TETRA TECH

October 9, 2020

Submitted via email:
kolson@@cityofkeywest-FL.gov

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

Subject: Key West Garrison Bight Seawall Assessment

Dear Ms. Olson:

Tetra Tech is pleased to submit this revised seawall assessment summary report for your review. The report discusses the condition of the City Marina at Garrison Bight (Charter Boat Row) seawall along the Southeast side of the Palm Avenue Causeway and provides our recommendations.

This report includes a copy of the project topographic survey, geotechnical report, and catalog of deficiencies found, which will serve as a basis for permitting and design in the future. A copy of the videos taken during the inspection will be provided for your reference. Additionally, swim-by videos of the other seawall sections in the vicinity (adjacent to the Palm Avenue Causeway) shall be provided for your review. If you have any questions or need any additional information, please feel free to contact me.

Sincerely,

David W. Frodsham, PE
Project Manager
FL PE No. 75507

cc: Doug Bradshaw, Director of Port & Marine Services
Francisco Martinez, Tetra Tech
Stuart McGahee, Tetra Tech

759 South Federal Highway, Suite 314 Stuart, FL 34994
Tel 772.781.3400 Fax 772.781.3411 www.tetratech.com
CA #: 2429

2020

CITY OF KEY WEST
PORT AND MARINE SERVICES

KEY WEST CITY MARINA AT GARRISON BIGHT
"CHARTER BOAT ROW" SEAWALL ASSESSMENT 2020

SUBMITTED: September 30, 2020
REVISED: October 9, 2020

This document has been digitally signed and sealed by Francisco J. Martinez, PE, License No. 86702 on the date adjacent to the Digital Signature. Printed copies of this document are not considered signed and sealed and the *SHA* authentication code must be verified on any electronic copies.	FRANCISCO J. MARTINEZ LICENSE No 86702 ★ STATE OF FLORIDA PROFESSIONAL ENGINEER ★

Francisco J Martinez

Digitally signed by Francisco J Martinez
Date: 2020.10.09 15:47:36 -04'00'

Francisco J. Martinez, PE
FL PE No. 86702

TETRA TECH

759 South Federal Highway, Suite 314 Stuart, FL 34994
Tel 772.781.3400 Fax 772.781.3411 www.tetratech.com
CA# 2429

TABLE OF CONTENTS

LIST OF FIGURES 2
LIST OF TABLES 2
APPENDICES 2
1. REPORT/INSPECTION TERMINOLOGY 3
2. EXECUTIVE SUMMARY 4
3. INTRODUCTION 6
4. SITE DESCRIPTION 8
5. INSPECTION METHODOLOGY 10
6. OBSERVATIONS AND ANALYSIS 11
7. CONCLUSIONS AND RECOMMENDATIONS 22

LIST OF FIGURES

Figure 1: Inspection Stationing Layout for Cataloguing Deficiencies 5
Figure 2: Project Limits and Surrounding Area 6
Figure 3: Typical Observed T-Pile Layout (left) and Anticipated Deficiencies (right) 7
Figure 4: Typical Seawall Cross-Section 8
Figure 5: Deficiency Locations - Station 0+00 to Station 6+00 12
Figure 6: Deficiency Locations - Station 6+00 to Station 10+10 13
Figure 7: Typical Minor Deficiencies – [Top Left] A-1 (Station 0+14), [Top Right] B-30 (Station 3+04), [Bottom Left] B-34 (Station 3+62), [Bottom Right] B-59 (Station 6+82) 18
Figure 8: Typical Moderate Deficiencies – [Top Left] B-70 (Station 7+86), [Top Right] B-53 (Station 5+48), [Bottom Left] B-26 (Station 2+86), [Bottom Right] B-102 (Station 10+06) 19
Figure 9: Typical Major Deficiencies – [Top Left] A-6 (Station 0+66), [Top Right] A-15 (Station 1+67), [Bottom Left] B-35 (Station 3+78), [Bottom Right] B-77 (Station 8+42 - 8+75) 20
Figure 10: Critical Deficiencies – [Top] A-4 (Station 0+39), [Bottom] B-45 (Station 4+44) 21

LIST OF TABLES

Table 1: Deficiency Severity Identifiers with Typical Observed Deficiencies 11
Table 2: Deficiency Locations and Descriptions 14
Table 3: Cost Estimate 23

APPENDICES

Appendix A: Topographic Survey (Florida Keys Land Surveying)
Appendix B: Geotechnical Report (Nutting Engineers)
Appendix C: Deficiencies Photo Log

1. REPORT/INSPECTION TERMINOLOGY

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.
Delamination: A horizontal or planar separation of the surfaces of concrete.
Deterioration: The decomposition of material during exposure to service.
Disintegration: The deterioration into small fragments or particles due to any cause.
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.
Honeycomb: Voids in concrete due to failure of the mortar to effectively fill the spaces between coarse aggregate. Often the result of insufficient vibration.
Low tide: The lowest level of the tide or the time at which the tide is lowest.
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 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.
Preservation: The process of maintaining a structure in its present condition of arresting further deterioration.
Random crack: A crack that meanders irregularly on the surface of concrete having no particular form.
Repair: To replace or correct deteriorated or damaged components or elements of a structure.
Spall: A chip of concrete broken from the surface of a concrete member.
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.
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. EXECUTIVE SUMMARY

From June 30 to July 1, 2020, Tetra Tech, Inc. (Tt) performed a limited structural assessment of the City Marina at Garrison Bight seawall, an area known as Charter Boat Row, on behalf of the City of Key West Port & Marine Services. The assessment was performed along the approximately 1,010 linear foot segment of the City Marina that extends from N Roosevelt Blvd. (along the seawall South of Palm Avenue Causeway) on the southeast corner of the Marina to the bridge crossing of Palm Avenue Causeway on the northwest. The seawall assessment was performed by qualified divers in the presence of a Florida licensed professional engineer with experience in seawall evaluation, design, permitting, and construction.

The purpose of the seawall assessment was to perform a visual above water and underwater inspection of the seawall condition and develop an existing conditions report that could be coupled with the recent shoreline topographic survey and geotechnical report. This report catalogs the deficiencies of the seawall and can then be used to develop engineering plans for the repair/replacement of the wall. Observations were limited to those readily apparent to the naked eye and observable from the front and/or top of the seawall. Recommendations contained within this report are made based upon engineering judgement and standard industry practices.

The following exhibit shows how the inspection transect was configured and referenced to provide a synopsis of the wall conditions. Figure 1 shows how the divers marked the basin bottom from 0-feet to 1,010-feet, along the toe of the wall.

Tape measures were used to mark the site from 0+00 feet (at N Roosevelt Blvd.) to 10+10 feet (at the bridge crossing of Palm Avenue Causeway) by placing measurement tape along the mudline of the wall. Measurements were then taken as needed perpendicular to the tape-marker at the mudline up the wall to the points of interest so that each deficiency could be catalogued. The inspection consisted of a limited nondestructive structural assessment sufficient to determine the existing visual condition of the bulkhead. Tetra Tech staff were onsite to coordinate field work logistics and catalog structural deficiencies within the designated limits of inspection.

Following the seawall inspection, it was determined that deficiencies are present at more than half of the total seawall. Although the overall condition of the seawall would not lead to immediate failure, the observed deficiencies would require a repair/replacement of the seawall within the next 5 years.

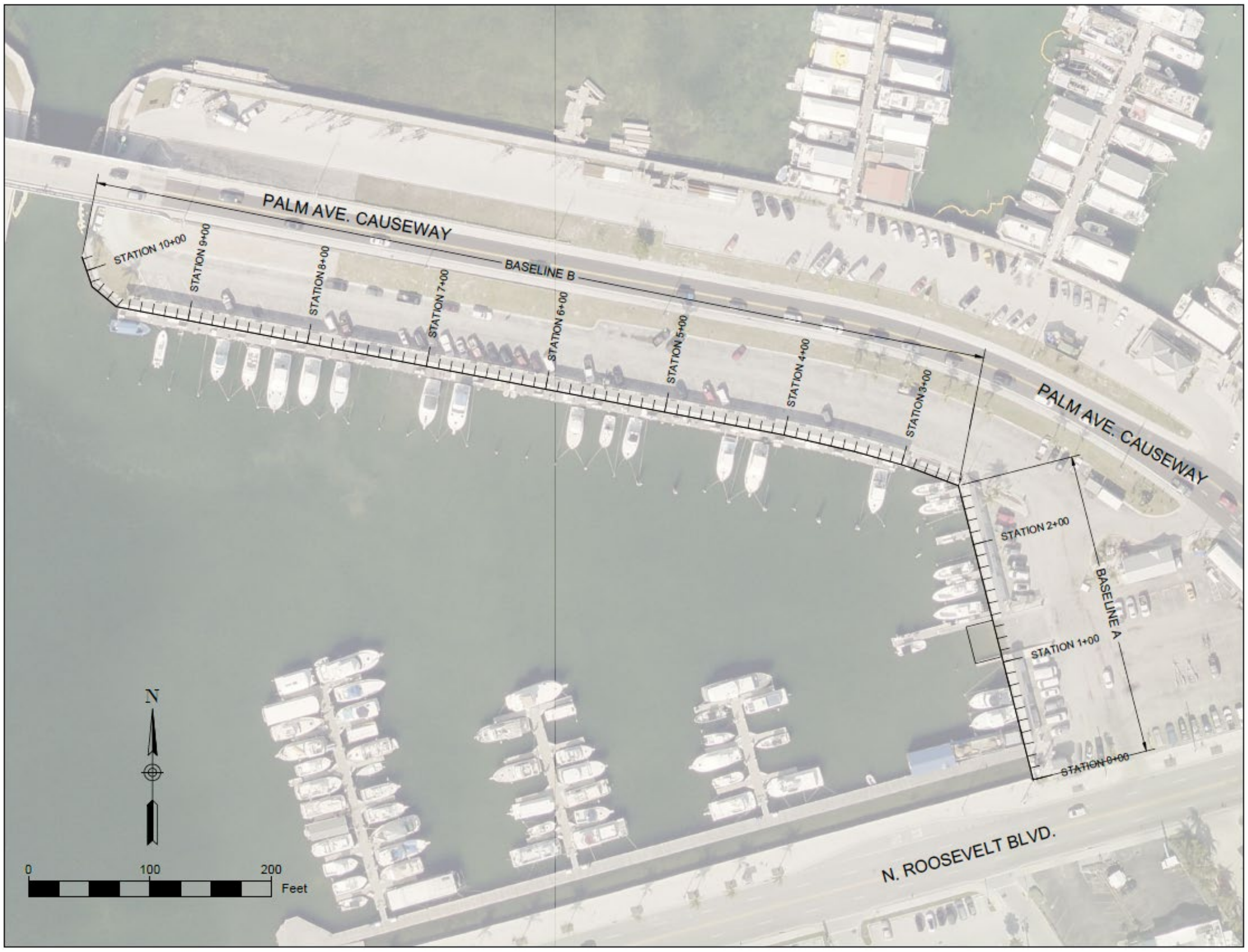


Figure 1: Inspection Stationing Layout for Cataloguing Deficiencies

3. INTRODUCTION

The project area is located along the central northern shore of Key West and lies within the Garrison Bight, tucked in south of the Palm Avenue Causeway. Global Positioning System (GPS) coordinates for the site are as follows: Latitude 24.560268° North, Longitude 81.784787° West. The portion of seawall encompassed by this project runs from the southeast corner of the seawall (adjacent to N. Roosevelt Blvd.) and runs northwest up to the bridge crossing of Palm Avenue Causeway (not including the seawall perpendicular to/underneath the bridge), as shown on Figure 2.

Figure 2: Project Limits and Surrounding Area

The seawall within the inspection area is comprised of a concrete pile & panel system with a concrete cap. As determined during the course of the inspection the structural composition of the seawall system is made up of concrete "T-piles" driven into the mudline with concrete panels placed in-between the driven piles. The panels would likely have been cast and installed to the depth of known hard bottom and/or to be partially embedded into the mudline, generally not embedded deeper than 3 feet below the mudline. The piles and panels are also held in place by the concrete cap which works as a consistent beam along the top of the seawall system. A typical layout of the observed T-pile system is shown on Figure 3. Although no evidence of tie-backs was observed, tie-backs most likely would have been installed in the cap to provide horizontal support to keep the piles from tilting waterward.

With respect to "T-pile" wall systems, one of the anticipated modes of failure is typically from cracking of the wings/flanges of the piles as they tend to be too thin to allow proper cover of the rebar reinforcement, leading to corrosion of the rebar and spalling of the concrete. Given that concrete "T-pile" wall systems are no longer in wide use, and the markings on some piles (i.e. "9-4-64") indicating that they were cast in 1964, it can be assumed that the seawall is approximately 55+ years old. Many "T-pile" walls were constructed in South Florida in the 1960's. "T-pile" walls have fallen out of favor due largely to the failure of the wings/flanges and have been replaced by other more reliable joining methods. Concrete pile & panel bulkhead systems typically have an anticipated service life of about 50-60 years.

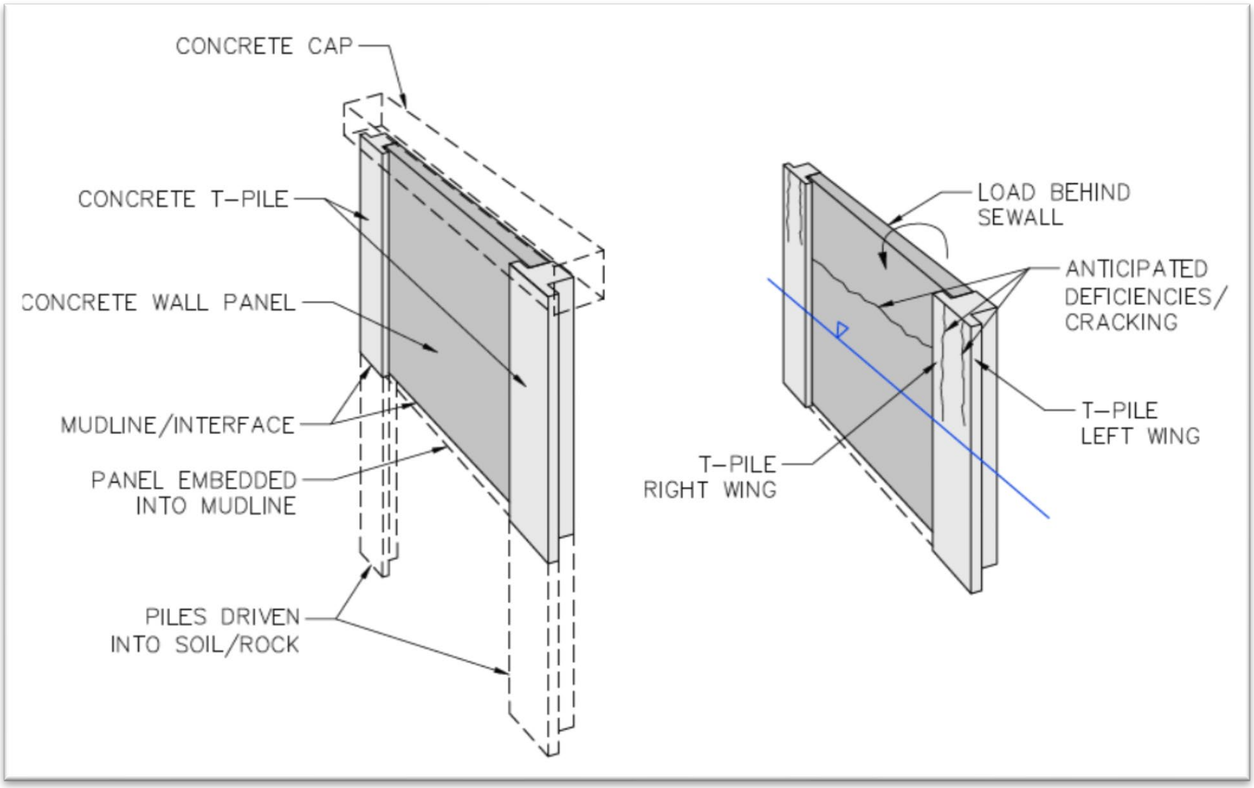


Figure 3: Typical Observed T-Pile Layout (left) and Anticipated Deficiencies (right)

4. SITE DESCRIPTION

The limits of inspection are approximately 1,010 linear feet of bulkhead with an existing dock structure along part of its length as shown on Figure 1. The bulkhead is part of a hardened shoreline surrounding the basin that supports a variety of docks and businesses. The exposed front face of the bulkhead ranged from approximately 7-ft to 14-ft with the average top of cap at elevation 4.6-ft NGVD and the mudline ranging from -2.6-ft NGVD to -9.2-ft NGVD based on the recent topographic survey obtain by Florida Keys Land Surveying on September 15, 2020 (Appendix A). During the June 30 to July 1, 2020 inspection, water depths along the bulkhead ranged from approximately 3 to 8 feet of seawater, with some of the deeper sections occurring on the southeast docks and past the northwest docks (heading toward the bridge). A typical cross-section of the seawall is shown in **Figure 4**. Sediment composition along the base of the bulkhead was mostly mud and fine sand mixed with large debris (concrete, rubble, pipes, etc.). Underwater visibility was approximately 5+ feet with no noticeable current detected during the assessment survey.

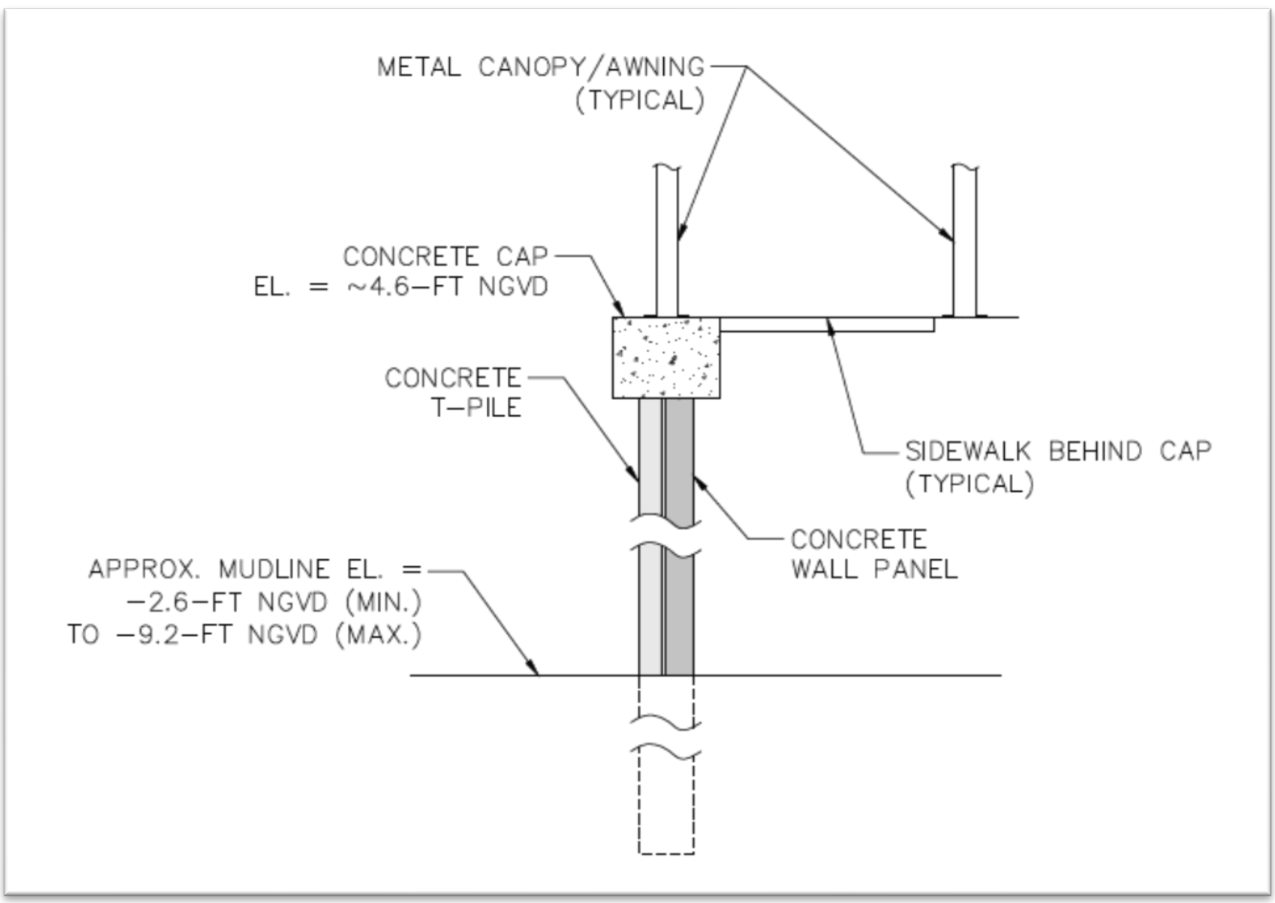


Figure 4: Typical Seawall Cross-Section

The shoreline of the City Marina at Garrison Bight is known locally as "Charter Boat Row" where various fishing and sport boat charters are available to the public, along with a boat ramp. The boat ramp had been recently repaired and found to be in good condition. For the purposes of this assessment, Charter Boat Row was divided into two sections: Baseline A – boat ramp and docks/piers with access directly from the bulkhead (Station 0+00 to Station 2+50), and Baseline B – wood docks abutting the bulkhead from which there is access (Station 3+04 to Station 9+62). However, for the purposes of this report, **Baseline A** will encompass anything below Station 2+50 and **Baseline B** will encompass anything above Station 2+50.

Below the wood docks of Baseline B there appears to be a shelf of solid material, assumed to be hard bottom, that extends from the seawall out to the supports of the wood dock, after which the bottom slopes steeply downward as it moves further out. In this area there also appears to be remnants of a pre-existing concrete dock, the piles and bents of which appear to have been abandoned in place, while sections of the deck were left on the seafloor.

Utility connections around Baseline A are typically placed underneath the cap (pump-out and electric) or through the cap (water). Utility connections around Baseline B are typically routed through the concrete wall panels and are strapped underneath the docks adjacent to the seawall. Behind/above the seawall cap is a sidewalk with a metal canopy/awning running down the length of the seawall along the boat charter locations, with utility valves located along the sidewalk.

5. INSPECTION METHODOLOGY

Field activities were performed using a 19-ft. catamaran in order to safely access the inspection area. A three-man dive team (including two divers and a tender) and an engineer were on site during the inspection. Divers trained in structure inspections used scuba to visually inspect the wall and catalogued deficiencies. Data were collected along a single transect positioned from southeast (0 ft.) to northwest (1,010 ft.) along the base of the bulkhead as shown on Figure 1.

The transect measuring tape was used by the divers to mark and ultimately record the location of each seawall deficiency by first marking the location of the observation linearly and then its location vertically, typically down from the cap. Due to the nature of the pile & panel seawall system, the piles were given a numerical value and used as the main reference point for notation (though the pile numbers were later consolidated/re-numbered in the final report). Inspection notes were first taken separately during the initial inspection, with videos of the seawall and deficiencies taken following the inspection. 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 cap. Still images were collected from the video and combined with underwater photography which were used together to record specific and representative images of the wall condition. Divers followed a systematic approach measuring all deficiencies along the wall using the tape measure and distances from the cap or bottom mudline. The information was then reviewed by the engineer to confirm observations and make more accurate representations of the observed deficiencies.

Observations were limited by what could be readily seen and accessed by the divers (from the water) and/or the engineer (from the land), and no additional efforts were made to access areas behind the seawall or below the sidewalk, respectively. Most of the seawall components below the low tide line were covered by heavy marine growth, which although it would not affect the detection of any significant deficiencies, would limit the visibility of possible minor deficiencies in these areas.

6. OBSERVATIONS AND ANALYSIS

Due to the consistency of the layout of the seawall and with failure modes expected to be signified by the condition of the piles, the observations made are typically referenced to pile numbers. Also, given the age and initial impression of the seawall conditions, observations were made in terms of deficiencies noted and given a severity rating as determined by the engineer. The deficiency severity/type was broken down into four (4) categories: Minor, Moderate, Major, and Critical. Table 1 shows a generalized summary of the types of observations contained within each deficiency type.

Table 1: Deficiency Severity Identifiers with Typical Observed Deficiencies

Deficiency Severity Levels	Typical Deficiency Description
Minor	Beginning stages of damage (hairline cracks, small spalls)
Moderate	Noticeable cracking/concrete face spalling, honeycombing, minor voids/undermining
Major	Cracking showing section separation of concrete, large spalls, corroded reinforcement, consecutive void/undermining areas beneath the seawall
Critical	Missing concrete sections/evidence of failure

The deficiency levels as shown in Table 1 were chosen to span from deficiencies that would not result in adverse effects in the near future, to deficiencies that represent a path for functional failure of the nearby seawall system. Deficiency Severity Levels can be described as follows:

- Minor: a deficiency that has just begun developing and would likely not contribute to a failure in the seawall system.
- Moderate: deficiencies that indicate a noticeable underlying structural defect that has not yet progressed to a state that would contribute to damage of other surrounding seawall components.
- Major: deficiencies that due to an underlying structural defect have caused noticeable damage to a component and are at risk of/are already contributing to damage of surrounding seawall components.
- Critical: deficiencies that have visibly diminished the structural capacity of the system and increase the risk of failure of nearby/surrounding seawall components. This designation does not, however, indicate that there is a failure of the seawall system.

Deficiencies have been quantified/described in Table 2 and their general locations can be seen on Figure 5 and Figure 6. Each deficiency has been given a numerical value preceded by the Baseline (A or B). The "location/pile #" indicates the structural component for the deficiency being addressed (referenced to the nearest pile), followed by a station which generalizes the location along the inspection transect.

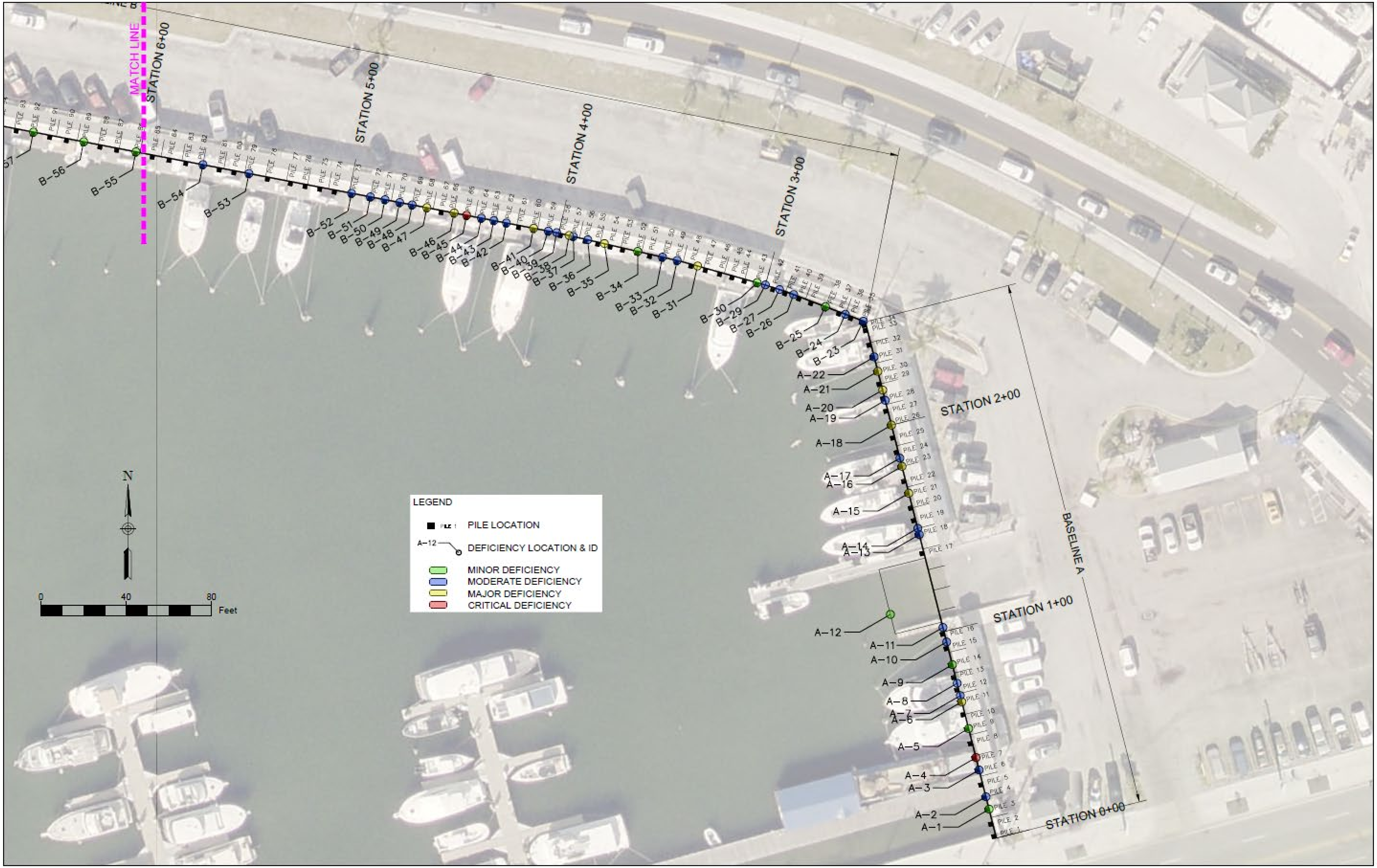


Figure 5: Deficiency Locations - Station 0+00 to Station 6+00

Figure 6: Deficiency Locations - Station 6+00 to Station 10+10

Table 2: Deficiency Locations and Descriptions

Baseline / Deficiency ID	Location / Pile #	Approx. Station Center	Deficiency Type	Description
A-1	Panel 3-4	0+14	Minor	14"x8" saw-cut hole in panel beside Pile 3 with some cracking extending from the cuts.
A-2	Pile 4	0+20	Moderate	22" long section of cracking along face/left wing with some spalling.
A-3	Pile 6	0+33	Moderate	Various cracks along face of pile up to 32" with impending spall.
A-4	Pile 7	0+39	Critical	60" long section of missing/spalled concrete in cap with corrosion/exposed rebar.
A-5	Pile 9	0+53	Minor	Hairline cracking observed at wings/face of pile.
A-6	Pile 11	0+66	Major	Full horizontal crack/separation near low-water line, and cracking along face/both wings with rust staining.
A-7	Panel 11-12	0+69	Moderate	Horizontal cracking along full length of panel, above water line.
A-8	Panel 12-13	0+75	Moderate	Void/undermining below panel with 10-23" of penetration.
A-9	Cap 13-16	0+84	Minor	Some horizontal hairline cracking observed along front face of cap.
A-10	Panel 15-16	0+95	Moderate	Horizontal cracking along full width of panel, above water line.
A-11	Panel 16-17	1+02	Moderate	Horizontal cracking along full width of panel, above water line.
A-12	Boat Ramp	1+14	Minor	Small void area, 4-6" penetration, below bottom of ramp footer - does not present an issue as there appears to be concrete overpour in this area.
A-13	Pile 18	1+47	Moderate	16" crack at top right wing of pile.
A-14	Panel 18-19	1+50	Moderate	Horizontal cracking along full width of panel, above water line.
A-15	Pile 21	1+67	Major	Top right wing of pile spalled/separated with cracking extending 32" from cap to below water at pile face.
A-16	Pile 23	1+80	Major	Top right wing/face of pile spalled/separated extending 28" from cap to below water.
A-17	Panel 24-25	1+84	Moderate	Horizontal cracking along full width of panel, above water line.
A-18	Pile 26	2+00	Major	Right-side face of pile has a large crack with some concrete separation extending 28" from cap to below water. Left-side face has also begun cracking, and there is honeycombing on the pile. The panel behind the pile is also starting to show vertical cracking adjacent to the pile.
A-19	Panel 27-28	2+12	Moderate	Panel cracking next to Pile 28 (right side of pile), with cracks extending toward Pile 27.
A-20	Panel 28-29	2+17	Major	Horizontal cracking along full width of panel, above water line. Also, void/undermining below panel with 5" of penetration.
A-21	Pile 30	2+26	Major	Top right wing spalled/separated with multiple cracks on face of pile extending 38" from cap to below water.
A-22	Pile 31	2+33	Moderate	Cracks with some face spalling developing in front of both wings on face of pile extending 33" from cap to below water and rust staining.
B-23	Pile 35	2+51	Moderate	Cracks developing on face of pile, mostly right side, extending 28" from cap to below water.
B-24	Culvert Panel 36-37	2+60	Moderate	Multiple cracks developing above culvert opening with exposed aggregate around mouth of opening.
B-25	Pile 38	2+70	Minor	Crack beginning to develop on face of pile above water.
B-26	Panel 40-41	2+86	Moderate	Horizontal cracking along full width of panel, above water line, with additional cracks developing near Pile 40.
B-27	Panel 41-42	2+93	Moderate	Horizontal cracking beginning near pipe cutouts by Pile 41, extending along full width of panel, above water line.
B-28	Pile 42	2+96	Moderate	Cracks developing on face of pile extending 22" down from cap.
B-29	Panel 42-43	3+00	Moderate	Horizontal cracking along full width of panel, above water line.
B-30	Pile 43	3+04	Minor	Cracks beginning to form on face of pile with some rust staining.
B-31	Cap @ 47-48	3+33	Major	Spalled/broken-off chunk of concrete from cap with exposed rebar.
B-32	Pile/Cap 49	3+43	Moderate	Gap in concrete cap around top of pile with cracking developing along the cap.
B-33	Pile/Cap 50	3+50	Moderate	Cracking on front face of pile extending 23" down from cap. Also, 3 spalls/broken-off chunks, 6-12" wide, from cap at location of embedded reinforcement.
B-34	Cap @ 52	3+62	Minor	Small spall/broken edge of cap at location of embedded reinforcement.
B-35	Cap @ 54-55	3+78	Major	3 spalls/broken-off chunks, 10-12" wide, from cap at location of embedded reinforcement, with additional cracking occurring along the cap and at top of cap.
B-36	Pile/Cap 56	3+86	Moderate	Cracking on right wing of pile extending 21" down from cap. Also, 2 spalls/broken-off chunks, 6" wide, from cap at location of embedded reinforcement.
B-37	Pile 57	3+93	Moderate	Cracking with initial separation at right wing of pile extending 29" down from cap to below water.
B-38	Cap @ 57-58	3+95	Major	40" long section of spalled concrete from the cap with exposed rebar around locations of embedded reinforcement, with hairline cracking at top of cap.
B-39	Cap @ 58-59	4+01	Moderate	2 spalls/broken-off chunks, 8-16" wide, from cap at location of embedded reinforcement.
B-40	Pile 59	4+05	Moderate	Cracking with initial separation at right wing of pile extending 24" down from cap to below water.

Table 2 (cont.): Deficiency Locations and Descriptions

Baseline / Deficiency ID	Location / Pile #	Approx. Station Center	Deficiency Type	Description
B-41	Pile 60	4+12	Major	Cracking along both wings and face with impending spalls, extending 28" down from cap to water.
B-42	Pile 62	4+25	Moderate	Cracking at right wing extending 24" down from cap.
B-43	Pile 63	4+31	Moderate	Cracking at right wing extending 24" down from cap with additional cracks on the face of the pile.
B-44	Pile 64	4+37	Moderate	Cracking at both wings extending 18" down from cap with additional cracks/spalls on the face of the pile.
B-45	Pile 65	4+44	Critical	Heavy cracking/impending spall of right wing extending down the full pile, fully spalled sections of pile at left wing with exposed/corroded rebar, and spalled/missing concrete toward mudline at pile-panel interface with 6-10" of penetration behind pile.
B-46	Pile 66	4+50	Major	Heavy cracking/impending spalling of both wings at front face of pile, extending 36" down from cap to below water.
B-47	Pile 68	4+63	Major	Cracking at both wings and face of pile extending 24" down from cap and spalled/missing sections of concrete along left wing.
B-48	Pile 69	4+70	Moderate	Cracking at left wing and face of pile with impending concrete spalling, extending 27" down from cap.
B-49	Pile 70	4+76	Moderate	Cracking at left wing of pile extending 26" down from cap, and some cracking beginning to develop toward right face of pile.
B-50	Pile/Cap 71	4+83	Moderate	Various cracks along face and wings of pile extending 17-24" down from cap with signs of impending spalls. Also, approx. 24"x24" section of honeycombing at bottom of cap with apparent gaps between cap and pile.
B-51	Pile 72	4+90	Moderate	Various cracks at right wing and face of pile extending 25" down from cap to water.
B-52	Pile 73	4+99	Moderate	Spalled/missing concrete at top right wing of pile approx. 3"x7", with seeming separation between the pile and cap.
B-53	Pile/Cap 79	5+48	Moderate	Various cracks along face of pile extending 27" down from cap, and various locations of honeycombing underneath the cap. Also some cracking visible at top of cap.
B-54	Pile 82	5+70	Moderate	Cracking on right wing and face of pile extending 20" down from cap.
B-55	Pile 86	6+02	Minor	Cracks beginning to develop on right wing of pile.
B-56	Pile 89	6+27	Minor	Cracks beginning to develop on wings and face of pile.
B-57	Pile 92	6+51	Minor	Cracks developing on pile extending 26" down from cap.
B-58	Cap @ 95	6+76	Moderate	2"x6" cavity in cap next to Pile 95 with 2-4" penetration.
B-59	Pile 96	6+82	Minor	Cracks developing on pile extending 24" down from cap.
B-60	Pile 97	6+90	Moderate	Cracking on right wing and face of pile extending 27" down from cap.
B-61	Pile 98	6+99	Moderate	Cracking on face of pile extending 23" down from cap with concrete separation, and additional cracking on wings.
B-62	Pile 100	7+15	Major	Large crack with concrete separation of right wing of pile extending 23" down from cap.
B-63	Pile 101	7+22	Moderate	Cracking developing on face of pile extending 24" down from cap.
B-64	Panels 103-110	7+38 to 7+96	Major	Voids/undermining beneath panels along approximately 58-ft section with 4-10" of penetration.
B-65	Pile 103	7+38	Major	Large cracks with concrete separation on face and left wing of pile extending 22" down from cap.
B-66	Pile 104	7+47	Moderate	Cracking on face and right wing of pile extending 24" down from cap.
B-67	Pile 105	7+55	Major	Large cracks with concrete separation on left wing of pile extending 30" down from cap, and cracks beginning to form on face by right wing of pile.
B-68	Pile 106	7+63	Moderate	Cracking on face of pile extending 24" down from cap with impending spall of concrete cover.
B-69	Pile/Cap 107	7+71	Moderate	Cracking on face of pile extending 17" down from cap with impending spall of concrete cover. Some hairline cracking also visible at top of cap.
B-70	Pile 108	7+80	Moderate	Cracking on face at right wing of pile extending 17" down from cap, and spalled/missing concrete along base of pile at mudline at both wings.
B-71	Pile 109	7+88	Major	Large crack and missing/spalled concrete with concrete separation of right wing extending 24" down from cap, and cracking occurring at left wing.
B-72	Panels 111-116	8+03 to 8+38	Major	Voids/undermining beneath panels along approximately 35-ft section with 3-6" of penetration.
B-73	Pile 112	8+11	Minor	Cracks beginning to develop on face and wing of pile, with some rust staining.
B-74	Pile/Cap 113	8+19	Moderate	Cracking on left wing of pile extending 20" down from cap, and additional cracking forming on face of pile. Some hairline cracking also visible at top of cap.

Table 2 (cont.): Deficiency Locations and Descriptions

Baseline / Deficiency ID	Location / Pile #	Approx. Station Center	Deficiency Type	Description
B-75	Pile 114	8+27	Moderate	Cracking on right wing of pile extending 24" down from cap, and additional cracking forming on left wing of pile.
B-76	Pile 115	8+35	Moderate	Cracks developing on face of pile extending 20" down from cap, with rust staining.
B-77	Panels 116-120	8+42 to 8+75	Major	Voids/undermining beneath panels along approximately 35-ft section with 8-14" of penetration.
B-78	Pile/Cap 117	8+50	Major	Cracking on right wing of pile with some concrete separation extending 23" down from cap, and additional cracking forming on left wing of pile. Bottom of pile at the mudline has missing/spalled concrete. Cap has some scattered small areas of honeycombing.
B-79	Pile/Cap 118	8+58	Major	Various cracks on face of pile with some concrete spalling extending 25" down from cap, with cracking also occurring on panel. Also, various areas of honeycombing are seen on the cap near Pile 118.
B-80	Pile 119	8+67	Major	Cracking with impending spalling on both wings of pile extending 24" down from cap with additional cracking across the face of the pile, with rust staining.
B-81	Pile 121	8+83	Moderate	Cracking on face and right wing of pile extending 21" down from cap, and with rust staining seeping from the cracks. Also, some cracking on the panel adjacent to the pile.
B-82	Panels 121-123	8+83 to 8+98	Major	Voids/undermining beneath panels along approximately 15-ft section with 3-8" of penetration, and spalled/missing portions of Pile 122 at bottom near mudline.
B-83	Cap @ 124-127	9+04 to 9+25	Moderate	Multiple locations on bottom of cap with areas of honeycombing, with some extending to the panel and causing cracks to form.
B-84	Panel 124-125	9+10	Moderate	Void/undermining below panel with 9-15" of penetration.
B-85	Pile 126	9+23	Major	Large section of right wing of pile cracking/spalling extending 27" down from cap with rust staining, and cracking forming along left wing of pile.
B-86	Pile 127	9+31	Major	Section of front face of pile is cracking/spalling extending 28" down from cap, with additional cracks forming.
B-87	Pile/Cap 128	9+39	Moderate	Cracking forming at left wing of pile and extending 20" down from cap, with cracking also forming along the bottom of the cap.
B-88	Panel 128-129	9+43	Major	Panel framing culvert is showing signs of degradation at the edges and at the culvert opening, with fully exposed rebar and missing/spalled concrete.
B-89	Pile 129	9+47	Moderate	Cracking forming on face of pile extending 24" down from cap.
B-90	Pile 130	9+55	Major	Cracking at face and left wing of pile extending 28" down from cap.
B-91	Pile 131	9+59	Moderate	Diagonal cracking along face/corner of corner pile with impending spalls.
B-92	Pile/Cap 132	9+62	Major	Cracking at both wings and across the face of the pile extending 27" down from cap. Also some horizontal hairline cracking at front of cap.
B-93	Pile 133	9+70	Major	Cracking/spalling right wing of pile with additional cracking on left wing, extending 28" down from cap, and with rust staining.
B-94	Pile 134	9+76	Major	Cracking with missing/spalled concrete at left wing with additional cracking extending 28" down from cap.
B-95	Panel 134-135	9+80	Moderate	Horizontal cracking along full width of panel, above water line, with additional diagonal cracking from an apparent impact.
B-96	Pile 135	9+83	Moderate	Vertical and diagonal cracking at face of pile extending 28" down from cap.
B-97	Pile 136	9+86	Major	Cracking at face of corner pile with spalling that extends diagonally 20" down from cap toward the center of the corner.
B-98	Pile 137	9+89	Major	Cracking and spalling of right wing along face extending 26" down from cap, with additional cracking along the face of the pile.
B-99	Panel/Cap 137-138	9+93	Moderate	Horizontal cracking along full width of panel, above water line. Cracking also on underside of cap extending from corroded embedded hardware.
B-100	Pile 138	9+96	Moderate	Top of pile cracked just below the cap.
B-101	Pile 139	10+02	Moderate	Cracking along face and left wing of pile extending 29" down from cap.
B-102	Panel 139-140	10+06	Moderate	Void/undermining below panel with 5-13" of penetration.
B-103	Pile 140	10+09	Moderate	Cracking along face and left wing of pile extending 24" down from cap.

The seawall system relies on the effectiveness/condition of the piles on either side of a concrete wall panel to remain serviceable. Due to the separation distance between many of these deficiencies and the locations of the deficiencies, it does not appear that any concrete wall panels are at immediate risk of falling or tilting waterward and this seawall is unlikely to have several sections fail at the same time within the near future.

For Minor deficiencies as noted above, there are currently no significant groupings or adjacent deficiencies that would contribute to damage/failure of the seawall system. Typical images of minor deficiencies are shown on Figure 7.

For Moderate deficiencies as noted above, the deficiencies did not appear to have affected the structural element to an extent that would indicate that it would cause further damage at or around that element. Mostly consisting of cracks on the piles, the cracks were not developed to where any impending spalls would damage the full pile wing, or only showed impending spalls of the surface of the concrete. These deficiencies will eventually develop into larger points of damage as corrosion of the reinforcement cannot be halted, causing expansion around the reinforcement and eventual spall of the concrete. The horizontal cracks on the concrete panel walls and undermining/voids beneath the panels indicate a lack of support at the bottom of the panel which could then cause future separation between the cap and panel. Typical images of moderate deficiencies are shown on Figure 8.

For Major deficiencies as noted above, the deficiencies consisted of damage to the structural elements that can then significantly lead to damage of other adjacent structural elements. Mostly consisting of cracks/spalls on the piles, the weakened sections of the pile wings would lead to the concrete panel walls to begin tilting waterward. As most of the observed cracks/spalls were observed at the splash zone and above, it is clear that the loads behind the seawall will continue to add pressure to the seawall (greater along the top) escalating the damage already observed. With void/undermining areas beneath the concrete panel walls, the “rolling” effect of the seawall can become greater. The other possible effect of undermining is the loss of material behind the seawall which could lead to damage of upland structures (i.e. sidewalks, pavement, etc.). Areas most notably affected by these types of deficiencies, where compounding effects could lead to further damage and failure extend from approximately Station 7+38 to Station 7+96 and Station 8+42 to Station 9+86. Typical images of major deficiencies are shown on Figure 9.

For the Critical deficiencies noted above, of which there were only two (2), the deficiencies showed a failure of the structural element which can then have a cascading effect on the seawall system. At Station 0+39 the spalled concrete cap has exposed rebar that is regularly exposed to additional seawater, causing additional corrosion and leading to separation of the bond/delamination between the concrete cap and seawall. At Station 4+44 the spalled/missing concrete on the pile (Pile 65) appears to already be causing the shifting of the concrete panel wall, as evidenced by the visibility of the panel edge and the damage observed on Pile 66. Images of the critical deficiencies are shown on Figure 10.

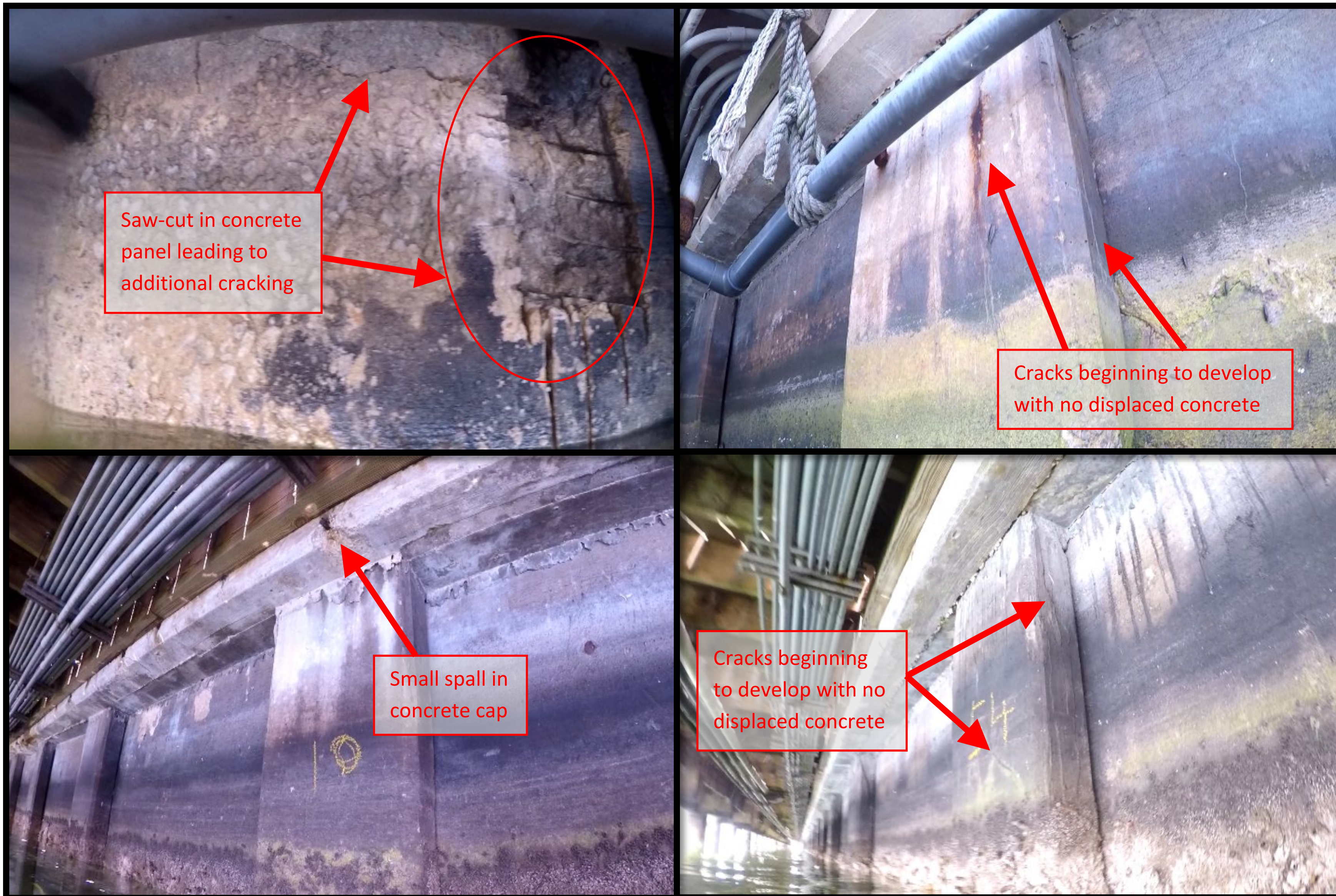


Figure 7: Typical Minor Deficiencies – [Top Left] A-1 (Station 0+14), [Top Right] B-30 (Station 3+04), [Bottom Left] B-34 (Station 3+62), [Bottom Right] B-59 (Station 6+82)

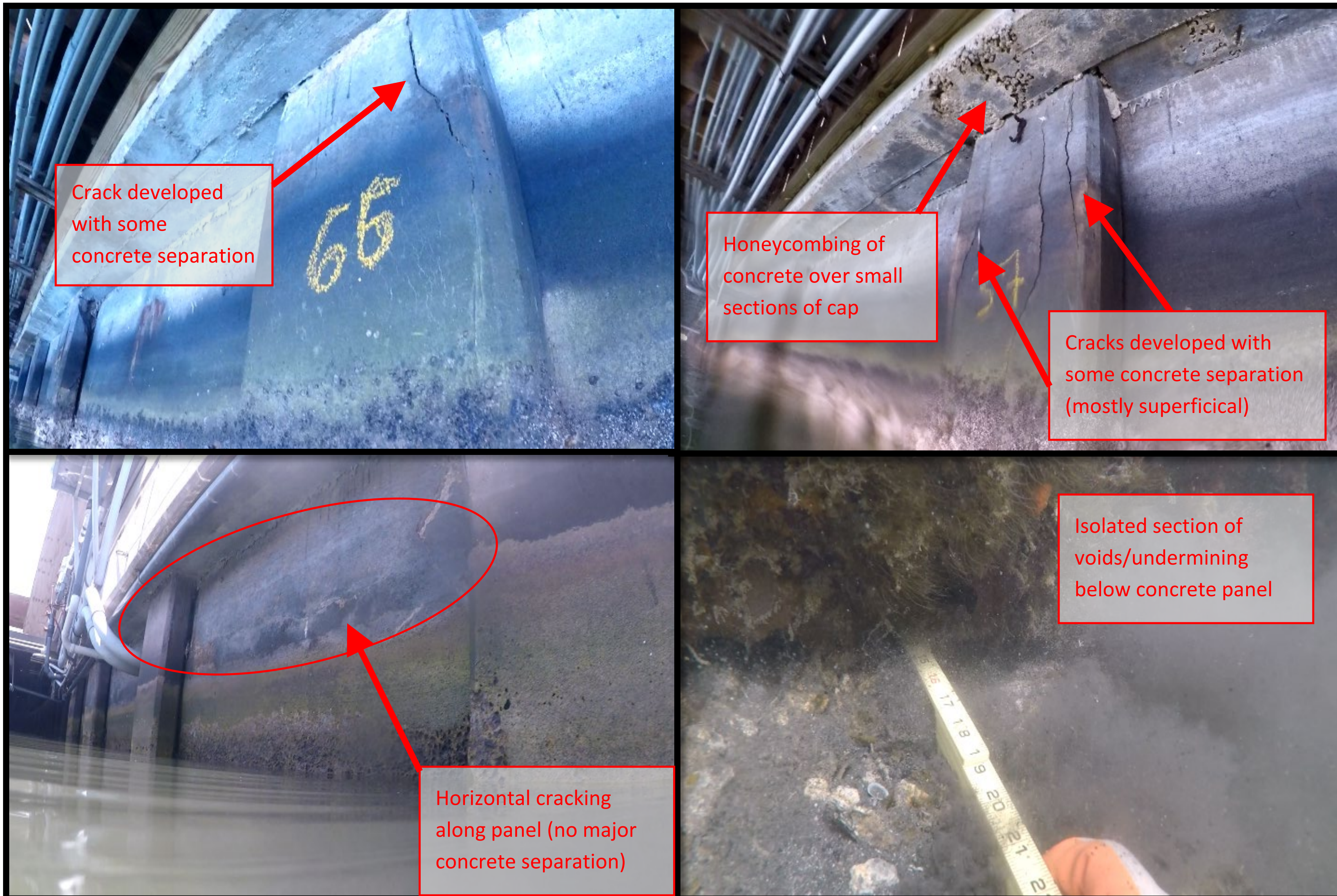


Figure 8: Typical Moderate Deficiencies – [Top Left] B-70 (Station 7+86), [Top Right] B-53 (Station 5+48), [Bottom Left] B-26 (Station 2+86), [Bottom Right] B-102 (Station 10+06)

Figure 9: Typical Major Deficiencies – [Top Left] A-6 (Station 0+66), [Top Right] A-15 (Station 1+67), [Bottom Left] B-35 (Station 3+78), [Bottom Right] B-77 (Station 8+42 - 8+75)

Figure 10: Critical Deficiencies – [Top] A-4 (Station 0+39), [Bottom] B-45 (Station 4+44)

7. CONCLUSIONS AND RECOMMENDATIONS

The majority of deficiencies noted during the inspection are cracking of the “T-piles” that form the structural support for the pile & panel seawall. In conjunction with apparent gaps beneath and behind some of the concrete wall panels, the seawall can be assessed as needing repair/replacement throughout. An investigation behind the seawall panels to account for loss of backfill material through undermining (primarily northwest of Station 7+38) would also be recommended as part of any repair activities. Based on the recent geotechnical analysis in this area, the soil makeup consists of mostly limestone and fine sands, so it is not expected that there would be a large amount of lost backfill material behind the seawall.

In reviewing the overall condition of the seawall, the seawall is reaching the end of its useful life with 50+ years of service. Based on the observations made, with many sections of the seawall experiencing the type of failure that is expected from a “T-pile” seawall, we recommend that the seawall be scheduled for replacement within the next 5 years. This timeline should give time for acquiring the necessary funding to replace the seawall, as well as go through the types of permitting and design that will be required.

Although the option for temporary repairs to the seawall exists, likely in the form of installing additional concrete piles in front of damaged piles and casting footers at the seawall panels, the effort and anticipated cost do not make it a preferable alternative to a full replacement of the existing seawall due to the age and overall condition of the seawall.

The layout of a replacement seawall would likely be a sheet pile cantilever wall (without tie-back supports) located 18” waterward of the existing seawall (or as permitting will allow) with a new concrete cap that encompasses the area of the existing cap. This will limit the amount of demolition required to the existing cap, but would require the temporary removal of the wood dock within the seawall area. The recent survey and geotechnical analysis in this area will be beneficial in the design of the replacement seawall. A rough order of magnitude estimate/opinion of probable cost associated with the seawall replacement is $3,800,000, with a general breakdown of the estimated associated costs shown in **Table 3**. A seawall length of 1,050 LF was utilized in the cost estimate to account for the distance differential between the measurement in front of the seawall and the actual length from the center of the seawall.

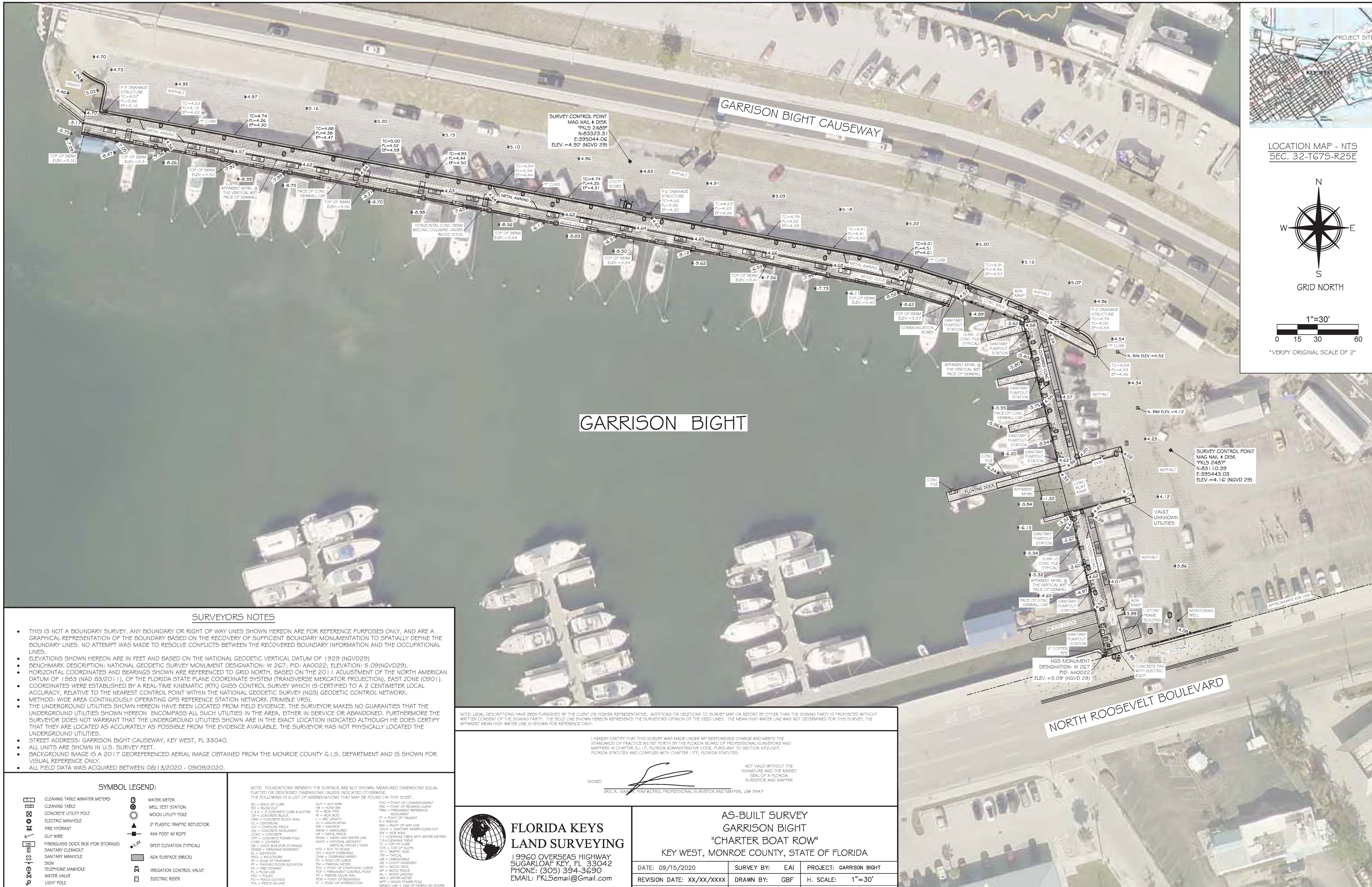
Table 3: Cost Estimate

Line					
	City of Key West Marina at Garrison Bight - 1,050 LF Seawall w/ Concrete Cap				**September 2020**
	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)	1,200	LF	11.00	13,200
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 - cap, sidewalks, slabs, wooden decks	3,150	SF	10.02	31,576
8	Temporary Utility Relocation, Pumpout, Water & Electric	1	LS	50,000	50,000
9	Steel Sheet Piling (24' long, A-690 including freight)	1,050	LF	850	892,500
10	Steel Sheet Piling installation (driven from water)	1,050	LF	380	399,000
11	Concrete - Cap, 6,000 PSI, Ext. Aggressive Env, 7 - #5 bar w/ Stirrups	1,050	LF	357	374,850
12	Extend Drainage Outfalls	3	EA	5,000	15,000
13	Tremie Grout for fill between sheetpile (= 1,050'x1.5'x8'/27)	467	CY	350	163,450
14	Sidewalk	6,300	SF	6.55	41,278
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	50	LF	35	1,750
20	Tremie Grout Gaps in Seawall Cap	20	CY	500	10,000
				Subtotal	**2,146,103**
				Direct Cost	**2,146,103**
	Contractor Cost				
24	FOOH & HOOH (Overhead) Combined (6% Typical of Direct Cost)	6.0%		128,766	128,766
25	Mobilization/ Demobilization (10% Typical of Direct Cost + above costs)	10.0%		227,487	227,487
26	Profit (17% Typical of Direct Cost + above costs)	17.0%		425,401	425,401
27	Bonds, Permits & Insurance (2% Typical of Direct Cost + above costs)	2.0%		58,555	58,555
	Direct + Contractor Cost			**840,209**	**2,986,312**
	Project Cost				
28	City of Key West Allowance Account for Administration and On-site Supervision (SIOH)	5.0%		149,316	149,316
29	Contingency	20.0%		627,126	627,126
	Direct + Contractor + Project Cost			**776,441**	**3,762,753**
				Total Construction Cost	**3,762,753**
	Prepared by: FJM				

Appendix A

Florida Keys Land Surveying (FKLS) Topographic Survey

September 2020



SURVEYORS NOTES

- THIS IS NOT A BOUNDARY SURVEY, ANY BOUNDARY OR RIGHT OF WAY LINES SHOWN HEREON ARE FOR REFERENCE PURPOSES ONLY, AND ARE A GRAPHICAL REPRESENTATION OF THE BOUNDARY BASED ON THE RECOVERY OF SUFFICIENT BOUNDARY MONUMENTATION TO SPATIALLY DEFINE THE BOUNDARY LINES. NO ATTEMPT WAS MADE TO RESOLVE CONFLICTS BETWEEN THE RECOVERED BOUNDARY INFORMATION AND THE OCCUPATIONAL LINES.
- ELEVATIONS SHOWN HEREON ARE IN FEET AND BASED ON THE NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD29)
- BENCHMARK DESCRIPTION: NATIONAL GEODETIC SURVEY MONUMENT DESIGNATION: W 267; PID: AA0022; ELEVATION: 5.09(NGVD29).
- HORIZONTAL COORDINATES AND BEARINGS SHOWN ARE REFERENCED TO GRID NORTH, BASED ON THE 2011 ADJUSTMENT OF THE NORTH AMERICAN DATUM OF 1983 (NAD 83/2011), OF THE FLORIDA STATE PLANE COORDINATE SYSTEM (TRANSVERSE MERCATOR PROJECTION), EAST ZONE (0901).
- COORDINATES WERE ESTABLISHED BY A REAL-TIME KINEMATIC (RTK) GNSS 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.
- METHOD: WIDE AREA CONTINUOUSLY OPERATING GPS REFERENCE STATION NETWORK (TRIMBLE VRS).
- THE UNDERGROUND UTILITIES SHOWN HEREON HAVE BEEN LOCATED FROM FIELD EVIDENCE. THE SURVEYOR MAKES NO GUARANTIES THAT THE UNDERGROUND UTILITIES SHOWN HEREON ENCOMPASS ALL SUCH UTILITIES IN THE AREA, EITHER IN SERVICE OR ABANDONED. FURTHERMORE THE SURVEYOR DOES NOT WARRANT THAT THE UNDERGROUND UTILITIES SHOWN ARE IN THE EXACT LOCATION INDICATED ALTHOUGH HE DOES CERTIFY THAT THEY ARE LOCATED AS ACCURATELY AS POSSIBLE FROM THE EVIDENCE AVAILABLE. THE SURVEYOR HAS NOT PHYSICALLY LOCATED THE UNDERGROUND UTILITIES.
- STREET ADDRESS: GARRISON BIGHT CAUSEWAY, KEY WEST, FL 33040.
- ALL UNITS ARE SHOWN IN U.S. SURVEY FEET.
- BACKGROUND IMAGE IS A 2017 GEOREFERENCED AERIAL IMAGE OBTAINED FROM THE MONROE COUNTY G.I.S. DEPARTMENT AND IS SHOWN FOR VISUAL REFERENCE ONLY.
- ALL FIELD DATA WAS ACQUIRED BETWEEN 08/13/2020 - 09/09/2020.

SYMBOL LEGEND:

- CLEANING TABLE W/WATER METERS
- CLEANING TABLE
- CONCRETE UTILITY POLE
- ELECTRIC MANHOLE
- FIRE HYDRANT
- GUY WIRE
- FIBERGLASS DOCK BOX (FOR STORAGE)
- SANITARY CLEANOUT
- SANITARY MANHOLE
- SIGN
- TELEPHONE MANHOLE
- WATER VALVE
- LIGHT POLE
- WATER METER
- WELL TEST STATION
- WOOD UTILITY POLE
- 2" PLASTIC TRAFFIC REFLECTOR
- 4X4 POST W/ ROPE
- SPOT ELEVATION (TYPICAL)
- ADA SURFACE (BRICK)
- IRRIGATION CONTROL VALVE
- ELECTRIC RISER

NOTE: FOUNDATIONS BENEATH THE SURFACE ARE NOT SHOWN. MEASURED DIMENSIONS EQUAL PLATTED OR DESCRIBED DIMENSIONS UNLESS INDICATED OTHERWISE.
THE FOLLOWING IS A LIST OF ABBREVIATIONS THAT MAY BE FOUND ON THIS SHEET.

BC = BACK OF CURB
BO = BLOW OUT
C & G = 2' CONCRETE CURB & GUTTER
CB = CONCRETE BLOCK
CBW = CONCRETE BLOCK WALL
CL = CENTERLINE
CLF = CHAINLINK FENCE
CM = CONCRETE MONUMENT
CONC = CONCRETE
CPP = CONCRETE POWER POLE
CVRD = COVERED
DB = DOCK BOX (FOR STORAGE)
DEASE = DRAINAGE EASEMENT
EL = ELEVATION
ENCL = ENCLOSURE
EP = EDGE OF PAVEMENT
FF = FINISHED FLOOR ELEVATION
FH = FIRE HYDRANT
FL = FLOW LINE
FND = FOUND
FO = FENCE OUTSIDE
FOL = FENCE ON LINE
GUY = GUY WIRE
HB = HOSE BIB
IP = IRON PIPE
IR = IRON ROD
L = ARC LENGTH
LS = LANDSCAPING
MB = MAILBOX
MEAS = MEASURED
MF = METAL FENCE
MHWL = MEAN HIGH WATER LINE
NGVD = NATIONAL GEODETIC VERTICAL DATUM (1929)
NTS = NOT TO SCALE
OH = ROOF OVERHANG
OHW = OVERHEAD WIRES
PC = POINT OF CURVE
PM = PARKING METER
PCC = POINT OF COMPOUND CURVE
PCP = PERMANENT CONTROL POINT
PK = PARKER KALON NAIL
POB = POINT OF BEGINNING
PI = POINT OF INTERSECTION
POC = POINT OF COMMENCEMENT
PRC = POINT OF REVERSE CURVE
PRM = PERMANENT REFERENCE MONUMENT
PT = POINT OF TANGENT
R = RADIUS
R/W = RIGHT OF WAY LINE
SSCO = SANITARY SEWER CLEAN-OUT
SW = SIDE WALK
T-1 =CLEANING TABLE WITH WATER METERS
T-2=CLEANING TABLE
TC = TOP OF CURB
TOS = TOE OF SLOPE
TS = TRAFFIC SIGN
TYP = TYPICAL
U/R = UNREADABLE
U/E = UTILITY EASEMENT
WD = WOOD DECK
WF = WOOD FENCE
WL = WOOD LANDING
WM = WATER METER
WPP = WOOD POWER POLE
WRACK LINE = LINE OF DEBRIS ON SHORE
WV = WATER VALVE

NOTE: LEGAL DESCRIPTIONS HAVE BEEN FURNISHED BY THE CLIENT OR HIS/HER REPRESENTATIVE. ADDITIONS OR DELETIONS TO SURVEY MAP OR REPORT BY OTHER THAN THE SIGNING PARTY IS PROHIBITED WITHOUT WRITTEN CONSENT OF THE SIGNING PARTY. THE BOLD LINE SHOWN HEREON REPRESENTS THE SURVEYORS OPINION OF THE DEED LINES. THE MEAN HIGH WATER LINE WAS NOT DETERMINED FOR THIS SURVEY, THE APPARENT MEAN HIGH WATER LINE IS SHOWN FOR REFERENCE ONLY.

I HEREBY CERTIFY THAT THIS SURVEY WAS MADE UNDER MY RESPONSIBLE CHARGE AND MEETS THE STANDARDS OF PRACTICE AS SET FORTH BY THE FLORIDA BOARD OF PROFESSIONAL SURVEYORS AND MAPPERS IN CHAPTER 5J-17, FLORIDA ADMINISTRATIVE CODE, PURSUANT TO SECTION 472.027, FLORIDA STATUTES AND COMPLIES WITH CHAPTER 177, FLORIDA STATUTES.

SIGNED

ERIC A. ISAACS, PSM #6783, PROFESSIONAL SURVEYOR AND MAPPER, LB# 7847

NOT VALID WITHOUT THE SIGNATURE AND THE RAISED SEAL OF A FLORIDA SURVEYOR AND MAPPER

FLORIDA KEYS
LAND SURVEYING
19960 OVERSEAS HIGHWAY
SUGARLOAF KEY, FL 33042
PHONE: (305) 394-3690
EMAIL: FKLSemail@Gmail.com

AS-BUILT SURVEY
GARRISON BIGHT
"CHARTER BOAT ROW"
KEY WEST, MONROE COUNTY, STATE OF FLORIDA

DATE: 09/15/2020	SURVEY BY: EAI	PROJECT: GARRISON BIGHT
REVISION DATE: XX/XX/XXXX	DRAWN BY: GBF	H. SCALE: 1"=30'
JOB NO.: 20-373	CHECKED BY: EAI	SHEET 1 OF 1

Appendix B

Nutting Engineers of Florida Inc. (Nutting) Geotechnical Report

July 2020

REPORT OF LIMITED
GEOTECHNICAL EXPLORATION

CITY MARINA AT GARRISON BIGHT
1801 N. ROOSEVELT BOULEVARD
KEY WEST, FLORIDA 33040

FOR

TETRA TECH
759 S. FEDERAL HIGHWAY, SUITE 314
STUART, FLORIDA 34994

PREPARED BY

NUTTING ENGINEERS OF FLORIDA, INC.
2051 NW 112TH AVE
SUITE 126
MIAMI, FLORIDA 33172

ORDER NO. 2245.3

JULY 2020

Nutting Engineers
of Florida Inc. | Established 1967
Your Project is Our Commitment

Geotechnical & Construction Materials
Engineering, Testing, & Inspection
Environmental Services

Offices throughout the state of Florida

www.nuttingengineers.com info@nuttingengineers.com

July 16, 2020

Mr. Dave Frodsham, P.E.
Tetra Tech
759 S. Federal Highway, Suite 314
Stuart, Florida 34994
Phone: (772) 781-3400
Email: dave.frodsham@tetratech.com

Re: Report of Geotechnical Exploration
City Marina at Garrison Bight
1801 N. Roosevelt Boulevard
Key West, Florida 33040

Dear Mr. Frodsham:

Nutting Engineers of Florida, Inc. (NE), has performed a Geotechnical Exploration at the referenced site in Key West, Florida. The purpose of this exploration was to develop information concerning the subsurface conditions at the soil boring locations specified, classify the recovered samples, and provide engineering properties for these soils to aid in the foundation design to be performed by others. This report presents our findings.

PROJECT INFORMATION

Per your email dated February 13, 2020 and review of the aerial photograph provided, we understand that plans for this project include the re-design and/or replacement of approximately 1,000 lineal feet of the existing seawall at the referenced site. We understand that engineering and foundation design for the proposed seawall will be performed by others, however subsurface soil information is needed for the design.

GENERAL SUBSURFACE CONDITIONS

Soil Survey Maps

A review of the Soil Survey for Monroe County indicates that at the time the survey was conducted, the soils at the site were described as Udorthents, limestone substratum-Urban land complex. About 40 to 70 percent of this map unit consists of Udorthents in open areas, and 25 to 60 percent consists of Urban land, or areas covered by concrete and buildings. The Udorthents consist of fill material that is light gray and white extremely stony loam about 55 inches thick. The fill material is underlain by hard, porous limestone bedrock. We note that the maximum depth of the survey is approximately 6 feet.

Subsurface Exploration

NUTTING ENGINEERS OF FLORIDA, INC. performed two (2) Standard Penetration Test (SPT) borings (ASTM D-1586) to a depth of forty feet below land surface. The location of the test borings is indicated on the attached site plan presented in the Appendix of this report.

Test Boring Results

In general, the test borings recorded a medium to dense fine to silty sand and limestone fragments to a depth of approximately three feet followed by soft to medium hard limestone with varying amounts of sand to a depth of approximately thirteen feet below ground surface. Beneath this, the borings encountered dense sand and limestone to depths of approximately eighteen to twenty-eight feet underlain by soft to medium hard limestone to a depth of forty feet, the maximum depth explored.

A detailed description of the soil/rock interlayering is given on the test boring logs in the Appendix.

Groundwater Table Observation

The immediate groundwater level was measured at the boring locations at the time of drilling. The groundwater level was encountered at approximately two to two and a half feet below the existing ground surface at the time of drilling.

The immediate depth to groundwater measurements presented in this report may not provide a reliable indication of stabilized or longer term depth to groundwater at this site. Water table elevations can vary dramatically with time through rainfall, droughts, storm events, flood control activities, nearby surface water bodies, tidal activity, pumping and many other factors. For these reasons, this immediate depth to water data **should not** be relied upon alone for project design considerations.

GENERAL FOUNDATION DESIGN PARAMETERS

In order to provide design parameters for the proposed seawall foundation, the values in the accompanying table may be used for design. The table is based on visual classification, empirical relationships and our experience with similar soil conditions. If more exact values area needed, specific tests should be performed.

The decision as to which type of earth retaining system will be best for this project will depend on the structural loading conditions feasibility, and costs. We recommend that discussions be held with all interested parties to provide input concerning the alternatives for this project.

CLOSURE

Our client for this geotechnical evaluation was:

Mr. Dave Frodsham, P.E.
Tetra Tech
759 S. Federal Highway, Suite 314
Stuart, Florida 34994

The contents of this report are for the exclusive use of the client, the client's design & construction team and governmental authorities for this specific project exclusively. Information conveyed in this report shall not be used or relied upon by other parties or for other projects without the expressed written consent of NUTTING ENGINEERS OF FLORIDA, INC. This report discusses geotechnical considerations for this site based upon observed conditions and our understanding of proposed construction for foundation support. Environmental issues including (but not limited to), soil and/or groundwater contamination are beyond our scope of service for this project.

Excavations of five feet or more in depth should be sloped or shored in accordance with OSHA and State of Florida requirements.

The Geotechnical Engineer warrants that the findings, recommendations, specifications, or professional advice contained herein, have been presented after being prepared in accordance with general accepted professional practice in the field of foundation engineering, soil mechanics and engineering geology. No other warranties are implied or expressed.

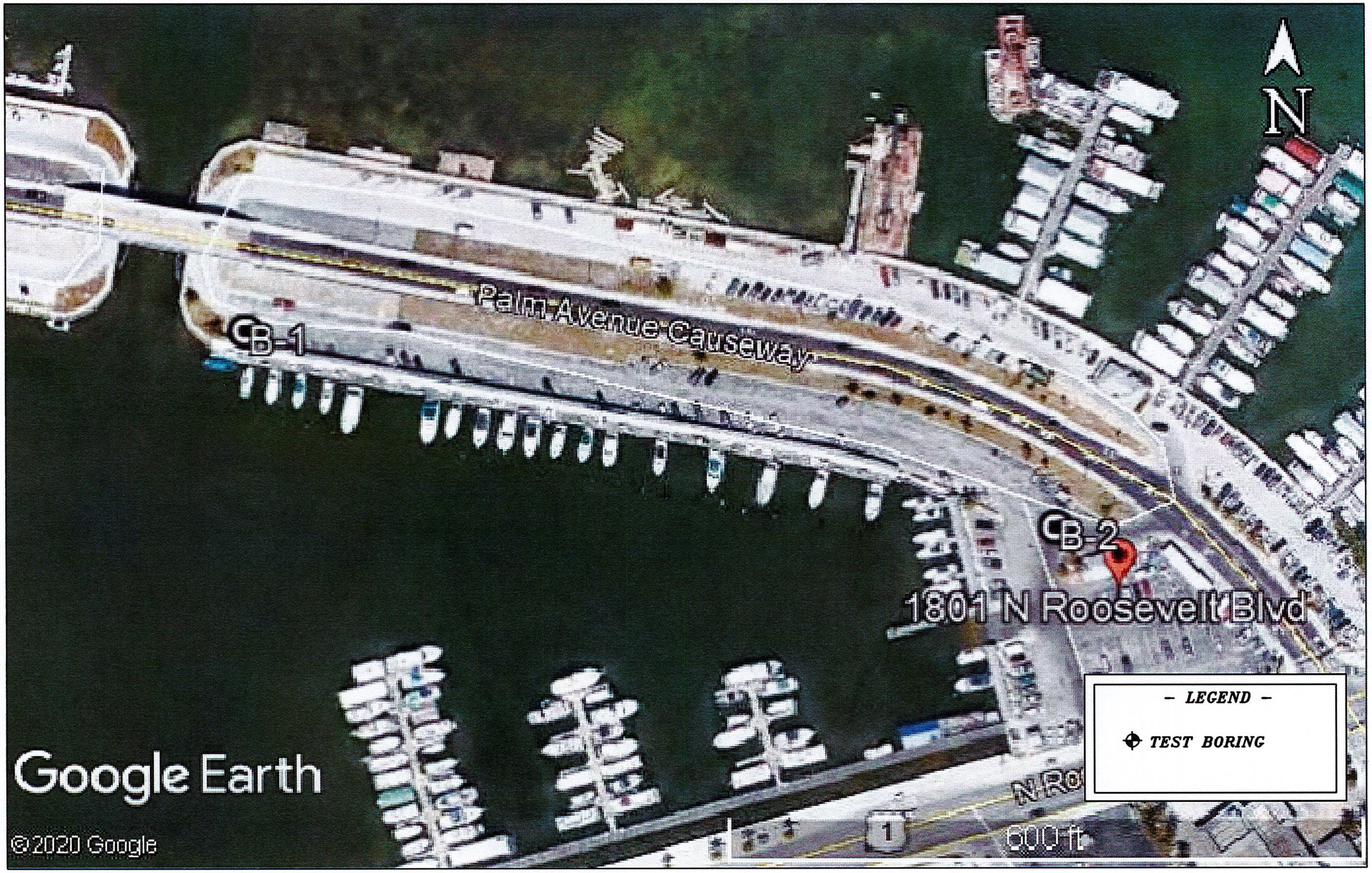
We appreciate the opportunity to provide these services for you. If we can be of any further assistance, or if you need additional information, please feel free to contact us.

Sincerely,
NUTTING ENGINEERS OF FLORIDA, INC.

Natalie Chacin /for
Adrian Ramirez
Engineering Intern

Richard Wohlfarth 7/17/20
Richard C. Wohlfarth, P.E #50858
Director of Engineering

Attachments: Boring Location Plan
Test Boring Log
Soil Property Table
Soil Classification Criteria
Limitations of Liability



NUTTING ENGINEERS OF FLORIDA, INC. ESTABLISHED 1967	CITY MARINA AT GARRISON BIGHT 1801 N. ROOSEVELT BLVD KEY WEST, FLORIDA	APPROXIMATE TEST LOCATIONS	NOT TO SCALE	FIGURE 1

BORING NUMBER B-1

Nutting Engineers of Florida

PROJECT NUMBER 2245.3

CLIENT Tetra Tech

PROJECT NAME City Marina @ Garrison Bight

PROJECT LOCATION 1801 N. Roosevelt Blvd., Key West, FL 33040

DATE STARTED 7/1/20 COMPLETED 7/1/20

SURFACE ELEVATION REFERENCE Same as road crown

DRILLING METHOD Standard Penetration Boring

GROUND WATER LEVELS:

LOGGED BY Dancor CHECKED BY A. Ramirez

AT TIME OF DRILLING 2.7 ft

APPROXIMATE LOCATION OF BORING As located on site plan

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	Blows	N-Value
0	Brown to light brown LIMESTONE FRAGMENTS, trace fine sand and roots	SS 1	8-23-31-18	54
	Lt. brown LIMESTONE FRAGMENTS	SS 2	6-4-4-4	8
5	Lt. brown LIMESTONE	SS 3	3-5-4-3	9
		SS 4	4-9-3-1	12
10	Lt. brown to gray LIMESTONE and fine SAND	SS 5	5-5-10-25	15
15	Lt. brown fine SAND and LIMESTONE	SS 6	13-25-30-45	55
20	Lt. gray LIMESTONE and fine SAND	SS 7	23-38-47-41	85
25		SS 8	18-23-24-36	47
30		SS 9	16-17-18-31	35
35	Lt. gray LIMESTONE	SS 10	6-6-11-5	17
40		SS 11	5-4-5-7	9
	Bottom of hole at 40.0 feet.			

SPT N VALUE: 10 20 30 40; PL MC LL: 20 40 60 80; FINES CONTENT (%): 20 40 60 80

TEST NUTTING BOREHOLE 2-2245.3 TETRA TECH - CITY MARINA @ GARRISON BIGHT.GPJ GINT US.GDT 7/9/20

Nutting Engineers of Florida

BORING NUMBER B-2

PROJECT NUMBER 2245.3

CLIENT Tetra Tech

PROJECT NAME City Marina @ Garrison Bight

PROJECT LOCATION 1801 N. Roosevelt Blvd., Key West, FL 33040

DATE STARTED 7/1/20 COMPLETED 7/1/20

SURFACE ELEVATION REFERENCE Same as road crown

DRILLING METHOD Standard Penetration Boring

GROUND WATER LEVELS:

LOGGED BY Dancor CHECKED BY A. Ramirez

AT TIME OF DRILLING 2.2 ft

APPROXIMATE LOCATION OF BORING As located on site plan

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	Blows	N-Value	▲ SPT N VALUE ▲ (10 20 30 40)
0	DRILLED ASPHALT				
	Lt. brown fine SAND and LIMESTONE FRAGMENTS	SS 1	24-10-14-6	24	▲
	Lt. brown fine SAND				
	Gray SILTY SAND	SS 2	2-1-7-6	8	▲
5	Lt. gray LIMESTONE	SS 3	7-6-3-3	9	▲
	Lt. brown LIMESTONE	SS 4	3-3-2-2	5	▲
10		SS 5	3-3-3-2	6	▲
15	Lt. brown to lt. gray fine SAND and LIMESTONE	SS 6	1-1-WOH-1		
20	Lt. brown fine SAND and LIMESTONE	SS 7	38-42-47-48	89	>>▲
25		SS 8	16-25-30-40	55	>>▲
30	Lt. gray LIMESTONE	SS 9	26-19-21-21	40	▲
35		SS 10	11-10-10-10	20	▲
40		SS 11	10-9-9-7	18	▲
	Bottom of hole at 40.0 feet.				

PL MC LL (20 40 60 80)

□ FINES CONTENT (%) □ (20 40 60 80)

TABLE OF SOIL PROPERTIES BORING B-1						
Depth (feet)	Description	Unit Weight (lb./cu.ft)		Angle of Internal Friction (Degrees)	Earth Pressure Coefficient	
		Saturated	Submerged		Passive	Active
0-13	LIMESTONE fragments and fine SAND	125	63	40	4.60	0.22
13-18	Fine SAND	115	53	30	3.00	0.33
18-40	LIMESTONE	135	73	40	4.60	0.22

Appropriate Factors of Safety should be used in the foundation design.

Note: Groundwater (WT) encountered at an approximate depth of 2.7 feet below existing ground surface at time drilling was performed.

Nutting Engineers
of Florida Inc. | Established 1967

TABLE OF SOIL PROPERTIES BORING B-2						
Depth (feet)	Description	Unit Weight (lb./cu.ft)		Angle of Internal Friction (Degrees)	Earth Pressure Coefficient	
		Saturated	Submerged		Passive	Active
0-2.5	Fine SAND and Limestone Fragments	115	53	30	3.00	0.33
2.5-4	Silty SAND	105	43	22	2.19	0.45
4-13	LIMESTONE	135	73	40	4.60	0.22
13-28	Fine SAND and LIMESTONE	115	53	30	3.00	0.33
28-40	LIMESTONE	135	73	40	4.60	0.22

Appropriate Factors of Safety should be used in the foundation design.

Note: Groundwater (WT) encountered at an approximate depth of 2.2 feet below existing ground surface at time drilling was performed.

SOIL AND ROCK CLASSIFICATION CRITERIA

SAND/SILT

N-VALUE (bpf)	RELATIVE DENSITY
0 – 4	Very Loose
5 – 10	Loose
11 – 29	Medium
30 – 49	Dense
>50	Very dense
100	Refusal

CLAY/SILTY CLAY

N-VALUE (bpf)	UNCONFINED COMP. STRENGTH (tsf)	CONSISTENCY
<2	<0.25	v. Soft
2 – 4	0.25 – 0.50	Soft
5 – 8	0.50 – 1.00	Medium
9 – 15	1.00 – 2.00	Soft
16 – 30	2.00 – 4.00	v. Stiff
>30	>4.00	Hard

ROCK

N-VALUE (bpf)	RELATIVE HARDNESS	ROCK CHARACTERISTICS
N≥ 100	Hard to v. hard	Local rock formations vary in hardness from soft to very hard within short vertical and horizontal distances and often contain vertical solution holes of 3 to 36 inch diameter to varying depths and horizontal solution features. Rock may be brittle to split spoon impact, but more resistant to excavation.
25≤ N ≤ 100	Medium hard to hard	
5≤ N ≤ 25	Soft to medium hard	

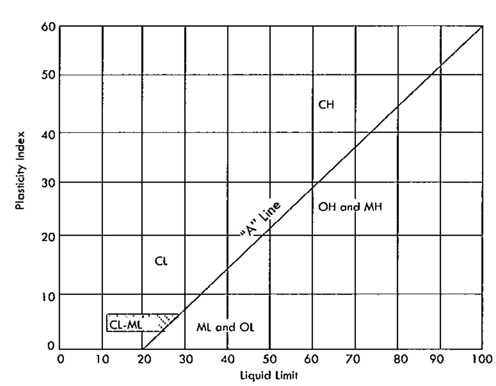
PARTICLE SIZE

Boulder	>12 in.
Cobble	3 to 12 in.
Gravel	4.76 mm to 3 in.
Sand	0.074 mm to 4.76 mm
Silt	0.005 mm to 0.074 mm
Clay	<0.005 mm

DESCRIPTION MODIFIERS

0 – 5%	Slight trace
6 – 10%	Trace
11 – 20%	Little
21 – 35%	Some
>35%	And

Major Divisions			Group Symbols	Typical names	Laboratory classification criteria		
Coarse-grained soils (More than half of material is *larger* than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than No. 4 sieve size)	Clean gravels (Little or no fines)	GW	Well-graded gavels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows: Less than five percent..........GW, GP, SW, SP More than 12 percent..............GM, GC, SM, SC 5 to 12 percent..............*Borderline cases requiring dual systems***	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_z = \frac{(D_{30})^2}{D_{10} x D_{60}}$ *between* 1 and 3	
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW	
		Gravels with fines (Appreciable amount of fines)	GW* d / u	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are *borderline* cases requiring use of dual symbols.
			GC	Clayey gravels, gravel-sand-clay mixtures		Atterberg limits above "A" line with P.I. greater than 7	
	Sands (More than half of coarse fraction is smaller than No. 4 sieve size)	Clean sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines		$C_u = \frac{D_{60}}{D_{10}}$ greater than 6; $C_z = \frac{(D_{30})^2}{D_{10} x D_{60}}$ *between* 1 and 3	
			SP	Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM* d / u	Silty sands, sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Limits plotting in hatched zone with P.I. between 4 and 7 are *borderline* cases requiring use of dual system.
			SC	Clayey sands, sand-clay mixtures		Atterberg limits above "A" line with P.I. more than 7	
Fine-grained soils (More than half of material is *smaller* than No. 200 sieve size)	Silts and clays (Liquid limit less than 50)		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity			
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy, clays, silty clays, lean clays			
			OL	Organic silts and organic silty clays of low plasticity			
	Silts and clays (Liquid limit greater than 50)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts			
			CH	Inorganic clays or high plasticity, fat clays			
			OH	Organic clays of medium to high plasticity, organic silts			
	Highly organic soils		PT	Peat and other highly organic soils			



Plasticity Chart

Nutting Engineers of Florida Inc. | Established 1967

LIMITATIONS OF LIABLILITY

WARRANTY

We warranty that the services performed by Nutting Engineers of Florida, Inc. are conducted in a manner consistent with that level of care and skill ordinarily exercised by members of the profession in our area currently practicing under similar conditions at the time our services were performed. ***No other warranties, expressed or implied, are made***. While the services of Nutting Engineers of Florida, Inc. are a valuable and integral part of the design and construction teams, we do not warrant, guarantee or insure the quality, completeness, or satisfactory performance of designs, construction plans, specifications we have not prepared, nor the ultimate performance of building site materials or assembly/construction.

SUBSURFACE EXPLORATION

Subsurface exploration is normally accomplished by test borings; test pits are sometimes employed. The method of determining the boring location and the surface elevation at the boring is noted in the report. This information is represented in the soil boring logs and/or a drawing. The location and elevation of the borings should be considered accurate only to the degree inherent with the method used and may be approximate.

The soil boring log includes sampling information, description of the materials recovered, approximate depths of boundaries between soil and rock strata as encountered and immediate depth to water data. The log represents conditions recorded specifically at the location where and when the boring was made. Site conditions may vary through time as will subsurface conditions. The boundaries between different soil strata as encountered are indicated at specific depths; however, these depths are in fact approximate and dependent upon the frequency of sampling, nature and consistency of the respective strata. Substantial variation between soil borings may commonly exist in subsurface conditions. Water level readings are made at the time and under conditions stated on the boring logs. Water levels change with time, precipitation, canal level, local well drawdown and other factors. Water level data provided on soil boring logs shall not be relied upon for groundwater based design or construction considerations.

LABORATORY AND FIELD TESTS

Tests are performed in *general* accordance with specific ASTM Standards unless otherwise indicated. All criteria included in a given ASTM Standard are not always required and performed. Each test boring report indicates the measurements and data developed at each specific test location.

ANALYSIS AND RECOMMENDATIONS

The geotechnical report is prepared primarily to aid in the design of site work and structural foundations. Although the information in the report is expected to be sufficient for these purposes, it shall not be utilized to determine the cost of construction nor to stand alone as a construction specification. Contractors shall verify subsurface conditions as may be appropriate prior to undertaking subsurface work.

Report recommendations are based primarily on data from test borings made at the locations shown on the test boring reports. Soil variations commonly exist between boring locations. Such variations may not become evident until construction. Test pits sometimes provide valuable supplemental information that derived from soil borings. If variations are then noted, the geotechnical engineer shall be contacted in writing immediately so that field conditions can be examined and recommendations revised if necessary.

The geotechnical report states our understanding as to the location, dimensions and structural features proposed for the site. ***Any significant changes of the site improvements or site conditions must be communicated in writing to the geotechnical engineer immediately*** so that the geotechnical analysis, conclusions, and recommendations can be reviewed and appropriately adjusted as necessary.

CONSTRUCTION OBSERVATION

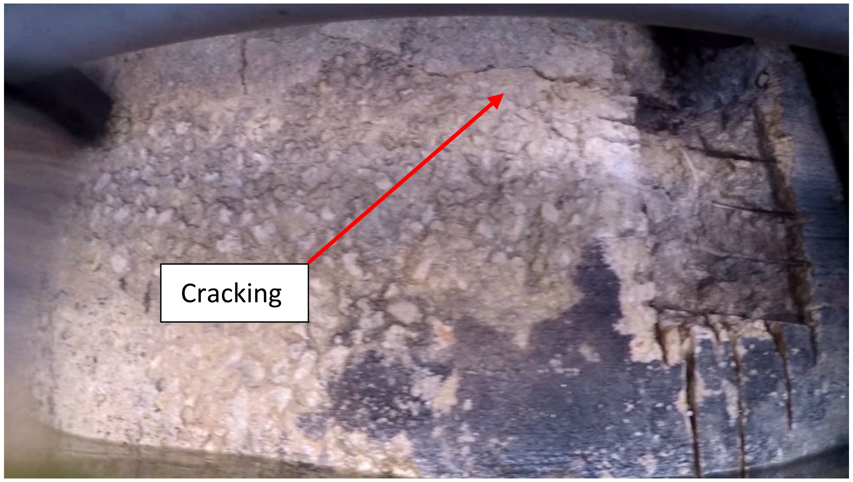
Construction observation and testing is an important element of geotechnical services. The geotechnical engineer's field representative (G.E.F.R.) is the "owner's representative" observing the work of the contractor, performing tests and reporting data from such tests and observations. ***The geotechnical engineer's field representative does not direct the contractor's construction means, methods, operations or personnel.*** The G.E.F.R. does not interfere with the relationship between the owner and the contractor and, except as an observer, does not become a substitute owner on site. The G.E.F.R. is responsible for his/her safety, but has no responsibility for the safety of other personnel at the site. The G.E.F.R. is an important member of a team whose responsibility is to observe and test the work being done and report to the owner whether that work is being carried out in general conformance with the plans and specifications. The enclosed report may be relied upon solely by the named client.

Appendix C

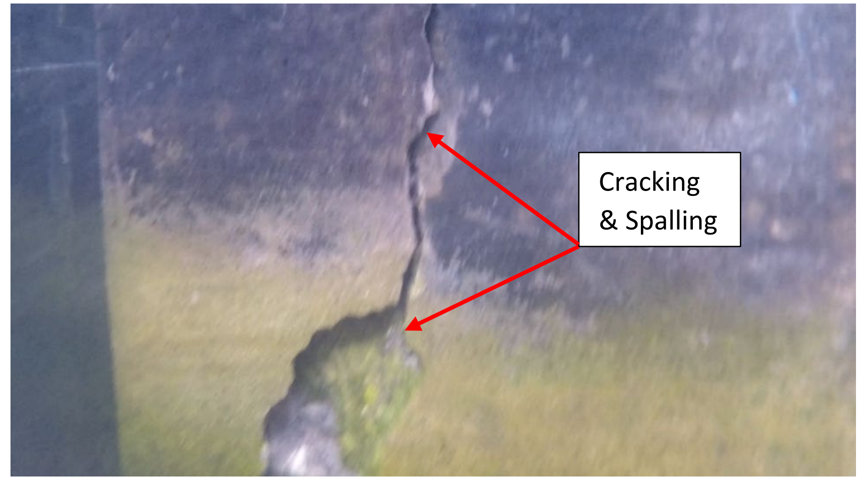
Deficiencies Photo Log

June 2020

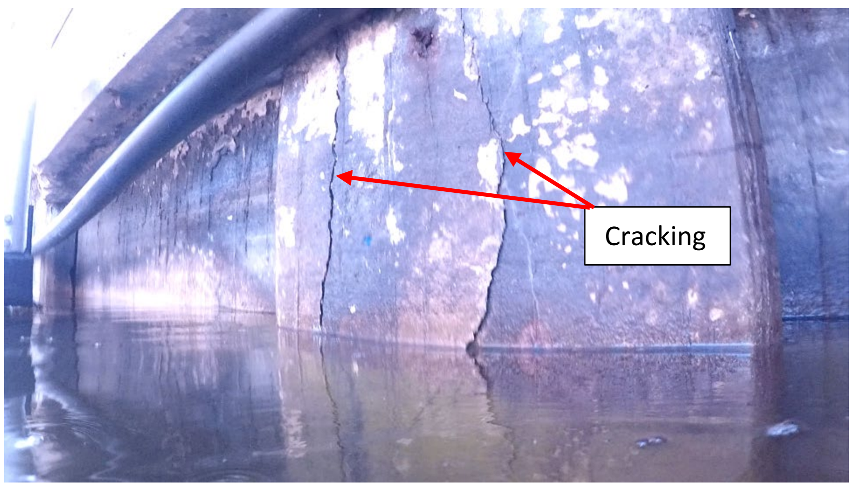
Pile Numbers displayed in Video and Photos during Inspection do not correlate to the Pile Numbers used in the Report, see list below for identification discrepancies:					
Pile #'s (in Video)	Pile #'s (in Report)	Pile #'s (in Video)	Pile #'s (in Report)	Pile #'s (in Video)	Pile #'s (in Report)
"3"	Pile 45	"37"	Pile 79	"71"	Pile 113
"5"	Pile 47	"40"	Pile 82	"72"	Pile 114
"7"	Pile 49	"44"	Pile 86	"73"	Pile 115
"10"	Pile 52	"47"	Pile 89	"75"	Pile 117
"12"	Pile 54	"50"	Pile 92	"76"	Pile 118
"13"	Pile 55	"54"	Pile 96	"77"	Pile 119
"15"	Pile 57	"56"	Pile 98	"79"	Pile 121
"17"	Pile 59	"58"	Pile 100	"80"	Pile 122
"18"	Pile 60	"59"	Pile 101	"83"	Pile 125
"20"	Pile 62	"61"	Pile 103	"84"	Pile 126
"22"	Pile 64	"62"	Pile 104	"85"	Pile 127
"23"	Pile 65	"63"	Pile 105	"88"	Pile 130
"24"	Pile 66	"64"	Pile 106	"89"	Pile 132
"26"	Pile 68	"65"	Pile 107	"90"	Pile 133
"28"	Pile 70	"66"	Pile 108	"91"	Pile 134
"29"	Pile 71	"67"	Pile 109	"92"	Pile 135
"30"	Pile 72	"69"	Pile 111	"93"	Pile 137
"35"	Pile 77	"70"	Pile 112	"96"	Pile 140



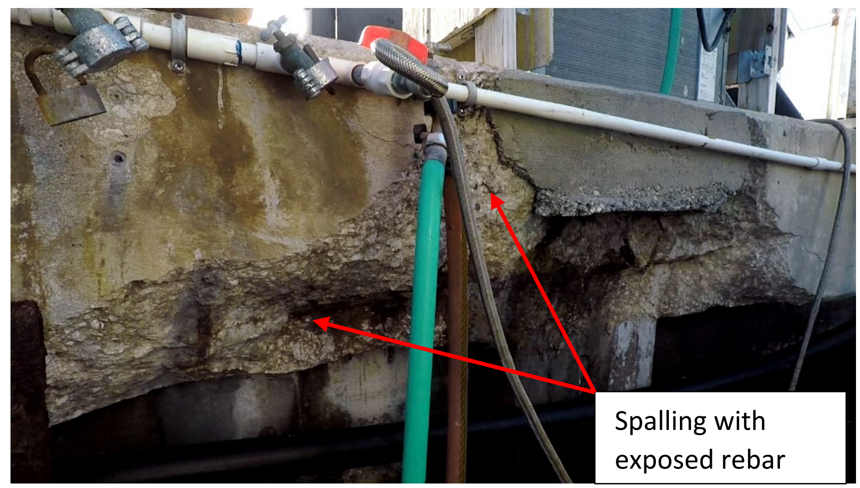
Deficiency A-1: Panel 3-4 (Station 0+14)



Deficiency A-2: Pile 4 (Station 0+20)

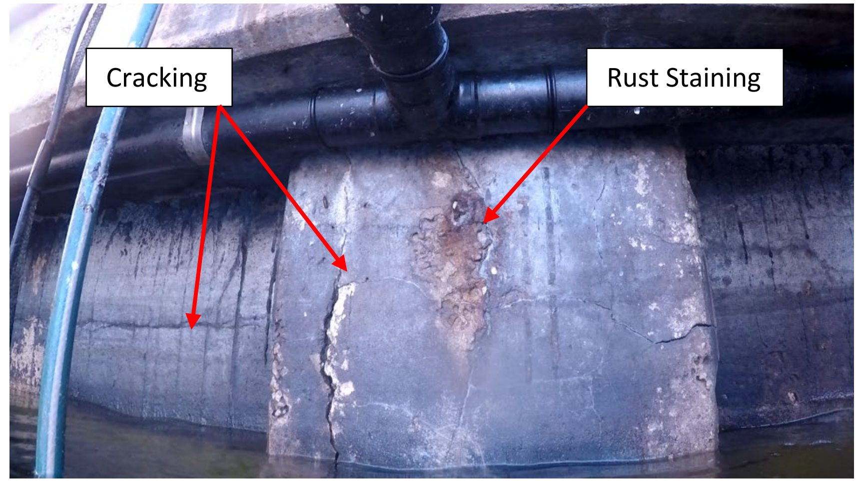


Deficiency A-3: Pile 6 (Station 0+33)

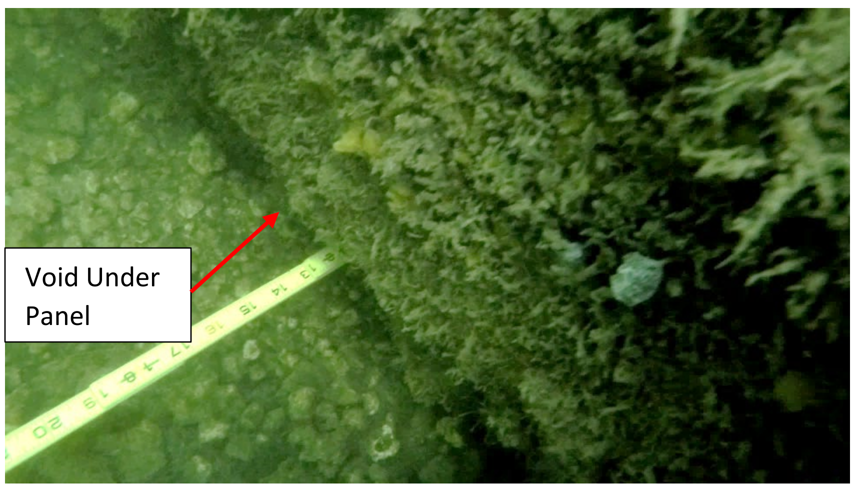


Deficiency A-4: Pile 7 (Station 0+39)

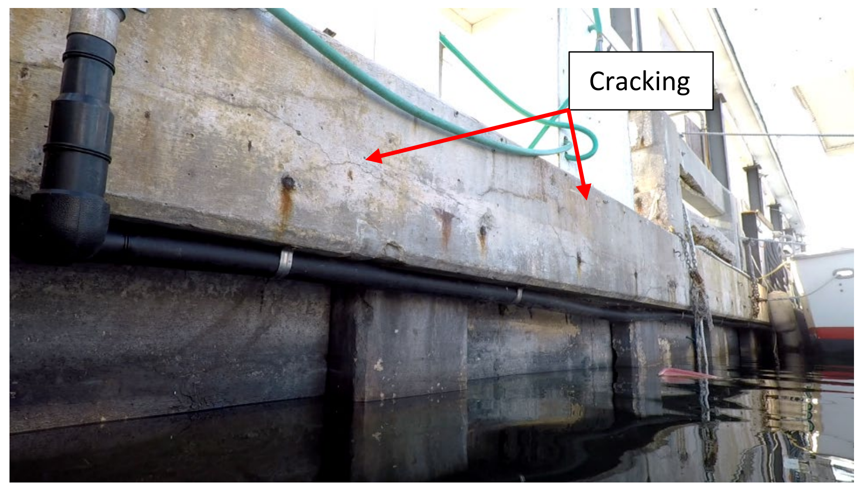
Deficiency A-6: Pile 11 (Station 0+66)



Deficiency A-6/A-7: Pile 11/Panel 11-12 (Station 0+66/0+69)



Deficiency A-8: Panel 12-13 (Station 0+75)

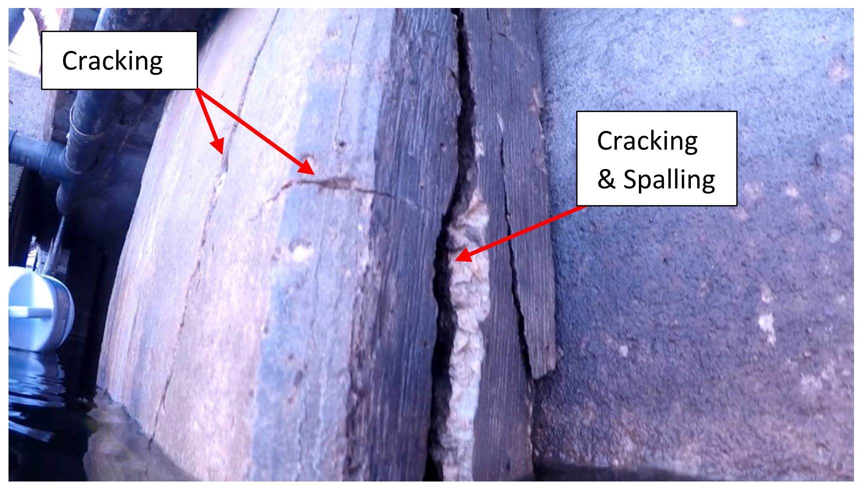


Deficiency A-9: Cap 13-16 (Station 0+84)

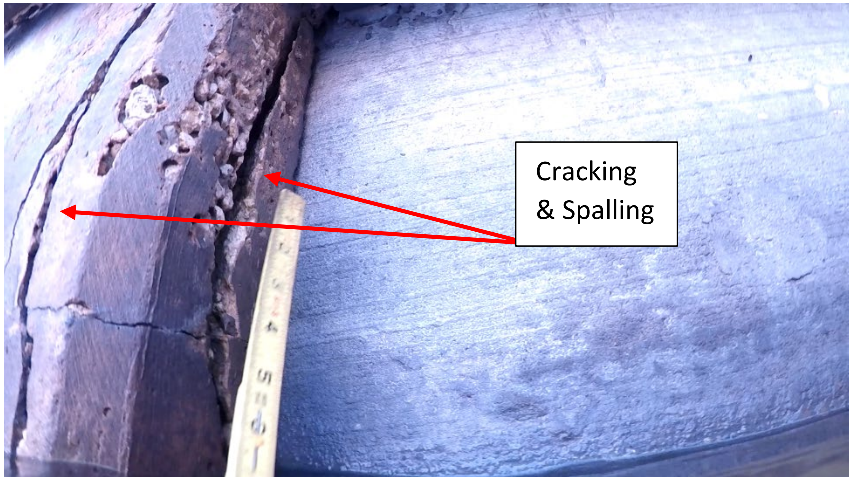
Deficiency A-12: Boat Ramp (Station 1+14)

Deficiency A-13: Pile 18 (Station 1+47)

Deficiency A-14: Panel 18-19 (Station 1+50)

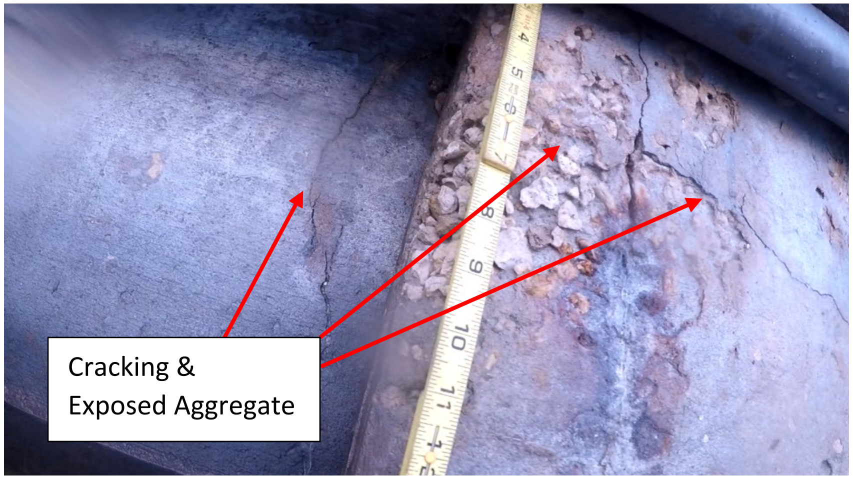


Deficiency A-15: Pile 21 (Station 1+67)

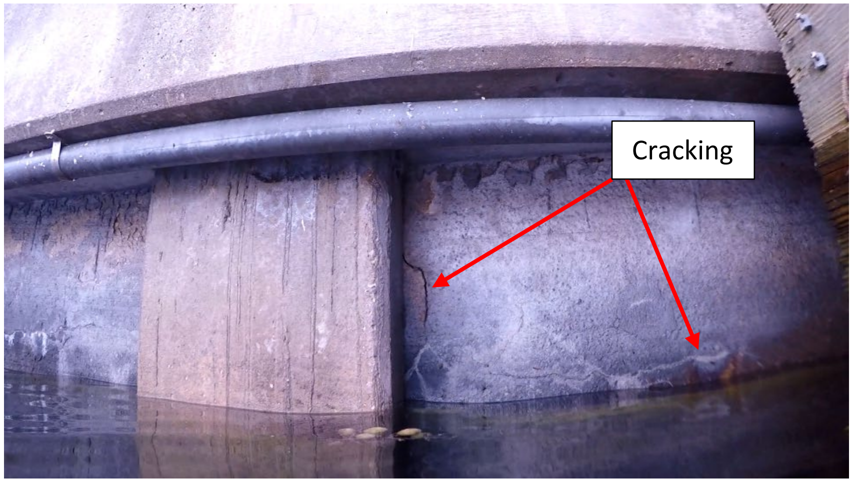


Deficiency A-16: Pile 23 (Station 1+80)

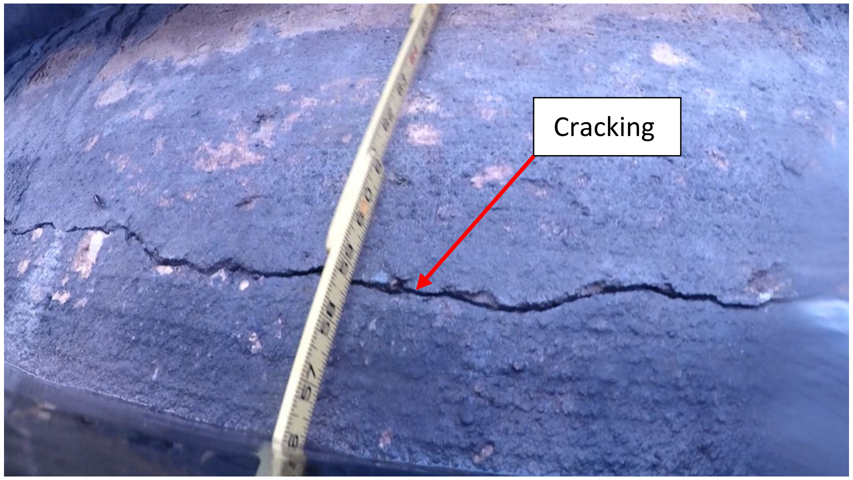
Deficiency A-18: Pile 26 (Station 2+00)_1 of 2



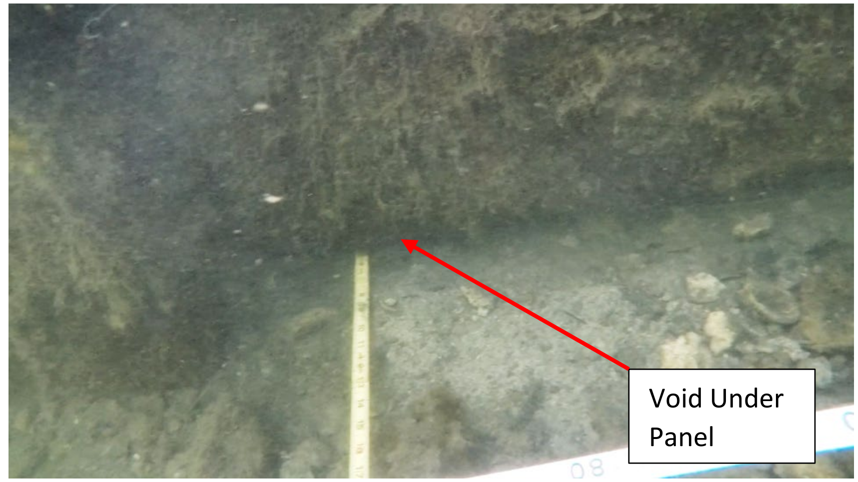
Deficiency A-18: Pile 26 (Station 2+00)_2 of 2



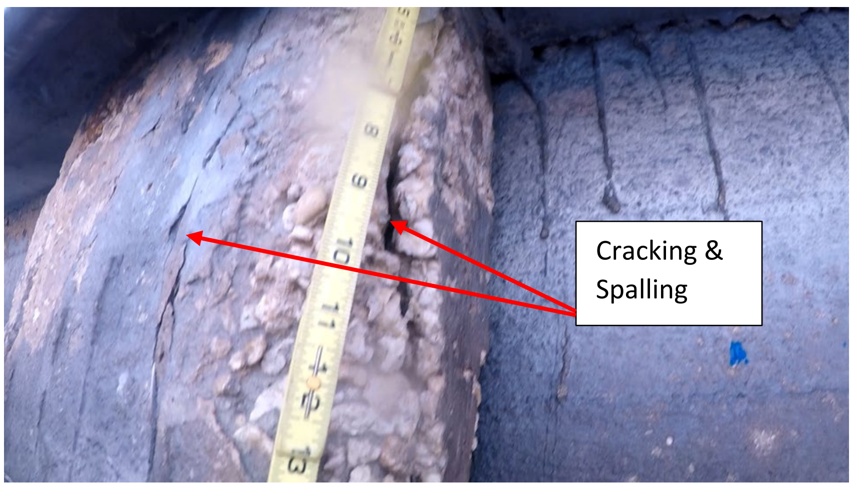
Deficiency A-19: Panel 27-28 (Station 2+12)



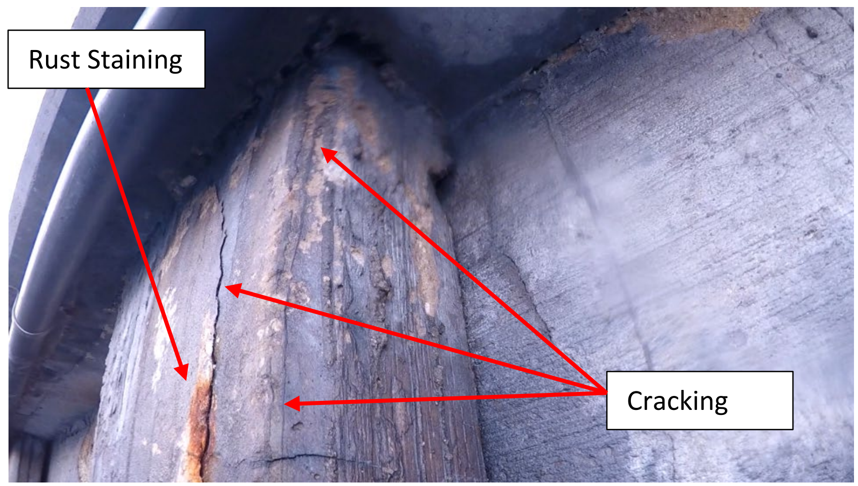
Deficiency A-20: Panel 28-29 (Station 2+17)_1 of 2



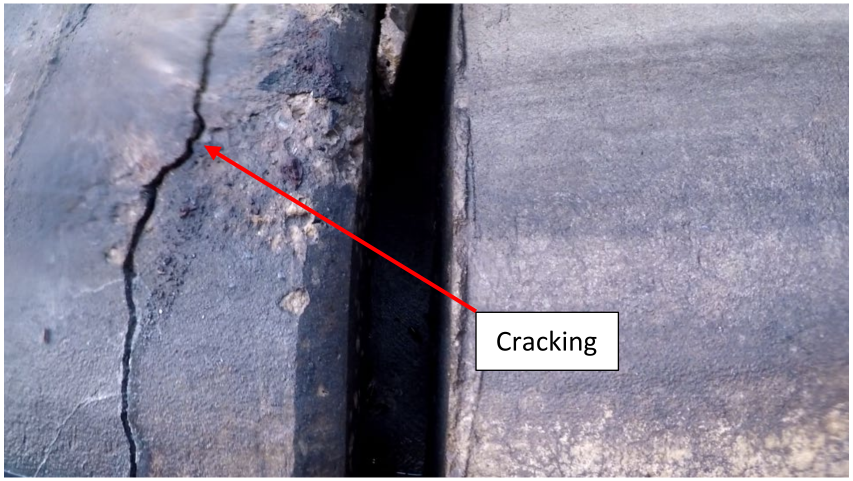
Deficiency A-20: Panel 28-29 (Station 2+17)_2 of 2



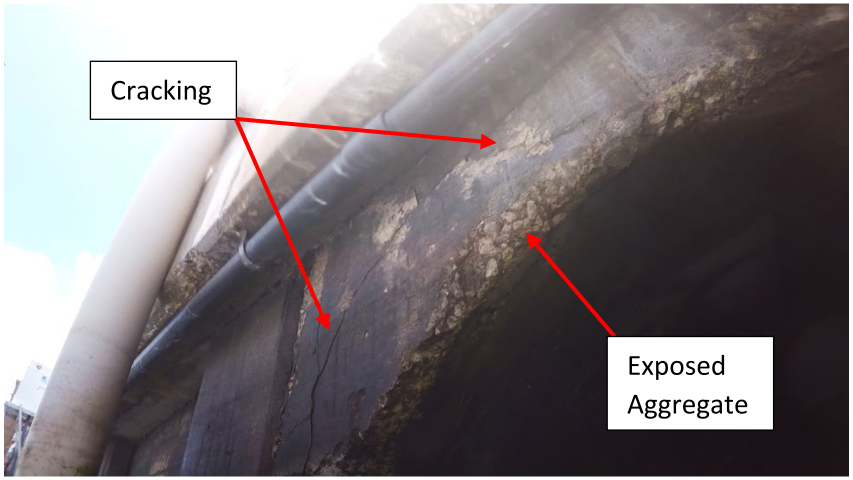
Deficiency A-21: Pile 30 (Station 2+26)



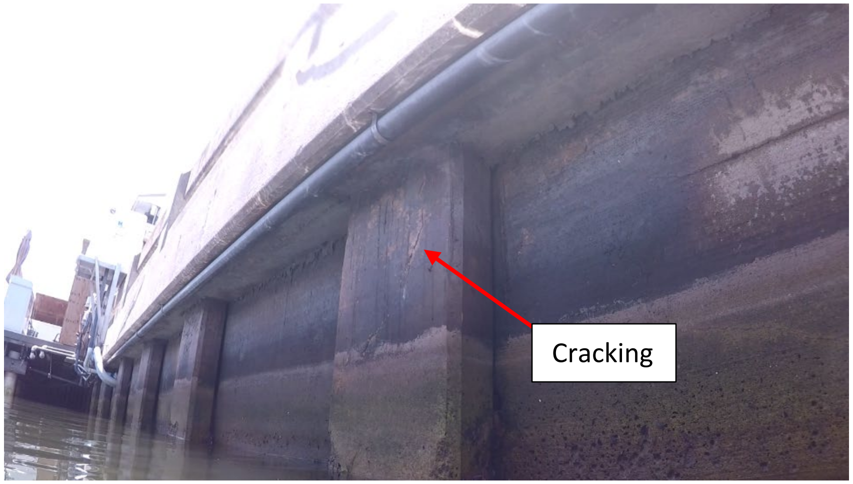
Deficiency A-22: Pile 31 (Station 2+33)



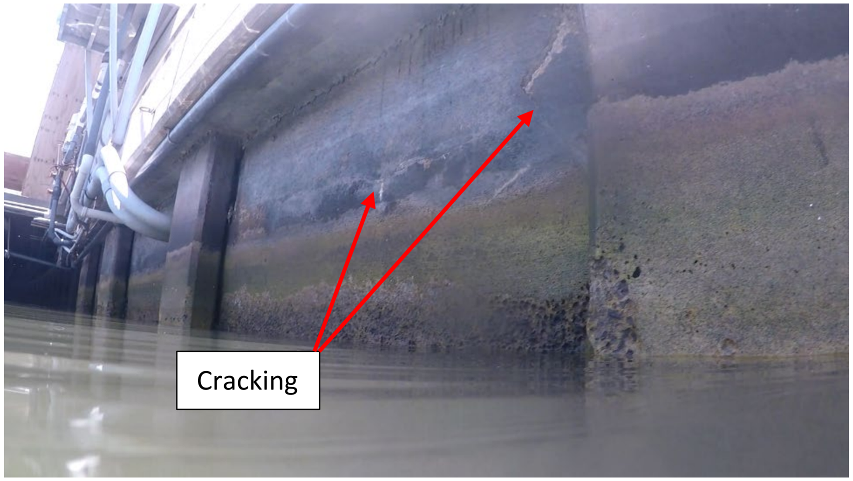
Deficiency B-23: Pile 35 (Station 2+51)



Deficiency B-24: Culvert Panel 36-37 (Station 2+60)

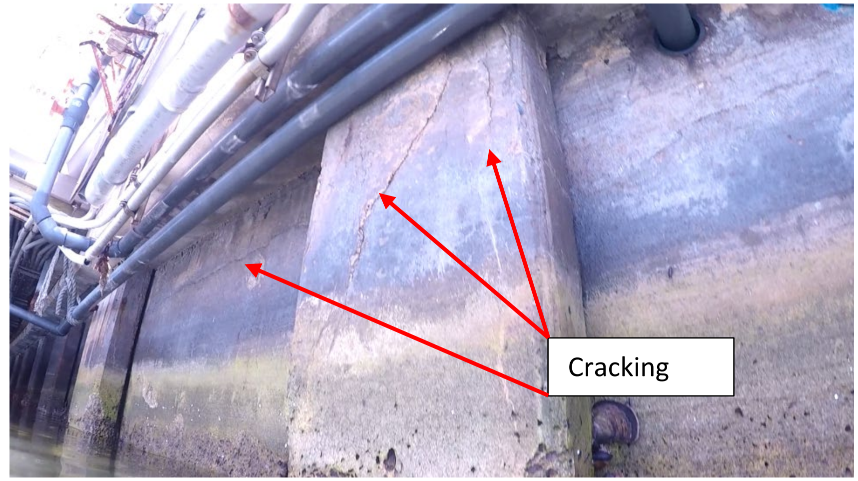


Deficiency B-25: Pile 38 (Station 2+70)

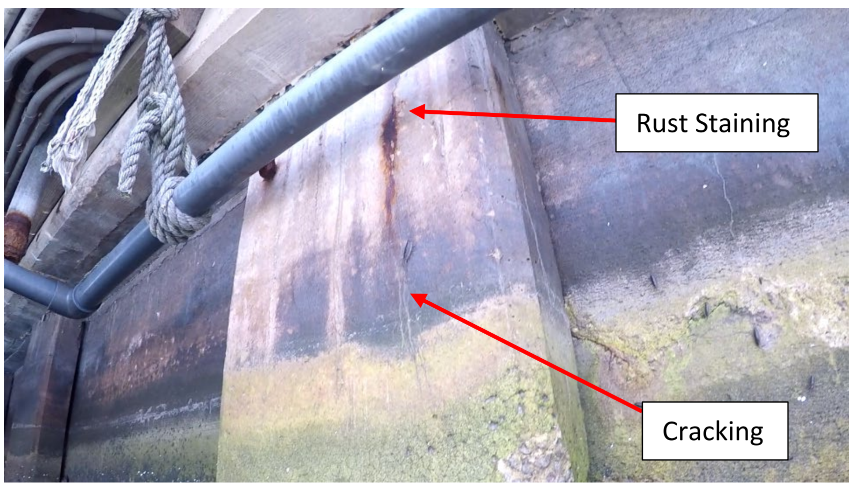


Deficiency B-26: Panel 40-41 (Station 2+86)

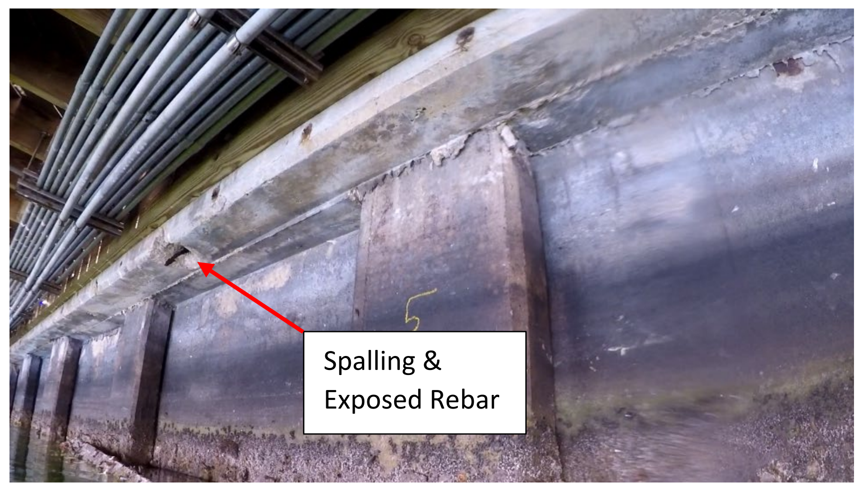
Deficiency B-27: Panel 41-42 (Station 2+93)



Deficiency B-28/B-29: Pile 42/Panel 42-43 (Station 2+96/3+00)

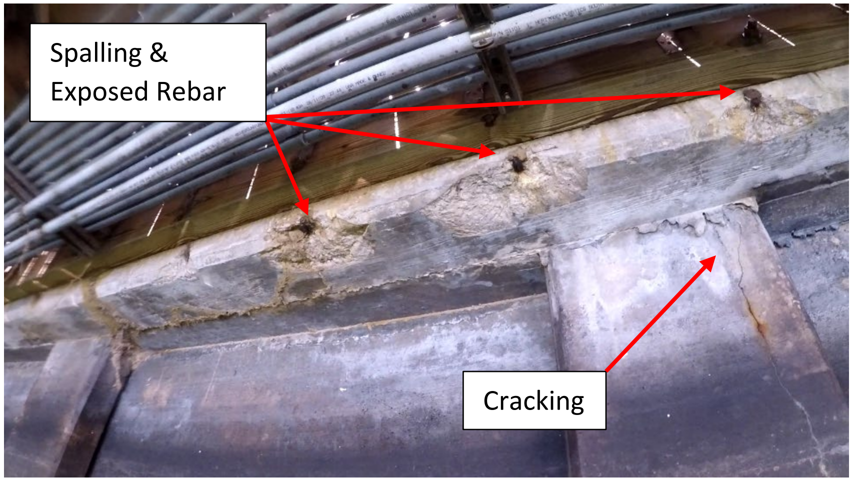


Deficiency B-30: Pile 43 (Station 3+04)

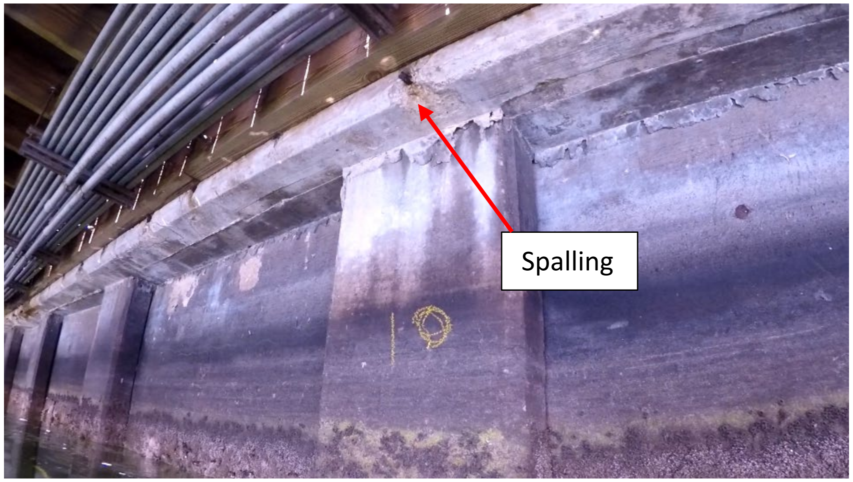


Deficiency B-31: Cap @47-48 (Station 3+33)

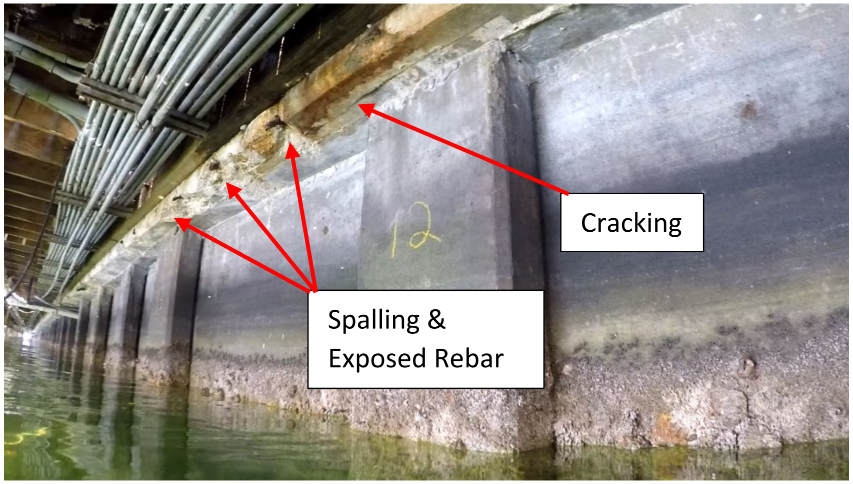
Deficiency B-32: Pile/Cap 49 (Station 3+43)



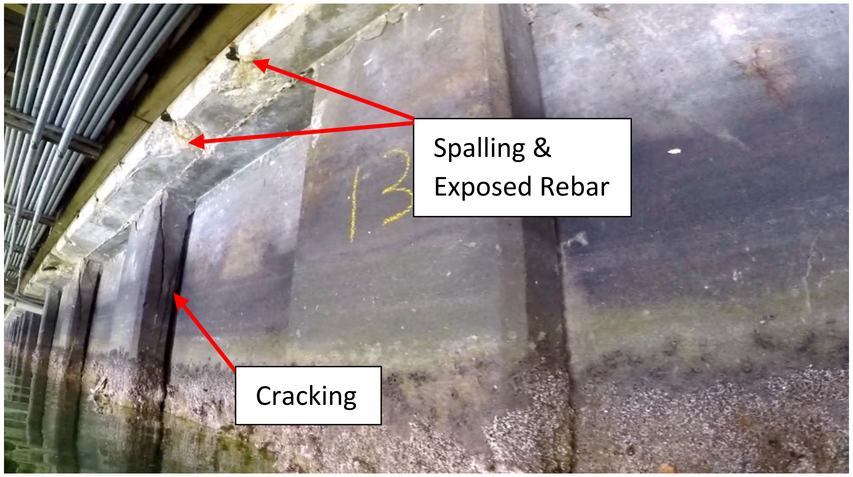
Deficiency B-33: Pile/Cap 50 (Station 3+50)



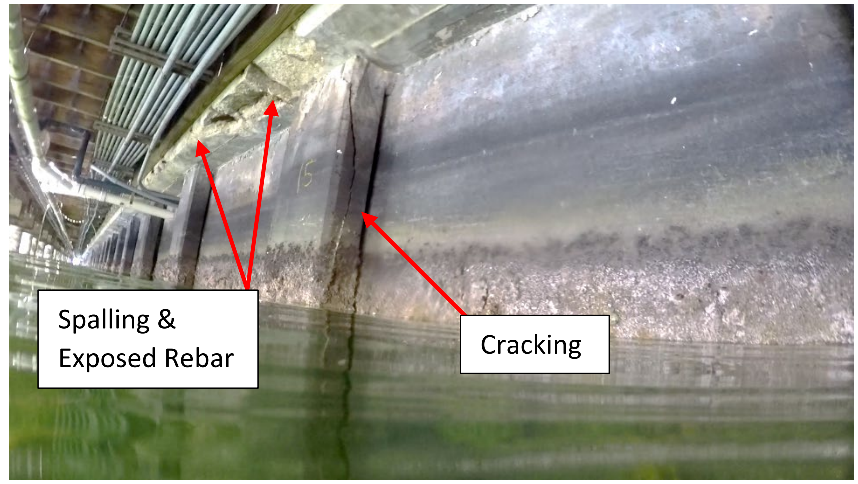
Deficiency B-34: Cap @52 (Station 3+62)



Deficiency B-35: Cap @54-55 (Station 3+78)

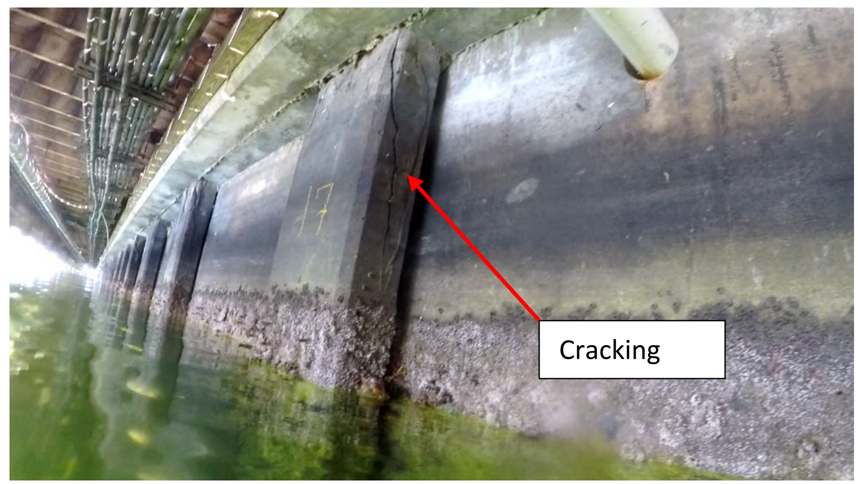


Deficiency B-36: Pile/Cap 56 (Station 3+86)

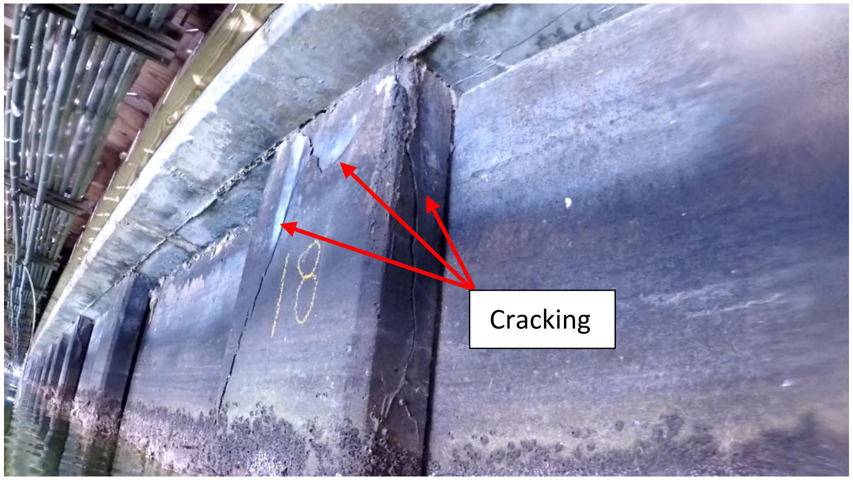


Deficiency B-37/B-38: Pile 57/Cap @57-58 (Station 3+93/3+95)

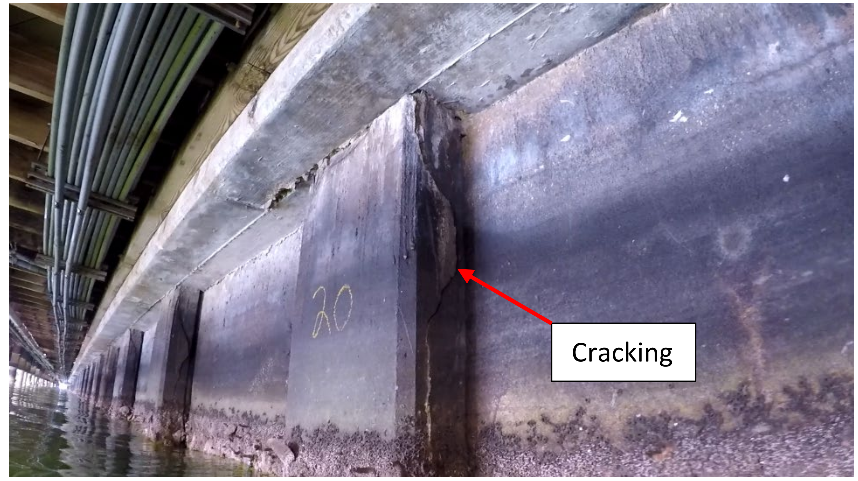
Deficiency B-39: Cap @58-59 (Station 4+01)



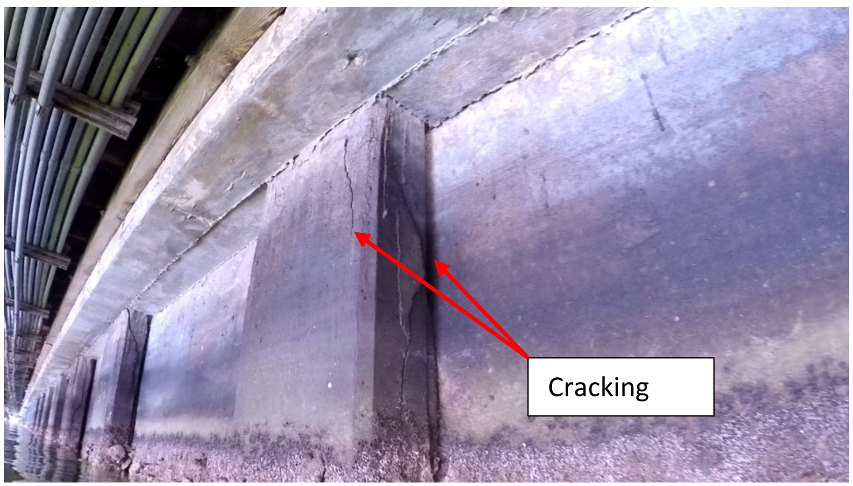
Deficiency B-40: Pile 59 (Station 4+05)



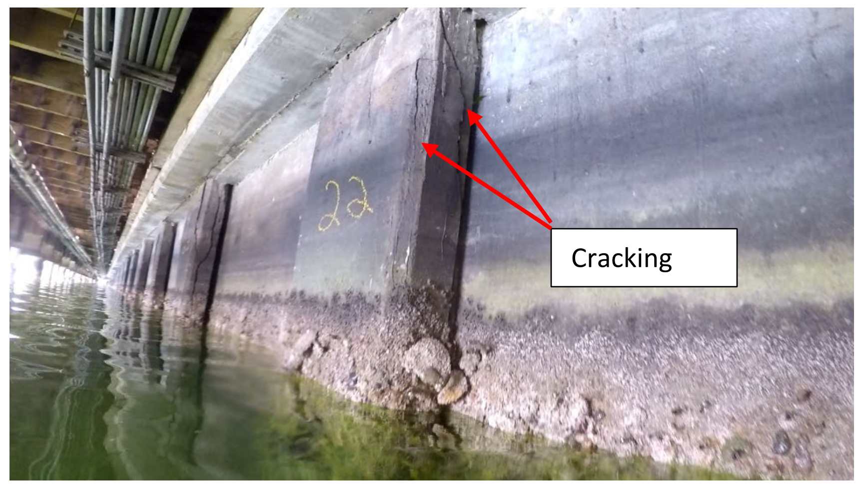
Deficiency B-41: Pile 60 (Station 4+12)



Deficiency B-42: Pile 62 (Station 4+25)

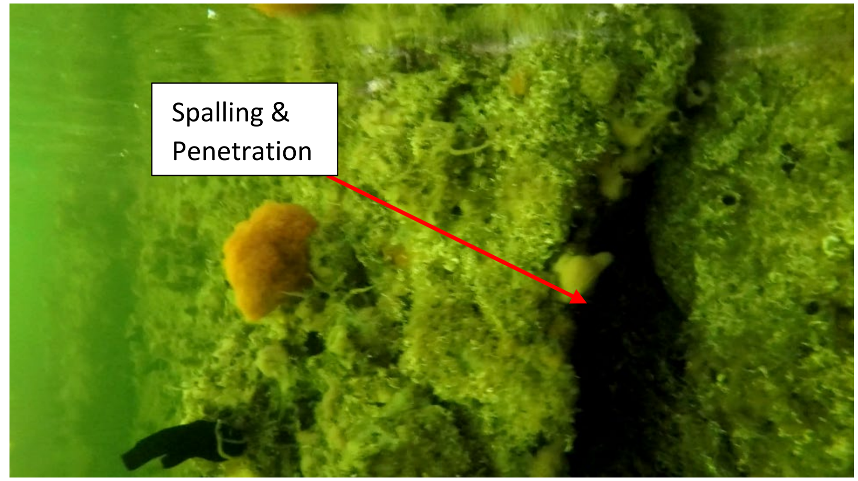


Deficiency B-43: Pile 63 (Station 4+31)

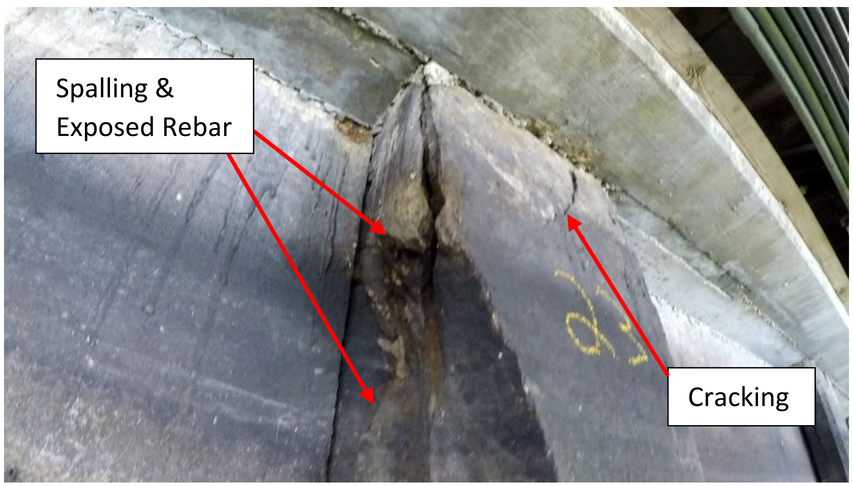


Deficiency B-44: Pile 64 (Station 4+37)

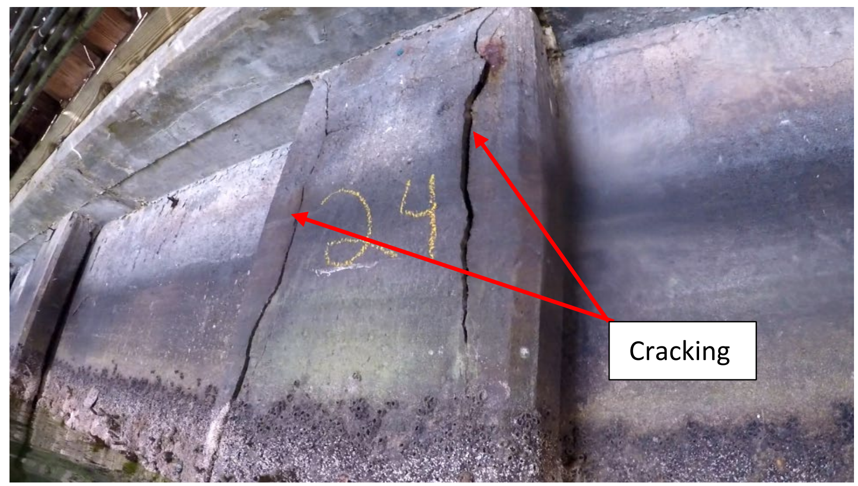
Deficiency B-45: Pile 65 (Station 4+44)_1 of 3



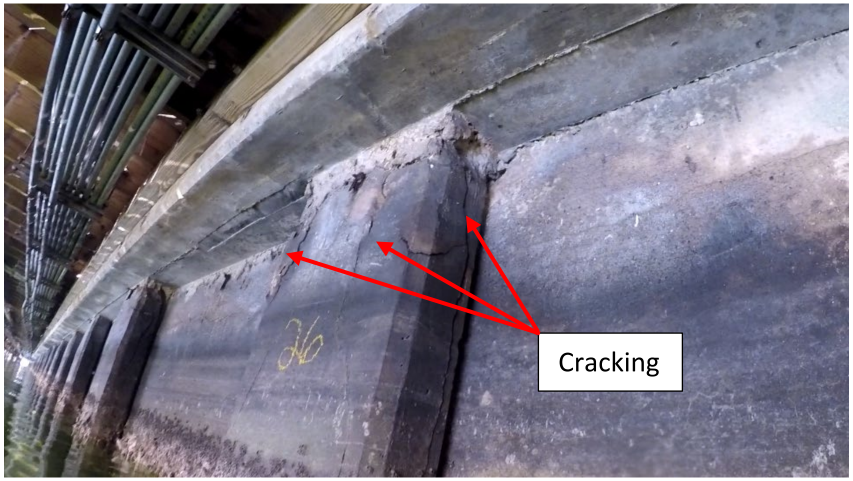
Deficiency B-45: Pile 65 (Station 4+44)_2 of 3



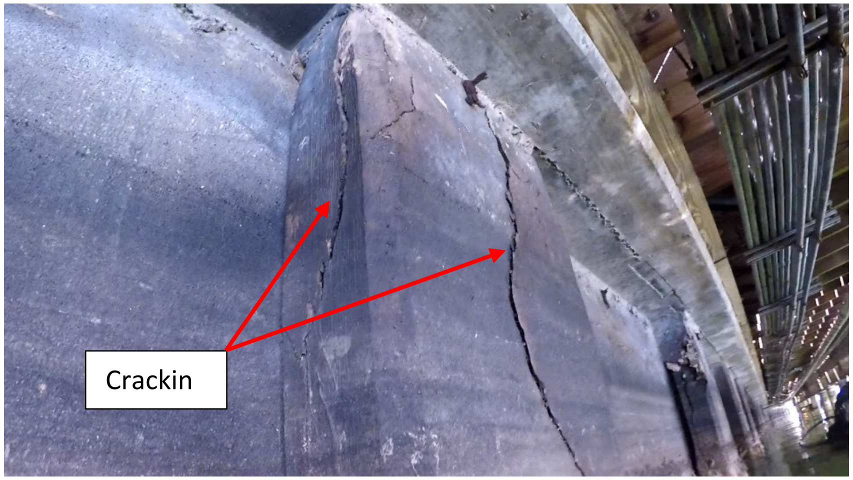
Deficiency B-45: Pile 65 (Station 4+44)_3 of 3



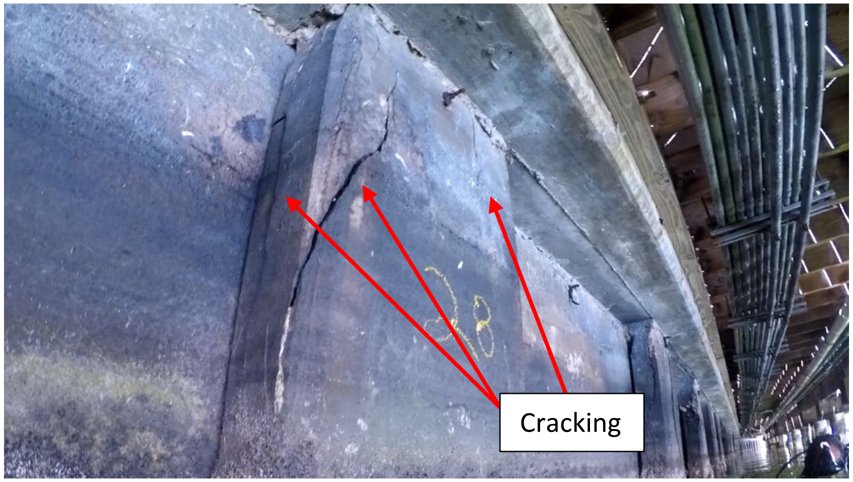
Deficiency B-46: Pile 66 (Station 4+50)



Deficiency B-47: Pile 68 (Station 4+63)

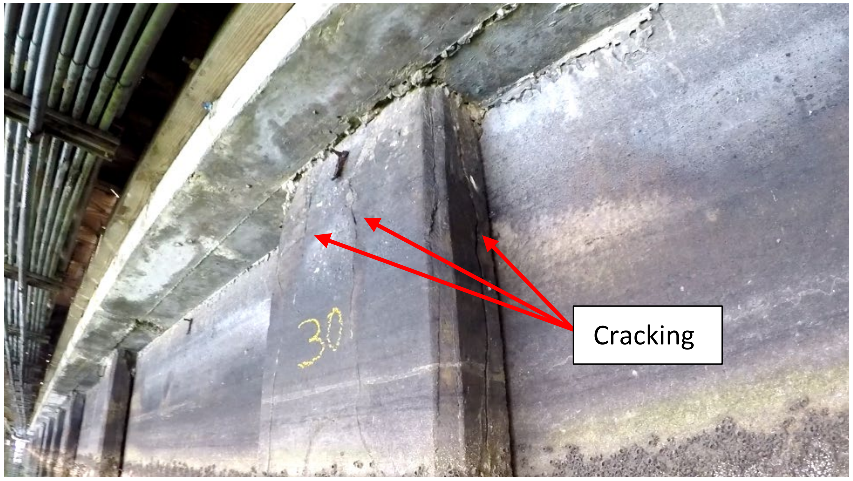


Deficiency B-48: Pile 69 (Station 4+70)

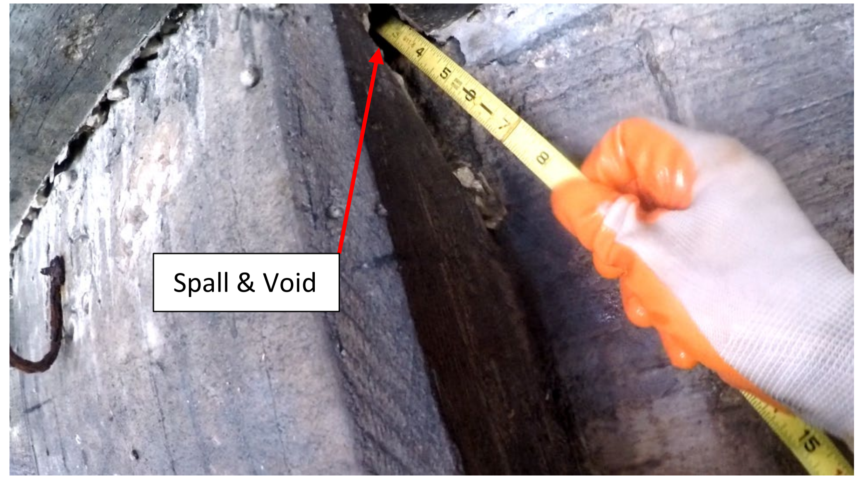


Deficiency B-49: Pile 70 (Station 4+76)

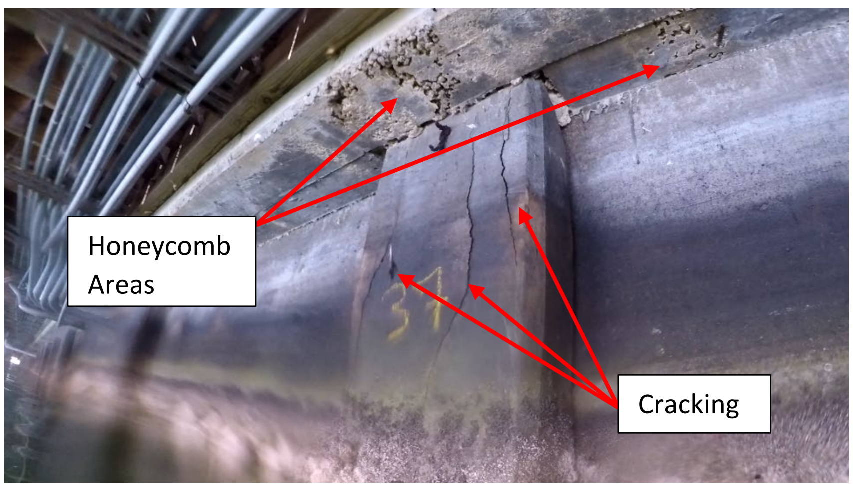
Deficiency B-50: Pile/Cap 71 (Station 4+83)



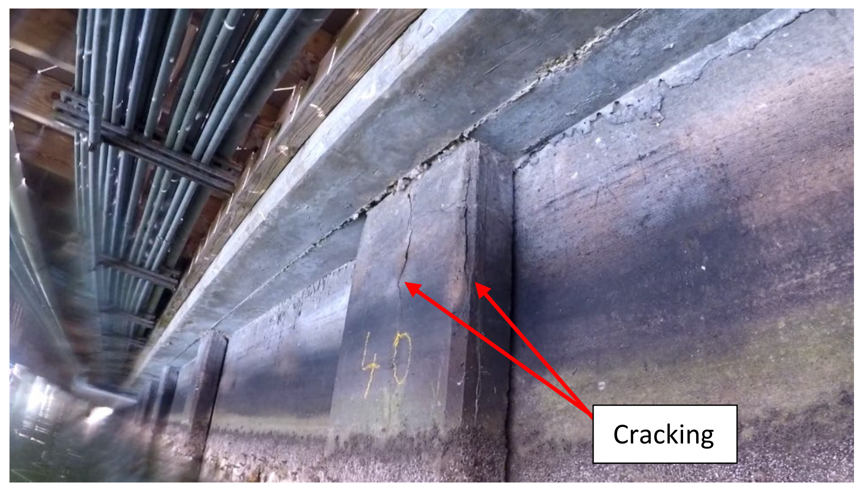
Deficiency B-51: Pile 72 (Station 4+90)



Deficiency B-52: Pile 73 (Station 4+99)

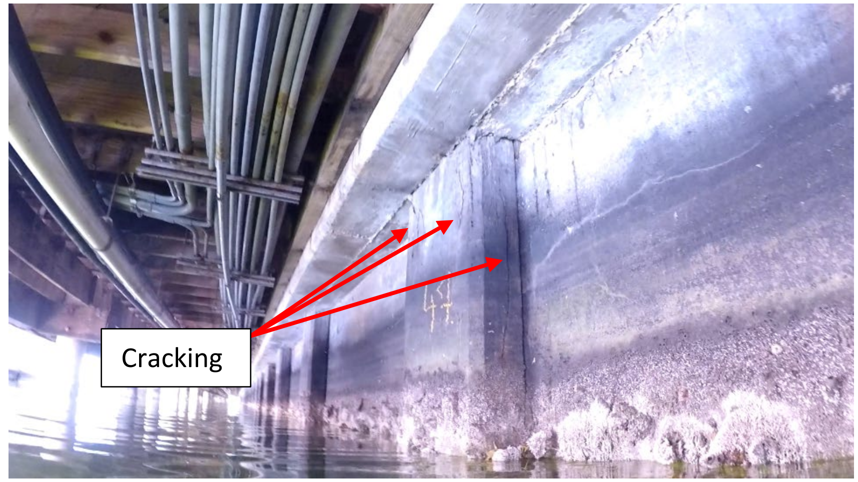


Deficiency B-53: Pile/Cap 79 (Station 5+48)



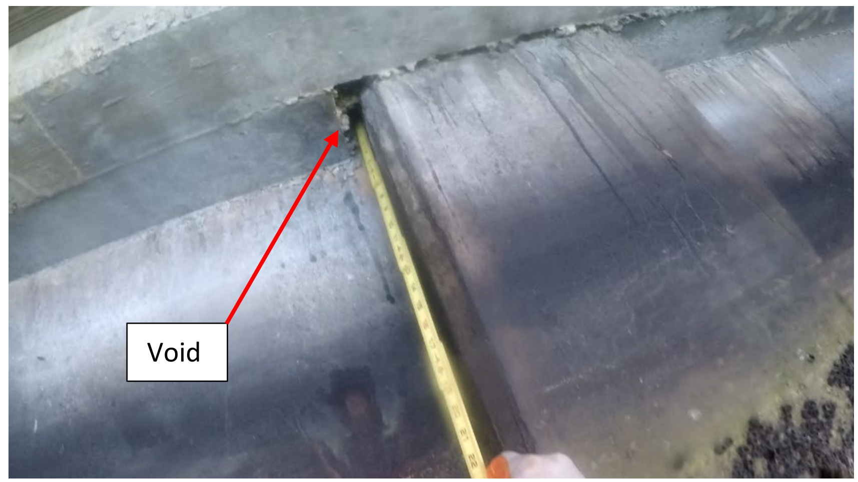
Deficiency B-54: Pile 82 (Station 5+70)

Deficiency B-55: Pile 86 (Station 6+02)

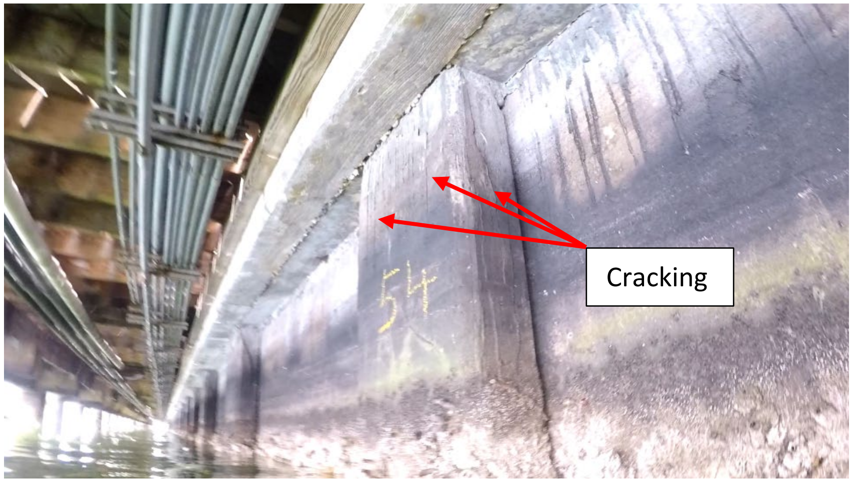


Deficiency B-56: Pile 89 (Station 6+27)

Deficiency B-57: Pile 92 (Station 6+51)

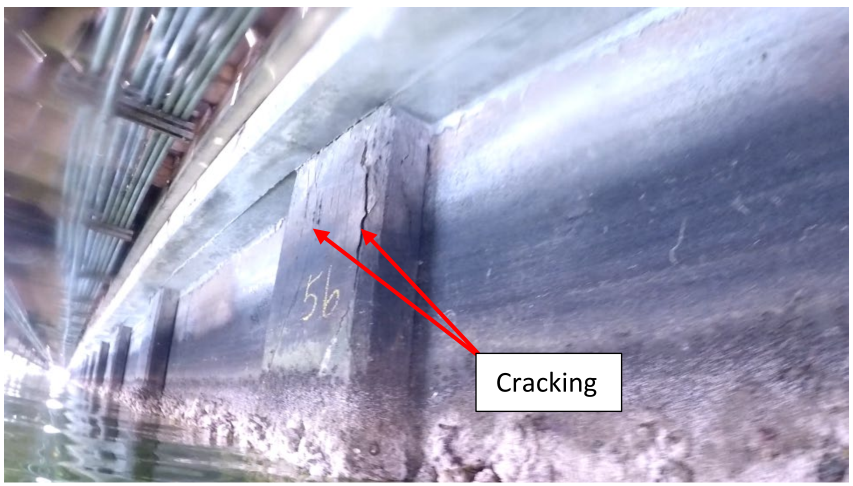


Deficiency B-58: Cap @95 (Station 6+76)



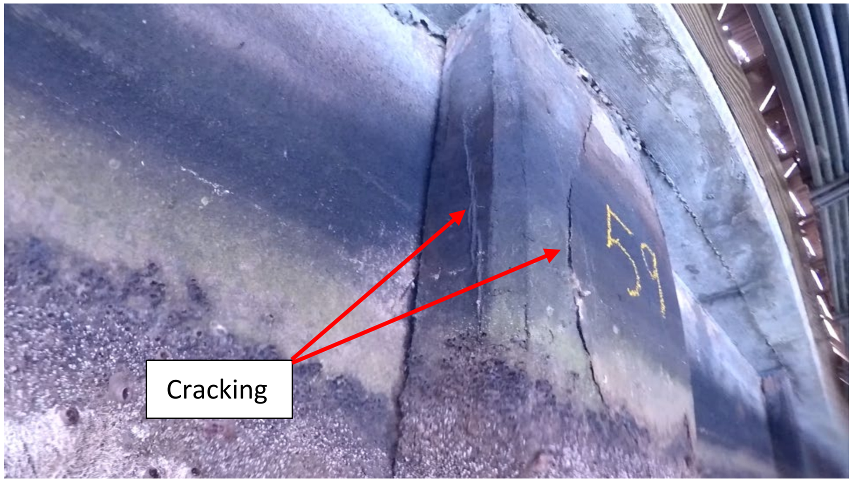
Deficiency B-59: Pile 96 (Station 6+82)

Deficiency B-60: Pile 97 (Station 6+90)

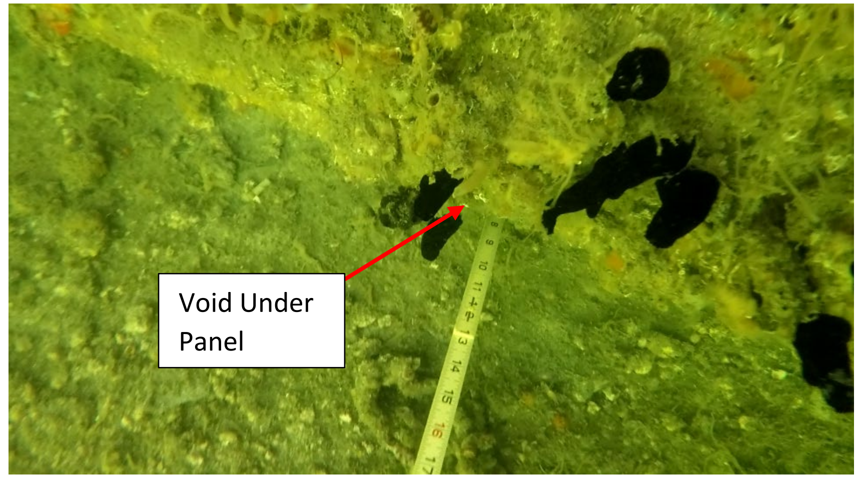


Deficiency B-61: Pile 98 (Station 6+99)

Deficiency B-62: Pile 100 (Station 7+15)

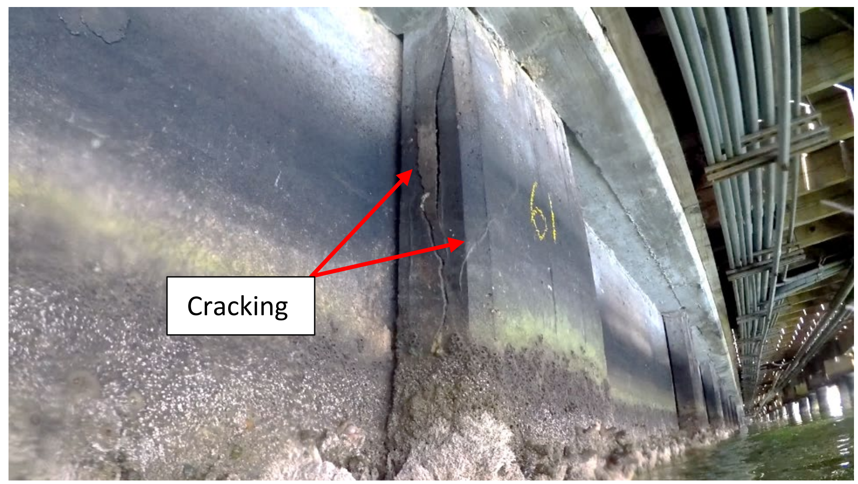


Deficiency B-63: Pile 101 (Station 7+22)

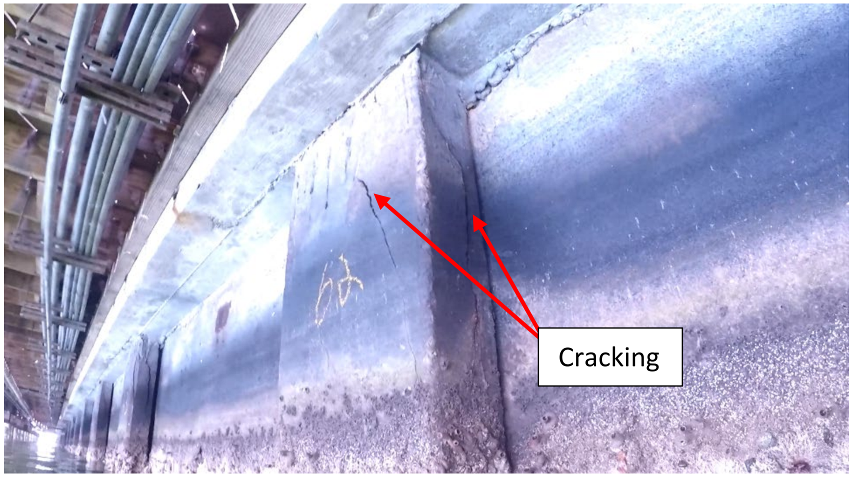


Deficiency B-64: Panel 103-110 (Station 7+38 to 7+96)

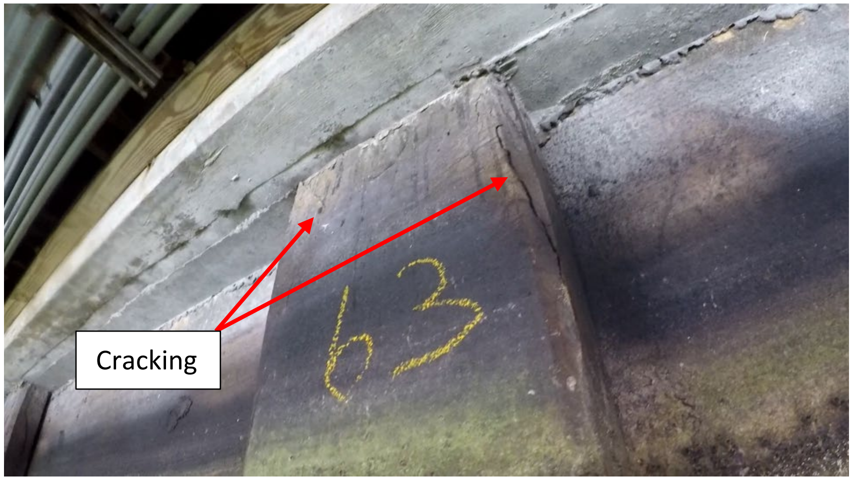
Deficiency B-65: Pile 103 (Station 7+38)_1 of 2



Deficiency B-65: Pile 103 (Station 7+38)_2 of 2

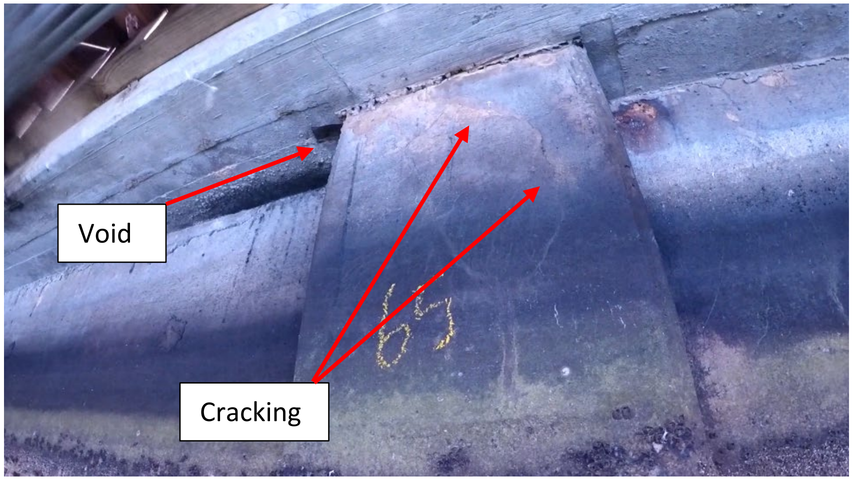


Deficiency B-66: Pile 104 (Station 7+47)



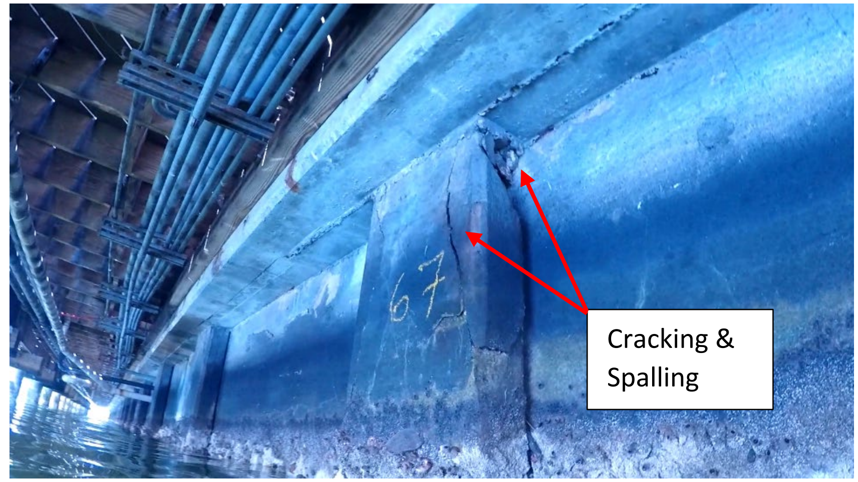
Deficiency B-67: Pile 105 (Station 7+55)

Deficiency B-68: Pile 106 (Station 7+63)

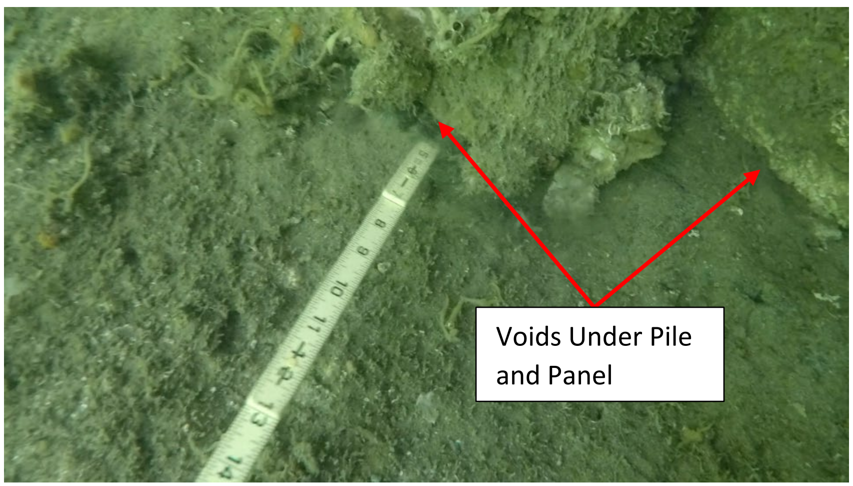


Deficiency B-69: Pile/Cap 107 (Station 7+71)

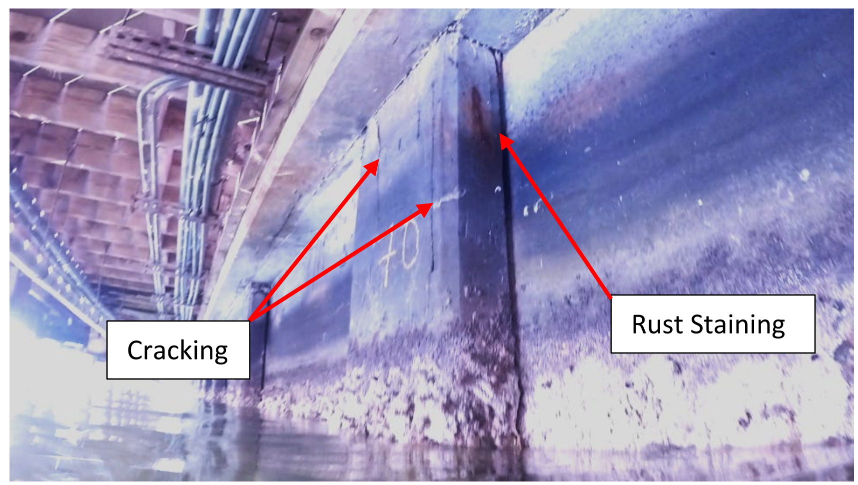
Deficiency B-70: Pile 108 (Station 7+80)



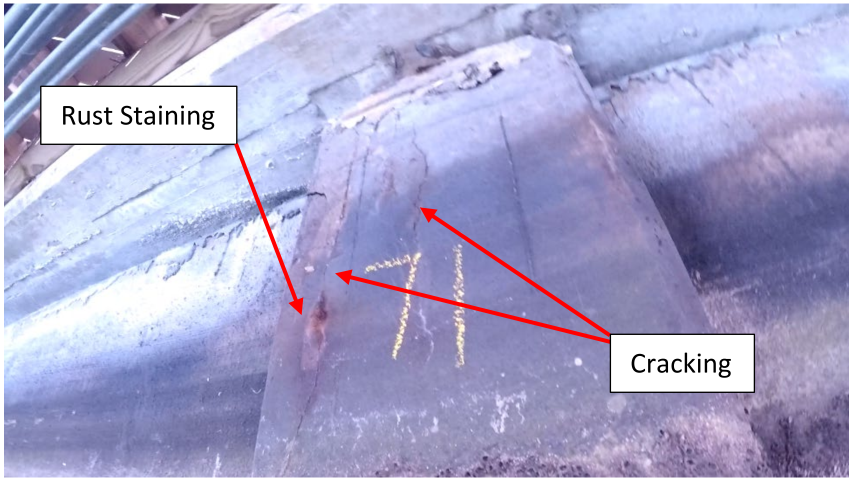
Deficiency B-71: Pile 109 (Station 7+88)



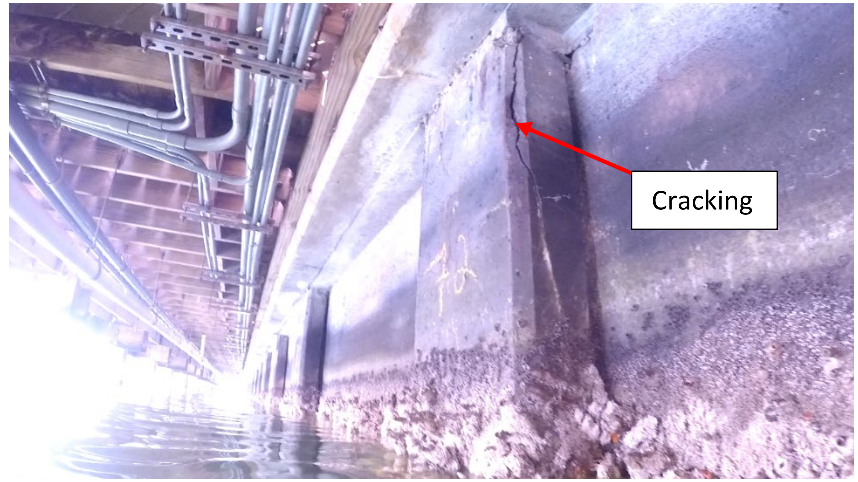
Deficiency B-72: Panels 111-116 (Station 8+03 to 8+38)



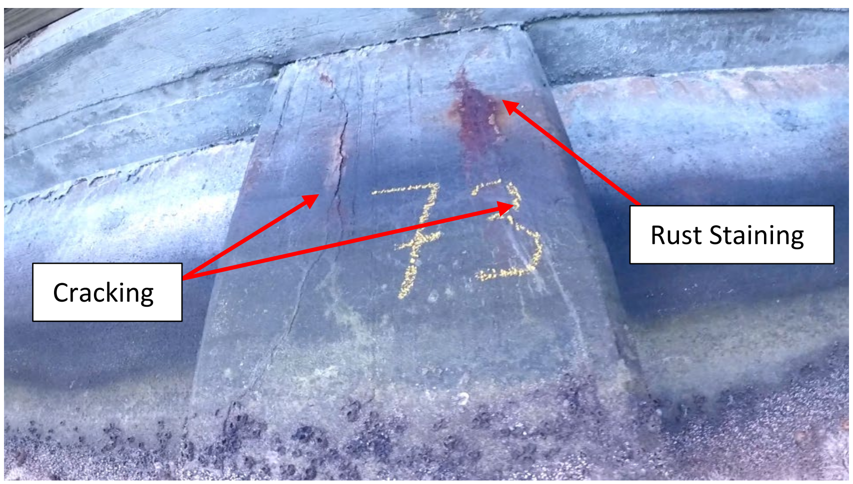
Deficiency B-73: Pile 112 (Station 8+11)



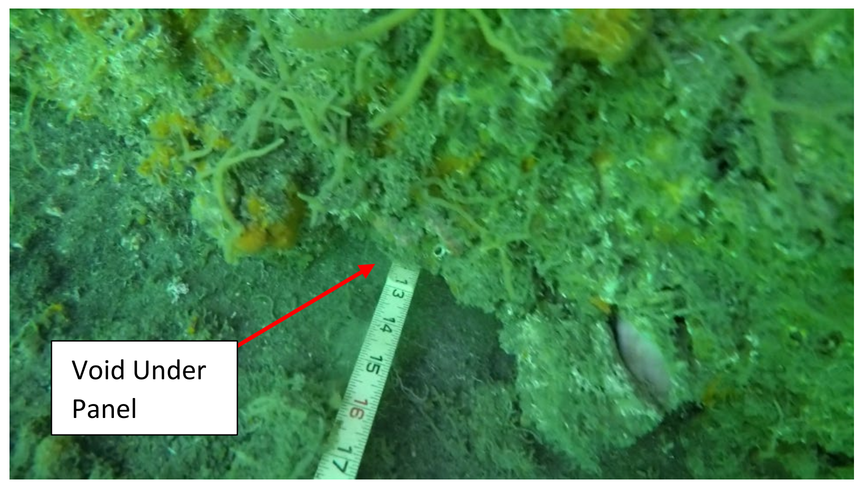
Deficiency B-74: Pile/Cap 113 (Station 8+19)



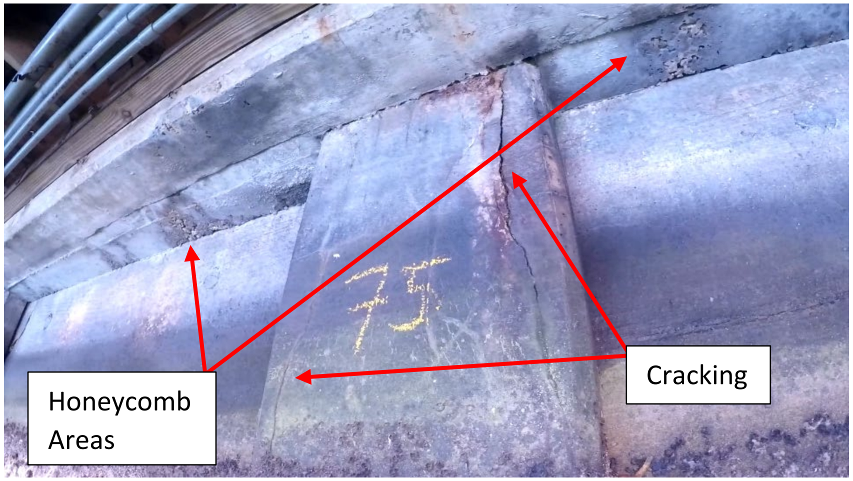
Deficiency B-75: Pile 114 (Station 8+27)



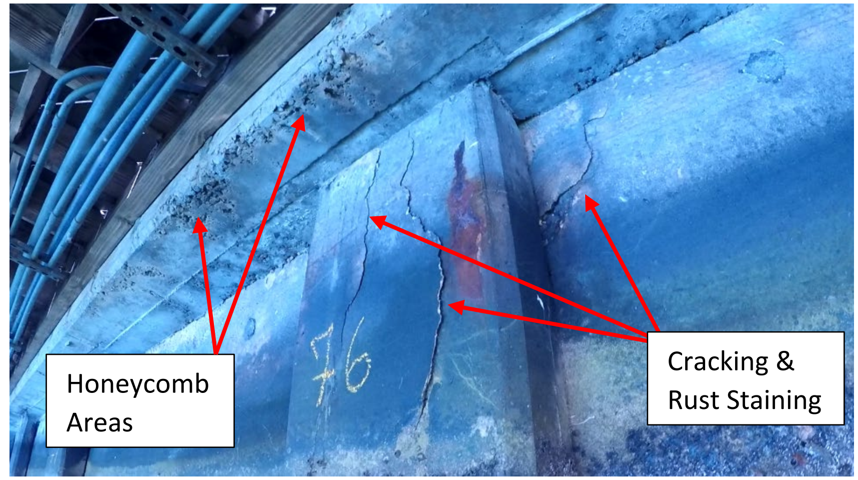
Deficiency B-76: Pile 115 (Station 8+35)



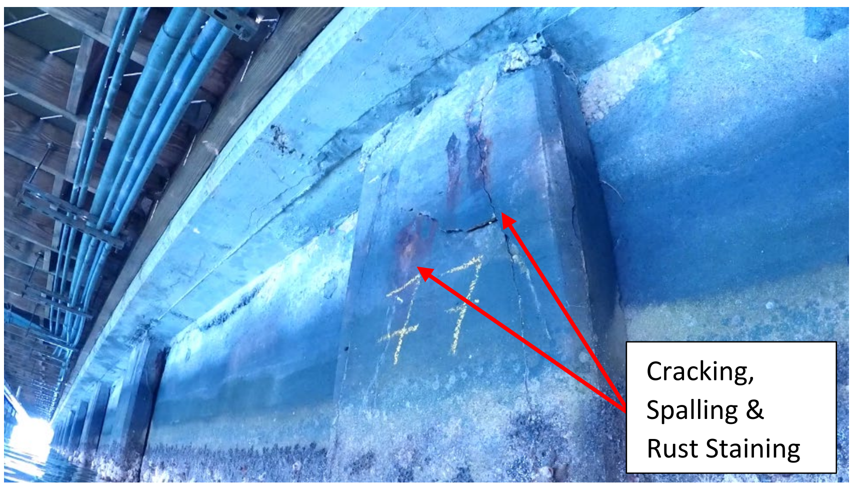
Deficiency B-77: Panels 116-120 (Station 8+42 to 8+75)



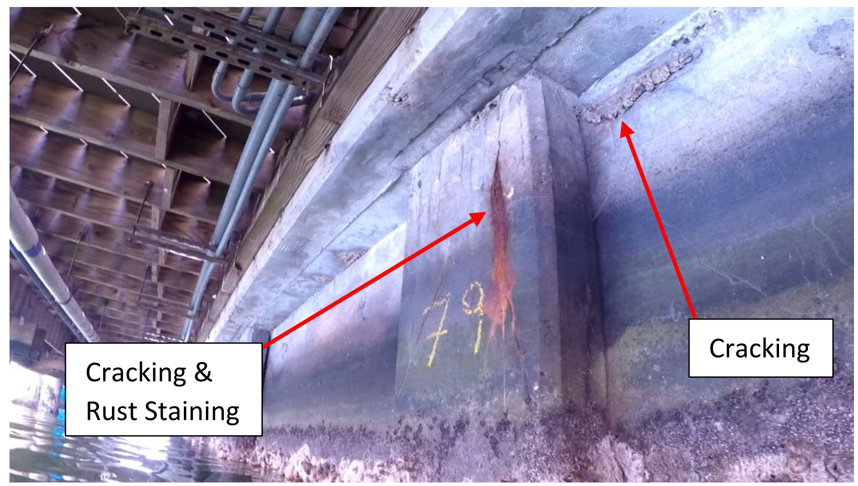
Deficiency B-78: Pile/Cap 117 (Station 8+50)



Deficiency B-79: Pile/Cap 118 (Station 8+58)



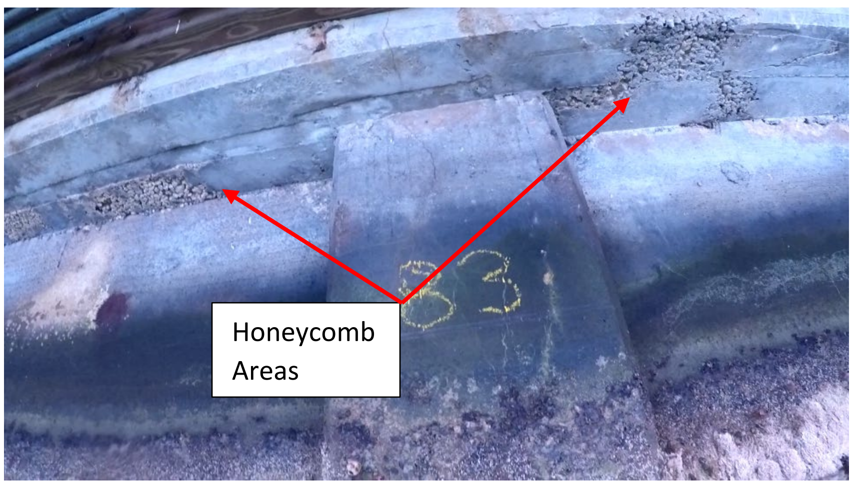
Deficiency B-80: Pile 119 (Station 8+67)



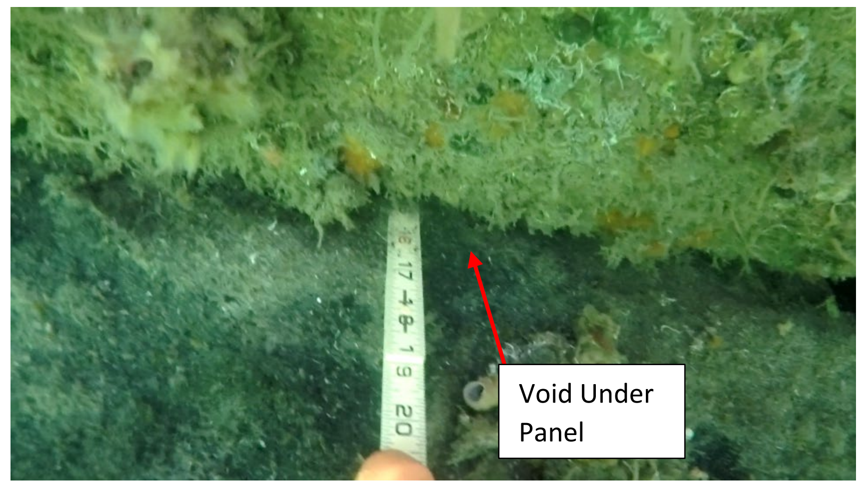
Deficiency B-81: Pile 121 (Station 8+83)

Deficiency B-82: Panels 121-123 (Station 8+83 to 8+98)

Deficiency B-83: Cap @124-127 (Station 9+04 to 9+25)_1 of 2



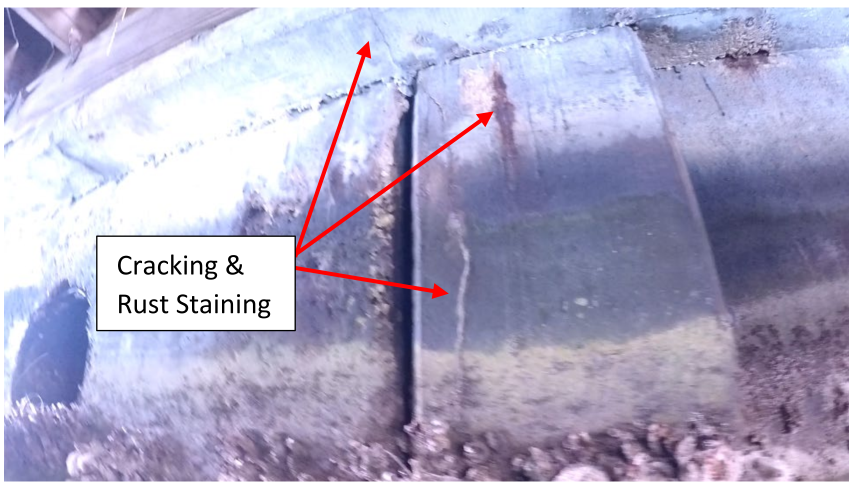
Deficiency B-83: Cap @124-127 (Station 9+04 to 9+25)_2 of 2

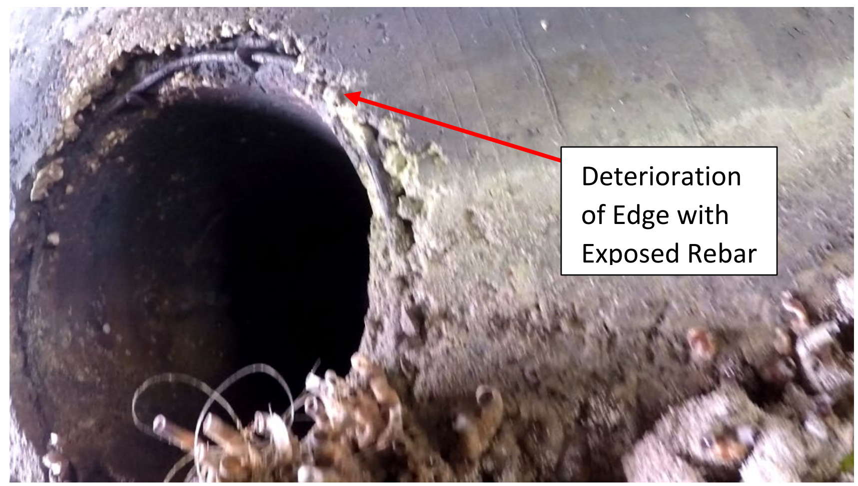


Deficiency B-84: Panel 124-125 (Station 9+10)

Deficiency B-85: Pile 126 (Station 9+23)

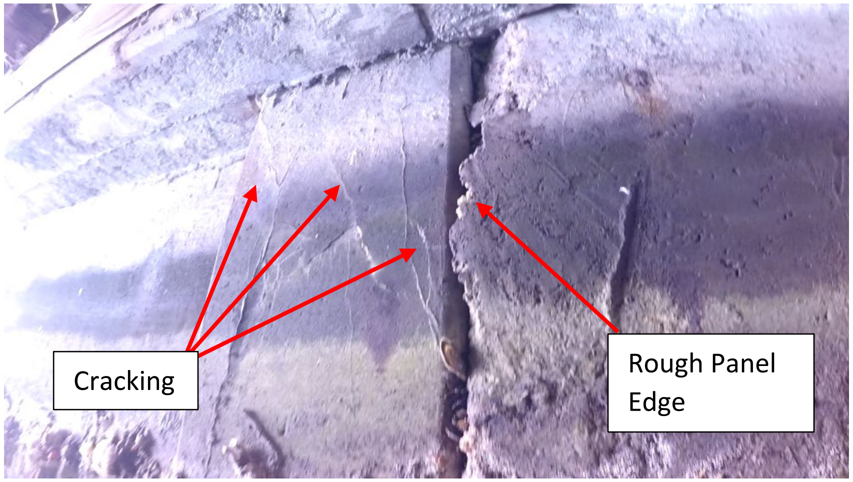
Deficiency B-86: Pile 127 (Station 9+31)





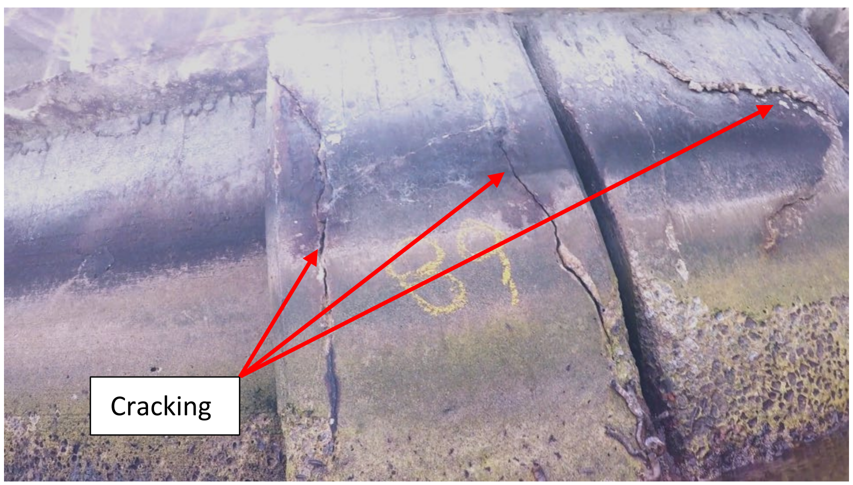
Deficiency B-87: Pile/Cap 128 (Station 9+39)

Deficiency B-88: Culvert Panel 128-129 (Station 9+43)



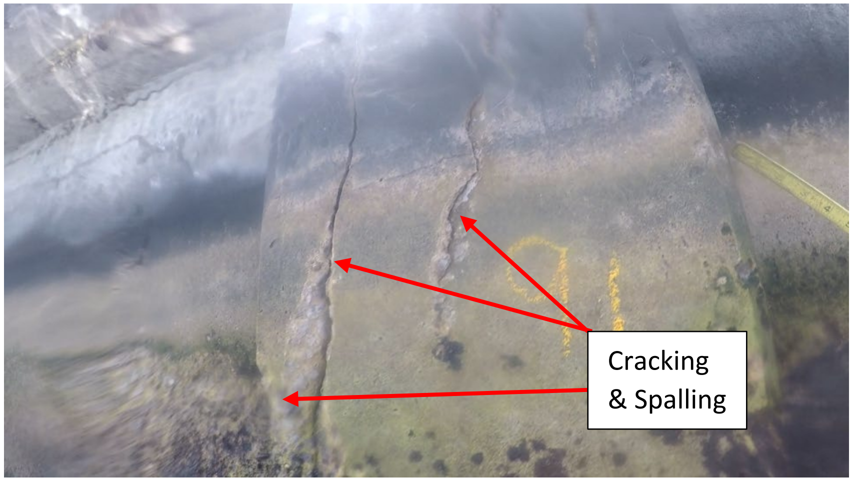
Deficiency B-89: Pile 129 (Station 9+47)

Deficiency B-90: Pile 130 (Station 9+55)

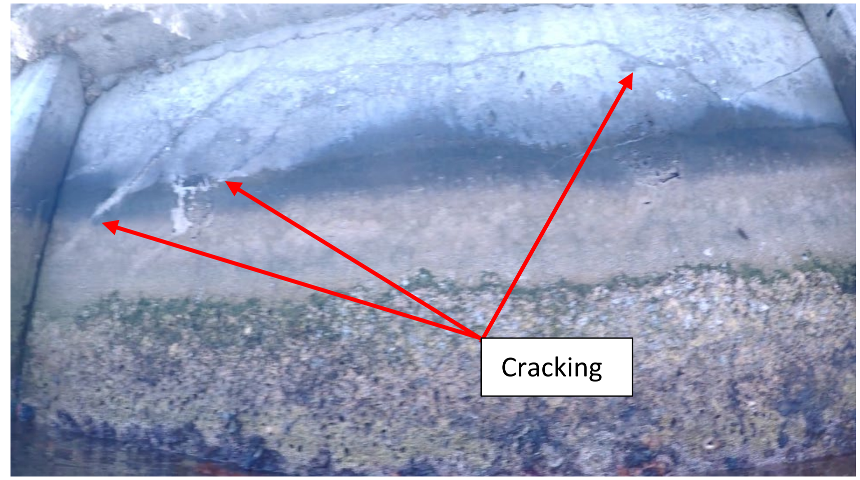


Deficiency B-91/B-92: Pile 131 & Pile/Cap 132 (Station 9+59/9+62)

Deficiency B-93: Pile/Cap 133 (Station 9+70)



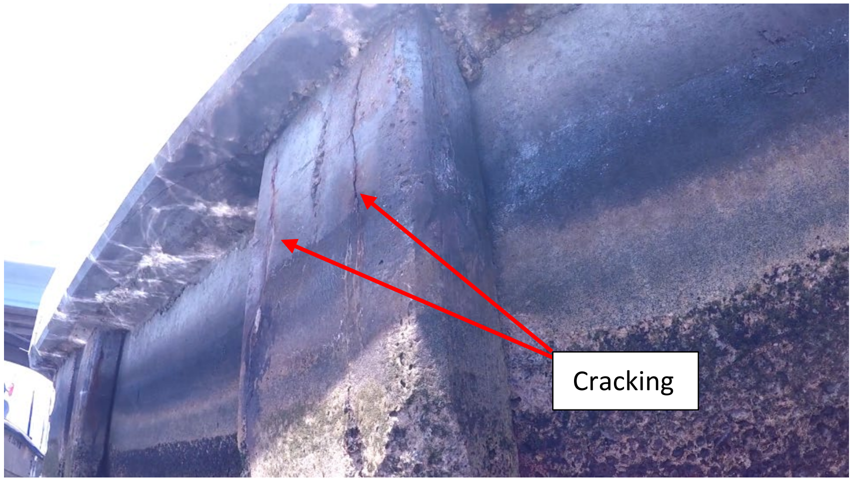
Deficiency B-94: Pile 134 (Station 9+76)



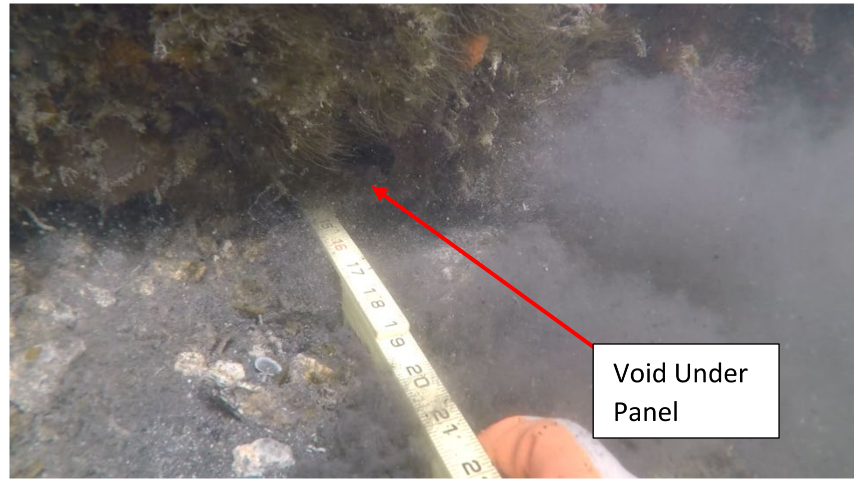
Deficiency B-95: Panel 134-135 (Station 9+80)

Deficiency B-96/97: Pile 135/136 (Station 9+83/9+86)

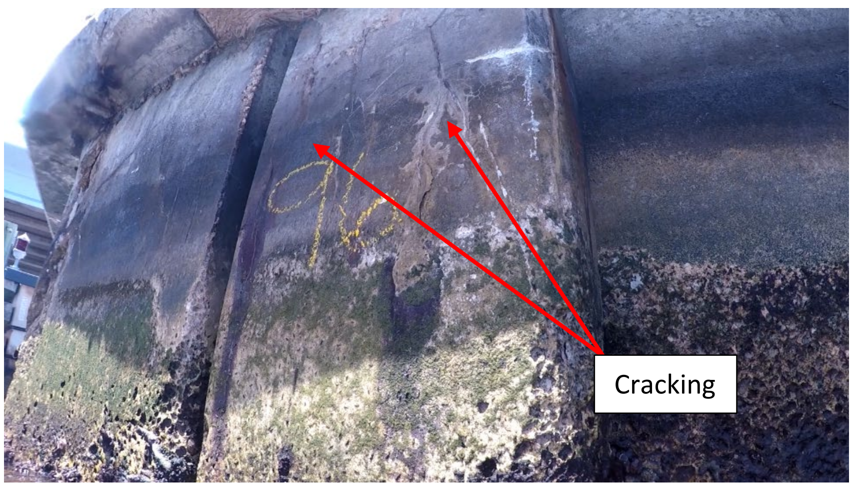
Deficiency B-98/99: Pile 137 & Panel/Cap 137-138 (Station 9+89/9+93)



Deficiency B-101: Pile 139 (Station 10+02)



Deficiency B-102: Panel 139-140 (Station 10+06)



Deficiency B-103: Pile 140 (Station 10+09)