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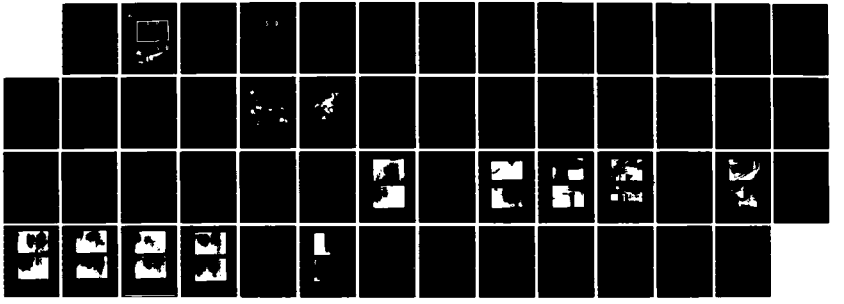

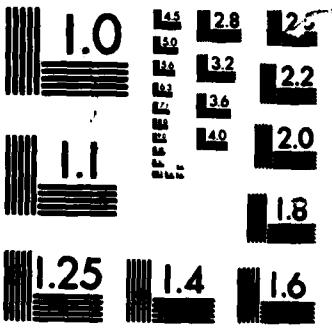

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UNDERWATER FACILITIES INSPECTIONS & ASSESSMENTS

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NORFOLK NAVAL SHIPYARD
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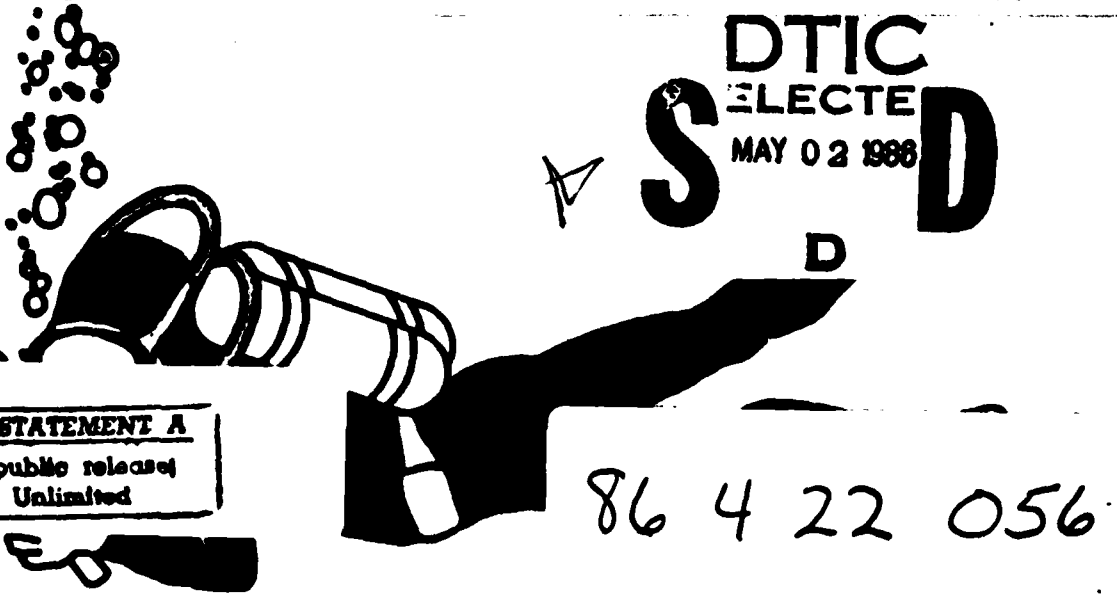

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PERFORMED FOR:

OCEAN ENGINEERING AND CONSTRUCTION PROJECT OFFICE
CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D.C. 20374

UNDER:

CONTRACT N62477-81-C-0161
TASK 1

BY:

COLLINS ENGINEERS, INC.
600 WEST JACKSON BOULEVARD
CHICAGO, ILLINOIS 60606

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19. ABSTRACT (Continue on reverse if necessary & identify by block number)

In August, 1981, an underwater inspection was conducted at the Norfolk Naval Shipyard, Portsmouth, Virignia to assess the condition of the submerged portions of the piers, wharfs, and quaywalls forming the perimiter of Slips 1, 3, 4, and 5. (Con't)

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A visual "swim-by" inspection was made of all facilities under investigation, and a more detailed visual and tactile instpetion was made of approximately 20 percent of the components. This detailed inspection included wire brush cleaning and scraping f slected areas, and documentation of conditins with color photography.

The perimeter of Slip 1 is formed by the quaywalls of Berths 3 through 6. Berths 3 and 6 are constructed of precast concrete bearing piles supporting a concrete deck in front to a steel sheet pile retaining wall. Berths 4 and 5 and the back wall of the slip consist of a cast-in-place concrete wall. The quaywalls at Berths 3 and 6 are generally in good condition and no immediate repairs are necessary. The walls at Berths 4 and 5 and the back of the slips are in fair condition, and no repairs are warranted at this time.

Slips 3, 4, and 5 are formed by Piers 3, 4, 5, and 6. These piers are supported by timber bearing piles and enclosed by a precast concrete sheet pile perimeter wall.

Generally, the concrete sheet pile faces are full and solid, and the concrete sheet piles are properly aligned; although there are many areas where the edges of the piles are cracked or broken off, reinforcing steel is exposed and the joint at the interlock is not ithgt. The concrete sheet piles of Piers 3, 4, and 5 and approximately the west 850 ft of Pier 6 are in fair to good condidtion. These areas of distress to the concrete sheet piles, however, do not warrant repairs at this time.

The inspection of Piers 3, 4, 5 and approximately the west 850 ft of Pier 6 was limited to the concrete sheet piles because there was no access to the timber bearing piles. In order to comprehensively assess the structural conditin of Piers 3, 4, 5, and 6, the timber piles must be made accessible.

Ap]proximately the east 150 feet of Pier 6 is supported by steel H-piles. There has been significant deterioration of these piles from the waterline to approximately Elevation - 20. It is estimated that there has been a 25 to 50 percent loss of cross-sectional area of these piles. Because complete design drawings are not available for this areaa of the pier, a complete detailed analysis of the load carrying capacity of the facility could not be made. A ppreliminary analysis, using limited available information, indicates that an interime load restriction should be placed on this area of Pier 6. It is recommended that an investigation be conducted to determine the configuration fo the existing structure, the amount of loss that has occurred to all the steel piles in the areas, and the loads acting on the structure.

Design loads furnished by Shipyard personnel are contained in the report. No reductions from these design loads are warranted for the quaywalls of Berths 3 through 6; Piers 3, 4, and 5; and the west 850 feet of Pier 6. For the east 150 feet of Pier 6, however, it is recommended that hte live load be restricted to 100 pounds per square foot unt8il a detailed investigation can be completed.

FOREWORD

The scope of the inspection at the Norfolk Naval Shipyard in Portsmouth, Virginia and the detail to which it was performed and reported was tailored specifically to the conditions at this facility. This report or the procedure associated with its formation is not intended to be a standard for inspections or reports covering other activities. Attempts are being made, however, toward establishing standards for procedures and formats for inspection and assessment reports. Through these standards, inspections performed by different persons, on many facilities and under a wide range of conditions can be effectively compared. It is expected that the inspections and assessments of the Norfolk facilities, like previous operations mandated under the underwater portion of the Specialized Inspection Program, will contribute significantly toward achieving that objective.

It should be noted that the choice of the level of inspection and the procedural detail to be employed will be an engineering judgment made separately for each activity/facility to suit its unique situation and needs. Accordingly, the procedures used at the Norfolk Naval Shipyard, rather than serve as a detailed model for inspections elsewhere, will provide guidance with general applicability to future inspections.

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EXECUTIVE SUMMARY

In August, 1981, an underwater inspection was conducted at the Norfolk Naval Shipyard, Portsmouth, Virginia to assess the condition of the submerged portions of the piers, wharfs, and quaywalls forming the perimeter of Slips 1, 3, 4, and 5.

A visual "swim-by" inspection was made of all facilities under investigation, and a more detailed visual and tactile inspection was made of approximately 20 percent of the components. This detailed inspection included wire brush cleaning and scraping of selected areas, and documentation of conditions with color photography.

The perimeter of Slip 1 is formed by the quaywalls of Berths 3 through 6. Berths 3 and 6 are constructed of precast concrete bearing piles supporting a concrete deck in front of a steel sheet pile retaining wall. Berths 4 and 5 and the back wall of the slip consist of a cast-in-place concrete wall. The quaywalls at Berths 3 and 6 are generally in good condition and no immediate repairs are necessary. The walls at Berths 4 and 5 and the back of the slip are in fair condition, and no repairs are warranted at this time.

Slips 3, 4, and 5 are formed by Piers 3, 4, 5, and 6. These piers are supported by timber bearing piles and enclosed by a precast concrete sheet pile perimeter wall.

Generally, the concrete sheet pile faces are full and solid, and the concrete sheet piles are properly aligned; although there are many areas where the edges of the piles are cracked or broken off, reinforcing steel is exposed and the joint at the interlock is not tight. The concrete sheet piles of Piers 3, 4, and 5 and approximately the west 850 ft of Pier 6 are in fair to good condition. These areas of distress to the concrete sheet piles, however, do not warrant repairs at this time.

The inspection of Piers 3, 4, 5 and approximately the west 850 ft of Pier 6 was limited to the concrete sheet piles because there was no access to the timber bearing piles. In order to comprehensively assess the structural condition of Piers 3, 4, 5, and 6, the timber piles must be made accessible.

Approximately the east 150 feet of Pier 6 is supported by steel H-piles. There has been significant deterioration of these piles from the waterline to approximately Elevation - 20. It is estimated that there has been a 25 to 50 percent loss of cross-sectional area of these piles. Because complete design drawings are not available for this area of the pier, a complete detailed analysis of the load carrying capacity of the facility could not be made. A preliminary analysis, using limited available information, indicates that an interim load restriction should be placed on this area of Pier 6. It is recommended that an investigation be conducted to determine the configuration of the existing structure, the amount of loss that has occurred to all the steel piles in the area, and the loads acting on the structure.

Design loads furnished by Shipyard personnel are contained in the report. No reductions from these design loads are warranted for the quaywalls of Berths 3 through 6; Piers 3, 4, and 5; and the west 850 feet of Pier 6. For the east 150 feet of Pier 6, however, it is recommended that the live load be restricted to 100 pounds per square foot until a detailed investigation can be completed.

The Executive Summary Table on the following page summarizes the condition of each facility; recommended repairs and associated costs; and recommended intervals between future inspections.

EXECUTIVE SUMMARY TABLE

Facility	General Condition Assessment and Recommendations
Quaywalls;	
Berths 3 & 6	Generally good condition. Recommend repair of hole in steel sheet pile wall at west end of Berth 3 as part of other maintenance work; estimated cost - $30,000. Recommend inspection at 3 to 5 year intervals.
Berths 4 & 5	Generally fair condition. Recommend inspection at 3 to 5 year intervals.
Pier 3	Approximately 30 percent of pile edges cracked.
Pier 4	Approximately 50 percent of pile edges cracked or broken off.
Pier 5	Approximately 75 percent of pile edges cracked or broken off; two piles twisted out of interlock.
Pier 6 (West 850 ft)	Generally good condition. Recommend inspection of Piers 3, 4, 5, and 6 at 3 to 5 year intervals.
Pier 6 (East 150 ft)	Poor condition; recommend further detailed investigation and interim load restriction of 100 psf.

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LIST OF FIGURES AND PHOTOGRAPHS

UNDERWATER FACILITIES
INSPECTION AND ASSESSMENT
AT
NORFOLK NAVAL SHIPYARD
PORTSMOUTH, VIRGINIA

1. INTRODUCTION

1.1 Purpose and Scope

This report consists of the results of a detailed underwater inspection and assessment of submerged portions of several Navy waterfront facilities at the Norfolk Naval Shipyard in Portsmouth, Virginia.

The investigation was conducted by Collins Engineers, Inc. for the Ocean Engineering and Construction Project Office of the Chesapeake Division, Naval Facilities Engineering Command as Task No. 1 of Contract N62477-81-C-0161.

The project included the piers, wharfs and quaywalls forming the perimeter of Slips 1, 3, 4, and 5 at the Shipyard. The facilities, generally, are constructed of concrete walls, precast concrete sheet piling, steel sheet piling, precast concrete piles, and steel H-piles.

1.2 Field Inspection Phase

The field inspection phase consisted of an underwater inspection of submerged steel and precast concrete bearing piles; steel and precast concrete sheet piles; and cast-in-place concrete walls by a structural engineer-diver and technician-divers. The inspection was conducted in such detail as to permit a general assessment of the physical condition of the portions of the substructure that are submerged or subject to frequent wetting by wave or tidal action. A visual "swim-by" inspection was made of all facilities under investigation and a more detailed visual and tac-

tile inspection was made of approximately 20 percent of the facility components. This detailed inspection included scraping and wire brush cleaning of selected areas of approximately 10 percent of the facilities.

The "swim-by" inspection was conducted in accordance with the government's guidelines for Level I Inspections and the detailed inspection was conducted in accordance with the guidelines for Level II Inspections. Those levels of inspection are defined below.

Level I: General Inspection: This type of inspection is essentially a "swim-by" overview, which does not involve cleaning of any structural elements, and therefore can be conducted much more rapidly than the other levels of inspection. The Level I inspection should confirm as-built structural plans and detect obvious major damage or deterioration due to overstress (collisions, ice), severe corrosion, or extensive biological attack. The underwater inspector shall generally rely primarily on visual and tactile observations to make condition assessments. Visual documentation (utilizing underwater television and/or photography) may be included with the quantity and quality adequate for documentation of the findings which will be representative of the facility condition.

Level II: Detailed Inspection: This type of inspection will often require prior cleaning of the structural elements. The purpose of the Level II inspection is to detect surface damage which may be hidden by marine growth and/or deteriorated surface material. Generally, cleaning is time consuming, and therefore is generally restricted to areas that are critical

or which may be representative of the entire structure itself. The amount and thoroughness of cleaning to be performed is governed by what is necessary to discern the exterior physical condition of the structural members, and to rapidly obtain nominal measurements by means of simple instruments such as calipers, measuring tapes, and ice picks. This level of assessment should identify areas that have been mechanically damaged or are in advanced states of deterioration. Visual documentation (utilizing underwater television and/or photography) and a sampling of physical measurements should be included with the quantity and quality adequate for documentation of the findings which will be representative of the facility condition.

1.3 Assessment Phase

The assessment phase of the investigation consists of summarizing the conditions encountered during the field inspection, evaluating their structural significance, and recommending actions that should be taken to insure long term cost-effective maintenance and utilization of the facilities.

The assessment is presented in this report complete with sketches depicting the configuration of the existing facilities, and sketches and photographs illustrating existing conditions.

2. ACTIVITY DESCRIPTION

2.1 Name of Activity

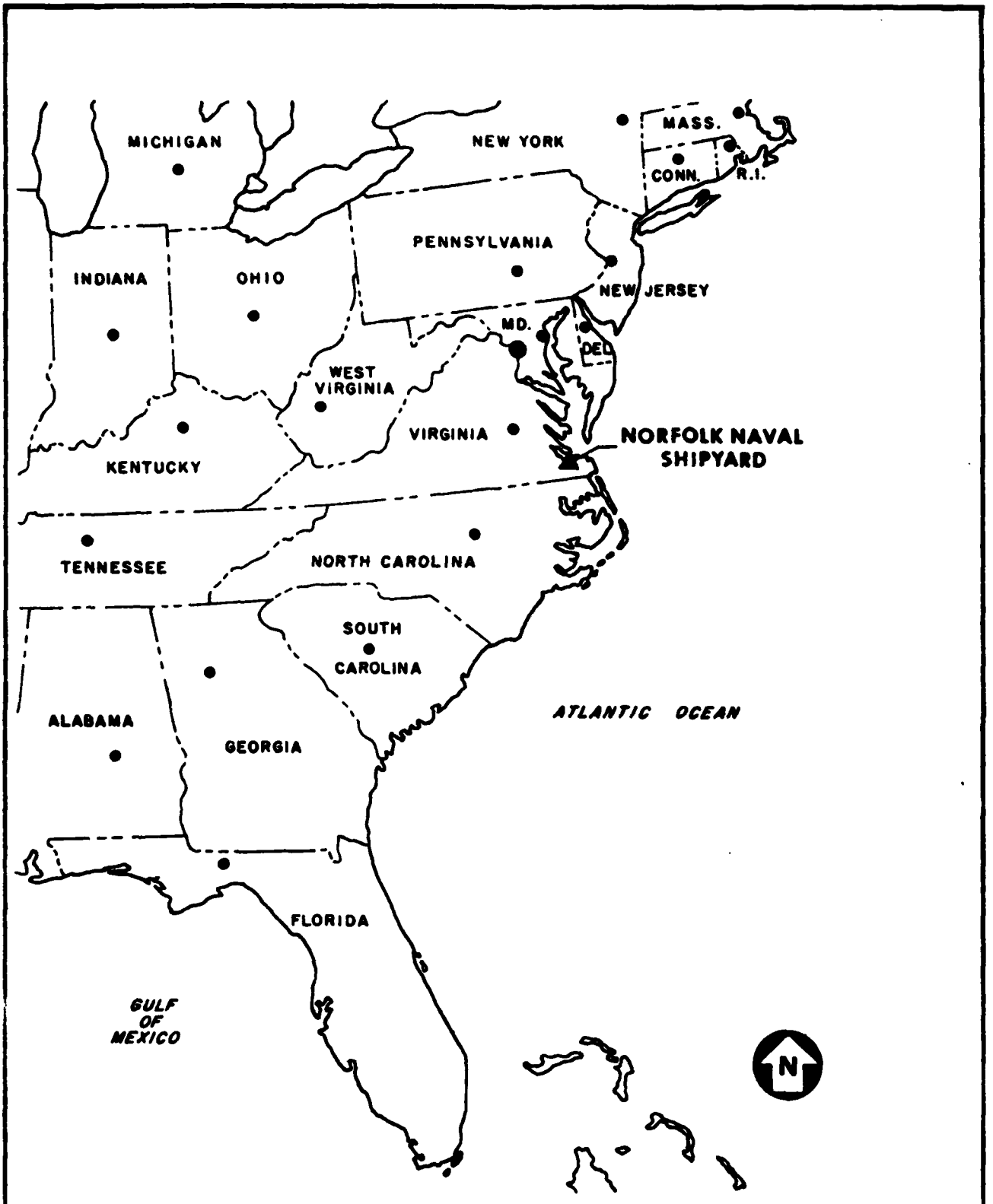
Norfolk Naval Shipyard, Portsmouth, Virginia

2.2 Location of Activity

The Norfolk Naval Shipyard is located in Portsmouth, Virginia on the Southern Branch of the Elizabeth River, adjacent to Chesapeake Bay. It is situated at Longitude 76°-17'-41" W and Latitude 36°-49'-19" N, near the mid-Atlantic coast with excellent access to one of the world's finest harbors, Hampton Roads. It is approximately 200 highway miles south of Washington, D.C., as shown in Figure 1, following this page. It is situated approximately 12 miles south of the Atlantic Fleet Headquarters, the U.S. Naval Station and Naval Air Station at Sewells Point.

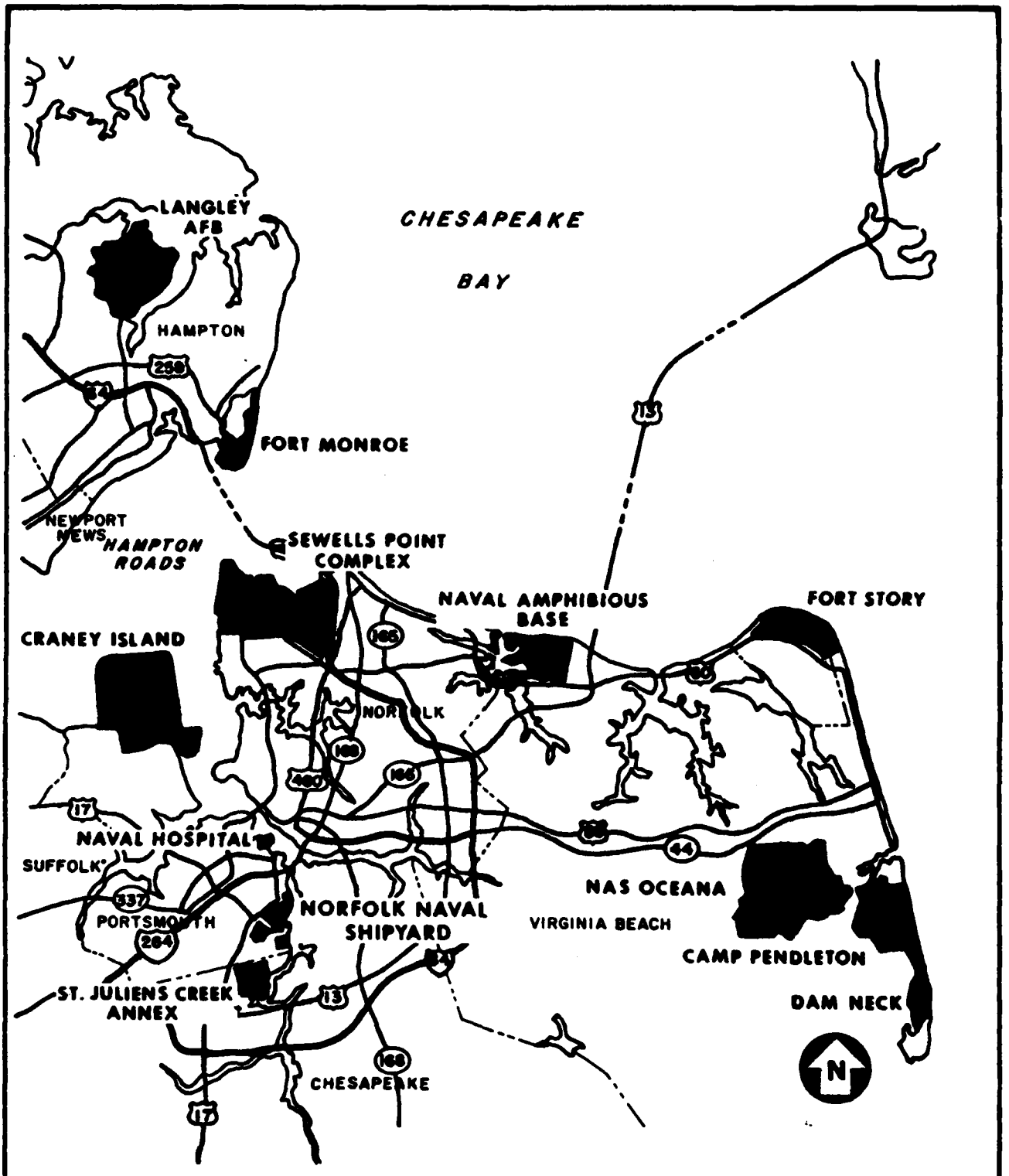
The Shipyard is located in that area of Virginia generally referred to as "Tidewater" which includes the cities of Norfolk, Virginia Beach, Chesapeake, Newport News and Hampton, as well as Portsmouth. In addition to the Shipyard, there are numerous other defense installations in the area including the Sewells Point Naval Complex; the Naval Amphibious Base at Little Creek; the Army Transportation Corps Training Center at Fort Storey; the Fleet Combat Directional System Training Center, located at Dam Neck; the Naval Air Station, Oceana and the Naval Regional Medical Center, Portsmouth. Refer to Figure 2 on Page 6 for a map of the area.

The Shipyard is bounded on the north by the property of the U.S. Coast Guard, on the east by the Elizabeth River and on the south and west by the city of Portsmouth. The Shipyard consists of a central core and several non-contiguous areas. Approximately 800 acres, as designated in Figure 3, on Page 7 are under the control of the Shipyard. Refer to Figure 4 on Page 8 for a map of the shipyard.



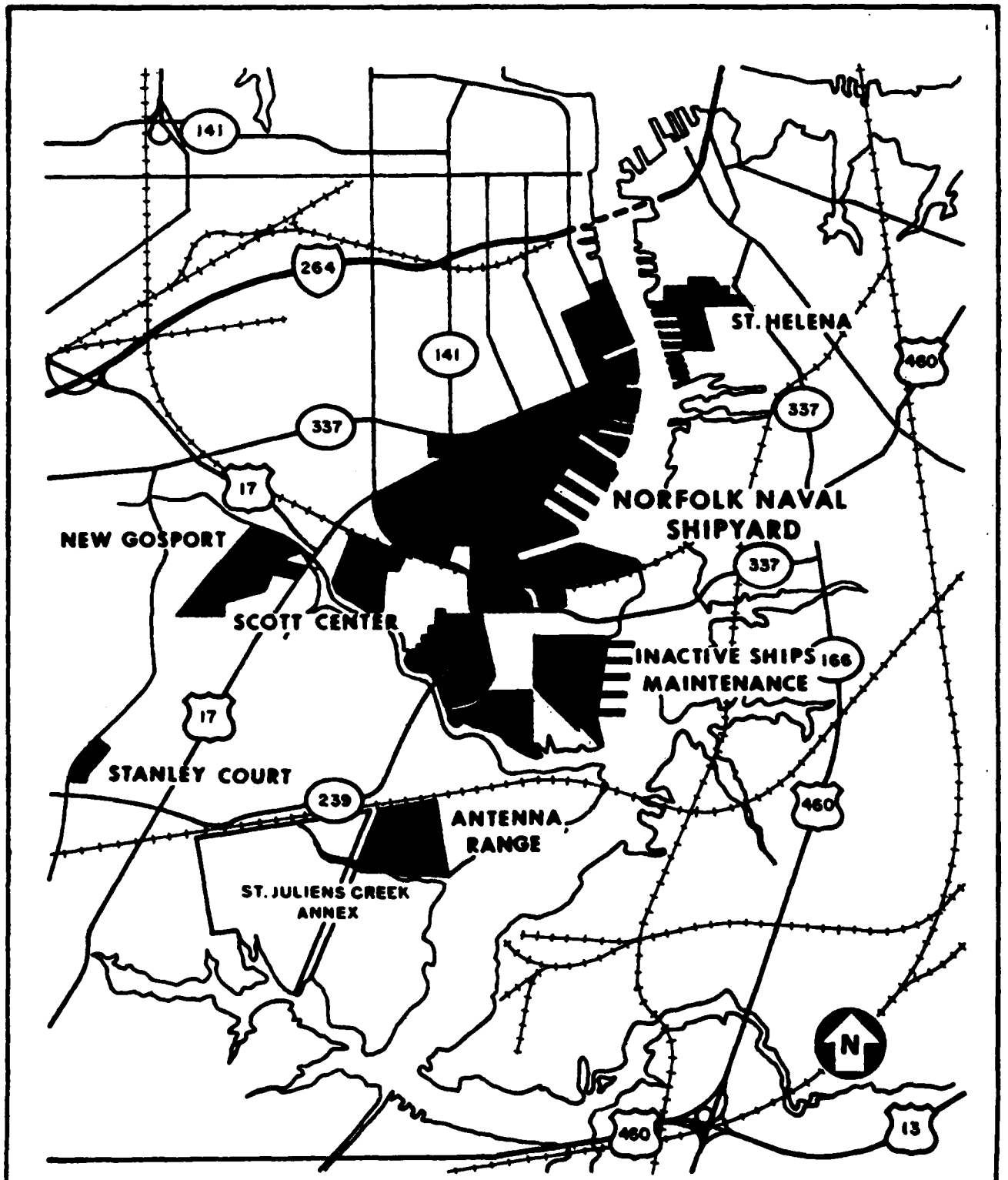
LOCATION MAP
NORFOLK NAVAL SHIPYARD
PORTSMOUTH, VIRGINIA

FIGURE 1



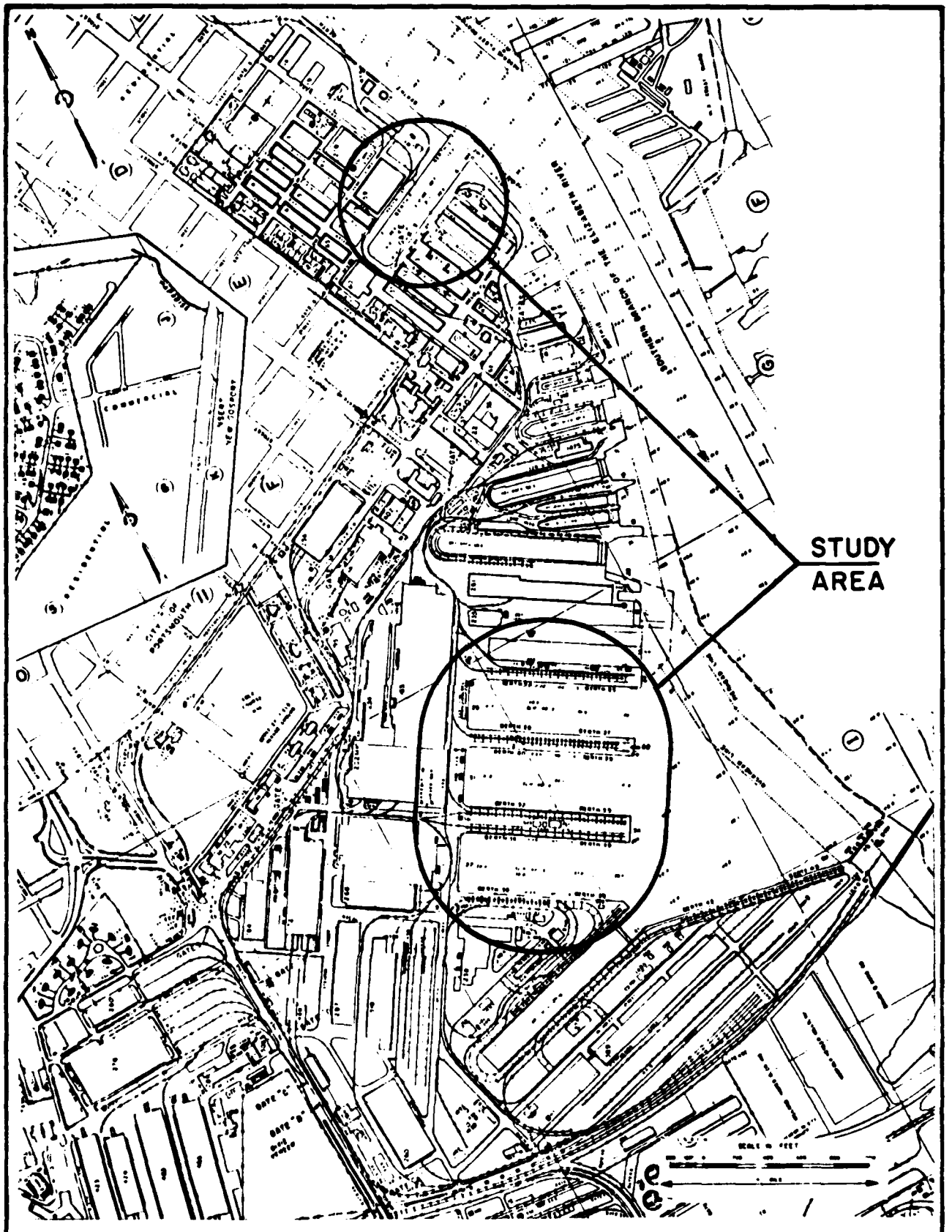
AREA MAP
NORFOLK NAVAL SHIPYARD
PORTSMOUTH, VIRGINIA

FIGURE 2



VICINITY MAP
NORFOLK NAVAL SHIPYARD
PORTSMOUTH, VIRGINIA

FIGURE 3



FACILITY MAP
NORFOLK NAVAL SHIPYARD
PORTSMOUTH, VIRGINIA

FIGURE 4

2.3 Mission of Activity

The mission of the Norfolk Naval Shipyard is: to provide logistical support for assigned ships and service craft; perform authorized work in connection with conversion, overhaul, repair, alteration, drydocking and outfitting of ships and craft as assigned; perform manufacturing research, development and test work as assigned and provide services and material to other activities and units as directed by competent authority.

The Norfolk Naval Shipyard is the largest shipyard in the world devoted exclusively to shipyard overhaul and repair. It has both conventional and nuclear repair capabilities.

2.4 Description of Activity

This program is concerned with the waterfront facilities which provide the interface between ships and shore support activities. These facilities are located within a secured section of the shipyard designated as the "Industrial Area". The waterfront facilities included in this investigation are shown in Figure 4 and their functions are listed below:

Berths 3 and 4 are used for yard and auxiliary craft,

Berths 5 and 6 are used for submarines, and yard service and auxiliary craft,

Berths 23 and 24 (Pier 3) are used for berthing of CVAs (Attack Aircraft Carriers) and other craft when necessary,

Berths 26 and 27 (Pier 4) are used to accommodate large surface ships including CVAs,

Berths 29 & 30 and 32 & 33 (Piers 4 and 5) are used for long term availabilities of surface ships for all sizes including CVAs,

Berths 35 and 36 (Pier 5) are used for surface ships as large as LPHs (Amphibious Assault Ships) for short or long term availabilities,

Berths 38 and 39 (Pier 6) is used to accommodate large surface ships for short term availabilities.

This task is concerned with Berths 3 through 6 and Berths 23 through 39.

2.5 Environmental Data

The land surface in the area of the shipyard generally ranges up to ten feet above Mean Low Water, with the largest portion less than five feet above. Most of the soils in the area are sandy loam topsoil; friable, mottled, sandy clay loam subsoil 30 to 40 inches in depth; underlain with sand. The soils are low to medium in fertility and strongly acid with organic content regarded as medium to low. Permeability ranges from slow to moderately rapid. Soils are moderately well drained. The water table at the shipyard proper ranges from two to five feet below the existing ground surface.

The area climate is moderate with relatively mild winters and long, warm summers. Monthly temperatures range from 32.2°F in January to 69.9°F in July. Averages indicate only five days annually when the daily minimum temperature fails to exceed 32°F. The average annual frost free period covers 239 days from March 23rd through November 18th. Frost penetration, for design purposes, is assumed to be 12 inches.

The geographical position of the Shipyard is north of the average track of hurricanes and other tropical storms. Winds of hurricane force have occurred on an average of once each seven years.

Tidal range at the site is:

Extreme High Water	+9.5 feet
Mean High Water	+2.8 feet
Mean Low Water	0.0 feet
Extreme Low Water	-5.1 feet

Datum is Mean Low Water.

The Shipyard is located in Seismic Probability Zone 1, where only minor earthquake damage would be expected.

3. PROJECT DESCRIPTION

3.1 Facilities Inspected

Quaywalls, Berths 3 through 6
Pier 3
Pier 4
Pier 5
Pier 6

3.2 Description of Facilities

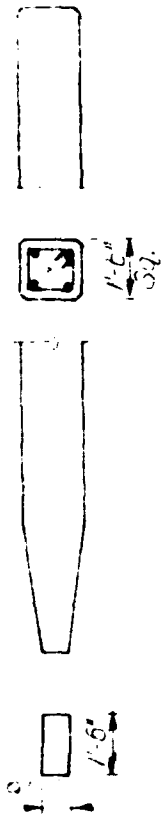
3.2.1 Quaywalls; Berths 3 through 6

The quaywalls of Berths 3 through 6 form Slip No. 1. The slip is approximately 850 feet long by 200 feet wide. Approximately the east 300 feet of both sides of the slip, i.e., Berths 3 and 6, are constructed of a steel sheet pile cutoff wall and precast concrete piles supporting a cast-in-place, reinforced concrete deck. The remainder of the sides of the slip, i.e., Berths 4 and 5 and the back wall of the slip, consists of cast-in-place concrete walls. Detailed drawings of this area of the slip are not available, but it appears that the walls are gravity or semi-gravity type retaining walls which were constructed in a timber cofferdam. Cofferdam sheathing and wales were present below mid-height for almost the entire length of the walls.

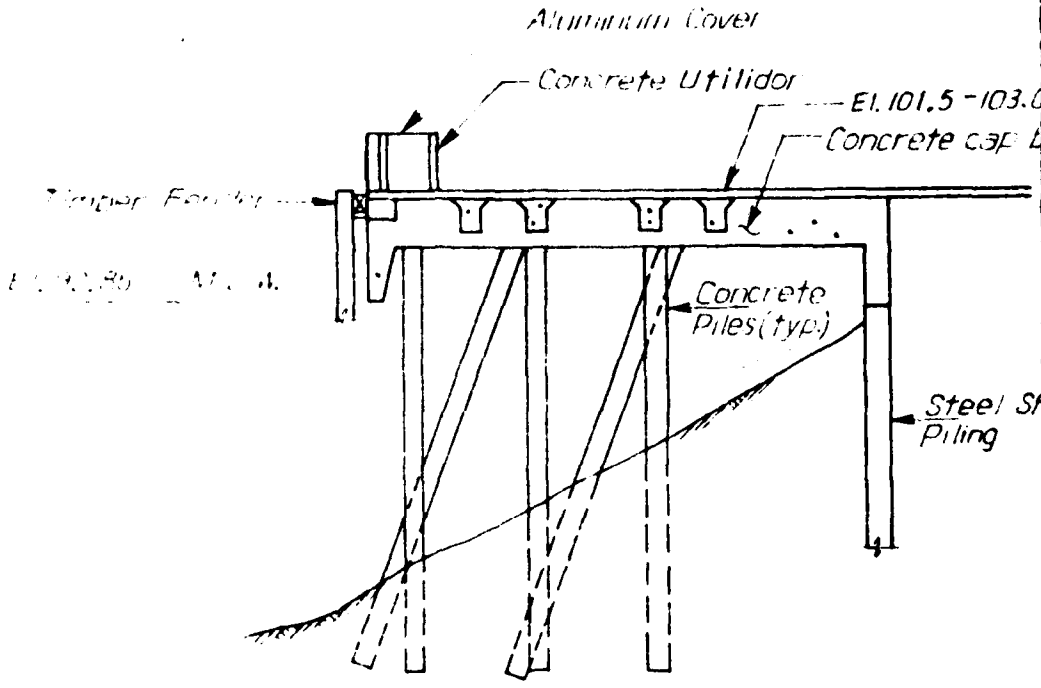
Shipyard engineering personnel have indicated that the maximum allowable loads for Berths 3 through 6 is 450 pounds per square foot.

The water depth in the slip varies from approximately 17 feet to 27 feet below Mean Low Water. The water near the sheet pile cutoff wall is as shallow as 3 feet. Underwater visibility at the time of the inspection ranged from six to twelve feet.

Refer to Figure 5, following this page, for a plan of Berths 3 through 6 and typical sections showing the configuration of the slip walls.



PILE DETAIL
(Concrete)



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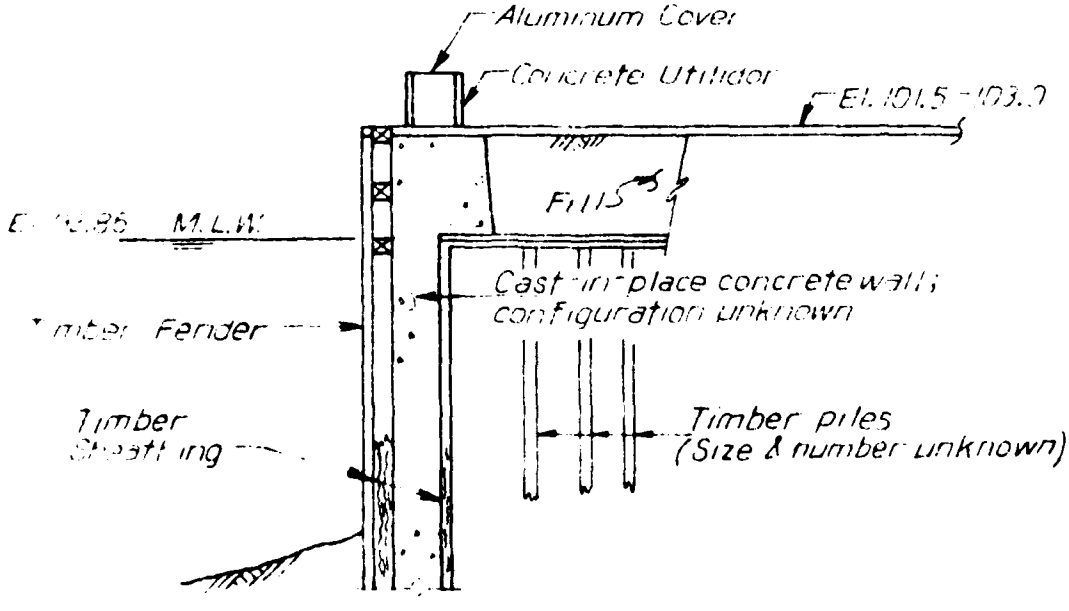

TYPICAL SECTION B-B
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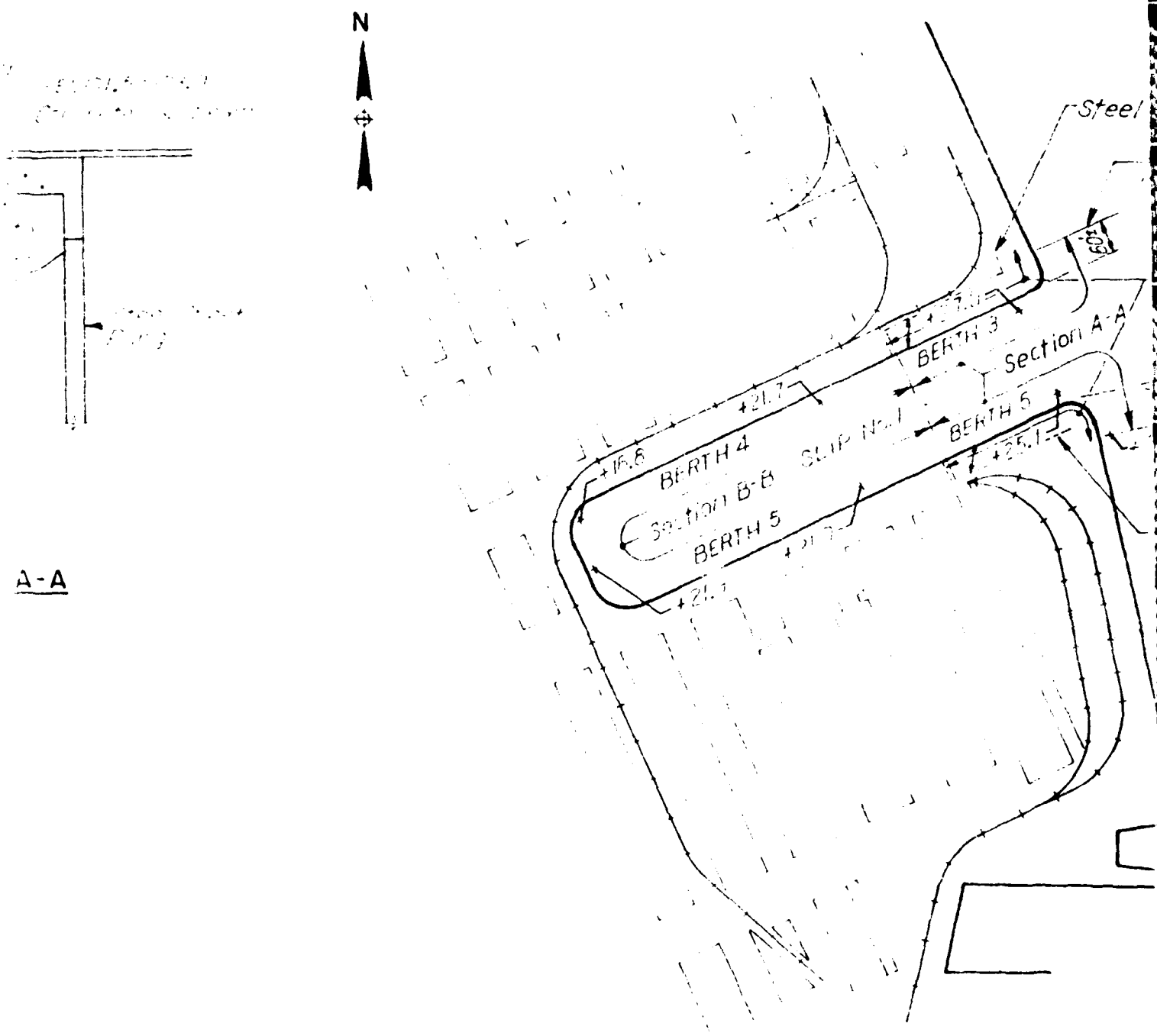

A-A

PLAN

NORFOLK NAVAL

GENERAL PLAN
BERTHS
(SLIP N

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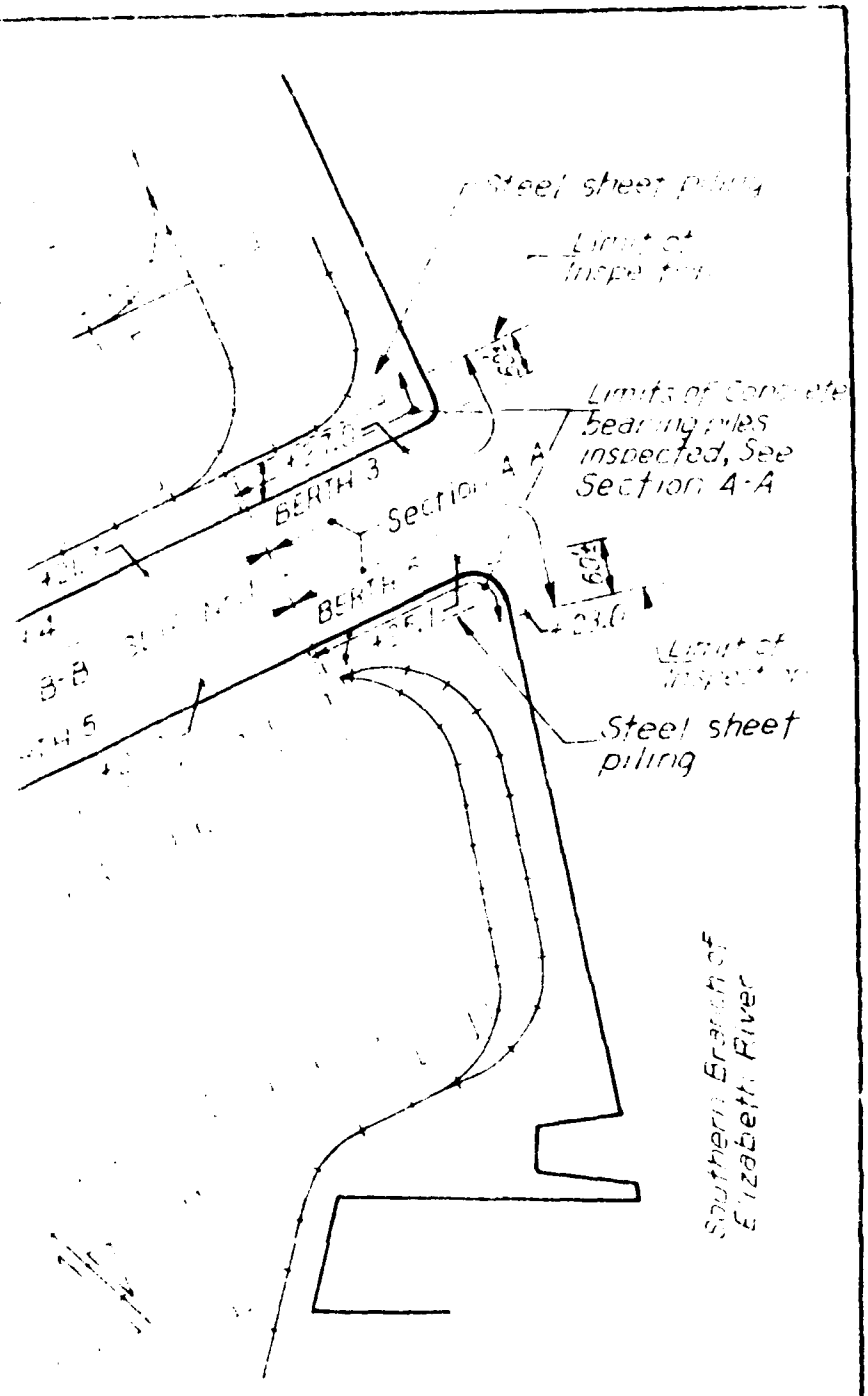


SCALE IN FEET

NORFOLK NAVAL SHIPYARD

GENERAL PLAN & SECTIONS
BERTHS 3 – 6
(SLIP No. 1)

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

COLLINS ENGINEERS, INC. | FIGURE 5

3.2.2 Piers 3, 4, 5 and 6

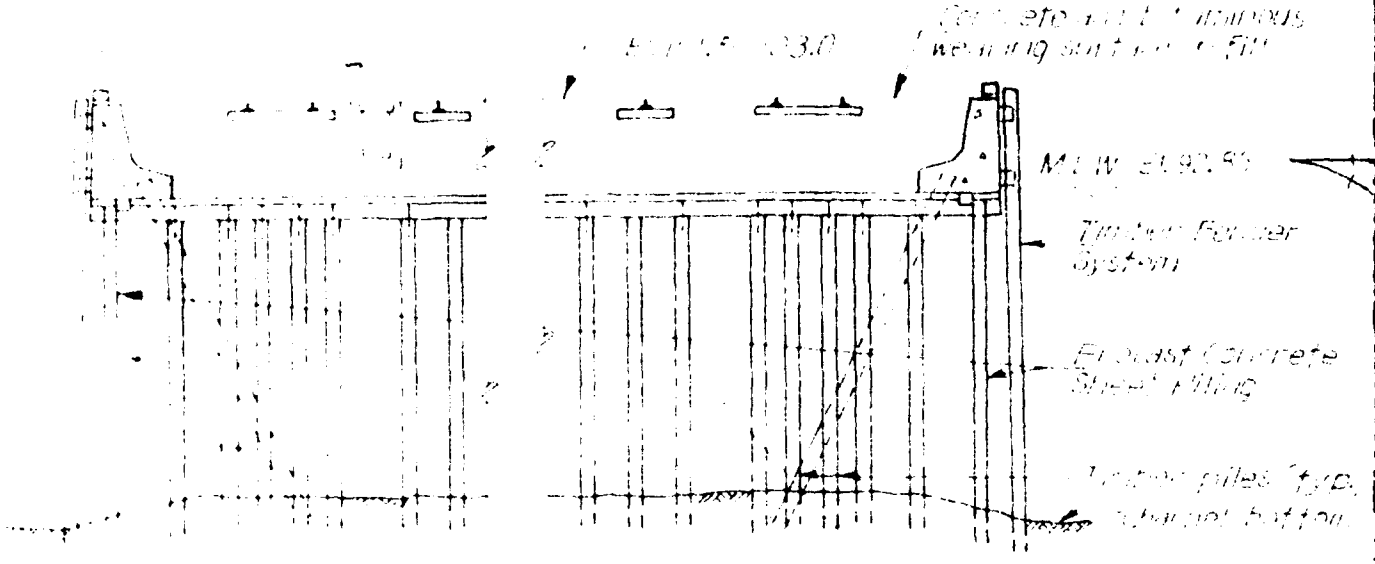
Piers 3, 4, 5 and 6 form Slips No. 2, 3 and 4. The slips are approximately 1000 ft long and 350 feet wide. The piers support railroad tracks, track mounted cranes, temporary offices and sheds, and miscellaneous support facilities.

Generally, the piers, and the wharfs which form the west end of the slips, consist of concrete and bituminous pavement over granular fill contained within a timber and concrete platform supported by individual timber piles and a precast concrete interlocking sheet pile perimeter wall. Refer to Figure 6 on the following page for a general plan of the piers and typical sections illustrating the structural configuration of the facility.

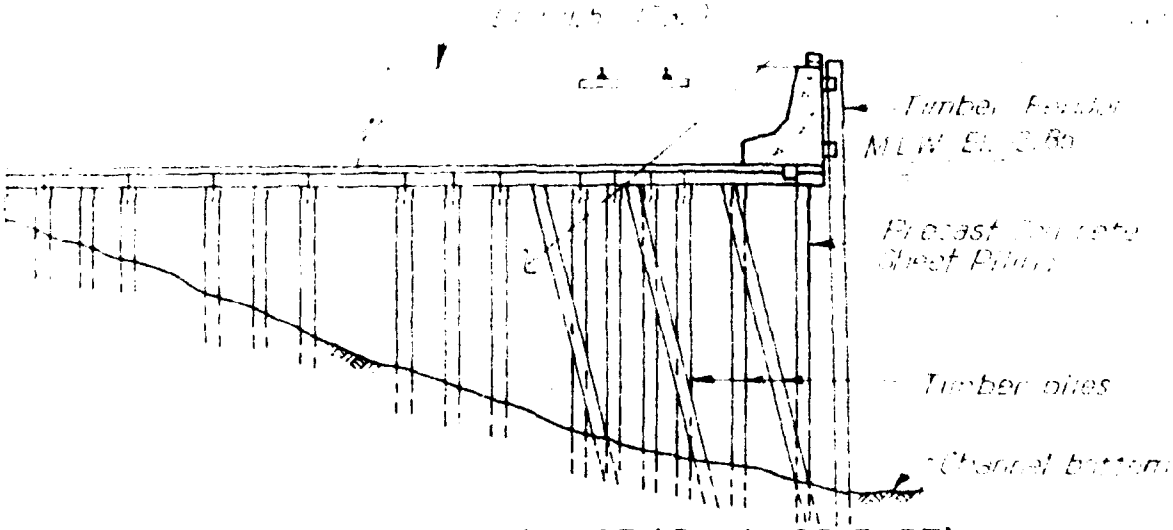
Approximately the east one hundred feet of Pier 6 consists of a reinforced concrete deck structure supported on steel H-piles. Detailed drawings of this portion of the structure were not available, but it appears that it is part of the pumping and dewatering system for the adjacent drydock.

Shipyard engineering personnel have indicated the following design loadings for these structures:

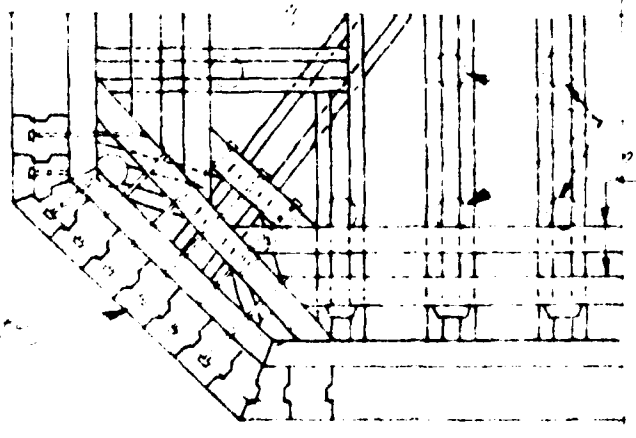
Facility	Allowable Load
Pier 3	600 pounds per square foot
Pier 4	
Berths 26 and 27	600 pounds per square foot
Berth 28	900 pounds per square foot
Berths 29 and 30	600 pounds per square foot minimum. Refer to Shipyard drawings.
Pier 5	
Center Section	900 pounds per square foot
Outer Sections	600 pounds per square foot
Pier 6	600 pounds per square foot



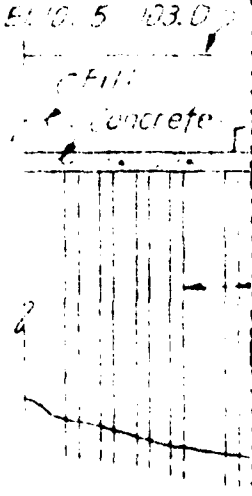
TYPICAL SECTION THROUGH PIER



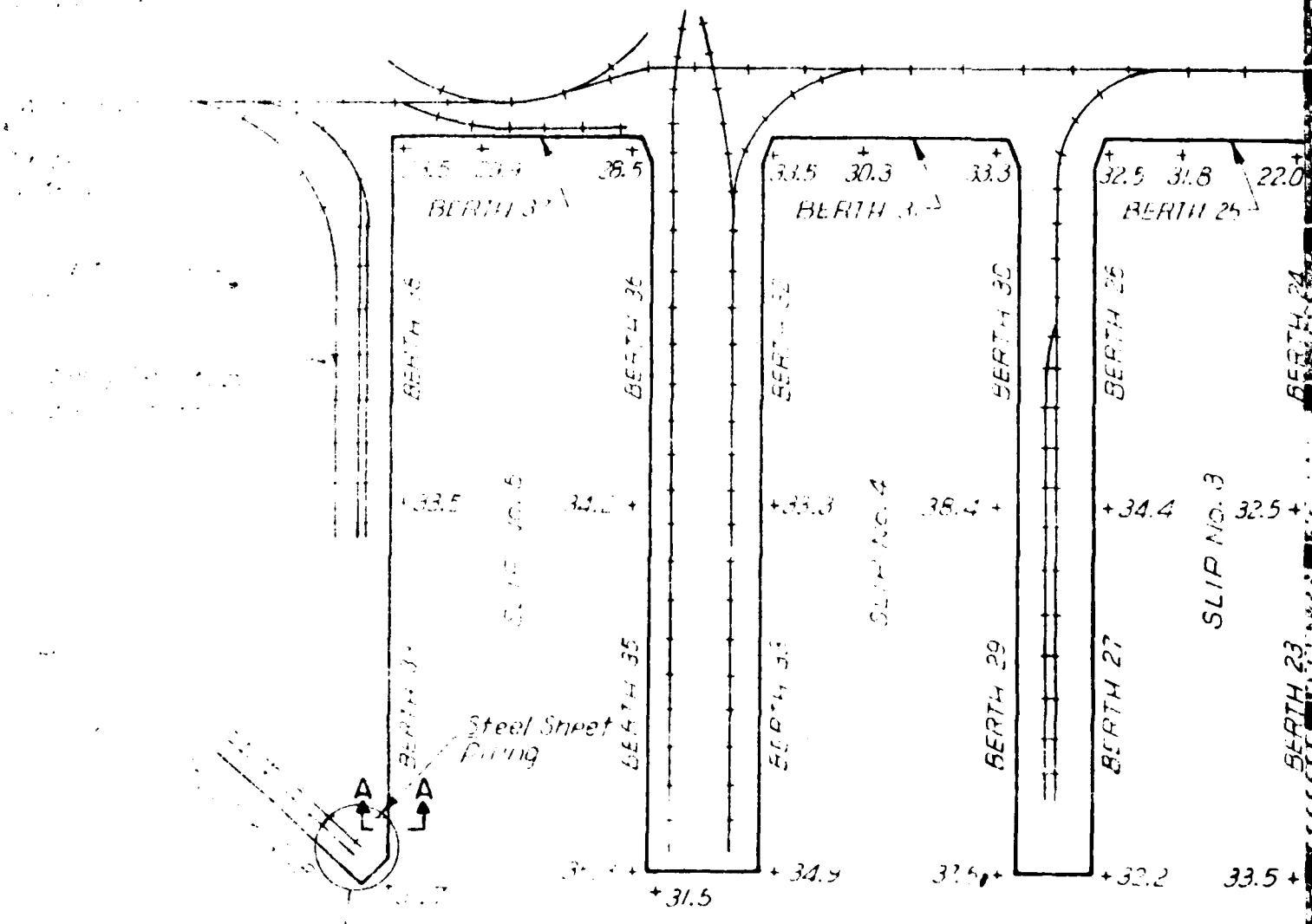
TYPICAL SECTION THROUGH WHARF (Berths 25, 31, 37)



TYPICAL PILE & FRAMING PLAN



SECTION



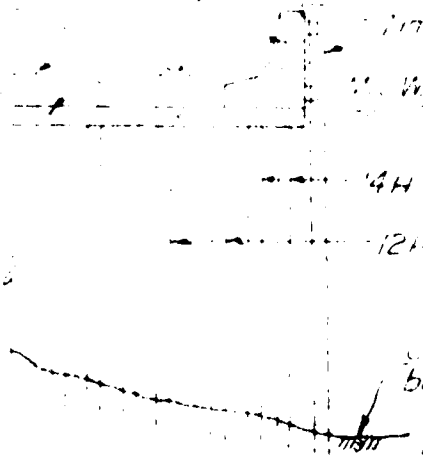
+ Approximate depth Mean Low Water

Southern Branch of Elizabeth River

PLAN

Notes:
This drawing deve
Public Works Drwg
and Drwg. No. N-S

0 10 20
SCALE IN

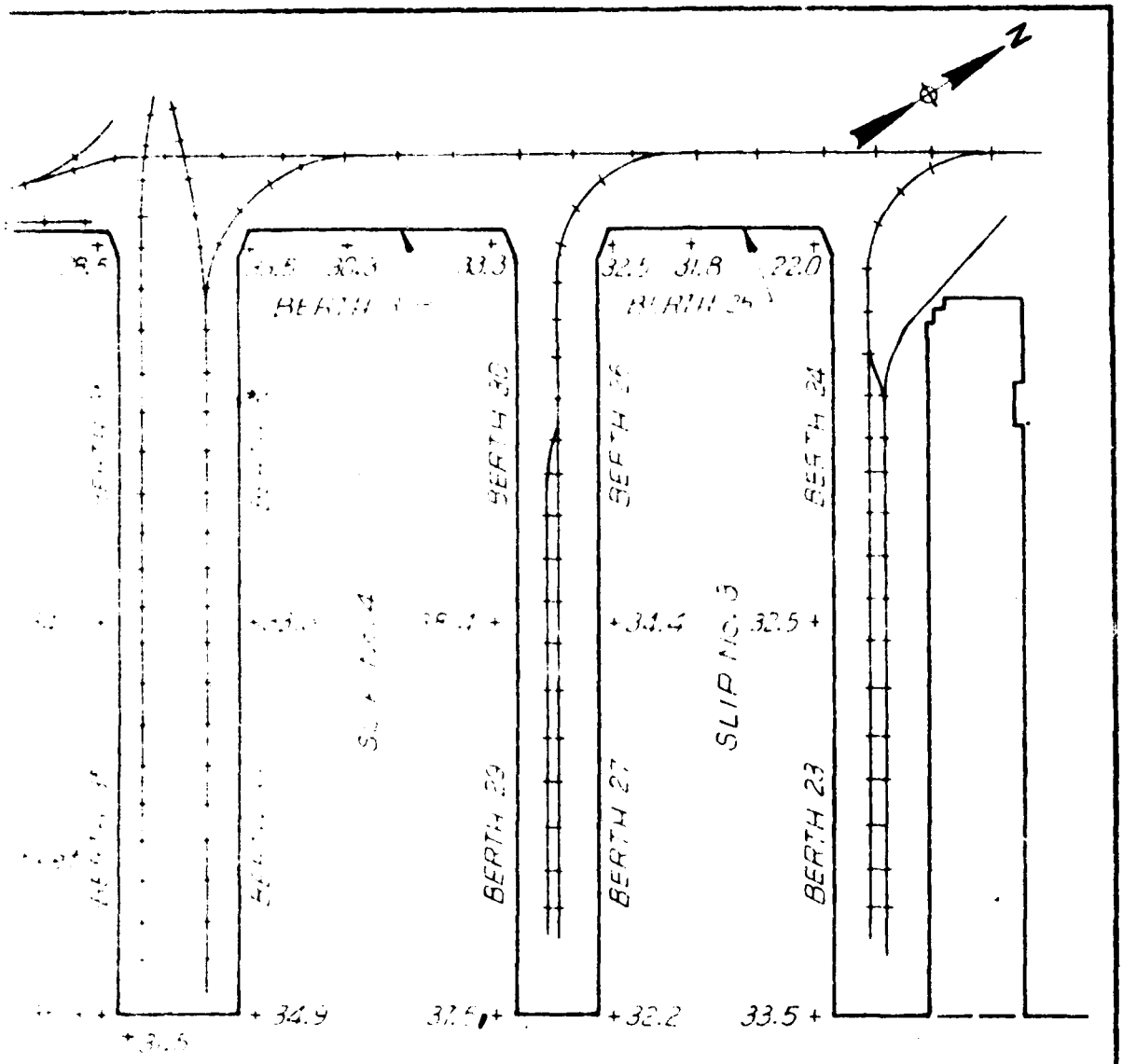


SECTION A-A

TYPICAL PRECAST CONC. PILE

NOTE:
Most of Water front (except part of Berth 39) outer face consists of bulkhead constructed of this type of reinforced concrete sheet pile.

NORFOLK NAV
GENERAL PLA
PIERS 3
(SLIP Nos
CHESAPEA
NAVAL FACILITIES EN
WASHING
COLLINS ENGINEERS



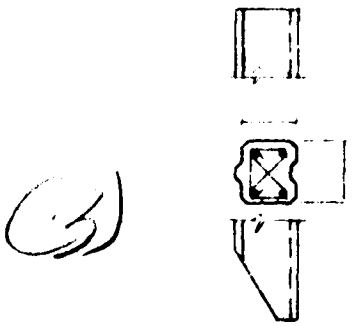
\+ Approximate depth below Mean Low Water

Southern Branch of Elizabeth River

PLAN

Note:
This drawing developed in part from Public Works Drwg. No. 38767 & 22620 and Drwg. No. N-3D-75

0 100 200 400
SCALE IN FEET



TYPICAL PRECAST CONC. PILE

...ter front (except part of Berth 39) ... consists of bulkhead constructed of ... reinforced concrete sheet pile.

NORFOLK NAVAL SHIPYARD
GENERAL PLAN & SECTIONS PIERS 3, 4, 5, & 6 (SLIP Nos. 3, 4, & 5)
CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.
COLLINS ENGINEERS, INC. | FIGURE 6

The water depth at the piers varies from approximately 22 feet to 39 feet below Mean Low Water. Underwater visibility at these piers ranged from six to twelve feet. There were significant amounts of refuse and debris in the water in these slips.

3.3 Inspection Level

A Level I inspection was conducted of all accessible underwater structural elements. A Level II Inspection was conducted in areas of apparent damage or deterioration, and a more detailed visual and tactile inspection was made of approximately 20 percent of the facilities' components. This Level II inspection included visual and tactile inspections, cleaning and scraping, and photographic documentation of the conditions.

3.4 Method of Investigation

In July, 1981, a detailed underwater inspection was made of the accessible portions of the Quaywalls of Berths 3 through 6 and Piers 3, 4, 5 and 6. The inspection included the concrete walls, concrete bearing piles, concrete sheet piling, steel bearing piles and steel sheet piling of these facilities from the area near the waterline at the time of the inspection to the channel bottom.

A visual inspection was made of all accessible foundation elements below the waterline, followed by detailed scraping, cleaning, probing and sounding to determine the presence and extent of distress.

The underwater inspection was conducted by a five-person team, including a structural engineer-diver and technician-divers. The diving and tending duties were rotated among the team members. The divers, using scuba equipment, worked from the piers and wharfs, from camels and barges, and from a small boat.

To conduct the inspection of wall type areas, sections of wall, generally 50 feet long, were delineated by weighted lines tied to the top of the facility. Divers, operating in a tethered mode, descended one line to the bottom; swam to the next line,

inspecting approximately a ten foot high strip of the sheet piles or wall; ascended approximately ten feet; and swam back to the first line, inspecting another strip of the wall. This procedure was repeated until the entire section of wall between the weighted lines was inspected from the channel bottom to the waterline. The diver then reported the general condition of the section just inspected to the notetaker. After completing the report, the diver moved to the next section. When significant distress or deterioration was found, the diver immediately surfaced and reported the specific conditions in detail.

In each section of wall, the diver scraped and cleaned representative areas to conduct Level II inspections during the Level I inspection. The Level I and Level II inspections were conducted at the same time because of the problems of scheduling access in the active shipyard.

The facilities inspected were located in active berthing areas. In order for the team to inspect the Quaywalls; Berths 3 through 6, barges were moved or breasted with logs and camels.

At Piers 3, 4, 5 and 6, ships, barges and camels that could not be moved were in place along the face of the facilities. There were also areas of floating waste materials that the divers could not enter for health reasons. Consequently, some areas of the sheet piling were not inspected. Generally, these areas were less than about twenty feet long and randomly located throughout Slips 3, 4, and 5. The larger areas listed below were not inspected underwater for the same reasons, or because ship personnel denied permission to enter the water near their vessels:

Pier 3	Station*0+00 to 2+00	
Pier 4	Station 1+00 to 2+50	
	3+00 to 5+00	
Pier 5	Station 4+00 to 4+50	*All stationing is measured along the face of the pier beginning at the inboard end of the pier.
	6+00 to 6+50	
	7+00 to 8+00	
Pier 6	Station 0+00 to 2+00	

Dive operations were scheduled on a daily basis, and coordinated with the Shipyard Diving Officer, the Berthing Officer, and the ships in the immediate area of the diving operations.

4. STRUCTURAL CONDITION ASSESSMENT

4.1 Existing Conditions

Generally, the underwater inspection indicated that the submerged portions of the facilities inspected are in fair to good condition. There are, however, many areas of deterioration, a few areas of displacement, and a number of the steel H-piles supporting the east end of Pier 6 are severely corroded.

4.1.1 Quaywalls; Berths 3 through 6

Refer to Figure 5 on Page 12, Figure 7 below, and Figure 8 on Page 19 for a plan and sections of the quaywalls.

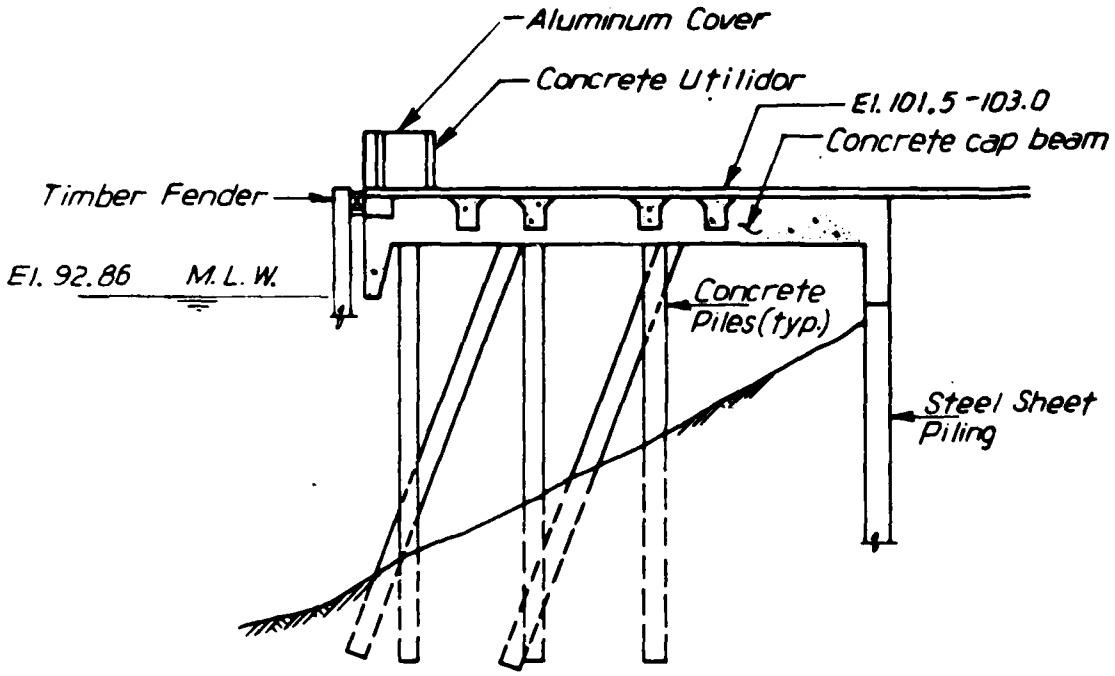


FIGURE 7 TYPICAL SECTION - BERTHS 3 AND 6

The steel sheet piling of the quaywalls at Berths 3 and 6 generally are in good condition. Except as described below, there is no visual evidence of significant material deterioration due to corrosion. Refer to Photographs 1 and 2 following this page for typical conditions above and below Mean Low Water.

PHOTOGRAPHS 1 and 2 - TYPICAL STEEL SHEET PILING AT BERTHS 3 AND 6

Near the west end of Berth 3, where the quaywall section meets the concrete wall section, there is a hole in the steel sheet piling approximately 2 ft square as shown in Photograph 3 on Page 20. The hole is near Mean low Water, and the fill material behind the wall appears to have washed out.

The precast concrete piling in the quaywall section is in good condition. The piles are generally covered with marine growth 1/2 in. to 1 in. thick. Refer to Photographs 4, 5 and 6 on Pages 20 and 21 for typical views of these piles underwater. When marine growth was cleaned from these piles, the concrete surfaces and edges were found to be sound and smooth.

The top portions of a few of the precast concrete piles were cracked near the pile cap, and some of the pile caps and deck beams were spalled and scaled. Refer to Photographs 7 through 10 on Pages 22 and 23 for typical views of these conditions.

The concrete wall sections along Berths 4 and 5 and at the west end of the slip are in fair condition. Although there are many surface defects, there is no evidence of actively progressing distress. Near the tidal zone there are many areas of

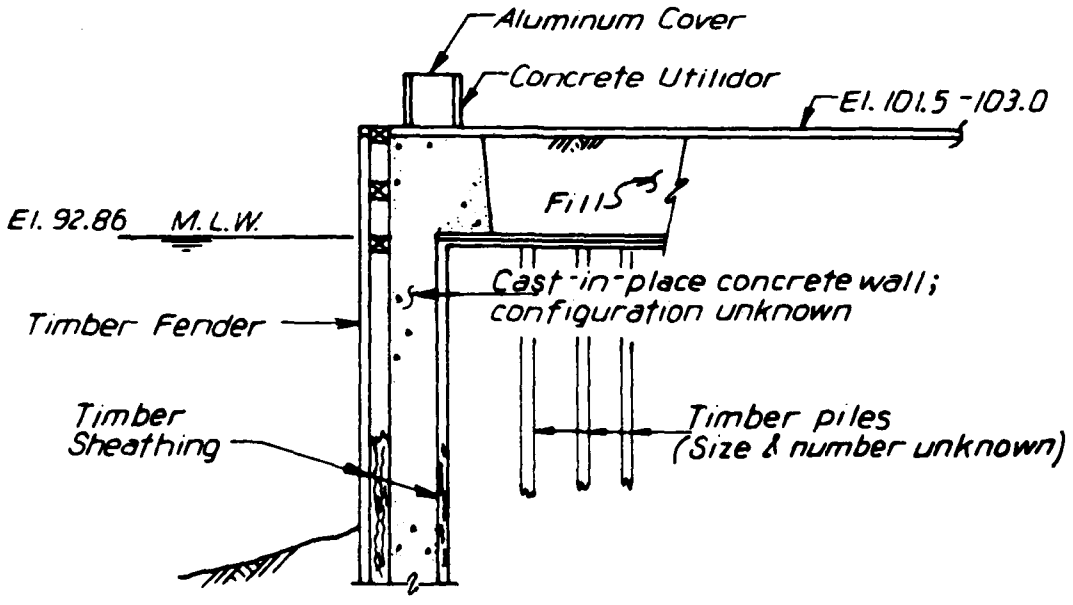
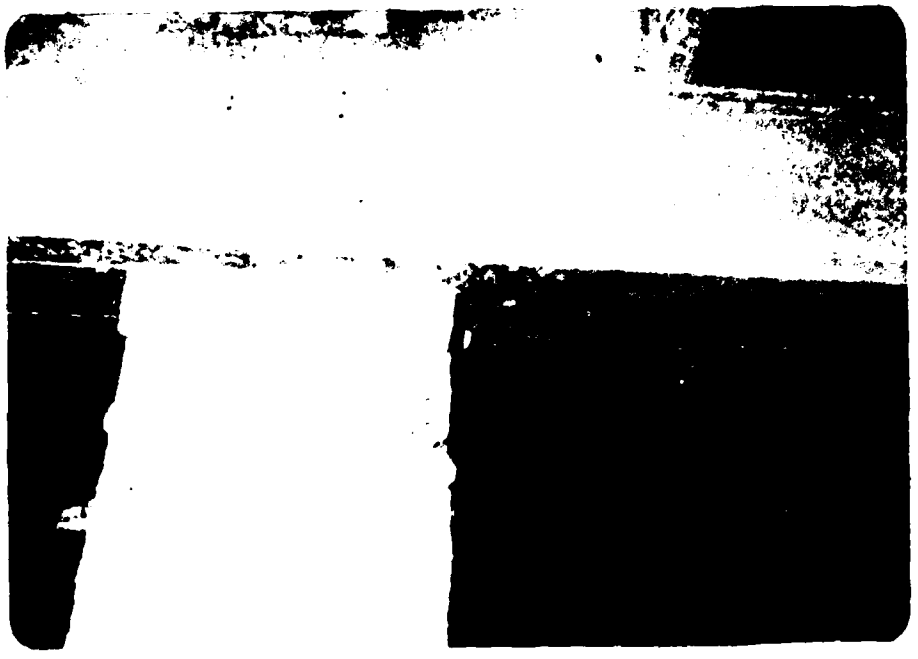
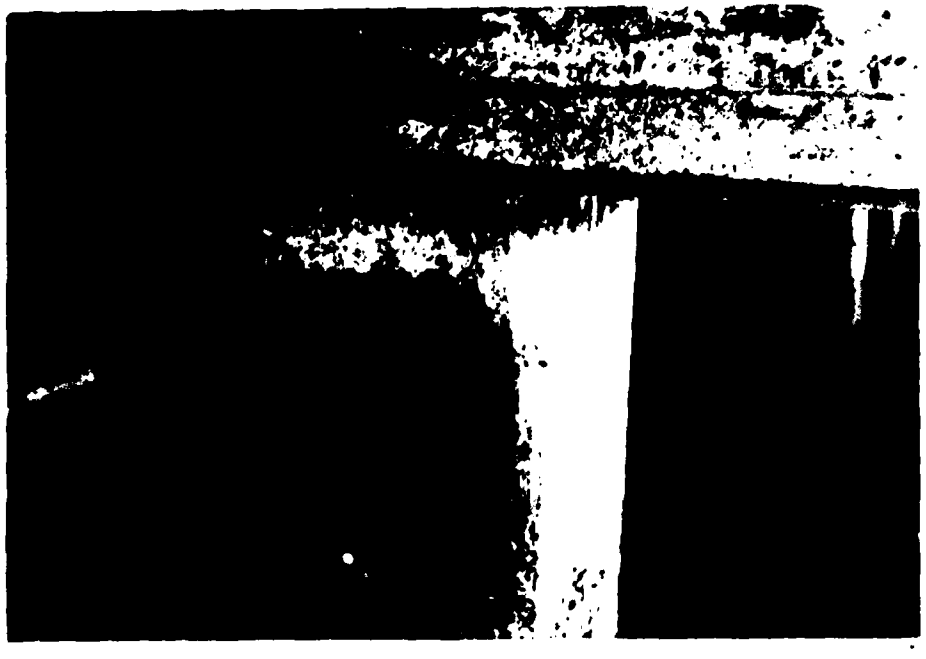


FIGURE 8 TYPICAL SECTION - BERTHS 4 AND 5

PHOTOGRAPHS 5 and 6 - TYPICAL PILES AT BERTH 3





PHOTOGRAPHS 7 and 8 - TYPICAL CRACKS AT TOP OF CONCRETE PILES, BERTHS 3 AND 6

PHOTOGRAPHS 9 and 10 - TYPICAL CRACKS IN PILE CAPS AND DECK BEAMS, BERTHS 3 AND 6

scaling and cracking, and throughout the full height of the wall there are many voids. The voids and scaling generally extend into the wall an average of 2 inches, but there are many areas that extend 6 inches to 12 inches into the wall. Below the waterline, these voids appear to be the result of poor consolidation of the concrete during construction, rather than post-construction deterioration. Refer to Photographs 11 and 12 on Page 25 for typical views of the bulkheads in Berths 4 and 5.

4.1.2 Piers 3, 4, 5, and 6

Refer to Figure 6 on Page 14 and Figure 9 below for the configuration of Piers 3, 4, 5 and 6. Since the area under the piers is inaccessible and available pier drawings are poor, the exact nature of the deck load distribution is unclear. These piers were built with timber bearing piles which are enclosed in concrete sheet piling around the perimeter of each pier. The only drawings which could be obtained were very old (as far back as 1917) and appeared to indicate the cross section shown in Figures 6 and 9. Public Works personnel assured the inspection team that the area under each pier and between the concrete sheet piling was completely filled with soil so that all of the timber bearing piles are buried in fill.

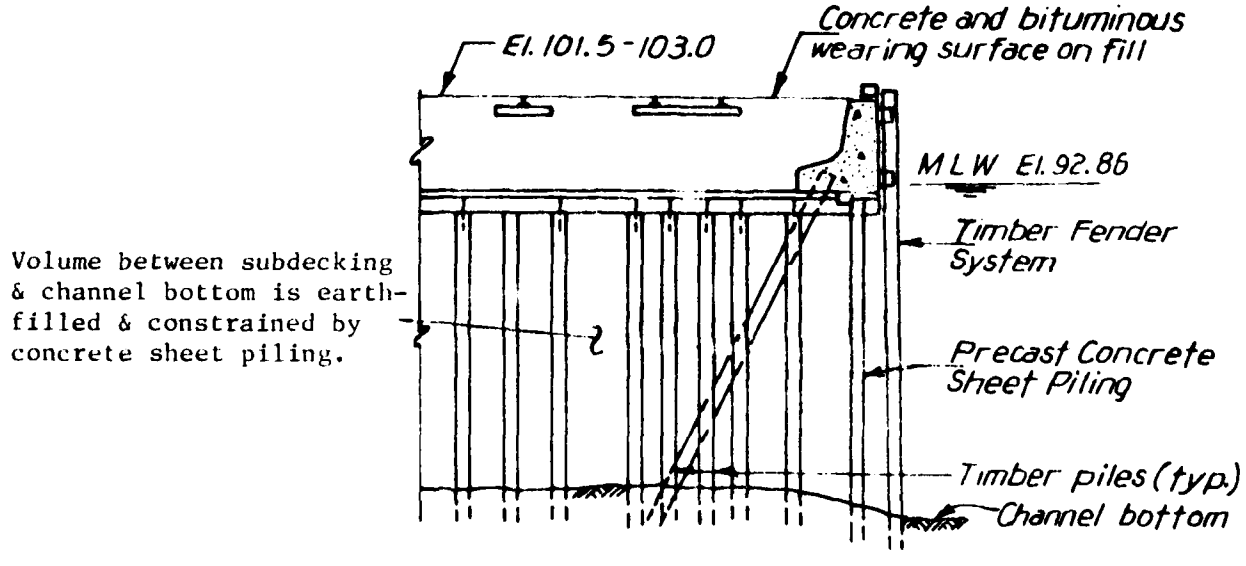


FIGURE 9 TYPICAL PARTIAL SECTION - PIERS 3, 4, 5., AND 6

PHOTOGRAPHS 11 and 12 - TYPICAL VIEWS OF BULKHEAD

BERTHS 4 AND 5
(Showing surface deterioration and well consolidated interior concrete)

The condition of the precast concrete sheet piling at each pier is similar in nature, although the degree of distress varies. Generally, the pile faces are full and solid, and the piles are properly aligned. There are many areas, however, where the edges of the piles are cracked or broken and the joint at the interlocking is not tight. Figure 10 below and Photographs 13 through 20 on Pages 27 through 30 show typical conditions.

Pier 3 concrete sheet piles are in fair to good condition. Overall, approximately 30 percent of the pile edges are cracked for at least partial height. There are a few broken edges, and in two areas piles are not interlocked.

The wall area between Piers 3 and 4 (Berth 25) is in fair condition. A number of concrete sheet piles have separated; approximately 50 percent of the pile edges are cracked or broken off; and five piles have broken concrete tongues or grooves. In this area there is also a section of wall, approximately 20 ft long in plan, constructed of steel sheet piling rather than concrete sheet piling.

Pier 4 concrete sheet piling is in fair to good condition. Approximately 50 percent of the concrete sheet piles have hairline cracks, edges broken off, and reinforcing steel exposed.

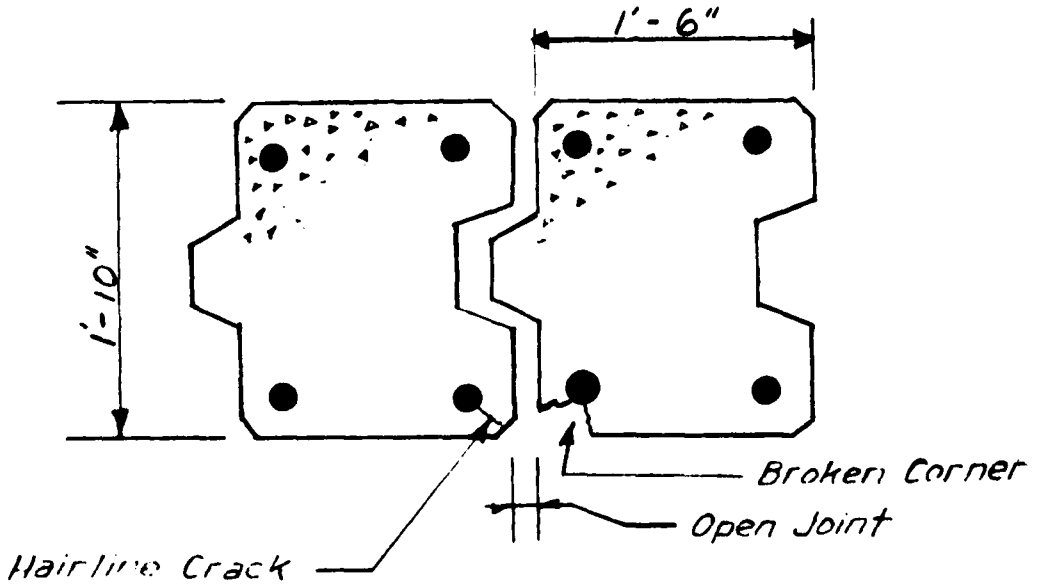


FIGURE 10 CONCRETE SHEET PILE DETERIORATION

PHOTOGRAPHS 13 and 14 - TYPICAL VIEWS OF CONCRETE SHEET PILES (PIER 3 SHOWN)

PHOTOGRAPHS 15 and 16 - TYPICAL VIEWS OF CONCRETE SHEET PILES (PIER 3 SHOWN)

PHOTOGRAPHS 17 and 18 - TYPICAL VIEWS OF CONCRETE SHEET PILES (PIER 4 SHOWN)

PHOTOGRAPHS 19 and 20 - TYPICAL VIEWS OF CONCRETE SHEET PILES (PIER 4 SHOWN)

The concrete sheet piles of the wharf between Piers 4 and 5 are in fair condition. Approximately three-fourths of the piles are cracked or have broken edges. Two piles have twisted and are not interlocked with adjacent piles.

The concrete sheet piling of Pier 5 is generally in good condition. Less than about 20 percent of the piles have hairline cracks.

The concrete sheet piling between Piers 5 and 6 is generally in good condition with only minor localized areas of deterioration.

At Pier 6, the concrete sheet piling for approximately the west 850 feet is generally in good condition with only a few areas of deterioration or dislocated piles.

The east 150 feet of Pier 6 is supported on steel H-piles. The piles are in poor condition. Two piles were cleaned near the waterline and at approximately ten foot intervals to the channel bottom. The pile flanges are severely corroded from the waterline to about elevation -20. The piles were measured with a scale, and it appears that the original section was an HP 14x102. That section would have an original flange thickness of 11/16 inches. The flange thickness has been reduced to approximately 3/16 inches at the edge and appears to taper to full thickness at the toe of the fillet. Refer to Photographs 21 and 22 following this page.

4.2 Condition Assessment

4.2.1 Quaywalls; Berths 3 through 6

The underwater inspection indicated that the quaywalls at Berths 3 and 6 are generally in good condition and are performing satisfactorily. There is no evidence of distress or deterioration that would significantly reduce the load carrying capacity of the piles. It is, therefore, recommended that the design loading of 450 pounds per square foot be maintained.

The underwater inspection indicated that, although the concrete wall section of Berths 4 and 5 exhibit many surface

PHOTOGRAPHS 21 and 22 - VIEW OF H-PILE FLANGES
WEST END OF PIER 6

defects, there is no evidence of actively progressing deterioration. In the absence of any detailed information as to the configuration of the structure, and in light of the apparent satisfactory performance of the structure, it is recommended that the present allowable loading of 450 pounds per square foot be maintained.

4.2.2 Piers 3, 4, 5 and 6

The concrete sheet piling of Piers 3, 4, 5 and 6 is in fair to good condition. There are areas of cracking, broken concrete, and misaligned piles, but the distress does not extend into the concrete beyond the reinforcing steel. There is no evidence of significant loss of cross section; no evidence of active deterioration; and no evidence of structural failure.

There is also no indication that the defects and damage found during the inspection occurred over time rather than as a result of construction. It is likely that the cracks on the chamfers of the piles occurred during curing or handling; and the broken tongues and grooves, and the misaligned piles were probably caused by construction operations. The piles are continuously submerged, and set back from the face of the pier so that they are not usually subject to damage from the environment or external forces. It is, therefore, recommended that the design loading indicated below be maintained.

Facility	Allowable Load
Pier 3	600 pounds per square foot
Pier 4	
Berths 26 and 27	600 pounds per square foot
Berth 28	900 pounds per square foot
Berths 29 and 30	600 pounds per square foot minimum. Refer to Shipyard drawings.
Pier 5	
Center Section	900 pounds per square foot
Outer Sections	600 pounds per square foot
Pier 6	600 pounds per square foot

As noted previously, shipyard operations prevented an underwater inspection of every area of the concrete sheet piling. All areas were inspected above water and no conditions were observed that would indicate the presence of significant distress in uninspected areas below the waterline. These inspection limitations do not preclude making a general assessment of the physical condition of the submerged portions of the facilities. There may, however, be localized areas of distress that were not detected during the inspection.

The steel H-piles at the east end of Pier 6 are actually part of the Dry Dock No. 8 structure. At the time of the inspection, no drawings of this Pier 6-Dry Dock No. 8 area were available. The divers inspected those steel H-piles that were along the Pier 6 face and a few interior H-piles that were close to that face.

The inspection of the interior steel H-piles was very limited, and was not expanded because of the conditions under which the inspection would have been conducted. The divers would not have been able to surface in an emergency, and therefore underwater tender-divers would have been required; special lighting and safety lines were needed; and there are discharge pipes of unknown origin in the area.

Approximately six months after the field inspection was completed, a drawing of the east end of Pier 6 was obtained from the Shipyard. The drawing, Dry Dock No. 8, Quay Wall, North of Entrance, Drawing No. N-SD 75, dated July 17, 1941, indicates that this area of Pier 6-Dry Dock No. 8 is supported by steel H-piles, concrete-filled pipe piles and timber piles. The drawing does not appear to correlate with the limited measurements made by the inspection team, nor the divers' recollection of pile details and spacing. Until it can be determined that this drawing reflects "as built" conditions, it cannot be used to perform a detailed analysis.

It is estimated that the steel H-piles inspected are less than five percent of the total number of steel H-piles of the

region in question. The losses experienced by the steel H-piles that were inspected may be greater than the losses experienced by the interior, adjancent piles because the exterior piles are more exposed to channel currents and pollution, but the piles were found to be heavily encrusted with marine growth that might have protected them from greater deterioration.

The steel H-piles along the Pier 6 face of the Pier 6-Dry Dock No. 8 area are in poor condition. Although no detailed measurements were made of the webs of these members, it is apparent that there has been a significant loss of section. It is estimated that there has been a 25 to 50 percent loss of cross-sectional area of the steel H-piles. The live load presently on this section of the pier, however, is relatively light, consisting of temporary buildings and water purification equipment.

Shipyard personnel have indicated that Pier 6 was designed for a live load of 600 pounds per square foot.

The dead load on the piles is believed to consist of a concrete and earth-filled deck structure approximately 10 feet thick. It is estimated the composite weight of the deck structure is approximately 130 pounds per cubic foot, which is equivalent to 1300 pounds per square foot.

The total load on the steel H-piles would then be about 1900 pounds per square foot (1300 psf, dead load, plus 600 psf, live load). In view of the minimum 25 percent loss of cross-sectional area of the steel H-piles found during the inspection, a reduction in the total allowable load on the piles to 1450 pounds (75 percent of 1900 lbs) would appear warranted. This would reduce the allowable live load on this portion of Pier 6 to 150 pounds per square foot (1450 psf, total allowable load, minus 1300 psf, dead load).

The above analysis is extremely crude and of limited value. The configuration and overall condition of the structure is not known, and therefore the structural response of the piles to applied loads can not be known. It has been assumed that the cross-sectional area of the steel piles controlled the design of the member, but other factors may have governed the design. Those

factors may have included the unbraced length of the pile, the length of embedment of the pile necessary to develop the its capacity through friction, and excess capacity provided in anticipation of corrosion losses.

5. CONCLUSIONS AND RECOMMENDATIONS

The underwater investigation of Quaywalls; Berths 3 through 6, and Piers 3, 4, 5 and 6 indicated that generally the submerged portions of these structures are performing satisfactorily and no immediate repairs are necessary.

It should be noted, however, that evaluations of Piers 3, 4, 5 and 6 are severely limited in this baseline inspection because of the inaccessibility of the bearing piles which support these piers. The limited funding and overview nature of these baseline inspections restricted the underwater examinations to the sheet piling which surrounds these piers.

The steel H-piles which support the east end of Pier 6, however, are severely corroded and their structural capacity is significantly reduced.

This inspection has established a "base line" condition for the quaywalls and piers. It is recommended that this information form the basis for evaluating the conditions encountered in subsequent inspections of these facilities to determine if deterioration is progressing. Because the quaywalls and the concrete pile portions of the piers are in fair to good condition with no evidence of significantly progressing deterioration, it is recommended that a visual inspection be made every three to five years. It is also necessary to point out that the condition of the timber bearing piles of Piers 3, 4, 5, and 6 can only be determined by breaking through the surrounding structure; i.e., through the decking above the timber piles or through the surrounding concrete sheet piling. This would obviously be a costly procedure, but it should be recognized as the only way to properly evaluate the structural integrity of the embedded timber bearing piles.

Interim inspections should also be made of any facility that is damaged by external forces.

Because of the significant deterioration at the east end of Pier 6 and the lack of information as to the structural configuration of that area, it is recommended that a detailed investigation be made. The investigation should include a review of available information, and field measurements to determine the configuration and arrangement of the foundation system. Underwater ultrasonic thickness measurements should be made to determine the remaining section of the steel members. The investigation should also include a determination of the loads placed on the structure by the adjacent drydock.

Presently, access to the deck portion of Pier 6 supported by steel H-piles is restricted by water purification equipment, storerooms, stored materials and concrete cubes which either occupy or block entry such that heavy loads are not anticipated. Use of this area should not be changed to allow heavier loads until its structural sufficiency is assured. As an interim measure, it is recommended that the live loads be restricted. The crude analysis presented in the previous section indicates that the live load should not exceed 150 pounds per square foot. Because that analysis was based on limited information, and because of the potential consequences of loading the pier beyond its present capacity, it is recommended that the live loads in the area of Pier 6 supported by steel H-piles not exceed 100 pounds per square foot.

It is estimated that the cost of a further detailed investigation of the H-pile supported area of Pier 6-Dry Dock No. 8 would be approximately $20,000 to $25,000 depending on the availability of design information and the physical conditions encountered during the detailed inspection.

It is also recommended that the portions of Dry Dock No, 8 which are not contiguous with Pier 6 be reviewed to determine if similar construction materials were used and if similar conditions exist.

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