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Waterfront Condition Assessment

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1. Project History

1.1. Waterfront Infrastructure

The Town of Beaufort owns approximately 2.3 acres of land and a corresponding 1,550 linear feet of shoreline along Front Street between Turner Street and Pollock Street, referred to in this report as the Central Waterfront as shown in Figure 1-1. The Central Waterfront is Town's main link between the Front Street commercial district and Taylor's Creek/Beaufort Harbor. The 2.3-acre land parcel includes three primary clusters of commercial buildings separated by two municipal surface parking lots, a 950-foot-long Town of Beaufort boardwalk, two public parks (Concert Park and Grayden Paul Park), public restrooms and a few utility and storage units. The Beaufort Docks, a 64-slip marina, a NOAA concessionaire dock, the Town's public dinghy dock, and several miscellaneous docks lie waterward of the Central Waterfront. In addition, two parcels of lands and their corresponding water areas (Finz Grill) and the Topsail Marine Memorial Park were also evaluated to support the development of the Town's waterfront plan.

The shoreline along the Central Waterfront is stabilized by a four primary structures, a 120-foot-long timber bulkhead along the west perimeter of Grayden Paul Park, a 220-foot-long vinyl sheet pile bulkhead along the central and east perimeters of Grayden Paul Park, a stone and masonry gravity wall that extends from 150 feet east of Pollock Street to Queen Street and a concrete sheet pile wall that extends from Queen to Turner Streets. Landward of the concrete sheet pile wall is another masonry structure that is assumed to be the original bulkhead for this segment of shoreline. The area between the two walls is backfilled with soils that supports the foundation for the timber boardwalk. There are no available records to indicate the construction of the various bulkhead structures though a review of historical aerial photographs from North Carolina Department of Transportation suggests the stone and masonry bulkhead origin dates to the early 1970's while the concrete sheet pile bulkhead was constructed in the late 1970's, consistent with design drawings dated from 1977. The timber and vinyl sheet pile bulkheads at Grayden Paul Park appear to have been constructed within the past decade.

The marina in its present configuration was constructed in the 1980's and consisted of fixed timber docks. By 2004, most of the marina was converted to floating docks, with the last updates to the floating docks performed around 2008/2009. The Town's dinghy dock at Grayden Paul Park was constructed in 2014 timeframe, with the boat lifts at the park installed in 2016. The dock seaward of Finz Grill was constructed in late 1980's/early 1990's as a fixed structure then replaced with a floating dock system around 2008. A dock was constructed at Topsail Marine Park in the early 2000's.

FIGURE 1-1: CENTRAL WATERFRONT AREA

1.2. Condition Assessment Scope

A condition assessment was performed by Moffatt & Nichol (M&N) on October 12th, 2021 to perform a routine above-water visual inspection of the waterfront infrastructure to assess the general condition and provide recommendations for future maintenance or replacement activities. The waterfront infrastructure includes timber bulkhead, the stone and masonry bulkhead (where visually accessible), the concrete sheet pile bulkhead, the timber boardwalk, fixed and floating dock infrastructure, and utility services for the Beaufort Docks. A condition assessment of the physical and utility services at the Beaufort Docks is limited to specific accessible areas and is not considered a comprehensive inspection of the marina facilities. The vinyl sheet pile wall and the dock infrastructure at Grayden Paul Park, the floating dock at Topsail Marine Park, and the floating dock at Finz Grill were not evaluated during the condition assessment. Opinion of probable costs were provided for repair and/or replacement for the concrete bulkhead and the Town Boardwalk since the Town of Beaufort is currently evaluating repair and replacement options.

1.3. Executive Summary

The condition assessment of the Central Waterfront indicated that the shoreline stabilization, marine infrastructure, and marine utilities were generally in fair condition, except for the concrete bulkhead which was rated as being in poor condition. The condition rating of the shoreline stabilization structures excluding the concrete bulkhead, is consistent with age and limited maintenance practices that have been performed by the Town. The repair cost for the timber bulkhead and stone and masonry bulkhead are approximately $30,000.

The concrete bulkhead is approaching the end of its service life. The condition assessment noted significant deficiencies in the concrete cap, anchoring system, and sheet piles. The cap elevation is also low relative to daily tide levels, making it susceptible to inundation during elevated tide conditions and providing limited flood protection to the Town Boardwalk and adjacent area. With the rising sea level trends occurring along the North Carolina cost, the frequency of inundation may increase.

Three approaches to repairing the concrete bulkhead to extend its service life 10 to 20-years were provided, with an associated repair costs ranging from $2.2 to $2.9 million. In addition, a replacement bulkhead option was presented with associated construction costs ranging from $2.6 to $4.0 million. The benefits of the replacement option include increased cap elevation, integrated utility corridors, and separation of the Town Boardwalk foundation.

Segments of the Town Boardwalk are uneven due to settlement of the underlaying foundation on the landward (north) side of the structure. The uneven structure does not meet federal and state accessibility guidelines. Since the seaward (south) side of the boardwalk foundation is supported on the cap of the concrete bulkhead, the boardwalk will need to be replaced when the Town repairs or replaces the bulkhead. The replacement cost of the boardwalk ranges from $1.0 to $1.3 million depending on material selection and finishes.

The fixed and floating dock infrastructure and associated utilities operated by the Town and concessionaires are in generally fair to good condition, with the newer installations having minor deficiencies. Periodic maintenance of the structures and the utility systems will be required in the next 5 years to maintain their function and performance through their service life.

The Beaufort Docks are in fair condition overall with specific structures or utility elements such as the fixed docks on the facility's east side, floating finger piers, and the timber and steel guide piles needing repair in the next 5 years to maintain function and performance and extend service life another 10 to 15 years. The utility system is functional if periodic maintenance is performed. Several recommended modifications to the fuel delivery system should be performed to align it with marina industry best practices.

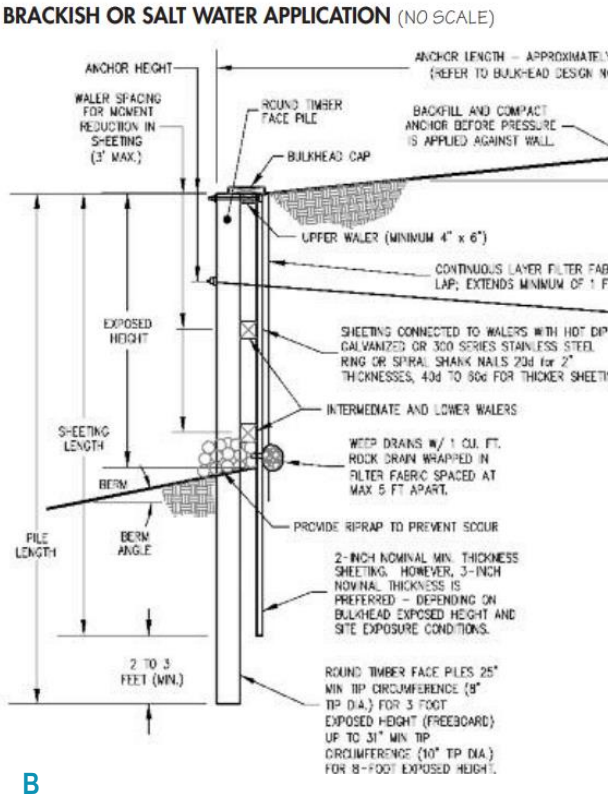
2. Timber Bulkhead

2.1. Description

A timber bulkhead stabilizes the east perimeter of Grayden Paul Park, from the kayak launch area to the gazebo, approximately 120 feet in length as shown in Figure 2-1. The timber bulkhead is a typical anchored wall design with tongue and grove 2-inch x 10-inch timber sheets connected with upper (cap), mid, and lower timber walers and supported by 8-inch x 8-inch square face piles at approximate 8-foot spacing. A galvanized tie-rod connected through the face pile is connected to a deadmen of unknown type (timber, concrete, or soil anchor). Construction and/or as-built drawings of the bulkhead are not available.

FIGURE 2-1: A. TIMBER BULKHEAD AT GRAYSON PAUL PARK B. TYPICAL TIMBER BULKHEAD DESIGN

A



B

Source: Southern Forest Products Association

2.2. Observations

The condition of the timber sheet piles, wale beams, and face piles were consistent with the age of the structure (approximately 10 to 15 years). The alignment of the wall was straight, with no seaward tilting of the bulkhead noted. Depressions in the soil behind the upper waler/cap were not observed, indicating that the timber sheets and the joints between the sheets have not deteriorated due to rot such that their integrity has been compromised, consistent with the observable portions of the timber bulkhead. The timber cap (upper waler) and some of the face piles exhibit signs of rot, with cracking and delamination. The anchoring hardware (tie-road and fasteners) exhibit light corrosion.

2.3. Maintenance/Repair

The repair to the timber bulkhead is considered typical maintenance required to maintain the integrity of the structure through the remainder of its service life, estimated to be approximately 15 years. The upper wale beam should be replaced within the next 5 years along with fasteners that exhibit significant corrosion. The wale beam may be replaced in kind with marine grade southern pine or another type of exotic lumber such as greenheart or purpleheart. Copper and/plastic caps to the top of the face piles is suggested to minimize water penetration.

The estimate maintenance/repair cost for the timber bulkhead is summarized in Table 2-1.

TABLE 2-1: ESTIMATED CONSTRUCTION COST FOR TIMBER BULKHEAD REPAIR

Item Description	Quantity		Unit Costs with Markups	Engineering Estimate with Markups
	Number	Unit		
Mobilization/General Conditions	1	LS	$1,500.00	$1,500.00
Upper Wale Beam	300	BF	$9.50	$2,850.00
Metal Fasteners	30	EA	$10.00	$300.00
Metal Caps	15	EA	$100.00	$1,500.00
			20% Contingency	$1,230.00
			Estimated Construction Cost	$7,380.00

3. Stone and Masonry Gravity Wall

3.1. Description

A stone and masonry wall that is aligned with the south edge of Front Street sidewalk, extends from the east side of Grayson Paul Park to Queen Street (approximately 550 linear feet) as shown in Figure 3-1. This 550-foot-long segment is part of the overall gravity wall that extends along the majority of Front Street, from 250 feet east of Fulford Street to Turner Street. The segment between Queen and Turner Streets is buried landward of the existing concrete sheet pile wall. Historic aerials photographs indicate the presence of this gravity wall in the early 1970's but the exact date of construction is unknown.

FIGURE 3-1: STONE AND MASONRY GRAVITY WALL

3.2. Observations

The condition of the stone and masonry gravity wall is rated as good based on the observations of exposed areas of the wall. Seaward rotation of the wall was not observed along the 550-foot-long segment. Open spalling of the masonry was noted at most expansion joints. Loss of granite stones were observed at several locations on the seaward edge of the masonry cap along a 75-foot section west of Grayson Paul Park.

3.3. Maintenance/Repair

The remaining service life of the gravity wall is estimated to be greater than 20 years unless conditions changes or rotation of the wall is detected. The repairs to the wall are intended to minimize water intrusion into the masonry where is may be lead additional spalling of the wall. It is assumed that approximately 25% of the wall should be repaired at this time. Spall repair consists of chipping off loose masonry and cleaning all exposed repair surfaces, adding a cementitious epoxy resin bonding primer to the exposed repair surface and placement of repair mortar or grout within a prepared form.

The estimate maintenance/repair cost for the timber bulkhead is summarized in Table 3-1.

TABLE 3-1: REPAIR COSTS FOR STONE AND MASONRY GRAVITY WALL

Item Description	Quantity		Unit Costs with Markups	Engineering Estimate with Markups
	Number	Unit		
Mobilization/General Conditions	1	LS	$5,000.00	$5,000.00
Spall Repair (Chipping/Bonding Agent/Mortar Repair	138	LF	$100	$13,750.00
			20% Contingency	$3,750
			Estimated Construction Cost	$22,500

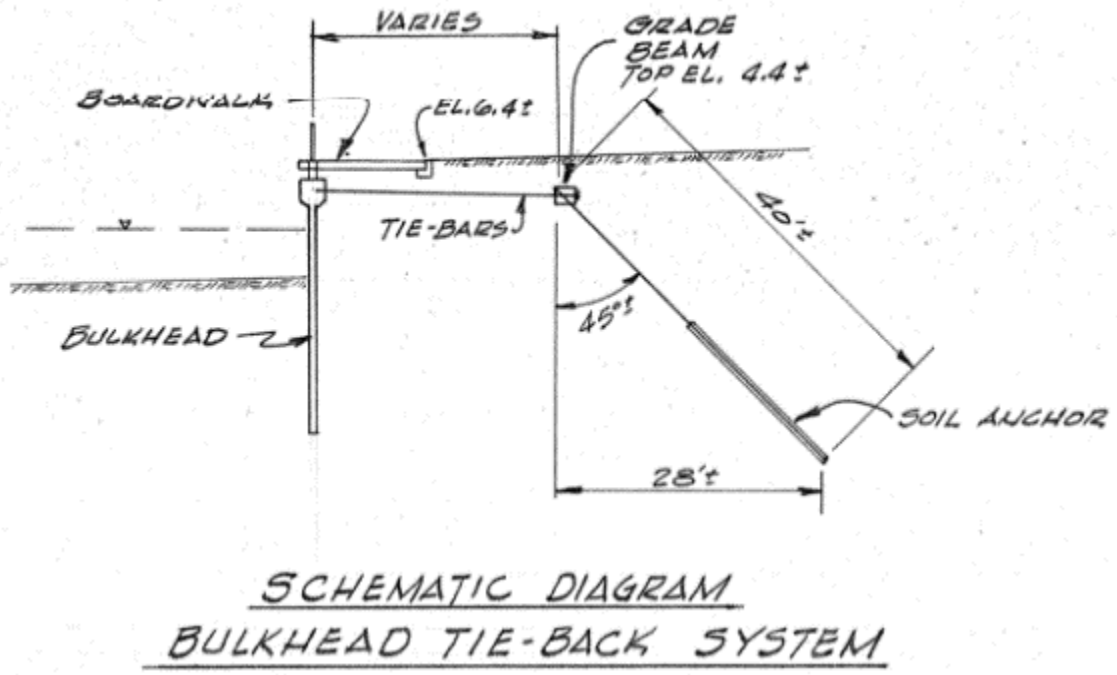
4. Concrete Bulkhead

4.1. Description

The concrete bulkhead is approximately 44 years old and consists of a 950-foot-long anchored concrete sheet pile wall with a reinforced concrete cap beam. According to the available record drawings (Figure 4-1), anchorage is provided by soil anchors set back from the bulkhead. Load is transferred by tie-rods which extend horizontally from the bulkhead cap to a grade beam beyond the boardwalk.

M&N has been provided multiple historic drawings by the Town of Beaufort. None of the historic information contain records on the design of the sheet piles, their length, their reinforcement, or the construction of the soil anchors. It is therefore not possible to accurately analyze the performance or load carrying capacity of the existing concrete bulkhead.

FIGURE 4-1: HISTORIC CROSS SECTION



Source: Rivers and Associates drawing W-476 dated 6/17/1977

4.2. Observations

The concrete sheet piles were primarily below water during the site visit, but some observations were able to be made. The sheet piles appeared to be generally free of marine growth. No sheet piles were noted to be leaning away from land.

A typical maintenance issue for concrete sheet piles is a failure at the interlock between sheet piles. The interlock is the joint between adjacent sheet piles as shown in Figure 4-2 below. Due to differential movement between piles, or cracks and spalls at the interlock, it can be possible for water to flow through the interlock. This can lead to sediment transfer through the bulkhead and voids in the backfill. It was observed that the backfill varied from approximately 12 to 18" below the top of the pile cap beam and that as the water level rose along the pile cap beam, water behind the bulkhead was at approximately the same elevation as observed in Figure 4-3 and

Figure 4-4. This could be an indication that water is flowing through the interlocks. It is also possible that the bulkhead was constructed with a drainage system which is allowing the water levels to equalize on both sides of the wall, however no records or visual indications of a such a system were found.

FIGURE 4-2: EXAMPLE DRAWING OF A TYPICAL CONCRETE SHEET PILE INTERLOCK

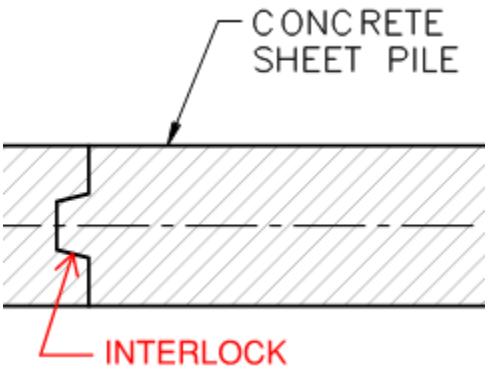


FIGURE 4-3: WATER LEVEL ON LANDSIDE OF BULKHEAD WITH SUBMERGED TIE-RODS

FIGURE 4-4: WATER LEVEL ON LANDSIDE OF BULKHEAD WITH SUBMERGED TIE-RODS

To fully evaluate the condition of the concrete sheet piles, the interlocks, and check if any of the sheet piles have been undermined, it is recommended to perform an underwater dive inspection if the bulkhead system is not replaced.

The concrete pile cap was observed to have longitudinal cracks along the entire length of the beam. There also appeared to be rust staining along the crack indicating corrosion of the reinforcing steel.

Some of the tie-rods providing anchorage to the bulkhead were uncovered from the backfill and showed signs of corrosion. Since the area behind the bulkhead has daily tidal water fluctuations, these tie-rods are repeatedly experiencing wetting and drying from salt water which increases their corrosion potential. The tie-rods appeared to have section loss from the corrosion thereby reducing the load carrying capacity of the anchorage system.

Soundings were performed along the face of the bulkhead, and the mudline elevation was found to vary from approximately 6-feet to 12-feet below the top of the timber boardwalk. Without the original design criteria for the bulkhead, more investigation would be required to determine if this is within the design mudline elevation. However, this free height range is within a typical range for anchored concrete sheet pile bulkheads.

4.3. Repair Options

Repair of the concrete bulkhead may extend the service life from 10 to 20 years depending on repair options. The benefit of extending the service life of the bulkhead is less intensive capital investment in the short-term by the Town. This benefit should be weighed in the context that the Town Boardwalk will have to be replaced as part of the bulkhead repair, the utility service trunk lines for Beaufort Docks may need repair or replacement to facilitate the bulkhead repair and temporary utility services to Beaufort Docks will also have to be provided to avoid disruption of operation. It should also be noted that repair of the bulkhead does not improve or restore the load capacity of the existing bulkhead – it will remain in its existing condition.

Repair of the bulkhead should address the following issues to maximize service life:

- Stabilize sheet pile panel interlocks to minimize loss of backfill,
- Repair concrete cap to reduce corrosion of reinforcing steel,
- Repair/replace anchoring system – tie-rod/grade beam/soil anchor, and
- Repair of concrete sheet pile cracks.

Repair recommendations previously provided to the Town to extend the service life of the bulkhead proposed replacing the concrete pile cap beam and exposed portions of tie-rods. Both elements exhibit signs of corrosion and diminished load carrying capacity necessitating repairs, consistent with the age of the bulkhead. The previous repair recommendations did not extend to the stabilization of the concrete interlocks to minimize piping of backfill or repair to spalling and cracking of the concrete sheet pile itself.

As recommended in Section 4.2, an underwater inspection of the sheet piles should be performed to get a complete understanding of the sheet pile's current condition and potential remaining lifespan. Depending on the preferred repair option, making a major investment in repairing the anchorage system only (as identified in the current repair recommendations) without addressing the potential issues with the concrete sheet piles may limit the extension of the service life and have limited value in the future as the repaired anchorage system may not be able to be reused in future bulkheads.

In addition, replacing the concrete pile cap beam and portions of the tie-rods may present numerous challenges because a temporary anchoring force will be required to prevent bulkhead failure during the repair period. Possible approaches include excavating behind the bulkhead wall to reduce the pressure on the bulkhead or installation of a new soil anchor system can minimize or avoid the need for temporary anchoring. Analyzing how much backfill will need to be removed to not overstress the concrete sheet piles during repairs to the anchoring system will be difficult due to the lack of information regarding the design of the existing bulkhead. Excavating behind the bulkhead will also have challenges due to the space constraints with existing tie-rods to be repaired, utilities, and potential undermining of the waterfront buildings. Providing temporary tie-rods to the existing anchors will not be accessible due to the existing tie-rods connecting to a concrete beam under the buildings. It would thus be necessary to install new soil anchors and a temporary steel wale when replacing the pile cap beam.

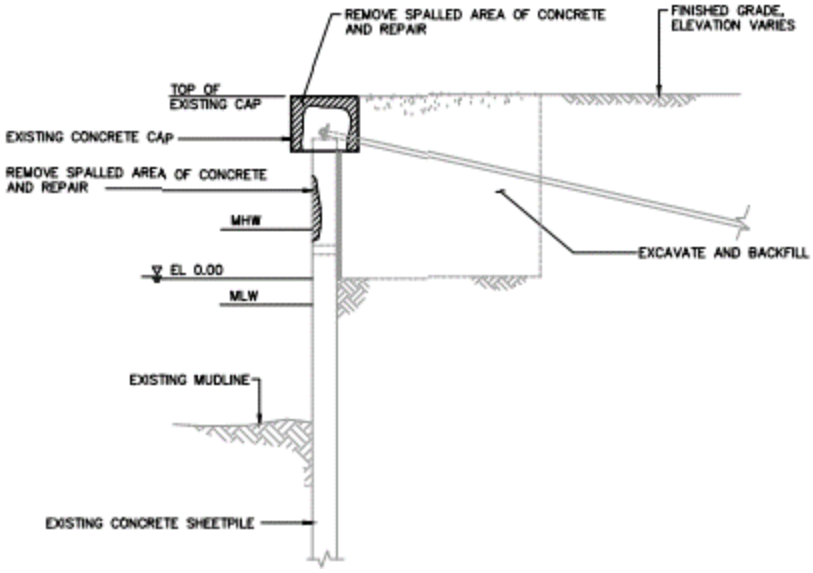
Three repair options were developed, with two options addressing partial repair of the concrete sheet piles and full repair and/or replacement of the concrete cap and anchorage. The third option offers full repair of the concrete sheet piles and concrete cap and replacement of the anchoring system.

4.3.1. Repair Option 1

This option consists of chipping away the spalled and cracked areas of the existing concrete cap and upper section above the Mean Lower Water (MLW) line of the concrete sheet pile, applying a bonding primer, and

encapsulating the old cap with a new cap composed of repair mortar. In addition, the area behind the concrete sheet pile will be excavated to the MLW line and geotextile installed on the rear face of the concrete sheet pile to minimize soil loss through the interlocks. New backfill material will be placed. The anchor system will also be replaced using a tie-rod connect to a helical or soil anchor depending on geotechnical conditions. Figure 4-5 shows a typical repair section for a concrete sheet pile bulkhead.

FIGURE 4-5: TYPICAL SECTION – REPAIR OPTION 1



Construction of this repair option will require removal of the Town boardwalk to facilitate excavation landward of the sheet pile to seal the panel interlocks, repair the cap, and replace the anchoring system. The excavation work may also be disruptive to commercial businesses and use of the Town's parking infrastructure. In addition, the trunk lines for all the marina utilities will need to be relocated and/or replaced or temporary utility connections installed to maintain marina operations. However, the removal of the main shore parallel floating dock for the Beaufort Docks may not be required to perform this option.

Table 4-1 summarizes the estimated opinion of construction cost for the repair option.

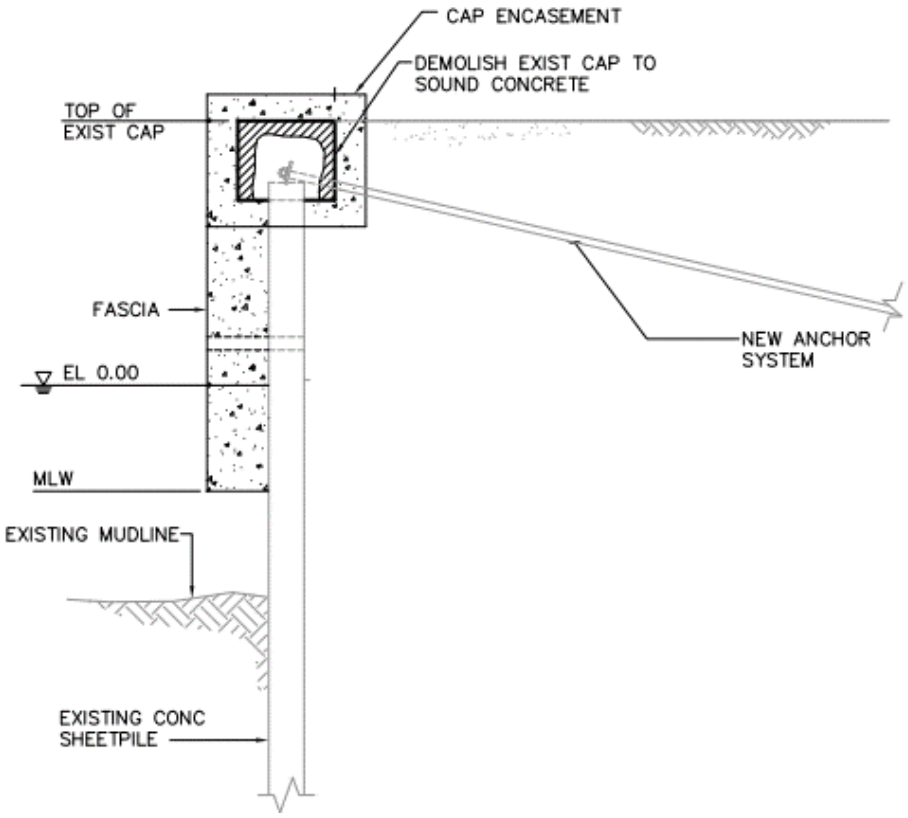
TABLE 4-1: OPINION OF CONSTRUCTION COST FOR REPAIR OPTION 1

Item Description	Quantity		Unit Costs with Markups	Engineering Estimate with Markups
	Number	Unit		
Mobilization/General Conditions	1	LS	$200,000.00	$200,000
Existing Cap Demolition	200	CY	$250.00	$50,000
Temporary Wale for Construction	950	LF	$825.00	$783,750
Excavation and Backfill	315	CY	$25.00	$7,875
New Concrete Cap	200	CY	$1,305.00	$261,000
New Anchors – Soil	63	EA	$11,600.00	$730,800
			Subtotal	$2,033,425
			30% Contingency	$610,027
			Estimated Construction Cost	**$2,643,452**

4.3.2. Repair Option 2

Repair Option 2 is like the first repair option with respect to concrete cap encapsulation and replacement of the anchoring system. In lieu of excavating landward of the bulkhead, placing geotextile to seal the interlocks, and backfilling with new material, a concrete drop fascia extending to MLW on the seaward face of the concrete sheet pile will be installed to repair surface spalls and act to seal the sheet interlocks in this zone. A typical section for this repair option is shown in Figure 4-6Table 4-2.

FIGURE 4-6: TYPICAL SECTION – REPAIR OPTION 2



The benefit of this option is the limited excavation on the landward side of the bulkhead which may lead to less disturbance of existing infrastructure and commercial operations. The Town Boardwalk will need to be removed and reconstructed in this option. One disadvantage of this option is the extensive amount of formwork required to construction the concrete fascia, which elevates the construction cost. Another drawback of the concrete fascia construction is the potential removal of the shore parallel floating dock to facilitate access, though a staged approach may be possible depending on utility routing on the dock.

Table 4-2 summarizes the estimated opinion of construction cost for the repair option.

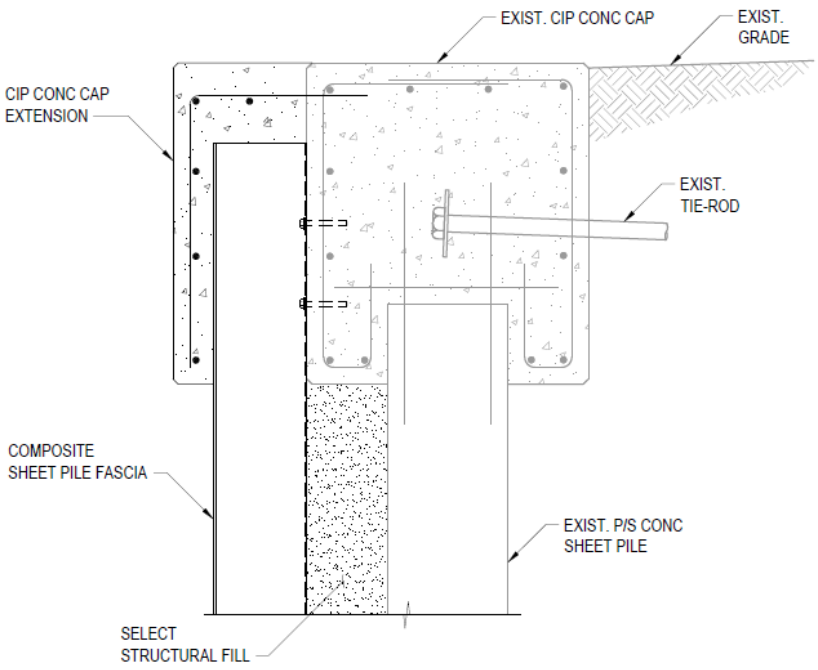
TABLE 4-2: OPINION OF CONSTRUCTION COST FOR REPAIR OPTION 2

Item Description	Quantity		Unit Costs with Markups	Engineering Estimate with Markups
	Number	Unit		
Mobilization/General Conditions	1	LS	$240,000.00	$240,000
Existing Cap Demolition	200	CY	$250.00	$50,000
Temporary Wale for Construction	950	LF	$825.00	$783,750
New Concrete Cap	200	CY	$1,305.00	$261,000
Concrete Fascia	390	CY	$1,305.00	$508,950
New Anchors – Soil	63	EA	$11,600.00	$730,800
			Subtotal	$2,574,500
			30% Contingency	$772,350
			Estimated Construction Cost	**$3,346,850**

4.3.3. Repair Option 3

This repair option addresses the four (4) main goals outlined in the section introduction by installing a composite slipform seaward of the bulkhead and backfilling the area between the existing concrete sheet pile and the slipform with granular material or concrete to effectively seal the sheet pile interlocks and encapsulate the spalled areas from the cap to the mudline as shown in Figure 4-7. The repair of the cap and replacement of the anchoring system are consistent with the first two repair options.

FIGURE 4-7: COMPOSITE SLIPFORM REPAIR



In addition to encapsulating the seaward face of the concrete sheet pile, this repair option has the same benefits described in Option 2. The opinion of construction cost should be consistent or slightly less than Option 1 since the slipform requires less intensive formwork and labor to construct. The opinion of probable construction for Option 1 is shown in Table 4-3.

TABLE 4-3: OPINION OF CONSTRUCTION COST FOR REPAIR OPTION 3

Item Description	Quantity		Unit Costs with Markups	Engineering Estimate with Markups
	Number	Unit		
Mobilization/General Conditions	1	LS	$350,000.00	$350,000
Existing Cap Demolition	200	CY	$250.00	$50,000
Composite Sheet Pile Fascia	950	LF	$1,500.00	$783,750
New Concrete Cap	200	CY	$1,305.00	$261,000
New Anchors – Soil	63	EA	$11,600.00	$730,800
Fill – Between Bulkheads	530	CY	$80.00	$42,400
			Subtotal	2,217,950
			30% Contingency	$665,385
			Estimated Construction Cost	**$2,883,335**

4.4. Bulkhead Replacement

A replacement of the existing concrete sheet pile bulkhead is recommended if the benefits of the lower, short-term capital investment associated with a repair option is outweighed by the need and cost to replace infrastructure along the Central Waterfront including the Town Boardwalk and floating dock and utility services infrastructure for the Beaufort Docks. In addition, repair options 1 and 2 do not address deterioration of the concrete sheet piles from MLW to the mudline, which may require the replacement of the concrete sheet pile sooner than the 10 to 20-year service life extension.

A replacement bulkhead would consist of the construction of a new sheet pile wall installed just outboard of the existing bulkhead. A new bulkhead would typically be constructed of steel sheet piles, though with the current wall height an FRP sheet pile system may be applicable. FRP sheet pile systems have the advantage of not being susceptible to corrosion as steel sheet piles are, although they are limited in their strength. Several approaches are used, often in combination, to mitigate the corrosion potential of steel sheet pile bulkheads and provide the recommended 50-year design life. Approaches could include construction of a concrete fascia in the tidal region, a protective coating system, cathodic protection using anodes, or providing additional sacrificial steel.

Design of a new bulkhead could include features to improve the current waterfront, such as a dedicated utility trench, raising the elevation of the boardwalk, or supporting the integration of flood resistant barrier to improve the resiliency of the waterfront. Incorporating elements that provide resiliency may allow the project to qualify for certain grant funding opportunities. Figure 4-8 shows a typical replacement bulkhead section.

FIGURE 4-8: TYPICAL SECTION – REPLACEMENT BULKHEAD

The opinion of construction cost is summarized in Table 4-4.

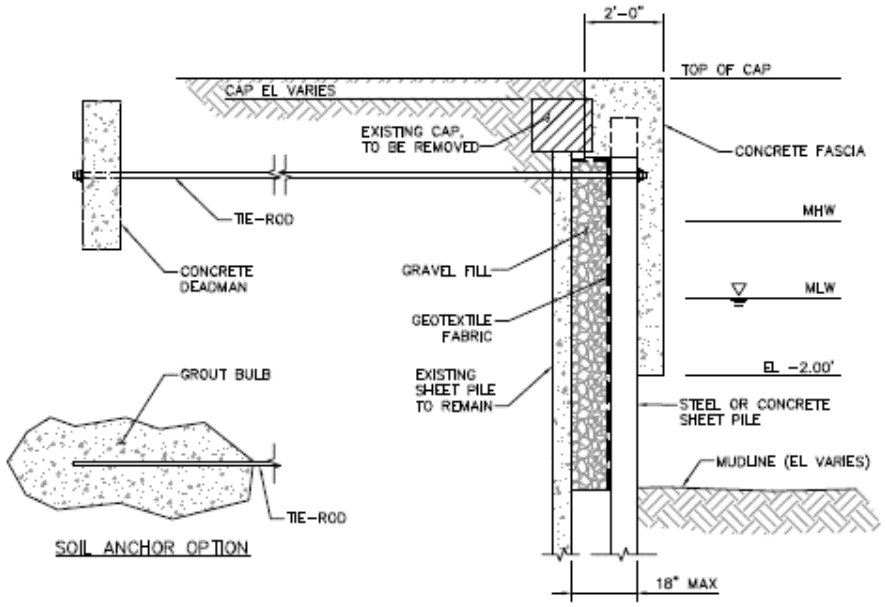


TABLE 4-4: OPINION OF CONSTRUCTION COST – BULKHEAD REPLACEMENT

Item Description	Quantity		Unit Costs with Markups	Engineering Estimate with Markups
	Number	Unit		
Mobilization/General Conditions	1	LS	$350,000.00	$350,000
Coated Steel Sheet Pile	950	LF	$2,000.00	$1,900,000
New Concrete Cap	220	CY	$1,305.00	$287,100
New Anchors – Soil	63	EA	$11,600.00	$730,800
Fill – Between Bulkheads	530	CY	$80.00	$42,400
Fill Behind Bulkhead	2100	CY	$34.00	$71,400
			Subtotal	$3,381,700
			30% Contingency	$1,014,510
			Estimated Construction Cost	**$4,396,210**

5. Timber Boardwalk

5.1. Description

The existing timber boardwalk is constructed of 2x timber decking diagonally aligned on transverse timber joists as shown in Figure 5-1. The timber joists are supported at the landside by a sole plate on a continuous concrete foundation. On the waterside edge, the timber joists are supported by a timber beam which is resting on steel channels on top of the bulkhead pile cap beam as shown in Figure 5-2.

5.2. Observations

FIGURE 5-1: TIMBER BOARDWALK VIEWING EAST

The timber boardwalk presents an ongoing maintenance item for the Town of Beaufort as exemplified by the multiple deck boards that have been replaced. The settlement of the foundation on the landward side of boardwalk provides an uneven walk path that does meet transverse slope requirements as outlined in ADA standards for accessible routes to buildings and recreational facilities such a piers, platforms, and boating facilities.

FIGURE 5-2: TIMBER BOARDWALK SUPPORTS. A. LANDSIDE AND B. WATERSIDE

A

B

M&N was provided with elevations that were taken along the boardwalk in 2017 and October 2021 by the Town of Beaufort. These elevations showed that along the waterside edge of the boardwalk there is approximately 1-inch of variation in elevation, however along the landside edge of the boardwalk there is 6 to 7-inches of variation in elevation. The readings in 2017 and 2021 are not aligned but trending elevation variations indicate that settlement of the boardwalk on its landside edge occurred prior to 2017.

5.3. Replacement

Repairs to the foundation of the boardwalk foundation will require dismantling the structure and reconstructing the entire structure in associated with the repair and/or replacement to the concrete sheet pile system. Since the boardwalk foundation and timber decking and railing are not salvageable due to issues with current design and age, the saving in cost to salvage and store the timber substructure members is minimal compared to purchase of new timber members.

The replacement boardwalk would have a foundation system independent of the bulkhead, most likely consisting of traditional timber pile support or a helical pile/pier anchor if the geotechnical conditions warrant the latter uses to offset continued settlement of backfill. The new boardwalk would be designed to meet current accessibility standards, Town's code requirements for handrails, and provide the opportunity to upgrade the southern pine deck boards to hardier and less maintenance heavy alternatives such as composite lumber, exotic hardwoods (Cumaru, Ipe, or Machiche), or modified lumber such as Kebony or Thermowood. These decking alternatives are typically 15 to 20% more than traditional southern pine decking.

Table 5-1summaries the opinion of probable cost for replacement of the boardwalk.

TABLE 5-1: OPINION OF CONSTRUCTION COST – BOARDWALK REPLACEMENT

Item Description	Quantity		Unit Cost	Engineering Estimate with Markups
	Number	Unit		
Mobilization/General Conditions	1	LS	$5,000.00	$5000
Timber Boardwalk Demolition (excludes utilities)	940	LF	$106.00	$99,640
Foundation – Helical Piles	1	LS	$415,000.00	$350,000
Timber Substructure	11,280	SF	$35.00	$507,600
Timber Decking and Handrails	11,280	SF	$25.00	$282,000
			Subtotal	$1,244,240
			30% Contingency	$373,272
			Estimated Construction Cost	$1,617,512

6. Piers and Floating Dock Infrastructure

6.1. Description

The primary dock infrastructure in the Central Waterfront is the Beaufort Docks, a 64-slip marina that was originally constructed in 1980 with fixed dock infrastructure. The marina was expanded with the addition of the west dock tree in the late 1990's and then substantially converted to a floating dock system between 2004 and 2008. The marina slips support berthing of 35-, 50-, and 55-foot vessels with side mooring opportunities at the T-head and transient docks for vessels generally up to 100-feet (vessel draft dependent). Fixed dock infrastructure remains on the east end of the marina, primarily to berth vessels 35-feet or under. The marina dock layout generally meets industry guidance except for the fixed docks and the west dock tree.

In addition to Beaufort Docks, the Town owns fixed and floating dock infrastructure at Grayden Paul Park including one of two transient dinghy docks for vessels moored in Taylor's Creek, a transient floating dinghy dock at Topsail Marine Park, and two fixed timber docks with associated floating dock systems that are leased to two concessionaires (Island Ferry operated on behalf of the US National Park System and Pirates Revenge). The floating dock infrastructure at Grayden Paul Park and the Island Ferry fixed/floating dock system was constructed circa 2014 while the Pirates Revenge dock was construct in the mid-2000's with subsequent modifications over the last 5 years.

6.2. Observations

6.2.1. Pirates Revenge Dock

This dock infrastructure consists of a 160-foot long by 6-foot-wide fixed timber dock connected to a 30-foot long by 8-foot-wide floating timber framed/deck dock as shown in Figure 6-1. The fixed timber dock shows moderate wear of structural members with corrosion of metal fasteners noted at approximately 50 percent of all locations. The dock was modified to accommodate the aluminum gangway but the modification may not fully support the gangway load as recommended by the gangway manufacturer.

FIGURE 6-1: PIRATES REVENGE FIXED AND FLOATING INFRASTRUCTURE

The timber decking of the fixed dock is in moderate condition based on age of facility. The timber handrail is primarily a picket style design with some modified handrails with steel mesh at the gangway access point to the floating dock. The floating dock system is in moderate condition, exhibiting reduced buoyance and freeboard in the longitudinal and traverse directions.

6.2.2. Island Ferry Dock

The Island Ferry Dock is a 45-foot long by 6-foot-wide fixed timber dock connected to a 60-foot long by 12-foot-wide floating timber framed/deck dock with two 45-foot long by 8-foot-wide finger piers as shown in Figure 6-2. The fixed timber dock is generally in good condition except for the timber handrail cap, which shows wear and degradation from ponding water. The floating dock system is in good condition overall, with the two fingers exhibiting reduced buoyance and freeboard in the transverse direction.

The two concessionaire docks are connected to a 150-foot long by 3-foot to 6-foot-wide fixed timber boardwalk that parallels the stone and masonry gravity wall and the concrete sidewalk. This boardwalk shows moderate wearing of deck boards.

FIGURE 6-2: ISLAND FERRY DOCK

6.2.3. Beaufort Docks

Fixed dock infrastructure that supports ten (10) slips that berth a mixture of private and commercial vessels is located along the shoreline on the east send of the facility and is accessed via an 8-foot-wide fixed timber shore parallel dock. Concessionaire offices, benches, and vessel equipment storage are located on the shore parallel dock. Each double berth slip has a one-half slip length fixed timber finger pier that is generally less than 3 feet in overall width. Figure 6-3 shows the fixed timber infrastructure.

The fixed dock infrastructure is in fair condition overall with observed necking and section loss of several timber mooring and pier support piles. Several of these timber piles were easily moved in the lateral direction when pushed, which may indicate that the pile has limited lateral capacity. The timber dock boards are in poor condition on the finger piers and fair condition on the shore parallel dock. The connections and overall condition handrail along the north side of the shore parallel dock may not meet Town building code.

FIGURE 6-3: FIXED DOCK INFRASTRUCTURE – BEAUFORT DOCK

Figure 6-4 indicates that the floating dock infrastructure is in fair condition overall, consistent with the age of system (15 to 20-years). There is observable sagging and heeling of the main and finger piers due to warping of timber structural members and absorption of water within the flotation billets. In addition, the connection hardware between the main and finger docks has corroded, leading to excessive movement of the finger pier when walking on it.

The floating docks are anchored by steel pipe piles with timber piles primarily anchoring the shore parallel dock. Pile guides to transfer load from the piles to the floating dock were missing in several locations. Excessive movement and necking/checking of the timber guide piles were observed. Similar conditions were noted for the timber mooring piles separating the double berth slips. Surface corrosion of the steel pipe piles was also evident at the waterline and free height areas.

One other observed deficiency is the transition plates at the seaward end of the aluminum gangway, which do not meet. accessibility guidelines for marina.

6.3. Repair/Replacement Options

The fixed timber dock infrastructure for the two concessionaires dock (Pirates Cove and Island Ferry) will need general maintenance to extend their service life between 10 to 15 years. This general maintenance consists of replacing timber deck and handrails, timber piles that show exceptional section loss at waterline, timber cross bracing, and metal fasteners at pile bents and cross bracing.

FIGURE 6-4: FLOATING DOCK INFRASTRUCTURE AT BEAUFORT DOCKS

The floating dock infrastructure at the concessionaire docks need minor maintenance to extend their service life another 20-years. Replacement of individual structural framing members and decking should be performed as needed. Flotation billets to correct heeling of the finger piers should also be added.

The floating dock infrastructure at the Beaufort Docks have a remaining service life of 10 to 15-years. This timeframe is consistent with an average design life of a floating dock system, which ranges from 20- to 30-years depending on construction material types and performance of routine maintenance. A percentage of timber framing and decking should be replaced to prolong the infrastructure. Additional maintenance considerations include replacing or adding flotation billets, the metal fasteners and connection hardware between the finger piers and main dock, and pile guides and associated rollers were missing or inoperable.

The timber guide and mooring piles should be replaced if they exhibit excessive necking or lateral movement, indicating that their capacity to anchor the docks are limited. The steel pipe piles will need to be recoated to

remove surface corrosion. This process includes removing of the flaking epoxy coating, sanding of surface corrosion, and application of epoxy coating.

Opinion of construction costs for maintenance activities of the fixed and floating dock infrastructure has not been prepared for this condition assessment since assessment only accessed specific areas of the marina. In addition, the Town is in the process of preparing of waterfront master plan that will evaluate the direction of existing and future waterfront infrastructure. Maintenance or construction costs for the waterfront infrastructure will be provided in that document.

7. Marine Utilities

7.1. Description

Utilities services to the fixed and floating dock infrastructure varies with location along the Central Waterfront, with the Beaufort Docks having a full suite of electrical and mechanical services befitting its operations. Utility services at the Town and concessionaire operated docks are limited. The Beaufort Marina provides the following utility services:

- Electrical – 120/240-volt and 120/208-volt single and three phase shore power and 120-volt convenience receptacles
- Mechanical – potable water, sanitary sewer system, and diesel fuel delivery
- Lighting – high mast and low-level footpath
- Information Technology – Wi-Fi

The Town and concessionaire operated docks are limited to the following utility services.

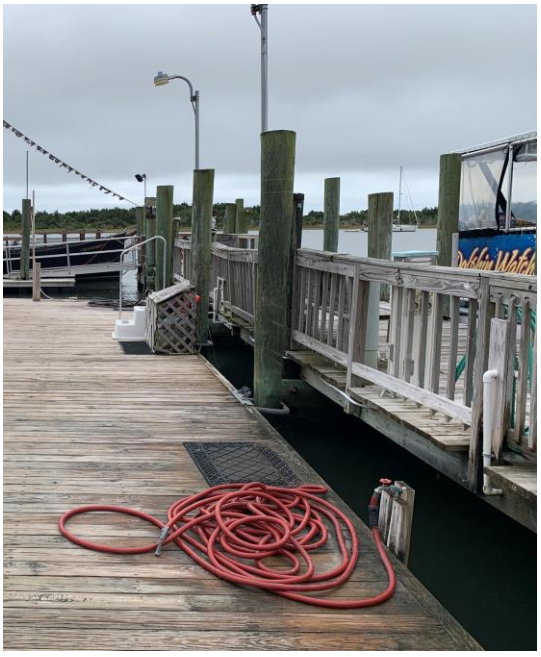
- Electrical – 120-volt single phase service (Pirates Revenge)
- Mechanical – potable water
- Lighting – high mast

7.2. Observations

7.2.1. Town/Concessionaire Docks

Potable water service is provided at the Island Ferry and Pirates Revenge docks as shown in Figure 7-1. This service consists of PVC supply line that feeds several PVC pipe risers mounted on a 2x4 or 2x6 timber backer board. Galvanized metal hose bids without frost protection are attached to the risers. Overall condition of the system is fair to good. The only consideration on the overall system is the degradation of PVC pipe due to UV exposure.

FIGURE 7-1: UTILITY SERVICES – TOWN/CONCESSIONAIRE DOCKS



Shore power (assumed 30amp 120-volt single phase service) housed in an aluminum power center is provided at the Pirates Revenge dock. The reliability of the power is unknown.

High mast lighting on aluminum poles is provided at two locations on the Island Ferry dock. Lighting fixtures appears to contain fluorescent lamps, with one light fixture missing.

7.2.2. Beaufort Docks

Electrical service at the facility has been upgraded several times since original installation. Based on observations of original power centers, it appears that 120/240-volt service with 30- and 50-amp twist-lock receptacles were provided at standalone mounts or housed in various types of power centers on the docks. Subsequently, it appears that 120/208-volt and 120/240-volt service with 100-amp twist-lock or pinned receptacles were added to the outer slips to accommodate power needs of vessels larger than 65-feet.

The east end of the marina is primarily 120-volt service on the standalone 2x4 timber risers with single receptacle for each slip as shown in Figure 7-2. Shore power for the slip where the 45-foot catamaran for Lookout Cruises is berthed has 50-amp 120/240-volt service receptacle. The shore power for the 50- and 50-foot slips in floating dock sections of the marina is 30- and 50-amp 120/240-volt receptacles housed in standalone timber risers or various aluminum cased power centers as shown in Figure 7-3. The 100-amp 208-volt three phase and 100-amp 120/250-volt single phase services are located on standalone timber risers as well as shown in Figure 7-3.

FIGURE 7-2: ELECTRICAL SERVICE – EAST SIDE BEAUFORT DOCKS

The panel boards and electrical distribution equipment for the shore power is located on the Town's boardwalk, adjacent to all gangway access points to the floating docks as shown in Figure 7-4. The equipment is not elevated above FEMA's 100-year base flood elevation (BFE), indicating the original equipment was installed prior to changes in the National Electrical Code (NEC) that mandate equipment be raised 2 to 3 feet above the BFE. The overall condition of the equipment is fair with the reliability of the system unknown.

FIGURE 7-3: ELECTRICAL SERVICE – CENTRAL AND WEST SIDE OF BEAUFORT DOCKS

FIGURE 7-4: ELECTRICAL DISTRIBUTION EQUIPMENT

Mechanical equipment includes potable water service that is standalone (similar PVC riser mount) or integrated into the power centers, a central sanitary pump-out unit on the west end of the facility, and diesel fuel delivery at each slip using fixed dispenser stations or mobile dispenser carts. Individual fire extinguishers mounted in cabinets are the only fire suppression system on the docks. Figure 7-5 shows the sanitary pumpout unit and the mobile fuel carts.

As noted earlier in observations for the east docks, the PVC risers for the potable water service are exposed to UV conditions, which may reduce their long-term reliability. The sanitary pumpout is a functioning system that will continue to support marina operations assuming routine maintenance is performed. If there is a desire to expand the system to other parts of the marina or upgrade the system, the grants from the State of North Carolina used for the purchase and installation of the present system may be applied and received for a new system.

FIGURE 7-5: SANITARY PUMPOUT AND FUELING FACILITIES

The at-slip fuel delivery system is typically provided at highly amenitized marina facilities that cater to a more luxury boating market so its presence is a key differentiator when attracting transient and local boaters. The system structure, however, generally does not follow marina industry guidance for marine fuel delivery systems. A key concern is exposed piping on the docks as shown in Figure 7-5. The pipe system is composed of materials that are subject to UV degradation and do not appear to consist of double-walled pipe construction, making it more susceptible to leaks. The location along the edge of floating dock also may pose a tripping hazard to marina patrons. In addition, a leak detection system was not observed nor were there clearly marked emergency shut-off and containment systems if there is a detected leak.

7.3. Repair/Replacement Options

Maintenance of the existing systems should continue to be performed to provide a functioning system for marina users. It is recommended to address exposure of fuel supply lines and incorporate clearly marked spill containment equipment and procedures. Modifications to other utility systems should be evaluated based on the Town's direction and timing of the repairs or replacement of the bulkhead on the Central Waterfront as temporary utility lines may be required or the utility system connections may need to be replaced entirely.

Opinion of construction costs for maintenance activities of the utility systems has not been prepared for this condition assessment since assessment only accessed specific areas of the marina. In addition, the Town is in the process of preparing of waterfront master plan that will evaluate the direction of existing and future waterfront infrastructure. Maintenance or construction costs for the utility services may be provided in that document.

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