 0+00	Broken cap	Poor	Replacement due to overall condition
STA 0+10	Honeycomb in cap	Poor	Replacement due to overall condition
STA 0+19	9”x12” hole in sheet	Poor	Replacement due to overall condition

7.0 ENVIRONMENTAL & PERMITTING DISCUSSION

The waters adjacent of the Key West Bight and project area are classified by the Florida Department of Environmental Protection (FDEP) as a Class III water body (Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife), and they are located inside the limits of the National Oceanic and Atmospheric Administration (NOAA) Florida Keys National Marine Sanctuary (FKNMS).

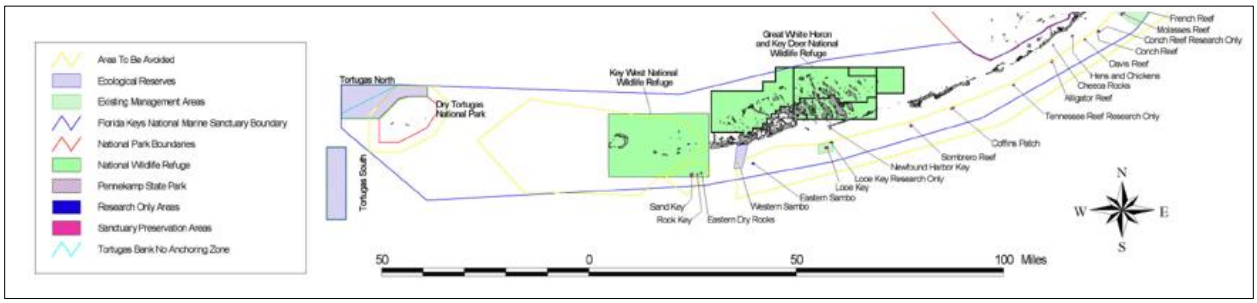


Figure 38: Limits of the FKNMS (http://floridakeys.noaa.gov/fknms_map/sanctuaryzoneboundaries.pdf)

Permitting along the shoreline, inside the FKNMS, normally involves submitting an environmental resource permit application to the Florida Department of Environmental Protection (FDEP) and the US Army Corp of Engineers (ACOE). Under normal circumstances, the project would be subjected to coral and benthic surveys to satisfy the requirements of the FKNMS. The National Oceanic and Atmospheric Administration (NOAA) would need to be consulted due to the existence of corals in the area.

Permitting along the shoreline, inside the FKNMS, involves submitting an environmental resource permit application to the Florida Department of Environmental Protection (FDEP) and the US Army Corp of Engineers (ACOE). This application along with the project benthic resource survey and coral inventory is submitted by the ACOE directly to the FKNMS and then forwarded to the National Marine Fisheries Service (NMFS), pursuant to Section 7 of the Endangered Species Act (ESA). During the permitting process, coral colonies are identified and mitigated for; in some cases the corals may be relocated and in others a fee mitigation is required.

In general the nationwide permitting process allows for improvements that extend up to 18-inches in front of the existing wall. There is some flexibility in this guideline depending on engineering constraints and/or local site conditions. However, given the state of disrepair and the recommendation of a seawall replacement for a portion of the project limits, it is advisable that this 18" minimum separation be adhered to when formulating a design solution. In many cases, adherence to this 18" parameter will qualify the project for an exemption.

Please note: Due to damage sustained to Key West in the wake of Hurricane Irma, Governor Scott issued an executive order that affords an expedited permitting review timeline for projects affected by the storm. The Statewide Emergency Orders were scheduled to expire in the midst of this writing. Consequently, Tetra Tech prepared and filed permit applications with FDEP and USACE in accordance with our contract in order to take advantage of that timeline and its inherent benefits to the City. In an abundance of caution, the proposed method was represented as a steel sheet pile replacement seawall for the full 700 LF length of the subject project, with the understanding that we may modify it at a later date to reflect the City's wishes for repairs. While fast-track permitting is not guaranteed and the emergency order does not absolve the City from regulatory requirements, there exists a possibility that the City may be afforded an expedited path to seawall permitting as a result of this effort.

8.0 CONCLUSIONS

In reviewing the wall condition, the most concerning locations were along Baseline C and D for the entire length of those portions. The general condition of the sheet piles within those segments is severely corroded, with fissures present in the corners of the piles, separation between sheets where the wall appears to have "toed out", and other modes of readily observable damage (pitting, spall, metal loss, and corrosion). It is likely that the wall is nearing the end of its useful life. Therefore, at a minimum, a project to replace Baseline C and Baseline D should be developed and permitted to shore up these concerns within the next few years.

The Schooner Wharf wall, encompassing Baseline A & B, is of less concern. While there are signs of localized damage, some corrosion throughout the sheets, and pitting throughout the cap, there is not quite the degree of degradation to the seawall as is the case for Baselines C & D along Conch Republic. The City may wish to repair the localized areas in piecemeal fashion to curtail costs. This report and the enclosed exhibits may be used as a guide for addressing the individual concerns in the design engineering documents, and much of the work should be able to be performed by a marine contractor working within the Bight.

The seawall along Baseline A & B may have between 5 and 10 years of useable life. That stated, the undertaking of a seawall project within the basin is bound to include several considerations that may make replacing Baseline A & B walls worthwhile. A seawall project, regardless of size, will include mobilization costs, reduced access to patrons, and other similar construction-related inconveniences. For these reasons, it may be worthwhile for the City to consider a bid alternate to replace the Schooner Wharf wall at the same time, and reset the clock on future replacement work. In so doing, the City could make an informed decision about the costs of prolonging the replacement of Baselines A & B versus replacing them together with Baselines C & D.

Should the City elect to only replace Baselines C & D, it's advisable that Baselines A & B be monitored on a yearly interval for signs of degradation and future repairs or replacements.

9.0 RECOMMENDATIONS

We recommend that the City of Key West conduct a seawall replacement project for the Conch Republic sections of this assessment, designated within this report as Baselines C & D. The same project could include, as a base bid, the repairs as outlined to Baselines A & B (grouting, epoxy repairs, and cap replacement), or they may be included with the Turtle Kraals seawall rehabilitation to the east.

At the City's discretion, they may wish to include an alternate bid item for a full replacement to include Baselines A & B. Pending the bid results and budgetary review, a determination for course of action regarding Baseline A & B may be decided at that time.

Preliminary structural analyses utilizing the information provided the in the geotechnical report indicate that a DZ-95 steel sheetpile of approximately 32 feet in length will support the soil profile site-wide.

The layout of the new seawall will be limited largely by permitting requirements of no more than 18" waterward of the existing seawall. The seawall replacement should be made via steel sheet piling installed as a cantilever wall (without tieback supports) so as to minimize the likelihood of conflicts with upland utilities. The steel should be specified of a length, gauge, thickness, coating as determined by structural

analysis. Provisions should be made for appropriate protective coatings. An example of the proposed cantilever positioning may be seen in Figures 39 & 40 below, as well as Appendix 2.

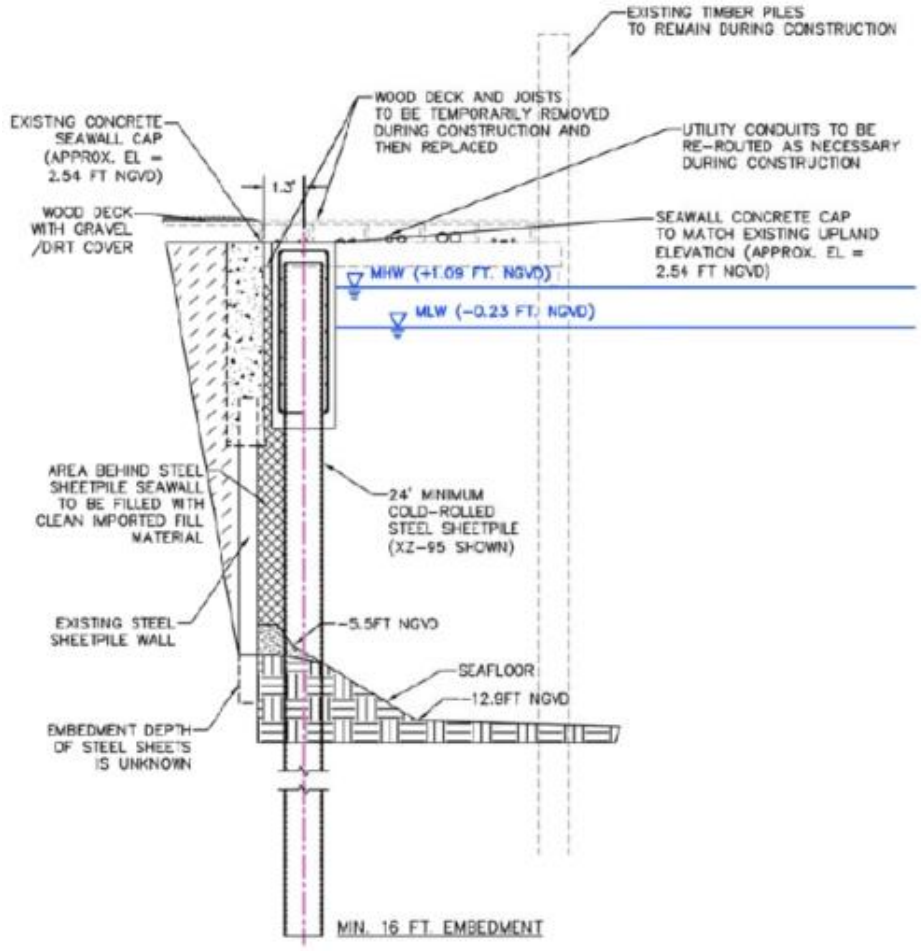


Figure 39: Cross Section of Proposed Replacement

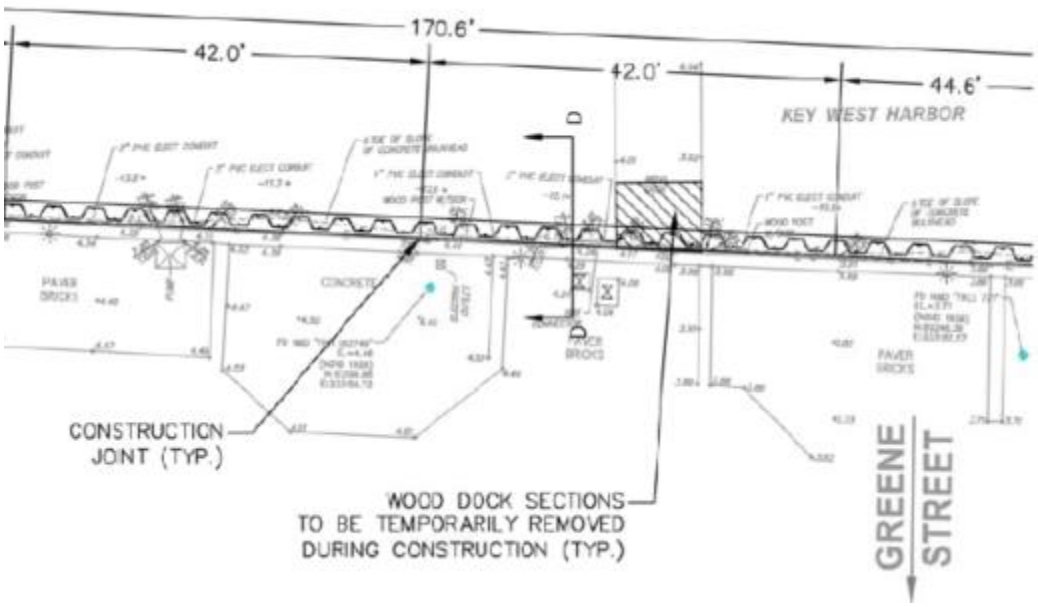


Figure 40: Typical Representation of Steel Sheet Cantilever Wall along Baseline C

The geotechnical report revealed a soil profile of Fill & Limerock from 0-5', Silt with Organics from 5-8', and Limestone, Poorly to Well Cemented from 8-30'. When considering seawall replacement alternatives, the presence of a silt/muck layer at 5-8' below the surface is of significance. Where possible, these layers should be avoided for setting tie-back rods, deadmen, or other forms of lateral support. Muck is prone to consolidation, and deadmen anchors in muck may become unstable. For this reason as well as the minimization of excavation, a cantilever system is preferable to tie-backs. The hard substrata typically encountered within the project limits the ability to use other non-steel sheet pile materials. Among the advantages to a steel wall is speed of installation in tandem with higher levels of structural viability. To that end, the project could be completed relatively quickly to minimize adverse effects to neighboring businesses.

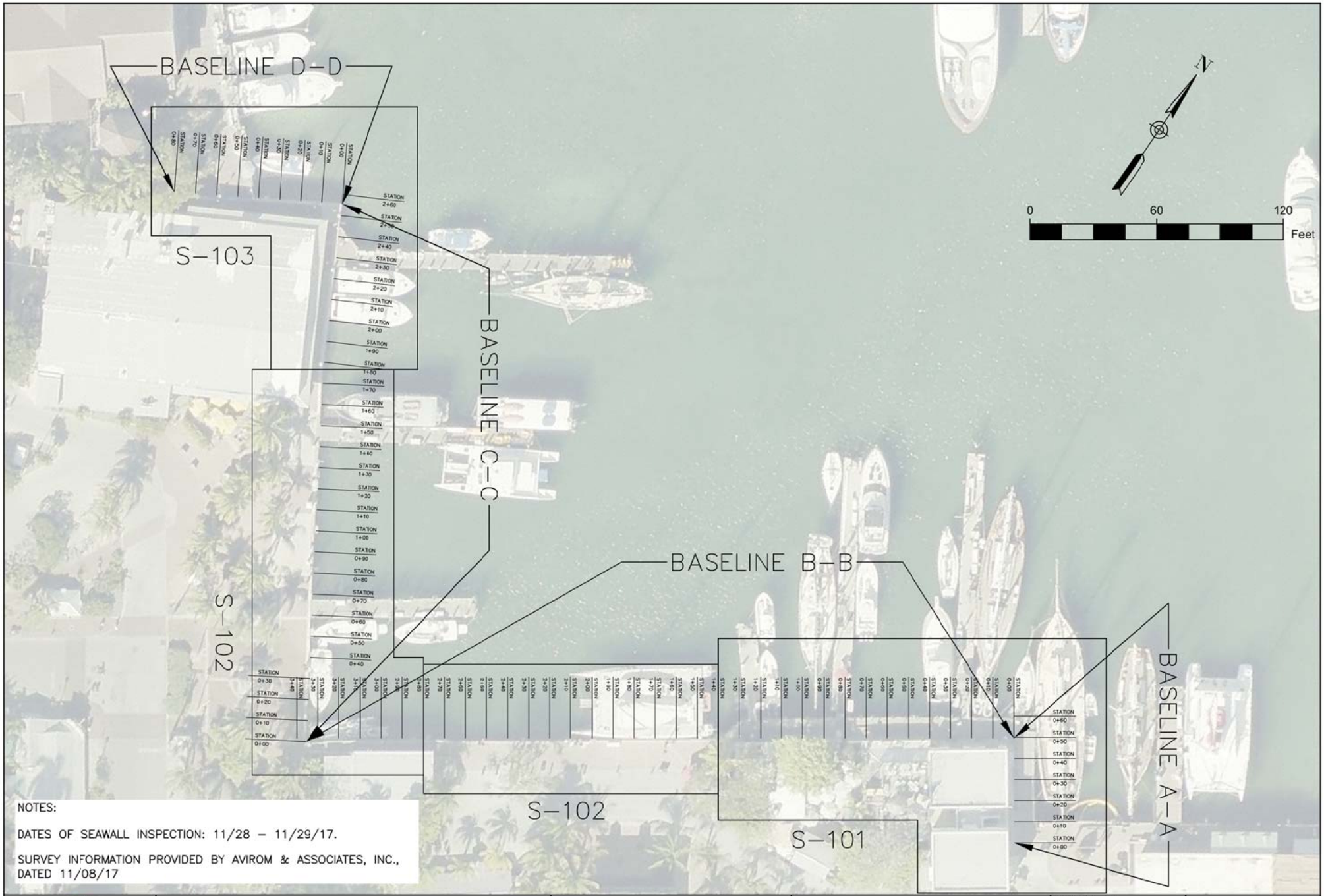
We recommend including an effort within the prospective contractor's scope of work to conduct pre- and post- construction surveys and videos to document the condition of the adjacent structures, as well as an effort to monitor vibrations on adjacent structures during construction activity to help provide reasonable assurance that those buildings will not be negatively impacted by the seawall installation. In the event that vibrations exceed established tolerances within the contract, adjustments may be made to construction methods to preserve those facilities.

10.0 ASSUMPTIONS OF ENGINEER'S OPINION OF PROBABLE COST

The Engineer's Opinion of Probable Cost provided in Appendix 6 has been developed under the assumption that the City will replace Baselines C & D with a cantilever steel sheet pile wall with concrete cap, and that they will elect to repair the defects along Baselines A & B in lieu of a full replacement.

APPENDIX 1

Existing Seawall Plan, Elevation (Front Face) and Cross Section Views



NOTES:

DATES OF SEAWALL INSPECTION: 11/28 – 11/29/17.

SURVEY INFORMATION PROVIDED BY AVIROM & ASSOCIATES, INC., DATED 11/08/17

CITY OF KEY WEST
SCHOONER WHARF TO CONCH REPUBLIC
SEAWALL INSPECTION

SEAWALL PLAN VIEW KEY SHEET

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Sheet 1 of 16

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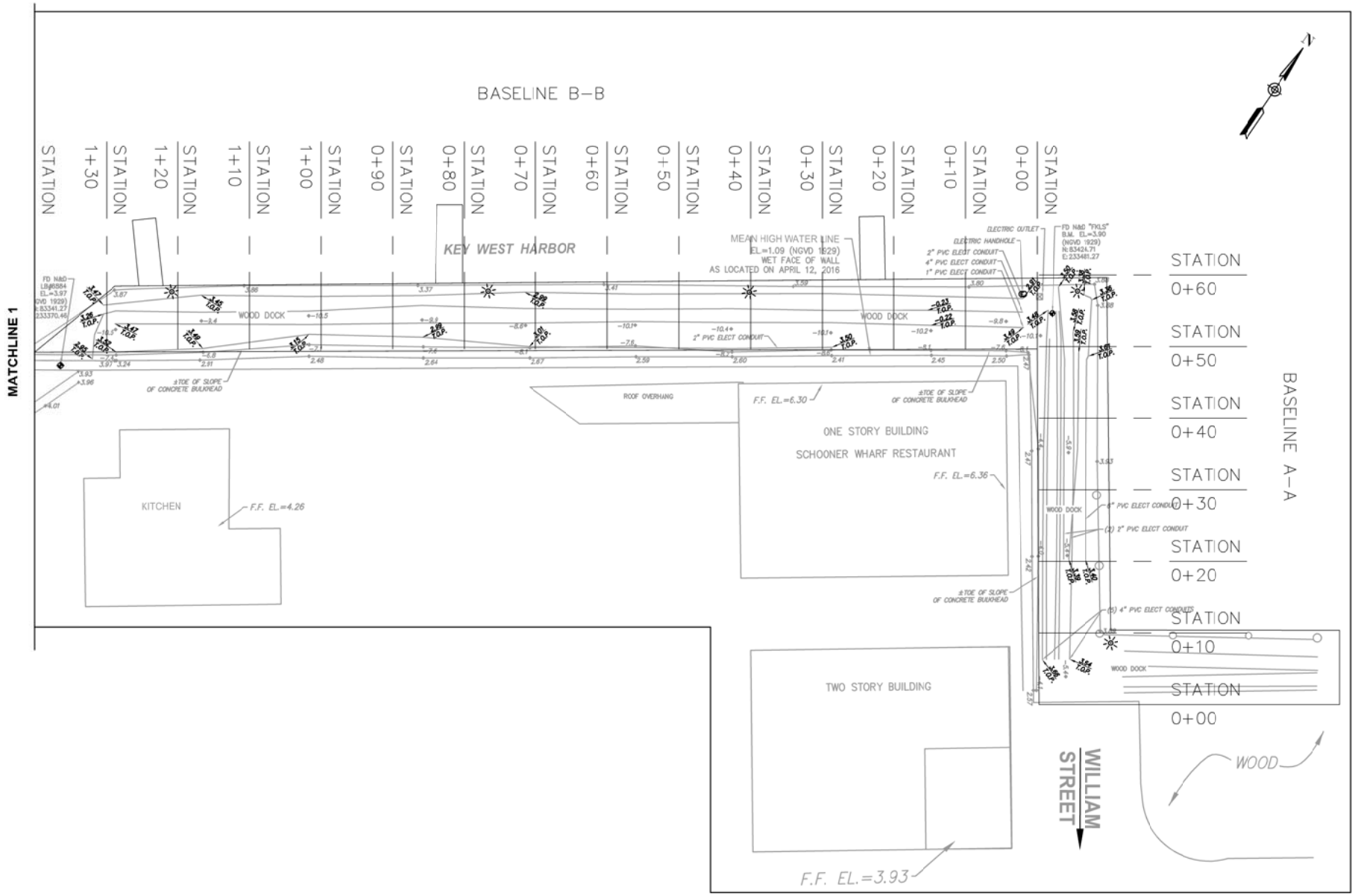

NOTES:

DATES OF SEAWALL INSPECTION: 11/28 – 11/29/17.

SURVEY INFORMATION PROVIDED BY AVIROM & ASSOCIATES, INC., DATED 11/08/17

CITY OF KEY WEST
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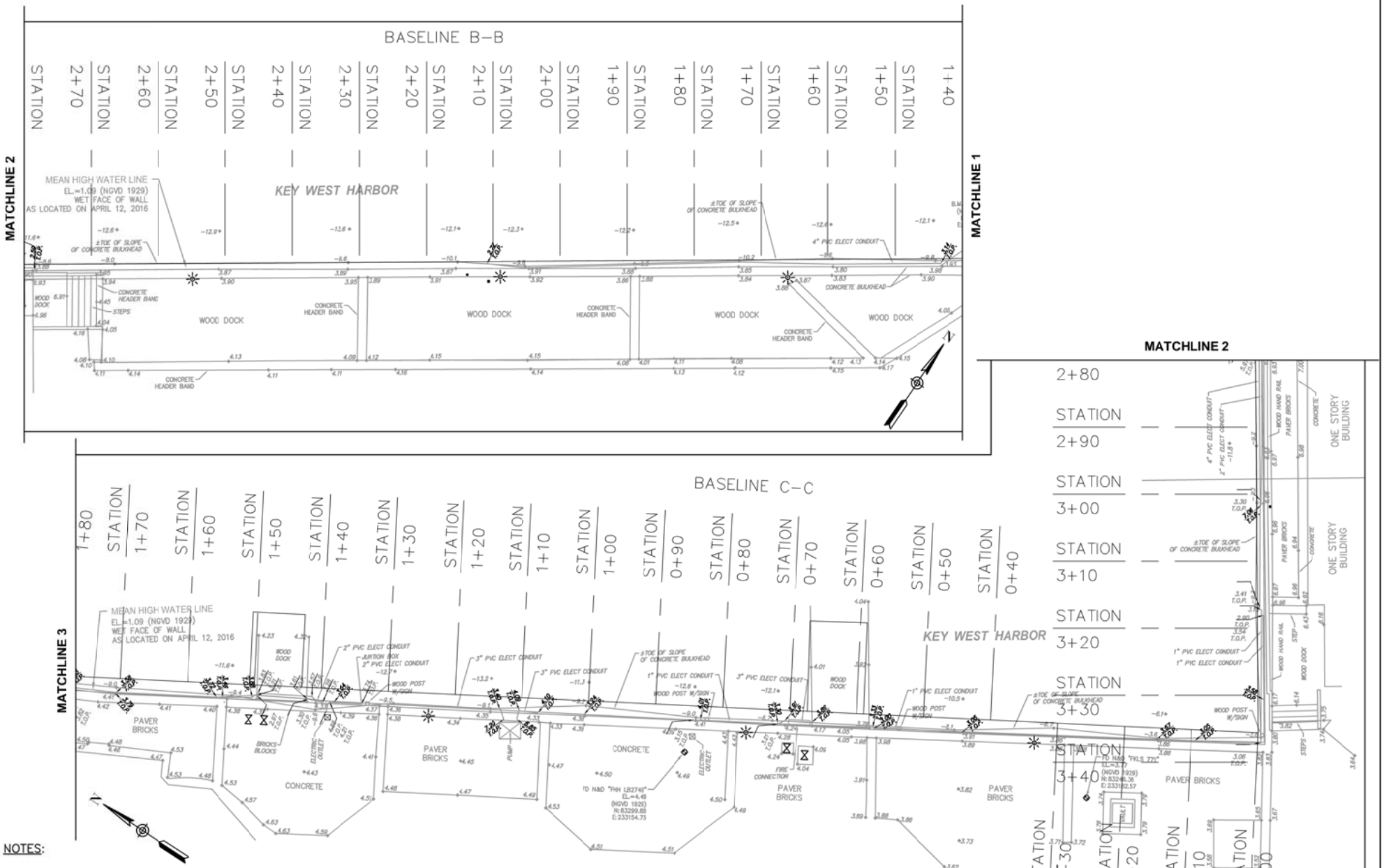
Sheet 2 of 16



NOTES:

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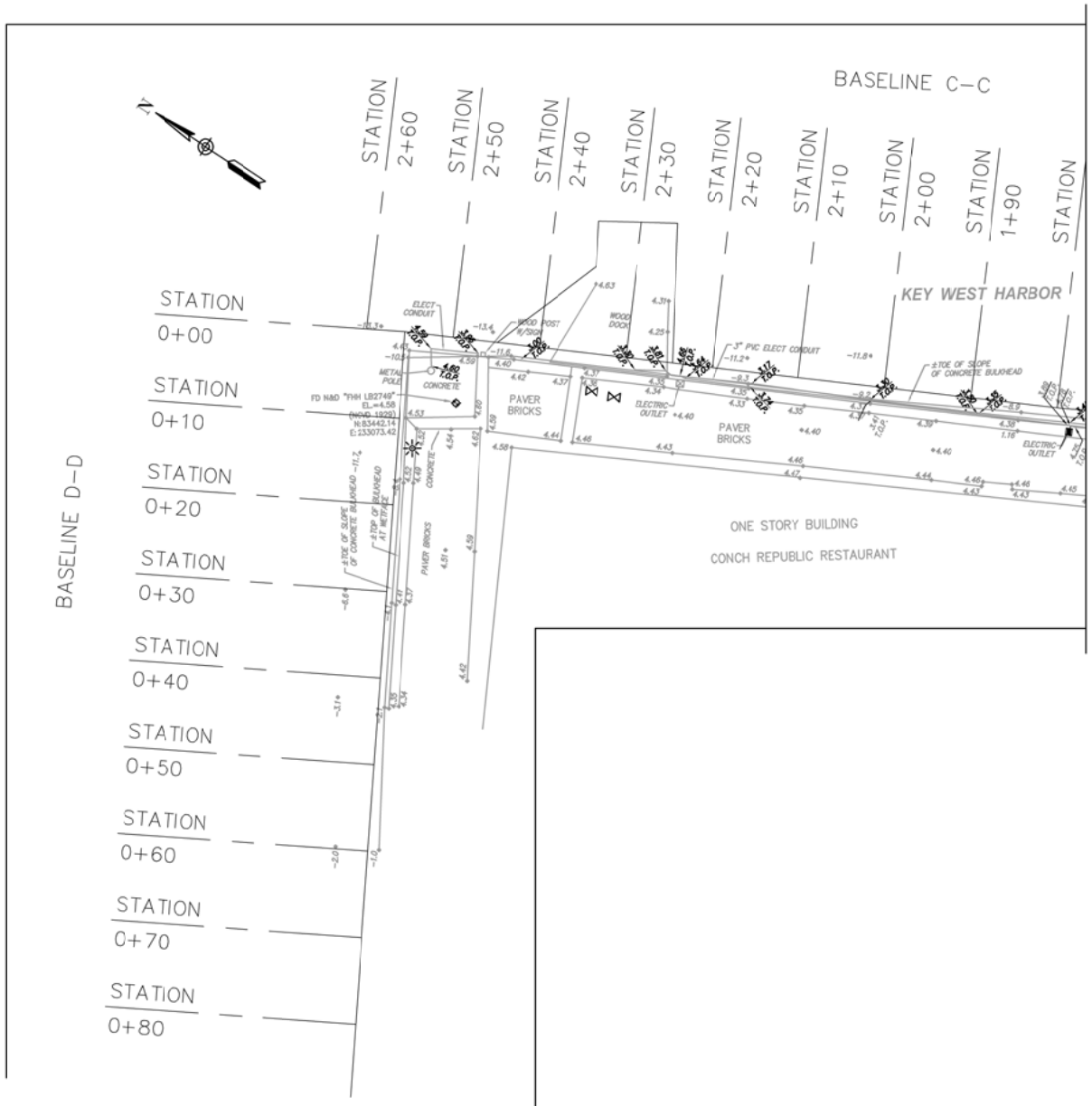

NOTES:

DATES OF SEAWALL INSPECTION: 11/28 – 11/29/17.

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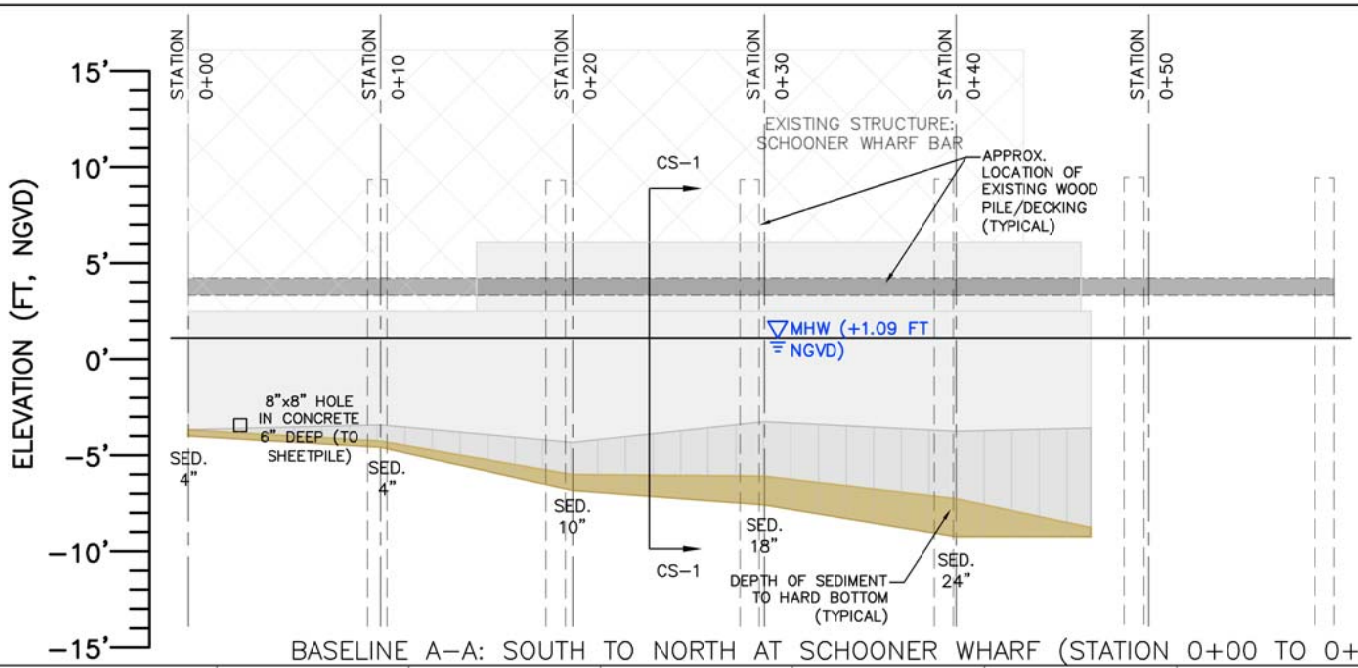
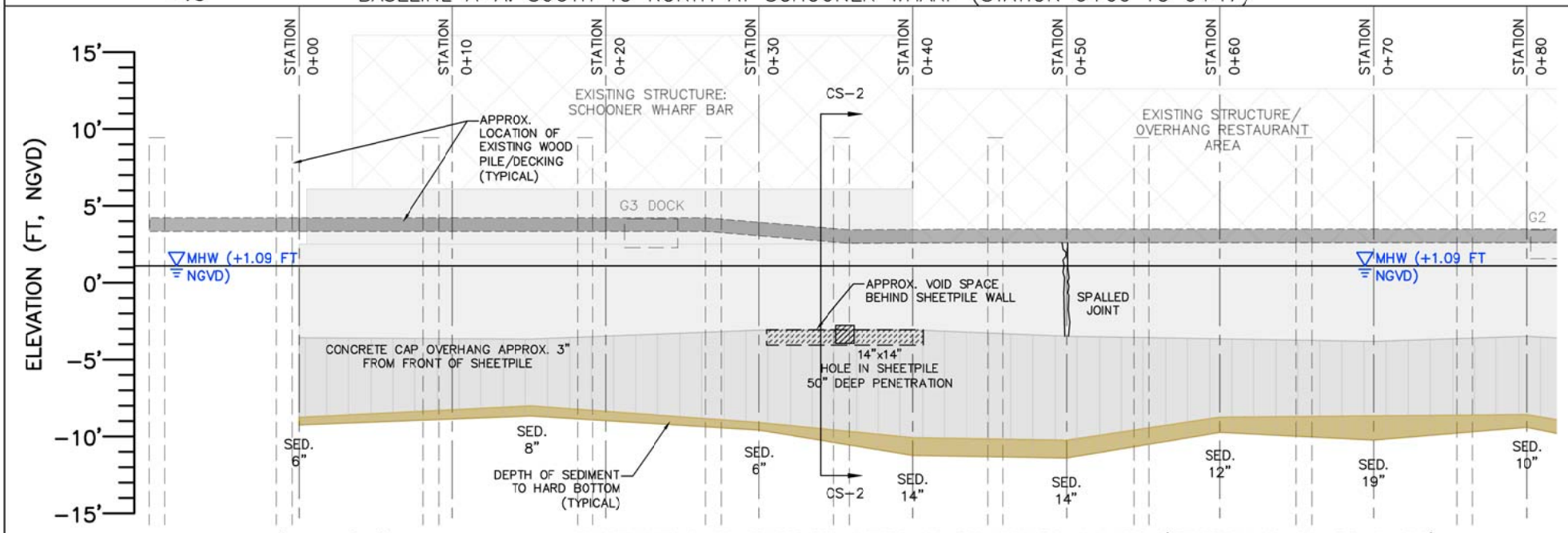
Sheet 4 of 16



BASELINE A–A: SOUTH TO NORTH AT SCHOONER WHARF (STATION 0+00 TO 0+47)



DATES OF SEAWALL INSPECTION: 11/28 – 11/29/17.

BASELINE B–B: EAST TO WEST AT SCHOONER WHARF (STATION 0+00 TO 0+80)

SEAL OF THE CITY OF KEY WEST, FLORIDA

CITY OF KEY WEST
SCHOONER WHARF TO CONCH REPUBLIC SEAWALL INSPECTION

SEAWALL FACE VIEW

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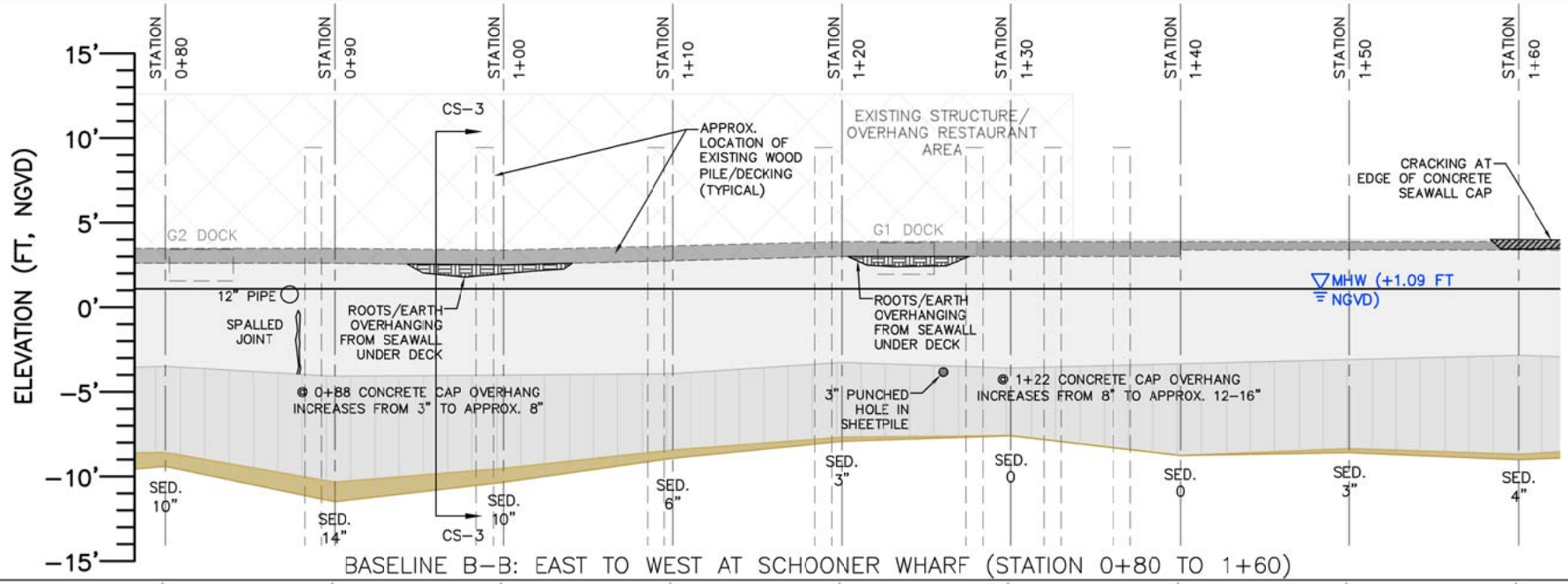
Sheet 5 of 16



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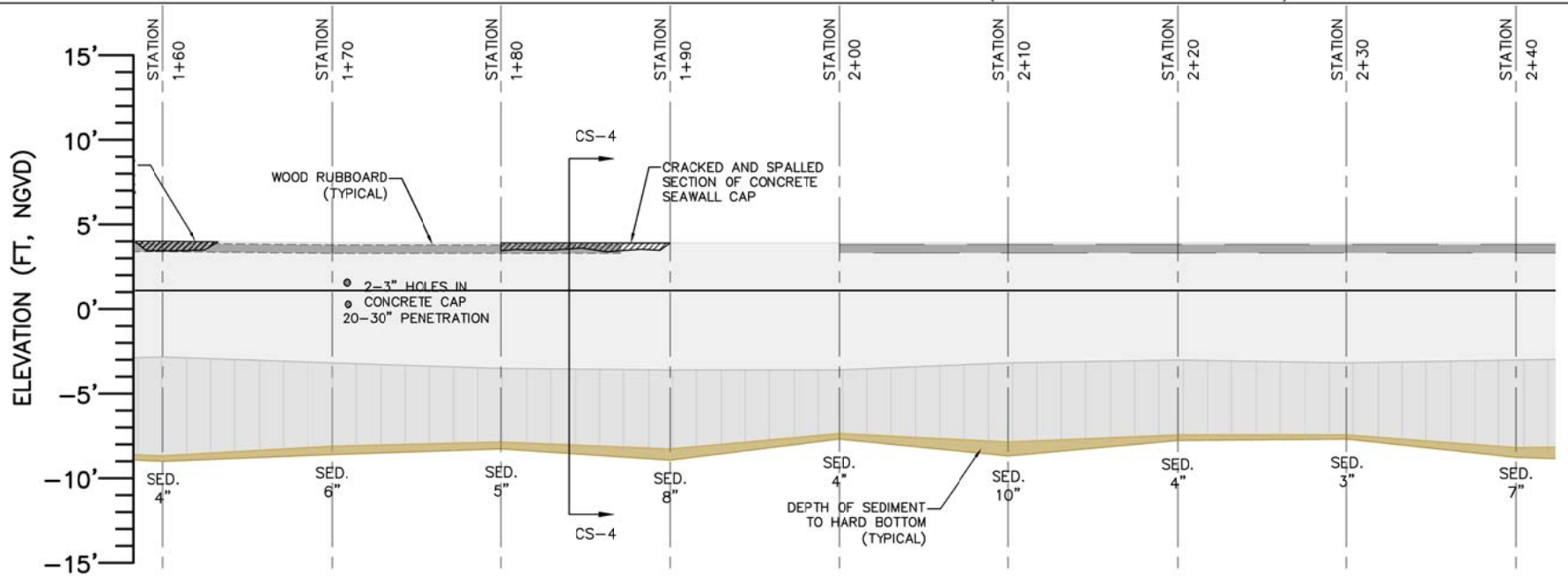

DATES OF SEAWALL INSPECTION: 11/28 – 11/29/17.

BASELINE B–B: EAST TO WEST AT SCHOONER WHARF (STATION 1+60 TO 2+40)

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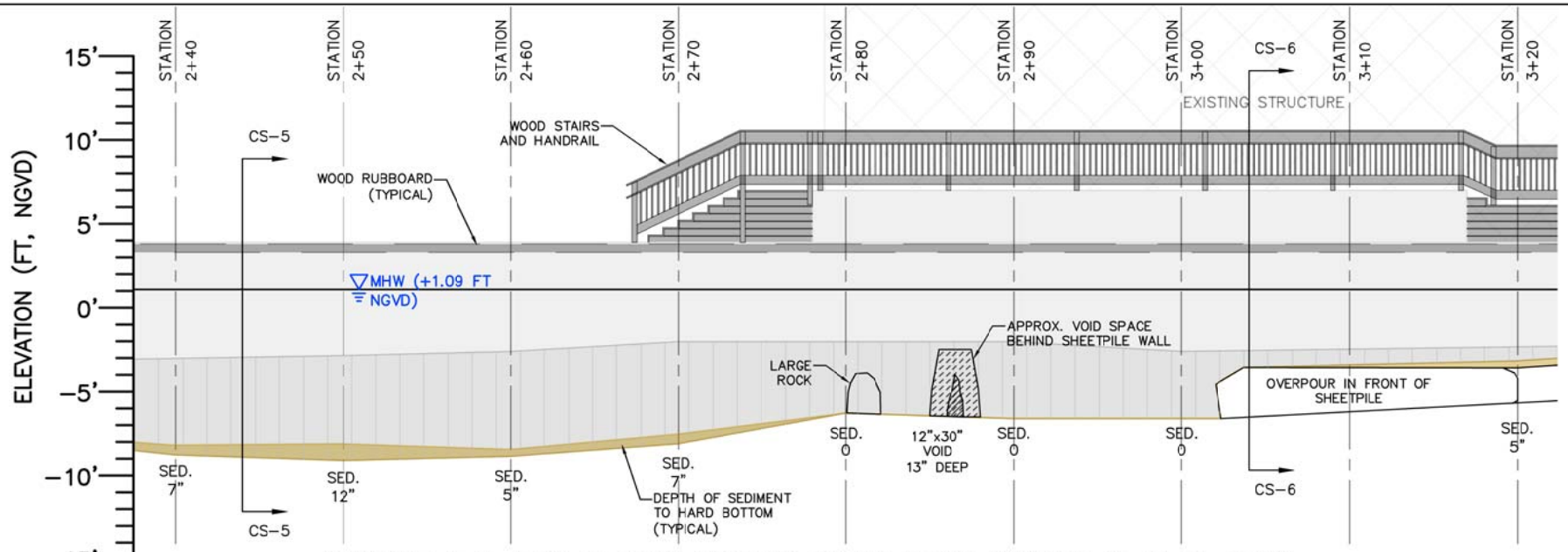
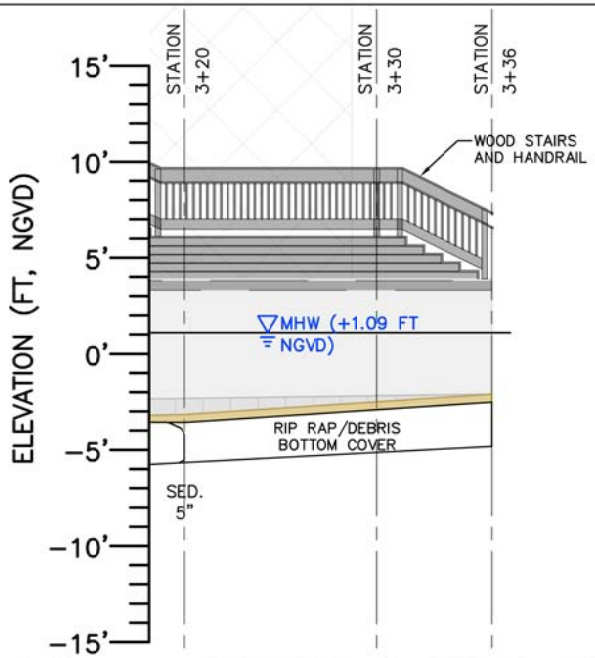
Sheet 6 of 16



BASELINE B–B: EAST TO WEST PAST SCHOONER WHARF (STATION 2+40 TO 3+20)



DATES OF SEAWALL INSPECTION: 11/28 – 11/29/17.

BASELINE B–B: EAST TO WEST PAST SCHOONER WHARF (STATION 3+20 TO 3+36)

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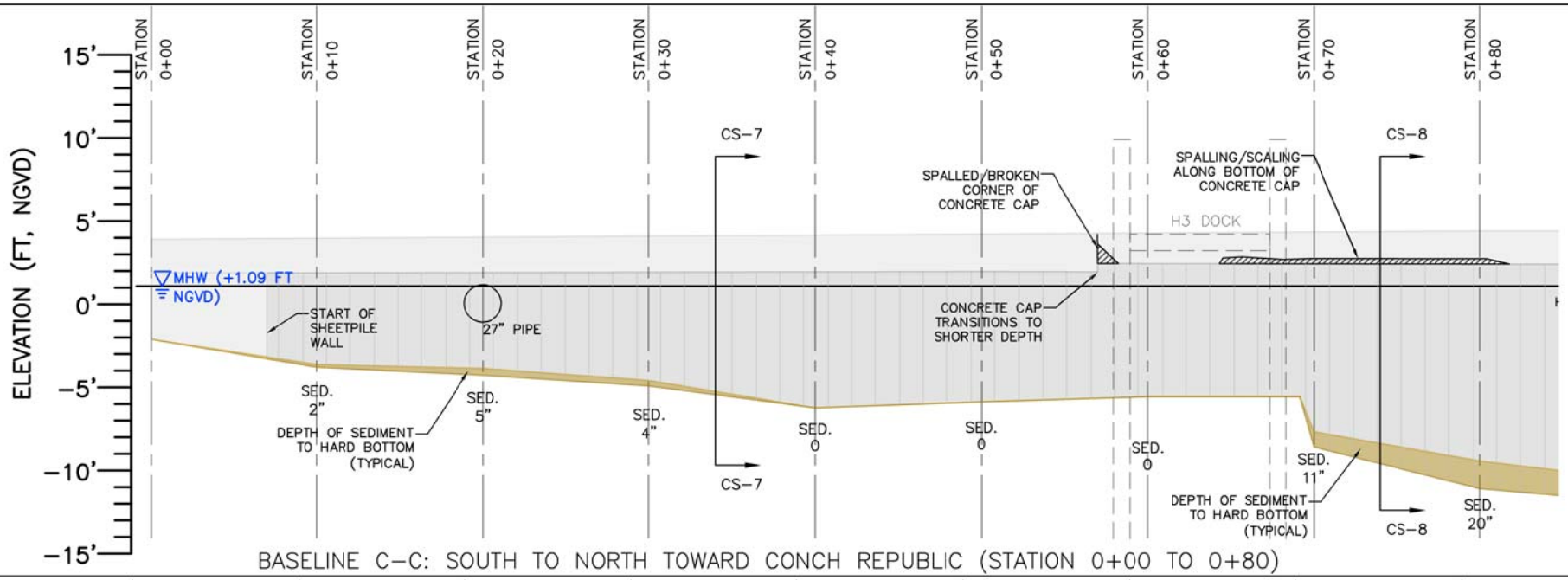
Sheet 7 of 16



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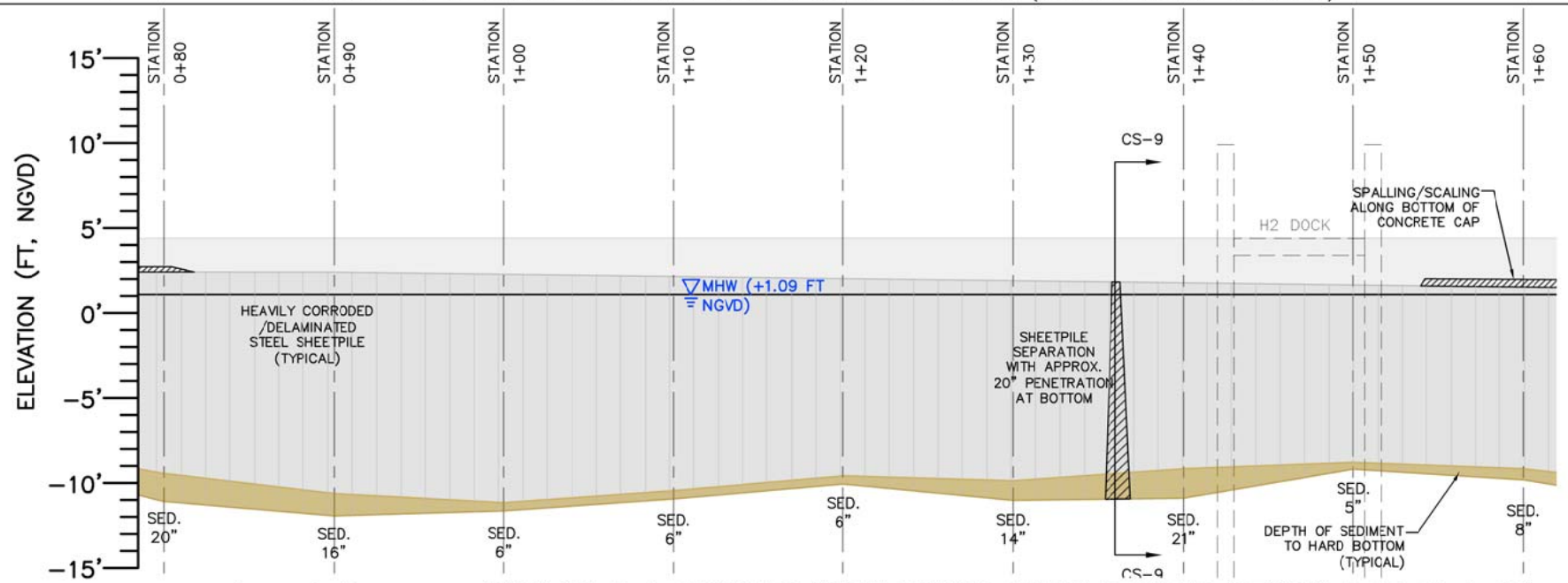

DATES OF SEAWALL INSPECTION: 11/28 – 11/29/17.

BASELINE C–C: SOUTH TO NORTH TOWARD CONCH REPUBLIC (STATION 0+80 TO 1+60)

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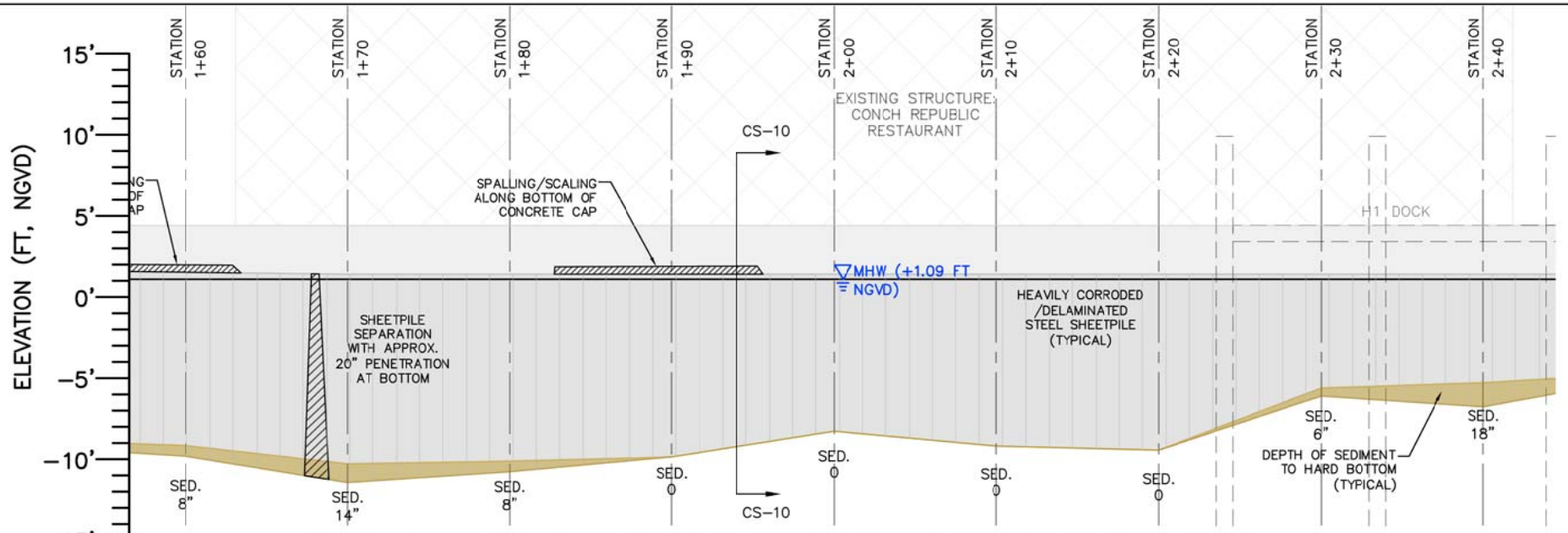
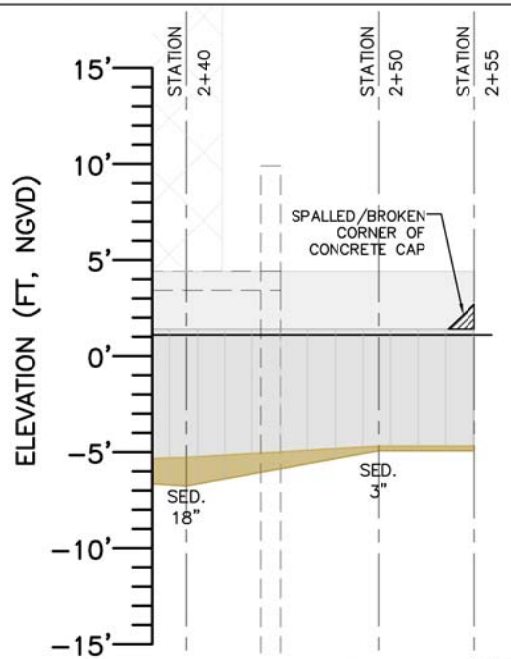
Sheet 8 of 16



BASELINE C-C: SOUTH TO NORTH AT CONCH REPUBLIC (STATION 1+60 TO 2+40)



DATES OF SEAWALL INSPECTION: 11/28 - 11/29/17.

BASELINE C-C: SOUTH TO NORTH AT CONCH REPUBLIC (STATION 2+40 TO 2+55)

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CITY OF KEY WEST
SCHOONER WHARF TO CONCH REPUBLIC
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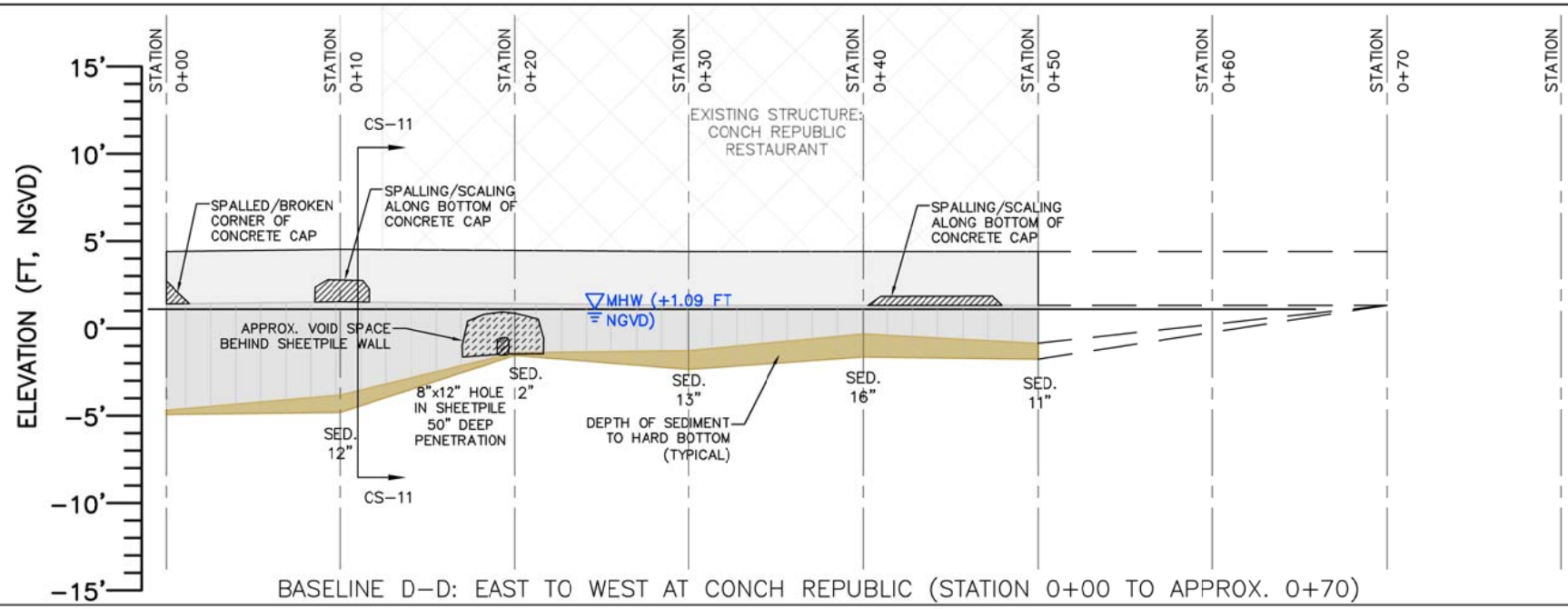
Sheet 9 of 16



BASELINE D-D: EAST TO WEST AT CONCH REPUBLIC (STATION 0+00 TO APPROX. 0+70)

DATES OF SEAWALL INSPECTION: 11/28 – 11/29/17.

CITY OF KEY WEST
SCHOONER WHARF TO CONCH REPUBLIC
SEAWALL INSPECTION

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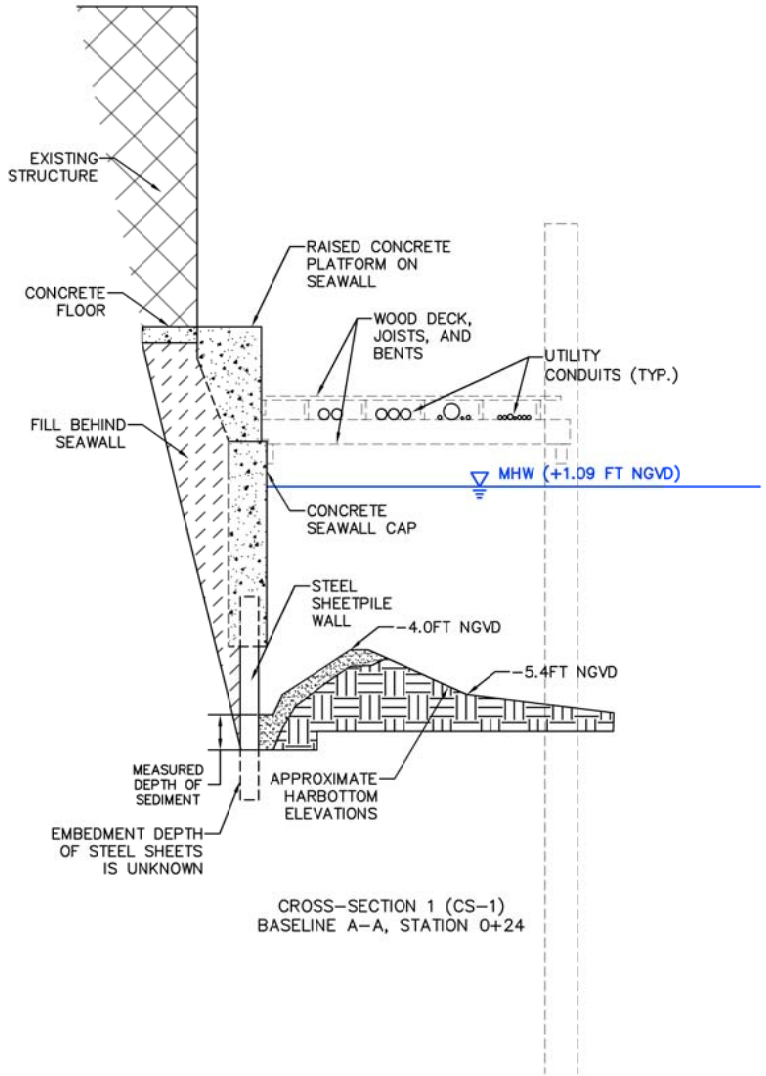
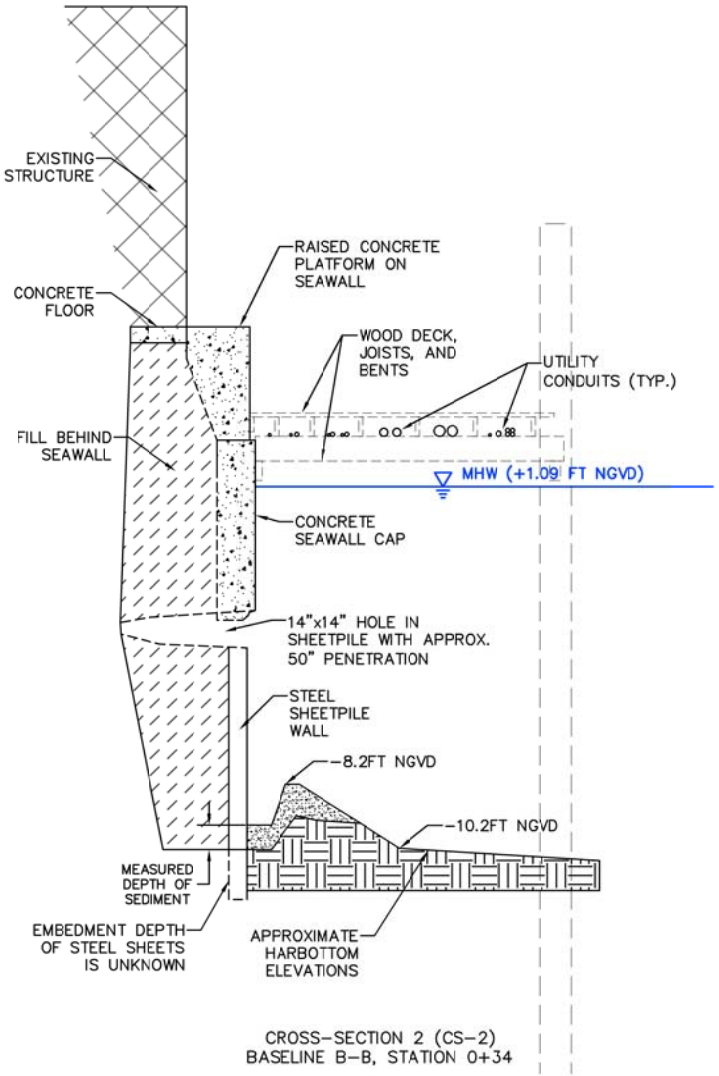
Sheet 10 of 16



CROSS-SECTION 1 (CS-1)
BASELINE A-A, STATION 0+24



CROSS-SECTION 2 (CS-2)
BASELINE B-B, STATION 0+34

0 6 12 Feet

DATES OF SEAWALL INSPECTION: 11/28 - 11/29/17.

CITY OF KEY WEST
SCHOONER WHARF TO CONCH REPUBLIC
SEAWALL INSPECTION

SEAWALL CROSS-SECTIONS

KEY WEST, MONROE COUNTY, FLORIDA

TETRA TECH INC.
759 SOUTH FEDERAL HWY
SUITE 314
STUART, FL 34994-2936
TEL: (772) 781-3400
FAX: (772) 781-3411
CERTIFICATE OF AUTHORIZATION NO. 2429

Designed by:	--
Drawn By:	F. MARTINEZ
Reviewed By:	D. FRODSHAM
Date:	2/5/18
Design file no:	SC_SEAWALL INSPECTION_V4_020518.DWG
Scale:	AS SHOWN

Sheet Reference:
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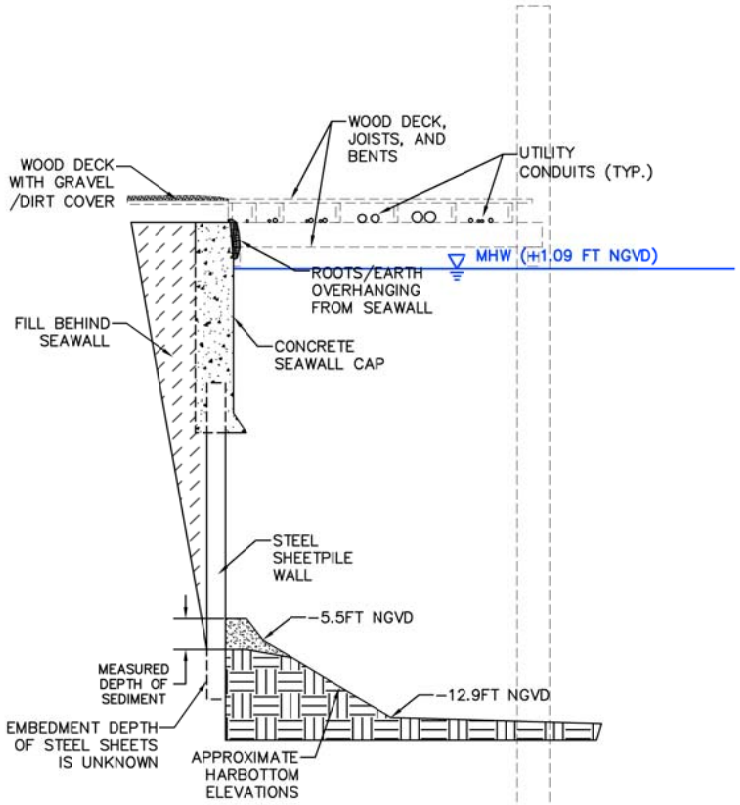
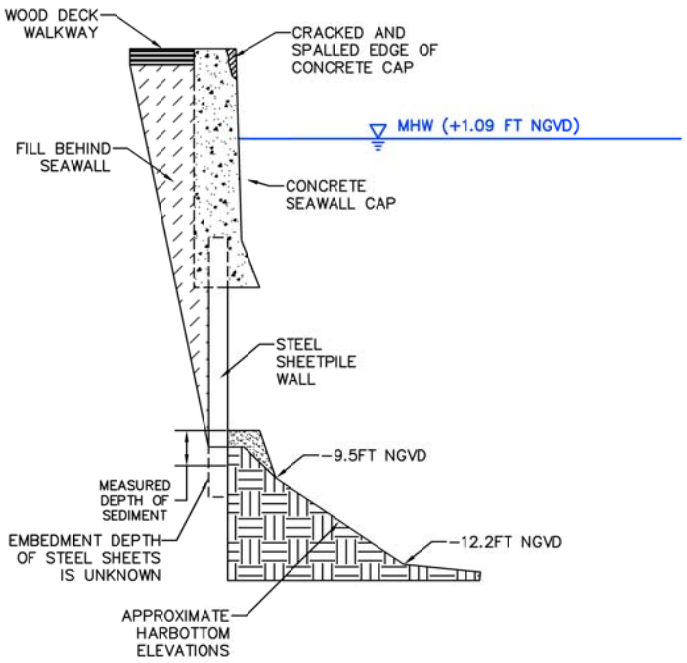


CROSS-SECTION 3 (CS-3)
BASELINE B-B, STATION 0+96



CROSS-SECTION 4 (CS-4)
BASELINE B-B, STATION 1+84

0 6 12 Feet

DATES OF SEAWALL INSPECTION: 11/28 - 11/29/17.

CITY OF KEY WEST
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SEAWALL CROSS-SECTIONS

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Sheet Reference:
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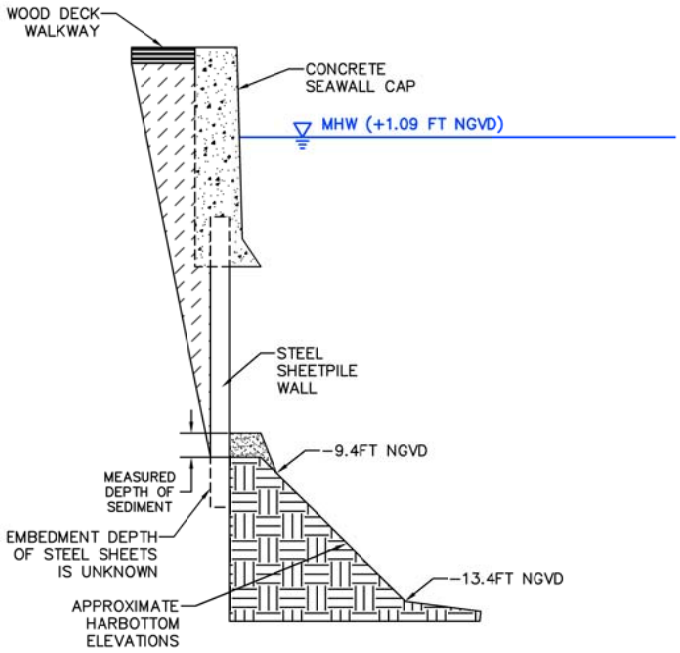
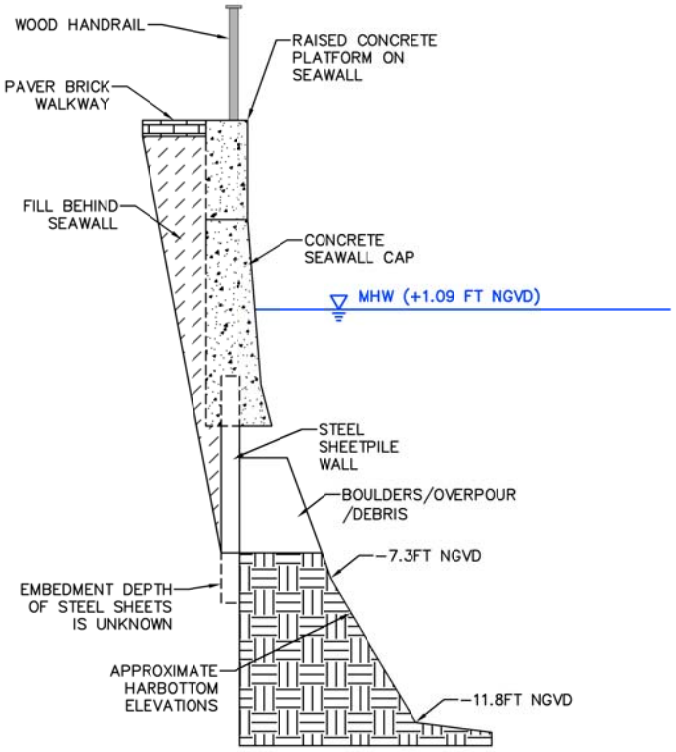


CROSS-SECTION 5 (CS-5)
BASELINE B-B, STATION 2+44



CROSS-SECTION 6 (CS-6)
BASELINE B-B, STATION 3+04

DATES OF SEAWALL INSPECTION: 11/28 - 11/29/17.

CITY OF KEY WEST
SCHOONER WHARF TO CONCH REPUBLIC SEAWALL INSPECTION

SEAWALL CROSS-SECTIONS

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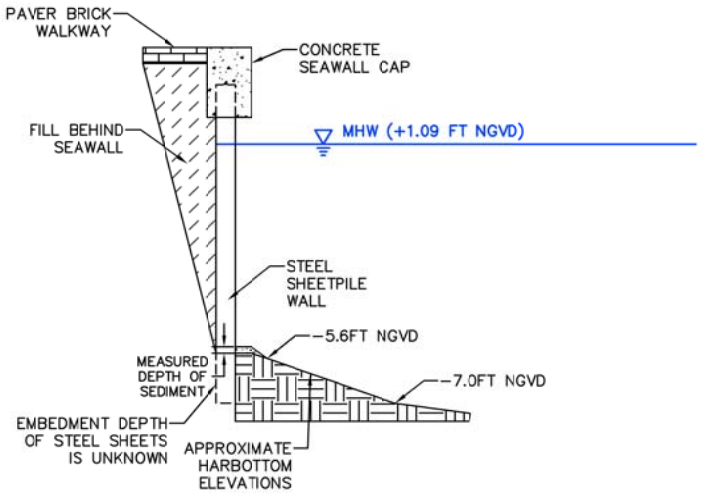
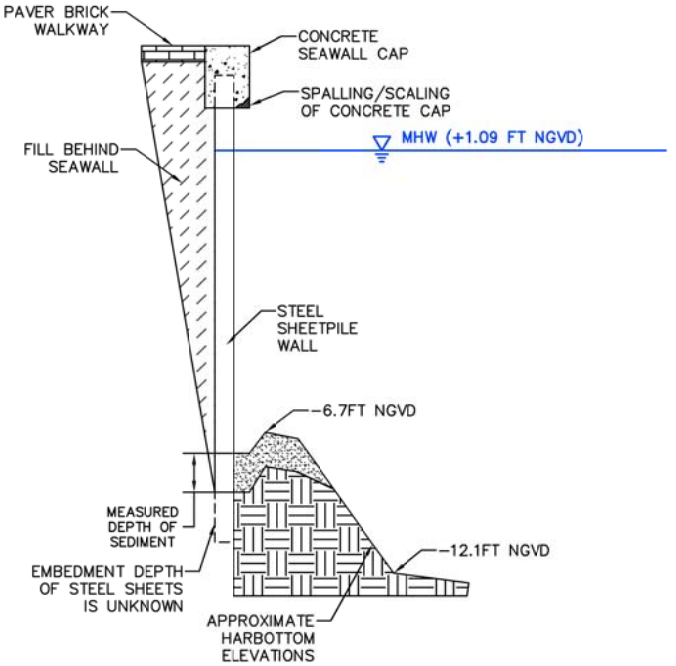


CROSS-SECTION 7 (CS-7)
BASELINE C-C, STATION 0+34



CROSS-SECTION 8 (CS-8)
BASELINE C-C, STATION 0+74

DATES OF SEAWALL INSPECTION: 11/28 - 11/29/17.

CITY OF KEY WEST
SCHOONER WHARF TO CONCH REPUBLIC
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Sheet Reference:
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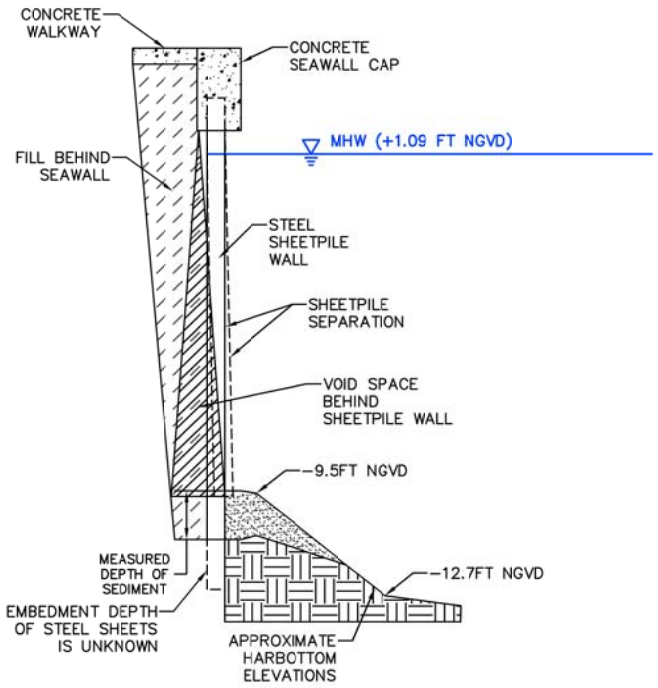
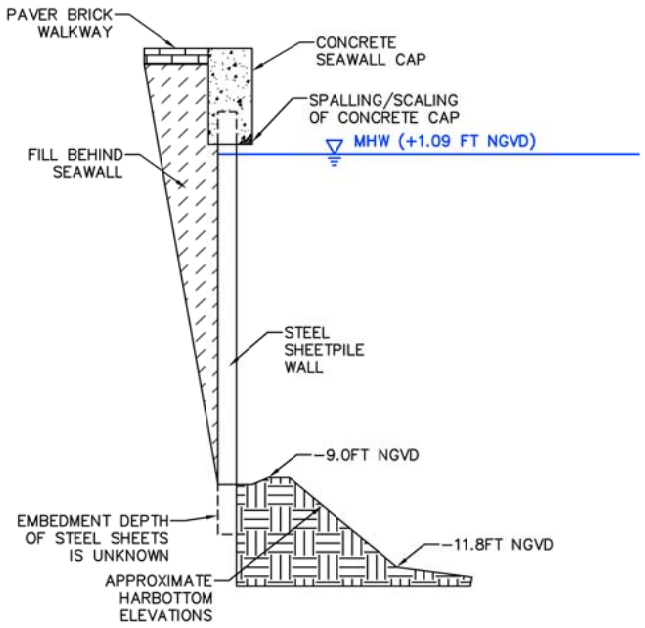


CROSS-SECTION 9 (CS-9)
BASELINE C-C, STATION 1+36



CROSS-SECTION 10 (CS-10)
BASELINE C-C, STATION 1+94

DATES OF SEAWALL INSPECTION: 11/28 - 11/29/17.

CITY OF KEY WEST
SCHOONER WHARF TO CONCH REPUBLIC
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Sheet Reference:
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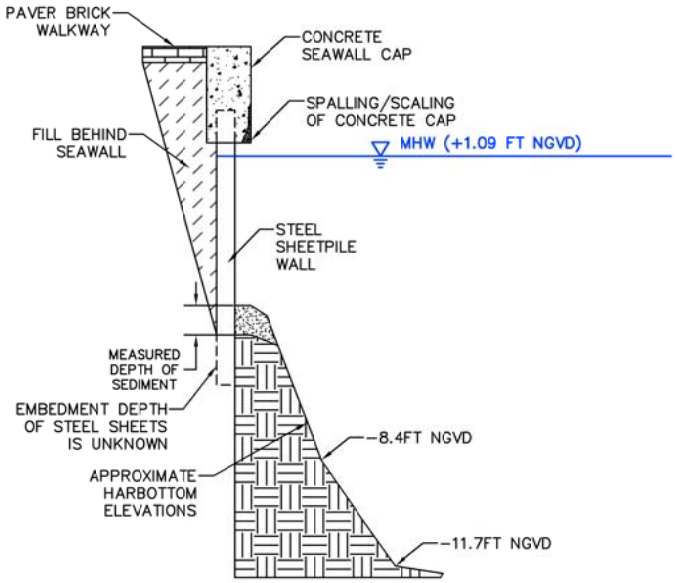

CROSS-SECTION 11 (CS-11)
BASELINE D-D, STATION 0+11

0 6 12 Feet

DATES OF SEAWALL INSPECTION: 11/28 - 11/29/17.

CITY OF KEY WEST
SCHOONER WHARF TO CONCH REPUBLIC SEAWALL INSPECTION

SEAWALL CROSS-SECTIONS

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Design file no:	SC_SEAWALL INSPECTION_V4_020518.DWG
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Sheet Reference:
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Sheet 16 of 16

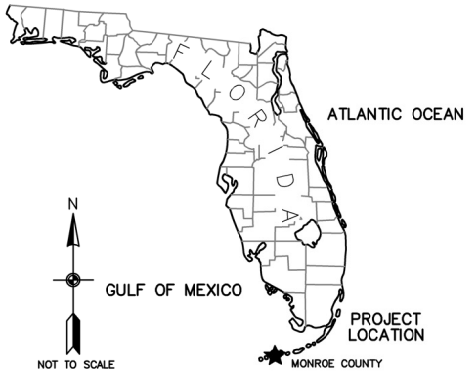
APPENDIX 2

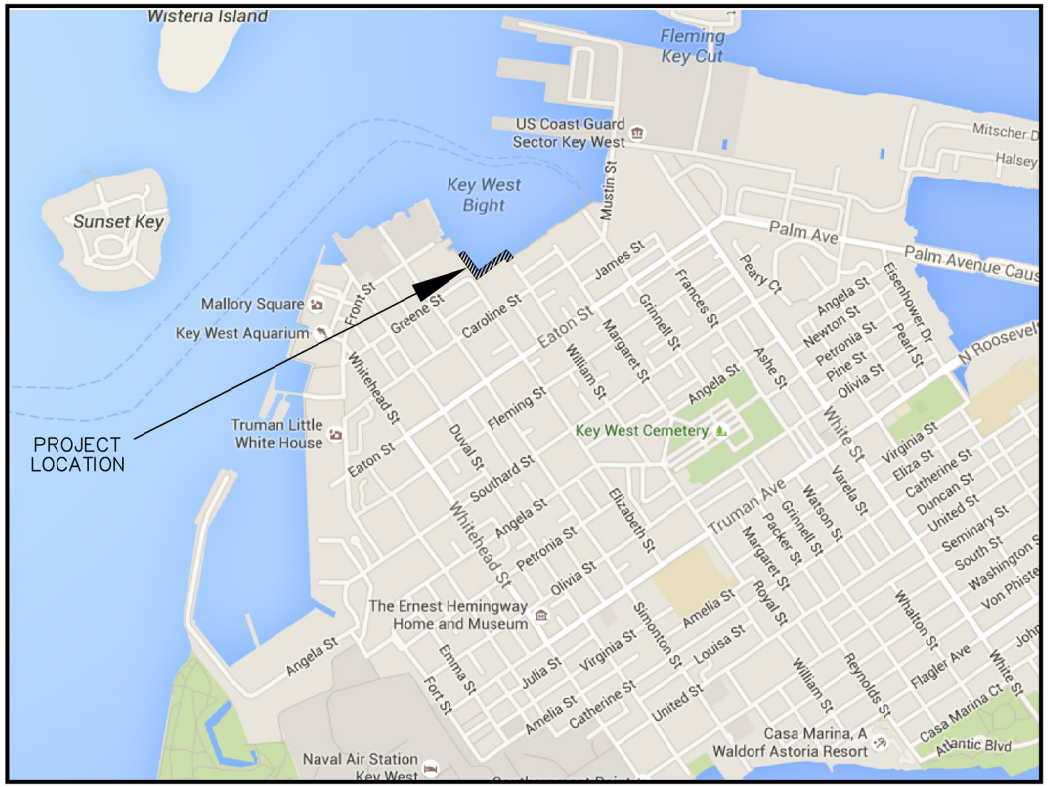
Permitting Drawings of Seawall Replacement

CITY OF KEY WEST

SCHOONER WHARF TO CONCH REPUBLIC SEAWALL REPAIR

SEAWALL REPAIR PERMITTING





VICINITY MAP

KEY WEST BIGHT, KEY WEST, FLORIDA

INDEX OF SHEETS

SHEET #	TITLE	LATEST UPDATE	REV.
G-001	COVER SHEET AND VICINITY MAP	1/25/2018	0
G-002	KEY WEST BIGHT LOCATION AND ACCESS	1/25/2018	0
G-003	VICINITY MAP AND DIRECTIONS TO SITE	1/25/2018	0
G-004	USDA/NRCS SOIL MAP	1/25/2018	0
C-101	SEAWALL PLAN VIEW	1/25/2018	0
C-102	SEAWALL PLAN VIEW	1/25/2018	0
C-103	SEAWALL REPAIR DESIGN PLAN VIEW	1/25/2018	0
C-104	SEAWALL REPAIR DESIGN PLAN VIEW	1/25/2018	0
C-105	SEAWALL REPAIR CROSS-SECTIONS	1/25/2018	0
C-106	SEAWALL REPAIR CROSS-SECTIONS	1/25/2018	0
C-107	SEAWALL REPAIR CROSS-SECTIONS	1/25/2018	0
C-108	DETAILS	1/25/2018	0

FOR PERMITTING NOT FOR CONSTRUCTION

CITY OF KEY WEST
SCHOONER WHARF TO CONCH REPUBLIC
SEAWALL REPAIR

COVER SHEET AND VICINITY MAP

KEY WEST, MONROE COUNTY, FLORIDA

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Sheet Reference:
G-001
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SEAL OF THE CITY OF KEY WEST, FLORIDA

CITY OF KEY WEST
SCHOONER WHARF TO CONCH REPUBLIC
SEAWALL REPAIR

KEY WEST BIGHT LOCATION AND ACCESS

KEY WEST, MONROE COUNTY, FLORIDA

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NO. 2429

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Reviewed By:	D. FRODSHAM
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Sheet Reference:
G-002
Sheet 2 of 12

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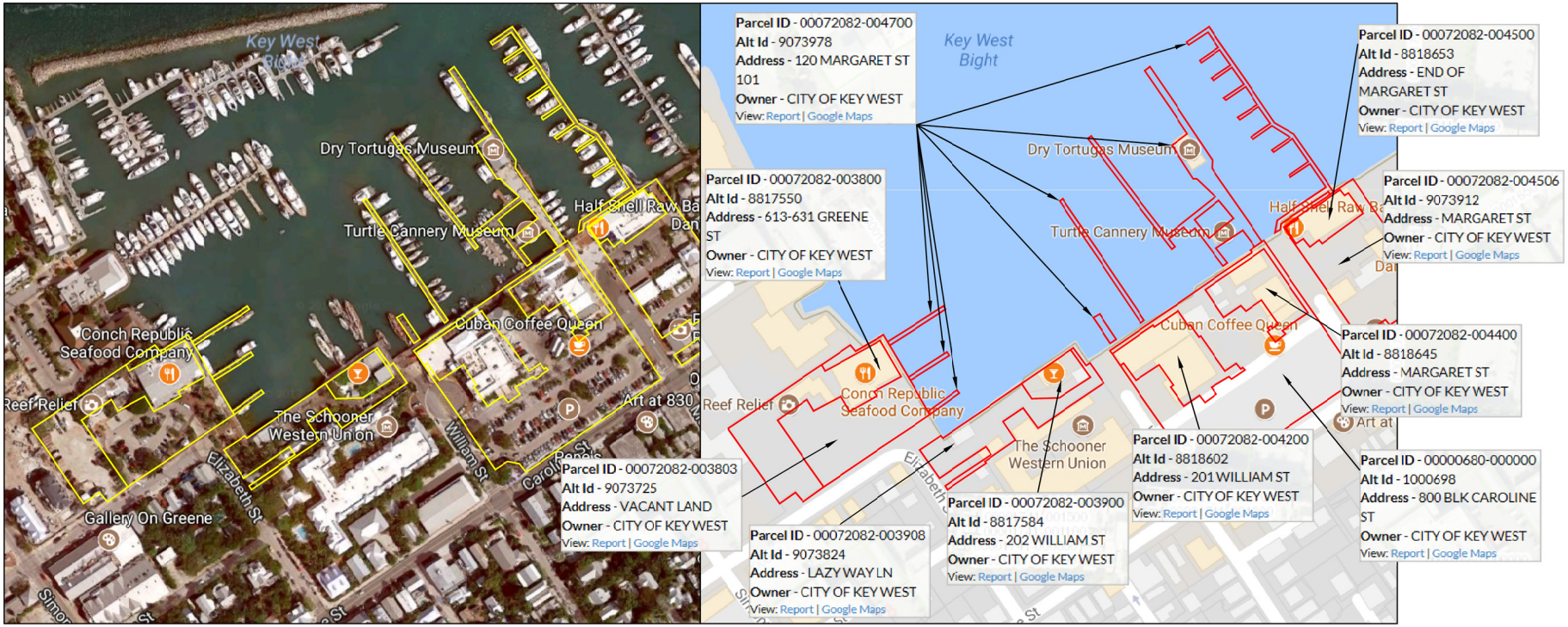

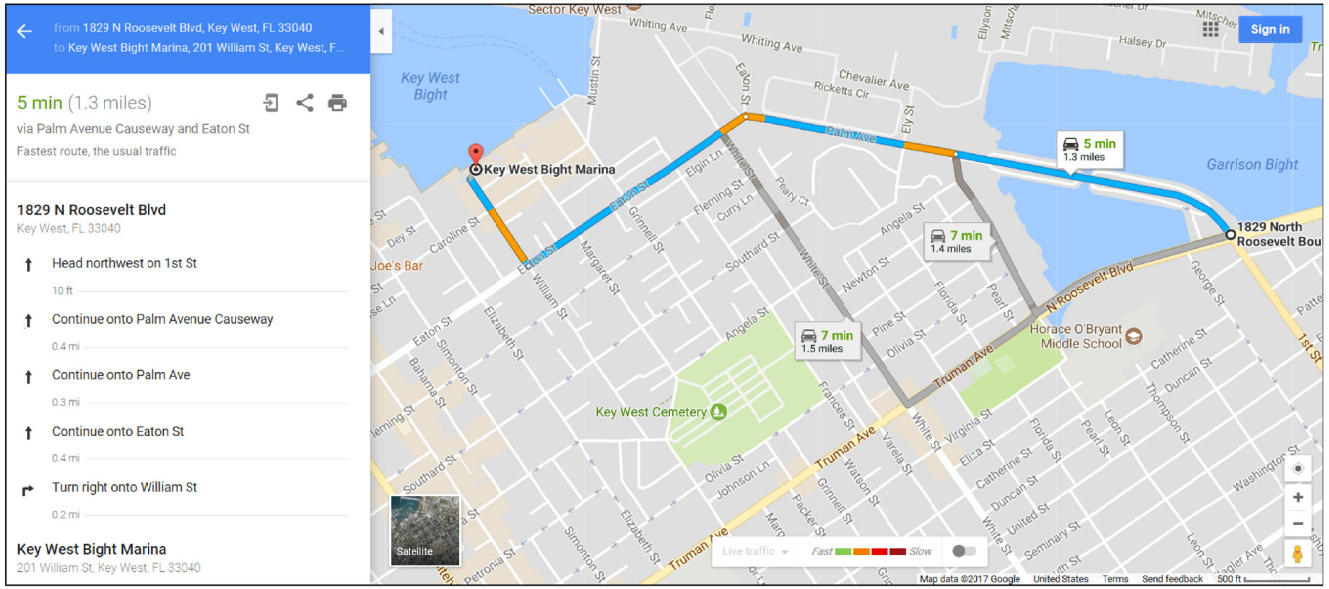

FOR PERMITTING NOT FOR CONSTRUCTION

CITY OF KEY WEST
SCHOONER WHARF TO CONCH REPUBLIC SEAWALL REPAIR

VICINITY MAP AND DIRECTIONS TO SITE

KEY WEST, MONROE COUNTY, FLORIDA

TETRA TECH, INC.
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Sheet Reference:
G-003
Sheet 3 of 12

P:\CITY OF KEY WEST\TASK 12. CONCH REPUBLIC TO SCHOONER WHARF\PERMITTING\KW_SC_PERMIT_COVER_V1.DWG

PROJECT LOCATION – RELEVANT SOIL CLASSIFICATIONS: #11 & #100

Monroe County, Keys Area, Florida (FL687)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
5	Islamorada muck, tidal	9.5	0.2%
7	Udorthents-Urban land complex	272.0	6.3%
11	Urban land	1,529.2	35.2%
13	Keyvaca very gravelly loam, extremely stony	21.5	0.5%
18	Beaches	10.5	0.2%
99	Water	18.2	0.4%
100	Waters of the Atlantic Ocean	2,181.5	50.2%
Subtotals for Soil Survey Area		**4,042.3**	**93.0%**
Totals for Area of Interest		**4,345.4**	**100.0%**

11—Urban land

Map Unit Setting
National map unit symbol: vnh
Elevation: 0 to 10 feet
Mean annual precipitation: 30 to 51 inches
Mean annual air temperature: 72 to 82 degrees F
Frost-free period: 358 to 365 days
Farmland classification: Not prime farmland

Map Unit Composition
Urban land: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit

Description of Urban Land

Setting
Landform: Islands
Landform position (three-dimensional): Interfluve, talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: No parent material

Properties and qualities
Slope: 0 to 1 percent
Frequency of flooding: Rare

Interpretive groups
Land capability classification (irrigated): None specified
Other vegetative classification: Forage suitability group not assigned (G156AC999FL)

Minor Components

Udorthents
Percent of map unit: 3 percent
Landform: Islands
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Linear
Other vegetative classification: Forage suitability group not assigned (G156AC999FL)

Beaches, tidal
Percent of map unit: 2 percent
Landform: Beaches on islands
Landform position (three-dimensional): Rise

Down-slope shape: Convex
Across-slope shape: Linear
Other vegetative classification: Forage suitability group not assigned (G156AC999FL)

100—Waters of the Atlantic Ocean

Map Unit Composition
Waters of the atlantic ocean: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Waters Of The Atlantic Ocean

Interpretive groups
Land capability classification (irrigated): None specified
Other vegetative classification: Forage suitability group not assigned (G156AC999FL)

FOR PERMITTING NOT FOR CONSTRUCTION

CITY OF KEY WEST
SCHOONER WHARF TO CONCH REPUBLIC
SEAWALL REPAIR

USDA/NRCS SOIL MAP

KEY WEST, MONROE COUNTY, FLORIDA

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Sheet Reference:
G-004
Sheet 4 of 12

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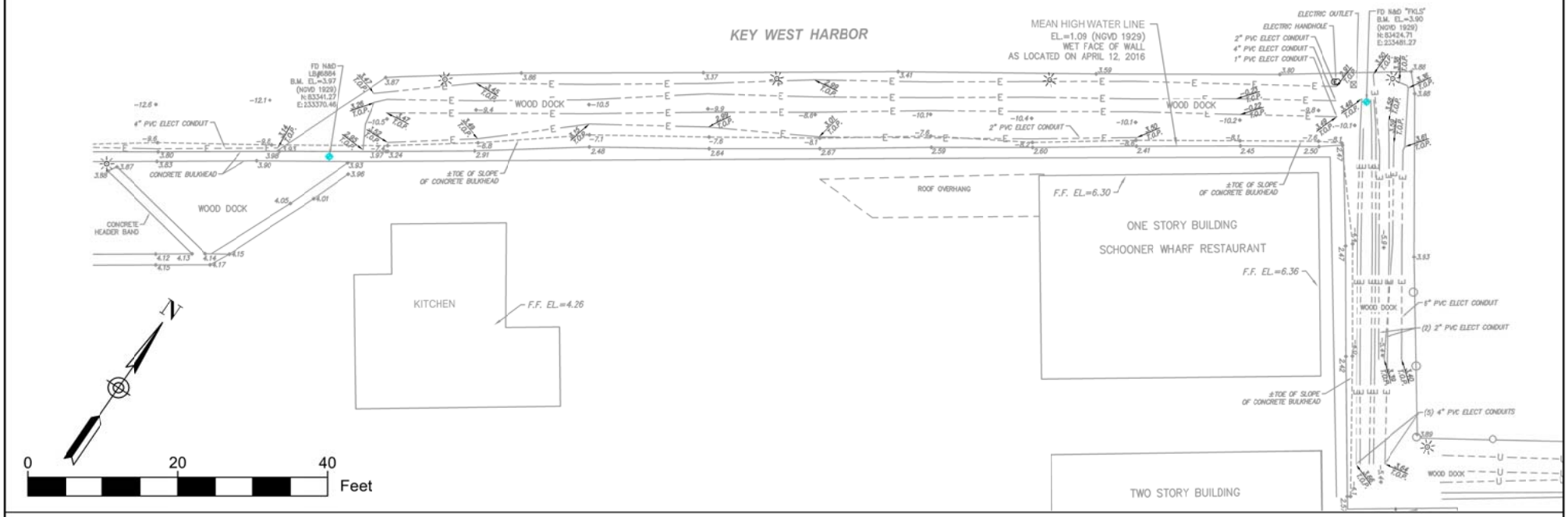

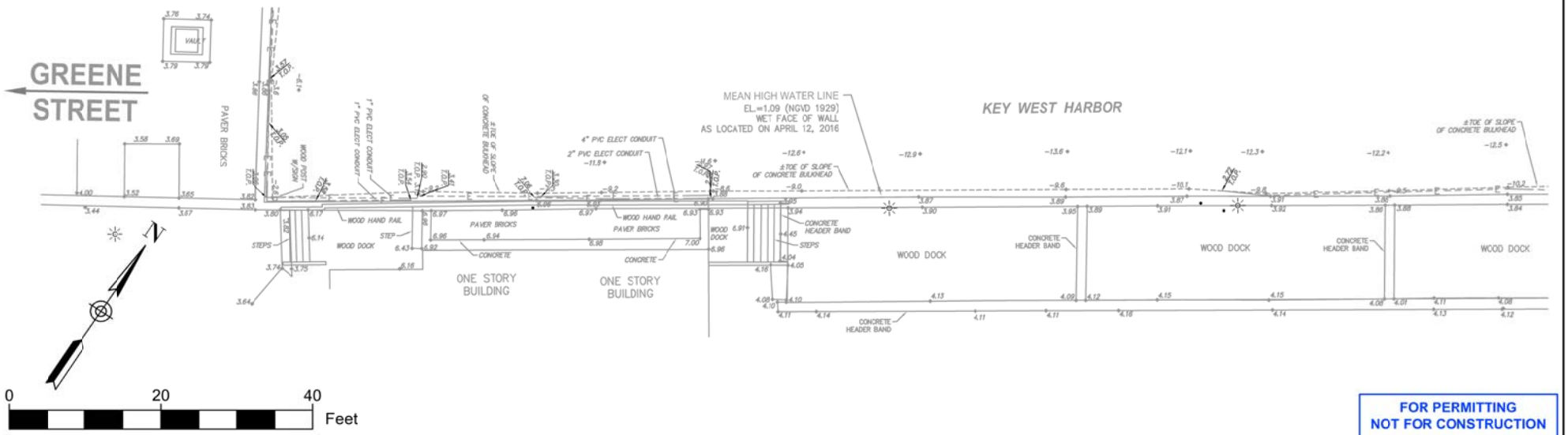

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CITY OF KEY WEST
SCHOONER WHARF TO CONCH REPUBLIC
SEAWALL REPAIR

SEAWALL PLAN VIEW

KEY WEST, MONROE COUNTY, FLORIDA

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Sheet Reference:
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Sheet 5 of 12

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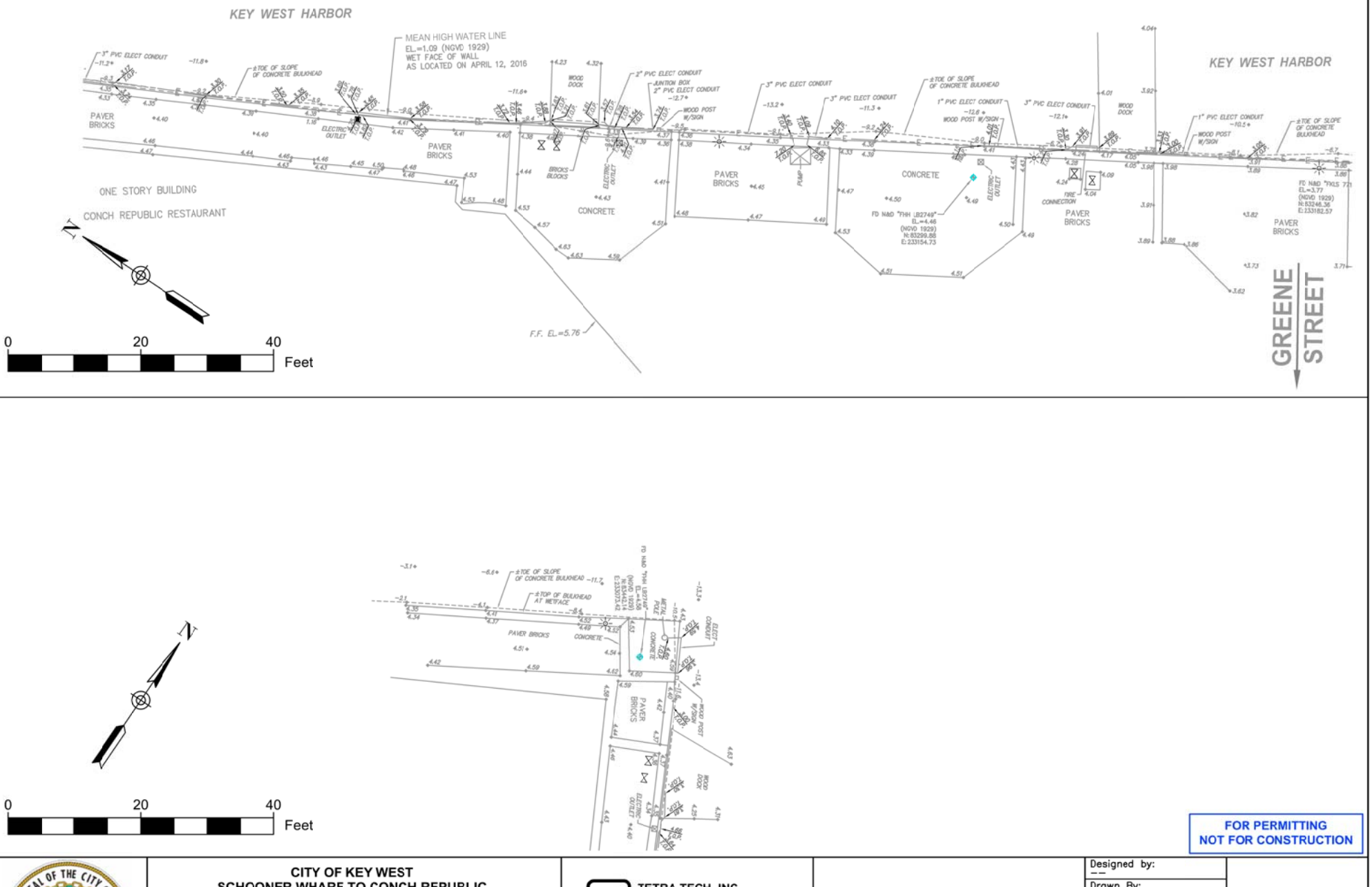

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CITY OF KEY WEST
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SEAWALL REPAIR

SEAWALL PLAN VIEW

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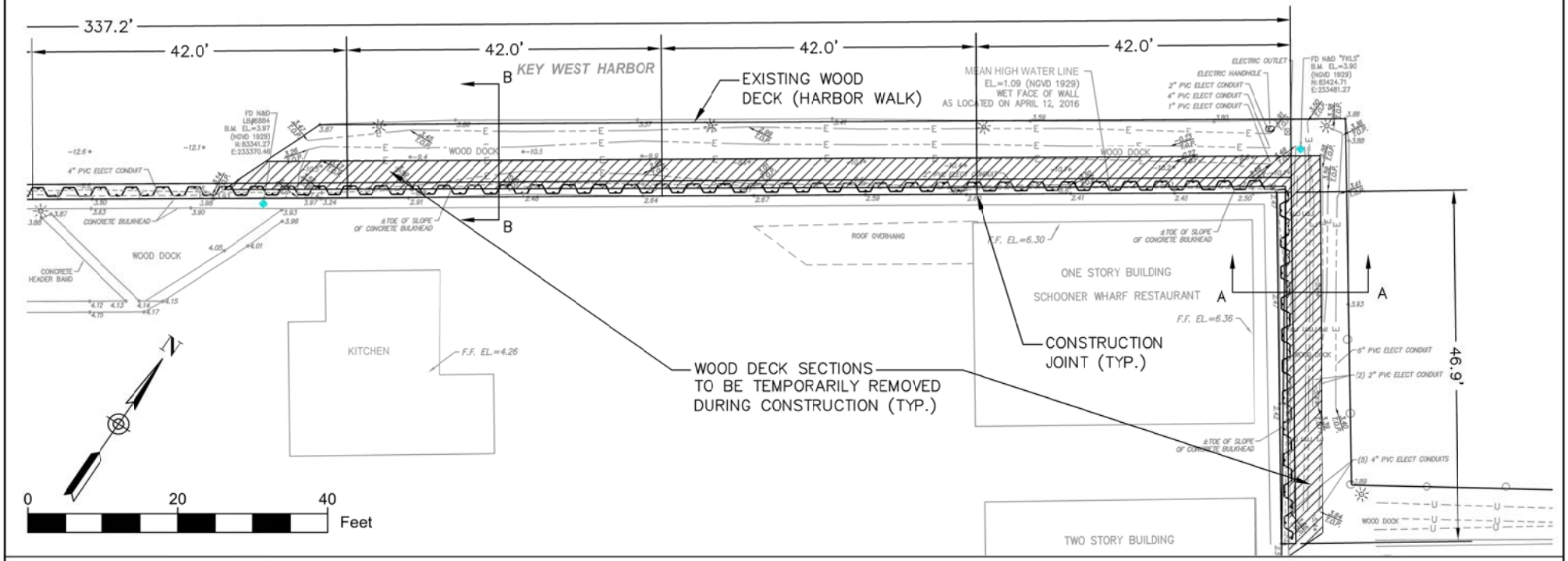

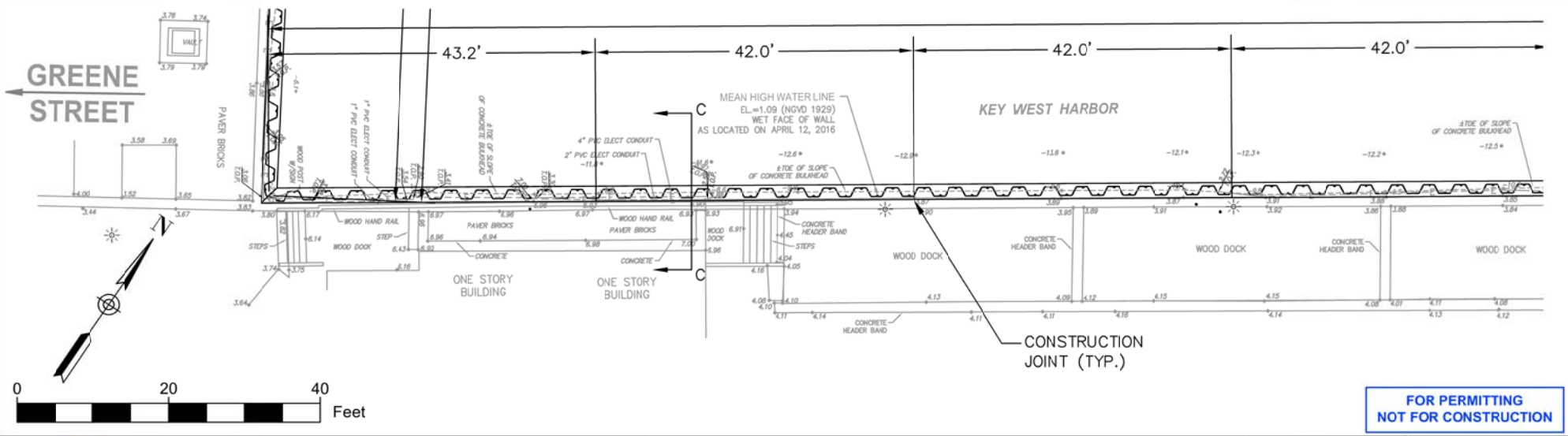

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SEAL OF THE CITY OF KEY WEST, FLORIDA

CITY OF KEY WEST
SCHOONER WHARF TO CONCH REPUBLIC
SEAWALL REPAIR

SEAWALL REPAIR DESIGN PLAN VIEW

KEY WEST, MONROE COUNTY, FLORIDA

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C-103
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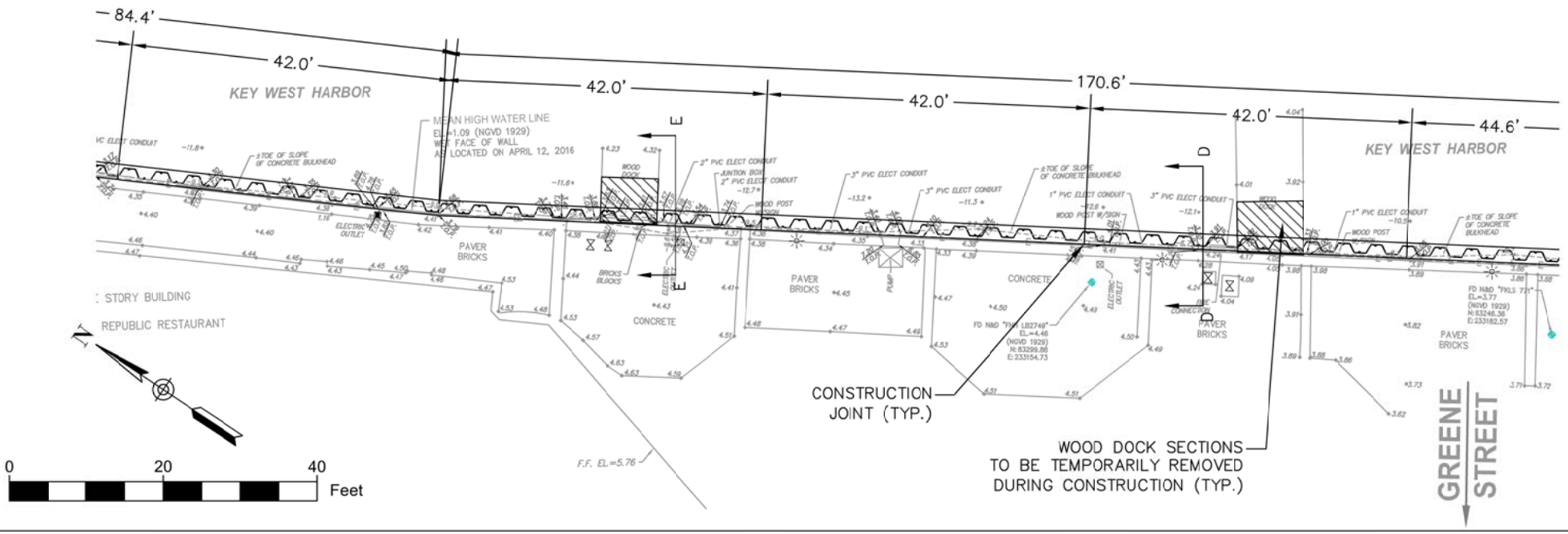

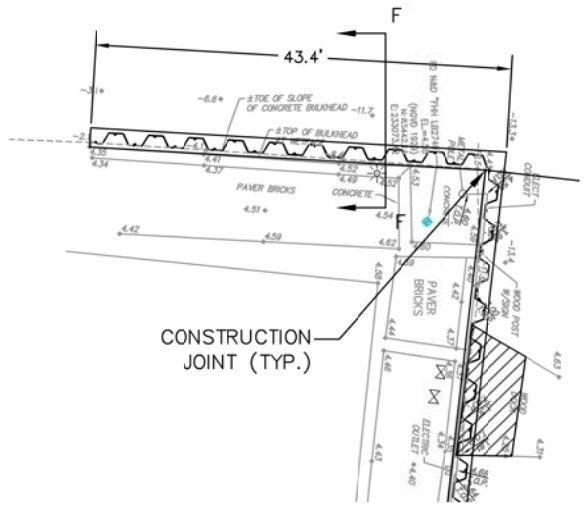

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CITY OF KEY WEST
SCHOONER WHARF TO CONCH REPUBLIC
SEAWALL REPAIR

SEAWALL REPAIR DESIGN PLAN VIEW

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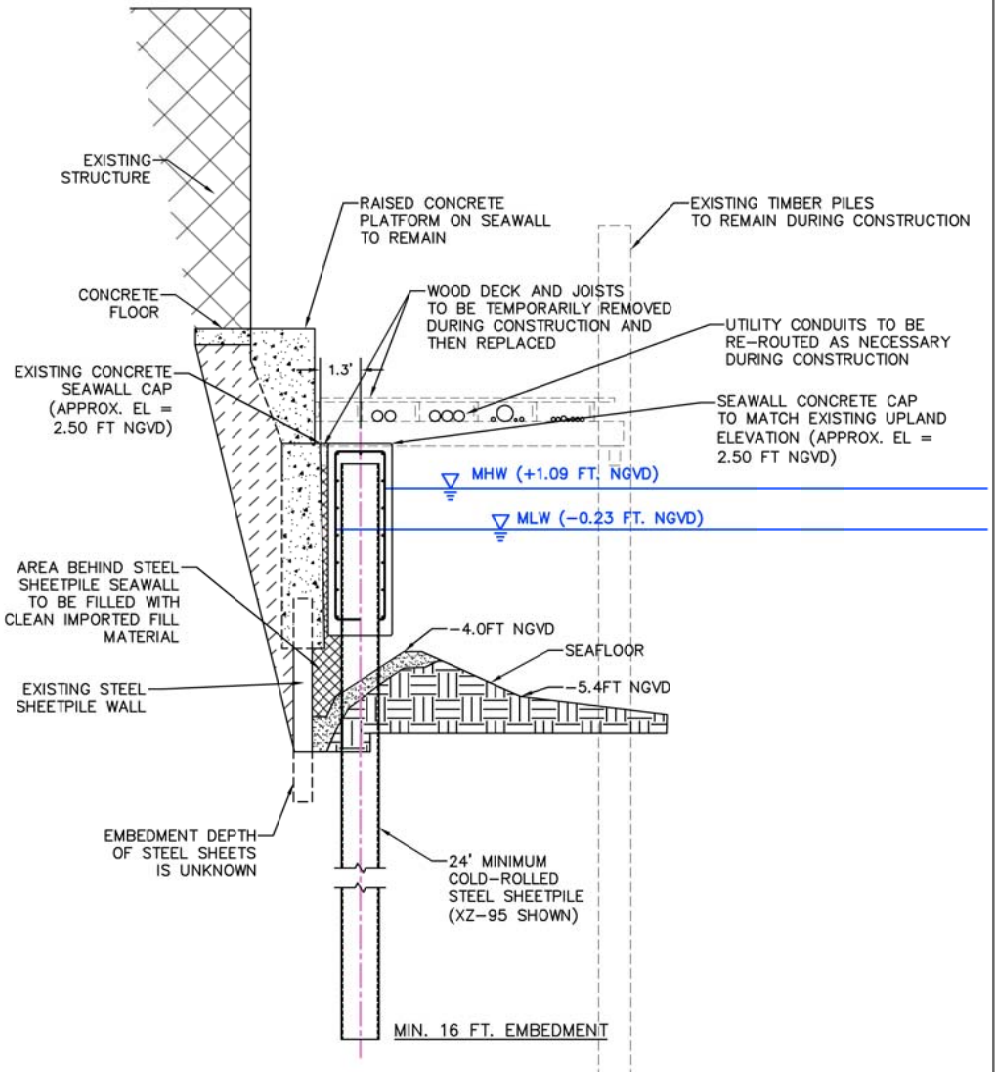
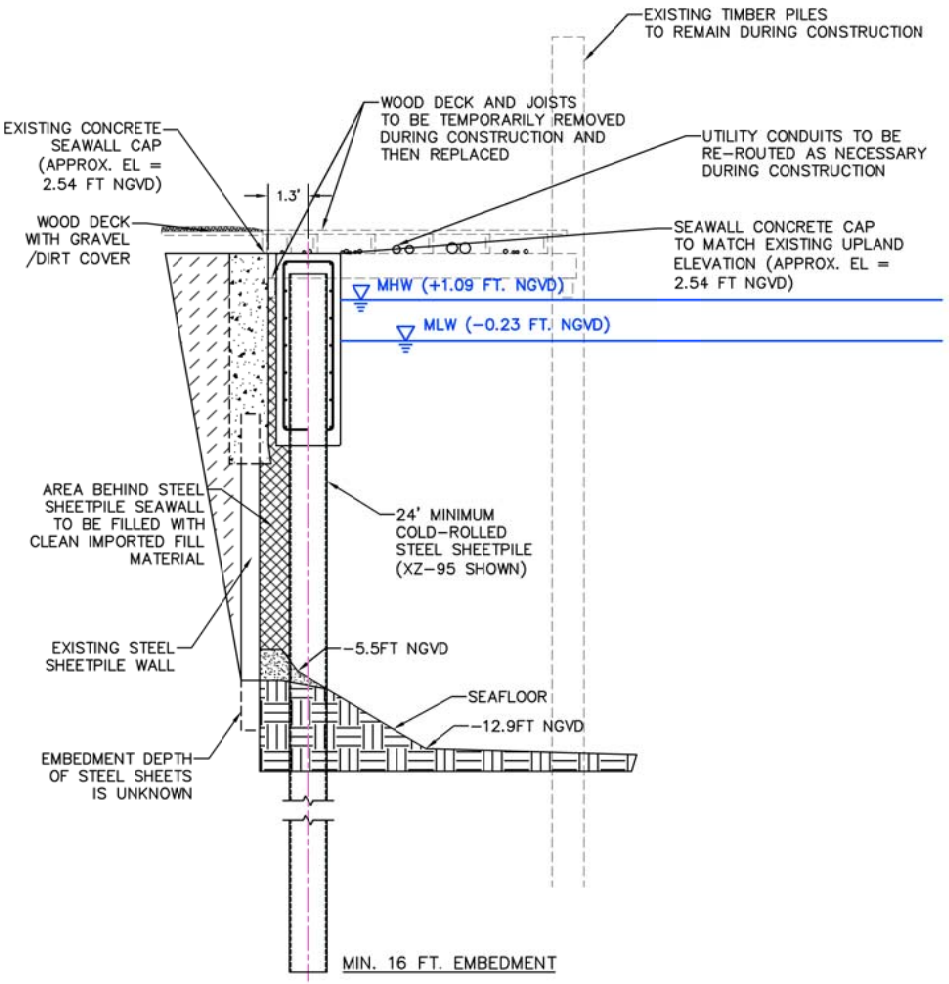


CROSS-SECTION A-A



CROSS-SECTION B-B

0 6 12 Feet

FOR PERMITTING NOT FOR CONSTRUCTION

CITY OF KEY WEST
SCHOONER WHARF TO CONCH REPUBLIC
SEAWALL REPAIR

SEAWALL REPAIR CROSS-SECTIONS

KEY WEST, MONROE COUNTY, FLORIDA

TETRA TECH, INC.
759 SOUTH FEDERAL HWY
SUITE 314
STUART, FL 34994-2936
TEL: (772) 781-3400
FAX: (772) 781-3411
CERTIFICATE OF AUTHORIZATION NO. 2429

Designed by:	--
Drawn By:	F. MARTINEZ
Reviewed By:	D. FRODSHAM
Date:	1/25/18
Design file no:	KW_SC_PERMIT_DESIGN_V1.DWG
Scale:	AS SHOWN

Sheet Reference:
C-105
Sheet 9 of 12

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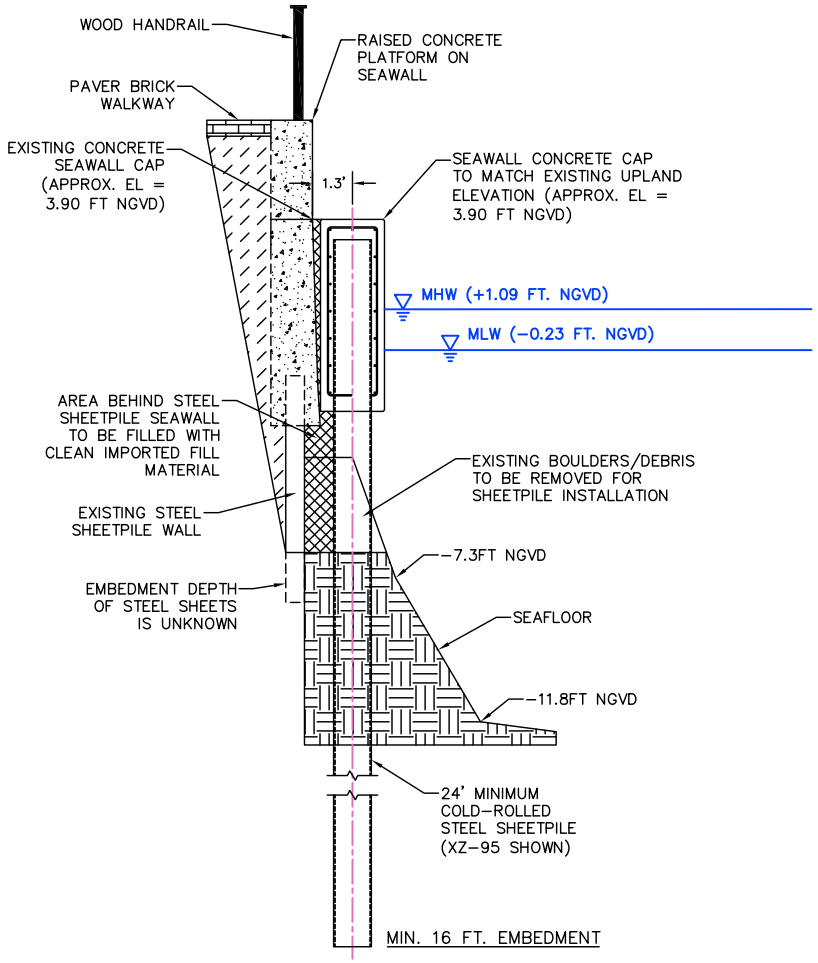

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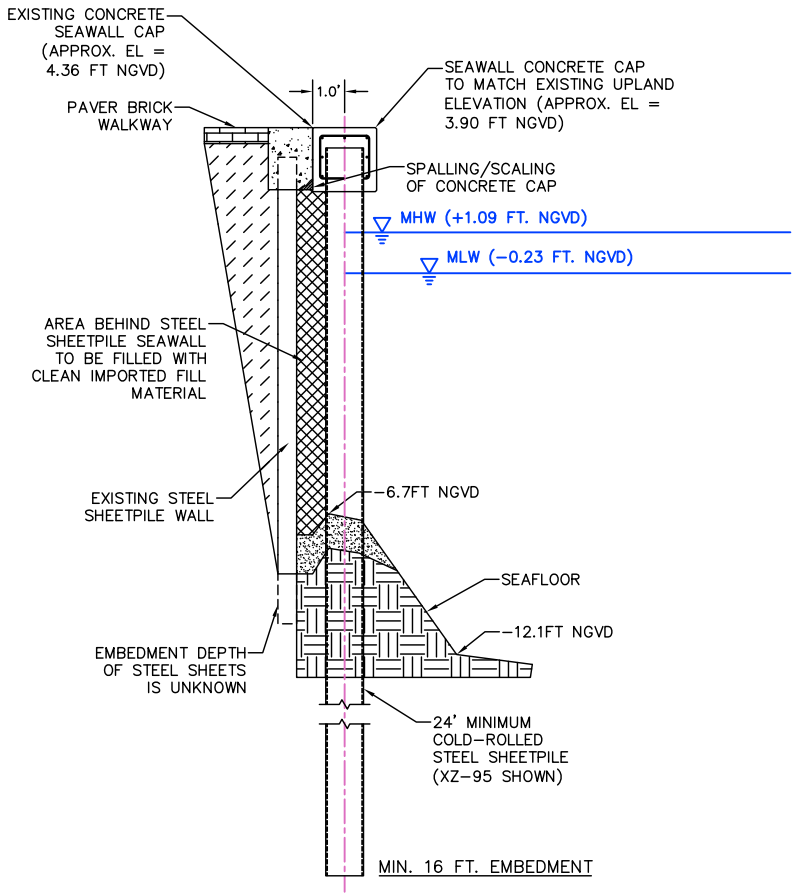

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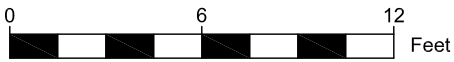

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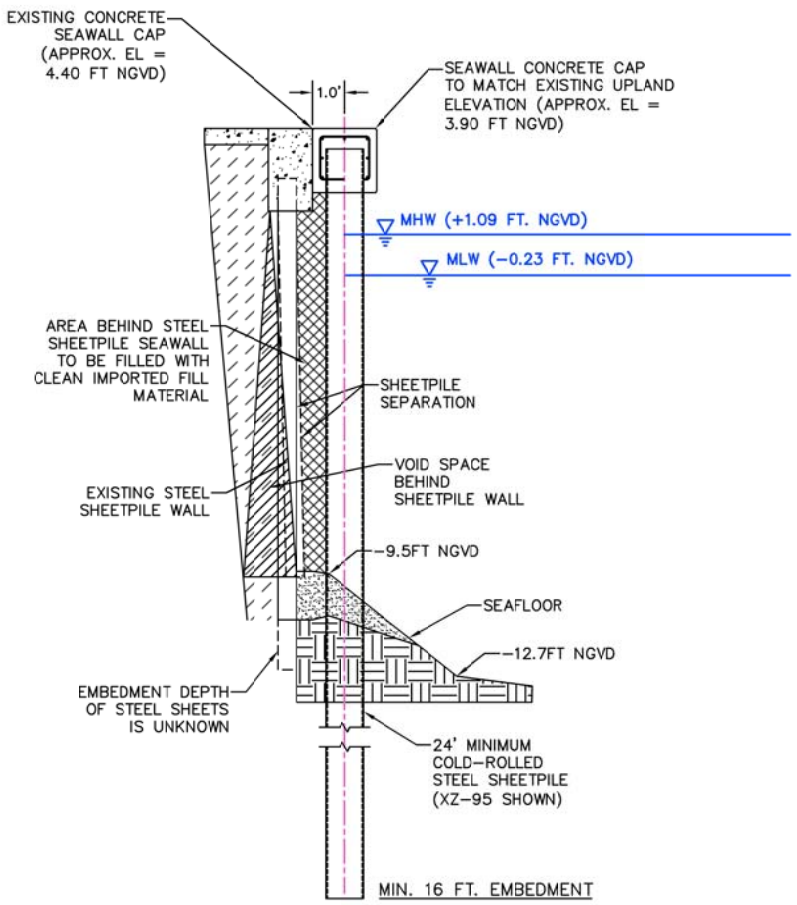

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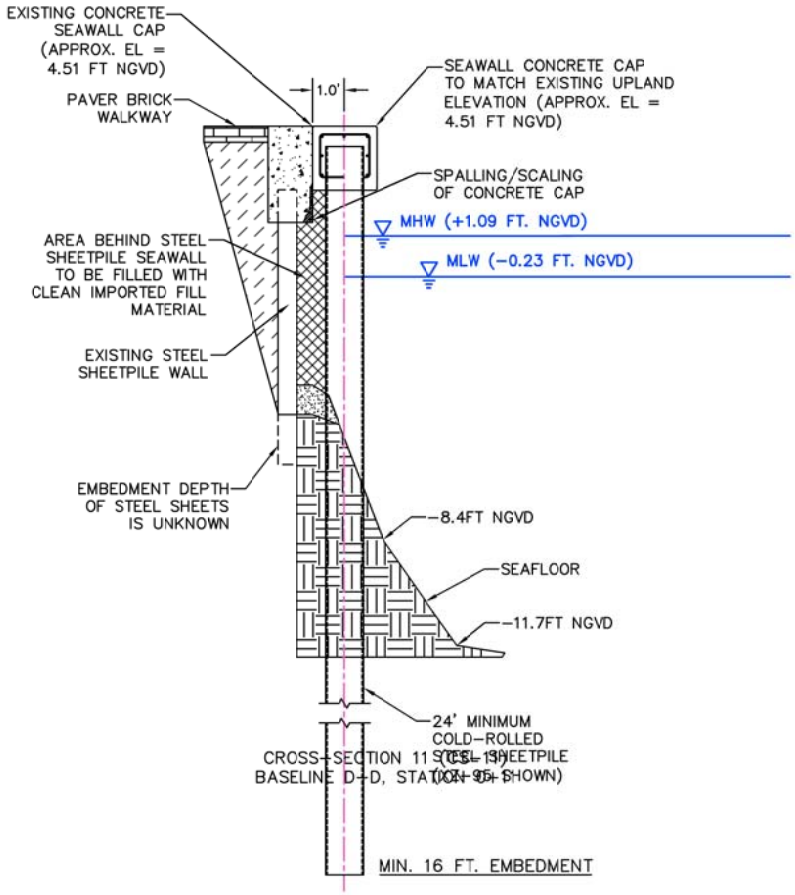

CROSS−SECTION 11 STEEL SHEETPILE BASELINE D−D, STATION 0+ 00 (XZ−95 SHOWN)

0 6 12 Feet

FOR PERMITTING
NOT FOR CONSTRUCTION

CITY OF KEY WEST
SCHOONER WHARF TO CONCH REPUBLIC
SEAWALL REPAIR

SEAWALL REPAIR CROSS-SECTIONS

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Reviewed By:	D. FRODSHAM
Date:	1/25/18
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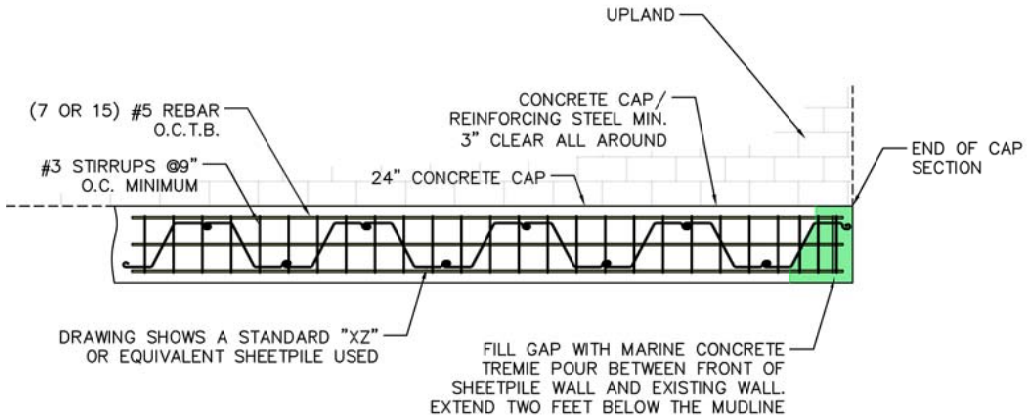


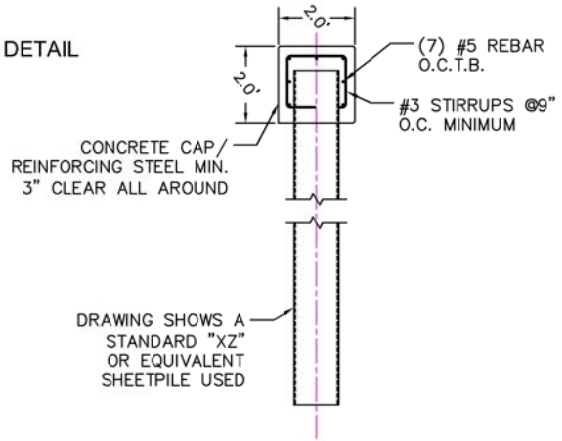
TYPICAL END REINFORCEMENT DETAIL

TYPICAL STEEL SHEETPILE SEAWALL:

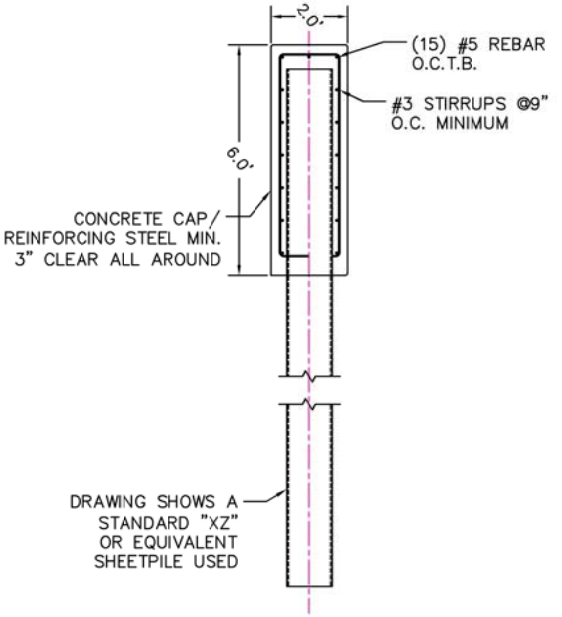
CONCRETE CAP
- CONCRETE f'c = 6,000 PSI IN 28-DAYS
- 1" CHAMFER ALL EXPOSED EDGES

XZ-95 STEEL SHEET PILE SPECIFICATIONS

- WIDTH	25.00 IN.
- HEIGHT	14.12 IN.
- THICKNESS	0.375 IN.
- SECTIONAL AREA	15.20 SQ. IN. PER LIN. FT.
- WEIGHT OF PILE	51.70 LB. PER LIN. FT.
- WEIGHT OF WALL	24.80 LB. PER SQ. FT.
- SECTION MODULUS	33.50 IN.^3 PER LIN. FT.
- MOMENT OF INERTIA	237.0 IN.^4 PER LIN. FT.
- COATING AREA BOTH SIDES	6.03 SQ. FT. PER LIN. FT.



SHORT CAP SHEETPILE LAYOUT



LONG CAP SHEETPILE LAYOUT

FOR PERMITTING
NOT FOR CONSTRUCTION

CITY OF KEY WEST
SCHOONER WHARF TO CONCH REPUBLIC
SEAWALL REPAIR

DETAILS

KEY WEST, MONROE COUNTY, FLORIDA

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Sheet Reference:
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APPENDIX 3

Coral Inventory and Benthic Resource Survey

CORAL INVENTORY AND BENTHIC RESOURCE SURVEY
CONCH REPUBLIC AND SCHOONER WHARF
KEY WEST, FLORIDA

Prepared By:

Tetra Tech, Inc.
759 South Federal Highway
Stuart, FL 34994

Prepared For:

City of Key West.
3140 Flagler Avenue
Key West, FL 33040

TETRA TECH

December 2017

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1.0 Introduction

On behalf of the city of Key West, Tetra Tech, Inc. (Tt) performed a coral inventory and benthic resource survey of the bulkhead extending from Conch Republic to Schooner Wharf to satisfy permitting requirements associated with the repair and fortification of the bulkhead. Qualified staff were onsite to coordinate survey logistics and catalogue benthic resources within the designated survey area. Survey activities were performed from November 27-December 1, 2017. Presented in this report are the findings of the survey.

The purpose of the survey is to determine the quantity of stony corals, spatial extent, size class, relocation candidates, and total coral tissue area within the project area. Additionally, the survey will identify any other biological resources within the project area. This survey will supply the regulatory agencies with the most up-to-date resource data for the project site. Further, data collected from this survey may be used during the planning phase of the project to minimize and avoid impacts to stony corals and/or other resources within the project area.

2.0 Site Description

The project area is located along the northwestern shore of Key West and lies within Key West Bight, adjacent to the Key West Marina and the Key West Ferry terminal (see Figure 1). Global Positioning System (GPS) coordinates for the site are as follows: Latitude 24º 33.655' North, Longitude 81º 48.136' West. The waters adjacent to the project area are classified by the Florida Department of Environmental Protection (FDEP) as a Class III (Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife) water body.

The survey area is an approximately 676-foot (ft.) bulkhead with an existing discontinuous dock and boardwalk structures along its length (see Figure 2). The bulkhead is a part of hardened shoreline within the marina basin that supports a variety of amenities. Water depths range from 3 to 10 feet of seawater (fsw). Sediment composition along the base of the bulkhead is predominantly biogenic mud/fine sand mixed with debris (concrete, rubble, pipes, etc.). Underwater visibility was approximately 2-5 feet; water temperature was 76° Fahrenheit, with no noticeable current detected during the survey.

3.0 Methods

Field activities were performed using a 19-ft. catamaran in order to safely access the survey area. Two (2) Tt certified scientific divers trained in marine biological resource identification cataloged stony corals and noted other marine benthic flora and fauna along the face of the approximately 676-ft. length of bulkhead and a 5 to 10-ft. buffer along the seafloor apron. Data were collected along a demarcated tape positioned along the base of the bulkhead in a general east (0 ft.) to west (676 ft.) direction along the base of the bulkhead. The tape was split into four segments: Segment 1=38 ft., Segment 2=343 ft., Segment 3=255 ft., Segment 4=40 ft. Figure 2 presents the survey area and demarcated tape location graphically.

The tape was used by divers to record the location of benthic resources along the bulkhead and buffer area. Underwater photography was used to record representative images of resources and

conditions present within the survey area. Divers followed the National Oceanic and Atmospheric Administration (NOAA) Protocol for Benthic Surveys of Coral Resources in Florida Keys National Marine Sanctuary (FKNMS) for seawalls and shoreline structures (rip rap, bulkheads, boat ramps, bridges) dated April 29, 2011.

Figure 1. Project vicinity map

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Figure 2. Survey area and demarcated tape location

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4.0 Results

No species listed as threatened or endangered, soft corals (gorgonians), or species of concern were documented during the survey. Silt-covered filamentous diatoms constitute the dominant cover on the bulkhead; discontinuous seagrass (*Halophila decipiens*) is the dominant species within the 5-10 ft. buffer zone water ward of the bulkhead. Other functional groups documented during the survey include sponges, bryozoans, tunicates, tube worms, fin fish, elasmobranchs, and motile invertebrates. The bottom of the marina basin is comprised of barren mud and detritus with minimal seagrass cover. Flora and fauna observed during the survey are presented in Table 1.

Table 1. List of marine species observed at the project site

Functional Group	Common Name	Scientific Name
Scleractinia	Lesser starlet coral	*Siderastrea radians*
Sponges	Yellow calcareous sponge	*Clathrina canariensis*
		Haliclona sp.
	Orange lumpy encrusting sponge	*Scopalina rutzleri*
Bryozoans	Fan bryozoan	*Reteporellina evelinae*
Tunicates	Black solitary tunicate	*Phallusia nigra*
	Colonial tunicate	*Botryllus* sp.
	Mangrove tunicate	*Ecteinascidia turbinata*
Segmented Worms	Social feather duster	*Bispira brunnea*
Seagrass	Paddle grass	*Halophila decipiens*
Algae	White scroll algae	*Padina jamaicensis*
Teleost (Fin Fish)	Tarpon	*Megalops atlanticus*
	Mangrove snapper	*Lutjanus griseus*
	Grunt (juvenile)	*Haemulon* sp.
	Polka-dot batfish	*Ogcocephalus radiatus*
Elasmobranchs	Nurse shark	*Ginglymostoma cirratum*
Other invertebrates	Spiny lobster	*Panulirus argus*
	Bivalve	

One species of stony coral, *Siderastrea radians*, was documented during the survey. A total of 754 individual coral colonies accounting for 6,511 square centimeters (cm^2) of live tissue were catalogued: 174 on the vertical face of the bulkhead, 70 on hardbottom, and 510 on debris or rubble ranging a distance of 1-5 ft. from the bulkhead. Table 2 summarizes the coral inventory by abundance and size class for the aforementioned corals. A comprehensive list of all stony corals catalogued during the survey is provided in Appendix A; representative photographs are illustrated in Appendix B.

Table 2. Coral Inventory by abundance & size class: Corals encrusting bulkhead and adjacent concrete/debris					
Size Class (cm)	**0 to <5**	**5 to ≤10**	**11 to ≤15**	**16-20**	**TOTAL**
Species					
Siderastrea radians	670	77	5	2	754
TOTAL by size class	670	77	5	2	754

The highest abundance of stony corals (264 colonies) are along the third segment of tape from 140-160 ft. These corals are encrusted to hardbottom (37 colonies) and rubble (227 colonies) 2-5 ft. from the bulkhead. The second highest abundance of coral colonies (145) are along the third segment of tape from 180-200 ft. Of these, the corals between the 180-195 ft. marks are attached to the bulkhead and cannot be relocated, regardless of size, due to their morphology (encrusting corals). Colonies between the 197-199 ft. marks are on movable rubble 2-4 ft. from the bulkhead and able to be relocated (23 colonies total). Figure 3 presents the coral inventory by transect segment in 10-ft. increments.

The majority (88.9 percent) of the stony corals documented were in the less than 5 centimeter (cm) size class, 10.2 percent in the 5 to ≤10 cm size class, 0.7 percent in the 11 to ≤15 cm size class, and 0.3 percent in the 16 to 20 cm size class. Table 3 summarizes the coral inventory by size class and location along each 10-ft. section of the bulkhead. Figures 4 through 7 present coral distribution by size class along the bulkhead.

Table 3. Coral Inventory by size class and location along length of bulkhead (10-ft. increments): Corals encrusting bulkhead and adjacent hardbottom/rubble/debris					
Location (ft.)	**0 to <5cm**	**5 to ≤10cm**	**11 to ≤15cm**	**16 to 20cm**	**Total**
1st segment of bulkhead					
0-38 ft.	–	–	–	–	0
2nd segment of bulkhead					
0-130	–	–	–	–	0
131-140	3	1	–	–	4
141-150	–	–	–	–	0
150-160	3	–	–	–	3
161-170	–	–	–	–	0
171-180	10	3	–	–	13
181-190	7	2	–	–	9
191-200	11	3	–	–	14
201-210	13	–	–	–	13
211-220	12	–	–	1	13
221-230	8	2	–	–	10
231-240	–	–	–	–	0
241-250	–	–	–	–	0
251-260	–	–	–	–	0
261-270	1	–	–	–	1
271-280	24	–	–	–	24

Table 3. Coral Inventory by size class and location along length of bulkhead (10-ft. increments): Corals encrusting bulkhead and adjacent hardbottom/rubble/debris					
Location (ft.)	**0 to <5cm**	**5 to ≤10cm**	**11 to ≤15cm**	**16 to 20cm**	**Total**
281-290	22	5	–	–	27
291-300	8	1	–	–	9
301-310	27	2	–	–	29
310-343	–	–	–	–	0
3rd segment of bulkhead	–	–	–	–	
0-20	–	–	–	–	0
21-29	5	3	–	–	8
30-40	62	1	–	–	63
41-50	121	3	1	–	125
51-60	129	8	2	–	139
61-70	28	2	–	–	30
71-80	–	–	–	–	0
81-90	1	1	–	–	2
91-100	1	–	–	–	1
101-110	–	–	1	–	1
111-120	12	3	–	–	15
121-130	20	1	–	–	21
131-140	–	2	–	–	2
141-150	1	3	–	–	4
151-160	6	8	–	–	14
161-170	9	–	–	–	9
171-180	3	1	–	–	4
181-189	55	8	–	1	64
190-200	66	14	1	–	81
201-210	2	–	–	–	2
210-255	–	–	–	–	0
4th segment of bulkhead					
0-40 ft.	–	–	–	–	0
TOTAL	**670**	**77**	**5**	**2**	**754**

Discontinuous seagrass (*Halophila decipiens*) cover was documented from 196-246 ft. and 265-300 ft. along the second segment of bulkhead. Seagrasses were encountered growing within the 5-10 ft. buffer zone adjacent to the base of the bulkhead with coverage less than 5%. Table 4 summarizes the abundance and location of seagrass. Figure 8 presents the locations of seagrass cover graphically.

Table 4. Seagrass Inventory by location & abundance along Segment 2 of bulkhead				
Location (ft.)	**Species**	**Location**	**B-B Score**	**Percent Conversion**
196	*H. decipiens*	3-5 ft. from wall	1	2.5
198-246	*H. decipiens*	5 ft. from wall	1	2.5
265-300	*H. decipiens*	3 ft. from wall	1	2.5

5.0 Conclusions and Recommendations

A total of 510 corals (all *S. radians*) that are ≤15 cm in maximum dimension were identified as potential candidates for relocation. The relocation status of these corals is based on the apparent unattached nature of the substrate type. These corals are located on rubble and various types of debris (usually metal pipe) and should therefore be able to be relocated with minimal effort. There are 242 ≤15cm corals and 2 >15 cm corals attached to the bulkhead or hardbottom that are not recommended for relocation due to their size and morphology: these stony corals are encrusted on the bulkhead or secure substrate and cannot be chipped off and relocated without damage. The total area of coral tissue suitable for relocation is 2,960 cm^2 while the total area of coral tissue not suitable for relocation is 3,551 cm^2. Table 5 summarizes the coral inventory by relocation potential.

Approximately 85 linear feet of seagrass (*Halophila decipiens*) is present along the second segment of the bulkhead within the 5-10 ft. buffer zone. Seagrasses located along the bulkhead may be relocated to a nearby suitable substrate. Impacts to mangroves will not occur as a result of the project as they are not within the proposed project area or adjacent buffer zone.

Table 5. Coral Inventory by relocation potential: Corals encrusting bulkhead and adjacent concrete/debris[1]									
Size Class (cm) and Surface Area (cm^2)	**# <15 cm Coral candidates for relocation**	**Total Surface Area <15 cm corals to relocate (cm^2)**	**# <15 cm Corals not able to be relocated**	**Total Surface Area <15 cm corals not relocated (cm^2)**	**# >15 cm Corals not able to be relocated**	**Total Surface Area >15 cm corals not relocated (cm^2)**	**TOTAL # relocatable corals**	**TOTAL # unrelocatable corals**	**TOTAL # corals**
SPECIES NAME									
Siderastrea radians	510	2960	242	3087	2	464	510	244	754
TOTAL by size/area	510	2960	242	3087	2	464	510	244	754
[1] Relocation potential determined by substrate type (i.e., unattached versus attached)									

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Figure 3. Coral abundance by tape segment (10-ft.)

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Figure 4. Coral inventory of stony corals in <5 cm size class by tape segment (10-ft)

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Figure 5. Coral inventory of stony corals in 5–10 cm size class by tape segment (10-ft)

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Figure 6. Coral inventory of stony corals in 11–15 cm size class by tape segment (10-ft)

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Figure 7. Coral inventory of stony corals in 16–20 cm size class by tape segment (10-ft)

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Figure 8. Seagrass cover by tape segment (10-ft)

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APPENDIX A
Stony Coral Inventory

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ID No.	Species	Max dimension (cm)	Min dimension (cm)	Area (cm^2)	Location (ft) Second segment	Comment No resources on 1st segment
1	Srad	4	4	16	155	on debris 3 ft. from wall
2	Srad	3	3	3	155	on debris 3 ft. from wall
3	Srad	2	2	4	155	on debris 3 ft. from wall
4	Srad	1	1	1	173	on rubble 5 ft. from wall
5	Srad	1	1	1	173	on rubble 5 ft. from wall
6	Srad	1	1	1	173	on rubble 5 ft. from wall
7	Srad	1	1	1	173	on rubble 5 ft. from wall
8	Srad	1	1	1	173	on rubble 5 ft. from wall
9	Srad	1	1	1	173	on rubble 5 ft. from wall
10	Srad	1	1	1	173	on rubble 5 ft. from wall
11	Srad	3	3	9	176	on debris 5 ft. from wall
12	Srad	2	2	4	176	on debris 5 ft. from wall
13	Srad	7	4	28	177	on rubble 5 ft. from wall
14	Srad	2	2	4	177	on rubble 5 ft. from wall
15	Srad	7	6	42	179	on debris 2-4 ft. from wall
16	Srad	5	5	25	179	on debris 2-4 ft. from wall
17	Srad	3	3	9	181	on debris 3 ft. from wall
18	Srad	3	3	9	181	on debris 3 ft. from wall
19	Srad	2	2	4	182	on debis 3-5 ft. from wall
20	Srad	2	2	4	182	on debis 3-5 ft. from wall
21	Srad	7	6	42	183	on debris 2 ft. from wall
22	Srad	4	4	16	183	on debris 2 ft. from wall
23	Srad	5	5	25	183	on debris 2 ft. from wall
24	Srad	4	2	8	183	on debris 2 ft. from wall
25	Srad	2	2	4	183	on debris 2 ft. from wall
26	Srad	3	2	6	192	on rubble/debris 5 ft. from wall
27	Srad	4	2	8	192	on rubble/debris 5 ft. from wall
28	Srad	2	2	4	192	on rubble/debris 5 ft. from wall
29	Srad	1	1	1	192	on rubble/debris 5 ft. from wall
30	Srad	1	1	1	196	on rubble/debris 1-3 ft. from wall
31	Srad	4	2	8	198	on rubble/debris 1-3 ft. from wall
32	Srad	1	1	1	198	on rubble/debris 1-3 ft. from wall
33	Srad	8	3	24	198	on rubble/debris 5 ft. from wall
34	Srad	8	1	8	198	on rubble/debris 5 ft. from wall
35	Srad	3	3	9	198	on rubble/debris 5 ft. from wall
36	Srad	4	4	16	198	on rubble/debris 5 ft. from wall
37	Srad	4	4	16	198	on rubble/debris 5 ft. from wall
38	Srad	5	4	20	198	on rubble/debris 5 ft. from wall
39	Srad	4	2	8	198	on rubble/debris 5 ft. from wall
40	Srad	3	3	9	204	on rubble/debris 2 ft. from wall
41	Srad	2	2	4	204	on rubble/debris 2 ft. from wall
42	Srad	1	1	1	204	on rubble/debris 2 ft. from wall
43	Srad	2	2	4	205	on rubble/debris 1 ft. from wall
44	Srad	2	2	4	205	on rubble/debris 1 ft. from wall
45	Srad	1	1	1	205	on rubble/debris 1 ft. from wall
46	Srad	2	2	4	209	on rubble/debris 1 ft. from wall
47	Srad	2	2	4	209	on rubble/debris 1 ft. from wall
48	Srad	1	1	1	209	on rubble/debris 1 ft. from wall

ID No.	Species	Max dimension (cm)	Min dimension (cm)	Area (cm^2)	Location (ft)	Comment
49	Srad	1	1	1	209	on rubble/debris 1 ft. from wall
50	Srad	1	1	1	209	on rubble/debris 1 ft. from wall
51	Srad	1	1	1	209	on rubble/debris 1 ft. from wall
52	Srad	1	1	1	209	on rubble/debris 1 ft. from wall
53	Srad	2	2	4	213	on rubble/debris 1-2 ft. from wall
54	Srad	2	2	4	213	on rubble/debris 1-2 ft. from wall
55	Srad	1	1	1	217	on rubble/debris 1-2 ft. from wall
56	Srad	1	1	1	217	on rubble/debris 1-2 ft. from wall
57	Srad	1	1	1	217	on rubble/debris 1-2 ft. from wall
58	Srad	1	1	1	217	on rubble/debris 1-2 ft. from wall
59	Srad	1	1	1	217	on rubble/debris 1-2 ft. from wall
60	Srad	2	2	4	217	on rubble/debris 1-2 ft. from wall
61	Srad	2	2	4	217	on rubble/debris 1-2 ft. from wall
62	Srad	2	2	4	217	on rubble/debris 1-2 ft. from wall
63	Srad	3	3	9	217	on rubble/debris 1-2 ft. from wall
64	Srad	3	3	9	217	on rubble/debris 1-2 ft. from wall
65	Srad	6	4	24	221	on rubble/debris 2 ft. from wall
66	Srad	6	6	36	221	on rubble/debris 2 ft. from wall
67	Srad	2	2	4	221	on rubble/debris 2 ft. from wall
68	Srad	2	2	4	221	on rubble/debris 2 ft. from wall
69	Srad	3	3	9	221	on rubble/debris 2 ft. from wall
70	Srad	2	2	4	223	on rubble/debris 1 ft. from wall
71	Srad	2	2	4	223	on rubble/debris 1 ft. from wall
72	Srad	4	4	16	227	on rubble/debris 1 ft. from wall
73	Srad	2	2	4	227	on rubble/debris 1 ft. from wall
74	Srad	2	2	4	227	on rubble/debris 1 ft. from wall
75	Srad	2	2	4	263	on rubble/debris 10 ft. from wall
76	Srad	2	2	4	273-275	on rubble/debris 3-5 ft. from wall
77	Srad	2	2	4	273-275	on rubble/debris 3-5 ft. from wall
78	Srad	1	1	1	273-275	on rubble/debris 3-5 ft. from wall
79	Srad	1	1	1	273-275	on rubble/debris 3-5 ft. from wall
80	Srad	1	1	1	273-275	on rubble/debris 3-5 ft. from wall
81	Srad	1	1	1	273-275	on rubble/debris 3-5 ft. from wall
82	Srad	1	1	1	273-275	on rubble/debris 3-5 ft. from wall
83	Srad	1	1	1	273-275	on rubble/debris 3-5 ft. from wall
84	Srad	1	1	1	273-275	on rubble/debris 3-5 ft. from wall
85	Srad	1	1	1	273-275	on rubble/debris 3-5 ft. from wall
86	Srad	1	1	1	273-275	on rubble/debris 3-5 ft. from wall
87	Srad	1	1	1	273-275	on rubble/debris 3-5 ft. from wall
88	Srad	1	1	1	273-275	on rubble/debris 3-5 ft. from wall
89	Srad	1	1	1	273-275	on rubble/debris 3-5 ft. from wall
90	Srad	1	1	1	273-275	on rubble/debris 3-5 ft. from wall
91	Srad	1	1	1	273-275	on rubble/debris 3-5 ft. from wall
92	Srad	1	1	1	273-275	on rubble/debris 3-5 ft. from wall
93	Srad	1	1	1	273-275	on rubble/debris 3-5 ft. from wall
94	Srad	1	1	1	273-275	on rubble/debris 3-5 ft. from wall
95	Srad	1	1	1	273-275	on rubble/debris 3-5 ft. from wall
96	Srad	1	1	1	273-275	on rubble/debris 3-5 ft. from wall
97	Srad	4	3	12	273-275	on rubble/debris 3-5 ft. from wall

ID No.	Species	Max dimension (cm)	Min dimension (cm)	Area (cm^2)	Location (ft)	Comment
98	Srad	4	3	12	273-275	on rubble/debris 3-5 ft. from wall
99	Srad	3	3	9	273-275	on rubble/debris 3-5 ft. from wall
100	Srad	2	2	4	285	on rubble 5 ft. from wall
101	Srad	2	2	4	285	on rubble 5 ft. from wall
102	Srad	5	5	25	285	on rubble 5 ft. from wall
103	Srad	4	4	16	285	on rubble 5 ft. from wall
104	Srad	3	3	9	285	on rubble 5 ft. from wall
105	Srad	3	3	9	285	on rubble 5 ft. from wall
106	Srad	2	2	4	285	on rubble 5 ft. from wall
107	Srad	3	3	9	286	on rubble 5 ft. from wall
108	Srad	4	3	12	286	on rubble 5 ft. from wall
109	Srad	4	4	16	286	on rubble 5 ft. from wall
110	Srad	4	4	16	286	on rubble 5 ft. from wall
111	Srad	4	4	16	286	on rubble 5 ft. from wall
112	Srad	3	3	9	286	on rubble 5 ft. from wall
113	Srad	2	2	4	286	on rubble 5 ft. from wall
114	Srad	2	2	4	286	on rubble 5 ft. from wall
115	Srad	3	2	6	286	on rubble 5 ft. from wall

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APPENDIX B
Photographic Documentation: Typical Photos of Representative Resources

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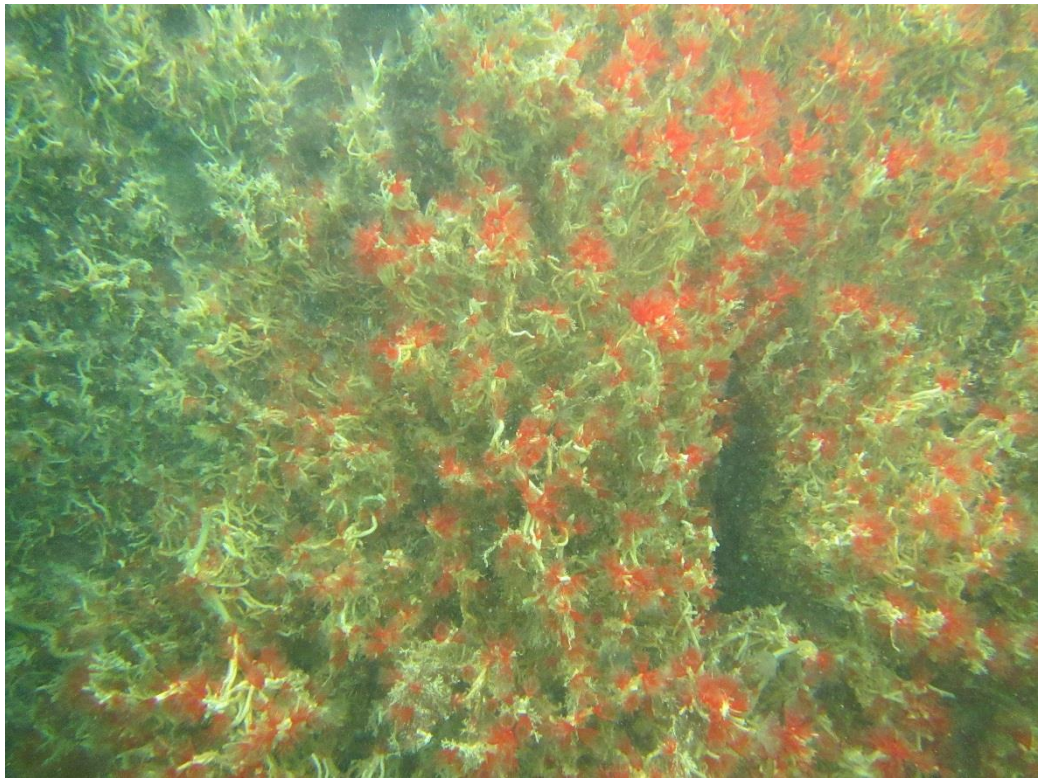
Resources on Bulkhead

Siderastrea radians **(Lesser starlet coral)**

Ecteinascidia turbinate/Scopalina rutzleri **(Mangrove tunicate/Orange lumpy encrusting sponge)**

Resources on Bulkhead

***Bispira brunnea* (Social feather duster)**



Other sponges/tunicates

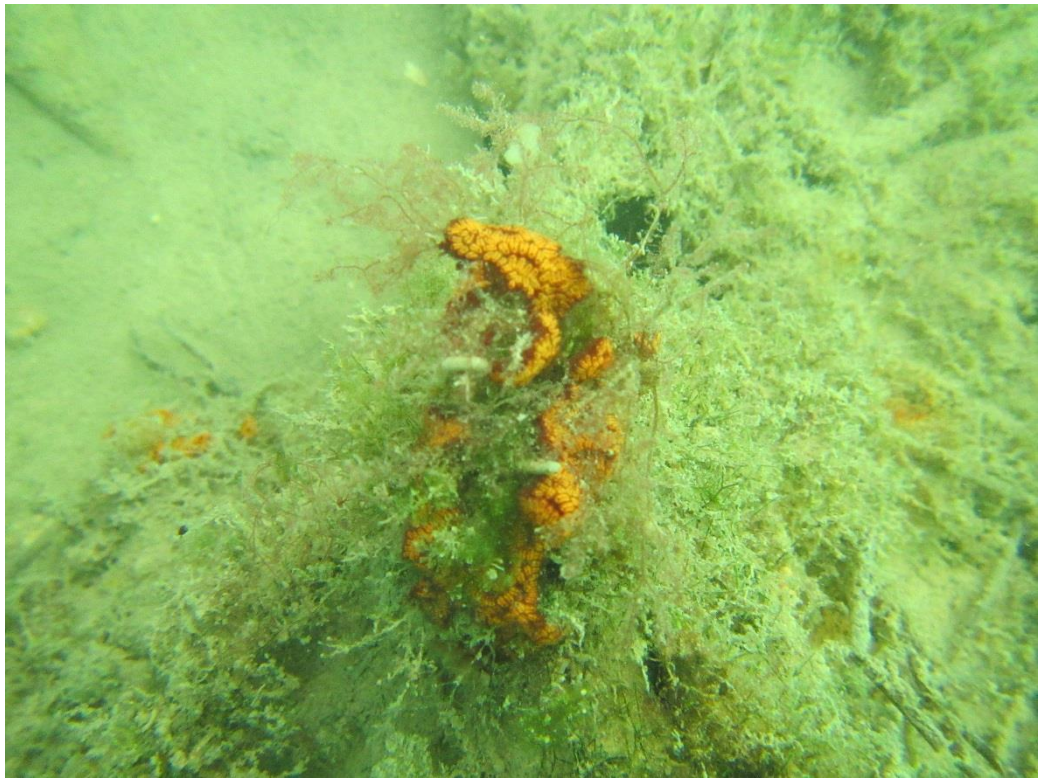
Resources within 5-ft. buffer zone

***Halophila decipiens* (Paddle grass)**

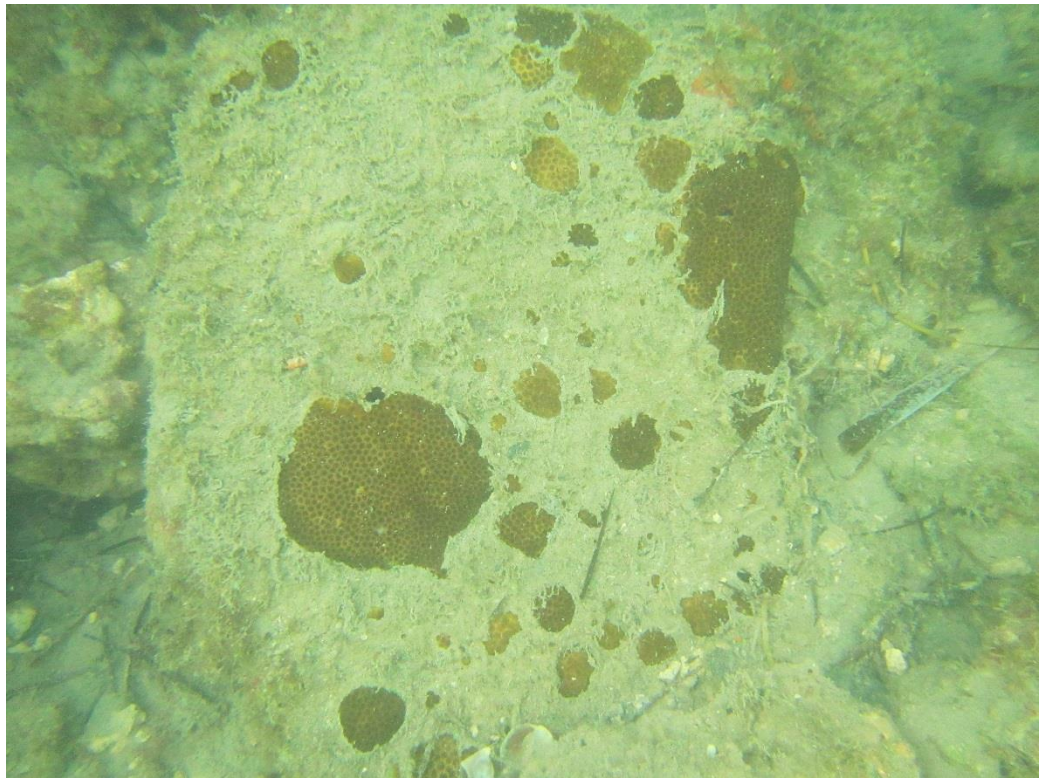
Bivalves

Resources within 5-ft. buffer zone

***Botryllus* sp. (Colonial tunicate)**

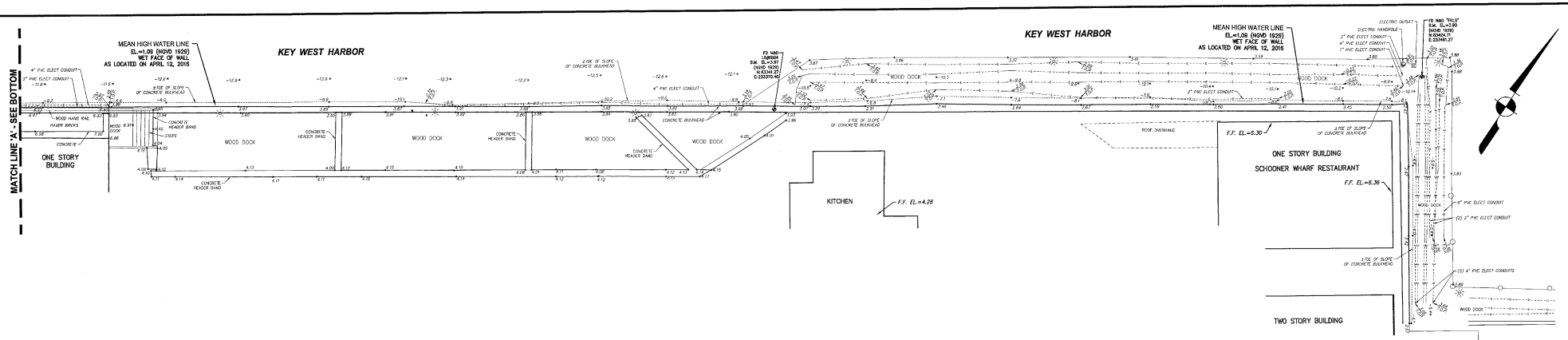


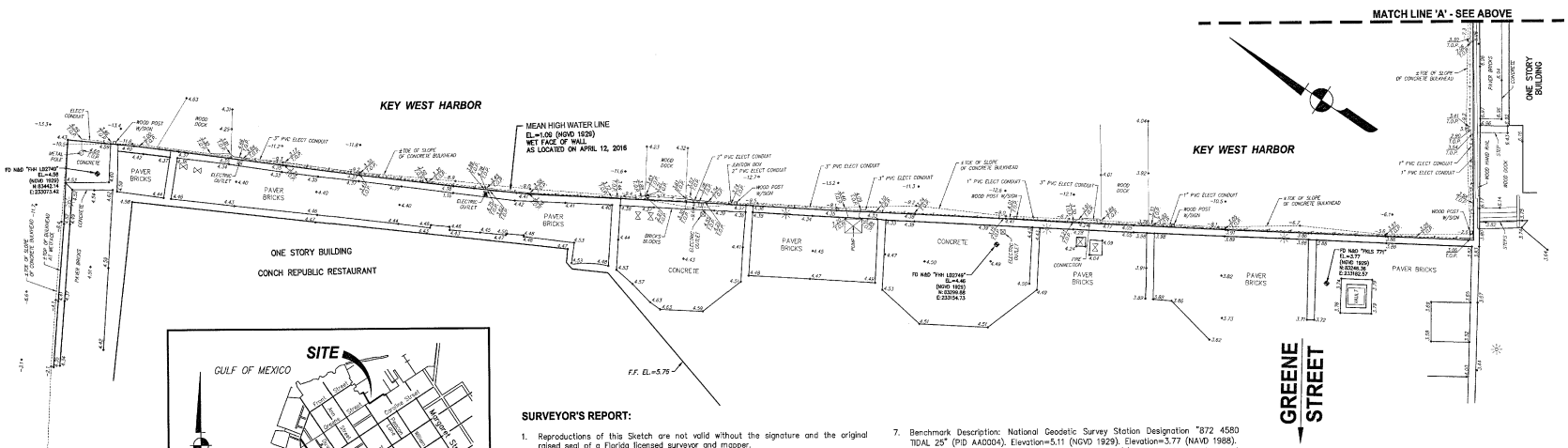
***Siderastrea radians* (Lesser starlet coral)**

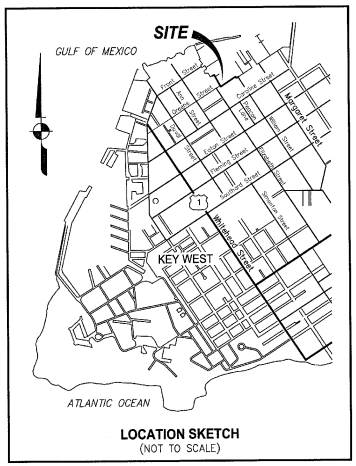


APPENDIX 4

Topographic Survey (Avirom)







LOCATION SKETCH
(NOT TO SCALE)

SURVEYOR'S REPORT:

1. Reproductions of this Sketch are not valid without the signature and the original raised seal of a Florida licensed surveyor and mapper.
2. No Title Opinion or Abstract to the subject property has been provided. It is possible that there are Deeds, Easements, or other instruments (recorded or unrecorded) which may affect the subject property. No search of the Public Records has been made by the Surveyor.
3. No underground improvements were located.
4. The electrical conduit banks and other utilities shown have been located from field survey information. The surveyor makes no guaranties that the electrical and other utilities shown comprise all such utilities in the area, either in service or abandoned. The surveyor further does not warrant that the electrical and other utilities shown are in the exact location indicated although he does certify that they are located accurately as possible from information available. Every effort has been made to obtain utilities pipe type and size, as shown. It is the responsibility of the end user to verify the invert and pipe size dimensions prior to design of new facilities.
5. The Grid coordinates shown hereon are based on the North American Datum of 1927, of the Florida State Plane Coordinate System (Transverse Mercator Projection), East Zone, established by a Real-Time Kinematic Survey (RTK) GPS Control Survey which is certified to a 2 centimeter local accuracy, relative to the nearest control point within the National Geodetic Survey (NGS) Geodetic Control Network.
   a. Method: Wide Area Continuously Operation GPS Reference Station Network.
   b. Equipment Used: Trimble R10 GNSS, Serial Number 5413460373 (Dual Frequency Receiver)
   c. Processing Software: Trimble Business Center, Version 3.51
6. Elevations shown hereon are in feet and based on the National Geodetic Vertical Datum of 1929 (NGVD 1929). To convert NGVD 1929 elevations to North American Vertical Datum of 1988 (NAVD 1988) for this site, the model value of (−)1.34 must be added algebraically to the NGVD 1929 height.
7. Benchmark Description: National Geodetic Survey Station Designation "872 4580 TIDAL 25" (PID AA0004). Elevation=5.11 (NGVD 1929). Elevation=3.77 (NAVD 1988).
8. Data shown hereon was compiled from instrument(s) of record and does not constitute a Boundary Survey.
9. a. This is NOT a Mean High Water Survey in accord with Chapter 177, Part II Florida Statutes.
   b. Mean High Water Elevation is 1.09 feet, NGVD 1929 (−0.25 feet, NAVD 1988), as located on April 12, 2016, and is shown for informational purposes only.
   c. The Mean High Water Elevation as shown hereon was established by extending the tidal datum shown at Mean High Water Interpolation Point No. 3260, which was obtained from the Florida Department of Environmental Protection Web Site, http://www.labins.org.
10. This map is intended to be displayed at a scale of 1:240 (1"=20').
11. Units of measurement are in U.S. Survey Feet and decimal parts thereof. Well identified features in this survey were field measured to a horizontal positional accuracy of 0.07'. The elevations on impervious surfaces were field measured to 0.05' and on ground surfaces to 0.1'.
12. Symbols shown hereon and in the legend may have been enlarged for clarity. These symbols have been plotted at the center of the field location and may not represent the actual shape or size of the feature.
13. Site Address: 613–631 Greene Street, Key West, FL 33040
14. Abbreviation Legend: B.M. = Benchmark; E = Existing; EL. = Elevation; F.B. = Field Book; F.F. = Finished Floor; GPS = Global Positioning System; ID. = Identification; L.B. = Licensed Business; N = Northing; NAD = North American Datum; NAVD = North American Vertical Datum; NGVD = National Geodetic Vertical Datum; PID = Point Identifier; P.L.S. = Professional Land Surveyor; PVC = Polyvinyl-Chloride Pipe; RTK = Real-Time Kinematic; T.O.P. = Top of Pipe.

SYMBOL LEGEND:

- BENCHMARK
- ELECTRIC CONDUIT(S)
- ELECTRIC SERVICE BOX
- METAL LIGHT POLE
- ELECTRIC OUTLET
- EXISTING ELEVATION
- WATER VALVE

0 10 20
GRAPHIC SCALE IN FEET
1" = 10'

NGVD 1929 ELEVATIONS

CERTIFICATION:

I HEREBY CERTIFY that the attached Topographic Survey of the hereon described property is true and correct to the best of my knowledge and belief as surveyed in the field under my direction. I FURTHER CERTIFY that this Topographic Survey meets the Standards of Practice set forth in Chapter 5J-17, Florida Administrative Code, pursuant to Section 472.027, Florida Statutes.

Date: 11-08-17

KEITH M. CHEE-A-TOW, P.L.S.
Florida Registration No. 5328
AVIROM & ASSOCIATES, INC.
L.B. No. 3300

AVIROM & ASSOCIATES, INC.
SURVEYING & MAPPING
50 S.W. 2ND AVENUE, SUITE 102, BOCA RATON, FLORIDA 33432
TEL. (561) 392-2594, FAX (561) 394-7125
www.AVIROM-SURVEY.com

REVISIONS	DATE	F.B. / PG.	BY	CK'D	REVISIONS	DATE	F.B. / PG.	BY	CK'D

TOPOGRAPHIC SURVEY
SCHOONER WHARF TO CONCH REPUBLIC
PORTION OF
WILLIAM A. WHITEHEAD'S MAP OF KEY WEST (UNRECORDED)
SECTION 31, TOWNSHIP 68 SOUTH, RANGE 25 EAST
CITY OF KEY WEST
MONROE COUNTY, FLORIDA

JOB #:	10157-3
SCALE:	1" = 10'
DATE:	11-08-2017
BY:	GYC
CHECKED:	K.M.C.
F.B.	1797 PG. 28-34
SHEET	1 OF 1

APPENDIX 5

Geotechnical Report (Ardaman)

GEOTECHNICAL RECOMMENDATIONS
TT PORT & MARINE SERVICES
SEAWALL IMPROVEMENTS
GREENE STREET & ELIZABETH STREET
KEY WEST, FL
DECEMBER 19, 2017
FILE NO.: 17-2606

Ardaman & Associates, Inc.

OFFICES

Orlando – 8008 S. Orange Avenue, Orlando Florida 32809 – Phone (407) 855-3860
Alexandria – 3609 Mac Lee Drive, Alexandria, Louisiana 71302 – Phone (318) 443-2888
Bartow – 1525 Centennial Drive, Bartow, Florida 33830 – Phone (863) 533-0858
Baton Rouge – 316 Highlandia Drive, Baton Rouge, Louisiana 70884 – Phone (225) 752-4790
Cocoa – 1300 N. Cocoa Blvd., Cocoa, Florida 32922 – Phone (321) 632-2503
Fort Myers – 9970 Bavaria Road, Fort Myers, Florida 33913 – Phone (239) 768-6600
Miami – 2608 W. 84th Street, Hialeah, Florida 33016 – Phone (305) 825-2683
Monroe – 1122 Hayes Street, West Monroe, Louisiana 71292 – Phone (318) 387-4103
New Orleans – 1305 Distributors Row, Suite I, Jefferson, Louisiana 70123 – Phone (504) 835-2593
Port St. Lucie – 460 Concourse Place NW, Unit 1, Port St. Lucie, Florida 34986 – Phone (772) 878-0072
Sarasota – 78 Sarasota Center Blvd., Sarasota, Florida 34240 – Phone (941) 922-3526
Shreveport – 7222 Greenwood Road, Shreveport, Louisiana 71119 – Phone (318) 636-3673
Tallahassee – 3175 West Tharpe Street, Tallahassee, Florida 32303 – Phone (850) 576-6131
Tampa – 3925 Coconut Palm Drive, Suite 115, Tampa, Florida 33619 – Phone (813) 620-3389
West Palm Beach – 2200 North Florida Mango Road, Suite 101, West Palm Beach, Florida 33409 – Phone (561) 687-8200

Ardaman & Associates, Inc.
Geotechnical, Environmental and
Materials Consultants

December 19, 2017
File No.: 17-2606

Mr. Stuart E. McGahee, P.E.
Tetra Tech
759 S. Federal Highway, Suite 314
Stuart, FL 34994

RE: GEOTECHNICAL RECOMMENDATIONS
TT PORT & MARINE SERVICES
SEAWALL IMPROVEMENTS
GREENE STREET & ELIZABETH STREET
KEY WEST, FL

1.0 INTRODUCTION

In accordance with your request and authorization, Ardaman & Associates Inc. has completed additional geotechnical studies of the above-captioned project site. Our work included performing soil borings, laboratory testing and engineering evaluation of the existing soil conditions.

Our report has been prepared specifically for this project. It is intended for the exclusive use of Tetra Tech, and its representatives. Our work has used methods and procedures consistent with local foundation engineering practices. No other warranty, expressed or implied, is made. We do not guarantee project information in any respect, only that our work meets normal standards of professional care.

2.0 SITE LOCATION AND DESCRIPTION

The site is located at the Northeast corner of the intersection of Greene Street and Elizabeth Street in the West, Key West, FL. A site vicinity map is presented as our Figure 1. The site consists of an operating boat pier facility where charter small and medium size boats take out tourists in pleasure or fishing trips.

3.0 PROJECT DESCRIPTION

We understand that the project will consist of the redesign and rehabilitation of the seawall that is currently at the subject site. The seawall has L shape with a long leg of about 330 feet extending to the East and short leg of about 200 feet to the North.

4.0 GENERAL SUFACE CONDITIONS

The boring logs in Appendix I present a detailed description of the soils encountered at the locations and the depths explored. The soil stratification shown on the boring logs is based on examination of recovered soil samples and interpretation of the driller's field logs. It indicates only the approximate boundaries between soil types. The actual transitions between adjacent soil strata may be gradual and indistinct.

The results of our test borings indicate the following general soil profile:

Depth below ground surface (feet)	Description
0 – 5	Fill, limerock
5 – 8	Silt with organics (muck)
8 – 30	Limestone, poorly to well cemented

The above soil profile is outlined in general terms only. Please, refer to the boring logs for soil profile details.

5.0 LABORATORY TEST RESULTS

Representative soil samples obtained during our field sampling operation were packaged and transferred to our laboratory for further visual examination and classification. Sieve analysis, organic content, moisture content and corrosion test results are discussed in section 7.3 of this report. The rest of the tests were used for classification of the soils and individual results are included in the boring logs presented in the Appendix.

6.0 DISCUSSIONS AND RECOMMENDATIONS

6.1 Suitable Fill Material and Compaction of Fill Soils

All fill materials should be free of organic materials, such as roots and vegetation. We recommend using fill with less than 10 percent by dry weight of material passing the U.S. Standard No. 200 sieve size.

All structural fill should be placed in level lifts not to exceed 12 inches in un-compacted thickness. Each lift should be compacted to at least 95 percent of the modified Proctor (ASTM D-1557) maximum dry density value. The filling and compaction operations should continue in lifts until the desired elevation(s) is achieved. If hand-held compaction equipment is used, the lift thickness should be reduced to no more than 6 inches.

6.2 Excavation of Existing Soils in the Proximity of the Seawall

The limestone layer present between 5 and 17 feet below grade is fairly hard with N values larger than 20. This suggests that excavating these soils will require equipment with appropriate power and tools as defined by the Contractor.

6.3 Reuse of Excavated Soils

The near surface limerock found at most of the boring between 0 and 5 feet below grade is appropriate for reuse as fill. However, the limerock is followed by silty soil with organics that is unsuitable fill. If the upper limerock is to be reused the contractor shall perform the excavation in a way that prevents the mixing of the limerock with the organics soils underlying it.

6.4 Sheet Pile Constructability

Sheet piles installed through the upper limestone layer shall be designed to support hard driving through the limestone layer between 5 and 17 feet below existing grade. Predrilling may be required to install sheet piles through this upper layers of limestone.

7.0 GEOTECHNICAL RECOMMENDATIONS FOR DESIGN

7.1 Soil Engineering Properties for Bulkhead Design

Table 3 presents our recommended engineering properties for the soils found in our field exploration. Note that a cohesion value has been assigned to the limestone layers, these values are considered conservative based on numerous testing and physical evidence for this type of soil.

Table 3
Engineering Soil Properties

Soil Type	Unit Weight (lbs/ft3)		Friction Angle (°)	Cohesion c (psf)
	Moist	Saturated		
Limerock fill	125	68	35	0
Sand (loose)	105	53	30	0
Sand silty	100	48	25	0
Limestone 4<N<30	120	65	20	1,000
Limestone N>30	125	67	20	5,000
Muck/Silt	70	29	13°	0

Please notice that if pre-drilling is used for sheet pile installation, the limestone properties will be degraded and for structural analysis/sheet pile design should be considered equal to those presented above for limerock fill.

7.2 Lateral Earth Pressure

Retaining wall design (if required) may be performed using the parameters presented in Table 4 below.

Table 4
Earth Pressure Parameters Recommendations

Fill or Soil Type	Moist Unit Weight (pcf)	Buoyant Soil Unit Weight (pcf)	Friction Angle	Active Pressure Coefficient	Passive Pressure Coefficient	At rest Pressure Coefficient
Sand (loose)	105	53	30	0.33	3.0	0.5
Limerock fill	125	68	35	0.27	3.69	0.43
Silty sand	100	48	25	0.41	2.46	0.56

Please notice that a conservative assumption regarding the friction angle between the retaining wall and the backfill material has been used to define the earth pressure coefficient.

Factors of safety against sliding, overturning and bearing capacity must be included in all earth pressure analysis. We recommended the following factors of safety:

1. Sliding 1.5
2. Overturning 2.0
3. Bearing Capacity 2.5

7.3 Corrosion Test Results and Environmental Classification Recommendations

A total of two corrosion tests were completed on limestone samples taken between 8 and 15 feet at boring locations B2 and B4. The results are summarized in the Table below:

Boring	Depth (ft.)	Ph	Resistivity (Ω-cm)	Sulfate (ppm)	Chloride (ppm)	Environmental Classification
	10	9.1	6200	10	2500	Extremely aggressive
	11	8.2	3300	32	3000	Extremely aggressive

Please, notice that due the proximity of the ocean the foundations and any superstructure shall be designed for an extremely aggressive condition.

CLOSURE

This report has been prepared in accordance with generally accepted local foundation engineering practice. The recommendations submitted herein are based on the data obtained from the soil borings presented in the Appendix and the assumed loading conditions previously described. This report may not account for all the possible variations that may exist between conditions observed in the borings and conditions at locations that were not explored. The nature and extent of any such variations may not become evident until further explorations are made or construction is underway. If variations are then observed, we recommend that Ardaman & Associates, Inc. be requested to inspect the actual site conditions and, if necessary, re-evaluate the recommendations of this report.

We recommend that we be given the opportunity to review more finalized plans to allow the evaluation of the possible conflict between the various structures, and the potential effects of the planned construction on adjacent property. In any case, in the event any changes occur in the design, nature or location of any project facilities from the conditions that were the basis of aour analyses, Ardaman & Associates, Inc. should be requested to review the conclusions and recommendations in this report. We also recommend that we be requested to review the final foundation drawings and earthwork specifications so that our recommendations may be properly interpreted and implemented in the contract documents.

It has been a pleasure to assist you on this phase of your project. Please contact us whenever we may be of service to you, and please call if you have any questions concerning this report.

Very truly yours,

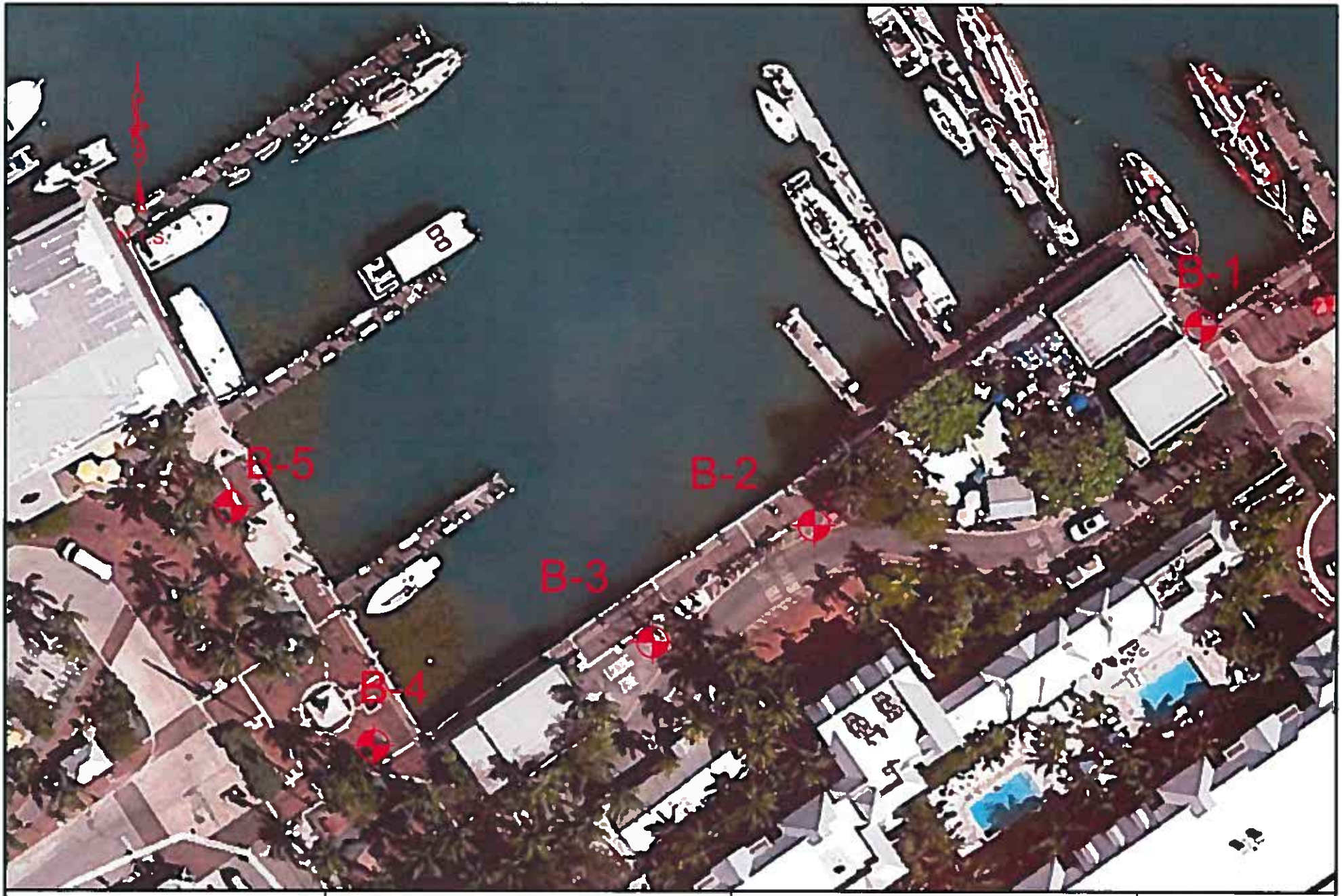
ARDAMAN & ASSOCIATES, INC.
FL Certificate No.: 0005950

12/20/17

Evelio Horta, Ph.D., P.E., G.E.
Senior Project Engineer
FL Reg. No. 46625

SITE PLAN
AND
BORING LOGS

Ardaman & Associates, Inc. Geotechnical, Environmental and Materials Consultants	SUBSURFACE EXPLORATION PROPOSED SEAWALL IMPROVEMENTS GREENE ST & ELIZABETH ST, KEY WEST MONROE COUNTY, FLORIDA	SITE VICINITY MAP Figure No 1.	File No.: 17-2606 Prepared By: EHJr Date: 12/20/17



Ardaman & Associates, Inc. Geotechnical, Environmental and Materials Consultants	SUBSURFACE EXPLORATION PROPOSED SEAWALL IMPROVEMENTS GREENE ST & ELIZABETH ST, KEY WEST MONROE COUNTY, FLORIDA	BORING LOCATION PLAN Figure No 2.	File No.: 17-2606 Prepared By: EHJr Date: 12/20/17

APPENDIX

STANDARD PENETRATION TEST BORING LOGS

Our borings describe subsurface conditions only at the locations drilled and at the time drilled. They provide no information about subsurface conditions below the bottom of the boreholes. At locations not explored, surface conditions that differ from those observed in the borings may exist and should be anticipated.

The information reported on our boring logs is based on our drillers' logs and on visual examination in our laboratory of disturbed soil samples recovered from the borings. The distinction shown on the logs between soil types is approximate only. The actual transition from one soil to another may be gradual and indistinct.

The groundwater depth shown on our boring logs is the water level the driller observed in the borehole when it was drilled. These water levels may have been influenced by the drilling procedures, especially in borings made by rotary drilling with bentonitic drilling mud. An accurate determination of groundwater level required long-term observation of suitable monitoring wells. Fluctuations in groundwater levels throughout the year should be anticipated.

The absence of a groundwater level on certain logs indicates that no groundwater data is available. It does not mean that no groundwater will be encountered at the boring location.

STANDARD PENETRATION TEST BORINGS

The Standard Penetration Test is a widely accepted method of testing foundation soils in place. The N-Value obtained from the test has been correlated empirically with various soil properties. These empirical correlations allow satisfactory estimates to be made of how the soil is likely to behave when subjected to foundation loads. Tests are usually performed in the boreholes at intervals of five feet. In addition, our Firm performs tests continuously in the interval directly below the expected foundation bearing grade where the soils will be most highly stressed.

Boreholes where Standard Penetration Tests will be performed are drilled with a truck-mounted CME 45A drill rig. The boreholes are advanced by rotary drilling with a winged bit that makes a hole about three inches in diameter. A bentonitic drilling mud is recirculated in order to remove the cuttings and support the walls of the borehole. The drag bit is specially modified to direct the mud upward and reduced disturbance of the soil ahead of the bit.

Occasionally, running or squeezing ground is encountered that cannot be stabilized by the drilling mud alone. In addition, drilling mud may be lost into the soil or rock strata that are unusually pervious. In such cases, flush-coupled steel casing with an outside diameter of about 3.5 inches is driven as a liner for the borehole.

After the borehole has been advanced to the depth where a Standard Penetration Test will be performed, the soil sampler used to run the test is attached to the end of the drill rods and lowered to the bottom of the borehole. The testing procedure used conforms closely to the methods recommended in ASTM D-1586. The sampler used has a split-barrel 24 inches long and an outside diameter of 2.0 inches. It is driven into the ground below the bottom of the borehole using a hammer that weighs 140 pounds and falls 30 inches. The driller records the number of hammer blows need to advance the sampler the second and third six-inch increments constitutes the test result; that is, the N-Value at the depth. The test is completed after the sampler has been driven not more than 24 inches or when refusal is encountered, whichever occurs first. Refusal occurs when 50 hammer blows advance the sampler six inches or less. After the test is completed, the sampler is removed from the borehole and opened.

The driller examined and classified the soil recovered by the sampler. He places representative soil specimens from each test in closed glass jars and takes them to our laboratory. In the laboratory, additional evaluations and tests are performed, if needed. The driller's classifications may be adjusted, if necessary, to conform more closely to the United Soil Classification systems, ASTM D-2487. Jar samples are retrained in our laboratory for sixty days, then discarded unless our clients request otherwise.

After completion of a test boring, the water level in the borehole is recorded.

STANDARD PENETRATION TEST BORING LOG

BORING 1

PROJECT: TT Port & Marine Services
Seawall Improvements

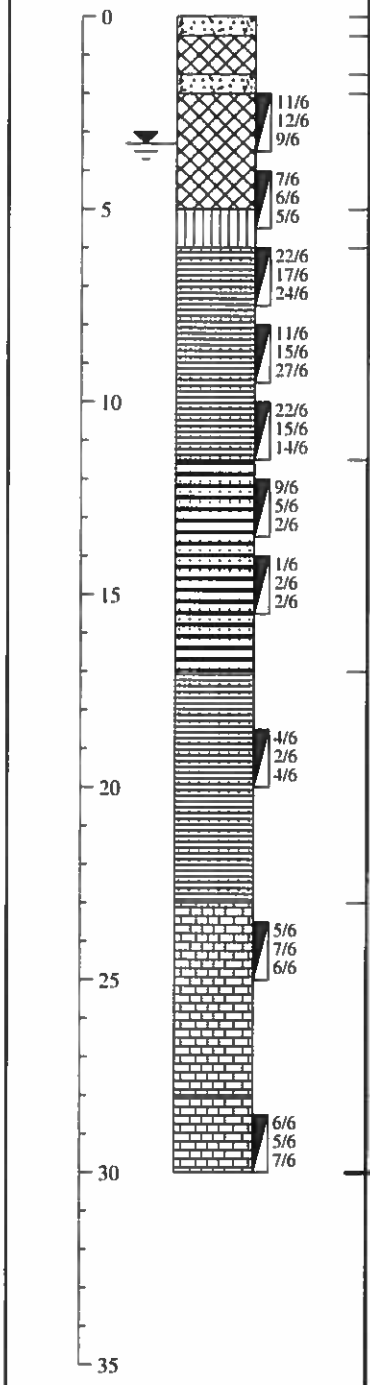
FILE No.: 17-2606

BORING LOCATION: See Plan

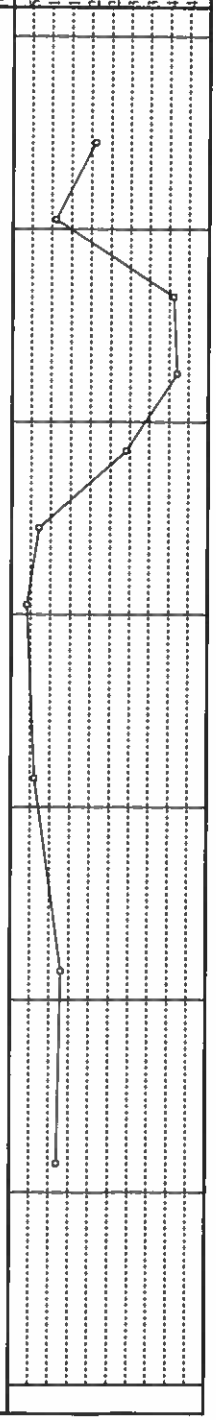
DRILL CREW: EG/FCH

WATER OBSERVED AT DEPTH 3.3'

DATE DRILLED: 11/17/17



DEPTH (FEET)	SOIL DESCRIPTION	SAMPLE No.	N VALUE
	CONCRETE slab, upper 6"	1	
	FILL, limerock	2	
	W=11%	3	
	Boring advanced from 0' to 2' using	4	21
	WOOD, fragments		
	FILL, limerock, white		11
	SILT, soft sandy, grey	5	
	-200=43%	6	41
	LIMESTONE, poorly cemented, white to pale brown		42
			29
	LIMESTONE, very poorly cemented, white	7	7
			4
	LIMESTONE, poorly cemented	8	6
	LIMESTONE, white	9	13
	LIMESTONE, white	10	12



NOTES:

FIELD TEST DATA ARE "BLOWS"/"INCHES DRIVEN" 140-LB HAMMER, 30-INCH FALL. (ASTM D-1586)

STANDARD PENETRATION TEST BORING LOG

BORING 2

PROJECT: TT Port & Marine Services
Seawall Improvements

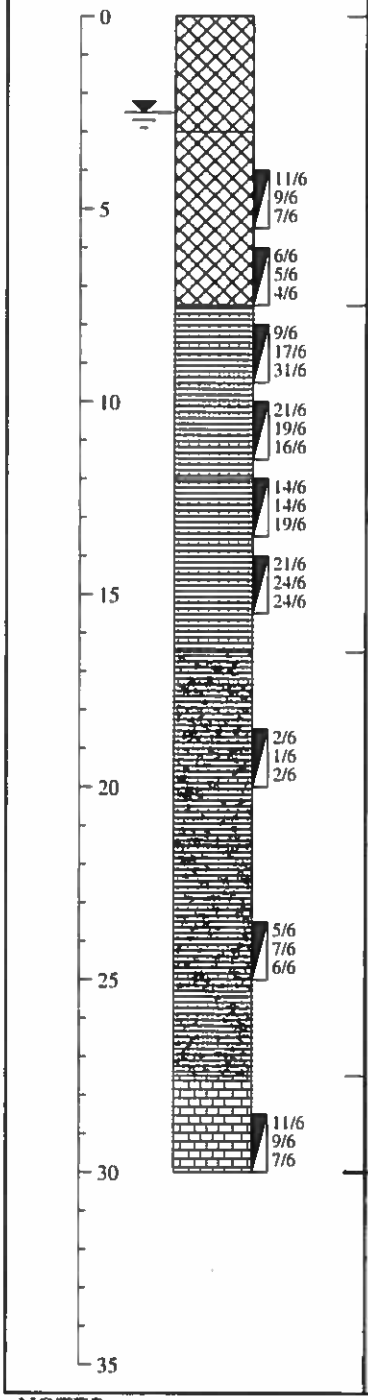
FILE No.: 17-2606

BORING LOCATION: See Plan

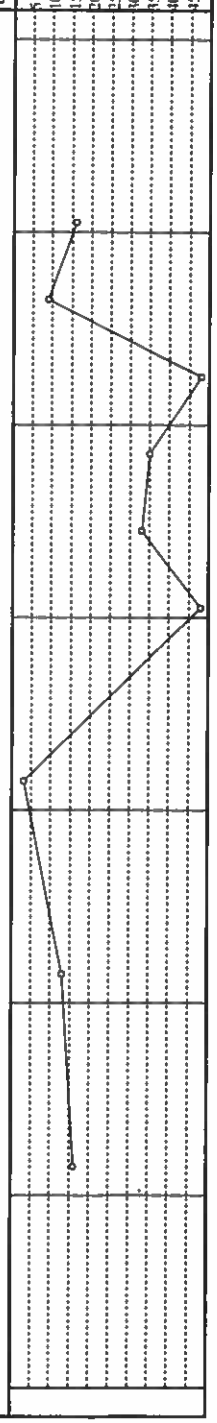
DRILL CREW: EG/FCH

WATER OBSERVED AT DEPTH 2.5'

DATE DRILLED: 11/16/17



DEPTH (FEET)	SOIL DESCRIPTION	SAMPLE No.	N VALUE
	FILL, limerock, white W=9%	1	
	Boring advanced from 0' to 4' using hand auger equipment		
	FILL, limerock, grey -200=10%	2	16
			9
	Limestone, poorly cemented with large pockets of sand, pale brown	3	48
			35
	LIMESTONE, poorly cemented sandy, white	4	33
			48
	LIMESTONE, poorly cemented with small voids (oolite)	5	
			3
	LIMESTONE, poorly cemented with small voids (oolite)	6	
			13
	LIMESTONE, pale brown	7	
			16



NOTES:

FIELD TEST DATA ARE "BLOWS"/"INCHES DRIVEN" 140-LB HAMMER, 30-INCH FALL. (ASTM D-1586)

STANDARD PENETRATION TEST BORING LOG

BORING 3

PROJECT: TT Port & Marine Services
Seawall Improvements

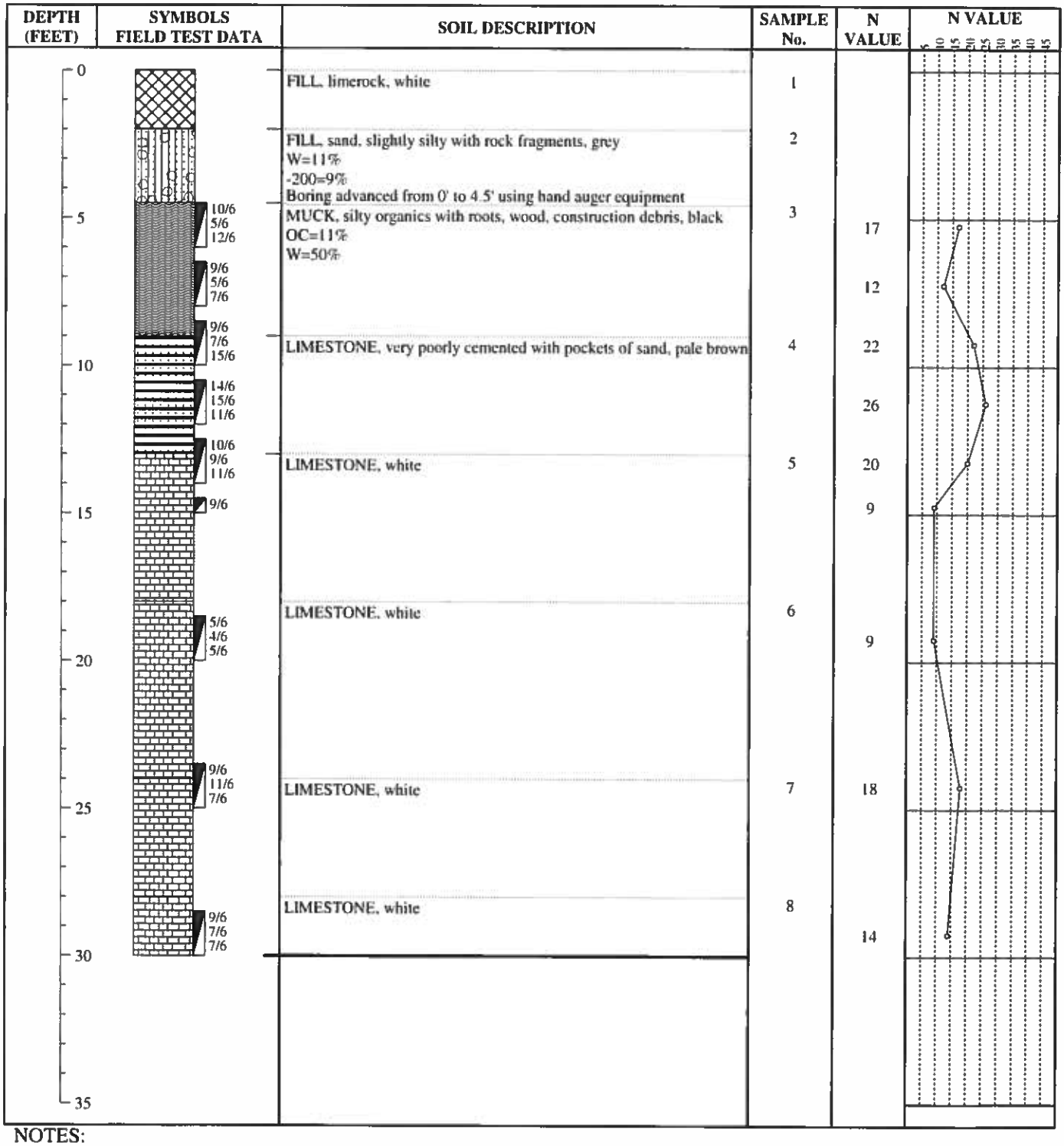
FILE No.: 17-2606

BORING LOCATION: See Plan

DRILL CREW: EG/FCH

WATER OBSERVED AT DEPTH ???????

DATE DRILLED: 11/15/17



NOTES:

FIELD TEST DATA ARE "BLOWS"/"INCHES DRIVEN" 140-LB HAMMER, 30-INCH FALL. (ASTM D-1586)

STANDARD PENETRATION TEST BORING LOG

BORING 4

PROJECT: TT Port & Marine Services
Seawall Improvements

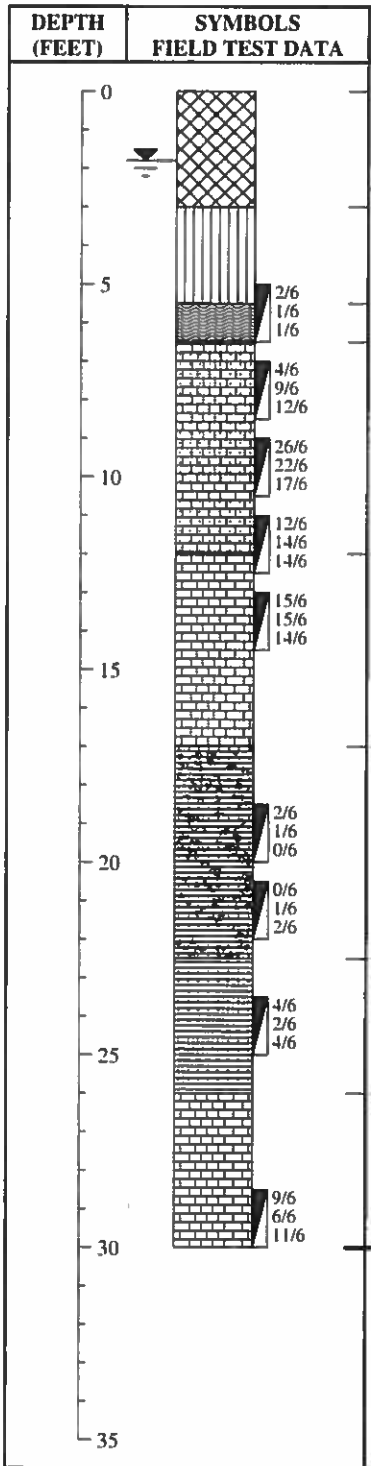
FILE No.: 17-2606

BORING LOCATION: See Plan

DRILL CREW: EG/FCH

WATER OBSERVED AT DEPTH 1.8'

DATE DRILLED: 11/16/17



DEPTH (FEET)	SYMBOLS FIELD TEST DATA	SOIL DESCRIPTION	SAMPLE No.	N VALUE
		FILL, limerock, white W=10%	1	
		Boring advanced from 0' to 5'using hand auger equipment SILT, soft, dark grey -200=40%	2	
		MUCK, silty organics, black OC=12%	3	2
		LIMESTONE, sandy, pale brown	4	21
				39
		LIMESTONE, white	5	28
				29
		LIMESTONE, poorly cemented with voids (oolite), grey	6	1
				3
		LIMESTONE, poorly cemented, pale brown	7	6
		LIMESTONE, white	8	17

N VALUE: 5 10 15 20 25 30 35 40 45

NOTES:

FIELD TEST DATA ARE "BLOWS"/"INCHES DRIVEN" 140-LB HAMMER, 30-INCH FALL. (ASTM D-1586)

STANDARD PENETRATION TEST BORING LOG

BORING 5

PROJECT: TT Port & Marine Services
Seawall Improvements

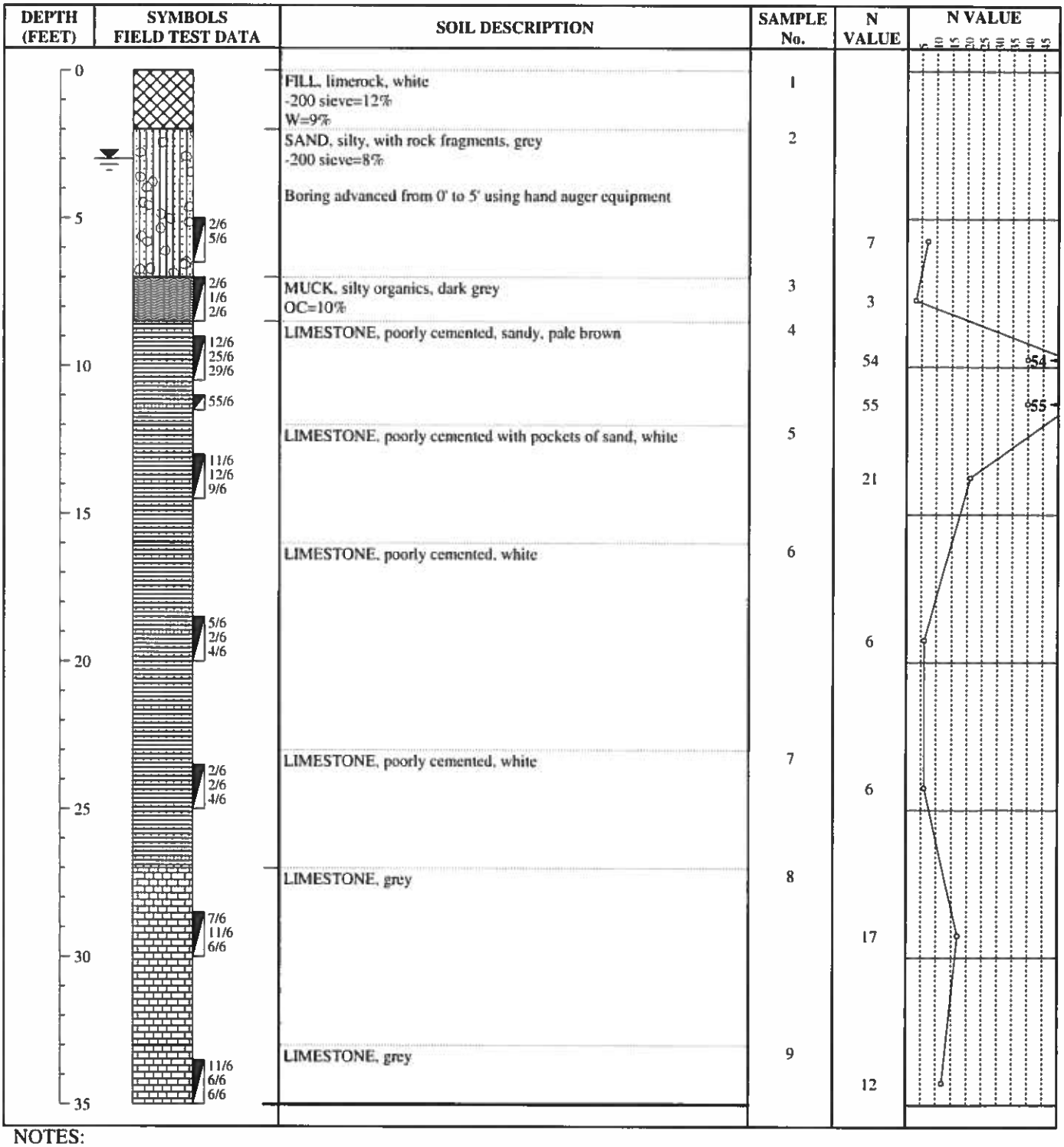
FILE No.: 17-2606

BORING LOCATION: See Plan

DRILL CREW: EG/FCH

WATER OBSERVED AT DEPTH 3'

DATE DRILLED: 11/15/17



NOTES:

FIELD TEST DATA ARE "BLOWS"/"INCHES DRIVEN" 140-LB HAMMER, 30-INCH FALL. (ASTM D-1586)

APPENDIX 6

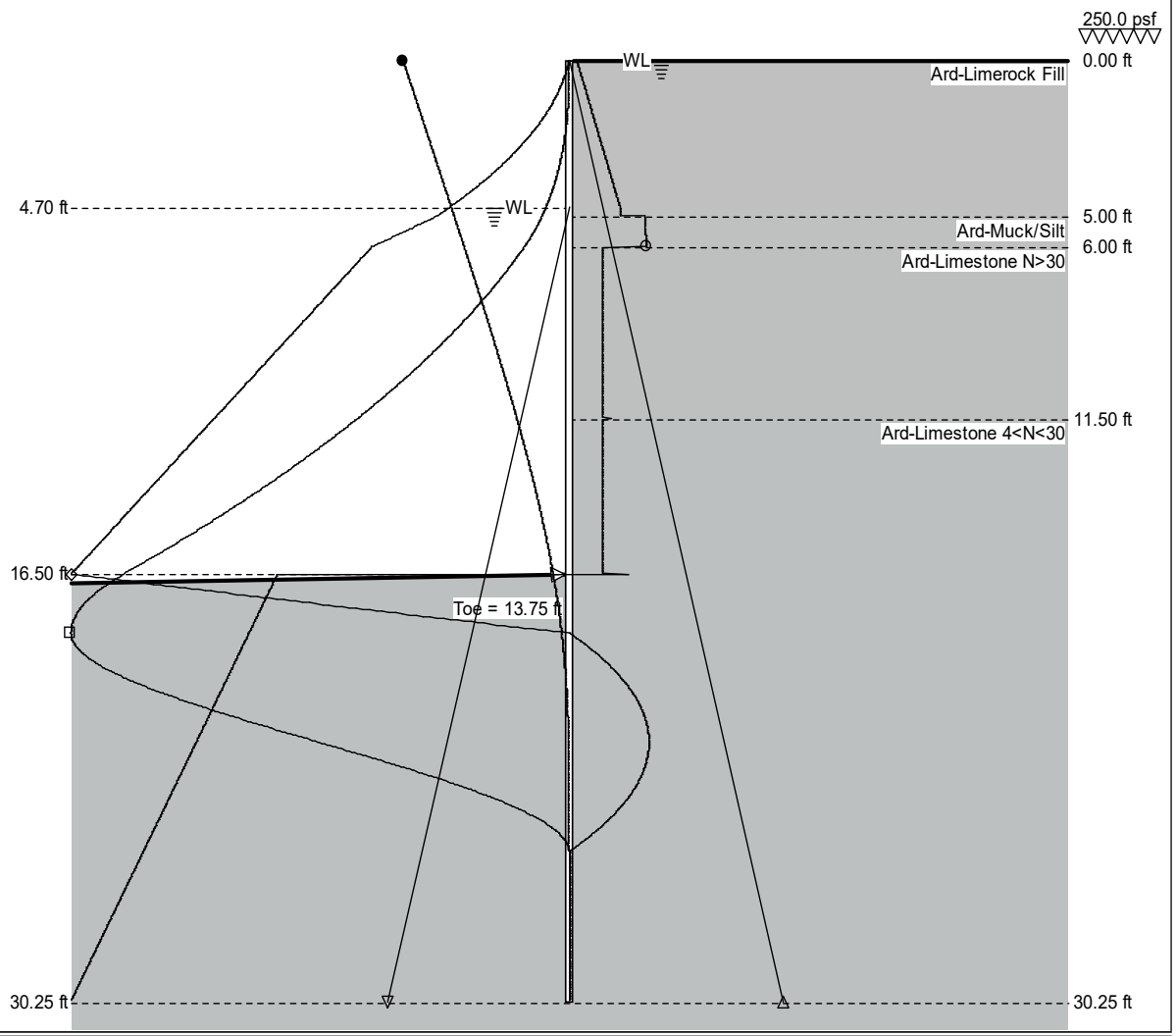
Preliminary Structural Analyses

Client: City of Key West
Site: Key West Bight

Title: Conch to Schooner Seawall
Designer: Francisco Martinez
Ref: KWCtoS
Page: 1
Date: 4.20.18

Sheet: PZ35
Pressure: Rankine
FOS: 2.0
Toe: Cantilever

	Maximum	d (ft)
○	683.4 psf	6.00
□	46646.9 ftlb/ft	18.40
◇	5114.8 lb/ft	16.51
●	1.2 in	0.00
△	1888.5 psf	30.25
▽	1595.1 psf	30.25



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SPW911, v2.40

Client: City of Key West
Site: Key West Bight

Title: Conch to Schooner Seawall
Designer: Francisco Martinez
Ref: KWCtoS
Page: 2
Date: 4.20.18

Sheet: PZ35
Pressure: Rankine
FOS: 2.0
Toe: Cantilever

Input Data

Depth Of Excavation = 16.50 ft Depth Of Active Water = 0.00 ft Water Density = 62.43 pcf
Surcharge = 250.0 psf Depth Of Passive Water = 4.70 ft Minimum Fluid Density = 31.82 pcf
Slope (passive) = 1.0 degrees

Soil Profile

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	ϕ(°)	δ(°)	K_a	K_{ac}	K_p	K_{pc}
0.00	Ard-Limerock Fill	125.00	68.00	0.0	0.0	35.0	0.0	0.27	0.00	3.69	0.00
5.00	Ard-Muck/Silt	70.00	29.00	0.0	0.0	13.0	0.0	0.63	0.00	1.58	0.00
6.00	Ard-Limestone N>30	125.00	67.00	5000.0	0.0	20.0	0.0	0.49	1.40	2.04	2.86
11.50	Ard-Limestone 4<N<30	120.00	65.00	1000.0	0.0	20.0	0.0	0.49	1.40	2.04	2.86

Solution

Sheet

Sheet Name	I (in^4/ft)	E (psi)	Z (in^3/ft)	f (psi)	Maximum Bending Moment (ftlb/ft)	Upstand (ft)	Toe (ft)	Pile Length (ft)
PZ35	369.40	3.04E+07	48.90	24970.3	101753.7	0.00	13.75	30.25

Maxima

	Maximum	Depth
Bending Moment	46646.9 ftlb/ft	18.40 ft
Deflection	1.2 in	0.00 ft
Pressure	683.4 psf	6.00 ft
Shear Force	5114.8 lb/ft	16.51 ft

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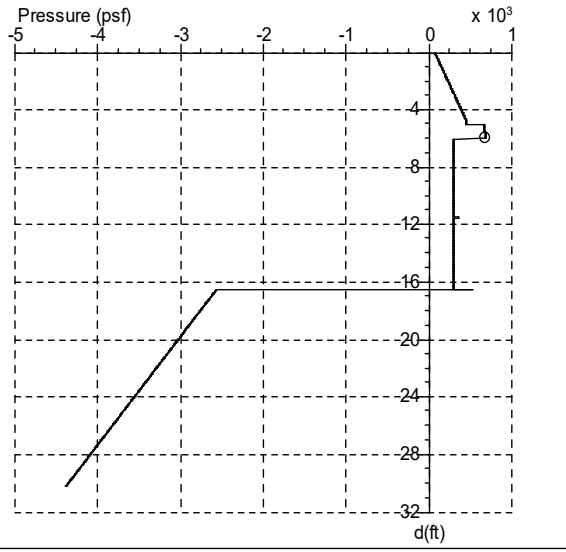
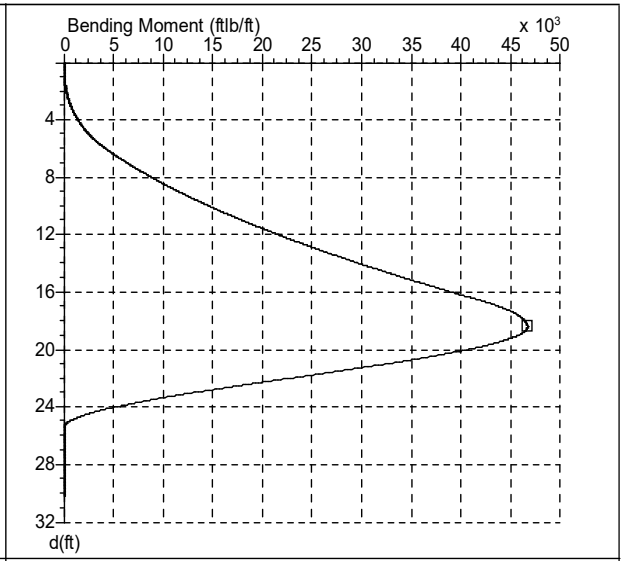
Client: City of Key West
Site: Key West Bight

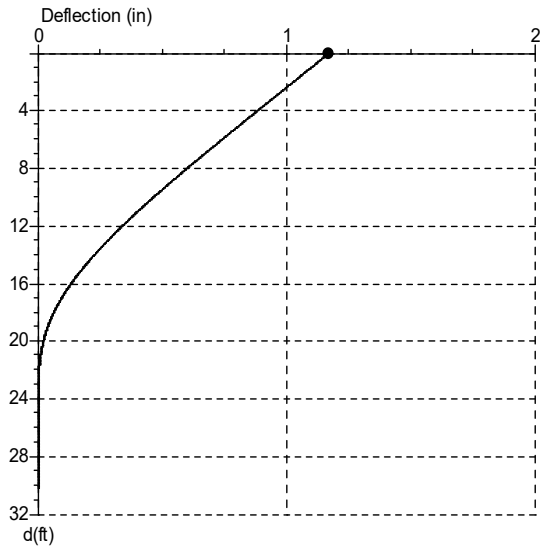
Title: Conch to Schooner Seawall
Designer: Francisco Martinez
Ref: KWCtoS
Page: 3
Date: 4.20.18

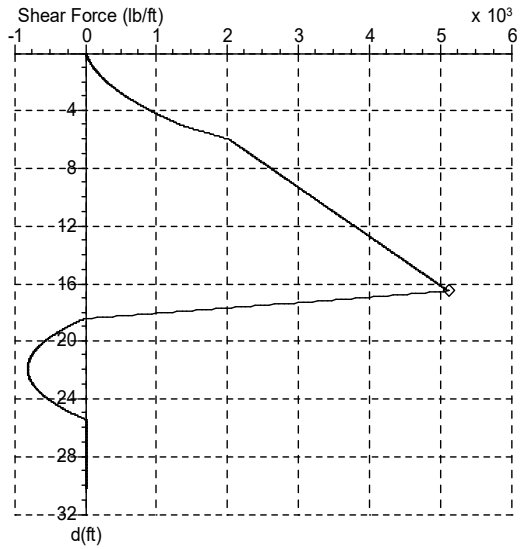
Sheet: PZ35
Pressure: Rankine
FOS: 2.0
Toe: Cantilever

Maximum		d (ft)
○	683.4 psf	6.00
□	46646.9 ftlb/ft	18.40
◇	5114.8 lb/ft	16.51
●	1.2 in	0.00









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SPW911, v2.40

Client: City of Key West
Site: Key West Bight

Title: Conch to Schooner Seawall
Designer: Francisco Martinez
Ref: KWCtoS
Page: 4
Date: 4.20.18

Sheet: PZ35
Pressure: Rankine
FOS: 2.0
Toe: Cantilever

depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)
0.00	67.5	0.0	1.2	0.0	10.17	292.9	15222.8	0.5	3251.0	20.35	-3076.5	38049.9	0.0	-655.1
0.27	89.9	2.6	1.2	22.1	10.44	292.9	16050.6	0.4	3324.9	20.61	-3113.2	35761.5	0.0	-708.0
0.54	110.3	11.0	1.1	47.6	10.71	292.9	16982.7	0.4	3406.1	20.88	-3146.7	33539.5	0.0	-747.1
0.80	132.7	28.3	1.1	81.6	10.98	292.9	17849.6	0.4	3480.0	21.15	-3183.4	30971.2	0.0	-780.5
1.07	153.0	52.9	1.1	117.9	11.24	292.9	18824.6	0.4	3561.2	21.42	-3220.2	28306.2	0.0	-803.8
1.34	175.4	91.2	1.1	163.7	11.51	366.6	19822.3	0.4	3646.2	21.68	-3253.6	25828.1	0.0	-816.0
1.61	197.8	143.0	1.1	215.8	11.78	292.9	20749.7	0.4	3720.0	21.95	-3290.4	23073.5	0.0	-819.7
1.87	218.2	203.3	1.0	268.5	12.05	292.9	21791.3	0.3	3801.3	22.22	-3323.8	20571.2	0.0	-814.2
2.14	240.6	285.6	1.0	332.4	12.31	292.9	22757.8	0.3	3875.2	22.49	-3360.5	17852.3	0.0	-798.4
2.41	263.0	386.5	1.0	402.5	12.58	292.9	23842.4	0.3	3956.4	22.75	-3397.3	15202.1	0.0	-772.5
2.68	283.4	495.7	1.0	471.7	12.85	292.9	24949.6	0.3	4037.7	23.02	-3430.7	12881.2	0.0	-740.0
2.94	305.8	636.6	1.0	553.7	13.12	293.0	25975.7	0.3	4111.5	23.29	-3467.5	10457.3	0.0	-694.6
3.21	326.1	785.1	0.9	633.6	13.38	293.0	27125.9	0.3	4192.8	23.56	-3504.2	8201.8	0.0	-639.0
3.48	348.6	972.5	0.9	727.4	13.65	293.0	28298.6	0.2	4274.1	23.83	-3537.7	6326.3	0.0	-579.6
3.75	371.0	1186.6	0.9	827.5	13.92	293.0	29384.2	0.2	4347.9	24.09	-3574.4	4487.6	0.0	-504.6
4.02	391.3	1406.0	0.9	923.9	14.19	293.0	30599.9	0.2	4429.2	24.36	-3607.8	3047.9	0.0	-427.5
4.28	413.7	1676.1	0.9	1035.8	14.46	293.0	31724.7	0.2	4503.1	24.63	-3644.6	1751.1	0.0	-332.9
4.55	436.1	1978.1	0.8	1154.0	14.72	293.0	32983.4	0.2	4584.4	24.90	-3681.4	787.9	0.0	-228.2
4.82	448.6	2281.6	0.8	1266.2	14.99	293.0	34264.7	0.2	4665.6	25.16	-3714.8	230.8	0.0	-124.2
5.09	666.1	2649.2	0.8	1412.9	15.26	293.0	35449.1	0.2	4739.5	25.43	-3751.6	0.0	0.0	0.0
5.35	670.7	3024.4	0.8	1581.5	15.53	293.0	36773.4	0.2	4820.8	25.70	-3785.0	0.0	0.0	0.0
5.62	675.8	3486.4	0.8	1768.3	15.79	293.0	38120.2	0.1	4902.1	25.97	-3821.7	0.0	0.0	0.0
5.89	680.9	4000.4	0.7	1956.5	16.06	293.0	39364.1	0.1	4976.0	26.23	-3858.5	0.0	0.0	0.0
6.16	292.8	4509.3	0.7	2069.6	16.33	293.0	40754.0	0.1	5057.3	26.50	-3891.9	0.0	0.0	0.0
6.42	292.8	5093.3	0.7	2150.8	16.60	-2578.5	42032.0	0.1	4920.4	26.77	-3928.7	0.0	0.0	0.0
6.69	292.8	5643.8	0.7	2224.7	16.87	-2615.3	43305.7	0.1	4200.7	27.04	-3965.4	0.0	0.0	0.0
6.96	292.8	6270.9	0.7	2305.9	17.13	-2652.0	44378.7	0.1	3470.9	27.31	-3998.9	0.0	0.0	0.0
7.23	292.8	6920.4	0.7	2387.1	17.40	-2685.4	45177.4	0.1	2798.6	27.57	-4035.6	0.0	0.0	0.0
7.50	292.8	7530.4	0.6	2460.9	17.67	-2722.2	45859.1	0.1	2049.3	27.84	-4069.0	0.0	0.0	0.0
7.76	292.8	8223.0	0.6	2542.1	17.94	-2759.0	46331.9	0.1	1289.9	28.11	-4105.8	0.0	0.0	0.0
8.03	292.8	8938.0	0.6	2623.4	18.20	-2792.4	46577.8	0.1	590.6	28.38	-4142.6	0.0	0.0	0.0
8.30	292.8	9607.6	0.6	2697.2	18.47	-2829.2	46636.2	0.1	-34.9	28.64	-4176.0	0.0	0.0	0.0
8.57	292.8	10365.7	0.6	2778.4	18.74	-2862.6	46374.9	0.0	-145.7	28.91	-4212.7	0.0	0.0	0.0
8.83	292.8	11074.3	0.5	2852.3	19.01	-2899.3	45710.3	0.0	-257.8	29.18	-4249.5	0.0	0.0	0.0
9.10	292.8	11875.4	0.5	2933.5	19.27	-2936.1	44684.0	0.0	-359.7	29.45	-4282.9	0.0	0.0	0.0
9.37	292.9	12698.9	0.5	3014.7	19.54	-2969.5	43466.0	0.0	-443.5	29.71	-4319.7	0.0	0.0	0.0
9.64	292.9	13467.2	0.5	3088.6	19.81	-3006.3	41844.3	0.0	-526.0	29.98	-4353.1	0.0	0.0	0.0
9.90	292.9	14333.7	0.5	3169.8	20.08	-3039.7	40141.9	0.0	-592.1	30.25	-4389.9	0.0	0.0	0.0

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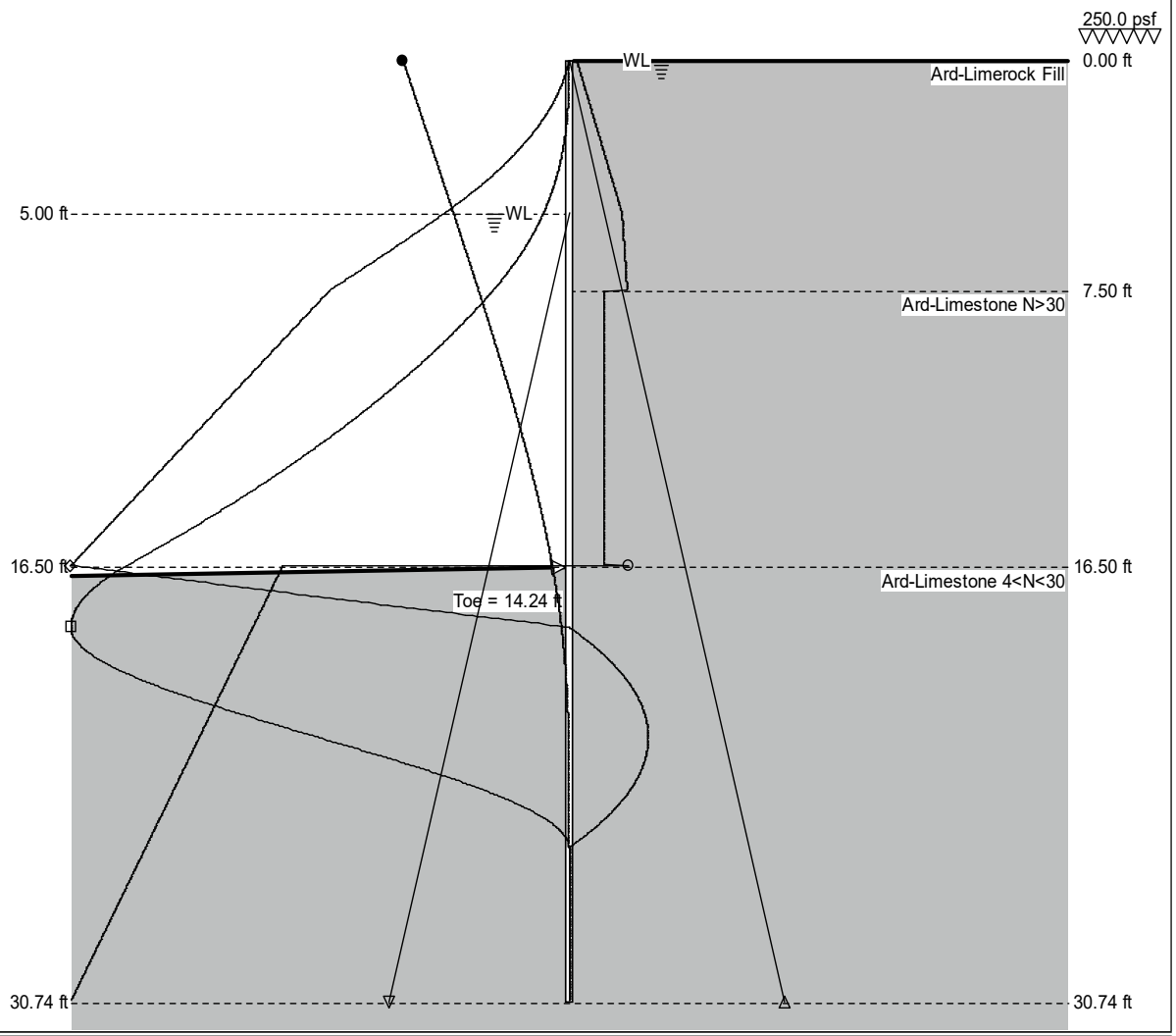
SPW911, v2.40

Client: City of Key West
Site: Key West Bight

Title: Conch to Schooner Seawall
Designer: Francisco Martinez
Ref: KWCtoS
Page: 1
Date: 4.20.18

Sheet: PZ35
Pressure: Rankine
FOS: 2.0
Toe: Cantilever

Maximum		d (ft)
○	525.0 psf	16.50
□	48890.9 ftlb/ft	18.52
◇	5401.9 lb/ft	16.49
●	1.3 in	0.00
△	1918.8 psf	30.74
▽	1606.7 psf	30.74



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SPW911, v2.40

Client: City of Key West
Site: Key West Bight

Title: Conch to Schooner Seawall
Designer: Francisco Martinez
Ref: KWCtoS
Page: 2
Date: 4.20.18

Sheet: PZ35
Pressure: Rankine
FOS: 2.0
Toe: Cantilever

Input Data

Depth Of Excavation = 16.50 ft Depth Of Active Water = 0.00 ft Water Density = 62.43 pcf
Surcharge = 250.0 psf Depth Of Passive Water = 5.00 ft Minimum Fluid Density = 31.82 pcf
Slope (passive) = 1.0 degrees

Soil Profile

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	ϕ(°)	δ(°)	K_a	K_{ac}	K_p	K_{pc}
0.00	Ard-Limerock Fill	125.00	68.00	0.0	0.0	35.0	0.0	0.27	0.00	3.69	0.00
7.50	Ard-Limestone N>30	125.00	67.00	5000.0	0.0	20.0	0.0	0.49	1.40	2.04	2.86
16.50	Ard-Limestone 4<N<30	120.00	65.00	1000.0	0.0	20.0	0.0	0.49	1.40	2.04	2.86

Solution

Sheet

Sheet Name	I (in⁴/ft)	E (psi)	Z (in³/ft)	f (psi)	Maximum Bending Moment (ftlb/ft)	Upstand (ft)	Toe (ft)	Pile Length (ft)
PZ35	369.40	3.04E+07	48.90	24970.3	101753.7	0.00	14.24	30.74

Maxima

	Maximum	Depth
Bending Moment	48890.9 ftlb/ft	18.52 ft
Deflection	1.3 in	0.00 ft
Pressure	525.0 psf	16.50 ft
Shear Force	5401.9 lb/ft	16.49 ft

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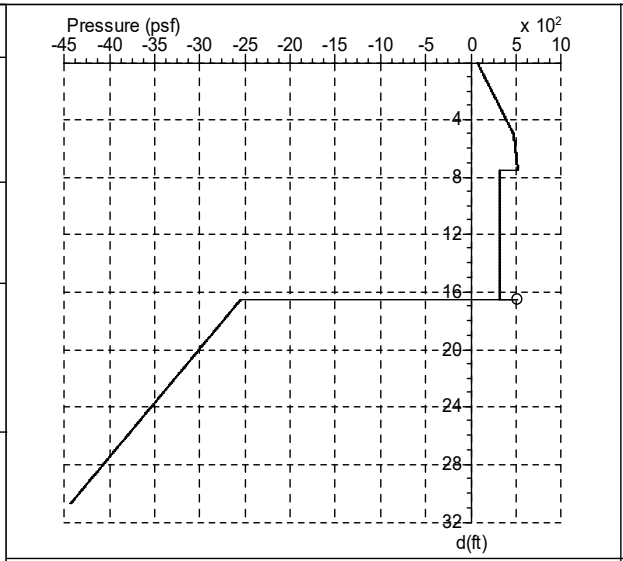
SPW911, v2.40

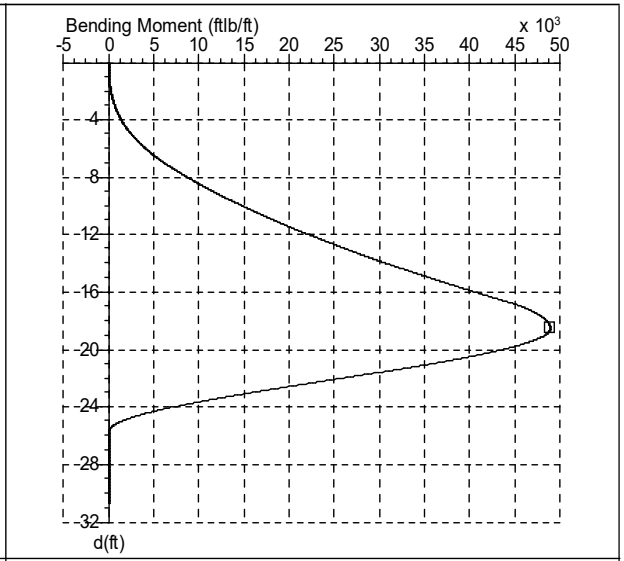
Client: City of Key West
Site: Key West Bight

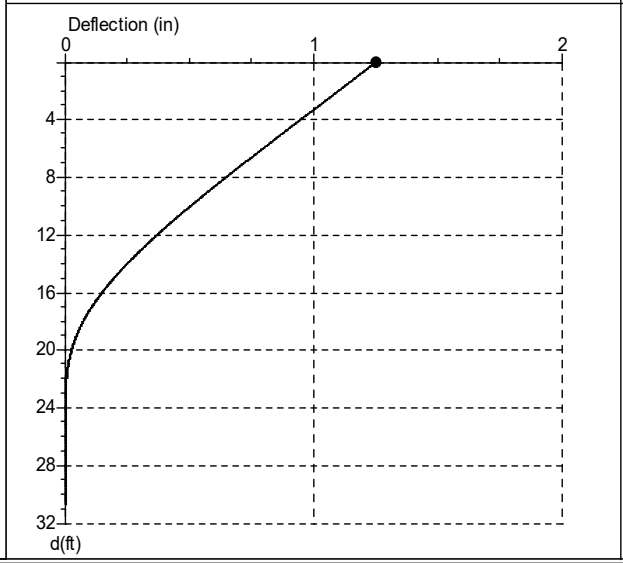
Title: Conch to Schooner Seawall
Designer: Francisco Martinez
Ref: KWCtoS
Page: 3
Date: 4.20.18

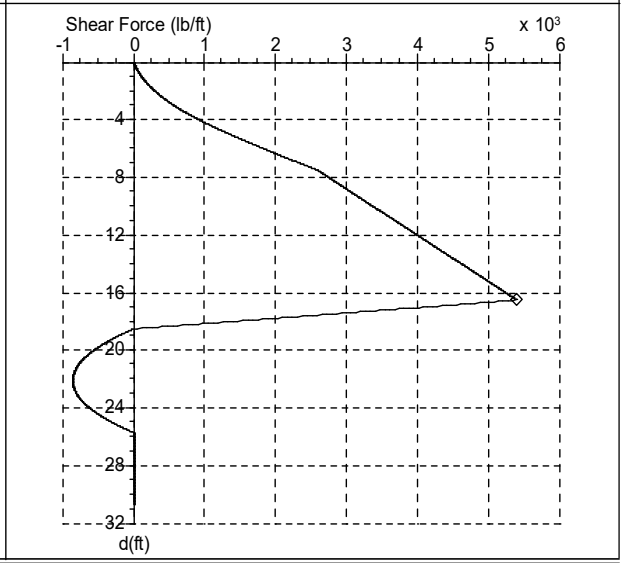
Sheet: PZ35
Pressure: Rankine
FOS: 2.0
Toe: Cantilever

Maximum		d (ft)
○	525.0 psf	16.50
□	48890.9 ftlb/ft	18.52
◇	5401.9 lb/ft	16.49
●	1.3 in	0.00









Tetra Tech

759 S. Federal Highway, Suite 314
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Tel: 772-781-3440
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SPW911, v2.40

Client: City of Key West
Site: Key West Bight

Title: Conch to Schooner Seawall
Designer: Francisco Martinez
Ref: KWCtoS
Page: 4
Date: 4.20.18

Sheet: PZ35
Pressure: Rankine
FOS: 2.0
Toe: Cantilever

depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)
0.00	67.5	0.0	1.3	0.0	10.34	311.9	16037.8	0.5	3478.4	20.67	-3100.9	38506.6	0.0	-719.6
0.27	90.3	2.7	1.2	22.5	10.61	311.9	16937.8	0.5	3558.3	20.94	-3138.2	36022.9	0.0	-768.6
0.54	111.0	11.4	1.2	48.6	10.88	311.9	17951.5	0.4	3646.2	21.22	-3172.2	33636.2	0.0	-803.8
0.82	133.7	29.4	1.2	83.3	11.15	311.9	18894.5	0.4	3726.2	21.49	-3209.5	30901.9	0.0	-832.5
1.09	154.4	54.9	1.2	120.5	11.42	311.9	19955.4	0.4	3814.1	21.76	-3246.9	28087.7	0.0	-850.6
1.36	177.2	94.7	1.1	167.5	11.70	311.9	21041.1	0.4	3902.0	22.03	-3280.9	25489.5	0.0	-858.0
1.63	199.9	148.6	1.1	221.0	11.97	311.9	22049.5	0.4	3981.9	22.30	-3318.2	22620.4	0.0	-856.1
1.90	220.6	211.3	1.1	275.1	12.24	311.9	23182.5	0.4	4069.8	22.58	-3352.2	20030.6	0.0	-845.2
2.18	243.4	297.1	1.1	340.8	12.51	311.9	24233.9	0.3	4149.7	22.85	-3389.5	17234.7	0.0	-823.2
2.45	266.2	402.1	1.1	412.9	12.78	311.9	25414.1	0.3	4237.6	23.12	-3426.9	14528.5	0.0	-790.7
2.72	286.8	516.0	1.0	484.0	13.06	311.9	26619.1	0.3	4325.5	23.39	-3460.9	12175.6	0.0	-752.0
2.99	309.6	662.9	1.0	568.3	13.33	311.9	27736.0	0.3	4405.4	23.66	-3498.2	9738.2	0.0	-699.4
3.26	330.3	817.8	1.0	650.6	13.60	311.9	28988.3	0.3	4493.3	23.94	-3535.6	7492.7	0.0	-636.2
3.54	353.1	1013.3	1.0	747.1	13.87	311.9	30265.3	0.3	4581.2	24.21	-3569.5	5647.5	0.0	-569.7
3.81	375.8	1236.8	1.0	850.1	14.14	311.9	31447.8	0.2	4661.2	24.48	-3606.9	3866.3	0.0	-486.4
4.08	396.5	1465.9	0.9	949.3	14.42	311.9	32772.1	0.2	4749.1	24.75	-3640.8	2501.5	0.0	-401.6
4.35	419.3	1747.9	0.9	1064.6	14.69	311.9	33997.5	0.2	4829.0	25.02	-3678.2	1312.7	0.0	-298.3
4.62	442.0	2063.2	0.9	1186.3	14.96	311.9	35369.1	0.2	4916.9	25.30	-3715.6	485.5	0.0	-184.4
4.90	462.7	2380.3	0.9	1302.4	15.23	312.0	36765.4	0.2	5004.8	25.57	-3749.5	76.8	0.0	-71.8
5.17	474.3	2764.1	0.9	1435.2	15.50	312.0	38056.3	0.2	5084.7	25.84	-3786.9	0.0	0.0	0.0
5.44	479.0	3145.7	0.8	1557.4	15.78	312.0	39499.9	0.2	5172.7	26.11	-3820.8	0.0	0.0	0.0
5.71	484.2	3601.8	0.8	1693.2	16.05	312.0	40968.3	0.1	5260.6	26.38	-3858.2	0.0	0.0	0.0
5.98	489.4	4096.3	0.8	1830.4	16.32	312.0	42324.7	0.1	5340.5	26.66	-3895.5	0.0	0.0	0.0
6.26	494.1	4579.6	0.8	1956.5	16.59	-2560.9	43829.7	0.1	5140.4	26.93	-3929.5	0.0	0.0	0.0
6.53	499.2	5148.6	0.8	2096.5	16.86	-2594.9	45070.3	0.1	4480.6	27.20	-3966.9	0.0	0.0	0.0
6.80	504.0	5700.3	0.7	2225.1	17.14	-2632.2	46238.5	0.1	3744.7	27.47	-4004.2	0.0	0.0	0.0
7.07	509.1	6345.4	0.7	2367.9	17.41	-2669.6	47198.0	0.1	2998.4	27.74	-4038.2	0.0	0.0	0.0
7.34	514.3	7030.9	0.7	2512.2	17.68	-2703.5	47886.8	0.1	2310.7	28.02	-4075.5	0.0	0.0	0.0
7.62	311.8	7688.6	0.7	2623.5	17.95	-2740.9	48439.8	0.1	1544.2	28.29	-4109.5	0.0	0.0	0.0
7.89	311.9	8438.9	0.7	2711.4	18.22	-2778.3	48775.6	0.1	767.2	28.56	-4146.8	0.0	0.0	0.0
8.16	311.9	9214.0	0.6	2799.3	18.50	-2812.2	48889.6	0.1	51.7	28.83	-4184.2	0.0	0.0	0.0
8.43	311.9	9940.0	0.6	2879.2	18.77	-2849.6	48727.6	0.1	-117.9	29.10	-4218.2	0.0	0.0	0.0
8.70	311.9	10762.4	0.6	2967.1	19.04	-2883.5	48217.8	0.0	-227.0	29.38	-4255.5	0.0	0.0	0.0
8.98	311.9	11531.4	0.6	3047.0	19.31	-2920.9	47288.6	0.0	-337.0	29.65	-4292.9	0.0	0.0	0.0
9.25	311.9	12401.0	0.6	3134.9	19.58	-2958.2	46007.4	0.0	-436.5	29.92	-4326.8	0.0	0.0	0.0
9.52	311.9	13295.3	0.5	3222.7	19.86	-2992.2	44567.0	0.0	-517.9	30.19	-4364.2	0.0	0.0	0.0
9.79	311.9	14129.9	0.5	3302.6	20.13	-3029.6	42711.8	0.0	-597.3	30.46	-4398.2	0.0	0.0	0.0
10.06	311.9	15071.5	0.5	3390.5	20.40	-3063.5	40807.7	0.0	-660.3	30.74	-4435.5	0.0	0.0	0.0

Tetra Tech

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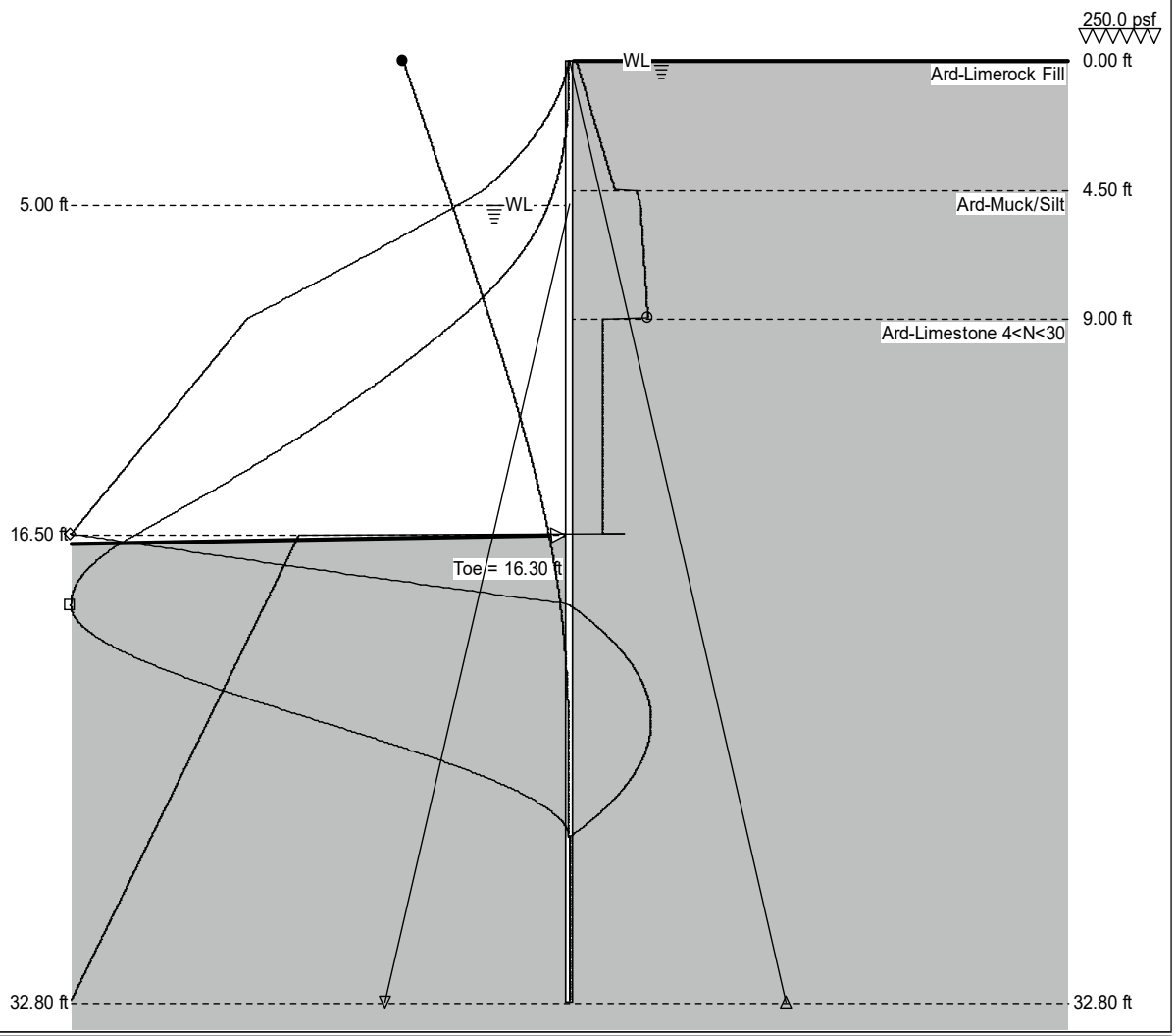
SPW911, v2.40

Client: City of Key West
Site: Key West Bight

Title: Conch to Schooner Seawall
Designer: Francisco Martinez
Ref: KWCtoS
Page: 1
Date: 4.20.18

Sheet: DZ-95 (A690)
Pressure: Rankine
FOS: 2.0
Toe: Cantilever

	Maximum	d (ft)
○	744.7 psf	8.99
□	63173.5 ftlb/ft	18.97
◇	6633.5 lb/ft	16.51
●	2.1 in	0.00
△	2047.6 psf	32.80
▽	1735.4 psf	32.80



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Client: City of Key West
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Title: Conch to Schooner Seawall
Designer: Francisco Martinez
Ref: KWCtoS
Page: 2
Date: 4.20.18

Sheet: DZ-95 (A690)
Pressure: Rankine
FOS: 2.0
Toe: Cantilever

Input Data

Depth Of Excavation = 16.50 ft Depth Of Active Water = 0.00 ft Water Density = 62.43 pcf
Surcharge = 250.0 psf Depth Of Passive Water = 5.00 ft Minimum Fluid Density = 31.82 pcf
Slope (passive) = 1.0 degrees

Soil Profile

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	ϕ(°)	δ(°)	K_a	K_{ac}	K_p	K_{pc}
0.00	Ard-Limerock Fill	125.00	68.00	0.0	0.0	35.0	0.0	0.27	0.00	3.69	0.00
4.50	Ard-Muck/Silt	70.00	29.00	0.0	0.0	13.0	0.0	0.63	0.00	1.58	0.00
9.00	Ard-Limestone 4<N<30	120.00	65.00	1000.0	0.0	20.0	0.0	0.49	1.40	2.04	2.86

Solution

Sheet

Sheet Name	I (in⁴/ft)	E (psi)	Z (in³/ft)	f (psi)	Maximum Bending Moment (ftlb/ft)	Upstand (ft)	Toe (ft)	Pile Length (ft)
DZ-95 (A690)	311.22	3.04E+07	37.72	32500.1	102158.2	0.00	16.30	32.80

Maxima

	Maximum	Depth
Bending Moment	63173.5 ftlb/ft	18.97 ft
Deflection	2.1 in	0.00 ft
Pressure	744.7 psf	8.99 ft
Shear Force	6633.5 lb/ft	16.51 ft

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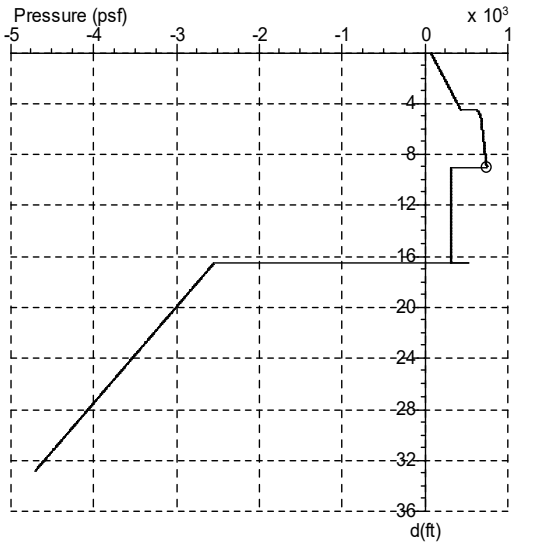
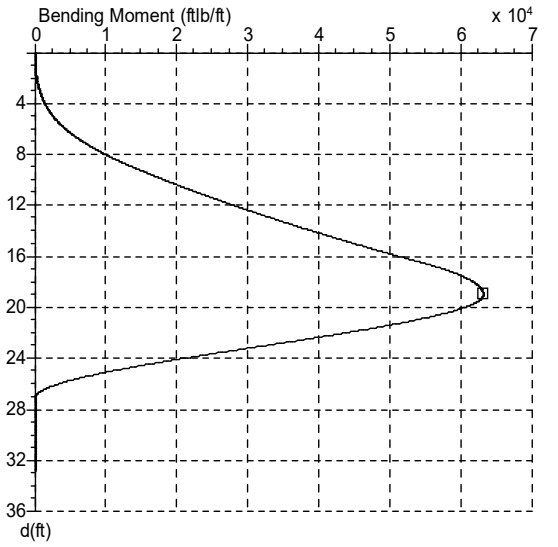
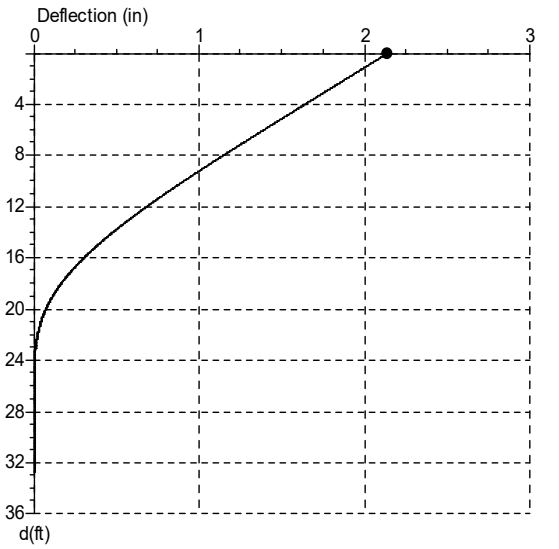
Title: Conch to Schooner Seawall
Designer: Francisco Martinez
Ref: KWCtoS
Page: 3
Date: 4.20.18

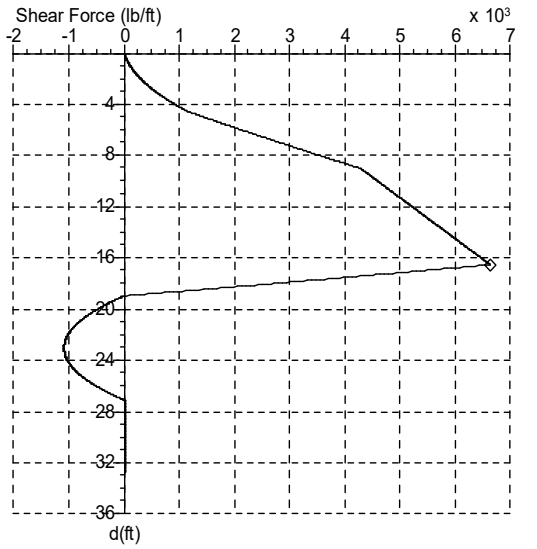
Sheet: DZ-95 (A690)
Pressure: Rankine
FOS: 2.0
Toe: Cantilever

Maximum		d (ft)
○	744.7 psf	8.99
□	63173.5 ftlb/ft	18.97
◇	6633.5 lb/ft	16.51
●	2.1 in	0.00









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SPW911, v2.40

Client: City of Key West
Site: Key West Bight

Title: Conch to Schooner Seawall
Designer: Francisco Martinez
Ref: KWCtoS
Page: 4
Date: 4.20.18

Sheet: DZ-95 (A690)
Pressure: Rankine
FOS: 2.0
Toe: Cantilever

depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)
0.00	67.5	0.0	2.1	0.0	11.03	312.2	23268.2	0.8	4920.5	22.06	-3284.6	42848.4	0.0	-1029.8
0.29	91.8	3.1	2.1	24.3	11.32	312.2	24623.3	0.8	5005.8	22.35	-3324.5	39488.4	0.0	-1062.5
0.58	113.9	13.1	2.1	52.7	11.61	312.2	26140.8	0.7	5099.7	22.64	-3360.7	36356.9	0.0	-1081.8
0.87	138.2	34.0	2.0	90.9	11.90	312.2	27544.9	0.7	5185.1	22.93	-3400.6	32863.1	0.0	-1091.6
1.16	160.2	63.8	2.0	132.0	12.19	312.2	29116.3	0.7	5279.0	23.22	-3440.5	29355.3	0.0	-1089.4
1.45	184.5	110.4	2.0	184.2	12.48	312.2	30715.9	0.6	5372.9	23.51	-3476.7	26186.7	0.0	-1077.1
1.74	208.8	173.7	1.9	243.7	12.77	312.2	32194.6	0.6	5458.2	23.80	-3516.6	22759.1	0.0	-1052.0
2.03	230.9	247.6	1.9	304.1	13.06	312.2	33848.1	0.6	5552.1	24.09	-3552.8	19727.2	0.0	-1018.8
2.32	255.2	348.8	1.8	377.5	13.35	312.2	35375.8	0.5	5637.5	24.38	-3592.7	16520.2	0.0	-970.9
2.61	279.5	473.2	1.8	458.2	13.64	312.2	37083.2	0.5	5731.4	24.67	-3632.5	13484.8	0.0	-910.9
2.90	301.6	608.1	1.8	538.0	13.93	312.2	38818.9	0.5	5825.3	24.96	-3668.8	10906.7	0.0	-846.0
3.19	325.9	782.5	1.7	632.6	14.22	312.2	40421.2	0.5	5910.6	25.25	-3708.7	8305.8	0.0	-763.2
3.48	347.9	966.6	1.7	725.0	14.51	312.2	42210.7	0.4	6004.5	25.54	-3748.5	5988.5	0.0	-668.4
3.77	372.2	1199.2	1.7	833.6	14.80	312.2	44028.4	0.4	6098.4	25.83	-3784.8	4160.4	0.0	-571.9
4.06	396.5	1465.4	1.6	949.6	15.09	312.2	45705.4	0.4	6183.8	26.12	-3824.6	2491.5	0.0	-454.2
4.35	418.6	1738.5	1.6	1061.3	15.38	312.2	47577.0	0.4	6277.7	26.41	-3860.9	1316.6	0.0	-336.8
4.64	643.7	2076.6	1.6	1218.6	15.67	312.2	49303.0	0.3	6363.0	26.70	-3900.7	436.5	0.0	-196.2
4.93	667.4	2469.7	1.5	1416.1	15.96	312.2	51228.5	0.3	6456.9	26.99	-3940.6	25.6	0.0	-43.7
5.22	675.7	2879.3	1.5	1600.1	16.25	312.2	53182.2	0.3	6550.8	27.28	-3976.8	0.0	0.0	0.0
5.51	681.2	3388.1	1.4	1804.2	16.54	-2552.6	54982.9	0.3	6563.7	27.57	-4016.7	0.0	0.0	0.0
5.80	686.2	3904.1	1.4	1991.2	16.83	-2592.4	56850.7	0.2	5791.0	27.86	-4053.0	0.0	0.0	0.0
6.10	691.7	4530.9	1.4	2198.5	17.12	-2632.2	58484.4	0.2	5006.1	28.15	-4092.8	0.0	0.0	0.0
6.39	697.2	5220.2	1.3	2407.4	17.41	-2668.5	59763.6	0.2	4282.3	28.44	-4132.7	0.0	0.0	0.0
6.68	702.2	5901.6	1.3	2598.7	17.71	-2708.3	60940.8	0.2	3474.6	28.73	-4168.9	0.0	0.0	0.0
6.97	707.7	6711.7	1.3	2810.8	18.00	-2744.6	61798.9	0.2	2729.9	29.02	-4208.8	0.0	0.0	0.0
7.26	712.6	7503.6	1.2	3005.0	18.29	-2784.5	62506.3	0.1	1899.3	29.31	-4248.7	0.0	0.0	0.0
7.55	718.1	8436.2	1.2	3220.2	18.58	-2824.3	62962.4	0.1	1056.7	29.61	-4284.9	0.0	0.0	0.0
7.84	723.6	9433.8	1.2	3437.1	18.87	-2860.6	63155.9	0.1	280.4	29.90	-4324.8	0.0	0.0	0.0
8.13	728.6	10397.4	1.1	3635.6	19.16	-2900.4	63084.6	0.1	-100.5	30.19	-4361.0	0.0	0.0	0.0
8.42	734.1	11520.2	1.1	3855.7	19.45	-2940.3	62541.9	0.1	-248.7	30.48	-4400.9	0.0	0.0	0.0
8.71	739.6	12709.5	1.1	4077.3	19.74	-2976.5	61649.4	0.1	-373.0	30.77	-4440.8	0.0	0.0	0.0
9.00	744.7	13848.6	1.0	4280.3	20.03	-3016.4	60264.5	0.1	-498.3	31.06	-4477.0	0.0	0.0	0.0
9.29	312.2	15148.0	1.0	4374.2	20.32	-3052.7	58670.3	0.1	-601.9	31.35	-4516.9	0.0	0.0	0.0
9.58	312.2	16353.8	1.0	4459.5	20.61	-3092.5	56583.5	0.1	-704.3	31.64	-4556.7	0.0	0.0	0.0
9.87	312.2	17707.1	0.9	4553.4	20.90	-3132.4	54185.1	0.0	-794.7	31.93	-4593.0	0.0	0.0	0.0
10.16	312.2	19088.7	0.9	4647.3	21.19	-3168.6	51766.8	0.0	-866.5	32.22	-4632.8	0.0	0.0	0.0
10.45	312.2	20369.1	0.9	4732.7	21.48	-3208.5	48880.4	0.0	-934.1	32.51	-4669.1	0.0	0.0	0.0
10.74	312.2	21804.5	0.8	4826.6	21.77	-3244.7	46082.3	0.0	-985.1	32.80	-4709.0	0.0	0.0	0.0

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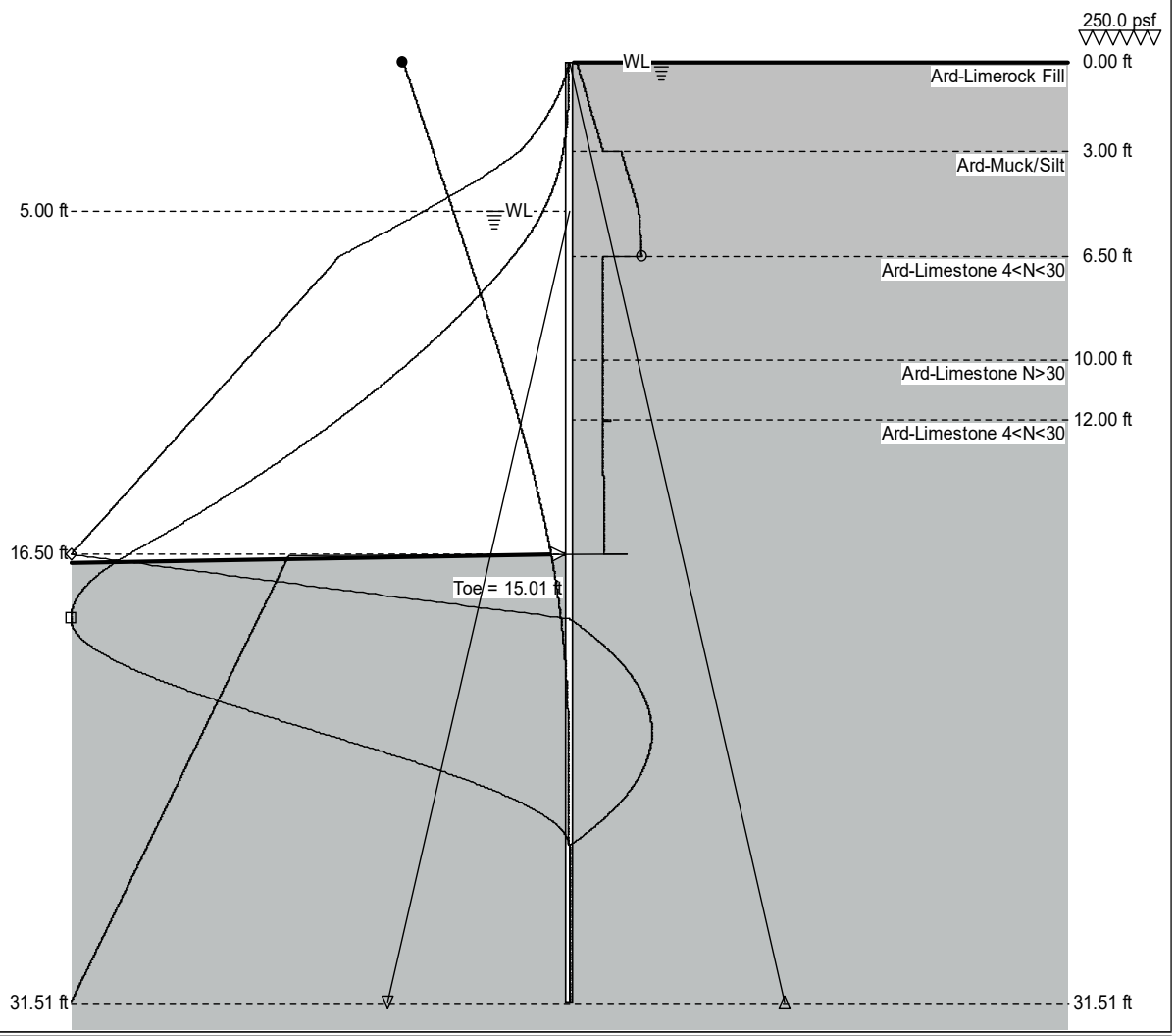
Toe: Cantilever

Maximum		d (ft)
○	662.1 psf	6.51
□	54567.6 ftlb/ft	18.64
◇	5782.2 lb/ft	16.49
●	1.5 in	0.00
△	1967.4 psf	31.51
▽	1655.2 psf	31.51



Tetra Tech

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SPW911, v2.40

Client: City of Key West
Site: Key West Bight

Title: Conch to Schooner Seawall
Designer: Francisco Martinez
Ref: KWCtoS
Page: 2
Date: 4.20.18

Sheet: PZ35
Pressure: Rankine
FOS: 2.0
Toe: Cantilever

Input Data

Depth Of Excavation = 16.50 ft Depth Of Active Water = 0.00 ft Water Density = 62.43 pcf
Surcharge = 250.0 psf Depth Of Passive Water = 5.00 ft Minimum Fluid Density = 31.82 pcf
Slope (passive) = 1.0 degrees

Soil Profile

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	ϕ(°)	δ(°)	K_a	K_{ac}	K_p	K_{pc}
0.00	Ard-Limerock Fill	125.00	68.00	0.0	0.0	35.0	0.0	0.27	0.00	3.69	0.00
3.00	Ard-Muck/Silt	70.00	29.00	0.0	0.0	13.0	0.0	0.63	0.00	1.58	0.00
6.50	Ard-Limestone 4<N<30	120.00	65.00	1000.0	0.0	20.0	0.0	0.49	1.40	2.04	2.86
10.00	Ard-Limestone N>30	125.00	67.00	5000.0	0.0	20.0	0.0	0.49	1.40	2.04	2.86
12.00	Ard-Limestone 4<N<30	120.00	65.00	1000.0	0.0	20.0	0.0	0.49	1.40	2.04	2.86

Solution

Sheet

Sheet Name	I (in⁴/ft)	E (psi)	Z (in³/ft)	f (psi)	Maximum Bending Moment (ftlb/ft)	Upstand (ft)	Toe (ft)	Pile Length (ft)
PZ35	369.40	3.04E+07	48.90	24970.3	101753.7	0.00	15.01	31.51

Maxima

	Maximum	Depth
Bending Moment	54567.6 ftlb/ft	18.64 ft
Deflection	1.5 in	0.00 ft
Pressure	662.1 psf	6.51 ft
Shear Force	5782.2 lb/ft	16.49 ft

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Title: Conch to Schooner Seawall
Designer: Francisco Martinez
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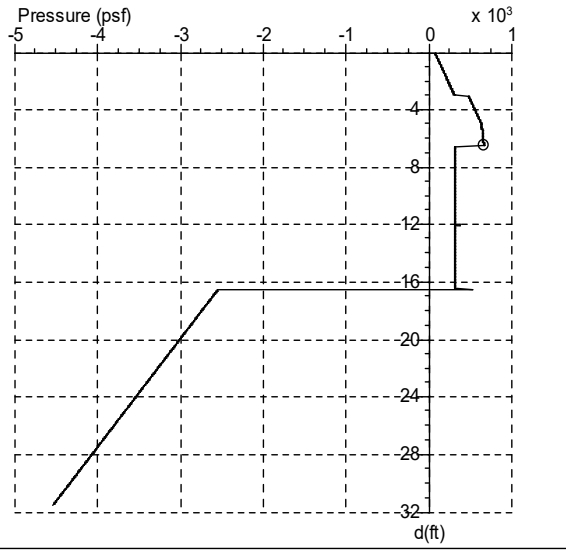
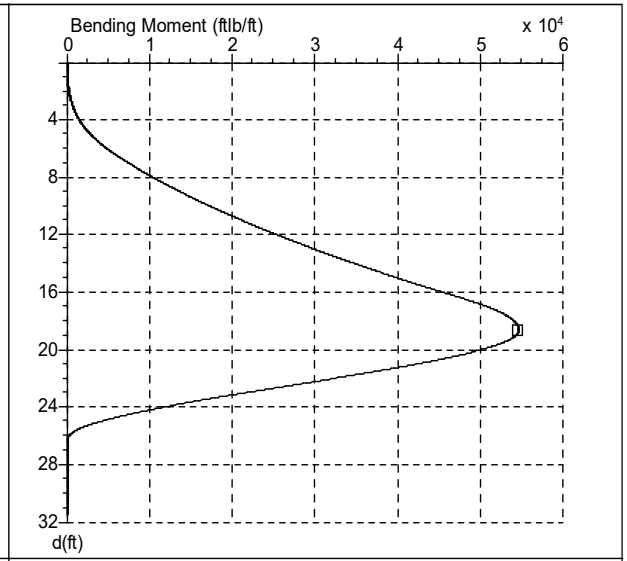
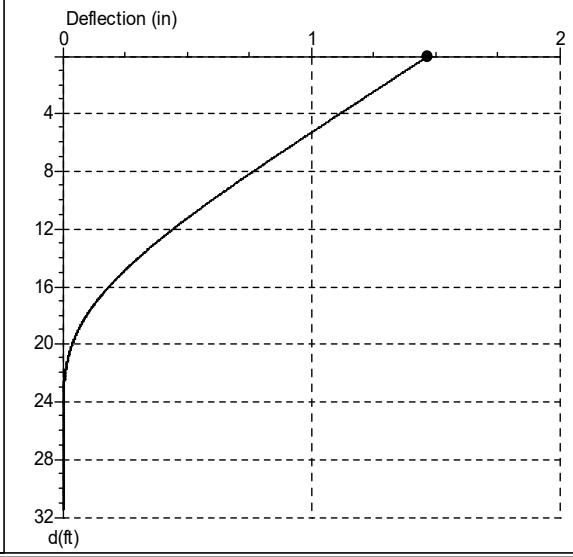
Page: 3
Date: 4.20.18

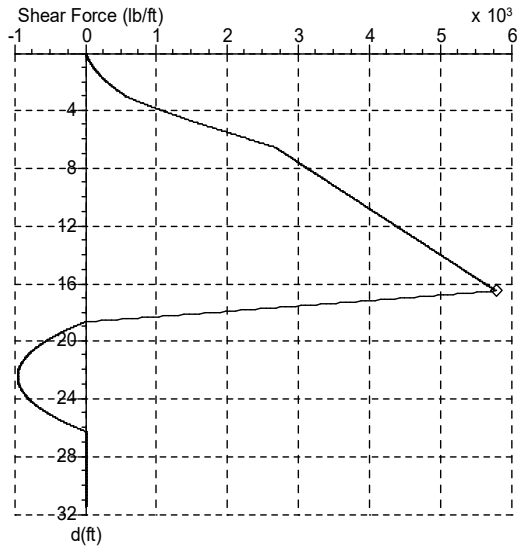
Sheet: PZ35
Pressure: Rankine
FOS: 2.0
Toe: Cantilever

Maximum		d (ft)
○	662.1 psf	6.51
□	54567.6 ftlb/ft	18.64
◇	5782.2 lb/ft	16.49
●	1.5 in	0.00









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SPW911, v2.40

Client: City of Key West
Site: Key West Bight

Title: Conch to Schooner Seawall
Designer: Francisco Martinez
Ref: KWCtoS
Page: 4
Date: 4.20.18

Sheet: PZ35
Pressure: Rankine
FOS: 2.0
Toe: Cantilever

depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)
0.00	67.5	0.0	1.5	0.0	10.60	311.6	19612.7	0.6	3938.8	21.19	-3170.3	40462.8	0.0	-855.8
0.28	90.8	2.9	1.4	23.2	10.88	311.6	20656.6	0.5	4020.6	21.47	-3208.6	37632.7	0.0	-898.5
0.56	112.1	12.0	1.4	50.1	11.15	311.6	21829.6	0.5	4110.7	21.75	-3243.4	34953.1	0.0	-927.8
0.84	135.4	31.1	1.4	86.2	11.43	311.7	22918.6	0.5	4192.6	22.03	-3281.7	31921.4	0.0	-949.4
1.12	156.6	58.1	1.4	124.8	11.71	311.7	24141.3	0.5	4282.6	22.31	-3320.0	28836.1	0.0	-960.0
1.39	179.9	100.4	1.3	173.7	11.99	381.8	25390.0	0.4	4374.5	22.59	-3354.8	26014.7	0.0	-960.0
1.67	203.3	157.8	1.3	229.4	12.27	311.7	26548.7	0.4	4458.2	22.87	-3393.1	22926.1	0.0	-949.4
1.95	224.5	224.5	1.3	285.9	12.55	311.7	27848.1	0.4	4548.3	23.15	-3427.9	20161.0	0.0	-930.2
2.23	247.8	315.9	1.3	354.4	12.83	311.7	29052.0	0.4	4630.2	23.43	-3466.2	17199.6	0.0	-898.6
2.51	271.2	428.0	1.2	429.7	13.11	311.7	30401.1	0.4	4720.2	23.70	-3504.5	14356.7	0.0	-855.8
2.79	292.4	549.5	1.2	504.0	13.39	311.7	31776.2	0.3	4810.3	23.98	-3539.3	11905.3	0.0	-807.4
3.07	479.2	706.8	1.2	605.1	13.66	311.7	33048.9	0.3	4892.2	24.26	-3577.6	9388.1	0.0	-743.5
3.35	500.4	880.8	1.2	734.0	13.94	311.7	34473.6	0.3	4982.2	24.54	-3615.9	7093.4	0.0	-668.6
3.63	523.7	1112.1	1.1	882.2	14.22	311.7	35924.4	0.3	5072.3	24.82	-3650.8	5230.5	0.0	-590.8
3.90	547.0	1387.1	1.1	1037.2	14.50	311.7	37265.9	0.3	5154.2	25.10	-3689.1	3459.9	0.0	-494.8
4.18	568.2	1676.6	1.1	1184.0	14.78	311.7	38766.3	0.3	5244.3	25.38	-3723.9	2132.7	0.0	-397.9
4.46	591.5	2040.4	1.1	1351.8	15.06	311.7	40152.9	0.2	5326.2	25.66	-3762.2	1016.5	0.0	-280.7
4.74	614.8	2453.6	1.0	1526.4	15.34	311.7	41703.0	0.2	5416.2	25.94	-3800.5	294.9	0.0	-152.5
5.02	634.3	2873.7	1.0	1690.9	15.62	311.8	43279.2	0.2	5506.3	26.21	-3835.3	11.6	0.0	-26.3
5.30	639.6	3386.2	1.0	1875.0	15.90	311.8	44734.6	0.2	5588.2	26.49	-3873.6	0.0	0.0	0.0
5.58	644.4	3898.4	1.0	2043.8	16.17	311.8	46360.4	0.2	5678.3	26.77	-3908.4	0.0	0.0	0.0
5.86	649.7	4513.2	1.0	2230.8	16.45	311.8	48012.2	0.2	5768.4	27.05	-3946.7	0.0	0.0	0.0
6.14	655.0	5182.2	0.9	2419.4	16.73	-2578.4	49466.6	0.1	5176.9	27.33	-3985.0	0.0	0.0	0.0
6.41	659.8	5837.8	0.9	2592.1	17.01	-2616.7	50863.6	0.1	4427.1	27.61	-4019.8	0.0	0.0	0.0
6.69	311.5	6606.5	0.9	2718.9	17.29	-2651.5	51944.5	0.1	3735.8	27.89	-4058.1	0.0	0.0	0.0
6.97	311.5	7330.0	0.9	2800.7	17.57	-2689.8	52922.5	0.1	2964.9	28.17	-4096.4	0.0	0.0	0.0
7.25	311.6	8150.8	0.8	2890.7	17.85	-2728.1	53676.4	0.1	2182.9	28.44	-4131.2	0.0	0.0	0.0
7.53	311.6	8997.5	0.8	2980.8	18.13	-2763.0	54164.6	0.1	1462.3	28.72	-4169.5	0.0	0.0	0.0
7.81	311.6	9789.8	0.8	3062.6	18.41	-2801.3	54481.8	0.1	659.2	29.00	-4204.3	0.0	0.0	0.0
8.09	311.6	10686.1	0.8	3152.6	18.68	-2839.6	54563.7	0.1	-26.3	29.28	-4242.6	0.0	0.0	0.0
8.37	311.6	11608.5	0.7	3242.7	18.96	-2874.4	54317.5	0.1	-152.5	29.56	-4280.9	0.0	0.0	0.0
8.65	311.6	12469.5	0.7	3324.5	19.24	-2912.7	53633.6	0.1	-280.7	29.84	-4315.7	0.0	0.0	0.0
8.92	311.6	13441.5	0.7	3414.5	19.52	-2947.5	52665.7	0.0	-387.7	30.12	-4354.0	0.0	0.0	0.0
9.20	311.6	14347.7	0.7	3496.4	19.80	-2985.8	51253.1	0.0	-494.8	30.40	-4392.3	0.0	0.0	0.0
9.48	311.6	15369.3	0.6	3586.4	20.08	-3024.1	49510.8	0.0	-590.8	30.68	-4427.1	0.0	0.0	0.0
9.76	311.6	16417.0	0.6	3676.5	20.36	-3058.9	47670.8	0.0	-668.5	30.95	-4465.4	0.0	0.0	0.0
10.04	319.2	17392.0	0.6	3758.7	20.64	-3097.2	45398.2	0.0	-743.5	31.23	-4500.3	0.0	0.0	0.0
10.32	311.6	18489.3	0.6	3848.7	20.92	-3132.0	43135.4	0.0	-802.0	31.51	-4538.5	0.0	0.0	0.0

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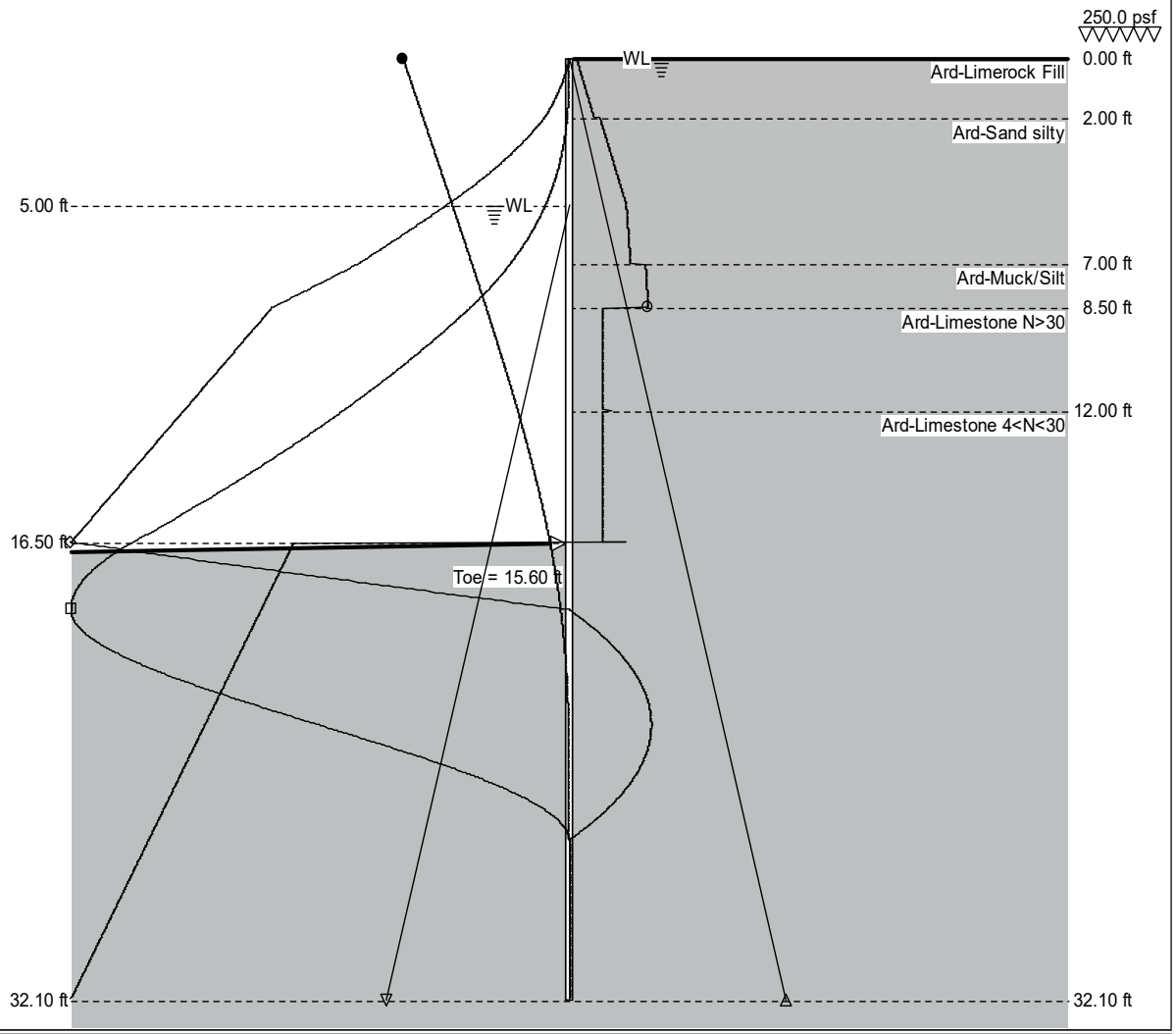
SPW911, v2.40

Client: City of Key West
Site: Key West Bight

Title: Conch to Schooner Seawall
Designer: Francisco Martinez
Ref: KWCtoS
Page: 1
Date: 4.20.18

Sheet: PZ35
Pressure: Rankine
FOS: 2.0
Toe: Cantilever

	Maximum	d (ft)
○	733.9 psf	8.51
□	58606.2 ftlb/ft	18.81
◇	6213.7 lb/ft	16.51
●	1.6 in	0.00
△	2004.1 psf	32.10
▽	1691.9 psf	32.10



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Page: 2
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Sheet: PZ35
Pressure: Rankine
FOS: 2.0
Toe: Cantilever

Input Data

Depth Of Excavation = 16.50 ft Depth Of Active Water = 0.00 ft Water Density = 62.43 pcf
Surcharge = 250.0 psf Depth Of Passive Water = 5.00 ft Minimum Fluid Density = 31.82 pcf
Slope (passive) = 1.0 degrees

Soil Profile

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	ϕ(°)	δ(°)	K_a	K_{ac}	K_p	K_{pc}
0.00	Ard-Limerock Fill	125.00	68.00	0.0	0.0	35.0	0.0	0.27	0.00	3.69	0.00
2.00	Ard-Sand silty	100.00	48.00	0.0	0.0	25.0	0.0	0.41	0.00	2.46	0.00
7.00	Ard-Muck/Silt	70.00	29.00	0.0	0.0	13.0	0.0	0.63	0.00	1.58	0.00
8.50	Ard-Limestone N>30	125.00	67.00	5000.0	0.0	20.0	0.0	0.49	1.40	2.04	2.86
12.00	Ard-Limestone 4<N<30	120.00	65.00	1000.0	0.0	20.0	0.0	0.49	1.40	2.04	2.86

Solution

Sheet

Sheet Name	I (in⁴/ft)	E (psi)	Z (in³/ft)	f (psi)	Maximum Bending Moment (ftlb/ft)	Upstand (ft)	Toe (ft)	Pile Length (ft)
PZ35	369.40	3.04E+07	48.90	24970.3	101753.7	0.00	15.60	32.10

Maxima

	Maximum	Depth
Bending Moment	58606.2 ftlb/ft	18.81 ft
Deflection	1.6 in	0.00 ft
Pressure	733.9 psf	8.51 ft
Shear Force	6213.7 lb/ft	16.51 ft

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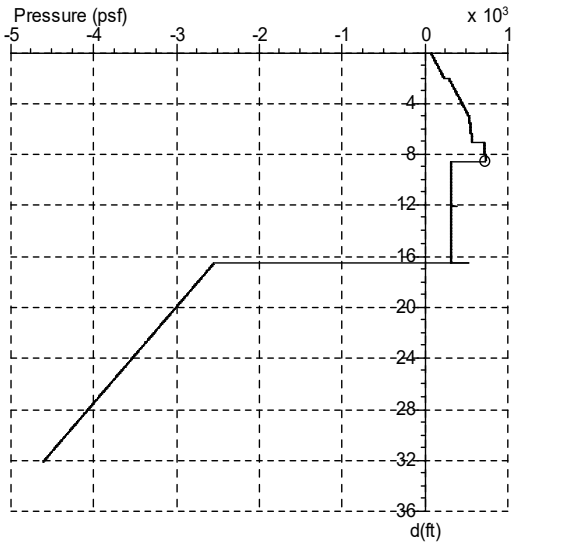
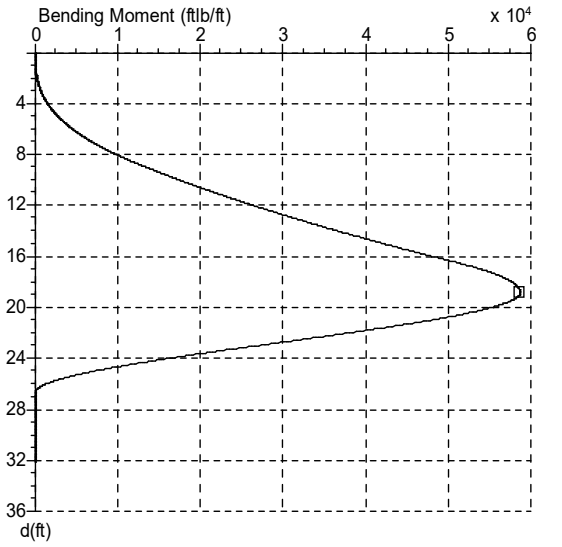
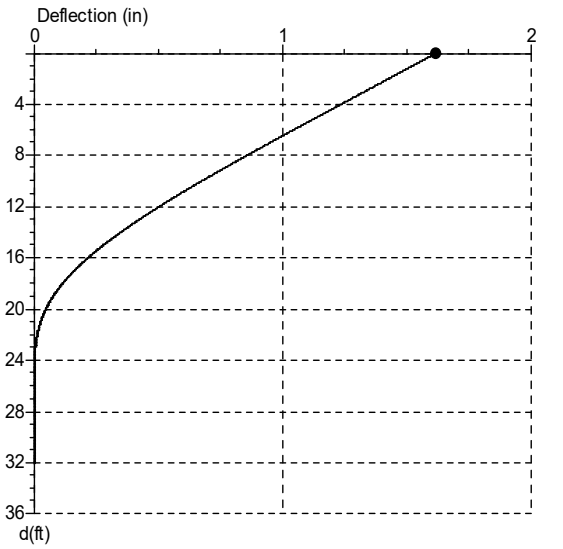
Title: Conch to Schooner Seawall
Designer: Francisco Martinez
Ref: KWCtoS
Page: 3
Date: 4.20.18

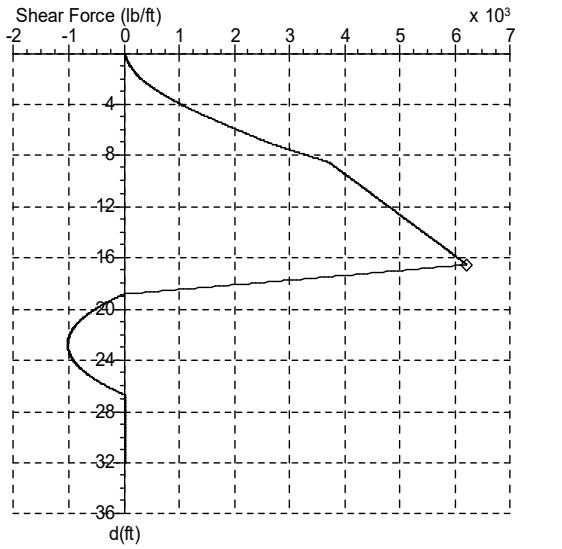
Sheet: PZ35
Pressure: Rankine
FOS: 2.0
Toe: Cantilever

Maximum		d (ft)
○	733.9 psf	8.51
□	58606.2 ftlb/ft	18.81
◇	6213.7 lb/ft	16.51
●	1.6 in	0.00









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SPW911, v2.40

Client: City of Key West
Site: Key West Bight

Title: Conch to Schooner Seawall
Designer: Francisco Martinez
Ref: KWCtoS
Page: 4
Date: 4.20.18

Sheet: PZ35
Pressure: Rankine
FOS: 2.0
Toe: Cantilever

depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)
0.00	67.5	0.0	1.6	0.0	10.79	312.3	20968.9	0.6	4424.6	21.59	-3222.4	41931.4	0.0	-937.5
0.28	91.3	3.0	1.6	23.7	11.08	312.3	22162.4	0.6	4508.2	21.87	-3261.5	38863.7	0.0	-976.6
0.57	112.9	12.5	1.6	51.3	11.36	312.3	23501.0	0.6	4600.1	22.16	-3296.0	35979.5	0.0	-1002.3
0.85	136.7	32.4	1.5	88.3	11.65	312.3	24741.4	0.5	4683.6	22.44	-3336.0	32735.8	0.0	-1019.6
1.14	158.3	60.7	1.5	128.1	11.93	312.3	26131.6	0.5	4775.5	22.73	-3375.0	29453.5	0.0	-1025.3
1.42	182.0	104.9	1.5	178.5	12.22	312.3	27549.7	0.5	4871.2	23.01	-3410.5	26467.1	0.0	-1020.6
1.70	205.8	164.9	1.5	235.9	12.50	312.3	28862.6	0.5	4954.8	23.29	-3449.5	23213.6	0.0	-1004.4
1.99	227.4	234.9	1.4	294.1	12.78	312.3	30332.6	0.4	5046.7	23.58	-3484.9	20314.5	0.0	-979.7
2.27	305.9	332.5	1.4	379.5	13.07	312.3	31692.4	0.4	5130.2	23.86	-3524.0	17224.0	0.0	-941.6
2.56	330.0	456.5	1.4	473.4	13.35	312.3	33214.1	0.4	5222.1	24.15	-3563.0	14272.5	0.0	-892.0
2.84	351.9	594.0	1.3	564.9	13.64	312.3	34762.7	0.4	5314.0	24.43	-3598.5	11741.0	0.0	-837.0
3.12	376.1	774.4	1.3	672.3	13.92	312.3	36194.1	0.4	5397.6	24.71	-3637.5	9157.1	0.0	-765.5
3.41	398.0	966.6	1.3	776.2	14.20	312.3	37794.4	0.3	5489.5	25.00	-3676.5	6819.4	0.0	-682.5
3.69	422.1	1211.0	1.3	897.2	14.49	312.3	39421.7	0.3	5581.4	25.28	-3712.0	4938.7	0.0	-597.1
3.98	446.3	1491.9	1.2	1025.4	14.77	312.2	40924.6	0.3	5665.0	25.57	-3751.0	3173.2	0.0	-492.2
4.26	468.2	1780.8	1.2	1148.0	15.06	312.2	42603.5	0.3	5756.9	25.85	-3786.5	1873.7	0.0	-386.8
4.55	492.4	2137.3	1.2	1289.7	15.34	312.2	44153.3	0.3	5840.4	26.14	-3825.5	814.6	0.0	-260.0
4.83	516.5	2536.4	1.2	1438.5	15.62	312.2	45883.9	0.2	5932.3	26.42	-3864.5	179.1	0.0	-121.7
5.11	531.8	2938.1	1.1	1579.5	15.91	312.2	47641.5	0.2	6024.2	26.70	-3900.0	0.0	0.0	0.0
5.40	537.5	3423.8	1.1	1736.9	16.19	312.2	49262.8	0.2	6107.8	26.99	-3939.0	0.0	0.0	0.0
5.68	542.8	3905.7	1.1	1881.5	16.48	312.2	51072.0	0.2	6199.7	27.27	-3974.5	0.0	0.0	0.0
5.97	548.6	4480.7	1.0	2042.2	16.76	-2583.9	52817.4	0.2	5527.7	27.56	-4013.5	0.0	0.0	0.0
6.25	554.4	5103.2	1.0	2204.6	17.04	-2619.4	54212.3	0.2	4832.3	27.84	-4052.5	0.0	0.0	0.0
6.53	559.7	5710.7	1.0	2353.7	17.33	-2658.4	55530.5	0.1	4056.3	28.12	-4088.0	0.0	0.0	0.0
6.82	565.4	6425.3	1.0	2519.4	17.61	-2693.9	56529.5	0.1	3340.9	28.41	-4127.0	0.0	0.0	0.0
7.10	708.7	7117.7	0.9	2682.5	17.90	-2732.9	57406.0	0.1	2543.0	28.69	-4166.0	0.0	0.0	0.0
7.39	714.0	7934.9	0.9	2892.0	18.18	-2771.9	58046.2	0.1	1733.6	28.98	-4201.5	0.0	0.0	0.0
7.67	719.3	8813.9	0.9	3103.0	18.47	-2807.4	58420.3	0.1	987.9	29.26	-4240.5	0.0	0.0	0.0
7.95	724.1	9667.1	0.9	3296.2	18.75	-2846.4	58600.0	0.1	156.6	29.54	-4276.0	0.0	0.0	0.0
8.24	729.4	10665.4	0.8	3510.1	19.03	-2885.4	58462.5	0.1	-121.7	29.83	-4315.0	0.0	0.0	0.0
8.52	312.2	11726.9	0.8	3714.4	19.32	-2920.9	57939.7	0.1	-247.9	30.11	-4354.1	0.0	0.0	0.0
8.81	312.3	12730.4	0.8	3797.9	19.60	-2959.9	56954.9	0.1	-375.8	30.40	-4389.5	0.0	0.0	0.0
9.09	312.3	13860.0	0.8	3889.8	19.89	-2995.4	55717.3	0.1	-482.0	30.68	-4428.5	0.0	0.0	0.0
9.37	312.3	14910.5	0.7	3973.4	20.17	-3034.4	54013.3	0.0	-588.0	30.96	-4467.6	0.0	0.0	0.0
9.66	312.3	16091.7	0.7	4065.3	20.45	-3073.5	51986.3	0.0	-682.4	31.25	-4503.0	0.0	0.0	0.0
9.94	312.3	17300.1	0.7	4157.2	20.74	-3108.9	49894.1	0.0	-758.4	31.53	-4542.1	0.0	0.0	0.0
10.23	312.3	18422.0	0.7	4240.8	21.02	-3147.9	47352.4	0.0	-830.9	31.82	-4577.5	0.0	0.0	0.0
10.51	312.3	19682.0	0.6	4332.7	21.31	-3183.4	44853.4	0.0	-886.9	32.10	-4616.5	0.0	0.0	0.0

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APPENDIX 7

Engineer's Opinion of Probable Cost

Line

City of Key West / Schooner Wharf to Conch Republic - 380 LF Seawall w/ Concrete Cap

February 2018

	Description	Quantity	Units	Unit Price	Amount
	Direct Cost				
	General - Seawall				
1	Upland Staging Area (provided by City of Key West)	1	LS	10,000	10,000
2	Utility Coordination	1	LS	3,000	3,000
3	Preconstruction Seismic Survey & Video	1	LS	4,500	4,500
4	Temporary Construction Fencing (6' High, 12' Sections of Chain Link with Wind Screen & Sandbags)	380	LF	11.00	4,180
5	Erosion & Sediment Control	1	LS	20,000	20,000
6	General Site Preparation & M.O.T.	1	LS	25,000	25,000
7	Demo - sidewalks, slabs, wooden decks	80	SF	10.02	802
8	Temporary Utility Relocation, Pumpout, Water & Electric	1	LS	50,000	50,000
9	Steel Sheet Piling (24' long, A-690 including freight)	380	LF	850	323,000
10	Steel Sheet Piling installation (driven from water)	380	LF	380	144,400
11	Concrete - Cap, 6,000 PSI, Ext. Aggressive Env, 7 - #5 bar w/ Stirrups	450	LF	357	160,650
12	Extend Drainage Outfalls	3	EA	5,000	15,000
13	Tremie Grout for fill between sheetpile (= 380'x1'x8'/27)	112	CY	350	39,200
14	Sidewalk (includes 36 sf section to be repaired)	1,685	SF	6.55	11,040
15	Lift & Reset Pavers	1,140	EA	11.30	12,882
16	Testing - Allowance for Concrete	1	LS	10,000	10,000
17	Vibration Monitoring - during pile driving operations	1	LS	11,000	11,000
18	Site Restoration (including sidewalk and other impacts)	1	LS	70,000	70,000
19	Chemical Grouting of Cracks/Seams (A-A & B-B)	50	LF	35	1,750
20	Tremie Grout Gaps in Seawall Cap (A-A & B-B)	20	CY	500	10,000
				Subtotal	**926,404**
	Bid Options				
21	Steel Sheet Pile Meets ASTM A690 Specification for Corrosion Resistance in Marine Environments	380	LF	15.49	5,886
22	Coal Tar Epoxy Coating: 16 Mils DFT after a Near White Sand Blast; Coated Full Length All Sides	9,120	SF	2.07	18,878
23				**Subtotal**	**24,765**
				Direct Cost	**951,169**
	Contractor Cost				
24	FOOH & HOOH (Overhead) Combined (6% Typical)	6.0%		57,070	1,008,239
25	Mobilization/ Demobilization (10% Typical)	10.0%		100,824	1,109,063
26	Profit (17% Typical)	17.0%		188,541	1,297,604
27	Bonds, Permits & Insurance (2% Typical)	2.0%		25,952	1,323,556
	Direct + Contractor Cost			**372,387**	**1,323,556**
	Project Cost				
28	City of Key West Allowance Account for Administration and On-site Supervision (SIOH)	5.0%		66,178	1,389,733
29	Contingency	20.0%		277,947	1,667,680
	Direct + Contractor + Project Cost			**344,124**	**1,667,680**
				Total Construction Cost	**1,667,680**
				Cost per FT	*2,375.27*

Prepared by: DWF