US Army Corps
of Engineers
Baltimore District

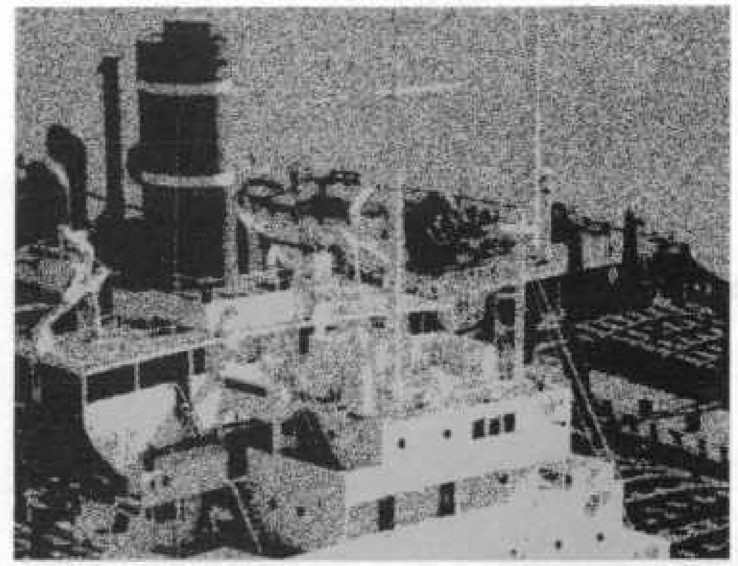
Final / August 1981

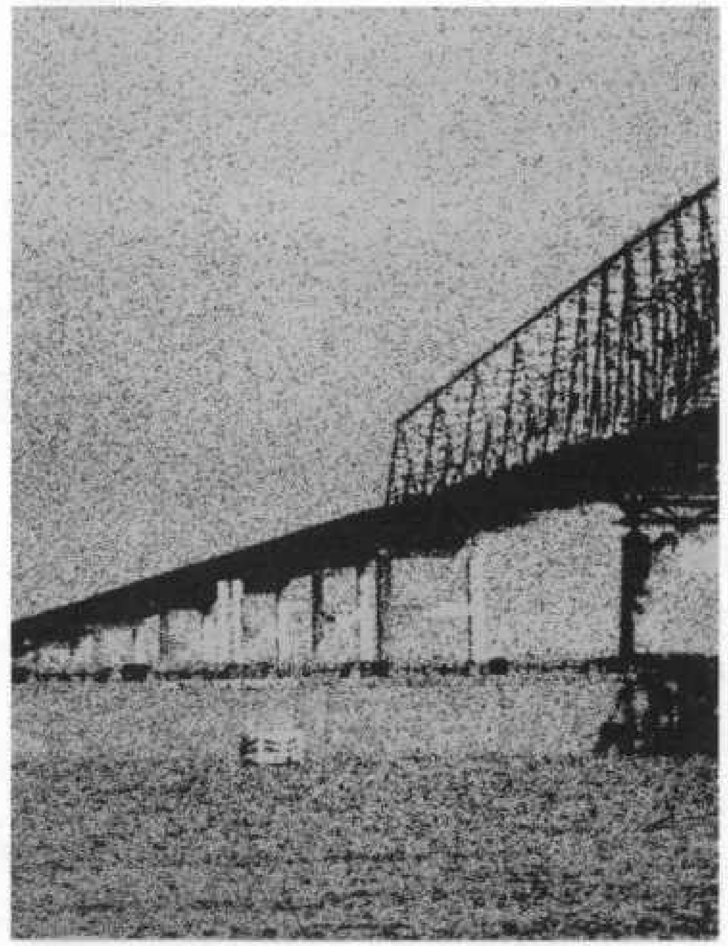
121

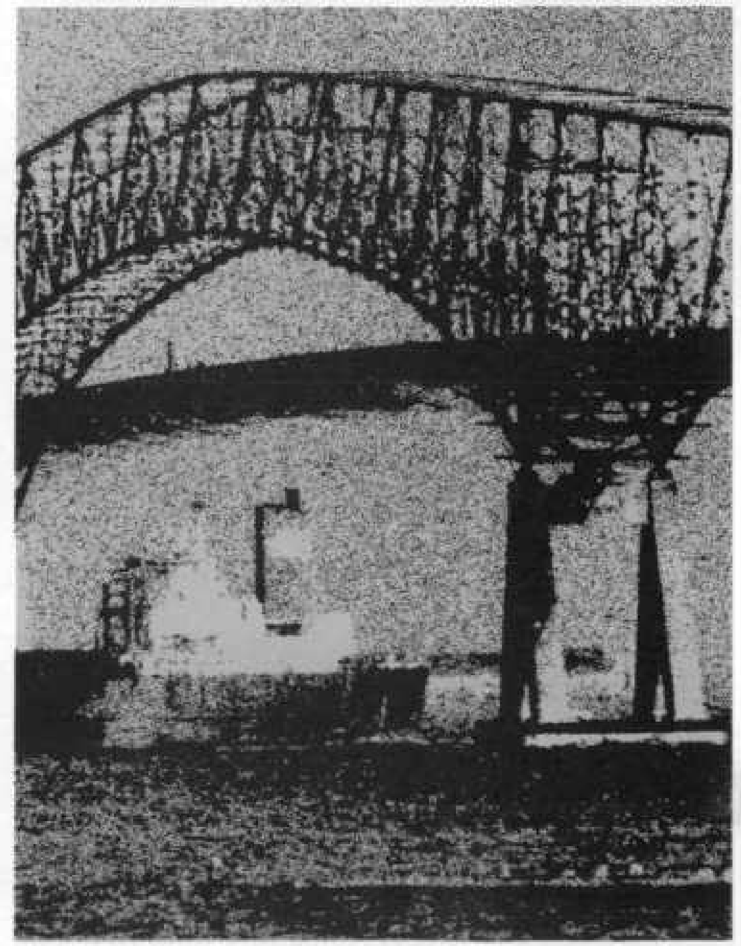
Combined Phase I and II
General Design Memorandum

Technical Appendices

Baltimore
Harbor and Channels,
Maryland and Virginia







APPENDIX A

HYDROGRAPHIC SURVEYS

AND

UTILITY CROSSINGS

AND RELOCATIONS

HYDROGRAPHIC SURVEYS AND UTILITY CROSSINGS AND RELOCATION

Introduction

Hydrographic condition surveys were conducted on all project channels between June and September 1977. In the Virginia channels, cross sections were made every 400 feet with soundings every 50 feet. In the Maryland channels, cross sections were made every 500 feet with soundings every 50 feet. In addition, utility investigations were conducted during the GDM. Plate A-31 illustrates the utility crossings which exist within or immediately adjacent to the limits of the project.

TABLE OF CONTENTS

US Army Corps
of Engineers
Baltimore District

Final / August 1981

Combined Phase I and II
General Design Memorandum

Technical Appendices

Baltimore Harbor
and Channels,
Maryland and Virginia

BALTIMORE HARBOR AND CHANNELS
MARYLAND AND VIRGINIA

COMBINED PHASE I AND II GENERAL DESIGN MEMORANDUM

TECHNICAL APPENDICES

TABLE OF CONTENTS

LIST OF TABLES

TABLE OF CONTENTS (continued)

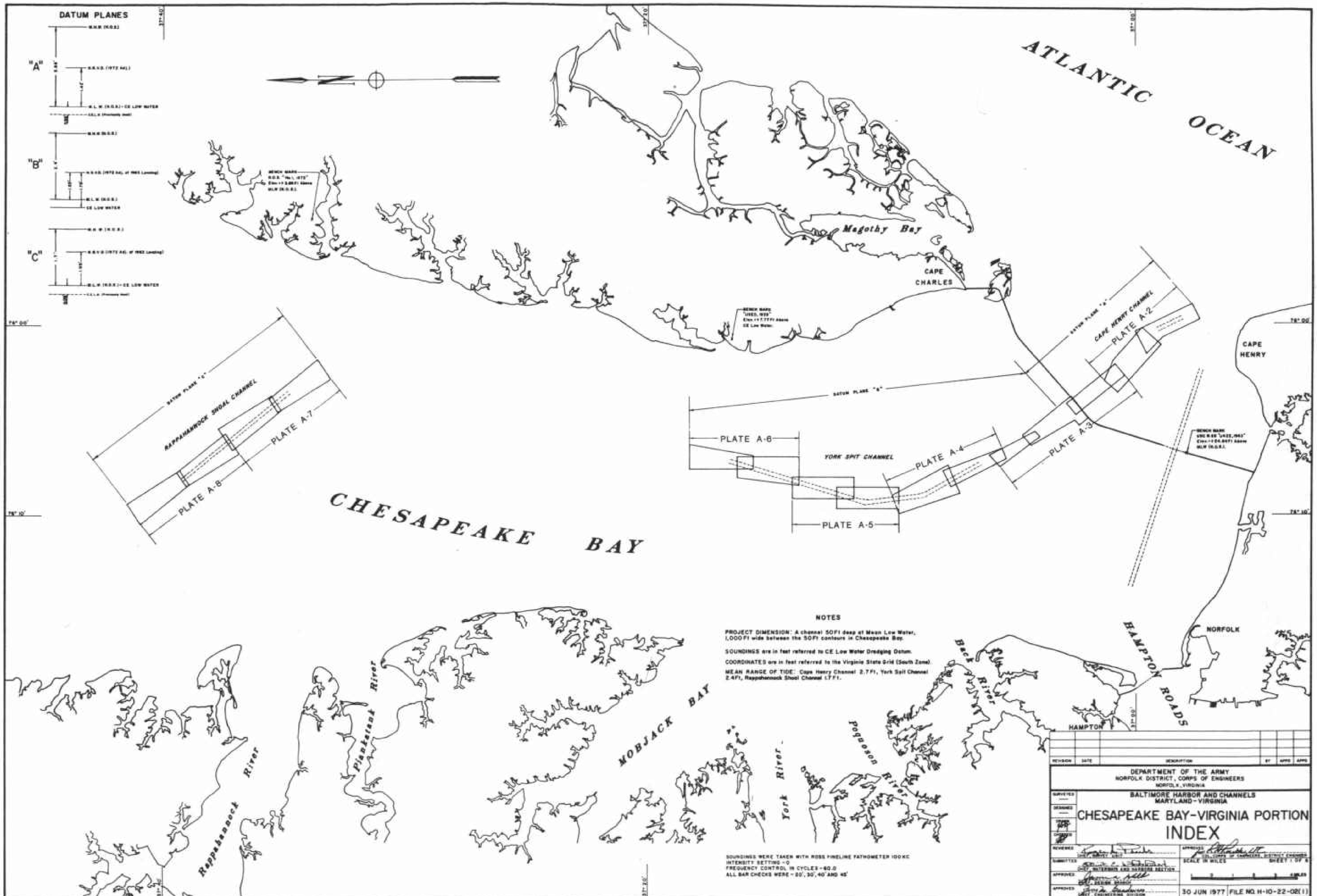
LIST OF TABLES (continued)

LIST OF FIGURES

LIST OF PLATES

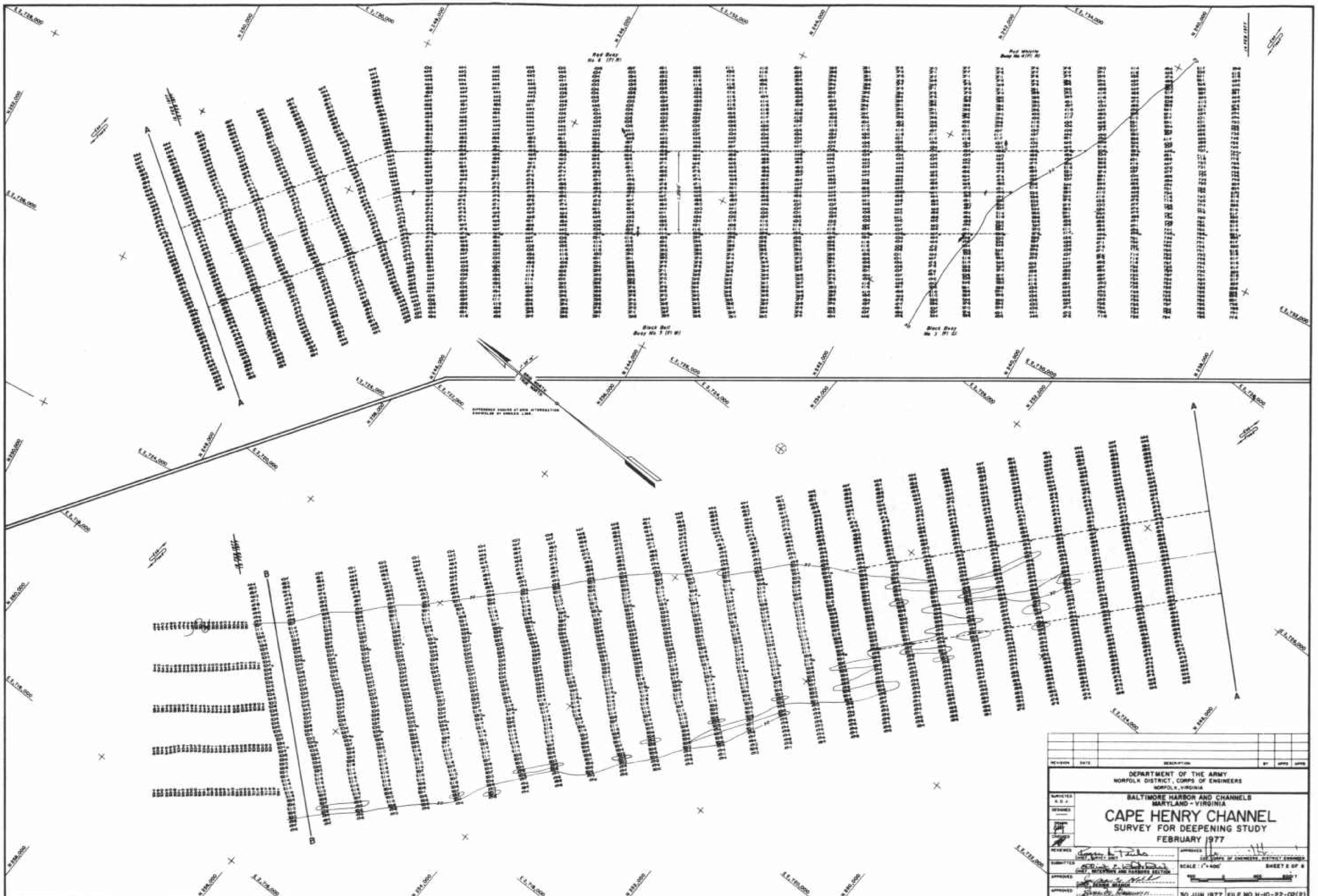
LIST OF PLATES (continued)

LIST OF PLATES (continued)



DATUM PLANES
"A"
"B"
"C"
ATLANTIC OCEAN
Magothy Bay
CAPE CHARLES
CAPE HENRY
CAPE HENRY CHANNEL
PLATE A-2
PLATE A-3
PLATE A-4
PLATE A-5
PLATE A-6
PLATE A-7
PLATE A-8
YORK SPIT CHANNEL
RAPPAHANNOCK SHOAL CHANNEL
CHESAPEAKE BAY
MOBJACK BAY
HAMPTON ROADS
NORFOLK
HAMPTON
Back River
Poquoson River
York River
Piankatank River
Rappahannock River
NOTES
PROJECT DIMENSION: A channel 50 Ft deep at Mean Low Water, 1,000 Ft wide between the 50 Ft contours in Chesapeake Bay.
SOUNDINGS are in feet referred to CE Low Water Dredging Datum.
COORDINATES are in feet referred to the Virginia State Grid (South Zone).
MEAN RANGE OF TIDE: Cape Henry Channel 2.7 Ft, York Spit Channel 2.4 Ft, Rappahannock Shoal Channel 1.7 Ft.
SOUNDINGS WERE TAKEN WITH ROSS FINELINE FATHOMETER 100 KC
INTENSITY SETTING - 0
FREQUENCY CONTROL IN CYCLES - 60.0
ALL BAR CHECKS WERE - 20', 30', 40' AND 45'
DEPARTMENT OF THE ARMY
NORFOLK DISTRICT, CORPS OF ENGINEERS
NORFOLK, VIRGINIA
BALTIMORE HARBOR AND CHANNELS
MARYLAND-VIRGINIA
CHESAPEAKE BAY-VIRGINIA PORTION
INDEX
30 JUN 1977
FILE NO. H-10-22-02(1)

PLATE A-1



MATCH TO PLATE A-3

PLATE A-2

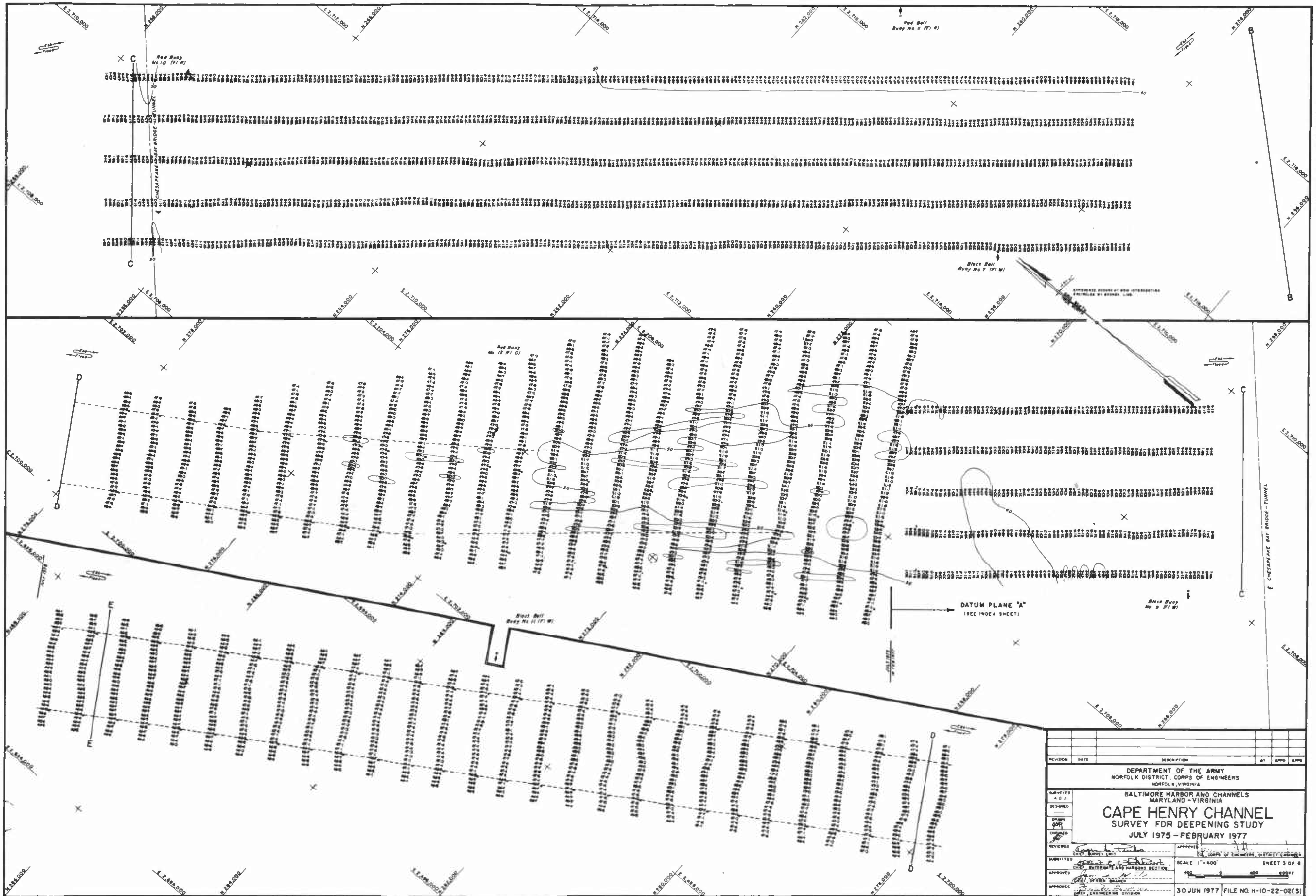
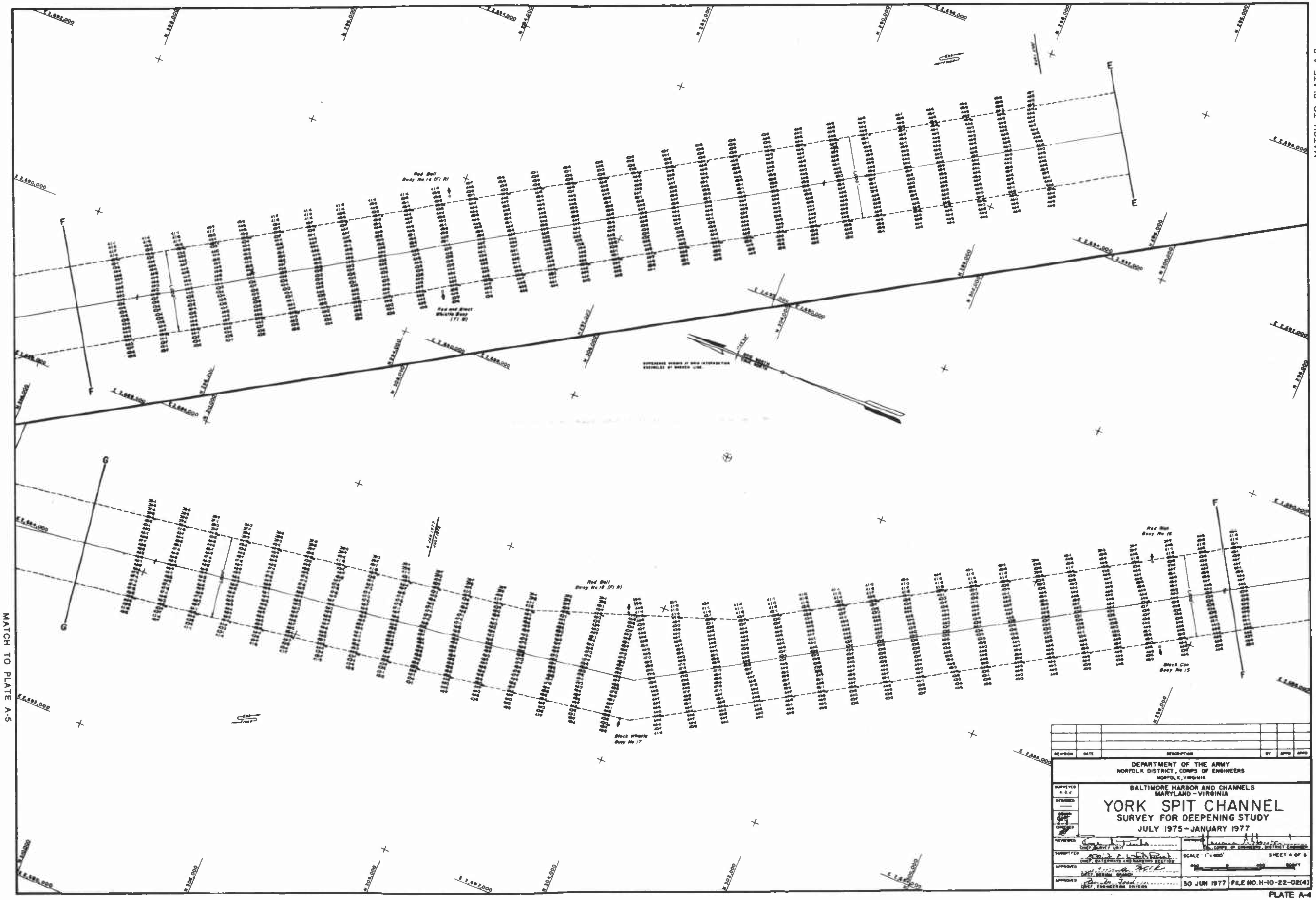

MATCH TO PLATE A-2
MATCH TO PLATE A-4
Red Buoy No 10 (Fl R)
Red Bell Buoy No 8 (Fl R)
Black Bell Buoy No 7 (Fl W)
Red Buoy No 12 (Fl G)
Black Bell Buoy No 11 (Fl W)
Black Buoy No 9 (Fl W)
CHESAPEAKE BAY BRIDGE-TUNNEL
DATUM PLANE "A"
(SEE INDEX SHEET)
REVISION
DATE
DESCRIPTION
BY
APPD
APPD
DEPARTMENT OF THE ARMY
NORFOLK DISTRICT, CORPS OF ENGINEERS
NORFOLK, VIRGINIA
SURVEYED
DESIGNED
DRAWN
CHECKED
BALTIMORE HARBOR AND CHANNELS
MARYLAND - VIRGINIA
CAPE HENRY CHANNEL
SURVEY FOR DEEPENING STUDY
JULY 1975 - FEBRUARY 1977
REVIEWED
CHIEF, SURVEY UNIT
APPROVED
COL, CORPS OF ENGINEERS, DISTRICT ENGINEER
SUBMITTED
CHIEF, WATERWAYS AND HARBORS SECTION
SCALE 1" = 400'
SHEET 3 OF 6
APPROVED
CHIEF, DESIGN BRANCH
APPROVED
CHIEF, ENGINEERING DIVISION
30 JUN 1977
FILE NO. H-10-22-02(3)

PLATE A-3

MATCH TO PLATE A-3



MATCH TO PLATE A-5

PLATE A-4

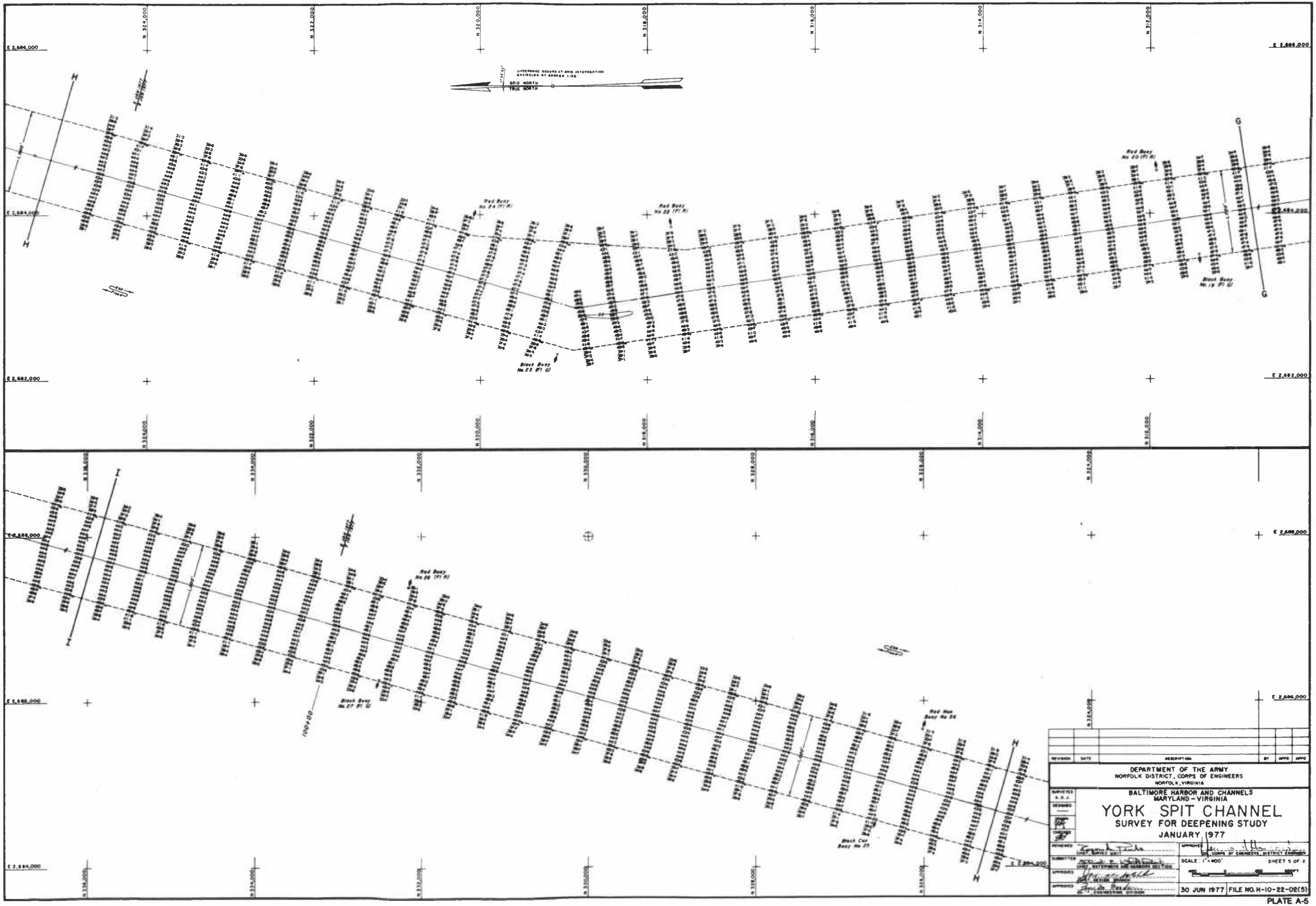
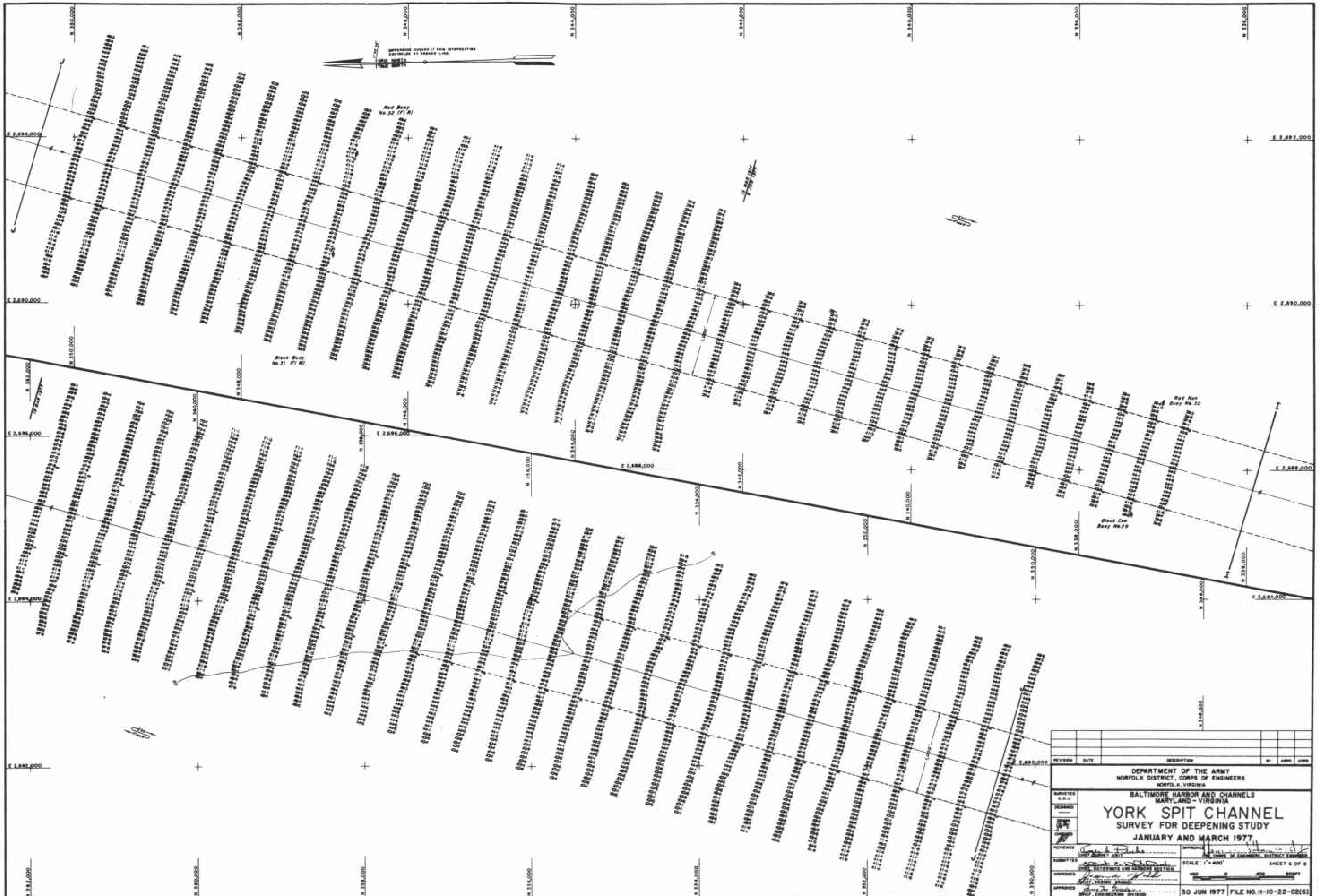

MATCH TO PLATE A-4
MATCH TO PLATE A-6
Red Buoy No 24 (Fl R)
Red Buoy No 22 (Fl R)
Red Buoy No 20 (Fl R)
Black Buoy No 23 (Fl G)
Black Buoy No 19 (Fl G)
Red Buoy No 26 (Fl R)
Black Buoy No 27 (Fl G)
Red Nun Buoy No 24
Black Can Buoy No 25
DEPARTMENT OF THE ARMY
NORFOLK DISTRICT, CORPS OF ENGINEERS
NORFOLK, VIRGINIA
BALTIMORE HARBOR AND CHANNELS
MARYLAND - VIRGINIA
YORK SPIT CHANNEL
SURVEY FOR DEEPENING STUDY
JANUARY 1977
SCALE 1" = 400'
SHEET 5 OF 6
30 JUN 1977
FILE NO. H-10-22-02(5)

PLATE A-5



MATCH TO PLATE A-5

PLATE A-6

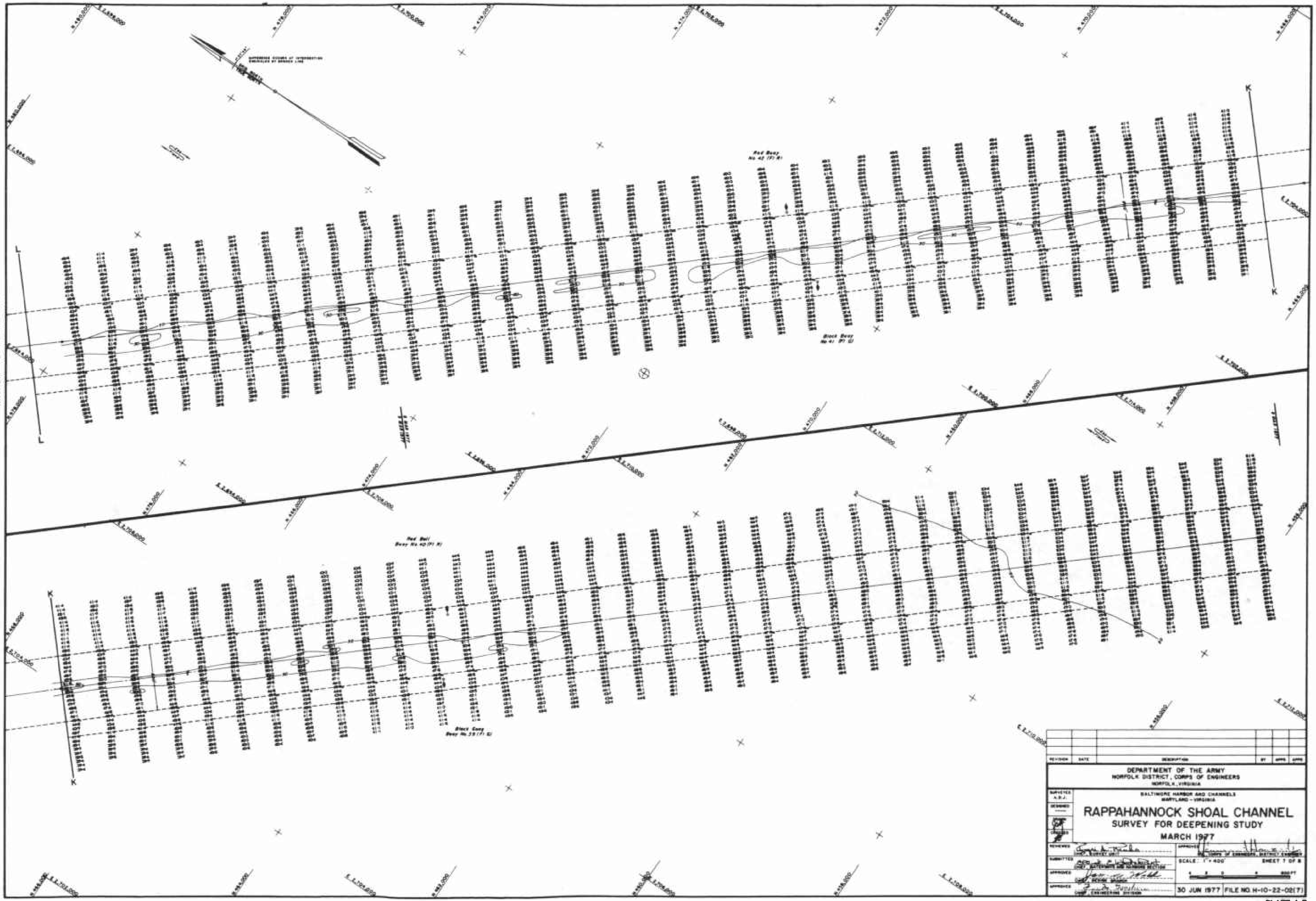
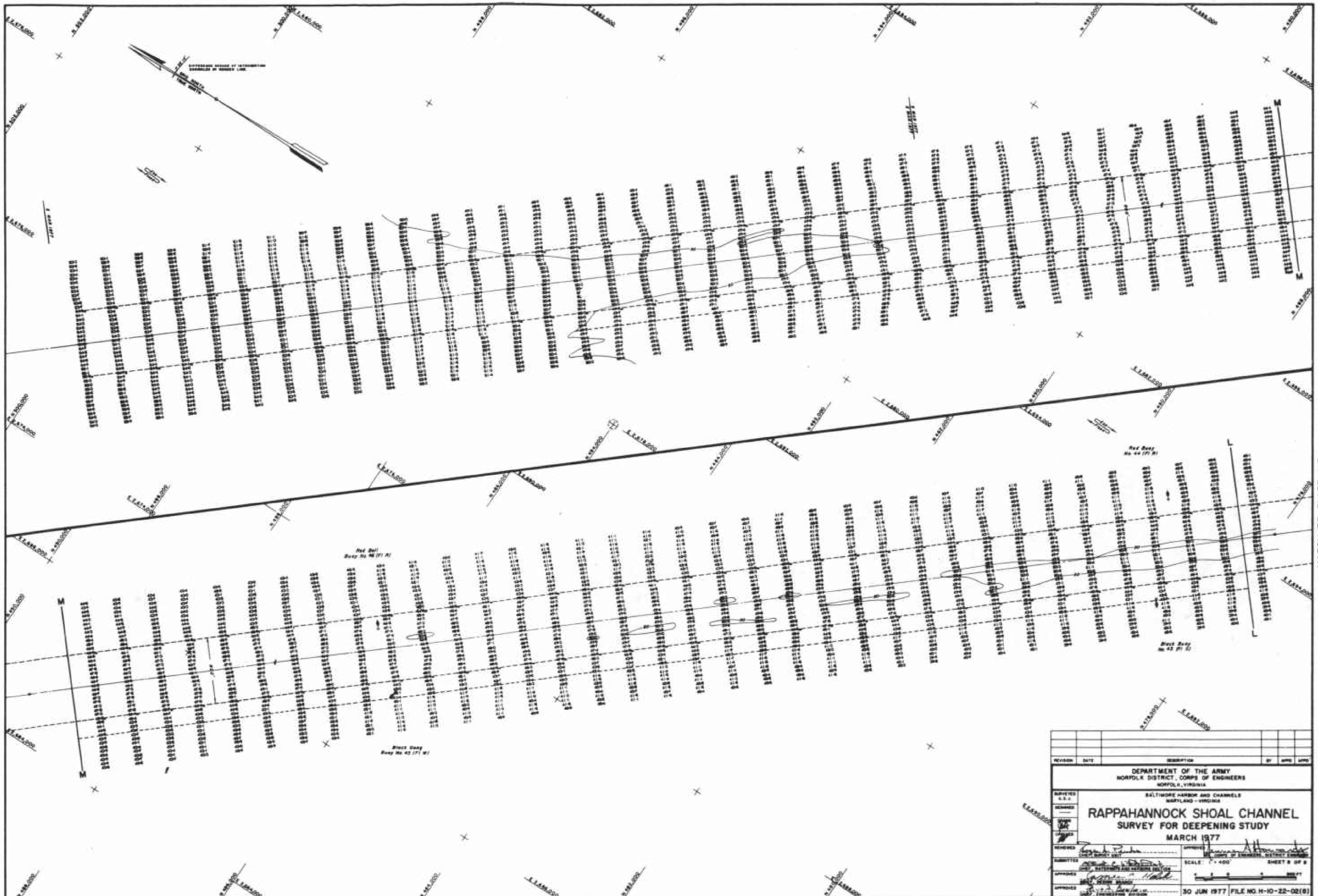

MATCH TO PLATE A-8
Red Buoy No. 42 (Fl R)
Black Buoy No. 41 (Fl G)
Red Bell Buoy No. 40 (Fl R)
Black Buoy No. 39 (Fl G)
DEPARTMENT OF THE ARMY
NORFOLK DISTRICT, CORPS OF ENGINEERS
NORFOLK, VIRGINIA
BALTIMORE HARBOR AND CHANNELS
MARYLAND - VIRGINIA
RAPPAHANNOCK SHOAL CHANNEL
SURVEY FOR DEEPENING STUDY
MARCH 1977
SCALE: 1" = 400'
SHEET 7 OF 8
30 JUN 1977
FILE NO. H-10-22-02(7)

PLATE A-7



MATCH TO PLATE A-7

PLATE A-8

NOTES

1. BASE PLAN TAKEN FROM NOAA CHART NO. 12273, TITLED "CHESAPEAKE BAY, SANDY POINT TO SUSQUEHANNA RIVER" DATED OCTOBER 29, 1977
2. MAP SHOWS EXISTING DIMENSIONS AND DEPTHS OF CHANNELS ONLY.
3. MAIN SHIP CHANNEL CONSISTS OF:
   CRAIGHILL SECTION
   CRAIGHILL - CUTOFF ANGLE
   CUTOFF SECTION
   CUTOFF - BREWERTON ANGLE
   BREWERTON SECTION
   BREWERTON - FT. McHENRY ANGLE
   FT. McHENRY SECTION

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE MARYLAND

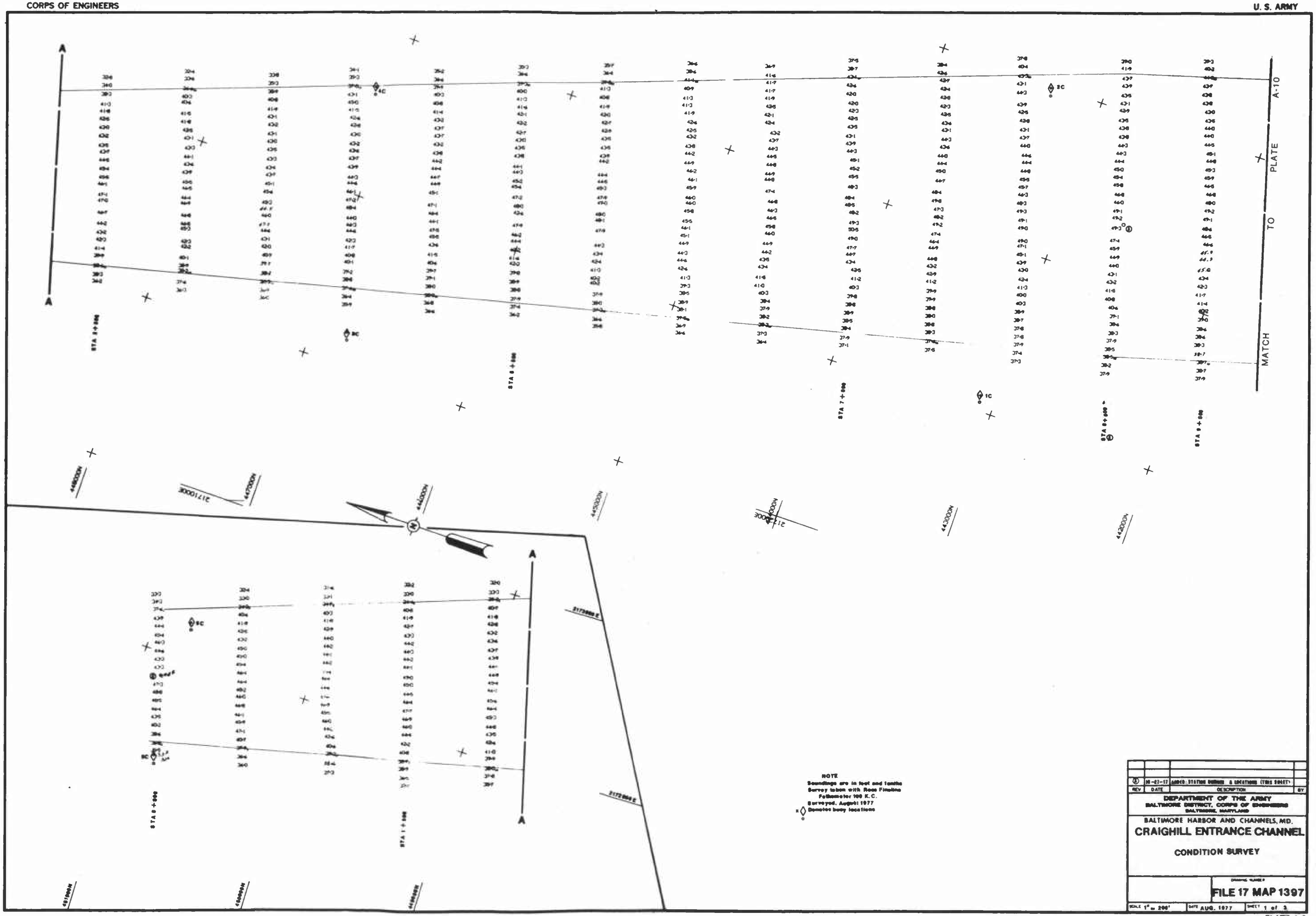
MUESER · RUTLEDGE · WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE NEW YORK N Y 10017

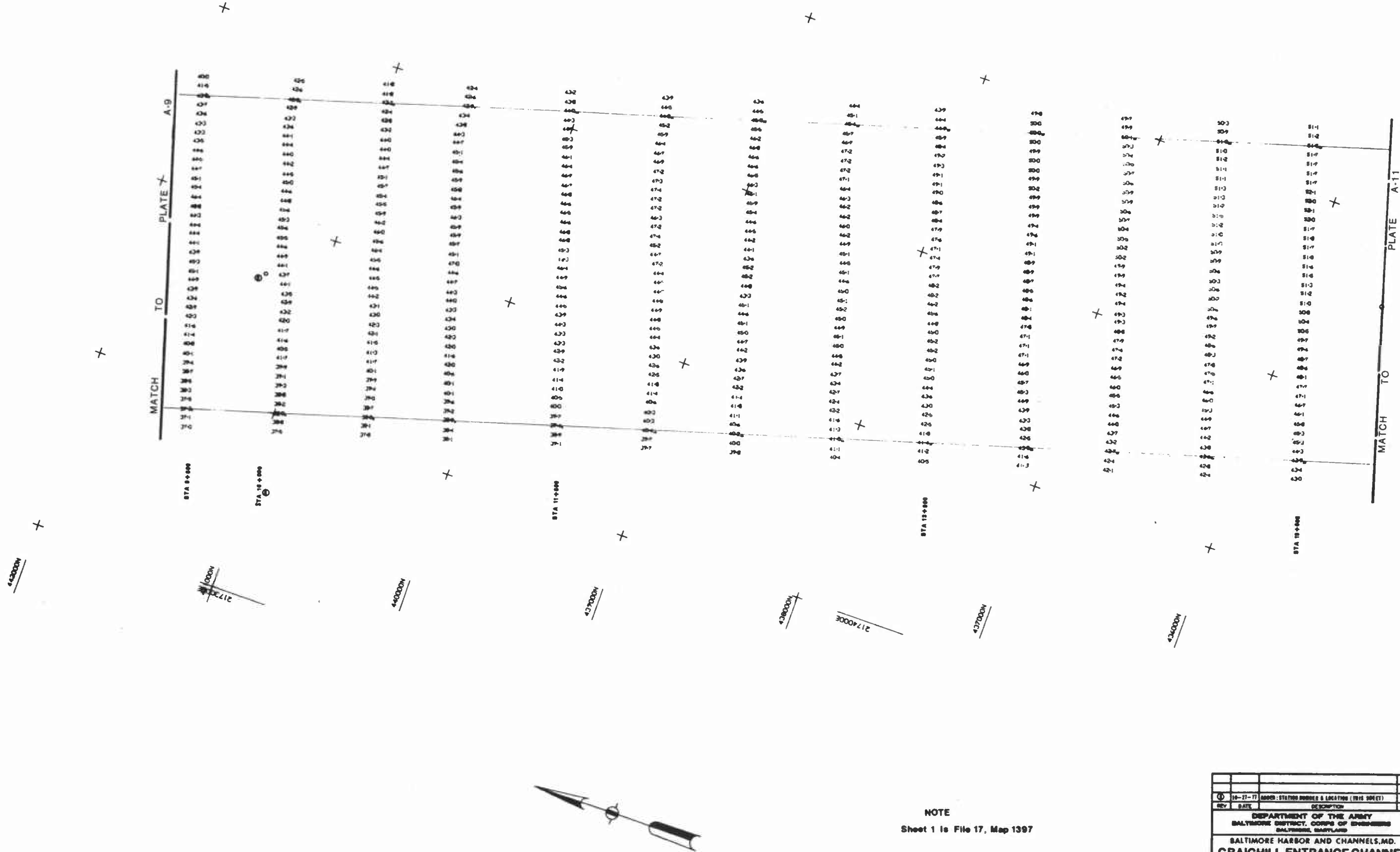
SCALE	MADE BY IM DATE 1/78	FILE NO
As Noted	CH'KD BY FCR DATE 1/78	1864

MARYLAND CHANNELS
KEY PLAN

MAP NO: 1

PLATE A-8A


A
A
A-10
PLATE
TO
MATCH
448000N
447000N
446000N
445000N
444000N
443000N
442000N
2171000E
2172000E
NOTE
Soundings are in feet and tenths
Survey taken with Ross Fineline
Fathometer 100 K.C.
Surveyed, August 1977
Denotes buoy locations
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND
BALTIMORE HARBOR AND CHANNELS, MD.
CRAIGHILL ENTRANCE CHANNEL
CONDITION SURVEY
FILE 17 MAP 1397
SCALE 1" = 200'
DATE AUG. 1977
SHEET 1 of 3
REV
DATE
DESCRIPTION
BY



NOTE

Sheet 1 is File 17, Map 1397

REV	DATE	DESCRIPTION	BY
1	10-27-77	ADDED: STATION NUMBERS & LOCATION (THIS SHEET)	

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

BALTIMORE HARBOR AND CHANNELS, MD.

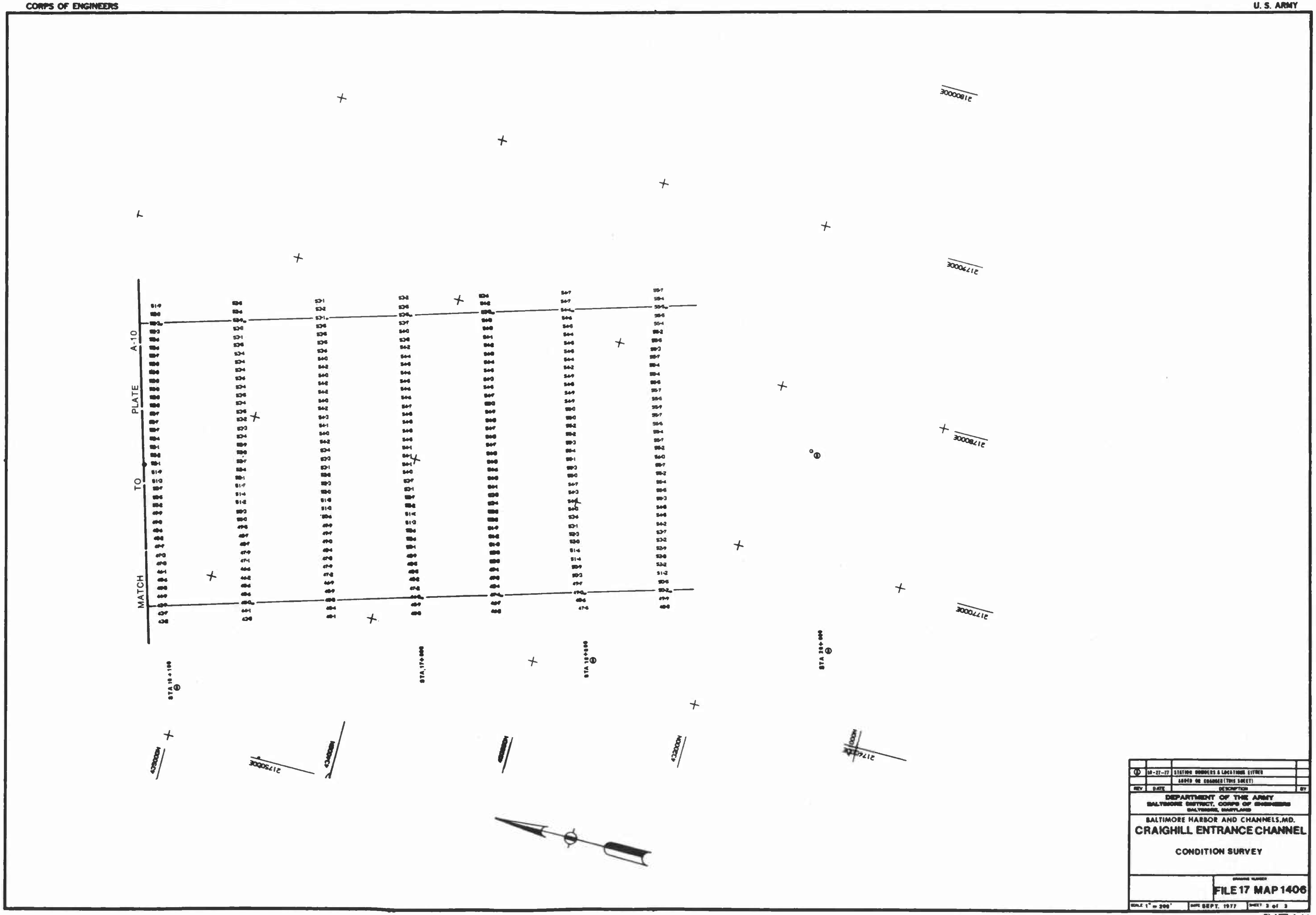
CRAIGHILL ENTRANCE CHANNEL

CONDITION SURVEY

DRAWING NUMBER

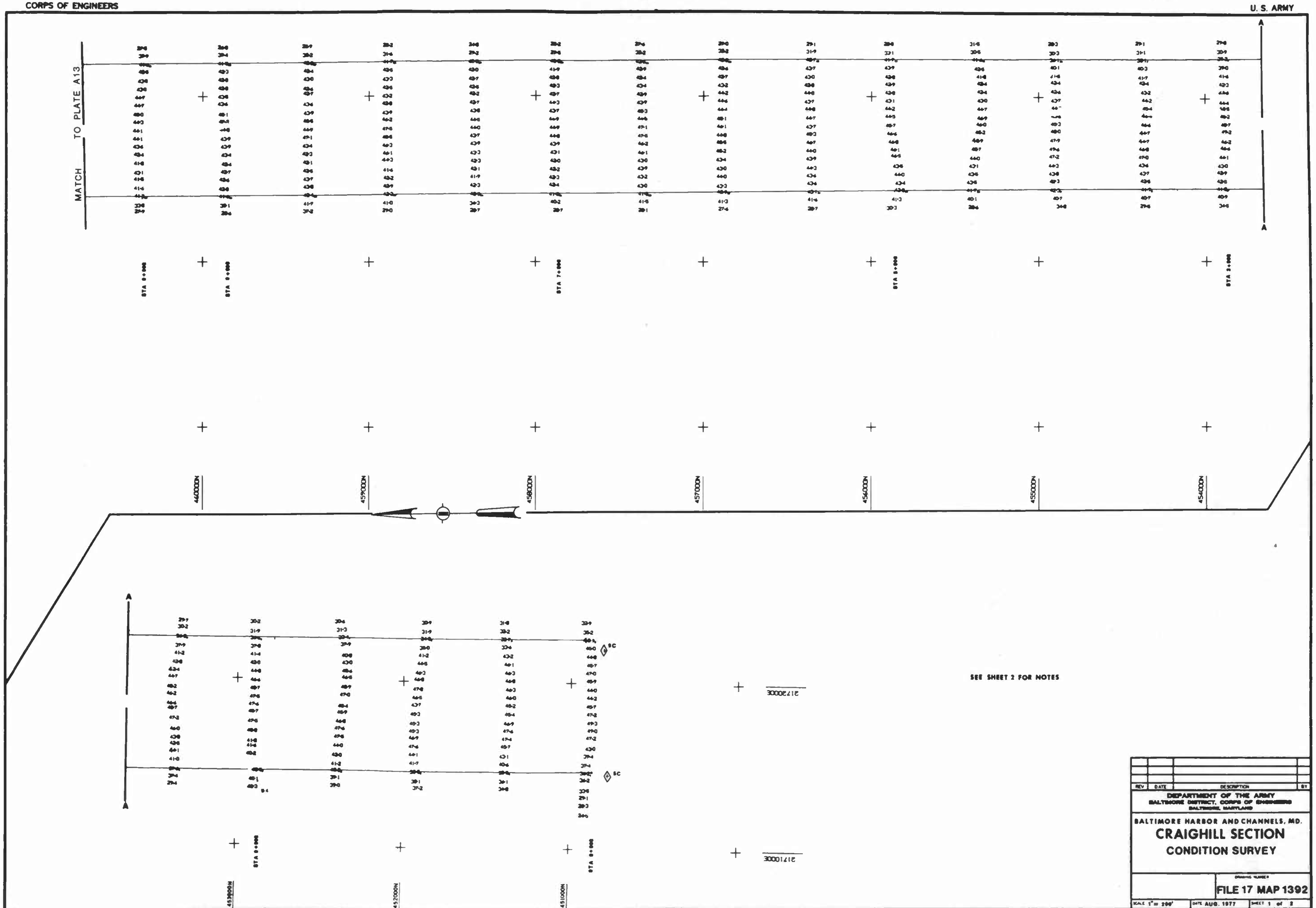
FILE 17 MAP 1405

SCALE 1" = 200' | DATE SEPT 1977 | SHEET 2 of 3


MATCH TO PLATE A-10
STA 184+000
STA 284+000
DEPARTMENT OF THE ARMY
BALTIMORE HARBOR AND CHANNELS, MD.
CRAIGHILL ENTRANCE CHANNEL
CONDITION SURVEY
FILE 17 MAP 1406
SEPT. 1977

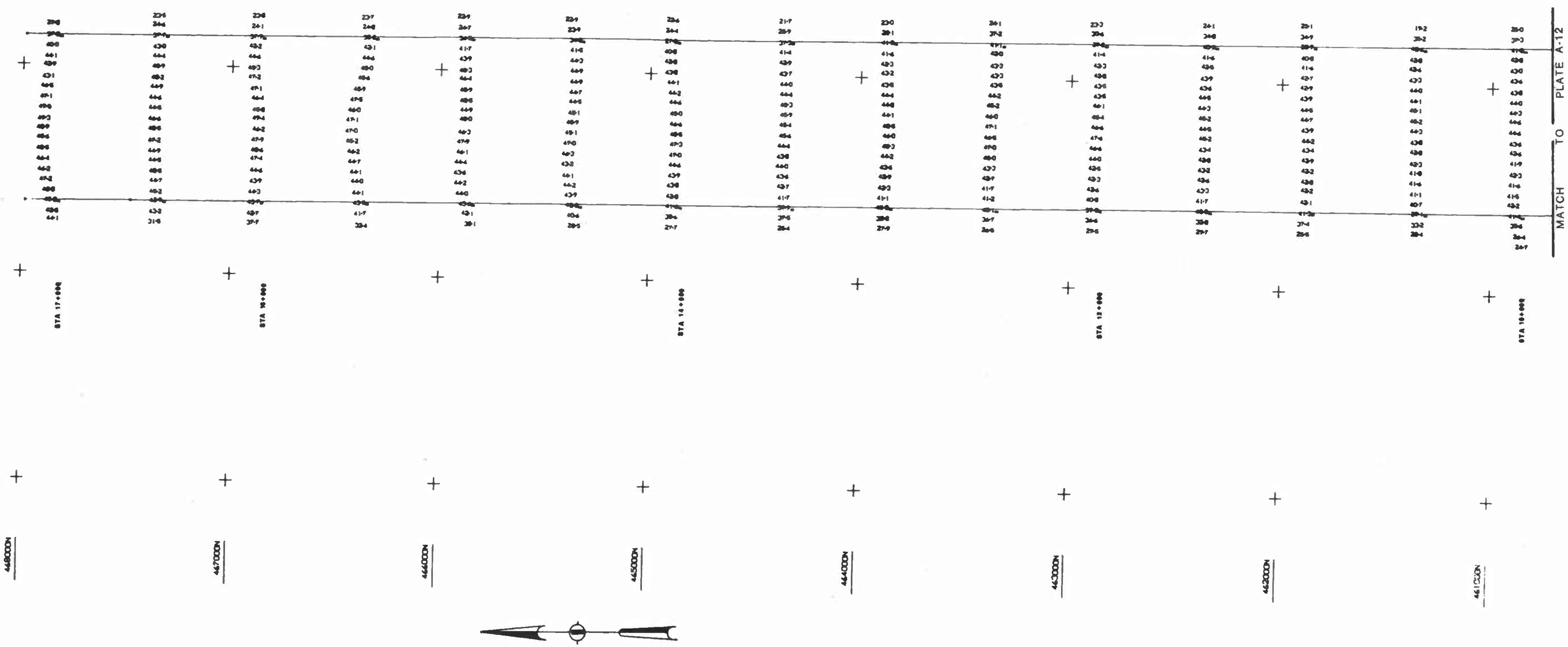
CORPS OF ENGINEERS

U. S. ARMY



CORPS OF ENGINEERS

U. S. ARMY



NOTE

Soundings are in feet and tenths
Survey taken with Ross Fineline
Fathometer 100 K.C.
Surveyed, June 1977

REV	DATE	DESCRIPTION	BY

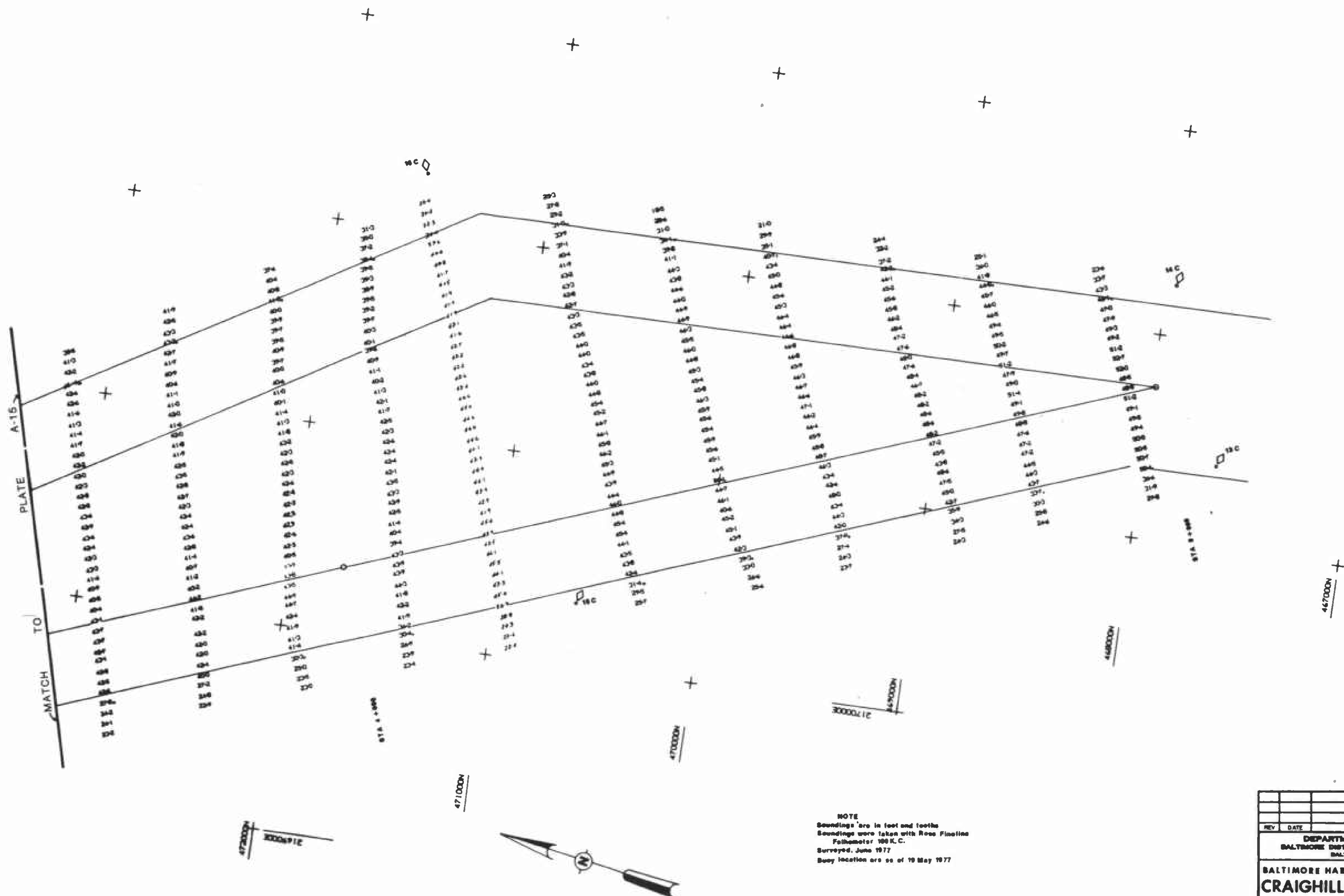
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

BALTIMORE HARBOR AND CHANNELS, MD.

CRAIGHILL SECTION
CONDITION SURVEY

DRAWING NUMBER FILE 17 MAP 1393

SCALE 1" = 200' | DATE AUG. 1977 | SHEET 2 of 2



NOTE
Soundings are in feet and tenths
Soundings were taken with Ross Fineline Fathometer 100 K.C.
Surveyed, June 1977
Buoy location are as of 19 May 1977

REV	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

BALTIMORE HARBOR AND CHANNELS, MD.

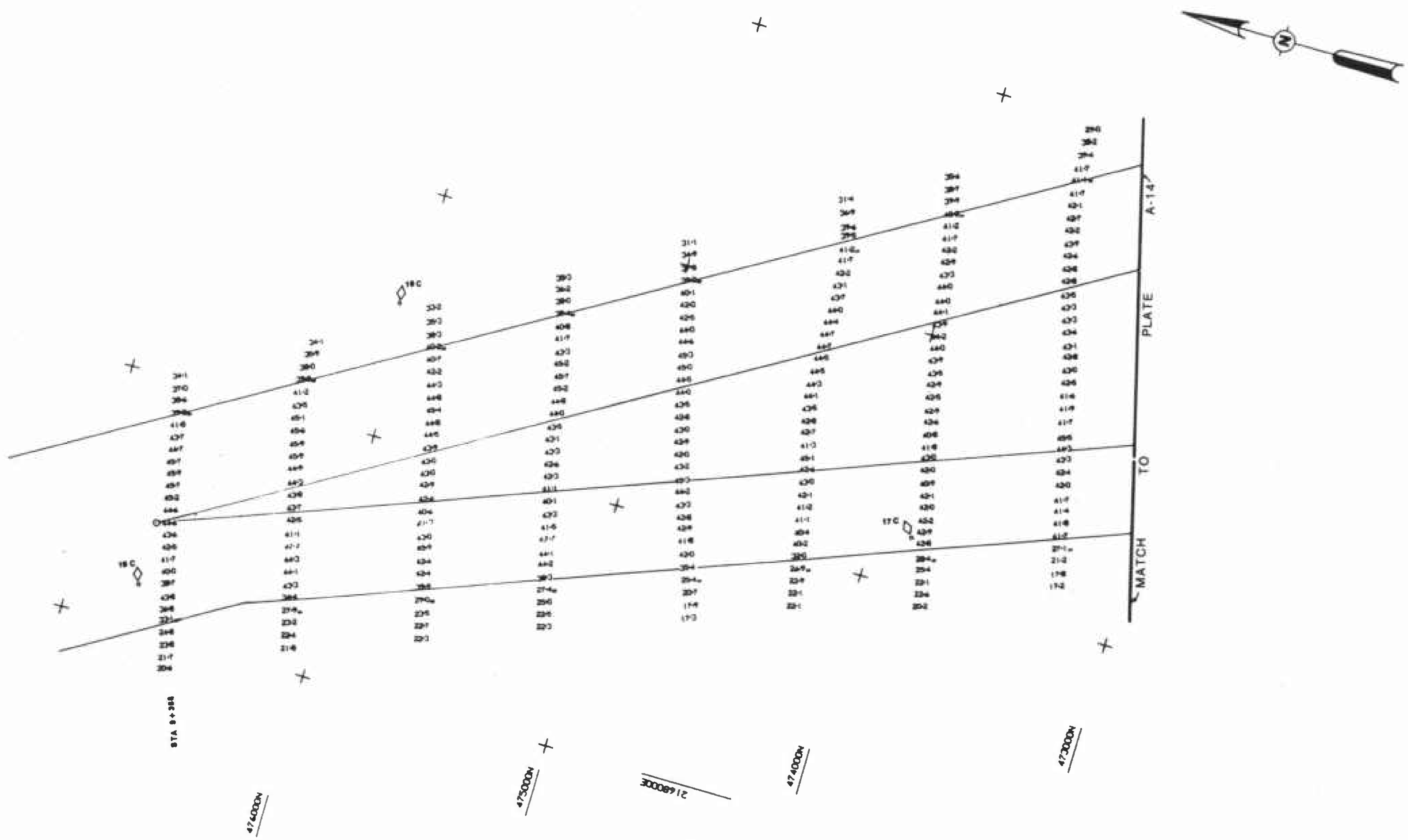
CRAIGHILL-CUTOFF ANGLE
AFTER DREDGING

DRAWING NUMBER
FILE 17 MAP 1388

SCALE 1" = 200' | DATE JUNE 1977 | SHEET 1 of 2

CORPS OF ENGINEERS

U. S. ARMY



REV	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

BALTIMORE HARBOR AND CHANNELS, MD.

CRAIGHILL-CUTOFF ANGLE
AFTER DREDGING

FILE 17 MAP 1389

SCALE 1" = 200' DATE JUNE 1977 SHEET 2 of 2

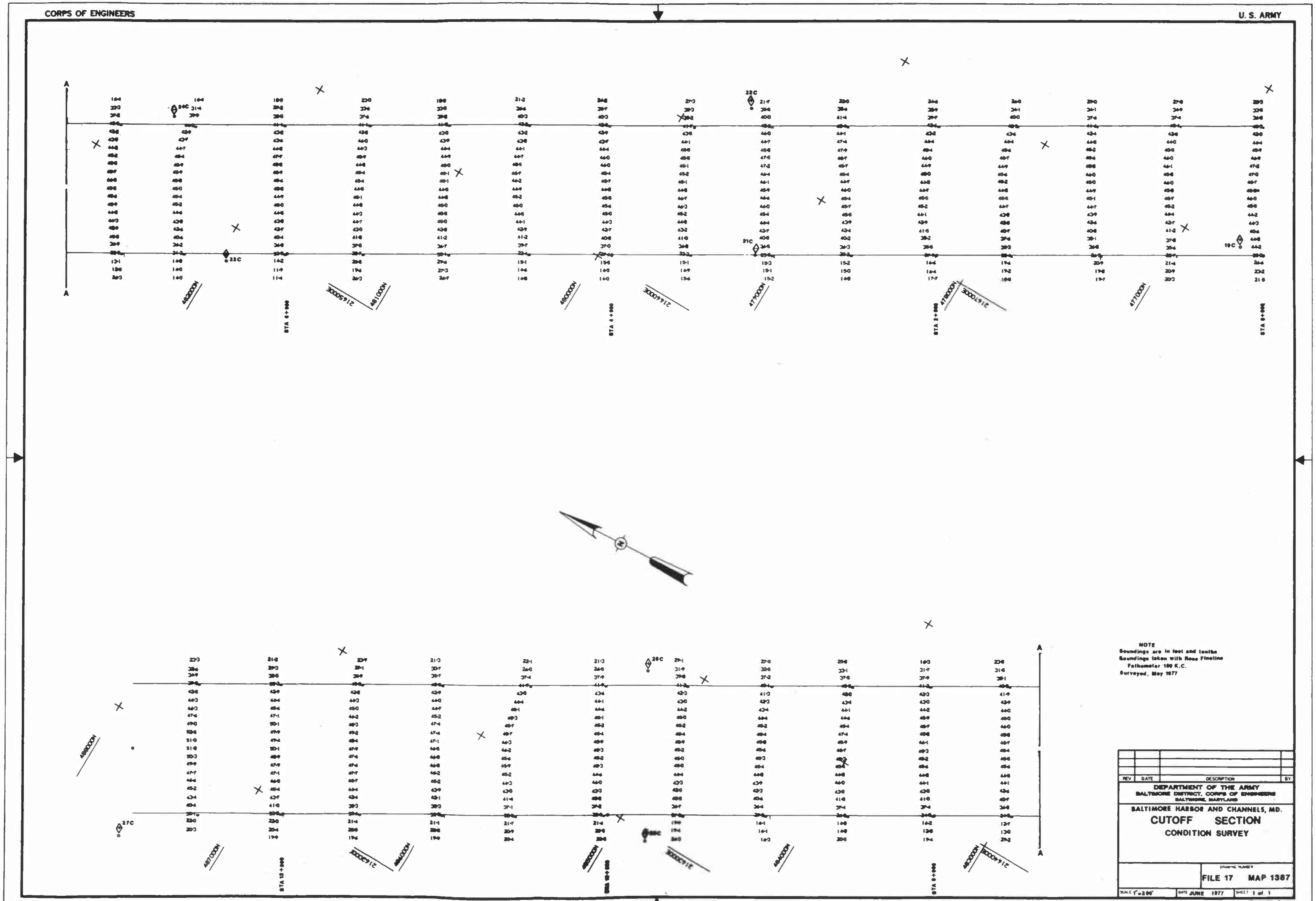
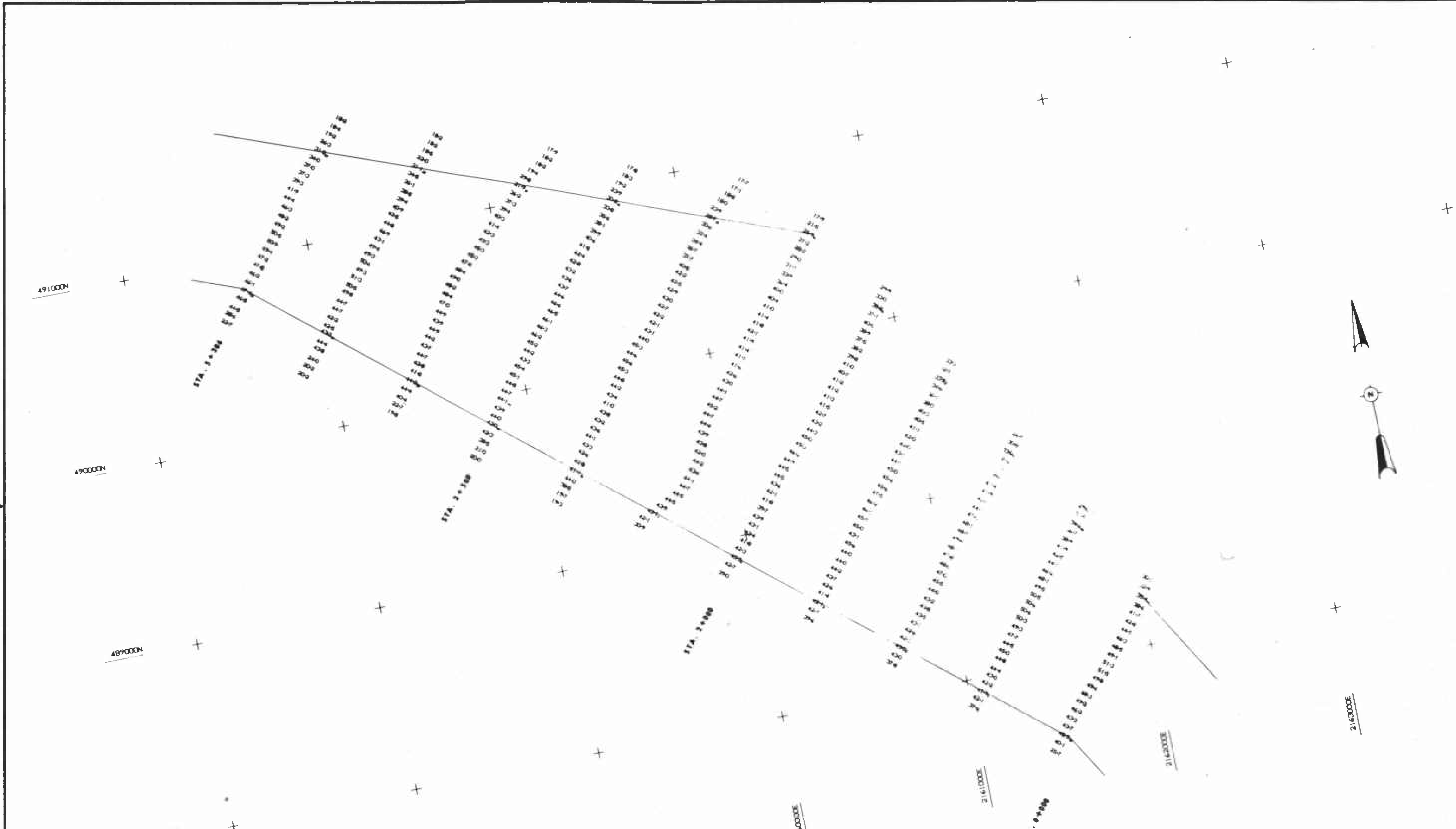

CORPS OF ENGINEERS
U. S. ARMY
NOTE
Soundings are in feet and tenths
Soundings taken with Ross Fineline
Fathometer 100 K.C.
Surveyed, May 1977
REV
DATE
DESCRIPTION
BY
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND
BALTIMORE HARBOR AND CHANNELS, MD.
CUTOFF SECTION
CONDITION SURVEY
FILE 17 MAP 1387
SCALE 1"=200'
DATE JUNE 1977
SHEET 1 of 1

PLATE A-16



REV	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

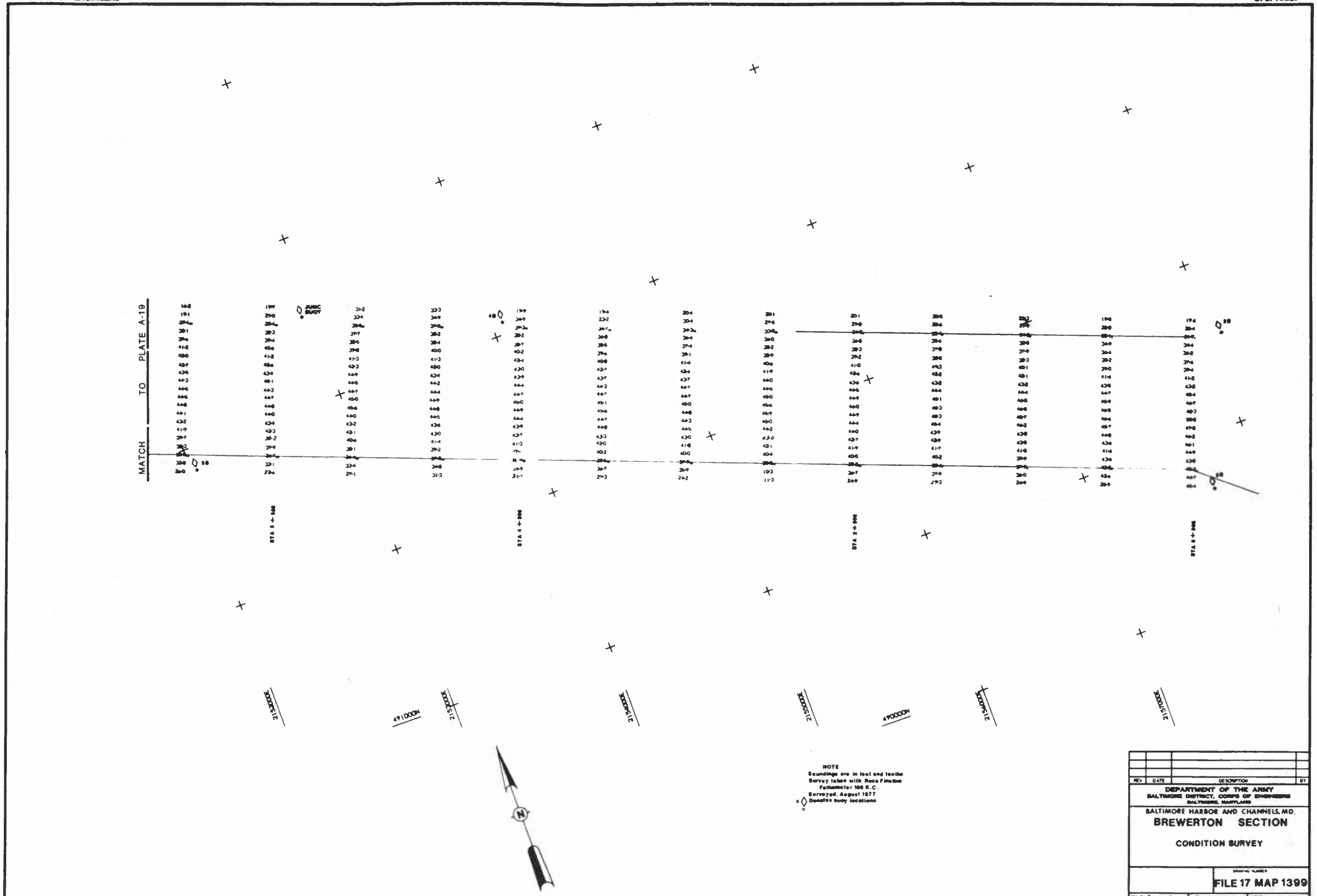
BALTIMORE HARBOR AND CHANNELS, MD.

CUTOFF-BREWERTON ANGLE

CONDITION SURVEY

DRAWING NUMBER
FILE 17 MAP 1306

SCALE | DATE MAR. 1977 | SHEET 1 of 1



REV	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

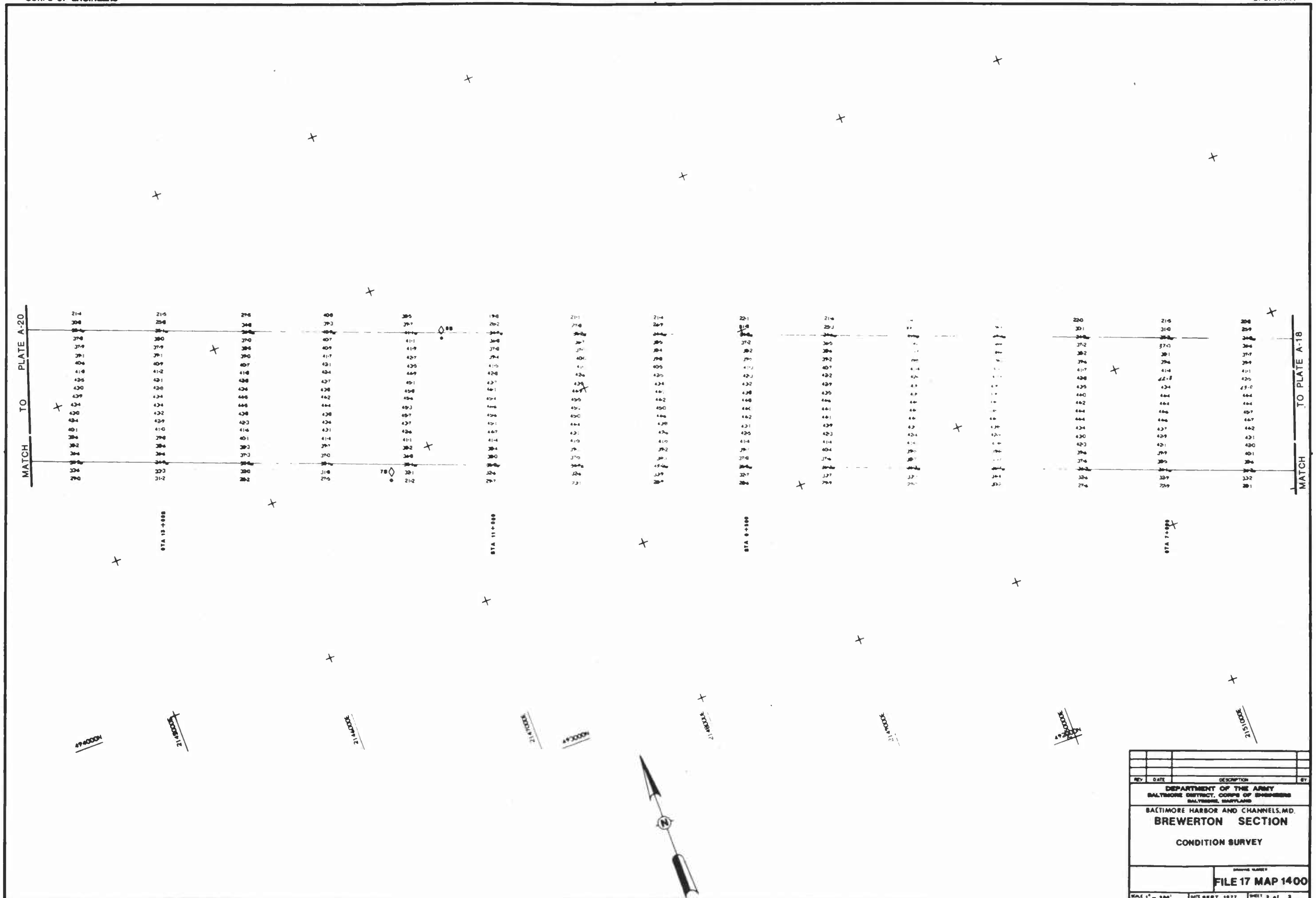
BALTIMORE HARBOR AND CHANNELS, MD.

BREWERTON SECTION

CONDITION SURVEY

DRAWING NUMBER
FILE 17 MAP 1399

SCALE 1" = 200' | DATE SEPT. 1977 | SHEET 1 of 3



DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

BALTIMORE HARBOR AND CHANNELS, MD.

BREWERTON SECTION

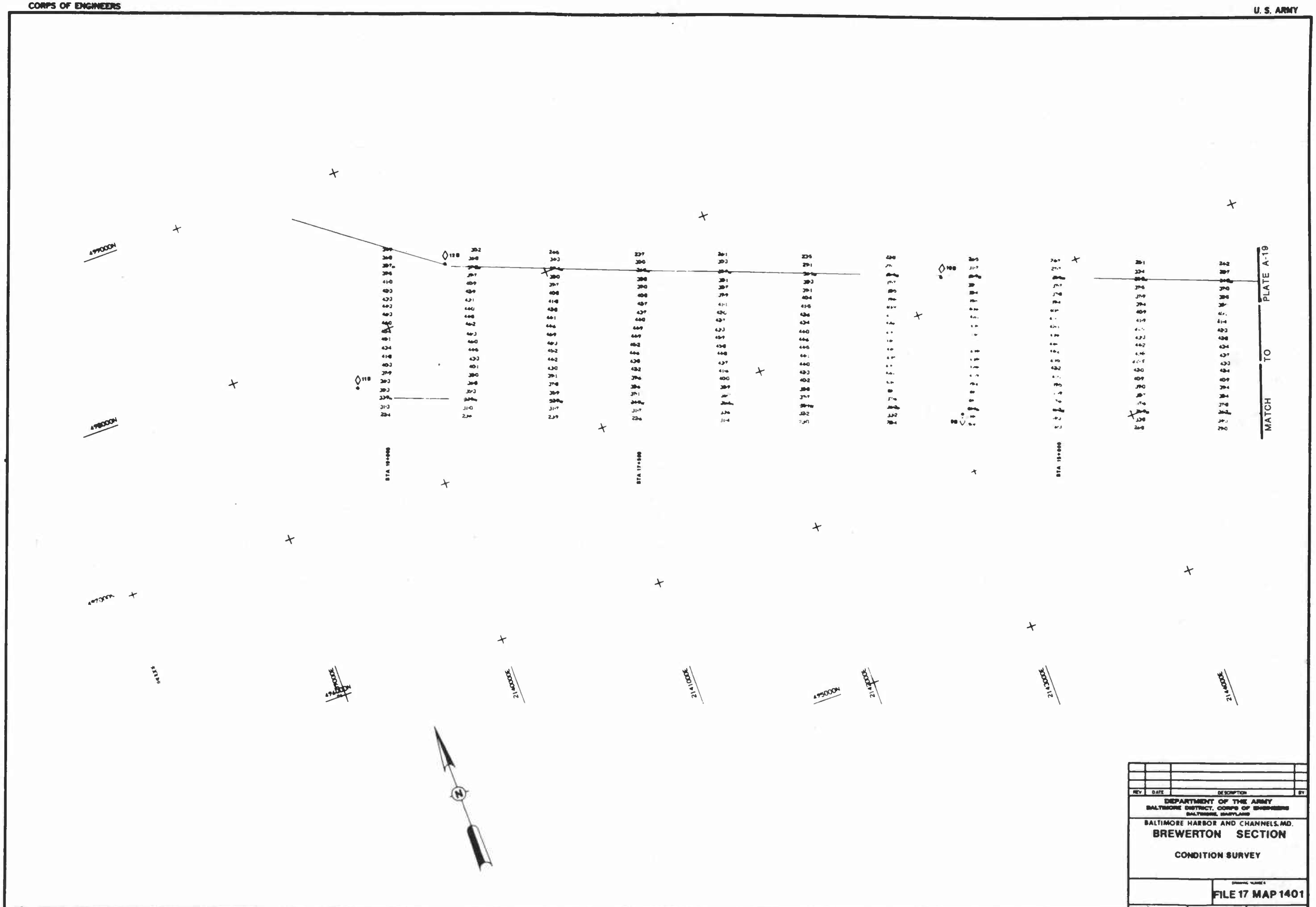
CONDITION SURVEY

FILE 17 MAP 1400

SCALE 1" = 200'　DATE SEPT. 1977　SHEET 2 of 3

CORPS OF ENGINEERS

U. S. ARMY



REV	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

BALTIMORE HARBOR AND CHANNELS, MD.

BREWERTON SECTION

CONDITION SURVEY

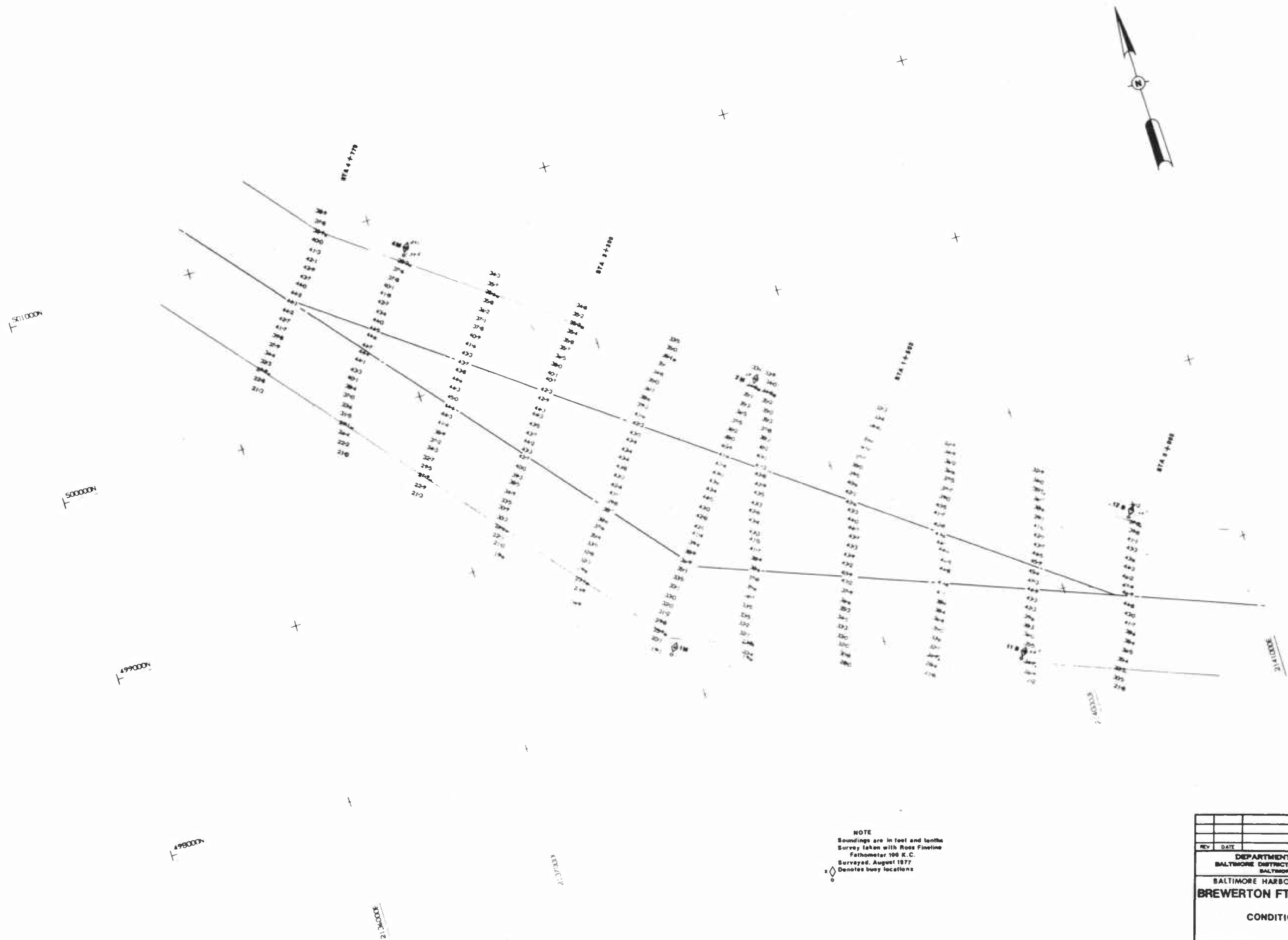
FILE 17 MAP 1401

SCALE 1" = 200' | DATE SEPT. 1977 | SHEET 3 of 3

PLATE A-20

CORPS OF ENGINEERS

U. S. ARMY



NOTE
Soundings are in feet and tenths
Survey taken with Ross Fineline
Fathometer 100 K.C.
Surveyed, August 1977
◊ Denotes buoy locations

REV	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

BALTIMORE HARBOR AND CHANNELS, MD.

BREWERTON FT. McHENRY ANGLE

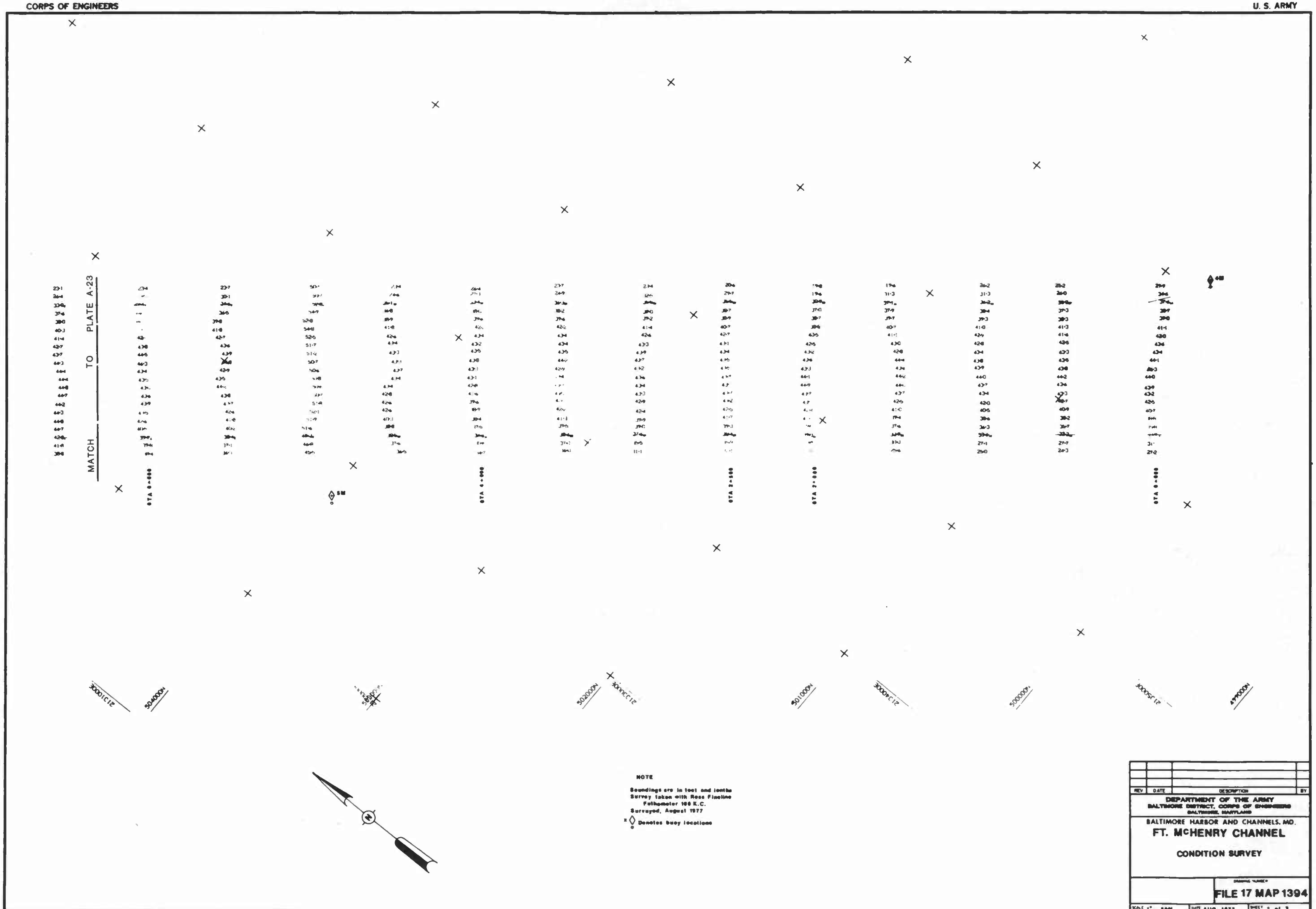
CONDITION SURVEY

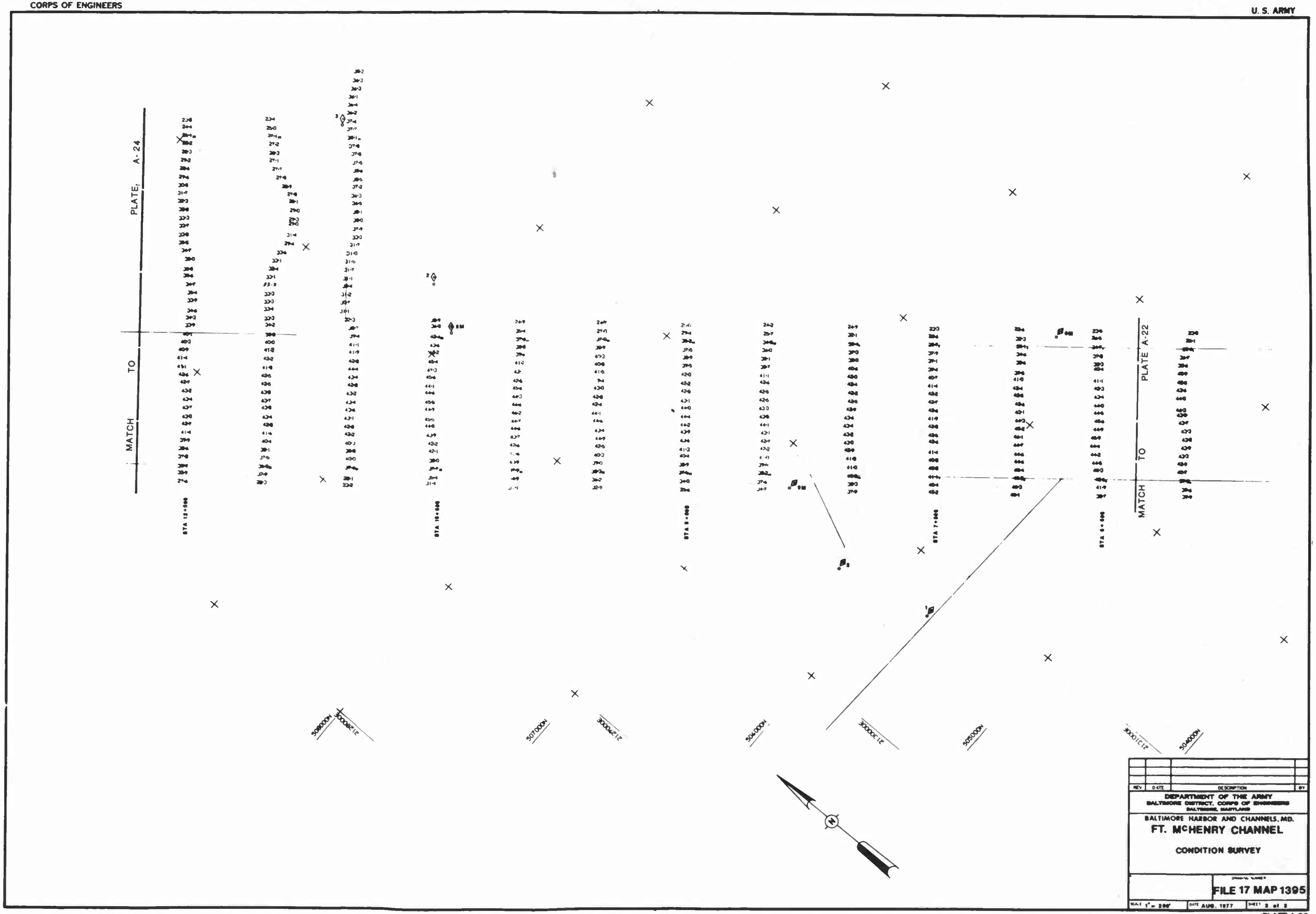
DRAWING NUMBER
FILE 17 MAP 1398

SCALE 1" = 200' | DATE AUG. 1977 | SHEET 1 of 1

PLATE A-21

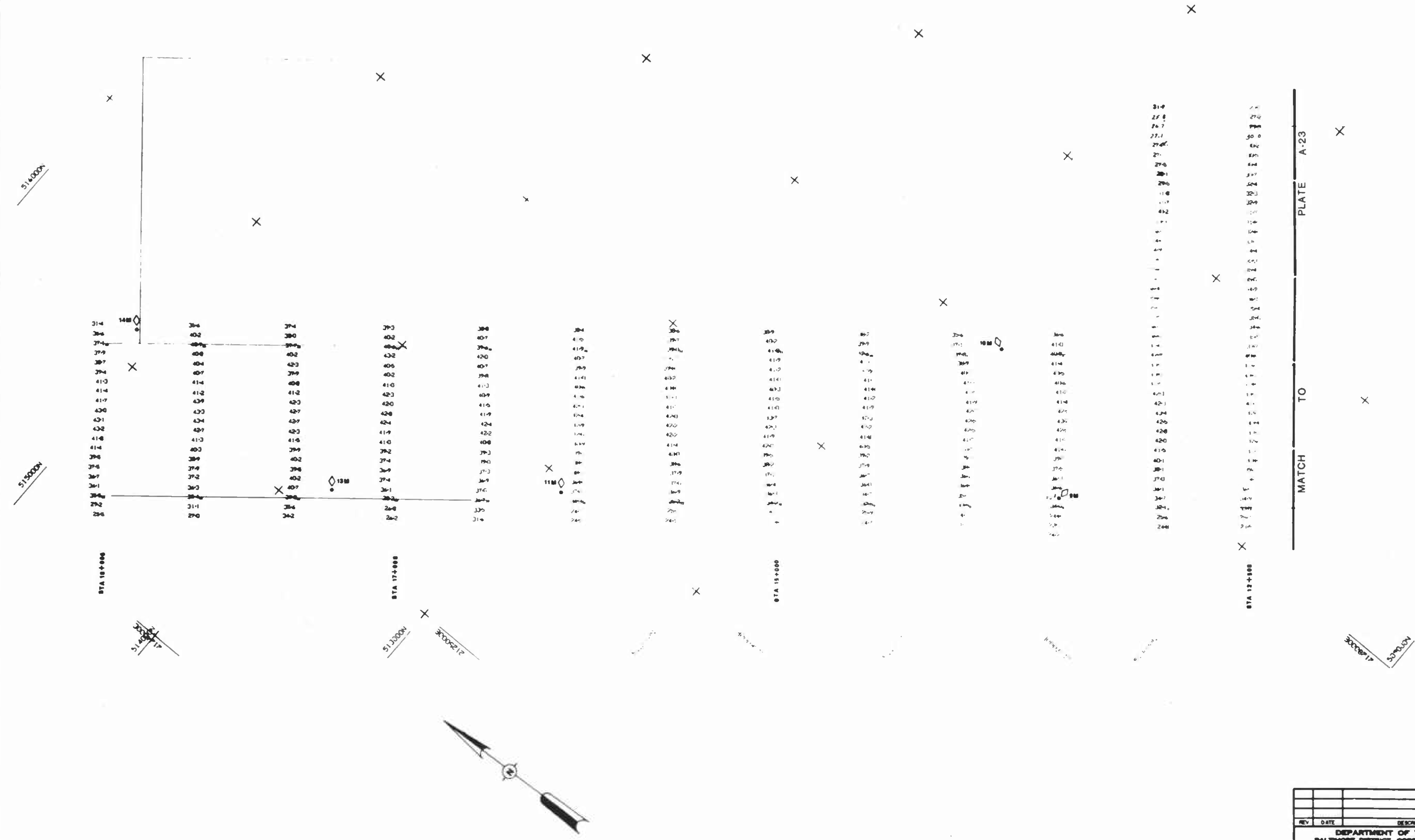
CORPS OF ENGINEERS U. S. ARMY




MATCH TO PLATE A-24
MATCH TO PLATE A-22
STA 12+000
STA 10+000
STA 8+000
STA 7+000
STA 6+000
508000N
2128000E
507000N
2127000E
506000N
2130000E
505000N
2131000E
504000N
N
REV
DATE
DESCRIPTION
BY
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND
BALTIMORE HARBOR AND CHANNELS, MD.
FT. McHENRY CHANNEL
CONDITION SURVEY
FILE 17 MAP 1395
SCALE 1" = 200'
DATE AUG. 1977
SHEET 2 of 3

CORPS OF ENGINEERS

U. S. ARMY



REV	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

BALTIMORE HARBOR AND CHANNELS, MD

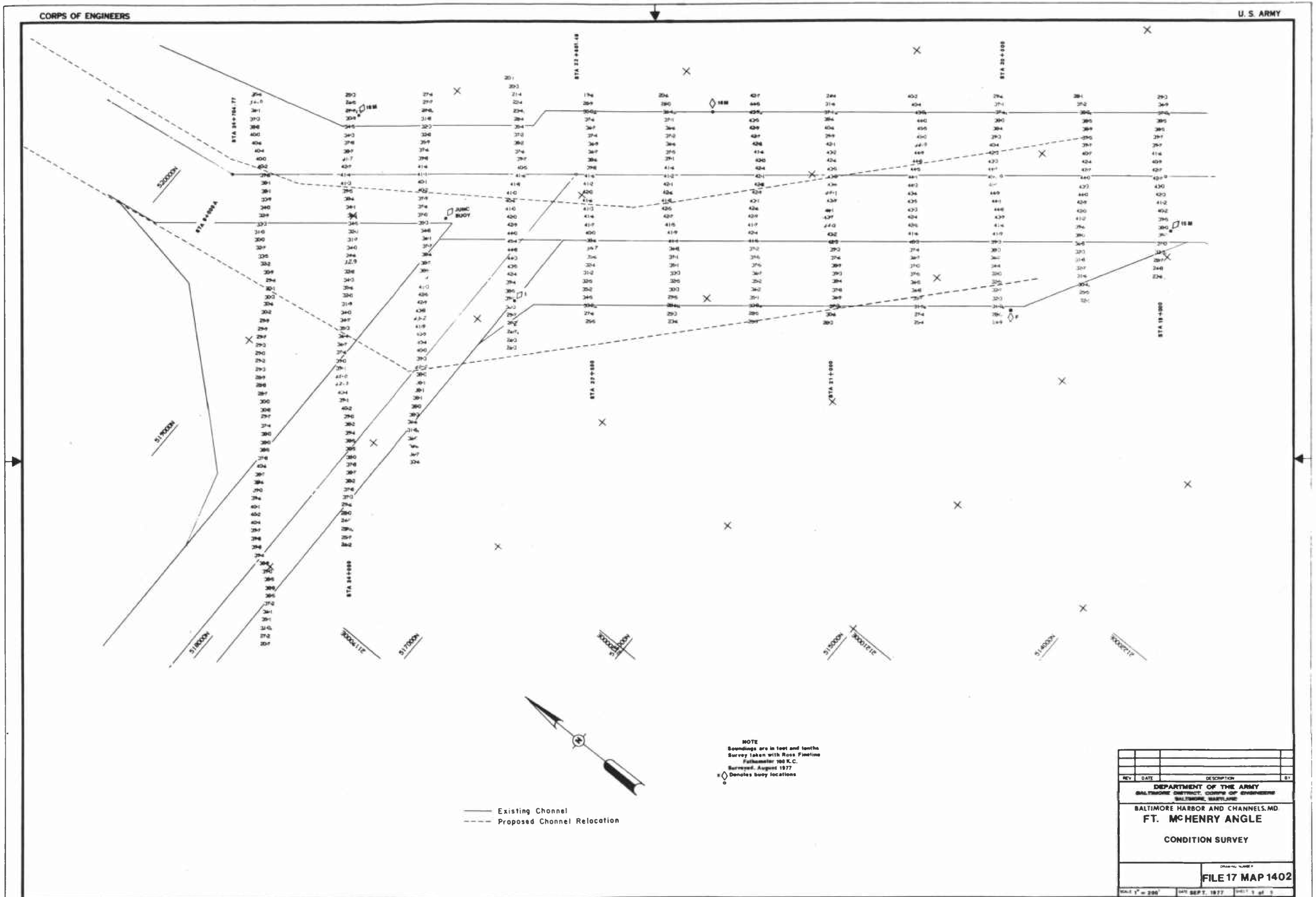
FT. McHENRY CHANNEL

CONDITION SURVEY

FILE 17 MAP 1396

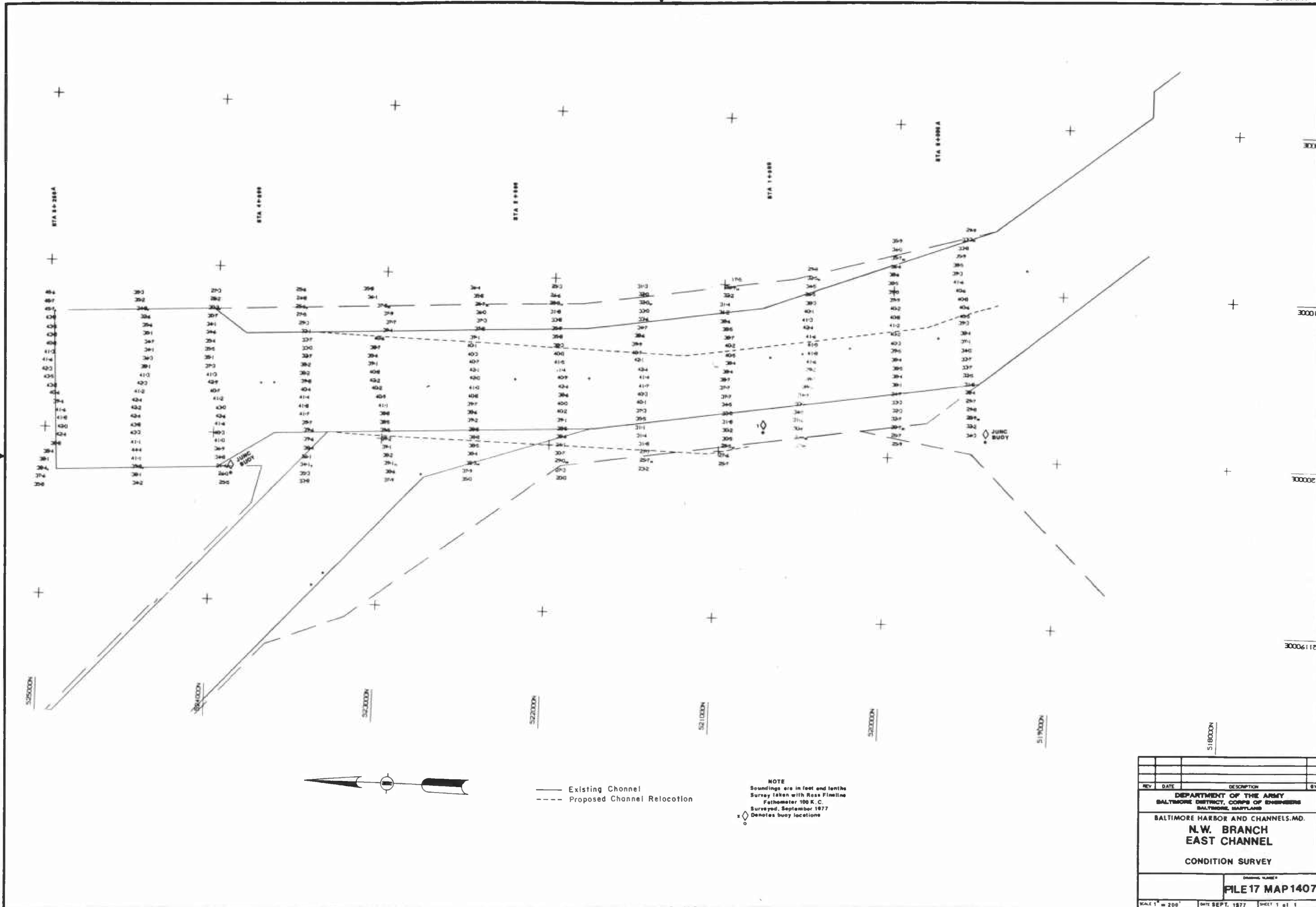
SCALE 1" = 200' | DATE SEPT. 1977 | SHEET 3 of 3

PLATE A-24



CORPS OF ENGINEERS
U. S. ARMY
JUNC BUOY
Existing Channel
Proposed Channel Relocation
NOTE
Soundings are in feet and tenths
Survey taken with Ross Finetine
Fathometer 100 K.C.
Surveyed, August 1977
Denotes buoy locations
REV
DATE
DESCRIPTION
BY
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND
BALTIMORE HARBOR AND CHANNELS, MD
FT. McHENRY ANGLE
CONDITION SURVEY
FILE 17 MAP 1402
SEPT. 1977

PLATE A-25


STA 0+000 A
STA 4+000
STA 8+000
STA 11+000
STA 8+000 A
JUNC BUOY
JUNC BUOY
525000N
524000N
523000N
522000N
521000N
520000N
519000N
518000N
3000212
3000121
3000112
3000611
Existing Channel
Proposed Channel Relocation
NOTE
Soundings are in feet and tenths
Survey taken with Ross Fineline
Fathometer 100 K.C.
Surveyed, September 1977
Denotes buoy locations
REV
DATE
DESCRIPTION
BY
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND
BALTIMORE HARBOR AND CHANNELS.MD.
N.W. BRANCH
EAST CHANNEL
CONDITION SURVEY
DRAWING NUMBER
PILE 17 MAP 1407
SCALE 1" = 200'
DATE SEPT. 1977
SHEET 1 of 1

CORPS OF ENGINEERS

U. S. ARMY

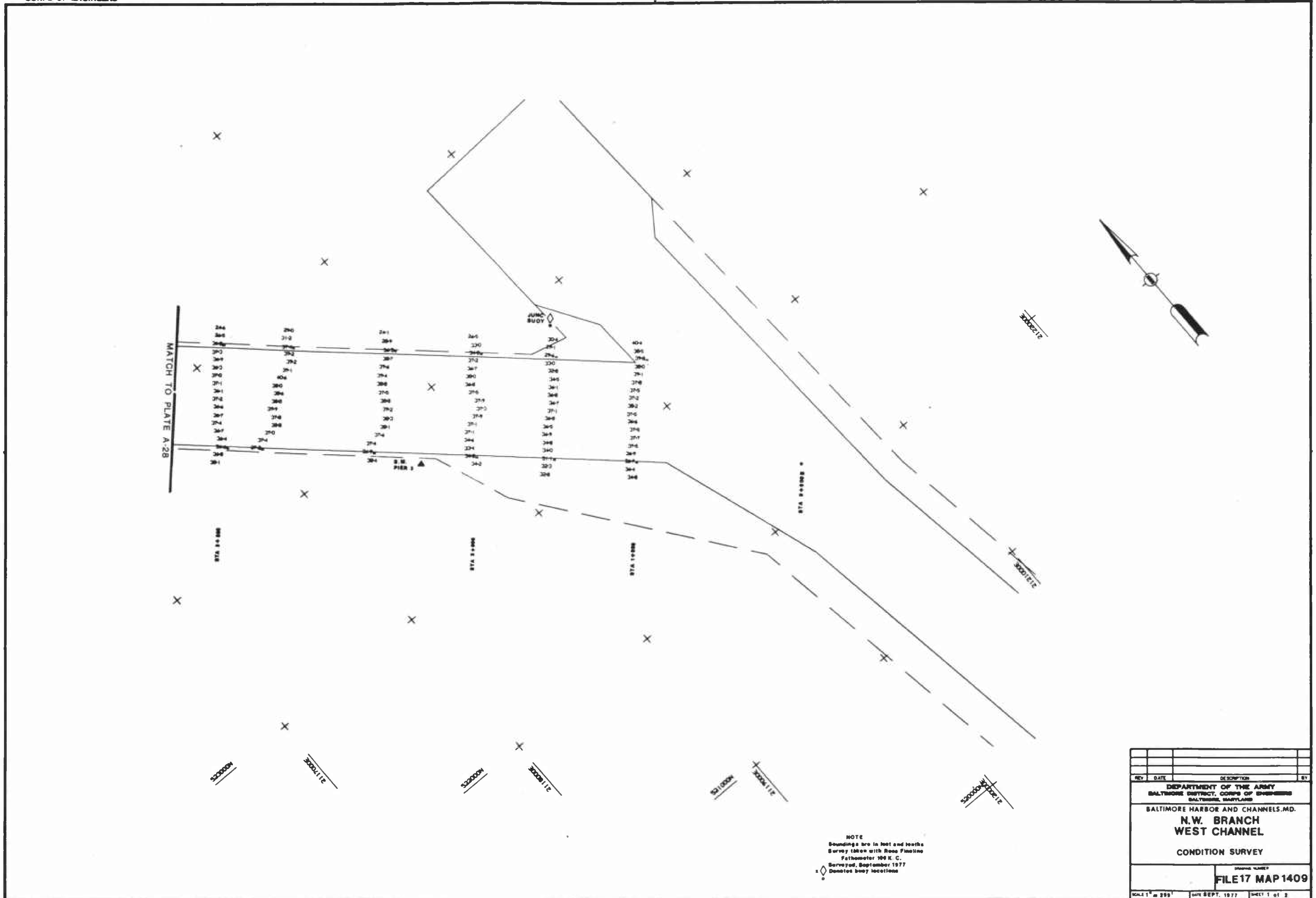
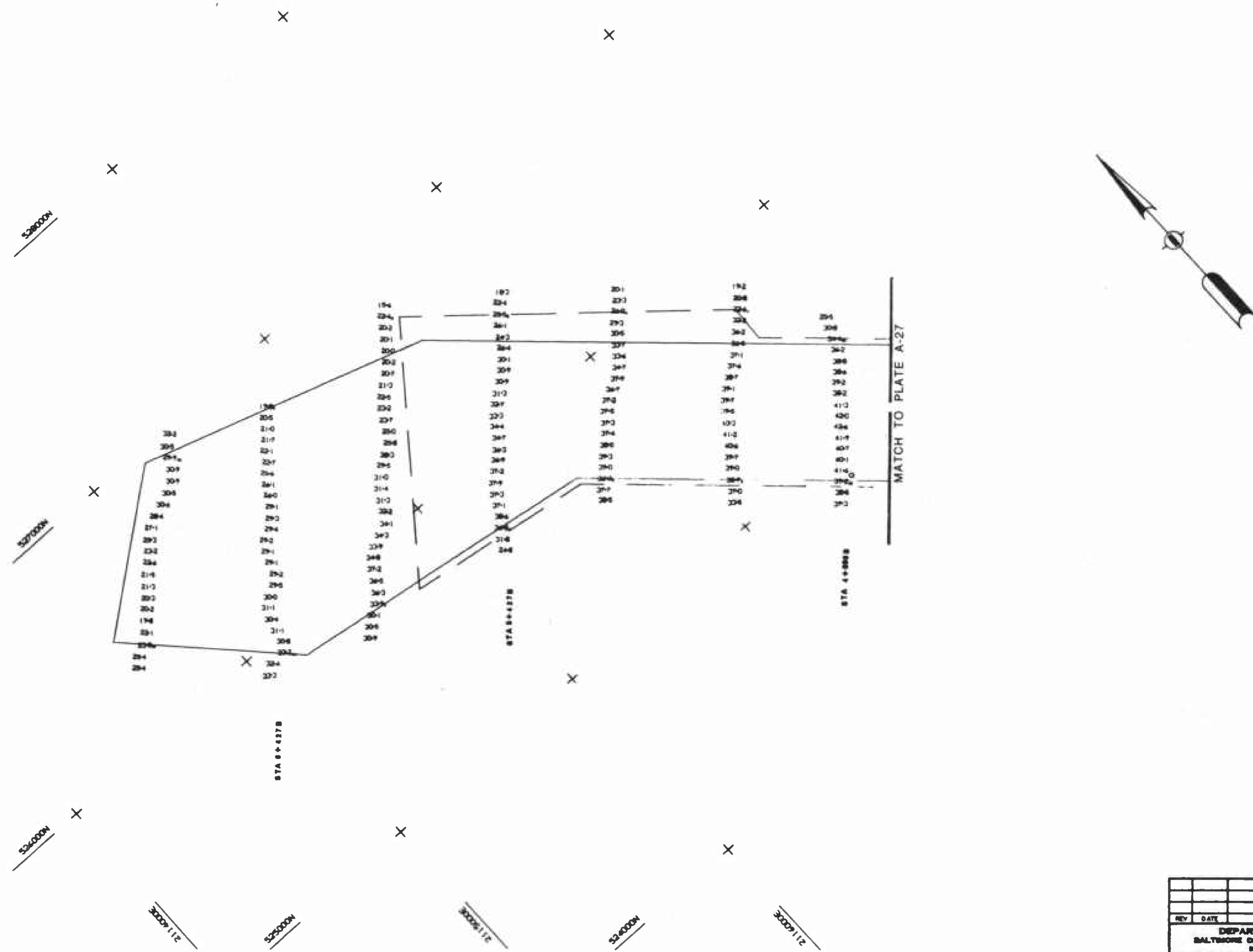


PLATE A-27

CORPS OF ENGINEERS

U. S. ARMY



REV	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

BALTIMORE HARBOR AND CHANNELS, MD.

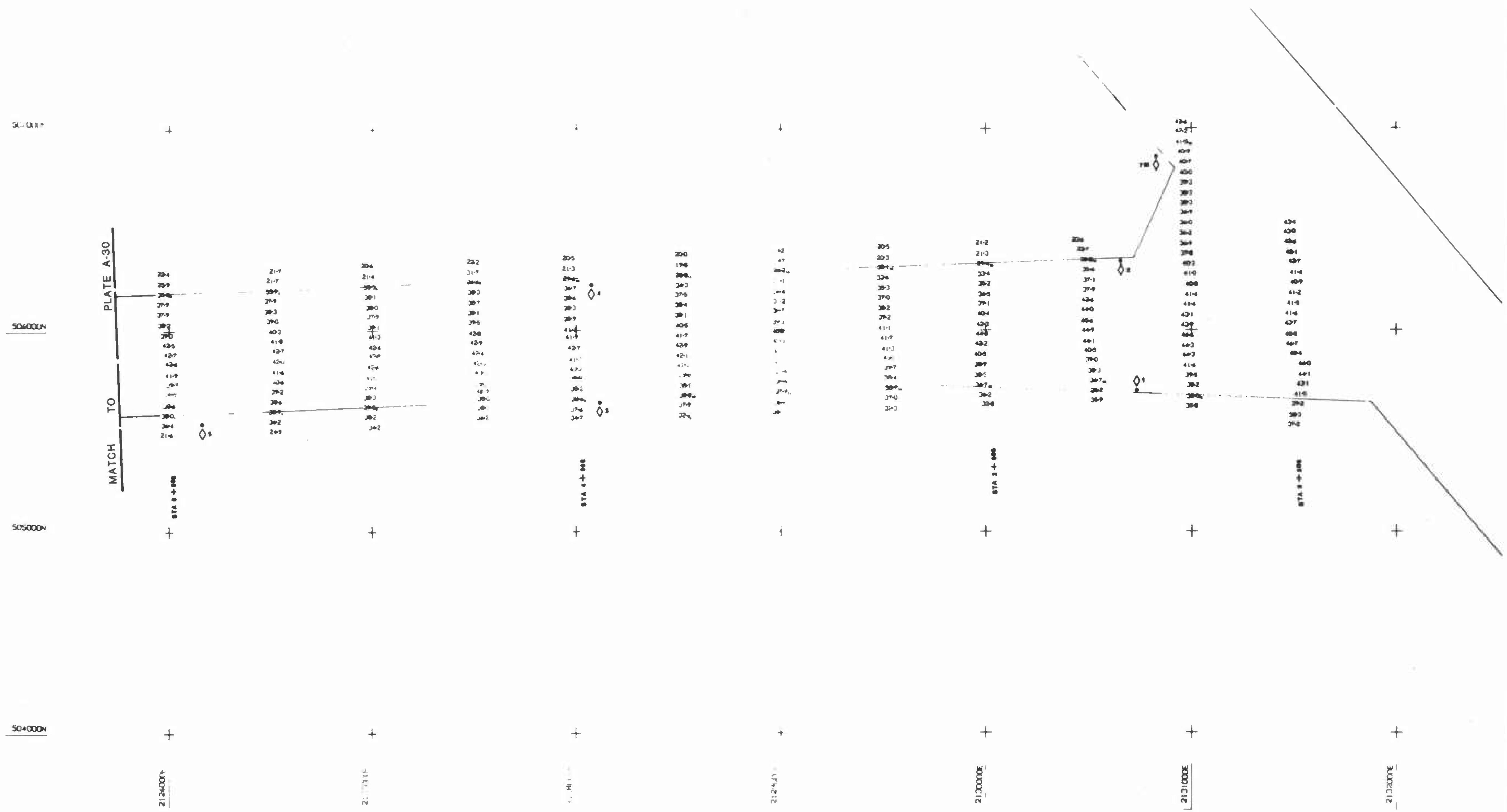
N.W. BRANCH
WEST CHANNEL

CONDITION SURVEY

FILE 17 MAP 1410

SCALE 1" = 200' | DATE SEPT. 1977 | SHEET 2 of 2

PLATE A-28



NOTE

Soundings are in feet and tenths
Survey taken with Ross Fineline
Fathometer 100 K.C.
Surveyed, August 1977
◊ Denotes buoy locations

REV	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

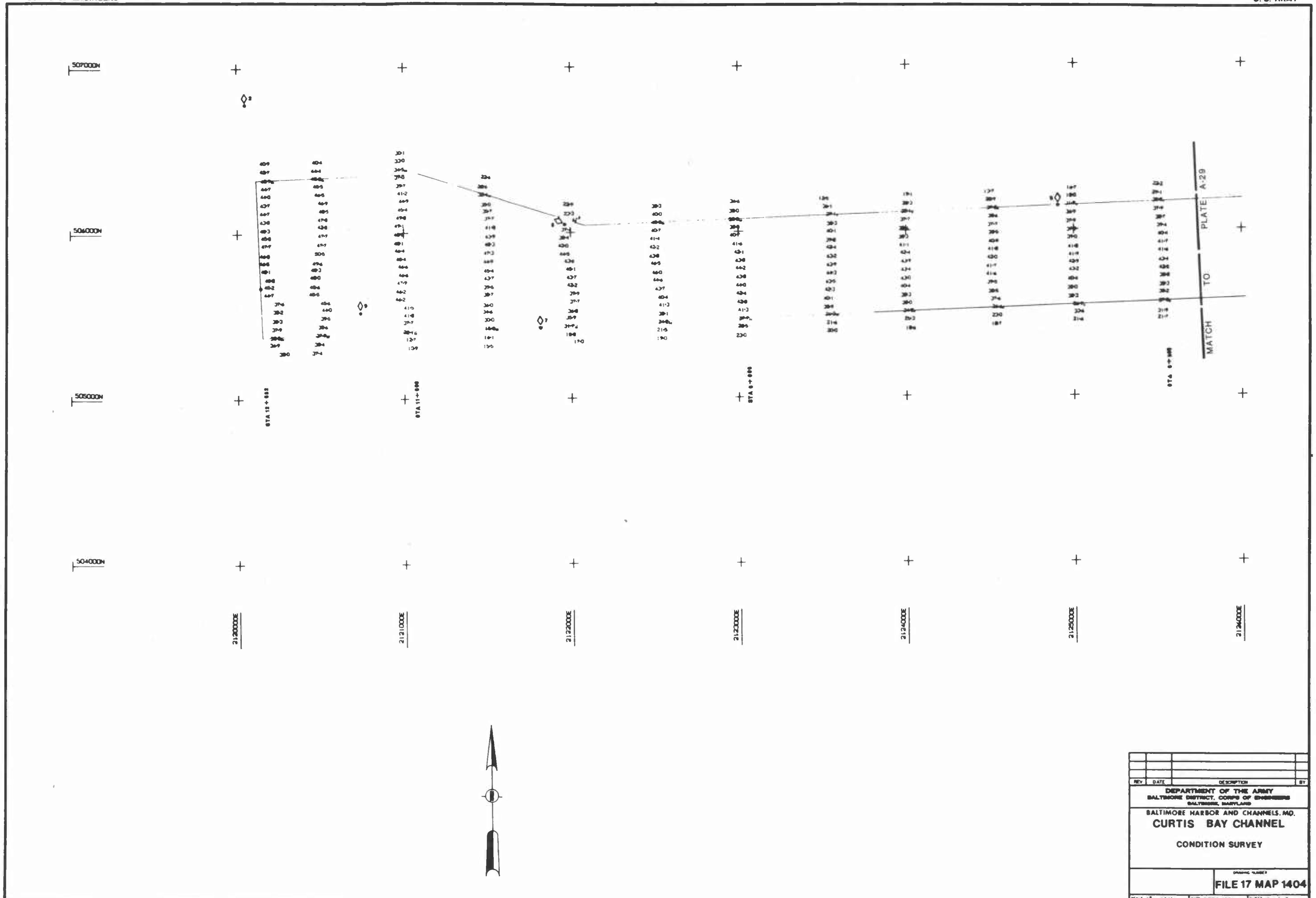
BALTIMORE HARBOR AND CHANNELS, MD.

CURTIS BAY CHANNEL

CONDITION SURVEY

FILE 17 MAP 1403

SCALE 1" = 200' | DATE SEPT. 1977 | SHEET 1 of 2


507000N
506000N
505000N
504000N
2120000E
2121000E
2122000E
2123000E
2124000E
2125000E
2126000E
MATCH TO PLATE A-29
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND
BALTIMORE HARBOR AND CHANNELS, MD.
CURTIS BAY CHANNEL
CONDITION SURVEY
FILE 17 MAP 1404
SCALE 1" = 200'
DATE SEPT. 1977
SHEET 2 of 2

CORPS OF ENGINEERS U. S. ARMY

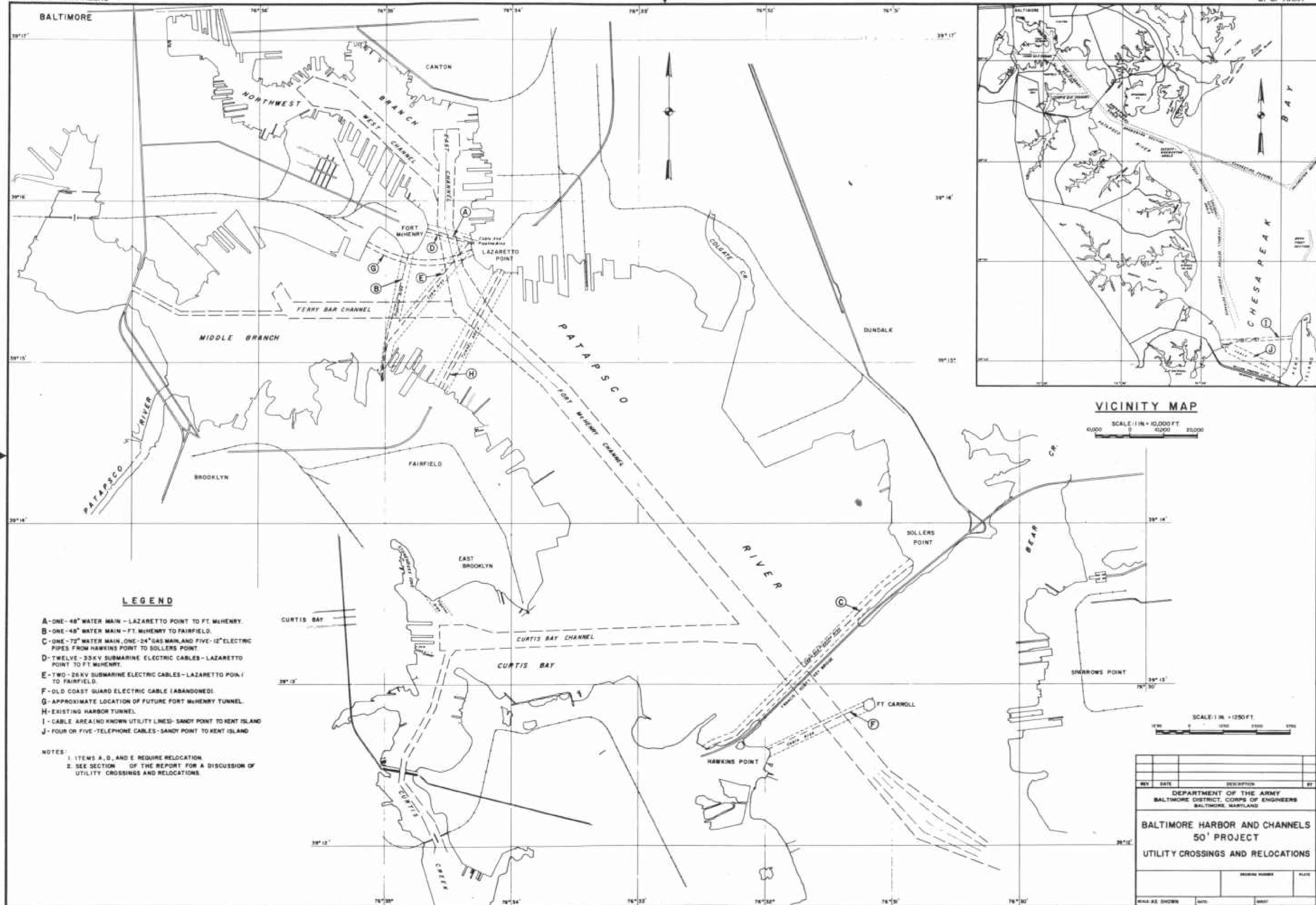


PLATE A-31

APPENDIX B

FOUNDATION EXPLORATION (GEOPHYSICAL)

BALTIMORE HARBOR AND CHANNELS
50 FT. PROJECT
GEOPHYSICAL FOUNDATION
EXPLORATION REPORT

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
P. O. BOX 1715
BALTIMORE, MARYLAND 21203

MUESER, RUTLEDGE, WENTWORTH & JOHNSTON
Consulting Engineers
415 Madison Ave.
New York, N. Y. 10017

OCEAN/SEISMIC/SURVEY, INC.
70 Oak Street
Norwood, N. J. 07648

February 17, 1978

MUESER · RUTLEDGE · WENTWORTH · & · JOHNSTON
Consulting Engineers

ROBERT C. JOHNSTON
SALVATORE V. DESIMONE
JAMES P. GOULD
ELMER A. RICHARDS
EDMUND M. BURKE
Partners

WILLIAM H. MUESER
PHILIP C. RUTLEDGE
PAUL M. WENTWORTH
Consultants

415 MADISON AVENUE
NEW YORK, N. Y. 10017
212 ELDORADO 5-4800
DANAROMIEL, NEW YORK

NICHOLAS W. KOZIAKIN
MAX BERNHEIMER
GEORGE L. MOORE
Senior Associates

DOMINIC A. ZARRELLA
PETER H. EDINGER
PHILIP L. CALDWELL
VYTAUTAS ANONIS
WALTER WALCHUK
HUGH S. LACY
ALFRED H. BRAND
Associates

February 17, 1978

Department of The Army
Baltimore District, Corps of Engineers
P. O. Box 1715
Baltimore, Maryland 21203

Attention: Colonel G. K. Withers
Contracting Officer

Re: Baltimore Harbor and Channels, 50 Ft. Project
Geophysical Foundation Exploration Report

Gentlemen:

Transmitted herewith is our report summarizing the site investigations, compilation of available subsurface data from other sources and our interpretation of these data, together with prints of drawings illustrating the results of these studies. This report is submitted in accordance with the requirements of Contract No. DACW 31-77-C-100 between the Baltimore District, Corps of Engineers, and Mueser, Rutledge, Wentworth & Johnston.

Since the field seismic exploration and the making of vibracore borings are beyond the scope of our normal professional services we retained Ocean/Seismic/Survey, Inc. as our subcontractors for this work and assigned our staff for the coordination and supervision of the work. Since our subcontractors also are expert in the interpretation of seismic data, the interpretation and presentation of the field data are the results of a combined effort by both firms.

Under separate covers we are forwarding the full size original tracings of the drawings included in the report, copies of the field boring logs which have been reviewed by our laboratory staff, the originals of the seismic data procured in the field and other sources and the bottled dry samples taken from sections of the vibracore tubes.

We are indebted to the staff of the Baltimore District for the guidance, assistance and cooperation they provided us throughout the project. Please accept our thanks for the opportunity to serve the Corps of Engineers.

Very truly yours,

MUESER, RUTLEDGE, WENTWORTH & JOHNSTON

By *Robert C. Johnston*
Robert C. Johnston

RCJ:ea
enc.

TABLE OF CONTENTS

1. INTRODUCTION

This report is submitted pursuant to the requirements of Contract No. DACW 31-77-C-0100 between the Baltimore District, Corps of Engineers and Mueser, Rutledge, Wentworth & Johnston, dated December 7, 1977. The scope of work required under this Contract includes a geophysical exploration of the Baltimore Harbor and Channels, analysis of the data, a vibracore boring program, and a compilation of existing subsurface information in the channels. Our technical subcontractor was Ocean/Seismic/Survey, Inc. of Norwood, New Jersey. This report summarizes all work performed under the Contract.

Drawings are included to illustrate results of the geophysical survey, the locations and logs of vibracore borings, and to present the existing subsurface data. All geophysical field data and vibracore boring logs generated in this survey will be submitted to the Baltimore District in a separate transmittal. The vibracore samples were delivered to the Virginia Institute of Marine Science in Yorktown, Virginia during the course of the field work. A record set of jar samples obtained from the larger vibracore samples, as the vibracores were made, was shipped to our office in New York City and will be delivered to the Baltimore District at the completion of our studies.

2. SITE DESCRIPTION

The work is located in Chesapeake Bay starting at Cape Henry Channel and extending to Baltimore, as generally shown on Maps Nos. 1 through 3. The channels provide access for ships through the more shallow portions of the Bay from the Atlantic Ocean to the Baltimore Inner Harbor area. For the purposes of this report, the channels at the southern end of the Bay which include The Cape Henry, The York Spit, and the Rappahannock Shoal are collectively identified as the Virginia Channels. In the northern end of the Bay the Craighill Entrance, Main Ship, Curtis Bay, East, and Northwest Channels are identified as the Maryland Channels. The several sections of the Main Ship Channel are shown on Map No. 1.

2.1 Available Information - The following information showing present channel conditions, proposed modifications, and available subsurface information was provided by the Baltimore District for our use during this work.

a. Twenty-three drawings prepared by Baltimore District, Corps of Engineers titled "Baltimore Harbor and Channels, Md." showing the condition of the Maryland Channels, as follows:

File 17, Maps 1208 and 1209..............dated Oct., 1967
File 17, Maps 1322 through 1324.......... dated Dec., 1972
File 17, Maps 1336 through 1340..........dated Oct., 1973
File 17, Maps 1345 through 1351.... ......dated July, 1974
File 17, Maps 1352 through 1354.......... dated Aug., 1974
File 17, Maps 1366 through 1368..........dated Oct., 1975

b. Twenty-two drawings prepared by the Baltimore District, Corps of Engineers titled "Baltimore Harbor and Channels, Md." showing the latest condition of the Maryland Channels and proposed revisions to the East and Northwest Channels, as follows:

File 17, Map 1386, revised.............. dated Oct. 27, 1977
File 17, Maps 1387 through 1389.......... dated June, 1977
File 17, Maps 1392 through 1395,
1397 & 1398............... dated Aug., 1977
File 17, Maps 1396, 1399 through 1404,
1407, 1409 & 1410..........dated Sept., 1977

c. Eight drawings prepared by the Norfolk District, Corps of Engineers, titled "Baltimore Harbor and Channels, Maryland-Virginia, Survey for Deepening Study", showing latest condition of the Virginia Channels, as follows:

File Nos. H-10-22-02 (1) through H-10-22-02 (8), dated June 30, 1977

d. Drawings titled "Subsurface Exploration and Disposal Areas",

File 17, Map 1040.1 and "Subsurface Exploration Logs",
File 17, Maps 1040.2 and 1040.3, dated Dec., 1963.

e. Drawings titled "Plan and Logs of Subsurface Exploration"

File 17, Map 1105 and "Logs of Subsurface Exploration",
File 17, Maps 1108 through 1112, dated Nov., 1964.

f. Drawings titled "Pierhead and Bulkhead Lines, Baltimore Harbor, Md.",

File 13, Maps 849 through 853 and
File 13, Map 940

Additional subsurface information was also procured through the cooperation of the Maryland State Roads Commission, the Baltimore Interstate Agency, and the J. E. Greiner Company. Subsurface information was also obtained from several of our firm's previous projects. The names of the projects, the owner or source of the information, and reference drawings are given in Table No. I.

2.2 Scope of 50 Ft. Project - The scope of the 50 ft. Project is to create a 50 ft. deep watercourse below Mean Low Water throughout the existing Maryland and Virginia Channels. In areas of Chesapeake Bay between the channels natural depths greater than 50 feet already exist and hence will not require dredging.

Dredging of the channels will be to the 50 ft. depth, plus a normal allowance of two feet for overdredging. In the Virginia Channels, this will require that the Cape Henry and York Spit Channels be lengthened to extend to the existing 50 ft. depth contours. Additionally, the Rappahannock Shoal Channel will be widened from its existing 800 feet to 1,000 feet. On Plates Nos. 1 through 12 the Baltimore District prepared the plans of the proposed channels. For reference purposes on Plates Nos. 9 through 12, the proposed width of the Rappahannock Channel is indicated by a dashed line and the existing channel by a solid line. In the Maryland Channels the existing dimensions will be maintained, except in the East and Northwest Channels, while dredging to the same depth described above. Plans on Plates Nos. 13 through 24 show the existing channels. The proposed dimensions of the East and Northwest Channels on Plates 22 and 23, respectively, are indicated by dashed lines. The revised dimensions were taken from drawing numbered File 17, Map 1407, titled "N. W. Branch, East Channel", dated September, 1977.

3. GEOLOGIC CONDITIONS

Chesapeake Bay is located in the Atlantic Coastal Plain geographic province. This unit is characterized by thick sequences of sand, silts and clays overlying crystalline bedrock. From their western terminus at the fall line the deposits dip in a seaward direction toward the Atlantic Ocean and continue into the ocean where they form the continental shelf. The regional dip is such that bedrock outcrops in some areas of Baltimore whereas the depth to bedrock at the southern portion of the Bay, near Cape Henry, Virginia is more than 2,000 feet. Extensive erosion during the Jurassic period removed any previous sediments above the bedrock. It is now overlain by geologically unconsolidated marine sediments dating from the Cretaceous, Tertiary, Pleistocene, and Recent periods. The older sediments are generally bedded parallel to the bedrock, however, younger sediments dip at a less steep angle than does the bedrock so as to create a succession of wedge shaped layers.

After deposition of the Tertiary soils and during the Pleistocene, the sea level fluctuated with respect to the land due to the formation and melting of glaciers, and possibly as the result of the elevation and depression of the land surface. Evidence that sea level at one time was approximately 250 feet lower than at present is clearly recorded in the ocean floor east of the Chesapeake Bay. Therefore, the upper part of the Tertiary soils were at one time above sea level and subject to erosion and increased consolidation through dessication. In the northwestern area of the Bay the younger sediments were completely removed by erosion so that only the Cretaceous and older Tertiary soils remain. The major rivers, such as the Susquehanna, cut deep channels during the Pliocene, when the land surface was higher than at present, which were widened during the Pleistocene, and finally flooded, creating broad shallow bays of which Chesapeake Bay is an example. Submergence of the river valleys caused them to become filled, possibly first with Pleistocene sand and gravel terrace deposits, then with soft clays and silts during Recent times. Thus, a characteristic subsurface feature of the Bay is a relatively shallow buried erosional surface which represents the interface between the looser and softer Pleistocene and Recent deposits and the older, more compact pre-Pliocene deposits.

Much of the subsurface geology of the Chesapeake Bay has been learned from engineering site investigations for the two structural crossings of the Bay. Both crossings happen to be located near channels surveyed for this project. The Chesapeake Bay Bridge-Tunnel crosses the Bay between the Cape Henry and York Spit Channels and the Chesapeake Bay Bridge is located approximately 2 miles south of the Craighill Entrance Channel. Review of literature developed on these projects and others indicates the following geologic information in the vicinity of the channels.

3.1 Virginia Channels

Chesapeake Bay Bridge-Tunnel - Extensive subsurface information in the southern portion of the Chesapeake Bay has been obtained from a preliminary series of 28 deep exploratory borings made for the Chesapeake Bay Bridge-Tunnel. The borings were made by a joint venture of Raymond Concrete Pile Company and Tidewater Construction Company between December 1957 and February 1958. Within the depths penetrated by most of the borings, approximately 150 feet, a complex stratigraphy was indicated. The overall profile included a buried erosional surface whose depressions are filled with soft silts and clays and occasionally layers of medium compact fine sand which was believed to be of Recent or Pleistocene age. Studies have shown that the boundary between the erosional surface and overlying sediments represents the top of the Tertiary deposits, which in this area are of the Miocene age. These soils are greenish gray in color and consist of fine sandy clay, silty clay containing some fine sand and silty fine sand, all containing at least a trace of shells, and in some cases definite shell beds. These soils were consolidated through dessication at times when the land was elevated with respect to the sea and are presently stiff to very stiff or medium compact to very compact. However, the Pleistocene and Recent soils overlying the Tertiary are only consolidated under the weight of their existing overburden or possibly slightly more as a result of local drying. In the vicinity of the Bridge-Tunnel alignment and York Spit Channel, the subsoil stratigraphy shown by the borings to the depths relevant to this project are as follows: From the Bay bottom at Elev. -52 to Elev. -72, the borings encountered a loose to medium compact gray fine sand, some silt, trace shells. The surface of the Tertiary soils began at Elev. -72 and consisted of stiff to very stiff green, gray fine sandy clay, some silt, trace shells. The location of one boring made for the Bridge-Tunnel alignment has been projected onto Plate No. 8, York Spit Channel, for a comparison with the geophysical data obtained during this current study.

The subsurface investigation for the Bridge-Tunnel also included a seismic reflection survey made by Alpine Geophysical Associates, Inc. of Norwood, New Jersey. The survey, which was made during the latter part of January 1958, paralleled the alignment of the Bridge-Tunnel Highway Crossing and extended one mile on either side of the alignment. A report which describes the field work, equipment, and interpretation of data was published in Transactions, ASCE, and is referenced herein. The report includes the correlation of the geophysical data and test borings made for the Bridge-Tunnel in the vicinity of the York Spit Channel, which was previously called the "Baltimore Channel." A more recent seismic reflection survey much larger in scope was undertaken by the Coastal Engineering Research Center to locate and identify deposits of sand suitable for use as fill in replenishing eroded beaches. The survey covered an area of 180 square miles bounded by Cape Henry at the south, the approximate alignment of the Bridge-Tunnel at the west and Cape Charles to the north, and as such, includes the Cape Henry Channel and the southern limit of the York Spit Channel. The geophysical data was correlated with 47 vibracore borings made for the study and several vibracore borings previously made by other sources. A paper by Meisburger thoroughly describes the project and is referenced herein.

3.2 Maryland Channels

Chesapeake Bay Bridge - Chesapeake Bay Bridge spans 4.3 miles across the Bay from Sandy Point, Maryland on the western shore of the Bay to Kent Island. The bridge was constructed by the State Roads Commission of Maryland and consists of two parallel spans. The subsurface investigations for the first span included 23 borings made by Raymond Concrete Pile Company in 1947 and 1948. At this time an alignment of a proposed alternative tunnel was also investigated by 15 borings. The alignment of the tunnel was approximately 4,000 feet north of that of the bridge. In a preliminary subsurface investigation undertaken in 1938, 29 test borings were made at the approximate location of the proposed tunnel. The logs of these borings were used for the following geologic interpretation of the site prepared by C. W. A. Supp of the J. E. Greiner Company, referenced herein. In the depths penetrated by the borings, the deepest of which reached 258 feet, the soils were identified Quatenary, Tertiary and Cretaceous materials. In the vicinity of the shipping channel at the proposed tunnel alignment the following subsurface stratification was deduced: from the bay bottom at a depth of 55 feet to approximately 66 feet the soils consisted of Recent and Pleistocene soft gray silts and clays; from depth 66 feet to approximately 75 feet the borings encountered Recent and/or Pleistocene sand and gravel deposits. These are probably outwash terrace deposits which filled former stream bed channels. Underlying these deposits are the Tertiary soils, which were identified as the Eocene Aquia "greensand". This material is very compact to medium compact glauconitic sand with thin local occurrences of sandstone. The Tertiary soils were believed to be severely eroded as indicated by their undulating topography and complete absence in some areas along the alignment.

Baltimore Outer Harbor Crossing - This bridge crosses the Patapsco River from Hawkins Point on the south bank to Sollers Point on the north shore. Ten borings were made in a preliminary site investigation in 1964 and 89 additional borings were made by Warren George, Inc. for the final investigation in 1969. Locations of seventeen of these borings are shown on Plate 20. Materials identified in the borings were of Recent, Pleistocene, and Cretaceous age. The soil profile across the River included two channels cut into underlying compact soils, the deeper reaching Elev. -120 feet, approximately 1,000 feet southwest of the Ft. McHenry Channel. In the vicinity of Hawkins Point the compact soils were believed to be the Patapsco formation stiff variegated silty clays and compact sands and gravels. However, beneath the filled channel in the river the compact material consisted of only compact sand and gravel presumed to be a Pleistocene deposit. Organic silty clay which fills the channel is of Pleistocene and Recent age. At the intersection of the Ft. McHenry Channel the profile includes a 60 ft. thick stratum of soft gray organic silty clay at the channel bottom whose consistency increased slightly with depth. The top 2 feet was believed to be in a semi-liquid state. Beneath this clay a 5 ft. deposit of brown and gray coarse to fine sand and gravel forms a thin mantle over the very compact underlying soils. In summary, during the Pleistocene sea level lowering thin terrace deposits of sand and gravel filled river and stream channels and were subsequently covered by thick deposits of silts and clays during periods of high sea levels.

Proposed Rt. I-95 Ft. McHenry Tunnel - The site of a proposed tunnel crossing of the Patapsco River has been investigated by the Baltimore Interstate Agency. The tunnel will complete the Interstate Highway Route I-95 through the Baltimore area. Numerous borings were made along three alternative alignments. The locations of 31 borings made in the vicinity of the East Channel are shown on Plate 22, while the logs of four selected borings are shown in the profile. These borings indicate that the surface of Cretaceous soils lies at a much higher elevation than to the south. These soils are all hard or very compact silty or clayey sands, which probably belong to the Patuxent Formation. The Agency's interpretation of the generalized soil profile indicates that harbor bottom deposits of varying thickness are underlain by estuarine deposits across the width of the harbor. The harbor bottom deposits contain decomposed organics and petroleum residue, while the estuarine deposits are soft to stiff organic clayey silts or organic sandy silts. Underlying these materials is a stratum of compact to very compact silty sand to gravelly sand. The surface of this stratum varies extensively even over local areas but it is generally below Elev. -60.

Borings previously made for the Baltimore District throughout the Maryland Channels generally indicate that the bottom sediments are soft organic silty clays or clayey silts of Recent age. Bottom sediments described as black or organic may be material deposited since earlier dredging of the channel. The change to gray silty clay may represent the surface of uppermost natural material which predates dredging.

Other major engineering projects which probably have subsurface information which would be of use in this project are the Baltimore Harbor Inner Tunnel crossing the Patapsco River in the vicinity of the north end of the Ft. McHenry Channel and at least two submarine cables located in the Baltimore Inner Harbor area. Unfortunately, this information was not available for this report.

4. GEOPHYSICAL EXPLORATION PROGRAM

The geophysical exploration program was planned to provide continuous seismic and side scan sonar data over the entire length of the channels. Initially the specifications included the requirements for geophysical, vibracore and dry sample borings. After procuring bids from qualified drilling contractors for the dry sample borings it became apparent that the high cost of the dry sample work would put the cost of the entire program considerably above the amount of available funds. Therefore, at a meeting on August 9, 1977 between representatives of the Baltimore District, Mueser, Rutledge, Wentworth & Johnston and Ocean/Seismic/Survey, Inc. the scope of the program was reviewed and we also made recommendations for changes in the geophysical program based on the capabilities of available equipment. To reduce the cost, the District deleted the dry sample boring work and made other revisions in the specifications, based on the August 9th discussions. The changes were incorporated in a revised Appendix A of the Contract, which was transmitted to us on September 7, 1977.

4.1 Field Work - The geophysical field work was completed between November 14, 1977 and December 8, 1977 by our subcontractor, Ocean/Seismic/Survey, Inc., 70 Oak Street, Norwood, New Jersey 07648, under the inspection of our Resident Engineers, Messrs. Frederick C. Rhyner and Raymond Cholewka. The surveys of the Cape Henry and York Spit Channels were completed using a boat named "Sea Lee", which is a 50 ft. long charter fishing boat docked at Wall's Marina in Norfolk, Virginia. The boat was owned by Mr. Lee Hollowell and leased from its captain, Mr. Eugene Payne of Virginia Beach, Virginia. For the remaining channels the survey vessel was the "Pan Pat", a 41 foot long boat used mainly for charter fishing trips. The boat's owner and captain was Mr. Harrison Woolford of Annapolis, Maryland. Each boat was equipped for the survey with two gasoline powered generators mounted on deck. The specific instruments used for the survey are identified in Table No. 2. The crew typically consisted of a geologist crew chief, three technicians, one helper, and the vessel captain.

Desired survey courses were planned prior to the field work to provide both side scan sonar coverage to 100 feet outboard each side of the channels and a continuous seismic profile along the channel. Because our subcontractor believed that the optimum range for side scan sonar on this project was a total of 600 feet, two courses were made approximately along the third points of the channels. A sinusoidal pattern was also made to provide seismic data for cross-sections of the channels. This pattern was determined in the field to avoid interference from ships. The survey was carried out by travelling at a slow speed to minimize acoustic interference resulting from the vessel's engine noise and water turbulence created by wakes. The survey courses, seismic data, and locations of obstructions are shown on Plates Nos. 1 through 24. Refer to Appendix A for a list of obstructions located by side scan sonar.

4.2 Description of Methods and Equipment - Following is a brief description of the seismic, side scan sonar, and electronic navigation methods and equipment used on this project. For more detailed information see the referenced text and articles.

Seismic Reflection Survey - A seismic reflection survey delineates subsurface data based on the acoustical properties of subsurface materials. The strata are determined by emitting repetitive, high energy sound waves from a source towed by the survey vessel. These mechanical waves are reflected or refracted at changes in acoustical properties of the overburden. Reflected waves are received by a group of pressure sensitive hydrophones which are trailed behind the sound source, the measured parameter being the time between the sound puise and the reflection. The depth at which a reflection occurs is determined from an assumed velocity of sound in each water and overburden. The velocity of sound in water is typically 4,900 fps and in unconsolidated coastal plain sediments it is approximately 5,440 fps. Because the ratio of reflected wave energy to the emitted wave energy is very low, the faint signals received by the hydrophones are suitably amplified and electronically filtered, then recorded by helix-type chart recorders on electrosensitive graph paper. The recorded time signals are analogous to the sub-bottom profile. Both the depth of seismic penetration and resolution of signal vary with the frequency of the emitted sound source. Low frequencies, approximately 100 to 1,000 cycles per second (cps), penetrate deeper into unconsolidated sediments than do higher frequencies but do not yield adequate resolution of shallow sub-bottom layers. Higher frequencies do give good resolution of shallow structures but have poor depth penetration. In coastal plain sediments, the acoustic variations between different strata are subtle compared with profiles of overburden and rock, and generally the higher frequencies better detect the fine sub-bottom structure.

Three sound sources used for this project were a "sparker", "uniboom", and a "sub-bottom profiler." The sparker produces an acoustic wave by discharging a charged capacitor across an electrode gap which is trailed just below the water surface approximately 150 feet behind the survey vessel. A high energy transformer on board the vessel generates necessary voltage for the spark. The resulting signal was filtered to 1,000 to 2,000 cps, which achieved the required depth penetration of approximately 300 feet. This device was used only in the Cape Henry and Rappahannock Shoal Channels. Deep seismic penetration in all other channels was obtained with a uniboom. This is an electromagnetic transducer eleven inches in diameter, with thick rubber membrane covering, which operates at frequencies similar to the sparker. It was also towed in a similar fashion behind the survey vessel. A string of ten receiving hydrophones were trailed immediately behind either the sparker or uniboom in a 2-inch diameter plastic tube approximately 12 feet long. The tube was filled with oil for bouyancy and electric insulation. To delineate shallower interfaces a sub-bottom profiler operating at a frequency of 3,500 cps was operated. Its typical depth of penetration was 125 feet. The acoustic waves are both emitted and received by a group of four 5-inch diameter transducers which were carried approximately three feet below the water surface directly alongside the survey vessel.

Side Scan Sonar Survey - Side scan sonar is a relatively new method of distinguishing topographic features of surfaces below water by the use of acoustic images. This type of investigation can be used to interpret natural bottom features and locate man-made objects resting on the bottom. The acoustic image is generated by two side looking transducers contained in a torpedo-like housing called a fish. The fish is trailed submerged behind the survey vessel. Each transducer emits a horizontally narrow acoustic beam but sufficiently large in the vertical plane to scan directly beneath the transducer and out to a variable distance to each side of the fish. Because the transducers operate at much higher frequencies than do the seismic instruments, the acoustic beam does not penetrate the overburden, but is reflected only by bottom features or objects projecting above the bottom. Depending on the selected range of the beam and the depth of water, objects as small as one to two feet across may be detected. Also, subtle natural features such as ripples or small sand dunes and even grain size may be interpreted from the data since different acoustical responses occur at variations in bottom topography.

The same transducers also serve as hydrophones to receive reflected signals. These signals are amplified and electronically recorded by a dual channel helix type graph recorder on electrosensitive graph paper. The form of the data approaches a plan map or acoustic photograph of the path of the survey vessel. Objects which give strong reflections are recorded as dark areas while features which do not reflect the beam, for instance depressions, are recorded as light areas. Wrecks or other unnatural reflectors are identified by sharp, dark images distinct from the surrounding topography. The quality of an image depends on its size, reflectivity, and orientation to the sonar beam, also the strength of the signal varies with its distance from the transducer. The direct distance between the transducer and a reflector located by the sonar is measured directly from the data as the elapsed time of reflection is converted to a lineal distance by the recorder. This distance is corrected to a horizontal distance using the depth of water sensed by the transducer, and solving the simple geometrical relationship.

Electronic Navigation System - Geographic positioning of the vessel was determined by an electronic navigation system which included a dual channel ranger, computer, plotter, and two slave beacons located on shore. The ranger determined the distances between the survey vessel and the two shore beacons of known coordinates. To monitor the vessel's course, the computer converted this information into x and y coordinates which were plotted at intervals of approximately one minute. The desired survey courses were plotted before the field work began so the vessel captain could detect deviations in his actual course during the survey. Bench marks locations suitable for placing the shore beacons at each channel were provided by the Baltimore and Norfolk Districts, Corps of Engineers. The ranger system operates at microwave frequencies and requires line of slight distances. As sections of the York Spit and Rappahannock Shoal Channels are several miles from land, it was necessary to elevate the shore beacons to approximately 50 feet to overcome the curvature of the earth.

5. VIBRACORE BORING PROGRAM

The scope of work on this project included making 13 vibracore borings to be used by the Baltimore District primarily for an analysis of the environmental impact of the proposed dredging. Specifications included a schedule of the required depths of the 13 vibracore borings. Locations of the borings were originally intended to be chosen after the completion of the geophysical survey; however, because the survey was not fully completed at the time the vibracore borings were about to be made, the Baltimore District selected the locations of the vibracore borings based on environmental considerations only. Based on the completed geophysical surveys of the Cape Henry and York Spit Channels, we relocated Boring No. VYC-3 to an area of the York Spit Channel where the geophysical data showed only a bottom layer. All other borings were made at locations designated by the District.

5.1 Field Work - The boring operations commenced on November 28, 1977 and were completed on December 3, 1977. Our Resident Engineer, Mr. Raymond Cholewka, inspected all borings. The drilled locations of the borings were determined by our subcontractor using sextant angles on fixed land objects in the Maryland Channels and sextant angles on buoys in the Virginia Channels. Locations of the borings and descriptions of materials encountered are shown on Plates Nos. 1 through 24.

The instructions by the District for the final locations of the vibracore borings and the depths of penetration required were transmitted by "Routing and Transmittal Slips" dated November 18, 1977 and November 22, 1977. These directives required 30 ft. vibracores to be made in the Virginia Channels and 40 ft. in the Maryland Channels with each boring penetrating to at least 60 feet below Mean Low Water. A summary of the vibracore work completed is shown on Table 2. All borings penetrated to the minimum lengths and depths with the exception of Boring No. MCC-5 where refusal occurred at 26.1 ft. of penetration rather than the 40 ft. desired. However, penetration at this boring was to Elev. -70 ft., thereby meeting the minimum requirement of penetration to 60 ft. below Mean Low Water. Boring logs prepared by Ocean/Seismic/Survey, Inc. are included in the Appendix and give the detailed records of the operations at each site.

Bay bottom elevations at the boring locations were determined by taking water level readings on the sampler H-beam and making corrections for the height of the tide. Visual classifications of the materials exposed at the ends of the 4 ft. length samples were made in the field. Additionally, small representative portions of the material were placed in jars to serve as a convenient record set of samples. In borings where the recoveries were less than full length of penetration we made our best judgment whether lack of recovery occurred at the surface or the lower end of the boring. The depths assigned to samples in the field were revised accordingly.

5.2 Description of Equipment - Equipment used by Ocean/Seismic/Survey, Inc. comprised an Alpine Vibracore unit operated from the R/V Atlantic Twin, a 90 ft. long catamaran vessel, which also carried the required auxiliary equipment.

General Description - The Alpine Vibracore is a self contained coring device designed to sit on the marine floor, vibrate a coring pipe into the sub-bottom sediments and recover sediment core samples which are continuous throughout the vertical column and relatively undisturbed. Core samples are recovered inside a plastic liner of 3.5 inch inside diameter up to 40 feet in length in one continuous vibratory operation. Some sediments, such as a homogeneous fine sand are sufficiently compacted as to prevent full penetration on a single vibratory attempt.

Coring Rig - The vibracore rig consists of a pneumatic impacting vibrator mounted on top of a coring pipe which is a four-inch standard plumbing pipe. The rigid plastic liner is fitted inside the coring pipe to retain the core material. A core retainer consisting of flexible steel fingers is fitted in the cutting head to prevent loss of material during pull out and rig retrieval, and to supplement retainage of the sample by side friction.

The vibrating head assembly is attached to a 46 ft. long aluminum H-tower and free to slide down the face of the H-beam. It is supported by cable during transfer from the support vessel to its resting position on the marine floor. The tower assembly is further supported by four rigid legs extending horizontally from the tower base and containing steel pads of two foot diameter at the extremities. Diagonal supports from the pads to the tower provide a rigid base mount for the vibracore rig to sit in an upright position on the sea floor. The cutting head, part of the coring pipe assembly, is tapered on the outside to provide ease of entry into the sediments.

Once the unit is in a stable upright position on the sea floor the cable is slackened, leaving the vibrator assembly free to move downward into the sediment. Driving power is provided by compressed air fed through one hose to the piston head and alternately exhausted from top and base of the piston through two other hoses outletting at the surface in air. Compressed air forces the piston up, then alternately drives the piston down against its base. On this project the piston was 8 inches in diameter and vibrated at 600 cycles per minute. The driving force against the coring pipe is provided by the combination of the impact of the piston at its base coupled to the weight of the head assembly which is constrained to move freely downward. Penetration of the coring pipe continues to the depth of the boring or until refusal occurs, at which depth the compressed air valve is shut off. The coring pipe is pulled out of the bottom into the framework of the tower, and the entire rig lifted to the vessel, oriented in a horizontal position and the plastic liner extracted from the coring pipe.

The recovered core sample is cut into manageable sections, on this project 4 ft. lengths, each section labelled by number and position in the core, the ends capped with flexible plastic caps, taped securely with plastic binding Scotch tape and stored for further inspection. As noted above, representative soil samples from the tube sections were bottled for ease of reference.

The rate of penetration into the sub-bottom is measured by a 360^{o} potentiometer, housed in a pressure case mounted on the vibrator guide. It is driven by a sprocket coupled to a chain stretched along the length of the tower. The potentiometer makes one revolution for each foot of penetration into the sub-bottom and is connected by an electric cable to a single-channel strip chart recorder on the vessel.

Evaluation of Core Stratigraphy - During operations the recovery length does not always exactly match depth of penetration. Possible causes for differences include expansion, pile driving, and densification. Expansion when applied to a core indicates that the recovered sample measures longer than the distance of penetration through that particular sediment. In medium stiff to stiff clays expansion usually does not exceed ten percent by volume. In very dense sands expansion may reach fifty percent of the volume cored. In dense sands the percentage of change depends on material type, in-situ density and stress history of the deposit. "Pile driving" occurs when the end of the coring pipe becomes plugged but continues to penetrate the soil column displacing soft sediments instead of coring through them. The effects of pile driving may go unnoticed if coring takes place through a sequence of layers some of which have a tendency for expansion during coring. Densification or compaction is the least observed phenomenon and when it occasionally occurs, appears to be restricted to cohensionless sediments.

6. SUBSURFACE STRATIGRAPHY

Plates Nos. 1 through 24 illustrate results of the geophysical survey and boring program in plan and profile format. An explanation of symbols used on these plates is given on information Drawing No. I-1. The location in plan of the course taken by the geophysical survey vessel is shown by solid line marked with short ticks at frequent intervals. Ticks represent the vessel location at times when its position was electronically determined, and are called "fixes." Fixes are numbered in decimal groups of six, but for clarity only the first number in each group has been shown. The plan also shows the locations of hulks and other probable obstructions identified by side scan sonar.

The profile is a section along the stationing line of the channel. Geophysical data shown is an interpretation of field data by Ocean/Seismic/Survey, Inc. As two survey courses were made approximately parallel to the channels, our subcontractor generally chose to show in profile data from the course which contained more subsurface information. Fix numbers at the top of the profile indicate from which course the data were taken. The channel bottom determined in the geophysical survey has been indicated by a solid heavy line. For comparison with previously available data, the Baltimore District has indicated with solid dots depths at the station line of channel as determined in their most recent condition surveys. It should be noted that solid dots represent bottom at station line of channel, whereas the solid heavy line indicates bottom along the survey course, which was generally several hundred feet distant from the station line. Also, seismic reflection survey equipment is designed principally for maximum penetration of sediments and thus the time scale, sensitivity, and frequency response are not as favorable for accurate measurement of water depth as are those of echo sounders designed for bottom profiling.

Lines below the bottom represent sub-bottom interfaces as determined by the seismic reflection survey. The interfaces actually distinguish differences in acoustic properties of sediments, however, because the compositional and physical properties which commonly differentiate sediments also produce acoustic contrasts, the acoustic profile is roughly comparable to geologic strata lines. Short dashes at the ends of some of interface lines indicate that the line was truncated on field data but it is believed that the interface actually continues beyond where the end of the line is shown.

Shown in plan are the location of 20 sections lettered A through U, taken at various transverse angles to the channels. Subsurface data along these sections are shown on Plates Nos. 25 through 30. Twenty sections were required by Contract: however since all survey data will be submitted to the Baltimore District, additional sections may be constructed as desired. The sections were taken along segments of the sinusoidal survey course at locations where boring information exists and also at approximately regular intervals to provide coverage over the entire project.

Boring locations are shown in plan and simplified logs of the borings are shown in profile. Locations and logs of borings made by others were taken from the references listed in Table No. 3. The simplified boring logs show the top and bottom of boring, penetration resistance as defined on Drawing No. I-1, and a brief description of materials encountered.

The elevation datum used for this project is the National Ocean Survey Mean Low Water at each channel locality. The coordinate system for the Virginia channels is the Virginia State Grid (South Zone). The coordinate system for Maryland channels is a Corps of Engineers grid which is related to the Maryland State grid as shown on Drawing No. I-1. Basic reference information pertaining to the geophysical survey is included in the Appendix. These comprise: logs of the vibracore borings; a list of possible obstructions located by side scan sonar; a detailed discussion of the navigation system utilized for control of the survey, and a table identifying beacon locations.

As a geophysical survey is an indirect means of determining sub-bottom stratification, an interpretation of what the seismic interfaces represent must be based on direct sampling information usually obtained from borings. In areas of this project where boring information is not presently available, the interpretation is less certain and must be confirmed by future subsurface investigations. The following interpretation of subsurface conditions is listed by channels. The principal interface lines are identified by letters A through G on the profiles. The physical significance of these lines is summarized in an explanatory table on Plate 1.

6.1 Virginia Channels

Cape Henry Channel - The seismic profile of the Cape Henry Channel shown on Plate 1 contains several well delineated reflections. The dominant reflection, identified on the profile as A, has a very undulating surface, a characteristic feature of an erosional surface. The erosional surface ranges in depth from approximately 10 to 20 feet below the bay bottom, except at the southern portion of the channel, where it deepens to nearly 40 feet below the bottom. It is continuous for at least 3 miles on the seismic record and is probably continuous throughout the Cape Henry area. This erosional surface probably corresponds to the top of the pre-Recent sediments.

At the southern end of the seismic profile exists a buried river channel as identified by the steeply inclined erosional surface which forms the banks, and elsewhere the river bed. This channel has been filled to the present bay bottom eliminating any surface expression of its existence. Reflections within the channel show cross-bedding of strata, a characteristic feature of stream-deposited sediments. Based on the present-day alignment of the James River, this buried river channel may represent its former channel at a time of lower sea level. Section A-A, shown on Plate 25, traverses a portion of buried channel and indicates that the main section of the buried river channel was slightly to the north of the profile shown on Plate 1. Boring No. VCC-1 was positioned in the Cape Henry Channel. At its location the bottom sediment extending to Elev. -55 was gray fine sand, trace silt, trace shell fragments. As shown on Section A, the first sub-bottom interface apparently represents the base of this material. This material is the characteristic surface sediment in the Chesapeake Bay entrance area. Borings at Chesapeake Bay-Bridge-Tunnel indicate that this sand is loose to medium compact, and, because of its striking uniformity over such a large areal extent it is probably of similar consistency in Cape Henry Channel. Underlying this sand is a stratum of orange-brown fine sand with some silt. While the overlying gray sand is known to be Recent, this orange-brown sand is probably a Pleistocene deposit which may contain appreciable amounts of gravel and even occasional cobbles. Penetration resistances indicate that the sand is distinctly more compact than the overlying Recent material. The base of this sand appears to be at the second sub-bottom interface, the erosional Surface A.

The boring penetrated the erosional surface at approximately 21 feet below the bay bottom. The penetration resistance increase in the vicinity of the erosional surface indicates that the sediment immediately below the erosional surface is more compact than both overlying materials. No sample was recovered below the erosional surface. No further prominent seismic reflectors appear between erosional surface A and the next prominent reflector, B. This indicates that the intervening sediment is relatively homogenous in content and texture.

Seismic reflector B is prominent and continuous over most of the Cape Henry survey area and is characterized by its relatively smooth, non-undulating surface. It slopes gently downward to the southeast. The reflector probably represents the top of Miocene Yorktown formation as reported by Meisburger.

Several deeper seismic reflections, not shown on this profile appear on the seismic records at depths of 120, 200 and 300 feet below the sea floor. These reflectors are also relatively smooth and slope gently downward to the southeast.

Based on the single boring and the patterns of shallow seismic reflections the upper several feet in the Cape Henry Channel appears to comprise relatively loose sands while a more compact mixture of sand and silt lie below it.

York Spit Channel - The same sequence of strata exists in all but the northern portion of York Spit Channel as appears in Cape Henry Channel. Seismic reflectors include an erosional surface, buried channels, extensive continuous reflectors, and two areas where no seismic reflections were recorded. An erosional surface identified as C has been traced from the southern end of the Channel on Plate 8 northward to where it terminates on Plate 3. It ranges from 3 to 13 feet below the bottom, except where it plunges to form the base of buried river and stream channels. In the vicinity of fix No. 120.1 (Plate 4), the erosional surface begins to dip gently to the north and gradually fades until it ends near fix No. 118.1 on Plate 3.

Two borings in the York Spit Channel penetrated the erosional surface. At Boring No. VYC-2 (Plate 4) the material beneath the interface comprised an eighteen feet thick stratum of light brown and gray clayey fine sand underlain by gray silty fine sand. At Boring No. VYC-1 (Plate 6) the interface probably represents the change from medium stiff gray silty clay to gray silty fine sand. The silty fine sand is much more compact than the overlying material. The erosional surface probably is the top of pre-Recent sediments.

Associated with the shallow erosional surface are five series of buried channels where the erosional surface has been incised to depths of 20 to nearly 40 feet below its average elevation. These depressions have the typical pattern of steeply inclined banks, forming what appear to be river channels which have been filled with cross-bedded sediments. Widths of the buried channels measure between approximately 800 and 3,200 feet between opposite wall boundaries. Those shown on Plates 7 and 8 may be part of a single meandering channel. Another depression, between fix Nos. 123 to 132, covering a span of two miles, shows the erosional surface C gradually deepening toward the central area where it deepens more steeply to at least 35 feet below the bottom. This central portion is devoid of seismic reflections from the surface downward, and has been indicated by SSA, meaning "soft sediment area." It is an area where the presence of soft material on the bottom masked the underlying reflectors. The thickness of the masking layer is generally not known.

Two other deeper prominently recorded seismic reflectors appear below the erosion surface. The shallower one marked E appears in the southern portion of York Spit Channel and ranges from Elev. -75 at the southern end of the channel on Plate 8 to Elev. -67 feet five miles northward. Its surface is very smooth and almost flat, except where incised by the erosional surface. North of the five mile extent the seismic reflection disappears, apparently converging upward to the erosional surface. Boring No. A1, which was projected from the Chesapeake Bay Bridge-Tunnel, shows Recent gray and dark gray silty fine sand lying above the reflector and Miocene age Yorktown formation of greenish gray silty clay with seams and pockets of sand lying below. Reflector E represents a surface of the Tertiary material in York Spit Channel.

The second deeper reflector is found at the southern end of the York Spit Channel at approximately Elev. -105 and extends for ten miles northward, rising gradually to Elev. -80, then declining to -90 before disappearing in the vicinity of fix No. 123, Plate 4. At one location this reflector horizon is incised by a deep buried river channel, fix No. 140 on Plate 6. The second interface parallels the upper one and is approximately 20 to 30 feet beneath it, and may be a facies change within the Yorktown formation between the silty clays and medium compact to very compact greenish gray fine to medium sands. These two component materials alternated in sequence along the route of the Bay-Bridge tunnel.

Toward the northern portion of the York Spit Channel, Plate 5, the erosional surface dips gently to the north. All layers lying above the erosional surface, as shown on Plates 5, 4,3, also dip gently northward. This feature probably represents a large embayment or estuary containing clay deposits, which was present when the sea level was about fifty feet lower than the present time. Deposition would have occurred during the rise of sea level after the most recent glacial era. From fix No. 118.1 to 111.4, nearly two miles, a soft sediment area was encountered. Boring No. VYC-3 was located in the center of this area to identify the sediments. A 29 ft. thick stratum of soft to medium gray clayey silt was penetrated which probably caused the seismic masking, although its depth throughout the area is not known.

Unfortunately, no boring information is available north of this soft sediment area; therefore, no conclusion can be drawn as to the significance of the reflections at the north end of the channel. The reflections do show parallel bedding of materials which dip northward. These may be part of the embayment described previously.

A minor sea floor surface feature exists in the southern portion of York Spit area. Sand waves interpreted from the seismic reflections appear between fix Nos. 156.6 and 160.1. Length of the larger sand mounds measures 100 to 120 feet, their height three to four feet. Distance between crests ranges between 100 and 130 feet. Northward the sand waves diminish to two feet in relief and gradually blend in with the sea floor.

Deep seismic reflectors interpreted as smooth gently inclined strata are also recorded on the seismic reflection records as deep as -300 feet.

Rappahannock Shoal Channel - Quality of the seismic records in the Rappahannock Shoal Channel is good, with the exception of two soft sediment areas where either no reflections are identifiable below the bottom or deeper than 20 feet below the bottom. The first occurs just north of the location of Boring No. VRC-2 on Plate 11 and the other surrounding Boring No. VRC-3 on Plate 10.

The patterns of seismic reflections are much more complicated in this channel than in either York Spit or Cape Henry. The interpreted features include erosional surfaces, deep buried channels, and areas of obscured seismic reflections.

There appear to be two prominent erosional surfaces, labelled F and G, which are in some places, close to each other. Both have features characteristic of erosional surfaces such as an irregular undulation, cutting off the upper portions of inclined layers, and incision of parallel layers forming depression walls. At the northern area of the channel, the upper erosional surface F ranges in depth between 5 and 25 feet below the bottom and at Boring No. VRC-4 appears at Elev. -67. It continues southward where it dips steeply forming the north bank of a deep depression at least 100 feet below MLW. Almost a mile southward it emerges as the south bank of the depression; then approximately one-half mile further south it again dips steeply, forming a north wall of a second depression. South of Boring No. VRC-2, Plate 11, the upper erosional surface is less distinct on the profile. Section K-K shows the shallow upper erosional surface with its irregular undulations truncating strata that converge upward and are cut off by it.

The deeper erosional surface G is shown at the northern end of the Rappahannock Channel and is recognized by the steeply inclined walls describing a 1,700 ft. wide buried channel. It is also recognized further to the south on Plate 11, where it abruptly truncates the inclined underlying layers and on Plate 12, where it dips steeply cutting into flat beds and forming the north bank of a deep depression.

The four vibracore borings show one to four feet of soft gray organic clayey silt, underlain generally by soft gray silty clay in most of the area to the south. In the northern sector, Boring No. VRC-4 shows a stratum of relatively compact brown fine to coarse sand with some gravel occurring about ten feet below the bottom, underlain by stiff to medium dark greenish gray clays and silts. The change in material corresponds with interface F which probably marks a change within the Pleistocene to medium stiff clay. The overlying sand is a Pleistocene outwash deposit which may also contain cobbles.

Boring No. VRC-3, made in one of the soft sediment areas, shows a thick column of soft sediments including organic clayey silt and soft silty clay. Penetration resistance is low throughout the 40 feet of core. Boring No. VRC-3 is located at a depression where seismic reflections are not recognizable below about 15 feet. However, soft sediments occurring at or close to the bay bottom may mask deeper reflections from strata that are actually quite compact. No single interpretation will necessarily explain all areas where seismic reflections are abruptly discontinued.

The sub-bottom geologic features in this area are rather complicated. It would require many additional seismic reflection survey miles correlated with appropriately placed borings to develop an accurate picture of sub-bottom conditions. In general, the four vibracore borings and the seismic reflection patterns indicate that the upper ten feet of sediments consists of soft materials such as the silt-clay mixtures.

Near fix No. 446.1 exists a ridge approximately 5 feet above the bottom. This ridge continues across the channel at an angle. It appeared on the side scan sonar. The other parallel seismic profile shows that this ridge represents the outcrop on the sea floor of the lower erosional surface. This may be an area of compacted, semi-consolidated sand and gravel, more resistant to dredging than the majority of the sediment forming the bottom of the channel.

6.2 Maryland Channels - The quality of seismic records made in the Maryland Channels varies from well-recorded sub-bottom reflectors in the Southern Craighill region to sparsely recorded reflectors toward the mid-region and the Baltimore areas. The Craighill sections, Plates 13 and 14, contain sequences of seismic reflectors to a sub-bottom depth of 35 feet. Toward the northern portion of the Craighill section and continuing to Baltimore Harbor, seismic reflectors become very spotty.

Many portions of the seismic records contain either no sub-bottom reflections or only very faint traces. The cause is not attributed to poor operation of the seismic instruments, but to the geologic conditions that exist in these areas. The bottom sediments are probably soft material containing interspersed gas pockets, however, these may be only a few feet thick. Seismic reflections in the Maryland Channels show many areas where no reflections exist below approximately 5 or 6 feet of the bottom.

In the Craighill Entrance Channel, Boring Nos. MCC-1A and MCC-1B each encountered a sequence of Recent soft organic silty clay overlying fine to medium sands with some silt. Underlying these materials were Pleistocene light brown gravelly sands containing only trace amounts of silt. Between fix Nos. 362 to 364 a soft sediment area was encountered where the sub-bottom feature is interpreted as a buried channel, as evidenced by the abruptly downward sloping reflectors near fix No. 362.1. The depression or channel area extends northward for about one mile. It is likely that the sediments within the depression may be gaseous, particularly in the upper portions and may be soft to a considerable depth. Between fix Nos. 365.3 to 365.6, a length of about 1,200 feet there is an abrupt discontinuation of seismic reflections. On both sides of the area there are reflections from 40 feet below the bottom. The reflectors are generally flat, but the seismic signal completely disappears between the reflectors. The interpretation is that a soft gaseous material exists within the upper ten feet of sediment masking any further signals below it. The sediments, however, probably exist below the gaseous material and the reflectors on both sides are probably continuous across the blank stretch.

Other erosional surfaces in the Maryland areas are either non-existent or very indistinctly defined. There appears to be no obvious pattern of inclined layers having been cut off near their tops, thus forming an erosional unconformity. The area from Cut-Off Brewerton Angle northward to the Brewerton-Ft. McHenry Angle contains very few seismic reflections. One faint reflector appears within 5 to 6 feet below the bottom. Borings Nos. MCC-3 and 4 encountered soft gray silty clay to a depth of 40 feet below the bottom. Boring No. MCC-5, made at the north end of the Ft. McHenry Section encountered a few feet of soft mud overlying a very stiff clay. This clay is thought to be of the cretaceous Raritan Formation and probably dips to the southeast.

In the Northwest Branch there is apparently a hard reflector which outcrops at the northwest end. The nature of this surface is unknown; it may be a gravelly sand or stiff clay. Near fix No. 327.1 there are about 1,600 feet of reflectors which show a pattern of a buried stream channel or an infilling of a depression.

7. CONCLUSIONS

On the basis of the information summarized in this report and plotted on the series of profile plates, we have reached the following conclusions regarding this survey of the Baltimore Harbor and Channels:

1. We believe that the program has generally served the purpose of delineating major groups of materials and general trends over the area. However, because of the dampening effect created by the presence of moderately thick soft organic materials, significant lengths were encountered where it was not possible to define deeper material by geophysical methods. To expand the information it will be essential to carry out additional borings, preferably including conventional spoon sampling and possibly also undisturbed thin-tube sampling for the detailed identification of the subsoil strata.

2. The general geologic setting of this portion of Chesapeake Bay comprises a series of wedged-shaped Tertiary and Cretaceous sediments dipping and thickening seaward. The older and generally harder Lower Cretaceous materials appear farthest to the north and west within Baltimore Harbor. Younger and less compact Tertiary sediments appear south and east beneath the Virginia Channels. In the Maryland Channels Pleistocene and Recent streams deeply

indented the Cretaceous sediments; whereas Pleistocene erosion through the Cape Henry area has produced a somewhat smoother surface on the older sediments. Nevertheless this survey has revealed possible pre-Recent or Pleistocene channels of rivers which flowed through the lower Chesapeake Bay.

3. The chief source of detailed information on geotechnical conditions consists of the investigations made for various crossing structures between Baltimore Harbor and the Chesapeake Bay Bridge and Tunnel. These sources deserve further detailed study and additional geotechnical investigations of the channels should not proceed without a comprehensive review of each of these sources of data. The geophysical survey of this study has confirmed to a marked extent the information contained in those detailed boring programs, as well as the borings made for this and earlier investigations.

4. It is likely that dredging of the channel bottom between Elev. -50 and -55 will encounter compact and possibly iron-cemented Pleistocene sands and hard Cretaceous clays at fairly numerous locations in the Maryland channels. The possibility of intersecting hard materials is less likely in the Virginia channels. Locations where present information indicates "hard bottom" above Elev. -55 are as follows:

a. York Spit Channel, generally near Station 560, surface of stiff Miocene Yorktown formation rises above Elev. -55.

b. Rappahannock Shoal Channel, near Station -80, Miocene surface rises above Elev. -55.

c. Craighill Cut-off Angle, Station 4+100 to Cut-off Section, Station 12, Pleistocene sand and gravel, probably partly iron-cemented, rise above Elev. -50.

d. Fort McHenry Section, near Station 22. Hard Cretaceous Patapsco clay rises above Elev. -50.

e. East Channel, near Station 1, near planned I-95 crossing, stiff to hard Pleistocene silty clay with gravel and ironpan lenses. Probably similar conditions throughout Northwest Channel, including new areas to be dredged.

f. Curtis Bay Channel, near Station 10, Boring FF-10, probable Pleistocene sand, gravel and cobbles. This is based on boring data from positions outside of the channel.

REFERENCES

(1) Alpine Geophysical Associates, Inc., "Sub-bottom Reflection Survey for Proposed Chesapeake Bay Highway Crossing Cape Charles, Va. to Little Creek, Va.", Sverdrup and Parcel, Consulting Engineers, St. Louis, Mo., March 10, 1958.

(2) Beckman, W. C., et. al., "SDR Survey for Proposed Chesapeake Bay Crossing", A.S.C.E. Transactions, Vol. 126, Part IV, pp. 278-290.

(3) Glaser, John D., "Coastal Plain Geology of Southern Maryland", Maryland Geological Survey Guidebook No. 1, 1968.

(4) Harrison, Wyman, "Pleistocene Record in the Subsurface of the Norfolk Area, Virginia", Guidebook For Field Trips, Norfolk Meeting, May 11-12, 1962 Norfolk College of William and Mary, Norfolk, Va., 1962.

(5) Hartman, Gregory L., "Evaluation of Estuarine Channel Conditions In Coos Bay, Oregon Using Side-Scan Sonar", Master of Ocean Engineering Thesis, School of Engineering, Oregon State University, Corvallis, Oregon, May, 1976.

(6) Meisburger, E., "Geomorphology and Sediments of the Chesapeake Bay Entrance", U. S. Army Corps of Engineers Coastal Engineering Research Center, Wash., D. C., Technical Memorandum No. 38, June, 1972.

(7) Moran, Proctor, Mueser & Rutledge, "Foundation Study, Chesapeake Bay Bridge-Tunnel Crossing", Sverdrup and Parcel, Consulting Engineers, St. Louis, Mo., April 3, 1958 (Unpublished report).

(8) Slotta, Larry S., "Side Scan Sonar Views of Channel Disturbances Associated with Marine Traffic and Dredging", Dredging and Its Environmental Effects, A.S.C.E., N.Y., 1976.

(9) Supp, C.W.A., "Engineering Geology of the Chesapeake Bay Bridge", Engineering Geology Case Histories, No. 1, Geologic Society of America, 1957.

TABLE NO. 1

IDENTIFICATION OF GEOPHYSICAL SURVEY EQUIPMENT

SYSTEM	PRIMARY EQUIPMENT	MANUFACTURER	DATA RECORDER	REMARKS
Seismic reflection	Sparker, 200 joule	Alpine Geophysical Associates, Inc. Norwood, N. J.	Gifft, sweep rate 1/8 sec.	Operating frequency: 1,000 - 2,000 cycles per second(cps)
	Uniboom, Model 231	E G & G, Waltham, Mass.	Gifft, sweep rate 1/8 sec.	Operating frequency: 1,000 - 2,000 cps
	Sub-bottom Profiler, 3.5 khz	Ocean Research Equipment	Alden, sweep rate 1/20 sec.	Operating frequency: 3,500 cps
Side Scan Sonar	Klein Side Scan Sonar, Model Modified SA-350	Klein Associates	Alden, dual channel double helix type, Model 9861 DOG	Operating frequency: 100,000 cps
Electronic Navigation	Mini-Ranger III System	Motorola, Inc.		Two reflector "slave" beacons used at various shore locations
	HP-9825A Computer	Hewlett-Packard	HP-9862A Plotter	

TABLE NO. 2

SUMMARY OF VIBRACORE BORINGS

BORING NUMBER	LOCATION		COORDINATES	BAY BOTTOM ELEVATION (ft.)	LENGTH OF PENETRATION (ft.)	LENGTH OF MATERIAL RECOVERED (ft.)	PER CENT RECOVERY
VCC-1	Cape Henry Channel	Virginia State Grid (South Zone)	N246,000* E2,728,000*	-42	24.0	20.6	85.8
VYC-1	York Spit Channel	Virginia State Grid (South Zone)	N293,800 E2,690,600	-44	19.9	19.9	100
VYC-2	York Spit Channel	Virginia State Grid (South Zone)	N319,000 E2,682,400	-36	37.0	37.0	100
VYC-3	York Spit Channel	Virginia State Grid (South Zone)	N337,400 E2,687,400	-44	36.7	34.7	94.6
VRC-1	Rappahannock Shoal Channel	Virginia State Grid (South Zone)	N463,400 E2,706,500	-45	35.2	38.5	109.4
VRC-2	Rappahannock Shoal Channel	Virginia State Grid (South Zone)	N470,700 E2,700,000	-45	38.5	35.3	91.7
VRC-3	Rappahannock Shoal Channel	Virginia State Grid (South Zone)	N478,800 E2,692,900	-44	38.7	32.6	84.2
VRC-4	Rappahannock Shoal Channel	Virginia State Grid (South Zone)	N485,700 E2,687,000	-45	28.2	28.5	101.1
MCC-1A	Craighill Entrance Channel	Corps of Engineers Grid	**	-38	38.7	28.7	74.2
MCC-1B	Craighill Entrance Channel	Corps of Engineers Grid	N441,000 E2,173,650	-37	36.0	26.0	72.2
MCC-2	Main Ship Channel Craighill Section	Corps of Engineers Grid	N467,800 E2,172,600	-24	40.0	33.0	82.5
MCC-3	Main Ship Channel Cutoff - Brewerton Angle	Corps of Engineers Grid	N490,000 E2,161,500	-30	40.0	29.0	72.5
MCC-4	Main Ship Channel Brewerton - Ft. McHenry Angle	Corps of Engineers Grid	N499,600 E2,139,300	-22	40.0	31.0	77.5
MCC-5	Main Ship Channel Ft. McHenry Section	Corps of Engineers Grid	N517,500 E2,123,000	-44	26.1	20.6	78.9

*Coordinates estimated because field data did not check

**Coordinates not determined in field. Boring made within approximately 50 feet of MCC-1B

TABLE NO. 3

SUMMARY OF BORINGS BY OTHERS

PROJECT NAME	SOURCE OR OWNER	BORING CONTRACTOR	DATE	REFERENCE DRAWINGS
Baltimore Outer Harbor Crossing Baltimore, Maryland	Maryland Transportation Authority	Warren George, Inc. Jersey City, New Jersey	1969	"Baltimore Harbor Outer Tunnel, Master Soils Plan and Profile, Design Section D-11", dated Jan. 23, 1970. (17 borings shown in Plan, 3 shown in Profile on Plate No. 20)
Proposed Route I-95 Ft. McHenry Tunnel, Baltimore, Maryland	Baltimore Interstate Agency	Not Stated	1973	"Segment "O" I-95, Borehole Location Plan", Plate No. 4, dated November, 1964. Numerous individual boring logs. (31 borings shown in Plan, 4 shown in Profile on Plate No. 22)
Baltimore Harbor and Channels, Maryland	Baltimore District, Corps of Engineers	Not Stated	1963	"Subsurface Exploration and Disposal Areas", File 17, Map 1040.1 and "Subsurface Exploration Logs" File 17, Maps 1040.2 and 1040.3, dated Dec. 1963 (42 borings shown in Plans and Profiles on Plates Nos. 13 thru 19)
			1964	"Plan and Logs of Subsurface Exploration ", File 17, Map 1105 and "Logs of Subsurface Exploration", File 17, Maps 1108 thru 1112, dated Nov. 1964. (10 borings shown in Plans and Profiles on Plates Nos. 20, 21 and 24)
Chesapeake Bay Bridge-Tunnel Cape Henry - Cape Charles, Va.	Moran, Proctor, Mueser & Rutledge	Joint Venture of Raymond Concrete Pile Co. and Tidewater Construction Co.	1958	"Chesapeake Bay Highway Crossing, Suspension Bridge Section, Baltimore Channel, Geologic Profile", drawing No. GS-4, dated Mar. 16, 1958. (1 boring shown in Plan and Profile on Plate No. 8)

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF DRAWINGS

LIST OF MAPS

LIST OF PLATES

ALPINE GEOPHYSICAL ASSOCIATES, INC.
OAK STREET
NORWOOD, NEW JERSEY

Job No. 400-141

Core No. VCC-1 **Date:** 12/3/77 **Area:** Cape Henry **Grid Position** See Comments

Run No. ____

Penetration ____ ft.
Recovery ____ ft.

Water Depth:
Uncorrected 44 1420
Tide ____
Corrected ____

Position:
Decca ____
Radar ____

Vibration Time:
Stop ____
Start ____
Total Elapsed Time ____

Jetting Time:
Stop ____
Start ____
Total Elapsed Time ____

Coring Time	Depth	Sample	Core Description
	0	#1	Dark gray fine sand, trace silt, trace organics, trace shells SP-SM
3	1		
3	2		
2	3		
2	4	#2	DO - gray
3	5		
3	6		
5	7		
7	8	#3	DO
7	9		
10	10		
7	11		
7	12	#4	DO
7	13		- - - - - - Orange brown fine sand & some silt SM
18	14		
18	15		
15	16	#5	
10	17		
8	18		
9	19		
10	20		

Coring Time	Depth	Sample	Core Description
	20		
10	21	#6	20.6 DO
15	22		No recovery
20	23		
26	24		- -
	25		
	26		
	27		
	28		
	29		
	30		
	31		
	32		
	33		
	34		
	35		
	36		
	37		
	38		
	39		
	40		

COMMENTS: Virginia State Grid - 246,000 N, 2,728,000 E

APPENDIX

VIBRACORE FIELD LOGS

Pages B-2 through B-9 contain field logs of the thirteen cores taken by the Alpine VIBRACORE coring divice. Descriptions of the sediment contents were made by the Ocean/Seismic/Survey marine geologist from short-length samples extracted from the plastic core liners at four foot intervals. Coring time refers to penetration time measured in seconds for each successive foot of penetration. The location of each VIBRACORE site is defined by State Grid coordinates.

STANDARD PENETRATION TESTING FIELD LOGS

Pages B-11 and B-12 contain field logs of 55 cores taken by the Corps of Engineers, Baltimore District, during August and September 1978. Twenty-five core samples were taken from the Rappahannock Channel and the remaining in York Spit. Drill holes were accomplished using a 1-3/8 inch I.D. by 2 inches by 24 inch long split spoon. Sample spoons were advanced by a 140 pound hammer falling 30 inches. The combined blow counts of the last foot of drive Standard Penetration are shown on the field logs. Soil descriptions are laboratory classifications based on the Unified Soil Classification System. Plates B-33 through B-41 are gradation curves reflecting the Standard Penetration Testing Analysis.

ALPINE GEOPHYSICAL ASSOCIATES, INC.
OAK STREET
NORWOOD, NEW JERSEY

Job No. 400-141

Core No. VYC-1 **Date:** 12/3/77 **Area:** York Spit Chanl **Grid Position** See Comments

Run No. ______

Penetration ___ **ft.**

Recovery ___ **ft.**

Water Depth:

- **Uncorrected** 45.5 1045
- **Tide** ___
- **Corrected** ___

Position:

- **Decca** ___
- **Radar** ___

Vibration Time:

- **Stop** ___
- **Start** ___
- **Total Elapsed Time** ___

Jetting Time:

- **Stop** ___
- **Start** ___
- **Total Elapsed Time** ___

Coring Time	Depth	Core Description	Coring Time	Depth	Core Description
—	0	#1 1" yellow-orange silty fine to medium sand, trace coarse sand over medium stiff gray clayey silt SM	—	20	
2	1		—	21	
2	2		—	22	
3	3		—	23	
4	4	#2 Trace fine sand ML	—	24	
4	5	Medium stiff gray sandy clay CL	—	25	
4	6		—	26	
4	7		—	27	
4	8	#3 Medium stiff gray clayey silt	—	28	
4	9		—	29	
4	10		—	30	
4	11		—	31	
6	12	#4 DO Fine gray sandy clay, medium stiff	—	32	
7	13		—	33	
13	14		—	34	
23	15		—	35	
23	16	#5 DO	—	36	
34	17		—	37	
36	18		—	38	
36	19		—	39	
57	20	#6 DO	—	40	

COMMENTS: Virginia State Grid - 293,800 N, 2,690,600 E

ALPINE GEOPHYSICAL ASSOCIATES, INC.
OAK STREET
NORWOOD, NEW JERSEY

Job No. 400-141

Core No. VYC-2 **Date:** 12/3/77 **Area:** York Spit Chan. **Grid Position** See Comments

Run No. ______

Penetration 37 **ft.**

Recovery 37 **ft.**

Water Depth:

- **Uncorrected** ___
- **Tide** ___
- **Corrected** ___

Position:

- **Decca** ___
- **Radar** ___

Vibration Time:

- **Stop** ___
- **Start** ___
- **Total Elapsed Time** ___

Jetting Time:

- **Stop** ___
- **Start** ___
- **Total Elapsed Time** ___

Coring Time	Depth	Core Description	Coring Time	Depth	Core Description
—	0	#1 Soft gray organic silt, some fine sand OL	—	20	
4	1		—	21	#6 Light gray-brown clayey fine sand SC
10	2		—	22	
8	3		—	23	
7	4		—	24	
6	5	#2 Soft gray clayey silt, some fine sand ML	—	25	#7 DO
2	6		—	26	
1	7	Holocene lagoonal sediment	—	27	
1	8	#3 DO	—	28	#8 DO
1	9		—	29	
1	10		—	30	
1	11		—	31	--Change to all gray shelly sediment
1	12		—	32	
1	13	#4 Medium stiff, light brown fine sandy clay CL	—	33	#9 Silty fine sand, trace shells, trace clay SM
1	14		—	34	
1	15	Pleistocene age	—	35	
1	16		—	36	
—	17	#5 Light brown-gray claey sand SC	—	37	- DO
—	18		—	38	
—	19		—	39	
—	20		—	40	

COMMENTS: Virginia State Grid - 319,000 N, 2,682,400 E

ALPINE GEOPHYSICAL ASSOCIATES, INC.
OAK STREET
NORWOOD, NEW JERSEY

Job No. 400-141

Core No. VYC-3 Date: 12/2/77 Area: York Spit Chan. Grid Position See Comments

Run No. ____

Penetration ____ ft.
Recovery ____ ft.
Water Depth:
Uncorrected 45.5 5 p.m.
Tide ____
Corrected ____
Position:
Decca ____
Radar ____
Vibration Time:
Stop ____
Start ____
Total Elapsed Time ____
Jetting Time:
Stop ____
Start ____
Total Elapsed Time ____

Depth	Coring Time	Core Description	Depth	Coring Time	Core Description
0		#1 Soft gray organic clayey silt OL	20		
1	1		21	2	
2	1		22	2	#7 DO
3	1	#2 DO	23	2	
4	1		24	2	
5	1		25	2	
6	1	#3 Gray silty clay, trace find sand ML	26	2	#8 DO
7	1		27	2	
8	1		28	3	
9	1	#4 Soft gray clayey silt, trace fine sand ML	29	3	
10	1		30	3	#9 Silty fine gray sand SM
11	1		31	3	
12	1		32	3	
13	1	#5 Medium stiff clayey silt, trace fine sand ML	33	5	
14	1		34	6	#10 Fine soft sandy clay, trace shell fragments
15	1		35	6	
16	1		36	6	No recovery
17	1		37		
18	1	#6 DO	38		
19	2		39		
20	2		40		

COMMENTS: Virginia State Grid - 337,400 N, 2,687,400 E

ALPINE GEOPHYSICAL ASSOCIATES, INC.
OAK STREET
NORWOOD, NEW JERSEY

Job No. 400-141

Core No. VRC-1 Date: 12/2/77 Area: Rappa. Shoal Chan. Grid Position See Comments

Run No. ____

Penetration 36 ft.
Recovery 38.5 ft.
Water Depth:
Uncorrected 45.5 1335
Tide ____
Corrected ____
Position:
Decca ____
Radar ____
Vibration Time:
Stop ____
Start ____
Total Elapsed Time ____
Jetting Time:
Stop ____
Start ____
Total Elapsed Time ____

Depth	Coring Time	Core Description	Depth	Coring Time	Core Description
0		#1 U. Soft dark gray organic clayey silt OL	20		
1			21	2	
2		#2 silty clay, soft gray CL	22	2	#7 DO
3			23	2	
4			24	2	
5			25	2	
6		#3 DO	26	2	#8 Organic silty clay, medium stiff, trace find sand, vegetation OL
7			27	2	
8			28	10	
9			29	10	
10		#4 DO, trace fine sand	30	33	#9 Gray clayey fine sand some gravel, trace m-c sand SC
11			31	43	
12			32	10	
13			33	10	
14		#5 gray clayey fine sand SC	34	9	#10 gray fine clayey sand SC
15			35	16	--B. of H
16	1		36		
17	1	#6 silty clay, gray, trace shells, trace fine sand & organics CL	37		
18	4		38		DO
19	3		39		
20			40		

COMMENTS: Virginia State Grid - 463,400 N, 2,706,500 E

ALPINE GEOPHYSICAL ASSOCIATES, INC.
OAK STREET
NORWOOD, NEW JERSEY

Job No. 400-141

Core No. VRC-2 **Date:** 12/2/77 **Area:** Rappa. Shoal Chan. **Grid Position** See Comments

Run No. ______

Penetration 38.5 ft.
Recovery 35.3 ft.
Water Depth:
Uncorrected 45.5 @12:40
Tide ______
Corrected ______ 0.2 ~~0.3~~ sec/ft
Position:
Decca ______
Radar ______
Vibration Time:
Stop ______
Start ______
Total Elapsed Time ______
Jetting Time:
Stop ______
Start ______
Total Elapsed Time ______

Coring Time	Depth	Core Description	Coring Time	Depth	Core Description
	0	#1 Organic gray soft clayey silt OL		20	
	1			21	
	2			22	
	3	#2 soft gray silty clay CL		23	#7 DO
	4			24	
	5			25	
0.2 ~~0.3~~ sec/ft	6			26	
	7	#3 DO		27	#8 DO, trace shell fragments
	8			28	
	9			29	
	10			30	
	11	#4 DO		31	#9 DO, med. stiff, some fine sand & some shells CL
	12			32	
	13			33	
	14			34	
	15	#5 DO		35	#10 DO 31, dark gray with vegetation
	16			36	
	17			37	No sample recovered
	18			38	
	19	#6 DO		39	
	20			40	

COMMENTS: Virginia State Grid - 470,700 N, 2,700,00 E

ALPINE GEOPHYSICAL ASSOCIATES, INC.
OAK STREET
NORWOOD, NEW JERSEY

Job No. 400-141

Core No. VCR-3 **Date:** 12/2/77 **Area:** Rappa. Shoal Chan. **Grid Position** See Comments

Run No. ______

Penetration 38.7 ft.
Recovery 32.6 ft.
Water Depth:
Uncorrected 45 1115
Tide ______
Corrected ______
Position:
Decca ______
Radar ______
Vibration Time:
Stop ______
Start ______
Total Elapsed Time ______
Jetting Time:
Stop ______
Start ______
Total Elapsed Time ______

Coring Time	Depth	Core Description	Coring Time	Depth	Core Description
	0	#1 Soft gray organic clayey silt, trace fine sand & shell frags. OL		20	#6 DO, trace find sand ML
2	1		2	21	
2	2		2	22	
2	3			23	
2	4	#2 Soft gray silty clay trace fine sand CL	2	24	#7 DO 21, trace shells
2	5		4	25	
2	6		4	26	
4	7		5	27	
2	8	#3 DO except no fine sand CL	5	28	#8 DO 24
2	9		9	29	
2	10		4	30	
2	11		3	31	
2	12	#4 medium stiff gray silty clay CL	4	32	#9 DO 24
2	13		3	33	
2	14		3	34	Assume no recovery below 32 feet
2	15		3	35	
2	16	#5 soft gray clayey silt ML	4	36	
2	17		4	37	
2	18		3	38	
2	19		3	39	
2	20			40	

COMMENTS: Virginia State Grid - 478,800 N, 2,692,900 E

ALPINE GEOPHYSICAL ASSOCIATES, INC.
OAK STREET
NORWOOD, NEW JERSEY

Job No. 400-141

Core No. VRC-4 Date: 12/2/77 Area: Rappa. Shoal Chan. Grid Position See Comments

Run No. ______

Penetration 28.2 ft.
Recovery 28.6 ft.

Water Depth:
Uncorrected ____
Tide ____
Corrected ____

Position:
Decca ____
Radar ____
____ ____

Vibration Time:
Stop ____
Start ____
Total Elapsed Time ____

Jetting Time:
Stop ____
Start ____
Total Elapsed Time ____

Coring Time	Depth	Core Description	Coring Time	Depth	Core Description
—	0	#1 Dark gray clayey silt some fine sand OL	—	20	#6 DO, except stiff
1	1		7	21	
2	2		7	22	
2	3		10	23	
2	4	#2 Light gray fine sand, trace shell fragments, some silt SM	12	24	#7 Gray clayey silt, some fine sand, trace organics, med. stiff ML
2	5		6	25	
2	6		11	26	
6	7		—	27	
7	8	#3 DO	—	28	-28.2 - DO except trace fine sand
5	9		—	29	
2	10		—	30	
3	11		—	31	
10	12		—	32	
11	13	#4 Light brown fine to medium sand, trace gravel	—	33	
10	14		—	34	
10	15		—	35	
12	16	#5 gray silty clay, trace fine sand, medium stiff CH	—	36	
36	17		—	37	
30	18		—	38	
5	19		—	39	
6	20		—	40	

COMMENTS: Virginia State Grid - 485,700 N, 2,687,000 E

ALPINE GEOPHYSICAL ASSOCIATES, INC.
OAK STREET
NORWOOD, NEW JERSEY

Job No. 400-141

Core No. MCC-1A Date: 11/30/77 Area: Baltimore Harbor Grid Position See Comments

Run No. ______

Penetration ____ ft.
Recovery ____ ft.

Water Depth:
Uncorrected 38 11:45
Tide ____
Corrected ____

Position:
Decca ____
Radar ____
____ ____

Vibration Time:
Stop ____
Start ____
Total Elapsed Time ____

Jetting Time:
Stop ____
Start ____
Total Elapsed Time ____

Coring Time	Depth	Core Description	Coring Time	Depth	Core Description
—	0		—	20	
0.2	1		7	21	
0.2	2		14	22	#3 Fine to medium light gray sand, some silt SM
0.2	3		10	23	
0.2	4		8	24	
0.2	5		8	25	
0.2	6		10	26	#4 Light gray fine sand SP
0.2	7		13	27	
0.2	8		12	28	
0.2	9		9	29	
0.2	10		8	30	
1	11		9	31	#5 DO
2	12		10	32	
2	13		11	33	
4	14	#1 Soft gray organic silty clay, trace shells & fine sand OL	12	34	#6 Light brown fine to medium sand, trace gravel, trace silt SP
8	15		10	35	
15	16		8	36	
23	17		11	37	#7 Gravelly fine to coarse sand, light brown SW
15	18	#2 DO	14	38	
13	19		—	39	
10	20		—	40	

COMMENTS: Maryland State Grid - 441,000 N, 973,650 E

ALPINE GEOPHYSICAL ASSOCIATES, INC.
OAK STREET
NORWOOD, NEW JERSEY

Job No. 400-141

Core No. MCC-1B Date: 11/30/77 Area: Baltimore Harbor Grid Position See Comments

Run No. ____

Penetration 36 ft.
Recovery 26 ft.
Water Depth:
Uncorrected 37
13:10
Tide ____
Corrected ____
Position:
Decca ____
Radar ____
Vibration Time:
Stop ____
Start ____
Total Elapsed Time ____
Jetting Time:
Stop ____
Start ____
Total Elapsed Time ____

Depth (ft.)	Coring Time	Core Description
0		#1 Dark gray organic silty clay, trace of sand & shell fragments OL
16		#2 Soft gray silty clay, trace fine sand, trace shells
20		#3 Dark gray, fine to medium silty sand trace shell fragments SM
24		#4 Fine to medium sand, light brown SP
28		#5 DO
32		#6 Fine to medium sand light gray, some fine gravel SP
36		#7 Light brown fine sand, trace silt & mica SP-SM

COMMENTS: Maryland State Grid - 441,000 N, 973,650 E

ALPINE GEOPHYSICAL ASSOCIATES, INC.
OAK STREET
NORWOOD, NEW JERSEY

Job No. 400-141

Core No. MCC-2 Date: 11/30/77 Area: Baltimore Harbor Grid Position See Comments

Run No. ____

Penetration ____ ft.
Recovery ____ ft.
Water Depth:
Uncorrected 24
Tide ____
Corrected ____
Position:
Decca ____
Radar ____
Vibration Time:
Stop ____
Start ____
Total Elapsed Time ____
Jetting Time:
Stop ____
Start ____
Total Elapsed Time ____

Depth (ft.)	Coring Time	Core Description
1	0.2	
7		#1 Soft organic gray silty clay, trace fine sand, trace shells OL
12	0.2	#2 Soft gray silty clay, trace fine sand, trace shell fragments CL
13	0.2	
14	1	
16		#3 DO CL
19	1	
20		#4 DO CL
21	2	
24		#5 DO CL
28		#6 DO
29	2	
30	4	
31	8	
32		#7 Fine to medium sand, some silt, gray SM
33	9	
34	8	
35	25	
36	5	#8 Fine to medium brown sand, trace silt, gray & mica SP-SM
37	5	
38	5	
39	5	
40		DO

COMMENTS: Maryland State Grid - 467,800 N, 972,600 E

ALPINE GEOPHYSICAL ASSOCIATES, INC.
OAK STREET
NORWOOD, NEW JERSEY

Job No. 400-141

Core No. MCC-3 **Date:** 11/29/77 **Area:** Baltimore Harbor **Grid Position** See Comments

Run No. ______

Penetration ___ ft.
Recovery ___ ft.
Water Depth:
Uncorrected 20
Tide ___
Corrected ___
Position:
Decca ___
Radar ___
Vibration Time:
Stop ___
Start ___
Total Elapsed Time 0.35
Jetting Time:
Stop ___
Start ___
Total Elapsed Time ___

Coring Time	Depth	Core Description	Coring Time	Depth	Core Description
	0	#1 Soft dark gray clayey sand, fine to medium trace shells & gravel CL		20	
0.2	1			21	#6 DO
	2			22	
	3			23	
	4			24	
	5	#2 Soft gray silty clay, trace fine sand CL		25	#7 DO
	6			26	
	7		0.2	27	
	8		1	28	
	9	#3 Soft gray silty clay, trace fine sand, trace shells CL		29	#8 DO No recovery below 29'
	10			30	
	11			31	
	12			32	
	13	#4 DO		33	
	14			34	
	15			35	
	16			36	
	17	#5 DO		37	
	18			38	
	19		1	39	
	20			40	

COMMENTS: Maryland State Grid - 490,000 N, 961,500 E

ALPINE GEOPHYSICAL ASSOCIATES, INC.
OAK STREET
NORWOOD, NEW JERSEY

Job No. 400-141

Core No. MCC-4 **Date:** 11/29/77 **Area:** Baltimore Harbor **Grid Position** See Comments

Run No. ______

Penetration ___ ft.
Recovery ___ ft.
Water Depth:
Uncorrected ___
Tide ___
Corrected ___
Position:
Decca ___
Radar ___
Vibration Time:
Stop ___
Start ___
Total Elapsed Time ___
Jetting Time:
Stop ___
Start ___
Total Elapsed Time ___

Coring Time	Depth	Core Description	Coring Time	Depth	Core Description
	0	#1 Soft black organic silt OL		20	
1	1		7	21	
2	2		8	22	
1	3	#2 Brown-gray organic silty clay CL	10	23	#7 DO
2	4		12	24	
1	5		6	25	
2	6	#3 DO - 3'	11	26	
6	7		12	27	#8 DO
7	8		12	28	
5	9			29	
2	10			30	
3	11	#4 Soft gray organic silty clay, trace fine sand CL		31	#9 DO No sample recovered below 31'
10	12			32	
11	13			33	
10	14			34	
10	15	#5 DO 11'		35	
12	16			36	
36	17			37	
30	18			38	
5	19	#6 DO 11'		39	
6	20			40	

COMMENTS: Maryland State Grid - 499,600 N, 939,300 E

ALPINE GEOPHYSICAL ASSOCIATES, INC.
OAK STREET
NORWOOD, NEW JERSEY

Job No. 400-141

Core No. MCC-5 **Date:** 11/29/77 **Area:** Baltimore Harbor **Grid Position** See Comments

Run No. ______

Penetration ____ **ft.**
Recovery ____ **ft.**
Water Depth:
Uncorrected ____
Tide ____
Corrected ____
Position:
Decca ____
Radar ____
____ ____
Vibration Time:
Stop ____
Start ____
Total Elapsed Time ____
Jetting Time:
Stop ____
Start ____
Total Elapsed Time ____

Coring Time	Depth (ft.)	Core Description
	0	#1 Very soft dark gray organic clayey silt Black, trace fine sand OL
1	1	
2	2	
2	3	
3	4	#2 DO
4	5	
4	6	
4	7	
5	8	#3 Light brown-gray silty clay, trace fine sand CL
7	9	
20	10	Pleistocene
22	11	
13	12	#4 Yellow-orange fine sand, some silt SM
20	13	
55	14	
40	15	#5 Hard light gray clay with some pockets of dark brown silty fine sand CH
38	16	
45	17	
45	18	
45	19	
48	20	

Coring Time	Depth (ft.)	Core Description
	20	#6 Hard dark brown clay, trace pockets silty fine sand CH
67	21	
87	22	
90	23	
95	24	
127	25	
140	26	
	27	
	28	
	29	
	30	
	31	
	32	
	33	
	34	
	35	
	36	
	37	
	38	
	39	
	40	

COMMENTS: Maryland State Grid - 517,500 N, 923,000 E

BALTIMORE HARBOR

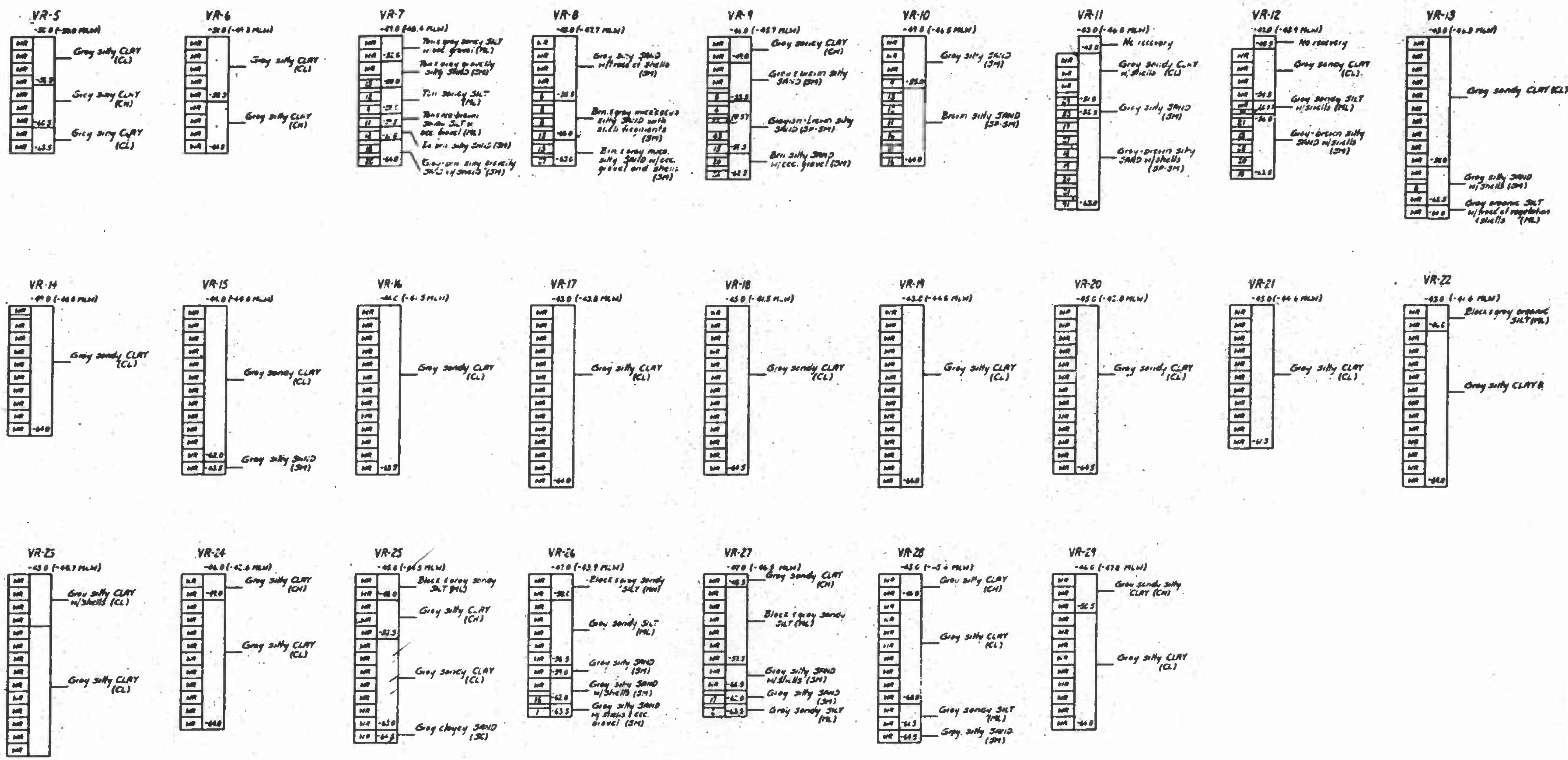
SIDE SCAN

POSSIBLE OBSTRUCTIONS

LOCATION (FIX NO.)	DESCRIPTION
5.5	Port channel - Distance from track line - 156 ft. Size - 10' x 15'
8.5 - 8.6	Port channel - Distance 190 ft. Size - 7'
10.2 - 10.3	Port channel - Distance 160 ft. Size - 10' diameter
26.5 - 27.1	Port channel - Distance 310 ft. Size - 5' x 10'
131.4 - 132.1	Port channel - Distance 300 ft. Size - 10'
133.5 - 133.6	Port channel - Distance 200 ft. Size - 6' x 10'
138.4 - 138.5	Starboard channel - Distance 150 ft. Size - 6' x 10'
149.1 - 149.2	Port channel - Distance 280 ft. Size - 4' x 8'
157.1 - 157.2	Port channel - Distance 100 ft. Size - 3' to 4' Diameter Debris
168.4 - 168.5	Port channel - Distance 200 ft. Size - 7'
182.1 - 182.2	Port channel - Distance 200 ft. Size - 10'
190.1 - 190.2	Port channel - Distance 98 ft. Shipwreck, length 100 ft., 9 ft. high from channel bottom
222.1 - 222.2	Port channel - Distance 25 ft. Size - 38' - possible shipwreck
226.5 - 226.6	Port channel - Distance 230 ft. Size - 35' - could be scarring

LOCATION (FIX NO.)	DESCRIPTION
229.6 - 230.1	Starboard channel - Distance 25 ft. Size - Approx. 12' x 23'
243.2 - 243.2	Starboard channel - Distance 280 ft. Size - 10' x 5'
	Port channel - Distance 180 ft. Size - 10' x 20'
244.2 - 244.3	Port channel - Distance 250 ft. Size - 4' x 10'
244.3 - 244.4	Starboard channel - Distance 110 ft. to 210 ft. Three objects of approx. equal size - 10' x 20'
251.3 - 251.4	Starboard channel - Distance 250 ft. Size - 3'
252.1 - 252.2	Starboard channel - Distance 260 ft. Size - 6' x 10'
252.3 - 252.4	Port channel - Distance 130 ft. Size - 5' x 19'
273.3 - 273.4	Starboard channel - Distance 250 ft. Size - 5' x 20'
283.6 - 284.1	Port channel - Distance 170 ft. Size - 5' x 15'
289.3 - 289.4	Starboard channel - Distance 220 ft. Size - 5' x 20'
293.2 - 293.5	Starboard channel - Distance 240 ft. Size - 10' x 10'
334.1 - 334.2	Port channel - Distance 260 ft. Size - 3' x 6'
350.6 - 351.1	Starboard channel - Distance 84 ft. Size - 4' x 22'
378.5 - 378.6	Port channel - Distance 110 ft. Size - 5' x 10'
379.3 - 379.4	Starboard channel - Distance 50 ft. Size - 10' x 20'

LOCATION (FIX NO.)	DESCRIPTION
383.4 - 383.5	Port channel - Distance 150 ft. Size - 8' x 4'
386.5 - 386.6	Starboard channel - Distance 75 ft. Size - 20' long, possible pipe or tree
388.2 - 388.3	Starboard channel - Distance 80 ft. Size - 20' long, very similar to obstruction 386.5 - 386.6
389.6 - 390.1	Starboard channel - Distance 30 ft. Size - 4' x 6'
404.3 - 404.4	Starboard channel - Distance 20 ft. Possible bottom feature Size - 10' x 20'
405.5 - 405.6	Port channel - Distance 40 ft. Size - 10' x 20', possible wreckage of small boat.
406.6 - 407.1	Starboard channel - Distance 100 ft. Size - 10' x 30', possible wreckage of small boat.
409.3 - 409.4	Port channel - Distance 110 ft. Size - 20' x 20'
411.4 - 411.5	Starboard channel (two objects) Distance 30 ft and 50 ft. Sizes - 4' x 4' and 4' x 10'
424.1 - 424.2	Port channel - Distance 100 ft. Size - 4' x 10'
432.3 - 432.4	Port channel - Distance 300 ft. Size - 10'
440.3 - 440.4	Starboard channel - Distance 60 to 140 ft. Possible anchor line or cable, length 180'
457.5 - 457.6	Starboard channel - Distance 70 ft. Size - 4' x 10'

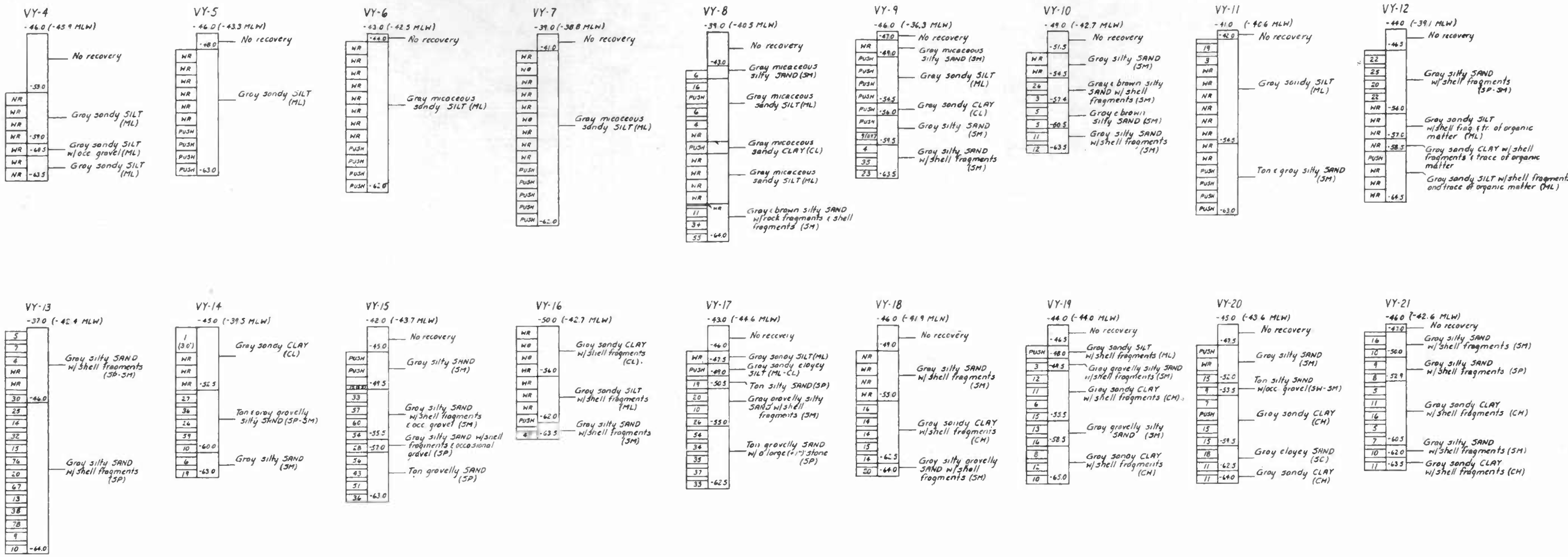


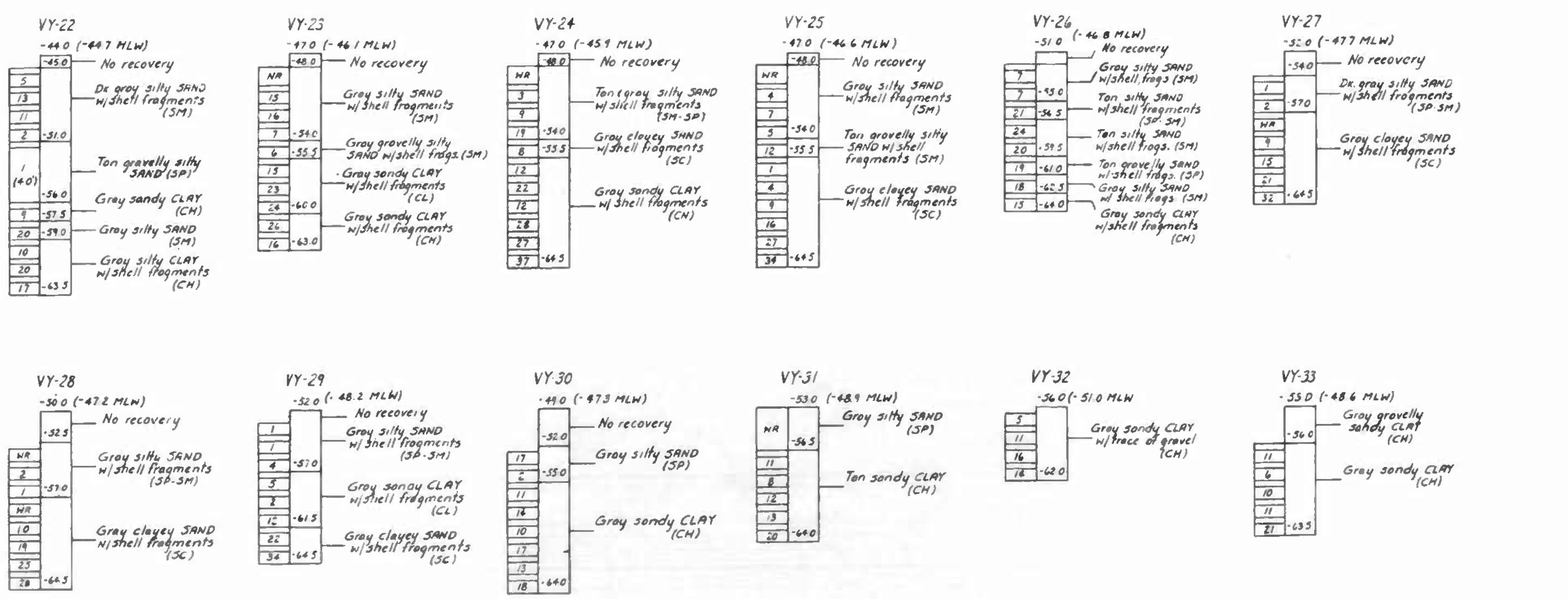
SUBSURFACE EXPLORATION NOTES

1. EXPLORATION WAS PERFORMED DURING AUGUST & SEPTEMBER 1978.
2. DRILL HOLES WERE ACCOMPLISHED BY STANDARD PENETRATION TEST PROCEDURE USING A 1⅜" I.D. x 2'-8" LONG SPLIT SPOON. SAMPLE SPOONS WERE ADVANCED BY A 140# HAMMER FALLING 30". THE COMBINED BLOW COUNTS OF THE LAST FOOT OF EACH 18" STANDARD PENETRATION ARE SHOWN ON THE LOGS UNLESS OTHERWISE INDICATED.
3. WR - INDICATES SPOON WAS ADVANCED BY WEIGHT OF DRILLING RODS
4. SOIL DESCRIPTIONS ARE LABORATORY CLASSIFICATIONS BASED ON THE UNIFIED SOIL CLASSIFICATION SYSTEM (MIL-STD-619B).
5. MEAN LOW WATER (MLW) ELEVATIONS SHOWN ON THE LOGS WERE DETERMINED FROM SURVEY SHEETS FOR THE "SURVEY FOR DEEPENING STUDY" DATED MARCH 1977.
6. FOR LOCATIONS OF SUBSURFACE EXPLORATION SEE SHEET.

DEPARTMENT
BALTIMORE DISTRICT,
BALTIMORE

RAPPAHANNOCK
SHOAL CHANNEL





SUBSURFACE EXPLORATION NOTES

1. EXPLORATION WAS PERFORMED DURING AUGUST 1978
2. DRILL HOLES WERE ACCOMPLISHED BY STANDARD PENETRATION TEST PROCEDURE USING A 1 3/8" I.D × 2'-8" LONG SPLIT SPOON. SAMPLE SPOONS WERE ADVANCED BY A 140# HAMMER FALLING 30" THE COMBINED BLOW COUNTS OF THE LAST FOOT OF DRIVE OF STANDARD PENETRATION ARE SHOWN ON THE LOGS UNLESS OTHERWISE INDICATED
3. WR - INDICATES SPOON WAS ADVANCED BY WEIGHT OF THE DRILLING RODS.
4. PUSH - INDICATES SPOON & RODS WERE HAND PUSHED BY DRILLER TO ADVANCE SPOON
5. SOIL DESCRIPTIONS ARE LABORATORY CLASSIFICATIONS BASED ON THE UNIFIED SOIL CLASSIFICATION SYSTEM (MIL-STD-619B).
6. MEAN LOW WATER (MLW) ELEVATIONS SHOWN ON THE LOGS WERE DETERMINED FROM SURVEY SHEETS FOR THE "SURVEY FOR DEEPENING STUDY" DATED JULY 1975 - JANUARY 1977.
7. FOR LOCATIONS OF SUBSURFACE EXPLORATION SEE SHEET

REV	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

York Spit Channel

DRAWING NUMBER | PLATE
SCALE | DATE | SHEET

ELECTRONIC NAVIGATION SYSTEM

General Operation

To monitor the vessel's location along the survey track lines, a Motorola Mini-Ranger MRS III navigational system was used. This was interfaced with a Hewlett-Packard 9825A computer, which in turn was interfaced with a Hewlett-Packard 9862A plotter.

The Mini-Ranger measures the distance between the vessel and each of the two beacons located ashore. The location of these beacons was precisely determined during the preliminary work. For each fix, the computer converts the two rages into x, y coordinates and moves the pen of the plotter to the corresponding location on a schematic diagram of the survey area on the plotter. In this way the surevy vessel is able to follow the pre-selected survey lines of the schematic, and the quality of the fixes can be monitored. The x, y coordinates of each fix are stored on digital magnetic tape, and the ranges and x, y coordinations are also printed. The time between fixes is controlled by the computer and is usually set to be between 30 and 60 seconds.

The Mini-Ranger operates on the basic principle of pulse radar. The elapsed time between the transmitted interrogation produced by the MRS III transmitter and the reply received from each referemce station is used as the basis for determining the range of each reference station. The standard MRS III operates at line-of-sight ranges up to approximately 37 kilometers, with appropriate calibration, the probable range measurement accuracy is better than 5 meters.

The Hewlett-Packard 9825A is a desk-top programmable computer. It has a 32-character LED display, 16-character thermal strip printer, and a typewriter-like keyboard--all with upper and lower case alphanumeric characters. It also incorporates a built-in two-track tape cartridge drive and 6714 bytes of memory which can be used for both program and/or data storages. Its precision capability is to twelve significant digits. The computer uses a high level programming language developed by Hewlett-Packard called HPL. The machine is so constructed that the instructions comprising a program are used in the same form that they are entered into memory. That is, unlike most other computers, even very large ones, the program does not require translation into another language that the machine can understand. The HP9825A is easily adapted (with the proper interfacing equipment) to communicate with, and/or control almost any device (or several devices) that can accept digital input-output. The HP9862A calculator plotter is an incremental type, having a flat bed plotting area of 25 cm x 28 cm. It is controlled completely by the HP9825A calculator. The programs used by this system in data acquisition and data reduction were all developed at Ocean/Seismic/Survey, Inc.

As noted above, the Mini-Ranger system is capable of ± 5 meter accuracy in range determination. So long as the circles of constant distance from the two beacons intersect at roughly perpendicular angles, the accuracy of positioning system is also ± 5 meters. Where these circles intersect at acute angles, the positioning accuracy deteriorates. In general this happens at points close to a line drawn through the beacons and at points having ranges considerably larger than the distance between the beacons.

Operations Specific to Chesapeake Bay

In most places the pre-existing coordinate system, for various reasons, is not well suited to the configuration required by our equipment and the survey area. Therefore, it is our custom to establish our own coordinate system. This was the case in Chesapeake Bay. We found it necessary and/or convenient to divide the proposed survey area into eight sections, each having its own Ocean/Seismic/Survey coordinate system. However, each of the Ocean/Seismic/Survey coordinate systems is related to the established Lambert system by a pair of simultaneous equations. It is a simple matter, especially with a computer, to convert coordinates of one system to those of another. Table lists, for each section, the Lambert coordinates and the Ocean/Seismic/Survey coordinates of each beacon, and the equations that convert Lambert to Ocean/Seismic/Survey coordinates.

While the Mini-Ranger is in general a very accurate and reliable instrument, it is at times subject to certain vicissitudes of the propagation path. For example, interference between the direct path and the path taken by the reflected (off the "ground") waves can cause erroneous readings.

Also, in a few cases we found that the instrument's capabilities were being pushed to the limit. Specifically, the reference stations have an azimuth angle of 80 degrees; if the survey craft is outside this angle, the quality of the fixes begins to deteriorate. This happened at the extremities of Section II - York Spit Channel and Section V - Brewerton.

There are several methods of dealing with bad position data: The data acquisition software normally averages a number of ranges that are reasonable (ignoring unreasonable values) before calculating x, y coordinates. Or in another mode of operation the computer rapidly prints a large number of range pairs before and after each fix (or even continuously between fixes if necessary). This enables us to monitor the behavior of the Mini-Ranger, and often to correct bad fixes at a later time with a high degree of accuracy. Finally, it is always reasonable, though slightly less accurate, to interpolate between fixes which are known to be good at times when the survey craft was on a constant heading. Any fixes which cannot be retrieved by the above methods are eliminated from the data set.

TABLE 4

Section	#	Identification	Lambert (ft.) (E/X, N/Y)	Lambert (m) (E/X, N/Y)	O/S/S (m) (x, y)	Equations X, Y = Lambert (m) x, y = O/S/S (m)
		BEACONS/REFERENCE POINTS — LOCATION/COORDINATES				
I Cape Henry Channel	1	Tidal BM 3	(2697385.7, 239338.1)	(822163.2, 72950.3)	(606.3, -1537.6)	X = 0.783221x + 0.621743y + 822644.4
	2	Cape Henry Light House (displaced)	(2728500, 225477)	(831646,68726)	(10660, 1049.3)	Y = 0.783221x - 0.621743y + 74531.5
II York Spit Channel	1	SHORAN Tower on Fisherman's Island	(2735085, 288044)	(833654, 87796)	(607, 563)	X = -0.259673x - 0.965697y + 834355.0
	2	Cape Charles Cement Plant Top of Mixing Tower	(2720998, 347745)	(829360, 105993)	(19295, -16)	Y = -0.259673y + 0.965697x + 87355.7
III Rappahanock	1	Windmill Pt. (displaced)	(2642801, 475506)	(805526, 144934)	(-12, 1117)	X = 0.196690x + 0.980466y + 804433.3
	2	Sting Ray Pt. (displaced)	(2637674, 454460)	(803963, 138519)	(5970, -1677)	Y = 0.196690y - 0.980466x + 144702.6
IV Craighill	1	Bodkin Tower	(2160852, 471642)	(658628, 143756)	(7677, 12984)	X = -y + 671611.4
	2	Raydist Tower Sandy Point	(2170297.4, 434703.0)	(661506.6, 132497.5)	(-3581.6, 10104.8)	Y = x + 136079.1
V Brewerton & S. Part of McHenry Ch.	1	Armistead RM-2 (displaced)	(2132266, 501740)	(649915, 152930)	(711,324)	X = 0.739003x + 0.673699y + 649171.12
	2	Rock Point (displaced)	(2148096, 485890)	(654740, 148108)	(7526, 11)	Y = 0.739003y - 0.673699x + 153170.24
VI Curtis Bay Channel & N. Part of McHenry Ch.	1	Fort Carrol Point	(2136143.1, 503579.1)	(651096.4, 153490.1	(-383.2, 1511.6)	X = -0.807799x - 0.589459y+ 651677.91
	2	Pier L 36 of Outer Harbor Bridge	(2136921, 507614)	(651333, 154721)	(150, 378)	Y = -0.807799y + 0.589459x+ 154937.88
VII East Channel of N.W. Branch	1	Young-2	(2118874.4, 525843.3)	(645832.9, 160277.0)	(0, 0)	X = 0.125159x + 0.992137y + 645832.9
	2	Ft. McHenry Sea Wall LXIV8107	(2119377.8, 521851.1)	(645986.4, 159060.2)	(1226.4, 0)	Y = 0.125159y - 0.992137x + 160277.04
VIII West Channel of N.W. Branch	1	FCN	(2121041.4, 522688.9)	(646493.4, 159315.6)	(0, 0)	X = -0.566250x - 0.824234y + 646493.4
	2	Young-2	(2118874.4, 525843.3)	(645832.9, 160277.0)	(1166.5, 0)	Y = -0.566250x + 0.824234y + 159315.6

BEACON LOCATIONS AND THE MATHEMATICAL RELATIONSHIP
LAMBERT AND OCEAN/SEISMIC/SURVEY
COORDINATES

PLAN LEGEND

Existing channel limits

Proposed channel limits

Section line of channel

GEOPHYSICAL DATA

A

Interpolated path taken by survey boat

Known position on survey course

A - Number of position (Fix No.)

Plan location of obstruction determined by side scan sonar survey

BORING DATA

— 3-1/2" diameter vibracore boring made by Ocean/Seismic/Survey, Inc. in 1977 under inspection of Mueser, Rutledge, Wentworth & Johnston.

— Borings made for the Baltimore District, Corps of Engineers.
Series AA made in 1963 (Borings are numbered 1 through 40. Prefix AA is deleted.)
Series JJ, FF & E made in 1964.

— Borings made in 1958 for the Chesapeake Bay-Bridge Tunnel by joint venture of Raymond Concrete Pile Company and Tidewater Construction Company.

— Borings made in 1969 for Baltimore Outer Harbor Crossing by Warren George, Inc.

— Borings made in 1973 for the proposed Route I-95 Ft. McHenry Tunnel crossing of the Patapsco River.

SECTION IDENTIFICATION

A — Letter designation of section

26 — Plate No. showing section

I — Plate No. showing plan

PROFILE LEGEND

• Elevations of bottom at station line of channel from Corps of Engineers condition surveys as noted.

GEOPHYSICAL DATA

Channel bottom along indicated course of survey boat

Sub-bottom reflections along indicated course of survey boat, projected to station line

SSA — Soft sediment area: Determination of sub-bottom interfaces prevented by unconsolidated deposits of unknown thickness

ML — Indicates match line

A,B,C,etc. - See Plate No.I for identification of interfaces

BORING DATA

A - Number and location of boring
- 3-1/2" diameter vibracore boring made in 1977 for this study
- Borings made by Others for various projects

B - For borings made by Others: Number of blows from a hammer free falling 30" required to drive a split spoon sampler one foot unless a specific penetration is indicated
- a) For borings except those made for the Corps of Engineers: 140 lb. hammer, 2" O.D. split spoon
- b) For borings made for the Corps of Engineers: 300 lb. hammer, 3" O.D. split spoon
  - WR - Sample taken under weight of rods
  - WH - Sample taken under weight of rods and hammer

C - For 1977 vibracore borings: Rate of sampler penetration in seconds per foot.

D - Unified Soils Classification of sample where available, or sample description or stratum description.

GENERAL NOTES

1. Plan of channels and coordinate system were drawn by the Baltimore District, Corps of Engineers.
2. Elevation datum is the National Ocean Survey Mean Low Water at channel locality.
3. Coordinate system for the Cape Henry, York Spit and Rappahannock Shoal Channels is the Virginia State Grid (South Zone). Coordinate system for all other channels is the Corps of Engineers grid which is related to the Maryland State Grid as follows:

Corps of Engineers		Maryland State Grid
North Coordinate	=	North Coordinate
East Coordinate	=	East Coordinate + 1,200,000 Ft.

4. Geophysical survey was made by Ocean/Seismic/Survey, Inc. between November 15, 1977 and December 8, 1977 under the inspection of Mueser, Rutledge, Wentworth & Johnston.
5. Sub-bottom reflections are interpretations of seismic data by Ocean/Seismic/Survey, Inc. and may not represent actual conditions. Locations of obstructions were determined by Ocean/Seismic/Survey, Inc.
6. All geophysical survey data shown were drawn by Ocean/Seismic/Survey, Inc.
7. 1977 vibracore borings were made by Ocean/Seismic/Survey, Inc. between November 28 and December 3 under the inspection of Mueser, Rutledge, Wentworth & Johnston. For information concerning borings made by Others, see "Summary of Borings by Others, Table No.3" in Mueser, Rutledge, Wentworth & Johnston report dated
8. Coordinates of 1977 vibracore borings were determined by Ocean/Seismic/Survey, Inc. Elevations were determined by Mueser, Rutledge, Wentworth & Johnston.
9. Sample classifications for 1977 vibracore borings were made by Mueser, Rutledge, Wentworth & Johnston and may not agree with the driller's classifications. Descriptions of materials for all other borings are those of the driller or of the sponsoring organization.
10. Channel bottom depths at station line taken from Norfolk District, Corps of Engineers "Survey for Deepening Study" dated June 30, 1977 and Baltimore District, Corps of Engineers "Condition Survey" dated March, June, August, September, 1977.

BALTIMORE HARBOR AND CHANNELS
50 FT. PROJECT
GEOPHYSICAL FOUNDATION EXPLORATION

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE MARYLAND

MUESER · RUTLEDGE · WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE., NEW YORK, N.Y. 10017

SCALE	MADE BY VK DATE 2/78	FILE NO
None	CH'KD BY FCR DATE 2/78	4864

INFORMATION DRAWING — DRAWING NO. I-1

NOTES

1. BASE PLAN TAKEN FROM NOAA CHART NO. 12273, TITLED "CHESAPEAKE BAY, SANDY POINT TO SUSQUEHANNA RIVER" DATED OCTOBER 29, 1977
2. MAP SHOWS EXISTING DIMENSIONS AND DEPTHS OF CHANNELS ONLY.
3. MAIN SHIP CHANNEL CONSISTS OF:
   - CRAIGHILL SECTION
   - CRAIGHILL - CUTOFF ANGLE
   - CUTOFF SECTION
   - CUTOFF - BREWERTON ANGLE
   - BREWERTON SECTION
   - BREWERTON - FT. McHENRY ANGLE
   - FT. McHENRY SECTION

SCALE: 1:80,000
(1" = Approx. 6,700 Ft.)

BALTIMORE HARBOR AND CHANNELS
50 FT. PROJECT
GEOPHYSICAL FOUNDATION EXPLORATION

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE MARYLAND

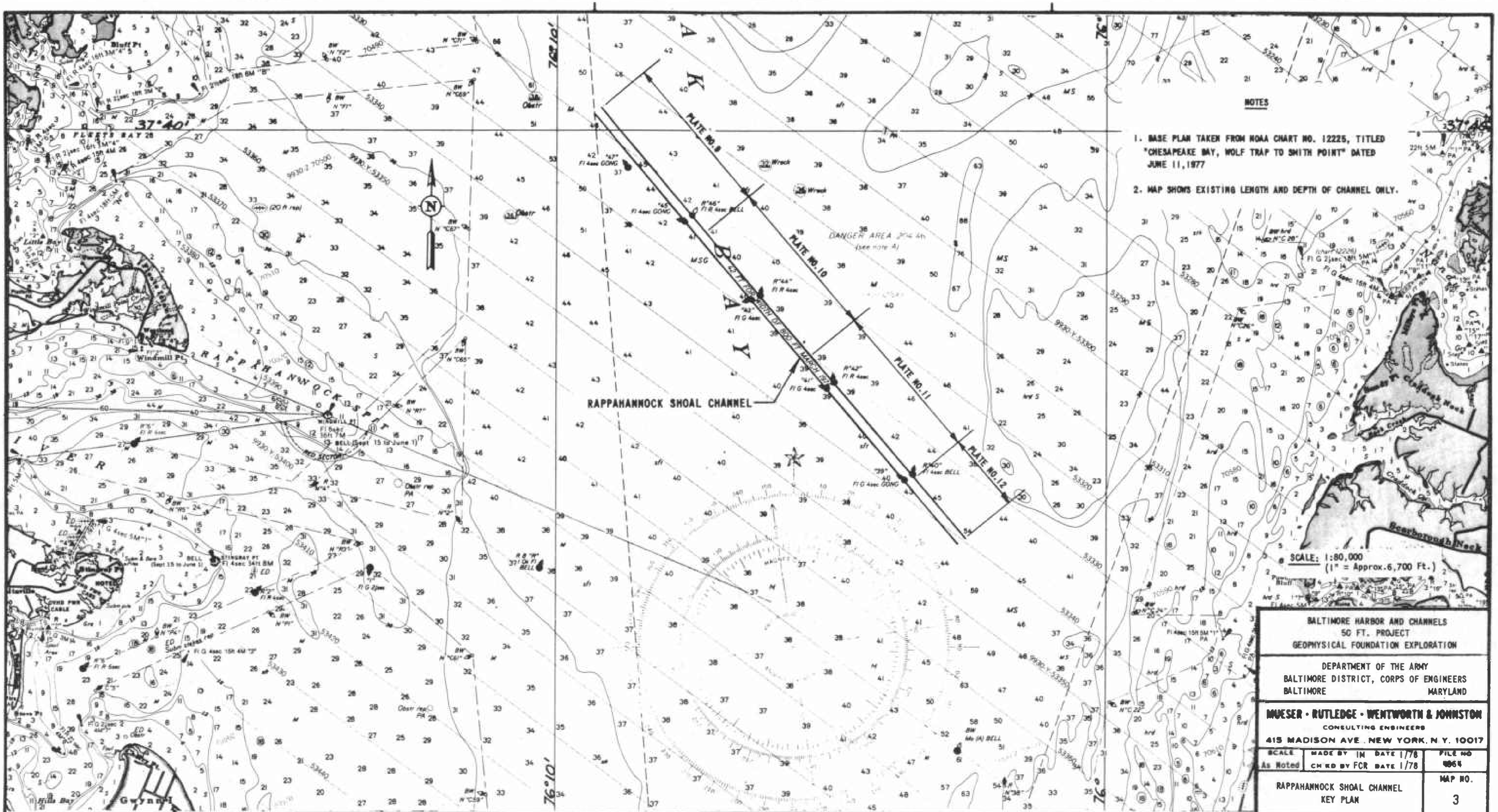
MUESER · RUTLEDGE · WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE. NEW YORK, N.Y. 10017

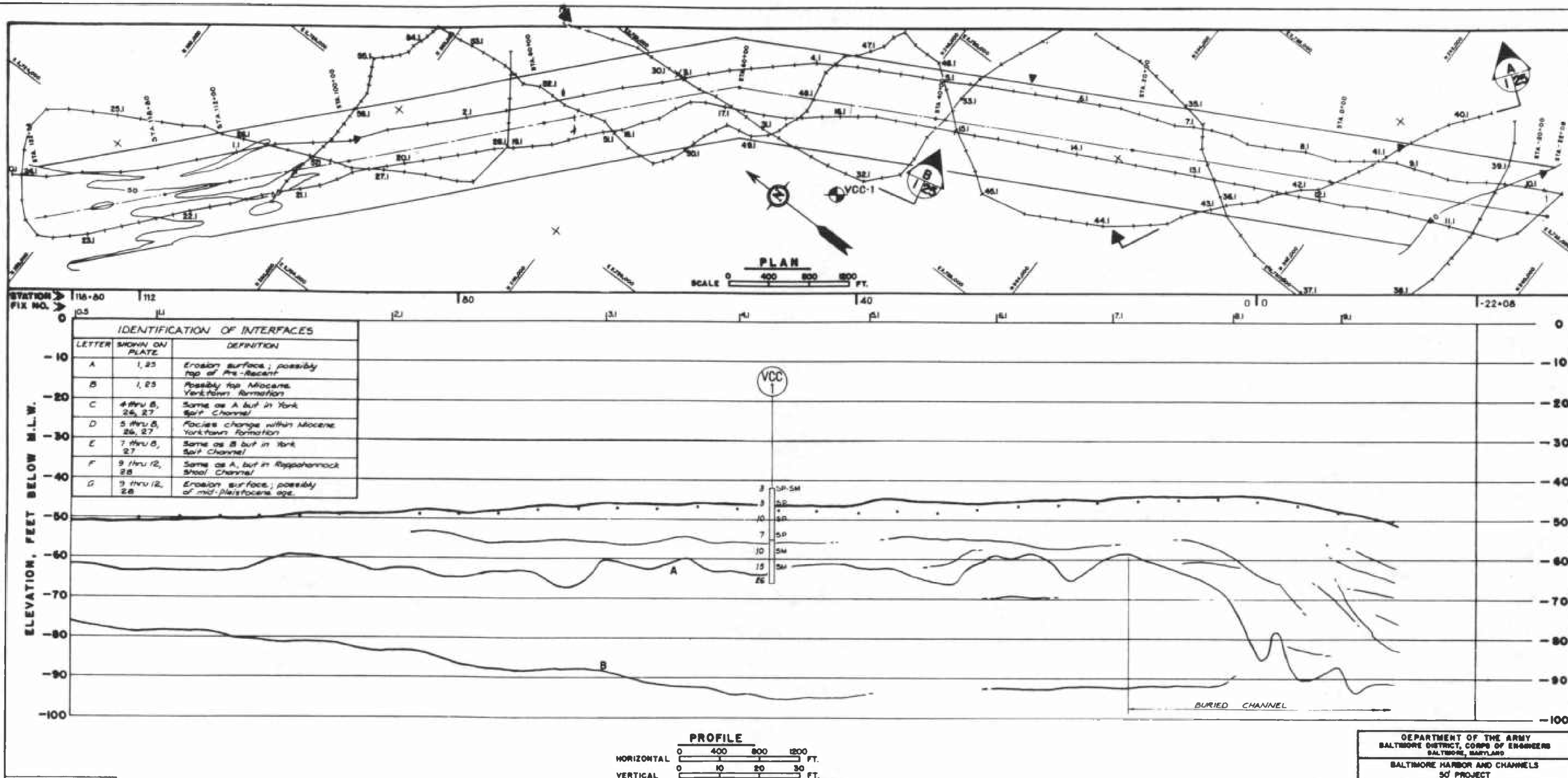
SCALE	MADE BY	DATE	FILE NO.
As Noted	JM	1/78	[illegible]
	CH'KD BY FCR	1/78	

MARYLAND CHANNELS
KEY PLAN

MAP NO.: 1


NOTES
1. BASE PLAN TAKEN FROM NOAA CHART NO. 12221, TITLED "CHESAPEAKE BAY ENTRANCE" DATED MAY 28, 1977
CHESAPEAKE BAY
CAPE CHARLES
CAPE HENRY CHANNEL
YORK SPIT CHANNEL
CHESAPEAKE CHANNEL
NORTH CHANNEL
INNER MIDDLE GROUND
Latimer Shoal
Old Plantation Flats
PLATE NO.1
PLATE NO.2
PLATE NO.3
PLATE NO.4
PLATE NO.5
PLATE NO.6
PLATE NO.7
PLATE NO.8
PROPOSED LENGTH OF CHANNEL, TYPICAL
37°10'
76°10'
SCALE: 1:80,000
(1" = Approx. 6,700 Ft.)
BALTIMORE HARBOR AND CHANNELS
50 FT. PROJECT
GEOPHYSICAL FOUNDATION EXPLORATION
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE MARYLAND
MUESER · RUTLEDGE · WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE., NEW YORK, N.Y. 10017
SCALE As Noted
CH'KD BY FCR
CAPE HENRY & YORK SPIT CHANNEL KEY PLAN
MAP NO. 2


NOTES
1. BASE PLAN TAKEN FROM NOAA CHART NO. 12225, TITLED "CHESAPEAKE BAY, WOLF TRAP TO SMITH POINT" DATED JUNE 11, 1977
2. MAP SHOWS EXISTING LENGTH AND DEPTH OF CHANNEL ONLY.
SCALE: 1:80,000
(1" = Approx. 6,700 Ft.)
RAPPAHANNOCK SHOAL CHANNEL
PLATE NO. 9
PLATE NO. 10
PLATE NO. 11
PLATE NO. 12
RAPPAHANNOCK SPIT
FLEETS BAY
Windmill Pt.
DANGER AREA
37°40'
76°10'
BALTIMORE HARBOR AND CHANNELS
50 FT. PROJECT
GEOPHYSICAL FOUNDATION EXPLORATION
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE MARYLAND
MUESER · RUTLEDGE · WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE. NEW YORK, N.Y. 10017
SCALE As Noted
MADE BY IN DATE 1/78
CH'KD BY FCR DATE 1/78
FILE NO
RAPPAHANNOCK SHOAL CHANNEL
KEY PLAN
MAP NO. 3



IDENTIFICATION OF INTERFACES

LETTER	SHOWN ON PLATE	DEFINITION
A	1, 25	Erosion surface; possibly top of Pre-Recent
B	1, 25	Possibly top Miocene Yorktown Formation
C	4 thru 8, 26, 27	Same as A but in York Spit Channel
D	5 thru 8, 26, 27	Facies change within Miocene Yorktown Formation
E	7 thru 8, 27	Same as B but in York Spit Channel
F	9 thru 12, 28	Same as A, but in Rappahannock Shoal Channel
G	9 thru 12, 28	Erosion surface; possibly of mid-Pleistocene age.

M.R.W.&J. File No. 4864

NOTES

1 For General Notes and Legends see Information Dwg. No. I-1

REVISIONS AND ADDITIONS		
DATE	BY	DESCRIPTIONS

DRAWN HJM & CO DATE 2-13-78

CHECKED FCR. DATE 2-15-78

OCEAN / SEISMIC / SURVEY, INC.

TO OAK STREET NORWOOD, N.J. 07647

MUESER, RUTLEDGE, WENTWORTH & JOHNSTON

CONSULTING ENGINEERS

415 MADISON AVE. NEW YORK, N.Y. 10017

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

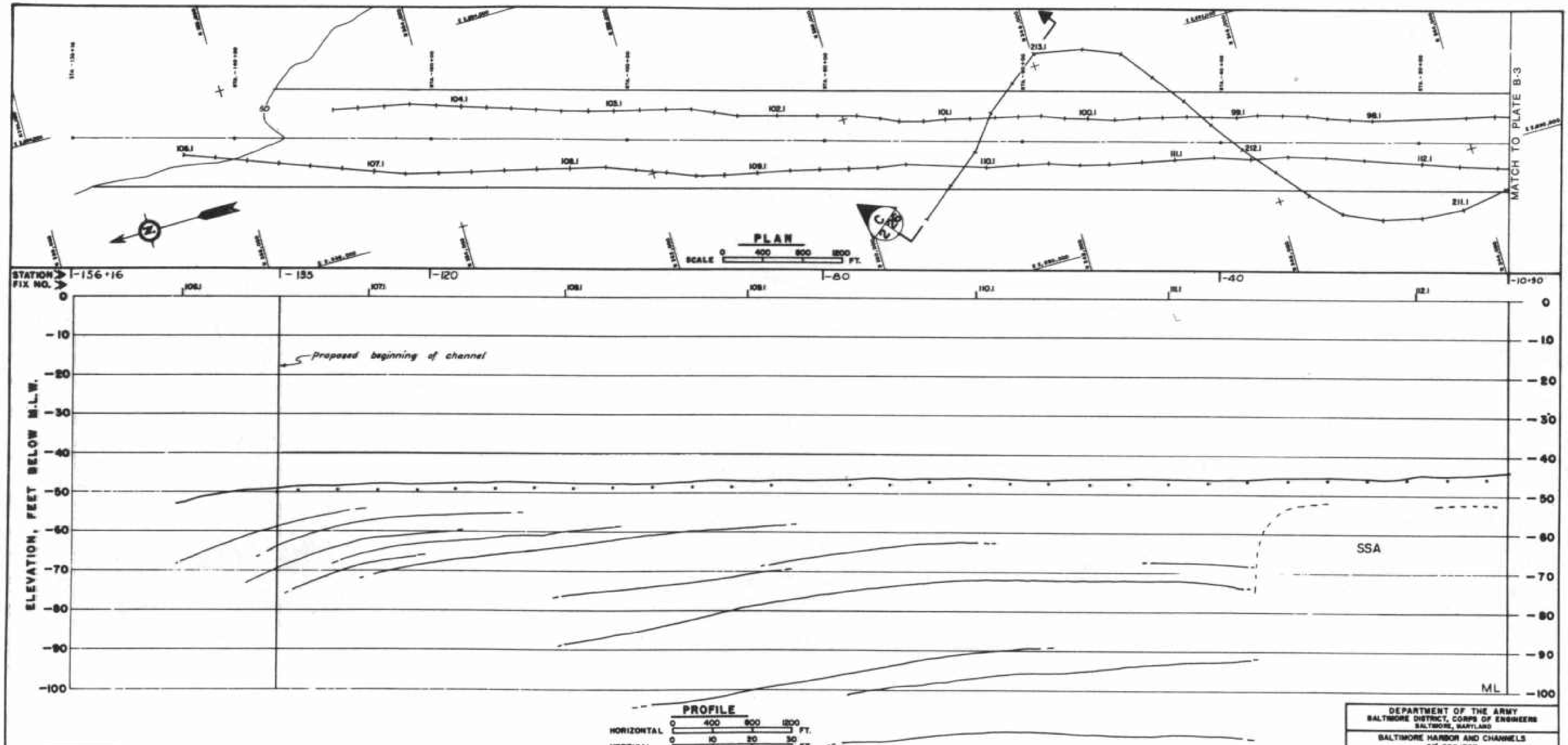
BALTIMORE HARBOR AND CHANNELS
50' PROJECT

GEOPHYSICAL FOUNDATION EXPLORATION

CAPE HENRY CHANNEL

PLATE 1

PLATE B-1



M.R.W.&J. File No. 4864

NOTES
1. For General Notes and Legends see Information Dwg. No. I-1

REVISIONS AND ADDITIONS		
DATE	BY	DESCRIPTIONS

DRAWN H.I.M. & C.D. DATE 2-15-7[illegible]
CHECKED F.C.R. DATE 2-15-7[illegible]

OCEAN / SEISMIC / SURVEY, INC.
70 OAK STREET NORWOOD, N.J. 07647

MUESER, RUTLEDGE, WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE NEW YORK, N.Y. 10017

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

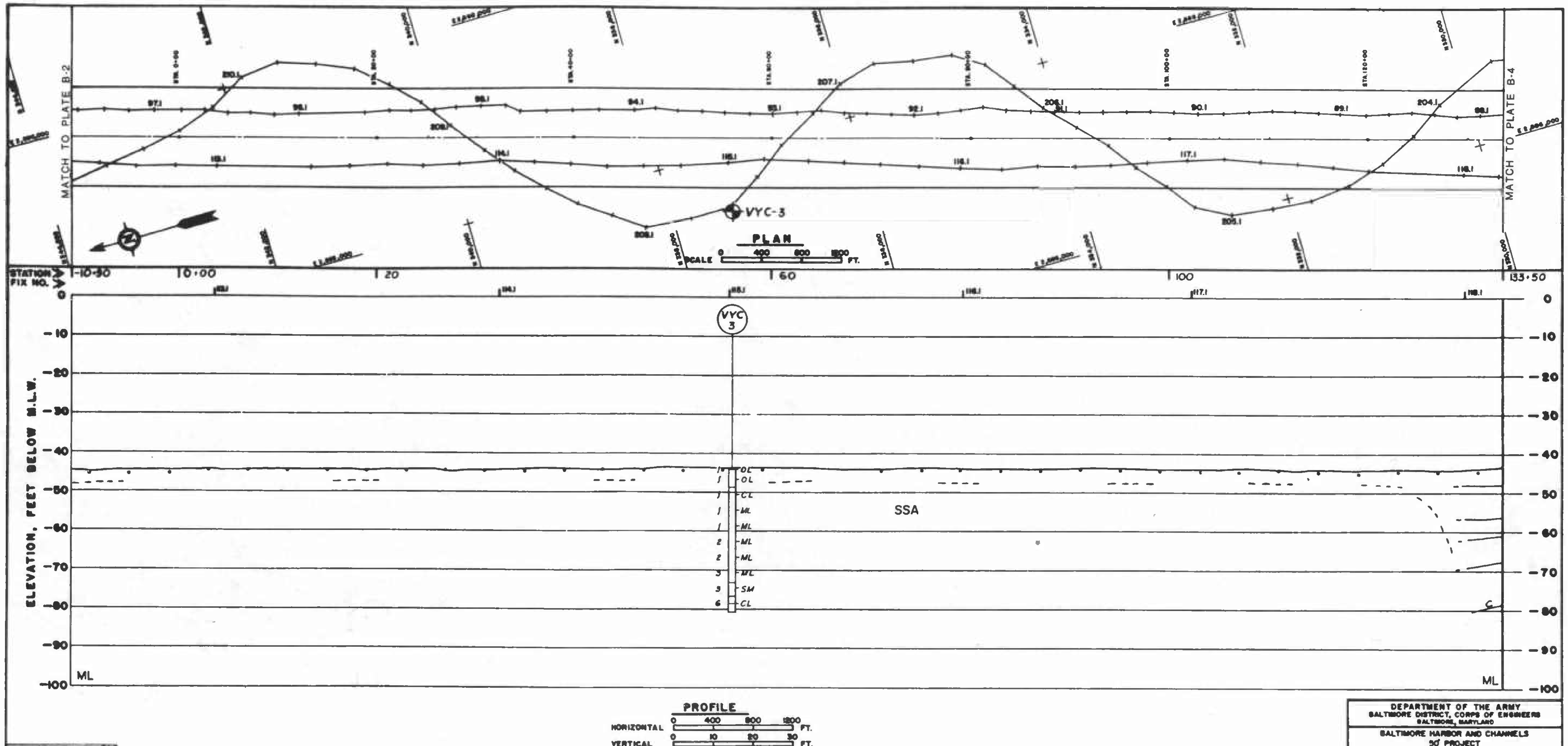
BALTIMORE HARBOR AND CHANNELS
50' PROJECT

GEOPHYSICAL FOUNDATION EXPLORATION

YORK SPIT CHANNEL

PLATE 2

PLATE B-2



M.R.W.&J. File No. 4864

NOTES

1. For General Notes and Legends see Information Dwg. No. I-1

DATE	BY	REVISIONS AND ADDITIONS DESCRIPTIONS

DRAWN H.M. & C.D. DATE 2-13-78

CHECKED F.C.P. DATE 2-15-78

OCEAN / SEISMIC / SURVEY, INC.
70 OAK STREET NORWOOD, N.J. 07647

MUESER, RUTLEDGE, WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE. NEW YORK, N.Y. 10017

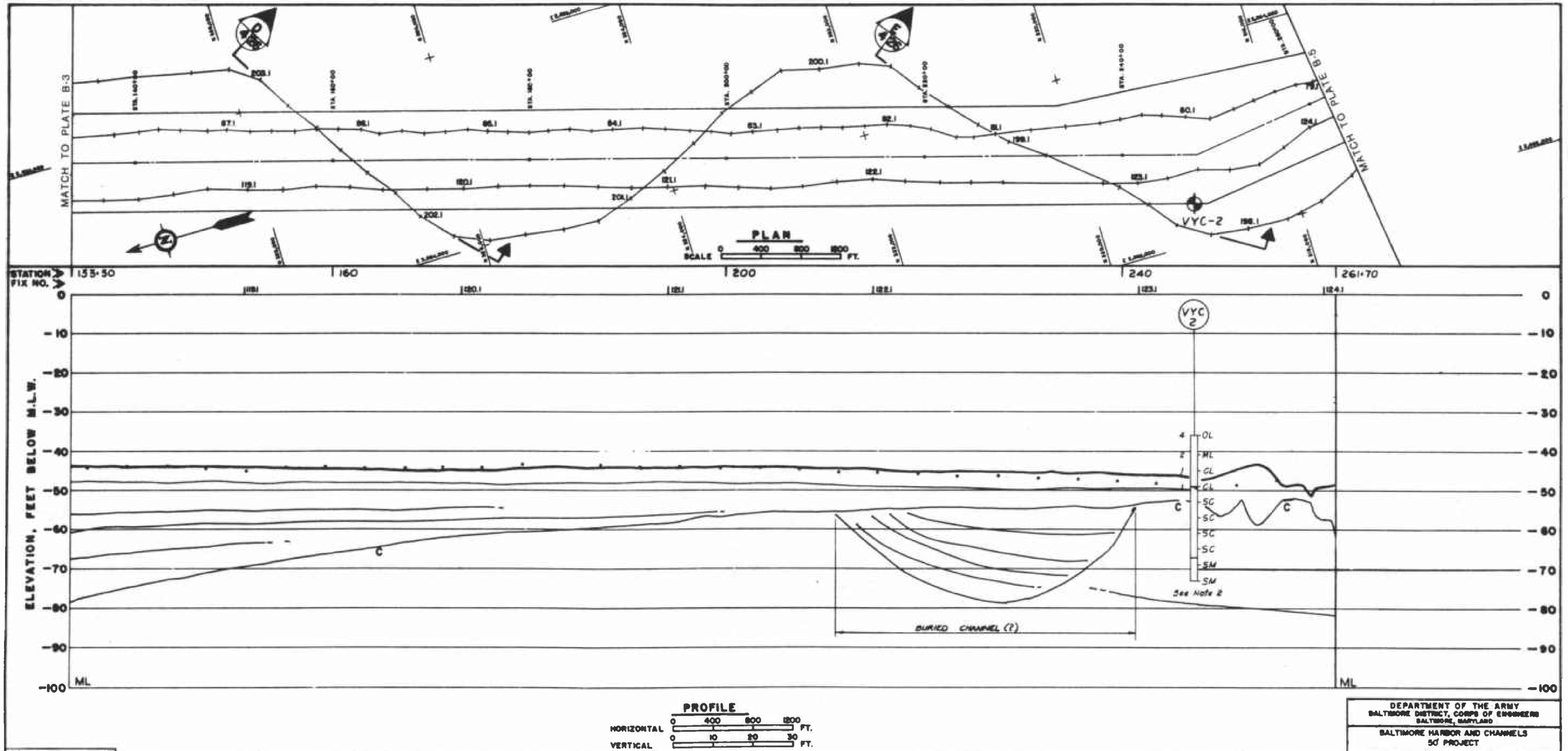
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

BALTIMORE HARBOR AND CHANNELS
50' PROJECT

GEOPHYSICAL FOUNDATION EXPLORATION

YORK SPIT CHANNEL

PLATE 3



M.R.W.&J. File No. 4864

NOTES

1. For General Notes and Legends see Information Drawing No. I-1
2. Chain recording rate of penetration broke at depth 16'. Rate of penetration below this depth not available.

REVISIONS AND ADDITIONS		
DATE	BY	DESCRIPTIONS

DRAWN HJK&CO DATE 2-13-78

CHECKED FCR DATE 2-14-78

OCEAN / SEISMIC / SURVEY, INC.
70 OAK STREET NORWOOD, N.J. 07647

MUESER, RUTLEDGE, WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE. NEW YORK, N.Y. 10017

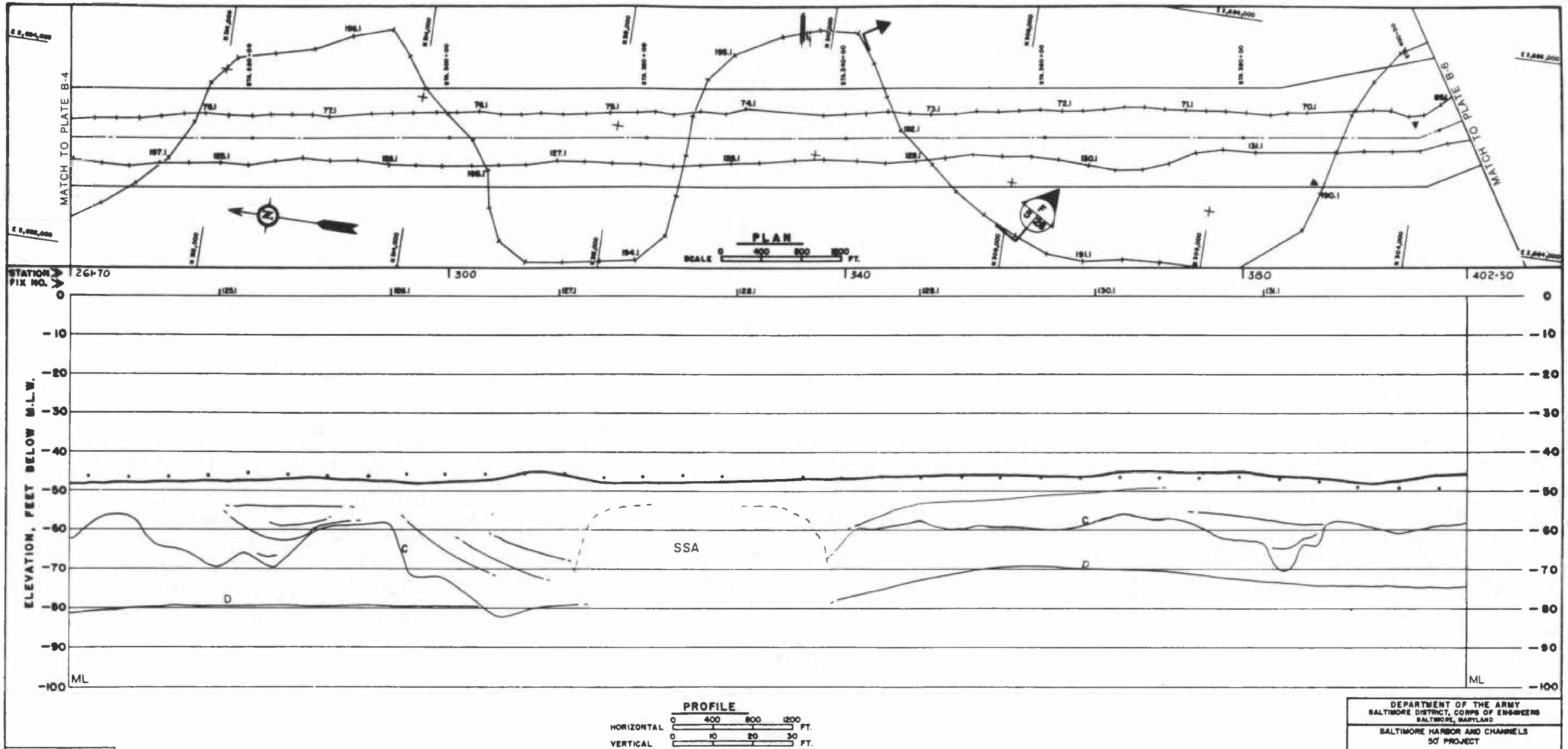
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

BALTIMORE HARBOR AND CHANNELS
50' PROJECT

GEOPHYSICAL FOUNDATION EXPLORATION

YORK SPIT CHANNEL

PLATE 4



M.R.W.&J. File No. 4864

NOTES

1. *For General Notes and Legends see Information Drawing No. I-1*

REVISIONS AND ADDITIONS		
DATE	BY	DESCRIPTIONS

DRAWN *H.I.M. & CO* DATE *8-13-79*

CHECKED *F.C.R.* DATE *8-14-79*

OCEAN / SEISMIC / SURVEY, INC.

70 OAK STREET NORWOOD, N.J. 07647

MUESER, RUTLEDGE, WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE. NEW YORK, N.Y. 10017

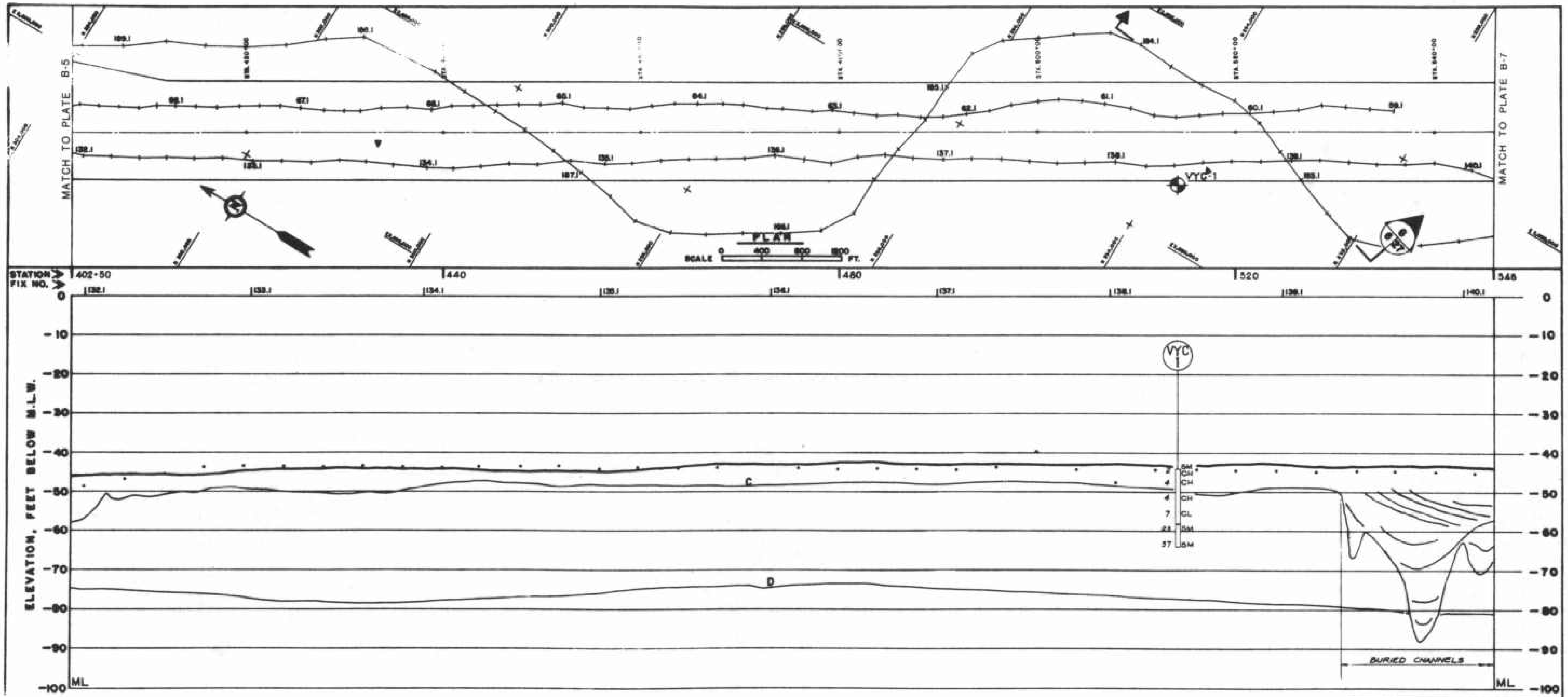
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

BALTIMORE HARBOR AND CHANNELS
50' PROJECT

GEOPHYSICAL FOUNDATION EXPLORATION

YORK SPIT CHANNEL

PLATE 5



M.H.W.L. File No. 4864

NOTES

1. For General Notes and Legends see Information Drawing No. I-1

REVISIONS AND ADDITIONS		
DATE	BY	DESCRIPTIONS

DRAWN H.M.&CO. DATE [illegible]

CHECKED F.C.R. DATE [illegible]

OCEAN / SEISMIC / SURVEY, INC.
70 OAK STREET NORWOOD, N.J. 07647

MUESER, RUTLEDGE, WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE. NEW YORK, N.Y. 10017

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

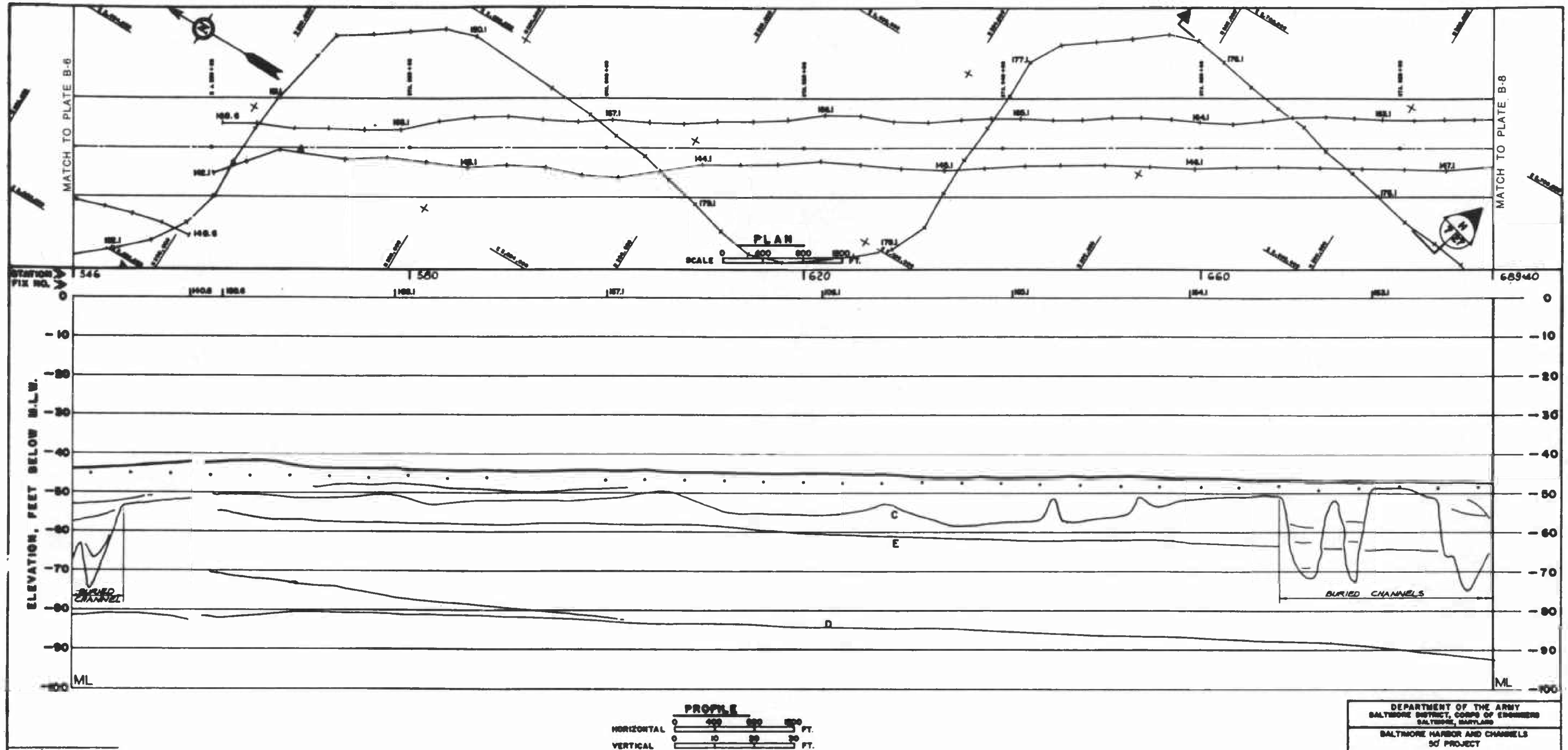
BALTIMORE HARBOR AND CHANNELS
50' PROJECT

GEOPHYSICAL FOUNDATION EXPLORATION

YORK SPIT CHANNEL

PLATE 6

PLATE B-6



M.R.W.&J. File No. 4864

NOTES
1. For General Notes and Legends see Information Drawing No. I-1.

DATE	BY	REVISIONS AND ADDITIONS DESCRIPTIONS

DRAWN HJM & CD DATE 2-13-74
CHECKED FCR DATE 2-14-74

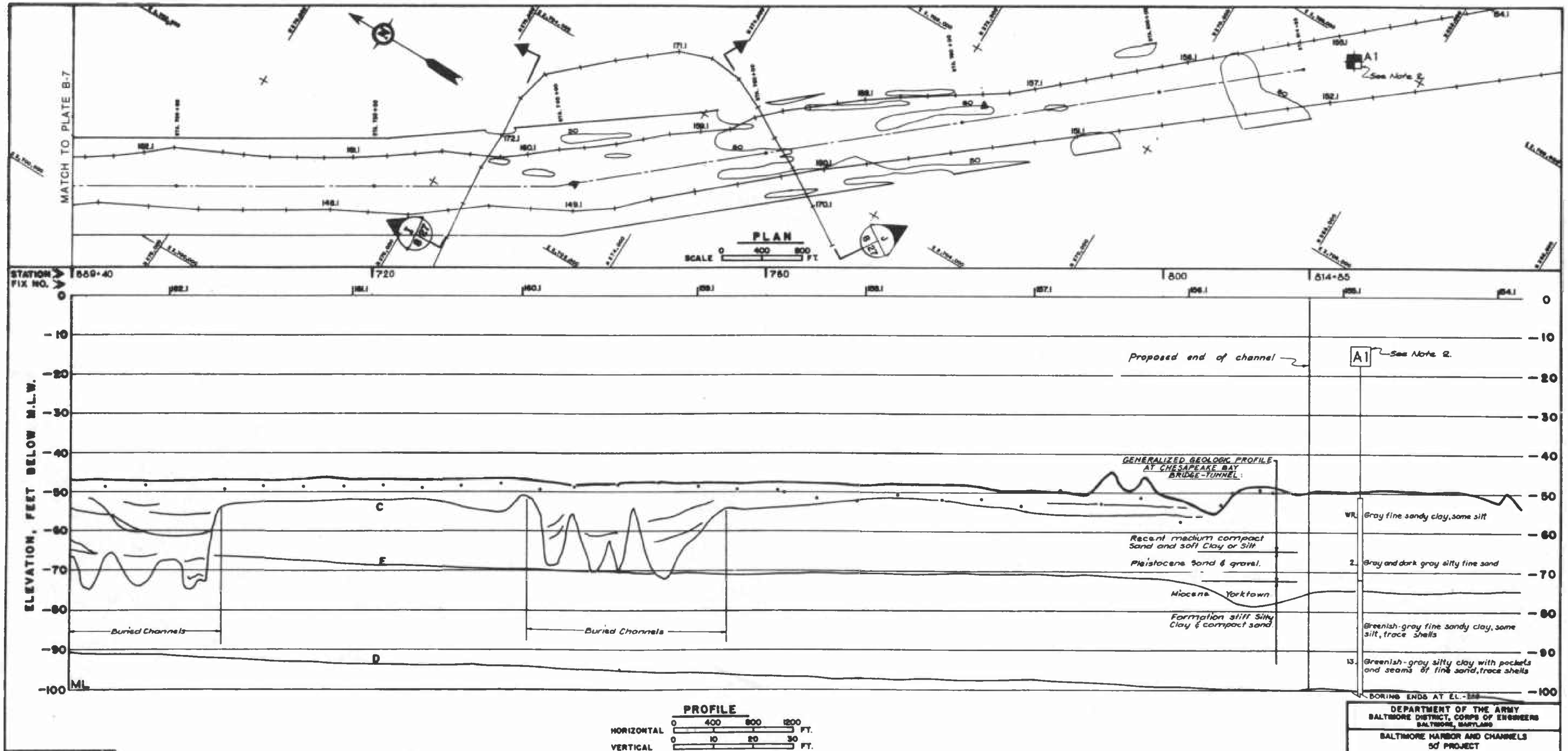
OCEAN / SEISMIC / SURVEY, INC.
70 OAK STREET NORWOOD, N.J. 07647

MUESER, RUTLEDGE, WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE. NEW YORK, N.Y. 10017

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

BALTIMORE HARBOR AND CHANNELS
50' PROJECT
GEOPHYSICAL FOUNDATION EXPLORATION
YORK SPIT CHANNEL

PLATE 7



M.R.W.&J. File No. 4864

NOTES

1. For General Notes and Legends see Information Drawing No. I-1
2. Boring No. A1 projected on Plan and Section 2025 ft. north and 950 ft. west of actual location. Actual coordinates are N 266,650 ; E 2,708,800.

REVISIONS AND ADDITIONS		
DATE	BY	DESCRIPTIONS

DRAWN HJM & CD DATE 2-13-78

CHECKED F.C.R. DATE 2-14-78

OCEAN / SEISMIC / SURVEY, INC.
70 OAK STREET NORWOOD, N.J. 07647

MUESER, RUTLEDGE, WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE. NEW YORK, N.Y. 10017

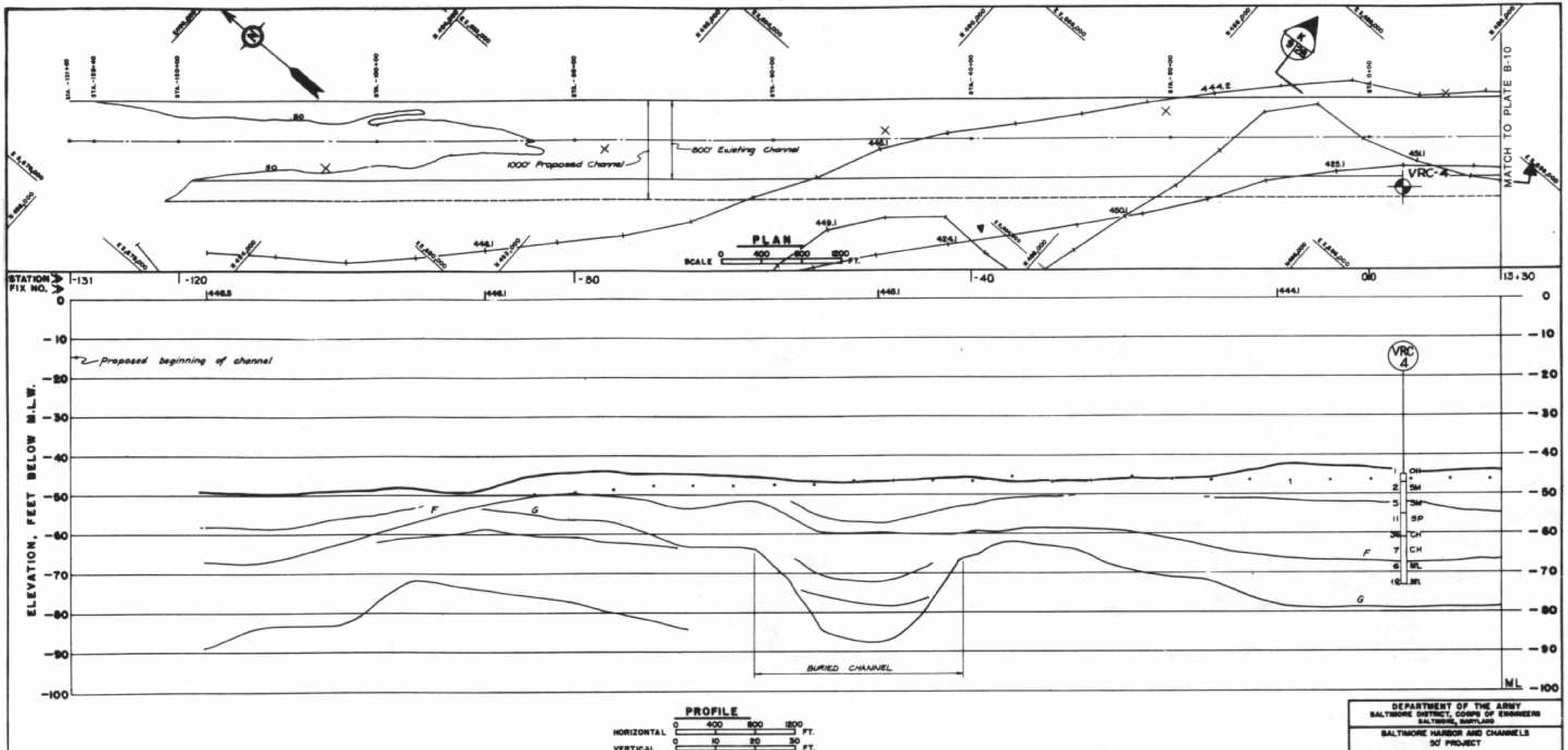
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

BALTIMORE HARBOR AND CHANNELS
50' PROJECT

GEOPHYSICAL FOUNDATION EXPLORATION

YORK SPIT CHANNEL

PLATE 8



M.R.W.&J. File No. 4864

NOTES
1. For General Notes and Legends see Information Drawing No. I-1

REVISIONS AND ADDITIONS		
DATE	BY	DESCRIPTIONS

DRAWN K.J.M.& C.D. DATE 2-13-78

CHECKED F.C.R. DATE 2-15-78

OCEAN / SEISMIC / SURVEY, INC.
70 OAK STREET NORWOOD, N.J. 07647

MUESER, RUTLEDGE, WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE. NEW YORK, N.Y. 10017

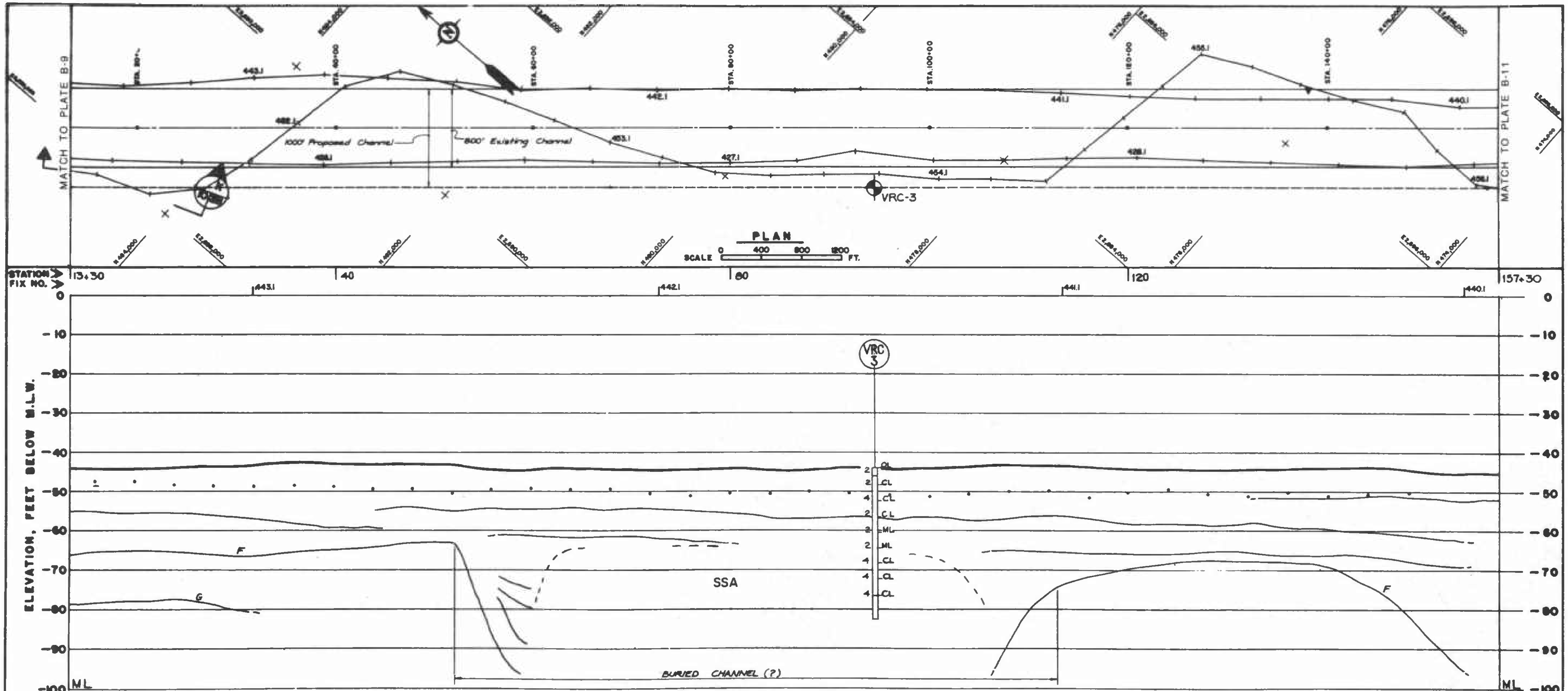
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

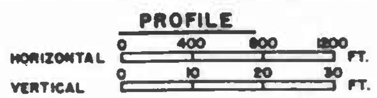
BALTIMORE HARBOR AND CHANNELS
50' PROJECT

GEOPHYSICAL FOUNDATION EXPLORATION
RAPPAHANNOCK SHOAL CHANNEL

PLATE 9

PLATE B-9





M.R.W.&J. File No. 4864

NOTES
For General Notes and Legends see Information Drawing No. I-1

REVISIONS AND ADDITIONS		
DATE	BY	DESCRIPTIONS

DRAWN H.J.M.&C.D. DATE 2-13-78
CHECKED F.C.R. DATE 2-15-78

OCEAN / SEISMIC / SURVEY, INC.
70 OAK STREET NORWOOD, N.J. 07647

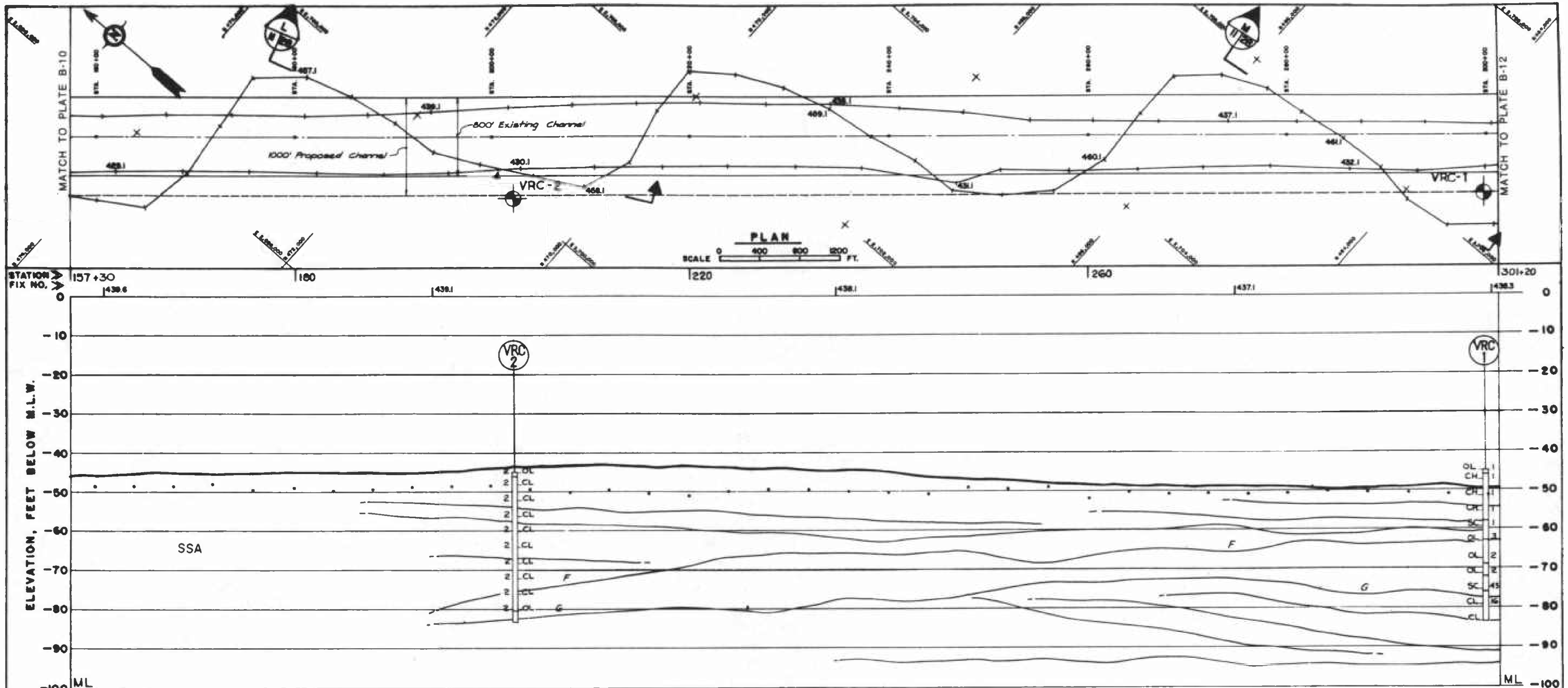
MUESER, RUTLEDGE, WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE. NEW YORK, N.Y. 10017

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

BALTIMORE HARBOR AND CHANNELS
50' PROJECT

GEOPHYSICAL FOUNDATION EXPLORATION
RAPPAHANNOCK SHOAL CHANNEL

PLATE 10



M.R.W.&J. File No. 4864

NOTES
1. For General Notes and Legends see Information Drawing No. I-1

REVISIONS AND ADDITIONS		
DATE	BY	DESCRIPTIONS

DRAWN H.J.M.&C.D. DATE 2-13-78

CHECKED F.C.R. DATE 2-15-78

OCEAN / SEISMIC / SURVEY, INC.
70 OAK STREET NORWOOD, N.J. 07647

MUESER, RUTLEDGE, WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE. NEW YORK, N.Y. 10017

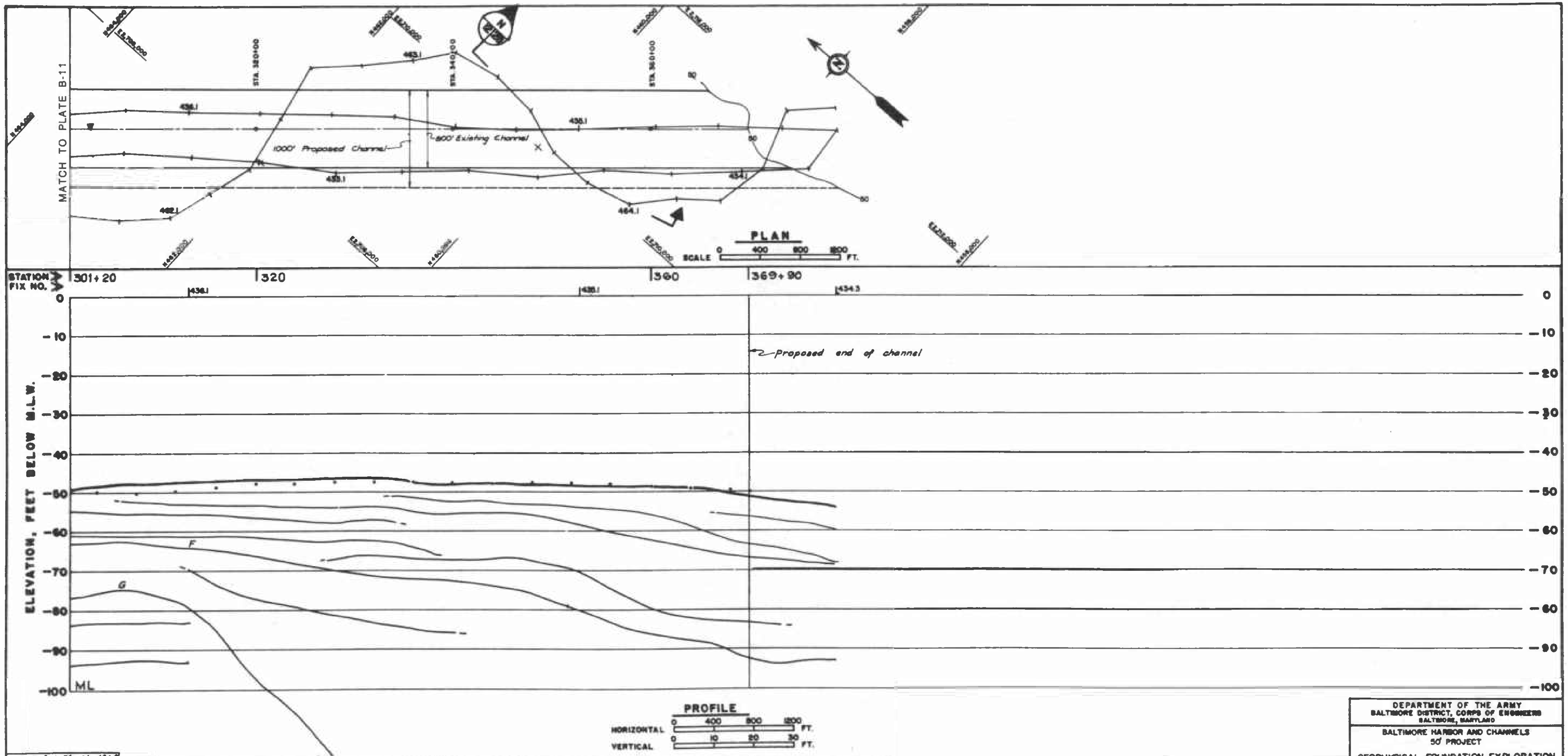
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

BALTIMORE HARBOR AND CHANNELS
50' PROJECT

GEOPHYSICAL FOUNDATION EXPLORATION
RAPPAHANNOCK SHOAL CHANNEL

PLATE 11

PLATE B-11



M.R.W.& J. File No. 4864

NOTES

1. For General Notes and Legends see Information Drawing No. I-1

REVISIONS AND ADDITIONS		
DATE	BY	DESCRIPTIONS

DRAWN N.J.M.&C.D. DATE 2-15-78

CHECKED F.C.R. DATE 2-15-78

OCEAN / SEISMIC / SURVEY, INC.
70 OAK STREET NORWOOD, N.J. 07647

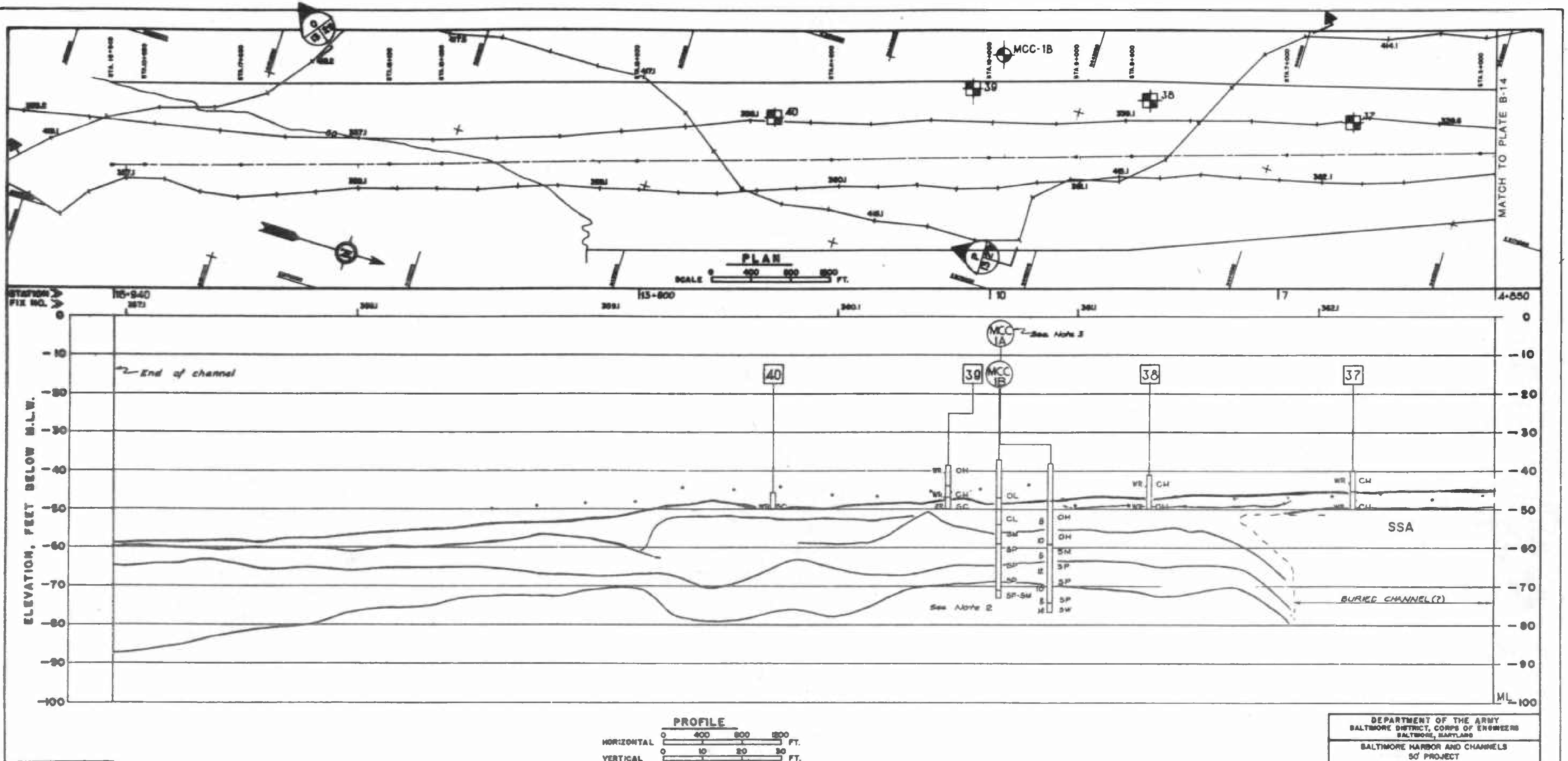
MUESER, RUTLEDGE, WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE. NEW YORK, N.Y. 10017

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

BALTIMORE HARBOR AND CHANNELS
50' PROJECT

GEOPHYSICAL FOUNDATION EXPLORATION
RAPPAHANNOCK SHOAL CHANNEL

PLATE 12



M.R.W.&J File No. 4864

NOTES
1. For General Notes and Legend see Information Drawing No. I-1.
2. Sampling barrel penetration purposely slowed by winch.
3. Coordinates of Boring No. MCC-1A were not determined in field. Boring was made within 50 feet of Boring No. MCC-1B.

REVISIONS AND ADDITIONS		
DATE	BY	DESCRIPTIONS

DRAWN HJK & CD DATE 2-13-74

CHECKED F.C.R. DATE 2-14-74

OCEAN / SEISMIC / SURVEY, INC.
70 OAK STREET NORWOOD, N.J. 07647

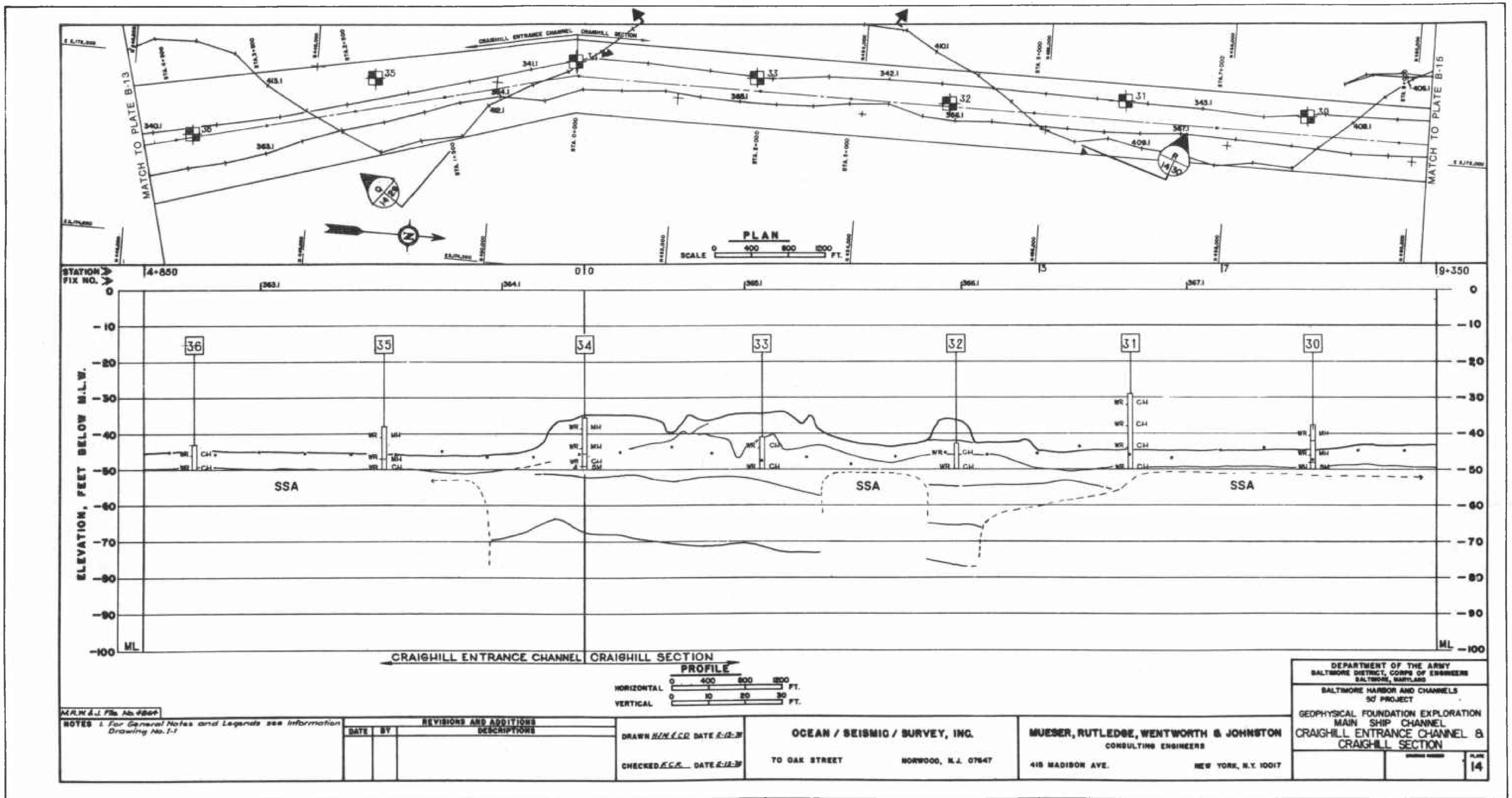
MUESER, RUTLEDGE, WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE. NEW YORK, N.Y. 10017

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

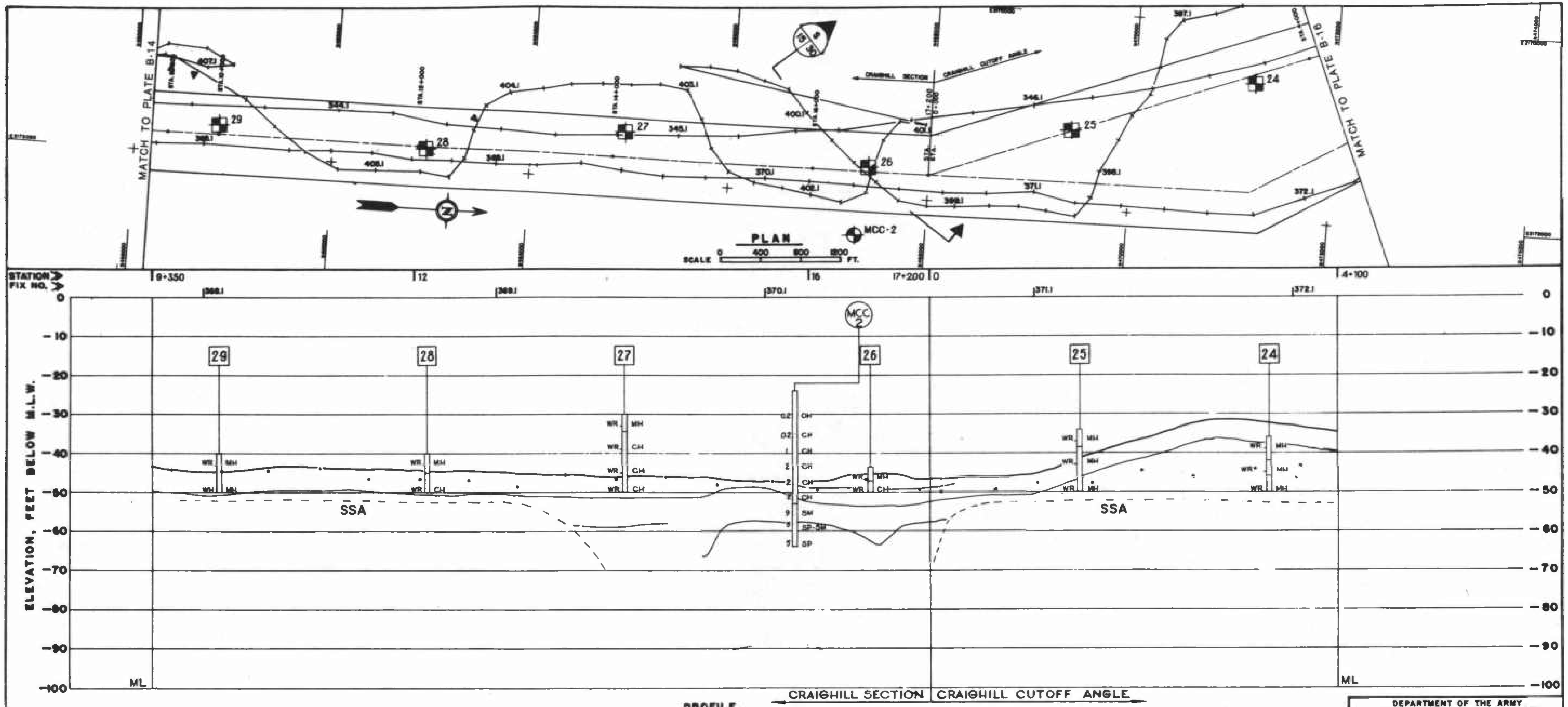
BALTIMORE HARBOR AND CHANNELS
50' PROJECT

GEOPHYSICAL FOUNDATION EXPLORATION
CRAIGHILL ENTRANCE CHANNEL

PLATE 13



CRAIGHILL ENTRANCE CHANNEL
CRAIGHILL SECTION
MATCH TO PLATE B-13
MATCH TO PLATE B-15
PLAN
SCALE 0 400 800 1200 FT.
36
35
34
33
32
31
30
STATION
FIX NO.
14+850
0+0
15
17
19+350
363.1
364.1
365.1
366.1
367.1
ELEVATION, FEET BELOW M.L.W.
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
ML
WR
CH
MH
SM
SSA
SSA
SSA
CRAIGHILL ENTRANCE CHANNEL | CRAIGHILL SECTION
PROFILE
HORIZONTAL 0 400 800 1200 FT.
VERTICAL 0 10 20 30 FT.
M.R.W.&J. File No. 4864
NOTES 1. For General Notes and Legends see Information Drawing No. I-1
REVISIONS AND ADDITIONS
DATE
BY
DESCRIPTIONS
DRAWN H.H. & C.D. DATE 2-12-31
CHECKED F.C.R. DATE 2-12-31
OCEAN / SEISMIC / SURVEY, INC.
TO OAK STREET NORWOOD, N.J. 07647
MUESER, RUTLEDGE, WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE. NEW YORK, N.Y. 10017
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND
BALTIMORE HARBOR AND CHANNELS
50' PROJECT
GEOPHYSICAL FOUNDATION EXPLORATION
MAIN SHIP CHANNEL
CRAIGHILL ENTRANCE CHANNEL &
CRAIGHILL SECTION
14



MRW&J FILE No. 4864

NOTES 1. For General Notes and Legends see Information Drawing No. I-1

REVISIONS AND ADDITIONS		
DATE	BY	DESCRIPTIONS

DRAWN HJM & CD DATE 2-13-78

CHECKED F.C.R. DATE 2-14-78

OCEAN / SEISMIC / SURVEY, INC.
70 OAK STREET NORWOOD, N.J. 07647

MUESER, RUTLEDGE, WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE. NEW YORK, N.Y. 10017

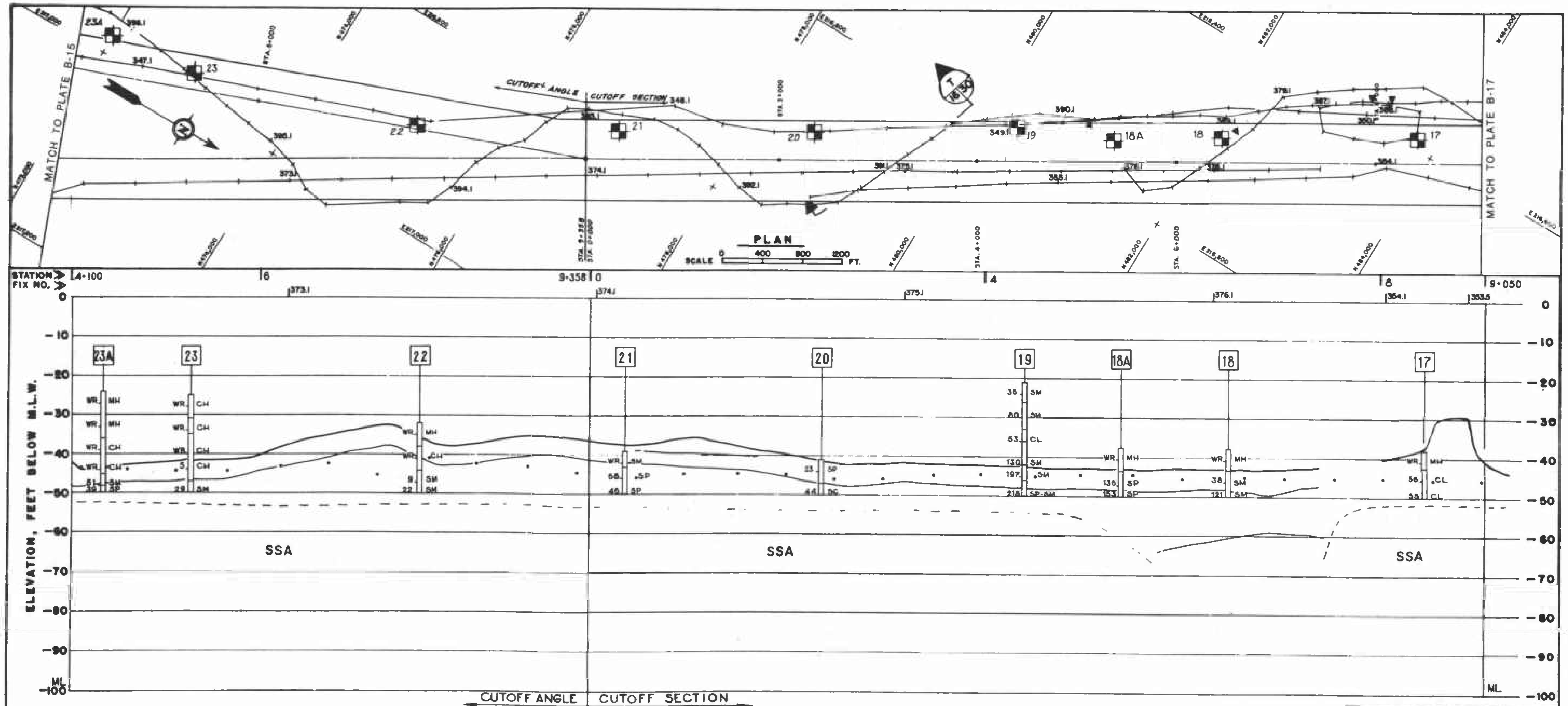
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

BALTIMORE HARBOR AND CHANNELS
50' PROJECT

GEOPHYSICAL FOUNDATION EXPLORATION
MAIN SHIP CHANNEL
CRAIGHILL SECTION &
CRAIGHILL CUTOFF ANGLE

PLATE 15

PLATE B-15



MRW&J FILE No. 4864

NOTES 1. For General Notes and Legend see Information Drawing No. I-1

REVISIONS AND ADDITIONS		
DATE	BY	DESCRIPTIONS

DRAWN HJM & CD DATE 2-13-78

CHECKED FCR. DATE 2-14-78

OCEAN / SEISMIC / SURVEY, INC.
70 OAK STREET NORWOOD, N.J. 07647

MUESER, RUTLEDGE, WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE. NEW YORK, N.Y. 10017

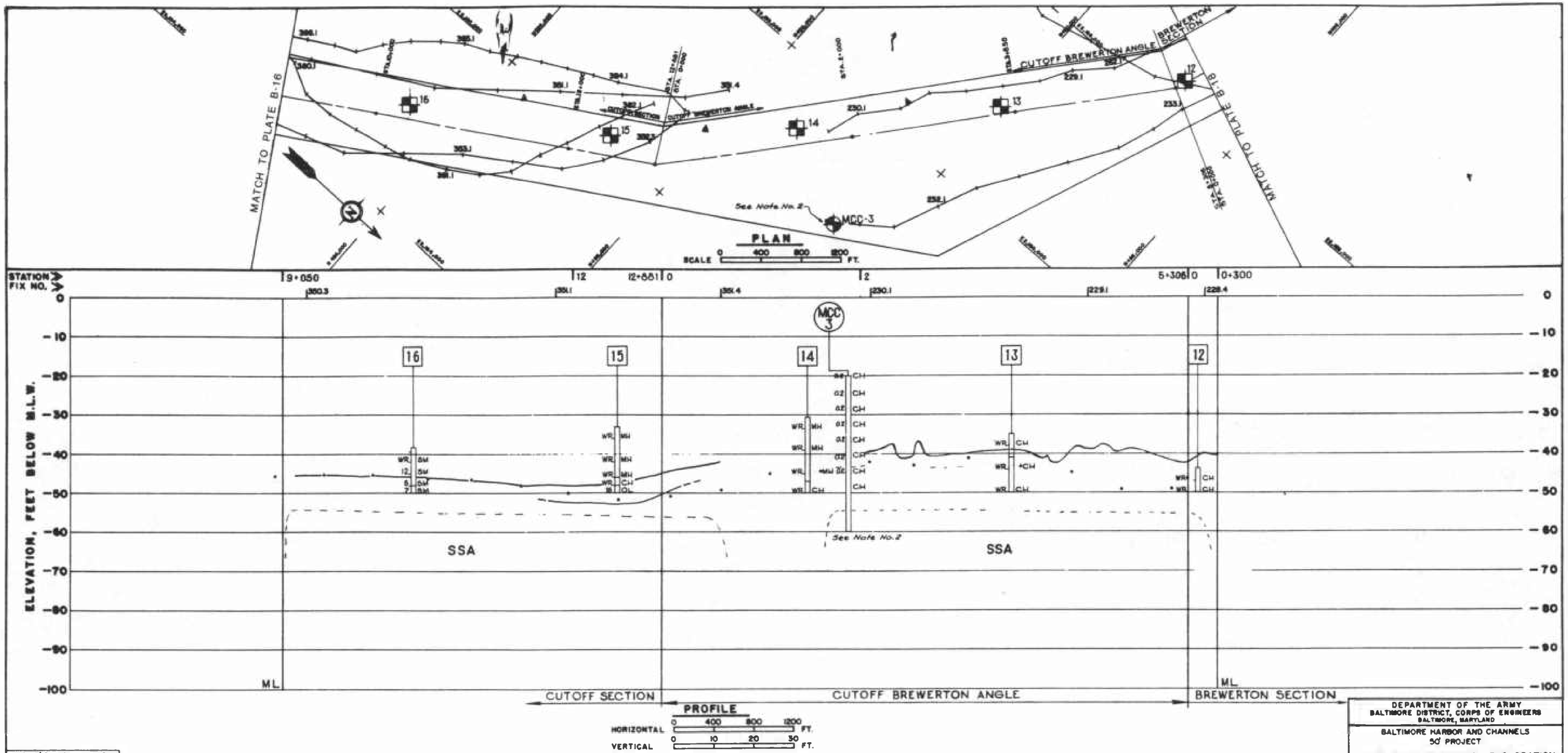
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

BALTIMORE HARBOR AND CHANNELS
50' PROJECT

GEOPHYSICAL FOUNDATION EXPLORATION
MAIN SHIP CHANNEL
CRAIGHILL CUTOFF ANGLE
& CUTOFF SECTION

PLATE 16

PLATE B-16



MRW&J FILE No. 4864

NOTES
1. For General Notes and Legends see Information Drawing No. I-1
2. Boring No. MCC-3 projected on Plan and Profile 480 feet South and 400 feet West of actual location. Actual coordinates: N 490,000 , E 1,261,500

REVISIONS AND ADDITIONS		
DATE	BY	DESCRIPTIONS

DRAWN HJM&CD DATE 2-13-78
CHECKED FCR DATE 2-14-78

OCEAN / SEISMIC / SURVEY, INC.
70 OAK STREET NORWOOD, N.J. 07647

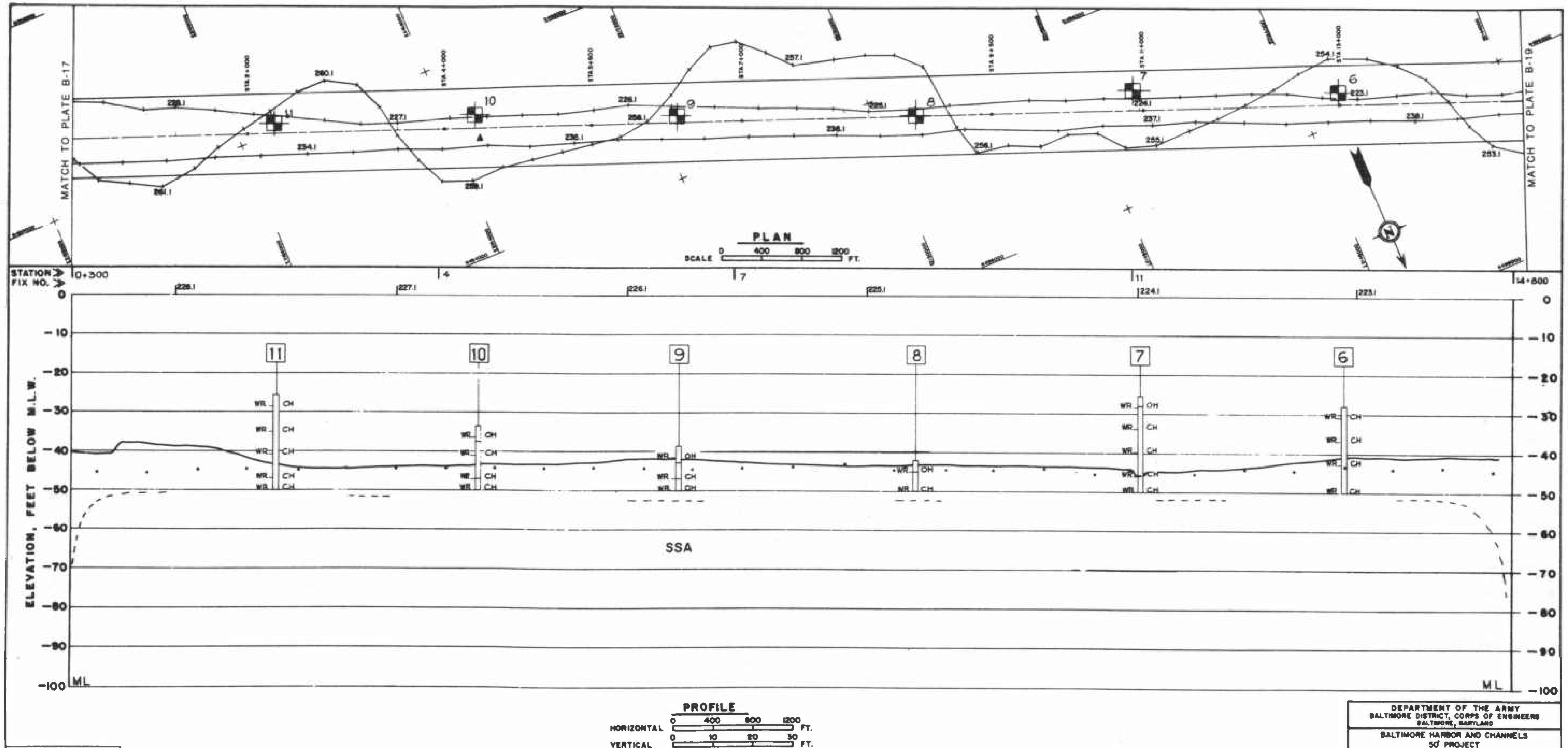
MUESER, RUTLEDGE, WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE. NEW YORK, N.Y. 10017

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

BALTIMORE HARBOR AND CHANNELS
50' PROJECT

GEOPHYSICAL FOUNDATION EXPLORATION
MAIN SHIP CHANNEL
CUTOFF SECTION
CUTOFF BREWERTON ANGLE

PLATE 17



MRW&J FILE No 4864

NOTES 1. For General Notes and Legends see Information Drawing No. I-I

REVISIONS AND ADDITIONS		
DATE	BY	DESCRIPTIONS

DRAWN HJM/CD DATE 2-13-78

CHECKED F.C.R. DATE 2-14-78

OCEAN / SEISMIC / SURVEY, INC.
70 OAK STREET NORWOOD, N.J. 07647

MUESER, RUTLEDGE, WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE. NEW YORK, N.Y. 10017

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

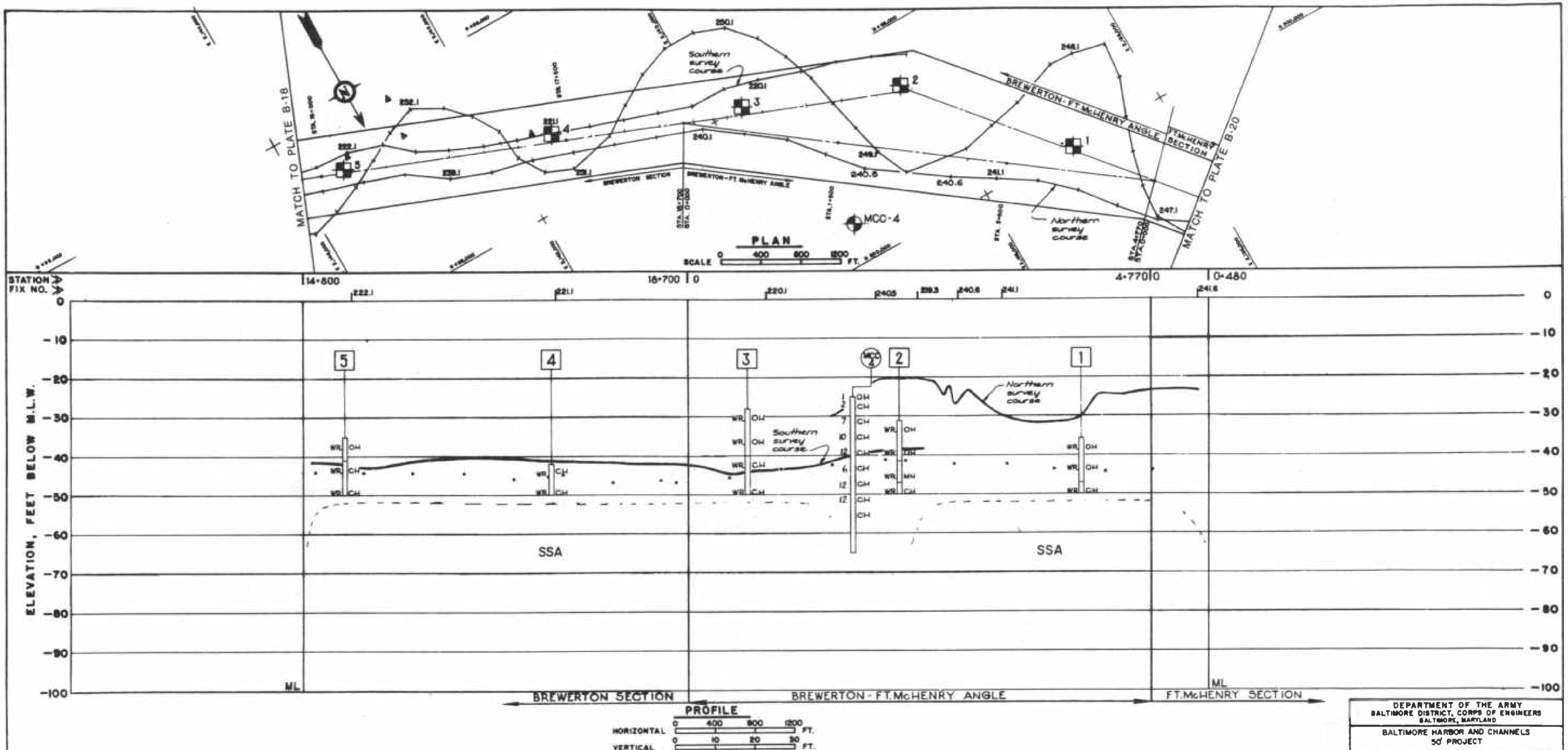
BALTIMORE HARBOR AND CHANNELS
50' PROJECT

GEOPHYSICAL FOUNDATION EXPLORATION

BREWERTON SECTION

PLATE 18

PLATE B-18



MRW&J FILE No. 4864

NOTES 1. For General Notes and Legend see Information Drawing No. I-1

REVISIONS AND ADDITIONS		
DATE	BY	DESCRIPTIONS

DRAWN HJM&CD DATE 2-13-78
CHECKED FCR DATE 2-14-78

OCEAN / SEISMIC / SURVEY, INC.
70 OAK STREET NORWOOD, N.J. 07647

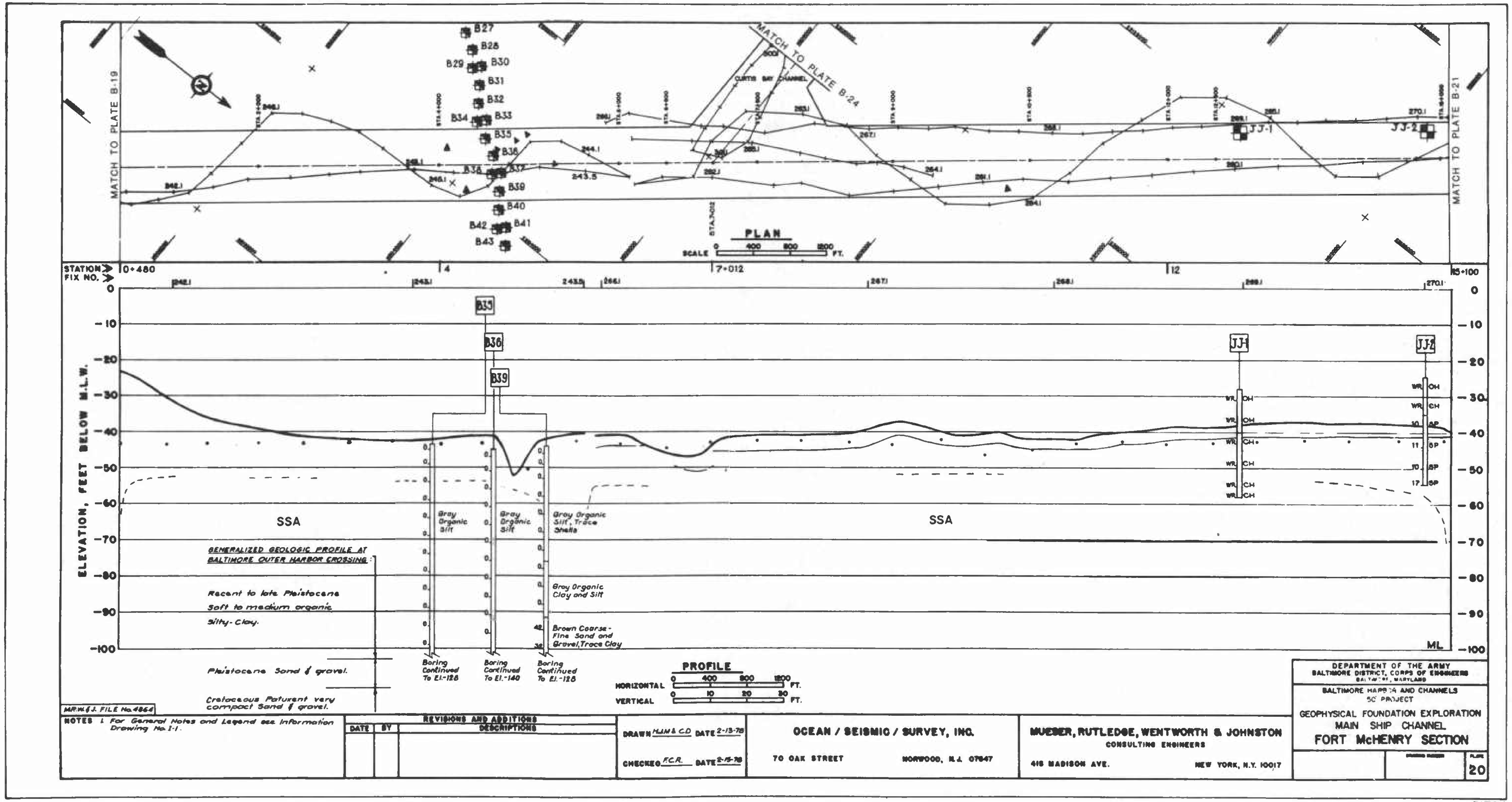
MUESER, RUTLEDGE, WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE. NEW YORK, N.Y. 10017

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

BALTIMORE HARBOR AND CHANNELS
50' PROJECT

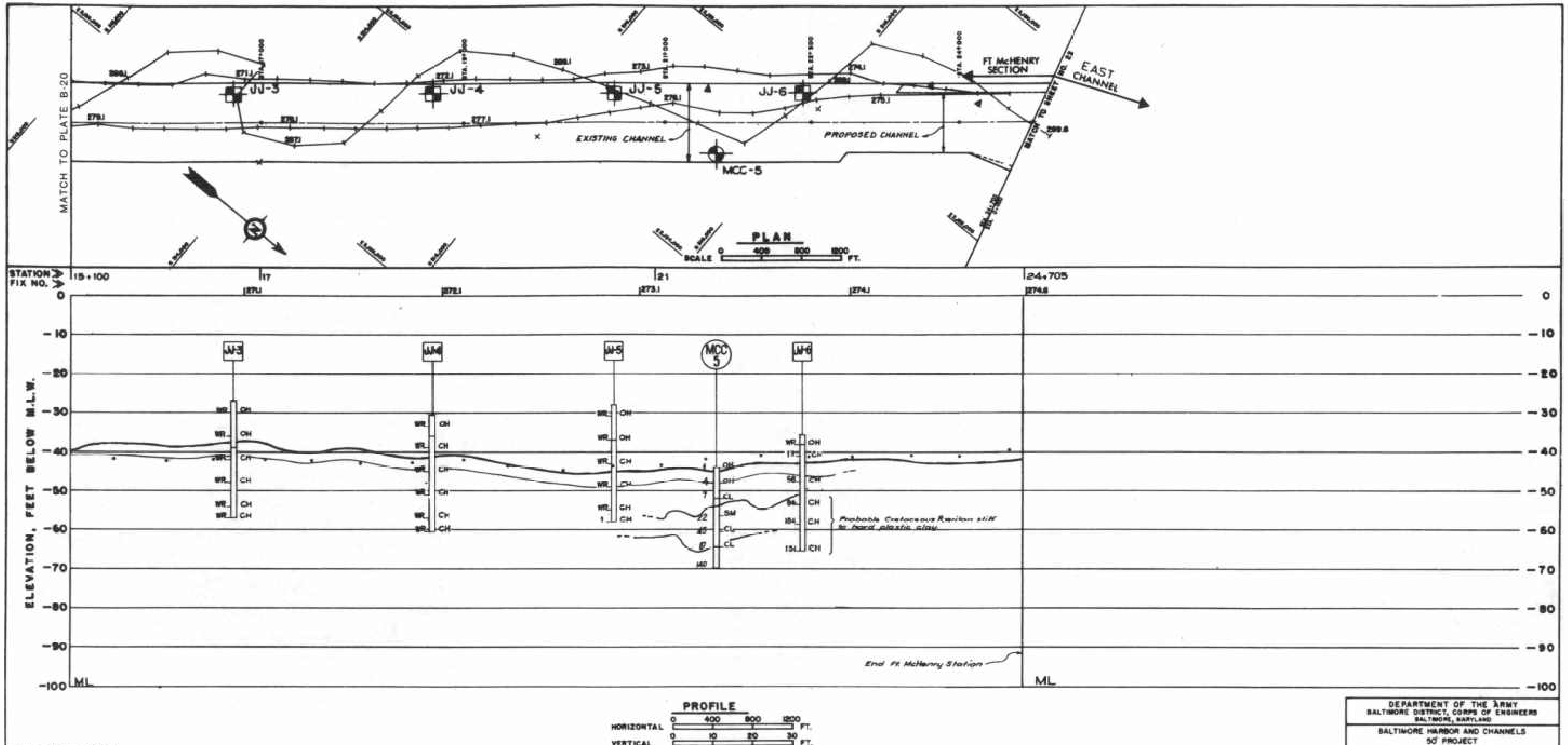
GEOPHYSICAL FOUNDATION EXPLORATION
MAIN SHIP CHANNEL
BREWERTON SECTION &
BREWERTON-FT. McHENRY ANGLE

PLATE 19



MATCH TO PLATE B-19
MATCH TO PLATE B-24
MATCH TO PLATE B-21
CURTIS BAY CHANNEL
B27
B28
B29
B30
B31
B32
B33
B34
B35
B36
B37
B38
B39
B40
B41
B42
B43
JJ-1
JJ-2
STA. 7+012
PLAN
SCALE 0 400 800 1200 FT.
STATION
FIX NO.
0+480
4
7+012
12
15+100
242.1
243.1
243.5
266.1
267.1
268.1
269.1
270.1
ELEVATION, FEET BELOW M.L.W.
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
SSA
SSA
ML
Gray Organic Silt
Gray Organic Silt
Gray Organic Silt, Trace Shells
Gray Organic Clay and Silt
Brown Coarse-Fine Sand and Gravel, Trace Clay
Boring Continued To El.-128
Boring Continued To El.-140
Boring Continued To El.-128
GENERALIZED GEOLOGIC PROFILE AT BALTIMORE OUTER HARBOR CROSSING
Recent to late Pleistocene Soft to medium organic Silty-Clay.
Pleistocene Sand & gravel.
Cretaceous Patuxent very compact Sand & gravel.
PROFILE
HORIZONTAL 0 400 800 1200 FT.
VERTICAL 0 10 20 30 FT.
MR.W.& J. FILE No. 4864
NOTES 1. For General Notes and Legend see Information Drawing No. I-1.
REVISIONS AND ADDITIONS
DATE BY DESCRIPTIONS
DRAWN M.J.M & C.D. DATE 2-13-78
CHECKED F.C.R. DATE 2-15-78
OCEAN / SEISMIC / SURVEY, INC.
70 OAK STREET NORWOOD, N.J. 07647
MUESER, RUTLEDGE, WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE. NEW YORK, N.Y. 10017
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND
BALTIMORE HARBOR AND CHANNELS
50' PROJECT
GEOPHYSICAL FOUNDATION EXPLORATION
MAIN SHIP CHANNEL
FORT McHENRY SECTION
PLATE
20

PLATE B-20



M.R.W.&J. FILE No. 4864

NOTES 1. For General Notes and Legend see Information Drawing No. I-1

REVISIONS AND ADDITIONS		
DATE	BY	DESCRIPTIONS

DRAWN H.J.M.&C.D. DATE 2-15-78

CHECKED F.C.R. DATE 2-15-78

OCEAN / SEISMIC / SURVEY, INC.
70 OAK STREET NORWOOD, N.J. 07647

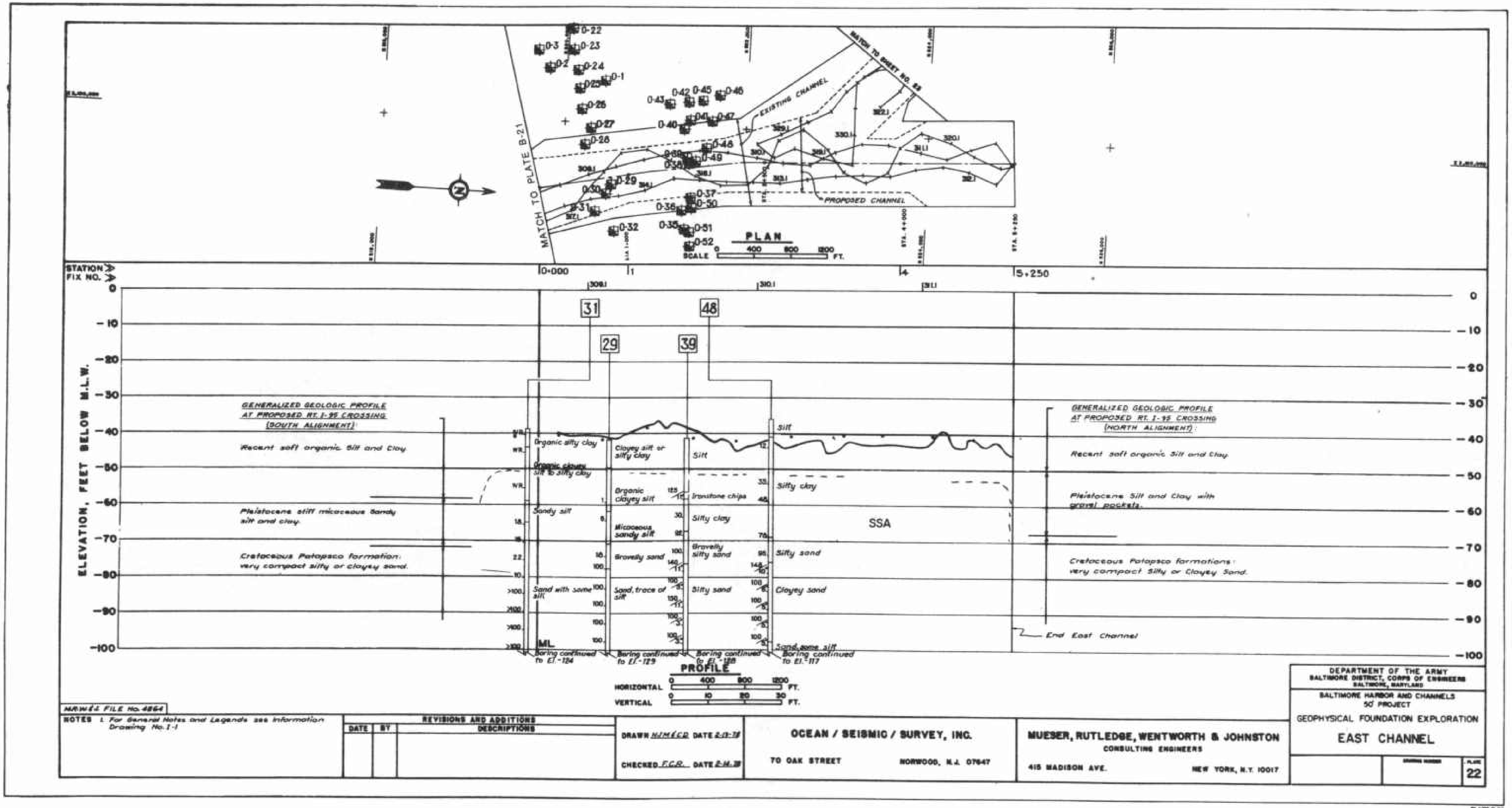
MUESER, RUTLEDGE, WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE. NEW YORK, N.Y. 10017

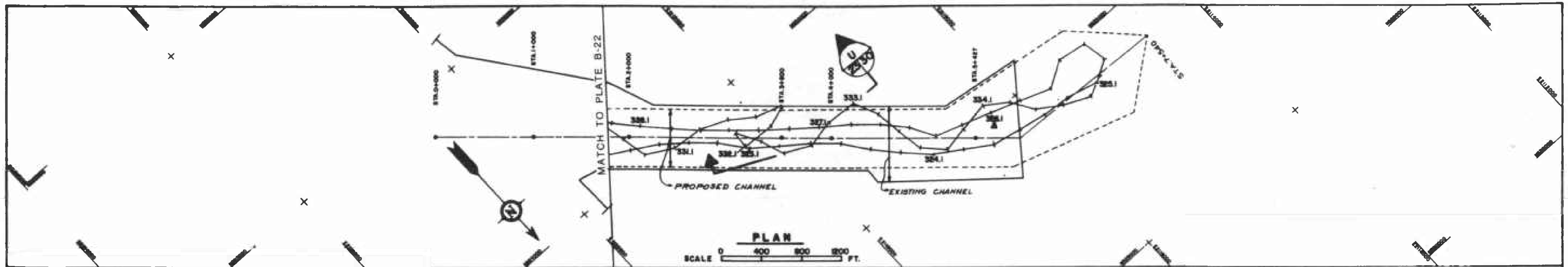
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

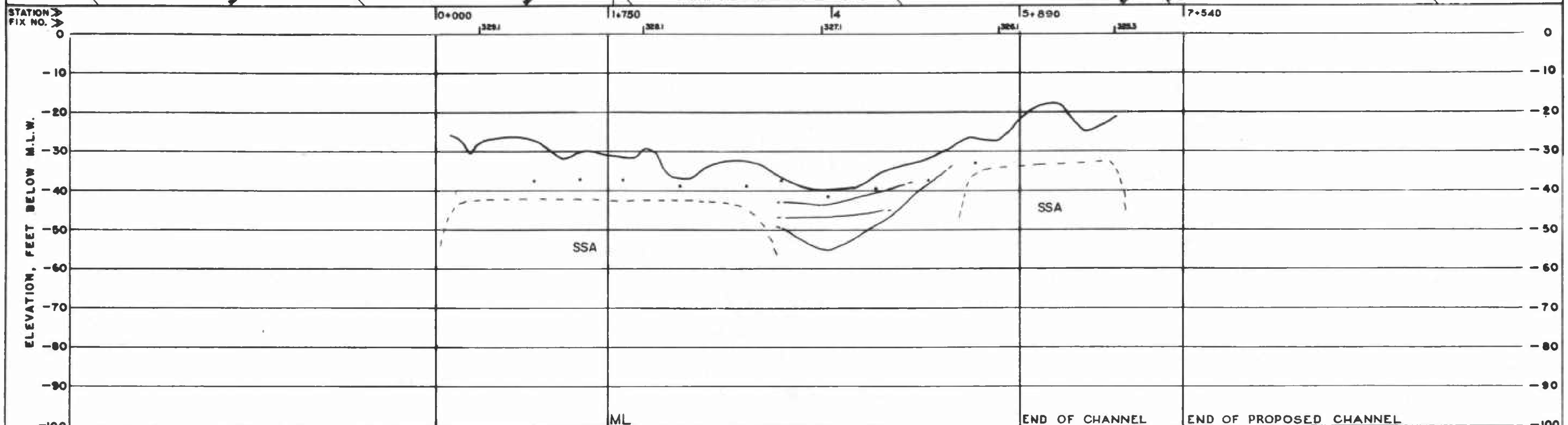
BALTIMORE HARBOR AND CHANNELS
50' PROJECT

GEOPHYSICAL FOUNDATION EXPLORATION
MAIN SHIP CHANNEL
FT. MCHENRY SECTION &
FT. MCHENRY ANGLE

PLATE 21


PLAN
SCALE 0 400 800 1200 FT.
MATCH TO PLATE B-21
MATCH TO SHEET NO. 23
EXISTING CHANNEL
PROPOSED CHANNEL
STATION
FIX NO.
0+000
5+250
ELEVATION, FEET BELOW M.L.W.
GENERALIZED GEOLOGIC PROFILE AT PROPOSED RT. I-95 CROSSING (SOUTH ALIGNMENT):
Recent soft organic Silt and Clay
Pleistocene stiff micaceous Sandy silt and clay.
Cretaceous Patapsco formation: very compact silty or clayey sand.
GENERALIZED GEOLOGIC PROFILE AT PROPOSED RT. I-95 CROSSING (NORTH ALIGNMENT):
Recent soft organic Silt and Clay
Pleistocene Silt and Clay with gravel pockets.
Cretaceous Patapsco formations: very compact Silty or Clayey Sand.
31
29
39
48
Organic silty clay
Organic clayey silt to silty clay
Sandy silt
Sand with some silt
ML
Boring continued to El. -124
Clayey silt or silty clay
Organic clayey silt
Micaceous sandy silt
Gravelly sand
Sand, trace of silt
Boring continued to El. -129
Silt
Ironstone chips
Silty clay
Gravelly silty sand
Silty sand
Boring continued to El. -128
Silt
Silty clay
Silty sand
Clayey sand
Sand, some silt
Boring continued to El. -117
SSA
End East Channel
PROFILE
HORIZONTAL 0 400 800 1200 FT.
VERTICAL 0 10 20 30 FT.
MR&W&J FILE No. 4864
NOTES 1. For General Notes and Legends see Information Drawing No. I-1
REVISIONS AND ADDITIONS
DATE
BY
DESCRIPTIONS
DRAWN MJM&CD DATE 2-13-78
CHECKED F.C.R. DATE 2-14-78
OCEAN / SEISMIC / SURVEY, INC.
70 OAK STREET NORWOOD, N.J. 07647
MUESER, RUTLEDGE, WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE. NEW YORK, N.Y. 10017
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND
BALTIMORE HARBOR AND CHANNELS
50' PROJECT
GEOPHYSICAL FOUNDATION EXPLORATION
EAST CHANNEL
22
PLATE B-22





PROFILE

HORIZONTAL 0 400 800 1200 FT.

VERTICAL 0 10 20 30 FT.

MRW&J FILE No. 4864

NOTES 1. For General Notes and Legends see Information Drawing No. I-1

REVISIONS AND ADDITIONS		
DATE	BY	DESCRIPTIONS

DRAWN HJM & CD DATE 2-13-78

CHECKED FCR DATE 2-14-78

OCEAN / SEISMIC / SURVEY, INC.
70 OAK STREET NORWOOD, N.J. 07647

MUESER, RUTLEDGE, WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE. NEW YORK, N.Y. 10017

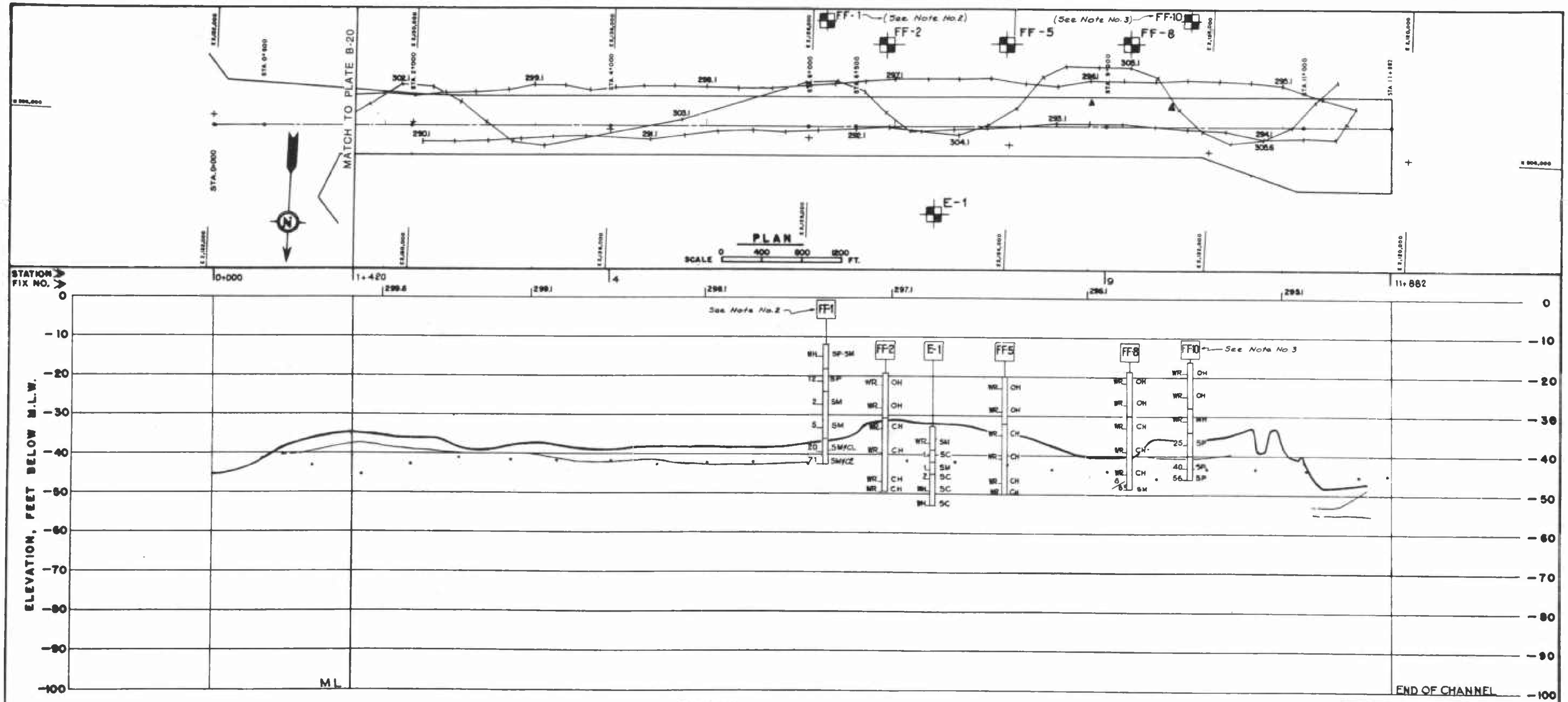
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

BALTIMORE HARBOR AND CHANNELS
50' PROJECT

GEOPHYSICAL FOUNDATION EXPLORATION

NORTHWEST CHANNEL

PLATE 23



PROFILE

HORIZONTAL 0 400 800 1200 FT.

VERTICAL 0 10 20 30 FT.

M.R.W.&J. FILE No. 4864

NOTES
1. For General Notes and Legends see Information Drawing No. I-1
2. Boring No. FF-1 shown on plan approx. 300 feet North of actual location.
3. Boring No. FF-10 shown on plan approx. 300 feet North of actual location.

REVISIONS AND ADDITIONS		
DATE	BY	DESCRIPTIONS

DRAWN H.J.M. & C.D. DATE 2-13-78

CHECKED F.C.R. DATE 2-14-78

OCEAN / SEISMIC / SURVEY, INC.
70 OAK STREET NORWOOD, N.J. 07647

MUESER, RUTLEDGE, WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE. NEW YORK, N.Y. 10017

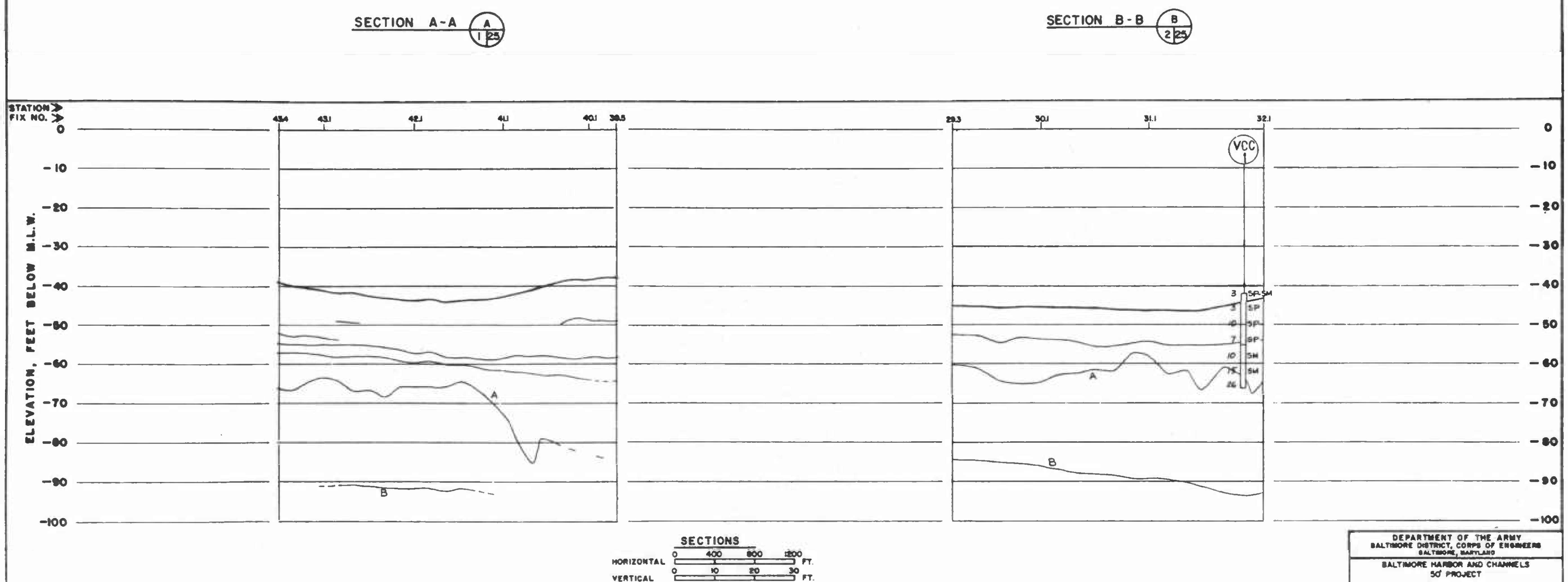
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

BALTIMORE HARBOR AND CHANNELS
50' PROJECT

GEOPHYSICAL FOUNDATION EXPLORATION

CURTIS BAY CHANNEL

PLATE 24



NOTES 1. For General Notes on Legends see Information Drawing No. I-1

REVISIONS AND ADDITIONS		
DATE	BY	DESCRIPTIONS

DRAWN HJM&CD DATE 2-13-78

CHECKED FCR DATE 2-14-78

OCEAN / SEISMIC / SURVEY, INC.

70 OAK STREET NORWOOD, N.J. 07647

MUESER, RUTLEDGE, WENTWORTH & JOHNSTON

CONSULTING ENGINEERS

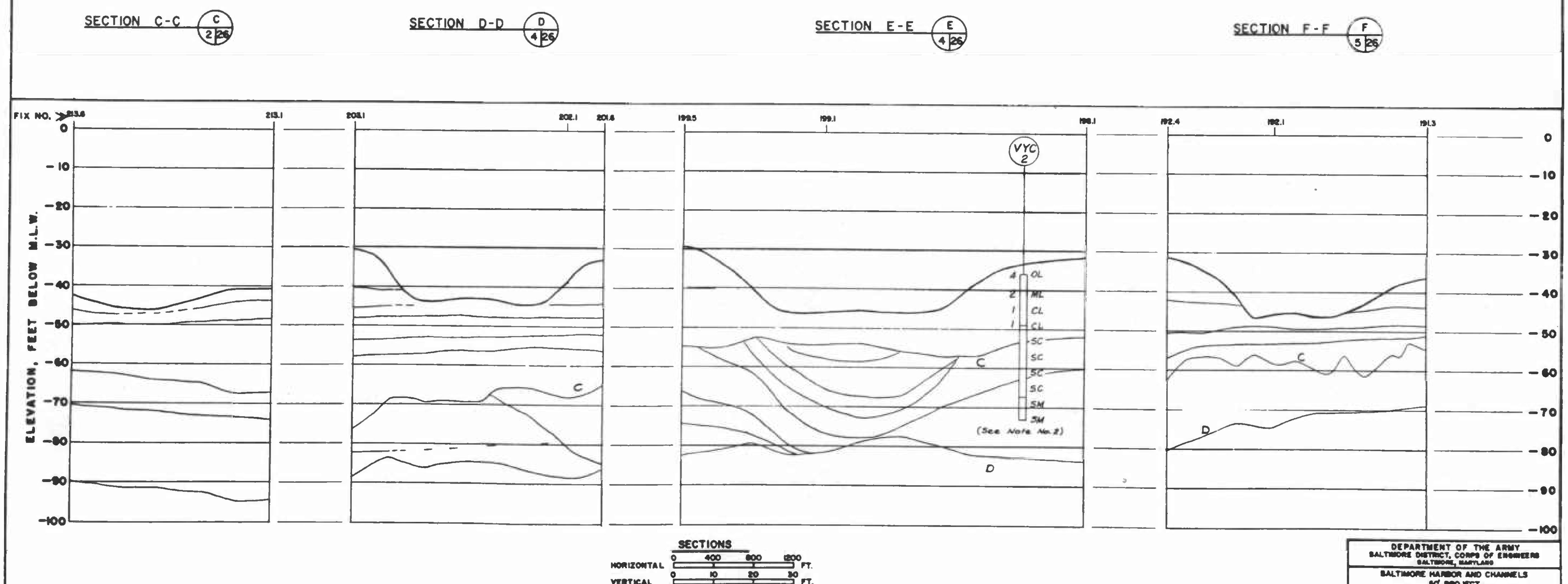
415 MADISON AVE. NEW YORK, N.Y. 10017

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

BALTIMORE HARBOR AND CHANNELS
50' PROJECT

GEOPHYSICAL FOUNDATION EXPLORATION
SECTIONS A-A, B-B

PLATE 25



NOTES
1. For General Notes and Legend see Information Drawing No. I-1
2. Chain recording rate of penetration broke at depth 16'. Rate of penetration below this depth not available.

REVISIONS AND ADDITIONS		
DATE	BY	DESCRIPTIONS

DRAWN HJM & CD DATE 2-13-78

CHECKED F.C.R. DATE 2-14-78

OCEAN / SEISMIC / SURVEY, INC.
70 OAK STREET NORWOOD, N.J. 07647

MUESER, RUTLEDGE, WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE. NEW YORK, N.Y. 10017

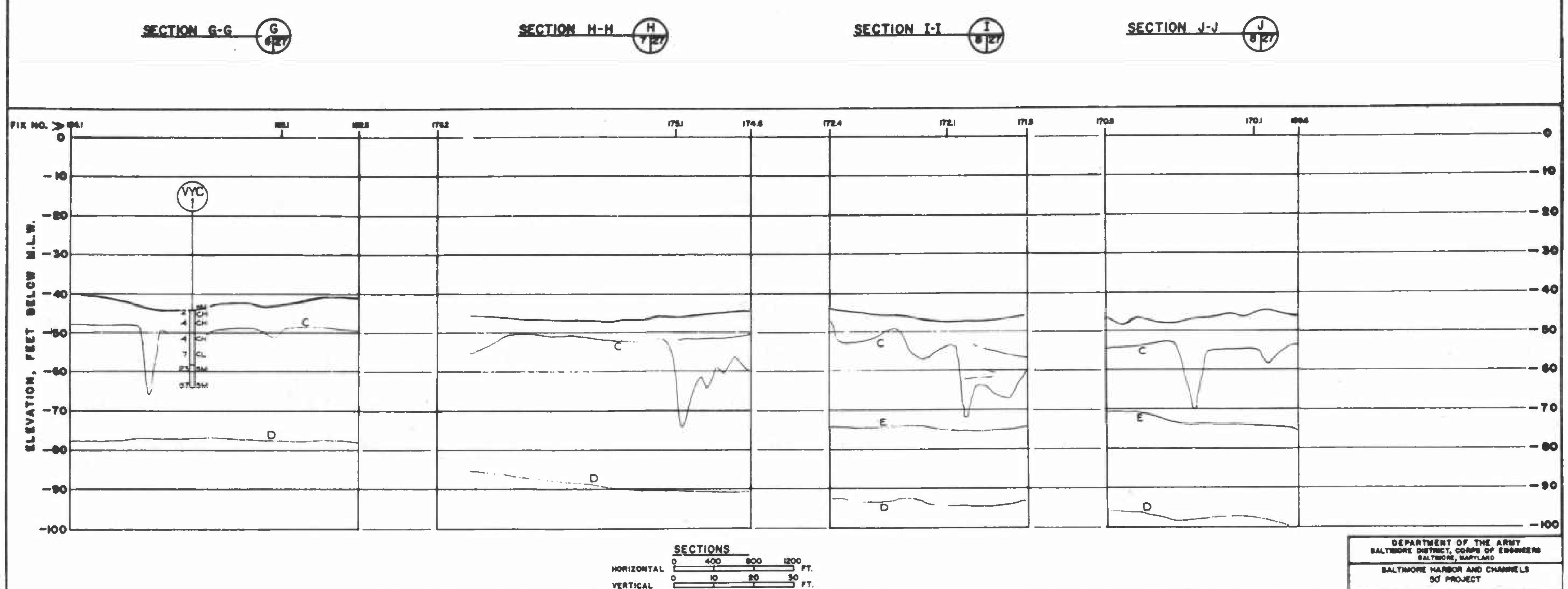
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

BALTIMORE HARBOR AND CHANNELS
50' PROJECT

GEOPHYSICAL FOUNDATION EXPLORATION
SECTIONS C-C, D-D, E-E, F-F

PLATE 26

PLATE B-26



NOTES

1. For General Notes and Legends see Information Drawing No. I-1

REVISIONS AND ADDITIONS		
DATE	BY	DESCRIPTIONS

DRAWN H.J.M. & C.D. DATE 2-14-78

CHECKED F.C.R. DATE 2-16-78

OCEAN / SEISMIC / SURVEY, INC.
70 OAK STREET NORWOOD, N.J. 07647

MUESER, RUTLEDGE, WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE. NEW YORK, N.Y. 10017

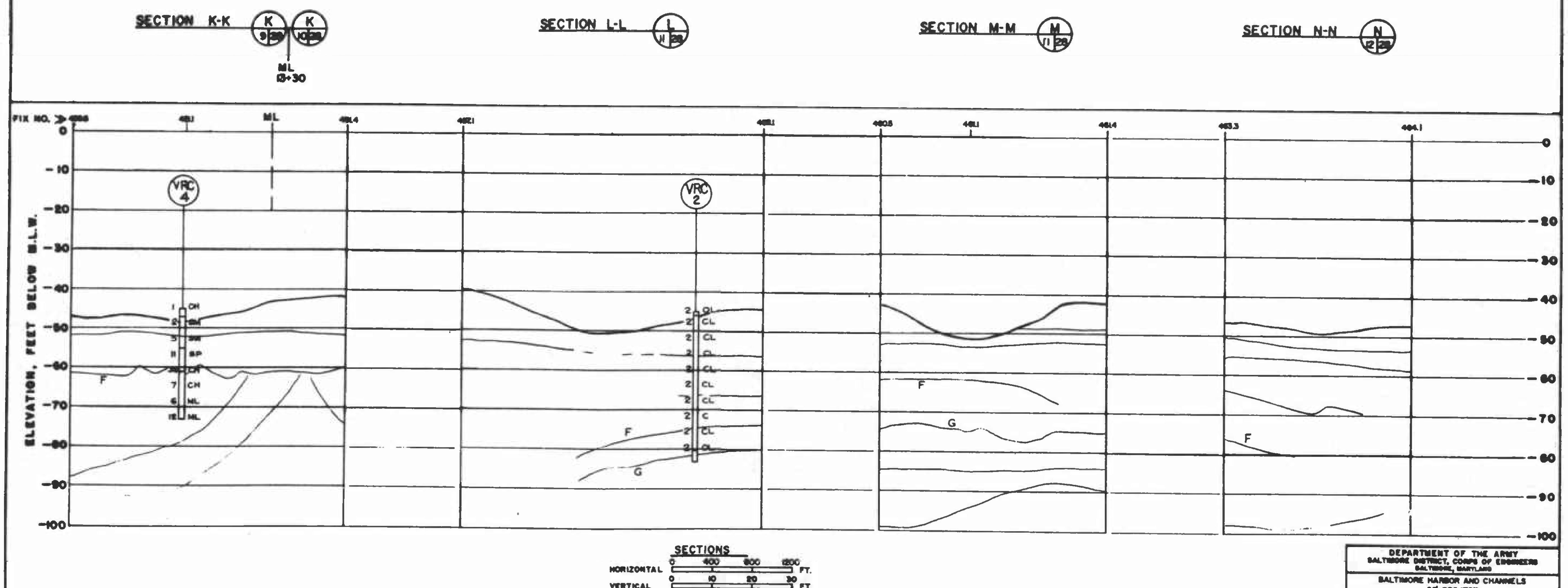
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

BALTIMORE HARBOR AND CHANNELS
50' PROJECT

GEOPHYSICAL FOUNDATION EXPLORATION
SECTIONS G-G, H-H, I-I, J-J

PLATE 27

PLATE B-27



NOTES
1. For General Notes and Legends see Information Drawing No. I-1

REVISIONS AND ADDITIONS		
DATE	BY	DESCRIPTIONS

DRAWN H.J.M.& C.D. DATE 2-14-78
CHECKED F.C.R. DATE 2-16-78

OCEAN / SEISMIC / SURVEY, INC.
70 OAK STREET NORWOOD, N.J. 07647

MUESER, RUTLEDGE, WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE. NEW YORK, N.Y. 10017

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

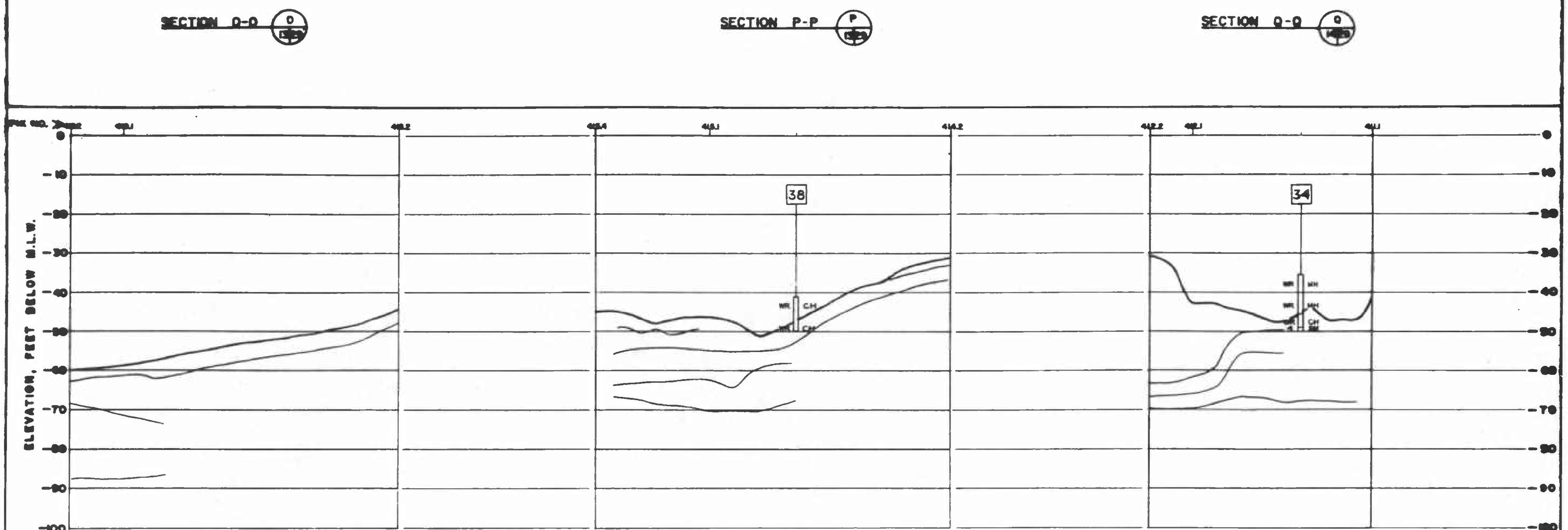
BALTIMORE HARBOR AND CHANNELS
50' PROJECT

GEOPHYSICAL FOUNDATION EXPLORATION
SECTIONS K-K, L-L, M-M, N-N

PLATE 28

1.4

PLATE B-28



SECTIONS

HORIZONTAL 0 400 800 1200 FT

VERTICAL 0 10 20 30 FT.

NOTES

1. For General Notes and Legends see Information Drawing No. I-1

REVISIONS AND ADDITIONS		
DATE	BY	DESCRIPTIONS

DRAWN H.J.M.&C.D DATE 2-14-76

CHECKED F.C.R. DATE 2-16-76

OCEAN / SEISMIC / SURVEY, INC.

70 OAK STREET NORWOOD, N.J. 07647

MUESER, RUTLEDGE, WENTWORTH & JOHNSTON

CONSULTING ENGINEERS

415 MADISON AVE. NEW YORK, N.Y. 10017

DEPARTMENT OF THE ARMY

BALTIMORE DISTRICT, CORPS OF ENGINEERS

BALTIMORE, MARYLAND

BALTIMORE HARBOR AND CHANNELS

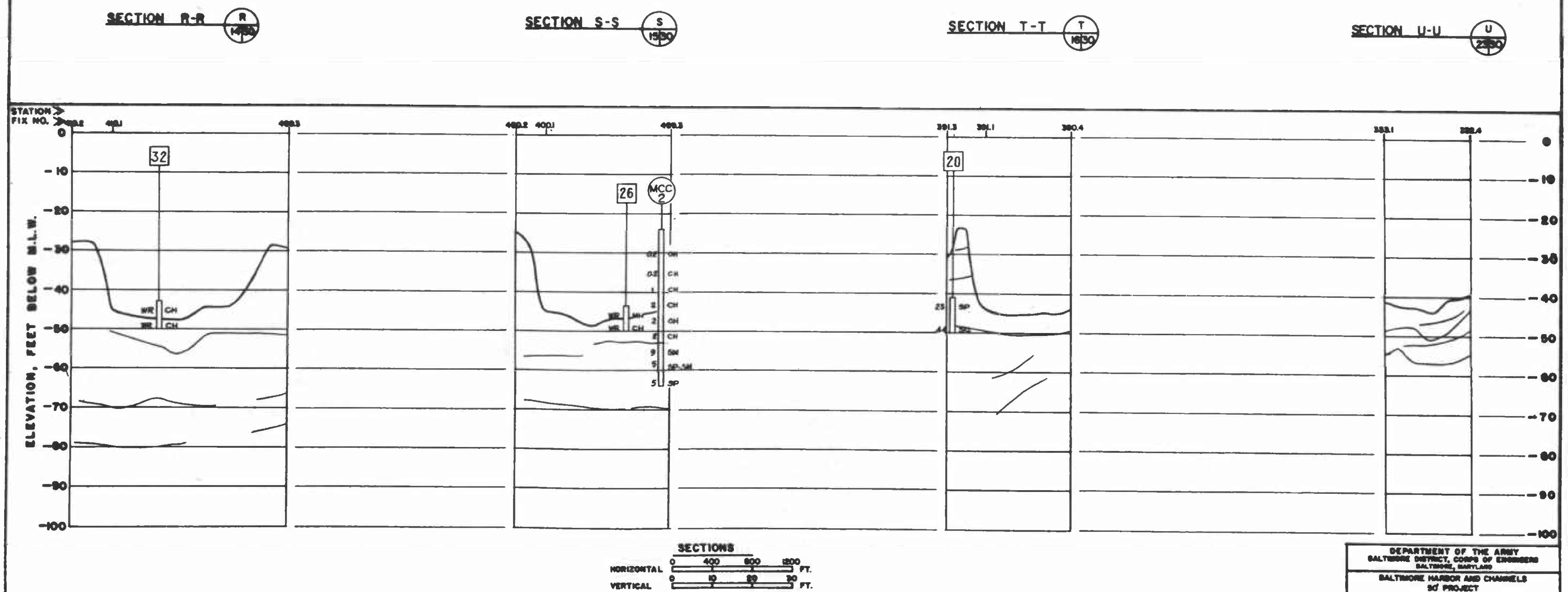
50' PROJECT

GEOPHYSICAL FOUNDATION EXPLORATION

SECTIONS O-O, P-P, Q-Q

PLATE 29

PLATE B-29



NOTES 1. For General Notes and Legends see Information Drawing No. I-1.

REVISIONS AND ADDITIONS		
DATE	BY	DESCRIPTIONS

DRAWN HJH&CD DATE 2-13-78

CHECKED FCR DATE 2-14-78

OCEAN / SEISMIC / SURVEY, INC.
70 OAK STREET NORWOOD, N.J. 07647

MUESER, RUTLEDGE, WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE. NEW YORK, N.Y. 10017

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

BALTIMORE HARBOR AND CHANNELS
50' PROJECT

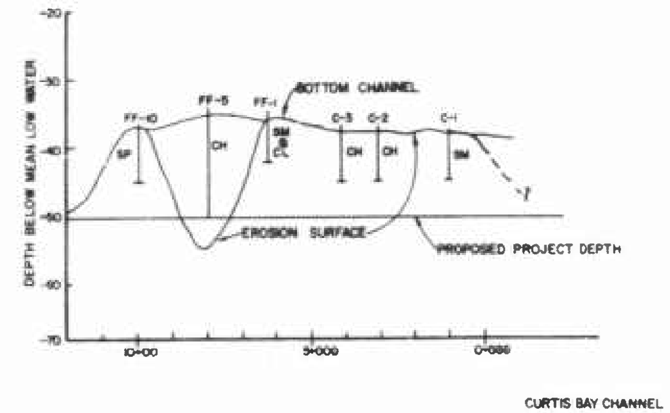
GEOPHYSICAL FOUNDATION EXPLORATION
SECTIONS R-R, S-S, T-T, U-U

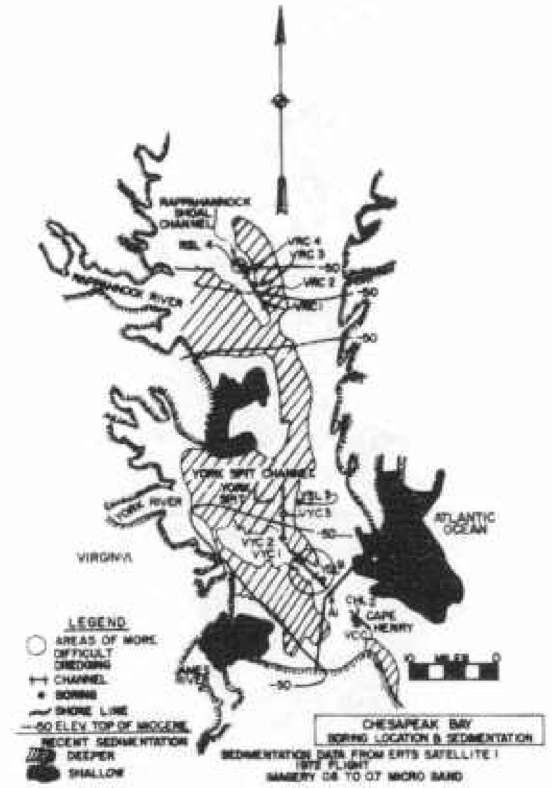
PLATE 30

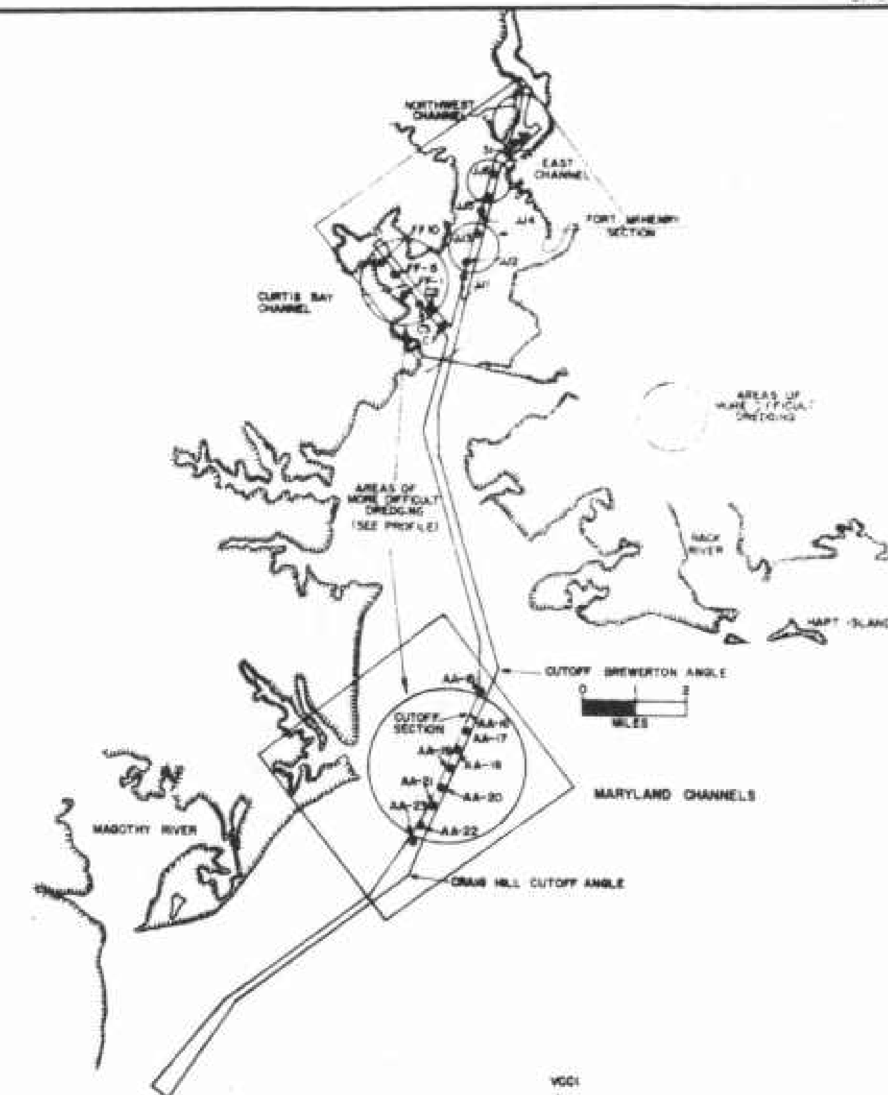
PLATE B-30

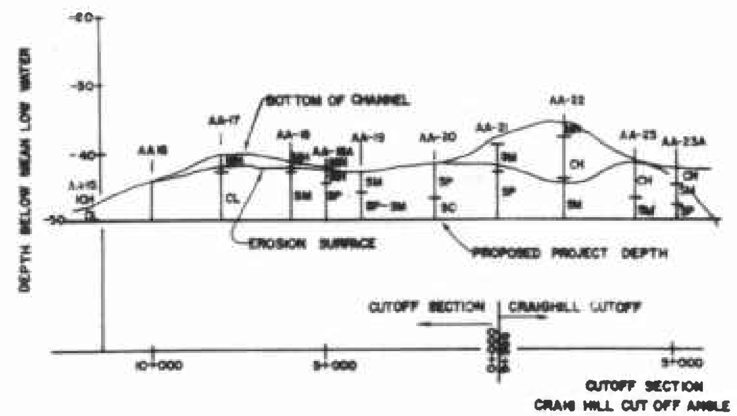
CORPS OF ENGINEERS | U. S. ARMY

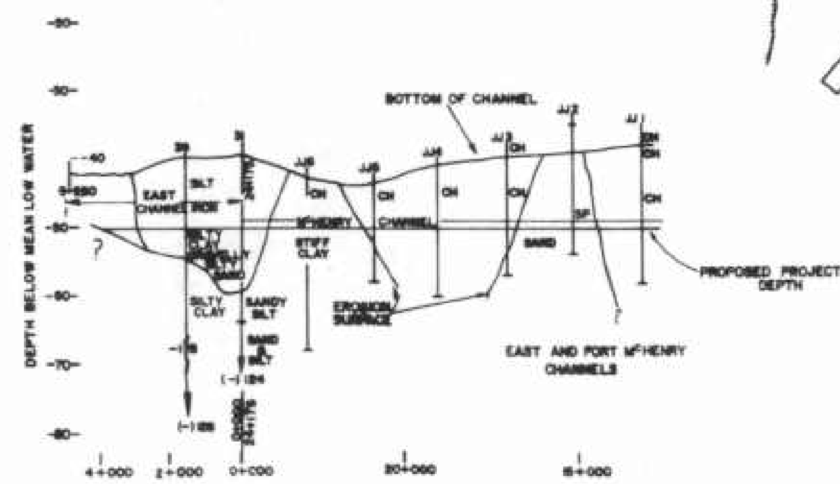
SEE SECTIONS H PARAGRAPH 10 THROUGH 22 OF MAIN REPORT FOR FURTHER SUBSURFACE EXPLORATION, REGARDING SOIL CONSISTENCY AND AREAS OF POTENTIAL DREDGING DIFFICULTY.

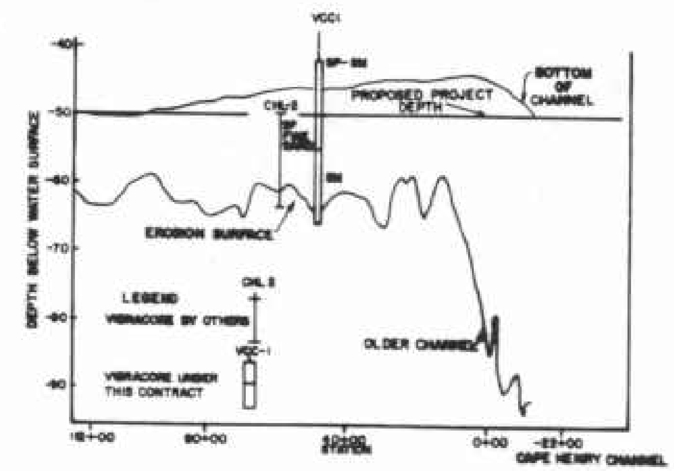












UNIFIED SOIL CLASSIFICATION

GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES.
GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
SP	POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES.
SM	SILTY SANDS, SAND-SILT MIXTURES
SC	CLAYEY SAND, SAND-CLAY MIXTURES
ML	INORGANIC SILTY AND VERY FINE SANDS, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY.
CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS.
OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY.
MH	INORGANIC SILTS, MICACEOUS OR FINE SANDY OR SILTY SOILS, ELASTIC SILTS.
CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS.
OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS.

NOTES

1. SEE APPENDIX - FOR DETAILED GEOPHYSICAL AND EXPLORATION REPORT
2. "EROSION SURFACE" DEFINED THROUGH GEOPHYSICAL EXPLORATION IN VA CHANNELS
3. ALL BORINGS IN VIRGINIA CHANNEL VIBRACORE EXCEPT FOR A1 IN YORK SPIT
4. ALL BORINGS IN MARYLAND CHANNELS STANDARD PENETRATION

REV	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

BALTIMORE HARBOR AND CHANNELS

GEOLOGIC PROFILES

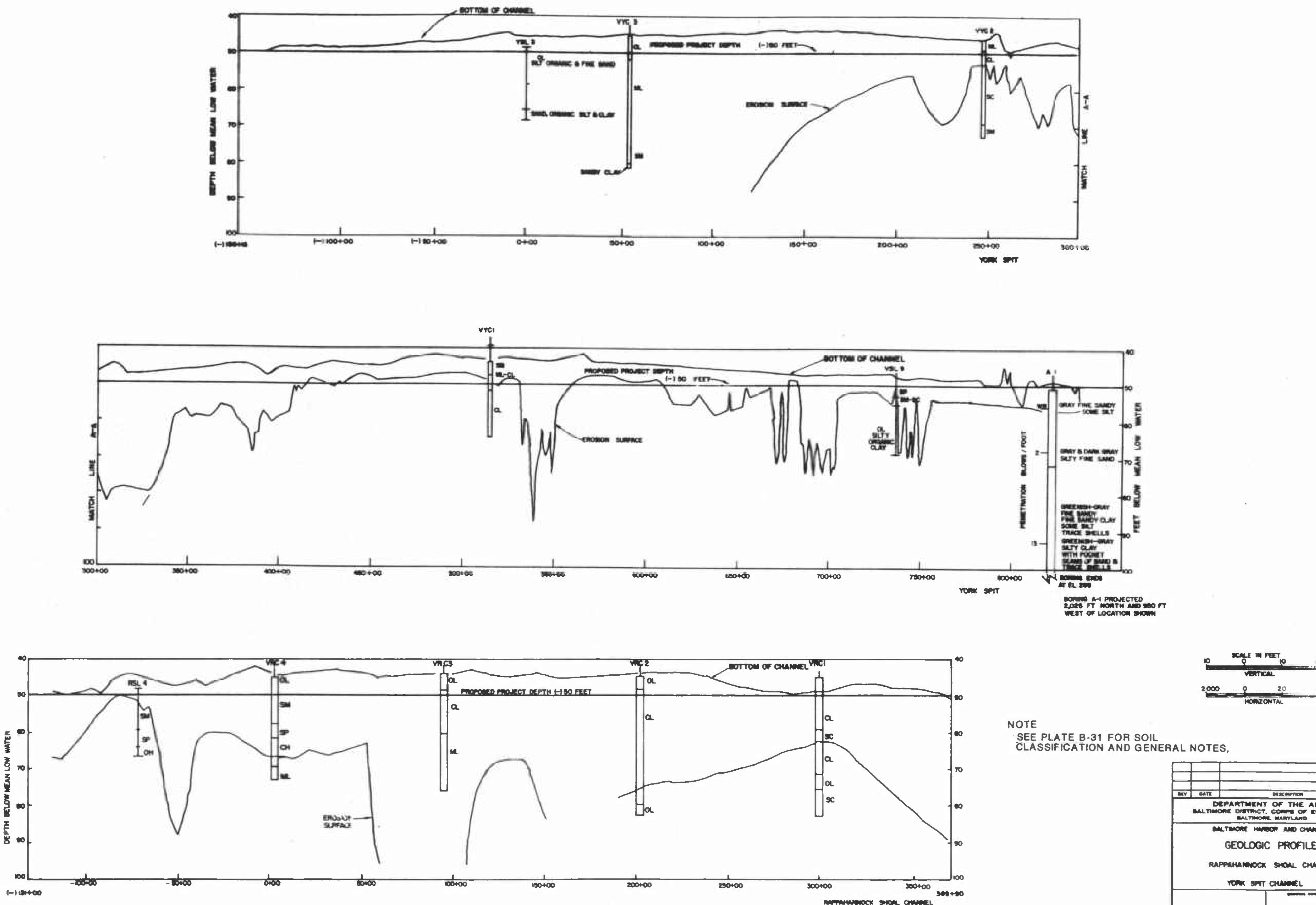
MARYLAND & CAPE HENRY CHANNELS

PLAN OF MARYLAND & VIRGINIA CHANNELS

PLATE 1

CORPS OF ENGINEERS

U. S. ARMY



NOTE
SEE PLATE B-31 FOR SOIL CLASSIFICATION AND GENERAL NOTES,

REV	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

BALTIMORE HARBOR AND CHANNELS

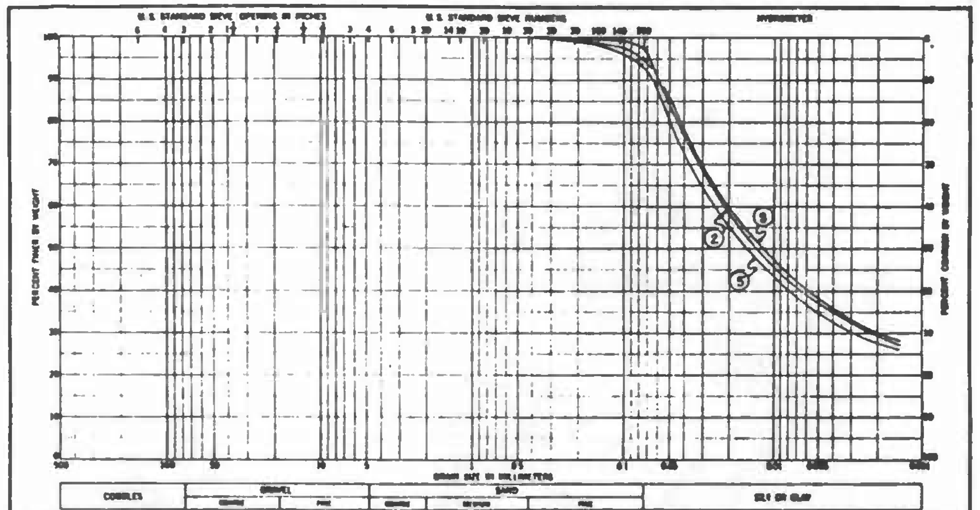
GEOLOGIC PROFILE

RAPPAHANNOCK SHOAL CHANNEL

YORK SPIT CHANNEL

PLATE 2

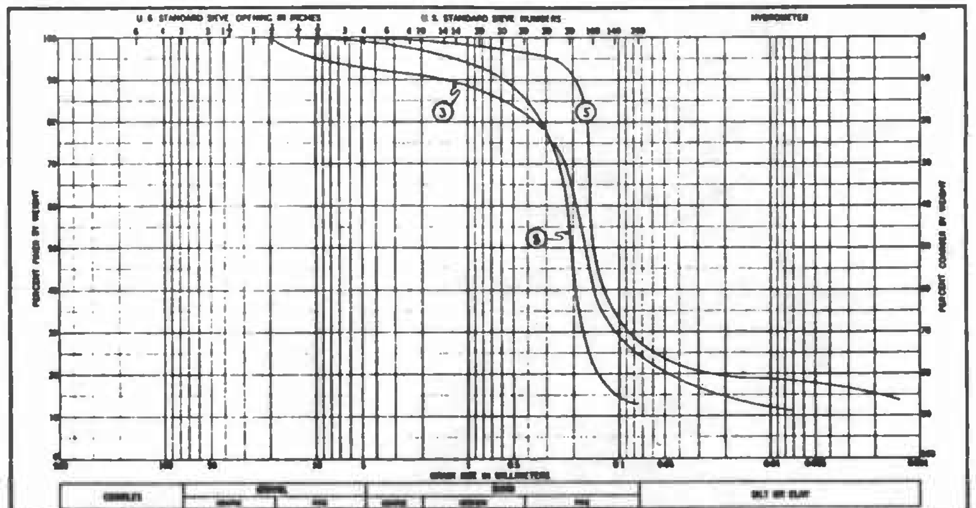
SCALE | DATE | SHEET



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-2	51.5-5[illegible]'	Silty clay CL	—			
J-5	56.0-57.5'	ditto CH	—	57	25	32
J-8	[illegible]	ditto CL	—			

GRADATION CURVES

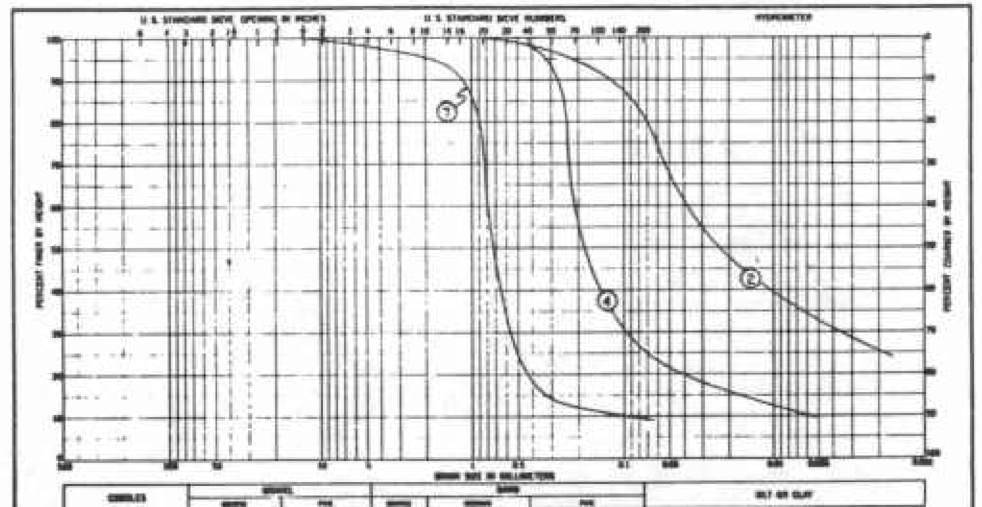
Project: Chesapeake Bay
Area: Rappahannock Channel
Boring No.: UH-VA 5
Date: Oct. 19[illegible]



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-3	52.0-5[illegible].5'	Gravelly, silty, sand SM	—			
J-5	55.0-5[illegible].5'	Clayey, silty, fine sand SM	—	45	27	1[illegible]
J-8	59.5-6[illegible].0'	Silty, sand SM	—			

GRADATION CURVES

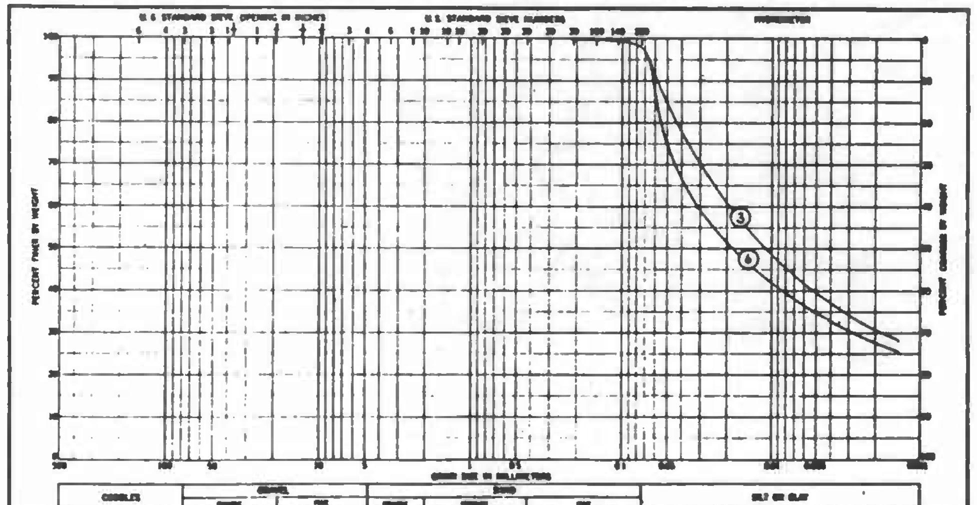
Project: Chesapeake Bay
Area: Rappahannock Channel
Boring No.: UH-VA 7
Date: Oct. 19[illegible]



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-2	47.5-4[illegible].0'	Fine sandy, clay CH	—	50	21	29
J-4	51.5-5[illegible].0'	Clayey, silty, fine sand SM	—			
J-7	55.0-5[illegible].5'	Silty, sand SP-SM	—			

GRADATION CURVES

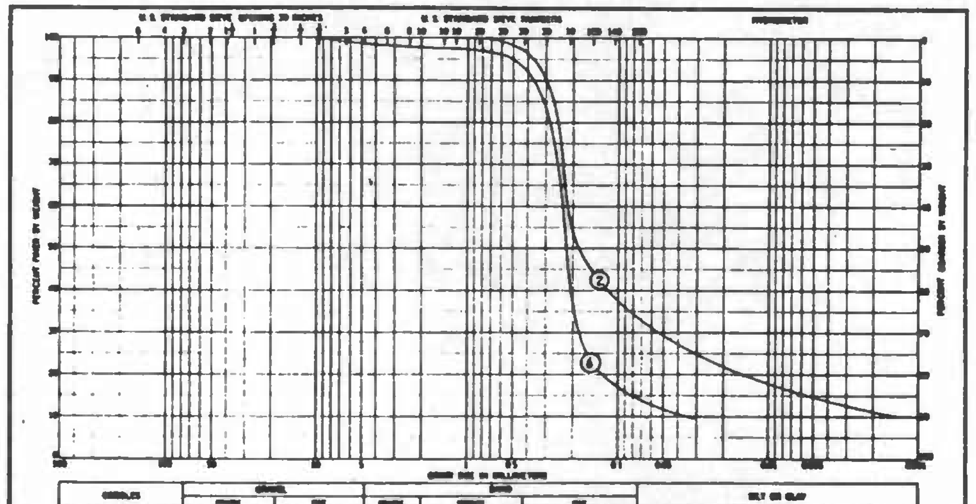
Project: Chesapeake Bay
Area: Rappahannock Channel
Boring No.: UH-VA [illegible]
Date: Oct. 19[illegible]



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-3	54.0-55.5'	Silty clay CL	—			
J-6	58.5-6[illegible].0'	ditto CH	—	53	24	29

GRADATION CURVES

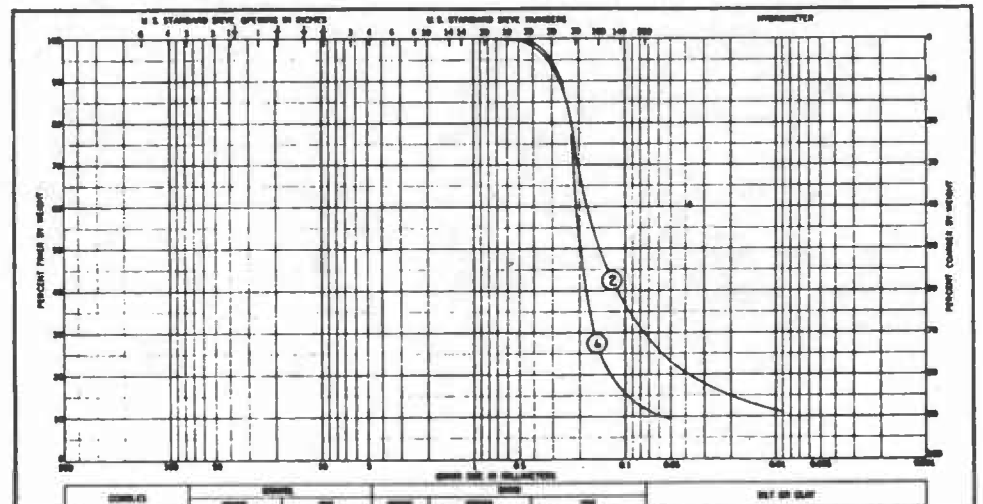
Project: Chesapeake Bay
Area: Rappahannock Channel
Boring No.: UH-VA 6
Date: Oct. 19[illegible]



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-2	49.5-51.0'	Silty, fine sand SM	—			
J-6	55.5-57.0'	ditto SM	—			

GRADATION CURVES

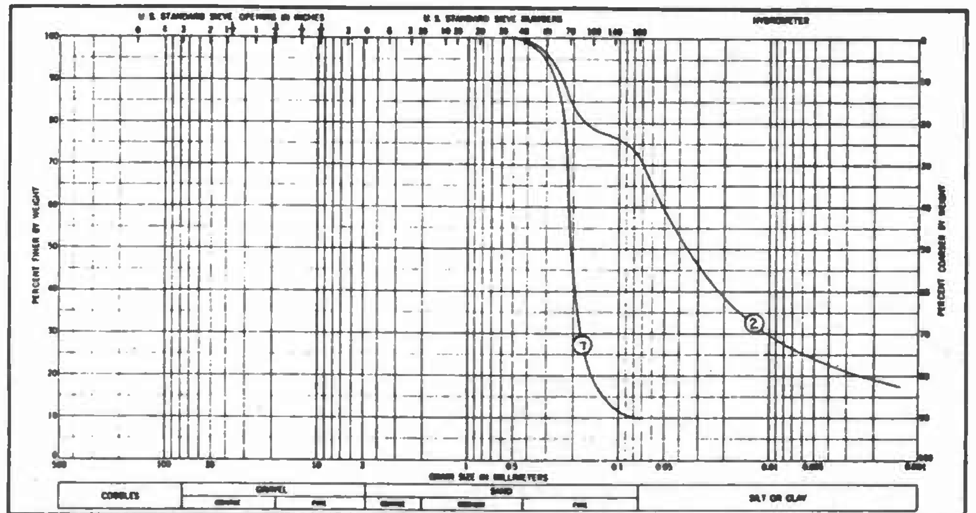
Project: Chesapeake Bay
Area: Rappahannock Channel
Boring No.: UH-VA 8
Date: Oct. 19[illegible]



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-2	50.5-5[illegible].0'	Silty, fine sand SM	—			
J-6	5[illegible].5-5[illegible]'	ditto SP-SM	—			

GRADATION CURVES

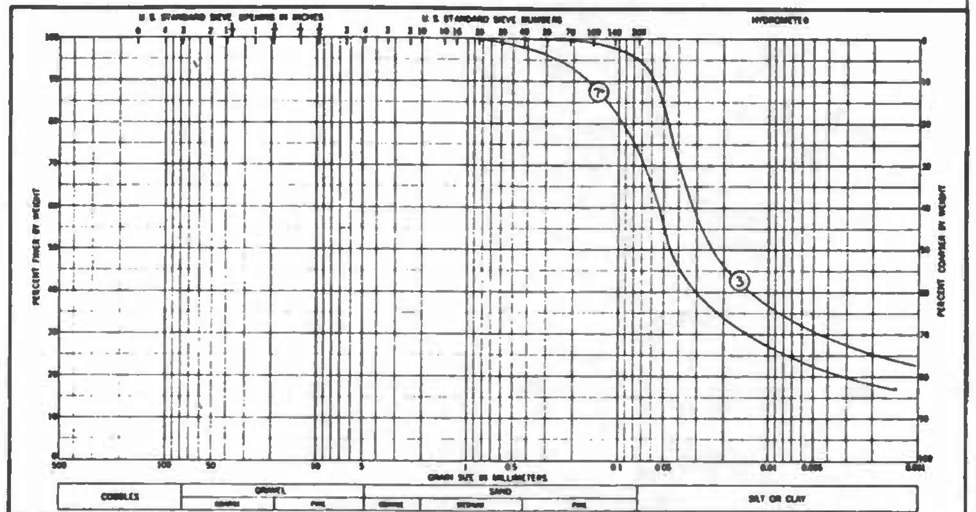
Project: Chesapeake Bay
Area: Rappahannock Channel
Boring No.: UH-VA 1[illegible]
Date: Oct. 19[illegible]



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-2	46.5-47.0'	Fine sandy clay CL	—	35	18	17
J-7	54.0-55.5'	Silty, fine sand SP-SM	—			

GRADATION CURVES

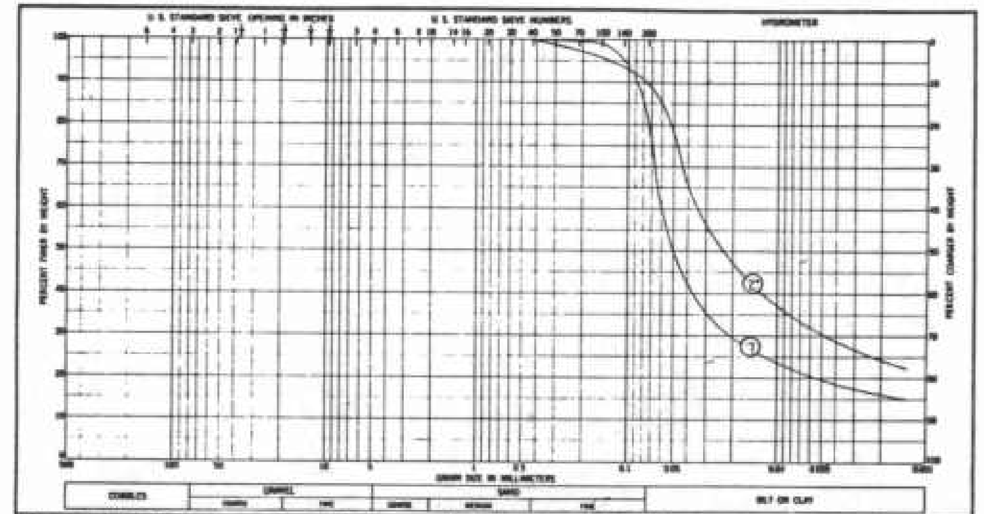
Project: Chesapeake Bay
Area: Rappahannock Channel
Boring No.: UI-VK 11
Date: Oct.1973



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-2	46.0-47.5'	Fine sandy, clay CL	—			
J-7	52.0-55.0'	ditto CL	—	33	16	17

GRADATION CURVES

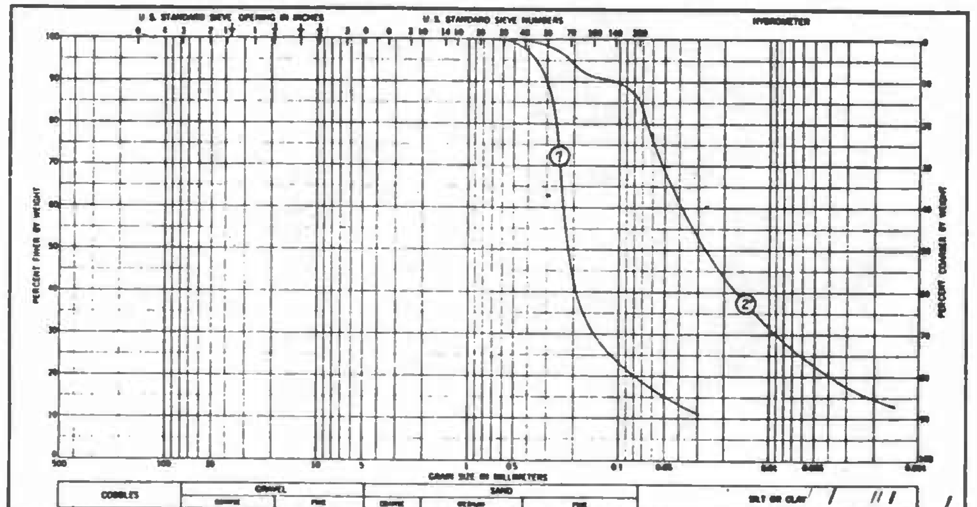
Project: Chesapeake Bay
Area: Rappahannock Channel
Boring No.: UI-VK 13
Date: Oct.1973



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-2,3,4	45.5-50.0'	Fine sandy, clay CL	—	41	20	21
J-7	53.0-54.5'	Fine sandy, silty, clay CL	—			

GRADATION CURVES

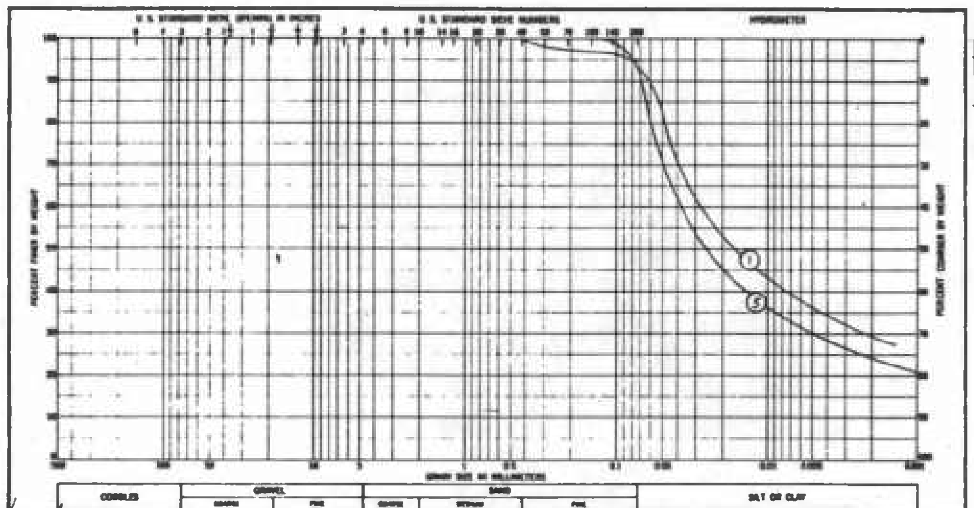
Project: Chesapeake Bay
Area: Rappahannock Channel
Boring No.: UI-VK 15
Date: Oct.1973



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-2&3	50.5-52.0'	Fine sandy, clay CL	—	40	20	20
J-7	57.5-59.0'	Silty, fine sand SM	—			

GRADATION CURVES

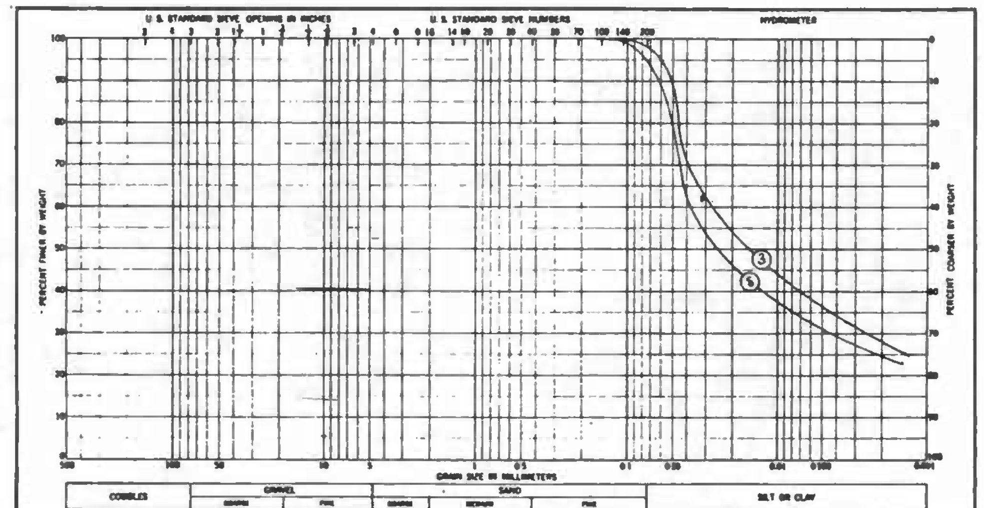
Project: Chesapeake Bay
Area: Rappahannock Channel
Boring No.: UI-VK 12
Date: Oct.1973



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-1	50.5-52.0'	Fine sandy, clay CL	—			
J-5	56.5-58.0'	ditto CL	—	40	21	19

GRADATION CURVES

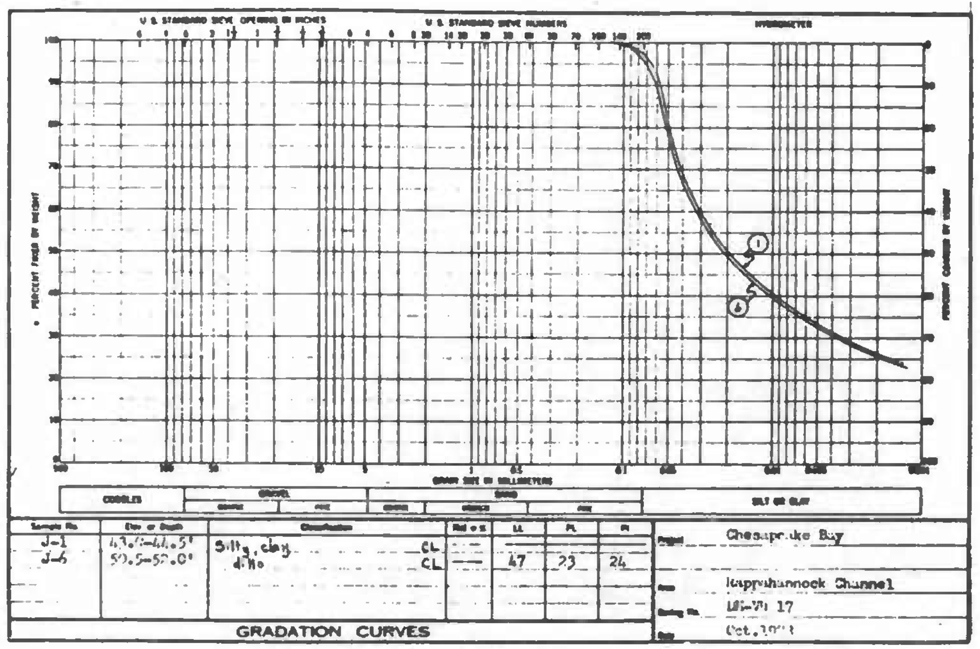
Project: Chesapeake Bay
Area: Rappahannock Channel
Boring No.: UI-VK 14
Date: Oct.1973

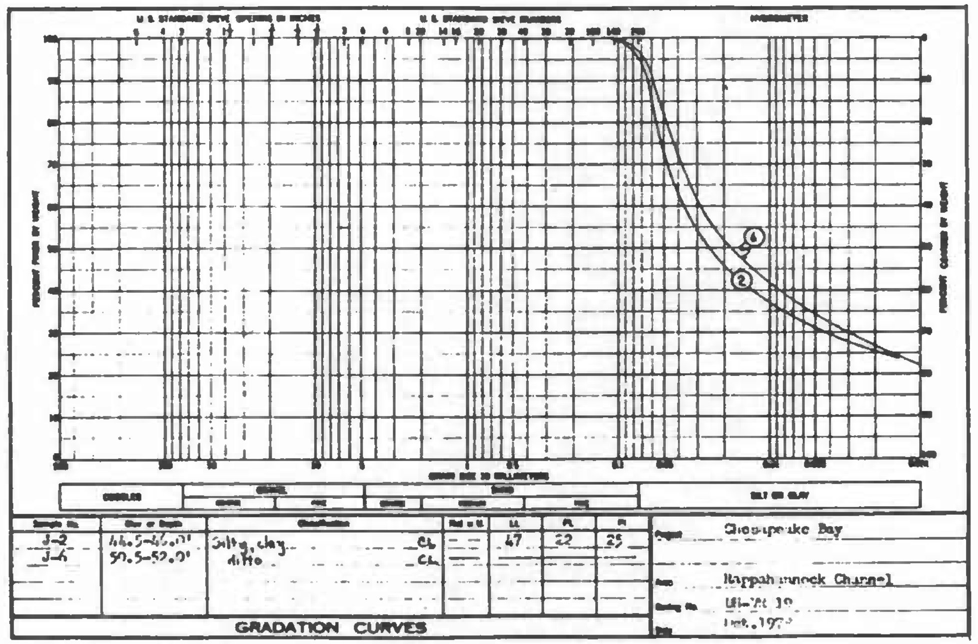


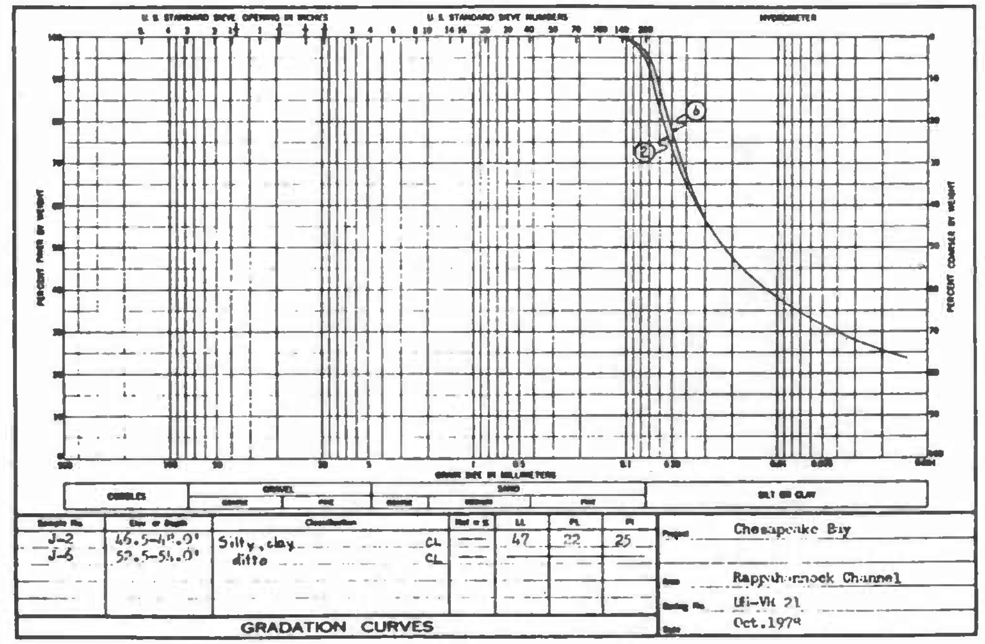
Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-3	47.0-48.5'	Fine sandy, silty, clay CL	—	41	21	20
J-8	54.5-56.0'	ditto CL	—			

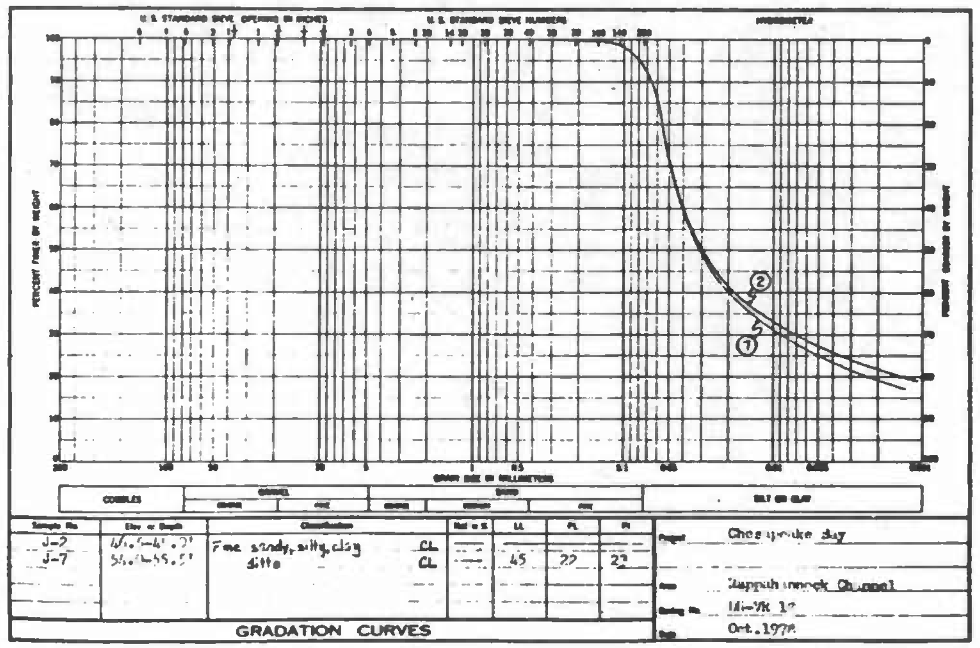
GRADATION CURVES

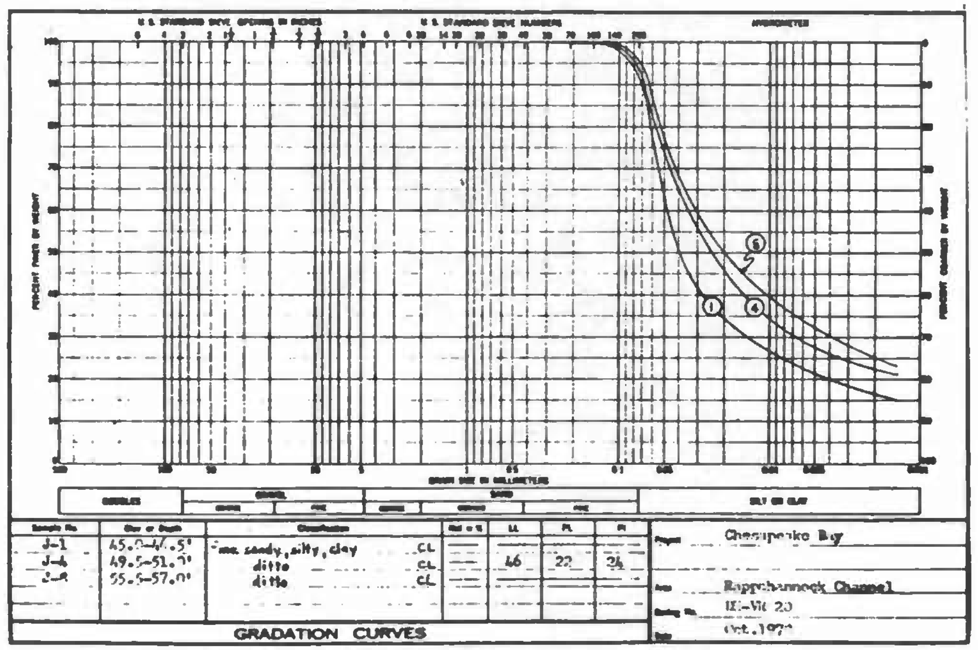
Project: Chesapeake Bay
Area: Rappahannock Channel
Boring No.: UI-VK 16
Date: Oct.1973

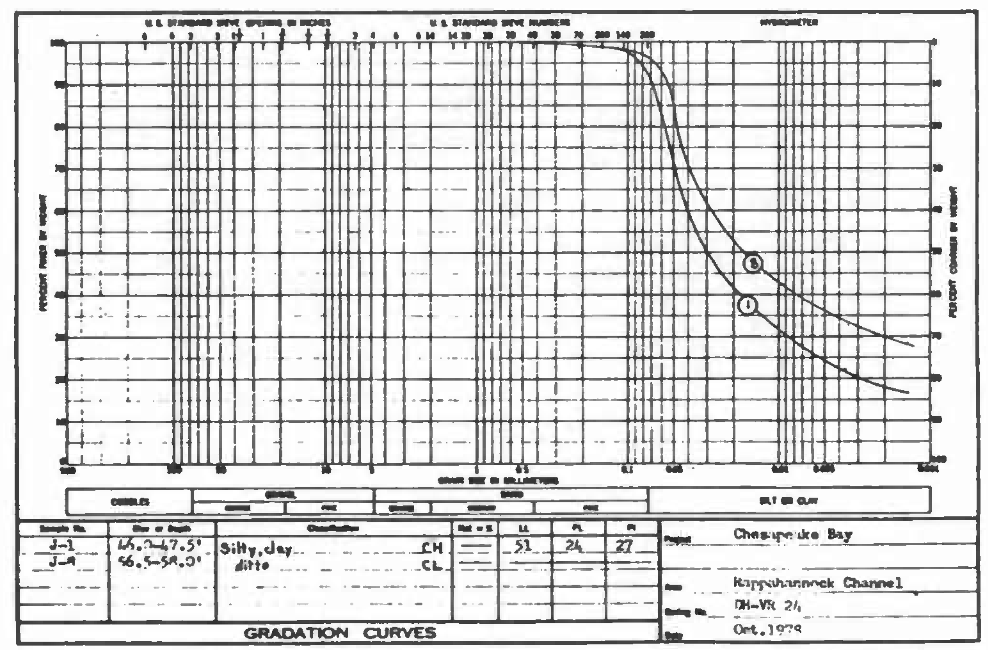

J-1
J-6
Silty, clay
ditto
CL
CL
47
23
24
Chesapeake Bay
Rappahannock Channel
GRADATION CURVES

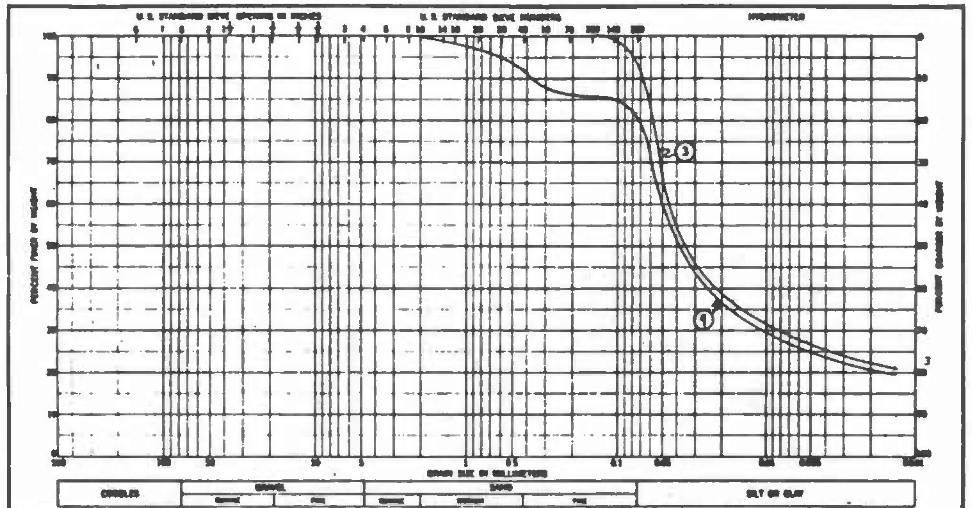

J-2
J-6
Silty, clay
ditto
47
22
25
Rappahannock Channel
GRADATION CURVES


J-2
J-6
Silty, clay
ditto
CL
CL
47
22
25
Chesapeake Bay
Oct. 1978
GRADATION CURVES


J-2
J-7
Fine sandy, silty, clay
ditto
CL
CL
45
22
23
Oct. 1978
GRADATION CURVES


J-1
J-6
Fine sandy, silty, clay
ditto
ditto
46
22
24
GRADATION CURVES

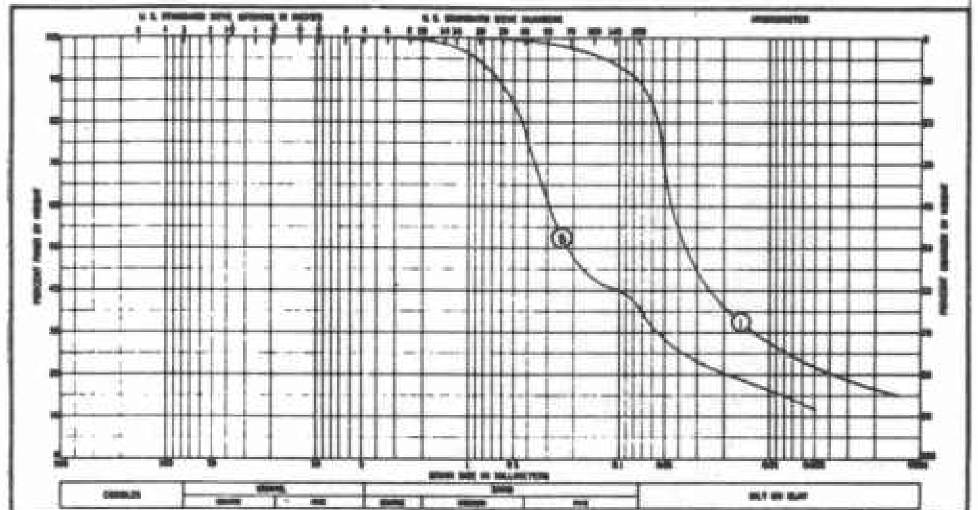

J-1
Silty, clay
ditto
CH
CL
51
24
27
Chesapeake Bay
Rappahannock Channel
GRADATION CURVES



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-3	48.[illegible]-49.5'	Silty, clay CH	—	51	25	26
J-9	5[illegible]. -6[illegible].5'	Sandy, silty, clay CL	—	47	23	24

GRADATION CURVES

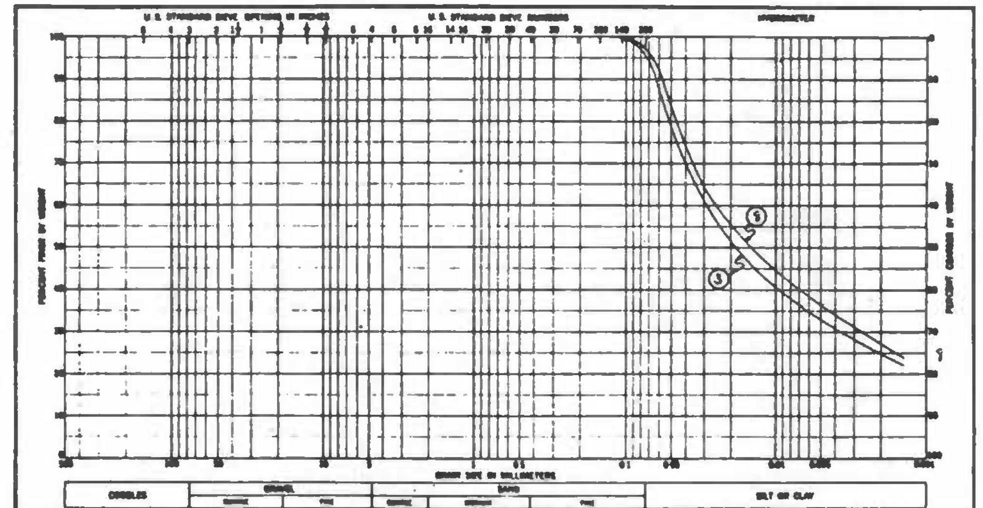
Project: Chesapeake Bay
Area: Rappahannock Channel
Boring No.: UH-VR 25
Date: Oct.1978



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-1	47.[illegible]-4[illegible].5'	Fine sandy, silty, clay CH	—	55	25	30
J-8	57.5-5[illegible].0'	Clayey, silty, sand SM	—			

GRADATION CURVES

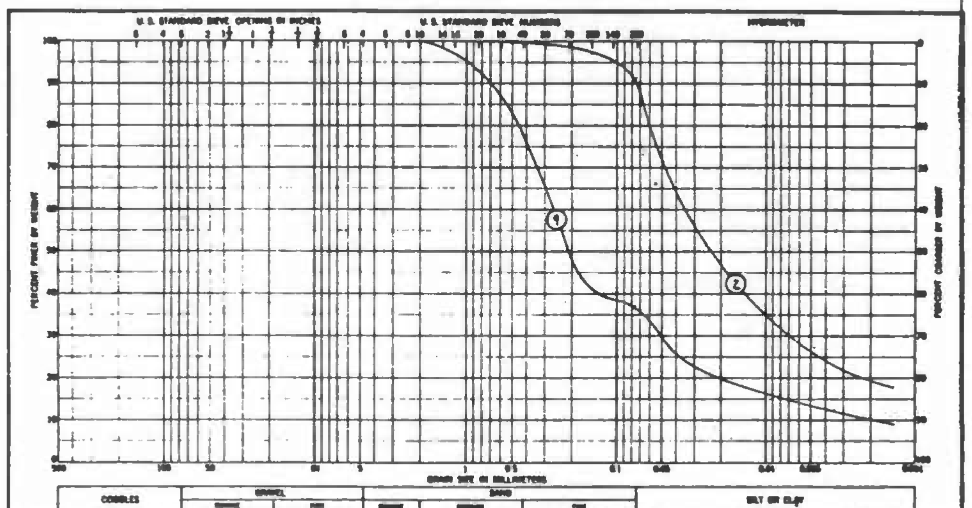
Project: Chesapeake Bay
Area: Rappahannock Channel
Boring No.: UH-VR 27
Date: Oct.1978



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-3	49.[illegible]-50.5'	Silty, clay CH	—	54	25	29
J-8	56.5-58.0'	ditto CL	—			

GRADATION CURVES

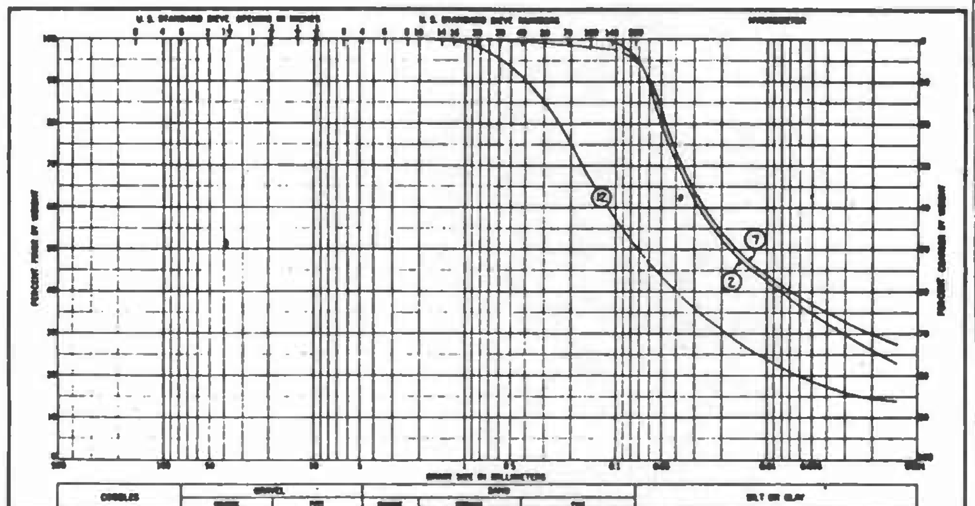
Project: Chesapeake Bay
Area: Rappahannock Channel
Boring No.: UH-VR 29
Date: Oct.1978



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-2	48.5-50.0'	Fine sandy, silt MH	—	50	40	10
J-9	59.0-60.5'	Silty, sand SM	—			

GRADATION CURVES

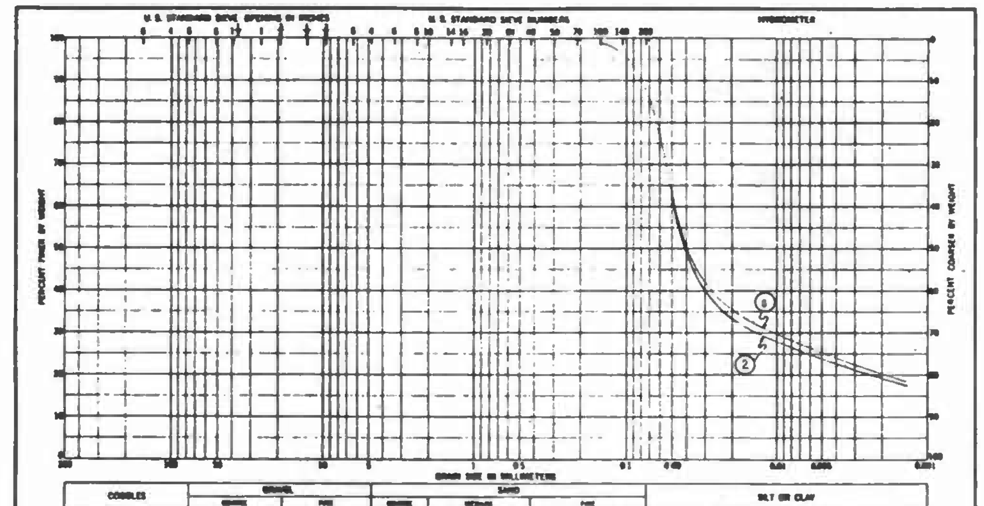
Project: Chesapeake Bay
Area: Rappahannock Channel
Boring No.: DH-VR 26
Date: Oct.1978



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-2	46.5-48.0'	Silty, clay CH	—	55	24	31
J-7	54.0-55.5'	ditto CL	—			
J-12	61.5-63.0'	Sandy, clayey, silt ML	—			

GRADATION CURVES

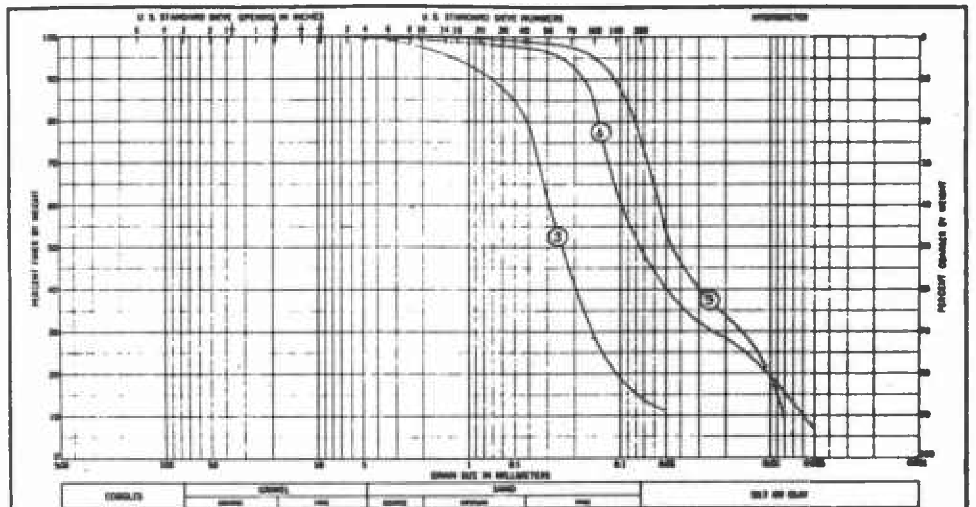
Project: Chesapeake Bay
Area: Rappahannock Channel
Boring No.: UH-VR 28
Date: Oct.1978



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-2	54.5-56.0'	Fine sandy, silt ML	—		N.P.	
J-6	60.5-62.0'	ditto ML	—			

GRADATION CURVES

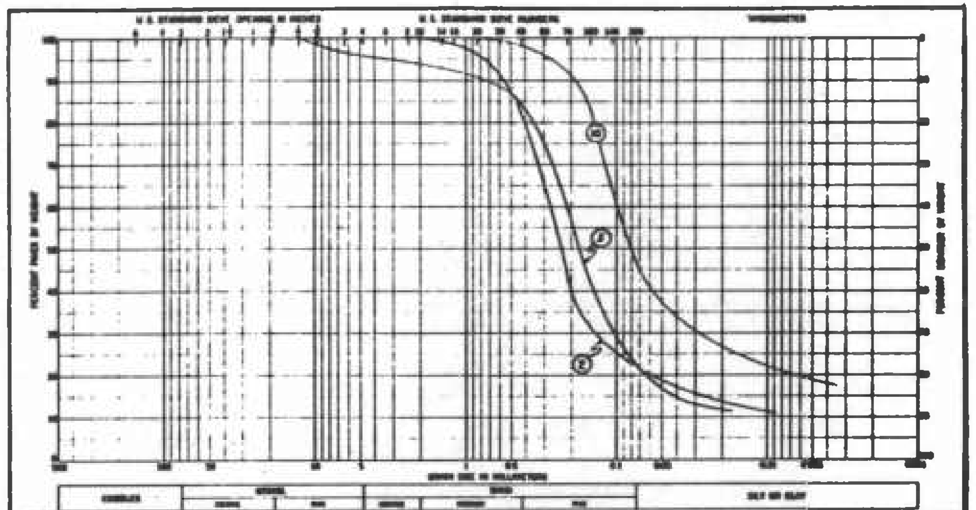
Project: Chesapeake Bay
Area: York Split Channel Drilling
Boring No.: VY-4
Date: Sept.1978



Sample No.	Elev. or Depth	Classification		Nat w %	LL	PL	PI
J-1	51.[illegible]-52.5'	Silty sand	SM	—	—	—	—
J-5	55.5-57.0'	Fine sandy, silty, clay	CL	—	35	24	11
J-9	60.0-61.5'	ditto	CH	—	57	24	33

GRADATION CURVES

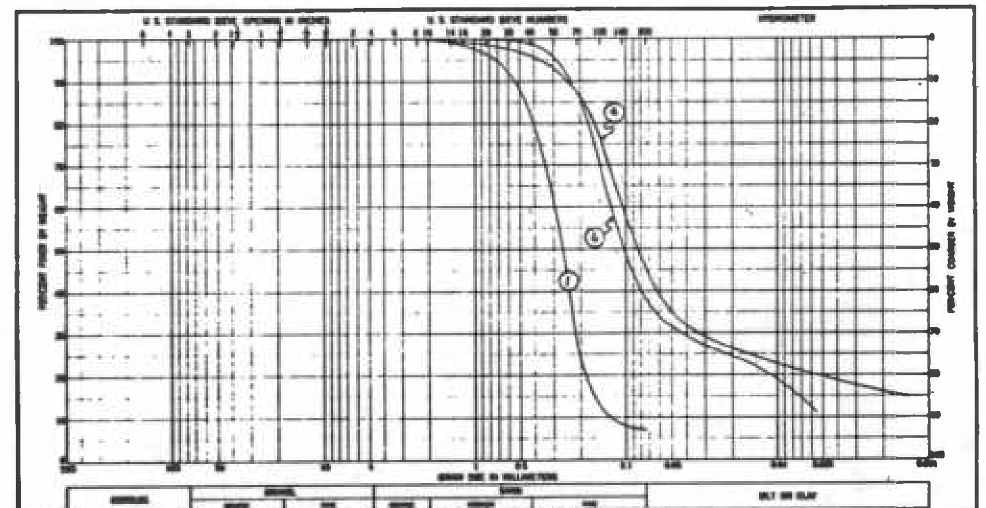
Project: Chesapeake Bay
Area: York Split Channel Drilling
Boring No.: VY-23
Date: Sept.1978



Sample No.	Elev. or Depth	Classification		Nat w %	LL	PL	PI
J-2	49.5-51.0'	Silty, sand	SM	—	—	—	—
J-5	54.0-55.5'	Gravelly, silty, sand	SM	—	—	—	—
J-10	61.5-63.0'	Silty, clayey, fine sand	SC	—	49	24	25

GRADATION CURVES

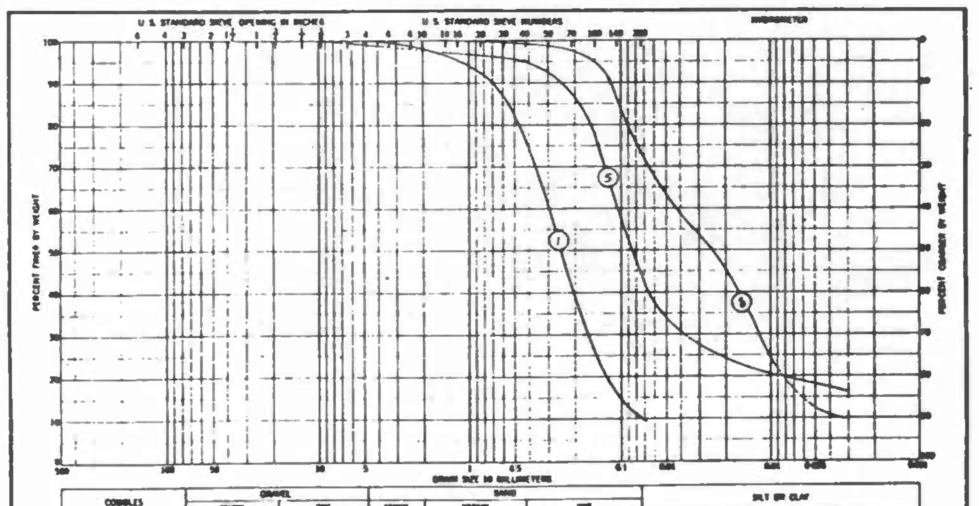
Project: Chesapeake Bay
Area: York Split Channel Drilling
Boring No.: VY-25
Date: Sept.197[illegible]



Sample No.	Elev. or Depth	Classification		Nat w %	LL	PL	PI
J-1	54.0-55.5'	Silty, sand	SP-SM	—	—	—	—
J-4	58.5-60.0'	Clayey, sand	SC	—	49	21	28
J-6	61.5-63.0'	Silty, clayey, sand	SC	—	—	—	—

GRADATION CURVES

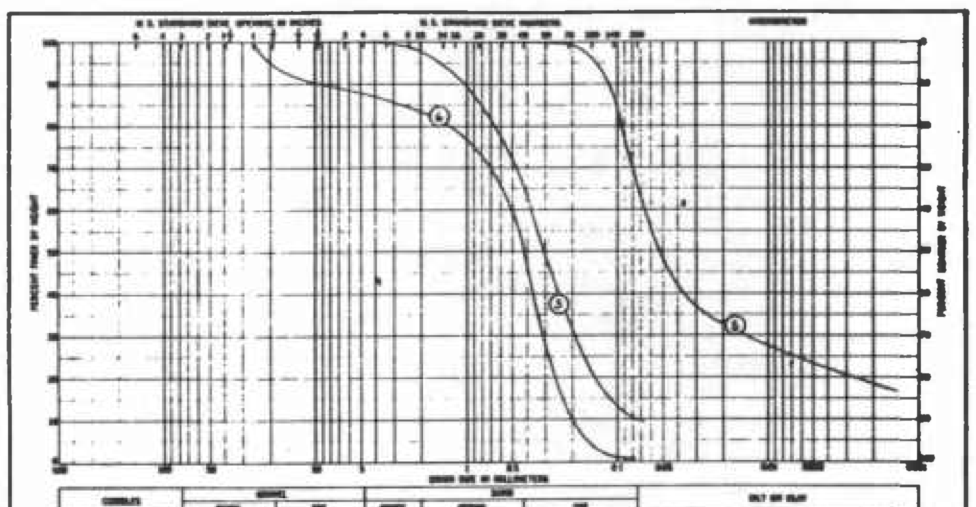
Project: Chesapeake Bay
Area: York Split Channel Drilling
Boring No.: VY-27
Date: Sept.1978



Sample No.	Elev. or Depth	Classification		Nat w %	LL	PL	PI
J-1	48.0-49.5'	Silty, sand	SP-SM	—	—	—	—
J-5	54.0-55.5'	Silty, clayey, sand	SC	—	43	26	17
J-8	58.5-60.0'	Fine sandy, clay	CH	—	65	23	42

GRADATION CURVES

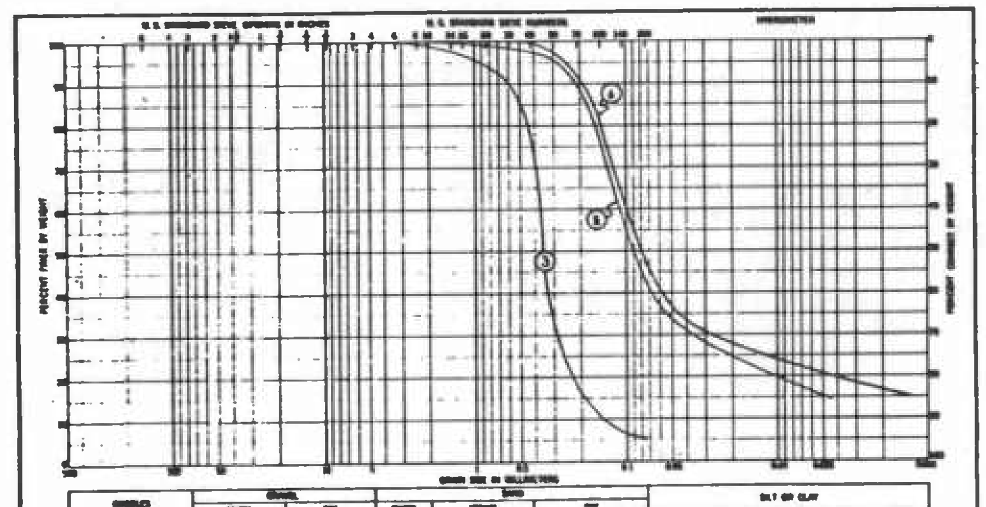
Project: Chesapeake Bay
Area: York Split Channel Drilling
Boring No.: VY-24
Date: Sept.197[illegible]



Sample No.	Elev. or Depth	Classification		Nat w %	LL	PL	PI
J-3	55.[illegible]-5[illegible].5'	Silty, sand	SP-SM	—	—	—	—
J-6	59.5-61.0'	Gravelly, sand	SP	—	—	—	—
J-8	62.5-6[illegible].0'	Fine sandy, clay	CH	—	61	21	[illegible]

GRADATION CURVES

Project: Chesapeake Bay
Area: York Split Channel Drilling
Boring No.: VY-26
Date: Sept.19[illegible]

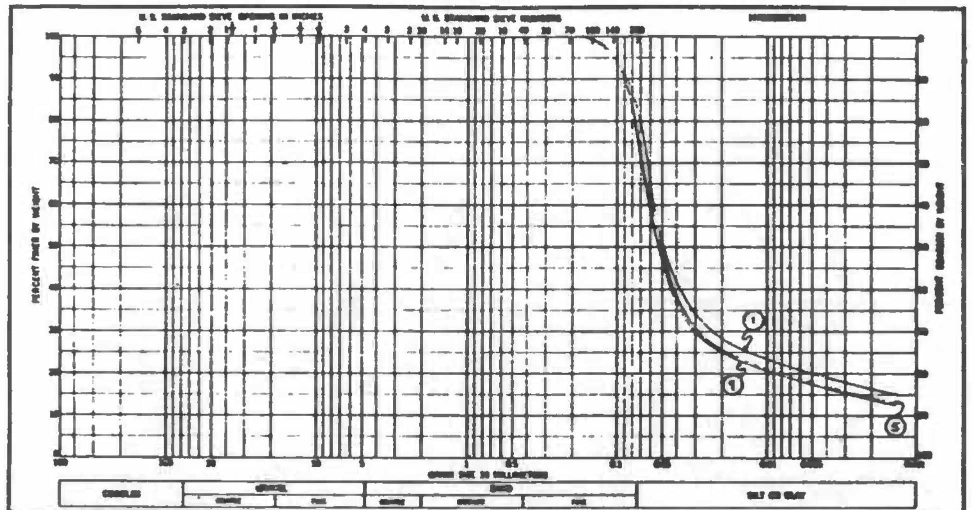


Sample No.	Elev. or Depth	Classification		Nat w %	LL	PL	PI
J-3	55.5-57.0'	Silty, sand	SP-SM	—	—	—	—
J-6	60.0-61.5'	Silty, clayey, fine sand	SC	—	39	25	14
J-8	63.0-64.5'	ditto	SC	—	—	—	—

GRADATION CURVES

Project: Chesapeake Bay
Area: York Split Channel Drilling
Boring No.: VY-28
Date: Sept.1978

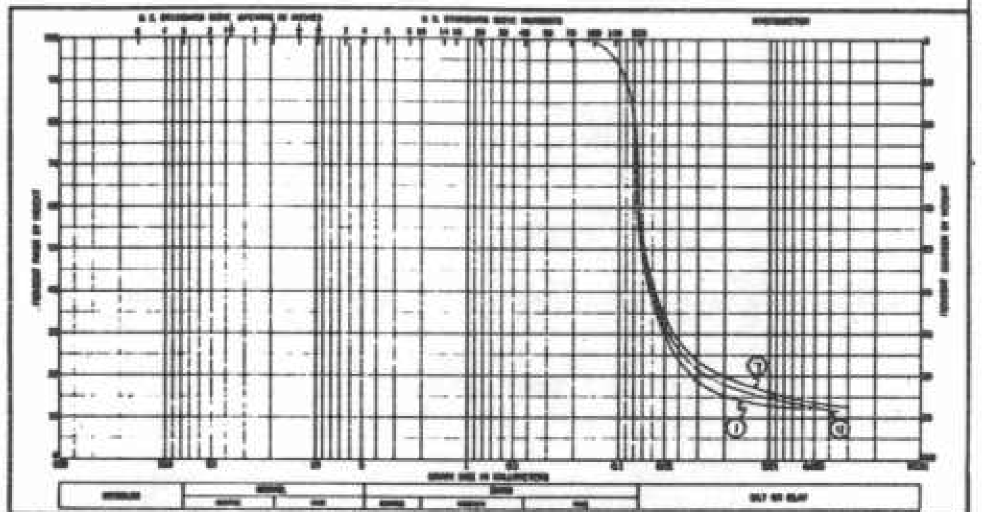
Plate B-37



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-1	48.0-49.5'	Fine sands, clayey, silt ML	—	37	24	13
J-5	54.0-55.0'	ditto ML	—			
J-9	60.0-61.5'	ditto ML	—			

GRADATION CURVES

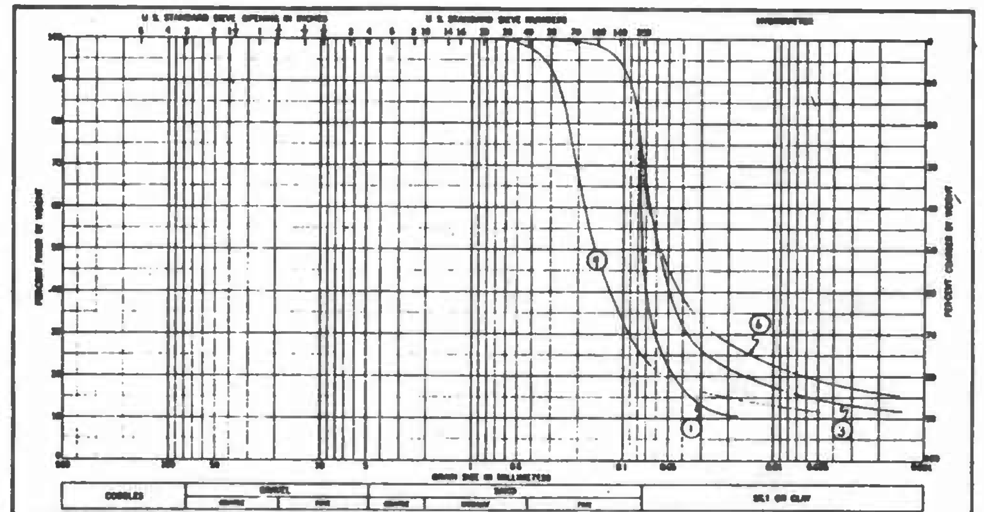
Project: Chesapeake Bay
Area: York Spit Channel Drilling
Boring No.: VY-5
Date: Sept.1978



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-3	41.0-42.5'	Fine [illegible] ML	—		N.P.	
J-7	50.0-51.5'	ditto ML	—	26	23	3
J-11	56.0-57.5'	[illegible] ML	—			

GRADATION CURVES

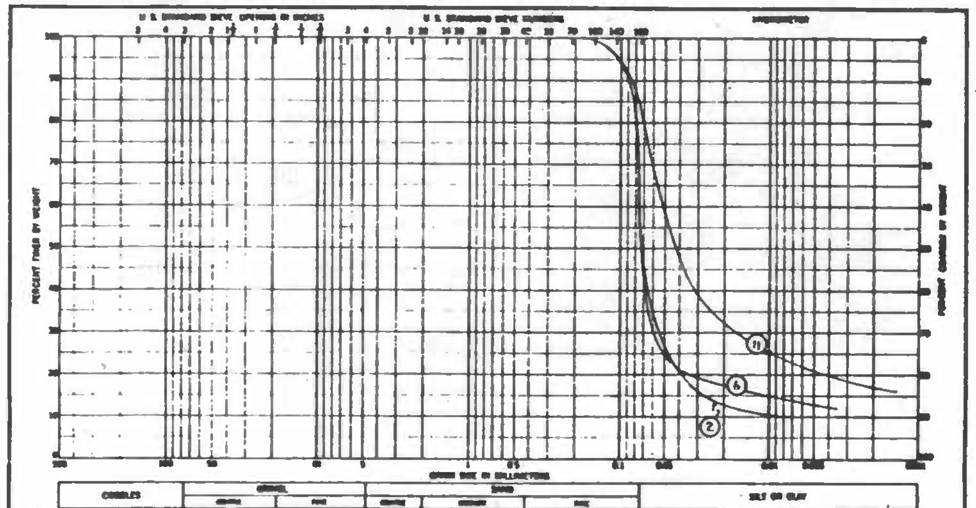
Project: Chesapeake Bay
Area: York Spit Channel Drilling
Boring No.: VY-7
Date: Sept.197[illegible]



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-1	47.0-48.5'	Silty, [illegible] ML	—			
J-3	50.0-51.5'	Fine sandy, silt MH	—			
J-6	54.5-56.0'	Fine sandy, silty, [illegible] ML	—	29	19	10
J-9	59.0-60.5'	Silty, fine sand SM	—			

GRADATION CURVES

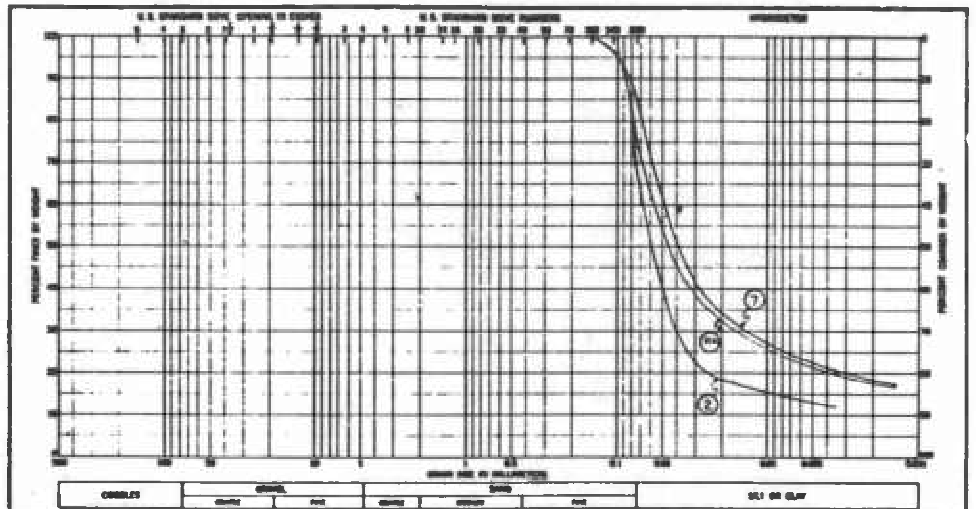
Project: Chesapeake Bay
Area: York Spit Channel Drilling
Boring No.: VY-9
Date: Sept.197[illegible]



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-2	45.5-47.0'	Fine sandy, silt ML	—		N.P.	
J-6	51.5-53.0'	ditto ML	—		N.P.	
J-11	59.0-60.5'	ditto ML	—			

GRADATION CURVES

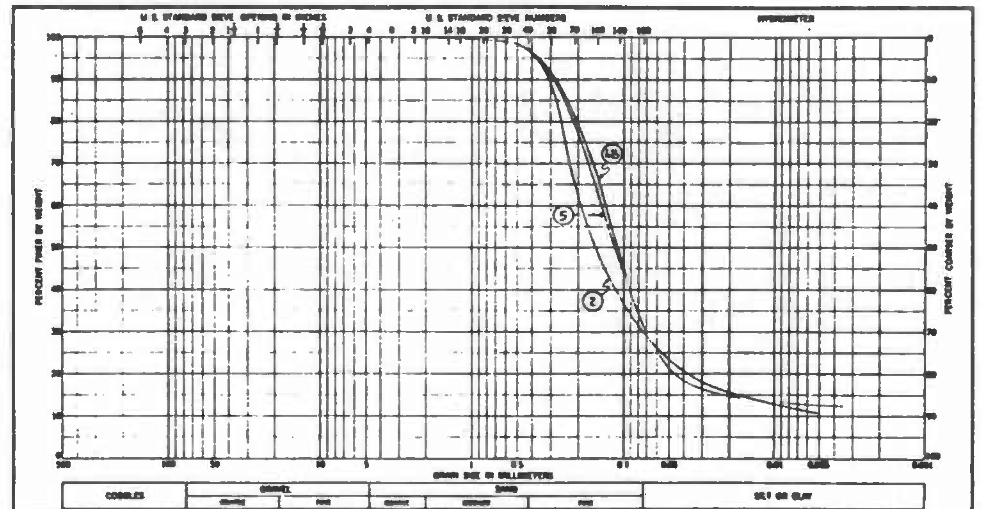
Project: Chesapeake Bay
Area: York Spit Channel Drilling
Boring No.: VY-6
Date: Sept.1978



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-2	44.5-46.0'	Fine sandy, silt ML		25	24	1
J-7	52.0-53.5'	Fine sandy, silty, [illegible] ML	—	30	22	8
J-11A	58.0-59.4'	Fine sandy, silt ML	—			

GRADATION CURVES

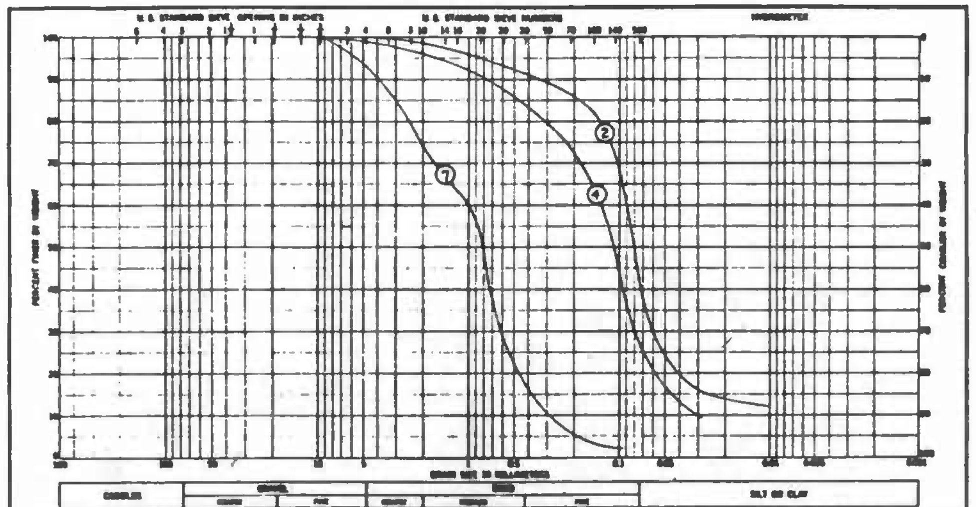
Project: Chesapeake Bay
Area: York Spit Channel Drilling
Boring No.: VY-[illegible]
Date: Sept.197[illegible]



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-2	53.0-54.5'	Silty, fine sand SM	—			
J-5	57.5-59.0'	ditto SM	—			
J-6A	60.0-60.5'	ditto SM				

GRADATION CURVES

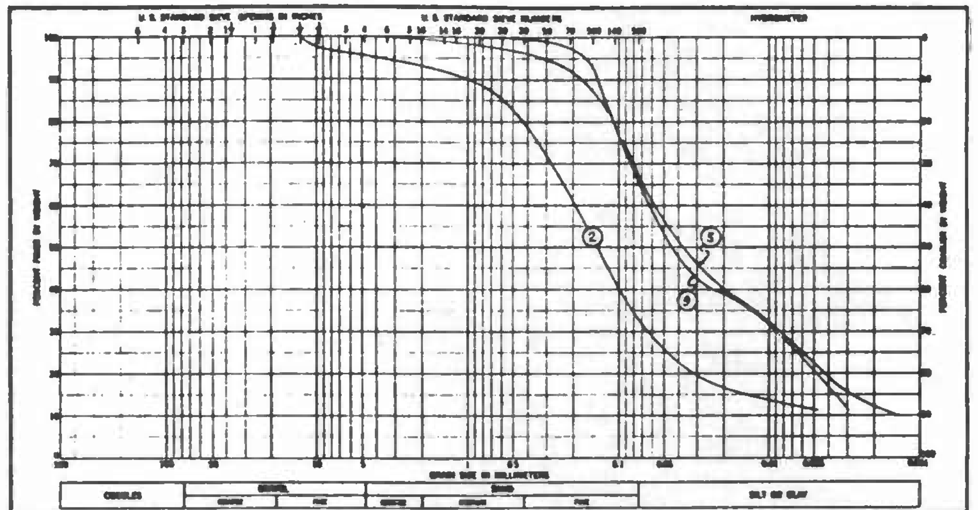
Project: Chesapeake Bay
Area: York Spit Channel Drilling
Boring No.: VY-10
Date: Sept.197[illegible]



Sample No.	Elev or Depth	Classification		Nat w %	LL	PL	PI
J-2	47.5-49.0'	Sandy, clayey silt	CL-ML	—	26	19	7
J-4	50.5-52.0'	Silty sand	SM	—			
J-7	55.0-56.5'	Gravelly sand	SP	—			

GRADATION CURVES

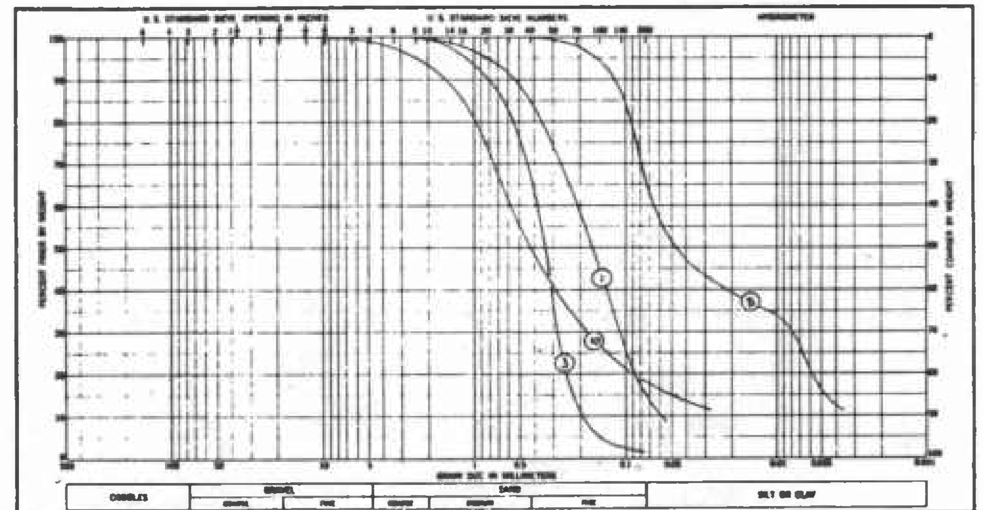
Project: Chesapeake Bay
Area: York Spit Channel Drilling
Boring No.: VY-17
Date: Sept. 1978



Sample No.	Elev or Depth	Classification		Nat w %	LL	PL	PI
J-2	48.0-49.5'	Gravelly, silty sand	SM	—			
J-5	52.5-54.0'	Fine sandy, silty clay	CH	—	66	22	44
J-9	58.5-60.0'	ditto	CH	—			

GRADATION CURVES

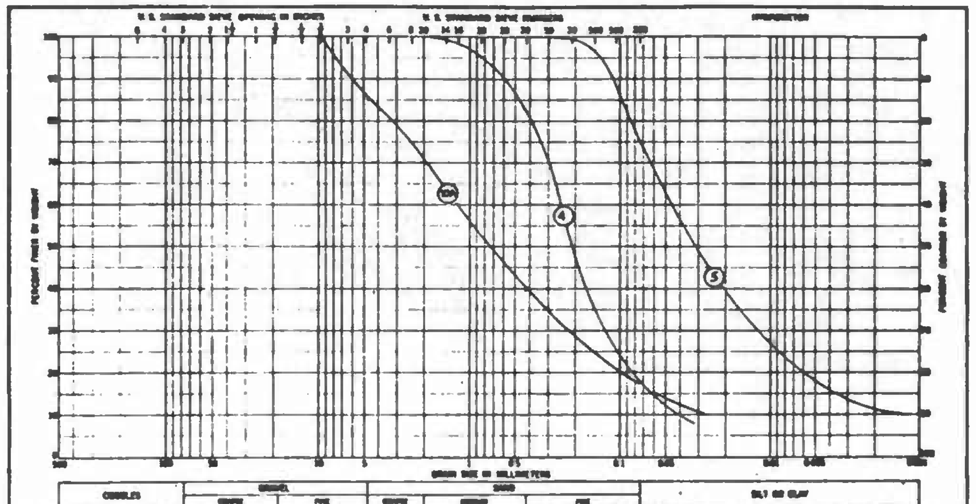
Project: Chesapeake Bay
Area: York Spit Channel Drilling
Boring No.: VY-19
Date: Sept. 1978



Sample No.	Elev or Depth	Classification		Nat w %	LL	PL	PI
J-1	47.0-48.5'	Silty sand	SM	—			
J-3	50.0-51.5'	Med. to fine sand	SP	—			
J-8	57.5-59.0'	Fine sandy, clay	CH	—	50	23	27
J-10	60.5-62.0'	Silty sand	SM	—			

GRADATION CURVES

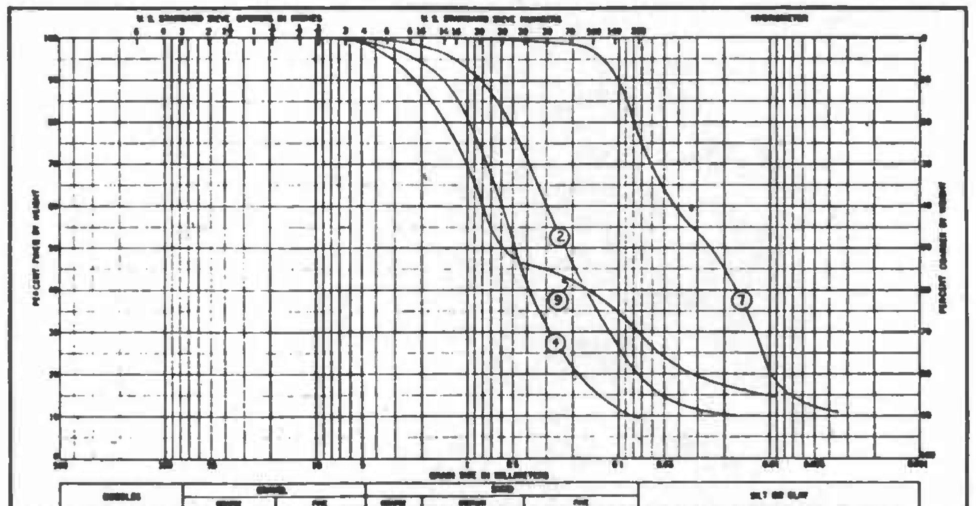
Project: Chesapeake Bay
Area: York Spit Channel Drilling
Boring No.: VY-21
Date: Sept. 1978



Sample No.	Elev or Depth	Classification		Nat w %	LL	PL	PI
J-4	51.0-55.0'	Silty sand	SM	—			
J-5	55.0-56.5'	Fine sandy clay	CH	—	62	24	38
J-10A	62.5-63.0'	Silty, gravelly sand	SM	—			

GRADATION CURVES

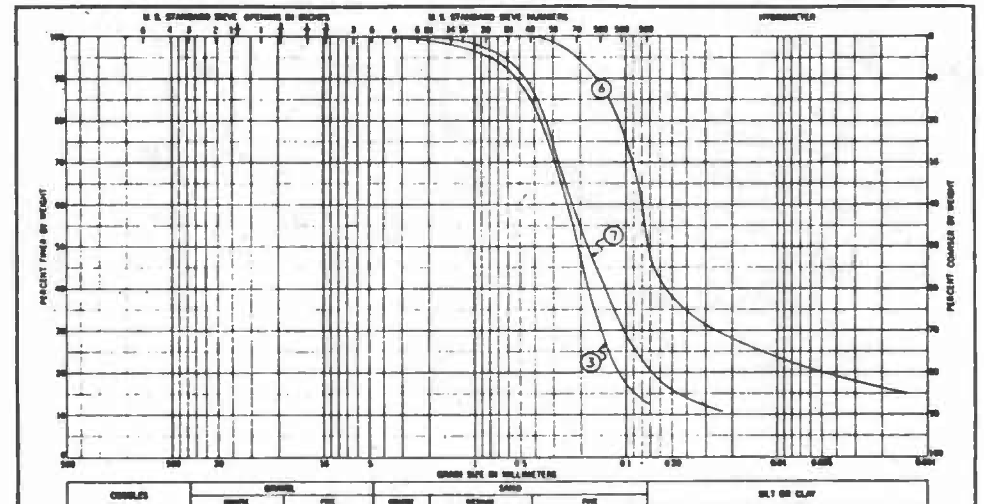
Project: Chesapeake Bay
Area: York Spit Channel Drilling
Boring No.: VY-18
Date: Sept. 1978



Sample No.	Elev or Depth	Classification		Nat w %	LL	PL	PI
J-2	49.0-50.5'	Silty sand	SM	—			
J-4	52.0-53.5'	Silty sand	SM-SM	—			
J-7	56.5-58.0'	Fine sandy, silty clay	CH	—	64	26	38
J-9	59.5-61.0'	Silty, clayey sand	SC	—			

GRADATION CURVES

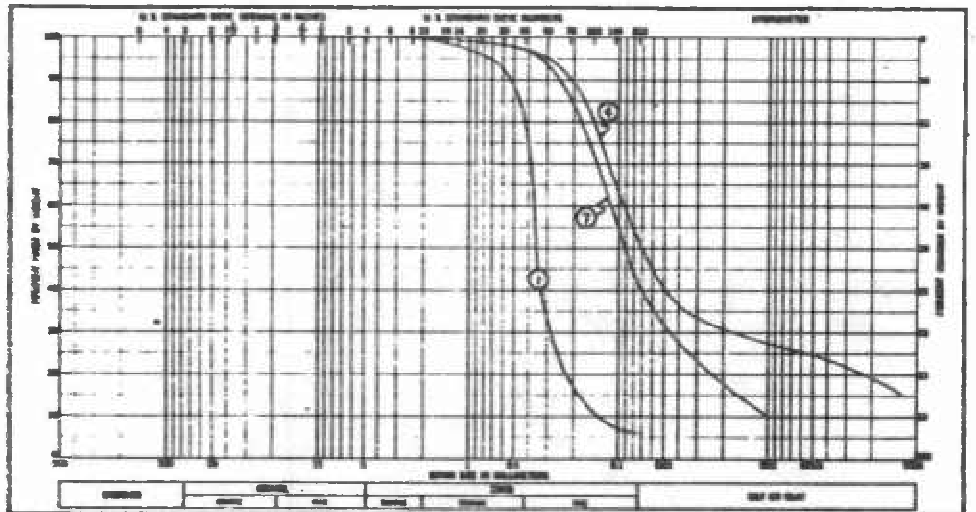
Project: Chesapeake Bay
Area: York Spit Channel Drilling
Boring No.: VY-20
Date: Sept. 1978



Sample No.	Elev or Depth	Classification		Nat w %	LL	PL	PI
J-3	48.0-49.5'	Silty sand	SM	—			
J-6	56.0-57.5'	Fine sandy, clay	CL	—	42	23	19
J-7	57.5-59.0'	Clayey, silty sand	SM	—			

GRADATION CURVES

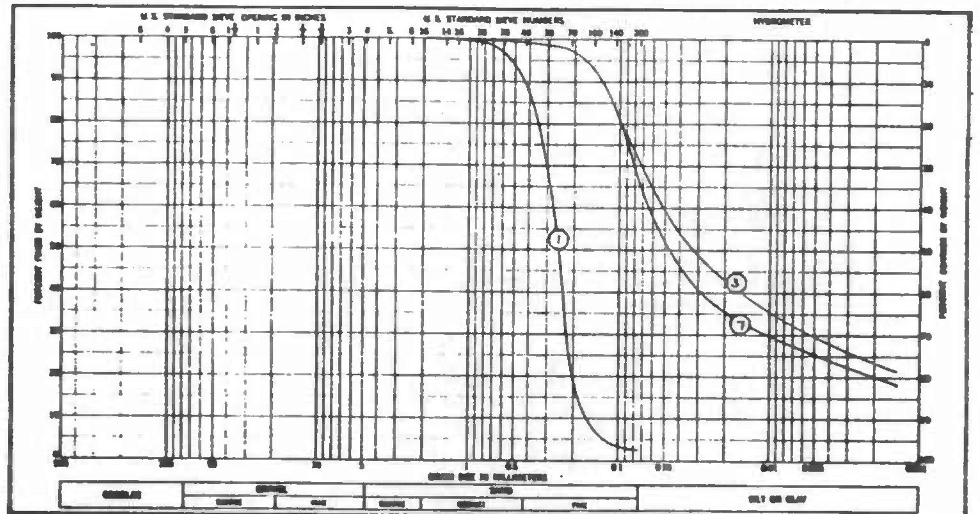
Project: Chesapeake Bay
Area: York Spit Channel Drilling
Boring No.: VY-22
Date: Sept. 1978



Sample No.	Elev or Depth	Classification		Nat w %	LL	PL	PI
J-1	52.5-54.0'	Silty, sand	SP-SM	—	—	—	—
J-4	57.0-58.5'	Fine sandy, clay	CL	—	48	23	25
J-7	61.5-63.0'	Silty, clayey, fine sand	SC	—	—	—	—

GRADATION CURVES

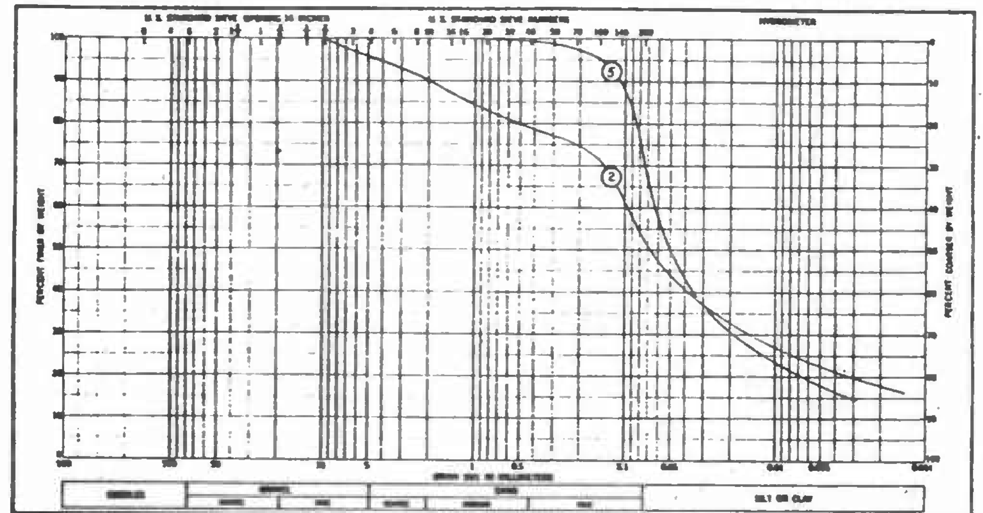
Project: Chesapeake Bay
Area: York Spit Channel Drilling
Boring No.: VT-29
Date: Sept. 1978



Sample No.	Elev or Depth	Classification		Nat w %	LL	PL	PI
J-1	53.0-55.0'	Med. to fine sand	SP	—	—	—	—
J-3	56.5-58.0'	Fine sandy, clay	CH	—	58	21	37
J-7	62.5-64.0'	ditto	CH	—	53	23	30

GRADATION CURVES

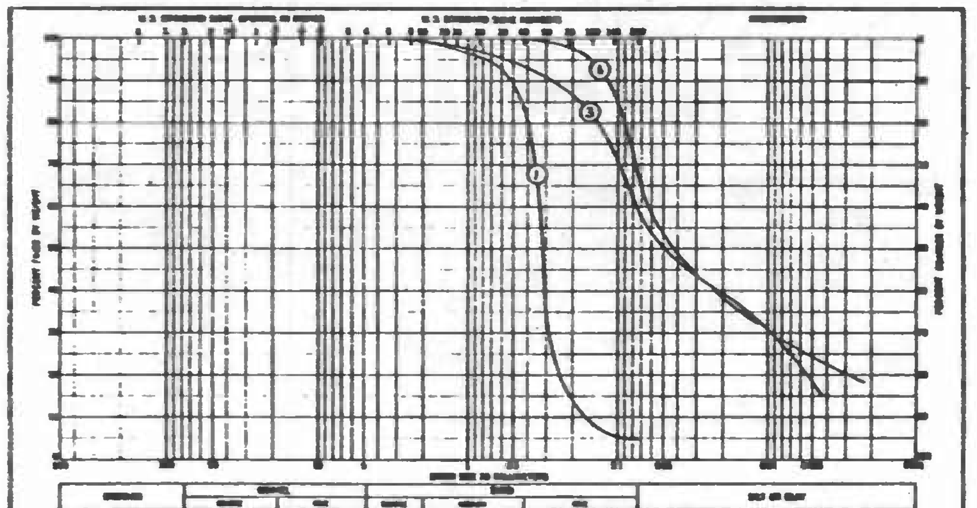
Project: Chesapeake Bay
Area: York Spit Channel Drilling
Boring No.: VT-31
Date: Sept. 1978



Sample No.	Elev or Depth	Classification		Nat w %	LL	PL	PI
J-2	54.5-56.0'	Gravelly, sandy, clay	CH	—	60	23	37
J-5	59.0-60.5'	Fine sandy, clay	CH	—	63	26	37

GRADATION CURVES

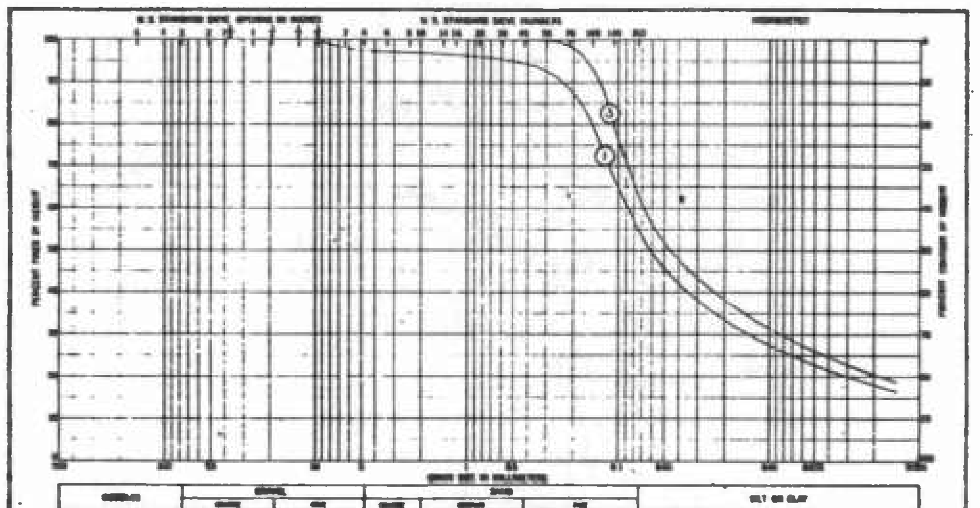
Project: Chesapeake Bay
Area: York Spit Channel Drilling
Boring No.: VT-33
Date: Sept. 1978



Sample No.	Elev or Depth	Classification		Nat w %	LL	PL	PI
J-1	52.0-53.5'	Med. to fine sand	SP	—	—	—	—
J-3	55.0-56.5'	Sandy, clay	CH	—	60	21	39
J-6	59.5-61.0'	Fine sandy, clay	CH	—	59	24	35

GRADATION CURVES

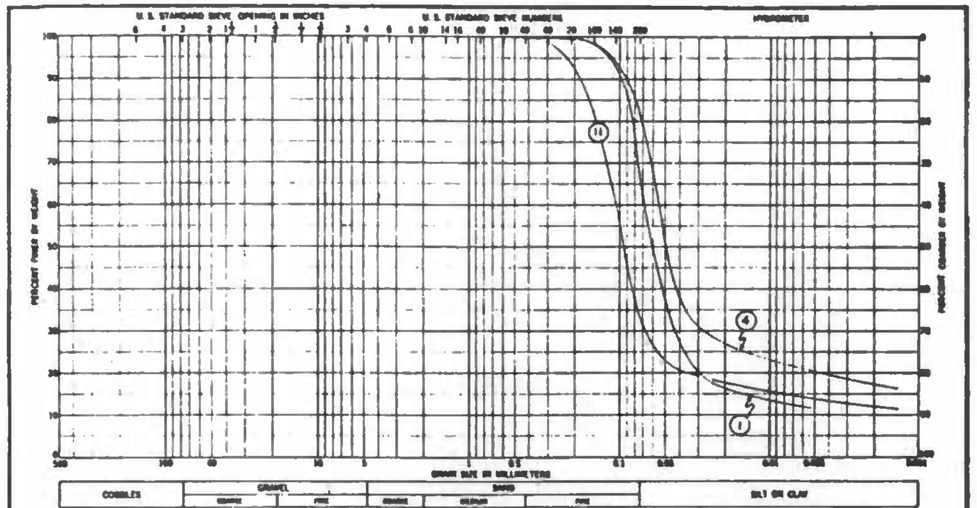
Project: Chesapeake Bay
Area: York Spit Channel Drilling
Boring No.: VT-30
Date: Sept. 1978



Sample No.	Elev or Depth	Classification		Nat w %	LL	PL	PI
J-1	56.0-57.5'	Fine sandy, clay (tr. gravel)	CH	—	57	25	32
J-3	59.0-60.5'	Fine sandy, clay	CH	—	—	—	—

GRADATION CURVES

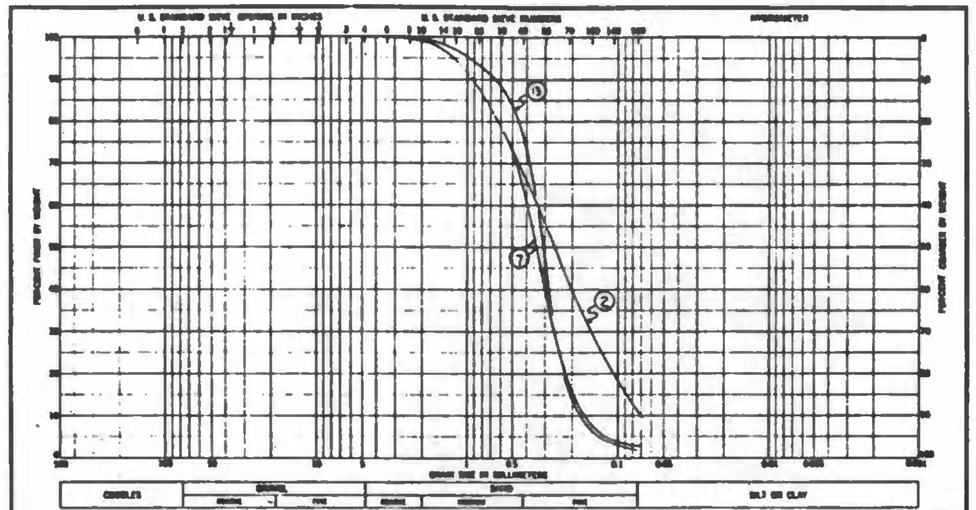
Project: Chesapeake Bay
Area: York Spit Channel Drilling
Boring No.: VT-32
Date: Sept. 1978



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-1	42.0-43.5'	Fine sandy, silt ML				
J-6	46.5-48.0'	Fine sandy, clayey, silt ML		30	23	7
J-11	57.0-58.5'	Silty, fine sand SM		42	29	13

GRADATION CURVES

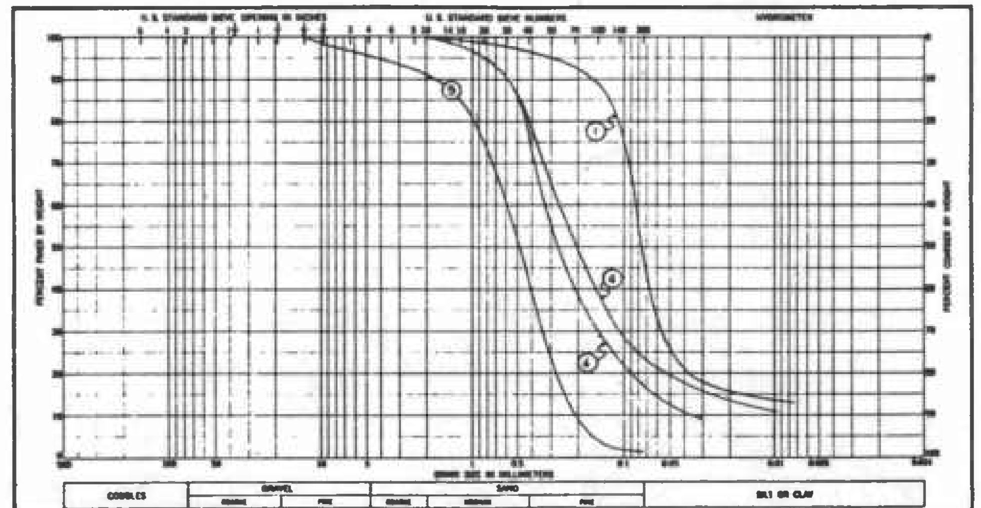
Project: Chesapeake Bay
Area: York Spit Channel Drilling
Boring No.: VY-11
Date: Sept.1977



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-2	38.5-40.0'	Silty, sand SP-SM				
J-7	49.0-50.5'	Med. to fine sand SP				
J-13	58.0-59.5'	ditto SP				

GRADATION CURVES

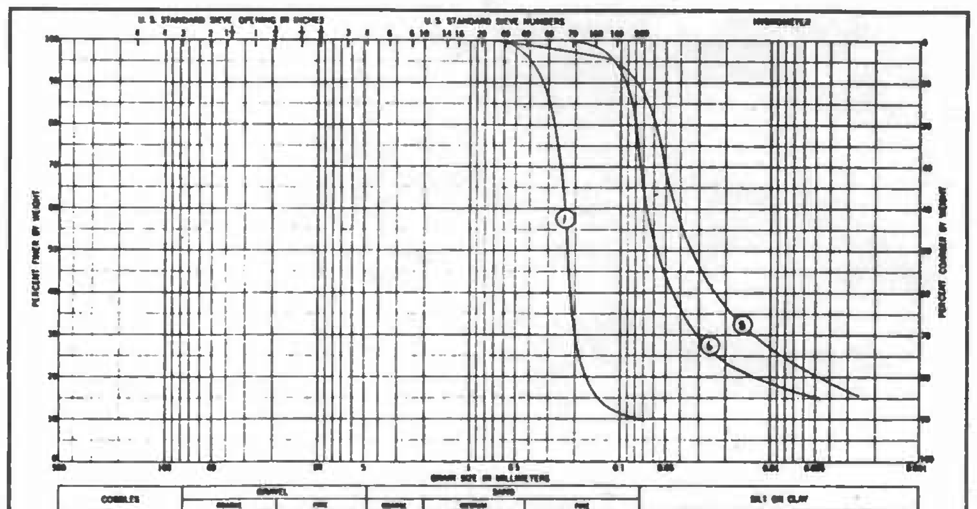
Project: Chesapeake Bay
Area: York Spit Channel Drilling
Boring No.: VY-13
Date: Sept.1978



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-1	45.0-46.5'	Silty, sand SM			N.P.	
J-4	49.5-51.0'	ditto SM				
J-6	52.5-54.0'	ditto SM				
J-9	57.0-58.5'	Gravelly, sand SP				

GRADATION CURVES

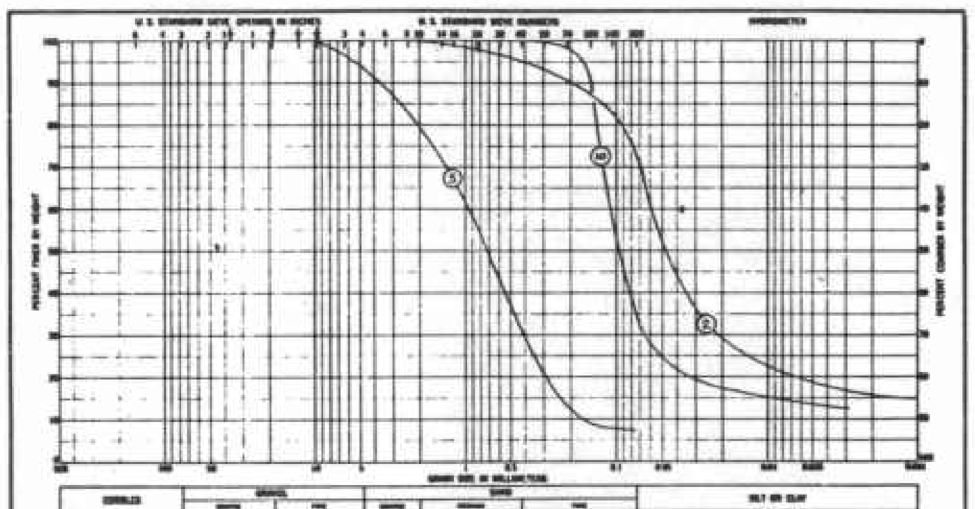
Project: Chesapeake Bay
Area: York Spit Channel Drilling
Boring No.: VY-15
Date: Sept.1978



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-1	46.5-48.0'	Silty, fine sand SP-SM				
J-6	54.0-55.5'	Fine sandy, silt ML			N.P.	
J-8	57.0-58.5'	Fine sandy, silty, clay CL		34	22	12

GRADATION CURVES

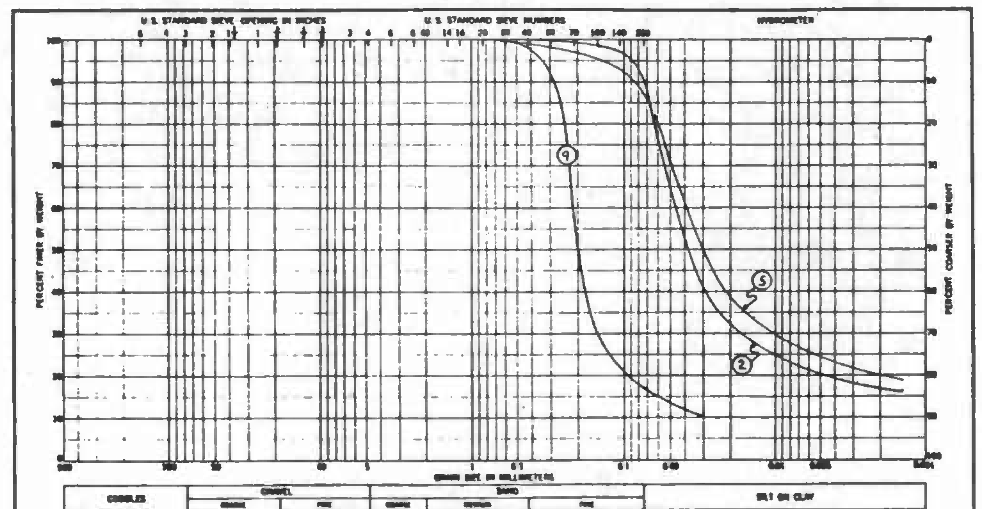
Project: Chesapeake Bay
Area: York Spit Channel Drilling
Boring No.: VY-12
Date: Sept.1978



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-2	48.0-49.5'	Sandy, silty, clay CL		31	22	9
J-5	52.5-54.0'	Gravelly, silty, sand SP-SM				
J-10	60.0-61.5'	Silty, fine sand SM				

GRADATION CURVES

Project: Chesapeake Bay
Area: York Spit Channel Drilling
Boring No.: VY-14
Date: Sept.1978



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-2	51.5-53.0'	Fine sandy, silty, clay CL		32	23	9
J-5	56.0-57.5'	Fine sandy, clayey, silt ML				
J-9	62.0-63.5'	Silty, fine sand SM				

GRADATION CURVES

Project: Chesapeake Bay
Area: York Spit Channel Drilling
Boring No.: VY-16
Date: Sept.1978

APPENDIX C

VIMS REPORT 1972

INTRODUCTION

During the summer of 1972, the Virginia Institute of Marine Science retrieved numerous bottom sediment samples from various channel locations in the Chesapeake Bay and communicationg river systems. These samples were later analysed for various parameters. The following is a portion of the subsequent report prepared by the Institute for the Norfolk District Corps of Engineers. Only data pertaining to those channels comprising portions of the Baltimore Harbor and Channels is displayed.

STUDY
OF
CHANNEL SEDIMENTS

BALTIMORE HARBOR

NORFOLK HARBOR

YORK ENTRANCE CHANNEL

DECEMBER 1972

Project Report under Contract No. DACW 65-72-C-0047 submitted to the United States Army Corps of Engineers by the Virginia Institute of Marine Science.

STUDY OF CHANNEL SEDIMENTS
CORPS OF ENGINEERS: SUMMER 1972

Bottom sediment samples were collected from seven channel locations in the Chesapeake Bay and communicating river systems. The sampling format involved long cores (designated "L") taken at two nautical mile intervals and surface samples (designated "S") taken at one-half mile intervals. Exact sampling sites were specified by the Corps of Engineers. Long cores were collected using a hydraulic vibrating corer leased from Ocean Science and Engineering Corp., Rockville, Md. Collection of surface samples utilized a Ponar grab or a three-foot gravity corer. Surface samples were iced in the field, returned to the laboratory where they were sieved through a 2 mm screen, homogenized, and refrigerated. Long cores were returned to the laboratory and stored in a "cold room." Four inch subsamples were cut from the cores, sieved through a 2 mm screen, homogenized and refrigerated.

The following areas were included in the study:

Thimble Shoals Channel
Newport News Channel
Norfolk Harbor Channel
Rappahannock Shoals Channel
Cape Henry Channel
York Spit Channel
York Entrance Channel

Parameters Studied and Methods Used:	Symbol
Total Solids[1]	TS
Volatile Solids[1]	VS
Chemical Oxygen Demand[1]	COD
Total Kjeldahl Nitrogen[1]	TKN
Total Phosphorus[2]	TP
Zinc[3]	Zn

Copper[3]	Cu
Lead[3]	Pb
Mercury[4]	Hg

1. Determinations of % Total Solids, % Volatile Solids, % Chemical Oxygen Demand, and Total Kjeldahl Nitrogen were made as prescribed in "Chemistry Laboratory Manual, Bottom Sediments," compiled by The Great Lakes Regional Committee on Analytical Methods, EPA (1969).

2. Total Phosphorus determinations were made using a VIMS modification of the procedure described in "Standard Methods for the Examination of Water and Wastewater," 13 ed. (1971). One-half gram samples were fumed with sulfuric and nitric acids. Digested sediments were removed by filtration and diluted filtrates were analyzed colorimetrically. Duplicate analysis showed that this method compared favorably with the EPA technique for sediment analysis, but consumed much less time per sample.

3. Zinc, Copper and Lead were determined by digesting one-half gram sediment samples in concentrated nitric acid for 24 hours and were analyzed by atomic absorbtion spectrophotometry (Varian Techtron, Mdl AA-5).

4. Mercury determinations were made by wet digestion and flameless atomic absorbtion spectrophotometry. One-half gram samples were digested in 10.0 ml concentrated sulfuric acid for 24 hours followed by oxidation with 20.0 ml 5.0% $KMnO_4$, reduction with hydroxylamine and stannous sulfate, and analyzed using a Coleman Mercury Analyzer, MAS 50.

All weights reported in techniques of analysis are wet weights. Final results have been corrected for % Total Solids and represent dry-weight concentrations.

Sample Designation Key

Area	Sample Designation: Surface Core/Grab	Sample Designation: Long Core
Thimble Shoals Channel	TSS	TSL
Newport News Channel	NNS	NNL
Norfolk Harbor Channel	(1)	E40L, E45L
Rappahannock Shoals Channel	RSS	RSL
Cape Henry Channel	CHS	CHL
York Spit Channel	YSS	YSL
York Entrance Channel	YES	YEL

(1) No surface samples collected from Norfolk Harbor. Data for this area is reported in Corps of Engineers Contract No. DACW-65-71-C-0047.

All surface samples are numbered consecutively in a given area and correspond to identification on the enclosed charts.

Long cores are numbered consecutively in a given area. In addition, long core subsamples are identified according to the core they came from and the distance (in feet) of that sample below mean low water (MLW).

Addendum to Project Report under Contract No. DACW 65-72-C-0047 - "Study of Channel Sediments - Baltimore Harbor, Norfolk Harbor, York Entrance Channel."

I. Statement on the determination and accuracy of sample locations: Samples were collected in accordance with a Corps of Engineers, Norfolk District Disposition Form dated 31 March 1972, approved by representatives of the Corps of Engineers and the Virginia Institute of Marine Science. The sampling vessel was the 90 foot Annandale owned and operated by Oceanic Enterprises, Baltimore, Md. The vessel was equipped with a Decca Transar Radar, Mdl. No. TM626, a Kelvin-Hughes 14/9 Radar and Kelvin-Hughes MS-32 Recording Echo Sounder with MS-34 indicator.

Station positioning was achieved in the channels by reference to fixed channel buoys. Visual positioning was adequate in stations adjacent to channel markers. At station locations removed from channel markers where visual alignment was neither practical nor accurate, radar positioning with reference to land masses and channel buoys was used. Assuming accurate buoy positions, sample locations indicated by the project report should be considered within a 100 yard radius of Corps specified sampling sites.

II. Estimation of mean low water depths were calculated as follows:

1. Where ship depth soundings were available, the depths were corrected for tide height from National Oceanic and Atmospheric Administration 1972 tide tables.
2. Where ship depth soundings were not available, Corps survey depths were taken.

CAPE HENRY - SURFACE

Series	TS %	VS %	COD %	TP ppm	TKN ppm	Zn ppm	Cu ppm	Pb ppm	Hg ppm
CHS-1	65.9	2.65	1.47	462	643	27.31	10.62	29.58	.20
CHS-2	73.5	1.34	1.41	420	179	11.33	4.12	17.00	.12
Mean	69.7	1.99	1.44	441	411	19.32	7.37	23.29	.16
Std.Dev.	5.4	.93	.04	30	328	11.30	4.60	8.90	.056

YORK SPIT - SURFACE

Series	TS %	VS %	COD %	TP ppm	TKN ppm	Zn ppm	Cu ppm	Pb ppm	Hg ppm
YSS-1	66.9	2.52	2.05	437	747	22.4	9.7	13.5	.43
YSS-2	67.2	2.46	1.74	528	533	33.8	8.1	8.1	.21
YSS-3	70.1	2.25	1.70	546	616	27.8	5.0	17.1	.12
YSS-4	57.3	3.42	1.38	616	1059	41.9	9.4	34.6	.17
YSS-5	63.3	2.69	2.54	620	710	37.3	8.0	15.4	.16
YSS-6	65.2	2.11	2.02	478	578	26.6	4.7	21.8	.19
YSS-7	71.4	1.43	.44	425	132	18.3	5.8	20.8	.15
YSS-8	73.5	1.80	2.34	404	443	26.1	5.1	13.0	.15
YSS-9	67.0	2.06	1.41	455	515	20.6	4.3	6.2	.14
YSS-10	69.1	2.00	1.53	399	565	26.0	5.4	26.8	.26
YSS-11	71.5	1.08	.50	446	184	10.8	1.4	11.4	.20
YSS-12	72.9	1.38	.45	425	250	21.8	5.9	7.9	.17
YSS-13	72.9	1.11	.53	334	227	21.5	1.4	7.9	.15
YSS-14	70.4	1.81	1.36	421	388	22.1	4.9	19.0	.14
YSS-15	76.8	0.60	.26	213	143	27.0	6.7	26.2	.18
YSS-16	69.2	1.58	1.04	868	549	30.0	6.9	16.1	.18
YSS-17	70.0	1.85	1.20	398	502	50.7	T	36.2	.11
YSS-18	79.4	0.56	.24	362	226	12.6	T	12.6	.20
YSS-19	66.0	1.99	1.42	522	623	24.4	T	31.5	.65
YSS-20	80.7	0.50	.22	136	73	T	T	T	-
YSS-21	75.1	0.80	.14	139	123	25.1	T	19.3	.12
YSS-22	77.0	0.54	.24	154	163	14.6	T	19.6	.18
YSS-23	77.0	0.58	.15	116	155	20.6	5.3	29.7	.07
YSS-24	78.2	0.96	.28	276	263	19.9	1.8	10.9	.21
Mean	71.2	1.59	1.05	405	407	24.27	4.28	17.75	.20
Std.Dev.	5.6	.79	.77	176	252	10.25	3.05	9.38	.12

T = trace

RAPPAHANNOCK SHOALS - SURFACE

Series	TS %	VS %	COD %	TP ppm	TKN ppm	Zn ppm	Cu ppm	Pb ppm	Hg ppm
RRS-1	50.5	6.05	5.87	675	1140	40.49	8.44	14.27	.22
RRS-2	48.9	5.21	5.31	697	1671	43.91	11.71	41.00	.28
RRS-3	48.5	5.21	4.98	744	1473	31.17	10.99	18.60	.28
RRS-4	54.8	3.67	3.37	571	1048	31.77	3.34	13.38	.35
RRS-5	54.7	5.22	3.89	553	1016	53.28	14.27	43.76	.30
RRS-6	55.4	4.98	4.08	470	1233	45.67	11.71	28.10	.12
RRS-7	57.9	4.69	3.61	535	839	42.34	8.64	33.70	-
RRS-8	56.7	4.13	3.26	562	981	43.40	10.85	31.83	.12
RRS-9	55.6	4.25	3.34	534	970	30.34	T	34.52	.09
RRS-10	50.3	4.95	3.97	499	1239	33.57	4.63	10.02	.54
RRS-11	50.9	5.22	4.72	548	1328	47.25	12.60	32.55	.16
RRS-12	58.9	4.37	3.68	573	1176	20.75	7.91	T	.18
Mean	53.6	4.83	4.17	580	1176	38.66	8.80	25.19	.24
Std.Dev.	3.6	.64	.85	82	234	9.16	4.13	13.49	.13

T = trace

CAPE HENRY - LONG CORES

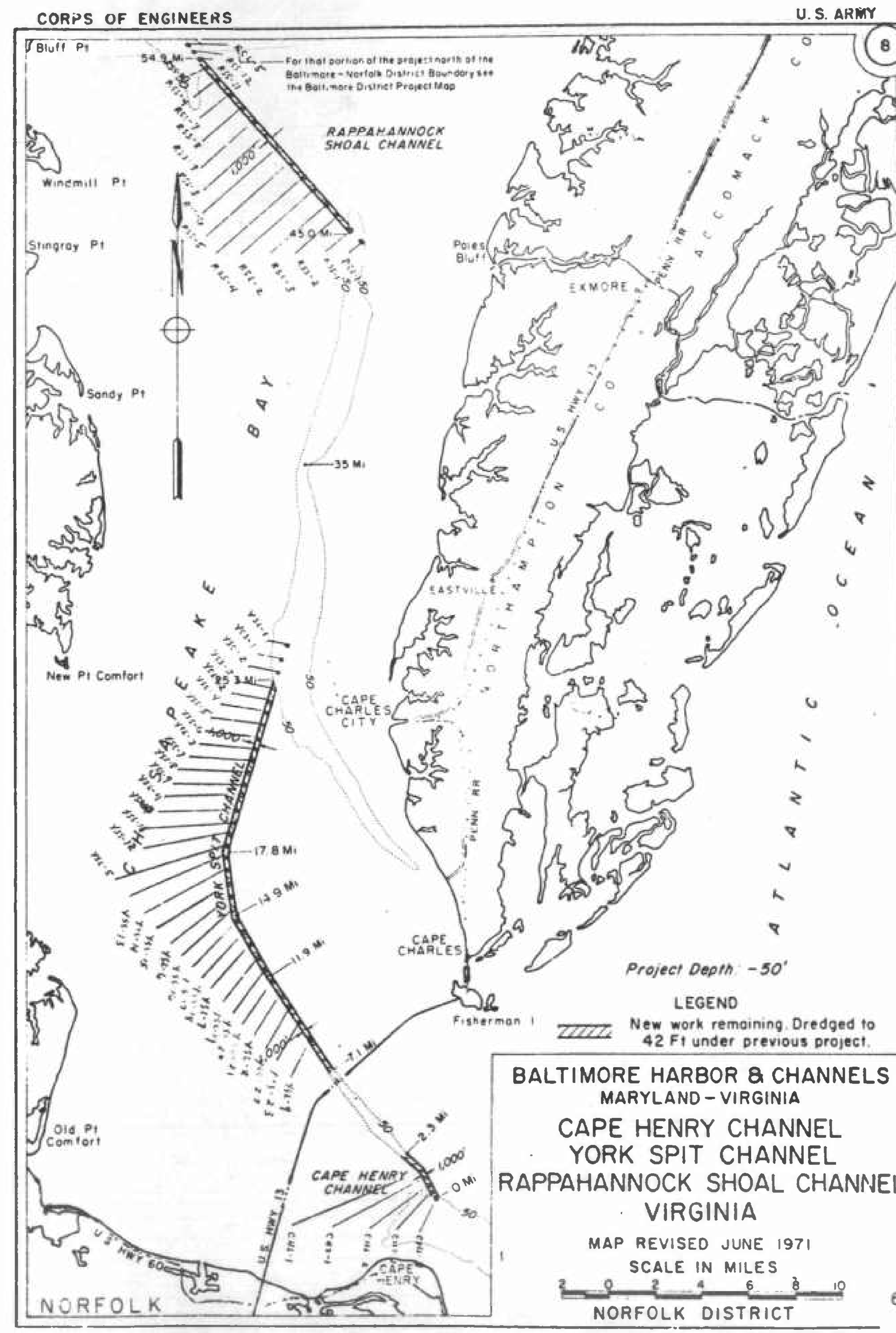
Series	TS %	VS %	COD %	TP ppm	TKN ppm	Zn ppm	Cu ppm	Pb ppm	Hg ppm
CHL #1-50	82.3	.99	.24	257	964	13.2	3.1	8.4	.06
CHL 55	82.6	.65	.045	169	62	12.8	8.8	7.2	.10
CHL #2-40	77.7	1.09	.36	329	162	13.8	8.7	7.7	.08
50	78.1	1.09	.45	379	169	12.2	5.6	9.1	.16
55	78.5	.94	.42	348	127	10.4	5.2	5.2	-
CHL #3-55	78.7	.90	.49	269	100	10.4	5.2	11.3	.09
Mean	79.6	.94	.33	292	264	12.13	6.10	8.15	.10
Std.Dev.	2.2	.16	.17	76	346	1.44	2.23	2.03	.04

YORK SPIT - LONG CORES

Series	TS %	VS %	COD %	TP ppm	TKN ppm	Zn ppm	Cu ppm	Pb ppm	Hg ppm
YSL #1-61	69.2	2.27	1.94	432	485	24.7	7.6	18.2	.14
YSL #2-57	68.7	2.52	1.99	501	585	34.3	3.7	20.0	.09
YSL #3-46.5	71.9	2.46	2.12	480	530	30.3	11.6	33.3	
YSL 50	73.2	2.36	2.00	401	497				.11
YSL 55	70.3	2.54	2.22	462	542	26.0	6.8	16.3	.15
YSL #4-47	74.7	1.26	.55	439	229	17.7	5.1	11.2	.21
YSL 50	75.6	1.52	3.14	357	345	25.1	11.9	13.2	.07
YSL 55	72.1	2.28	1.65	1164	467	25.5	8.1	18.1	.12
YSL #5-47	74.8	1.20	1.01	389	186	23.2	6.9	16.5	.09
YSL 50	71.2	2.75	2.12	427	531	30.7	7.7	20.6	.10
YSL 55	76.9	2.00	1.86	370	397	21.6	7.0	13.0	.10
YSL #6-49	77.3	1.29	.48	343	170	17.8	4.9	12.2	
YSL 50	71.0	2.41	2.12	416	451	27.3	7.9	20.2	.14
YSL #7-48	74.5	1.80	1.64	132	276	21.8	6.6	30.4	.07
YSL 50	67.2	2.55	1.85	369	296	40.3	11.2	25.3	.12
YSL 55	70.9	2.85	3.07	358	399	28.3	11.7	22.8	.20
YSL #8-49	79.3	.76	3.39	238	88	14.1	5.9	20.6	.06
YSL 50	82.6	.40	.09	24	16	7.3	3.1	13.6	.07
YSL 55	69.1	1.91	3.46	298	668	30.6	11.9	19.5	.11
YSL #9-51	76.7	.51	.32	95	612	14.9	8.3	17.3	.11
YSL 55	81.4	.67	.23	105	102	26.0	5.4	26.8	.05
Mean	73.9	2.01	1.77	371	375	24.37	8.16	19.95	.11
Std.Dev.	4.4	1.04	1.02	227	188	7.56	2.32	5.62	.04

RAPPAHANNOCK SHOALS - LONG CORES

Series	TS %	VS %	COD %	TP ppm	TKN ppm	Zn ppm	Cu ppm	Pb ppm	Hg ppm
RSL #1-45.5	61.3	3.83	3.32	568	890	36.9	6.4	20.7	.11
RSL 50	76.3	1.56	1.35	361	302	16.1	3.8	12.0	.06
RSL 55	78.5	1.32	.94	209	211	15.0	4.7	11.9	.08
RSL #2-47	64.6	3.37	2.87	508	708	39.5	8.1	18.9	.14
RSL 50	61.1	3.74	3.39	539	969	44.5	11.7	21.1	.11
RSL 55	63.9	3.57	3.27	497	838	32.7	6.8	19.7	.09
RSL #3-48	47.1	5.63	5.48	741	1727	58.2	14.1	32.0	.14
RSL 50	56.9	3.73	3.48	553	894	37.1	6.9	22.3	.11
RSL 55	66.9	3.07	2.29	434	641	35.3	8.3	20.7	.07
RSL #4-46	65.9	3.09	4.55	456	1031	47.7	7.7	21.0	.10
RSL 50	71.6	2.27	1.52	391	354	28.2	10.1	18.3	.79
RSL 55	78.0	1.45	.28	361	197	27.2	28.3	15.8	.07
RSL #5-45	60.0	3.42	3.32	508	784	33.2	7.6	18.5	.07
RSL 50	77.7	1.76	1.58	303	291	22.3	7.4	10.0	.07
RSL 55	78.9	1.29	.55	216	99	21.4	5.8	14.1	.07
Mean	67.2	2.87	2.61	443	662	33.02	9.18	18.47	.14
Std.Dev.	9.4	1.24	1.50	141	432	11.89	5.89	5.38	.18



APPENDIX D

VIMS REPORT 1978

INTRODUCTION

During 1978, the Virginia Institute of Marine Science (VIMS) retrieved numerous bottom sediment samples from the Baltimore Harbor and Channels and potential disposal areas in the Virginia portion of the Chesapeake Bay and the Atlantic Ocean. They later analysed these sediments as well as fifteen sediment samples from the Maryland sections of the Baltimore Harbor navigation channels for a variety of parameters. Concurrently, VIMS performed elutriate analyses for all potential overboard disposal areas.

During the performance of the geophysical survey and foundation exploration contained in Appendix B of this volume, the contractor extracted thirteen vibracores from the channels; i.e., five from the Maryland channels, and eight from the Virginia channels. VIMS additionally analysed these vibracores for a variety of parameters. The locations of the vibracores are contained within the plates found in Appendix B. The results of the analyses comprise pages 31 and 32 of this appendix. Each vibracore was divided into three sections, i.e., surface, middle, and bottom. Each section was individually analysed for the various parameters reported.

CONTRACT REPORT

BALTIMORE HARBOR AND CHANNELS: SURFACE SEDIMENTS IN VIRGINIA CHANNELS

by

Robert J. Byrne

Robert J. Huggett

Virginia Institute of Marine Science

Gloucester Point, Virginia 23062

May 1978

FINAL REPORT

Prepared for

Department of the Army

Baltimore District

Corps of Engineers

Under

Contract No. DAC W31-78-C-0038

Summary

Bottom surface sediment samples in the Virginia Channels portion of the Baltimore Harbor and Channels Project and the four specified disposal sites were obtained and chemically analysed in accordance with DAC W31-78-C-0038. In addition, chemical analyses were performed on 15 sediment samples delivered to us from Maryland.

In total, 90 stations were occupied in Virginia Channels and the four proposed disposal sites for bottom surface sediments for bulk chemical analyses. Samples from the Maryland Channels were supplied by the Maryland Geological Survey.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

SEDIMENT AND WATER SAMPLING PROCEDURE

Sampling Procedure

Sample Collection

In the Cape Henry, York Spit, and Rappahannock Channels, samples were recovered at 1 km intervals. In each of the four disposal areas, ten samples were recovered in a suitably spaced grid pattern so that the entire area of the site is represented. In the case of Site No. 3, Wolf Trap, sampling was concentrated in the eastern extension.

After the sampling was conducted in each of the channels and disposal sites, a field determination of sediment type (i.e. clay, silty clay, silty sand, sand) for each station was determined.

Station position was determined by calibrated Loran C navigation system. The station locations and field sediment type determinations will be transmitted to the Corps as a listing of coordinates (Table 1) and a visual display on appropriate National Ocean Survey charts (Figures 1, 2 and 3).

Sampling Technique

Previous experience in sediment collections in the Chesapeake Bay indicates that sample recovery will be insufficient if a coring device is used. Therefore, the Smith-MacIntyre grab which has shown positive results even in medium to fine sands was used. After recovery of the sampler to the surface of the sampling vessel, sufficient sediment was extracted from the horizon between 5 and 15 cm of the surface and sealed in containers without air entrapment and appropriately marked with station identification. Along with the primary sample, a short core was extracted so that in addition to bulk chemical characteristics a cut of each sample is being sent to the Baltimore District for reference and/or granulometric analysis. After retrieval to the deck, samples were refrigerated and transported to the laboratory and stored at 4^{o}C.

Elutriate Test

Sediment samples from the channel sites were secured by the Smith-MacIntyre grab sampler. About 1 gallon of sediment was collected for each elutriate test and stored in airtight containers so that no air bubbles were contained. The samples were refrigerated aboard the ship and maintained under refrigeration (not frozen) at the laboratory until the tests were run.

Water samples were collected in non-contaminating containers and were refrigerated aboard the ship and at the laboratory at 2 to 4^{o}C.

Table 1

SAMPLING STATION COORDINATES

	Sample Number	Latitude (N)	Longitude (W)	Field Description*
Disposal Area No. 1	1	36°46.9'	75°54.2'	SM
	2	36°46.9'	75°53.7'	SM
	3	36°47.6'	75°54.2'	SM
	4	36°47.6'	75°53.7'	SM
	5	36°48.3'	75°54.2'	SM
	6	36°48.3'	75°53.7'	MS
	7	36°49.0'	75°54.2'	S
	8	36°49.0'	75°53.7'	SM
	9	36°49.7'	75°54.2'	S (sh)
	10	36°49.7'	75°53.7'	S (sh)
Disposal Area No. 2	11	37°16.2'	76°05.4'	M
	12	37°15.9'	76°05.2'	M (or)
	13	37°15.7'	76°05.0'	M
	14	37°15.4'	76°04.8'	M
	15	37°15.2'	76°04.7'	M
	16	37°15.0'	76°04.5'	M (sh)
	17	37°14.7'	76°04.3'	M (sh)
	18	37°14.5'	76°04.2'	M (sh)
	19	37°14.2'	76°04.0'	M
	20	37°14.0'	76°03.8'	M (sh)
Disposal Area No. 3	21	37°20.4'	76°07.2'	M
	22	37°20.3'	76°06.7'	M
	23	37°20.8'	76°06.6'	M
	24	37°20.9'	76°07.0'	M
	25	37°21.5'	76°06.9'	M
	26	37°21.4'	76°06.5'	M (sh)
	27	37°22.0'	76°06.8'	M
	28	37°21.9'	76°06.4'	M
	29	37°22.6'	76°06.7'	M
	30	37°22.5'	76°06.3'	M

*Field Description

SG = sandy-gravel
S = sand
MS = muddy-sand
SM = sandy-mud
M = mud
(sh) = shells
(or) = organic material

SAMPLING STATION COORDINATES

	Sample Number	Latitude (N)	Longitude (W)	Field Description*
Disposal Site No. 4	31	37°42.3'	76°10.7'	MS
	32	37°42.3'	76°11.2'	M
	33	37°42.7'	76°11.3'	MS (or)
	34	37°42.7'	76°10.8'	MS
	35	37°43.2'	76°11.3'	M
	36	37°43.2'	76°10.8'	SM
	37	37°43.7'	76°11.4'	M
	38	37°43.7'	76°10.9'	SM
	39	37°44.1'	76°11.4'	M
	40	37°44.1'	76°10.9'	M
Cape Henry Channel	41	36°58.3'	75°59.9'	MS
	42	36°58.9'	76°00.2'	SM
	43	36°59.3'	76°00.5'	SM
	44	36°59.8'	76°01.2'	SM
York Spit Channel	45	37°02.8'	76°04.4'	SM
	46	37°03.2'	76°04.8'	S (sh)
	47	37°03.8'	76°05.3'	MS (sh)
	48	37°04.2'	76°05.6'	SG
	49	37°04.8'	76°06.0'	SM
	50	37°05.2'	76°06.4'	MS
	51	37°05.6'	76°06.6'	MS
	52	37°05.9'	76°07.0'	SM
	53	37°06.4'	76°07.4'	MS (sh)
	54	37°06.9'	76°07.7'	MS
	55	37°07.3'	76°08.0'	MS (sh)
	56	37°07.8'	76°08.3'	MS
	57	37°08.3'	76°08.7'	MS
	58	37°08.7'	76°09.0'	MS
	59	37°09.2'	76°09.0'	SM
	60	37°09.7'	76°09.1'	SM

*Field Description

SG = sandy-gravel
S = sand
MS = muddy-sand
SM = sandy-mud
M = mud
(sh) = shells
(or) = organic material

SAMPLING STATION COORDINATES

	Sample Number	Latitude (N)	Longitude (W)	Field Description*
York Spit Channel (cont'd.)	61	37°10.3'	76°09.2'	M
	62	37°10.8'	76°09.3'	M
	63	37°11.4'	76°09.2'	S
	64	37°11.8'	76°09.0'	SM
	65	37°12.4'	76°08.8'	SM (sh)
	66	37°12.8'	76°08.6'	M
	67	37°13.2'	76°08.5'	SM
	68	37°13.8'	76°08.3'	SM
	69	37°14.4'	76°08.0'	SM
	70	37°14.9'	76°07.9'	SM
	71	37°15.3'	76°07.8'	M
	72	37°15.9'	76°07.5'	M
	73	37°16.3'	76°07.3'	M
	74	37°16.8'	76°07.2'	M
Rappahannock Shoal Channel	75	37°33.9'	76°02.6'	M
	76	37°34.5'	76°03.2'	M (sh)
	77	37°34.8'	76°03.5'	M
	78	37°35.3'	76°03.9'	M
	79	37°35.6'	76°04.3'	M
	80	37°36.0'	76°04.7'	M
	81	37°36.5'	76°05.2'	M
	82	37°37.3'	76°06.1'	M
	83	37°37.6'	76°06.4'	M
	84	37°36.8'	76°05.6'	M
	85	37°38.2'	76°07.0'	M
	86	37°38.5'	76°07.4'	MS
	87	37°39.0'	76°07.9'	MS
	88	37°39.3'	76°08.3'	MS (sh)
	89	37°39.7'	76°08.7'	M
	90	37°40.3'	76°09.2'	M

*Field Description

SG = sandy-gravel
S = sand
MS = muddy-sand
SM = sandy-mud
M = mud
(sh) = shells
(or) = organic material

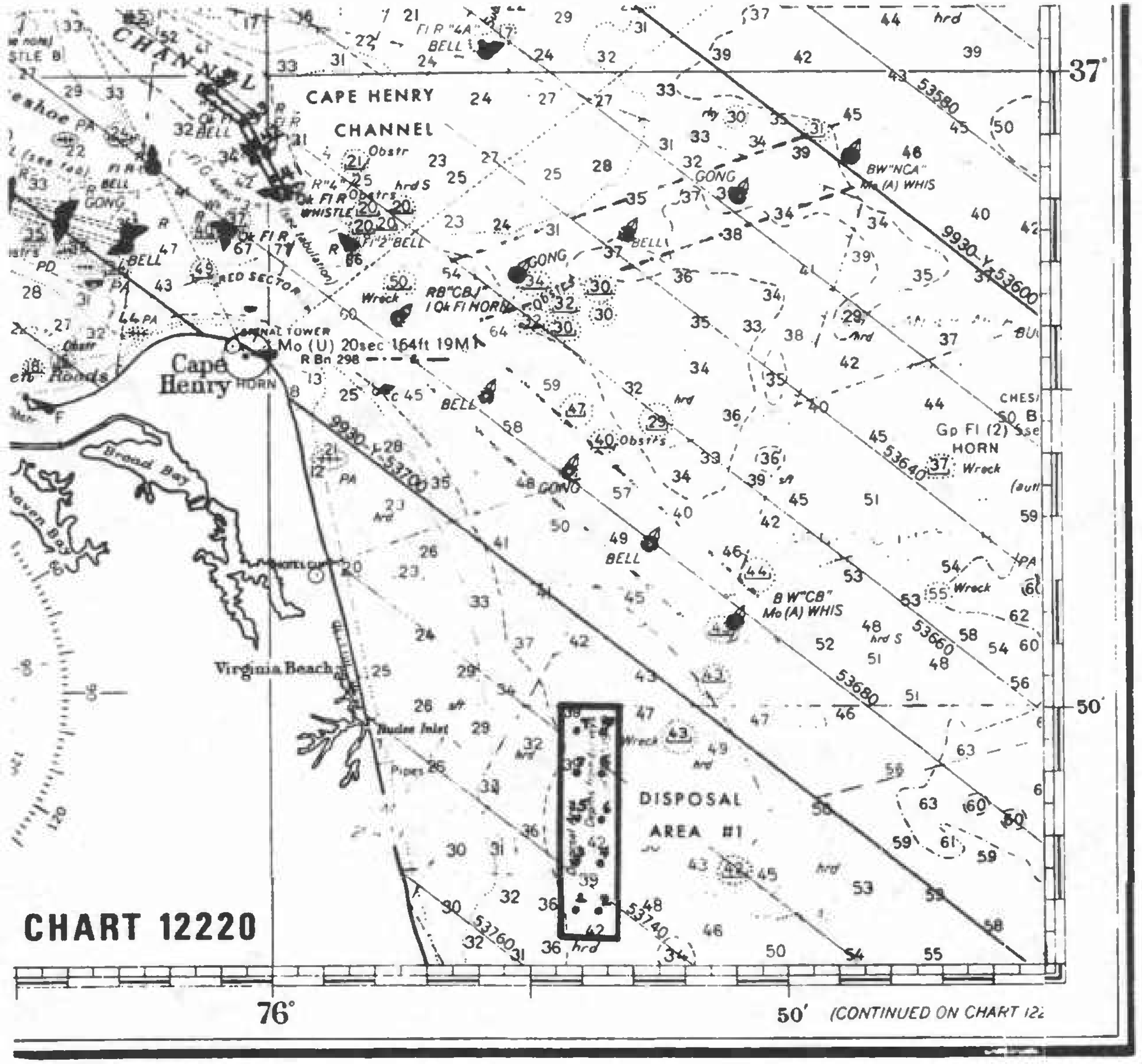


FIGURE 1

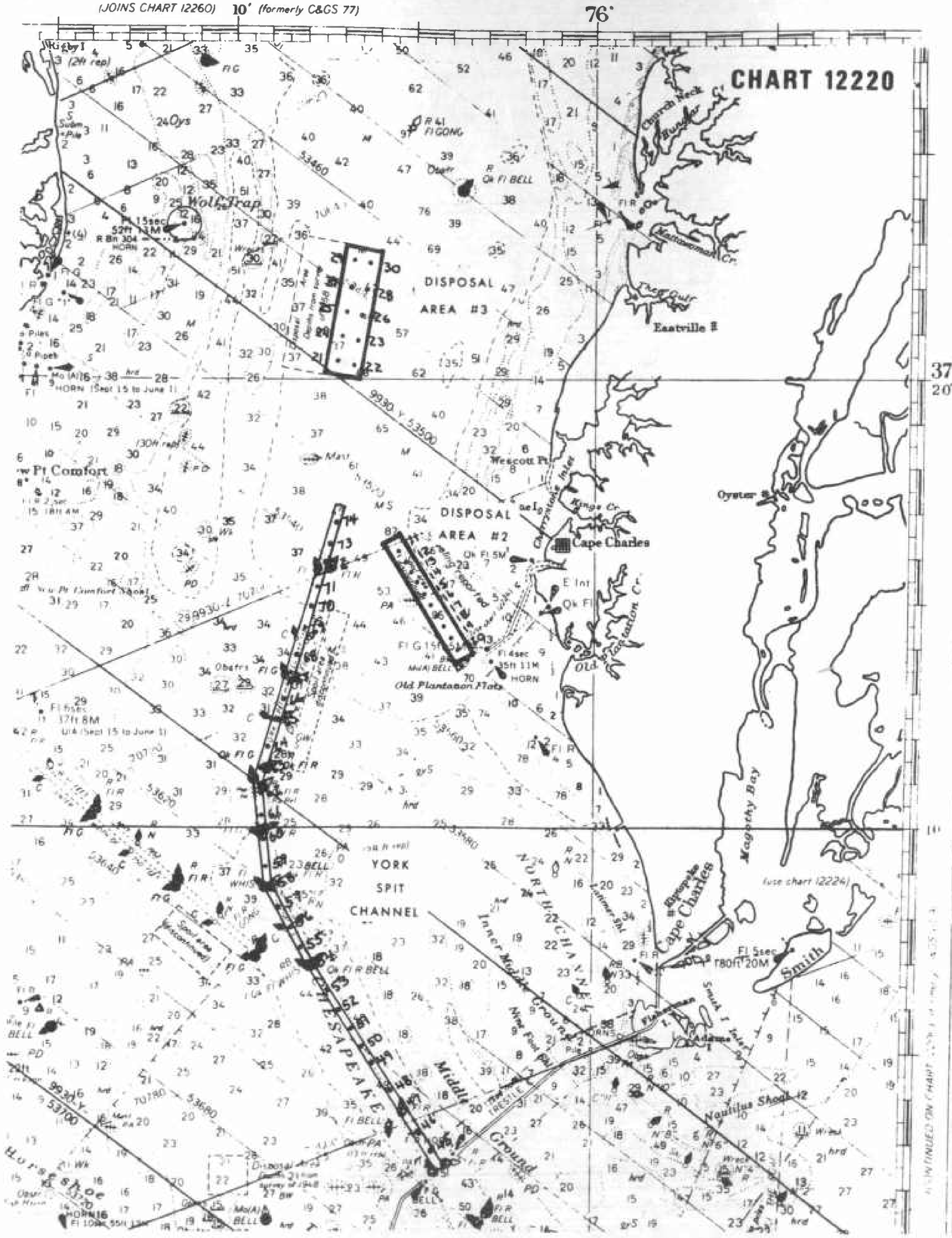


FIGURE 2

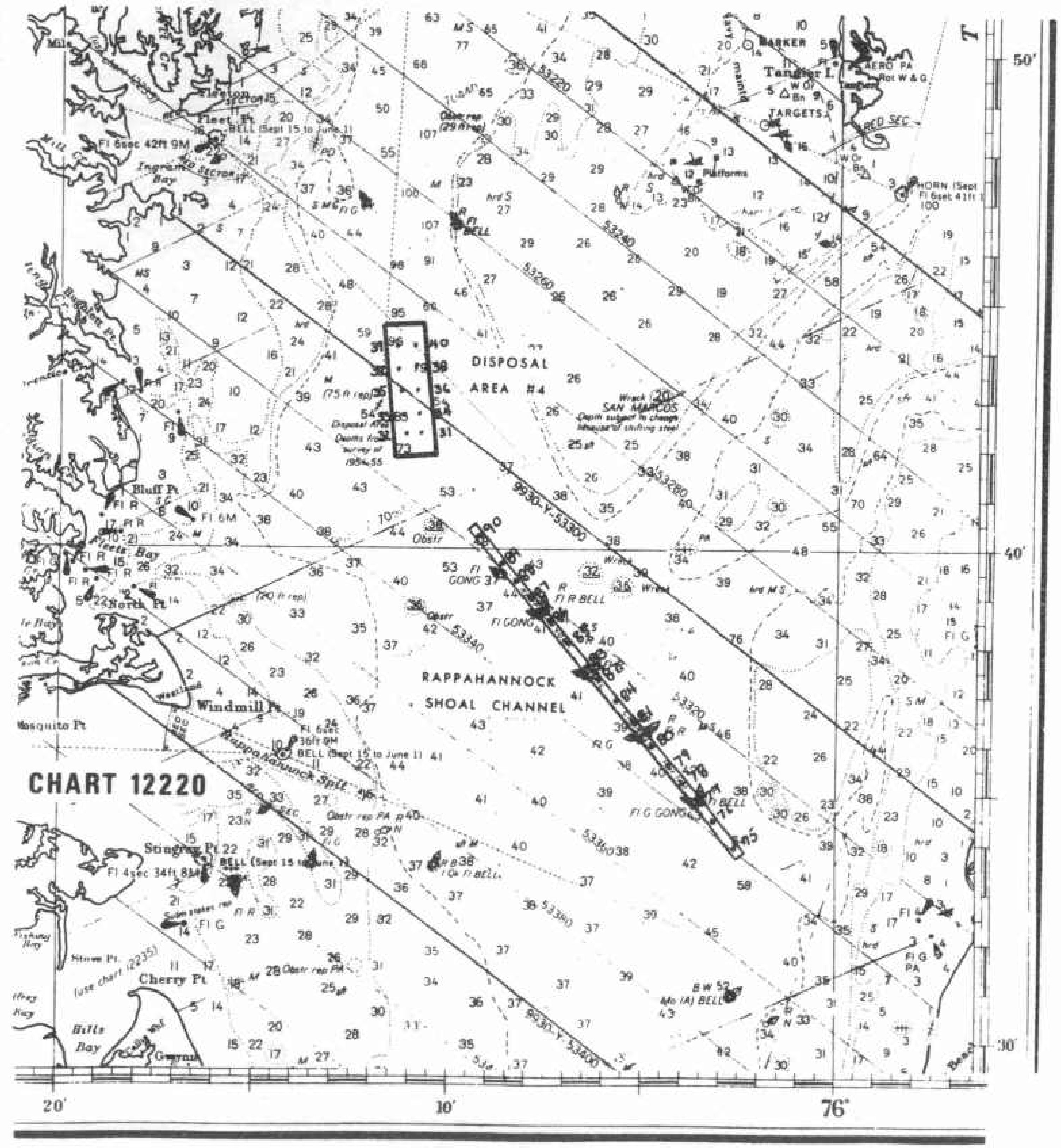


FIGURE 3

CHEMICAL ANALYSIS

METHODS AND PROCEDURES

SEDIMENT (Suite A)

Total Kjeldahl Nitrogen (TKN)

The samples were digested with a solution containing sulfuric acid, potassium sulfate, and mercuric sulfate converting organic nitrogen to ammonium sulfate. The digested samples were steam-distilled into a saturated boric acid solution and titrated with standard hydrochloric acid.

Total Phosphorus (TP)

The samples were digested in concentrated HNO_3 and evaporated to dryness; concentrated H_2SO_4 was added and heated until the solution cleared. Water was then added and the samples were filtered through a glass filter. The filtrates were analyzed for total phosphorus by the single solution method, using ascorbic acid as the reducing agent. The developed samples were read on a Klett-Summerson Photoelectric colorimeter, model 900-3.

Metals (Cd, Zn, Pb, Cr, Cu)

One gram of sample was heated to fuming with five milliliters of concentrated HNO_3 acid. After cooling, five additional milliliters of acid were added, heated and cooled. The samples were then centrifuged and the supernatants measured for volume and analyzed on a Varian Atomic Absorption Spectrophotometer, model AA-5.

Mercury (Hg)

The samples were digested with concentrated H_2SO_4 overnight. The digested samples were oxidized with 5% $KMNO_4$ and transferred to

Mercury (cont'd.)

300 ml BOD bottles. After the addition of reductant* solution the BOD bottles were immediately attached to the aeration apparatus of a Coleman Mercury Analyzer MAS-50. Mercury concentrations were then determined from standard curves.

* Composition of reductant solution:

H_2O	600 ml
H_2SO_4	100 ml
NaCl	5 grams
$(NH_2OH)_2SO_4$	20 grams

q.s. to 1 liter

Hexane Extractables

The sediment samples were dried with magnesium sulfate monohydrate, then soxhlet-extracted with hexane (Standard Methods for the Examinations of Water and Wastewater, 12th Ed., APHA, Inc., N.Y., 1965; 531-532). The hexane was then evaporated to dryness. The weight of solid residue from the solvent evaporation yielded oil and grease.

Volatile Solids

The sediment samples were dried in an oven at 103°C to constant weight. The dried samples were placed in a muffle furnace for one hour at 550-600°C. The decrease in weight after ashing is reported as volatile solids.

Chemical Oxygen Demand (COD)

The parameter was determined by the dichromate reflux method. The oxidizable substances were oxidized by a standard solution

Chemical Oxygen Demand (cont'd.)

of potassium dichromate in sulfuric acid. The excess dichromate was then titrated with standard ferrous ammonium sulfate. Silver sulfate was used as a catalyst, and mercuric sulfate used to eliminate the interference of chloride ions.

Total Organic Carbon (TOC)

TOC values were calculated from the COD values (wet basis) using the following equation:

$$\% \text{ Organic C (dry weight)} = (\text{mg O/kg wet sediment}/\%\text{TS}) \times (0.288)/(100)$$

The 0.288 factor used in the above equation is the so-called "Redfield Ratio" of oxygen to carbon by weight. (The Influence of Organisms on the Composition of Seawater, p. 26-77. In M. N. Hill (Ed.) The Sea, Vol. 2. Interscience, New York).

ELUTRIATE PREPARATION (Suite A)

A 500 gram portion of the homogenized sediment was mixed with 2 liters of "site" water in a one-gallon wide-mouth jar and agitated on a Burrell shaker for 30 minutes. The agitated mix was allowed to settle for 1-1/2 hours then centrifuged for ten minutes at 10 x 10^3 rpm (9800 x gravity) and/or filtered through 0.45 millipore filters.

Metals (Cd, Pb, Zn, Cr, Cu)

Lead, Cadmium, Zinc, Chromium, Copper were determined by the solvent extractions technique on a Varian Aerograph AA-5 Atomic Absorption Spectrophotometer. Ammonium Pyrolodine Dithiocarbamate

Metals (cont'd.)

(APDC) was used as a chelating agent and the metals were extracted with Methyl Isobutyl Ketone (MIBK), (Methods for Chemical Analysis of Water and Wastes, Environmental Protection Agency, 1971).

Other components (COD, TKN, TP, Hexane Extractables) were determined on the elutriate water by the methods previously described for "Sediments".

SEDIMENT (Suite B)

Kepone

Each sample (20 gm) was dessicated on a ratio of three parts dessicant (consisting of Na_2SO_4-"Quso," 9:1) to one part sediment. The dessicated samples were Soxhlet extracted (16 hrs) with petroleum ether, ethyl ether (1:1) and the resulting extract volume reduced by rotary evaporation to approximately fifteen (15) ml. Two (2) ml of the concentrate were placed on florisil clean-up column (Moseman, et. al., 1977) and the final extract analyzed by ECGC (Tracor 222) under the following parameters:

^{63}Ni detectors at 350°C

columns: 4mm ID x 6 ft x 1/4 in O.D.

3% OV-1 on 80/100 supelcoport

4% SE-30/6% OV-210 on 80/100 Gas-Chrom Q at 210°C

injection port at 230°C

5% Methane in Argon flow at 80ml/min

Polychlorinated Biphenyls and Heptachlor

The sediment samples were dried to constant weight at 45°C, and Soxhlet-extracted for 16 hours using hexane.

The concentrated extract was placed on successive clean-up columns of florisil and activated silica gel, and eluted with 1:1 pentane-hexane. The final extract was analyzed by electron capture gas chromatography. The resultant chromatograms were compared to standards of arochlor 1242, 1254, and 1260 and heptachlor.

Table 2

SEDIMENT (DRY BASIS)

Sample #	TVS	COD	TOC	TKN	Hexane	TP	Hg	Cd	Cu	Zn	Cr	Pb	Kepone	PCB	Heptachlor
	%	%	%	ppm	mg/kg	ppm	ppm	ppm	ppm	ppm	ppm	ppm			
1													N.D.**	N.D.	N.D.
2	1.44	0.42	0.12	199	97.5	307	<0.01	0.18	1.82	16.0	3.4	2.7			
3	1.29	0.35	0.10	146	106	266	<0.01	0.11	1.50	16.4	2.7	3.6			
4	1.46	0.29	0.08	134	58.2	232	0.047	0.17	1.48	14.4	2.3	3.1			
5	0.91	0.24	0.07	158	98.1	284	<0.01	0.10	1.35	13.8	2.7	3.0			
6	0.82	0.25	0.07	111	108	268	<0.01	0.08	1.00	12.6	2.3	3.1			
7	0.31	0.02	0.01	45.8	70.9	111	<0.01	0.08	0.34	3.62	0.49	2.5			
8	1.09	0.64	0.19	242	104	247	<0.01	0.05	2.02	17.7	3.5	5.6			
9	0.94	<0.40*	<0.2*	26.5	89.1	57.7	<0.01	0.04	0.38	2.52	0.49	1.9			
10													N.D.	N.D.	N.D.
11													N.D.	N.D.	N.D.
12	2.75	1.77	0.51	1040	796	222	<0.01	0.32	5.56	31.5	9.4	9.6			
13	2.33	3.69	1.06	1120	573	197	0.425	0.35	7.67	39.8	13.9	13.0			
14	3.38	3.28	0.94	972	766	368	<0.01	0.39	8.15	41.6	13.5	13.0			
15	3.88	1.64	0.47	1460	667	284	0.014	0.38	7.49	38.7	13.1	12.0			
16	3.21	3.39	0.98	1160	382	268	0.038	0.75	51.2	24.8	7.8	18.0			
17	1.65	1.29	0.37	594	450	174	<0.01	0.65	2.59	15.3	3.6	8.4			
18	2.21	2.98	0.86	772	1000	217	0.01	0.62	5.27	26.5	6.5	11.0			
19	2.89	2.77	2.75	918	669	222	<0.01	0.48	5.38	28.9	5.8	11.0			
20													N.D.	N.D.	N.D.
21	2.38	2.45	0.71	710	339	297	0.49	0.30	5.92	35.2	9.4	8.0			
22													N.D.*	N.D.	N.D.
23	2.75	2.56	0.74	756	309	262	<0.01	0.30	6.36	36.1	9.6	8.7			
24	2.61	2.70	0.78	598	271	255	0.07	0.24	5.24	34.1	9.2	7.3			
25	2.84	2.37	0.68	847	547	235	<0.01	0.24	5.69	35.6	9.4	8.9			
26	2.50	2.39	0.69	697	431	281	0.03	0.25	5.78	34.6	9.5	8.2			
27	2.72	2.72	0.78	797	326	319	0.26	0.23	6.32	37.6	10.3	9.7			
28	2.56	2.70	0.78	734	294	295	<0.01	0.22	5.95	34.6	9.3	7.9			
29	2.71	2.82	0.81	617	320	261	0.18	0.24	5.83	35.6	9.2	8.1			
30													N.D.	N.D.	N.D.
31													N.D.	N.D.	N.D.
32	3.94	3.93	1.13	1310	750	254	<0.01	0.16	8.23	57.6	14.6	15.0			
33	3.40	4.14	1.19	872	733	182	0.048	0.43	8.06	51.9	14.4	14.0			
34	1.66	1.44	0.41	482	182	159	<0.01	0.34	5.56	33.3	7.6	7.2			
35	6.79	8.33	2.40	2680	2390	610	<0.01	0.71	14.7	75.6	22.0	23.0			
36	2.19	3.56	1.02	591	196	217	0.01	0.35	4.41	29.9	9.9	6.9			
37	6.48	6.80	1.96	2560	2530	366	<0.01	0.95	14.5	73.6	22.3	23.0			
38	2.28	1.24	0.36	424	178	283	0.033	0.38	2.94	30.2	7.0	13.0			

*ppm

**N.D. ≤ 0.01 ppm

SEDIMENT

Sample #	TVS %	COD %	TOC %	TKN %	Hexane Ext. mg/kg	TP ppm	Hg ppm	Cd ppm	Cu ppm	Zn ppm	Cr ppm	Pb ppm	Kepone	PCB	Heptachlor
39	7.19	8.34	2.40	2810	2840	214	0.07	1.07	14.7	76.1	22.0	24.0			
40													N.D.*	N.D.	N.D.
41	2.08	0.74	0.21	285	117	261	<0.01	<0.01	2.59	18.4	4.4	6.0			
42	2.78	2.07	0.60	975	244	357	<0.01	<0.01	2.55	16.4	5.7	3.5			
43													N.D.	N.D.	N.D.
44	1.40	1.14	0.33	228	149	86.4	<0.01	<0.01	1.80	21.4	5.6	2.6			
45	5.45	0.46	0.13	386	61.5	158	<0.01	<0.01	2.84	18.2	4.8	5.5			
46	1.89	0.08	0.02	23.8	37.2	46.8	<0.01	<0.01	0.17	4.8	0.73	1.5			
47	0.69	0.32	0.01	89.3	56.9	122	<0.01	<0.01	0.35	12.9	2.0	3.0			
48	0.45	0.20	0.06	67.9	33.1	75.3	<0.01	<0.01	0.47	13.9	2.1	2.9			
49													N.D.	N.D.	N.D.
50	0.80	0.38	0.11	177	125	163	0.29	<0.01	1.03	11.5	2.2	1.9			
51	0.65	0.32	0.09	113	91.8	104	<0.01	0.10	0.84	14.2	2.4	2.0			
52	0.73	0.68	0.20	136	112	56.2	<0.01	0.06	0.96	17.3	3.8	3.0			
53	1.37	0.24	0.07	152	126	251	0.053	0.01	1.93	18.9	3.8	2.1			
54													N.D.	N.D.	N.D.
55	1.17	0.70	0.20	288	124	134	<0.01	0.17	1.87	15.4	4.8	3.4			
56	0.61	<0.40*	<0.2*	93.6	105	49.6	<0.01	0.15	1.31	9.2	2.9	2.7			
57	0.52	0.006	0.003	74.9	50.9	115	<0.01	0.04	0.59	11.1	3.1	2.8			
58	1.56	0.65	0.02	249	90.2	138	<0.01	0.18	2.40	18.1	8.1	4.5			
59													N.D.*	N.D.	N.D.
60	1.10	0.36	0.10	145	119	202	<0.01	0.11	1.13	14.7	4.3	2.6			
61	1.52	0.93	0.27	386	255	195	<0.01	<0.01	3.80	24.1	7.7	5.6			
62	1.14	0.91	0.26	271	118	148	<0.01	<0.01	2.33	19.6	5.4	4.1			
63	0.68	0.17	0.05	119	85.3	127	<0.01	<0.01	1.09	12.4	3.2	2.2			
64													N.D.	N.D.	N.D.
65	1.26	0.86	0.25	279	89.8	277	<0.01	<0.01	2.51	36.9	6.4	5.1			
66	1.52	0.71	0.002	374	97.1	192	0.021	<0.01	2.47	20.4	5.6	4.2			
67	0.90	0.29	0.08	156	71.5	53.1	<0.01	<0.01	1.59	18.2	4.5	2.8			
68													N.D.	N.D.	N.D.
69	1.29	0.48	0.14	191	134	301	<0.01	<0.01	2.09	18.8	5.1	2.4			
70	1.84	1.36	0.39	494	182	185	<0.01	<0.01	4.25	29.5	7.9	6.8			
71	2.94	2.32	0.67	824	366	307	0.01	0.30	5.52	32.8	11.0	9.6			
72	2.29	0.20	0.06	556	135	188	0.028	0.30	4.47	24.5	8.1	5.9			

*ppm

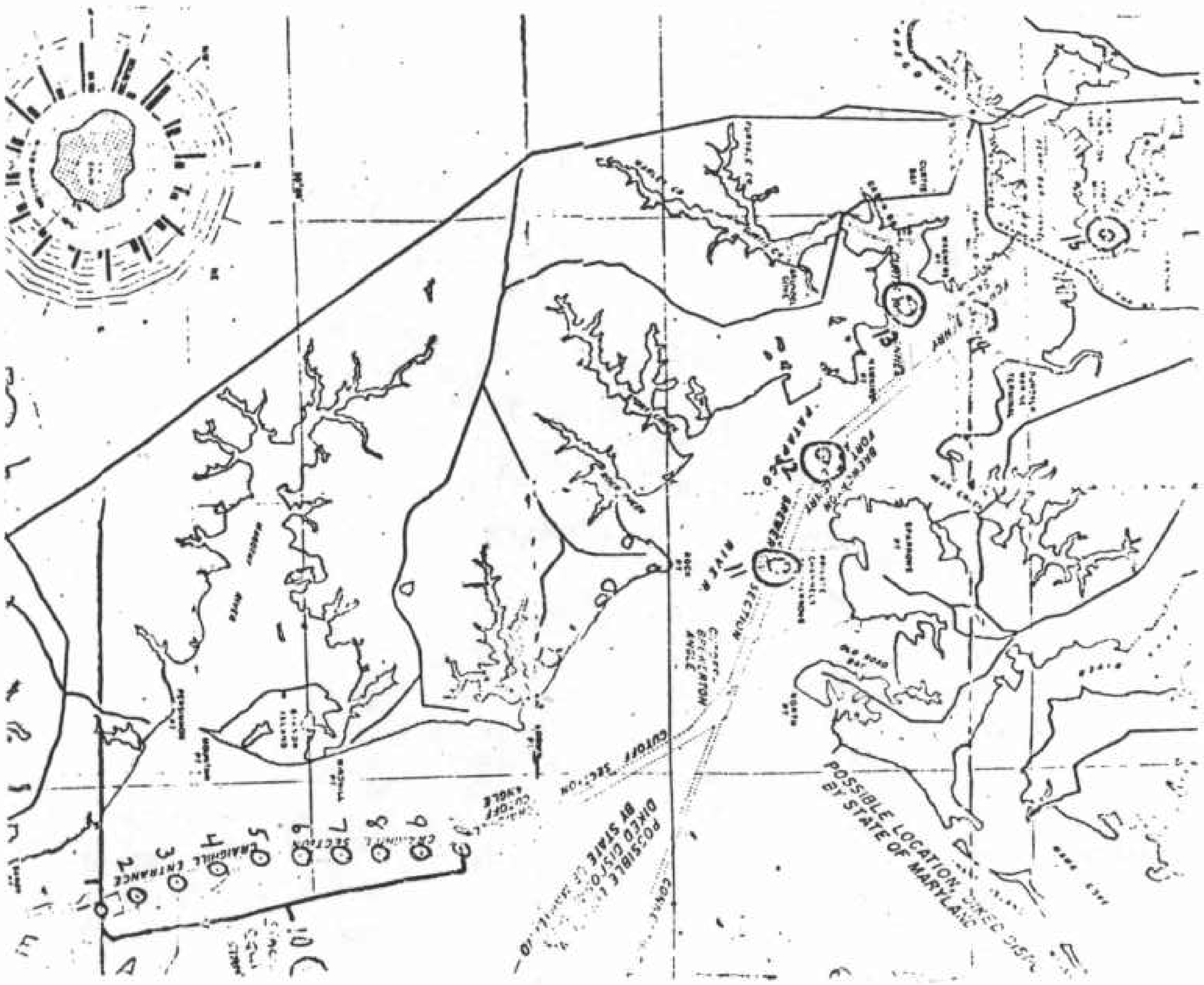
*N.D. ≤ 0.01 ppm

SEDIMENT

Sample #	TVS %	COD %	TOC %	TKN %	Hexane Ext. mg/kg	TP ppm	Hg ppm	Cd ppm	Cu ppm	Zn ppm	Cr ppm	Pb ppm	Kepone	PCB	Heptachlor
73													0.06	N.D.*	N.D.
74	3.57	3.14	0.09	955	316	223	0.026	0.28	7.58	37.4	13.0	9.8			
75	4.66	3.47	1.00	1010	232	176	0.401	0.55	6.40	33.6	16.5	8.1			
76	4.66	3.86	1.11	1030	191	244	0.198	0.38	6.75	37.4	18.1	9.9			
77	3.22	2.86	0.82	673	134	215	<0.01	<0.01	5.58	33.6	14.1	7.0			
78	3.09	4.22	1.21	1070	141	362	<0.01	0.07	7.17	44.3	24.2	6.4			
79	3.23	3.18	0.92	779	152	252	<0.01	<0.01	6.11	7.05	15.7	9.4			
80													0.04	N.D.	N.D.
81	3.83	3.39	0.98	914	187	200	0.148	0.19	6.32	36.4	14.9	11.0			
82	4.57	4.48	1.29	1660	784	226	0.066	0.12	9.55	50.4	16.9	17.0			
83	3.93	4.02	1.16	1230	574	187	0.021	0.05	8.37	45.2	14.2	14.0			
84	3.48	3.24	0.93	859	180	209	0.034	<0.01	6.72	35.8	15.1	11.0			
85													0.02	N.D.	N.D.
86	0.53	0.17	0.05	25.0	130	67.2	<0.01	<0.01	1.37	7.2	1.9	1.1			
87	0.51	0.52	0.15	74.6	95.2	41.0	<0.01	<0.01	0.57	9.5	2.0	2.5			
88	2.64	0.90	0.26	561	100	173	0.045	0.27	4.06	26.6	11.0	6.8			
89	4.71	3.47	1.00	1060	115	402	<0.01	0.36	6.07	37.5	18.2	10.0			
90													0.05	N.D.	N.D.
MC1	8.38	11.2	3.23	3430	5340	549	0.34	1.34	44.8	302	37.7	61	0.03	N.D.	N.D.
MC2	8.81	8.62	2.48	3360	2820	447	0.32	1.48	43.8	270	35.2	66	N.D.*	N.D.	N.D.
MC3	3.87	5.53	1.59	1270	298	278	0.28	0.62	47.3	152	16.0	18	0.03	0.14	N.D.
MC4	4.39	4.37	1.26	1330	374	318	0.05	0.64	12.7	71.9	16.8	17	0.02	N.D.	N.D.
MC5	4.65	5.74	1.65	1740	278	270	0.14	0.62	13.0	70.8	16.1	17	N.D.	N.D.	N.D.
MC6	7.86	9.31	2.68	3460	1850	630	0.47	1.30	41.8	267	33.7	60	0.03	N.D.	N.D.
MC7	7.41	7.38	2.13	3280	1930	632	0.34	1.04	40.8	245	31.2	55	N.D.	N.D.	N.D.
MC8	7.81	14.7	4.24	2500	4110	634	0.35	1.10	57.1	301	27.5	68	N.D.	N.D.	N.D.
MC9	6.49	8.32	2.39	2060	1390	388	0.34	1.01	34.6	218	25.4	46	N.D.	N.D.	N.D.
MC10	3.67	5.65	1.63	1790	239	298	0.02	0.58	17.6	88.7	20.9	20	N.D.	N.D.	N.D.
MC11	5.22	10.1	2.92	2740	2170	654	0.21	1.21	41.0	256	63.4	59	N.D.	N.D.	N.D.
MC12	8.71	13.4	3.85	3640	6690	705	0.55	2.76	128	704	251	160	N.D.	N.D.	N.D.
MC13	8.21	12.5	3.59	3400	4320	483	0.40	1.74	119	323	133	115	N.D.	0.03	N.D.
MC14	9.26	11.9	3.42	3520	5740	805	0.66	3.08	236	607	286	165	N.D.	0.05	N.D.
MC15	8.44	11.7	3.37	3140	944	455	0.46	0.84	44.4	75.0	38.2	27	N.D.	0.03	N.D.

MC = Maryland Channel

*N.D. $\leq$ 0.01 ppm



Maryland Channel

FIGURE 4

Table 3

ELUTRIATES AND WATER (SEDIMENTS ON DRY BASIS)

Parameter / Sample #	Total Solids %	COD ppm	TOC %	TKN ppm	Hexane Ext. ppm	TP ppm	Hg ppm	Cd ppb	Cu ppb	Sample Site
Sediment #42	67.48	2.06%	0.60%	975	244	356	<0.01 ppm	≤0.01 ppm	2.6 ppm	Cape Henry Chan. Sed. #42
Water #42		83		0.39	0.6	0.03	≤0.01	≤0.5	3.9	Cape Henry Chan. H_2O #42
Elut. #42-42		79		0.98	0.8	0.05	≤0.01	≤0.5	3.0	Cape Henry Chan. Sed. & H_2O #42
Water 1(5)		58		0.50	0.8	0.03	≤0.01	≤0.5	4.1	Disposal Area 1 Station 5
Elut. #42-1(5)		81		0.68	0.5	0.04	≤0.01	≤0.5	1.2	Sed. #42 & H_2O Site 1 - Sta. 5
Sediment #44	80.60	1.14%	0.33%	228	149	86.5	<0.01 ppm	≤0.01 ppm	1.8 ppm	Cape Henry Chan. Sed. #44
Water #44		41		0.51	<0.5	0.04	≤0.01	≤0.5	3.6	Cape Henry Chan. H_2O #44
Elut. #44-44		75		0.45	0.6	0.05	0.03	≤0.5	1.4	Cape Henry Chan. Sed. & H_2O #44
Elut. #44-1(5)		75		0.46	0.6	0.07	≤0.01	≤0.5	0.8	Sed. #44 & H_2O Site 1 - Sta. 5
Sediment #53	79.30	0.59%	0.07%	152	126	251	0.05 ppm	≤0.01 ppm	1.9 ppm	York Spit Chan. Sed. #53
Water #53		66		0.28	<0.5	0.03	≤0.01	≤0.5	2.0	York Spit Chan. H_2O #53
Elut. #53-53		61		0.49	<0.5	0.04	≤0.01	0.7	1.1	York Spit Chan. Sed. & H_2O #53
Elut. #53-1(5)		76		0.50	0.6	0.04	≤0.01	0.6	1.0	Sed. #53 & H_2O Site 1 - Sta. 5
Water 2(15)		61		0.50	<0.5	0.03	≤0.01	0.7	2.0	Disposal Area 2 Station 15
Elut. 53-2(15)		48		0.41	<0.5	0.05	≤0.01	0.7	0.70	Sed. #53 & H_2O Site 2 - Sta. 15
Water 3(25)		14		0.36	0.5	0.03	≤0.01	≤0.5	3.3	Disposal Area 3 Station 25
Elut. #53-3(25)		18		0.40	0.6	0.06	≤0.01	0.6	0.90	Sed. #53 & H_2O Site 3 - Sta. 25
Sediment #69	74.59	0.48%	0.14%	191	134	301	<0.01 ppm	≤0.01 ppm	2.1 ppm	York Spit Chan. Sed. #69
Water #69		17		0.41	0.5	0.02	≤0.01	≤0.5	2.0	York Spit Chan. H_2O #69

ELUTRIATES AND WATER (SEDIMENTS ON DRY BASIS)

Parameter Sample #	Total Solids %	COD ppm	TOC %	TKN ppm	Hexane Ext. ppm	TP ppm	Hg ppm	Cd ppb	Cu ppb	Sample Site
Elut. #69-69		50		0.43	0.8	0.06	≤0.01	≤0.5	1.0	York Spit Chan. Sed. & H_2O #69
Elut. 69-1(5)		49		0.49	0.7	0.05	≤0.01	0.7	1.2	Sed. #69 & H_2O Site 1 - Sta. 5
Elut. 69-2(15)		43		0.42	0.7	0.06	≤0.01	0.7	1.1	Sed. #69 & H_2O Site 2 - Sta. 15
Elut. 69-3(25)		26		0.48	1.2	0.06	0.02	≤0.5	1.0	Sed. #69 & H_2O Site 3 - Sta. 25
Sediment #78	60.14	4.22%	1.21%	1070	141	362	<0.01 ppm	0.07 ppm	7.2 ppm	Rappahannock Shoals Sed. #78
Water #78		6.1		0.22	0.5	0.02	≤0.01	≤0.5	2.3	Rappahannock Shoals H_2O #78
Elut. #78-78		37		0.81	1.3	0.06	≤0.01	≤0.5	1.1	Rappahannock Shoals Sed. & H_2O #
Water 4(36)		21		0.68	0.5	0.02	≤0.01	≤0.5	4.5	Disposal Area 4 - Station 36
Elut. 78-4(36)		27		0.90	0.9	0.08	≤0.01	≤0.5	1.0	Sed. #78 & H_2O Site 4 - Sta. 36
Sediment #86	76.81	0.17%	0.05%	25.0	130	269	<0.01 ppm	≤0.01 ppm	1.4 ppm	Rappahannock Shoals Sed. #86
Water #86		20		0.45	<0.5	0.02	≤0.01	≤0.5	3.0	Rappahannock Shoals H_2O #86
Elut. #86-86		0		0.32	0.8	0.06	≤0.01	≤0.5	1.6	Rappahannock Shoals Sed. & H_2O #
Elut. 86-4(36)		18		0.25	0.5	0.03	≤0.01	0.7	2.3	Sed. #86 & H_2O Site 4 - Sta. 36
		Chemical Oxygen Demand	Total Organic Carbon	Total Kjeldahl Nitrogen		Total Phos-phorus	Mercury	Cadmium	Copper	

ELUTRIATES AND WATER (SEDIMENTS ON DRY BASIS)

Parameter Sample #	Zn ppb	Cr ppb	Pb ppm	TVS %	Sample Site
Sediment #42	16.4 ppm	5.75 ppm	3.54	2.78	Cape Henry Chan. Sed. #42
Water #42	7.4	≤2.5	<0.05		Cape Henry Chan. H_2O #42
Elut. #42-42	4.2	≤2.5	<0.05		Cape Henry Chan. Sed. & H_2O #42
Water 1(5)	5.3	≤2.5	<0.05		Disposal Area 1 Station 5
Elut. #42-1(5)	0.32	≤2.5	<0.05		Sed. #42 & H_2O Site 1 - Sta. 5
Sediment #44	21.5 ppm	5.63 ppm	2.64	1.40	Cape Henry Chan. Sed. #44
Water #44	6.4	≤2.5	<0.05		Cape Henry Chan. H_2O #44
Elut. #44-44	0.88	≤2.5	<0.05		Cape Henry Chan. Sed. & H_2O #44
Elut. #44-1(5)	1.4	≤2.5	<0.05		Sed. #44 & H_2O Site 1 - Sta. 5
Sediment #53	19.0 ppm	3.87 ppm	2.08	1.37	York Spit Chan. Sed. #53
Water #53	5.9	≤2.5	<0.05		York Spit Chan. H_2O #53
Elut. #53-53	2.0	≤2.5	<0.05		York Spit Chan. Sed. & H_2O #53
Elut. #53-1(5)	2.6	≤2.5	<0.05		Sed. #53 & H_2O Site 1 - Sta. 5
Water 2(15)	6.0	≤2.5	<0.05		Disposal Area 2 Station 15
Elut. 53-2(15)	0.80	≤2.5	<0.05		Sed. #53 & H_2O Site 2 - Sta. 15
Water 3(25)	7.2	≤2.5	<0.05		Disposal Area 3 Station 25
Elut. #53-3(25)	0.48	≤2.5	<0.05		Sed. #53 & H_2O Site 3 - Station 25

ELUTRIATES AND WATER (SEDIMENTS ON DRY BASIS)

Parameter Sample #	Zn ppb	Cr ppb	Pb ppm	TVS %	Sample Site
Sediment #69	18.9 ppm	5.20 ppm	2.36	1.29	York Spit Chan. Sed. #69
Water #69	5.5	≤2.5	<0.05		York Spit Chan. H_2O #69
Elut. #69-69	0.57	≤2.5	<0.05		York Spit Chan. Sed. & H_2O #69
Elut. 69-1(5)	1.2	≤2.5	<0.05		Sed. #69 & H_2O Site 1 - Sta. 5
Elut. 69-2(15)	1.2	≤2.5	<0.05		Sed. #69 & H_2O Site 2 - Sta. 15
Elut. 69-3(25)	0.66	≤2.5	<0.05		Sed. #69 & H_2O Site 3 - Sta. 25
Sediment #78	44.2 ppm	24.1 ppm	6.34	3.09	Rappahannock Shoals Sed. #78
Water #78	6.5	≤2.5	<0.05		Rappahannock Shoals H_2O #78
Elut. #78-78	0.72	≤2.5	<0.05		Rappahannock Shoals Sed. & H_2O #78
Water 4(36)	32.2	≤2.5	<0.05		Disposal Area 4 Station 36
Elut. 78-4(36)	0.24	≤2.5	<0.05		Sed. #78 & H_2O Site 4 - Sta. 36
Sediment #86	7.21 ppm	1.99 ppm	1.07	0.53	Rappahannock Shoals Sed. #86
Water #86	5.4	≤2.5	<0.05		Rappahannock Shoals H_2O #86
Elut. #86-86	2.8	≤2.5	<0.05		Rappahannock Shoals Sed. & H_2O #86
Elut. 86-4(36)	1.1	≤2.5	<0.05		Sed. #86 & H_2O Site 4 - Sta. 36
	Zinc	Chromium	Lead	Total Volatile Solids	

Sample ID	% TS	% VS	Dry wt. COD %	TKN ppm	TP ppm	Pb ppm	Cu ppm	Cd ppm	Cr ppm	Zu ppm	Hg ppm	O & G ppm	Kepone ppm
MCC-5 Surface	39	9.1	12	3200	600	89	220	2.0	220	460	.44	3500	<0.010
3.8 meters	83	.72	.08	60	65	2.7	6.9	<0.05	8.2	17	0.017	150	
6.3 meters	80	6.2	2.5	540	120	13	40	.60	14	87	0.037	120	
VYC-1 Surface	69	2.7	3.0	540	91	5.1	4.3	.49	7.0	40	0.013	300	<0.010
3.8 meters	74	1.5	2.4	370	160	6.9	3.5	.41	3.8	23	0.011	110	
6.1 meters	75	4.0	2.0	350	110	5.9	3.5	.43	3.8	26	0.012	140	
VYC-2 Surface	76	1.7	1.0	410	190	4.8	3.6	.24	4.4	32	0.017	120	<0.010
6.4 meters	71	1.1	.14	180	120	2.1	2.0	<0.05	4.5	8.0	0.009	28	
11.3 meters	75	2.4	1.7	280	150	7.0	2.8	.47	3.9	22	0.009	20	
VYC-3 Surface	69	2.5	2.2	740	180	6.9	5.0	.39	6.8	42	0.016	150	<0.010
5.8 meters	72	2.6	2.4	590	230	4.0	4.7	<0.05	9.5	27	0.013	28	
10.7 meters	75	2.5	2.8	580	130	5.9	5.5	.31	10	31	0.009	150	
VCC-1 Surface	78	1.0	.44	230	42	3.1	1.4	.06	6.6	12	0.006	150	<0.010
3.8 meters	81	.92	.40	120	120	2.5	1.6	<0.05	2.1	10	0.006	120	
6.2 meters	84	.71	.02	90	85	3.5	5.5	.20	2.3	12	<0.005	140	
VRC-2 Surface	64	3.2	3.0	710	150	6.2	5.9	.17	10	43	0.008	190	<0.010
5.9 meters	66	3.2	2.7	710	180	6.5	6.0	.12	11	36	0.008	60	
10.8 meters	56	6.2	9.7	1800	240	13	15	.55	16	110	0.032	490	
VRC-1 Surface	55	4.5	4.9	1800	290	12	9.1	.20	14	60	0.047	240	<0.010
5.7 meters	65	3.5	3.0	400	200	4.4	4.0	.15	4.9	20	0.014	150	
11.9 meters	78	5.5	1.9	230	88	7.1	2.6	.56	3.3	13	0.010	70	
VRC-4 Surface	48	4.6	5.1	1600	220	13	10	.42	13	72	0.033	770	<0.010
3.7 meters	89	.38	.21	76	130	2.0	6.8	<0.05	3.2	6.4	0.024	150	
8.7 meters	72	3.9	3.0	670	220	6.4	9.4	.65	6.4	53	0.065	320	

Sample ID	% TS	% VS	Dry wt. COD %	TKN ppm	TP ppm	Pb ppm	Cu ppm	Cd ppm	Cr ppm	Zu ppm	Hg ppm	O & G ppm	Kepone ppm
VRC-3 Surface	62	2.8	3.0	730	170	5.6	6.4	.26	10	45	0.015	180	<0.010
5.0 meters	73	2.2	2.2	530	250	4.3	4.4	<0.05	8.2	23	<0.005	130	
9.9 meters	75	2.4	1.7	450	200	5.1	4.4	.28	10	25	0.074	110	
MCC-4 Surface	27	11	16	3400	980	380	320	2.8	290	1600	.60	6000	<0.010
4.6 meters	43	6.4	7.4	2300	340	15	15	.47	18	79	0.033	300	
9.1 meters	47	6.5	7.7	2400	310	11	16	.45	17	75	0.057	460	
MCC-3 Surface	43	6.3	9.1	2500	280	14	12	.28	12	83	0.021	300	<0.010
3.8 meters	45	5.6	6.8	2100	230	14	13	.11	16	72	0.040	200	
8.6 meters	46	6.4	6.8	2600	260	13	14	.46	16	78	0.020	200	
MCC-2 Surface	37	6.7	9.8	2600	360	15	15	.32	17	114	0.024	320	<0.010
5.0 meters	41	5.8	6.7	1900	280	15	14	.39	17	77	0.017	230	
9.7 meters	85	.95	1.2	99	93	3.7	7.0	.13	7	11	<0.005	220	
MCC-1 Surface	35	6.5	8.3	2100	290	17	17	.43	19	110	0.046	460	<0.010
4.2 meters	90	.39	.55	150	33	0.9	1.3	.06	4.2	2.2	<0.005	170	
7.8 meters	84	.72	.29	.93	150	3.9	7	.74	4.3	14	<0.005	88	
MCC-1 Run #R Surf.	33	6.8	8.3	2300	400	18	17	.33	19	110	0.030	3909	<0.010
3.7 meters	90	.37	.59	56	55	2.2	1.3	.06	4.3	2.3	<0.005	150	
7.4 meters	88	.68	.30	75	160	3.6	5.6	.06	6.0	10	<0.005	91	

APPENDIX E

TECHNICAL CORRESPONDENCE

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
1825B Virginia Street
Annapolis, MD 21401

March 13, 1978

District Engineer
Baltimore District, Corps of Engineers
Post Office Box 1715
Baltimore, MD 21203

Dear Sir:

This is to provide you with additional information pertaining to the proposed 50-foot deepening of Baltimore Harbor and Channels. As per your request, we will address:

1) Wolf Trap Light, Tangier Island, and Smith Island as potential sites for spoil disposal;
2) Possible dredging time of year restrictions to reduce biological impacts; and,
3) Components of a monitoring program.

Additional information on the Cape Charles disposal site will be forthcoming from NMFS.

Alternative Spoil Disposal Sites

The Wolf Trap Light disposal site is a previously used open water disposal area. It was last used for the disposal of 520,000 cubic yards of spoil from the fiscal year 1977 maintenance dredging of the York Spit Channel. To accomodate spoil from the 50-foot deepening, it has been proposed that the disposal area be expanded approximately 1,500 yards eastward. Unfortunately, there has been no monitoring to assess the biological impacts of the previous disposal operations. Consequently, prediction of the impacts of disposal in the extended area is difficult and every attempt should be made to fully utilize the previously impacted area before extending the spoil dumping into new areas. It appears that there are no important commercially harvested shellfish concentrations in close proximity to the Wolf Trap site. Blue crabs may overwinter in this area, although the major concentrations occur southward. Spoil disposal will disrupt the existing benthic community and the extent of recolonization will depend primarily on the nature of the spoil material. Neighboring areas may also be affected by turbidity, submarine mud flows and off-site transport of spoil by water currents, but very sensitive bottoms such as oyster bars or aquatic grass beds are not likely to be affected.

Tangier Island is another possible site for spoil disposal. Erosion on the western shore of the Island is a severe problem, with the shoreline receding approximately 20 feet per year. It has been proposed that placement of spoil material along the shoreline could protect the existing shoreline from erosion. Presumably the spoil could be planted with marsh and/or dune vegetation to aid in stabilization and provide benefits to fish and wildlife resources.

Two years ago a State Task Force studied the erosion problem at Tangier Island and possible solutions. One of the remedies they examined was similar to the present proposal. It involved pumping sand from an off-shore source along the shoreline and stabilizing it with a groin field and sand bag sills. They determined that: 1) since there is little sand in the littoral system and the site is directly exposed to a long western fetch, frequent beach nourishment would be required for maintenance; and, 2) although the net littoral drift is southward, southwest winds in the summer would cause some of the material to enter Tangier Channel and compound an already difficult maintenance problem there. VIMS, as part of the State Task Force study, conducted a survey of the benthic species along the western shore. They found that the area was surprisingly productive with 60 species of invertebrates identified and a faunal density of approximately 4,000 individuals per square meter. The major groups were: polychaetes (36% by number, 25 species), molluscs (39% by number, 9 species), amphipods (16% by number, 6 species), isopods (5.7% by number, 5 species), miscellaneous (3.3% by number, 15 species). No grass beds or significant concentrations of commercially harvested species were mentioned in their report.

If the fine grain sediments from the Rappahannock Shoal channel are deposited along Tangier Island's western shore, rapid erosion of the material can be expected. In addition to causing shoaling of the Tangier Channel, the rapid erosion would impact adjacent productive benthic habitat, and the concommittant turbidity could affect the commercial crab shedding industry. The inescapable conclusion is that a plan must be developed to confine and protect the spoil material. Since Tangier Island is in Virginia, the acceptability of this to Maryland, the local assurer, remains to be seen.

Spoil disposal along the western shore of Smith Island has also been raised as a possibility. The most beneficial site for spoil disposal would be along the western shore where the erosion is encroaching toward the community of Rhodes Point. The situation is similar to that of Tangier Island and many of the same problems associated with spoil disposal along the shoreline occur. It appears that it would be necessary to confine and protect the spoil from erosion in order to avoid blocking the channel at Sheep Pen Gut and impacting adjacent

aquatic habitat. The shallow water area has not been surveyed biologically, but based on the Tangier Island survey probably supports a moderately productive benthic fauna. Local watermen have told us that the area does not contain the extensive grass beds which are common in the more protected areas around Smith Island and which help to make it one of the most important soft and peeler crab producing areas in Chesapeake Bay. The general Smith Island area also supports a significant commercial oyster harvest as well as a smaller soft clam harvest, but the western shore near Rhodes Point is not a major production area. The nearest charted oyster bar, Church Creek, located between 1 and 2 miles offshore, has had a harvest limited to 79 bushels in the 1964-65 season, 57 bushels in the 1976-77 season, and no harvest reported during the intervening years. A congressionally authorized study is currently underway by the Baltimore District, CCorps of Engineers to examine erosion control, flood prevention, and navigation improvements at Smith Island. Further information on the potential for spoil disposal along the Smith Island shoreline will become available as the study progresses.

Time of Year Restrictions

Dredging projects are frequently required to restrict their operation during periods of especially sensitive or intense biological activity. In the lower Chesapeake Bay many species of finfish may be adversely affected by dredging during their egg, larval or post-larval stages. Unfortunately, sensitive stages of some important species are likely to be found in these waters at almost any time of the year (see our 23 December 1977 report). Consequently, there is no clear benefit derived by restricting dredging during a particular period. However, the blue crab deserves special attention because of its commercial importance and its vulnerability due to the habit of the females to congregate in the lower Bay to overwinter before spawning. Therefore, we suggest that dredging in the Cape Henry and York Spit channels be restricted from November 15 to March 15 to avoid impacting overwintering blue crabs and interference with the Virginia winter crab harvesting fleet. A winter dredge restriction would be less effective for the Rappahannock Shoal channel where overwintering crabs are not nearly as concentrated. It may be more beneficial to restrict dredging in the Rappahannock Shoal channel during the summer months when general biological activity is high and when species such as crabs and oysters are reproducing. These suggested time of year restrictions may have to be adjusted depending on which spoil disposal sites are selected.

In the Maryland portion of the project there appears to be no need for a dredging restriction in Baltimore Harbor since pollution has limited its use for most species. However, the Baltimore approach channel passes in the vicinity of charted oyster bars. The fact that the oyster bars are located in much shallower water than the channel should help to lessen the possibility of impact by sedimentation.

This was shown to be the case during the monitoring of the Kent Island disposal site in 1975. Nevertheless, the possibility of injury to oysters either by sedimentation or entrainment of larvae would be diminished if the approach channel dredging was not conducted during the summer oyster spawning season from June 15 to September 15.

Monitoring

Even with careful planning, the removal and disposal of such massive amounts of bottom material has the potential to result in unforseen damage to the ecology of Chesapeake Bay. Consequently, we believe that a program should be initiated to monitor important environmental parameters. Information obtained from a carefully designed and executed monitoring program can be used to reduce environmental impacts by modifying the operation of the initial project, which will take several years to complete, as well as future maintenance. The monitoring program should include, but not necessarily be limited to, the following components. There should be before and after surveys of the benthic fauna in both the dredge and disposal areas. Suitable control stations should be established in similar unaltered areas. The sampling should be conducted with sufficient frequency to determine the rate and extent of recolonization. Dredge and disposal sites should be periodically sampled for the presence of fish eggs and larvae. Periodic measurements of the bottom topography of the disposal sites should be made to determine the fate of the spoil. Vertical and horizontal profiles of the concentrations of suspended sediment in the turbidity plume should be taken to disclose the area of impact. Measurements of salinity and oxygen should be correlated with studies performed with the Bay Model to determine the effects of the project on the salt wedge and oxygen concentrations in the deepened channel. Chemical monitoring should be directed towards those parameters which the pre-project surveys show to be of most concern. We understand that the pre-project samples from the Virginia channels have shown that the levels of pollutants are generally well within the limits set by the Dredge Spoil Criteria Committee for open water disposal. Hence, extensive chemical monitoring may not be warranted. In Maryland, where the channels contain higher concentrations of pollutants, we understand the Department of Natural Resources intends to conduct a comprehensive monitoring operation of the disposal site at Hart and Miller Islands.

Please keep us informed on the progress of the project and do not hesitate to contact us if we can be of further assistance.

Sincerely yours,

Glenn Kinser
Supervisor
Annapolis Field Office

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
1825B Virginia Street
Annapolis, MD 21401

December 23, 1977

District Engineer
Baltimore District, Corps of Engineers
Post Office Box 1715
Baltimore, MD 21203

Dear Sir:

This is to provide you with fish and wildlife resource information relating to the proposed deepening to 50 feet of the Baltimore Harbor and Channels. This project is authorized by Section 101 of the River and Harbor Act, dated 31 December 1970, Public Law 91-611. We intend that the information provided in this report will be used in the preparation of the environmental impact statement and that the official position of the Fish and Wildlife Service on the project will be established at a later date after review of the EIS and other information yet to be developed. The report is derived from existing, available information sources. There are several areas of the project where site specific survey information is not available. Because of the short time available for preparation of this report, we have been unable to conduct the studies needed to fill these information gaps and our resource data is of necessity of a more general nature.

The actual 53 miles of channel deepening will span approximately 175 miles from the mouth of Chesapeake Bay to the upper reaches of the estuary at Baltimore. Thus, the channel will cross a wide range of environmental gradients typically observed in estuaries, such as salinity, temperature, nutrients, substrate composition, etc. To facilitate a description of the resources, the project area can be divided into two broad sections, the three Virginia channels and the Baltimore Harbor channels.

Virginia Channels Area

The three Virginia channels which will require deepening are Cape Henry, York Spit, and Rappahannock Shoal. We understand that three primary sites are being examined for spoil disposal. They are all open water sites. The Dam Neck site is approximately three miles east of the Virginia Beach shore. A second site is a deep trough near Cape Charles. The third site is a deep area approximately 8 miles north of the Rappahhannock Shoal Channel.

The Virginia channels occupy the lower third of the Bay and are within the so called "polyhaline" ecological zone of the estuary (Figure 1). The longitudinal salinity gradient varies from close to 30 ppt at Cape Henry to approximately 19 ppt at the upper Rappahannock Shoal Channel. During periods of high freshwater river discharge the salinities in the upper waters may drop by as much as 5 ppt. Since Chesapeake Bay is a bi-layer estuarine system with a salt wedge, there is also a vertical salinity gradient.

The three main sources of primary production are phytoplankton, submerged aquatic vegetation, and the marsh and upland vegetation. In the lower Bay, phytoplankton typically have spring and fall growth pulses controlled by factors such as nutrients, day length, and turbidity. Diatoms, and to a lesser extent dinoflagellates, dominate the phytoplankton, although the contribution of the ultra-minute nannoplankton has not been well studied. Phytoplankton, by serving as the major food source for the zooplankton, play a vital role in the Bay ecology.

Submerged aquatic vegetation is another source of primary production, but its input is probably relatively small. Submerged grass and algae beds, however, are excellent habitat for many invertebrates and small fishes. They also serve as an important food source for waterfowl. Because they are limited to relatively shallow areas where light can penetrate to the bottom, it is not likely that there are productive beds in close proximity to the channel or deep water disposal sites.

The productivity of marshes and upland vegetation is released to the Bay in the form of dissolved nutrients and bits of decaying vegetation known as detritus. The nutrients foster the growth of plankton and other micro-organisms which are a basic part of the estuarine food web. The detritus, enriched by the growth of bacteria and fungi, becomes a food source for a wide variety of invertebrates such as worms, snails, bivalves, amphipods, mysids and copepods. Marshes are highly valued for their role as a nursery for developing fishes and as a habitat for birds and mammals. They also act as a natural shoreline erosion buffer and can filter silt and pollutants from upland surface water runoff and the water column. There is no marsh land close to the channels or deep water disposal sites.

Zooplankton in the lower Bay occur in two broad seasonal congregations, neither of which is dominated by endemic species, but are composed of members of the Atlantic Continental Shelf populations (Table 1). The winter/spring assemblage is basically boreal, the dominant species being the copepod Acartia clausi. The summer/fall assemblage is primarily composed of sub-tropical species with A. tonsa being the dominant one. The zooplankton form an important link between the phytoplankton and higher trophic levels in the estuarine food web.

Benthic invertebrates of the polyhaline zone in the lower Bay exhibit a high diversity and a distribution pattern which is largely determined by the patterns in bottom sediment type (Table 2). The benthic invertebrates play an essential role in the aquatic food web by serving as food sources for a large variety of species in higher trophic levels. Among the invertebrates of particular interest are the commercially harvested species (Table 3).

In the lower Bay, the largest commercial fishery is for blue crabs. Harvesting occurs on a year round basis and includes a winter dredging fleet. Female crabs migrate south during the late summer and fall to the higher salinity waters of the lower Bay. The adult females pass the winter in the deeper portion of the lower Bay (Pearson, 1948), an area which includes the York Spit and Cape Henry channels and the Cape Charles disposal area (Figure 2). During the spring the crabs move into shallower water, but return to cooler, deeper water to spawn in late spring and summer. After hatching the zoeae larval stage remains planktonic for about 6 weeks. The greatest concentrations of zoeae occur between Cape Charles and Cape Henry in the upper water levels in the vicinity of the channel, with lesser numbers up-Bay and seaward (Van Engle, 1958). As they pass through the megalops stage and into the young crab stage, they settle to the bottom and migrate up-Bay.

There is a very minor commercial fishery during the winter for rock crabs (Cancer irroratus) (Van Engle, personal communication). Rock crabs move into the lower Bay from the Ocean in mid-November and depart in April. They are found east of the Bay Bridge-Tunnel and the lower York Spit.

Oysters (Crossostrea virginica) comprise an important commercial fishery in Virginia. Because they are non-motile filter feeders and require a hard substrate for attachment of their larval stage, they are especially vulnerable to the high levels of sedimentation often associated with dredging and spoil disposal. Since they are most abundant in waters less than 25 feet deep and occur only infrequently in waters greater than 35 feet deep (Lippson, 1973), it is unlikely that productive oyster bars are located close to the channels or deep water disposal sites.

Commercial harvesting of hard clams (Mercenaria mercenaria) is centered primarily in the Bay tributaries. Although the clams occur throughout the lower Bay, their concentrations are apparently only high enough to support a modest commercial fishery there. There are likely to be scattered populations of hard clams in the Virginia channels, particularly in Cape Henry and York Spit (Haven, personal communication) and possibly in the disposal sites.

Musick (1972) has listed 209 fish species which may occur in Chesapeake Bay, not including 78 fresh water species which may inhabit the upstream portions of the tributaries. Only 29 species inhabit the Bay year round (two of these are primarily marine species). The remaining 180 species (172 marine species, 7 anadromous species, and 1 catadromous species) migrate in and out of the Bay. Fifty-nine of the marine species are regular summer visitors with 44 of these occuring in the Bay both as adults and juveniles, 5 occuring mostly as adults, and 10 occuring mostly as juveniles. The summer visitors also include 93 species occuring infrequently. Only 6 marine species are regular winter visitors, with 4 of these occuring both as adults and juveniles. The winter visitors include an additional 16 species which enter the Bay on an infrequent basis. In addition to the migrations into and out of the Bay, many resident species show a seasonal migration from the tributary and shoal areas to deeper waters within the Bay during the winter.

It is apparent that: 1) most of the fish species occuring in the Bay are migratory; 2) the spring and fall seasons are the periods of greatest migratory activity; 3) the peak in the number of fish species inhabiting the Bay happens in the summer; and, 4) many species occur in the Bay during their juvenile stages.

A large variety of species are caught commercially in the lower Bay (Table 4). Trawling is prohibited in the channel. Drift net fishing is particularly popular along the western shore (Merriner, personal communication). There is a substantial catch by sport fishermen and the vicinity of the Bay Bridge-Tunnel is especially popular. Species of sport or commercial importance occuring in the project area as larvae or juveniles are of particular interest since they may be more susceptible to dredging impacts. Weakfish (Cynoscion regalis) spawn in the lower Bay and coastal waters at the Virginia Capes during June and July and then move into nursery areas in the lower salinity waters of the rivers (Fish and Wildlife Service, 1968). Croaker (Micropogon undulatus) spawn in early fall to early winter in coastal waters, mostly in North Carolina. The postlarval stages move into the Bay in October (considerable variation) and continue onto the lower salinity nursery grounds. Movement downstream into the lower reaches of the rivers and into the lower Bay occurs as the fish increase in size and reaches a peak the following spring. Menhaden (Brevoortia tyrannus) larvae enter the Bay from offshore spawning areas as early as October and proceed to the nursery areas in tidal creeks. As growth continues they move into the main stems of rivers and into the main body of the Bay. In mid-April the post larvae and early juveniles of spot (Leiostomus xanthurus) move from the spawning grounds in coastal waters near North Carolina into the Bay on their way to lower salinity nursery areas.

Chesapeake Bay is a major nesting and feeding stop for migrating waterfowl of the Atlantic Flyway. The open water areas of the Bay are frequented by diving ducks such as scoter, oldsquaw, scaup, goldeneye, canvasback, bufflehead, ruddy duck, eider, redhead and merganser. Additional species occuring in the more protected shallow water areas include gadwall, widgeon, pintail, mallard, black duck, shoveler, blue- and green-winged teal, brant, Canada and snow geese, and swan.

The following species included in the Department of the Interior list of endangered species may occur within the Chesapeake Bay Basin area:

Maryland Darter	Etheostoma selare
Shortnose Sturgeon	Acipenser brevirostrum
Delmarva Fox Squirrel	Sciurus niger cinereus
Southern Bald Eagle	Haliaeetus leucocephalus leucocephalus
Artic Peregrine Falcon	Faloo peregrinus fundrius
American Peregrine Falcon	Falco peregrinus anatum
Eskimo Curlew	Numenius borealis

Baltimore Harbor Channels Area

The Baltimore Harbor Channels are located in the mesohaline ecological zone near its transition with the oligohaline zone (Figure 1). There is a longitudinal salinity gradient which may undergo significant variations dependent on the amount of freshwater inflow from the Susquehanna River.

During a wet period such as may occur in the spring, the salinity might be 3 ppt at the mouth of the Patapsco River and 6 ppt at the Bay Bridge. During dry periods such as tend to happen in the fall, the salinity might increase to 8 ppt at the mouth of the Patapsco River and as much as 13 ppt at the Bay Bridge.

Of the 66 invertebrate species which Pfitzenmeyer (1970) found in the upper Bay the most common species included: the molluscs, Macoma balthica, M. phenax and Rangia cuneata; the arthropods, Edotea trilobia, Gammarus sp., Cyathura polita, and Leptochurus plumulosus; the polchaete worms, Scolecolepides viridis and Heteromastus filiformis. Invertebrate species of commercial importance include the blue crab, oyster and soft clam. The Maryland commercial landing of blue crabs totalled 20,885,500 pounds in 1976. There is also a large sport crab fishery which was estimated at 3,160,900 pounds in 1976 (Speir, Weinrich and Early, 1977). Chartered oyster bars in the vicinity of the Baltimore approach channel are shown in Figures 3 and 4. Although all these bars are open to public harvest, some are no longer productive (Table 5). The records of commercial harvest of soft clams from the Bay waters in the vicinity of the Baltimore approach channel are shown in Table 6. In general, most soft clams are found in waters less than 20 feet deep (Lippson, 1973).

The upper Bay supports both a commercial and a large sport finfish fishery. The harvests of selected species for areas of the upper Bay (Figure 5) are shown in Table 7. The upper Bay is also known for its spring run of anadromous (Alosa sapidissima, A. pseudoharengus, A. aestivalis, A. mediocris, and Morone saxatilis) and semi-anadromous (M. americana and Perca flavescens) fish to their spawning grounds in the upper reaches of the tributaries.

The distribution and abundance of fauna in Baltimore Harbor is quite distinct from that of the Bay due to the impact from the large Harbor industrial complex. Pfitzemmeyer (1975) divided the Harbor into three zones: the semi-healthy zone which extends from the mouth to Fort Carroll; the semi-polluted zone which lies between Fort Carroll and Fort McHenry; and the polluted zone which is composed of the inner harbors and tributaries (Figure 6). His survey revealed 31 invertebrate species in the Harbor (Table 8). Benthic biomass was low with only 2.9 g/m^2 in the semi-healthy zone, 1.7 g/m^2 in the semi-polluted zone, and 0.2 g/m^2 in the polluted zone. These values are significantly less than the 19.6 g/m^2 found at the Chester River reference station. The principal reason for the paucity of benthos is the fact that the sediments are grossly contaminated with a number of pollutants. For example, the Environmental Protection Agency (1974) found that the concentrations of metals in the Harbor ranged from 3 to 50 times greater than the concentrations in the Bay. In addition to the large amount of chemical pollutants, the Harbor also has high concentrations of coliform bacteria and associated organisms. A new species of amoeba, Acanthamoeba hatchetti, which causes death in laboratory animals, has recently been isolated from Harbor sediments (Sawyer, Visvesuara and Harks, 1977).

Dovel (1975) found that the utilization of Baltimore Harbor as spawning habitat is very limited. The Harbor is, however, used as a nursery and feeding ground for several fish species, white perch being the most abundant, although many show signs of stress. Several bottom dwelling species are conspicuously absent, probably due to the polluted nature of the bottom sediments.

Potential Impacts of Particular Concern - Dredge Sites

In the Virginia channels the most obvious direct impact of the dredging is the severe disruption to the benthos. Repopulation can be expected within 1 or 2 years, but the composition of the repopulated community may be changed in areas where the exposed sediments differ from the existing sediments or where the hydraulics of the new channel result in alterations in currents, shoaling rates, oxygen concentrations, etc. There is a general lack of information on the benthos, especially in the areas which have not been dredged previously. We suspect that the type and extent of recolonization in the previously undredged areas will not be sufficient to return these areas to pre-project conditions. The new portions of the York Spit Channel are the least likely to return to the pre-project state since its benthic communities are thought to be more limited by specific substrate conditions which are likely to be altered by dredging (Boesch, personal communication). On the other hand, the organisms inhabiting the more uniform clayey silt sediments of the Rappahannock Shoal Channel or those adapted to tolerate the motile shifting sands of the Cape Henry Channel are more likely to fully repopulate after dredging.

As the York Spit and Cape Henry channels lie within the general area of the lower Bay where large numbers of female blue crabs congregate to overwinter and spawn, the impact to this species may be significant. Dredging in the York Spit and Rappahannock Shoal Channels during the winter will result in the loss of those crabs overwintering in the dredge area. The Virginia winter blue crab dredging fleet should not be immediately affected since they are not permitted to work in the channels. Crabs overwintering in areas adjacent to the dredge area should not be significantly impacted (Van Engle, personal communication). There is speculation that dredging during November could harass the migrating crabs into moving out of the Bay and thus lead to decreased catches. Dredging during the late spring and summer could affect spawning success by smothering eggs or interfering with the feeding or respiration of the larval or young crab states. The zoeal larval stages may avoid being substantially impacted since they generally are located in the upper water layers where the sediment plume should be much reduced.

The extent to which these impacts will affect the general blue crab population levels throughout the Bay is difficult to determine, but there are two main factors that suggest that the effect will not be substantial. The first is that the channels make up only a small part of the overwintering area. The second factor is that there is evidence to indicate that the size of the spawning stock does not determine the size of the population of blue crabs

surviving to harvestable age (Pearson, 1948). This point is hotly contested, especially by Maryland crab fishermen who feel that the Virginia practice of harvesting overwintering females results in diminished populations in Maryland. The large magnitude of the commercial and recreational blue crab fisheries of both Maryland and Virginia requires that careful study be given to all aspects of potential impact of the project on this species. Consideration should be given to restricting the dredging in the York Spit and Cape Henry Channels during the late fall and winter to minimize the impact on the blue crabs.

Adult finfish should be able to avoid being impacted during the dredging operation, but species which feed on benthic invertebrates may be affected by a temporary lack of forage species in the channel. The larvae and young juveniles are much more susceptible to impact, particularly by clogging of the gills from the elevated levels of suspended sediments.

In Maryland, the dredgng of Baltimore Harbor and approach channel can be expected to result in many of the impacts typically associated with dredging of this kind: temporary loss of the benthic community and impacts associated with increased turbidity and sedimentation. The fact that almost all of the channel has been previously dredged suggests that no unique organisms or communities will be lost and that the existing species should be able to repopulate successfully. Adverse impacts could occur if toxic chemicals trapped in the sediments are released to the water column during dredging. The dredging in the Maryland and Virginia channels is not expected to affect the status of any endangered species.

Potential Impacts of Particular Concern - Spoil Disposal Sites

In many cases the impacts associated with the disposal of dredged spoil can be greater than with the actual dredging. With the method of open water disposal as proposed in the Virginia section, the major impacts stem from: 1) the burial of the bottom community; 2) the generation of elevated levels of turbidity and sedimentation; 3) the release of toxic materials; and, 4) changes in the bottom topography and sediment composition.

The Dam Neck disposal site in a previously used site which is approved by EPA for the disposal of dredged material which satisfies their criteria for ocean dumping (EPA, 1970). We understand that dredged material from Cape Henry and at least part of the York Spit is being considered for disposal at Dam Neck and will satisfy EPA's ocean dumping criteria. At this time we do not have any information on the benthic community which would allow prediction of impacts. As the site lies within the migratory route of many fish species, it is possible that a large sediment plume could have an effect on the southern migration of such species as spot, weakfish, croaker, rockfish and summer flounder. Eggs, larvae and post-larvae effecting a demersal habit would be particularly vulnerable.

The disposal site near Cape Charles is a deep hole lying within a long trough. Dr. Robert Lipson of the National Marine Fisheries Service has several sets of sampling data from this area which show the presence of a very rich and diverse fauna. Sampled species include: coral, starfish, sea cucumbers, whelks, razor clams, blue crabs, rock crabs, hermit crabs, lady crabs, sand sharks, sea bass, blennies and hakes. The presence of two species of coral is noteworthy because it constitutes a unique community within Chesapeake Bay and would probably not be capable of recolonizing after spoil disposal. Dr. Lippson's data also included some physical measurements which indicate that a salt wedge extends up through the trough. There were no indications that the deep portions of the trough undergo oxygen depletion or other water quality stresses sometimes characteristic of deep holes. In view of the high productivity and uniqueness of the fauna and the unknown potential impacts on the water currents and salt wedge, we believe that it would be ill-advised to utilize this site for spoil disposal. A detailed report of the available faunal and physical data will be prepared and forwarded to you shortly in a separate letter.

Regarding the disposal site located approximately 8 miles north of the Rappahannock Shoal Channel, we do not have specific information on the existing benthos which would be impacted. In some cases, such deep areas may have surprising water currents which could transport the spoil material far away from the disposal site and lead to more extensive and unanticipated fishery impacts. Actual current measurements and, if appropriate, modeling studies with the Chesapeake Bay Model should be used to estimate the fate of the spoil deposited at this or other open water disposal sites. The clayey silt sediments of the Rappahannock Shoal Channel are finer than that of the other two Virginia channels and would be more likely to create a large turbidity plume and be transported away from the disposal site to uncontaminated areas. Fine sediments also tend to contain greater pollutant concentrations. We understand that a sampling program has been instituted to determine the characteristics of the dredge and disposal site sediments. This information will be a valuable aid to the prediction of disposal impacts. One of the most important factors determining the extent of recolonization by benthic organisms is the similarity between the sediments of the spoil material and the sediments of the disposal site. The more similar the two sediments are, the more rapidly and completely the original species will be able to repopulate the area. Some species of clams and worms can survive burial by as much as one meter of like material (i.e., sand on sand or mud on mud) or can be smothered by as little as a few centimeters of unlike material (Waterways Experimental Station, 1977).

We understand that the current planning for the disposal of the spoil from the Maryland channels is for all of the spoil to be deposited in the proposed Hart and Miller Island diked facility. We will not discuss the impacts to fishery resources associated with the Hart and Miller Island disposal area as this has already been covered in an EIS. It will suffice to say that that construction of this diked facility will result in the permanent loss of

1100 acres of estuarine habitat. Since the environmental losses associated with such diked areas make them one of the least desirable methods of spoil disposal, every effort should be made to extend the life of the Hart and Miller Island disposal area. If all of the dredge material from the Baltimore channels is deposited into the Hart and Miller Island facility, it will be filled in less than 10 years. As there will always be a need for a confined disposal site to contain the polluted spoil from Baltimore Harbor, we can forsee the need for another diked disposal area in only a few years. In order to maximize the benefits derived from the Hart and Miller Island containment facility, other forms of disposal, such as marsh creation or open water disposal, should be considered for the relatively uncontaminated dredged material from the approach channel.

<u>Long-Term Impacts of the Project</u>

Possible effects of the channel deepening on the salt wedge, oxygen concentrations in the bottom waters, and shoaling patterns should be addressed in the EIS. As the existing spoil disposal sites become filled to capacity, finding new acceptable sites for the disposal of dredged material will be increasingly difficult. Therefore, it is vital that the amount of maintenance dredging required for the deepened channels be determined and a plan for the disposal of the spoil developed. Indirect impacts relating to the increased number of large draft ships traversing Chesapeake Bay, such as illegal discharges of bilge and balast water or spills of toxic materials from ship accidents, should also be addressed in the EIS so that the full range of environmental impacts will be available for review.

Sincerely yours,

Glenn Kinser

Glenn Kinser
Supervisor
Annapolis Field Office

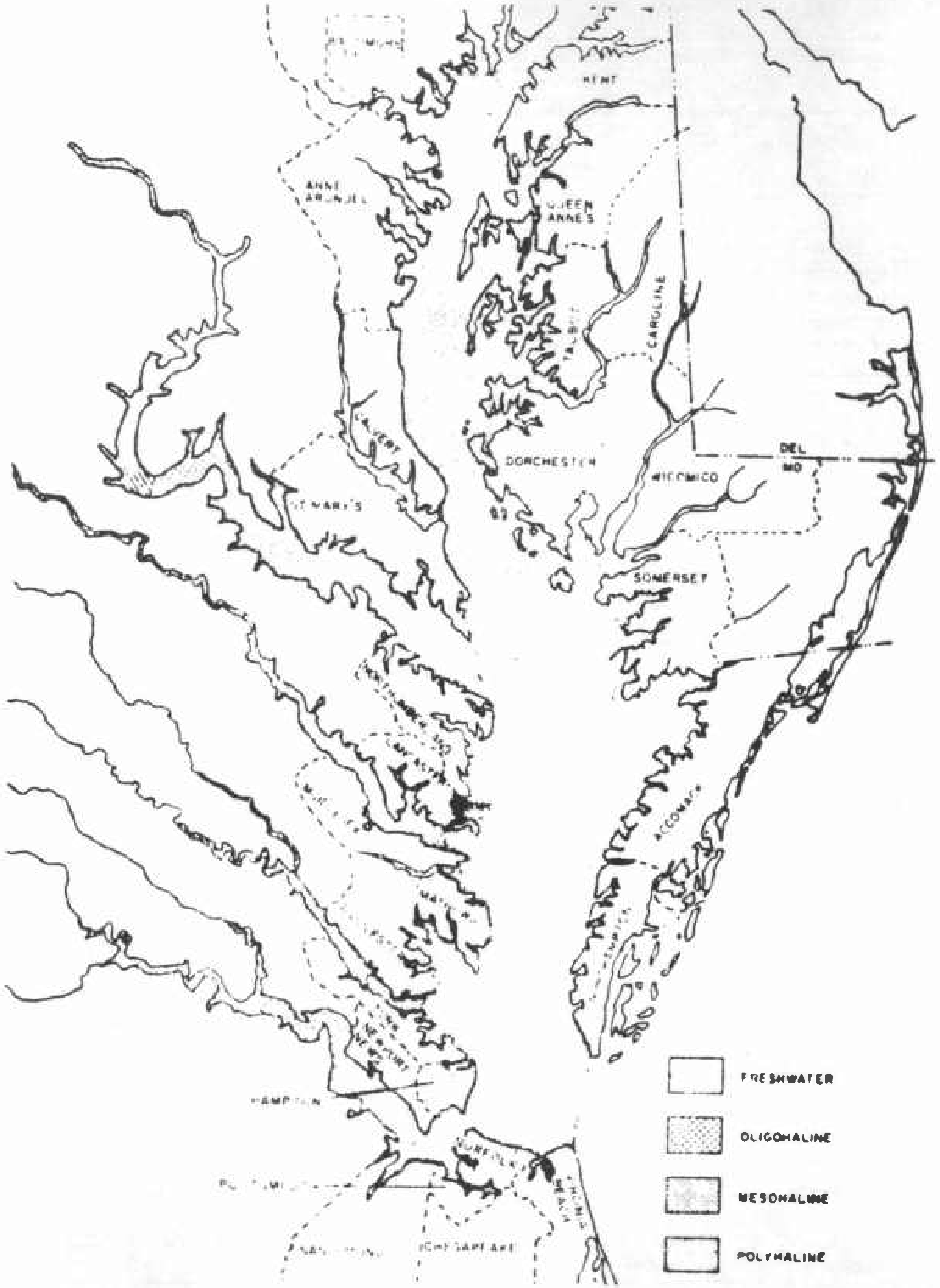


Figure 1. The ecological zones of the Chesapeake Bay according to the Venice System. Cross-hatched areas are areas of transition between adjacent zones.

Table 1: Dominant zooplankters characteristic of estuarine zones during winter-spring (January-June) and summer-fall (July-December)

Winter-Spring	Summer-Fall
	Polyhaline Zone[1]
Cyanea capillata (S)	Aurelia aurita (S)
Mnemiopsis leidyi (Ct)	Chrysaora quinquecirrha (S)
Podon polyphemoides (Cl)	Beroe ovata (Ct)
Acartia clausi (Co)	Evadne tergestina (Cl)
Temora longicornis (Co)	Penilia avirostris (Cl)
Pseudocalanus sp. (Co)	Acartia tonsa (Co)
Sagitta elegans (Ch)	Pseudodiaptomus coronatus (Co)
	Paracalanus spp. (Co)
	Oithona spp. (Co)
	Sagitta tenuis (Ch)
	Mesohaline Zone[2]
Cyanea capillata (S)	Aurelia aurita (S)
Mnemiopsis leidyi (Ct)	Chrysaora quinquecirrha (S)
Podon polyphemoides (Ct)	Mnemiopsis leidyi (Ct)
Acartia clausi (Co)	Podon polyphemoides (Cl)
Acartia tonsa (Co)	Acartia tonsa (Co)
	Oithona brevicornis (Co)
	Brachionus plicatilis (R)

Table 1 (Continued)

Winter-Spring	Summer-Fall
Oligohaline Zone[3]	
Cyanea capillata (S)	Chrysaora quinquecirrha (S)
Eurytemora affinis (Co)	Acartia tonsa (Co)
	Eurytemora affinis (Co)
Tidal Freshwater[4]	
Cyclops vernalis (Co)	Cyclops vernalis (Co)
Mesocyclops edax (Co)	Mesocyclops edax (Co)
Bosmina longirostris (Cl)	Eurytemora affinis (Co)
	Diaphanosoma brachyurum (Cl)
	Bosmina longirostris (Cl)

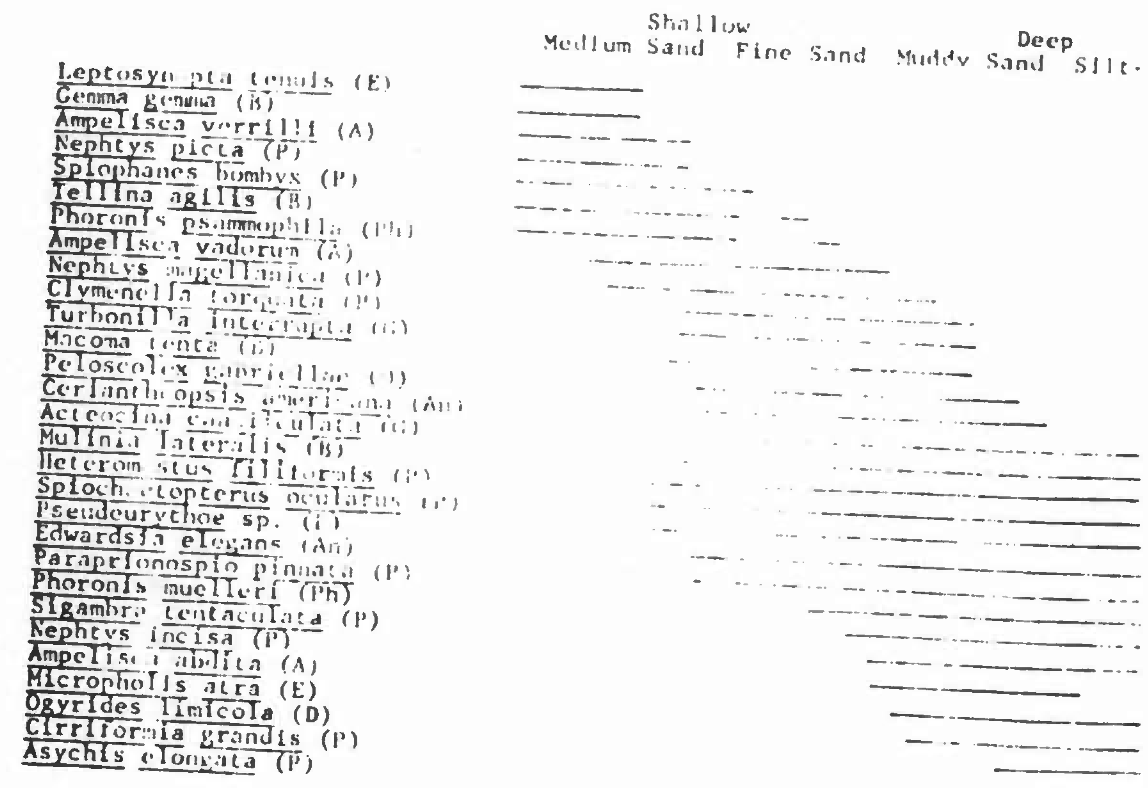
Sources:
1 G. Grant (unpublished); Burrell (1972)
2 Lippson (1973), Heinle et al. (1974), Burrell (1972)
3 Lippson (1973), Burrell (1972)
4 Davies and Jensen (1974), Burbidge (1972)

Key:
- S Scyphozoa
- Ct Ctenophora
- R Rotifera
- Cl Cladocera
- Co Copepoda
- Ch Chaetognatha

Source of Table: Roberts et al. 1915.

Table 2

Zonation of Dominant Macrobenthos in the Polyhaline Zone



- A - Amphipoda
- An - Anthozoa
- B - Bivalvia
- D - Decapoda (Crustacea)
- E - Echinodermata
- G - Gastropoda
- O - Oligochaeta
- P - Polychaeta
- Ph - Phoronida

Source: Roberts et al. (1975)

Table 3. 1976 Virginia Shellfish Landings (Preliminary)

SHELLFISH	Chesapeake Bay Pounds	Chesapeake Bay Dollars	Chesapeake Bay Tributaries (Excluding Potomac River) Pounds	Chesapeake Bay Tributaries (Excluding Potomac River) Dollars
Crabs, blue, hard (Callinectes sapidus)	14,592,336	2,920,155	3,601,428	707,601
Crabs, soft & peeler (C. sapidus)	131,884	105,202	320,719	221,201
Clams, hard (meats) (Mercenaria mercenaria, M. campechiensis)	7,658	7,434	290,812	272,977
Conchs (meats) (Busycon spp., Palinices heros)	68,375	17,487	0	0
Oysters (meats) (Crassostrea virginica)	426,559	414,966	2,034,270	2,093,192
TOTAL SHELLFISH	15,226,812	3,465,244	6,247,229	3,294,971

Source: Department of Commerce fisheries statistics

Figure 2. Major area for overwintering blue crabs.

Table 4.
1976 Virginia Fishery Landings (Preliminary)

FISH	Chesapeake Bay Pounds	Chesapeake Bay Dollars	Chesapeake Bay Tributaries (excluding Potomac River) Pounds	Chesapeake Bay Tributaries (excluding Potomac River) Dollars
Alewives (Alosa aestivalis, A. pseudoharengus)	1,826,602	67,446	959,801	37,735
Bluefish (Pomatomus saltatrix)	2,262,689	174,521	407,836	34,546
Butterfish, unclassified (Peprilus triacanthus)	65,200	14,137	23,014	6,750
Cobia (Rachycentròn canadum)	2,495	407	170	22
Carp (Cyprinus carpio)	240	12	13,387	756
Catfish & Bullheads (Ictalurus spp.)	7,136	170	683,568	153,634
Croaker, unclassified (Micropogon undulatus)	2,192,875	287,878	1,156,454	162,854
Drum, black (Pogonias cromis)	2,445	121	861	44
Drum, red (Sciaenops ocellata)	7,964	678	839	99
Eels, common (Anguilla rostrata)	13,820	5,230	186,092	72,378
Flounder, winter (Pseudopleuronectes americanus)	91	21	0	0
Flounder, fluke (Paralichthys dentatus)	128,015	47,321	21,899	6,768
Gizzard shad (Dorosoma cepedianum)	0	0	3,240	54
Harvest fish (Peprilus alepidotus)	12,407	4,848	1,034	449
Herring, sea (Clupea harengus harengus)	100	5	42	2
Hickory shad (Alosa mediocris)	0	0	2,033	608
King mackerel (Scomberomorus cavalla, S. regalis)	8,007	3,059	301	127
King fish (Menticirrhus spp.)	13	1	0	0
Mackerel, Atlantic (Scomber scombrus)	12,600	1,890	0	0
Menhaden (Brevoortia tyrannus)	8,041,465	172,316	10,094,730	205,427
Mullet (Mugil spp.)	16,491	1,135	3,209	360
Pompano (Trachinotus carolinus)	3,117	1,575	0	0

Table 4. (continued)
1976 Virginia Fishery Landings (Preliminary)

FISH	Chesapeake Bay Pounds	Chesapeake Bay Dollars	Chesapeake Bay Tributaries (excluding Potomac River) Pounds	Chesapeake Bay Tributaries (excluding Potomac River) Dollars
Sand perch (Bairdiella chrysura)	310	25	0	0
Scup or Porgy, unclassified (Stonotomus chrysops)	1,216	191	158	19
Sea bass, unclassified (Centropristes striatus)	5,134	866	0	0
Sea trout, grey (Cynoscion regalis)	1,680,674	262,394	498,471	83,667
Sea trout, spotted (Cynoscion nebulosus)	20,113	5,033	7,843	1,233
Shad (Alosa sapidissima)	179,213	48,789	288,529	112,666
Sharks, grayfish (Mustelus and Squalus species)	6,018	270	563	120
Spanish mackerel (Scomberomorus maculatus)	36,059	9,345	4,681	880
Spot (Leiostomus xanthurus)	548,708	105,569	229,866	33,102
Striped bass (Morone saxatilus)	114,684	65,126	186,962	89,916
Sunfish (Lepomis spp.)	11	4	0	0
Tautog (Tautoga onitis)	587	18	179	12
White perch (Morone americana)	3,665	1,010	66,799	17,260
Unclassified for food	5,421	799	625	86
Unclassified for industrial	5,899,121	143,045	1,592,082	29,573
TOTAL FISH	23,098,706	1,425,252	16,435,268	1,051,147

Source: Dept. of Commerce fishery statistics

Figure 3. Oyster Bars

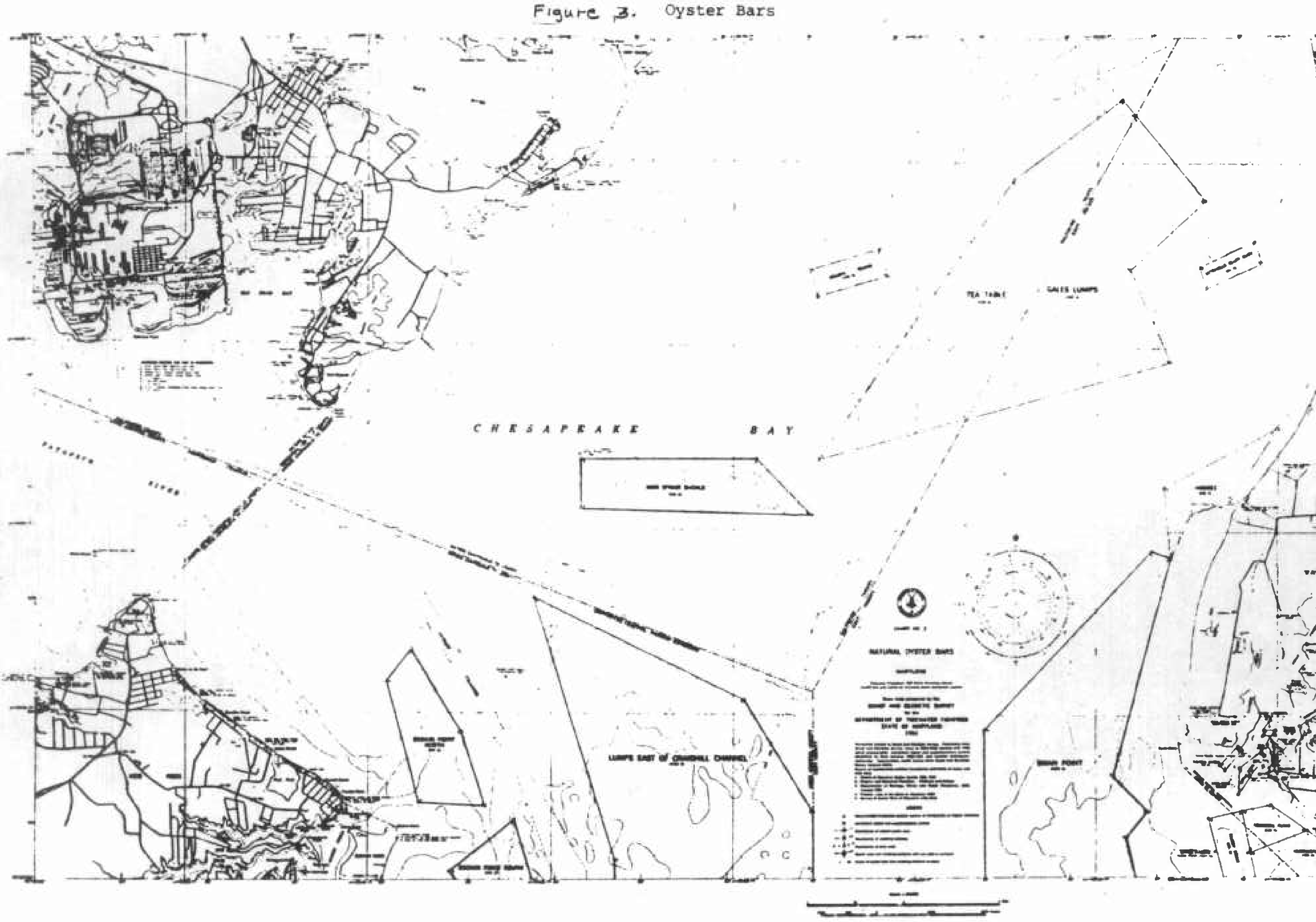


Figure 4. Oyster Bars.

Table 5. **Natural Oyster Bars - Baltimore Harbor to Magothy River**

Bars	Production in Bushels 66-67	67-68	68-69	69-70	70-71	71-72	72-73	73-74	74-75	75-76	76-77
Bodkin Point (North)	0	0	0	0	0	0	0	0	0	0	0
Bodkin Point (South)	0	0	0	0	0	0	0	0	0	0	0
Lumps East of Craighill Channel	37.01	813	2,136	4,298	0	0	0	0	0	2,431	2,915
Mountain Point	0	0	0	0	0	0	0	0	0	10	123
Outer Magothy	0	0	0	0	0	0	0	0	0	0	0
Sandy Point (North)	0	0	0	0	0	6,069	4,395	541	115	320	110
Sandy Point (South)	599	97	0	24,254	13,869	693	515	2,056	1,256	1,779	3,304
Swan Point	41,428	6,005	0	83,833	152,435	172,966	41,055	4,605	5,834	4,252	3,138
Love Point	5,292	3,737	0	154,564	125,266	39,452	17,889	13,210	26,823	7,217	5,407
Broad Creek	0	103	0	36,677	27,534	3,201	15,392	2,027	7,297	617	3,392
Man O'War	0	0	0	0	0	0	0	0	0	0	0

Table 6. Soft Clam Harvest In Bushels From Upper Chesapeake Bay Waters[1]

County	66-67[2]	67-68	68-69	69-70	70-71	71-72	72-73	73-74	74-75	75-76
Queen Annes	7,862	1,708	19,230	11,288	40,552	22,011	58	323	10,213	2,994
Kent	7,550	6,613	7,575	16,085	19,075	32,235	0	103	2,999	1,804
Anne Arundel	10,654	1,446	3,600	626	242	0	0	29	37	0
Baltimore	0	0	0	0	0	0	0	0	0	0

[1]Excludes the Chester River

[2]Harvest from July of the first year to June of the following year

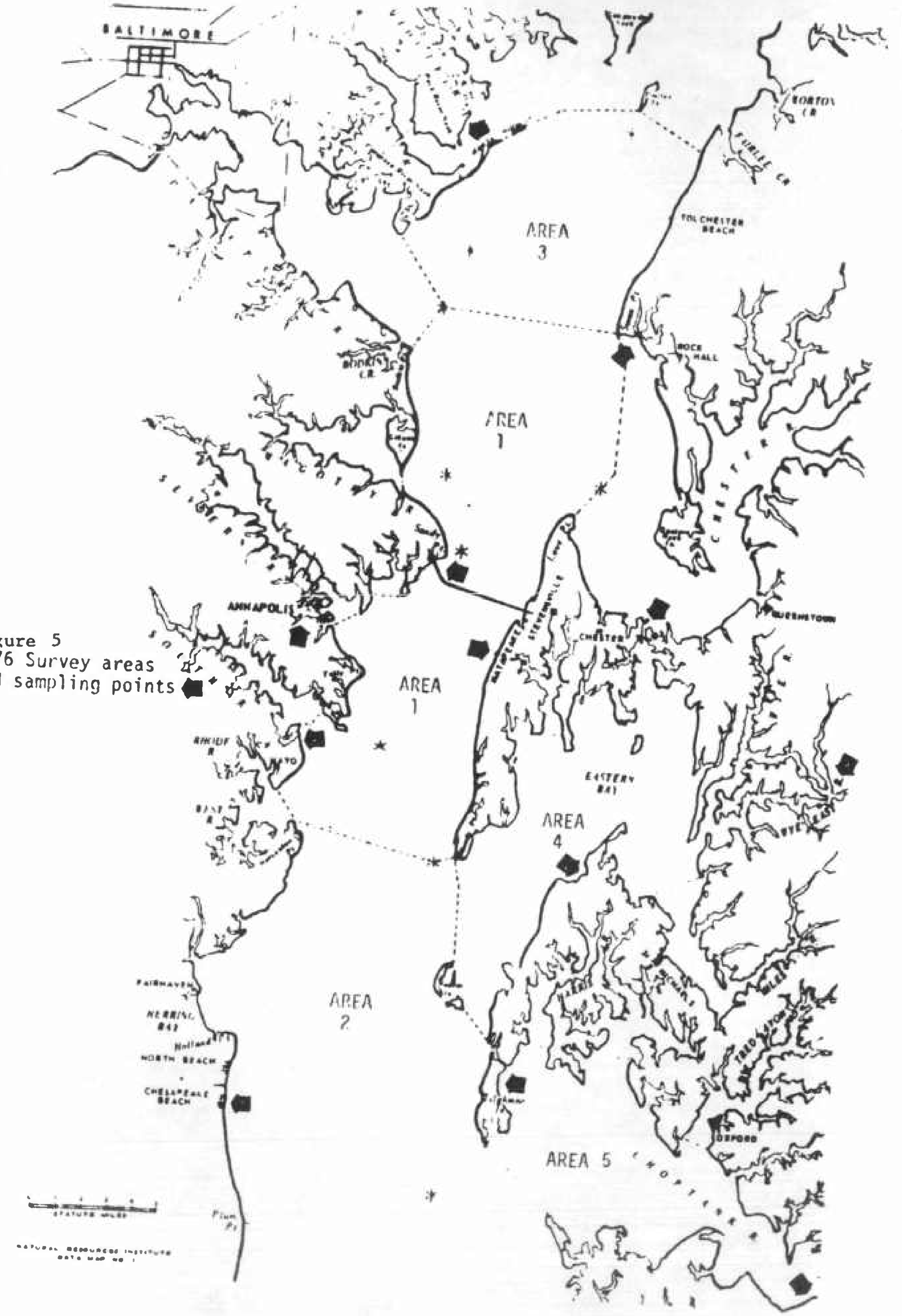


Figure 5
1976 Survey areas and sampling points

Table 7. Comparison of sport and commercial catch within sport fishing survey areas for 1976.

	Harvest in pounds by species				
	Striped bass	Bluefish	White perch	Croaker	Spot
Area 1 - sport	500,286	766,402	60,930	4,947	5,364
commercial	138,589	76,554	17,373	30	117
Area 2 - sport	21,966	2,067,722	2,727	1,589	5,265
commercial	114,224	44,937	8,554	21	84
Area 3 - sport	3,712	19,421	141,012	19	5,990
commercial	181,010	35,421	22,732	0	0
Area 4 - sport	6,879	40,551	28,012	0	525
commercial	9,316	734	9,663	0	0
Area 5 - sport	2,958	21,091	25,595	4,134	1,708
commercial	38,040	1,524	16,390	0	0
Totals sport	535,800	2,915,179	266,274	10,689	18,853
commercial	481,179	159,170	74,718	51	201
Entire Maryland Chesapeake Bay & tidewater tributaries (exclusive of Potomac River) commercial fin-fish harvest	1,452,289	398,055	392,232	3,313	1,090

Source: Speir, et al., 1977

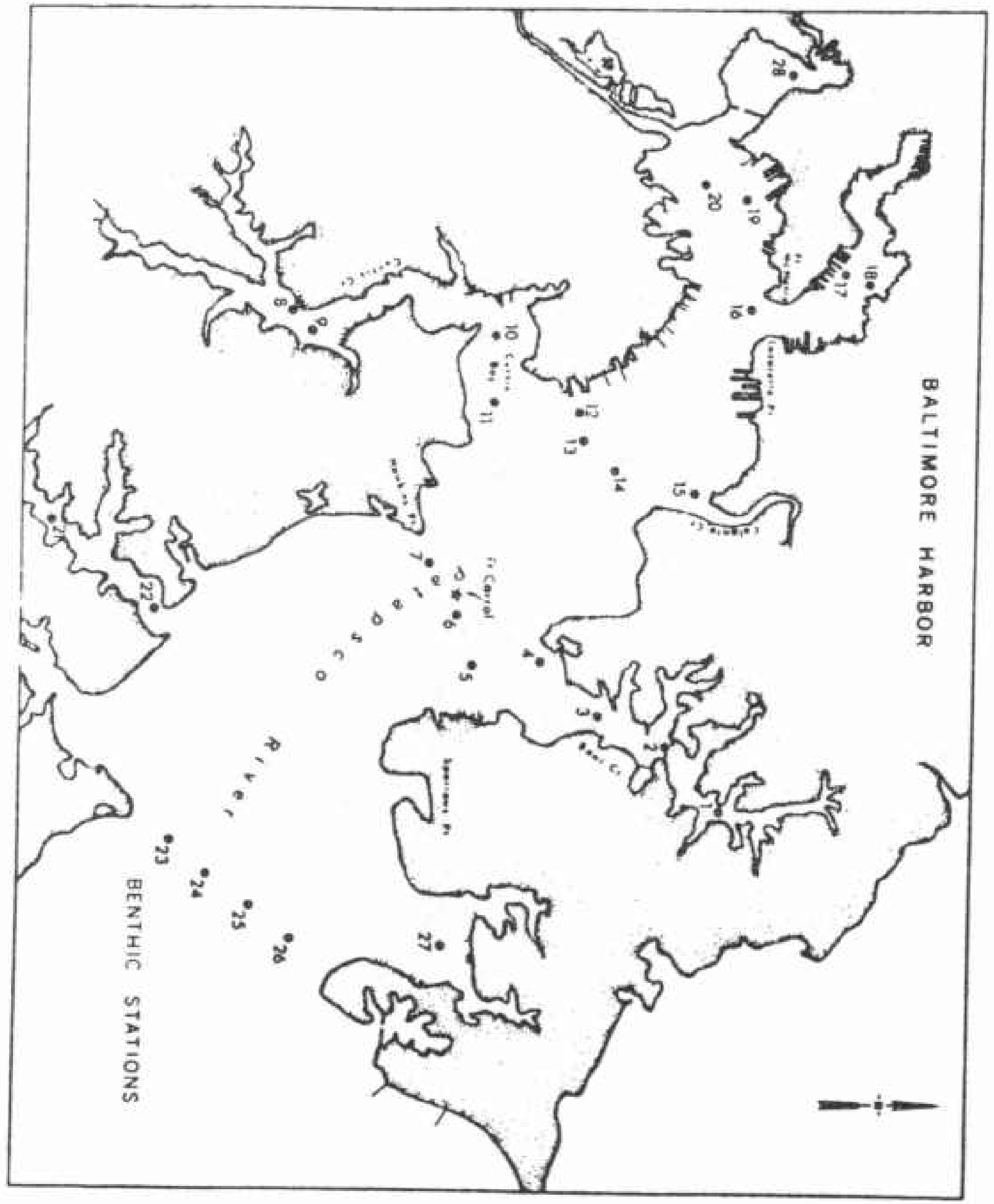


Figure 6. Benthic sampling stations in Baltimore Harbor.

Table 8. Benthic species in Baltimore Harbor.

	SPECIES	REFERENCE STATIONS SEMI-HEALTHY BALTIMORE HARBOR 22	23	24	25	26	27
COELENTERATA	1. F. lineata				7	8	
	2. D. leucolena			4	1		1
PLATYHELMENTHES	3. S. ellipticus						
NEMERTEA	4. M. leidyi	6	13	33	28	45	24
	5. T. pellucidus						
ANNELIDA	6. Limnodrilus sp.	3	6	2		7	
	7. H. filiformis	145	94	355	447	368	127
	8. S. viridis	416	944	798	52	38	22
	9. S. benedicti	100	226	2	8	3	7
	10. P. gouldi						
	11. E. heteropoda	7	1	2	35	20	19
	12. E. lactea						
	13. H. fragilis						
	14. N. succinea	23	15	91	482	146	70
	15. H. grayi	5	265	40		5	56
	16. P. ligni						
	17. Unid. sp.						
ARTHROPODA	18. B. amphitrite						
	19. N. americana			1		2	4
	20. L. americanus						
	21. C. varians						
	22. L. savignyi						
	23. C. polita	1	6	45	5	28	16
	24. E. attenuata						
	25. E. triloba			15	6		
	26. C. almyra						
	27. M. edwardsi		6	14	3		
	28. Gammarus sp.	5		1	11	5	2
	29. C. mucronatus				2		
	30. M. nitida	1			2		
	31. C. compta	12		14			
	32. L. plumulosus	366	546	674	428	549	35
	33. A. longimana						
	34. C. lacustre	8	6	8	1		2
	35. H. arenarius						
	36. R. harrisi				4		
INSECTA	37. C. attenuatus	53			1		
	38. Procladius sp.	2					
	39. Unid. sp. (Odonata)						
MOLLUSCA	40. B. recurvus		1	1			
	41. C. leucophaeta		4	1			
	42. C. virginica						
	43. M. arenaria				1		
	44. M. balthica	18	1	27	160	195	147
	45. M. phenax	10	12	23	58	128	61
	46. M. lateralis						
	47. R. cuneata	9	211	123	45	201	131
	48. G. gemma						
	49. O. impressa						
	50. H. solitaria						
	51. E. rupicolum						
	52. Hydrobia sp.						
CHORDATA	53. M. manhattensis						

Table 8. (continued)

	SPECIES	REFERENCE STATIONS SEMI-POLLUTED BALTIMORE HARBOR 6	5	8	13	20	12	7	16	21	19
COEL.	1. E. lineata	83	3								
	2. D. leucolena	2	19								
PLATY.	3. S. ellipticus										
Nem.	4. M. leidyi	8	18	2	14	5		8	1		13
	5. T. pellucidus										
ANNE.	6. Limnodrilus sp.	6	1119	13	27	850	59	65	626		490
	7. H. filiformis	30	122	10	2	289		100	1	157	
	8. S. viridis	3369	2496	98	3	741	72	1317	602	33	480
	9. S. benedicti	956	2035	86	46	801	8	214	106	48	59
	10. P. gouldi										
	11. E. heteropoda	49	90	46	23	56	9	11	9	6	10
	12. E. lactea										
	13. H. fragilis										
	14. N. succinea	177	125	326	375	84	62	157	76	1	31
	15. H. grayi	13	608	60	118	272	990	14	620	2	137
	16. P. ligni			45			7	3			
	17. Unid. sp.										
ARTH.	18. B. amphitrite	1	2								
	19. N. americana										
	20. L. americanus										
	21. C. varians										
	22. L. savignyi										
	23. C. polita	15	4		30	3	12	1	1	1	
	24. E. attenuata										
	25. E. triloba										
	26. C. almyra										
	27. M. edwardsi		1								
	28. Gammarus sp.	1		8							
	29. C. mucronatus		2	3							
	30. M. nitida	18		1							
	31. C. compta									1	
	32. L. plumulosus	1		1	9			1		4	
	33. A. longimana										
	34. C. lacustre	1	9						1		
	35. H. arenarius										
	36. R. harrisi	8	2	2	1		1				
INS.	37. C. attenuatus									89	
	38. Procladius sp.									15	
	39. Unid. sp.										
MOLL.	40. B. recurvus										
	41. C. leucophaeta			7			1				
	42. C. virginica										
	43. M. arenaria										
	44. M. balthica	36	34	4	14	158	2	139	84	296	58
	45. M. phenax					1					
	46. M. lateralis										
	47. R. cuneata			16	4		2	2			
	48. G. gemma										
	49. O. impressa										
	50. H. solitaria										
	51. E. rupicolum										
	52. Hydrobia sp.										
CHOR.	53. M. manhattensis										

Table 8. (continued)

	SPECIES	REFERENCE STATIONS 15	4	28	14	9	10	POLLUTED BALTIMORE HARBOR 2	17	3	18	1	11
COEL.	1.												
	2.												
PLATY.	3.												
NEM.	4.	4	1	1	1		2	1					
	5.												
ANNE.	6.	364	2094	178	903	21	498	322	1	1	288		
	7.	2	545	1		1				1			
	8.	848	48	3	52	81	211	8	1	3		1	
	9.	60	209	28	32	878	18	9	5	1	2	63	
	10.												
	11.	11	109	4	13	70	24						4
	12.												
	13.												
	14.	33	10	1	25	15	20	6	3		2		6
	15.	6	847	107	14	7	560	293	5	2		3	2
	16.						1						
	17.												
ARTH.	18.												
	19.	1											
	20.												
	21.												
	22.												
	23.		1										
	24.												
	25.												
	26.												
	27.												
	28.											1	
	29.												
	30.												
	31.												
	32.											5	
	33.												
	34.												
	35.												
	36.												1
INS.	37.							1					
	38.											1	
	39.												
MOLL.	40.												
	41.												
	42.												
	43.												
	44.	6	1	90	16	7					1	1	
	45.												
	46.												
	47.												
	48.												
	49.												
	50.												
	51.												
	52.												
CHOR.	53.												

Source: Pfitzenmeyer (1975)

References

Boesch, D. 1977. Personal communication.

Dovel, W. L. 1975. "Fish and Eggs and Larvae" pp. 14-38. In: A Biological Study of Baltimore Harbor, Ted S. Y. Koo (ed.), Center for Environmental and Estuarine Studies, Special Report No. 6 of Univ. of Maryland. 115 pp.

Environmental Protection Agency. 1974. Distribution of metals in Baltimore Harbor sediments. Technical Report 59, Annapolis Field Office, Region III.

Environmental Protection Agency. 1977. Ocean dumping, final revisions of regulations and criteria. Federal Register, 42(7): 2462-1325.

Fish and Wildlife Service Report. 1968. Characterization of Coastal and Estuarine Fish Nursery Grounds As Natural Communities.

Haven, Dexter. 1977. Personal communication.

Lippson, A. J. (ed.). 1973. The Chesapeake Bay in Maryland, An Atlas of National Resources. The Johns Hopkins University Press, Baltimore.

Merriner, John. 1977. Personal communication.

Musick, J. A. 1972. "Fishes of Chesapeake Bay and the Adjacent Coastal Plain" pp. 175-212. In: A Check List of the Biota of Lower Chesapeake Bay, Marvin L. Wass (ed.), Special Scientific Report No. 65 of Virginia Institute of Marine Science.

Pearson, J. C. 1948. Fluctuations in the abundance of the blue crab in Chesapeake Bay. Research Report 14 of the U. S. Fish and Wildlife Service.

Pfitzenmeyer, H. T. 1970. Benthos. In: Gross physical and biological effects of overboard spoil disposal in Upper Chesapeake Bay. National Resources Inst., University of Maryland, Spec. Sci. Rpt. No. 3. 66 pp.

Pfitzenmeyer, H. T. 1975. "Benthos" pp. 39-69. In: A Biological Study of Baltimore Harbor, Ted S. Y. Koo (ed.), Center for Environmental and Estuarine Studies Special Report No. 6 of University of Maryland. 115 pp.

Roberts, M. H., Jr., D. F. Boesch and Me. E. Bender. 1975. The Chesapeake Bay: A Study of Present and Future Water Quality and its Ecological Effects. Volume II: Analysis and Projection of Ecological Conditions. Final Report to National Commission on Water Quality.

Sawyer, T. K., G. S. Visvesuara and B. A. Harke. 1977. Pathogenic amoebas from brackish and ocean sediments, with a description of Acanthamoeba hatchetti, n. sp. Science, 196: 1324-1325.

References

Speir, Harley J., D. R. Weinrich and R. S. Early. 1977. 1976 Maryland Chesapeake Bay Sport Fishing Survey. Federal Aid Completion Report. Project Number F-32-R. 99 pp.

Van Engel, W. A. 1977. Personal communication.

Van Engel, W. A. 1958. The blue crab and its fishery in Chesapeake Bay. Part 1 - Reproduction, early development, growth, and migration. Commercial Fisheries Review. 20(6): 6 - 17.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Environmental and Technical Services Division
Environmental Assessment Branch
Oxford, Maryland 21654

October 11, 1978

Mr. Norman Edwards
Environmental Analysis Branch
Baltimore District
Corps of Engineers
P.O. Box 1715
Baltimore, Maryland 21203

Dear Norm:

Enclosed is an Interim Report, dated October 3, 1978, on the results of a biological and hydrographic survey of the "Old Plantation Flats Deep Trough" conducted by the Virginia Institute of Marine Science. The Virginia Institute of Marine Science has satisfactorily completed the requirements of the contracts and I recommend final payment.

I agree with the findings of the report and concur with the tentative conclusion that no overboard spoil be permitted in the Deep Trough. My letter to Colonel Withers, dated March 27, 1978, offered similar findings and reached the same conclusion, i.e. "--that the Old Plantation Flats (Cape Charles disposal site) not be considered as a spoil disposal site."

Thank you for the opportunity to comment.

Cordially,

Bob

Robert L. Lippson, Ph.D.
Research Coordinator

Enclosure

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Environmental and Technical Services Division
Environmental Assessment Branch
Oxford, Maryland 21654

March 27, 1978

Col. G. K. Withers, USA
District Engineer
Baltimore District
Corps of Engineers
P.O. Box 1715
Baltimore, Maryland 21203

Dear Colonel Withers:

As per your request and the request of the U.S. Fish and Wildlife Service, we are pleased to submit information and comments pertaining to the proposed 50-foot deepening of Baltimore Harbor and channels, specifically with reference to the Cape Charles disposal site (Old Plantation Flats).

In addition, we have reviewed the comments submitted by the U.S. Fish and Wildlife Service, dated December 23, 1977, and March 13, 1978, and are in accord with their findings.

In 1969, a series of stations were established throughout Chesapeake Bay as discrete sampling areas for the study of blue crab population dynamics (Fig. 1). In order to assess relative stock strengths and intercept the movement of juvenile blue crabs up the Bay from the lower Bay spawning grounds, a number of stations were located along Virginia's Eastern Shore, including Old Plantation Flats, west of Cape Charles City.

The Old Plantation Flats Deep Station sampling area extended south of the mouth of Old Plantation Creek, north to a line passing through Wescott Point at Cherrystone Inlet (Fig. 2). Samples were taken from depths ranging from 25 to 155 feet with a 25-foot semi-balloon trawl and a 42-inch oyster dredge. Bottom salinities in the deeper areas (95-155 feet) ranged from 24.0 - 29.3 ppt with definite salinity stratification occurring between surface and bottom waters.

Of all stations in lower Chesapeake Bay, the Old Plantation Flats deep station exhibited the greatest faunistic diversity and included a number of exotic or incidental species not commonly seen in Chesapeake Bay (Tables 1-2). It should not be implied that these species do not occur in other areas of the Bay, but only that the faunistic assemblage, in the aggregate, at Old Plantation Flats is decidedly more varied and abundant.

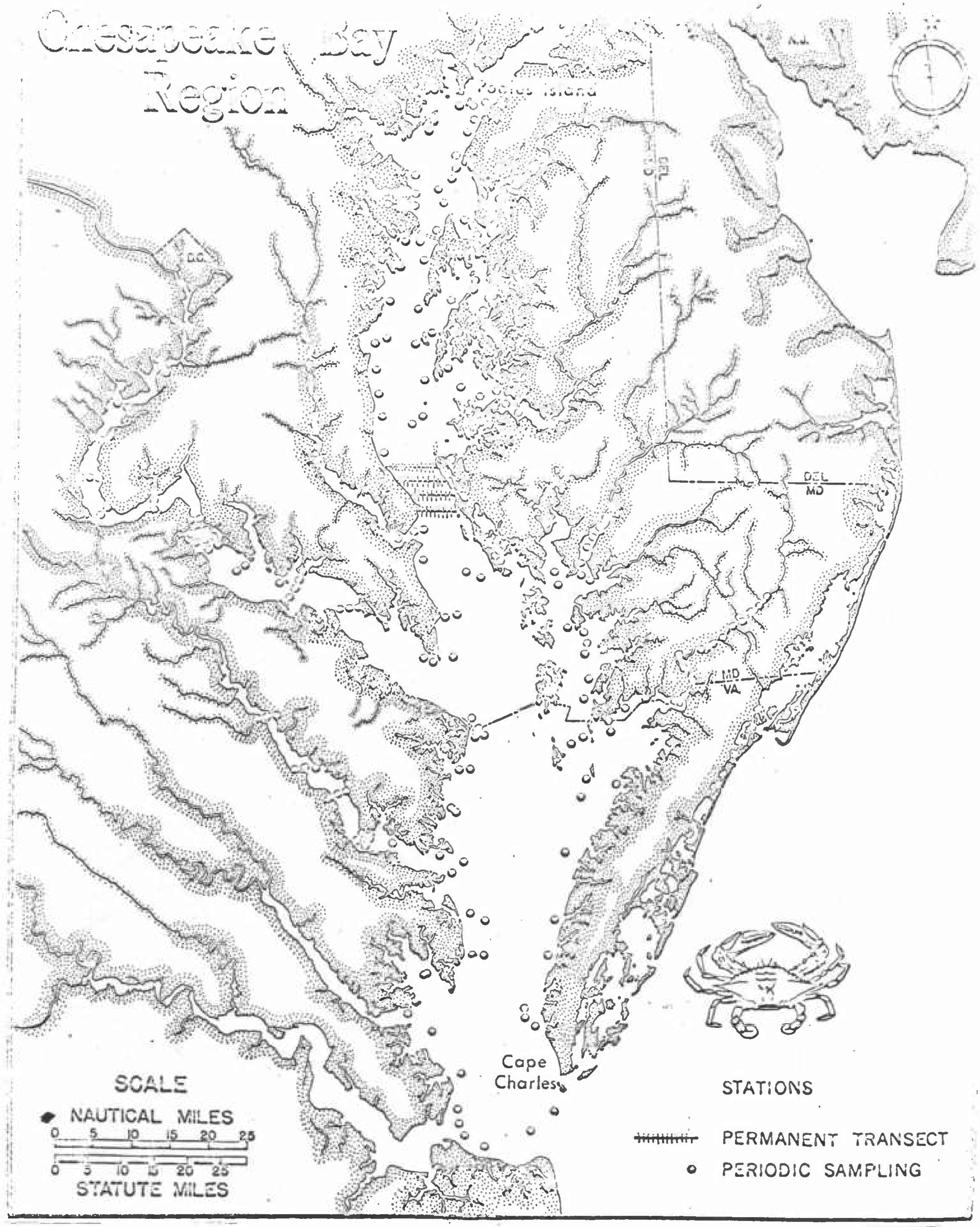
An environment which supports a large number of species, such as Old Plantation Flats, generally occurs when the milieu is relatively unstressed, there is an ample supply of nutrients, suitable micro-habitats are available, and recruitment of organisms from outside the immediate area takes place. The proximity of Old Plantation Flats trough to the mouth of Chesapeake Bay and adjacent coastal waters, in effect, produces a compatible extension of inshore oceanic waters. This continuum allows typical marine species to extend their distribution into the estuary, some permanently and others only transitorily. In addition, characteristic estuarine species are also attracted to the Old Plantation Flats trough, particularly as an overwintering area.

The substrate within the trough can be generally characterized as a sand and shell bottom with limited areas of black muds. It is reasonable to assume, based on the nature of the bottom, that hydrological events regularly maintain the integrity of the bottom. This allows a further assumption that spoil material placed in the trough will eventually be displaced to other regions of the Bay. One could argue, therefore, that the impact on the trough fauna will be ephemeral, and based on past studies, recolonization can be expected to occur in the future. What we cannot predict is when recolonization will occur and what mix of species will reappear, since little is known about the dynamics of this area or the physiological and ecological requirements of the species which inhabitat the trough. Further, if one accepts the assumption that the spoil material will not remain in the trough more or less permanently, but will be dispersed to other areas, would it not be preferable to place the spoil in an area where it will have a minimal impact on the living resources? Placing the spoil in a site where it may exert a substantial impact on the biota, without any long range expectations that the spoil will remain in place, constitutes an unacceptable risk which the National Marine Fisheries Service cannot endorse. We strongly recommend that the Old Plantation Flats (Cape Charles disposal site) not be considered as a spoil disposal site.

Sincerely,

Robert L. Lippson, PhD
Research Coordinator

4 Enclosures



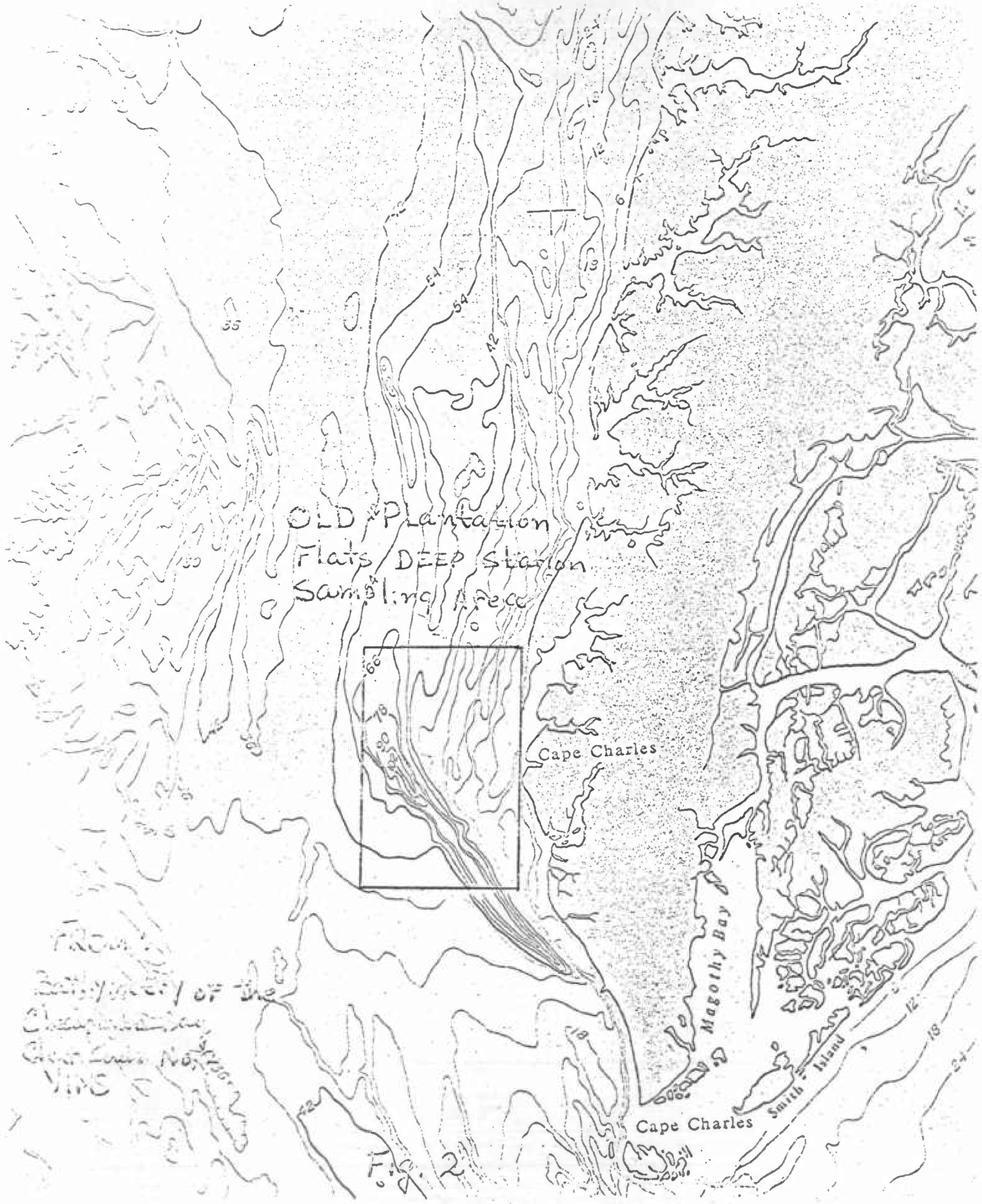


TABLE I. LIST OF FISHES COLLECTED AT OLD PLANTATION FLATS DEEP STATION

Common Name	Scientific Name
Sandbar shark	*Carcharhinus milberti*
Spiny dogfish	*Squalus acanthias*
Clearnose skate	*Raja eglanteria*
Little skate	*Raja erinacea*
Southern stingray	*Dasyatis americana*
American eel	*Anguilla rostrata*
Conger eel	*Conger oceanicus*
Blueback herring	*Alosa aestivalis*
Round herring	*Etrumeus teres*
Bay anchovy	*Anchoa mitchilli*
Inshore lizardfish	*Synodus foetens*
Oyster toadfish	*Opsanus tau*
Skilletfish	*Gobiesox strumosus*
Red hake	*Urophycis chuss*
Spotted hake	*Urophycis regius*
Striped cusk-eel	*Rissola marginata*
Atlantic silverside	*Menidia mendia*
Lined seahorse	*Hippocampus erectus*
Northern pipefish	*Syngnathus fuscus*
Black sea bass	*Centropristis striata*
Rough scad	*Trachurus lathami*
Pinfish	*Lagondon rhomboides*

Common Name	Scientific Name
Scup	*Stenotomus chrysops*
Silver perch	*Bairdiella chrysura*
Weakfish	*Cynoscion regalis*
Banded drum	*Larimus fasciatus*
Northern kingfish	*Menticirrhus saxatilis*
Atlantic croaker	*Micropogon undulatus*
Northern sennet	*Sphyraena borealis*
Striped blenny	*Chasmodes bosquianus*
Feather blenny	*Hypsoblennius hentzi*
Goby	*Gobiosoma sp.*
Northern searobin	*Prionotus carolinus*
Summer flounder	*Paralichthys dentatus*
Winter flounder	*Pseudopleuronectes americanus*
Hogchoker	*Trinectes maculatus*
Blackcheek tonguefish	*Symphurus plagiusa*
Striped burrfish	*Chilomycterus schoepfi*

TABLE II. LIST OF INVERTEBRATES COLLECTED AT OLD PLANTATION FLATS DEEP STATION

Common Name	Scientific Name
Phylum Porifera	
Boring sponge	*Cliona sp.*
Phylum Cudaria	
Purple whipcoral	*Leptogorgia virgulata*
Star coral	*Astrangia danae*
Phylum Bryoyoa (Ectoprocta)	
Branching bryozoan	*Alcyonidium sp.*
Phylum Mollusca	
Jingle shell	*Anomia simplex*
Blue mussel	*Mytilus edulis*
Quahog	*Mercenaria mercenaria*
Limpet	*Crepidula fornicata*
Moon snail	*Polinices sp.*
Atlantic oyster drill	*Urosalpinx cinerea*
Whelk	*Busycon sp.*
Chiton	*Chaetopleura apiculata*
Squid	*Lolliguncula brevis*

Phylum Arthropoda

Horseshoe crab	*Limulus polyphemus*
Mantis shrimp	*Squilla empusa*
Amphipod	*Caprella sp.*
Pink shrimp	*Penaeus duorarum duorarum*
Shrimp	*Trachypeneus constrictus*
Sand shrimp	*Crangon septemspinosa*
Porcellanid crab	*Polyonx gibbesi*
Hermit crab	*Pagurus longicarpus*
Hermit crab	*Pagurus pollicaris*
Blue crab	*Callinectes sapidus*
Calico crab	*Ovalipes ocellatus*
Rock crab	*Cancer irroratus*
Mud crab	*Eurypanopeus depressus*
Mud crab	*Neopanope texana sayi*
Spider crab	*Libinia emarginata*
Spider crab	*Libinia dubia*

Phylum Echinodermata

Starfish	*Asterias forbesi*
Sea cucumber	*Thyone briareus*
Sea urchin	*Arbacia punctulata*
Sand dollar	*Mellita quinquiesperforata*
Tunicate	*Botryllus schlosseri*

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
6TH AND WALNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

DEC 5 1978

Mr. Norm Edwards
U. S. Army Corps of Engineers
Baltimore District
P. O. Box 1715
Baltimore, Maryland 21203

Dear Mr. Edwards:

We received your memo of August 25, 1978 containing data describing sediments to be dredged during the proposed deepening of Baltimore Harbor and Channels to fifty feet MLW. We reviewed the data in an effort to provide a preliminary determination as to the acceptability of the dredged material for overboard disposal. We offer the following comments.

Materials taken from the Rappahannock Shoals Channel, the York Spit Channel, and the Cape Henry Channel appear acceptable for open water disposal within the Chesapeake Bay. However, prior to our final determination on the matter we must review data describing disposal area physical and biological characteristics.

Material to be dredged from the Maryland Channels, especially those within the Patapsco River appear to be significantly polluted and therefore should be disposed of in a contained environmentally sound area. If overboard disposal of these materials is to be seriously considered, various bioassay and bioaccumulation tests may be required.

It is proposed that material from the Cape Henry Channel, and portions of the York Spit Channel may be disposed of in the ocean.

As you are aware, ocean dumping is regulated by the Final Revision of the Ocean Dumping Regulations and Criteria, F.R. Vol. 42, No. 7, promulgated pursuant to P.L. 92-532, the Maring Protection, Research, and Sanctuaries Act of 1972, 33 U.S.C. 1401 et seq. Dredged materials which meet the criteria of Sections 227.13(b), paragraphs 1, 2, and 3 are considered environmentally acceptable for ocean dumping. Based upon the data provided in "Study of Channel Sediments" under Contract DACW-65-72-C-0047, both the Cape Henry Channel and the York Spit

Channel below 37°10'' appear to meet the criteria without further testing. The York Spit above 37°10'' appear to have increasingly finer sediments with increased heavy metals content and a greater percent of volatile solids indicating higher organic content. Ocean dumping for the Upper York sediments is not eliminated but further testing may be required as provided in Section 227.32 of our regulations.

An additional concern of the EPA is the choice of an ocean dump site for the dredged material. The EPA does not consider the existing Damn Neck site as adequate for further disposal. Any new site would require an EIS and formal site designation. The Region would like to coordinate a site selection with the Corps of Engineers.

Sincerely yours,

John R. Pomponio
Acting Chief
Wetlands Review Section

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

MAILING ADDRESS:
COMMANDER (dpl)
FIFTH COAST GUARD DISTRICT
FEDERAL BUILDING
431 CRAWFORD STREET
PORTSMOUTH, VIRGINIA 23705

16612
Ser No. 248
1 May 1978

Mr. William E. Trieschman, Jr.
Chief, Planning Division
Department of the Army
Baltimore District Corps of Engineers
P.O. Box 1715
Baltimore, MD 21203

Dear Mr. Trieschman:

As requested in your letter of 24 March 1978, a review of one-way channels for deep draft vessels has been made. Enclosure (1) describes the various costs that may be expected to establish and maintain the required aids to navigation. With regard to comments concerning the one-way channel concept, you are advised that the Coast Guard cannot endorse this modus operandi because of the inherent hazards to navigation that may be involved. This District's comments as previously provided by correspondence of 29 April 1974 are still valid. A copy of these comments is attached for your convenience.

I am pleased to assist you in this matter and if we can be of further service please contact the Fifth Coast Guard District's Planning Officer.

Sincerely,

G. L. KRAINE
Captain, U. S. Coast Guard
Chief of Staff
Fifth Coast Guard District

Encl: (1) Estimated cost of Aids to Navigation
(2) CCGD5 Ltr 5900 of 29 April 1974

BALTIMORE HARBOR AND CHANNELS, MARYLAND AND VIRGINIA
ESTIMATED COSTS, AIDS TO NAVIGATION

		50'
1.	Cape Henry Channel	
	a. relocation of existing aids	$ 1,787
	b. establishment of new aids	23,540
	c. maintenance of new aids (ANNUAL)	2,965
2.	York Spit Channel	
	a. relocation of existing aids	4,225
	b. establishment of new aids	28,500
	c. maintenance of new aids (ANNUAL)	3,725
3.	Rappahannock Shoal Channel	
	a. relocation of existing aids	3,250
	b. establishment of new aids	19,000
	c. maintenance of new aids (ANNUAL)	963
4.	Craighill Entrance	
	a. relocation of existing aids	1,164
	b. establishment of new aids	19,000
	c. maintenance of new aids (ANNUAL)	1,943
5.	Craighill Section to Fort McHenry Channel	
	a. relocation of existing aids	4,074
	b. establishment of new aids	-
	c. maintenance of new aids (ANNUAL)	-
6.	Curtis Bay Channel	
	a. relocation of existing aids	970
	b. establishment of new aids	2,430
	c. maintenance of new aids (ANNUAL)	267
		49'
7.	Northwest Branch - East Channel	
	a. relocation of existing aids	970
	b. establishment of new aids	8,830
	c. maintenance of new aids (ANNUAL)	1,110
		40'
8.	Northwest Branch - West Channel	
	a. relocation of existing aids	388
	b. establishment of new aids	11,260
	c. maintenance of new aids (ANNUAL)	1,089

ENCLOSURE -1

(Conc) Copy

(mpx)

5900

29 April 1974

Colonel Robert S. McGarry
Department of the Army
Baltimore District
Corps of Engineers
P. O. Box 1715
Baltimore, Maryland 21203

Dear Colonel McGarry:

Members of my staff have reviewed the changes made to the Supplement to June 1969 Review Report - Baltimore Harbor and Channels, Maryland and Virginia in accordance with the agreements reached at our meeting of 21 March 1974.

In general the Coast Guard cannot endorse the deepening of only half of the channel because of inherent safety deficiencies. The only apparent benefit of a single lane 50' deep inbound channel is the reduced cost of the initial dredging and additional maintenance dredging involved. There appears to be no benefit related to safety.

Our comments are submitted in such a manner that they may form an appendix or annex to the supplement and if used in this way it is suggested that Part II, paragraphs 2 and 3 be annotated to indicate the location of Coast Guard comments.

Sincerely,

ROSS P. BULLARD
Rear Admiral, U. S. Coast Guard
Commander, Fifth Coast Guard District

Encl: (1) Coast Guard Comments

ENCLOSURE 2

U. S. COAST GUARD COMMENTS

Page 7, SINGLE LANE CHANNEL

If present import and export commodities only are considered a single lane channel does offer some appeal from the cost standpoint, However, once there is a deeper channel, single or full width, there is a considerable likelyhood that there would be an increase in the number and type of exports desiring, or requiring, the use of the deeper channel. A deeper channel may result in export traffic shifting from other deep water ports to the port of Baltimore. This consideration plus the fact that deep draft vessels will enter will undoubtably increase the demand for deep draft outbound. Therefore, although a single inbound lane appears attractive at this time it will undoubtable generate a future demand for a deeper outbound channel and increase traffic volume while restricting traffic movement.

Page 7, SINGLE LANE CHANNEL WIDTHS single?

With a full width channel a vessel normally has the full width of the channel available to maneuver. Only during passing situations does a vessel keep to its side of the channel. A single lane deeper channel will in effect reduce the maneuvering room for deep draft vessels thereby increasing the risk of grounding. Further, the availability of deeper drafts will result in an increase in ship length as well as beam. An increase in length has a significant effect on required maneuvering room and should be considered in determining needed channel width. There is also a strong likelyhood that changing pollution prevention requirements for tank vessels, involving tank arrangement and size and segregated ballast, will result in changed ship proportions. For a given draft, the beam of future vessels will undoubtably increase. The beam figures of 122 feet is therefore not considered valid for future planning. More likely a beam as great as 140 or 150 feet and possibly greater may be expected along withproportional increases in length. The net effect of a single lane channel of deeper draft will be to significantly reduce maneuvering room for the larger vessels the channel is intended to accommodate.

For the branch channels there is no assurance that large vessels would be under the control of tugs nor that they would operate at reduced speeds. In order to be assured of these operational restrictions appropriate regulatory action would have to be initiated.

Page 8, ONE-WAY INBOUND CHANNEL

Marking a channel with buoys as other aids to navigation is only one aspect of safety. There is a point of no return after which an increase in the number of aids would result in no increase in safety. The previously stated reduction in maneuvering room of a narrow one way inbound channel would have a significant impact upon safety; There would also be no effective way to regulate the use of channels such that all outbound vessels would be limited to and use the shallower outbound lane. The economic incentive to disregard any regulations would be significant and the presently available penalty provision were significant the law enforcement problem would be of a magnitude beyond available Coast Guard resources.

Page 8, TWO-WAY INBOUND LANE CHANNEL

The use of a single inbound lane for both inbound and outbound vessels having drafts in excess of 42 feet presents numerous safety and control problem in addition to that related to reduced maneuvering room.

In instances where an outbound ship using the deeper inbound lane encountered inbound ships, two different procedures would be followed depending upon the draft of the inbound vessel: (1) If that vessel were of a draft greater than 42 feet, it would be required to wait until the outbound vessel cleared the channel before proceeding into the channel, or (2) If the inbound vessel were of a draft less than 42 feet, it would proceed up what would normally be the outbound lane thereby passing the outbound vessel starboard to starboard. In the first instance, a very positive vessel traffic control system would have to be developed and implemented. In the latter instance, the very dangerous reversal of a fundamental navigational rule would occur. That rule is, of course, Article 25 of the Inland Rules of the Road, which requires vessels in narrow channels to keep to that side of the channel which lies on the starboard side of such vessel.

The positive vessel traffic system would have to cover the entire Chesapeake Bay from Baltimore to the sea. There are three geographic areas where the outbound, heavily laden vessel would have to utilize the inbound lane. These areas are the Baltimore Harbor "Main Ship Channel," the Rappahannock Shoal Channel, and the York Spit Channel. An improved communications network would be an element of this traffic system, but would not in itself provide the degree of safety which at first seems indicated. This is because, though the law requires all vessels over 300 gross tons as well as certain other vessels to be equipped with bridge-to-bridge radiotelephone equipment, it does not require these vessels to cease navigating should that equipment become inoperative. On the contrary, the law specifically states that failure of a vessel's radiotelephone equipment shall not obligate the master to moor or anchor his vessel. Therefore, in order to make the communications aspect of the traffic system effective, the law would have to be changed to prohibit vessels from transiting the Chesapeake Bay if their bridge-to-bridge radiotelephone communications capabilities were inpaired.

In considering a departure from the Rules of the Road such as would be involved in instances where outbound vessels used the inbound lane and inbound vessels used the outbound lane, certain factors must be carefully evaluated. While some of the ships involved in such situations would be under the control of a pilot familiar with these unorthodox procedures, other vessels would be under the control of persons totally unfamiliar. The confusion which would be likely to develop on the part of unfamiliar mariners could have catastraphic results.

Though it is now estimated that only one ship per week would leave Baltimore using this procedure, there is no doubt that more frequent use of the procedure will occur when the deeper channel in available. Indeed, viewing the long range energy situation, and, its possible effect upon coal shipments, such a possibility seems likely.

Page 12, Part XI, SUMMARY AND CONCLUSIONS

The safety aspects of a single inbound lane for inbound only on two way traffic should be the subject of an indepth study. This study should include factors related to maneuvering room for larger ships, the increased volume of traffic resulting from the deeper channel and psychological factors related to channel use in a nontraditional manner. In summation, we believe the use of a narrow, deep, single lane channel, whether for one way or two way traffic is frought with problems and manifestly unsafe. Even the economics are questionable as the single lane concept would increase aides to navigation and law enforcement costs add make the need for an active vessel traffic control system virtual necessity.

ASSOCIATION OF MARYLAND PILOTS

1316 SOUTH BAYLIS STREET

TELEPHONE 342-6013 BALTIMORE, MARYLAND 21224 TELEPHONE 276-1337

April 28, 1978

Mr. William E. Trieschman, Jr.
Chief, Planning Division
Department of the Army
Baltimore, District, Corps of Engineers
P.O. Box 1715
Baltimore, Maryland 21203

Re: Baltimore Harbor and Channels
50 Foot Channel Project

Dear Mr. Trieschman:

Your letter of March 20, 1978 requesting comment on the feasibility of dredging a 50 foot channel in two stages with a deeper inbound lane for some period of time before completion of the entire project was turned over to Richard Owen of our Association for a reply.

His comments, as well as the comments of Captain Cherry of Bethlehem Steel are enclosed.

If we can be of any further assistance, please call upon us.

Very truly yours,

George A. Quick
President

cc: R.W. Owen
J.V. Cherry

To: Mr. William Trieschman, Jr., Corps of Engineers

From: Richard Owen, Association of Maryland Pilots

Re: 50 Foot Channel Project

It has been well established in ship control studies that a vessel moving through the water generates strong hydrodynamic forces interacting with the bottom and banks of channels and with other vessels in meeting and overtaking situations which seriously influence the overall controllability of vessels transiting narrow channels and canals. These studies include theoretical analyses, model testing and the experience of pilots in the actual operation of vessels in a wide variety of channel configurations. The current proposal by the Corps of Engineers to implement a deepened one-way channel concept in Chesapeake Bay and in the approaches to Baltimore Harbor must be considered on the basis of these studies and on the experience of local pilots in handling vessels of 100,000 DWT under present channel conditions.

Although pilot association representatives indicated in 1973 that operation of vessels in an asymmetrically deepened channel and in starboard to starboard passings would present few problems, we feel compelled to re-evaluate controllability problems based on experience with newer and larger vessels which represent a considerable departure from the more traditional designs of the 1960's. New vessel types now include containerships, automobile carriers, roll-on-roll-off vessels, large tankers, and liquid natural gas carriers. These vessels by the very nature of variations in design and in subsequent handling characteristics, cover a wide spectrum of maneuverability and control from those that are relatively stable to those that are unwieldy. Considering the high risk potential of many of these vessels in terms of peril to human life and damage to the environment, port approach planning and channel design must be based on the requirements for safe channel widths and depths necessary for those ships that fall in the less desirable end of the control spectrum.

The following paragraphs address the items discussed with Army Corps of Engineers representatives at the 23 February 1978 meeting in the offices of the Association of Maryland Pilots.

The transit distance from the mouth of the Chesapeake Bay to the head of navigation on the Patapsco River is 150 miles. Currently 40 miles of this distance requires the use by deep draft vessels of partially restricted channels varying in width from 1,000 to 600 feet. Upon completion of the one-way inbound lane project, channel distances will increase to 50 miles due to additional channel extensions at York Spit and Rappahannock Channel areas utilizing natural deep water contours to provide continuous 50 feet depths. At that time vessels of 100,000 to 150,000 dead weight tons are expected to call at the port's facilities at drafts up to and possibly greater than 45 feet. These vessels will be required to negotiate asymmetrically deepened channels of only 500' to 600' width for one-third the transit distance from seaward to Baltimore. This represents a significant reduction in safety margins, especially during periods of fog, heavy ice, high winds, and heavy rain, when the risk of collision or grounding will obviously increase.

PROBLEMS ASSOCIATED WITH OPERATING 60,000 TO 150,000 DWT IN A NARROWER INBOUND CHANNEL

A vessel sailing off the centerline of a narrow channel generates an asymmetrical flow condition around the body of the ship, causing a side-force toward the near bank and a turning moment away from the near bank. These forces tend to draw a vessel toward the bank while turning the bow toward the middle of the channel. To maintain its lateral position in the channel a vessel must compensate for this effect by angling away from the near bank and toward the channel centerline. The rudder is employed to counter the turning moment by application of rudder angle toward the near bank. Thus an equilibrium condition is established by judicious use of the rudder. The amount of required rudder angle becomes a function of vessel speed, rudder size, depth to draft ratio, distance from the channel centerline and other related factors.

The effects upon steering in an asymmetrically deepened section of the Panama Canal have been studied by Taylor Model Basin (now Naval Ship Research and Development Center) and found not to have any serious influence on the performance of ships. This study is the only available literature on the subject of asymmetrically deepened channels and deals with fully restricted or confined waterways with walls. Although forces acting on a vessel in partially restricted channels such as those of the Chesapeake Bay will be less severe, it should be noted that the Panama Canal study dealt with vessels of only 57,000 DWT at relatively low speeds, with no cross currents, and with vessels whose drafts permitted use of the entire original channel width. Conditions in the proposed one-way Chesapeake Bay channel project will be somewhat different.

Under the current proposal a large deeply laden inbound vessel will operate with a 10' step on its port side and a larger variation in bank elevation on the starboard side. The continuous operation of each deep draft inbound vessel in the off-centerline position coupled with this variation in bank height will generate an asymmetrical flow around the body of the ship, causing a deterioration of directional stability and requiring constant rudder angle toward the near bank during the entire passage through each channel section. These conditions will require constant course compensation for lateral drift toward the near bank. According to model tests and theory the amount of compensation will lie in the range of from 0.5° to 2.0°.

York Spit and Rappahannock Channels are crossed by currents at angles of 20° to 30° in some sections. A vessel sailing into a two knot current at twenty degrees on the bow must allow 5° for the effect of current at a transit speed of ten knots. Strong crosswinds may reduce or augment the amount of lateral drift due to bank effect and current. Although a deeply laden vessel is less susceptible to the effects of wind, an allowance of one to two degrees may be required.

The total allowance for bank effect, wind and current will increase the effective width of any large vessel transiting the Chesapeake Bay channels by a significant amount under normal conditions. For a large 150,000 ton ship of 145' beam and 900' length between perpendiculars the effective beam increases to about 270 feet when allowing 8° for wind, current and bank forces. Under sever wind conditions, especially from the northwest, tidal current velocities may increase to as much as four knots in some areas of the Lower Bay (currents in the Bay are known to be highly sensitive to wind.) This will require a much greater allowance for wind and current, so that the swept path brings the vessel dangerously close to the channel limits.

CONTROL PROBLEMS OF OUTBOUND VESSELS WHEN A DEEPER INBOUND CHANNEL EXISTS

Outbound channel lane widths will be reduced to 400 feet in the Virginia channels and to 300 feet in the Baltimore Harbor and approach channels under the proposal for a deeper inbound lane. If the new cut is left unmarked with buoys an outbound vessel will be able to utilize the original channel width for the major portion of its transit, moving to the righthand side to permit inbound traffic to pass. The effect of the 10 foot bottom step on maneuverability and control is open to question. A deeply laden outbound vessel may experience difficulty in maintaining the off-centerline position in meeting other vessels for the following reasons.

A strong turning moment and sideforce will undoubtedly develop due to close proximity of the near bank. This will be augmented to some degree by the presence of the deeper inbound cut on the outbound vessels port side. In addition strong interaction forces are generated by two vessels passing close together which will cause an increase in turning moment even at reduced speed. Since outbound vessels will presumably seek the centerline of the outbound lane in meeting situations, the starboard side of a vessel of 100 feet beam in the 300 foot channel section will lie only 100 feet from the near bank. This will permit little room for yaw angles due to wind, current and bank effects. As yaw angles develop away from the near bank a flow constriction will occur between the starboard quarter and the near bank causing a sheering force from which the vessel may be unable to recover, driving her across the channel into other traffic or aground. This description of forces generated by moving vessels and of problems in maneuverability and control is well supported in research literature.

INHERENT PROBLEMS OF NAVIGATING THE CHANNELS AFTER THE CENTERLINE OR EDGE OF THE DEEPER INBOUND CHANNEL HAVE BEEN MARKED WITH BUOYS

Present channel widths provide reasonable room for safe transit and maneuvering under local conditions. Ships customarily steer along the centerline or nearly so of each channel, moving momentarily to the channel side to permit meeting and overtaking other vessels in the waterway, then returning to the centerline position. According to Corps of Engineer representatives the Coast Guard feels compelled to mark the western edge of the deepened inbound lane with buoys. Coast Guard's position is a difficult one: not to mark the channel limits for large deeply laden vessels invites legal action in the event of grounding, whereas marking the channel in such a manner erects an obstacle course for those vessels whose draft would normally permit use of the entire channel width. Under the buoyed channel proposal all vessels using the channels, both inbound and outbound, will be compelled to transit in the off-centerline position. The outbound lane will be reduced to 300 feet in the Baltimore approach and in Rappahannock Channel, and to 400 feet in York Spit Channel. Each outbound vessel, which must include those of 100,000 to 150,000 tons calling at the port, must operate in these extremely narrow zones. When allowance is made for wind, current, bank effect and steering yaw angles, collision with buoys is inevitable. Navigation bridge levels and deck cargo configurations on many vessels limit visibility in the area forward of the vessel, so that buoys may be lost from sight within one-half mile of the ship. It must be concluded that marking the deepened channel edge with buoys, while aiding inbound vessels constrained by draft to use the deepened lane, is clearly unacceptable in impositions placed upon other vessels.

ECONOMIC INCENTIVES OF USING A DEEP DRAFT INBOUND CHANNEL FOR OUTBOUND TRAFFIC, AND SAFETY PROBLEMS WITH SUCH UNORTHODOX USAGE

Navigation regulations require each to transit on the right side of narrow channels, and usage of the deeper inbound channel by outbound traffic introduces serious legal questions and problems in traffic control. While economic incentives of using the deeper inbound channel for outbound traffic may arise, there is no reason why regulations forbidding such usage cannot be enforced.

If use of the inbound lane by outbound traffic is permitted several problems are foreseen. A large vessel transiting the inbound lane of 500 to 600 feet width must do so with no opposing traffic for reasons of maneuverability and control mentioned in preceding comments. This necessitates a highly reliable communications system, not only among piloted vessels but among tugs and barge traffic, local commercial freighters, small craft whose size permits use of the channels, and coastwise traffic operating with independent pilots. Any failure or breakdown in communication equipment or any misunderstanding of the intentions of a vessel transiting on the wrong side of the channel may have grave consequences. Delays to inbound vessels to permit use of the inbound lane by outbound traffic may increase transit time by as much as two hours. Normal transit time for a large deep-draft vessel is twelve to thirteen hours under ideal conditions. Industry representatives have consistently rejected pilot association requests for an additional pilot on such vessels. The extension of transit time to fourteen to fifteen hours under the conn of one pilot is unreasonable and unsafe.

ADEQUACY OF AUTHORIZED CHANNEL WIDTHS

Present channel widths in both Baltimore approaches and the Virginia channels appear acceptable for reasons outlined in the Corps of Engineers' comments regarding partially and fully restricted channels. Clearances proposed by the Committee on Tidal Hydraulics (May 1965) are based upon an analysis of fully restricted channels, and a small reduction in width requirements for the partially restricted channels of the Chesapeake Bay does not seem unreasonable. The liklihood of two very large vessels meeting in the channels is difficult to predict on a statistical basis at this time. But with improvements in navigational aids and their proper maintenance, channel clearances as proposed should provide acceptable maneuvering conditions.

MINIMUM KEEL CLEARANCES

The subject of under-keel clearances introduces an area in which many questions arise as to what is safe and proper. To the salt water draft must be added fresh water allowance, sinkage or squat factors, and additional allowances for trim or drag and for maintenance of controllability. Reliable sinkage or squat curves have been developed for fully restricted canals, but no definitive analysis has yet been established for partially restricted channels. Tide levels and their relation to weather conditions present another aspect in establishing guidelines for keel clearances. Because of these variables the pilot association wishes to hold in abeyance any endorsement of the recommendations of the Corps of Engineers at this time.

A bibliography is attached with a list of source material on the subjects discussed above.

****

April 1978

BIBLIOGRAPHY

Baltimore Harbor & Channels: Maryland and Virginia. Supplemental Information Requested by the Office of Management and Budget to June 1969 Review Report, Department of the Army, Baltimore District. Corps of Engineers, 19 July 1974.

Baltimore Harbor & Channels: Maryland and Virginia. Advanced Engineering and Design. Plan of Study, Department of the Army, Baltimore District. Corps of Engineers, May 1977.

Wicker, C.F. "Evaluation of Present State of Knowledge of Factors Affecting Tidal Hydraulics and Related Phenomena." Committee on Tidal Hydraulics, Corps of Engineers, U.S. Army Report No. 3, Chapter X, Design of Channels for Navigation, May 1965.

Moody, Charles G. "The Handling of Ships Through a Widened and Asymmetrically Deepened Section of Galliard Cut in the Panama Canal." David Taylor Model Basin, Report No. 1705, August 1964.

"Notes on Controllability." Technical and Research Bulletin No. 1-27, Chapter 4: Ship Maneuvering and Control in Shallow and Restricted Waters, Society of Naval Architects and Marine Engineers, Panel H-10, May 1971.

Tothill, J.T. "Ships In Restricted Channels: A Correlation of Model Tests, Field Measurements and Theory." National Research Council, Division of Mechanical Engineering, Ship Section, Ottawa, Canada, 1966.

Garthune, R.S., et al. "The Performance of Model Ships in Restricted Channels in Relation to the Design of a Ship Canal." David Taylor Model Basin, Report No. 601, August 1948.

Sjostrum, C.H. "On Shallow Water Effects in River Channels; for Pilots' Association for the Bay and River Delaware." John J. McMullen Associates, New York, February 1968.

Sjostrum, C.H. "Effect of Shallow Water on Speed and Trim." Society of Naval Architects and Marine Engineers, New York. September 1965, Revised August 1966.

Schoenherr, K.E. "Data for Estimating Bank Suction Effects in Restricted Water and On Merchant Ship Hulls." First Symposium on Ship Maneuverability. David Taylor Model Basin, Report 1461, 1960.

Moody, C.G. "Two-Way Traffic for Large Bulk-Cargo Ships in Gaillard Cut of the Panama Canal." Naval Ship Research and Development Center, Report 229-H-03, August, 1970.

Eda, H. "Directional Stability and Control of Ships in Restricted Channels." Society of Naval Architects and Marine Engineers, New York, November 1971.

Port Approach Design: A Survey of Ship Behavior Studies. National Ports Council, London, 2 Volumes, September 1975.

Dand, I.W. "Hydrodynamic Aspects of Shallow Water Collisions." Royal Institution of Naval Architects, London, April, 1976.

Gates, E.T. and Herbich, J.B. "Mathematical Model to Predict the Behavior of Deep-Draft Vessels in Restricted Waterways." Texas A & M University (TAMU - SG -77-206) Report No. 200, June 1977.

Bethlehem Steel Corporation

S. M. MOODIE
VICE PRESIDENT
MARINE DIVISION
J. D. KERR
A. F. CHERNEY
ASSISTANT VICE PRESIDENTS

MARINE DIVISION
EDGEMERE PLANT OFFICE
NORTH POINT BOULEVARD AND SNYDER AVENUE
MAIL: BOX 6656
SPARROWS POINT, MD. 21219

IN REPLY REFER TO

E & M - Baltimore
Channel Project

April 5, 1978

Capt. George Quick
President
Association of Maryland Pilots
1316 S. Baylis Street
Baltimore, Maryland 21224

Re: 50' Channel

Dear George:

Please refer to letter from Army Engineers of March 20, 1978, which you sent me for comment.

I really do believe that a 600 foot, 500 ft. and 300 ft. wide deep draft inbound channel is safe. However, as the Coast Guard is opposed, I am afraid that we will have to wait for completion of the entire project. If we fight the issue now, it will probably delay the project for yet another study. If possible, I would favor dredging in increments, say, the first pass to 45 foot and the second to 50 foot.

You know much more about ship control problems than I. However, from what I have read, there should be no control problems in the Chesapeake channels because of the extensive area available for the water pressures caused by the ship moving in the channel to escape. The Chesapeake channels cannot be compared to the Panama Canal cuts in this regard. I quote from a SNAME study entitled Directional Stability and Control of Ships in Restricted Channels - "When canal width is increased, there is a significant improvement in ship controllability." "In narrow waterways (e.g., W/B ______ 4), shallow water depth has no serious adverse effect upon ship control if sufficient bottom clearance exists for sinkage at a given speed. In other words, the effects of waterway width on the dynamic motion of ships are much more important than the effects of water depth."

I consider the authorized channel widths of 1000 ft., 800 ft. and 600 ft. adequate.

The chance of two 150,000 DWT vessels passing in the channels, for all practical purposes, is non-existent. If it happened that two 150,000 DWT vessels were operating in the Chesapeake Bay at the same time, the pilots would make sure they passed in the Bay, not in the dredged channels.

It is interesting to note that the Army Engineers plan to specify a keel clearance of 5 foot. The required keel clearance in the Orinoco River is 2 ft. and the Great Lakes 2 ft., for example.

I don't see any navigating problems with the edge of the deeper channel marked by buoys. I don't see any problem if it isn't marked, the deep draft ship just stays close to the existing buoys.

There are certainly economic advantages to load any ship as deep as possible. However, the Coast Guard can decree the allowable outbound draft as can the Association of Maryland Pilots. However, if there are no inbound deep draft vessels due and a ship is finishing loading, say, grain or coal, I can see no reason why she couldn't load to the allowable deeper draft for inbound vessels. Even if there was a deep draft inbound vessel due, the owner of outbound vessel could arrange a payment to the owner of the inbound vessel for the delay until their vessel cleared Cape Henry. On the other hand, a loading vessel owner may find it economic to wait for the deep draft channel to clear in order to take advantage of the deeper draft.

I am researching under keel clearance required in other areas of the world similar to the Chesapeake.

If you require any further opinion, please do not hesitate to ask.

Very truly yours,

J. V. Cherry
J. V. Cherry
Asst. to Vice President

JVC/cdl

NABPL-F 20 March 1978

Mr. George A. Quick
President
Association of Maryland Pilots
131 South Baylis Street
Baltimore, Maryland 21224

Dear Mr. Quick:

Reference is made to the 23 February 1978 meeting among members of the Baltimore District and Messrs. Richard Owen and Alexander Kaufman of the Association of Maryland Pilots, where various aspects of the Baltimore Harbor and Channels 50-foot project were discussed.

Our office met with the Fifth Coast Guard District on 16 February 1978 to discuss safety aspects of our proposed construction schedule. This schedule utilizes the one-way channel concept whereby deepening of the inbound channel is completed in 5 years and the entire project is completed 3 years later. In order to provide adequate channel widths for deep draft inbound vessels during the last 3 years of construction, the initial inbound channel dredging will provide the following widths; 600 feet in the Virginia channels, 500 feet in the Maryland channels, and 300 feet in the Branch channels. Inclosure 1 shows the location of the deeper inbound lane in relation to the existing channel configuration. The Coast Guard reaffirmed their stand against one-way channels on a permanent basis or as a "short-term" method of construction. In addition, they informed us that should a one-way channel be implemented on a "short-term" basis, the centerline of the channel would have to be marked and new mid-channel ranges would have to be established.

Your representatives and the Fifth Coast Guard District have stated that operation of a one-way channel for any period of time would be unsafe. Accordingly, I would appreciate receiving a letter from you discussing the following items which were addressed at the 23 February meeting.

a. Control problems of outbound vessels when a deeper inbound channel exists.

b. Inherent problems of navigating the channels after the centerline or edge of the deeper inbound channel have been marked with additional buoys.

c. Problems associated with operating 60,000 to 150,000 dead weight ton (DWT) vessels in a narrower inbound channel.

d. Economic incentives of using a deep draft inbound channel for outbound traffic, the problems of policing such activities should the Coast Guard issue appropriate regulations prohibiting outbound vessels from using the deeper inbound channel, and safety problems with such unorthodox channel usage.

In addition, your comments are requested concerning the adequacy of the authorized channel widths of 1000 feet for the Virginia channels, 800 feet for the main ship channels in Maryland, and 600 feet for the Northwest Branch and Curtis Bay channels in Baltimore Harbor.

In our June 1969 Review Report, the analysis of required channel widths was based on a 90,000 DWT bulk cargo "design" ship with a beam of approximately 122 feet and results of investigations made during the study of the proposed sea level Panama Canal (Incl. 2). Presently the largest ship envisioned using the project is 150,000 DWT with a beam of 145 feet which, using the criteria presented in the 1969 Review Report, would require widening the channels beyond the widths presently authorized. However, since the relationships developed during the Panama Canal Study were based on restricted channel conditions which require wider bank clearance and the frequency of two 150,000 DWT vessels passing each other is low, we plan to proceed with the channel widths as presently authorized. Any information on the likelihood of two 150,000 DWT vessels passing would be beneficial.

Our records of vessel traffic passing ~~through~~ the Port of Baltimore show nearly 300 ships annually transiting the channels with drafts in excess of 37 feet. Despite these figures, we still plan to specify a required keel clearance of 5 feet. A copy of the analysis presented in the June 1969 Review Report is attached as Inclosure 3. Any information you might have on desired minimum keel clearances would also be beneficial.

I would appreciate receiving your comments by 28 April 1978 so that they may be included in our report.

NABPL-F
Mr. George A. Quick

20 March 1978

Per your request, a copy of the July 1974 Supplemental Information Report and May 1977 Plan of Study are inclosed.

Sincerely yours,

5 Incls
As stated

WILLIAM E. TRIESCHMAN, Jr.
Chief, Planning Division

Copy furnished:
Fifth Coast Guard District
431 Crawford Street
Portsmouth, Virginia 23705

Baltimore Harbor and Channels
Maryland and Virginia
Combined Phase 1 and 2
General Design Memorandum
Technical Appendices Final 9/81
2.16