AD-A167 643 UNDERWATER FACILITIES INSPECTION AND ASSESSMENT AT DEPERMING FACILITY US...(U) AGI (J) AND ASSOCIATES INC SEATTLE WA JUL 81 CHES/NAVFAC-FPO-1-81-(16)SET ET AL. 1/1

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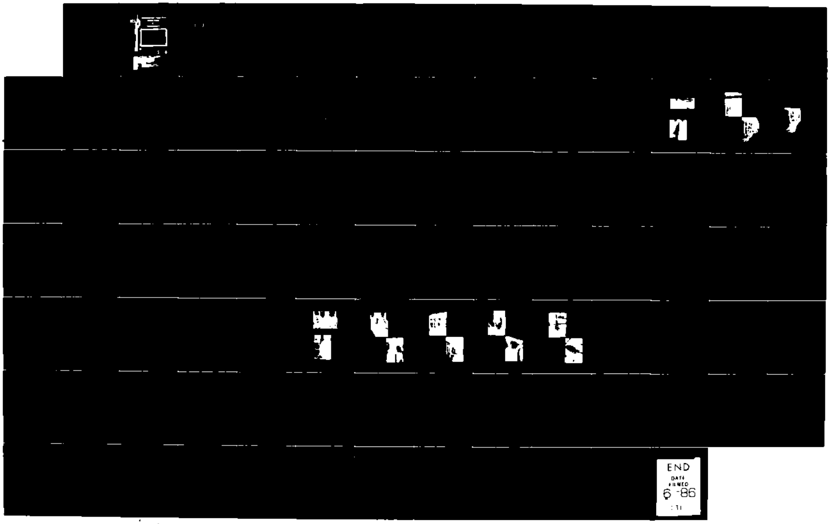

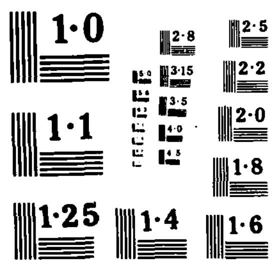
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UNDERWATER FACILITIES
INSPECTION AND ASSESSMENT

AT

DEPERMING FACILITY
U.S. NAVAL STATION
NORFOLK, VIRGINIA

FPO-1-81-(16) July 1981

Performed for:

Ocean Engineering and Construction Project Office
Chesapeake Division
Naval Facilities Engineering Command
Washington, D.C. 20374

Under:

Contract N62477-80-C-0265
Task 3

By:

J. Agi & Associates Co. Inc.
1414 Alaskan Way, Suite 600
Seattle, Washington, 98101

Project No: 81-2-2-044

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Seattle, WA 98101

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16. SUPPLEMENTARY NOTATION

17. COSATI CODES

FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if nec.)
Underwater inspection, Mooring inspection Deperming Facility U.S. Naval Station Norfolk

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Nondestructive ultrasonic testing and inspection of a sampling of piles in the piers which make up the Deperming Facility at U.S. Naval Station, Norfolk, Virginia, was carried out. This inpsection has shown that on an overall basis the piles are in good condition, however, evidence of both mechanical & (Con't)

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BLOCK 19 (Con't)

biological deterioration was found.

The objective of the underwater facility assessment conducted at the U.S. Naval Station, Norfolk, Virginia, was to assess the physical condition and repairability of the structural members supporting the Deperming FAcility. After a Level I "swim by" of the entire facility, a Level II inspection procedure was carried out to insure the acquisition of sufficiently detaild data related to the internal structural integrity of each pile inspected as to enable determination to be made of the overall bearing capacity and lateral stability of the pier. The data provided is sufficiently detailed to facilitate comparisons with subsequent periodic inspections for purposes of determining progressive deterioration with time.

The Level II inspection covered 182 piles (30% of the total of 607 piles i the facility) throughout the facility including Piers A, B, C, D, E and the Building DS-9 Platform. The overall condition of the piles found to be good. Of the 182 piles inspected, 129 (71%0 are undamaged. A total of 36 (20%) piles were found to have sustained significant strutural damage and loss of cross-sectional area as a result of one or more of the following destructive agents: mechanical impact and/or abrasion, excessive drilling of boltholes for the attachment of brace timbers, fungal decay, insect and marine borer infestation. Maintenance of these piles will be required. In additional to the above noted damage, 17 (9%) piles were found to have sustained light damage. These piles are rated at 90-100% of their original cross-sectional area and should not require maintenance at this time. Several timber braces throughout the inspected structures were also noted to have sustained damage.

The results of this sample inspection indicate that a reduction in the loading capacity has occurred in certain localized areas. Maintenance of the damaged areas should be cararied out in order to insure full design load capacity, also a more comprehensive inspection to locate all weakened areas would be warranted.

FOREWORD

The scope of the inspection at the Deperming Facility, Norfolk, VA and the detail to which it was performed and reported was tailored specifically to the conditions at this facility. This report and the procedure associated with its formation are not intended to be standards 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 inspection and assessment of the Deperming Facility, 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 judgement made separately for each activity/facility to suit its unique situation and needs. Accordingly, the procedures used at the Deperming Facility, rather than serve as a detailed model for inspections elsewhere, will provide guidance with general applicability to some types of future inspections.

EXECUTIVE SUMMARY

Nondestructive ultrasonic testing and inspection of a sampling of piles in the piers which make up the Deperming Facility at the U.S. Naval Station, Norfolk, Virginia, was carried out. This inspection has shown that on an overall basis the piles are in good condition, however, evidence of both mechanical and biological deterioration was found.

The objective of the underwater facility assessment conducted at the U.S. Naval Station, Norfolk, Virginia, was to assess the physical condition and repairability of the structural members supporting the Deperming Facility. After a Level I "swim by" of the entire facility, a Level II inspection procedure was carried out to insure the acquisition of sufficiently detailed data related to the internal structural integrity of each pile inspected as to enable determination to be made of the overall bearing capacity and lateral stability of the pier. The data provided is sufficiently detailed to facilitate comparisons with subsequent periodic inspections for purposes of determining progressive deterioration with time.

The Level II inspection covered 182 piles (30% of the total of 607 piles in the facility) throughout the facility including Piers A, B, C, D, E and the Building DS-9 Platform. The overall condition of the piles was found to be good. Of the 182 piles inspected, 129 (71%) are undamaged. A total of 36 (20%) piles were found to have sustained significant structural damage and loss of cross-sectional area as a result of one or more of the following destructive agents: mechanical impact and/or abrasion, excessive drilling of boltholes for the attachment of brace timbers, fungal decay, insect and marine borer infestation. Maintenance of these piles will be required. In addition to the above noted damage, 17 (9%) piles were found to have sustained light damage. These piles are rated at 90-100% of their original cross-sectional area and should not require maintenance at this time. Several timber braces throughout the inspected structures were also noted to have sustained damage.

The results of this sample inspection indicate that a reduction in the loading capacity has occurred in certain localized areas. Maintenance of the damaged areas should be carried out in order to insure full design load capacity, also a more comprehensive inspection to locate all weakened areas would be warranted.

See the following table for a cost breakdown for required maintenance.

EXECUTIVE SUMMARY TABLE

Facility	Year Built*	Length (ft.)	Structure Type	Recommendations†	Estimated Repair Cost**
Pier A	1940	1,015	Timber pile	Repair pile 20-2. Carry out full scale inspection of all uninspected piles.	1@$2,500
Pier B	1940	1,230	Timber pile	Repair 7 piles. Carry out full scale inspection of all uninspected piles.	7@$2,500
Pier C	1940	850	Timber pile	Repair 17 piles by concrete jacketing damaged area. Repair 2 piles by extension of existing concrete jackets replace 2 piles. Carry out full scale inspection of all uninspected piles.	17@$2,500 2@$1,500 2@$3,000
Pier D	1940	850	Timber pile	Repair 4 piles by concrete jacketing. Repair 3 piles by extension of existing concrete jacket. Carry out full scale inspection of all uninspected piles.	4@$2,500 3@$1,500
Pier E (including Bldg. DS-9 Platform)	1940	280	Timber pile	No significant damage found. Carry out full scale inspection of all uninspected piles.	N/A
				Plus miscellaneous	4,000
				TOTAL ESTIMATED REPAIRS:	$90,000

Overall Structure: A projection of the results of a detailed full scale inspection would indicate that approximately 174 piles will require maintenance. Total estimated cost of repairs is approximately . . . . . $270-$300,000

* estimate of 40 year structure age provided by CHESDIV.
**based on sample inspection.
† All piles (bearing and batter) in this facility were inspected by visual and/or tactile methods. "Uninspected piles" refers to those not inspected by the use of ultrasonic transmission equipment.

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SECTION 1 - INTRODUCTION

1.1 CONTRACT

Department of the Navy
Chesapeake Division, Naval Facilities Engineering Command
Building 212
Washington Navy Yard, Washington, D.C. 20374

1.2 CONTRACT NO.

N62477-80-C-0265
Modification No. P00002
Task No. 3

1.3 CONTRACT DATE

August 25, 1980

1.4 CONTRACT DESCRIPTION

The contractor shall provide all required technical, non-personnel engineering services for Ocean Engineering Services in support of underwater facility assessment at various locations. Task 3 awarded under this contract is for engineering services for a Level II inspection of 182 timber piling at the Deperming Facility at the U.S. Naval Station, Norfolk, Virginia.

1.5 INTRODUCTION TO PROJECT

This report is prepared under the Underwater Inspection Program conducted by the Ocean Engineering and Construction Project Office (FPO-1), Chesapeake Division, Naval Facilities Engineering Command as a part of NAVFAC's specialized Inspection Program. This is a task oriented engineering service program in support of inspection, analysis and design of repairs of the submerged portions of Navy Waterfront Facilities.

This report covers the inspection carried out at the Deperming Facility at the U.S. Naval Station, Norfolk, Virginia. The purpose of this project is to provide a base line assessment in sufficient detail to facilitate comparisons with subsequent periodic inspections for purposes of determining progressive deterioration of the facility with time.

A description of the activity, its location and mission is provided. Detailed data is given relative to the Deperming Facility in terms of location, function and construction.

1.6 DEFINITION: LEVEL II INSPECTION

Level II underwater inspections quantify the structural condition of a facility through definitive engineering-data-measurement techniques. This type of inspection is required in cases where engineering evaluations, structural analyses, and design of repairs are required.

Level II inspections normally include visual documentation using underwater television and/or photography and detailed measurements including ultrasonics, X-ray diffraction, magnetic particle testing, dye penetrant testing or other diver nondestructive testing techniques. Corings of concrete, wood and steel structures are also sometimes required. Detailed dimensions will also be taken.

Detailed results with repect to individual piling, overall assessment of structural condition, and recommendations are provided.

SECTION 2 - ACTIVITY DESCRIPTION

2.1 NAME OF ACTIVITY

Deperming Facility, U.S. Naval Station, Norfolk, Virginia.

2.2 LOCATION OF ACTIVITY

The Deperming Facility is located within the Sewells Point Area Navy Complex at Norfolk, Virginia (see Figures 1 and 2, pages 2-2 and 2-3). The Sewells Point Complex is favorably situated in the world's largest natural harbor, Hampton Roads. This strategic location enjoys access to the Atlantic Ocean through Chesapeake Bay providing a natural protective site for its main function of homeporting the majority of current active ships in the Atlantic Fleet. The specific location of the Deperming Facility is approximately mid channel of the Elizabeth River between the cities of Norfolk and Portsmouth.

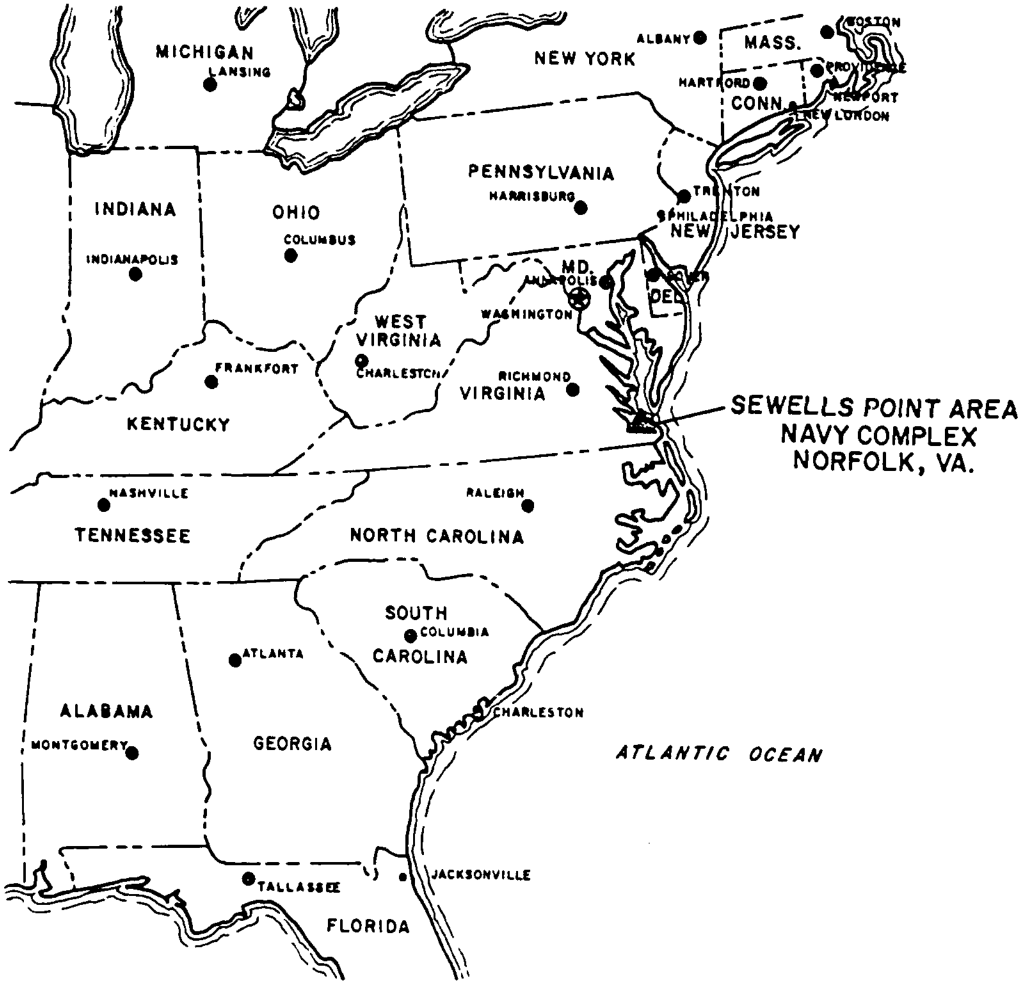
2.3 MISSION OF ACTIVITY

The major program concern for the Naval Station is the homeporting of the Atlantic Fleet ships. To support this function, the Naval Station has complete backup facilities and services including the inspected Deperming Facility.

2.4 DESCRIPTION OF ACTIVITY

This program is concerned with waterfront facilities which provide the interface between the fleet vessels and the support activities. The task under the current contract covers only the Deperming Facility.

The Deperming Facility consists of five finger piers identified by letters A-E. These piers are arranged into three deperming berths of differing sizes to facilitate various types of vessels ranging from submarines to aircraft carriers (see Figures 3 and 4, pages 2-4 and 2-5). The deperming berths are non-magnetic wooden structures and serve to



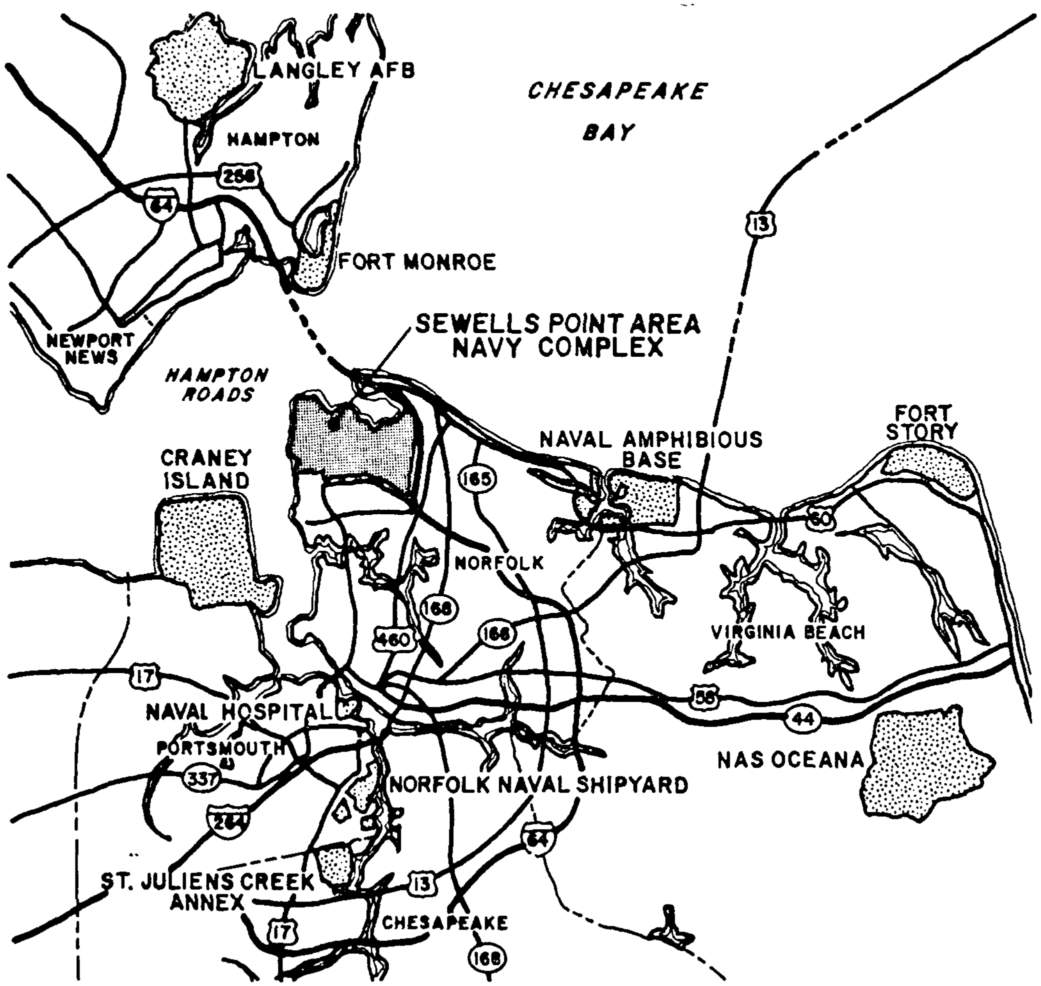
north

Not To Scale

Sewells Point Area
Navy Complex

LOCATION
MAP

FIGURE 1



Not To Scale

Sewells Point Area
Navy Complex

VICINITY
MAP

FIGURE 2

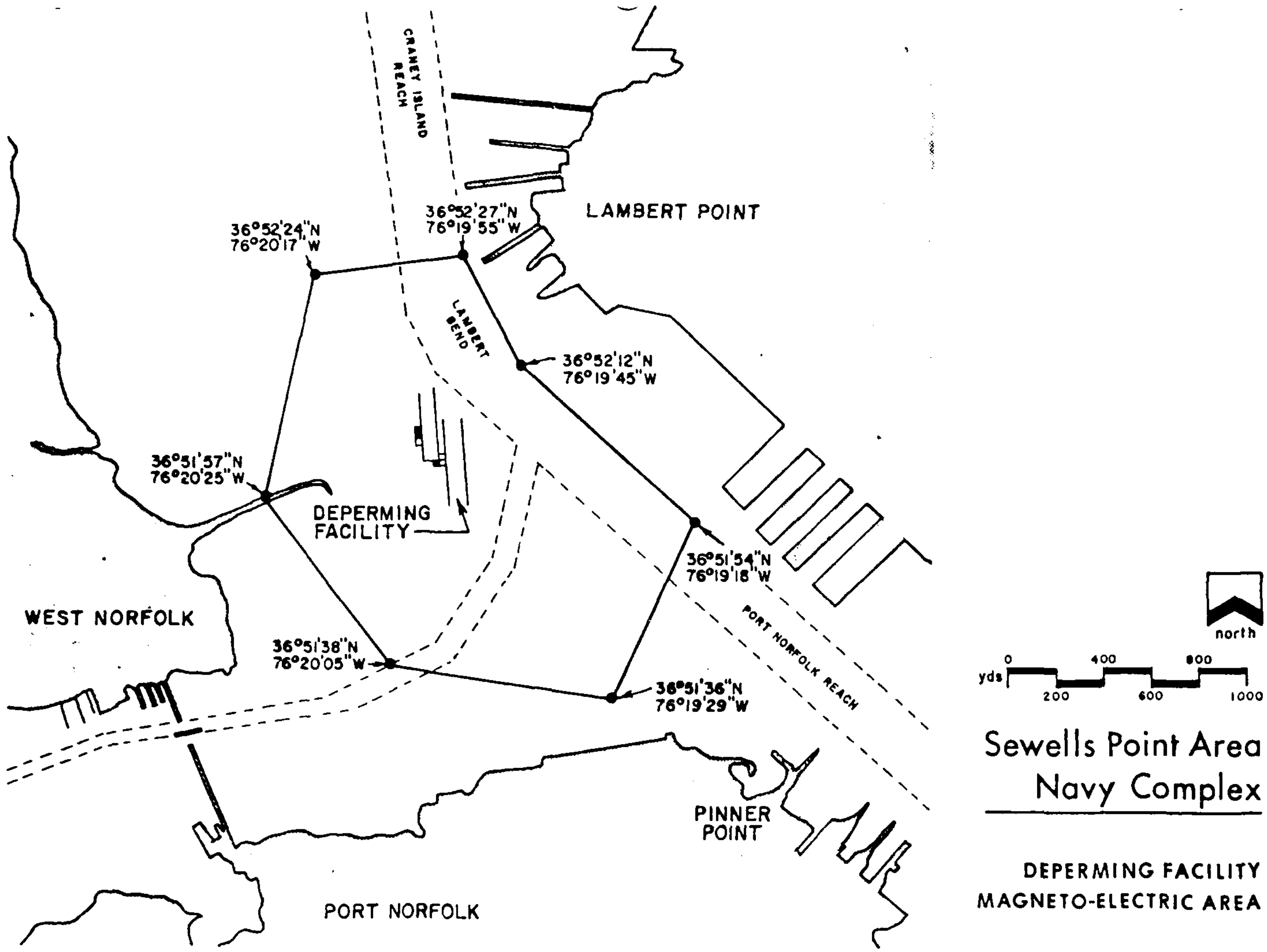
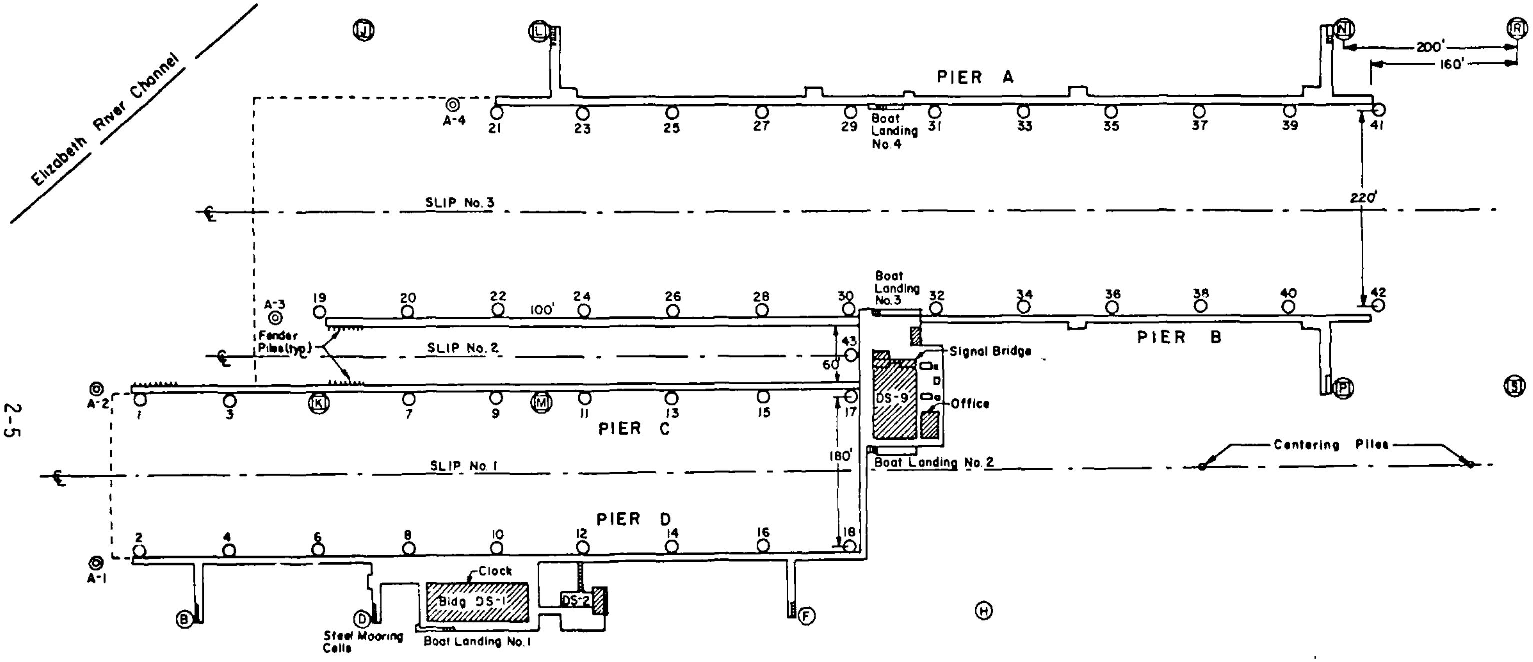

CRANEY ISLAND REACH
LAMBERT POINT
LAMBERT BEND
36°52'24"N
76°20'17"W
36°52'27"N
76°19'55"W
36°52'12"N
76°19'45"W
36°51'57"N
76°20'25"W
DEPERMING FACILITY
36°51'54"N
76°19'18"W
WEST NORFOLK
36°51'38"N
76°20'05"W
36°51'36"N
76°19'29"W
PORT NORFOLK REACH
PINNER POINT
PORT NORFOLK
north
yds
0
200
400
600
800
1000
Sewells Point Area
Navy Complex
DEPERMING FACILITY
MAGNETO-ELECTRIC AREA

FIGURE 3



LEGEND

○ 37-PILE DOLPHIN

▢ 73-PILE DOLPHIN

◎ 61-PILE DOLPHIN

IDENTIFICATION OF PIERS
AND MOORING SLIPS
DEPERMING FACILITY, DEGAUSSING DEPT.
NAVAL STATION, NORFOLK, VIRGINIA
Figure 4

SCALE: 1" = 160' Approx. Oct, 1981

support the electrical wires and other equipment used in Degaussing/Deperming operations. This project was carried out to inspect a sampling of the wood piles which support the facility.

2.5 ENVIRONMENTAL DATA

The examined facility is located in mid channel of the Elizabeth River (see Figures 1-3). The Elizabeth River is part of Hampton Roads, the world's largest natural harbor.

The Sewells Point complex is located in the physiographic coastal plain province. The area in general is underlain by non-indurated to poorly indurated sedimentary gravels, sands and clays. The topsoil layers found throughout the Sewells Point Area vary only slightly. It is, except where topsoil has been brought in for the promotion of vegetative growth, typically sandy loam.

The topographic variation in the Tidewater area is relatively slight. The mean elevation is fifteen (15) feet across Tidewater and approximately 11 feet across the Sewells Point complex based on mean sea level as 0 elevation. The high elevation is the runway 10/28 at the Naval Air Station at 15.5 feet and low elevation is 3 feet in several areas in the south portion of the site. The bay and harbor provide the principal natural drainage for the land. The site slopes slightly toward the west as opposed to a perceived northern slope.

The area's climate is moderate with the winters relatively mild. Warm summers are frequently tempered by northeasterly breezes from the Atlantic Ocean. The mean minimum temperature for this region is 50.5°F. The mean maximum temperature is 68°F with the monthly averages varying from 41.2°F in January to 78.6°F in July.

The extreme minimum temperature recorded in the past 23 years was 8°F in February 1965 and the extreme maximum temperature recorded was 105°F which occurred in July 1952. Prolonged cold waves seldom penetrate this area and the daily minimum temperature rarely goes below 20°F. The average frost free period covers 239 days from March 23rd through November 18th.

Precipitation is well distributed throughout the year. The annual average is 46.25 inches with a high of 6.50 inches occurring during July. Snowfall averages 9.1 inches per year, occurring chiefly during December and January. Major melting occurs within 24 hours after the snowfall has ceased. A record that still survives is the cumulative depth of snowfall totalling 37.7 inches which occurred druing the winter of 1935-36. Frost penetration for design use is calculated to be 12 inches.

The wind velocity is less than 12 knots 80 percent of the time and seldom exceeds 20 knots. The prevailing wind direction is generally southwestern in the early winter, spring and early summer, with the highest velocity usually occurring during the hours of darkness. However, northeasterly winds prevail about 25 percent of the time with highest velocity occurring during the daylight hours.

The geographical position of the Complex with respect to principal storm tracks is especially favorable, being south of the average path of the storms originating in the higher latitudes and north of the usual track of hurricanes and other tropical storms. Occasionally, these tropical storms have passed nearby or invaded the area when subnormal atmospheric pressures have existed. Usually, these have had little effect other than greater than normal tides and higher wind velocities. Winds of hurricane force have occurred on an average of once every seven years. The mean range of tide in Hampton Roads is 2.5 feet. The average velocities in mid channel at strength of flood or ebb tide is bout 1¼ knots; however, currents are greatly influenced by the winds.

SECTION 3 - PROJECT DESCRIPTION

3.1 STRUCTURE INSPECTED

Deperming Facility, U.S. Naval Station, Norfolk, Virginia.

3.2 STRUCTURE DESCRIPTION

As shown on the vicinity map on Drawing No. 1, page 3-10, the Deperming Facility is located in approximately mid channel of the Elizabeth River between the cities of Norfolk and Portsmouth, Virginia. The facility is comprised of four finger piers identified as Piers A, B, C and D. A fifth pier section, Pier E interconnects Piers B, C and D. See Photographs 1 and 2 page 3-2, and the location plan in Drawing No. 1.

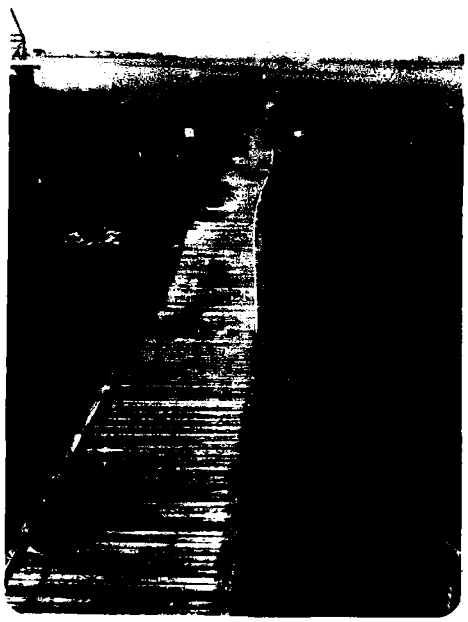
In Pier A, the pile bents are numbered 1 and 2 from the west. In bents 1-31 the pile rows are numbered 1 through 3 from the west, in bents 32 through 60 the pile rows are numbered 1 and 2. The platform for Building DS-9 is located between bents 31 and 32. The inspected piles in this structure are identified as bent 2 rows 1 through 7, with the bents numbered consecutively from the east and the rows numbered from the north. Pile bents in Pier C are numbered 1-42 from the north and pile rows are numbered 1-3 from the west. In Pier D the bents are numbered 1-42 and the rows 1 and 2 in the standard fashion. In Pier E, which interconnects Piers C and D through the building DS-9 platform, the bents are numbered 1-8 from the west and the pile rows designated consecutive numbers from the north.

Extensive timber bracing extends from the pile tops down approximately 10 feet. This bracing is arranged in both the diagonal cross-brace and horizontal waler configuration. See Photographs 4 and 5, on page 3-3 and 3-4, and the accompanying Drawing No. 3, page 3-12.

The mudline to cap pile lengths ranged from 43 to 45 feet. The average pile diameter in Piers A and B (which are of newer construction than the original Piers C and D) is 16 inches. The pile diameters in Piers C, D and E are 14 inches.

PHOTOGRAPH 1

Overview of Deperming Facility with Pier B in mid photo flanked by Pier A on the right and Pier C on left.



PHOTOGRAPH 2

Pier C. Note deperming berth for submarines and small craft in berth to right and larger berth left. Also note impact deflections of Pier C.

PHOTOGRAPH 3

Typical condition of timber deck. Note steel rod used to inspect for fungal decay of pile tops.

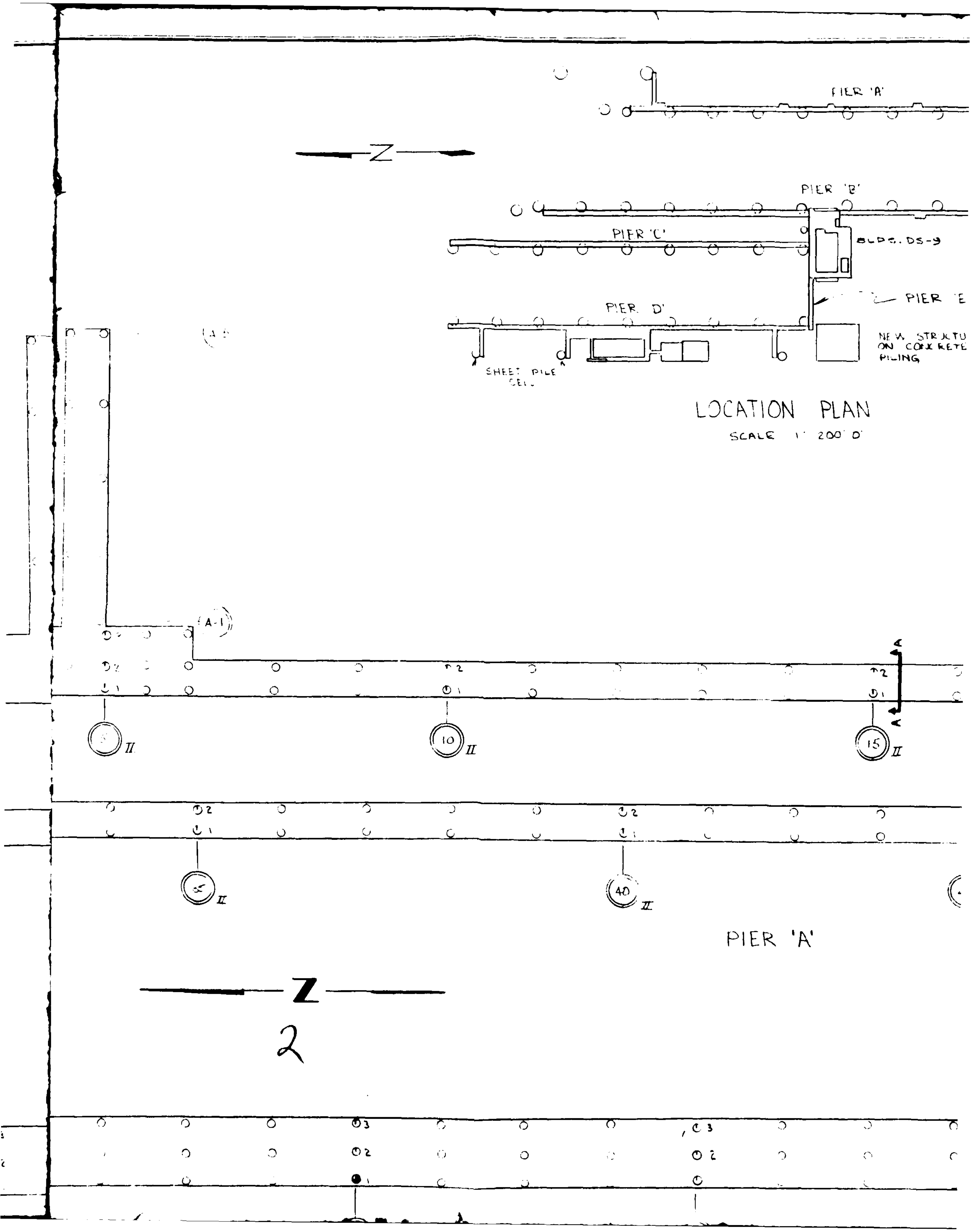
PHOTOGRAPH 4

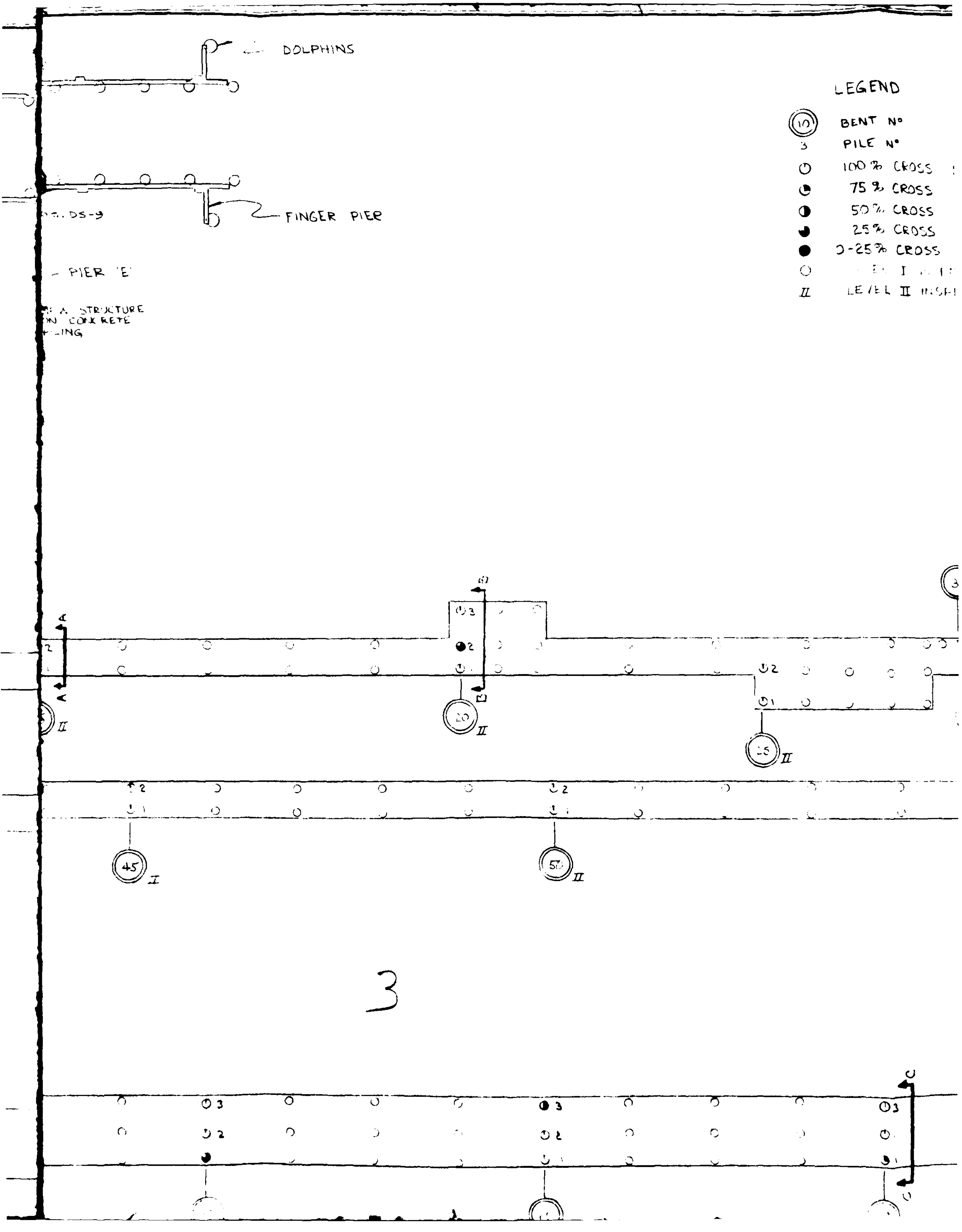
Pier C - Bent 19. Typical pier construction, showing untreated deck assembly and treated bolted pile caps and timber bracing. Also note several open boltholes in center pile.

PHOTOGRAPH 5

Pier C - Bent 9. Refurbished bent showing one additional pile at right side of structure. Note good condition of brace timbers.

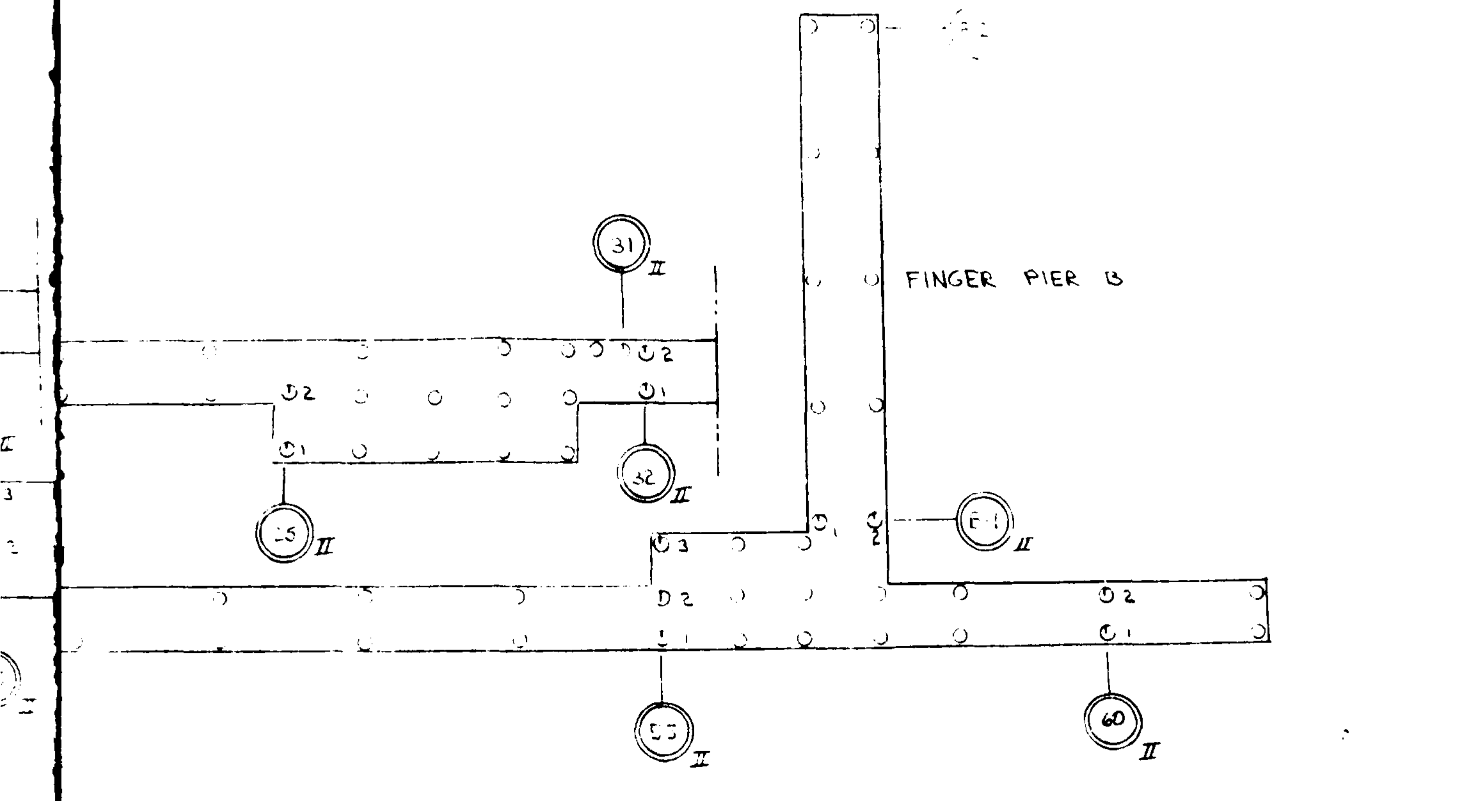
VICINITY MAP


PIER 'A'
PIER 'B'
PIER 'C'
BLDG. DS-9
PIER 'E
PIER D'
NEW STRUCTU
ON CONCRETE
PILING
SHEET PILE
CELL
LOCATION PLAN
SCALE 1" 200' 0"
A-1
10 II
15 II
40 II
PIER 'A'
2


DOLPHINS
FINGER PIER
DS-9
PIER 'E'
STRUCTURE
CONKRETE
LEGEND
BENT No
PILE No
100 % CROSS
75 % CROSS
50 % CROSS
25 % CROSS
0-25 % CROSS
LEVEL II INSP
20
25
45
50
3

LEGEND

(10)	BENT No
3	PILE No
○	100 % CROSS SECTIONAL AREA
◔	75 % CROSS SECTIONAL AREA
◑	50 % CROSS SECTIONAL AREA
◕	25 % CROSS SECTIONAL AREA
●	0-25 % CROSS SECTIONAL AREA
○	[illegible] I [illegible]
II	LEVEL II INSPECTION



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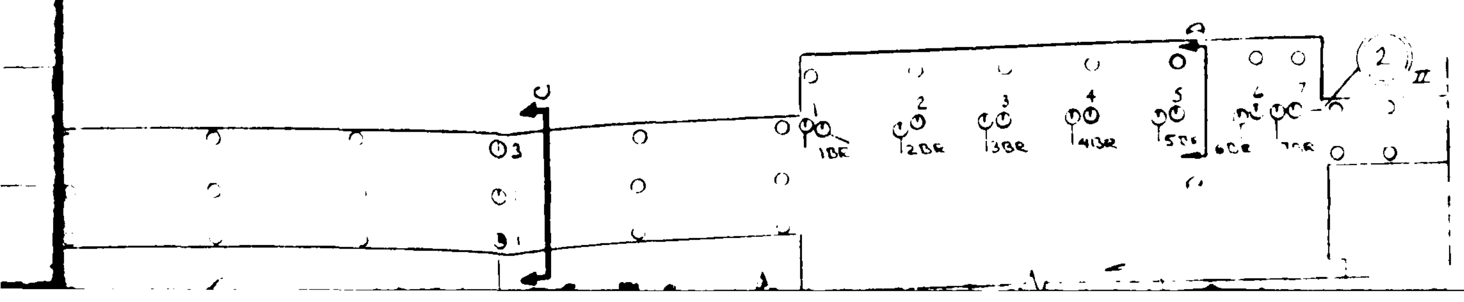

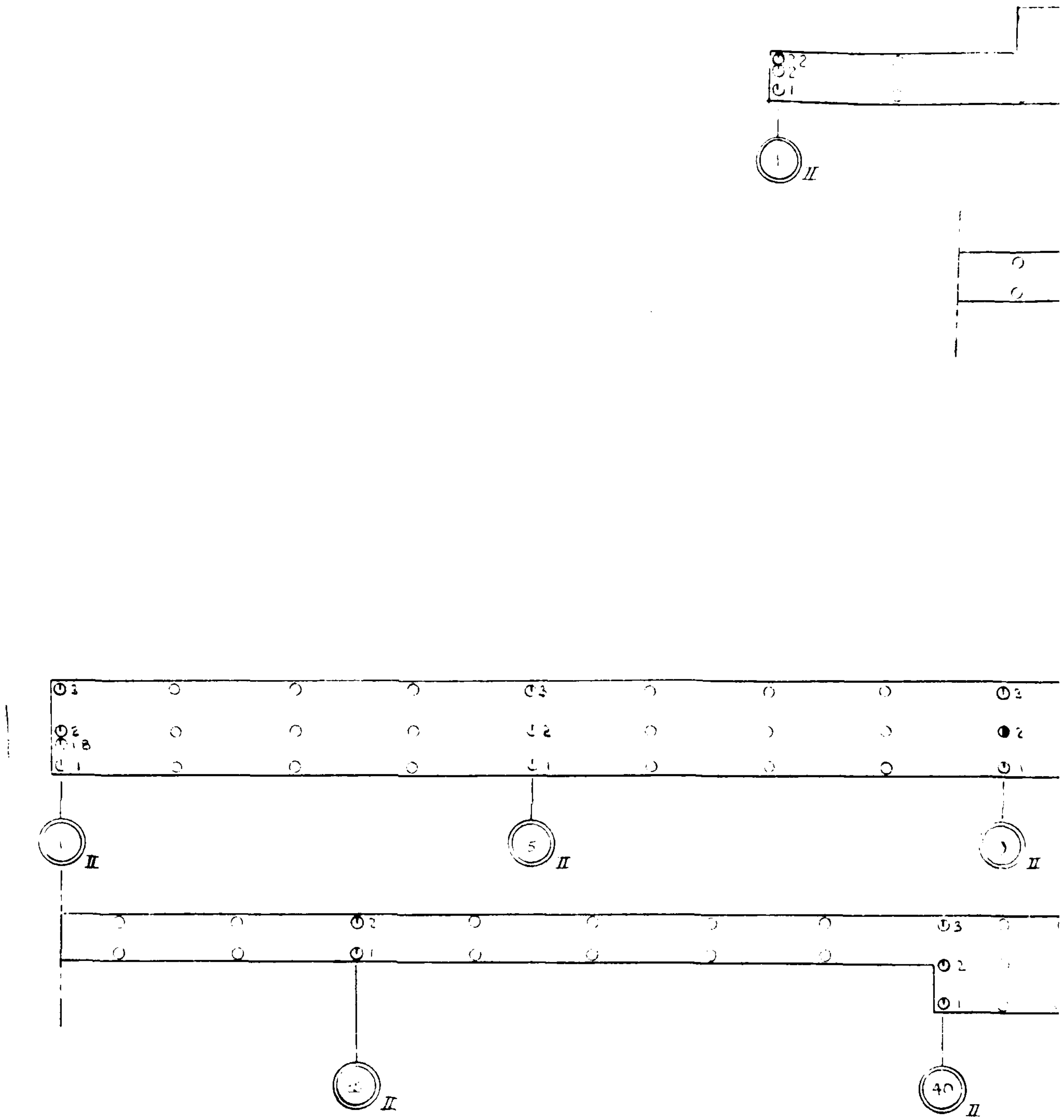

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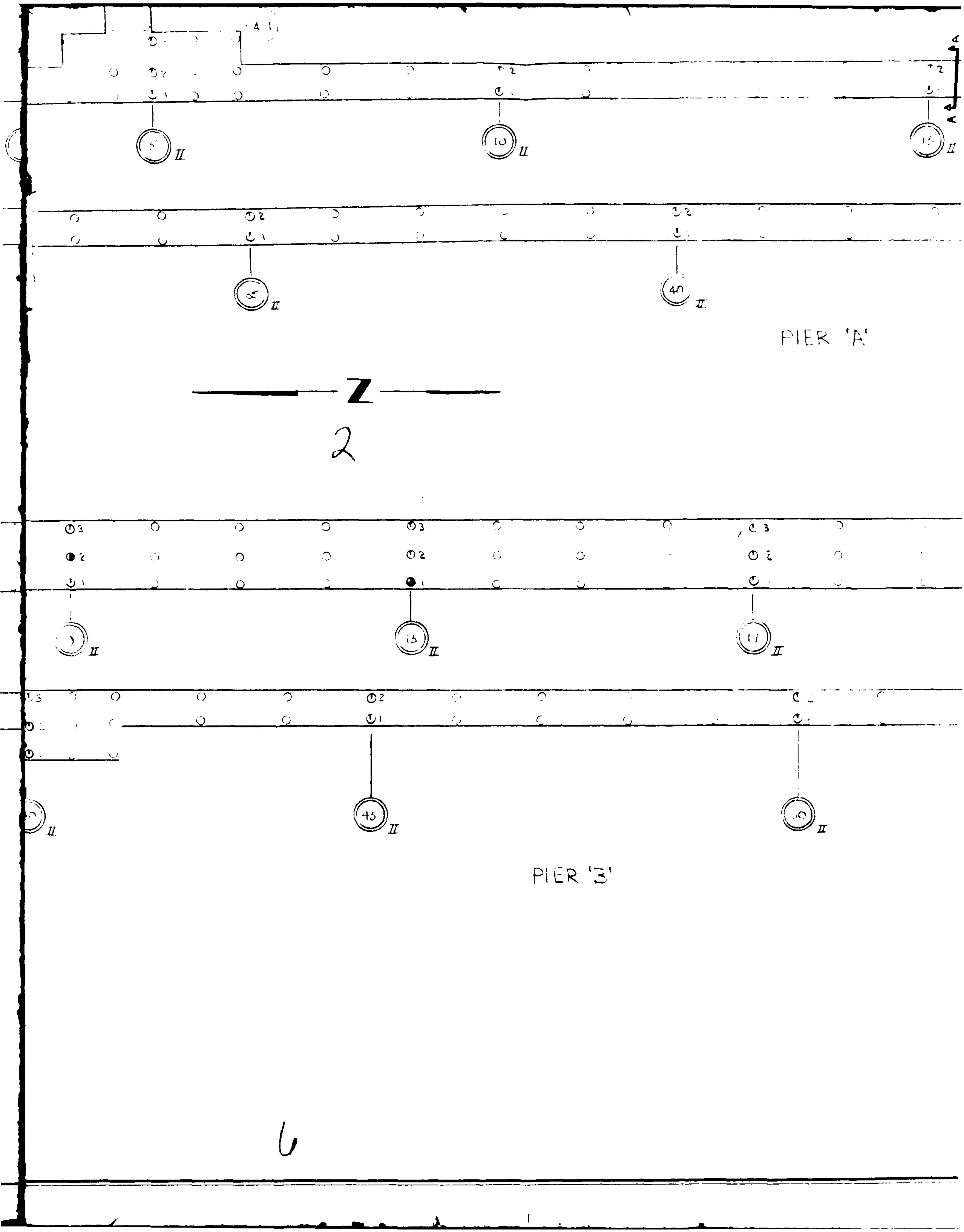
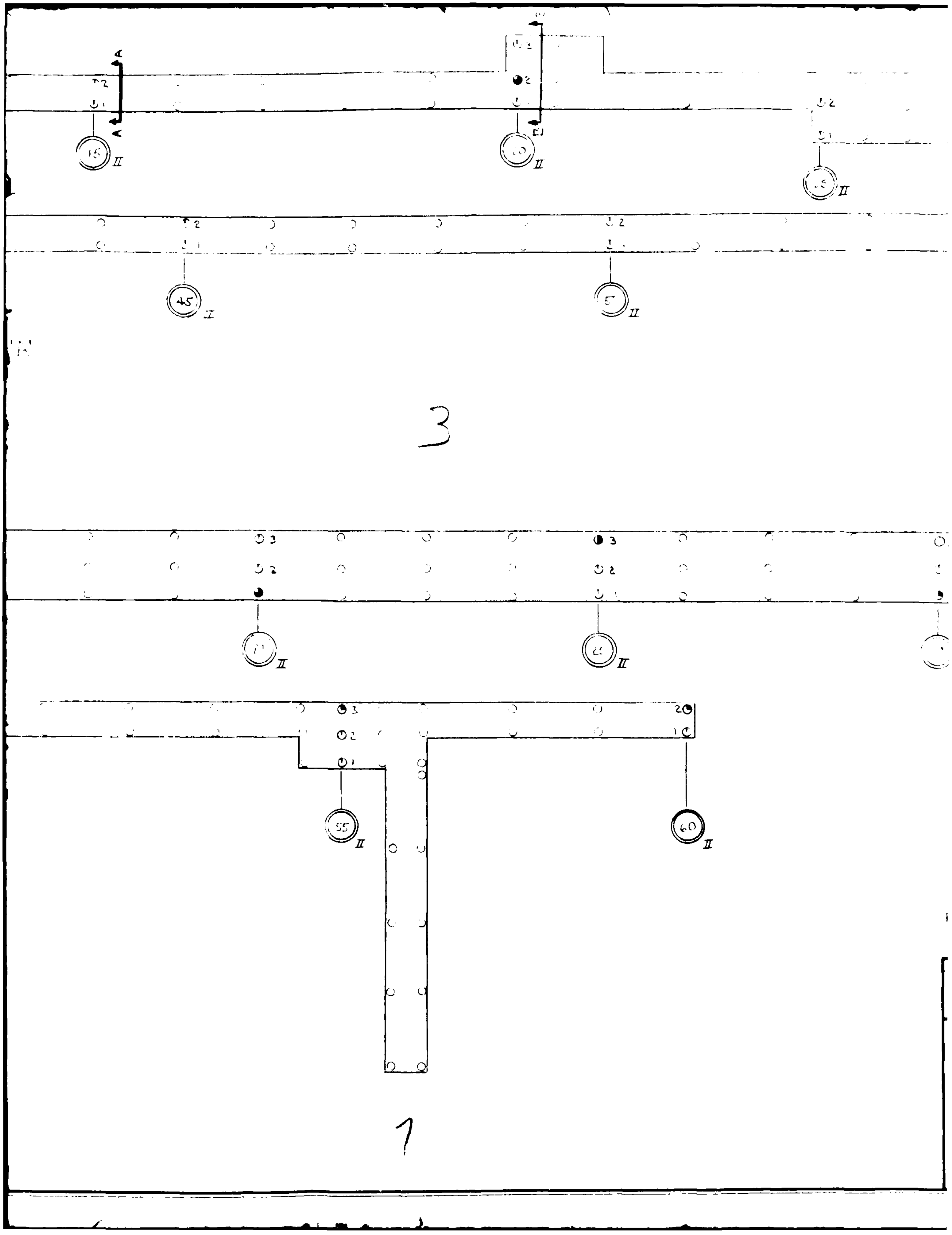
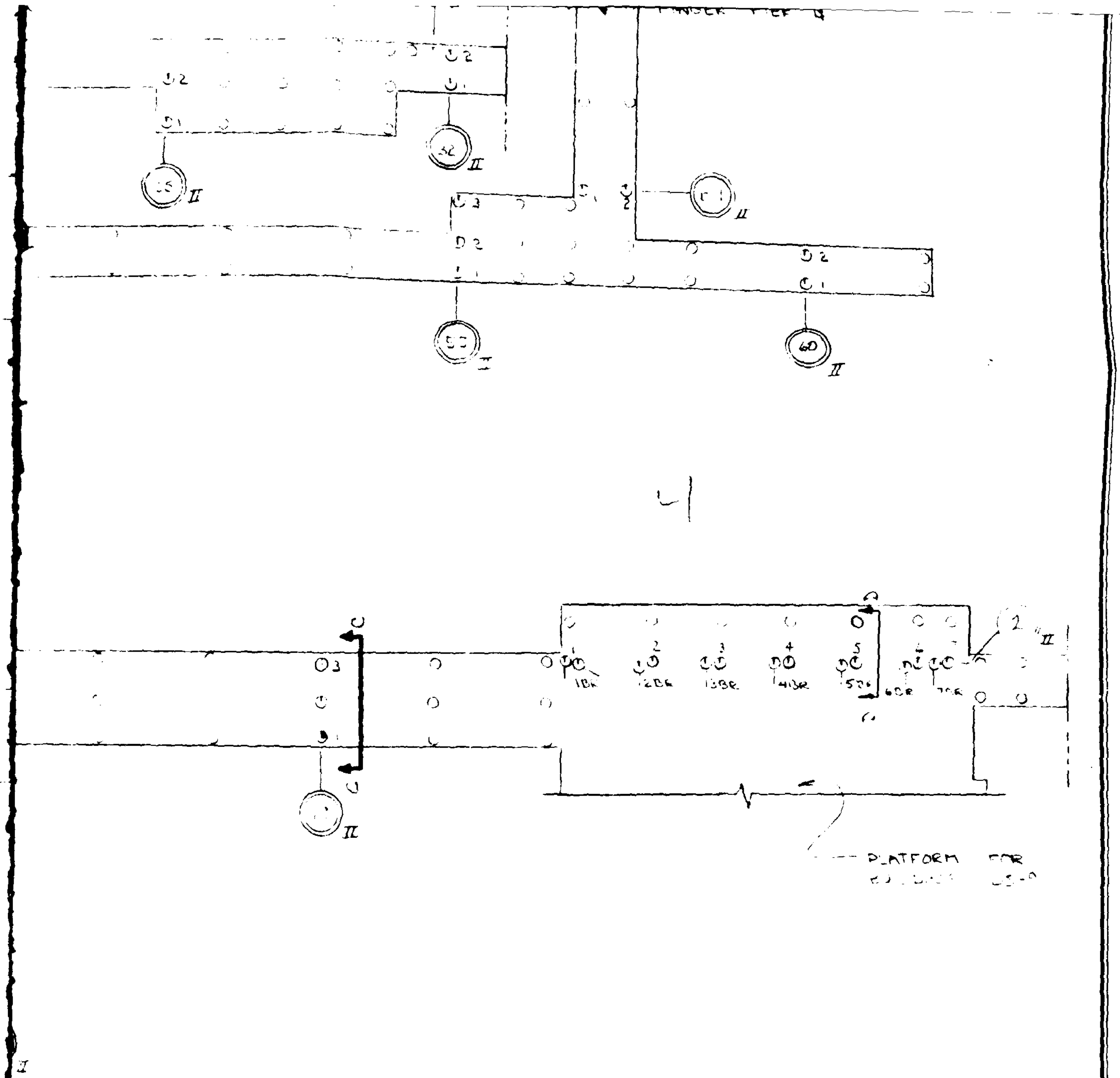
NCAL 5567


PIER 'A'
Z
2
PIER 'B'
6



15 II
20 II
45 II
55 II
60 II
3
1



REF DWGS - NAVFAC DWG No 4044687 4044688, 4044689

J. AGI & ASSOCIATES CO. LTD.
Suite 600, 1414 Alaskan Way, Seattle, WA

PLAN SHOWING VICINITY MAP, LOCATION PLAN, LOCATION & CONDITION OF INSPECTED PILING IN PIERS A, B AND BUILDING PLATFORM No.9 OF U.S. NAVY DEPERMING FACILITY, NORFOLK, VIRGINIA

CHES DIV NAV FAC ENG COM
REPORT No. FPO-1-81-(16)
CONTRACT No. N62477-81-0265
TASK 3

DWG. No. 1

8

SCALE	1" = 20'
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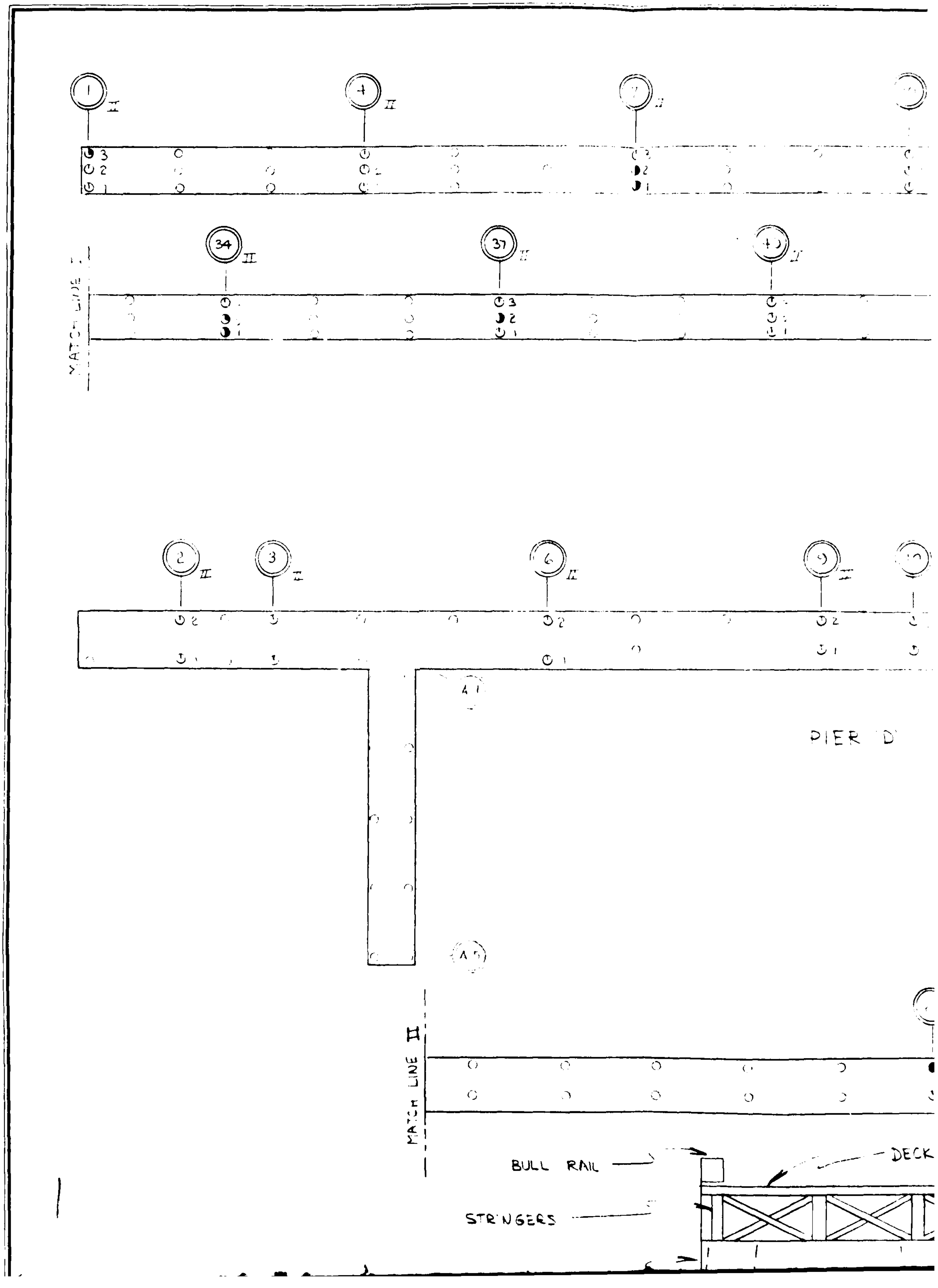
APPROVED	
DATE	JUNE 22, 1981
PROJECT No	81-1-2-044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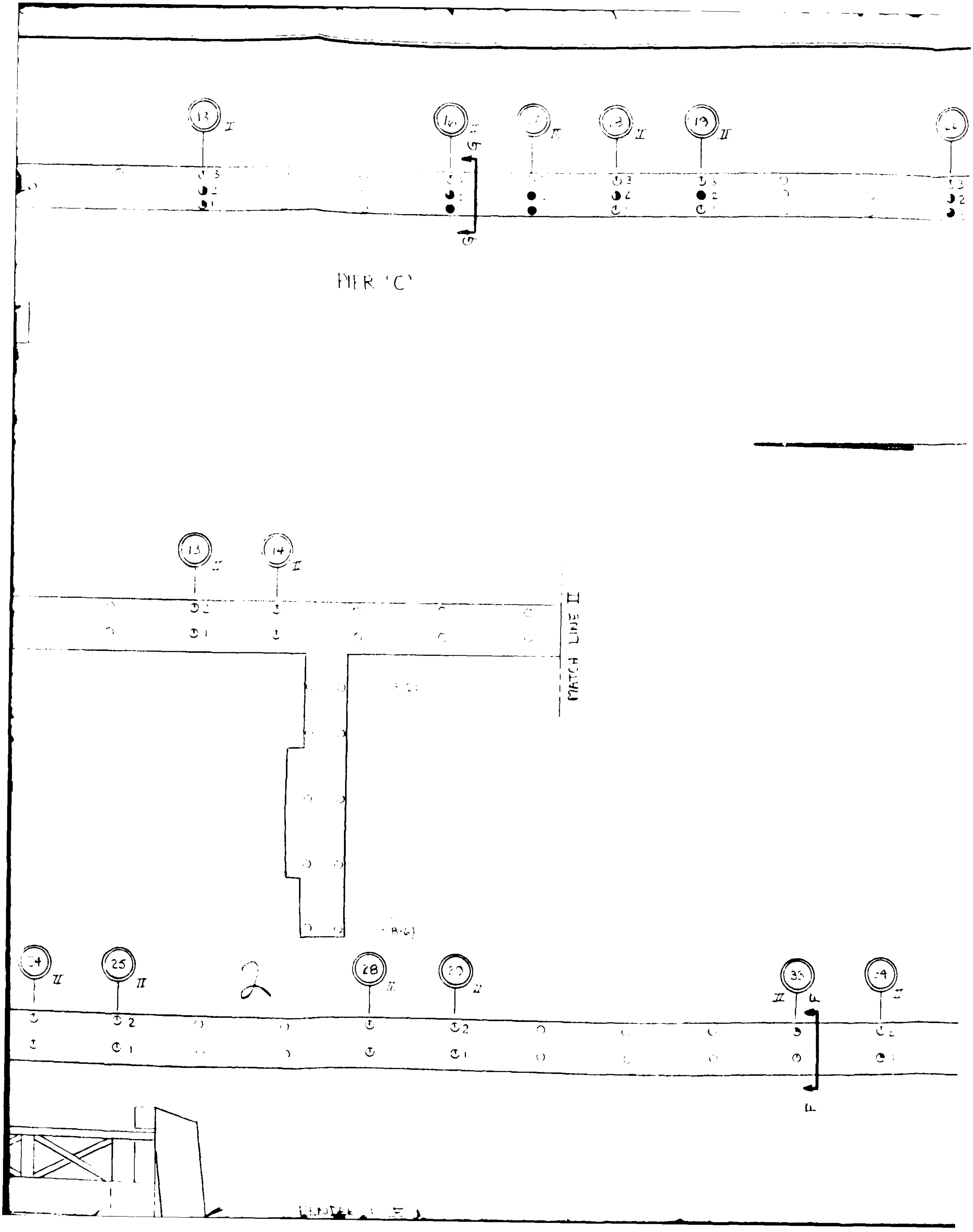
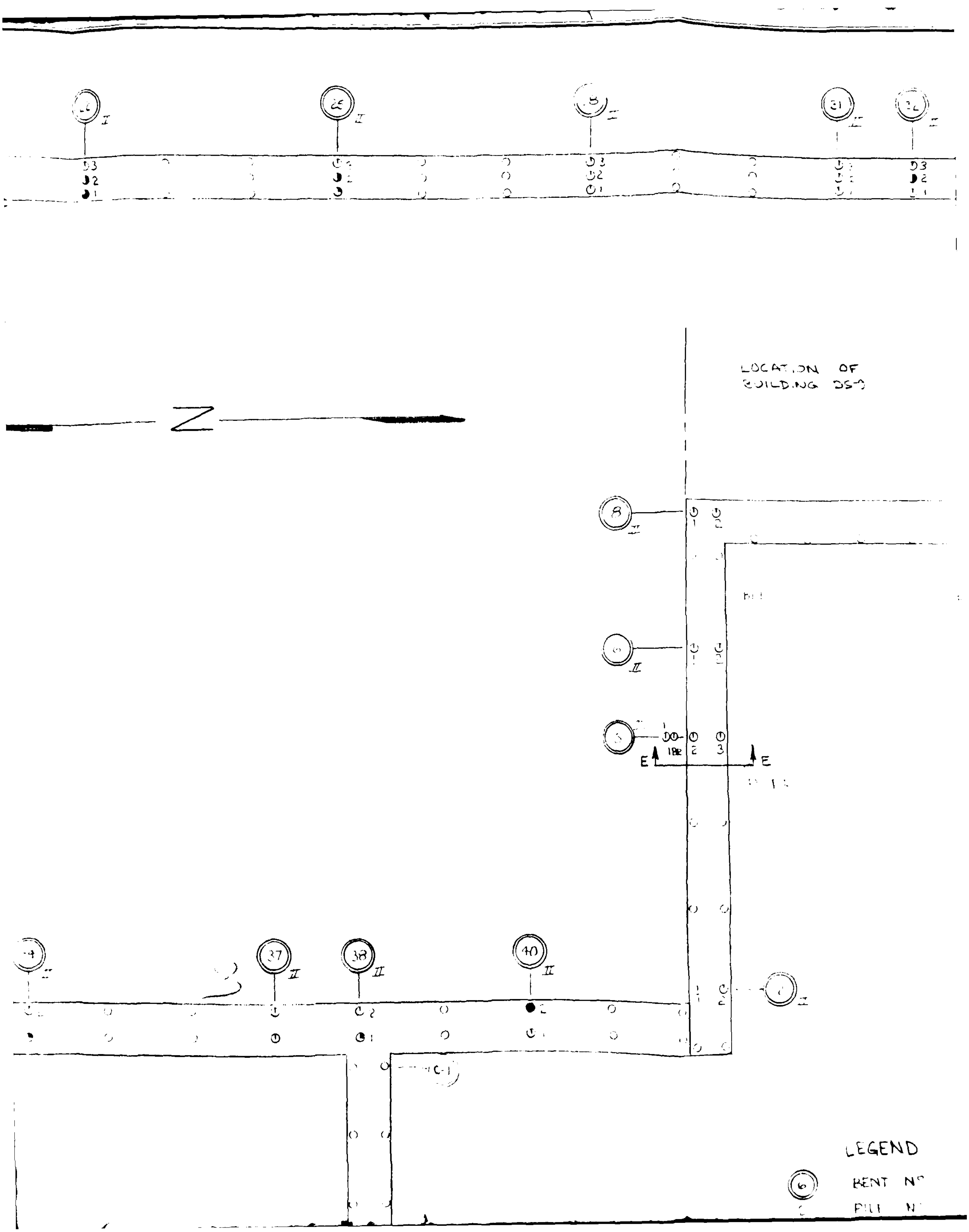
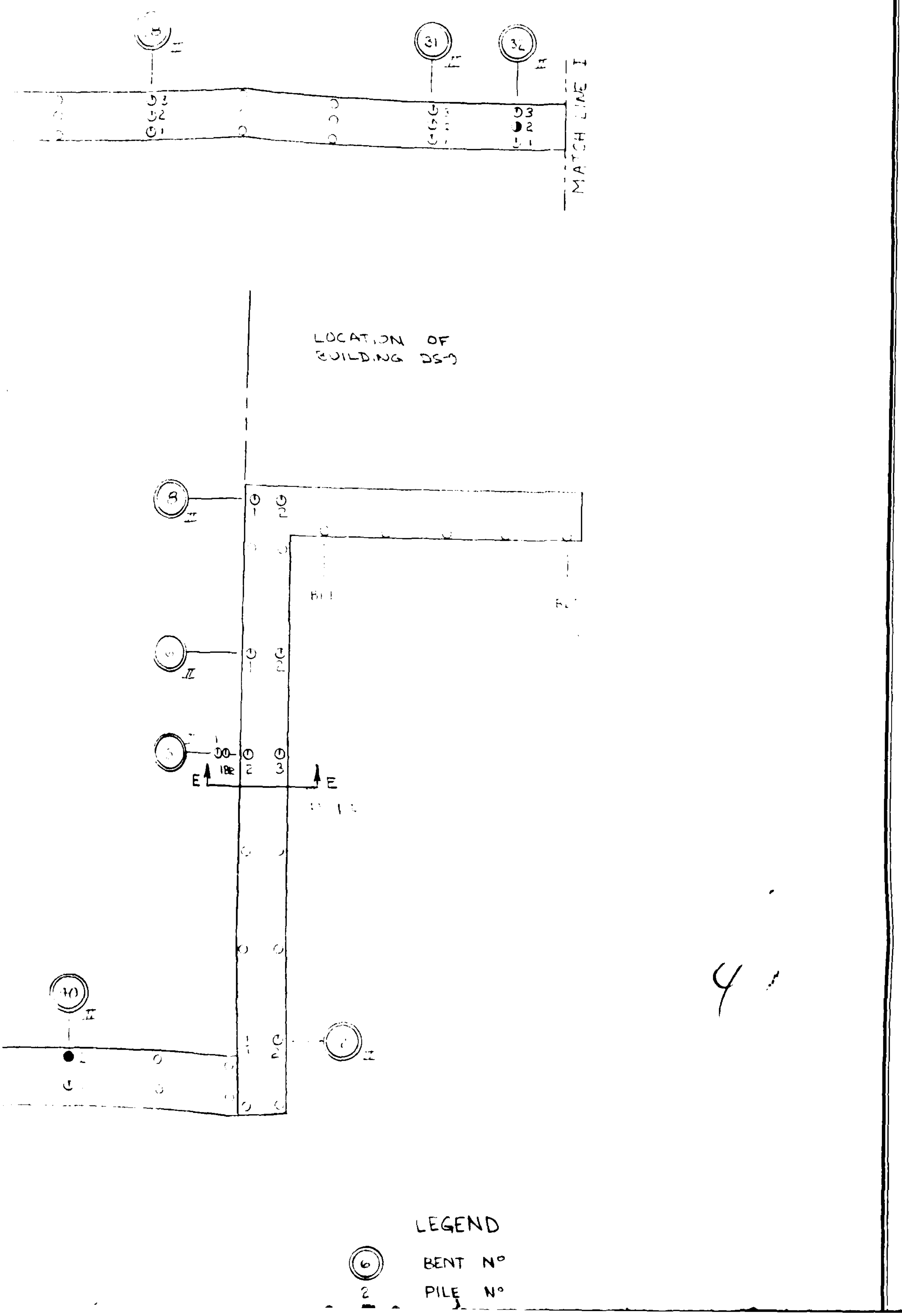
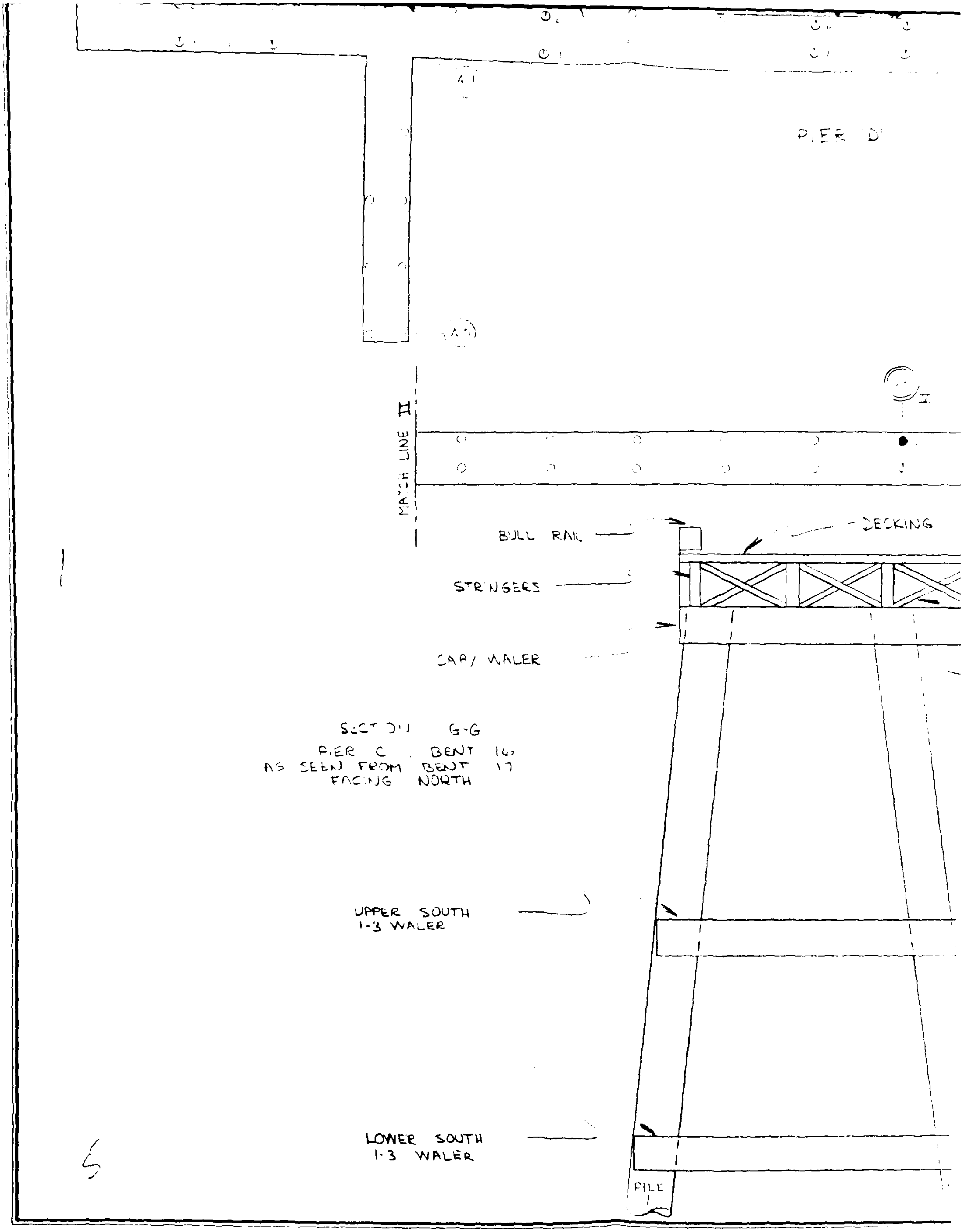
PIER 'D'
MATCH LINE II
BULL RAIL
STRINGERS
DECK

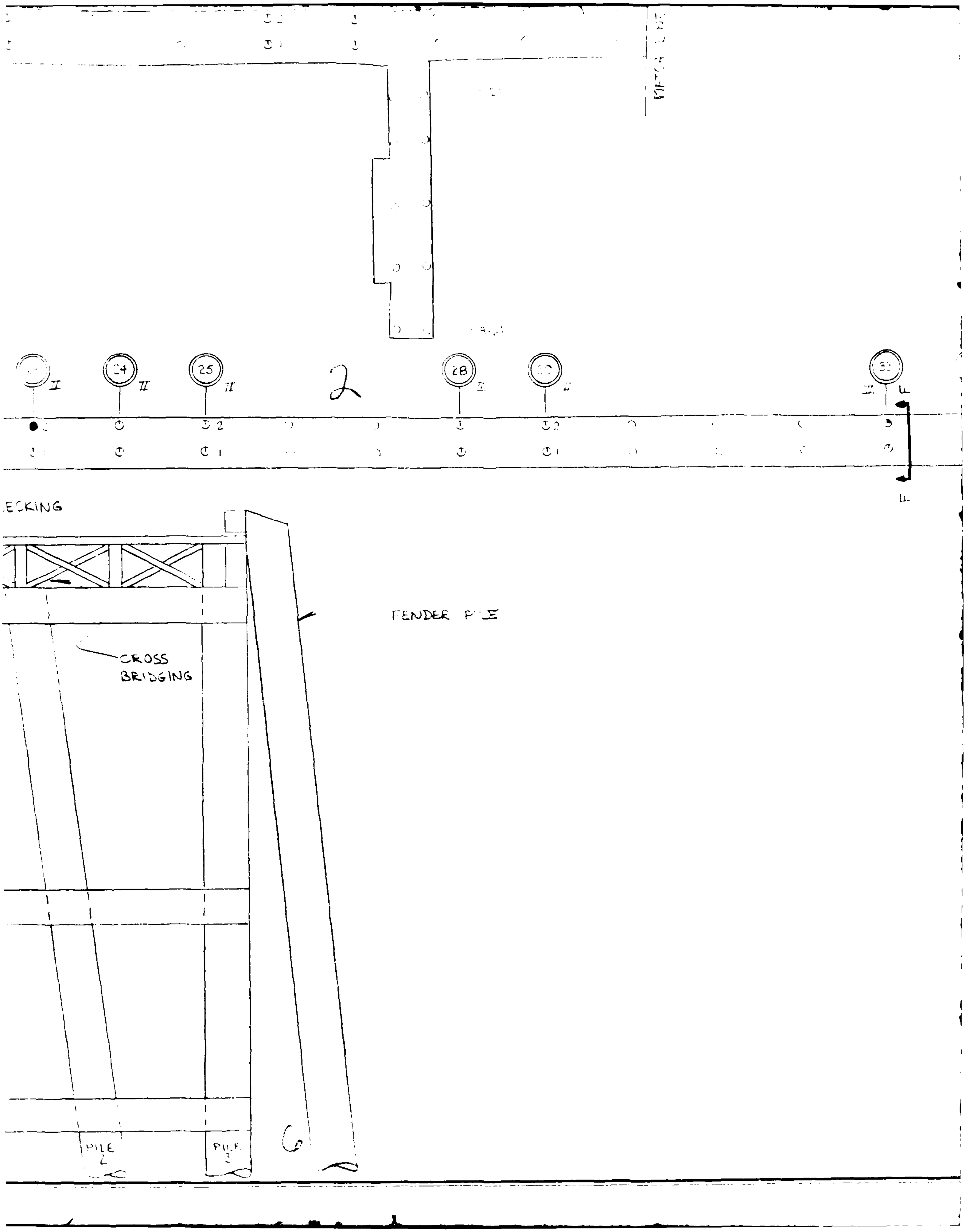

13
19
PIER 'C'
13
14
MATCH LINE II
25
28
33

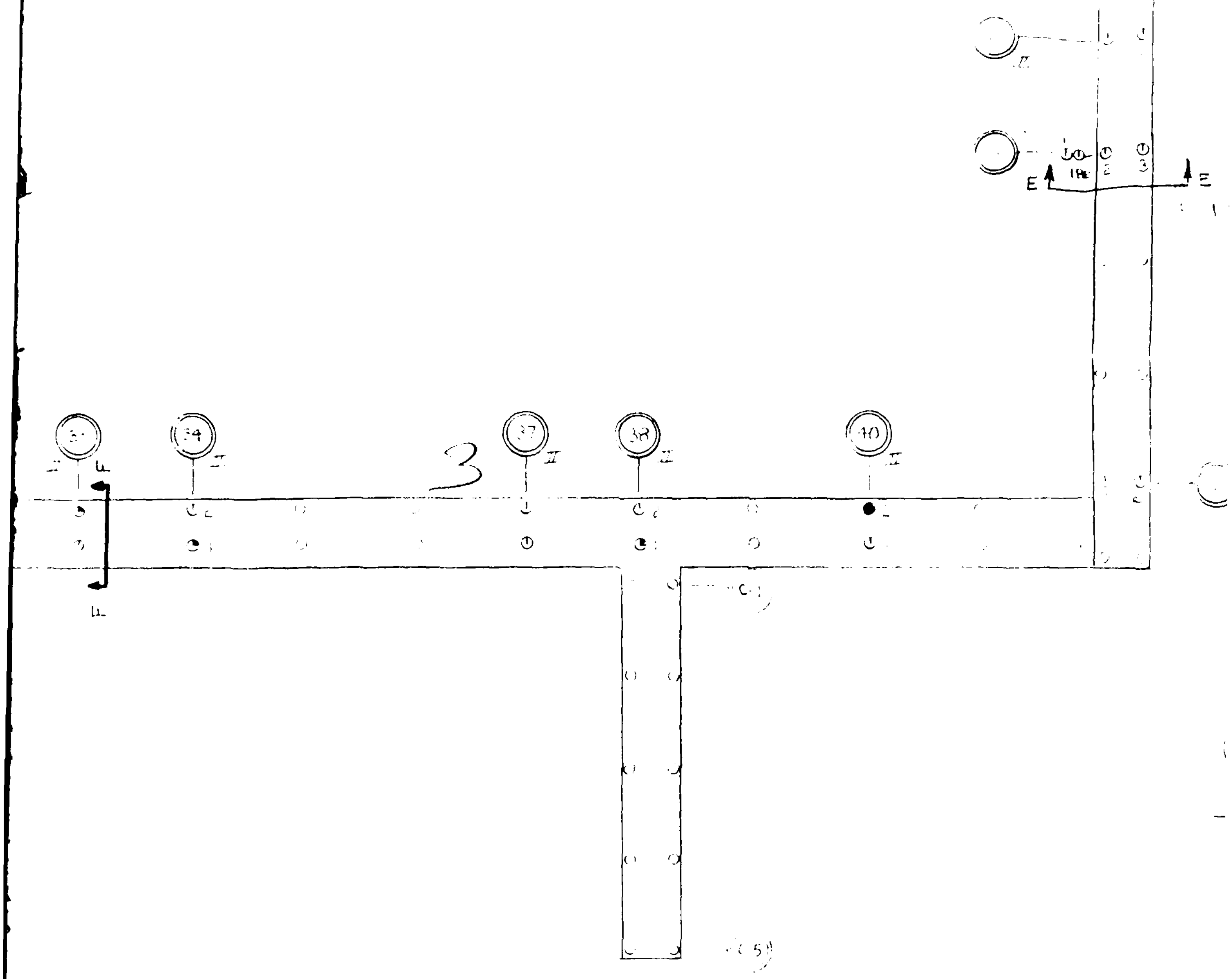


LOCATION OF
BUILDING DS-9
8
37
38
40
E
E
LEGEND
BENT No
PILE No


31
32
MATCH LINE I
LOCATION OF
8
E
E
LEGEND
6
BENT N°
2
PILE N°
4


PIER 'D'
MATCH LINE II
BULL RAIL
DECKING
STRINGERS
CAP/ WALER
SECTION G-G
PIER C , BENT 16
AS SEEN FROM BENT 17
FACING NORTH
UPPER SOUTH
1-3 WALER
LOWER SOUTH
1-3 WALER
PILE


24
25
2
28
CROSS
BRIDGING
FENDER
6
PILE 2
PILE 3



REF DWGS - NA

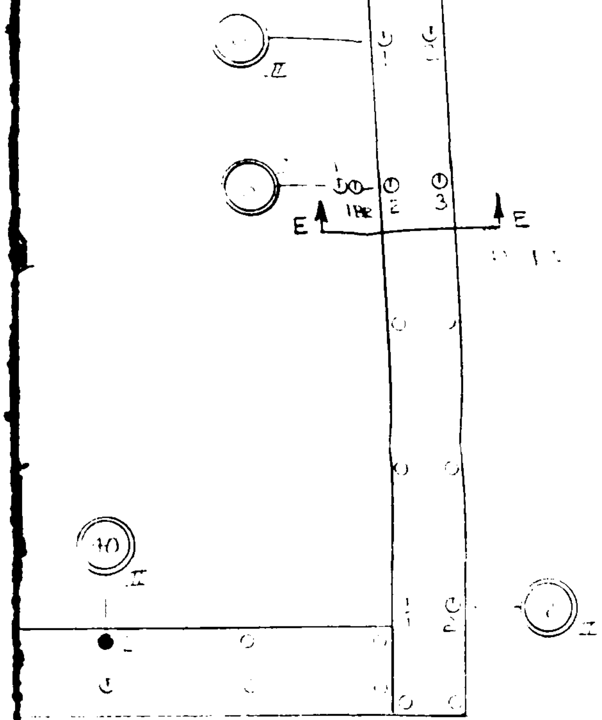
J. AGI
Suite (

LOCATION (

U.S. NAVY DI

CO

7

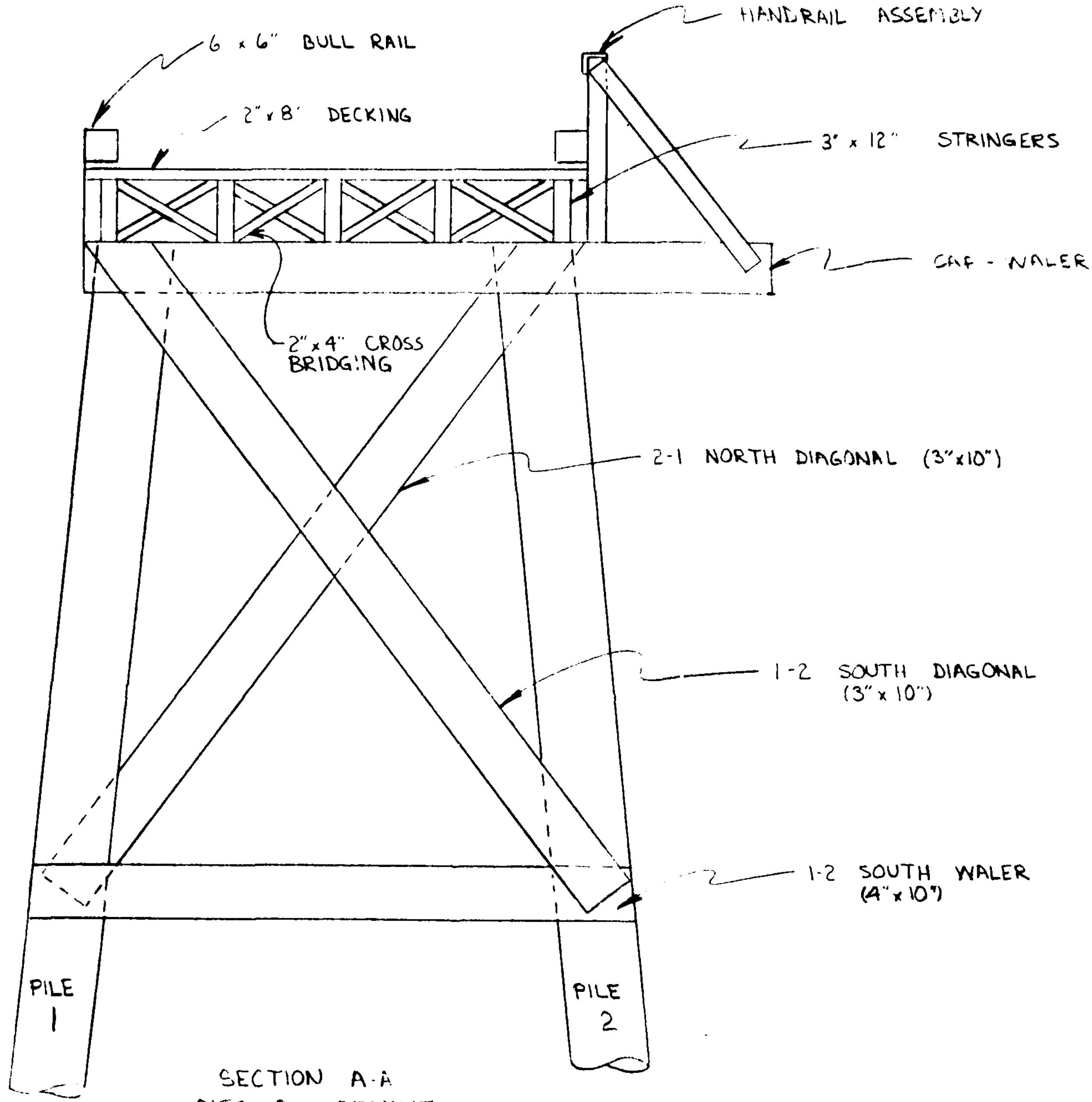


LEGEND

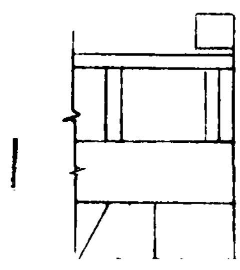
(6)	BENT N°
2	PILE N°
—○	BATTER PILE
◷	100% CROSS SECTIONAL AREA
◔	75% CROSS SECTIONAL AREA
◑	50% CROSS SECTIONAL AREA
◕	25% CROSS SECTIONAL AREA
●	0-25% CROSS SECTIONAL AREA
○	LEVEL I INSPECTION
II	LEVEL II INSPECTION

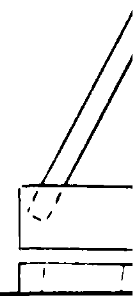
REF DWGS - NAVFAC DWG. No 4044690, 4044691

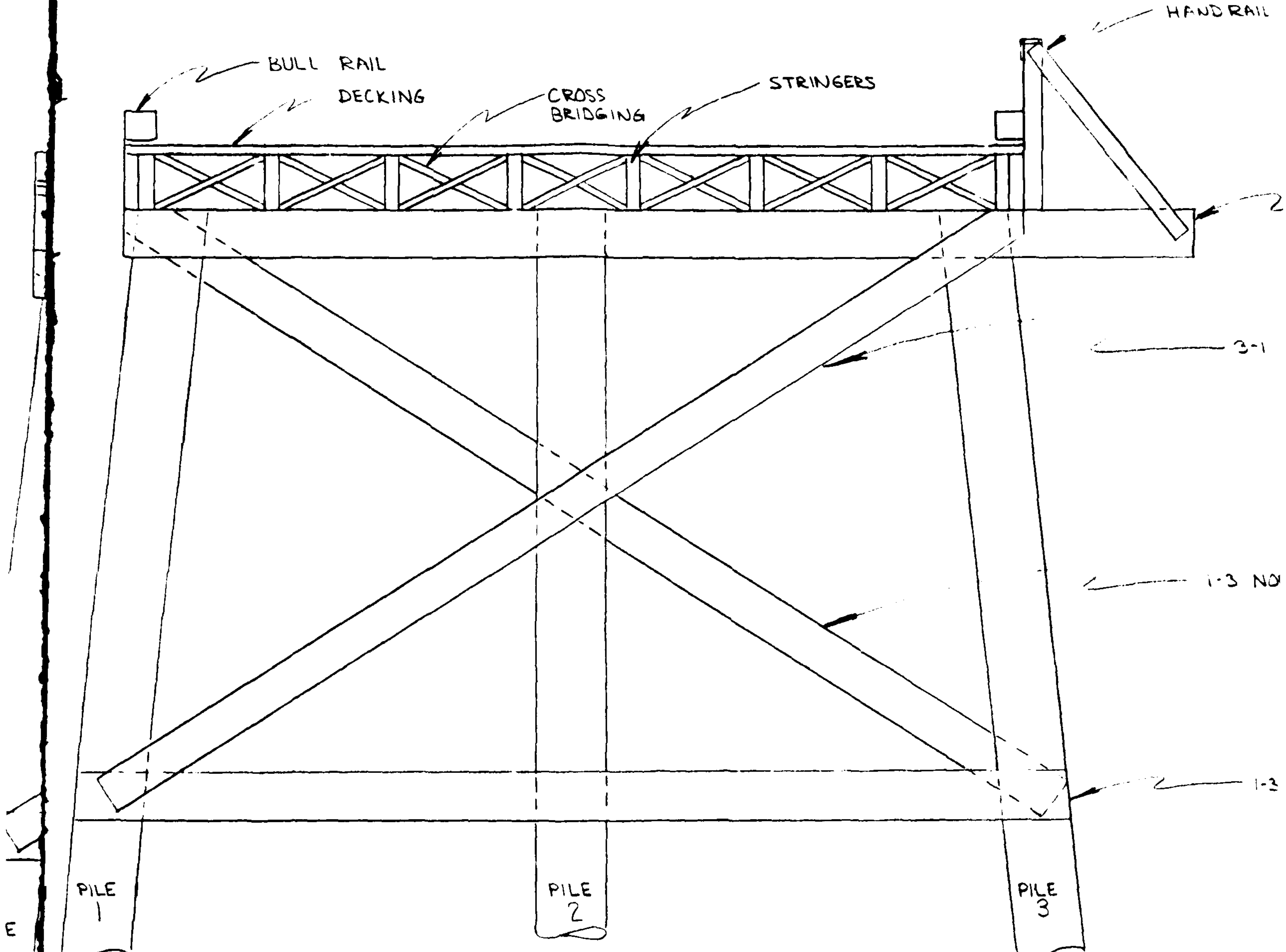
J. AGI & ASSOCIATES CO. LTD. Suite 600, 1414 Alaskan Way, Seattle, WA	SCALE 1" = 20'
	DRAWN CP
PLAN SHOWING LOCATION & CONDITION OF INSPECTED PILING IN PIERS C, D AND E OF U.S. NAVY DEPERMING FACILITY, NORFOLK, VIRGINIA	CHECKED
	APPROVED
CHES DIV NAV FAC ENG COM REPORT No. FPO-1-81 (16) CONTRACT No. N62477-81-0265 TASK 3	DATE JUNE 23, 1981
DWG. No. 2	PROJECT No **81-1-2-044**



SECTION A-A
PIER A, BENT 15
AS SEEN FROM BENT 16
FACING NORTH

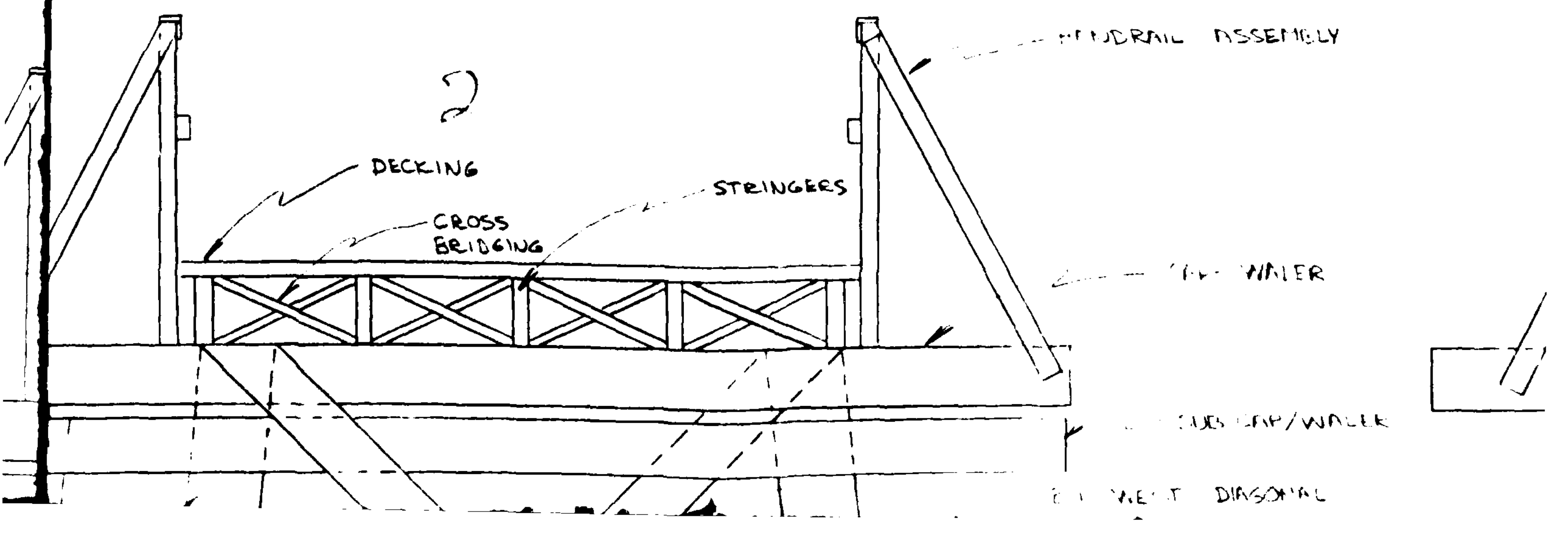


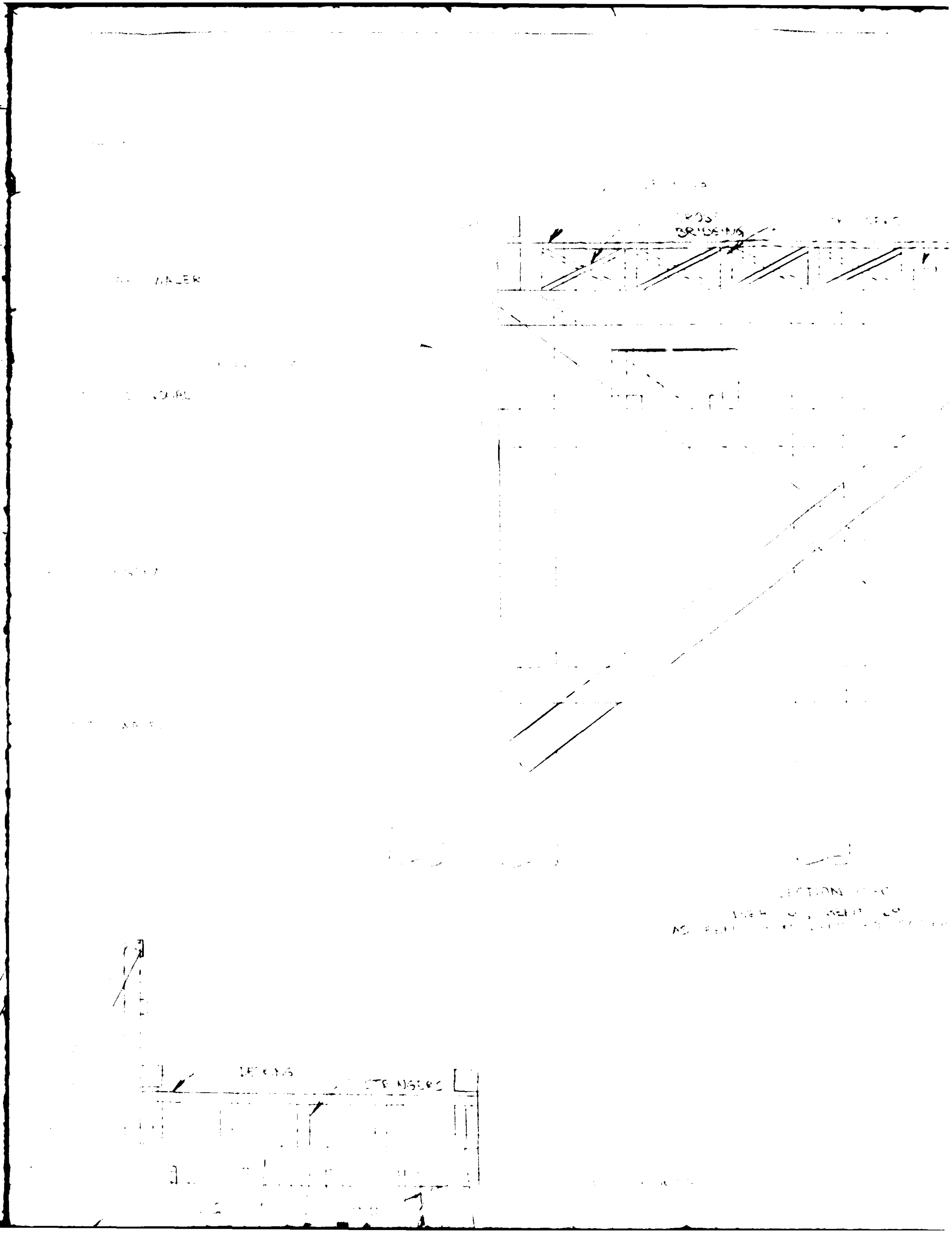


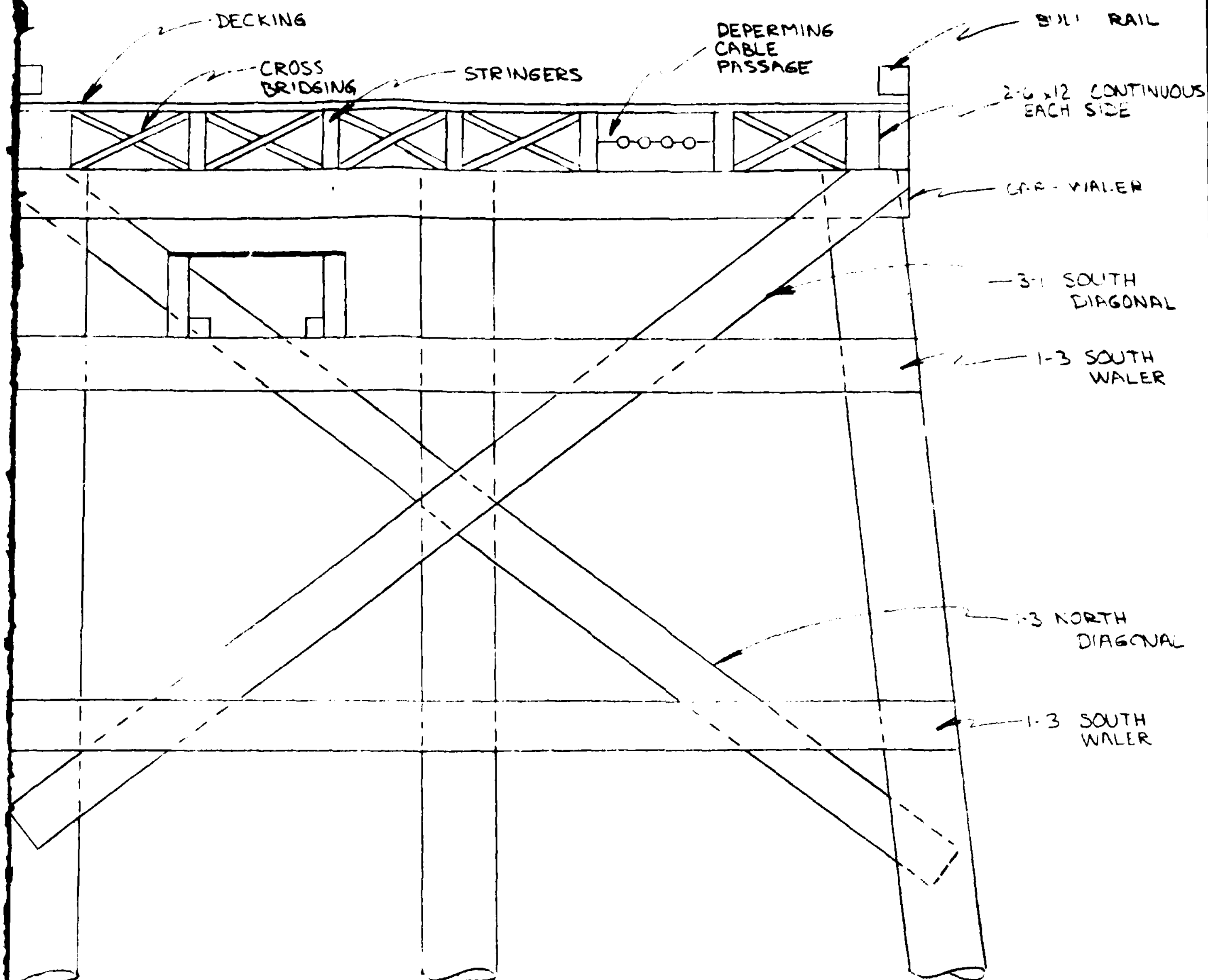


SECTION B-B

PIER A, BENT 20
AS SEEN FROM BENT 21
FACING NORTH



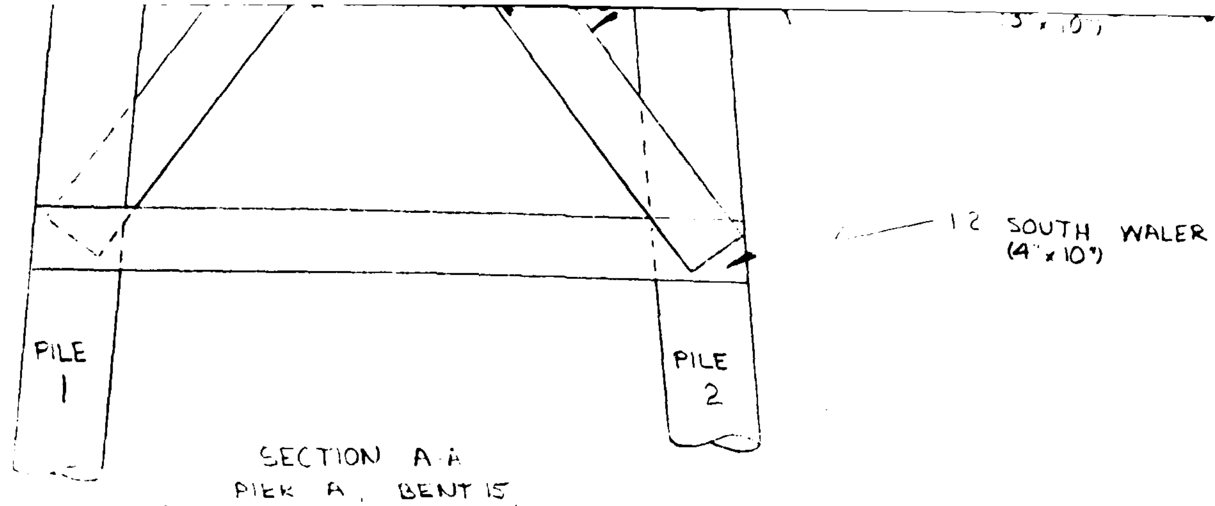

BRIDGING
WALER



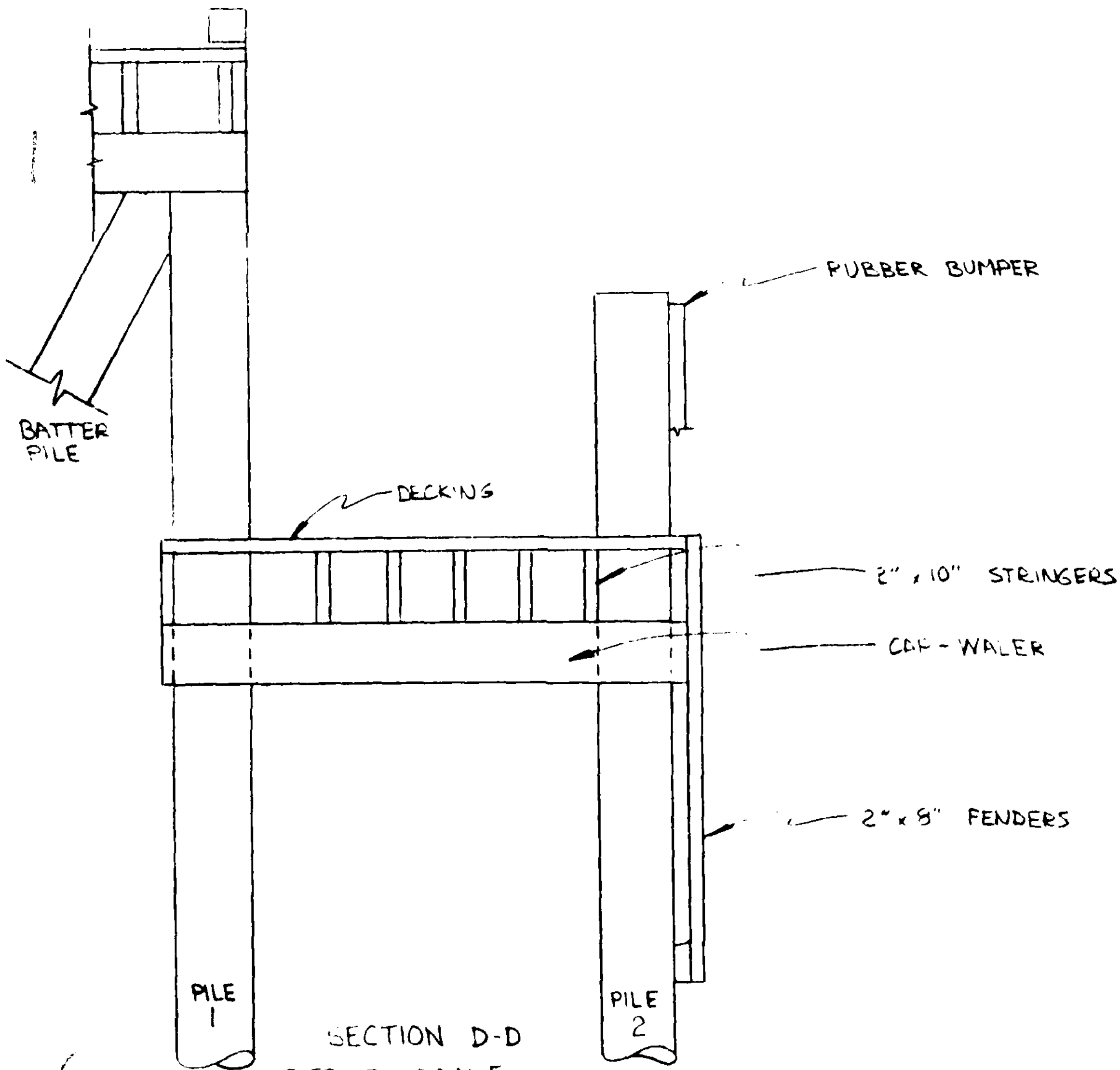
SECTION C-C
PIER B, BENT 29
AS SEEN FROM BENT 30 FACING NORTH

4

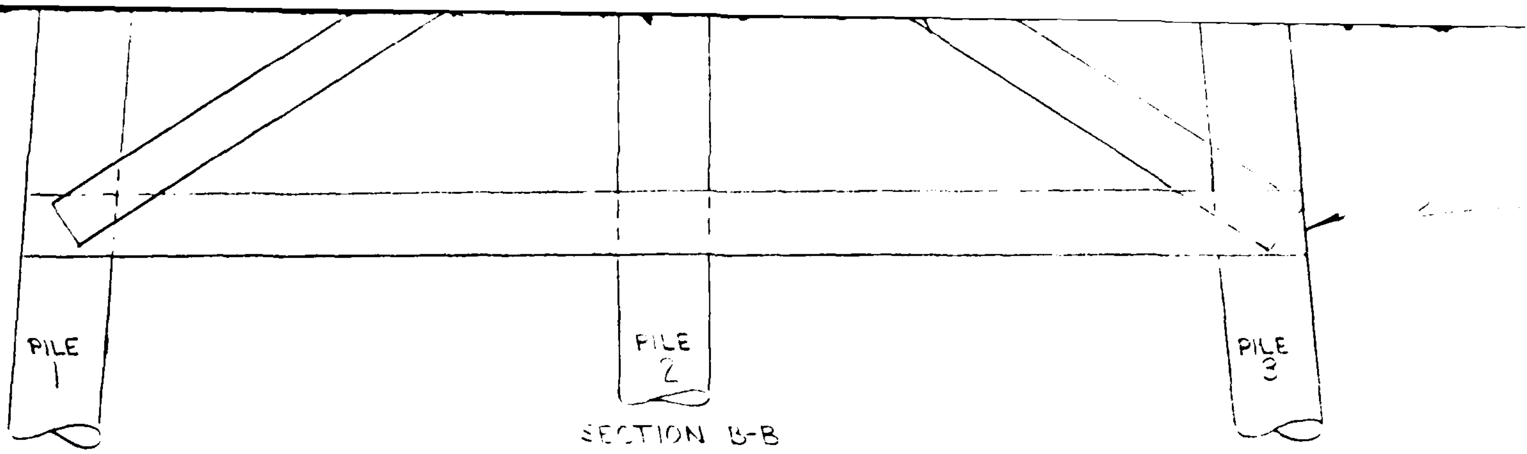
PIPE SUPPORTS



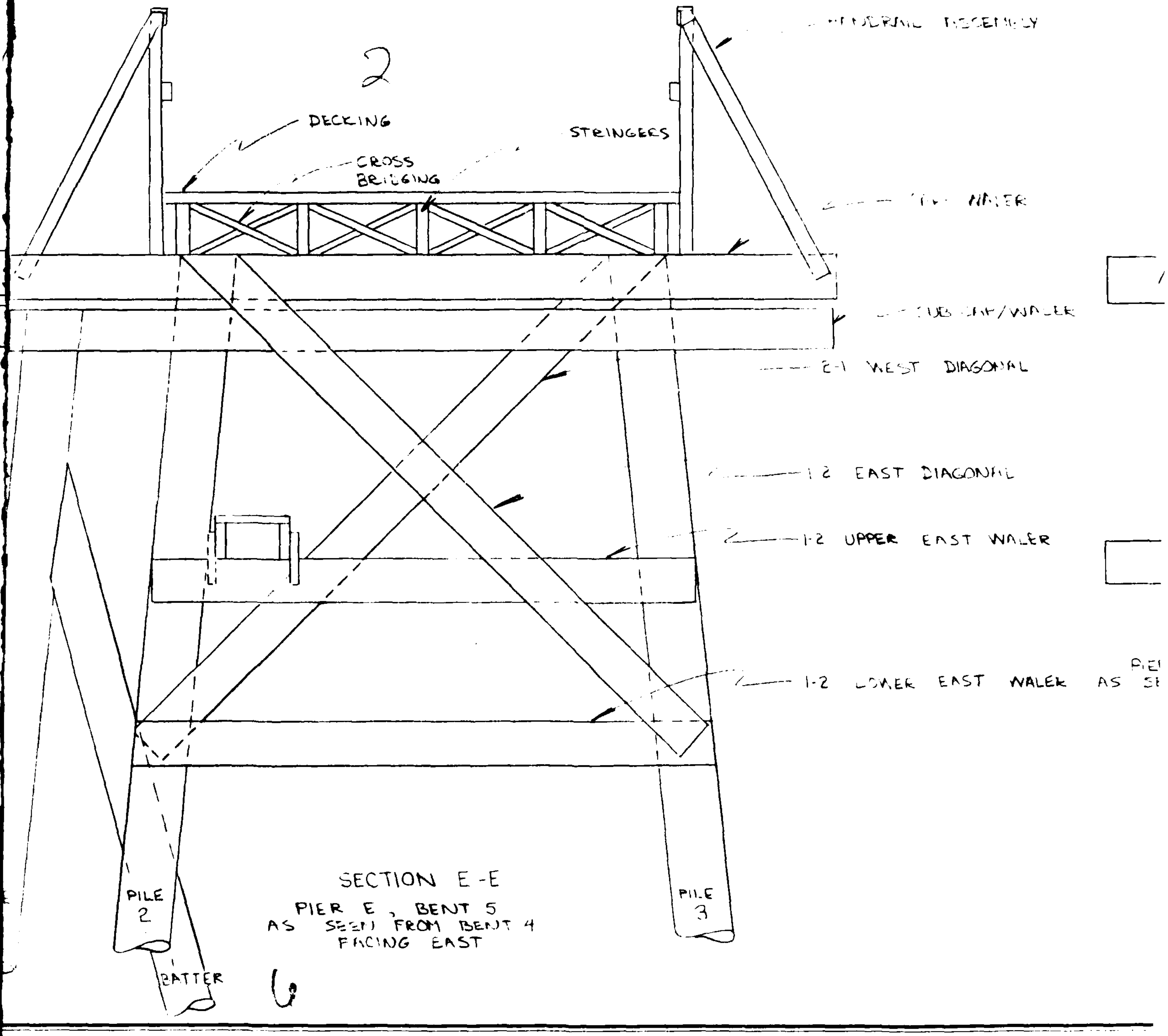
SECTION A-A
PIER A, BENT 15
AS SEEN FROM BENT 16
FACING NORTH



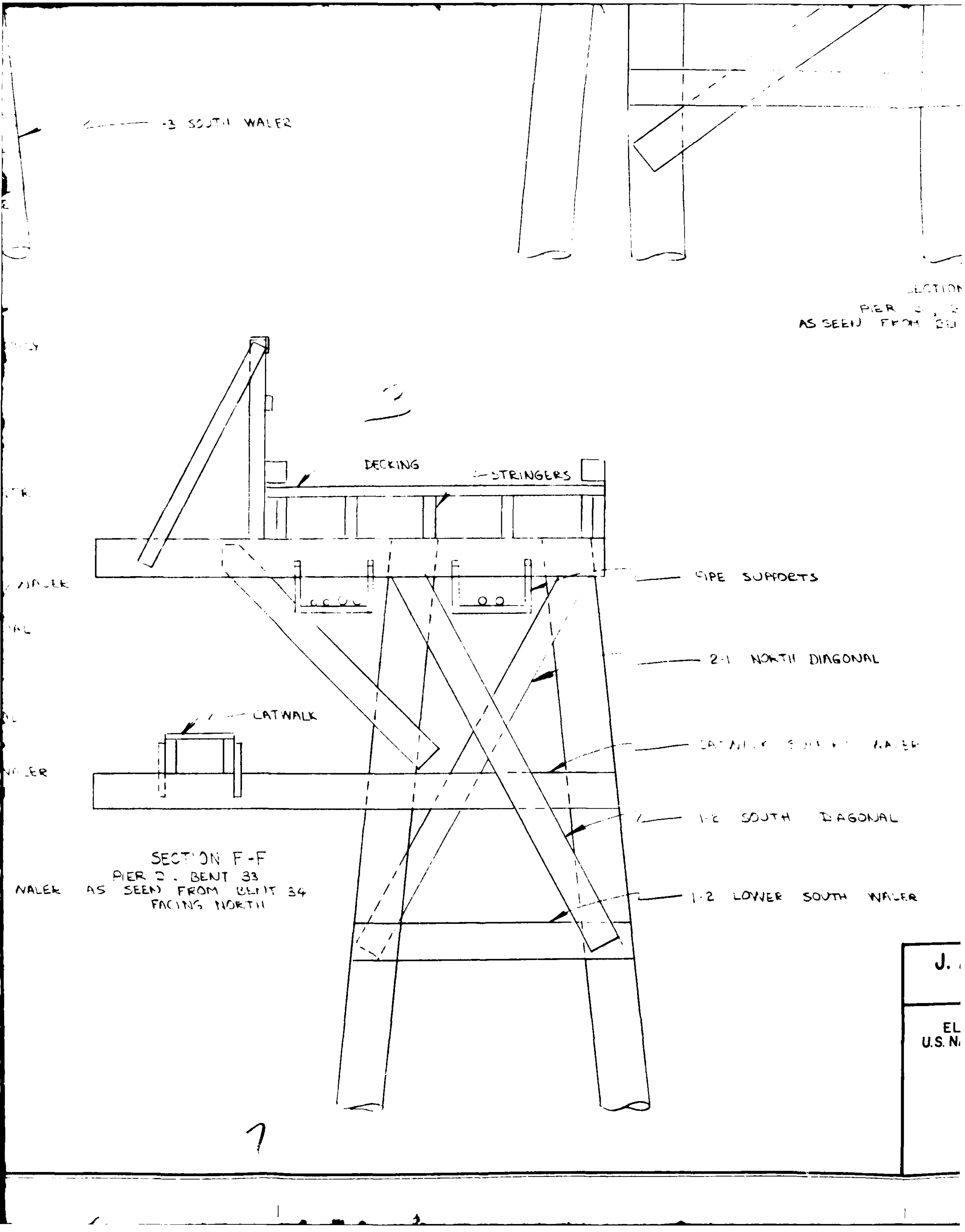
SECTION D-D
PIER B, ROW 5
AS SEEN FROM ROW 6
FACING NORTH



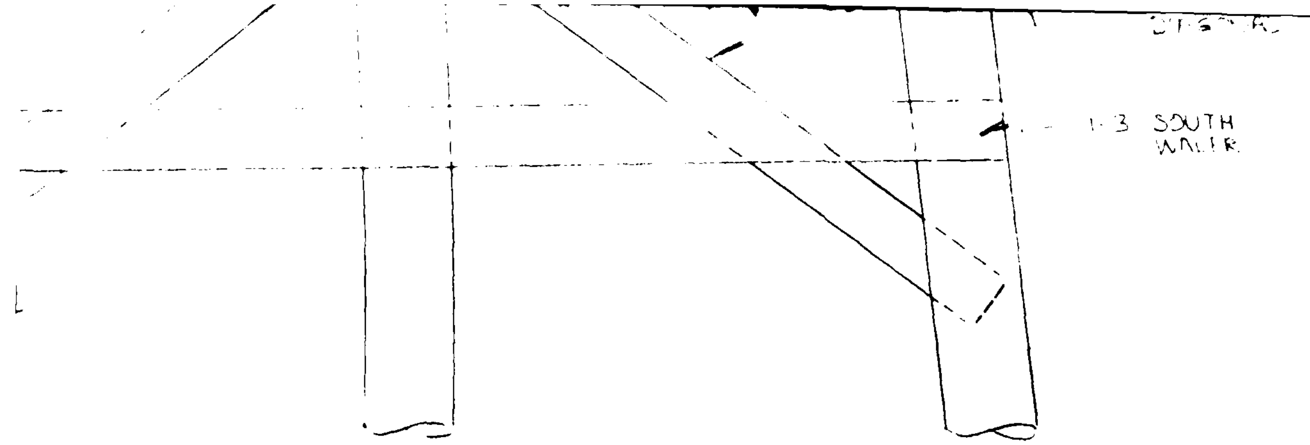
SECTION B-B
PIER A, BENT 20
AS SEEN FROM BENT 21
FACING NORTH



SECTION E-E
PIER E, BENT 5
AS SEEN FROM BENT 4
FACING EAST



-3 SOUTH WALER
AS SEEN FROM
DECKING
STRINGERS
PIPE SUPPORTS
2-1 NORTH DIAGONAL
CATWALK
1-2 SOUTH DIAGONAL
1-2 LOWER SOUTH WALER
SECTION F-F
PIER 2 . BENT 33
AS SEEN FROM BENT 34
FACING NORTH
WALER
J.
EL
U.S. N
7



SECTION C-C
PIER [illegible], BENT 29
AS SEEN FROM BENT [illegible] FACING NORTH

4

[illegible]

NORTH DIAGONAL

[illegible] WALER

SOUTH DIAGONAL

LOWER SOUTH WALER

REF DWG - NAVFAC DWG No 4044[illegible]

J. AGI & ASSOCIATES CO. LTD. Suite 600, 1414 Alaskan Way, Seattle, WA	SCALE 1" = 2'
	DRAWN CP
ELEVATION VIEWS OF SEVERAL SECTIONS OF U.S. NAVY DEPERMING FACILITY, NORFOLK, VIRGINIA	CHECKED E B V.
CHES DIV NAV FAC ENG COM *REPORT No. FPO-1-81-(16)* CONTRACT No. N62477-81-0265 TASK 3	APPROVED A
	DATE JUNE 24, 1981
DWG. No.3 8	PROJECT No. 81-1-2-044

Maximum water depth encountered was approximately 35 feet. The underwater visibility was absolute zero and precluded the acquisition of underwater photographs.

3.3 INSPECTION LEVEL

A Level II inspection was carried out. This included visual inspection and ultrasonic testing as well as photographic documentation of the examined piles.

3.4 INSPECTION PROCEDURE

3.4.1 Equipment

- B.C. Research ULTRASCAN-PTM4*, pile testing instruments.
- Underwater telephone.
- Nikonos IVA Camera with Strobe.
- Calipers.
- Miscellaneous ancillary equipment and SCUBA equipment.

3.4.2 Background on Instrumentation and Methods

The ULTRASCAN-PTM4 pile testing instruments are the result of studies initiated, at B.C. Research in 1955, to develop instruments for nondestructive testing of inplace marine piling. It was found that the velocity and strength of sound waves passing through wood varied inversely with voids in wood caused by marine borers. Based on this principle, instruments were developed which use magnetostrictive transducers to provide an ultrasonic "scan" of the pile. The plane waves which penetrate the wood, from the transmitting transducer, initiate transmission of secondary sonic patterns in the direction of the wood grain. As these wave trains transmit along the axis of the pile they produce radial sets of waves which are picked up by the transducer. Undamaged wood is an excellent transmitter of these waves whereas damaged wood attenuates the sound. During the development stage extensive axial load testing of pile sections was carried out and

* Patented

correlations were established between the sonic readings and the remaining undamaged cross-section of the pile. A direct meter readout is provided showing the percentage of sound wood remaining. Verification and refinement of the initial methods has been carried out by testing inplace piling, removing the piles and subjecting them to inspection and axial load testing. Good correlation was found between the sonic readings, the remaining undamaged area of the pile and the strength ratings based on the sonic instruments.

The testing crew consists of two men, a SCUBA diver who provides visual observations and scans the entire surface of the pile with the sonic "probe" and a surface technician who monitors the observations and readings produced on the meter. The probe is attached to the pile by the diver at the water surface. The diver then proceeds to scan the entire length of the pile from the surface to the mudline. The instruments provide a continuous cross-sectional area readout which is recorded by the surface technician. When the mudline is reached, the probe is moved onto the adjacent pile in the bent and the process is repeated from the mudline to the surface. Removal of fouling is not required for operation of the unit. The pile "ratings" are given in terms of undamaged cross-sectional area remaining in each pile. These ratings are based on the least cross-sectional area found as revealed by sonic and visual data. The ratings are given in quartiles and indicate both the location and degree of loss of pile cross-section in damaged piles. Based on the data provided, the new L/d ratio of a pile can be established in light of damage found. The L/d ratios and the reduced pile capacities of the damaged piles are provided in Table 4, pages T-12 through T-16.

The ULTRASCAN is used to detect and assess marine borer and mechanical damage in the immersed areas of the pile from mudline to the high tide level. Additional inspection is carried out from the high tide level to the cap to locate any possible mechanical or fungal damage.

3.4.3 Reasons for Selection of Particular Instrumentation and Methods

Bankia damage in piling can only be determined by underwater inspection, with many attendant difficulties. If the *Bankia* are alive and the siphons are extended, recognition is not too difficult. If the siphons are retracted or the *Bankia* are dead, detection of the burrow openings is not easy. In many instances, fouling must be scrubbed off the piling in order to facilitate an inspection. If visibility is limited, as frequently occurs in industrial locations, visual inspection is hopeless. Even if teredine entry holes are observed, an evaluation of internal damage, by purely visual means, is not possible.

Because of these difficulties, the sonic testing method was initially developed to locate and evaluate teredine damage. It was felt that *Limnoria* damage could be readily detected visually, since the damage progressed from the surface inward. Experience, however, has shown that the sonic testing method substantially enhances the detection and evaluation of damage even in areas where *Limnoria* is the primary source of infestation. Some of the reasons for this are as follows:

1. In areas with poor or nonexistent underwater visibility, sonic testing expedites the examination by locating the damage and providing for a quantitative evaluation of the residual strength.

2. *Limnoria* attack very often takes the path of least resistance. That is, *Limnoria* will gain access into a pile through a small breach in the creosoted layer and destroy the untreated heartwood with very little surface evidence of damage. A good example of this is a U.S. Navy fuel dock. In this particular structure a considerable number of piles, which have been destroyed by *Limnoria*, show no obvious visual indication of damage. The reason for this is that the *Limnoria* has gained access to the pile through open boltholes. The boltholes are virtually impossible to detect unless all fouling is removed from the pile and a

minute visual examination is carried out. This type of visual examination would be very time consuming and costly. It would be further restricted by poor underwater visibility.

3. Limnoria damage, particularly in southern waters, very often exposes the treated pile to teredine attack which would be very difficult to detect and assess visually.

3.5 SCOPE OF WORK

This project, which is a sampling inspection, was carried out to determine the overall condition of the facility and to provide sufficiently detailed information to facilitate comparisons with subsequent periodic inspections for purposes of determining progressive deterioration with time.

Piling in the following bents were subjected to inspection and testing for a total of 182 piles or 30% of the total number of piles in the facility.

Piles inspected in:

Pier A - Bents: 1, 5, 10, 15, 20, 25, 31, 32, 35, 40, 45, 50, 55, 60 and Finger Pier B.

Pier B - Bents: 1, 5, 9, 13, 17, 21, 25, 29, 35, 40, 45, 50, 55, 60.

Pier C - Bents: 1, 4, 7, 10, 13, 16, 17, 18, 19, 22, 25, 28, 31, 32, 34, 37, 40, 42.

Pier D - Bents: 2, 3, 6, 9, 10, 13, 14, 23, 24, 25, 28, 29, 33, 34, 37, 38, 40.

Pier E - Bents 2, 5, 6, 8.

Building Platform DS-9 - Bent 2

In addition to the above detailed inspection, a generalized rapid "swim by" inspection of all other piles in the structure was carried out.

3.6 TIME OF INSPECTION

The field testing was carried out during the week of June 15, 1981.

3.7 PERSONNEL ON PROJECT

Jerry Agi	-	Project Manager
Erling Vegsund	-	Project Supervisor
Herbert Lober	-	Engineering Technician/Draftsman
Catherine McKinnon	-	Report Preparation.

3.8 ONSITE PERSONNEL

Erling Vegsund	-	Project Supervisor
Herbert Lober	-	Diver/Technician

SECTION 4 - STRUCTURAL CONDITION ASSESSMENT

4.1 OBSERVED INSPECTED CONDITION

The objective of this inspection was to examine a representative sampling of the structural piles in the facility in order to determine the overall condition of the structures and to provide detailed structural data on the 182 examined piles. To achieve the best possible sampling results, pile bents throughout all structures were selected for testing. This type of sampling would give a representative sample of piles and ambient water conditions across and throughout the length of the piers. See Table 1 and Drawings 1, 2 and 3, pages 3-5, 3-6 and 3-7 for the piles tested.

The piles were found to have a light to moderate amount of marine fouling growth on their surface. In the intertidal zone, barnacles and hydroid growth up to ½" thickness was common. In the submerged zone the fouling was sparse and consisted chiefly of oysters. The overall condition of the examined piles (with exception of Pier C) is good. Of the 182 piles tested and inspected with the ULTRASCAN-PTM4, 129 (71%) are undamaged; 17 (9%) piles have sustained incipient to light attack or damage and are rated at 90-100% of their original cross-sectional area; 10 (6%) piles have sustained light to moderate damage and are rated at 75-100% of their original cross-sectional area; 13 (7%) piles have sustained heavy damage and are rated at 50-75%; 6 (3%) piles are rated at 25-50%, and 7 (4%) piles are rated at 0-25%. The piles in the last two groups have sustained heavy damage and loss of cross-sectional area.

Damage to piles has been caused by one or a combination of the following factors: mechanical impact and/or abrasion; excessive drilling of boltholes; fungal decay; insect infestation and decay; possible marine borer damage. Photographs 6 through 15, pages 4-5 through 4-9, illustrate the various factors responsible for the damage to the piling and in some cases, to the intertidal zone timber bracing.

The damaged piles were found in all of the examined structures (excluding Pier E and the Building DS-9 Platform) but were found to be concentrated in Pier C. The following table shows the number of significantly damaged piles found in the detailed ultrasonic inspection. (See Table 3 for additional damaged piling found in the "Rapid Visual Swim By Inspection".)

	Number of Significantly Damaged Piles*
Pier A	1
Pier B	7
Pier C	21
Pier D	7
Pier E	0
DS-9 Platform	0
TOTAL:	36

*Piles rated at 75% or less of their original cross-sectional area.

The damage on individual piles was found to range from the pile top down through the intertidal zone. The tops of all piling were examined for fungal deterioration by probing (see Photograph 3, on page 3-3). In several instances as detailed in Table 1, the piles have sustained extensive fungal decay resulting in total section loss of the untreated heartwood core of the piles. This damage typically extends down 1-3 feet from the top of the pile. Five of the piles with damage at their tops were found to have undergone restorative maintenance (by concrete jacketing) of their intertidal zones. The fact remains however that because of the damage at the top of the piles, the bearing capacity of these five piles (Pier C, Bent 16-2, Bent 18-2, Pier D, Bent 13-2, Bent 23-2, and Bent 38-2) is severely reduced.

The largest percentage of damaged piles were found to be damaged in the intertidal zone. No piles were found to have sustained significant section loss in the submerged zone. Evidence of marine borer activity was however found (see Photograph 15, page 4-9) on some fender piles which had been removed from Pier D.

The majority of the damage found has been caused by fungal decay or dry rot. Pages 4-10 through 4-13 discuss fungal deterioration at length. As detailed in the Discussion section, two main factors govern fungal decay. These are the presence of a suitable wood source and moisture content. As detailed in Table 1, several piles have sustained extensive fungal damage even though they have been pressure impregnated with a preservative designed to protect against decay. The reasons these piles have deteriorated are all related to the exposure of the untreated - unprotected heartwood of the piles. Exposure of the untreated wood has resulted from several factors. Several piles have been notched to facilitate the installation of brace timbers. As shown in Photograph 7, page 4-5, this notching effectively removes the outer treated shell and exposes the untreated wood to decay (note that marine borer damage can also occur if the notches are in the tidal zone). As shown in Photographs 10 and 13, pages 4-7 and 4-8, the pile tops are not capped or covered. Instead the "caps" consist of parallel timbers bolted to each side of the pile bents, leaving the top of the pile exposed. Because preservative retention is minimal at the end grain of a pile, the potential for fungal decay is great. Also, the pile top being exposed, readily soaks up rain or other water (from leaking pipes and hoses, etc.) and therefore provides a natural environment for fungal decay. To prevent this type of damage, consideration should be made to protect untreated surfaces by various methods of field treating with preservatives or covering the exposed pile tops with treated caps. In addition, wherever possible, notchin~ or other forms of exposure, such as excessive drilling of boltholes, leaving untreated surfaces exposed, should be avoided.

4.2 STRUCTURAL CONDITION ASSESSMENT

Based on this partial or sampling inspection, the overall condition of the Deperming Facility is good. Nevertheless, damage to certain piling in all structures (excluding Building D5-9 and Pier E) has occurred. The damage as detailed above and in the accompanying Table 1 has been caused by a variety of mechanical or biological factors. This damage has resulted in varying degrees of loss of pile cross-sectional area and a corresponding decrease in the bearing capacity of the piles. In Table 4, pages T-12 through T-16, the reduced bearing capacity of all damaged piles has been calculated by an inhouse computer program using the Southern Pine Association modified Euler equation for long columns. This table shows the significant reduction in the bearing capacity of the piles for all of the damaged area classification i.e. 75%, 50%, 25%, and 0%.

PHOTOGRAPH 6

Pier C - Bent 15. Diver performing general swim by inspection. Note broken off brace timber and general erosion of ends of the horizontal braces.

PHOTOGRAPH 7

Pier C - Bent 8-Pile 1. Pile has sustained approximately 30 loss of cross-sectional area due to mechanical abrasion and fungal and insect infestation.

PHOTOGRAPH 8

Pier C - Bent 36-Pile 2. Pile has sustained approximately 80% loss of cross-section between the horizontal timber braces.

PHOTOGRAPH 9

Pier C - Bent 36-Pile 2. Note extensive loss of cross-section as a result of insect and fungal deterioration.

PHOTOGRAPH 10

Pier C - Bent 17. Note pile in foreground. The pile caps and braces have been smashed by impact.

PHOTOGRAPH 11

Pier C - Bent 17. Pile 1 on left has been smashed, pile 2 has broken at elevation of walers. Note several boltholes in pile 2 and also in pile 1 of bent 16 in background.

PHOTOGRAPH 12

Pier C - Bent 8-Pile 2. Typical concrete jacketed pile. Note approximately 2" concrete thickness around pile.

PHOTOGRAPH 13

Pier D - Bent 13-Pile 2. Concrete jacketed pile with jacket extending from 1 ft below pile cap to approximately - 5 ft.

PHOTOGRAPH 14

Pier D - Bent 23-Pile 2. Pile has sustained approximately 80% loss of cross-section 2 feet above a concrete jacket.

PHOTOGRAPH 15

Pulled untreated pile. Note teredine tunnels in vicinity of knife.

4.3 DISCUSSION

The overall condition of the examined piles in all but Pier C is generally good. Some damaged piles were however found in all the examined structures and particularly heavy damage was found in Pier C. The types of damage found are typical of problems found in timber marine facilities. During the normal service life of a facility the piling are subject to mechanical impact, abrasion and the possible opening of cracks, splits and checks in the pile. As soon as the protective creosote layer, which is relatively narrow, is breached the pile becomes vulnerable to biological deterioration from either fungal decay, insect or marine borer infestation.

Fungal decay as evidenced in Photographs 7, 8, 9 and 14, is one of the chief causes of pile deterioration in the Deperming Facility. The following discussion* details the cause and characteristics of fungal decay.

Decay in wood is caused by living fungi, which are simple plants having the unique capacity to break down and utilize wood cell wall material as food. The fungus in an area of decaying wood is generally invisible but present as a growing network of microscopic threads (hyphae) that penetrate and ramify throughout the wood. Such areas are initially infected by the germination of fungus spores, which are functionally equivalent to the seed of higher plants. These spores, which are produced in great numbers, are microscopic; they are distributed so widely by wind, insects, and other means that they are commonly present on most exposed surfaces.

Many spores never germinate for lack of a sufficiently moist environment or from prolonged exposure to direct sunlight. Others die shortly after germination for lack of water or food, or from the toxic components of wood preservatives. Established infections of decay fungi in marine structural members may result from the spores being carried by rain, snow melt, or condensation from openly exposed surfaces into areas

*Decay In Wood Bridges, J.W. Clark and W.E. Eslyn. Forest Products Laboratory, U.S. Department of Agriculture.

favorable for successful germination. Such areas include exposed pile tops, fastener holes, joint interfaces, or seasoning checks having the required moisture for a sustained period in decay-susceptible wood. Because environmental conditions in wood above ground may be unfavorable for fungus growth much of the time, a new surface infection generally does not quickly penetrate far into the wood from the germination site. However, under continuing favorable conditions, the fungus may penetrate members sufficiently to become well established in a few weeks.

Once established, the fungus continues to grow as long as favorable conditions prevail. Such growth is associated with changes in the character of the invaded wood. The wood cell walls may be perforated, thinned, or the walls of adjacent cells may be disassociated, with a consequent loss of structural strength. At the same time the porosity of the infected wood increases. The greater porosity results in more water absorption during a given interval of rain or other wetting. As fungus growth progresses, an increasing number of growing hyphae occupy the margin of the expanding area of infection and this accelerates the rate of decay.

Significant wood decay can only occur when four essential conditions prevail for fungus growth. Depriving the fungus of any one of these requirements will effectively curtail decay. These growth requirements are as follows.

A sufficient supply of oxygen must be available to fungi for their respiration. Comparatively small amounts of oxygen are necessary for vigorous growth and even less is required for dormant existence, but decay fungi cannot survive without some free oxygen. Unfortunately, this essential requirement by the fungi is generally not subject to practical, manipulative control in marine structures.

A favorable temperature range is a second requirement for fungus growth. At freezing temperatures, and below, fungi simply become dormant but remain alive and capable of a resumption of growth when prevailing temperatures rise above freezing. Growth rates gradually increase from near freezing to an optimum range at approximately 75° to 85° F, but growth drops off rapidly for most decay fungi as temperature rises above 90° F. Only temperatures well in excess of 100° F are lethal for most decay fungi. Such high temperatures do not occur naturally in marine structures other than at surface areas of dark wood exposed directly to summer sun. Rarely do these high surface temperatures penetrate appreciably into the wood. Thus, the temperature requirement also is not generally subject to control in members to limit fungus growth.

An adequate supply of food is a third requirement for fungal growth. Where decay is present in timbers the wood itself constitutes the food supply. Untreated wood with low natural decay resistance will be available and used as food when other conditions are favorable. If the wood is a naturally durable species, it will be initially resistant in some degree to fungus attack, but it may lose its resistance as a result of weathering or leaching. However, an effective degree of decay prevention is possible through the process of poisoning the wood with appropriate wood-preserving chemicals. Treatment specifications must be balanced against costs and other practical considerations for new structural materials, for replacement materials, and for materials in existing structures that can be treated in-place.

Available water is the fourth essential required for initiation and spread of wood decay. Dry wood will not decay althouth the widely used misnomer "dry-rot" may imply that possibility. Moisture content of wood is one of the most significant factors regarding wood decay because a considerable amount of water is required for fungus growth and, in many instance the moisture content of wood in service is subject to control.

Not only does the amount of water in wood directly control the possibility of fungus infection and growth, but it is significant to the decay process in less direct ways. Prolonged or repeated wettings contribute to leaching and a consequent loss of natural decay resistance. Further, during the seasoning of large timbers, the loss of water is accompanied by shrinkage that normally results in the development of seasoning checks. Such checks may expose untreated parts of preservative-treated timbers and may also form water-trapping pockets which can become infection sites for decay fungi.

The moisture content of large wood members is rarely uniform. In marine structures exposed to natural weather cycles, variations in moisture content are likely to be large. Fungus activity is directly affected only by the moisture content of the wood in the immediate vicinity of the infection. Thus a member may be well seasoned and generally dry, but be infected and severely decayed at a localized area such as a water trapping check, near a joint interface, or at some other point where the wood is continuously or repeatedly wetted at short intervals or where drying of the wood is inhibited after wetting.

Evidence of insect attack was also found in conjunction with the fungal decay in some piling. As was the case with marine borers, no live specimens were found and therefore identification of the insect type could not be made. Generally however, insect damage can be caused by either termites, carpenter ants or beetles.

Marine borer damage was found in an untreated fender pile which had been pulled from Pier D. In addition to the above noted confirmed evidence of marine borer damage (see Photograph 15), several piles displayed possible old marine borer damage in the intertidal zone. Positive identification of the type of damage was not possible because of the age of the damage and the fact that one or more types of damage (such as fungal and marine borer) have apparently occurred at the same tidal elevation. The following discussion details marine borer related problems caused by the internal teredine borers and the external Limnoria borers.

In general wood piling in the marine environment are subject to attack and damage by various species of marine borers. In the Pacific Northwest, loss of pile bearing strength occurs almost entirely from attack by

Bankia setacea and Limnoria lignorum. In southern waters, teredine borers such as Teredo navalis and crustacean borers such as Limnoria tripunctata are of economic importance.

Both Bankia and Teredo are members of the family of internal marine borers Teredinideae. These animals begin their life cycle as free swimming larvae. When a suitable wood surface is found, they attach themselves and begin boring into the wood. At this point they also undergo a metamorphosis or body change to the adult, 'ship worm' form. As the animal bores into the wood it increases in size up to one-half inch or more in diameter and several feet in length. With this loss of wood volume, only a light infestation of borers will completely destroy a pile. When alive and actively boring the only visible signs of the animal are the two slender posterior siphons which extend beyond the wood. When the animal dies the only external sign of damage is the original 'pinhole' sized point of entry.

Limnoria attacks and damages wood at its surface. These animals begin boring as soon as they are hatched; they tunnel to a depth of approximately one-quarter inch and then bore along below the surface. Auxilliary tunnels are bored as the main tunnels are increased in length in order to provide access to water for respiration. The end result of many of these animals tunnelling on a pile is a seriously weakened 'honeycomb' like surface which is then abraded by wave action. As the older surfaces are eroded, new wood is exposed to attack. Whereas teredines can destroy an unprotected pile in as little as nine months, the destructive action of Limnoria requires much more time.

Commerical protection for marine piles normally involves full cell pressure impregnation of creosote or a combination of creosote and water-borne toxic salts. Bankia larvae do not settle on well creosoted timbers, however, a mature Bankia can penetrate the creosote layer of a pile via a firmly attached untreated piece of wood. Limnoria lignorum is generally restricted by creosoting; whereas a second limnorial species, Limnoria tripunctata, is creosote-resistant. Although this species has been found at scattered locations in the northwest Pacific

Coast, no documented cases of extensive economic damage have, as yet, been encountered in this area. In southern waters, however, Limnoria tripunctata has been of considerably more concern. Apart from its own destructive activity, Limnoria tripunctata can expose the untreated areas of a pile to Bankia attack by destroying the protective creosoted layer.

During the lifetime of creosoted piling in the marine environment, creosote will gradually leach out of the treated sapwood. As this process continues, the underlying heartwood becomes increasing vulnerable to marine borer attack. The time period between the driving of piling and the stage where general deterioration begins, will depend upon several factors. The most important of these factors includes the quality of the creosote treatment, the amount of pollution present in the environment, the presence or absence of floating logs and debris which may cause physical damage to the protective creosote layer through abrasion and breakage, as well as the growth on the piling of algae, barnacles, sea anemones and other marine life. The latter will, to the extent it is present, hamper the settlement of marine borer larvae on a pile and, therefore, constitute an additional barrier to infestation.

During the driving of treated piling, some accidental damage to a small percentage of these piles commonly occurs. Splitting or abrasion may provide entry points for marine borers, which subsequently may lead to the complete destruction of the pile within one or two years. Since physical damage sustained during the driving of a pile often occurs at the mudline, underwater inspection is necessary for positive identification of all piling subjected to this type of damage.

After the initial period of one or two years, the remaining sound piles may last several years before a widespread marine borer attack becomes noticeable.

At this stage, Limnoria commonly appear on piling surfaces, eroding away the sapwood wherever the creosote has disappeared to a sufficient degree. Two types of attack are common: the "general attack" and the "cavity".

The general attack occurs only superficially and is characterized by a more extensive Limnoria activity concentrated at a limited area and extending in depth rather than width, reaching inwards to deeper layers of the wood. Limnoria cavities may occur when physical abrasion has reduced the thickness of the creosoted sapwood, or where cuts or open boltholes have not been closed by adequate repairs. However, even when no physical damage is present, Limnoria activity does sometimes occur and is probably a result of an initially uneven creosote retention, or attack by Limnoria tripunctata.

With the increasing age of a pile, the probability of teredine attack also increases. Teredo as well as Limnoria may gain entry through physically damaged areas on a pile. In undamaged piles, premature ingress of a Teredo may take place through knots, where the initial creosote retention is normally low. If, however, the borer dies before penetrating through the knots into the heartwood, which is sometimes the case, or where the absence of knots excludes their use as points of entry, an otherwise undamaged pile should resist teredine attacks until the process of creosote leaching has progressed to an advanced stage.

In view of the above observations, some general predictions about the service life of a marine structure may be made. Care should be taken, however, not to overestimate the reliability of prediction, since environmental fluctuations may drastically effect the projected service life of piling. Also, and even where the environment is quite stable, individual differences between piling and the rates with which they succumb to creosote leaching make such predictions difficult. Therefore, it is generally a valid procedure to schedule sonic and visual inspections of marine piling at approximately 5-year intervals. When the stage is reached where widespread marine borer attack has set in, the inspection interval should be shortened to less than five years.

4.4 RECOMMENDATIONS

Based on the results of the current sampling inspection, the following recommendations are made.

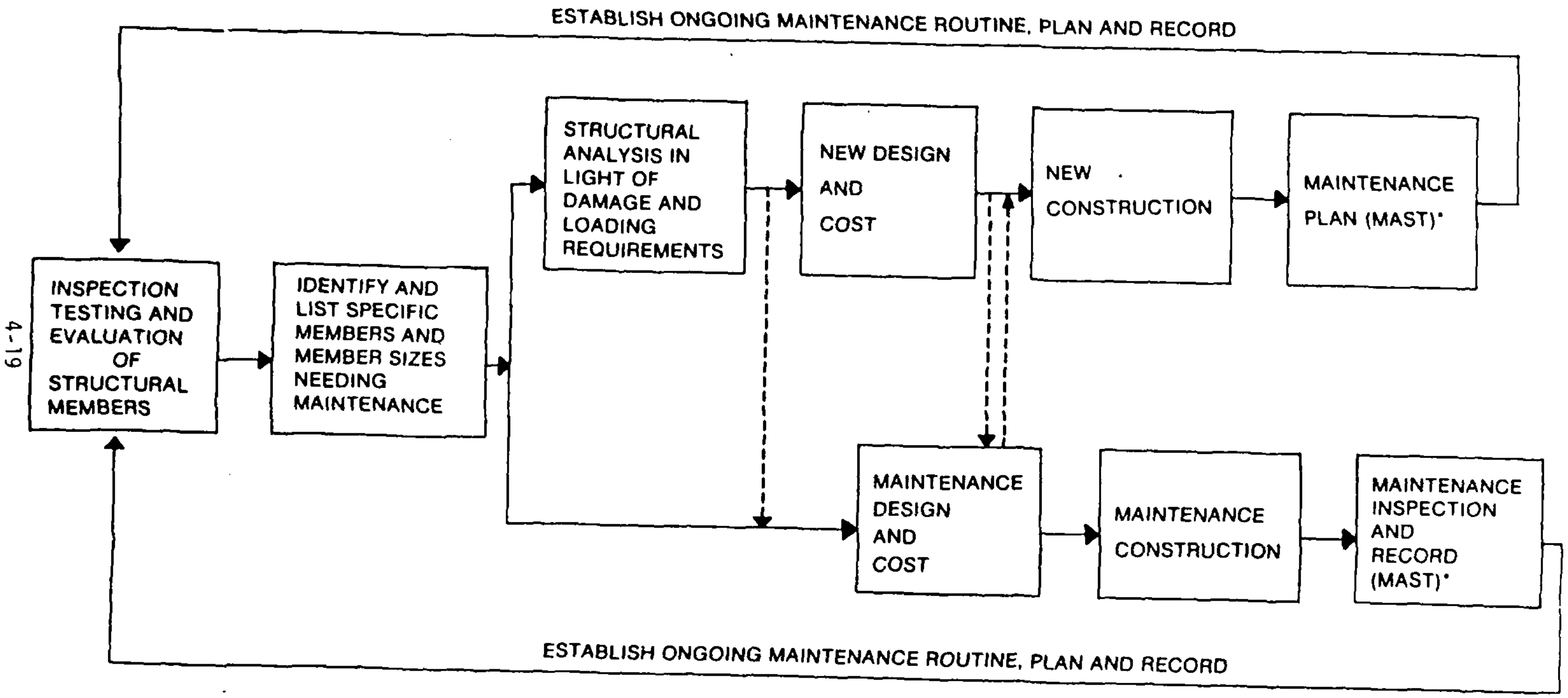
A detailed full scale sampling inspection and ultrasonic testing of all piles is warranted. The level of damage found in these structures, particularly in Pier C, demands this type of inspection to ensure that sufficiently detailed information is available for maintenance planning. Specifically, as was carried out in this inspection, the entire length of the piles from cap to mudline should be inspected, then if damage is found, the most cost effective maintenance can be designed. As mentioned earlier, several of the inspected piles were found to have undergone restorative maintenance in the intertidal zone by concrete jacketing. In five cases, the value of this maintenance has been negated by fungal deterioration (see Photograph 14, page 4-9) above the concrete jacket. Perhaps a detailed inspection of the entire pile would have shown the areas above the proposed concrete jackets to be deteriorated and an alternate maintenance design could have been carried out to include all the defective area(s). In light of this, the Chart 4-1, page 4-19, illustrates the various stages for effective maintenance planning for marine facilities.

In addition to the piling, it is recommended that all other structural components such as the lateral bolted timber caps, stringers, deck planking and brace timbers be inspected for possible maintenance requirements concurrent with the proposed pile inspection. Once the above inspection and subsequent maintenance have been carried out, repeat inspections at regular intervals should be scheduled to monitor the condition of the structures.

Once the recommended full scale inspection and subsequent maintenance has been carried out, it is recommended that periodic visual inspections and repeat ultrasonic testing be carried out at approximately five year intervals. These inspections would serve to monitor the condition of the structures as they age and also would point out areas that might require maintenance.

A further recommendation is that periodic inspections of the fender piles be carried out. It was noted that several fenders at the north end of Pier B have been broken by ship impact. As these piles serve to protect the structural piling, they should be kept in good repair.

MAINTENANCE PLANNING - MARINE FACILITIES



(*MAST — "MARINE STRUCTURES INVENTORY AND STRUCTURAL DATA SYSTEM" COMPUTER PROGRAM.)

CHART 4-1

4.5 ESTIMATION OF COST OF REPAIRS

A sampling inspection such as the one carried out in this project is designed to determine whether or not structural deterioration of the piles has occurred. If significant damage is found, a Phase II inspection is generally carried out to identify all defective piles for subsequent maintenance.

As shown in section 4.1 and 4.2 of this report, significant damage and deterioration of piling has occurred. For this reason we would recommend that all remaining piles be nondestructively tested and inspected in order to a) provide an exact number of piles requiring maintenance for estimation purposes and b) the identification of these piles. This inspection would also provide detailed information necessary to design the most cost effective maintenance plan for the facility.

For broad estimation purposes the results of this sampling inspection have been used to estimate the cost of repair of the piles found damaged in this inspection and to extrapolate the level of damage and cost of repair of the remaining uninspected piles.

In the current inspection, a total of 36 piles were found to have sustained significant damage warranting maintenance or replacement. Five of these 36 piles have previously had concrete jackets installed in the intertidal zone, extension of the concrete jacket to the pile cap would effectively refurbish these piles. Two piles were found to be smashed and will require replacement. The remaining 29 piles have damage in the intertidal zone or at the cap. These piles might be repaired by concrete jacketing from the intertidal zone to the cap or if its is more cost effective, they could be replaced with new piling.

The cost of these repairs is estimated as follows:

1.	Extension of concrete jackets on piles to pile cap	$1,500/unit x 5	=	$ 7,500
2.	Installation of smashed piles	$3,000/unit x 2	=	6,000
3.	Installation of concrete jacket from intertidal zone to cap	$2,500/unit x 29	=	72,500
4.	Miscellaneous			4,000
		TOTAL:		$90,000

Extrapolation of the damage found in the sample inspection to the overall structure indicates the following level of damage and cost of repairs.

The current 30% sample inspection of 182 piles has shown that approximately 29% of the piles in the facility have sustained damage. It is estimated that there are approximately 600 piles in the facility and therefore it is expected that 29% of 600 piles or 174 piles have sustained significant damage. The estimated cost of repair of these piles would be approximately $270,000 (three times the estimated cost of the sampling inspection). As discussed earlier in this section, this fee should be made only as a rough guide, cost estimates for repair should infact be based on a detailed full scale inspection.

SECTION 5 - CONCLUSIONS

On an overall basis the examined facility was found to be in relatively good condition. All structures were found to have sustained some degree of damage to the piling and other structural timbers, particularly the horizontal and diagonal bracing in the intertidal zone. The level of damage in the newer piers i.e. Piers A and B and the recently refurbished Pier E, is significantly less than the damage found in the original structure, Piers C and D. A projection of the results of a full scale inspection would indicate that approximately 174 piles will require maintenance. The information provided by a full scale inspection will allow for cost effective maintenance planning for the facility.

The Chart 4-1 (page 4-19) shows a typical facilities maintenance planning procedure for marine structures.

LEGEND TO TABLES

B.	=	*Bankia setacea*
BR	=	Battered pile
c	=	Cavity resulting in loss of cross-section
conc.	=	Concrete encased pile
D	=	Damaged fender pile
E	=	East
h	=	Heavy attack
i	=	Incipient attack
ITZ	=	Intertidal zone
L.	=	*Limnoria*
LA	=	Limited access to sonic inspection
l	=	Light attack
m	=	Moderate attack
MBC	=	Marine-borer cavity
MB	=	Marine-borer
mdl	=	Mudline
m.l.w.	=	Mean low water
N	=	North
NB	=	Not bearing
n.a.	=	Pile not accessible for sonic inspection
n.i.	=	Pile missed by sonic inspection
NP	=	New replacement pile
n.t.	=	Pile not tagged
S	=	South
s	=	Severe attack
s	=	Pile has been stubbed
VO	=	Visual inspection only
W	=	West
un	=	Undamaged

TABLE 1

REMAINING CROSS-SECTIONAL AREA AND DESCRIPTION OF DAMAGE
ON INDIVIDUAL PILING

U.S. NAVY - DEPERMING FACILITY, NORFOLK, VA.

Pile ID Bent Pile	Area Rating	Remarks
PIER A		
1 - 1	100	Check at cap
2	100	
2.2	100	
5 - 1	100	Missing waler in ITZ
2	100	
3	100	Concrete jacket in ITZ to 0'
10 - 1	100	
2	100	
15 - 1	100	
2	100	
20 - 1	100	Light checking in ITZ
2	25	75% cross-section loss in upper 2 ft due to fungal attack
3	100	
25 - 1	100	
2	100	Loose waler and diagonal braces
32 - 1	100	
2	100	Broken bent waler
31 - 1	100	
35 - 1	100	
2	100	Small check in ITZ
40 - 1	100	
2	100	
45 - 1	100	
2	100	
50 - 1	100	
2	100	

Pile ID Bent Pile	Area Rating	Remarks
55 - 1	100	Loose bent waler
2	90	Checked at cap, OK. Light fungal in upper 8" of pile
3	100	
FINGER PIER-B, PIER A:		
1 - 1	100	
2	90	Light fungal at top of pile
60 - 1	100	Checks from cap to ITZ. Broken waler.
2	100	
PIER B:		
1 - 1	100	
1.8	100	New pile, L.A. at mdl.
2	90	Light fungal at top, 2% mech. abrasion in ITZ
3	100	
5 - 1	100	
2	100	
3	100	
9 - 1	100	Pile is checked from cap to ITZ - OK
2	50	~50% cross section loss in upper 1 ft due to fungal damage
3	100	Spacer block between pile and diag. brace is loose. Also waler is hanging loose on the pile

TABLE 1

REMAINING CROSS-SECTIONAL AREA AND DESCRIPTION OF DAMAGE ON INDIVIDUAL PILING

U.S. NAVY - DEPERMING FACILITY, NORFOLK, VA.

Pile ID Bent Pile	Area Rating	Remarks
PIER B (Contd):		
13 - 1	25	~75% cross-section loss in upper 2 ft due to fungal damage, pile cracked from top to ITZ
2	100	
3	90	Light fungal in upper 2" and waler is split and has old *L.* damage - OK
17 - 1	100	
2	100	Old *L.* attack at end of waler in ITZ-OK
3	100	Waler hanging off of pile 3
21 - 1	25	~75% cross-section loss in upper 2 ft due to fungal damage
2	100	
3	100	
25 - 1	100	
2	100	Old *L.* attack at end of waler in ITZ-OK
3	50	~50% cross-section loss in upper 2 ft due to fungal damage
29 - 1	75	~10% cross-section loss in upper 1 ft due to fungal damage
2	100	
3	100	

Pile ID Bent Pile	Area Rating	Remarks
DS-9 PLATFORM:		
2 - 1	100	
1br	100	
2	100	
2br	100	
3	100	Loose waler hanging off pile
3br	100	
4	100	
4br	100	
5	100	Diag. brace is loose
5br	100	
6	100	
6br	100	
7	100	
7br	100	
PIER B:		
35 - 1	100	Large check at top of pile - OK
2	100	
40 - 1	100	
2	100	
3	100	
45 - 1	100	
2	100	
50 - 1	100	
2	100	
55 - 1	100	
2	100	
3	75	~25% cross-section loss in upper 1 ft due to fungal damage, waler split at bolt
60 - 1	100	
2	75	10% mech. abrasion in upper ITZ, walers are missing, brace loose

TABLE 1

REMAINING CROSS-SECTIONAL AREA AND DESCRIPTION OF DAMAGE
ON INDIVIDUAL PILING

U.S. NAVY - DEPERMING FACILITY, NORFOLK, VA.

Pile ID Bent Pile	Area Rating	Remarks	Pile ID Bent Pile	Area Rating	Remarks
PIER C:			16 - 1	0	90% cross-section loss in top 2 ft, 10% cross-section loss in ITZ.
1 - 1	100		2	25	Concrete jacket in ITZ, looks intact, 75% cross-section loss top 2 ft.
2	100		3	100	Light fungal at top.
3	75	10% mech. section loss at cap, deck stringers are smashed.	17 - 1	0	Smashed from cap down to ITZ.
4 - 1	90	N.diag. is split at pile 1. Light fungal attack on top of pile.	2	0	Broken in ITZ due to impact.
2	100		18 - 1	100	N.diag. brace is loose.
3	100	Loose brace.	2	50	Concrete jacket in ITZ, 50% cross-section loss top 1 ft.
7 - 1	50	50% cross-section loss top 2 ft.	3	100	
2	50	Open boltholes in ITZ - OK. 30% cross-section loss in top 2 ft.	19 - 1	100	
3	100	Small shake off in ITZ - OK.	2	0	90% cross-section loss at top, 20% cross-section loss in ITZ in old open boltholes.
10 - 1	100	Pile is checked at top.	3	100	Light fungal at top.
2	100		22 - 1	25	3 open boltholes in ITZ-OK. 75% cross-section loss top 2 ft.
3	100		2	50	50% cross-section loss top 1 ft. 2 open bolt holes in ITZ - OK.
13 - 1	75	Light fungal at top of pile, 15% cross-section loss at old boltholes in ITZ.	3	90	5% cross-section loss at top of pile.
2	50	30% cross-section loss in upper 2 ft. due to fungal damage 10% cross-section loss in ITZ due to abrasion and fungal damage.	25 - 1	75	N.waler loose and 15% mech. and fungal cross-section loss in pile.
3	100		2	50	10% cross-section loss in old boltholes in ITZ, 30% cross-section loss top 1 ft.
			3	100	North and south walers are loose, N.diag. is cut off at pile 2.

TABLE 1

REMAINING CROSS-SECTIONAL AREA AND DESCRIPTION OF DAMAGE
ON INDIVIDUAL PILING

U.S. NAVY - DEPERMING FACILITY, NORFOLK, VA.

Pile ID Bent Pile	Area Rating	Remarks	Pile ID Bent Pile	Area Rating	Remarks
PIER C (contd):			40 - 1	90	5% cross-section loss in ITZ, light fungal attack at top.
28 - 1	100	Concrete jacket in ITZ - OK. N.diag. brace is broken at pile 1.	2	90	10% cross-section loss in old bolthole.
2	90	∿5% cross-section loss in old bolt holes.	3	100	Note: Bent has rotated ∿20° clockwise about pile 3 due to impact.
3	100	L.A.	42 - 1	50	5% cross-section loss in ITZ in open boltholes, 50% cross-section loss top 2 ft.
31 - 1	90	5% cross-section loss at waler notch.	2	25	75% cross-section loss top 2 ft.
2	90	5% cross-section loss at top of pile.			
3	100				
32 - 1	90	2% cross-section loss at open bolt hole.	PIER D:		
			2 - 1	100	
2	50	2% cross-section loss in open bolt hole, 50% loss top 2 ft.	2	100	
			3 - 1	100	Concrete jacket in ITZ, bent walers cut off.
3	100		2	100	
34 - 1	50	30% cross-section loss in open bolt hole, broken waler at pile 1.	6 - 1	100	South waler is missing.
			2	100	Heavy fungal deterioration in walers and braces.
2	75	20% cross-section loss at waler in upper ITZ.	9 - 1	100	Broken north and south lower walers.
			2	90	Light fungal in top of pile.
3	90	5% cross-section loss top 1 ft.			
			10 - 1	100	
37 - 1	100		2	100	
2	50	5% cross-section loss in open bolt hole, 50% cross-section loss at top 2 ft.	13 - 1	90	5% cross-section loss in boltholes.
			2	0	Concrete jacket in ITZ, 90% cross-section loss top 2 ft. above concrete jacket.
3	100				

TABLE 1

REMAINING CROSS-SECTIONAL AREA AND DESCRIPTION OF DAMAGE
ON INDIVIDUAL PILING

U.S. NAVY - DEPERMING FACILITY, NORFOLK, VA.

Pile ID Bent Pile	Area Rating	Remarks
PIER D (cont'd):		
14 - 1	100	N.diag. loose and hanging from pile 2.
2	100	
23 - 1	100	Large check from cap to ITZ, concrete jacket in lower ITZ to -8'. L.A. at cap.
2	0	Large check from cap to ITZ, 80% cross-section loss in lower ITZ due to fungal attack.
24 - 1	100	
2	100	Concrete jacket from lower ITZ to -8'.
25 - 1	100	
2	90	5% fungal and insect cross-section loss.
28 - 1	100	
2	90	Light fungal on top.
29 - 1	100	
2	100	
33 - 1	100	
2	75	25% fungal attack in upper 1 ft.
34 - 1	75	25% fungal attack in upper 1 ft.
2	100	
37 - 1	100	
2	100	
38 - 1	75	10% fungal section loss at top.
2	50	Concrete jacket in ITZ to -8'. 5% abrasion in ITZ above concrete jacket. 50% fungal cross-section loss in upper 2 ft.
40 - 1	100	
2	0	South waler is destroyed. 90% cross-section loss in upper 3 ft.
PIER E:		
2 - 1	100	
2	100	Light checking at cap.
5 - 1	100	New pile.
1br	100	New pile.
2	100	
3	100	
6 - 1	100	
2	100	
8 - 1	100	
2	100	West waler is loose.

TABLE 2

NUMBER AND PERCENTAGE OF PILING IN EACH CROSS-SECTIONAL AREA CLASSIFICATION

U.S. NAVY, DEPERMING FACILITY
NORFOLK, VA.

Percent Remaining Cross-Sectional Area	Number	Percent
100	129	71
90	17	9
75	10	6
50	13	7
25	6	3
0	7	4
TOTAL:	182	100%

TABLE 3

DEFECTIVE MEMBERS IDENTIFIED BY
RAPID VISUAL "SWIM BY" INSPECTION

U.S. NAVY, DEPERMING FACILITY, NORFOLK, VA.

Structure/Member Identification	Condition/Remarks
PIER A:	
Bent 5	North and south walers are missing.
Bent 9	Waler and north diagonal are loose.
Bent 12	Waler is loose.
Bent 14	One waler is missing.
Bent 17	Walers missing, diagonal braces loose.
Bent 19	North diagonal brace is broken at lower end.
Bent 26	Loose waler.
Bent 36	Waler missing.
Bent 40	Light *L.* attack to walers.
Bent 46	Pile 2, large check at cap.
Bent 53	Both walers missing.
Bent 59	Loose bent waler.
Pier B:	General note: Several fender piles are broken off.
Bent 59	North waler missing.
Bent 56	North diagonal broken.
Bent 47	North waler missing.
Bent 46	South waler missing.
Bent 43	North and south walers missing.
Bent 38	North and south walers missing, north diagonal loose.
Bent 37	North diagonal is cracked.
Bent 36	South diagonal is loose.
Bent 35	Upper north waler is split, lower elevation walers are OK.
Bent 33	North and south walers are missing.
Bent 19	North and south walers are missing.
Bent 14	North waler is missing.

TABLE 3

DEFECTIVE MEMBERS IDENTIFIED BY
RAPID VISUAL "SWIM BY" INSPECTION

U.S. NAVY, DEPERMING FACILITY, NORFOLK, VA.

Structure/Member Identification	Condition/Remarks
Pier B (contd):	
Bent 12	Pile 3 has a large check from cap to ITZ.
Bent 10	Pile 3 has a loose spacer block between pile and diagonal brace.
Bent 4	Pile 2 has an open bolthole in the ITZ - OK.
Pier C:	
Bent 3	Pile 2 is cut off 2 feet below cap. Loose south waler at pile 1.
Bent 5	Pile 2 has 20% cross-sectional loss due to mechanical abrasion and fungal at bolthole.
Bent 5	Pile 3 has an open bolthole - OK.
Bent 6	Pile 1 has 20% cross-sectional loss due to abrasion and light fungal.
Bent 6	Pile 3 has an old loose bolt.
Bent 8	Pile 1 has 30% cross-sectional loss mechanical and fungal in ITZ.
Bent 9	New pile added to west of pile 1.
Bent 11	Pile 2 is not bolted to cap.
Bent 12	Pile 2 is cut off 2 feet below cap.
Bent 15	Pile 2 has ∿20% cross-sectional loss at waler.
Bent 17	Pile 2, north and south bolted caps cracked and the braces and walers are smashed.
Bent 20	Pile 2 has 10% cross-sectional loss in old bolthole.
Bent 22	South upper waler and north lower waler broken in ITZ. Pile 2 has 5% mechanical abrasion and fungal at old boltholes. Not bolted to cap.
Bent 23	Walers are missing. Pile 2 has 6 open boltholes ∿20% cross-sectional loss at boltholes.

TABLE 3

DEFECTIVE MEMBERS IDENTIFIED BY
RAPID VISUAL "SWIM BY" INSPECTION

U.S. NAVY, DEPERMING FACILITY, NORFOLK, VA.

Structure/Member Identification	Condition/Remarks
PIER C (contd):	
Bent 24	North upper waler is cracked and lower waler is loose.
Bent 26	Pile 1 has 6 open boltholes ∿20% cross-sectional loss at walers.
Bent 26	Pile 2 has 20% cross-sectional loss due to impact and old *L.* damage.
Bent 29	Pile 2 has ∿5% cross-sectional loss at upper waler.
Bent 29	Pile 2 has ∿2% cross-sectional loss at upper waler.
Bent 36	Pile 2 has 75% cross-sectional loss in boltholes and location of waler.
Bent 33	Pile 2 has 50% fungal loss below waler.
Bent 35	Pile 1 has diagonal brace loose, 10% cross-sectional loss in pile.
Bent 38	Row 1 waler destroyed at pile 1. South diagonal brace cracked.
Bent 39	Walers are loose on bolts in ITZ.
Bent 41	Bent is rotated ∿10° about pile 3 due to impact.
DS-9 PLATFORM:	
General Note:	Some broken interior and exterior bracing - generally good condition. Piling are in generally good condition.

TABLE 3

DEFECTIVE MEMBERS IDENTIFIED BY
RAPID VISUAL "SWIM BY" INSPECTION

U.S. NAVY, DEPERMING FACILITY, NORFOLK, VA.

Structure/Member Identification	Condition/Remarks
PIER D:	
General Note: Several piling have fungal decay on their tops, also some of the deck has suffered fungal deterioration.	
Bent 2-A	Bent is non structural, piling are loose.
Bent 23	Pile 2 - 80% cross-sectional loss at waler elevation (fungal) above concrete jacket (see Photograph).
Bent 27	Broken waler at pile 2.
Bent 36	South waler missing, concrete jacket in ITZ. Pile 2 has 10% fungal cavity.
PIER E:	
Bent 4	Broken waler at pile 3.

TABLE 4

COLUMN LOAD CAPACITY CALCULATIONS
OF DAMAGED PILING

Pile load capacities were calculated by an inhouse computer program using the Southern Pine Association modified Euler equation for long columns where,

$$P_{ult} = \frac{0.30\ E}{(L/d)^2} \times A$$

Pile lengths (L) were taken from mudline to cap. The unsupported length of pile (USL) was taken from below the bracing at the top and ten feet was added at the mudline to allow for the point of fixity. Effective length factor (K) of 0.8 was used. Other program parameters used are described below:

Bent	-	bent identification
PIle	-	pile (row) identification
ITP	-	type of wood (1=fir)
Length	-	unsupported length - in this project, 10 feet was added onto the USL since the point of fixity at the bottom was considered to be 10 feet below the mudline.
EFF-L Factor	-	effective length factor, K. K=0.8 was used for these calculations
ORG-DIA	-	original pile diameter - taken at mudline
EFF-ARA	-	remaining cross-sectional area based on sonic testing, on the following basis:

Factor	Cross-Sectional area remaining
1.00	100%
0.90	90%-100%
0.75	75%-100%
0.50	50%- 75%
0.25	25%- 50%
0.005*	0%- 25%

(*the program cannot handle 0.000)

EFF-DIA	-	effective pile diameter
EFF-ARA	-	effective cross-sectional area of pile

C	-	compression parallel to grain, in psi, for fir
L/D	-	length over diameter ratio
P-ULT, LB	-	ultimate loading capacity of the pile column in pounds. This refers only to the column length as shown and does not take into account soil conditions (other than to establish the point of fixity), and what the pile was originally driven to in terms of design loads.

It is strongly emphazied that these calculations deal only with the ultimate capacity of the wood pile column within the fixity conditions and USL parameters as perceived. These load calculations are <u>not</u> design load calculations.

(Structural analysis in light of lateral loading was not included since this is considerably beyond the scope of this project. Such an analysis would require details on imposed lateral loading and structural analysis of the entire facility in terms of these loads and existing structural parameters.)

U.S.N. DEPERMING FACILITY PILE
LOADING CAPACITIES, NORFOLK VA.
9 JULY 81

BENT	PILE	ITP	LENGTH FT	EFF-L FACTOR	ORG-DIA FT	EFF-ARA FACTOR	EFF-DIA FT	EFF-ARA IN2	C PSI	L/D	P-ULT LB
PIER A											
20	2	1	45.00	1.000	1.330	0.250	0.665	50.01	105	68	5243.
PIER B											
9	2	1	45.00	1.000	1.330	0.500	0.940	100.03	210.	48	20971.
13	1	1	45.00	1.000	1.330	0.250	0.665	50.01	105.	68	5243.
21	1	1	45.00	1.000	1.330	0.250	0.665	50.01	105.	68	5243.
25	3	1	45.00	1.000	1.330	0.500	0.940	100.03	210.	48	20971.
29	1	1	45.00	1.000	1.330	0.750	1.152	150.04	314.	39	47184.
55	3	1	45.00	1.000	1.330	0.750	1.152	150.04	314.	39	47184.
60	2	1	45.00	1.000	1.330	0.750	1.152	150.04	314.	39	47184.
PIER C											
1	3	1	45.00	1.000	1.330	0.500	0.940	100.03	210.	48	20971.
7	1	1	45.00	1.000	1.330	0.500	0.940	100.03	210.	48	20971.
	2	1	45.00	1.000	1.330	0.500	0.940	100.03	210.	48	20971.
13	1	1	45.00	1.000	1.330	0.750	1.152	150.04	314.	39	47184.
	2	1	45.00	1.000	1.330	0.500	0.940	100.03	210.	48	20971.
16	1	1	45.00	1.000	1.170	0.005	0.083	0.77	2.	544	1.
	2	1	45.00	1.000	1.170	0.250	0.585	38.70	81.	77	3140.
17	1	1	45.00	1.000	1.170	0.005	0.083	0.77	2.	544	1.
	2	1	45.00	1.000	1.170	0.005	0.083	0.77	2.	544	1.
18	2	1	45.00	1.000	1.170	0.500	0.827	77.41	162.	54	12559.
19	2	1	45.00	1.000	1.170	0.005	0.083	0.77	2.	544	1.
22	1	1	45.00	1.000	1.170	0.250	0.585	38.70	81.	77	3140.
	2	1	45.00	1.000	1.170	0.500	0.827	77.41	162.	54	12559.
25	1	1	45.00	1.000	1.170	0.750	1.013	116.11	243.	44	28258.
	2	1	45.00	1.000	1.170	0.500	0.827	77.41	162.	54	12559.
32	2	1	45.00	1.000	1.170	0.500	0.827	77.41	162.	54	12559.
34	1	1	45.00	1.000	1.170	0.500	0.827	77.41	162.	54	12559.
	2	1	45.00	1.000	1.170	0.750	1.013	116.11	243.	44	28258.

U.S.N. DEPERMING FACILITY PILE
LOADING CAPACITIES, NORFOLK VA.
9 JULY 81

BENT	PILE	ITP	LENGTH FT	EFF-L FACTOR	ORG-DIA FT	EFF-ARA FACTOR	EFF-DIA FT	EFF-ARA IN2	C PSI	L/D	P-ULT LB
37	2	1	45.00	1.000	1.170	0.500	0.827	77.41	162.	54	12559.
42	1	1	45.00	1.000	1.170	0.500	0.827	77.41	162.	54	12559.
	2	1	45.00	1.000	1.170	0.250	0.585	38.70	81.	77	3140.
PIER D											
13	2	1	45.00	1.000	1.080	0.005	0.076	0.66	1.	589	1.
23	2	1	45.00	1.000	1.080	0.005	0.076	0.66	1.	589	1.
33	2	1	45.00	1.000	1.080	0.750	0.935	98.94	207.	48	20516.
34	1	1	45.00	1.000	1.170	0.750	1.013	116.11	243.	44	28258.
38	1	1	45.00	1.000	1.170	0.750	1.013	116.11	243.	44	28258.
	2	1	45.00	1.000	1.170	0.500	0.827	77.41	162.	54	12559.
40	2	1	45.00	1.000	1.170	0.005	0.083	0.77	2.	544	1.

Execution Terminated 14:16:25 T=0.11 RC=0 $.43

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