INSPECTION REPORT LEONARD'S WHARF NEW BEDFORD WATERFRONT FACILTIES INSPECTIONS



MARCH 2009



EXECUTIVE SUMMARY

Leonard's Wharf is a 1080 foot long filled pier structure retained by steel sheet piling, which was installed in 1974. The pier provides operational berthage for fishing vessels.

Leonard's Wharf was observed to be in generally poor to serious condition, with significant deficiencies. These deficiencies include severe corrosion of bolts fastening the tie back wale to the sheeting, and the presence of several large areas of subsidence at the eastern end of the wharf, corresponding with holes in the sheeting. Other deficiencies noted during the inspection include damages and deterioration of the timber fender system, cleats and timber curb.

High priority remedial repairs include:

- A test pit investigation of the tie back system should be performed in order to verify the integrity of its components. Any of the internal components that are in similar deteriorated condition to the external hardware should be removed and replaced. The opinion of probable cost for this work is approximately \$15,000.
- Replace the connection hardware to the lower wale. This will include excavation behind the bulkhead to expose the internal wale along the length of the bulkhead and the removal and replacement of all fastening bolts. The opinion of probable construction cost for this work is approximately \$204,000.
- Repair the holes observed in the steel sheetpile bulkhead. The opinion of probable construction cost for this work is approximately \$20,000.
- Install concrete reinforcement of the sheeting near the head of the wharf. A six inch thick reinforced concrete overlay, attached to the existing sheeting, will result in a cost of approximately \$500 per lineal foot, resulting in an opinion of probable cost of \$651,000 to reinforce the entire pier.
- Replace areas of the UHMW rub rail on the face of the timber wale. The opinion of probable construction cost for this work is approximately \$27,000.
- Replace the corroded and damaged access ladders. The opinion of probable construction cost for this work is approximately \$22,000.

Low priority remedial repairs include:

• Install cathodic protection along the steel sheetpile. Sacrificial anodes minimize corrosion along the sheetpile by corroding at a higher rate than the metal sheetpile. The opinion of probable construction cost for this work is approximately \$183,000.

• Remove and replace damaged and worn areas of the timber wale. The opinion of probable construction cost for this work is approximately \$46,500.

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SECTION 1 INTRODUCTION

1.1 – Background and Objectives

The New Bedford Harbor Development Commission (HDC) has retained Pare Corporation (PARE) and Childs Engineering Corporation (CEC) to perform an above and below water inspection, and to develop a report of existing conditions for Leonard's Wharf in New Bedford, Massachusetts. Inspections were performed in accordance with the ASCE Manuals and Reports on Engineering Practice No. 101 – Underwater Investigations: Standard Practice Manual. The major objectives of the inspection report are to provide the HDC with an assessment of existing conditions at the facility, and to substantiate requests for funding for the maintenance and repair of the facility.

1.2 – Scope of Work

The scope of this investigation is to provide an inspection and evaluation of the present condition of the pier and appurtenant structures, and to provide information that will assist in both prioritizing repair needs and planning/conducting maintenance and operation.

The investigation is divided into three parts: 1) provide a description of the facility, including review of available reports, investigations, and data previously submitted to the owner pertaining to the wharf and appurtenant structures; 2) perform a visual inspection of the site above and below water; 3) prepare and submit a final report presenting the evaluation of the structure, including recommendations for remedial actions, and associated costs.

SECTION 2 DESCRIPTION OF SITE

2.1 - Site Location

Leonard's Wharf is an approximate 1,058 foot long steel sheet pile bulkhead pier structure with solid fill. It is located south of Homer's Wharf and north of the NSTAR storage tank and power facility along the New Bedford waterfront on Buzzard's Bay as shown in Figure 1 – Locus Plan.

2.2 - Facility Description

The original structure was an earth-filled stone wharf and was mainly used for the berthing of whaling vessels. Currently Leonard's Wharf consists of a steel sheet pile bulkhead with solid fill and an asphalt deck providing dock space for modern fishing draggers and lobster boats.

The steel sheet piling bulkhead is comprised of a PZ-38 section, installed in 1974. The sheeting is provided with interior double channel tieback wales, with tierods spaced at 6 foot intervals. The sheeting is fastened to the wales with two 1.5 inch diameter bolts at three foot intervals.

The bulkhead is partially protected with 12 inch diameter timber fender piles at approximately 10 feet on center with 12 inch by 12 inch top and bottom timber wales. Most of the wharf, however, is protected with a 6 inch x 8 inch timber chock bolted to the top of the steetpile wall with a 2 inch x 5 inch UHMW rub rail bolted to the waterside face. Rubber tire fenders are attached to the face of the sheetpile spaced 12 feet on center. A C15 x 40 steel channel cap is located on top of the sheeting. An 8 inch x 12 inch timber curb is supported by 3 inch x 3 inch x 12 inch timber blocking spaced 36 inches on center on top of the cap channel. 32 inch long mooring cleats are spaced approximately 30 feet on center, and are bolted to a concrete block measuring 54 inches long by 16 inches wide and 12 inches high. The wharf is provided with an asphalt deck.

According to available plans, the most recent repairs to the structure were completed in 1998. The repairs included but are not limited to: removal of the original timber fender system, installation of current rubber tire fenders, installation of fender pile clusters at the corners of the wharf, upgrading light posts and fixtures, installation of new safety ladders, patching holes in the sheetpile wall, and various repairs to the bituminous deck surface.

SECTION 3 EXISTING CONDITIONS

3.1 General

The topside and underwater inspections of Leonard's Wharf were performed on November 18, 2008. For reference purposes, a baseline was established along the top of the bulkhead during the inspection. Station 0+00 was located at the northwest corner of the bulkhead at its intersection with Homer's Wharf and extended to station 10+58 at the southwestern end of the bulkhead at its intersection with the NSTAR property. Observations were made in relation to their location along the baseline as appropriate and as noted herein.

Leonard's Wharf was observed to have significant deficiencies, including several large areas of subsidence at the head of the wharf, corresponding with holes in the sheeting. Severe corrosion of bolts fastening the tie back wale to the sheeting was observed along the majority of the pier. Other deficiencies noted during the inspection include a broken portion of the timber curb from Station 6+37 to Station 6+45 and a broken cleat at Station 7+45.

3.2 Steel Sheet Piling

The steel sheet piling system at Leonard's Wharf is in poor condition. Major deficiencies observed include **severely corroded connection hardware** and **two large corrosion holes in the sheeting**. The bolts connecting the internal wale to the steel sheetpile between station 5+00 and 10+00 were observed to be severely corroded, with typically 70-100% section loss.

The first corrosion hole is located at station 5+70, approximately 2 feet below Mean Low Water. It is 13 inches long by 5 inches wide and runs through both the flange and web. Fill material could be seen inside and is actively being flushed out from behind the sheet. The second large corrosion hole was observed approximately 1 foot below Mean Low Water at Station 6+71. The

hole was located within the web of the steel sheetpile section and measured 1 foot long by 4 inches wide. Fill was observed escaping from this hole. It is understood that prior patching was performed at the head of the wharf in 1998.

Typically, below the mean low water elevation the steel sheetpile bulkhead was observed to have a corrosion byproduct buildup of approximately 1/8 inch to 1/4 inch. The byproduct was apparently getting thicker closer to the mudline. Small pits were observed on the steel and are approximately 1/16 inch to 1/8 inch deep. It was also noted that the bottom 3 rungs of the safety ladders are all severely corroded and are either completely missing or are unusable.

During the inspection of the sheetpile, ultrasonic thickness (UT) and cathodic potential (CP) reading were taken. The readings were taken at the mudline, mean low water, and approximately halfway between the two. Conditions at this facility were found to be similar to adjacent facilities such as Fisherman's Wharf, Steamship Pier, and Homer's Wharf which all indicated potential readings between .3 and .5 volts. The following table illustrates the results.

STATION	ELEVATION	UT Inner Flance	UT Web	UT Outer Flance	СР
0+00	Mud	0.460	0.265	0 420	0.398
0.00	Mid	01100	0.200	01.20	0.000
	MLW	0.450	0.265	0.495	0.391
2+00	Mud	0.470	0.325	0.470	0.403
	Mid	0.465	0.300	0.475	0.402
	MLW	0.520	0.320	0.510	0.356
4+00	Mud	0.485	0.290	0.435	0.402
	Mid	0.455	0.330	0.445	0.394
	MLW	0.495	0.355	0.505	0.363
6+00	Mud	0.480	0.355	0.510	0.400
	Mid	0.425	0.225	0.455	0.393
				Too Heavy	
	MLW	0.295	0.235	Pitting	0.370
8+00	Mud	0.460	0.330	0.475	0.346
	Mid	0.465	0.315	0.455	0.345
	MLW	0.510	0.315	0.510	0.396
10+00	Mud	0.485	0.330	0.475	0.397
	Mid	0.460	0.330	0.460	0.390
	MLW	0.500	0.385	0.470	0.387

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3.3 Subsidence

Several areas of local subsidence were observed behind the bulkhead. Smaller depressions with water ponding were observed behind the bulkhead from Station 5+50 to Station 5+62 as shown in Photo No. 4 in Appendix A: Photographs. Two depressions were observed to have grass and weeds growing within the exposed fill material. The depression at Station 5+70 measured 24

inch wide by 16 inches long by 4 inches deep, with the depression at Station 5+75 measuring 22 inches wide by 36 inches long by 15 inches deep.

Large sinkholes were observed on both sides of the concrete block that supports the cleat at Station 5+72 as shown in Photos No. 5 and 6 in Appendix A: Photographs. A sinkhole observed at Station 6+70 was 12 inches wide by 30 inches long and was 16 inches deep as shown in Photo No. 12 in Appendix A: Photographs. These sinkholes correspond with corrosion holes in the sheetpile bulkhead that were observed during the underwater inspection.

3.4 Fender System

The fender system at Leonard's Wharf was observed to be in overall fair condition. Typical deficiencies were similar to the adjacent structures including damaged timber wale and missing or loose UHMW rub rails. The rubber tire fenders attached to the bulkhead face were observed to be in good condition. From Station 0+00 to Station 0+20, an older timber fender system protects the steel sheetpile bulkhead. It is comprised of 12 inch diameter timber fender piles at approximately 10 feet on center with 12 inch by 12 inch top and bottom timber wales. Only 1 fender pile was observed as part of this fender system and it was in overall fair condition with some signs of minimal rot. The top and bottom wales were observed to be in overall poor condition. They were predominantly hollow due to rot. At the time of the inspection, no vessels were observed docked against the older fender system.

From Station 0+20 to the end of the new fender system at Station 10+58, the timber wales and UHMW rub rails were observed to be in overall poor condition. The rubber tire fenders were observed to be in overall good condition. Typical deficiencies include loose or missing UHMW rub rail and significant damage to the wales in several areas, as shown in Photographs No. 2, 3, 8, 9, and 13 in Appendix A: Photographs. Specific locations of damaged wales, loose rub rails, and missing rub rails are provided in Appendix E: Field Notes.

3.5 Appurtenances

Galvanized steel ladders are located around the bulkhead to provide access to and from the deck to the water below. Overall the ladders were observed to be in poor condition. Some of the ladders are in good condition above mean high water, while others have been damaged during impact with vessels causing damage to the rungs and buckling of members. All of the ladders are corroded below mean high water rendering them useless during times of low water.

Life rings were observed along the bulkhead at several locations, attached with a 4 inch x 4 inch post notched into the timber curb.

4.0 – Structural Condition Assessment

4.1 General

Based on the observations obtained from the site inspections, the following provides our assessment of the various structural components. Existing structural condition determinations were based on visual and tactile observations only, and were limited to accessible and visible portions of the structures.

Based upon the visual inspection of topside and underwater structures along with the observed thickness readings, Leonard's Wharf is in generally poor to serious condition and is in need of rehabilitation. The severely corroded connection hardware reduces the structural capacity of the bulkhead. This condition needs to be addressed without delay. It is recommended that the allowable loading on the head of the pier be restricted to light vehicular traffic, in an effort not to overstress the deteriorated fasteners. It is also recommended that this area be further inspected, with test pits carried out, to determine the degree of corrosion of the interior wale and to enable the design of repairs to the tieback system.

While the majority of the steel sheet piling was observed to exhibit typical section loss for steel of this age in a marine environment, the head of the pier has several large holes in the steel sheetpile bulkhead near the head of the pier require rehabilitation. If not addressed quickly, the fill materials will continue to wash out through the hole, creating sinkholes in the pier deck above. The sheeting at the head of the pier has advanced corrosion as compared to the rest of the facility, and should be reinforced to continue to provide service. The corners of the sheeting at the head of the pier has advanced in 1998.

The following table represents the thickness readings and estimated remaining section of the steel sheetpile.

Nom	inal Flange Thickness = (0.500"	Nominal Web Thickness =0.375"										
Inner Flange	Percent Remaining	Web	Percent Remaining	Outer Flange	Percent Remaining								
0.460	92.0	0.265	70.7	0.420	84.0								
0.450	90.0	0.265	70.7	0.495	99.0								
0.470	94.0	0.325	86.7	0.470	94.0								
0.465	93.0	0.300	80.0	0.475	95.0								
0.520	104.0	0.320	85.3	0.510	102.0								
0.485	97.0	0.290	77.3	0.435	87.0								
0.455	91.0	0.330	88.0	0.445	89.0								
0.495	99.0	0.355	94.7	0.505	101.0								
0.480	96.0	0.355	94.7	0.510	102.0								
0.425	85.0	0.225	60.0	0.455	91.0								
0.295	59.0	0.235	62.7	0.475	95.0								
0.460	92.0	0.330	88.0	0.455	91.0								
0.465	93.0	0.315	84.0	0.510	102.0								

Table 4.1 – Remaining Steel Sheetpile Thickness

0.510	102.0	0.315	84.0	0.475	95.0	
0.485	97.0	0.330	88.0	0.460	92.0	
0.460	92.0	0.330	88.0	0.470	94.0	
0.500	100.0	0.385	102.7			

Typical UT thickness readings on the web indicated average section loss of 17.3% with a maximum reading of 40.0% loss at Station 6+00 midway between mean low water and the mudline. Average section loss on the flanges was 6.9% with a maximum reading of 41.0% section loss on the inner flange at Station 6+00 at the mudline. Using the average section loss and estimating the construction date to 1974, average corrosion rates indicate a loss of section of approximately 0.009 inches per year.

SECTION 5 RECOMMENDATIONS AND OPINION OF PROBABLE COST

5.1 – Recommendations - General

Based on conditions observed during the inspections, and the corresponding assessments of the existing structures, the following recommendations are provided for the repair and rehabilitation of these structures.

Opinions of probable cost were generated based upon current industry unit prices for similar work. Breakdowns of cost are provided in the Appendix. The cost opinions provided are for <u>construction only</u> and do not include allowances for engineering, permitting, or construction administration. A 20 percent contingency has been included with these costs. The opinions shown herein are based on a limited investigation and are provided for general information only. This should not be considered an engineer's estimate, as final design has not been performed, and actual construction costs may be somewhat less or considerably more than indicated, due to fluctuations in the market.

In general, the overall condition of Leonard's Wharf is critical, with severely corroded tieback connection hardware, and holes in the steel sheet piling. The repairs presented below must be implemented to maintain the integrity of the structure. If deferred these maintenance items could develop into larger safety concerns and deficiencies that are more costly to address.

5.2 – High Priority

The following items are considered to have a High Priority, as they affect the usability and safety of the structure:

A test pit investigation of the tie back system should be performed in order to verify the integrity of its components. Any of the internal components that are in similar to the external hardware should be removed and replaced. The opinion of probable construction cost for this work is approximately \$15,000.

Replace the connection hardware to the lower wale. This will include excavation behind the bulkhead to expose the internal wale along the length of the bulkhead and the removal and replacement of all fastening bolts. The opinion of probable construction cost for this work is approximately \$204,000.

Repair the holes observed in the steel sheetpile bulkhead. Similar conditions at nearby structures have been repaired using a steel plate patch welded to the bulkhead face. The opinion of probable construction cost for this work is approximately \$20,000.

Install reinforcement of the sheeting near the head of the wharf. While the limits of the reinforcement can be determined with a more thorough investigation, it has been assumed that the entire face of the pier will need reinforcement. A six inch thick reinforced concrete overlay, attached to the existing sheeting, will result in a cost of approximately \$500 per lineal foot, resulting in an opinion of probable cost of \$651,000 to reinforce the entire pier.

Replace the UHMW rub rail on the face of the timber wale. Some of the existing UHMW is in good condition and may be reused. If the rub rail is not replaced and refastened, replacement of the timber wale will also become a high priority. The opinion of probable construction cost for this work is approximately \$27,000.

Replace the corroded and damaged access ladders. The ladders are built into the fender system and therefore incur similar damage from docking vessels. The opinion of probable construction cost for this work is approximately \$22,000.

Install cathodic protection along the steel sheetpile. Sacrificial anodes minimize corrosion along the sheetpile by corroding at a higher rate than the metal sheetpile. The opinion of probable construction cost for this work is approximately \$183,000.

5.3 – Lower Priority

The following items are considered to have a Lower Priority, as they presently do not affect the usability and safety of the structure, but will need to be addressed in approximately 5 to 10 years.

Remove and replace damaged and worn timber wale. Currently the UHMW rub rail protects the wale, which will extend the life of the timber; however, if the current condition of the rub rail is not addressed, the timber wale may be damaged to the extent that it will be moved to the list of high priority repairs. The opinion of probable construction cost for this work is approximately \$46,500.

Figures Leonard's Wharf New Bedford, Massachusetts







Appendix A Photographs Leonard's Wharf New Bedford, Massachusetts

Inspection Date: November 18, 2008



Photo No. 1: Overview of the Leonard's Wharf bulkhead with docked vessel from Station 0+00 looking east.



Photo No. 2: Overview of the timber curb. Note the loose UHMW rub rail along the timber wale.

Inspection Date: November 18, 2008



Photo No. 3: Loose UHMW held to fender system with nylon rope.



Photo No. 4: Subsidence with ponded water from Station 5+50 to Station 5+62.

Inspection Date: November 18, 2008



Photo No. 5: Area of subsidence (4" deep) at Station 5+70.



Photo No. 6: Area of subsidence (15" deep) at Station 5+75.



Photo No. 7: Corrosion hole in the steel sheetpile at Station 5+70. (Photo by Childs Engineering Corp).



Photo No. 8: Corrosion hole in the steel sheetpile at Station 5+70. (Photo by Childs Engineering Corp).

Inspection Date: November 18, 2008



Photo No. 9: Damaged timber wale near Station 5+90.



Photo No. 10: Damaged fender system from Station 6+00 to Station 6+60.





Photo No. 11: Broken and missing timber curb from Station 6+37 to Station 6+45.



Photo No. 12: Area of subsidence (16" deep) at Station 6+70.



Photo No. 13: Corrosion hole in the steel sheetpile at Station 6+71. (Photo by Childs Engineering Corp.)



Photo No. 14: Corrosion hole in the steel sheetpile at Station 6+71. (Photo by Childs Engineering Corp.)



Inspection Photographs

New Bedford Waterfront Facilities Inspections

Inspection Date: November 18, 2008



Photo No. 15: Loose UHMW from Station 6+80 to approximately Station 7+19.



Photo No. 16: Broken cleat at Station 7+45.



Photo No. 17: Buckled galvanized ladder at Station 7+89.



Photo No. 18: Overview of the bituminous deck.



Photo No. 19: Overview of the pier from Station 10+63 looking East.



Photo No. 20: Typical view of the steel sheetpile bulkhead, rubber tire fender, loose UHMW rub rail, and damaged wale.



Photo No. 21: Typical underwater hardware. (Photo by Childs Engineering Corp.)



Photo No. 22: Typical underwater view of the steel sheetpile. (Photo by Childs Engineering Corp.)





Photo No. 23: Typical underwater hardware. (Photo by Childs Engineering Corp.)



Photo No. 24: Typical underwater view of the steel sheetpile. Note the corrosion of the steel. (Photo by Childs Engineering Corp.)



Appendix B Key Personnel Leonard's Wharf New Bedford, Massachusetts

KEY PERSONNEL

The following personnel were involved with this project including but not limited to the topside and underwater inspections and the preparation of this report:

Name	Employer	Responsibilities
Karl Hammond, P.E.	PARE Corporation	Project Manager, Lead Engineer
Ernest O. Rabideau, Jr., P.E.	PARE Corporation	Project Reviewer
Matt Bellisle, P.E.	PARE Corporation	Principal in Charge
Craig Sams, P.E.	Childs Engineering Corporation	Principal in Charge
Robert Garrity, P.E.	Childs Engineering Corporation	Project Engineer for Underwater Inspections
Kevin Champagne, P.E.	PARE Corporation	Support Engineer
Richard Fitzgerald, P.E.	Childs Engineering Corporation	Underwater Inspection Team
Charlie Marshall Roberts	Childs Engineering Corporation	Underwater Inspection Team
Robert Welch	Childs Engineering Corporation	Underwater Inspection Team
Phil Iantosca	Childs Engineering Corporation	Underwater Inspection Team
Nicholas B. Sarata	Childs Engineering Corporation	Underwater Inspection Team
Ryan McCoy	PARE Corporation	Topside Inspection
Briscoe B. Lang	PARE Corporation	Permitting Services

Appendix C Backup Data for Cost Estimates Leonard's Wharf New Bedford, Massachusetts

LEONARD'S WHARF

OPINION OF PROBABLE CONSTRUCTION COST

February, 2009

WF	IARF REHA	BILITATI	ON		
	NIT PRICE	TOTAL			
High Priority Repairs					
1. Mobilization/Demobilization	1	LS	\$	25,000.00	\$ 25,000.00
2. Demolition and Removal	1	LS	\$	25,000.00	\$ 25,000.00
3. Tieback Test Pits	1	LS	\$	15,000.00	\$ 15,000.00
4. Tieback Connection Repair					
4a. Tieback Excavation/Backfill	3,805	CY	\$	30.00	\$ 114,150.00
4b. New Tieback Hardware	30	DAY	\$	3,000.00	\$ 90,000.00
5. Sheetpile Patching	2	EACH	\$	10,000.00	\$ 20,000.00
6. UHMW Rub Rail	1,070	LF	\$	30.00	\$ 32,100.00
7. Ladders	11	EACH	\$	2,000.00	\$ 22,000.00
8. Cathodic Protection	73,200	LB	\$	2.50	\$ 183,000.00
			Subt	otal	\$ 526,250.00
			Cont	ingency 20%	\$ 105,250.00
			Tota	I	\$ 631,500.00
Low Priority Repairs					
1. Timber Wale	7	MBF	\$	6,500.00	\$ 46,410.00
			Subt	otal	\$ 46,410.00
			Cont	ingency 20%	\$ 9,282.00
			Tota		\$ 55,692.00

PROJECT NON BETTERS WATERFRONT INSPECTIONS PROJECT NO.	08216.00
SUBJECT OPINION OF PROBABLE COST	
COMPUTATIONS BY	DATE 3/9/09

EXCAVATION



CHECK

 $A = (12')(2') + \frac{1}{2}(12')(12') = 96 FT^{2}$

V= 96 FT 2 (1070 FT) = 102, 720 FT 3

= 3,805 CY

@\$30/64 = \$114, 150

BOLTS

@ 3' O.C., 40 LF/DAY, 1070 LF = 30 DAY 40 LF = 30 DAY @ \$3,000/DAY = \$90,000

TIEBACK REPAIR = \$204, 150

= \$20,000

SHEETPILE PATCH

2 PATCH, 2FT2, UNDERWATER WELDING

PAGE ____OF ___



PROJECT NEW BEDFORD WATERFRINT INSPECTING ROJECT NO.	08216.00	
SUBJECT OPINION OF PROBABLE GST		
COMPUTATIONS BY ZMM		
	DATE	

TIMBER WALE

1070 LF, 8×10 TREATED TIMBER: 7, 140 BF $O^{43,000/MBF} = 421, 450$ $\pm 1NSTALLATION = 425,000$

UHMW RUBRAIL

1070 LF, ZX5 UHMW RAIL = 900 BF / 1070 LF G\$30/LF = \$32100

LADDERS 11@ \$2,000

CATHODIL PROTECTION

MAX LOSS = 100%

$$\frac{1}{2} \left(\frac{1/2!}{35 \text{ sp}} \right) = .00714 \text{ In/YK} = \left(\frac{1 \text{ min}}{.001 \text{ In}} \right) = 7.14 \text{ min/YK}$$

$$\frac{1}{30000} \times 1000 \text{ mages Hight}$$

$$\frac{1}{3000} \frac{1}{3000} \times 1000 \text{ mages Hight}$$

$$\frac{1}{3000} \frac{1}{3000} \times 1000 \text{ mages Hight}$$

$$\frac{1}{3000} \frac{1}{3000} \times 1000 \text{ sp}$$

$$I = 32,100 \text{ sp} \left(0.015 \text{ A/sp} \right) = 32,100 \text{ sp}$$

$$I = 32,100 \text{ sp} \left(0.015 \text{ A/sp} \right) = 481.57\text{ A}$$

$$S = 7.6 \text{ Ib/AYK}$$

$$W = 4 \text{ st}$$

$$W = 4 \text{ st}$$

$$= (20 \text{ ms})(7.6 \text{ Ib/AAR})(481.5\text{ A}) = 73,188 \text{ Ib}$$

$$(0.42.50)/16 = \frac{4183,000}{18300}$$

Appendix D References Leonard's Wharf New Bedford, Massachusetts

REFERENCES

The following references were utilized during the preparation of this report and the development of the recommendations presented herein:

- 1. "About the Port Key Locations", New Bedford Harbor Development Commission, http://www.newbedford-ma.gov/PortofNewBedford/AboutPort/KeyLocations.html
- 2. "Maritime History of Massachusetts Merrill's Wharf Historic District", National Park Service, <u>http://www.nps.gov/history/NR/travel/maritime/mer.htm</u>.
- 3. Construction Drawings "Proposed Repairs and Improvements to Wharves and Piers in New Bedford and Fairhaven, MA", Tibbetts Engineering Corp., January 23, 1998 (Revised March 20, 1998).
- 4. Construction Drawings "Construction of Steamship Pier and Coalpocket Pier", Tibbetts Engineering Corp., June 1977 (Revised November 1977).

Appendix E Field Notes Leonard's Wharf New Bedford, Massachusetts

WARDER DROMS TO TUP OF THIMBER	Colto	0,0	21 1100	21 150	20	25 3120	R5+C 32	23	23 5150	8	6	21 2400	2 1	23 8450	12	00+6 72	1000	16.5 10150					
NEW BUDGOED WARPERBART FACILITIES INSPECTION NWIS, 2009 45°E INSPECTION	LEONARY'S WHAR	STA 0400-0470 - 12"X12" TOP 120	Borrow wate	STA 0+17 - R" 0 TIMER FLUDTE PIL	F TP ROT/WORN	STA 0120 - START AVEN DE SYSTEM	* 9"×7" 71m/BCK (2 to be access)	3" XS" (HANKA Rice DAVI	* Rubber from and more a prese	(0) 12' 0 (. All 10 - 20 - 20 - 20 - 20 - 20 - 20 - 20 -		SPA ON DO - SANET & TIM BOR CITES	* 35" × 15" CAP (HAMME W 8" X17" TIMER	CURR NOS 31 x12" REDER STO SO O C		STA 04 19- CLEAT (32' ON 54 2 16 xm)	STA DI 33- END OF UNIM SAFIT LUNE	SAN and S- GALY LANK / 18 " CLUNC W/	62 " HAND RAILS + GOOD	STA OF 36- END OF URIMM STRIF LODGE	STA 0151 - CLUNT / END OF UTININ STAD LAND		

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New Beid Ford Leonards WHAFE **CHILDS ENGINEERING CORPORATION** SHEET NO Waterfront and Structural Engineering CALCULATED BY_ BOX 333, MEDFIELD, MA 02052 CHECKED BY____ All Whents have Debus & CABle was SCALE ____ PDI IN 11:25 -12:35 WAY PDI , 59.45 OUT 10150 LII - MLW - NO COFTIM Light Pitting 1/0" Deep 10+58 St. MHW - Thick scale - + Surface Eust, MID- Steel 30% contry Steel Smooth MUD - Steel snooth contrar 60% NTm = 2 2" Above MCN tie Back NUT Typical Coordes 15- @ mus come 1/4" Black Byproda to レガ 10+00 87 MO - 19 Corros an Black 5 Steel Smoth Steel Out. Smooth 100% conting Coss MLW 57 9:51 LADDErs C Bollon and Bert 6 Rustin MJO stall smooth "4" corror by product mit Pitts 1/4" Deep 1/4" where 1/4" by product 9400 52 STATION 8190. The Back Bolt Not Altached Hole wsheet 8-182 - 75% Gove Bolt General condition on tic Back Polls are Hearthy 8-150 Corroded 70-100% Deterrorous treBACK 10% of Bitts the @setm LeFT 30% an marginal BSN4 BAD



CHILDS ENGINEERING CORPORATION

Waterfront and Structural Engineering BOX 333, MEDFIELD, MA 02052

OB	
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STA Steel Emoth "15" corrorin By Roald 8700 MUD very small ports 20% 14" Black Carosmi By Prosteri Pto Y8" wrise & Deep " MAD COATING 60% what steelsmooth MW + ie Back Bolt Pictures miDievel cleaning. Outer finge Clean the BACK Bolt & TAKE PRETURE 8+65 -PHOTO The BACK 8+70 LADDER - Bent - Also Botton 4 Rungs missing 8410 1' Organize P.Pe commy Through Bulk Heal 8108 -2'ABOVE MHW Hornsonhal Rubslipe top is Broken file BAUKE on BIKHO - 'stud only left 7+63 2 HARdware & severly corrolad Pictures of missing tie Back Bolts 51/2 7+25 RUBSTIP HANGIN IN WAter UHMW StA 7410 -

SIA 7100 - L2 · MINOU - SUFFACE Rut SAAll pits - O'S CONTEd MID - Pits on astribe Glange Steelsmooth O'B CONTRO MUD - 1/4" Corrosson Byponer Block Rowden Steel Pitmy vergeman

Steel ABour WHT a Heavy scale 3/8 of scale

JOB CHILDS ENGINEERING CORPORATION SHEET NO. Waterfront and Structural Engineering CALCULATED BY..... DATE BOX 333, MEDFIELD, MA 02052 CHECKED BY_ SCALE @ 7,00 Dolphow on corner - Buttom wrap to off. Piles good solid top roboling anne is BAD; SAFTY LADORT BOTTOM BAD Bottomword Dophin on Corner @ 5+65 Piles Look 600 loose tio Back Botts Look GOOD verhele - 13" Guz @ 2m" in Floring & " in web PHSTox (2) Hole 5"WIDE Area Around FT very three 5+70 - Elev. 2' Below Tre Back - T. C Back of MUN F.NCS common of - Below a smike Hole in Deck Cotting 60% allet sleel - 3mill All smoun 6100 14 Byproduct Pitted & Awy 1/0 -1/0" Deeps @10 confeel Mind - Sitted 1/8 Deen 1/8 wine MLW SLALL PHTS Tie Robs Start to get BAD 60% of the Head on the Rog 6132 -Ast



CHILDS ENGINEERING CORPORATION

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JOB	
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Hole nostect · Below the Back ABox water time Heary Scale 1/2" threke 71 Where a smiktloke a Deck is STA 6+71 Hole & Corrosron Bort 1'Longvert 4'NIDE Fill Beiman FITI Beyond a common our W NEB 1/2" Fron outshal Elm W WEB 1/2" Fron outshiel Elman top - Below CAP . Hole no same sheet ENTAR WED MISSING # 2 PHOTOS of Hole Below WHTEN Rub strip Gen NO Plates on Flanges 1 PHOLO of Hole More WATER Hole for bott has opened up CAN SEE WHILE ON other STHr 5+64 which Holds while to sheet SPE APILLORE CADDER Bolton & running missing Changels 60% Loss crosport SHip kesting on Bolk Kend MLW - Down Block Drucia From necess to The top of the sheet MLW- steel 1/8 corrozow By Andre 7 Pits 1/8" > 1/8 Sty 5100 Level 2 MID - 10% - 20% HATACT - PATS SMAll FAITLY SONDTL PIT 1/16" Deep 3/8" WIDE MUD 14" corroson By preduct - 5mod the wery shallow pots LADDER Kower Runes message Heavy Corross StA 4120 out MLW SUIFAIR RUST O'NO CONTAN STEEL SUMOOTH MND 1/8 CORROSION By Product Comall Arts 2008 COAL 51A 3100 - L2 - 18 Corros row By froduct Small Pitz 20% contro MUD

KYAW - trom VAICE

JOB CHILDS ENGINEERING CORPORATION SHEET NO. Waterfront and Structural Engineering CALCULATED BY_____ DATE BOX 333, MEDFIELD, MA 02052 CHECKED BY SCALE All COAlm Missing & SULFAce Rust St4 170-Ender some Time Rubin on them NUTS for while missing Fender Pile snapped off a timber Rubstip SCA 2115 with P.Le - Fender Pile Broken of a Cover timber kilo 51/4 2125 Ferda Pila M.B. & Broken 4' off mut 514.2440 Marm While romnection BAD SAFLY LADER HEAVY LOSS ON STOR C HAWNEL StA 3+04 Rubstrip - Off - SAFLy LADDER _ Bottom Heavy Corrosion SPA 4400 LIII - MUD TYP 1/0" Pits on sulface way starl Ven corrorium By Product. 20% COAL INTHOT mad 1/4° collogon Byprodur 40% COATIN INTACT MLW



CHILDS ENGINEERING CORPORATION

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SCALE Ky" corrosm By prov 1, 0,75 STA 2+00 KIT. , MUD 14" cost. - steelsmoth miD Olo contine no Trac 7 O YO COATTAN SUFFAC RUS7 MLW Slee 1 Smooth MUD - Sterl - 1/4 Corroson By pront STA-LI 100 MID Surfine hust Smooth MIN SAFTY LADDER MESEND Botton 3 Runap shallow steel writing 10" corroson Bypotet (MUD) 1/10" PTS Sta Oto O's contra surface lint LAST 40' Conservation & High writer 12×12 truton good I Fendra PAC good more 14" Aurky Alstan Alstas.or



UT no Inches

Leonards Wharf

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Station	Elevation	Inner Flange	WEB	Outter Flange	° CP
0+00	Mud	,460	.265	. 420	, 398
	Mid	- too shallow	and an and the second s	anna ar Athan an Saraistan an Anna an A	
	MLW	. 450	,265	, 495	. 39/
0+25	Mud				
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2+00	Mud	. 470	,325	470	. 403
	Mid	. 465	. 300	. 475	. 402
	MLW	.520	,320	,510	, 356
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Leonards Wharf

6			UT	- ·	СР	
Station	Elevation	Inner Flange	WEB	Outter Flange	CF	
3+50	Mud					
	Mid					
	MLW					
3+75	Mud					
	Mid					
	MLW					
4+00	Mud	485	290	435	. 402	
	Mid	,455	.330	.445	. 394	
	MLW	. 495	. 355	,505	.363	
4+25	Mud					
	Mid			· · · · · · · · · · · · · · · · · · ·		
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4+50	Mud					
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4+75	Mud					
ل و ، پ	Mid					
	MIW				-	
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6+00		1700	1350	465	39.7	
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6+25	Mud	······		· ·		
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6.80			<u></u>			
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	Mid				4	
	MLW					
16+75	Mud				4	
1	Mid	· · · · · · · · · · · · · · · · · · ·			4	
	MLW	1				

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Station	Elevation	Inner Flange	WEB	Outter Flange	UL CL
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	Mid				
	MLW				
7+25	Mud				
	Mid				
	MLW				
7+50	Mud				
	Mid				
	MLW			· · ·	
7+75	Mud		<u></u>		
1.1.	Mid				
	MIW				
8±00	Mud	460	270	. 475	. 346
0700	Mid	UIX VIX	715	455	.345
		510	315	510	396
0175	Mud	a 310	يب وي ،		
8+23	Mid			· · · · · · · · · · · · · · · · · · ·	-
· ·		· · · · · · · · · · · · · · · · · · ·			4
0.50					
8+50					-
		<u> </u>			4
8+75	Mud				4
	Mid				4
	MLW		,		
9+00	Mud				4
	Mid	· · · · · · · · · · · · · · · · · · ·	· · · · · · · · · · · · · · · · · · ·		4
	MLW		L		
9+25	Mud				1
	Mid				
	MLW		· · · · · · · · · · · · · · · · · · ·		
9+50	Mud				
	Mid				
	MLW		· · · · · · · · · · · · · · · · · · ·		
9+75	Mud				-
	Mid				
	MLW			· · · · · · · · · · · · · · · · · · ·	
10+00	Mud	.485	, 33.0	-475	7971
	Mid	. 460	. 330	.460	1 1011
	MLW	500	.385	. 470	1 .397
10+25	Mud				
1	Mid	1			1
	NALIA/				

Leonards Wharf

Leonards Wharf

Station	Elevation	2	CD		
Station	Elevation	Inner Flange	WEB	Outter Flange	
10+50	Mud		na ta kana Alexana		
	Mid				
	MLW				

Corner @ 10+58