UNDERWATER FACILITIES
INSPECTIONS 
AND 
ASSESSMENTS 
AT

PHILADELPHIA NAVAL SHIPYARD

PHILADELPHIA, PA

VOLUME II FILE COPY

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Underwater inspection, Philadelphia Naval Shipyard, Philadelphia, PA

19. ABSTRACT (Continue on reverse if necessary & identify by block number)
The inspected facilities covered in Volume II are Pier 5, the Barge Basin and
associated Bulkhead, Pier 6, Pier 6-A and associated Bulkhead, the Drydock
Wharves and Wharves K, J, I, H and G.
Pier 5 has recently been rebuilt. There is a new concrete super-

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structure and some new piles have been driven. The pile foundation was found
to be in excellent condition. Generally the concrete superstructure is in
excellent condition, however, upon cursory inspection it is revealed that
there is some deterioration of the concrete truss cantilever on the east and
west sides of the pier. Spalling of the concrete is occurring at or near the
elevation of mean low water exposing the reinforcing steel to the marine
environment. If the reinforcing steel is not protected from the marine
environment, corrosion will occur and eventually cause a reduction in the
live-load capacity of the truss. Providing proper protections for the steel
is recommended. Tension cracks were observed on the concrete crane rail
beams. However, when reinforcing steel is exposed to the marine environment
it will corrode. This deterioration should be monitored. Live-loading on
Pier 5 can be maintained at current levels (600 psf).

The pile foundation of the Barge Basin is in good condition. Anomalies are
limited to damage caused by berthing forces at the perimeter of the basin.
The bulkhead between the Barge Basin and Pier 6 has been partially
reconstructed. The new structure, supported by steel H-piles, is in excellent
condition. The older timber pile-supported structure is in good condition.
The timber piles of a portion of the wharf near the Barge Basin are loaded
eccentrically, a condition which is marginal and should be corrected. The
seawall directly to the west of the Barge Basin is in poor condition and
should be repaired. Live-loading on the Barge Basin and associated wharf can
be maintained at current levels (200 psf).

Pier 6 is in good condition. There are 65 piles which have been damaged due
to berthing forces generally occurring at the perimeter of the pier; these
piles should be repaired. Otherwise, the timber pile foundation is in
excellent condition. Live-loading on Pier 6 can be maintained at current
levels (600 psf).

Pier 6-A and the associated Wharf to Pier 6 are in fair condition. There are
36 piles which have been damaged due to berthing forces. These piles should be
repaired. Along the wharf from Pier 6-A to Pier 6 timber softness was
detected to a depth of 4" in the structural timber. Due to the soft timber
the live-load capacity of the structure should be reduced to 200 psf. The
cement seawall is beginning to deteriorate and should be repaired. At the
southeast corner of Pier 6-A there are many broken piles in a concentrated
area. As a result, the relieving platform is unsupported and in this area
loading should be restricted to 50 psf until repairs have been made.

The Drydock Wharves have 242 piles with anomalies rendering them ineffective.
These piles should be repaired. The general condition of the structural
timber is good. Overall, live-loading can be maintained at current levels on
the Drydock Wharves, however, a localized concentration of damaged piles
occurs on Section A near Drydock No. 4 and until repairs are made, loading
should be restricted to 100 psf in this area. The steel sheet pile along the
inshore perimeter of Section A is showing signs of accelerated deterioration.
Downgrading of the sheet piles' capacity to resist lateral earth pressure is
not recommended at this time. Cathodic protection systems should be analyzed
to determine possible sources of deterioration and protection alternatives.
Possibly galvanic anodes could be installed to inhibit further deterioration
of the sheet pile wall.
The inspected facilities covered in Volume II are Pier 5, the Barge Basin and associated Bulkhead, Pier 6, Pier 6-A and associated Bulkhead, the Drydock Wharves and Wharves K, J, I, H and G. Pier 5 has recently been rebuilt. There is a new concrete superstructure and some new piles have been driven. The pile foundation was found to be in excellent condition. Generally the concrete superstructure is in excellent condition, however, upon cursory inspection it is revealed that there is some deterioration of the concrete truss cantilever on the east and west sides of the pier. Spalling of the concrete is occurring at or near the elevation of mean low water exposing the reinforcing steel to the marine environment. If the reinforcing steel is not protected from the marine environment, corrosion will occur and eventually cause a reduction in the live-load capacity of the truss. Providing proper protection for the steel is recommended. Tension cracks were observed on the concrete crane rail beam. The observed vertical cracking is a common condition in concrete beams. However, when reinforcing steel is exposed to the marine environment it will corrode. This deterioration should be monitored. Live-loading on Pier 5 can be maintained at current levels (600 psf).

The pile foundation of the Barge Basin is in good condition. Anomalies are limited to damage caused by berthing forces at the
perimeter of the basin. The bulkhead between the Barge Basin and Pier 6 has been partially reconstructed. The new structure, supported by steel H-piles, is in excellent condition. The older timber pile-supported structure is in good condition. The timber piles of a portion of the wharf near the Barge Basin are loaded eccentrically, a condition which is marginal and should be corrected. The seawall directly to the west of the Barge Basin is in poor condition and should be repaired. Live-loading on the Barge Basin and associated wharf can be maintained at current levels (200 psf).

Pier 6 is in good condition. There are 65 piles which have been damaged due to berthing forces generally occurring at the perimeter of the pier; these piles should be repaired. Otherwise, the timber pile foundation is in excellent condition. Live-loading on Pier 6 can be maintained at current levels (600 psf).

Pier 6-A and the associated Wharf to Pier 6 are in fair condition. There are 36 piles which have been damaged due to berthing forces, these piles should be repaired. Along the wharf from Pier 6-A to Pier 6 timber softness was detected to a depth of 4" in the structural timber. Due to the soft timber the live-load capacity of the structure should be reduced to 200 psf. The concrete seawall is beginning to deteriorate and should be repaired. At the southeast corner of Pier 6-A there are many broken piles in a concentrated area. As a result, the relieving platform is unsupported and in this area loading should be restricted to 50 psf until repairs have been made.
The Drydock Wharves have 242 piles with anomalies rendering them ineffective. These piles should be repaired. The general condition of the structural timber is good. Overall, live-loading can be maintained at current levels on the Drydock Wharves, however, a localized concentration of damaged piles occurs on Section A near Drydock No. 4 and until repairs are made, loading should be restricted to 100 psf in this area. The steel sheet pile along the inshore perimeter of Section A is showing signs of accelerated deterioration. Downgrading of the sheet piles' capacity to resist lateral earth pressure is not recommended at this time. Cathodic protection systems should be analyzed to determine possible sources of deterioration and protection alternatives. Possibly galvanic anodes could be installed to inhibit further deterioration of the sheet pile wall.

The structural timber observed on Wharves K, J, I, H and G is in excellent condition. In two locations (Wharves K and J), there has been a localized failure of the relieving platform due to overloading on the top deck. In these two locations loading should be restricted until repairs are made. Portions of this wharf structure are translating in the outshore direction due to excessive lateral earth pressure exerted on the sheet pile wall. This creates eccentric loading on the vertical piles which, in turn, reduces their column capacity. At this time the combined stress occurring in the vertical piles is not critical, however, if translation is allowed to continue, overstressing will occur. The sections of wharf which have been observed to be translating
should be tied back and anchored. Until the wharf is stabilized, the area from the face of the wharf inshore 70' should be restricted to 300 psf live-loading. This will limit excessive lateral earth pressure due to live-loading from acting on the sheet pile wall.

Refer to the following Executive Summary Table to review each facility's construction, recommendations and repair cost estimates.
<table>
<thead>
<tr>
<th>FACILITY</th>
<th>YEAR BUILT</th>
<th>TOTAL NO. OF PILES</th>
<th>SIZE (LxW-FT.)</th>
<th>STRUCTURES</th>
<th>RECOMMENDATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pier 5</td>
<td>1912-1979</td>
<td>approx. 3,000</td>
<td>790'x110'</td>
<td>Pile-supported high concrete deck structure</td>
<td>1) Replace broken piles.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2) Repair non-bearing piles.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>3) Monitor tension cracks.</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4) Repair spalling on concrete and utility tunnel.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5) Re-inspect after repair.</td>
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<tr>
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<td></td>
</tr>
<tr>
<td>Barge Basin &amp; Bulkhead to Pier 6</td>
<td>Circa 1939</td>
<td>approx. 850</td>
<td>163'x60'</td>
<td>Timber pile-supported, low deck, earth fill, relieving platform structure. The original portion of the bulkhead is a timber pile-supported, low deck, earth fill relieving platform structure. The rebuilt section consists of steel H-piles arranged in bents with a low steel deck.</td>
<td>1) Replace broken piles.</td>
</tr>
<tr>
<td></td>
<td>1903-1979</td>
<td>approx. 740</td>
<td>747' in length</td>
<td></td>
<td>2) Repair non-bearing, and wild piles.</td>
</tr>
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<td></td>
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<td>3) Repair eccentric pile through 8 of bulkheads.</td>
</tr>
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<td></td>
<td>4) Repair spalling on concrete and utility tunnel.</td>
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<td></td>
<td>5) Re-inspect after repair.</td>
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</tr>
<tr>
<td>Pier 6</td>
<td>Circa 1940</td>
<td>approx. 8,500</td>
<td>970'x100'</td>
<td>Timber pile-supported, low deck, earth fill, relieving platform structure.</td>
<td>1) Replace broken piles.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2) Post and brace broken repair non-bearing, and displaced, and repaired.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3) Re-inspect after repair.</td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
<td>Pier 6A &amp; Bulkhead East to Pier 6</td>
<td>Circa 1903</td>
<td>approx. 1,100</td>
<td>235'x70'</td>
<td>Timber pile-supported, low deck, earth fill, relieving platform structure.</td>
<td>1) Replace or repair broken piles.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2) Repair split, wild, and displaced piles.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3) Repair spalling on concrete and utility tunnel.</td>
</tr>
<tr>
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<td></td>
<td>4) Immediate restriction 10' radius of broken made.</td>
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<tr>
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<td></td>
<td></td>
<td>5) Limit live-load capacity.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6) Re-inspect after repair.</td>
</tr>
</tbody>
</table>

Cost estimates are based on 1983 U.S. East Coast prices. Mobilization/demobilization costs have been omitted.
# EXECUTIVE SUMMARY TABLE

<table>
<thead>
<tr>
<th>SUPPORTED HIGH CONCRETE STRUCTURE</th>
<th>RECOMMENDATIONS</th>
<th>ESTIMATED COST (THOUSANDS)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1) Replace broken pile.</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>2) Repair non-bearing, partially bearing and split piles.</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>3) Monitor tension cracks in crane rail beam on a yearly basis.</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>4) Repair spalling on concrete truss cantilever and utility tunnel.</td>
<td>19.8</td>
</tr>
<tr>
<td></td>
<td>5) Re-inspect after repairs and in 6 years thereafter.</td>
<td>--</td>
</tr>
</tbody>
</table>

Large Basin is a timber pile-supported, low deck, earth fill, relieving platform structure. Original portion of the bulkhead consists of timber pile-supported, low deck, earth fill, relieving platform structure, built section consists of H-piles arranged in bents to low steel deck.

<table>
<thead>
<tr>
<th>SUPPORTED TIMBER STRUCTURE</th>
<th>RECOMMENDATIONS</th>
<th>ESTIMATED COST (THOUSANDS)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1) Replace broken piles.</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td>2) Repair non-bearing, partially bearing, split and wild piles.</td>
<td>8.4</td>
</tr>
<tr>
<td></td>
<td>3) Repair eccentric piles associated with Bents 4 through 8 of bulkhead. Re-inspect each year</td>
<td>10.0</td>
</tr>
<tr>
<td></td>
<td>4) Repair spalling on concrete seawall.</td>
<td>3.8</td>
</tr>
<tr>
<td></td>
<td>5) Re-inspect after repairs and in 6 years thereafter.</td>
<td>--</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SUPPORTED TIMBER शarking platform structure.</th>
<th>RECOMMENDATIONS</th>
<th>ESTIMATED COST (THOUSANDS)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1) Replace broken perimeter piles.</td>
<td>15.0</td>
</tr>
<tr>
<td></td>
<td>2) Post and brace broken interior piles, repair non-bearing, partially bearing, split and displaced, and wild piles.</td>
<td>20.0</td>
</tr>
<tr>
<td></td>
<td>3) Re-inspect after repairs and in 6 years thereafter.</td>
<td>--</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SUPPORTED TIMBER शarking platform structure.</th>
<th>RECOMMENDATIONS</th>
<th>ESTIMATED COST (THOUSANDS)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1) Replace or repair broken piles.</td>
<td>36.0</td>
</tr>
<tr>
<td></td>
<td>2) Repair split, wild, and partially bearing piles.</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td>3) Repair spalling on concrete seawall.</td>
<td>7.1</td>
</tr>
<tr>
<td></td>
<td>4) Immediate restriction of live-loading within 10' radius of broken piles until repairs are made.</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>5) Limit live-load capacity to 200 psf.</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>6) Re-inspect after repairs and in 2 years thereafter.</td>
<td>--</td>
</tr>
<tr>
<td>FACILITY</td>
<td>YEAR BUILT</td>
<td>TOTAL NO. OF PILES</td>
</tr>
<tr>
<td>------------------</td>
<td>------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>Drydock Wharf</td>
<td>Circa 1941</td>
<td>Section &quot;A&quot; approx. 4,300</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Section &quot;B&quot; approx. 2,800</td>
</tr>
<tr>
<td>Wharves K, J, I, H, and G</td>
<td>Circa 1943</td>
<td>12,060</td>
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*Cost estimates are based on 1983 U.S. East Coast prices. Mobilization/demobilization costs have been omitted.
<table>
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<th>JRES</th>
<th>RECOMMENDATIONS</th>
<th>ESTIMATED COST (THOUSANDS)</th>
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</thead>
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<tr>
<td>pile-supported, low deck, fill, relieving platform</td>
<td>1) Replace or repair broken piles.</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>2) Repair split and displaced, wild, non-bearing, and partially bearing piles.</td>
<td>77.2</td>
</tr>
<tr>
<td></td>
<td>3) Repair local pile cap-deck failure.</td>
<td>1.1</td>
</tr>
<tr>
<td></td>
<td>4) Repair damaged pile caps.</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>5) Investigate cathodic protection system.</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>6) Downgrade live-load capacity of Section &quot;A&quot; north of Bent 220 and inshore 20' to 100 psf until repairs are completed.</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>7) Enforce dredge limits.</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>8) Re-inspect after repairs and in 6 years thereafter.</td>
<td>--</td>
</tr>
</tbody>
</table>

| pile-supported, low deck, fill, relieving platform | 1) Replace broken piles.                                                          | 7.0                        |
|                                                   | 2) Repair split piles, and wild piles.                                             | 14.4                       |
|                                                   | 3) Install tie-back system along sections of Wharves K, J, and I. Restrict live-load capacity to 300 psf from the face of the wharves inshore 70' until repairs are completed. | 605                        |
|                                                   | 4) Repair damaged pile caps. Restrict live-load capacity to 0 psf in a radius of 10' until repairs are completed. | 10                         |
|                                                   | 5) Sections of wharf requiring tie-back system should be inspected yearly. Re-inspect after repairs and in 6 years thereafter. | --                         |
|                                                   | 6) Shim non-bearing piles                                                         | 26                         |
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<td>Pier 5, Bent 43, Pile LL. Illustrates typical condition of pile to pile cap connection. Note sand and cement eroded from concrete exposing aggregate. Diameter of washer is 3&quot;.</td>
<td>7</td>
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<td>Pier 5, West side; shows spalling and cracking in concrete cantilever members at the edge of the pier.</td>
<td>7</td>
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</tr>
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4.7 PIER 5

4.7.1 DESCRIPTION

Pier 5 is located to the west of Dry Dock No. 2 and to the east of the Barge Basin on the northern bank of the Delaware River (see Figures 4, [Vol. I] and 45-49).

The original pier constructed circa 1912 measured approximately 80' in width by 657' in length. The original pier was removed down to the tops of the piles or pile clamps and rebuilt circa 1944 to 1946. Public Works Drawing B-4000 and B-4001 indicate the rebuilt pier was enlarged to 110' in width by 767' in length. Apparently the pier was rebuilt again in 1979 to the existing structure. Its overall dimensions are approximately 790'x110'.

The structure is supported by approximately 3,000 timber piles arranged in bents 10' on center. The design pile capacity is 20 tons. The present deck live-load capacity is 600 psf. The deck elevation is 12.39'. During our divers' inspection this facility was functioning as a berthing facility for a YFN B.

Reference 2 (See Appendix A-25)
PLAN

LEGEND

- Non-bearing pile
- Broken pile
- Displaced-split pile
- Core location (pile, cap, deck) level 3 inspection
- Minimum pile diameter, level 2 inspection
- Soundings (ft) below MLW
- Modified level 1 inspection
- Level 1 inspection

NOTES
1. Pile spacing
2. Many wild piles not level 3
3. Observation deck was blocked

REFERENCE:
NAVFO Dwg # 2032643
PLAN

NOTES
1. PILE SPACING VARIES WITHIN EACH BENT
2. MANY WILD PILES EXIST BUT ARE NOT INTEGRAL WITH THE STRUCTURE AND ARE NOT LOCATED ON THIS PLAN
3. OBSERVATION OF THE CANTILEVER STRUCTURE ON THE EAST SIDE OF THE PIER WAS BLOCKED BY BARRIERS DURING THE INSPECTION

REFERENCE:
NAVФAC DWG NO 2032649

CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
NAVФС DWG NO 47
LEGEND

- Core location (pile, cap, deck) Level 3 inspection
- 25' soundings (ft) below MLW
- Modified Level 1 inspection
- Level 1 inspection performed on all piles within bent or row

REFERENCE: NAVFAC Dwg No. 2032443
CONC COLUMN HAS AN AREA OF 2" OF SPALLED CONC.

NOTES
1. PILE SPACING VARIES WITHIN EACH BENT

GRAPHIC SCALE

CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D.C.

PHILADELPHIA NAVAL SHIPYARD
PHILADELPHIA, PA

PIER 5 48
CONC. TRUSS CANTILEVER

UTILITY TUNNEL

TYPICAL SECTION

CRANERAIL BEAM

TIMBER FILE CLAMPS

REFERENCE
NAVAL DWG NO. 2032643
4.7.2 OBSERVED INSPECTION CONDITION

Quantities of specific anomalies found on Pier 5 are listed as follows:

1 broken pile
1 split and displaced pile
4 non-bearing piles
1 partially-bearing pile

The locations of these anomalies can be found on Figures 45 through 49.

From the observation of core samples taken at various locations on Pier 5 the condition of the timber was found to be excellent with softness ranging from 1/4" to 1/2". Minimum pile diameters observed range from 10"-17" and indicate that there has not been any loss of cross-sectional area since the time of original construction. Fasteners used on the timber portions of the structure are found to have no loss of steel due to corrosion (see Photo #31).

The concrete superstructure was generally found to have only minor damage. Some spalling was found on all of the concrete members comprising the truss cantilever at the perimeter of the pier and along the utility tunnel (see Photo #32). The approximate total area of concrete effected is 1400 sq. ft. In areas located on Figures 45 through 49 there is some reinforcing steel exposed to the environment. There are two concrete crane rail beams running the full length of the pier. Divers found that there are tension cracks extending to the full depth of the beams in various locations noted on Figures 45 and 46. In some areas of the concrete...
PHOTO NO. 31: Pier 5, Bent 43, Pile LL; illustrates typical condition of pile to pile cap connection. Note sand and cement eroded from concrete exposing aggregate. Diameter of washer is 3".

PHOTO NO. 32: Pier 5, west side; shows spalling and cracking in concrete cantilever members at the edge of the pier.
superstructure near MLW, the fine aggregates have eroded out of
the concrete leaving a rough surface of concrete consisting of the
remaining large aggregates (see Photo #13, Vol. I).

Apparantly the original structure of the pier was demolished and
only partially removed. There are many piles which remain in place
and unmarked on the figures since they are not part of the
structure. Also, the original concrete structure was simply
broken up and dropped onto the river bottom, where it remains.
4.7.3 STRUCTURAL ASSESSMENT

The timber pile foundation appears to be in excellent condition with no apparent deviations from the structure's original construction. The specific anomalies referred to earlier should be repaired in order to attain full live-load capacity.

The spalled areas on the concrete truss and utility tunnel are posing no immediate threat to the structure's live-load capacity, although if this condition is not repaired the deterioration of the concrete will continue and the reinforcing steel will be exposed to the marine environment and consequently, corrosion will occur. The unremoved demolished portions of the original structure do not effect the structural integrity of this facility.

Large tension cracks are an indication that the beam has been overstressed. Also when the steel reinforcing is exposed to the marine environment corrosion will occur. When corrosion significantly decreases the cross-sectional area of the steel, strength will be lost in the composite structure. Observations indicate that there was no significant corrosion occurring during the time of our inspection.
4.7.4 RECOMMENDATIONS

The single broken pile (see Figure 46) should be replaced. In order to properly install a new pile, it should be driven through the concrete deck and pulled into place. The estimated cost to install a new creosoted pile through the deck is $1,500 plus mobilization and demobilization. The other six (6) piles with anomalies should be reconditioned (shimmed, posted or clamped, see Appendix A-15 through A-21) and refastened to the pile cap. The estimated cost for reconditioning is $400 per pile. The total estimated cost would be $2,400.

Initially, tension cracks in the crane rail beam should be inspected closely and then monitored on a yearly basis, so as to determine any change in conditions or deterioration of reinforcing steel. The spalled areas of the concrete truss cantilever and utility tunnel should be patched. The old concrete should be chipped away to sound concrete and cleaned where needed. Pneumatically-placed concrete should be placed to provide proper cover for the reinforcing steel. The estimated cost to provide proper cover and prepare the concrete surface is $14.16/sq.ft. The total surface area in need of cover is 1,400 sq. ft. The total estimated cost of repair is $19,824.

Live-loading in deck areas directly associated with damaged (broken, split and wild) piles should be restricted to 25% of the current recommended live-load capacity until those piles are repaired. Following the implementation of the recommended
repairs, live-loading can be maintained at current levels (600 psf). The estimated life of this facility with proper maintenance is in excess of 25 years. The entire facility should be re-inspected after repairs and in 6 years thereafter. This inspection will enable Shipard personnel to determine any change in existing conditions. This report should be used as a baseline for all future inspections.
4.8 - BARGE BASIN AND THE BULKHEAD TO PIER 6

4.8.1 - DESCRIPTION

The Barge Basin is located just to the west of Pier 5 (see Figure 50). The bulkhead from Pier 6 to the Barge Basin is located adjacent to and to the east of Pier 6 and runs past Dry Dock No. 3 to the Barge Basin (see Figures 4, [Vol. I] and 50-52).

The Barge Basin was constructed circa 1939. This structure consists of a timber pile-supported, low deck, earth fill, relieving platform structure. Integral with this structure is the foundation associated with the barge crane. There are approximately 850 piles supporting this structure. The outer perimeter of the structure is bordered by timber sheet piles. The timber pile bearing capacity is assumed to be 15 tons. The top deck elevation is +12.99'. The Barge Basin was functioning as a transfer facility for barges during our divers' inspection (see Figure 50).

The bulkhead between Pier 6 and the Barge Basin was originally constructed circa 1903 and 1918. Part of the bulkhead collapsed and was rebuilt circa 1979. The rebuilt section consists of steel H-piles arranged in bents with a low steel deck. The original section remaining consists of a timber pile-supported, low deck, earth fill, relieving platform structure similar to the Barge Basin. There are approximately 740 piles supporting this structure.

Reference 2 (see Appendix A-25)
PIECE CAP IS SUPPORTED BY A BLOCK RUNNING NORTH-SOUTH AND SPANNING 2 BENTS

SEE FIG 51 FOR THIS AREA

LIMIT OF DIVES ACCESS

PLAN

REFERENCE
PW Dwg No C-8994

SECTION A-A

NOTES:
1. LEVEL 1 INSPECTION ON ALL PILES UNLESS NOTED OTHERWISE
2. ALL PILES ARE FOUND TO HAVE AN ACCEPTABLE MINIMUM DIAMETER
NOTES
1. LEVEL 1 INSPECTION ON ALL PILES
2. ALL PILES ARE FOUND TO HAVE ACCEPTABLE MINIMUM DIAMETERS.

AREA TO THE NORTH LINE IS INACCESSIBLE TO DIVERS.
APPROX AREA OF SPALL ON CONC ON SEAWALL FACE.

18.5' 60'

1/8" WIDE CRACK ON FACE OF SEAWALL.
1" WIDE CRACK FROM TOP TO BOTTOM OF SEAWALL FACE.
PILE CAP BROKEN 3/4" MISSING.
PILES A, B, BC, CD ARE 6 PILE CAP WHICH SUPPORT PILE CAP AT BENTS 4.
PILE CAP AT PILE ROW 1 ON THE PILES OR THE 1/8".

REFERENCE:
LIMIT OF DIVERS ACCESS

CONC. SPALLED AT ML - REBAR EXPOSED

NOTES:
1. FROM PIER 4 TO 18 FT AT TIMBER SHEETING LEVEL: INTERMITTENT.

PLATE:

LEGEND:

- NON-BEARING PILE
- 25' SOUNDFINGS (FT) BELOW MLW
- DM*1 D-METER LOCATION

REFERENCE:
P.W. DWG NO. A-2269, C-13535, D-13977
NAVY DWG NO. 1243408
DRY DOCK NO 3

THEORETICAL VALUES FOR THE HP 14X73 - WEB .505" FLANGE .505"

STEEL THICKNESS READINGS

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<th>DM*2</th>
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<tr>
<td>EL (FT)</td>
<td>WEB (IN)</td>
</tr>
<tr>
<td>+1.0</td>
<td>.495</td>
</tr>
<tr>
<td>0.0</td>
<td>.495</td>
</tr>
<tr>
<td>-2.0</td>
<td>- .515</td>
</tr>
<tr>
<td>-1.0</td>
<td>- .600</td>
</tr>
<tr>
<td>-10.0</td>
<td>- .600</td>
</tr>
<tr>
<td>ML (THK)</td>
<td>470</td>
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</tbody>
</table>

NOTES
- LAND AREA PHOTOGRAPHS HAVE BEEN INSTALLED
- PILE CAPS ARE TO BE 48" IN DIAMETER MINIMUM DIAMETER
- PILE HEADS ARE NOT TO BE FITTED OTHERWIESE

REFERENCE
PUR Dwg No 1240408

CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D.C.

PHILADELPHIA NAVAL SHIPYARD
PHILADELPHIA, PA

BULKHEAD TO PIER 6 52
4.8.2 OBSERVED INSPECTION CONDITION

Specific anomalies noted on the structural piles are listed as follows:

**Barge Basin**
- 4 broken piles
- 3 non-bearing piles
- 2 wild piles
- 7 partially-bearing piles

**Bulkhead from Pier 5 to Pier 6**
- 1 broken pile
- 4 split piles
- 5 non-bearing piles

Locations of these anomalies are found on Figures 50, 51 and 52, (see Photos #33 and #34).

The general condition of the timber was found to be good. Pile diameters observed range from 9" to 14". From the inspection of core samples taken it was found that the outer layer of soft wood is approximately 1/2" to 1" thick. The timber piles in the bulkhead on either side of the Barge Basin (Bents 1-4 and 1A-7A) are effected by an outer layer of soft timber approximately 2" deep (see Figure 51). Associated with this is a slight hourglass shape, effecting the piles closer to the sheet pile wall (Rows G & H). Minimum pile diameters in this area are greater than 7".

Where the timber sheet pile was accessible, it was found to be in excellent condition. Bents 52 through 71 of the bulkhead have recently been reconstructed. The new construction consists of a steel H-pile supported low deck structure. The steel was found to
PHOTO NO. 33: Bent 10, Pile A; non-bearing perimeter pile with drift pin exposed, and broken pile cap.

PHOTO NO. 34: Bent 3, Pile A; illustrates non-bearing pile.
have orange corrosion nodes (see Photo #35) covering most of its surface area. The surface of the steel was pitted, although there is not a significant loss of steel (see Photos #36 and #37).

The fender system along the bulkhead from Station 3+53 to 0+00 and around the Barge Basin is in poor condition. A new fender system has been installed along the new sections of the wharf and it is in excellent condition.

At Bents 4 through 8 of the bulkhead, the "A" pile row has been blocked with an east-west pile cap (2,12x12's) running below the normal pile cap. This repair is deteriorating. The blocking is not fully bearing on the pile or the pile cap and there is eccentric loading (see Figure 53).

The concrete seawall of the Barge Basin is in good condition and is functioning well. The concrete seawall associated with the older section of the bulkhead is deteriorating. Large cracks and spalled areas are present and noted on Figures 51 and 52. The total estimated surface area of spalled concrete is 270 square feet.
PHOTO NO. 35: Drydock 3 Bulkhead to Pier 6, Bent 65, Pile A; illustrates typical condition of steel H-pile, approx. El. -4'. Orange corrosion nodes 1"-2" diameter.

PHOTO NO. 36: Drydock 3 Bulkhead to Pier 6, Bent 65, Pile C, D-meter location at El. -4'; illustrates typical pitting of steel H-piles. Pits approx. 1/16" deep. Orange corrosion nodes 1"-2" diameter also visible.
PHOTO NO. 37: Drydock 3, Bulkhead to Pier 6, Bent 64, Pile A; illustrates corrosion and marine growth on steel H-pile. Note flange thickness.
SECTION A-A

NOTE: SEE FIG. 51 FOR LOCATION OF SECTION A-A
4.8.3 STRUCTURAL ASSESSMENT

Calculations indicate that the structural piles are capable of carrying the imposed load (see Appendix A-1 to A-7). The steel H-piles have no apparent loss in section or capacity.

Some piles in Bents 4 through 8 have been blocked (see Figure 53). This repair is presently unstable. The "A" pile row in this area is most severely effected. Apparently there is a lateral force acting on the piles to the south. This is causing the repaired blocking to roll (see Figure 53). As a result, the piles are not fully bearing on the pile cap. The eccentricity created by this movement should be corrected.

The concrete seawall associated with the bulkhead from Station 0+00 through Station 3+53 has extensive spalling and cracking on its face. Although this condition is not good, the wall is functional as a gravity wall. The cracking and spalling should be repaired to prevent further deterioration.
4.8.4 RECOMMENDATIONS

The five (5) broken piles should be replaced by driving new piles. The estimated cost to drive a new perimeter pile is $1,000. The total estimated cost is $5,000.

The fifteen (15) non-bearing or partially bearing piles should be refastened to the pile cap and shimmed. The four (4) split piles should either be posted or refastened to the pile cap. The two (2) wild piles should be refastened to the pile cap. The estimated cost to repair one pile is $400. The total estimated cost of repairs is $8,400 (see Appendix A-15 to A-21 for details).

The condition of eccentric piles associated with Bents 4 through 8 should be repaired. The eccentric vertical piles should be pulled into a plumb position below the pile cap to assure that the piles are fully bearing on the caps. Fasten two 4x12 clamps below the pile caps running east and west. The new 4x12 clamps should run back to the "EF" pile row. In addition, 4x12 cross-bracing should be added to induce stability as shown in Appendix A-19. To install these repairs an estimated four-man diving crew with a small barge will take 5 days. At $2,000/day the estimated cost is $10,000 (see Appendix A-19).

Spalling on the face of the concrete seawall associated with the old bulkhead should be repaired. The surface of the concrete should be chipped away to sound concrete. In areas of significant loss of concrete, welded wire mesh should be installed.
Pneumatically-placed concrete should then be placed so as to provide sufficient cover to the area. The estimated cost per square foot of repair area is $14.16. The total estimated cost is $3,823 (270 sq.ft.).

Live-loading in deck areas directly associated with damaged (broken, split and wild) piles should be restricted to 25% of the current recommended live-load capacity until those piles are repaired. Upon implementation of these repairs, provided that dredge limits are abided by and that there is proper maintenance, the live-load capacity should remain at 100 psf, with exception to the new construction where the live-loading should be the original design capacity. The life expectancy of the old structure is in excess of 10 years. The life expectancy of the newest construction is in excess of 25 years.

The entire bulkhead and Barge Basin should be reinspected after repairs and in 6 years thereafter. That portion of the bulkhead between Bents 4 and 8 should be inspected on a yearly basis due to the unstable condition present there. These inspections will enable Shipyard personnel to determine any change in conditions. This report should be used as a baseline for all future inspections.
4.9 PIER 6

4.9.1 DESCRIPTION

Pier 6 is located to the west of Dry Dock No. 3 and to the east of Pier 6-A on the northern bank of the Delaware River (see Figures 4 [Vol. I] and 54). This facility was constructed circa 1940 and is a timber pile-supported low deck, earth fill, relieving platform structure. The structure is approximately 970'x100' and is supported by approximately 8,500 timber piles. The timber pile capacity (driven) is assumed to be 15 tons. Presently the live-load capacity of Pier 6 is 600 psf. The top deck elevation of Pier 6 is +12.3'. During our divers' inspection Pier 6 was being used as a docking facility for various ships.

Reference 2 (see Appendix A-25)
95% of perimeter piles in this area have been repaired.

PILE CAP
CRUSHED

DECKING

EL + 12.5 ft
MLW EL + 0 ft

TIE ROD

PILE CAP

MUDLINE

BENT 126 TO 189 ONLY

102 ft

TYPICAL SECTION
LOCATION: EVERY OTHER BENT-
PILAR FOR FULL LENGTH OF PIER

950' ' OVERALL

PLAN

PILES WHICH HAVE BEEN REPAIRED

950' ' OVERALL

PLAN

REFERENCE: Y&D DWG NO. C-11366
95% of perimeter piles in this area have been repaired.

Piles which have been repaired:

Diagram showing piles with labels and symbols indicating their condition and location.

Legend:
- Wild pile
- Non-bearing pile
- Broken pile
- Displaced-split pile
- Core location (pile, cap)
- Minimum pile diameter
- 50% of pile bearing
- Bearing pile
- Batter pile
- -26.0' soundings (ft) below mean
- MB: Marine Borers observe
- Limit of diver's access

Note:
1. Access to many piles is due to spacing of piles.
95% of perimeter piles in this area have been repaired.

LEGEND

- WILD PILE
- NON-BEARING PILE
- BROKEN PILE
- DISPLACED-SPLIT PILE
- CORE LOCATION (PILE, CAP, DECK), LEVEL 3 INSPECTION
- MINIMUM PILE DIAMETER, LEVEL 2 INSPECTION
- 50% PILE BEARING ON PILE CAP
- BEARING PILE
- BATTER PILE
- 26.0' SOUNDINGS (FT) BELOW MLW
- MARINE BORERS OBSERVED
- LIMIT OF DIVER'S ACCESS

NOTE:
1. ACCESS TO MANY PILES RESTRICTED DUE TO SPACING OF PILES.
4.9.2 OBSERVED INSPECTION CONDITION

A list of the quantities of specific anomalies noted is as follows:

- 15 broken piles
- 14 non-bearing piles
- 25 split and displaced piles
- 6 wild piles
- 5 partially-bearing piles

The exact locations of these anomalies can be found on Figure 54. Access to all portions of the pier was not gained due to the close spacing of piles.

The timber throughout the pier was found to be in good condition. Core samples taken throughout the facility indicate that generally there is 1/4" to 1" of softness on all timber. The measurement of pile diameters and the observation of the timber conditions reveal that there has been no change in the minimum pile diameters of the structural piles since they were driven (see Photo #38).

The fasteners used throughout the facility are corroded, but can be classified as in good condition and functional. The fender system at the south end of the pier is suffering from fungal attack and is in poor condition. The rest of the fender system is in good condition. The concrete seawall is in excellent condition with only minor spalling and cracking.

The tie-rods used to provide lateral stability to the platform found throughout the facility are in excellent condition (see Photo #39, Appendix A-22). Although the corrosion rate on the webs of the H-sections seems to be accelerated, there is no structural deficiency.
PHOTO NO. 38: Pier 6, Bent 31, Pile A; broken perimeter pile with sapwood chipped away revealing sound timber.

PHOTO NO. 39: Pier 6, Bents 170-171; illustrates typical condition of tie-rod with orange corrosion node. Tie-rod diameter is 3".
At Bents 45 through 62 on the east side of the pier, there is a severe drop in the mudline elevation. At Bent 45 there is a 15' drop in the mudline between the C pile and the A pile. At Bent 62 this drop in elevation is only 3'.

In various locations throughout the facility marine borers were found. Although they are present, they have not caused any significant damage.

Between Bents 26 and 27 in the area of the B and C piles, a deck plank has failed (see Photo #40). This failure has opened up a gap in the deck. Behind this gap there is a second layer of timber deck material which is preventing the earth fill from leaching out.

On the west side of the pier from Bent 74 through Bent 138, extensive reconditioning of the perimeter piles has been undertaken. These repairs consist mainly of posted piles and refastened piles.
PHOTO NO. 40: Pier 6, Bents 26-27, Pile A; broken deck plank, approx. 12" wide as viewed from below the relieving platform.
4.9.3 STRUCTURAL ASSESSMENT

The damaged piles located near the perimeter of the pier apparently are caused by excessive berthing forces. Generally this results in the failure of the fastening at the pile cap or a broken pile.

Apparently overdredging or silt displacement due to prop wash has occurred at Bent 45 on the east side of the pier. This condition does not effect the capacity of the piles in the area to necessitate a reduction in their load carrying capacity.

In the area of Bents 26 and 27, a deck timber has failed due to overloading. This is a localized failure which apparently was repaired previously. The surrounding timbers showed no sign of overloading. The repairs which were made to the structural piles on the west side of the pier are functioning as they were designed and are in good condition.
4.9.4 RECOMMENDATIONS

The 15 broken piles should be repaired. The broken perimeter piles should be replaced and the broken interior piles should be posted and braced. The total estimated cost of repair is $15,000. The non-bearing piles, partially bearing piles, split and displaced piles and wild piles (50 piles total) should be refastened to the cap so that full bearing is attained. The total estimated cost of repair is $20,000 ($400 per repair). The dredging limits should be strictly enforced, particularly at the southern end of the pier.

Live-loading in deck areas directly associated with damaged (broken, split and wild) piles should be restricted to 25% of the current recommended live-load capacity until those piles are repaired. Following implementation of the recommended repairs, live-loading can be maintained at current levels (600 psf). Areas which were not directly observed are assumed to be in similar condition to those areas which were accessed. The estimated life of this structure is in excess of 25 years.

The entire pier should be re-inspected after repairs and in 6 years thereafter. This inspection will enable Shipyard personnel to determine any change of condition. This report should be used as a baseline for all future inspections.
4.10 PIER 6A AND THE BULKHEAD EAST TO PIER 6

4.10.1 DESCRIPTION

Pier 6A and the adjacent bulkhead to the east are located on the
northern bank of the Delaware River just to the west of Pier 6 at
the Philadelphia Naval Shipyard (see Figure 4, Vol. I). The struc-
ture was constructed circa 1903. Its overall dimensions are
235'x70'. The pier is a timber pile-supported, low deck, earth
fill, relieving platform type of structure (see Figures 55, 56).
There are approximately 1,100 timber-bearing piles. Each pile is
assumed to have a driven capacity of 15 tons. The assumed allow-
able live-load capacity of the structure is 500 psf. During our
diver's inspection this facility was functioning as a tool storage
area for the shipyard workers.

The bulkhead between Pier 6 and Pier 6A is of similar relieving
platform construction as Pier 6A. It is supported by 84 timber
piles with a timber sheet pile wall running inshore of the "C"
pile row (see Figure 55). The total length of the bulkhead is
142.7'.

Reference 2 (see Appendix A-25)
PIER G

1

5

10

VERTICAL CRACKS ON SEAWALL 4' LONG 12' DEEP, EACH WITH 20 SQ FT OF SPALLED CONCRETE

PIECE CAP MISSING

142.7'

15

TIMBER SHEET PILING

20

80%

25

29

PIER 6A

TYPICAL SECTION

SCALE IN FEET

PLAN

SCALE IN FEET

LEGEND

- BROKEN PILE

- WILD PILE

50% - 50 PERCENT OF PILE BEARING ON PILE CAP

NOTES:

1. LEVEL 1 INSPECTION ON ALL PILES.

2. SPALLING 2'-6'' DEEP WAS NOTED ON THE BOTTOM 3' OF THE ENTIRE LENGTH OF SEAWALL.
SEAWALL SPALLING

PILE CAP

ABRADED PILE TOP

BOG REMAINS

NOT ACCESSIBLE

PLAN

SCALE IN FEET

10 0 10 20 30 40

10 0 10 20 30

SCALE IN FEET

TYPICAL CROSS SECTION

CONCRETE SEAWALL

PILING INACCESSIBLE AREA

EARTH FILL

DECK EL.+12'

MLW EL.+0.6

PILING CLAMPS

TIMBER PILES

10-12" TIMBER SHEETING
Timber sheeting extends to southern end of pier and does not close off the interior of the pier.

Limit of divers access.

Pile cap is missing.

Legend:
- Broken pile
- Displaced - Split pile
- Core location (pile, cap, deck) level 9 inspection
- Minimum pile diameter, level 2 inspection
- 25' soundings (ft) below MLW
- 50% - 50 percent of pile bearing on pile cap
- Limit of divers access

Notes:
1. Level 1 inspection on all piles - Higher levels of inspection where noted.

Graphic scale in feet:
- Deck el. -12'
- MLW el. +0'
- E clamps
- Water piles

Pile clamps are missing in this area.

SEAWALL SPALLED EXPOSING PILE CLAMPS

LIMIT OF DIVERS ACCESS

CRACK IN SEAWALL 6' WIDE 2' MAX DEPTH

PILE CAP IS MISSING

NOT ACCESSIBLE

SEAWALL SPALLED EXPOSING PILE CLAMPS

VERTICAL CRACK IN SEAWALL 2' WIDE

PILE CLAMPS - CAPS ARE DAMAGED IN THIS AREA

PLAN

SCALE IN FEET

DECK EL. -12'

MLW EL. +0'

E CLAMPS

WATER PILES

DELAWARE RIVER - FLOOD EBB
4.10.2 OBSERVED INSPECTION-CONDITION

Specific anomalies noted concerning the structural piles are listed as follows:

36 broken piles
1 split and displaced pile
1 wild pile
2 partially-bearing piles

Locations of these anomalies can be found on Figures 55 and 56.

Throughout Pier 6A and the associated bulkhead, soft spots were sporadically found in the timber of the piles, deck and sheet pile. The depth of softness in these spots ranges from 1-1/2" to 4" deep. The softness is assumed to be caused by a general deterioration of the timber fibers (see Section 4.0, Vol. I). The largest concentration of soft spots were found on the structural members of the bulkhead between Pier 6A and Pier 6. Pile diameters observed range from 10" to 13".

Pile diameters observed and measured indicate that there has been no significant change in the minimum cross-sectional area since they were driven. The fasteners observed are functional, although in some cases it is estimated that a 30% loss of steel cross-section has occurred.

As shown on Figures 55 and 56 there are areas where the seawall is spalled and cracked. Some of the cracks are as much as 6" wide. The approximate total surface area which is effected by spalling or cracking is 500 square feet.
The fender system is basically non-functional and/or missing throughout Pier 6A and the associated bulkhead. Along the full length of the west side of Pier 6A a soil berm exists along the "W" pile row. The difference in the mudline depth varies from 1' in height to 8' in height between the "U" and "W" pile rows. The apparent cause is a combination of siltation under the relieving platform and dredging adjacent to the perimeter of the pier.
4.10.3 STRUCTURAL ASSESSMENT

The specific anomalies listed in Section 4.10.2 are a result of lateral overloading due to berthing forces possibly transmitted by camels.

Soft timber will reduce the capacity of the effected member. According to calculations, see Appendix A-1 to A-8, the reduced column capacity of a pile with 4" of softness is still greater than the assumed driven capacity. Live-load capacity is limited by softness in the timber decking.

The cracking and spalling of the concrete seawall is a result of aging and settlement. Particular attention should be directed to the south end of Pier 6A. In the area of Bent 41, there are large cracks on both the east and west sides of the pier. This could be an indication that the south end of the pier is beginning to translate to the south. Although movement of the bearing piles was not detected, the fact that there are no north/south batter piles leads to the assumption that the only structural resistance to the lateral earth pressures is the timber piles' ability to resist bending and whatever cohesiveness the superstructure has to offer.

The soil berm along the west side of Pier 6A does exert some lateral pressure on the vertical bearing piles, however this pressure is not critical. The maximum dredge limits have not been exceeded and undermining is not a controlling factor in the analysis.
The 36 broken piles should be replaced or posted (see Appendix A-15 to A-22). The estimated cost to repair one pile is $1,000. The total estimated cost of repair is $36,000. The split pile, wild pile and partially bearing piles should be refastened to the pile cap. The estimated cost to repair one pile is $400. The total estimated cost is $1,600. At the south end of the pier where there are many damaged piles in close association to each other, live-loading should be prohibited.

Spalling and cracking on the face of the concrete seawall should be repaired. The surface of the concrete should be chipped away to sound concrete. Large cracks should be filled. In areas of significant loss of concrete, welded wire mesh should be installed. Pneumatically-placed concrete should then be placed so as to provide sufficient cover to the area. The estimated cost per square foot of repair area is $14.16. The total estimated cost of repair is $7,080 (500 sq.ft.).

Live-loading in deck areas directly associated with damaged (broken, split and wild) piles should be restricted to 25% of the current recommended live-load capacity until those piles are repaired. At the southeast end of the pier live-loading should be reduced to 50 psf in the concentrated area of broken piles. Due to the timber softness, the live-load capacity of Pier 6A and the bulkhead should be limited to 200 psf. Upon implementation of these repairs, provided that dredge limits are observed and the...
structure is properly maintained, the life expectancy of the structure is in excess of 5 years.

Consideration should be made as to how to replace or rebuild the structure to return it to its original capacity, if that capacity is needed. The entire pier and bulkhead should be re-inspected after repairs and in 2 years thereafter. This inspection will enable Shipyard personnel to determine any change in conditions. This report should be used as a baseline for future inspections.
4.11 DRYDOCK WHARF

4.11.1 DESCRIPTION

The Drydock Wharf is located approximately 560 feet to the west of Pier 6A and to the east of Wharf K on the northern shore of the Delaware River (see Figures 4 [Vol. I] and 57). The Drydock Wharf is divided into three sections: Section "A" begins at the north-easternmost corner of the structure and continues to Drydock No. 4, it is sometimes known as the "Battleship Wharf"; Section "B" is located between Drydock No. 4 and Drydock No. 5; Section "C" is located between Drydock No. 5 and Wharf K, (see Figure 57). The low deck, earth-filled, timber pile-supported relieving platform structures were constructed circa 1941.

The east side of Section "A" is approximately 395 feet long, the south side 600 feet long, and the west side 224 feet long. Steel sheet piling is located approximately 50 feet inshore of the seawall and extends from the underside of the timber decking to the river bottom. Approximately 4,300 piles, including batter piles and intermediate bents are arranged in bents with 5-foot spacing, (see Figures 58 through 61). The design pile capacity is assumed to be 15 tons. The deck elevation is +14'. The designated live-load capacity at the time of our inspection is 700 psf. During our inspection Section "A" was being used as a permanent mooring for a battleship.

The east side of Section "B" is 224 feet long, the south side 280 feet long, and the west side 216 feet long. Steel sheet piling is located approximately 45 feet inshore of the seawall. Approximate-
approximately 2,800 piles, including batter piles and intermediate bents are arranged in bents with 5-foot spacing (see Figures 62 and 63). The design pile capacity is assumed to be 15 tons. The deck elevation is +14'. The designated live-load capacity at the time of our inspection is 300 psf. During our inspection Section "B" was being used as a temporary mooring for various oil barges, floating cranes and a personnel barge.

The east side of Section "C" is 214 feet long and the south side 184 feet long. Steel sheet piling is located approximately 50 feet inshore of the seawall. Approximately 1,500 piles including batter piles and intermediate bents are arranged in bents with 5-foot spacing (see Figure 64). The design pile capacity is assumed to be 15 tons. The deck elevation is +14'. The designated live-load capacity at the time of our inspection is 300 psf. During our inspection Section "C" was being used as a temporary mooring for various oil barges.

Typical cross sections of the drydock wharves can be found on Figure 65.

Reference 2 (see Appendix A-25)
SCHUYLKILL RIVER

WHARF 1

DRY DOCK WHARF SECTION 'C'

FIGURE 64

DRY DOCK NO. 3

FIGURE 63

DRY DOCK WHARF SECTION 'B'

FIGURE 62

DRY DOCK WHARF SECTION 'A'

FIGURE 61

FIGURE 60

FIGURE 59

FIGURE 58

REFERENCE D & D NO. A-2560

GRAPHIC SCALE

CHESapeake DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON D.C.

AS SHOWN

CHILDS ENGINEERING CORPORATION
BOX 325
MEDITERRANEAN

D Dry Dock Wharf 57

-38-
LEGEND

- WILD PILE
- BROKEN PILE
- DISPLACED - SPLIT PILE
- CORE LOCATION, LEVEL 3 INSPECTION
  50-30 50 PERCENT OF PILE BEARING ON PILE CAP
  -20+ SOUNDINGS (FT) BELOW MLW
  -.---- LIMITS OF ACCESS

NOTES:

1. LEVEL 1 INSPECTION ON ALL PILES - HIGHER LEVELS OF INSPECTION WHERE NOTED.
2. FENDER SYSTEM NON-EXISTANT OR HEAVILY DETERIORATED
3. CONCRETE SEAWALL IN EXCELLENT CONDITION

REFERENCE DRAWINGS:
NAYC 1240400, C-11122, C-11124, C-11125
C-11126, C-11127, D-17161

GRAPHIC SCALE

CHESapeake DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON D.C.

PHILADELPHIA NAVAL SHIPYARD, PHILADELPHIA, PA

DRYDOCK WHARF "A" 58
PILES FASTENED TO PILE CAP
WITH TIMBER SCABS.

PILE CAP ABRADED

PLAN

DELAWARE RIVER

EBB → # → FLOOD

REFERENCE DRAWINGS:
NAVFAC 1240 2CC C-11125, C-11124, C-11126
C-11125, C-11127 D-17167
PLAN

LEGEND

- WILD PILE
- NON-BEARING PILE
- BROKEN PILE
- DISPLACED-SPLIT PILE
- CORE LOCATION, LEVEL 3 INSPECTION
- 50 PERCENT OF PILE BEARING ON PILE CAP
- SOUNplings (FT) BELOW MLW
- LIMITS OF ACCESS

NOTES:

1. LEVEL 1 INSPECTION ON ALL PILES - HIGHER LEVELS OF INSPECTION WERE NOTED
2. TYPICAL CROSS SECTION FOUND ON FIGURE 70

REFERENCE DRAWINGS:
NAVFAC 1240400, C-11122, C-11124, C-11126
C-11125, C-11127, D-11161

GRAPHIC SCALE

CHESapeake DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D.C.

PHILADELPHIA NAVAL SHIPYARD
PHILADELPHIA, PA

DREDOCK WHARF "A" 59

-40-
SEVERE DETEORIATION OF STEEL SHEET PILES DUE TO CORROSION - BENTS 146 TO 170

PERFORATION OF STEEL SHEET PILING DUE TO CORROSION

PILES FASTENED TO PILE CAP WITH TIMBER SCABS.

DELWARE RIVER

EBB

FLOOD

STEEL THICKNESS READINGS

BENT 180

ELEV. BELOW MWL READING (IN.)

-1 ON WEB .325
-3 ON WEB .355

THEORETICAL VALUE OF PZ32 SECTION
WEB -.375"

REFERENCE DRAWINGS:
NAVAC 124040C, C-11122, C-11124
C-11125, C-11126, C-11127, D-11161
SEVERE DETERIORATION OF STEEL SHEET PILES DUE TO CORROSION - BENTS 146 TO 190

STEEL SHEETING

LEGEND
- NON-BEARING PILE
- BROKEN PILE
- DISPLACED - SPLIT PILE
- CORE LOCATION, LEVEL 3 INSPECTION
- 50 PERCENT OF PILE DIAMETER, LEVEL 2 INSPECTION
- 50 PERCENT OF PILE BEARING ON PILE CAP
- SOUNDED (FT) BELOW MLW
- LIMIT OF ACCESS
- 4 METER LOCATION

THEORETICAL VALUE OF P332 SECTION WEB = .375"
PLAN

STEEL THICKNESS READING
BENT 235-236 CAISSON - DM*1
FL (FT BELOW MLW) READING (IN)

<table>
<thead>
<tr>
<th>FL (FT BELOW MLW)</th>
<th>READING (IN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>.400</td>
</tr>
<tr>
<td>-2</td>
<td>.440</td>
</tr>
<tr>
<td>-4</td>
<td>.310</td>
</tr>
<tr>
<td>-6</td>
<td>.380</td>
</tr>
<tr>
<td>-8</td>
<td>.360</td>
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<tr>
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</tr>
<tr>
<td>-15</td>
<td>.375</td>
</tr>
<tr>
<td>-20</td>
<td>.390</td>
</tr>
</tbody>
</table>

LEGEND

\[ \triangle \] WILD PILE
\[ \odot \] NON-BEARING PILE
\[ . \] BROKEN PILE
\[ \times \] DISPLACED - SPLIT PILE
\[ \square \] CORE LOCATION, LEVEL 3 INSPECTION
\[ + \] MINIMUM PILE DIAMETER, LEVEL 2 INSPECTION
\[ +2\% \] SOUNDINGS (FT) BELOW MLW

DM*1 D-METER LOCATION
**** LIMIITS OF ACCESS

NOTES:

1. LEVEL 1 INSPECTION ON ALL PILES -
   HIGHER LEVELS OF INSPECTION WHERE NOTED

REFERENCE DRAWINGS:
NAV FAC 124040C, C-11122, C-11124
C-11125, C-11126, C-11127, D-17161

GRAPHIC SCALE

CHESapeake DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
PHILADELPHIA NAVY YARD, PHILADELPHIA, PA
W01 R01300001110001

DRIYDOK WHARF "A" 61

-42-
PLAN

LEGEND:

- WILD PILE
- NON-BEARING PILE
- BROKEN PILE
- DISPLACED - SPLIT PILE
- CORE LOCATION - LEVEL 1 INSPECTION
- MINIMUM PILE DIAMETER - LEVEL 2 INSPECTION
- STEEL SHEET PILE
- DIA. METER LOCATION
- LIMITS OF ACCESS

NOTE:
1. LEVEL 1 INSPECTION WHERE LEVEL 2 INSPECTION WAS NOT MADE
2. SEE FIGURE 70 DRYDOCK WAREhouses FOR CROSS-SECTION

STEEL THICKNESS DESIGN:

<table>
<thead>
<tr>
<th>PDIAM (IN)</th>
<th>48</th>
<th>46</th>
<th>44</th>
<th>42</th>
<th>40</th>
<th>38</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLAME (IN)</td>
<td>18</td>
<td>16</td>
<td>14</td>
<td>12</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>W/B (IN)</td>
<td>340</td>
<td>340</td>
<td>340</td>
<td>340</td>
<td>340</td>
<td>340</td>
</tr>
</tbody>
</table>

THEORETICAL PZ 92 VALUES ARE:
WEB .375" FLANGE .506"

REFERENCE DRAWINGS: NAVTEL 112513B
PW C-10402, C-11127, C-11130, C-11131, C-11132, C-13536
NOTE:
1. LEVEL 1 INSPECTION ON ALL PILES - HIGHER INSPECTION WHERE NOTED.
2. PILE CAPS SHOW DETERIORATION AT P

REFERENCE DRAWINGS: NAVFAC 113545B
PWC-10402, C-11127, C-11130, C-11131, C-11132, C-13536
LEGEND
Δ WILD PILE  ● BROKEN PILE
● NON-BEARING PILE  ○ DISPLACED - SPLIT PILE
□ CORE LOCATION, LEVEL 3 INSPECTION
* SOUNDINGS (FT) BELOW MLW
**** LIMITS OF ACCESS

NOTE:
1. LEVEL 1 INSPECTION ON ALL PILES, HIGHER LEVELS OF INSPECTION WHERE NOTED.
2. PILE CAPS SHOW DEPOTRATIZATION AT PERIMETER.
**Legend**

- **NON-BEARING PILE**
- **BROKEN PILE**
- **DISPLACED - SPLIT PILE**
- **CORE LOCATION, LEVEL 3 INSPECTION**
- **MINIMUM PILE DIAMETER, LEVEL 2 INSPECTION**
- **SOUNDINGS (FT) BELOW MLW**
- **WILD PILE**
- **LIMITS OF ACCESS**

**Notes:**
1. LEVEL 1 INSPECTION ON ALL PILES - HIGHER LEVELS OF INSPECTION WHERE NOTED
2. CROSS SECTION FOUND ON FIGURE 70

**Reference Drawings:**
- NAVFAC 1153-58, C-10402, C-1127
- C-1130, C-1131, C-1132, C-13536
**LEGEND**

- **NON-BEARING PILE**
- **BROKEN PILE**
- **DISPLACED - SPLIT PILE**
- **CORE LOCATION, LEVEL 3 INSPECTION**
- **MINIMUM PILE DIAMETER, LEVEL 2 INSPECTION**
- **SOUNDINGS (FT) BELOW MLW**
- **WILD PILE**
- **LIMTS OF ACCESS**

**NOTES:**
1. LEVEL 1 INSPECTION ON ALL PILES - HIGHER LEVELS OF INSPECTION WHERE NOTED.
2. CROSS SECTION FOUND ON FIGURE 70.
4.11.2 OBSERVED INSPECTION CONDITION

Specific anomalies detected which relate to the structural piles are tabulated as follows:

SECTION A
69 non-bearing piles
28 broken piles
33 split and displaced piles
9 piles with less than 100% bearing
15 wild piles

SECTION B
25 non-bearing piles
13 broken piles
15 split and displaced piles
6 wild piles

SECTION C
10 non-bearing piles
8 broken piles
10 split and displaced piles
1 wild pile

These anomalies can be located on Figures 58 through 64.

Visual inspection of core samples of timber piles, caps and deck- ing indicate that there is no more than 1/2" of softness in the timber. This condition is found throughout the facility. Minimum pile diameters measured ranged from 11" to 18". Marine borers were not observed. From our observations we conclude that there has not been a loss of cross-sectional area associated with the timber piles since their placement.

Damage to pile caps (24 in all) was observed throughout Sections A, B and C of the facility. This damage is a result of abrasion and/or local overloading. Damage of the pile caps due to abrasion
is confined to areas where the fender system is no longer functional, while local overloading of the pile caps occurs where perimeter piles are broken or are located 2 to 3 feet inshore of the seawall (see Photo #41).

In general, inspection of fastenings reveals a 15-20% loss of steel due to corrosion. More extensive corrosion of the fastenings was observed in isolated areas.

The surface of the steel sheet piling is very rough and pitted. The outer layer of corrosion is a soft orange corrosion by-product with pockets of trapped gas. Closer to the surface of the steel is a harder black layer of corrosion by-product. Corrosion holes ranging from 1/2" diameter to 1"x18" were observed in the sheet pile wall along the south side of Section "A", (see Figure 60, Photo #42). The results of D-meter readings taken on the sheet pile wall indicate a steel loss of between 5 and 50% with the average steel loss approximately 15% (see Figures 60, 61, and 62 for D-meter readings).

Many shimmed and non-bearing piles were observed between Bents 220 through 244 of Section "A", with some piles shimmed up to 12 inches. Steel caissons approximately 5 feet in diameter were also observed in the area. The caissons extend through the decking. Caps that could transfer deck loads to the caissons were not observed.

A local failure of the timber decking was observed between Bents 31 and 32 of Section "B", adjacent to the steel sheet pile wall.
PHOTO NO. 41: Drydock Wharf C, Bent 66, Pile A; illustrates split in pile cap. Failure of pile cap due to overloading.

PHOTO NO. 42: Drydock Wharf A, Bent 184; rusted knuckle in steel sheet pile wall, approx. E1-2'. Corroded knuckle is approx. 3/4" wide and 14' long.
Earth fill has leached out of the structure, but the extent of loss is not known.

The fender system along the east face of Section "A" is non-existent, and heavily damaged along the south face, particularly in the area where the battleship is moored. The fender systems of Sections "B" and "C" are in good condition.

The concrete seawall was observed to be in excellent condition in general, with the exception of a 6" wide vertical crack found between Bents 67 and 68 of Section "B".

By comparing soundings obtained by Childs Engineering Corporation personnel with maximum safe designed dredge depths obtained from the Hudson Engineers Report of 1976, it is noted that the maximum dredge depth has been exceeded at the southwest corner of Section "B" by 5 feet. Maximum dredge depths are approached but not exceeded at all other sounding locations.
4.11.3 STRUCTURAL ASSESSMENT

Most of the specific anomalies listed in the previous section are a result of local berthing forces. Lateral forces have broken, split and/or displaced many perimeter piles. As a result, in many areas pile caps are left unsupported at the perimeter leading to local failure of the pile cap. In addition, pile caps have been abraded or crushed by impact loads.

Non-bearing piles along the west side of Section "A" are the result of missing shims. The widespread use of shims and short posts in the area may be part of the original construction, or may have been required at a later date to counteract the effects of settlement. The function of the caissons located between Bents 221 through 243 cannot be determined from our inspection or through our government-furnished information. However, since the caissons extend through the deck, we must assume that they offer little vertical support to the deck.

As a result of our observations and analysis of the structural timber piles (see Appendix A-1 to A-8) we conclude that minimum pile diameters and the condition of the timber are both at acceptable levels.

The failure of the timber decking between Bents 31 and 32 of Section "B" adjacent to the steel sheet pile wall is a local condition and does not reflect a general weakness of the timber decking throughout the facility.
Corrosion holes in the knuckles and web of the sheet pile wall along the south side of Section "A" may result in loss of fill. Although no sinkholes were observed in the pavement adjacent to the holes, the possibility does exist that sinkholes will form in the future. The general loss of steel section of the knuckles and web due to corrosion does not at this time threaten the structural integrity of the sheet pile wall. However, if deterioration of the steel is allowed to continue, more holes will form, and the wall may reach a point where it is unable to restrain the lateral earth forces exerted on it.

Maximum safe designed dredge depths have been exceeded at the southwest corner of Section "B" by five (5) feet. Over-dredging threatens the lateral stability of the structure and should be avoided.
4.11.4 RECOMMENDATIONS

The forty-nine (49) broken piles should be repaired by replacing them with new piles, (see Appendix A-15, A-18). The estimated cost per pile for repair with a new pile is $1,000. The eighty (80) split and displaced or wild piles and the one hundred thirteen (113) non-bearing or partial bearing piles should be reconditioned (shimmed, posted or clamped, see Appendix A-16, A-17) and refastened where needed to the pile cap. The cost to recondition a pile is estimated to be $400. The total estimated cost to implement these repairs is $126,200.00 plus mobilization/demobilization.

We recommend that the local pile cap and deck failure observed on the east side of Section "B" be repaired to prevent further loss of fill (see Appendix A-21). The estimated cost of excavation and backfill is $15/cu.yd. at approximately 30 cu.yd. = $450.00. The estimated cost of timber is $5/bf (in place) at approximately 120 bf = $600.00, for an estimated total of $1,050 plus mobilization/demobilization.

The twenty-four (24) damaged pile caps should be repaired. At an estimated cost of $500/repair, the total estimated cost is $12,000 plus mobilization/demobilization (see Appendix A-20).

We recommend that the cathodic protection system servicing the battleship mooring at Section A be analyzed to determine whether it is or has been contributing to the corrosion of the steel sheet pile wall. No specific repairs to the holes observed in the steel
sheet pile wall are recommended at this time. However, it is recommended that the wall be re-inspected every year to monitor the general loss of steel due to corrosion, the formation of new holes and the loss of fill material. Additionally, a protection system using galvanic anodes could be installed to prevent further deterioration of the steel.

We recommend that the dredge limits established in the Hudson Engineering Report of 1976 not be exceeded.

We recommend that the live-load capacity of Section "A" north of Bent 220 and inshore 20' be downgraded from 700 psf to 100 psf until the recommended repairs are completed in the area. It is emphasized that re-shimming non-bearing piles in the area may not be a permanent solution if the cause of the non-bearing piles is settlement.

Live-loading in deck areas directly associated with damaged (broken, split and wild) piles should be restricted to 25% of the current recommended live-load capacity until those piles are repaired. Following the implementation of the recommended repairs, live-loading can be maintained at current levels (Wharf A, 700 psf; Wharves B and C, 300 psf). We estimate the life of the inspected portions of the facility to be in excess of 15 years. The entire wharf should be re-inspected after repairs are made and in 6 years thereafter. This inspection will enable Shipyard personnel to determine any changes of conditions. This report should be used as a baseline for future inspections.
4.12 WHARVES K, J, I, H, G

4.12.1 DESCRIPTION

Wharves K, J, I, H and G are located on the east shore of the Schuylkill River adjacent to the drydock wharves and to the west of Dry Dock No. 5 at the Philadelphia Naval Shipyard (see Figures 4 [Vol. I] and 66-78). These wharves were constructed circa 1943. The structure is a low deck, earth fill, timber pile-supported relieving platform. There are approximately 12,060 structural piles. The approximate total length of the Wharves K, J, I, H, and G is 3,315'. The timber pile capacity is assumed to be 15 tons per pile. The live-load capacity of these structures is 300 psf. During our diver's inspection these facilities were being used as a berthing area for various fuel barges.

Reference 2 (see Appendix A-25)
LOCATION PLAN
FOR WHARVES K, J, I, H AND G
PILE CAPS BETWEEN PILE 12 AND THE SHEET PILE WALL ARE CRUSHED AND DEFLECTED DOWN 6°
PLAN

LEGEND

- NON-BEARING PILE
- DISPLACED - SPLIT PILE
- or - CORE LOCATION (PILE, CAP, DECK) LEVEL 3 INSPECTION
  - MINIMUM PILE DIAMETER, LEVEL 2 INSPECTION
  - 25' SOUNDINGS (FT) BELOW MLW
  - 50 PERCENT OF PILE BEARING ON PILE CAP
  ------ LIMIT OF DIVERS ACCESS

NOTES:

1. LEVEL 1 INSPECTION ON ALL PILES -
   HIGHER LEVELS OF INSPECTION WHERE NOTED.
2. TYPICAL CROSS SECTION FOUND ON FIGURE 73.

REFERENCE DRAWINGS:
C-11023, C-10474, C-10420
C-10422, C-11128, C-12537

GRAPHIC SCALE

CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D.C.
PHILADELPHIA NAVAL SHIPYARD

WHARF K

-56-
LEGEND

- WILD PILE
- NON-BEARING PILE
- DISPLACED- SPLIT PILE
- CORE LOCATION (PILE, CAP, DECK) LEVEL 3 INSPECTION
- MINIMUM PILE DIAMETER, LEVEL 2 INSPECTION
- 25 SOUNDINGS (FT) BELOW MLW
- 50% - 75% 50 PERCENT OF PILE BEARING ON PILE CAP
- LIMIT OF DIVERS ACCESS

NOTES:
1. LEVEL 1 INSPECTION ON ALL PILES-
HIGHER LEVELS OF INSPECTION WHERE NOTED.
NOTES
1. LEVEL I INSPECTION
2. CONC. CURBING ALONG
3. DURING THE INSPECTION
4. TYPICAL CROSS SECTION
LEGEND

- Non-Bearing Pile
- Displaced - Split Pile
- Core Location (Pile, Cap, Deck) Level 3 Inspection
- Minimum Pile Diameter, Level 2 Inspection
- 25' Soundings (FT) Below MLW

NOTES:
1. Level 1 inspection on all piles. Higher levels of inspection where noted.
2. Conc. curbing along Wharf J is deteriorated (Petals were being installed during the inspection).
3. Typical cross section can be found on Figure No. 77.

REFERENCE:

Graphic Scale:

Chesapeake Division
Naval Facilities Engineering Command
Washington, D.C.
Philadelphia Naval Shipyard, Philadelphia, PA

WHARF J 69
PLAN

LEGEND

- NON-BEARING PILE
- BROKEN PILE
/ DISPLACED - SPLIT PILE
/ CORE LOCATION (PILE, CAP, DECK) LEVEL 3 INSPECTION
- MINIMUM PILE DIAMETER, LEVEL 2 INSPECTION
- SOUNDINGS (FT) BELOW MLW
- 50 PERCENT OF PILE BEARING ON PILE CAP

NOTES:
1. LEVEL 1 INSPECTION ON ALL PILES - HIGHER LEVELS OF INSPECTION WHERE NOTED
2. CONC CURBING ALONG WHARF J IS DETERIORATED
3. FENDER SYSTEM IN THE AREA OF STS 3+5 IS IN POOR CONDITION
4. TYPICAL CROSS SECTION CAN BE FOUND IN FIGURE NO. 77

REFERENCE:

NAV NO
C-11033 C-9774 C-10422
C-10420 C-11128 C-15537

GRAPHIC SCALE

0 18' 20' 30'

SCALE IN FEET

CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND

PHILADELPHIA NAVAL SHIPYARD
PHILADELPHIA, PA 19106-5766

WHARF J 70
PLAN

LEGEND
- NON-BEARING PILE
- BROKEN PILE
\[ \times \] DISPLACED- SPLIT PILE
- CORE LOCATION (PILE, CAP, DECK) LEVEL 3 INSPECTION
- MINIMUM PILE DIAMETER, LEVEL 2 INSPECTION
- 25' SOUNDINGS (FT) BELOW MLW
- 50% 50 PERCENT OF PILE BEARING ON PILE CAP

NOTES:
1. LEVEL 1 INSPECTION ON ALL PILES - HIGHER LEVELS OF INSPECTION WHERE NOTED
2. CONC CURBING ALONG PERIMETER OF WHARF J IS DETERIORATED
3. TYPICAL CROSS SECTION CAN BE FOUND IN FIGURE N1 77

GRAPHIC SCALE

CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND

-60-
PLAN

PILE CAP CRUSHED OVER PILE

PILE CAP CRUSHED OVER PILE - 27" SHEET PILE WALL PILE CAP 16 x 4 - AND DEFLECTED DOWN APPROX. 3'-4"

TYPICAL CROSS SECTION

ML 16 SPACES @ 4' O.C.
PLAN

LEGEND

♀ NON-BEARING PILE
○ B晨KEN PILE
♀ DISPLACED- SPLIT PILE
♀ CORE LOCATION (PILE, CAP, PECK) LEVEL 3 INSPECTION
♀ MINIMUM FILE DIAMETER, LEVEL 2 INSPECTION
♀ 25' SOUNDINGS (FT) BELOW MLW
♀ 50% " 50 PERCENT OF FILE BEARING ON FILE CAP
♀ LIMIT OF DIVERS ACCESS

NOTES:
1. LEVEL 1 INSPECTION ON ALL PILES-
HIGHER LEVELS OF INSPECTION WHERE NOTED.
2. TYPICAL CROSS SECTION FOUND ON FIGURE 83.
PLAN

REFERENCE DRAWINGS:
C-10411 C-10416 C-9774
PLAN

LEGEND

◇ NON-BEARING PILE

Core Location (Pile, Cap, Deck) Level 3 Inspection

Minimum Pile Diameter, Level 2 Inspection

2-5' Soundings (FT) Below MLW

LIMIT OF DIVERS ACCESS

NOTES:

1. LEVEL 1 INSPECTION ON ALL PILES-
   HIGHER LEVELS OF INSPECTION WHERE NOTED.

2. FENDER SYSTEM MISSING OR DAMAGED IN
   THIS AREA BETWEEN BENTS 75 TO 139

3. TYPICAL CROSS SECTION FOUND ON FIGURE 83.

REFERENCE DRAWINGS:
C-10411 C-10416 C-9774

CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
PHILADELPHIA NAVAL SHipyard PHILADELPHIA PA 19116

WHARF 1 74
PLAN

LEGEND

◊ Non-bearing pile
• Broken pile
✓ Displaced - split pile
10° Core location (pile, cap, deck) level 3 inspection
−24' Minimum pile diameter, level 2 inspection
−26' Soundings (ft) below MLW
50% 8 50 percent of pile bearing on pile cap
----- Limit of divers access

NOTES:
1. Level 1 inspection on all piles - higher levels of inspection where noted.
2. Typical cross section found on Figure 83.

REFERENCE DRAWINGS:
3276 B-3351 C-9774 C-10411 C-10414 C-11033
3537 NAVFAC Dwg 1240403

GRAPHIC SCALE

<table>
<thead>
<tr>
<th>0</th>
<th>10'</th>
<th>20'</th>
<th>30'</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCALE IN FEET</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON D.C.

PHILADELPHIA NAVAL SHIPYARD
PHILADELPHIA, PA 19140

WHARF H 75
LEGEND

- WILD PILE
- NON-BEARING PILE
- DISPLACED - SPLIT PILE
- CORE LOCATION (PILE, CAP, DECK) LEVEL 3 INSPECTION
- MINIMUM PILE DIAMETER, LEVEL 2 INSPECTION
- 25' SOUNINGS (FT) BELOW MLW
- 50% - 75% 50 PERCENT OF PILE BEARING ON PILE CAP
- LIMIT OF DIVERS ACCESS

NOTES:
1. LEVEL 1 INSPECTION ON ALL PILES - HIGHER LEVELS OF INSPECTION WHERE NOTED.
2. BENT IOT FILE 1 REPAIRED WITH WIRE ROPE TYING PILE AND FILE CAP TOGETHER.
3. TYPICAL CROSS SECTION FOUND ON FIGURE 63.
LEGEND

- Non-bearing pile
- Broken pile
- Displaced - Split pile
- Core location (pile, cap, deck) level 9 inspection
- Minimum pile diameter, level 2 inspection
- Soundings (ft) below MLW

LIMIT OF DIVERS ACCESS

NOTES:
1. Level 1 inspection on all piles - higher levels of inspection where noted.
2. Typical cross section found on Figure 63

REFERENCE DRAWINGS:
B-3276 B-3551 C-9774 C-10411 C-10414 C-11033
C-11037 NAVFAC DWS 124G493

CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D.C.

PHILADELPHIA NAVAL SHIPYARD
WHARF G 77
LEGEND

- "CORE LOCATION (PILE, CAP, DECK) LEVEL 3 INSPECTION
- " MINIMUM PILE DIAMETER, LEVEL 2 INSPECTION
- " 25' SOUNDINGS (FT) BELOW MLW
- " 50 PERCENT OF PILE BEARING ON PILE CAP
- " LIMIT OF DIVERS ACCESS

NOTES:

1. LEVEL 1 INSPECTION ON ALL PILES—HIGHER LEVELS OF INSPECTION WHERE NOTED.

REFERENCE DRAWINGS:
8-3296 8-3551 C-9774 C-10411 C-10414 C-11033
C-18537 NAVFAC DWG. 1240403
4.12.2 OBSERVED INSPECTION CONDITION

Specific anomalies noted concerning the structural piles are listed as follows:

<table>
<thead>
<tr>
<th>Wharf</th>
<th>K</th>
<th>J</th>
<th>I</th>
<th>H</th>
<th>G</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broken Piles</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Split Piles</td>
<td>15</td>
<td>11</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>33</td>
</tr>
<tr>
<td>Non-Bearing Piles</td>
<td>170</td>
<td>262</td>
<td>36</td>
<td>44</td>
<td>3</td>
<td>515</td>
</tr>
<tr>
<td>Partially-Bearing piles</td>
<td>6</td>
<td>9</td>
<td>1</td>
<td>8</td>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td>Wild Piles</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

Approx. Total No. of Piles 1665 4245 2085 2505 1560

Throughout Wharves K, J, I, H and G, core samples of the timber piles, deck caps and timber sheet piles indicate that timber softness (see Section 4.0) ranges from 0" to 1/2" in depth.

The pile diameters which were measured, generally range from a minimum of 10" to a maximum of 16". There is no observed deterioration or reduction of the piles' cross-sectional area subsequent to being driven.

The fasteners which were visible appeared to have a thin layer of corrosion on the metal surface with little or no pitting observed. Estimated loss of steel due to corrosion is less than 20%.

The fender system is generally in poor condition along the majority of the wharves. Fungal attack on the timber and localized failure due to berthing forces are found throughout each wharf, with the exception of Wharf G which has been reconditioned.
The seawall along the wharves is functional and generally in good condition. There is minor spalling along the expansion joints (see Photo #43). The concrete curbing at the top of the seawall is deteriorating around the scuppers. Portions of the curbing along Wharf J were under repair during the inspection. At the time of inspection, it is estimated that approximately 5% of the total length of the curbing is in need of repair. The lower elevations of the seawall are showing some loss of the fine aggregate in the concrete as described in Section 4.0, Vol. I, Page 15, a condition which does not effect the overall strength of the concrete.

Along the full length of Wharves K, J, I, H, and G, the seawall has irregular bulges and separation of the expansion joints. This irregular bowing is particularly evident along Wharves K and J where the seawall is as much as 6" out of alignment.

As shown on Figures 67, 68, 69 and 76, there is a large number of non-bearing piles generally associated with the adjacent batter piles (see Photo #44). The highest concentration of the non-bearing piles occurs at the junction of Wharves K and J and along the north end of Wharf H.

The elevation of the mudline along the sheet pile wall ranged from -6' at Bent 15, Wharf K to -1' in areas which were inaccessible to the divers (Wharves G & H). Generally the mudline along the sheet pile wall was at El.-3 and had no severe variance in that elevation. Typically, at Pile C the mudline drops off at a sharper angle, then levels off outshore of the wharf.
PHOTO NO. 43: Wharf H, Sta. 0+21: illustrates a 2" gap in the seawall construction joint. Note sand and cement eroded from concrete exposing aggregate.

PHOTO NO. 44: Wharf K, Bent 18, Pile M; non-bearing pile.
Pile cap failure has occurred in two locations. In the area of Station 0+75 on Wharf K, Bent 18 at Pile M (see Figure 67), the pile cap has failed in horizontal shear and vertical shear over the pile, (see Photo #45). It is also deflected down approximately 6"-8" from its original position. A similar situation has occurred on Wharf J at approximately Station 10+65, Pile L (see Figure 72). The pile cap has failed over the last pile in the bent. In each location approximately 4 to 6 bents are affected in varying degrees of severity.

At the north end of Wharf H and southwest end of Wharf G a tie-back system has been installed (see Figure 76). This system consists of a steel WF section spanning two pile caps, bearing on the ends of the pile caps. A steel rod is attached to the center of the WF section and runs parallel to the pile cap in the inshore direction. Presumably the tie-rod is anchored to a deadman behind the timber sheet pile wall. The condition of the tie-back system is consistent with its age. There were no visible signs of deterioration, however, there is some mechanical damage at Station 5+30 on Wharf H, where the WF section is deformed. Also on Wharf G, Station 0+70, there is a WF section missing. Apparently this damage was caused by excessive berthing force.

Wharf G has large quantities of flotsam entrapped below the relieving platform. This debris curtailed the divers' access to the sheet pile wall.
PHOTO NO. 45: Wharf K, Bent 18, Pile M; illustrates failure of pile cap due to overloading.
4.12.3 STRUCTURAL ASSESSMENT

Damage which occurs at the perimeter of the wharf can be attributed to excessive berthing forces transmitted by camels. These forces are allowed to effect the structural piles only when the fender system has failed or is non-existent.

Based on a maximum area of 16 sq. ft. supported by one pile, calculations indicate that there has been no change in the live-load capacity of these wharves (see Appendix A-1 to A-8). Minimum pile diameters and the condition of the timber are both at acceptable levels.

Alignment of the seawall and the location of high quantities of non-bearing piles are proportional to each other. Wherever there is a large concentration of non-bearing piles, the seawall is out of alignment. This condition arises from the translation of the relieving platform in the outshore direction. Accompanying the translation is the rotation of the batter piles and consequently the lifting of the relieving platform off the adjacent vertical piles. This condition is caused by excessive lateral earth pressure possibly originating from a live-load acting on the sheet pile wall. The equalizing reaction of the batter pile to lateral force is a vertical force in the upward direction. This condition can easily overstress the batter pile fastenings and create combined stresses in the vertical piles. If the translation is allowed to continue, eventually the overstressing will exceed the ultimate capacity of the timber and fasteners. As a result, failure of the structure will occur.

-71-
Lateral earth pressure originating from the soil retained by the vertical piles is an additional force which adds to the combined stress in the vertical pile. The lateral force generally is greatest where the mudline drops off at the face of the pier, at pile row B or C. The greater the slope of this drop-off, the greater the lateral pressures will be on the vertical pile. When dredging occurs, the natural slump of the soil will not be achieved immediately due to the resistance offered by the vertical piles. At the present time, lateral pressure due to the soil resting on the vertical piles does not contribute significantly to the forces acting on the vertical piles; however, in the future, if excessive dredging occurs along the face of the pier and the soils' natural slump is not allowed to occur, the lateral forces will be more significant.

The failure of the pile caps at Station 0+75 of Wharf K and Station 10+65 of Wharf J are similar in that they are both localized failures. The pile cap and the wale fastened to the timber sheet pile have been displaced downward approximately 4'6". Splitting and crushing of the pile cap have also occurred. The displacement of the wale is a result of overloading its connection to the timber sheet pile wall. When the fasteners failed, this transferred the load to the pile cap causing it to deflect and therefore fail in horizontal shear and vertical shear. The condition of the timber of the affected members is sound, therefore it is assumed that before the failure there was no loss of strength in the structure. The cause of the failure is then attributed to a local overload on the top deck.
4.12.4 RECOMMENDATIONS

The seven (7) broken piles should be replaced. A new creosoted pile should be driven adjacent to the old pile and sprung in under the pile cap, then shimmed to assure proper bearing area (see Appendix A-15 to A-18). The estimated cost to replace one pile in this fashion is $1,000. The total estimated cost is $7,000.

Split piles should be clamped or posted where necessary to assure full bearing of the pile and cap (see Appendix A-16, A-17). The estimated cost of one repair is $400. There are 33 piles which are split. The total estimated cost of repair is $13,200. The 3 wild piles should be refastened to the pile cap in a similar manner. The estimated cost per repair is $400. The total estimated cost is $1,200.

The 515 non-bearing piles in this area should be shimmed to attain full bearing. The average cost to shim one pile is estimated to be $50. The estimated total cost is $25,750. The non-bearing piles in this facility have not been included in the typical pile top repair tabulation because the quantities of non-bearing piles cannot be considered typical or average.

The translation of some sections of the seawall is a serious problem. Along Wharf K (Stations 1+35 through 4+42), Wharf J (Stations 0+00 through 5+00 and Stations 10+15 through 11+30) and Wharf I (Stations 0+00 through 0+50) tie-back systems should be installed to upgrade the capacity of the area behind the wharves. The surcharges applied to the soil inshore of the relieving
platform have created the overload condition resulting in the non-bearing piles. Until the tie-back systems are installed, live-loading behind the relieving platform's sheet pile wall (from the face of the wharves inshore 70') should be restricted to 300 psf (see Appendix A-23). The tie-back system should be of similar construction to that installed on Wharves G and H. This system consists of a WF section bearing on the ends of two pile caps with a 3" diameter tie-rod bolted to the WF section and running parallel to the pile caps in the inshore direction (see Appendix A-22). Approximately 90' inshore there should be an anchoring system, preferably steel H-piles driven with opposing batter along the axis of tension. Depending upon soil conditions, a conventional concrete anchor system could be used in place of steel H-piles. The total number of tie-backs needed is 121. If a tie-back system is employed, the live-load capacity of the wharf itself will not be upgraded, only the live-load capacity of the area directly inshore of the sheet pile wall. Potentially, this area could be upgraded to a live-load of 600 psf. The cost of one tie-rod, installed, is estimated to be $5,000. The total estimated cost of repair is $605,000.

These repairs will solve the problem as it exists presently, however, in the future tie-backs will have to be installed along the full length of the wharf to stabilize the bulkhead as it reacts to loading inshore of the sheet pile. The magnitude of the total cost of these repairs is very large with respect to the improvement of loading capacity. Rebuilding the wharf with a
tied-back steel sheet pile wall would greatly increase a larger portion of the facilities' live-load capacity.

At approximately Station 0+75 of Wharf K and Station 10+65 of Wharf J, repairs should be made to the damaged pile caps. To properly repair the structure, the earth fill above the damaged area should be excavated and shored. The damaged portions of the pile caps and deck planks should be replaced with new timber. The wale running along the top of the sheet pile should be repositioned and refastened. The earth fill should then be replaced. There are 9 sections of pile cap that need to be replaced and approximately 124 sq.ft. of deck plank in need of repair. The total cost of repair is approximately $10,000. See Appendix A-21 for cost breakdown and cross-section. Until the pile caps are repaired, live-loading should be restricted to 0 psf in a radius of 10' around the perimeter of the two damaged areas. Upon completion of the described repairs the live-load capacity will be 300 psf.

Live-loading in deck areas directly associated with damaged (broken, split and wild) piles should be restricted to 25% of the current recommended live-load capacity until those piles are repaired. Following the implementation of the recommended repairs, live-loading can be maintained at current levels (300 psf). Provided that dredge limits are observed, and that the structure is properly maintained, the life expectancy of the structure is in excess of 20 years.
The entire wharf should be re-inspected after repairs and in 6 years thereafter. The portions of the wharves that have been observed to be translating outshore should be inspected on a yearly basis. This will enable Shipyard personnel to determine any change in conditions. This report should be used as a baseline for future inspections.
APPENDIX

CALCULATIONS

Average capacity of relieving platform structure ... A-1 - A-7
Timber pile data summary . . . . . . . . . . . . . . . . . . . . . . A - 8
Typical reduced timber capacity due to softness ... A-9 - A-11
Timber sheet pile analysis . . . . . . . . . . . . . . . . . . . A-12 - A-13
Forces acting on batter piles (Wharves K, J, I, H & G) . . . A - 14

CONCEPTUAL DESIGN

Replacement timber pile . . . . . . . . . . . . . . . . . . . . . . A - 15
Refastening of timber pile . . . . . . . . . . . . . . . . . . . . . A - 16
Posted timber pile . . . . . . . . . . . . . . . . . . . . . . . . . . A - 17
Timber pile long post . . . . . . . . . . . . . . . . . . . . . . . . A - 18
Timber bracing detail . . . . . . . . . . . . . . . . . . . . . . . . A - 19
Pile cap sister . . . . . . . . . . . . . . . . . . . . . . . . . . . A - 20
Pile cap repair . . . . . . . . . . . . . . . . . . . . . . . . . . . A - 21
Tie-back detail . . . . . . . . . . . . . . . . . . . . . . . . . . . A - 22
Cost Estimate Breakdowns . . . . . . . . . . . . . . . . . . . . A - 24
References . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . A - 25
THE MAJORITY OF THE FACILITIES AT THE PNSY CONSIST OF THE LOW DECK, EACH FILLED TIMBER PILE SUPPORTED, RELIEVING PLATFORM STRUCTURE. GENERALLY, THE BENT SPACING IS 4' ON CENTER AND THE PILE SPACING IS 4' ON CENTER. DUE TO LOOSE QUALITY CONTROL DURING THE CONSTRUCTION OF SOME FACILITIES, ON A REGULAR BASIS THE BENT SPACING IS AS MUCH AS 5' AND THE PILE SPACING IS ALSO 5'. THESE MAXIMUM SPACINGS ARE NOT TYPICAL AND ARE NOT CONTROLLING FACTORS. THE FOLLOWING CALCULATIONS HAVE TAKEN THE AVERAGE EXISTING CONDITION AND DETERMINED THE LIMITING COMPONENTS WITH RESPECT TO THE TOP DECK LIVE LOAD CAPACITY. ALSO IN THE APPENDIX ARE ANALYSES OF SINGULAR ANOMALIES AND NON-TYPICAL CONDITIONS.
DETERMINE TIMBER PILE COLUMN CAPACITY

**ASSUME:**

- $E = 160 \times 10^6 \text{ #/in}^2$
- $l = 480'' = 40'\text{''}$
- $K = 17$
- $e = 2.75''$

**REDUCED PILE DIAMETER DUE TO TIMBER SOFTNESS**

FROM THE TIMBER CONSTRUCTION MANUAL

**USE:**

$$ F_c' = \frac{3.619 \cdot E}{(K \cdot l)^2} $$

- $F_c' = 387 \text{ #/in}^2$
- $F_c = 387 \text{ #/in}^2 \times (0.9) \text{ (Factor) DURATION OF LOAD FACTOR}$
- $F_c = 348 \text{ #/in}^2$

$$ P = F_c \cdot A $$

- $P = (348 \text{ #/in}^2) \times 95 \text{in}^2$
- $P = 33K \times 16.5 \text{ Tons}$

16.5 TON COLUMN CAPACITY > 15 TON DRIVEN CAPACITY

**THEREFORE THE DRIVEN CAPACITY IS LIMITING**
**DETERMINE DECK TIMBER CAPACITY**

**Assume:**
- $F_u = 1650 \text{ lb/ft}^2$
- $M_{max} = \frac{W \times L}{12}$
- $F_v = 120 \text{ lb/ft}^2$
- $F_{cu} = 315 \text{ lb/ft}^2$
- $k = 48''$
- **Reduced section** $= 3\frac{1}{2}'' \times 1\frac{1}{4}''$

**Bending**
- $S = 23 \text{ in}^3$
- $M_{max} = S \times F_u \times 0.9$
- $W = \frac{12 \times M_{max}}{L^2}$
- $W = 117 \text{ k/ft} = 2.13 \text{ k/ft}$

**Horiz. Shear**
- For rectangular beams $F_v = \frac{3V}{2A}$
- $W = \frac{2F_v A \times 9 (2)}{3 \times 8''} = 40''$
- $W = 0.14 \text{ k/ft} = 1.68 \text{ k/ft}$ limiting

**Crushing**
- Area of bearing $= 144 \text{ in}^2$
- $W = \frac{(315 \text{ lb/ft}^2)(144 \text{ in}^2) \times 9 (0.7)}{60 \text{ in}}$
- $W = 455 \text{ lb/ft} = 5.46 \text{ k/ft}$
DETERMINE TIMBER PILE CAP ABILITY

12x12 PILE CAP

\[ \text{Assume: } F_b = 1650 \text{ psi} \]

\[ F_v = 120 \text{ psi} \]

\[ F_{la} = 315 \text{ psi} \]

USE REDUCED SECTION DUE TO SOFTNESS 11x11

BENDING

\[ S = 221 \text{ in}^3 \]

\[ M_{max} \leq F_b \cdot \frac{S}{12} \]

\[ M_{max} = 328,195 \text{ in-lb} \]

\[ W = \frac{12 \cdot M_{max}}{E \cdot I} \]

\[ W = 1.7 \text{ k/ln} = 20 \text{ k/ft} \]

HORIZONTAL SHEAR

\[ \frac{F_v}{W} \]

For rectangular beams:

\[ F_v = \frac{3V}{2A} \]

\[ W = 2 \cdot F_v \cdot A \cdot \frac{V}{E} \]

\[ W = 67.7 \text{ k/ln} = 8 \text{ k/ft} \] LIMITING

CRUSHING

\[ \text{Area of bearing } A_n = 180 \text{ in}^2 \]

\[ W = \frac{(315 \text{ psi})(180 \text{ in}^2)}{48 \text{ in}^2} \cdot \frac{9}{1.47} \]

\[ W = 2,549 \text{ k/ft} \]
Determining unit dead load imposed by low deck, earth fill, relieving platform structure.

- In considering the DL on timber piles and timber pile caps use a unit load of 1.5 k/ft².

- In considering the DL on the timber decking use a unit load of 1.3 k/ft².
IN ASSUMING A MAXIMUM BENT SPACING OF 5' AND A PILE SPACING OF 4', WE CAN DETERMINE THE ALLOWABLE LIVE LOAD CAPACITY.

LIMITING FACTORS -
- **Pilecap** - 8 k/ft
- **Deck Plank** - 1.68 k/ft²
- **Timber Pile** - 30 k

- THE DL ON THE TIMBER PILE IS 1.5 k/ft²; ASSUME AN AREA OF 16 ft² IS SUPPORTED BY 1 PILE DUE TO THE TYPICAL LOAD DISTRIBUTION.

  \[ \text{Total DL} = 24 \text{ k} \]
  \[ \text{Allowable Load} = 30 \text{ k/pile} \]
  \[ LL = 30 \text{ k} - 24 \text{ k} = 6 \text{ k} \]
  \[ LL = 375 \text{ PSF} \]

  IF THE ALLOWABLE LOAD IS 40 k/pile THEN \( LL = 1000 \text{ PSF} \)

- THE DL ON THE PILE CAP IS 1.5 k/ft²; ASSUME AN AREA OF 16 ft² IS SUPPORTED.

  \[ \text{Total DL} = 24 \text{ k} \]
  \[ \text{Allowable Load for 4' Span} = 32 \text{ k} \]
  \[ LL = 32 \text{ k} - 24 \text{ k} = 8 \text{ k} \]
  \[ = 500 \text{ lb/ft²} \]
- The DL on the deck planking is 1.3 K/ft² with a 5' bent spacing; the length of deck plank under consideration is 3.33'.

  Total DL = 4.3 K
  Total Allowable Load = 5.5 K

  LL = 5.5 K - 4.3 K = 1.29 K
     = 388 #/ft²

In the typical relieving platform structure, the timber decking is the capacity which limits the live loading. The calculations show that 388 #/ft² is the maximum LL that the typical relieving platform can handle. Although, if the pile spacing and bent spacing are less than 4' and 5' respectively, the capacity of the relieving platform is much greater.
## Timber Pile Data Summary

<table>
<thead>
<tr>
<th>Facility</th>
<th><strong>Range of Structural Timber Softness Detected</strong></th>
<th><strong>Range of Pile Diameters Observed</strong></th>
<th>Timber Pile Driven Capacity***</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern Seawall</td>
<td>3/4&quot; ave.</td>
<td>11&quot; - 15&quot;</td>
<td>3 - 20</td>
</tr>
<tr>
<td>Pier 7</td>
<td>2&quot; - 6&quot;</td>
<td>10&quot; - 15&quot;</td>
<td>15</td>
</tr>
<tr>
<td>Pier 1 &amp; Bulkhead</td>
<td>1&quot; ave.</td>
<td>11&quot;</td>
<td>15</td>
</tr>
<tr>
<td>Pier 2</td>
<td>1&quot; - 2&quot;</td>
<td>10&quot; - 14&quot;</td>
<td>15</td>
</tr>
<tr>
<td>Wharves 4A &amp; 4B</td>
<td>3/4&quot; ave.</td>
<td>9&quot; - 14&quot;</td>
<td>15</td>
</tr>
<tr>
<td>Pier 4</td>
<td>1/2&quot; ave.</td>
<td>9&quot; - 13&quot;</td>
<td>15 - 20</td>
</tr>
<tr>
<td>Pier 5</td>
<td>1/4&quot; - 1/2&quot;</td>
<td>10&quot; - 17&quot;</td>
<td>20</td>
</tr>
<tr>
<td>Barge Basin &amp; Bkhd</td>
<td>1/2&quot; - 1&quot;</td>
<td>9&quot; - 14&quot;</td>
<td>15</td>
</tr>
<tr>
<td>Pier 6</td>
<td>1/4&quot; - 1&quot;</td>
<td>10&quot; - 14&quot;</td>
<td>15</td>
</tr>
<tr>
<td>Pier 6A-Bulkhead</td>
<td>1&quot; - 4&quot;</td>
<td>10&quot; - 13&quot;</td>
<td>15</td>
</tr>
<tr>
<td>DD Wharves</td>
<td>1/2&quot; ave.</td>
<td>11&quot; - 18&quot;</td>
<td>15</td>
</tr>
<tr>
<td>Wharves K, J, I, H, G</td>
<td>1/2&quot; ave.</td>
<td>10&quot; - 16&quot;</td>
<td>15</td>
</tr>
<tr>
<td>Wharf F/Pier F</td>
<td>1/2&quot; - 1&quot;</td>
<td>11&quot; - 15&quot;</td>
<td>15</td>
</tr>
<tr>
<td>Wharf E</td>
<td>1/2&quot; - 1 1/2&quot;</td>
<td>9&quot; - 14&quot;</td>
<td>15</td>
</tr>
<tr>
<td>Rowan Ave.</td>
<td>NA*</td>
<td>NA*</td>
<td>NA*</td>
</tr>
<tr>
<td>2nd Street</td>
<td>1 1/2&quot; - 3&quot;</td>
<td>9&quot; - 12&quot;</td>
<td>15</td>
</tr>
<tr>
<td>Preble Ave.</td>
<td>1 1/4&quot; - 2&quot;</td>
<td>8&quot; - 10&quot;</td>
<td>15</td>
</tr>
<tr>
<td>Broad Street</td>
<td>1 1/2&quot; - 3&quot;</td>
<td>11&quot; - 14&quot;</td>
<td>15</td>
</tr>
<tr>
<td>Wharf L</td>
<td>1/2&quot; - 1 1/2&quot;</td>
<td>9&quot; - 10&quot;</td>
<td>15</td>
</tr>
<tr>
<td>Wharf N</td>
<td>1&quot; - 3&quot;</td>
<td>9&quot; - 14&quot;</td>
<td>15</td>
</tr>
</tbody>
</table>

* NA = Not Applicable

** For detailed account of timber softness, i.e., variations between piles, caps, decking; see individual facility's Observed Inspection Condition.

*** Timber pile driven capacities have been extrapolated from GFI such as the Hudson Engineers Report or actual NAVFAC or PW drawings.
TYPICAL TIMBER SOFTNESS

PIER 7

DETERMINE REDUCED CAPACITY OF TIMBER PILE CAP DUE TO TIMBER SOFTNESS.

\[ F_b = 1650 \text{ psi} \]
\[ F_v = 120 \text{ psi} \]
\[ F_{cd} = 315 \text{ psi} \]
\[ L = 48" \]

**BENDING**

\[ S = 130 \text{ in}^3 \]
\[ M_{av} = 0.9 \]
\[ M_{av} = 195 \text{ in}-\text{lb} \]
\[ W = \frac{12 \times M_{av}}{L} = 12.1 \text{ k/ft} \]

**HORIZONTAL SHEAR**

\[ W = \frac{2F_v A'}{2L} (2) = 6.3 \text{ k/ft} \]

**CRUSHING**

Assume area of bearing \( A' = 165" \)

\[ W = \frac{F_{cd} A'}{48} \]

\[ W = \frac{315 \text{ psi} (165 \text{ in})}{48 \text{ in}} = 7.8 \text{ k/ft} \]
**Typical Timber Softness**

**PIER 7**

**DETERMINE REDUCED CAPACITY OF TIMBER DECKING DUE TO SOFTNESS**

\[ F_w = 1650 \text{ psi} \]
\[ F_v = 120 \text{ psi} \]
\[ F_{cd} = 315 \text{ psi} \]

**ORIGIINAL 4 X 12 DECKING**

**AREA OF TIMBER REMAINING AFTER A REDUCTION IS CONSIDERED**

Assume \( A' = 30 \text{ in}^2 \)

**BENDING**

\[ S = 15 \text{ in}^2 \]
\[ \text{Max} = S \quad \frac{F_w}{A'} \]
\[ \text{Minx} = 22.2 \text{ in} - K \]

\[ W = \frac{12 \text{ Max}}{K} = 1.37 \text{ K/ft} \quad \text{where} \quad K = 45 \text{ in} \]

**Horiz. SHEAR**

\[ W = 2 \frac{F_v A'}{3K} = 1.23 \text{ K/ft} \quad \text{where} \quad K = 45 \text{ in} \]

**CRUSHING**

Area of bearing 120 in\(^2\)

\[ W = \frac{(315 \text{ psi})(120 \text{ in}^2)(0.68)}{60 \text{ in}} = 4.6 \text{ K/ft} \]

WE CONCLUDE THAT THE LIMITING FACTOR ON PIER 7 IS THE HORIZONTAL SHEAR CAPACITY OF THE REDUCED SECTION OF THE DECK PLANK.

**WHEN LOADING ON THE DECK PLANK IS ANALYSED THE DL = 1.3 K/ft\(^2\) ALLOWABLE LOAD = 1.23 K/ft\(^2\)**

**THIS IS A CONDITION OF IMPENDING FAILURE**
REDUCED TIMBER PILE CAPACITY
(Bulkhead Between Pile C and Pile G)

ASSUME:

- \( E = 1.6 \times 10^6 \text{ psi} \)
- \( L = 15' = 180" \)
- \( k = 0.7 \)
- \( \gamma = 1.75 \text{ ksf} \)

From AITC Use:

\[
F_c' = \frac{3.619E}{(K8/\gamma)^2}
\]

- \( F_c' = 11 \text{ ksf} \)
- \( F_c = 11 \text{ ksf} (0.1) \)
- \( F_c = 1.1 \text{ ksf} \)
- \( P = F_c A \)
- \( P = 0.99 \text{ ksf} (38.5 \text{ in}^2) \)
- \( P = 38.1 \text{ k} \)

19T Col. Cap. > 15T Driven Cap

Therefore, Driven Capacity is Limiting.
TINFERN SHEET FILE ANALYSIS

SUNCHARGE ACTING @ F-1 = 600 PSF + 1.5 PSF
= 600 PSF + (10.5 x 125 PSF) + 25 x 125 PSF
= 2062 PSF

Determine K = Pt OR CONTRAWEIGHT

For z = 2 ft x = 0.1 H
H' = 11 + 8/11 = 12

x = 2.8

L = H + x = 11 + 2.8 = 13.8 ft

Calculate total load W

W = \( \frac{945 \times 11.9}{2} \) (1.8) + \( \frac{1120 \times 728}{2} \) (2.8) = 14,215 LB/FT HAM LAM

Evaluate:

\( M_W = \frac{W}{9} \times \left( 1.8 \times 13.8 \right) / 8 = 24.2 \text{ FT-L} \)

Using 11.5 x 11.5 k = 50,000 lbs

\( S = 25.3 \text{ in}^2 \ F_L = 400 \text{ PSF} \)

\( (S)(1.8)(1.5) = 21.4 \text{ FT-L} \geq 24.2 \text{ FT-L} \)
\[ \begin{align*}
\text{Table:} & \\
\text{Col. 1} & \text{Col. 2} & \text{Col. 3} & \text{Col. 4} & \text{Col. 5} \\
& \gamma_h & \gamma_h & P_a & P_a \\
\text{1.013} & 2.023 & - & 932 & 2 \\
\text{2.023} & 0 & - & 1179 & 0 \\
\end{align*} \]

**Notes:**

- SCALE
- CALCULATED BY: SAT
- CHECKED BY: DA1

**Equation:**

\[ (\frac{\text{mass}}{\text{area}} \cdot \text{height}) (1 - \frac{\text{height}}{\text{mass}}) \]

- \( \text{mass} = 7.1 \text{ k} \)
- \( \text{height} = \frac{2}{3} \)
- \( \text{mass} \cdot \text{height} = \frac{14}{3} \text{ k} \)
- \( \text{height}^2 = \frac{4}{9} \text{ k}^2 \)
- \( \text{mass} \cdot \text{height} > \frac{14}{9} \text{ k}^2 \)
- \( 10.6 > 7.1 \text{ k} \)

**Conclusion:**

\[ \checkmark \]
LATERAL EARTH PRESSURE ACTS ON SHEET PILE WALL

LATERAL EARTH PRESSURE

VERTICAL PILE RESISTANCE

RESOLUTION OF FORCES

\[ PV, \text{ LIVE LOAD + DEAD LOAD} \]

\[ BV, \text{ BATTER PILE VERTICAL COMPONENT} \]

\[ BH, \text{ BATTER PILE HORIZONTAL COMPONENT} \]

\[ LH, \text{ LATERAL EARTH PRESSURE} \]

\[ LV, \text{ LATERAL LOAD} \]

NOTE: TO DEVELOP DISPLACEMENT OF POINT 'A', AS SHOWN, THE RESULTANT OF \[ LH \]

AND \[ BV \] MUST EXCEED THE RESULTANT OF \[ PV \] AND \[ BH \]
REPLACEMENT TIMBER PILE
CONCEPTUAL DESIGN

EXISTING PILE CAP

PILING CUT TO FIT
BEFORE PULLING
INTO PLACE

EXISTING BAD PILE
LEFT IN PLACE

NEW TREATED TIMBER
PILE DRIVEN THROUGH
HOLE CUT IN PIER DECK

NEW PILE FASTENED TO
PILE CAP AFTER BEING
PULLED INTO PLACE

MUDLINE

ESTIMATED COST TO REPLACE
TIMBER PILE = $1000
CONCEPTUAL DESIGN

REFASTEN TIMBER PILE TO PILE CAP

EXISTING PIER DECK

EXISTING PILE CAP

EXISTING PILE

ELEVATION

ESTIMATED COST TO REFASTEN TIMBER PILE TO PILE CAP - $4,000

PLAN

GRAPHIC SCALE

NO SCALE

A-18

CHESapeake DIVISION
NAval FacILITIES ENGINEERING COMMAND

CHILO ENGINEERING CORPORATION
BOX 202
WESTFIELD, MA

PHILADELPHIA NAVAL SHIPYARD
PHILADELPHIA, PA

CLAMP TIMBER PILE
POSTED TIMBER PILE
CONCEPTUAL DESIGN

EXISTING PILE CAP

NEW 4X10 TREATED TIMBER SCABS

MLW

DAMAGED PIECE OF PILE CUT OUT AND REPLACED BY TREATED PILE BUTT

ESTIMATED COST TO POST A TIMBER PILE $400

NEW 7/8" GALVANIZED BOLTS

POSTING DETAIL

<table>
<thead>
<tr>
<th>GRAPHIC SCALE</th>
<th>POSTED TIMBER PILE</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO SCALE</td>
<td>POSTED TIMBER PILE</td>
</tr>
</tbody>
</table>

CHESapeake DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D.C.

PHILADELPHIA NAVAL SHIPYARD
PHILADELPHIA, PA

CHILDERS ENGINEERING CORPORATION
P.O. Box 322
MERTFELD, WA

A-17
TIMBER PILE LONG POST
CONCEPTUAL DESIGN

- TIMBER DECK
- EARTH FILL
- EXISTING PILE CAP
- STEEL SCAP PLATE
- USE NEW 7/8" GALVANIZED BOLTS TO FASTEN POST TO CAP OR CLAMPS
- NEW TREATED TIMBER PILE POST

NOTE:
STEEL SLEEVES OR STEEL PIPE CAN BE ADDED TO PROVIDE MOMENT CONNECTION AT THE MUPLINE

1" DOWEL
BACK FILL ABOVE SPICE JOINT
EXISTING PILE CUT BELOW ML

NOTE: 1. CROSS BRACING MUST BE USED BETWEEN ADJACENT LONG POSTS TO INSURE STABILITY IF THERE IS NO MOMENT CONN. AT THE ML
2. ESTIMATED COST OF REPAIR IS $1500 PER PILE

GRAPHIC SCALE
NO SCALE

A-18
SECTION

CONCEPTUAL DESIGN

BENTS 4 THRU 8

BULKHEAD WEST OF BARGE BASIN

NOT TO SCALE
CONCEPTUAL DESIGN

CONC. SEAWALL

LAG BOLT Ø

TIMBER DECK

G x 12 TIMBER SISTERS

STEEL PLATE OR ANGLE

TRIM TIMBER PILE TO FIT STEEL Ø

SECTION

TIMBER PILE

EXISTING PILE CAP

G x 12 TIMBER SISTERS

FASTENER Ø

STEEL PLATE OR ANGLE

PLAN

NOT TO SCALE.

A-20

PILE CAP SISTER
CROSS SECTION OF DAMAGED AREA

(WHARF 5, STA 0-75; WHARF J, STA 10+65)

REPAIR PROCEDURE
1. LOCATE DAMAGED AREA OF WHARF
2. EXCAVATE OVER DAMAGED AREA
3. REPLACE ANY DAMAGED STRUCTURAL MEMBER
4. BACKFILL EXCAVATION

COST ESTIMATES
1. COST OF EXCAVATION AND BACKFILL - $15/CF @ APPROX. 289 CF = $4335
2. COST OF TIMBER - $5/FT (LINEAL) @ APPROX. 1052 FT = $5260

TOTAL EST. COST = $9595 + MOB + FUEL
CONCEPTUAL DESIGN

ELEVATION

SECTION - A

NOTE:
FENDER SYSTEM NOT SHOWN FOR CLARITY
In areas where translation has occurred, the 300 psf live load limit should be extended to 70 ft from the face of the wharf as shown.

**Typical Cross Section**

(Work: A. J. H. G.)
1) REPLACEMENT PILE - UNIT COST $1000 (IN PLACE)

2) PILE TOP REPAIR i.e. REFASTEN, SHORT POST, PILE CAP SISTER

ASSUME:

<table>
<thead>
<tr>
<th>CREW</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Foreman</td>
<td></td>
</tr>
<tr>
<td>2 Dock Builders</td>
<td>$1100 /DAY</td>
</tr>
<tr>
<td>1 Laborer</td>
<td></td>
</tr>
<tr>
<td>1 Diver</td>
<td></td>
</tr>
</tbody>
</table>

AVERAGE LABOR COST PER REPAIR - 275

MATERIALS COST PER REPAIR - 125

AVERAGE COST/REPAIR $400

3) LONG POST REPAIR

CREW COST/REPAIR $750

MATERIALS COST/REPAIR $250

AVERAGE COST/REPAIR $1000

4) TIMBER SHEET PILE REPAIR

2 STEEL H-PILES IN PLACE (UNIT COST) $2000

COST OF MISCELLANEOUS MATERIALS $500

COST OF LABOR $500

EST. TOTAL $3000

NOTE:
1) COSTS ARE BASED ON 1983 U.S. EAST COAST PRICES.
2) COSTS DO NOT INCLUDE MOBILIZATION/DEMOBILIZATION
REFERENCES

1. Master Plan for Naval Base, Philadelphia, PA
   August 1975

2. Divers Inspection, Engineering Evaluation and
   Preliminary Recommendations for Piers and
   Bulkheads at the Philadelphia Naval Shipyard,
   Philadelphia, Pennsylvania; prepared by
   Hudson Engineers, Inc., Philadelphia, PA
   September 1976

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