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Subject: Vulnerability Assessment and Resilience Planning, Municipal Fishing Pier, Lincolnville, Maine
Penobscot Bay Working Waterfront Resiliency Analysis
State of Maine, Department of Marine Resources

Wood Environment & Infrastructure Solutions, Inc. (Wood) is pleased to provide the Maine Department of Marine Resources (DMR) this report on the baseline characterization, vulnerability assessment and resilience planning for the Municipal Fishing Pier, Lincolnville, Maine. This report provides findings for one of ten sites included in DMR's Penobscot Bay Working Waterfront Resiliency Analysis project. Reports on the other nine sites are provided under separate cover. Our work was performed in general accordance with the scope of work and the terms and conditions included in Wood's proposal dated 1 March 2019.

1.0 INTRODUCTION

As proposed for DMR's Penobscot Bay Working Waterfront Resilience project, Wood conducted an assessment of the Municipal Fishing Pier in Lincolnville, Maine which included:

- Facility baseline characterization including a review of available site documents, interviews with community representatives, survey of site topography and elevations of key site features, and review of the general condition of existing site structures by a Wood structural engineer;
- Facility vulnerability analyses based on the baseline survey data, condition of structures, and modelling of potential storm surge and wave affects under three sea-level rise (SLR) scenarios; and
- Development of resilience measures, including strategies for incremental adaptation under the modelled storm and SLR scenarios.

This report contains a summary of our document review, personnel interviews, structural observations, photographs documenting our observations (**Appendix A**), and the approximate location of potential structural deficiencies. Following our analysis of the site and as part of the vulnerability analysis, we were able to identify the risks for the affected site features (see **Table 5**) from inundation data. Inundation maps developed for the site by Wood's consulting partner, Woods Hole Group (WHG) are provided in **Appendix B**. The vulnerability analysis establishes the future risk framework for the site and its structural features. Wood has evaluated the degree of impact of these site-specific vulnerabilities, and we have provided recommendations for improved resilience (e.g., repair, reinforcement) in relation to the feature's immediate performance and/or expected performance per the vulnerability analysis.

As part of the subsequent discussion, the following terms are defined below:

Base Flood Elevation (BFE) -	Elevation of flooding, including wave height, having a 1% chance of being equaled or exceeded in any given year.
Checks	A separation of the wood occurring across or through the rings of annual growth and usually as a result of seasoning.
Coastal High hazard Area (CHHA) -	Area within a special flood hazard area extending from off-shore to the inland limit of a primary frontal dune along an open coast and any other area that is subject to high velocity wave action.
Design Flood Elevation (DFE)	Based on the design flood, the DFE is the higher of the base flood elevation (BFE) shown on FIRMs prepared by FEMA or the flood elevations shown on the map adopted by a community.
FIRM -	Flood Insurance Rate Map. Official map of a community on which FEMA has delineated both special flood hazard areas and the risk premium zones applicable to the community.
Highest Annual Tide (HAT) –	The elevation of the highest predicted astronomical tide expected to occur at a specific tide station over the National Tidal Datum Epoch.
Mean Higher High Water (MHHW) –	The average of the higher high water height of each tidal day observed over the National Tidal Datum Epoch. The highest high tide or water height is referred to as the Highest Astronomical Tide (HAT) and is defined as the highest level which can be predicted to occur under average meteorological conditions and any combination of astronomical conditions.
National Tidal Datum Epoch –	The specific 19-year period (Currently 1983 to 2001) adopted by the National Ocean Service as the official time segment over which tide observations are taken and reduced to obtain mean values (Mean Lower Low Water, etc.) for tidal datums.
Pre-FIRM	Construction or substantial improvement occurred on or before December 31, 1974.
Shakes	Lengthwise separations of the wood along the grain, usually occurring between or through the rings of annual growth.
Splits	A separation of the wood through the piece to the opposite surface or to an adjoining surface due to tearing apart of the wood cells.
Still Water Elevation –	Elevation that the surface of the water would assume in the absence of waves referenced to a specified vertical datum at the defined recurrence interval.
Wave Height –	Vertical distance between the crest and the trough of a wave.

2.0 DOCUMENT REVIEW AND PERSONNEL INTERVIEWS

Wood was escorted by Mr. David Kinney, Town Administrator, during a site visit on 22 June 2019. We discussed the site features and historical development of the site. Mr. Kinney mentioned that the primary use of the pier is for fisherman and to support the local fishing economy. He also mentioned that the site receives a portion of its traffic from commuters traveling on work boats to and from Islesboro Island. It was disclosed that the observed deterioration of the pier deck was attributed to snow plowing.

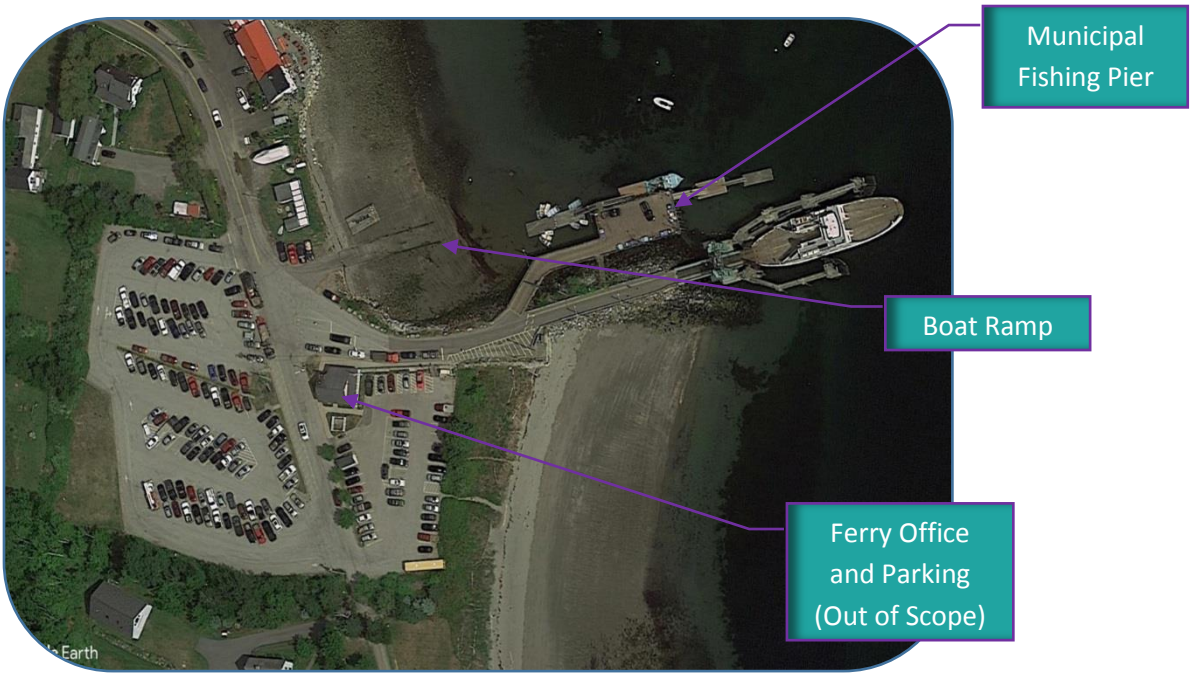
Mr. Kinney stated that within the last 2 years the water level has been less than 6 inches above the top of the deck. He also mentioned that the existing boat ramp is too shallow, requiring the vehicles to be partially submerged during unloading of the boat. The following is a summary of key site features identified during the site visit:

- The site consists of the timber pier and a boat ramp (See **Figure 1** below).
- The pier is supported by timber piles.
- There were no other structures identified onsite specifically associated with the Municipal Fishing Pier.
- Three (3) wooden floating dock systems are located on the north side of the wharf (see **Photograph No. 28**).
- A boat ramp and associated parking.
- There is no formal ongoing maintenance plan in place; maintenance is addressed, as needed, when a deficiency is identified.

As part of our site assessment and to furnish more detailed background information, the Town has provided the following additional information to aid in our analysis:

- Structural Assessment Report dated May 18, 2016 from David B. Kinney, P.E. of Pinnacle Hill Engineering
- Deck Inspection Report dated May 1, 2019 from David B. Kinney, P.E. of Pinnacle Hill Engineering
- Design drawings for the pier sealed by Dave L. Porter, P.E., undated
- Material and Installation Specifications for the pier from Maine DOT, undated.

Figure 1: Site Overview



3.0 OBSERVATIONS AND FINDINGS

Tirrell Day and Lane Gray of Wood performed a site assessment and gathered geospatial data for key site features during the 22 June 2019 visit. This assessment included documenting the general condition and recording elevations of key features and structures. At the request of the Town, the limits of our investigation include the fishing pier, approach, attached floating docks, and a boat ramp. The adjacent ferry terminal facilities are not a part of our assessment. Photos of the site features and Wood's noteworthy observations are included in the Photolog (**Appendix A**). Elevations discussed in this report are with respect to North American Vertical Datum of 1988 (NAVD88). The site facilities and their associated elevations are included in **Table 1** for reference. During our site visit the approximate tidal levels where between -5.3 ft and 6 ft (predicted min. of -5.3 ft, max. of 6.4 ft).

3.1 Property Overview

This site is a 0.5-acre property containing a wooden pier and boat ramp. The pier is located at the north side of an existing ferry terminal for Lincolnville. There are three (3) floating docks attached to the structure via gangways and tie ropes to pulleys (**Figure 1**). One dock consists of two floats connected by an intermediate bridge and ropes. Attachment of the gangways to the dock are at a steel or wooden header (**Photograph 30**). Wood observed the function of the gangway and floats during tidal action and the system appeared to function as intended.

The pier appears to be constructed of timber decking on stringers, to cross beams and on battered and vertical timber piles (**Photographs 9 – 19**). Details on timber pile embedment are provided in the referenced design drawings, which range roughly from 30 to 60 feet. The Subsurface conditions of the site were not probed or verified by testing as part of Wood's scope of work. The pier connects to the ferry access road at two (2) locations, one being for vehicular access to the pier and the other as a pedestrian waiting area for the ferry. Timber framing appears to be attached using a combination of apparent galvanized steel through-bolts, nails, and/or screws. Details for connection are consistent with information reviewed in the design drawings.

Shoreline protection exists to the west and south side of the pier and is provided by means of large (1.5 ft to 4 ft) riprap (**Photographs 46 & 47**). Wave attenuators exist between the ferry bridge piers (**Photographs 48 & 49**). These structures were noted but were not a part of our assessment. Site utilities include electrical and water lines. Two hoists are provided as part of the site equipment.

Table 1: Site Elevations

Location	***Lowest Horizontal Member***	***Lowest Deck or Adjacent Grade***	***First Finished Floor / Mid Mark***	***Lowest Opening/ Critical Elevation***
Source	***Estimate***	***Survey***	***Survey***	***Survey***
Facility	***[ft]***	***[ft]***	***[ft]***	***[ft]***
Pier	7.48	9.02	n/a	n/a
Floating Dock 1	n/a	n/a	n/a	9.04
Floating Dock 2	n/a	n/a	n/a	6.88
Floating Dock 3	n/a	n/a	n/a	6.9
Shoreline Protection	n/a	11.92	n/a	16.92
Boat Ramp	n/a	1.86	5.52	10.39

**Estimates indicate measurements referenced or derived from the actual site survey data.*

A boat ramp is located on the west side of property, providing boat launching access from McKay Road (**See Photographs 43 - 46, Appendix A)**. The ramp is not paved and appears to be unmaintained. Two to three parking spots are available near the boat ramp.

3.2 Noted Deficiencies

The fishing pier was viewed from above during access to the deck and below from the floating docks. We noted weathered timber members throughout which exhibited signs of checking, splitting and shakes. Gouges were observed at several piles with

some conditions appearing moderate to major in severity of damage due to loss of cross-sectional area at the tips. A synthetic pile wrap was provided on some piles as protection (**Photographs 11 - 16**). This may be attributed to bacterial infestations such as marine borers, weathering, or combination of both. In contrast, some members such as the deck timbers, appear to have extensive deterioration at the surface but minimal weathering is noted from the underside (**Photographs 17 – 19**). This variation can be explained by the surface wear from ploughing activities as opposed to the underside of the same timber (See **Photograph 14**). These members, being almost 4 inches in thickness, may be able to sustain extensive wear prior to a need for replacement. Nonetheless, a destructive investigation of the worst case would reveal the integrity of the wood fibers to determine their behaviour under the design loading.

The general condition of the floating dock appears to be good, however the floats seem to be for temporary use only based on the attachment to the pier using ropes. In addition, the gangway attachment for Floating Dock 1 exhibits mild corrosion at the header. The docks are secured by ropes instead of another more stable means, such as isolated timber piles

Overall, electrical conduits and connections are secured under fixtures and covers which are suitable for damp or wet conditions. We did note partially exposed electrical equipment and an enclosure housing equipment for the hoist which was not sealed from moisture intrusion.

3.3 Risk Framework

As a basis for the vulnerability analysis, water surface elevation (WSE) exposure profiles were developed by WHG which summarize current and potential future tidal and storm surge inundation/wave impacts. The key flood elevation profiles provided include the Mean Higher High Water (MHHW), the Highest Astronomical Tide (HAT), the 1% Still Water Level, and the Base Flood Elevation (BFE). Values for these scenarios are site specific and take into consideration the topographic survey data obtained by Wood.

The MHHW and HAT tidal datums (present day) were sourced from the nearest long-term NOAA tide station and from spatial files developed by Maine Geological Survey[1]. The 1%-annual-chance still water level (present day) was obtained from the 2016 FEMA Flood Insurance Study for Knox County.

Table 2: Transect 1

Scenario	***MHHW***	***HAT***	***1% Still Water Level***	***1% Wave Crest Elevation (BFE)***
Present day	4.8	7.1	9.3	17
Short Term (+1 ft)	5.8	8.1	10.3	11-17
Mid Term (+2 ft)	6.8	9.1	11.3	12-17
Long Term (+4 ft)	8.8	11.1	13.3	15-20

Table 3: Transect 2

Scenario	**MHHW**	***HAT***	***1% Still Water Level***	***1% Wave Crest Elevation (BFE)***
Present day	4.8	7.1	9.3	11-15
Short Term (+1 ft)	5.8	8.1	10.3	12-17
Mid Term (+2 ft)	6.8	9.1	11.3	13-18
Long Term (+4 ft)	8.8	11.1	13.3	16-20

[1] https://www.maine.gov/dacf/mgs/hazards/highest_tide_line/index.shtml

Site-specific wave modelling was conducted for existing and future sea levels to better quantify wave hazards and potential increases in wave heights at the site. Wave modelling was conducted using FEMA's overland wave modelling approach for consistency in providing an estimate of the 1% BFE for the future scenarios.

For potential future flood impacts, relative SLR scenarios were reviewed using the U.S. Army Corps of Engineers' Sea-Level Change Curve Calculator (Version 2017.55), specifying the Bar Harbor long-term tide gauge, a regionally-informed vertical land movement rate (from NOAA), and the NOAA et. al (2017)[2] SLR curves.

In discussion with the project team, the preferred SLR scenarios defined for evaluating short-term, mid-term, and long-term impacts were selected as 1 ft, 2 ft, and 4 ft, respectively. These projected increases in sea level roughly correspond with NOAA's Intermediate scenario for the years 2030, 2050, and 2085 with a rather low exceedance probability (17%) and are within the SLR scenarios recommended by Maine DOT for design of transportation infrastructure.

3.4 Site Vulnerabilities

The flood modelling data provided above in **Table 2 and Table 3** include scenarios for the Short Term, Mid Term, and Long Term SLR scenarios. NOAA's Intermediate scenario mentioned above compared with these timeframes should be taken into consideration for the identified return periods as illustrated in **Table 4**.

Table 4: Flood Return Period

Event Return Period	Percent Chance of Occurrence per Period			
	5 Years	10 Years	25 Years	50 Years
100 Year Flood (1%)	4.9%	9.6%	22.2%	39.5%
500 Year Flood (0.2%)	1%	2%	4.9%	9.5%

The various site features have been summarized in **Table 5**, for each facility, indicating the associated risk and flood scenario which result in inundation. Those elevations noted as 0 ft indicate an elevation equal to the identified feature of the facility. No elevations are noted in Table 5 where no inundation of the feature was identified (i.e., flood elevation is lower than that of the site feature). Below are the site-specific vulnerabilities based on our review of the property.

3.4.1 Fishing Pier

From our preliminary non-destructive investigation, elements of the pier appeared to be securely fastened and restrained against movement with fasteners or other mechanical means. The behaviour of the structure for the Present Day scenario, considering the 1% Stillwater already above the lowest horizontal member, is dependent on these elements being properly attached. Wave heights exceed 5 ft, creating an increased risk of distressed or delaminated members given they are considerably weathered or not properly attached to resist uplift or lateral loading from wave and wind. The possibility of structural failure increases when moving forward in the future as wave heights and associated forces increase. Under the Long Term scenario, the usability of the structure comes into question because the HAT is estimated at over 3 ft above the top of deck elevation and the MHHW, which occurs daily, is close to the pier deck elevation.

Site utilities which include water and electricity (**Photographs 20 - 27**) are exposed to wave action and inundation at the pier for the Present Day. As mentioned earlier, many electrical items appear to be protected from exposure to moisture, however some items were noted, such as the hoists motor, which will be submerged by the 1% Stillwater of the Present Day (**Photograph 25**). The risk also includes the electrical panel noted near the pier entrance (**Photograph 26 & 27**) already for the Present Day with regard to the BFE.

[2] https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf

Table 5: Site Elevations and Risks

Facility			Inundation above Elevation of Facility															
Description			Present Day				Short Term Scenario				Mid Term Scenario				Long Term Scenario			
	Elevation (ft) to NAVD88		MHHW [ft]	HAT [ft]	1% Stillwater [ft]	BFE [ft]	MHHW [ft]	HAT [ft]	1% Stillwater [ft]	BFE [ft]	MHHW [ft]	HAT [ft]	1% Stillwater [ft]	BFE [ft]	MHHW [ft]	HAT [ft]	1% Stillwater [ft]	BFE [ft]
Pier	Lowest Horizontal	7.48 ft			1.82	7.52		0.62	2.82	8.52		1.62	3.82	9.52	1.32	3.62	5.82	12.52
	Lowest Deck or Adjacent Grade	9.02 ft			0.28	5.98			1.28	6.98		0.08	2.28	7.98		2.08	4.28	11
Floating Dock 1	Buoy Chain max elevation	0 ft																
	Gangway support	9.04 ft			0.26	5.96			1.26	6.96		0.06	2.26	7.96		2.06	4.26	11
Floating Dock 2	Buoy Chain max elevation																	
	Gangway support	6.88 ft		0.22	2.42	8.12		1.22	3.42	9.12		2.22	4.42	10.1	1.92	4.22	6.42	13.1
Floating Dock 3	Buoy Chain max elevation	0 ft																
	Gangway support	6.9 ft		0.2	2.4	8.1		1.2	3.4	9.1		2.2	4.4	10.1	1.9	4.2	6.4	13.1
Shoreline Protection	Top of riprap	11.92 ft				3.08				4.08				4.08			1.38	7.08
	Critial Elevation	16.92 ft																2.08
Boat Ramp	Begin	1.86 ft		5.24	7.44	11.1		6.24	8.44	11.1	4.94	7.24	9.44	14.1	6.94	9.24	11.44	17.1
	Mid-Mark	5.52 ft		1.58	3.78	7.48		2.58	4.78	7.48	1.28	3.58	5.78	10.5	3.28	5.58	7.78	13.5
	Top/Slope	10.39 ft				2.61				2.61			0.91	5.61		0.71	2.91	8.61

Note: Facility elevations presented in this Table are referenced to NAVD88.

3.4.2 Floating Docks

The floating dock assembly consists of the gangway, pontoons, and a bridge at one location (**Photograph 28 - 42**). The critical elevation for proper function of the floating docks is the MHHW/HAT for these scenarios. As is indicated in **Table 5** for the Present Day Scenario, minimal risk is foreseen for damage to the pier-gangway connection. However, for all future scenarios the risk of damage increases and for the Long Term the MHHW is almost 2 ft above the top of deck elevation. In addition, attachment of the pontoons by means of ropes only would allow for excessive movement and damage to the pier with this current unsecure connection.

3.4.3 Shoreline Protection

Shoreline protection is provided at most locations on the site and between the adjacent bridge as a wave barrier (**Photographs 43 – 47**). However, one location near the boat ramp has been scarcely covered with riprap which appears to be undersized (**Photograph 46**). The average size of the rock observed appears suitable for the application during most scenarios. For the Long Term scenario, wave heights reach nearly 6 ft for the BFE. For major revetment overtopping and waves which exceed 5 feet in height, testing of the current design or a complete redesign and construction is recommended.

3.4.4 Boat Ramp

Although the current condition of the ramp is not ideal for its intended use, it is our opinion that the Present Day and Short Term scenarios present minimal risk for inundation which compromises the function of this feature. For the Mid and Long Term scenario, the combination of limited approach space near the main road and the rising MHHW create conditions which impair the functionality of the ramp, at a minimum.

4.0 RECOMMENDATIONS

4.1 General Recommendations

In accordance with American Society of Civil Engineers / Structural Engineering Institute Standard 24 – Flood Resistant Design and Construction (ASCE 24), existing structures that sustain substantial damage, or that are substantially improved, are treated as new construction. This standard considers damage beyond routine maintenance or otherwise minimal damage following an event, which nonetheless requires major improvements and even applies to structures classified as pre-FIRM. **For new construction we recommend, in light of the forecasted increase in water levels and the schedule for these events in relationship to the life of the structure, design should be based on the either BFE plus 2 feet of freeboard, the DFE, or 500-year event, whichever is higher.** It is understood that local requirements coupled with available resources will dictate the ability for the communities to incorporate proactive designs. The following recommendations are provided with regard to areas of the site which fall within a special flood hazard area:

- All new construction, substantially improved, and substantially damaged buildings must be elevated on pilings, posts, piers, or columns so that the bottom of the lowest horizontal structural member of the lowest floor is at or above the BFE with any applicable freeboard (or DFE), per ASCE 24.
- The foundation system must be anchored to resist flotation, collapse, lateral movement due to wind and water loads acting simultaneously on all components of the building.
- Use of flood damage-resistant materials above the BFE per ASCE 24 and the local Building Code.
- Electrical and Plumbing Equipment should be located on the landward side of any building and/or behind structural elements. They must be elevated and designed to prevent flood waters from entering and accumulating in components during flooding.
- Install shutoff and isolation valves on water and sewer lines that extend into the flood-prone areas.

This list is not comprehensive but rather applies to site features observed during our site visit. There may exist other relevant items addressed in any of the above-mentioned design standards which are applicable for the site at a future date. We recommend a detailed site assessment be performed during the design stage to ensure implementation of all applicable items.

4.2 Site Specific Recommendations

Although the risks, vulnerabilities, and associated recommendations addressed herein are in reference to features located within the property limits of the Municipal Fishing Pier, there may be features of similar construction in close proximity and exposed to similar risks as described in this report but fall outside the scope of our assessment. We recommend that these sites and features undergo a similar assessment with the assumption that similar or greater risks may apply. The following are recommendations for the features identified at risk within the Municipal Fishing Pier, Lincolnville.

4.2.1 Fishing Pier

The following recommendations are provided in reference to the **Present Day** scenario for flood values provided in **Table 2** above:

- Confirm positive attachment of all structural members to their substrate or load-bearing elements. Incorporate redundancies in design as needed based on a detailed structural analysis. Recommend a destructive investigation to confirm the presence of shipworms / marine borers and determine the need for any corrective action per a Structural Engineer Licensed in the State of Maine.
- Utilities and equipment should be properly secured to resist design wind and water loading or relocated above the flood elevation as specified in ASCE 24. Watertight enclosures should be incorporated for electrical equipment and

conduits. This would include the hoist motor and electrical appurtenances being encased in moisture resistant enclosures and elevated above the Mid Term 1% Stillwater with at least 1 foot of freeboard.

The following recommendations are provided in reference to the **Short Term and all future scenarios** for inundation values provided in Table 2 above:

- Consider raising the pier in response to rising water levels and into zone of less impact and a construction incorporating a sustainable design at the current location.

While raising the pier may reduce the impact of rising sea levels and storm events, such construction is expensive, particularly considering the need to accommodate impacts to adjacent structures, roads and utilities, and a detailed costing analysis should be executed which considers these interrelated aspects. With regard to resisting anticipated design forces, it is likely more feasible to invest in proactive pier maintenance, such as weatherizing vulnerable assets and properly securing structures (e.g., chains, anchors, tie-backs, etc.). With regard to rising water levels, the Town may find a detailed cost-benefit analysis to be a valuable tool for weighing the impact to local communities, businesses and industry against the costs for retrofit, adaptation or relocation of each impacted asset.

4.2.2 Floating Dock

The following recommendation is provided in reference to the **Present Day scenario** with regard to construction of the floating dock assembly:

- Clean and coat all corroded steel framing members and replace corroded hardware. Confirm that all members are positively connected and the substrate is in decent condition to resist the intended design loading
- Confirm the gangway attachments ability to resist the design loading and repair or replace as needed.

The following recommendation is provided in reference to the **Short Term and all future scenarios** with regard to construction of the floating dock assembly:

- Given the pier elevation is not scheduled to be raised, consider raising the gangway and gangway platform to accommodate the rising water level. This alternative will provide an elevated gangway platform above the deck elevation. Although raising the pier is highly recommended for subsequent scenarios, gangway alterations may be a viable option due to reduced cost.

4.2.3 Shoreline Protection

The following recommendation is provided in reference to the **Present Day and all future scenarios** with regard to the current shoreline protection:

- Provide at least 2 feet of material thickness for areas of minimal coverage with riprap of mean diameter 2.25 ft, to help prevent further erosion.

The following recommendation is provided in reference to the **Long Term scenario** with regard to construction of the revetment:

- Recommend analysis and/or testing to confirm suitability of existing revetment to resist the anticipated loading for the long term scenario. Revise riprap size accordingly and as needed.

4.2.4 Boat Ramp

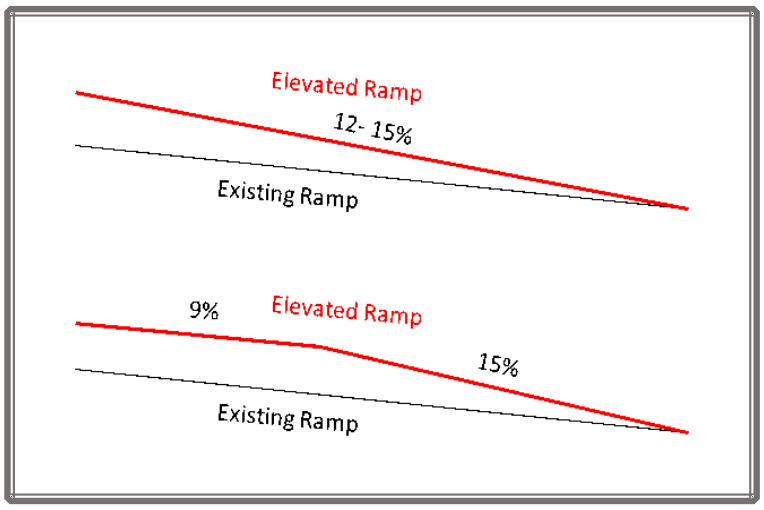
The following recommendation is provided in reference to the **Present Day and Short Term scenarios** with regard to the existing boat ramp:

- Recommend regrading ramp to provide a slope between 12% and 15% for optimal boat unloading conditions. A structural means of maintaining slope stability, such as modular reinforced concrete units or paving, for the intended use and design life should be incorporated.

The following recommendation is provided in reference to the **Mid Term and Long Term scenarios** with regard to existing boat ramp:

- Recommend raising the ramp, commensurate with the rising tide, and providing the recommended slope. Depending on available space, options which incorporate variable site slopes may be necessary (Figure 2). In the case where local re-grading, such as the access road, is required in response to rising water levels, remediation of the ramp should be coordinated. Other options, such as a boat lift/drop or trolley system should be explored based on comparative costs for site development as local and federal permitting agencies allow.

Figure 2: Ramp Remediation Options



5.0 OPINION OF PROBABLE CONSTRUCTION COSTS

The costing information provided below corresponds with our recommendations for remedial action of the corresponding events as outlined in **Table 2 and 3** of this report. These estimated costs include the associated design and engineering services where applicable. In **Table 6** is a summary of the estimated cost for repair or replacement of the identified vulnerabilities. A cost savings may also be expected for combined efforts for items similar in nature, for example, replacing an electrical cabinet while updating and/or securing electrical conduits. We have not considered this variable in our values. Where a complete replacement option is provided, this option and associated costs may be implemented sooner depending on the priorities and funding available to the Town. Costing for the referenced scenario represents summation of all non-complementary improvements. That is, where other repairs or intermediate retrofitting are performed during preceding scenarios the associated costs become additive. All costs are based on present value without inflation. Provided below is a more detailed description of the items included for the associated risk scenario.

Table 6: Repair / Replacement / Retrofitting Costs

Facility	***Present Day***	***Short Term***	***Mid Term***	***Long Term***
Fishing Pier	$375,000	$2,100,000	$2,100,000	$2,950,000
Floating Docks	$535,000	$550,000	$585,000	$825,000
Shoreline Protection	$310,000	$335,000	$360,000	$565,000
Boat Ramp	$195,000	$195,000	$255,000	$325,000
TOTAL:	**$1,415,000**	**$3,180,000**	**$3,300,000**	**$4,665,000**

5.1 Present Day Scenario

The following costs should be expected to accommodate events associated with the Present Day scenario.

Fishing Pier:

- Confirm positive attachment of all structural members to their substrate or load-bearing elements. Incorporate redundancies in design as needed based on a detailed structural analysis. Destructive investigation to confirm material integrity. Design and Construction **$350,000.**
- Utilities and equipment should be properly secured to resist design wind and water loading or relocated above the flood elevation as specified in ASCE 24. Watertight enclosures should be incorporated for electrical equipment, machinery and conduits. Design and Construction **$25,000.**

Floating Docks:

- Moor all floats to independent float piles or using mooring chains/ropes anchored to the seabed. Design and Construction **$250,000.**
- Clean, coat or replace all corroded steel. Confirm gangway condition to resist the intended design loading. Design and Construction **$285,000.**

Shoreline Protection:

- Provide riprap revetment in areas of minimal or no coverage near existing boat ramp. Design and Construction **$310,000**.

Boat Ramp:

- Re-grade boat ramp with steeper slope and add structural slope protection. Design and Construction **$195,000.**

3.2 Short Term Scenario

This section includes costs which are expected due to the need for substantial improvements, however some of these actions are recommended earlier. Items which are not addressed in the earlier time period are included here unless addressed during the course of other referenced improvements. The following costs should be expected to accommodate events associated with the Short Term scenario:

Fishing Pier:

- Raising of the pier due to rising water levels with sustainable design. Design and Construction **$2,100,000.**

Floating Docks:

- Moor all floats to independent float piles or using mooring chains/ropes anchored to the seabed. Design and Construction **$250,000.**
- Raise gangway and gangway platform to accommodate rising water level. Design and Construction **$250,000 - $300,000.**

Shoreline Protection:

- Provide riprap revetment in areas of minimal or no coverage near existing boat ramp. Design and Construction **$335,000**.

Boat Ramp:

- Re-grade boat ramp with steeper slope and add structural slope protection. Design and Construction **$195,000.**

5.3 Mid Term Scenario

Fishing Pier:

- Raising of the pier due to rising water levels with sustainable design. Design and Construction **$2,100,000.**

Floating Dock:

- Moor all floats to independent float piles or using mooring chains/ropes anchored to the seabed. Design and Construction **$250,000.**
- Raise gangway and gangway platform to accommodate rising water level. Design and Construction **$335,000.**

Shoreline Protection:

- Provide riprap revetment in areas of minimal or no coverage near existing boat ramp. Design and Construction **$360,000**.

Boat Ramp:

- Re-grade boat ramp with steeper slope and add structural slope protection. Design and Construction **$255,000.**

5.4 Long Term Scenario

Fishing Pier:

- Raising of the pier due to rising water levels with sustainable design. Design and Construction **$2,950,000.**

Floating Dock:

- Moor all floats to independent float piles or using mooring chains/ropes anchored to the seabed. Design and Construction **$300,000.**
- Raise gangway and gangway platform to accommodate rising water level. Design and Construction **$525,000.**

Shoreline Protection:

- Verification of suitable sizing and thickness of existing riprap. Corrective action as needed. Design and Construction **$565,000**.

Boat Ramp:

- Re-grade boat ramp with steeper slope and add structural slope protection. Design and Construction **$325,000.**

6.0 QUALIFICATIONS OF THE REPORT

The DMR should understand that our observations may be inconclusive, or it may not be possible to identify a definitive cause of distress based on a structural inspection and visual observations alone/without further testing. The recommendations are made based on these limitations.

The "Opinion of Probable Construction Costs" is made on the basis of Wood PLC's judgment, as experienced and qualified professionals generally familiar with the construction industry. However, since Wood, PLC has no control over the cost of labor, materials, equipment, or services furnished by others, or over the construction contractor's methods of determining prices, or over competitive bidding or market conditions, Wood cannot, and does not, guarantee that proposals, bids, or actual

construction cost will not vary from the Opinion of Probable Construction Costs prepared by Wood PLC. We have attempted to consider all aspects of the work and site conditions, based on information made available to us at this stage of the project. Costs will be modified during subsequent stages of project execution, as the level of project definition increases. All costs are based on actual costs as provided by RS Means Costworks 2018, additional or other specified suppliers vendors and contractors.

7.0 CLOSING

Wood appreciate the opportunity to provide these services to DMR on this project. Please contact us with any questions or comments.

Sincerely,
Wood Environment & Infrastructure Solutions, Inc.

Tirrell Day, PE
Senior Structural Engineer

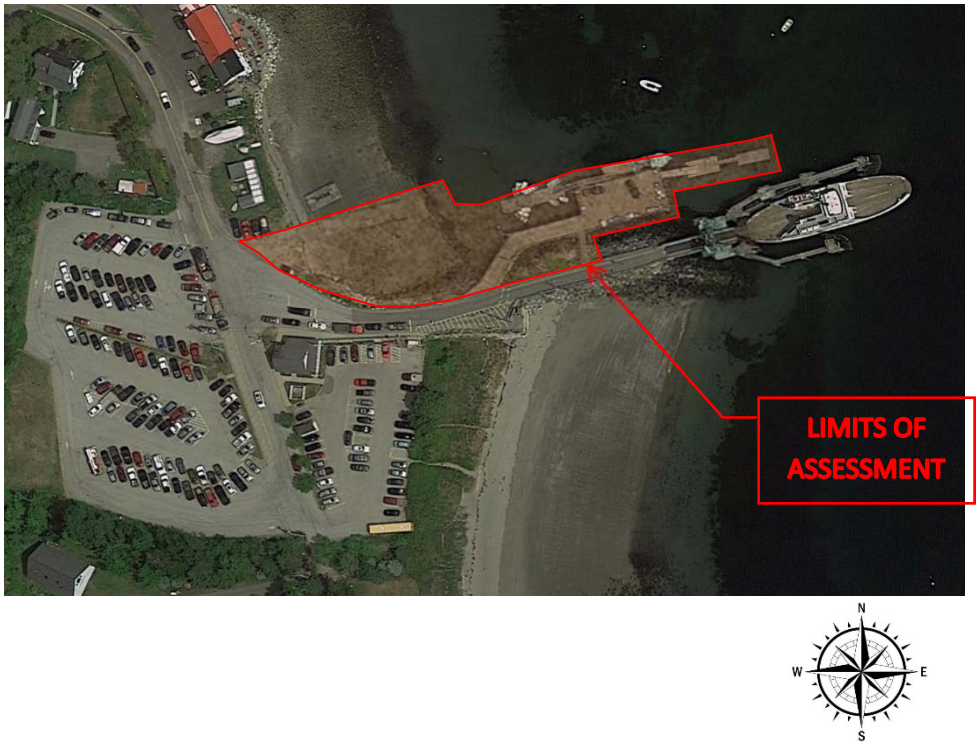
D. Todd Coffin
Associate Project Manager

Attachments: Appendix A - Photolog
Appendix B – Inundation Maps

Appendix A - Photolog for Municipal Fishing Pier Lincolnville, ME

By: T. Day *Date:* 11OCT2019 *Reviewed:* K. Sun *Date:* 11OCT2019

Photograph No. 1:



Comment:

Overview of Site

Photograph No. 2:

Comment:

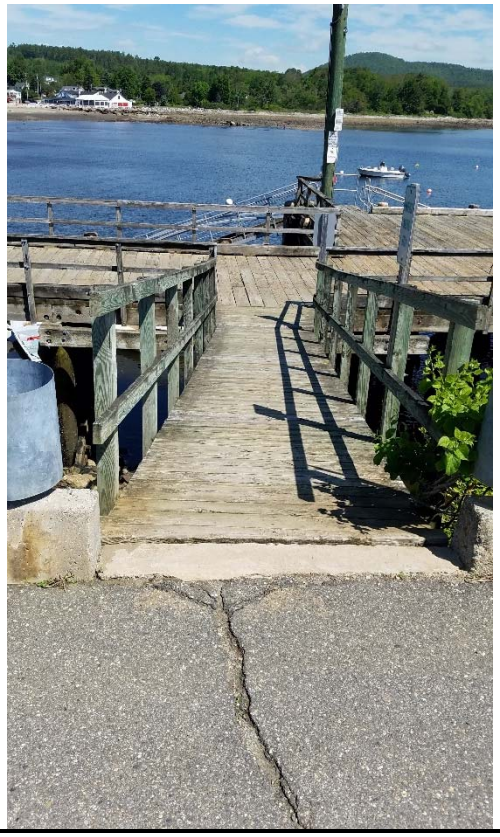
View of pier entrance extending from access road to ferry terminal

By: T. Day Date: 11OCT2019 Reviewed: K. Sun Date: 11OCT2019

Photograph No. 3:  	**Comment:** **View of timber pier from above at west end looking east.**
Photograph No. 4: 	**Comment:** **View of timber pier from deck at east end looking west.**

By: T. Day Date: 11OCT2019 Reviewed: K. Sun Date: 11OCT2019

Photograph No. 5:



Comment:

View of timber pier access walkway from ferry access to pier deck, looking north.

Photograph No. 6:

Comment:

Overview of pier access construction at south side looking north.

Typical construction is deck on stringers, on crossbeams, on timber piles. Lateral stability is provided by cross-bracing and battered piles.

By: T. Day Date: 11OCT2019 Reviewed: K. Sun Date: 11OCT2019

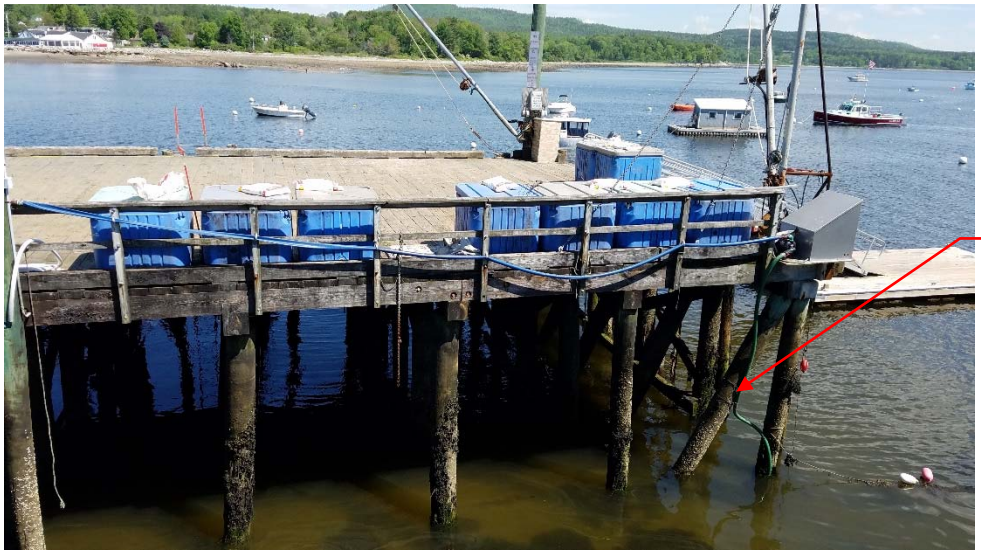
Photograph No. 7:

Comment:

Overview of pier construction at south side looking north.

Typical construction is deck on stringers, on crossbeams, on timber piles. Lateral stability is provided by cross-bracing and battered piles.

Photograph No. 8:



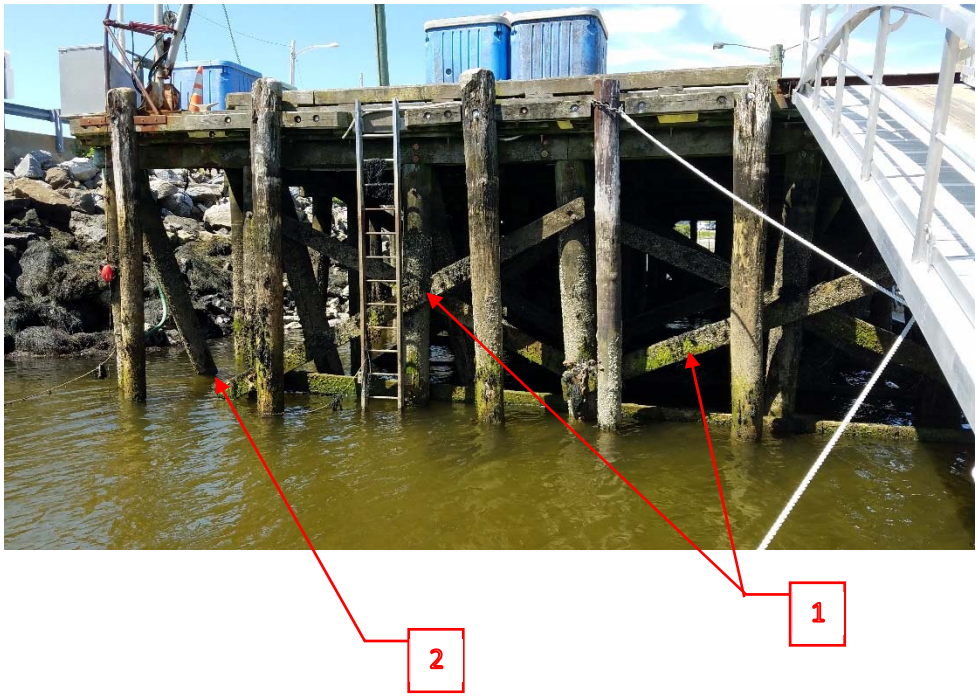
Comment:

Additional view at east end of pier, looking north.

1. **View of battered piles.**

By: T. Day Date: 11OCT2019 Reviewed: K. Sun Date: 11OCT2019

Photograph No. 9:



Comment:

Closer view of east elevation of pier.

1. **View of cross bracing at timber piles.**
2. **Battered piles oriented against incoming tide / waves.**

Photograph No. 10:

Comment:

Closer view of west elevation of pier.

1. **View of weather piles (typical).**

By: T. Day Date: 11OCT2019 Reviewed: K. Sun Date: 11OCT2019

Photograph No. 11:

Comment:

View of north elevation of pier access.

1. **View of weathered and delaminated piles (typ.).**

Photograph No. 12:

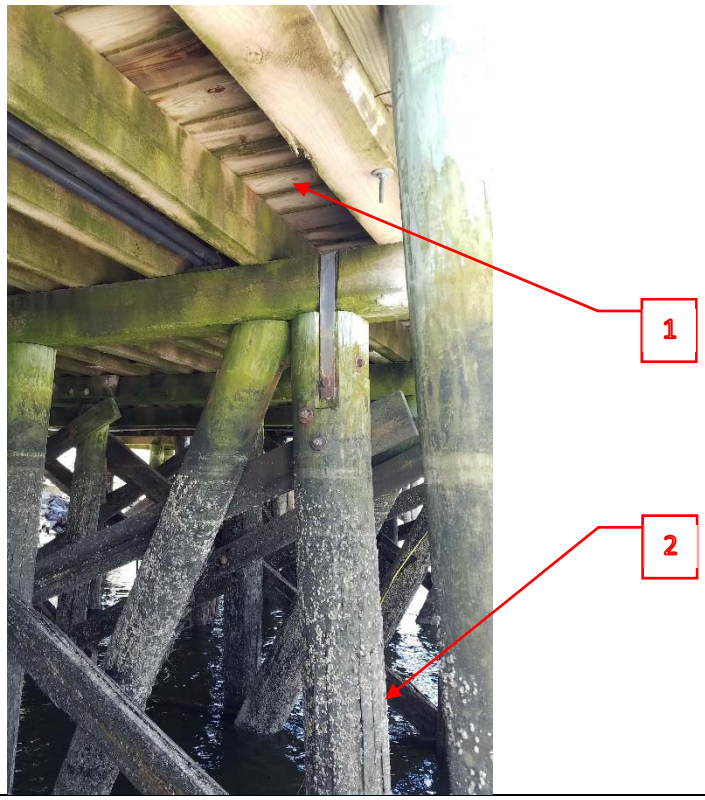
Comment:

Close up of typical construction at underside of pier.

1. **Indication of approximate current MHHW.**
2. **Mild to moderate corrosion of fastening hardware.**

By: T. Day Date: 11OCT2019 Reviewed: K. Sun Date: 11OCT2019

Photograph No. 13:



Comment:

View at underside of pier.

1. **Deck noted in decent condition from below.**

2. **Piles possibly affected by bacterial infestation and/or weathering. Integrity of wood fiber should be verified.**

Photograph No. 14:

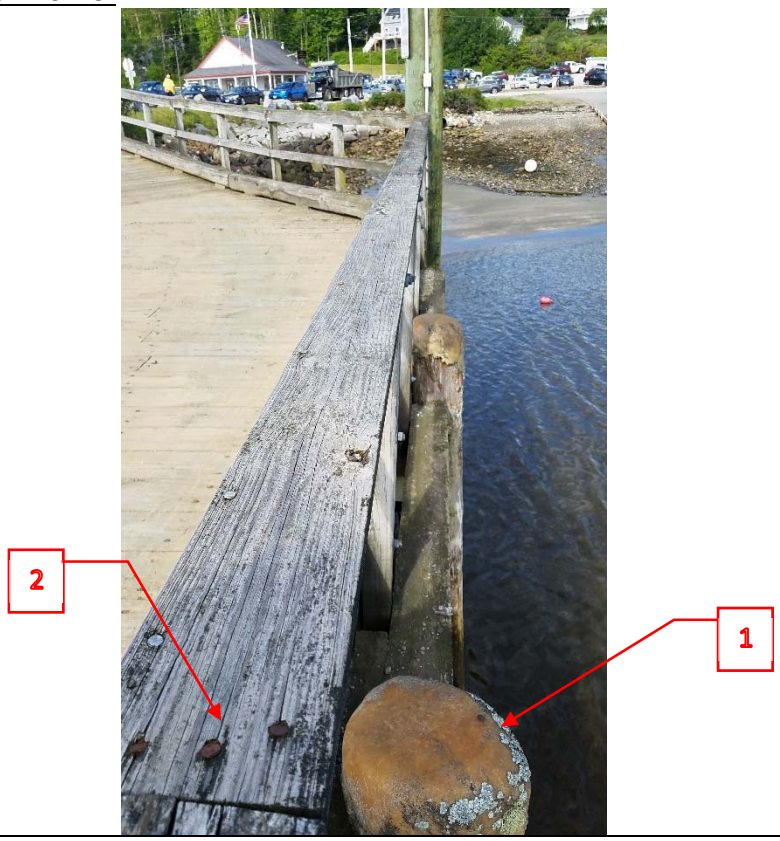
Comments:

Close up of underside of pier.

1. **Close up view revealing condition of wood at underside of deck.**
2. **Electrical conduit which appears to be suitable for moist conditions.**

By: T. Day Date: 11OCT2019 Reviewed: K. Sun Date: 11OCT2019

Photograph No. 15:

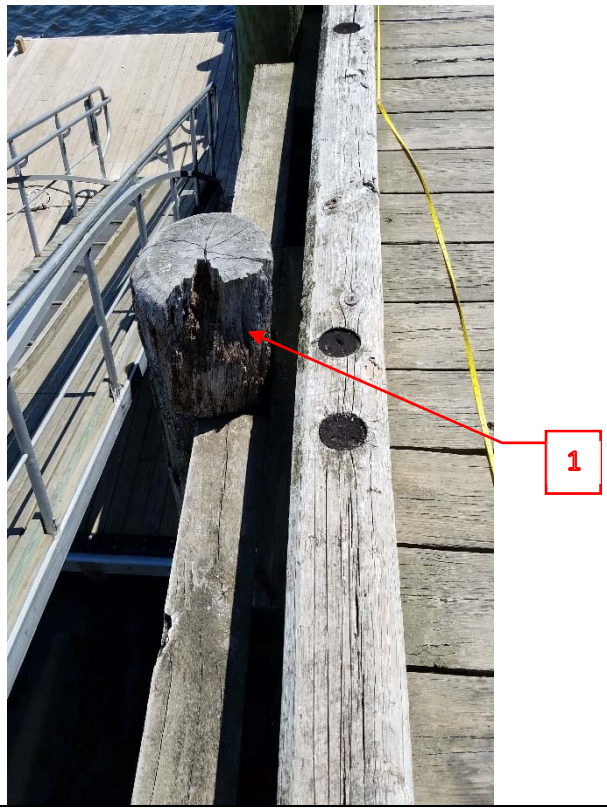


Comments:

View from top of pier.

1. **Pile covers at weathered timber**
2. **View of weathered railing and corroded fasteners.**

Photograph No. 16:

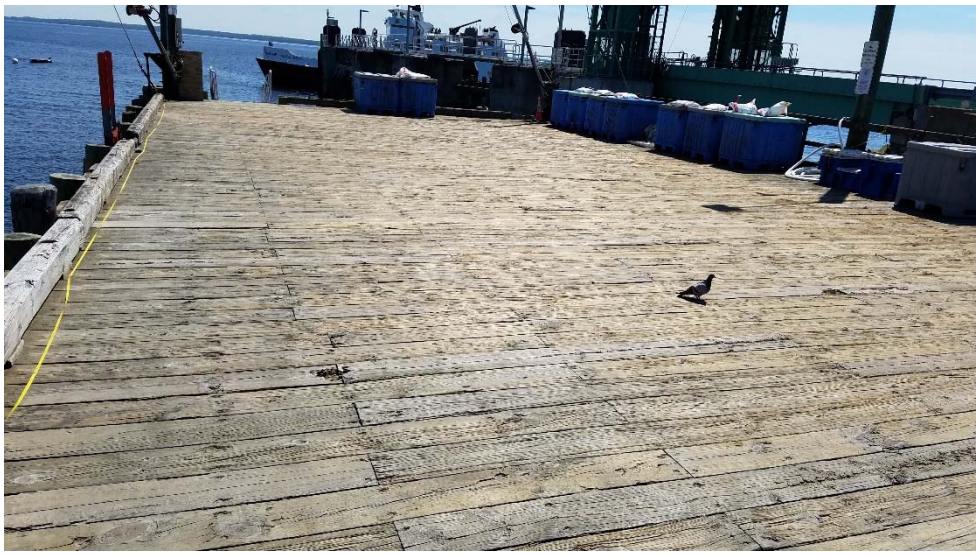
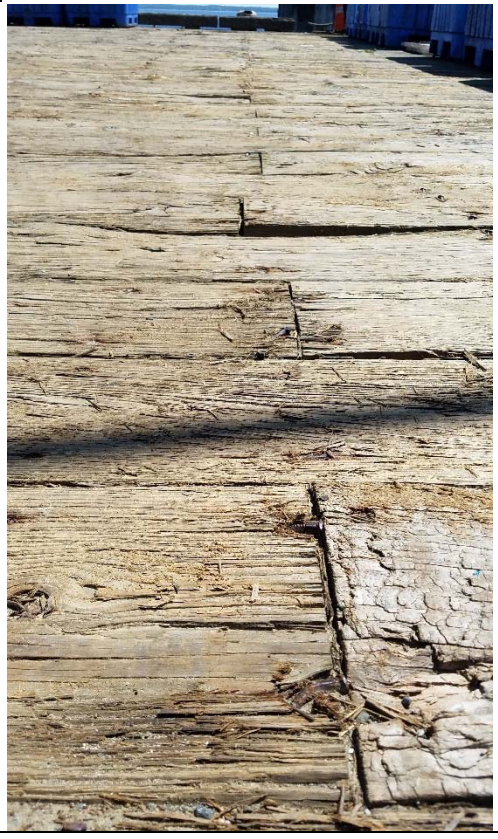


Comment:

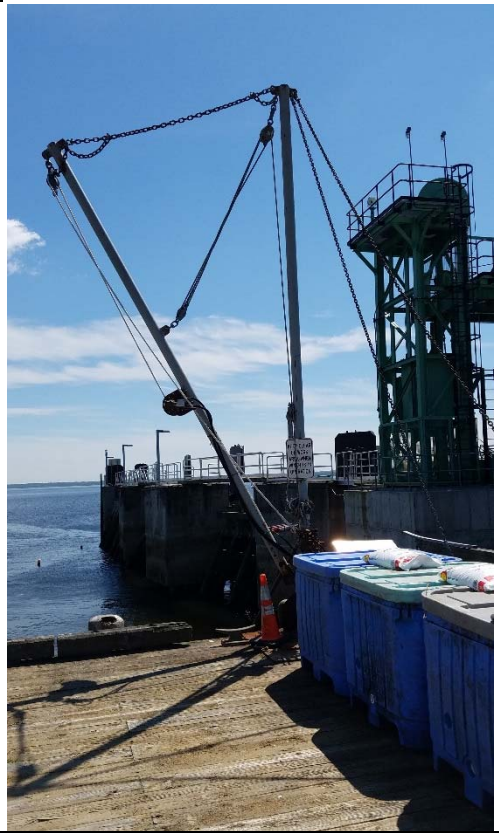
View at top of deck.

1. **Timber pile with gouging.**

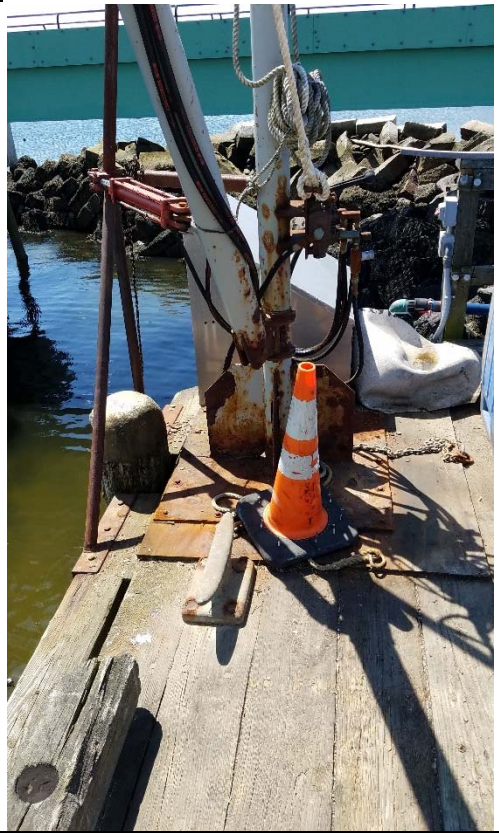
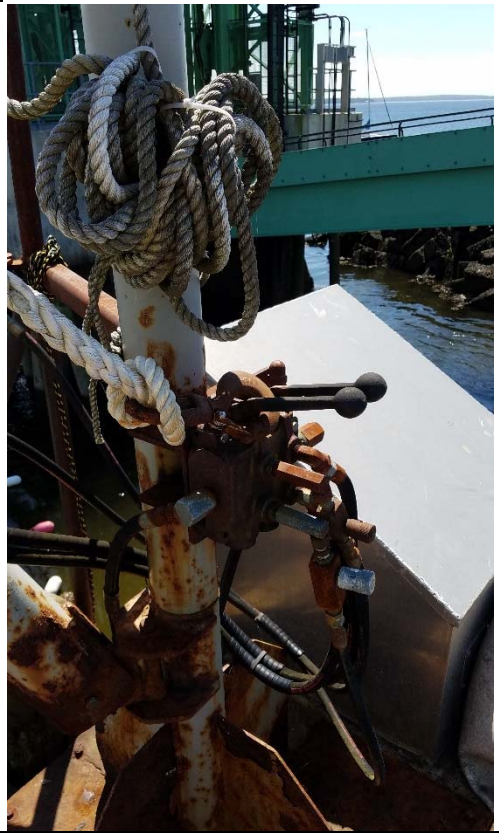
By: T. Day Date: 11OCT2019 Reviewed: K. Sun Date: 11OCT2019

Photograph No. 17: 	**Comment:** **Overall view of deck timber.**
Photograph No. 18: 	**Comment:** **Close-up of deck timbers revealing weathered appearance.**

By: T. Day Date: 11OCT2019 Reviewed: K. Sun Date: 11OCT2019

Photograph No. 19: 	**Comment:** **Close-up of deck timbers. View of a 5-inch diameter gouge in surface of decking.**
Photograph No. 20: 	**Comment:** **View of a pier hoist at southeast corner.**

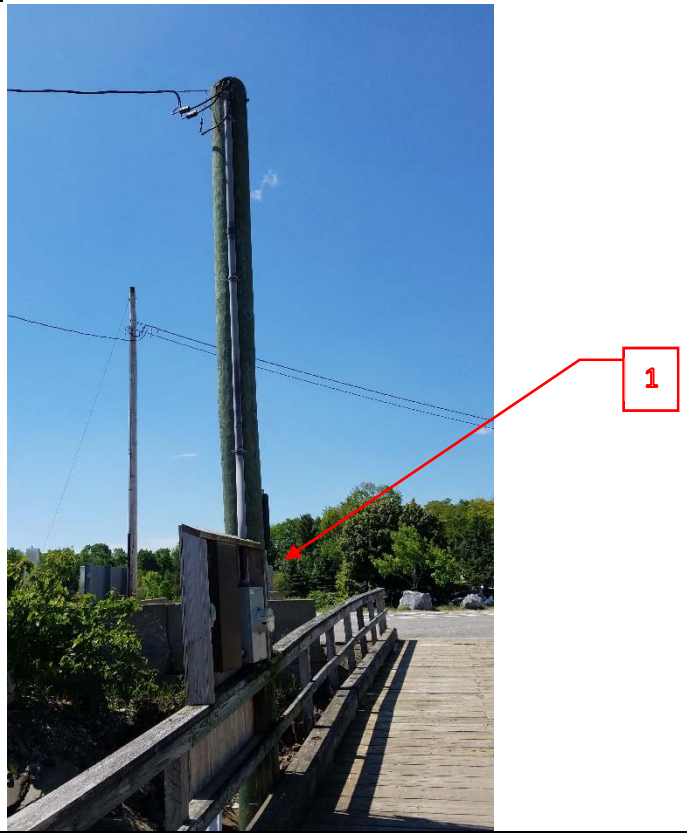
By: T. Day Date: 11OCT2019 Reviewed: K. Sun Date: 11OCT2019

Photograph No. 21: 	**Comment:** **Closer view of the pier hoist.**
Photograph No. 22: 	**Comment:** **Close-up of equipment. Framing and fittings exhibit signs of moderate to major corrosion.**

By: T. Day Date: 11OCT2019 Reviewed: K. Sun Date: 11OCT2019

Photograph No. 23: 	**Comment:** **View of water pump at surface of deck. Equipment is not secured from moisture or inundation.**
Photograph No. 24: 	**Comment:** **View of an additional pier hoist at northeast corner of pier.**

By: T. Day Date: 11OCT2019 Reviewed: K. Sun Date: 11OCT2019

Photograph No. 25:  	**Comment:** **Closer view of hoist and operation panel.** **1. View of opening in equipment housing. Elevation is well below the Present Day BFE of 6 ft above top of deck.**
Photograph No. 26:  	**Comment:** **View of electrical panel near entrance to pier.**

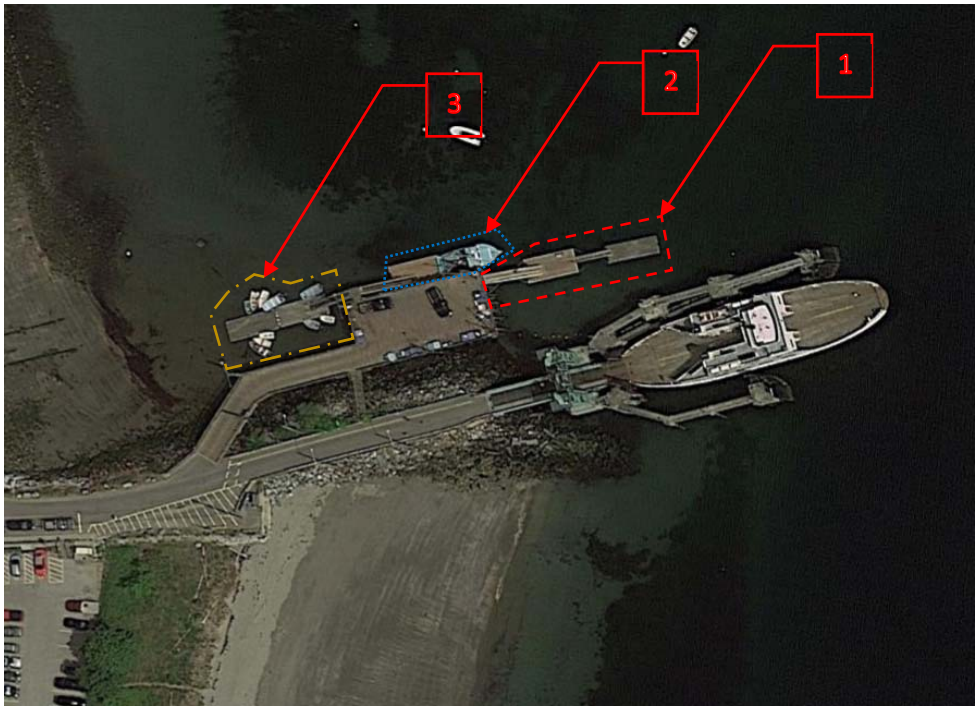
By: T. Day Date: 11OCT2019 Reviewed: K. Sun Date: 11OCT2019

Photograph No. 27:

Comment:

Close up of electrical panel in previous photo.
The current BFE lies just barely below the panel.

Photograph No. 28:

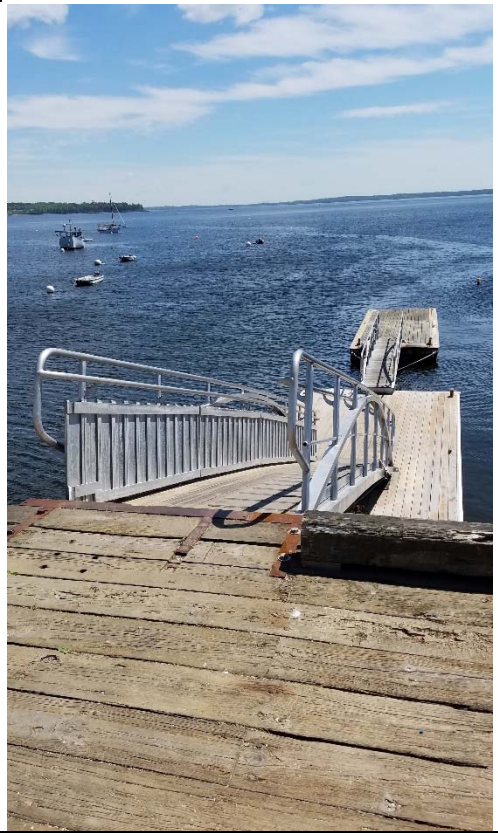


Comment:

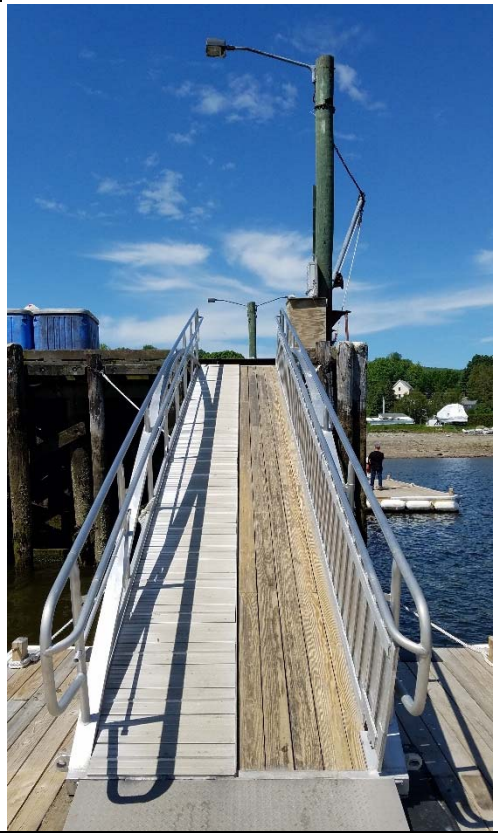
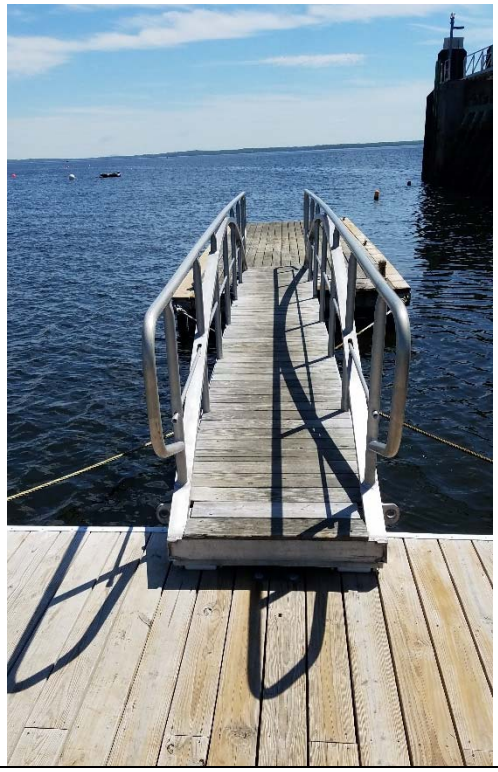
Floating Dock Key

1. **Floating Dock 1**
2. **Floating Dock 2**
3. **Floating Dock 3**

By: T. Day Date: 11OCT2019 Reviewed: K. Sun Date: 11OCT2019

Photograph No. 29: 	**Comment:** **Overview of Floating Dock No. 1 at east side of pier.**
Photograph No. 30: 	**Comment:** **View of Floating Dock No. 1 from the pier.** **View of gangway and attachment to deck.**

By: T. Day Date: 11OCT2019 Reviewed: K. Sun Date: 11OCT2019

Photograph No. 31: 	**Comment:** **View of gangway from below on float.**
Photograph No. 32: 	**Comments:** **View of bridge between the two (2) pontoons of Floating Dock No.1** **View of the condition of the float.**

By: T. Day Date: 11OCT2019 Reviewed: K. Sun Date: 11OCT2019

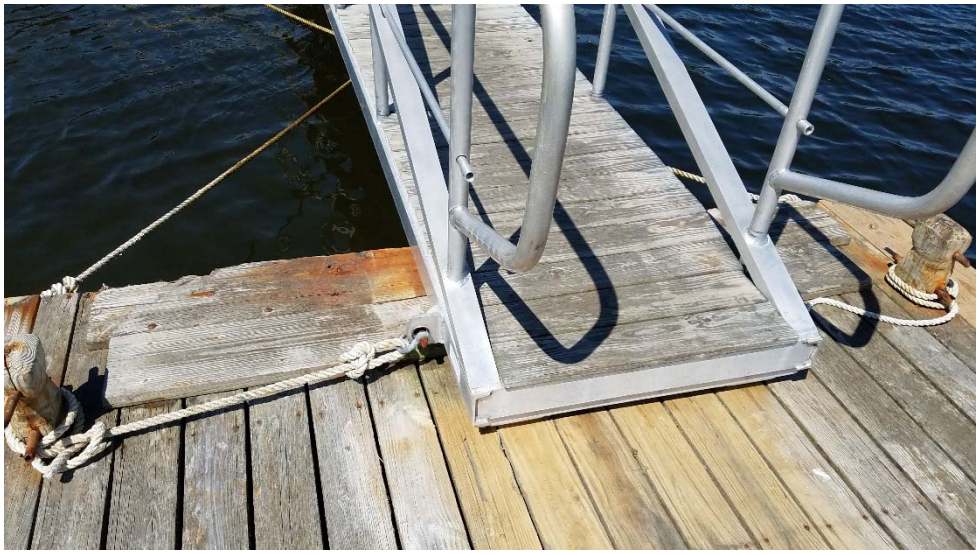
Photograph No. 33:

Comment:

View of the condition exterior panel of Floating dock No. 1

Deck exhibits signs of mild weathering.

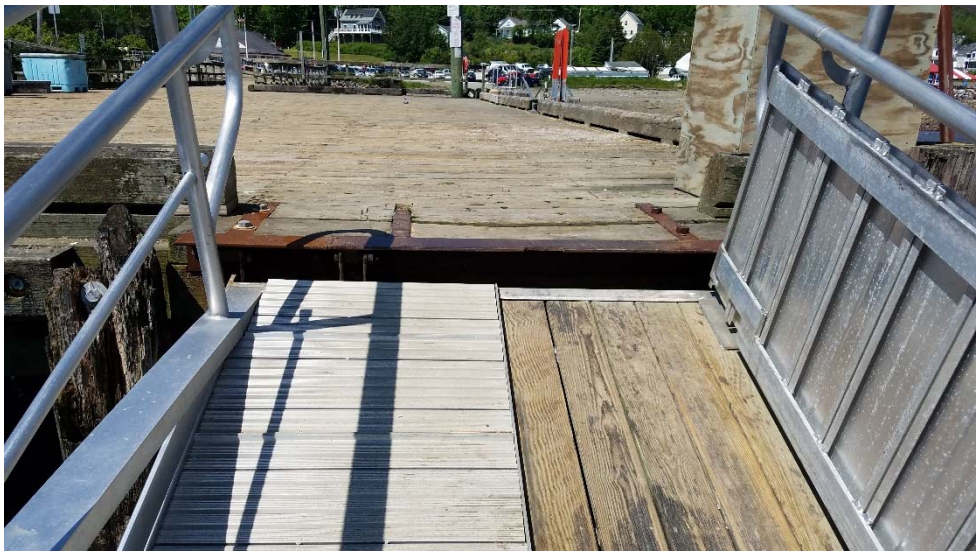
Photograph No. 34:



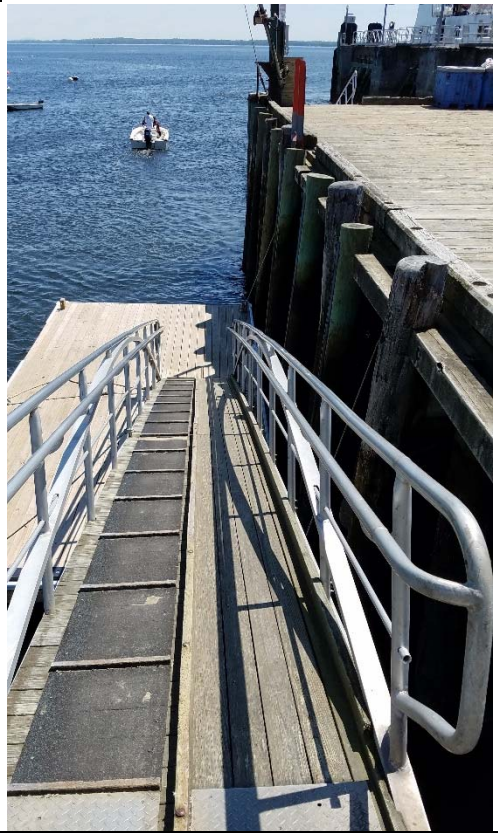
Comment:

Close-up of bridge attachment to float. Ropes visible as means to secure floats to each other and the pier.

By: T. Day Date: 11OCT2019 Reviewed: K. Sun Date: 11OCT2019

Photograph No. 35: 	**Comment:** **Close-up at gangway attachment to pier.** **View of ropes used to secure floats and gangway to pier.**
Photograph No. 36: 	**Comment:** **View of floating dock 1.** **Attachment of gangway to pier.**

By: T. Day Date: 11OCT2019 Reviewed: K. Sun Date: 11OCT2019

Photograph No. 37: 	**Comment:** **Overview of Floating dock 2 & 3**
Photograph No. 38: 	**Comment:** **View of Gangway for Floating Dock 2**

By: T. Day Date: 11OCT2019 Reviewed: K. Sun Date: 11OCT2019

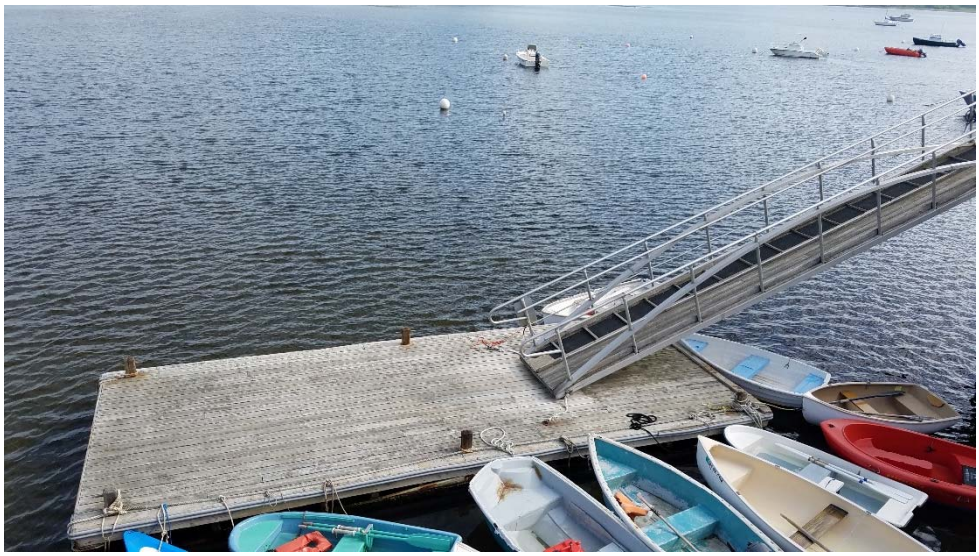
Photograph No. 39:

Comment:

View of typical condition of a float at Floating Dock 2.

1. **Deck wood appears in decent condition.**
2. **The pontoons appear to function as intended.**

Photograph No. 40:

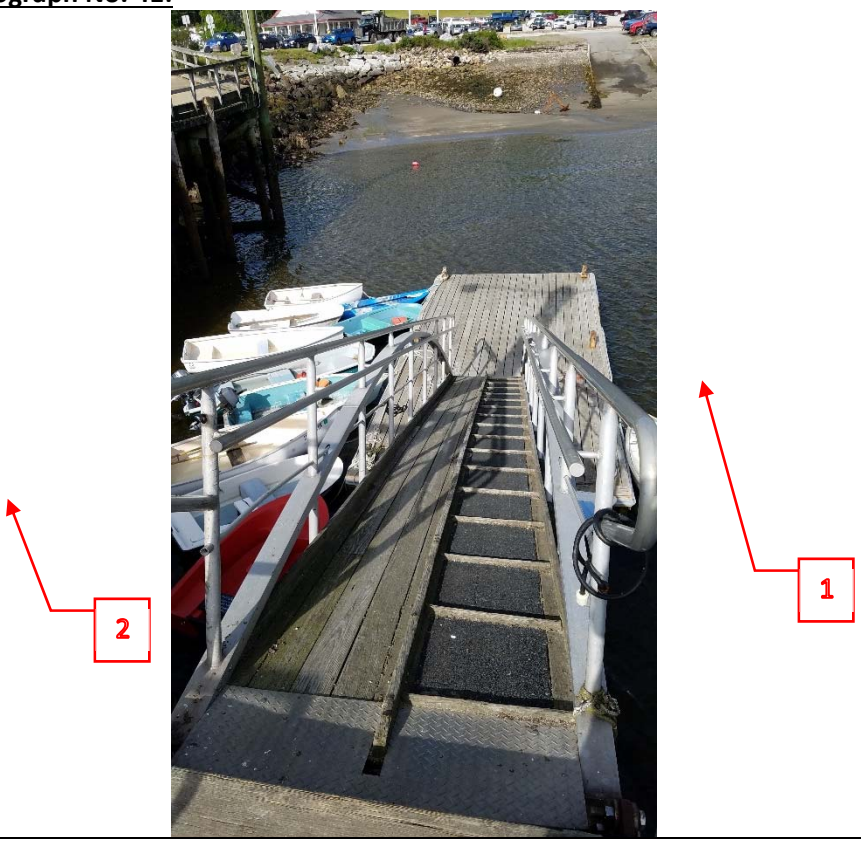


Comment:

Overview of floating dock 3.

By: T. Day Date: 11OCT2019 Reviewed: K. Sun Date: 11OCT2019

Photograph No. 41:



Comments:

Overview of floating dock 3.

View of gangway and attachment to pier.

Photograph No. 42:

Comments:

View of gangway support at Floating Dock 3.

Floating dock deck members appear to exhibit signs of mild weathering.

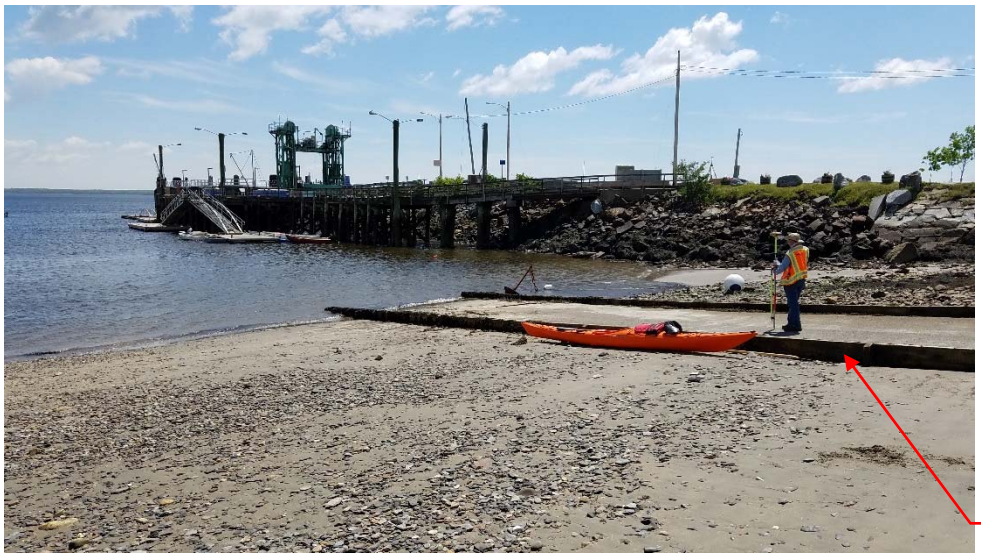
By: T. Day Date: 11OCT2019 Reviewed: K. Sun Date: 11OCT2019

Photograph No. 43:

Comments:

View of shoreline protection and boat ramp.

Photograph No. 44:



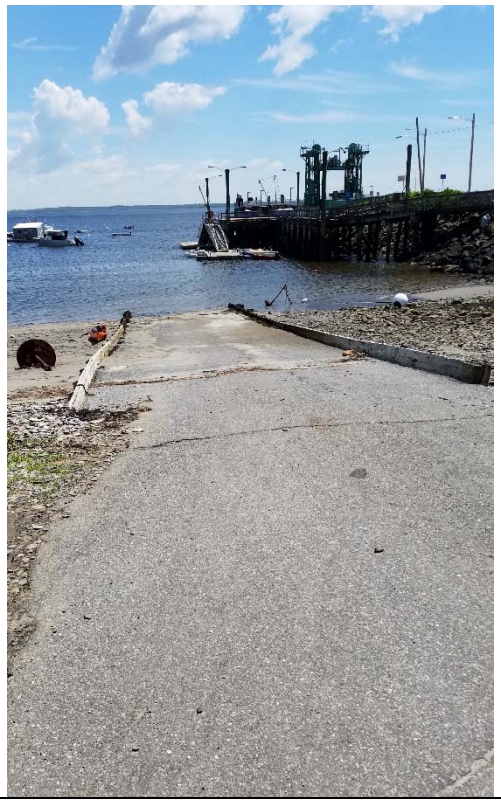
Comment:

View of boat ramp.

1. **Perimeter boards at edge of ramp.**

By: T. Day Date: 11OCT2019 Reviewed: K. Sun Date: 11OCT2019

Photograph No. 45:



Comment:

Close up of boat ramp.

Paved ramp with timber border.

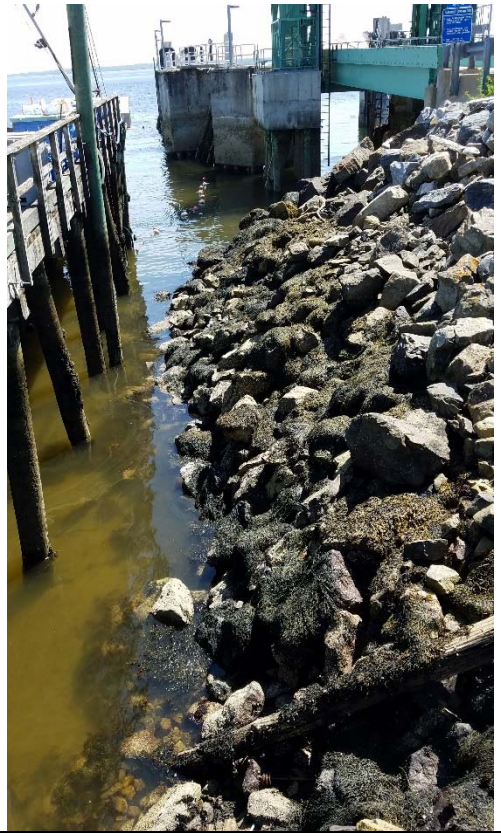
Photograph No. 46:

Comments:

Overview of shoreline in vicinity of the boat ramp.

1. **Shoreline erosion from lack of suitable shoreline protection.**
2. **Drainage structure outlets into the site.**

By: T. Day Date: 11OCT2019 Reviewed: K. Sun Date: 11OCT2019

Photograph No. 47: 	**Comments:** **View of riprap at south side of pier**
Photograph No. 48: 	**Comments:** **View of wave protection between bridge piers at the ferry terminal.**

By: T. Day Date: 11OCT2019 Reviewed: K. Sun Date: 11OCT2019

Photograph No. 49:

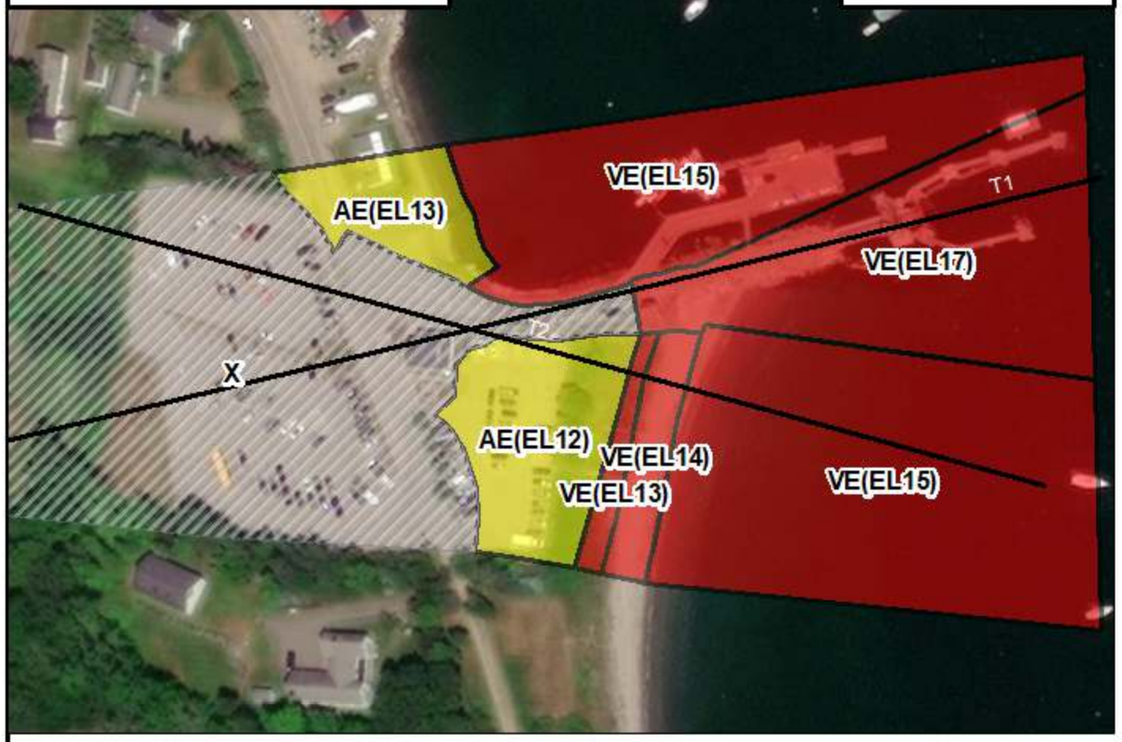
Comment:

View of wave protection in the form of large rocks and concrete rubble between the ferry terminal bridge span.

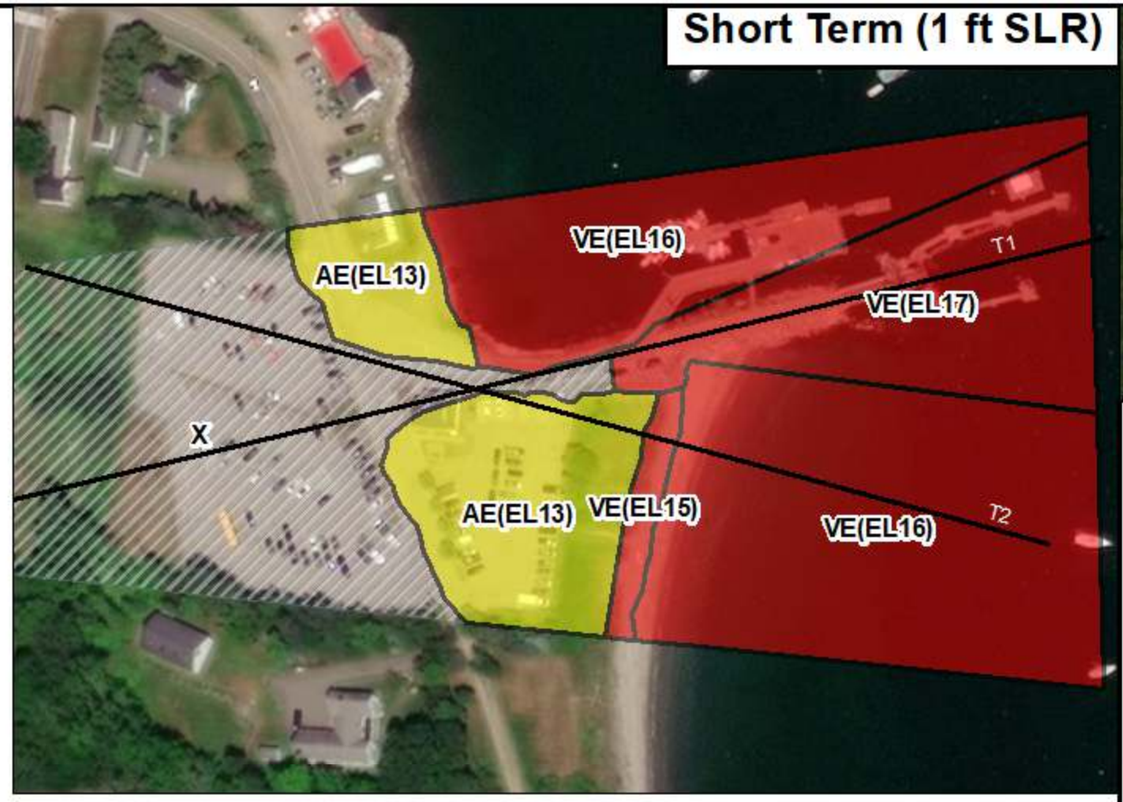
Appendix B – Inundation Maps

Site: Lincolnville, ME

Present Day



Short Term (1 ft SLR)



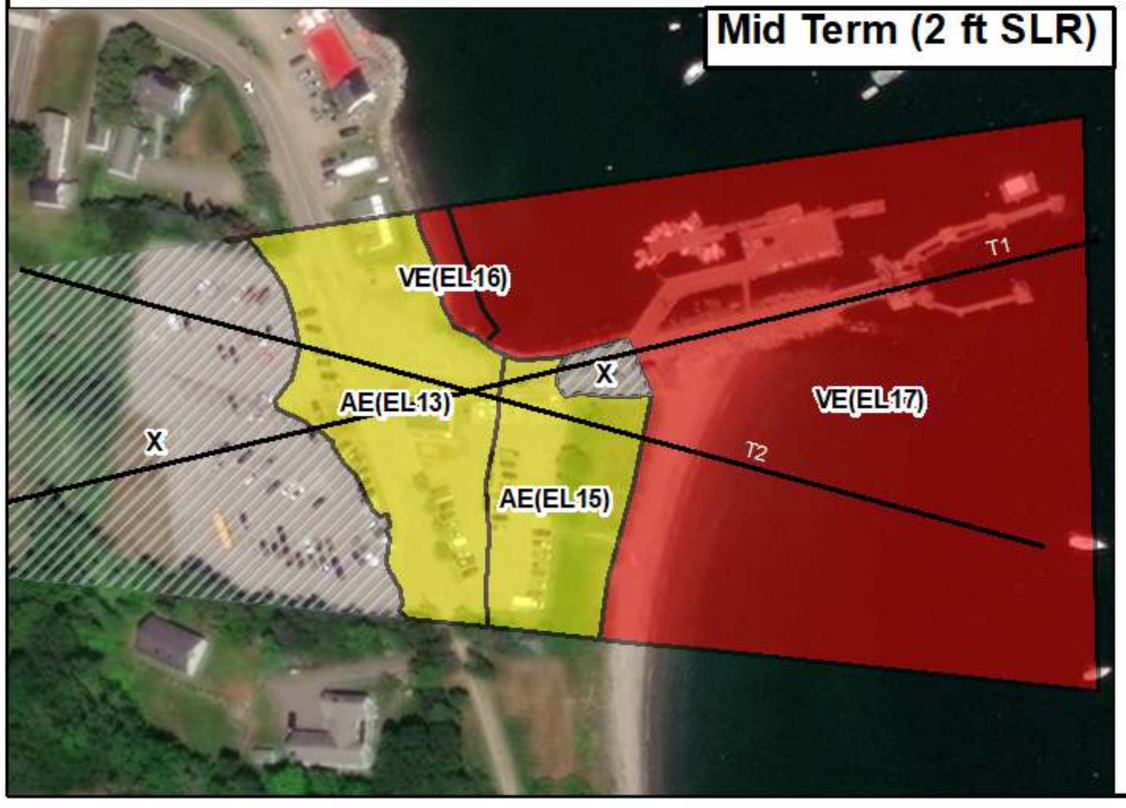
1. Maps indicate the 1%-annual-chance flood zones and base flood elevations.

2. This does not constitute a revision to the FEMA FIRM map which is done through FEMA's Letter of Map Revision process for which additional analysis and/or modeling may be required.

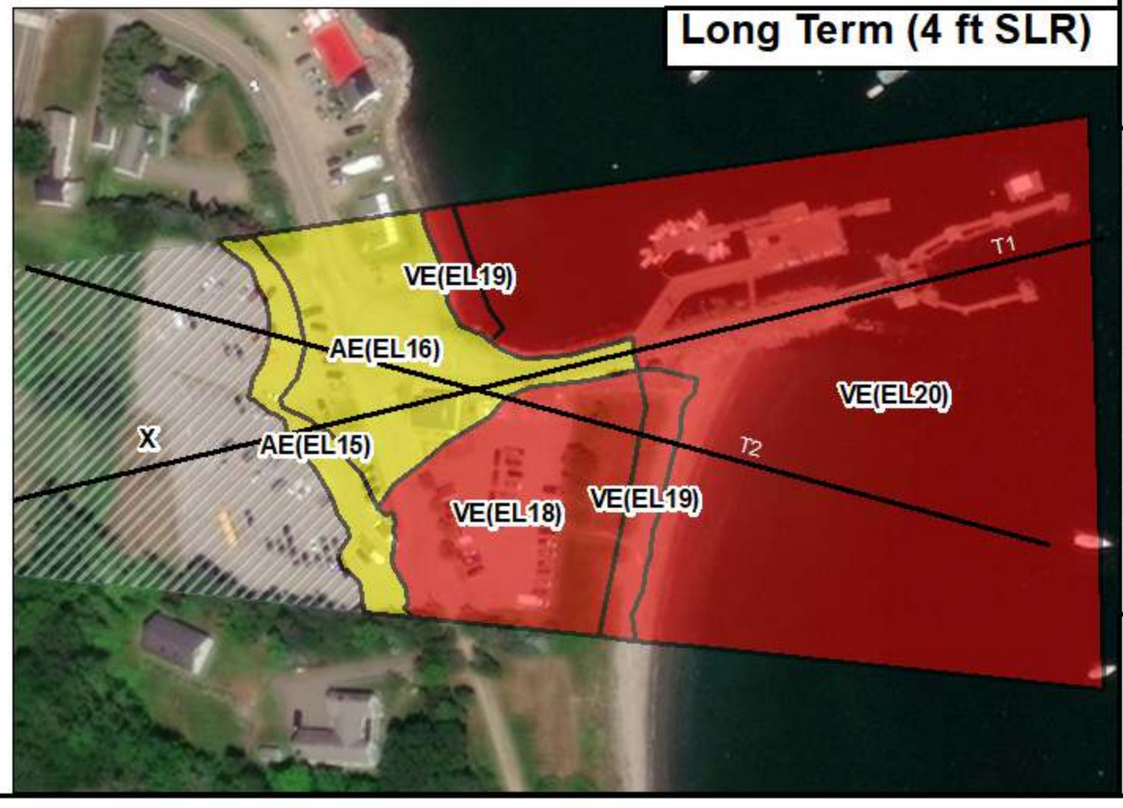
3. Flood mapping was developed for planning purposes only. No other use of this map should be made.

4. Elevations in reference to vertical datum NAVD88

Mid Term (2 ft SLR)



Long Term (4 ft SLR)



Legend

- Lincolnville Transects
- AE
- VE
- X

N

Zone AE : Coastal flood zone. Base Flood Elevations determined.

Zone VE : Coastal flood zone with velocity hazard (wave action). Base Flood Elevations determined.

Zone X : Areas determined to be outside the 1% annual chance floodplain.

0 37.5 75 150 Feet

WOODS HOLE GROUP
A CLS COMPANY