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REVIEW OF PROJECT CHANNEL WITH RECOMMENDED MODIFICATIONS, TANGIER ISLAND, VIRGINIA

by

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EXECUTIVE SUMMARY

Channel shoaling is more severe in the East Channel, which is the longer and more heavily used of the two channels serving the harbor at Tangier, Virginia. Shoaling in the East channel is caused by longshore transport from wind-waves along the east shore of Tangier. Shoaling in the West Channel results from tidal deposition on flood and ebb deltas.

Five actions have been identified as having potential for reducing the frequency of maintenance dredging in the project channels. The easiest action to implement would be to perform advance maintenance dredging under the next dredging contract. An analysis is provided in this report to assist in design work to accomplish this. The other four actions would appear to offer more permanent results but necessarily involve detailed engineering and coordination to achieve the necessary approvals. These actions are summarized as follows:

a. Construct a new channel through Mailboat Harbor to Tangier Sound and abandon the East Channel;

b. Construct sediment traps to intercept the longshore transport before it enters the East Channel;

c. Construct jetties north and south of the entrance to West Channel;

d. Construct a low dike across Mailboat Harbor to concentrate tidal flow through East and West Channels.

A new channel through Mailboat Harbor (option a) holds the most promise for a long-term reduction in volume dredged, as well as providing the desired access to Tangier Sound under more sheltered conditions than the present East Channel. Sediment traps (option b) and jetties (option c) could result in reduced dredged volumes for East and West Channels, respectively, until these structures filled up. The dike across Mailboat Harbor (option d) may provide some premanent reduction of shoaling in the existing channels.

PREFACE

This study and related engineering design was conducted under Indefinite Delivery No. 65-80-D-0015 by Waterway Surveys & Engineering, Ltd. (WS & E) for the Norfolk District, Corps of Engineers. The work was monitored by Mr. Samuel McGee, Project Manager, Dredging Management Branch. Coastal Engineering work was prepared by Cyril Galvin, Coastal Engineer, a firm on sub-contract to WS & E. Text on Tides and Coastal Processes was prepared by James R. Hill, Junior Coastal Engineer, under direct supervision of Cyril Galvin, Coastal Engineer. Text on Channel Shoaling was prepared by James L. Overton, Civil Engineer under the direct supervision of J. Woodville Holton, Jr., Professional Engineer. Graphics were under the direction of Patricia L. Carney, Senior Cartographic Technician and Karen L. Bowes typed the report.

A previous report prepared by the authors entitled "Evaluation of Long-Term Dredged Material Disposal, Tangier Island, Virginia" presents additional supporting data. Photo plates of Tangier shorelines with explanatory remarks have been furnished separately. Recommended solutions presented herein were prepared by Messers Holton, Hill, Overton, and Dr. Galvin.

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FIGURES

TABLES

PART I: INTRODUCTION

This report presents the results of a study and evaluation of the Tangier Island Project Channel design and recommendations for measures to extend the dredging interval required for maintenance. The work is primarily based on existing data and records. However, some field investigations were accomplished to predict coastal processes and identify channel hydraulic characteristics. This study is not presented as being a comprehensive engineering evaluation but rather a review of the overall maintenance dredging problem caused by high shoaling rates.

PART II: ANALYSIS OF CHANNEL SHOALING

The dredged channels serving the island of Tangier, Virginia are generally referred to as the East and West Channels (Figure 1). Channel shoaling is caused by deposition of fine sand and silt mixed with some clay and organic particles washed from the surrounding tidal flats and salt marshes. APPENDIX I contains the entire channel sediment analysis furnished by the Corps and Figure 2 summarizes the sediment data along the channel route.

It can be seen that the West Channel sediments are primarily fine sand while those in the basin are organic clay and silt sediments. The East Channel exhibits a varied sediment pattern particularly where the channel leaves the shelter of the island. Table 1 presents a summary of the channel sediment grain size. It is interesting to note that where both channels leave the protection of the island (Stations 38+00 W and 35+00 E) the sediments have the same grain size - D_{50} = 0.18.

TABLE 1: TANGIER CHANNEL SEDIMENT SIZE

Channel Station	D_{50} size (mm)
38 + 00 W	0.18
11 + 00 W	0.17
5 + 00 E	0.11
30 + 00 E	0.12
38 + 00 E	0.18
55 + 00 E	0.15

In order to prepare the discussion that follows, channel centerline profiles were constructed from past surveys furnished by the District. The assumption is made that the shoaling patterns revealed by the analysis of centerline data represents the shoaling patterns for full channel width. This assumption appears to be valid due to the narrow channel widths and is consistent with the scope of this study. It is noted that this assumption also allows for a direct comparison of the rates of channel depth reduction due to shoaling without consideration of the actual

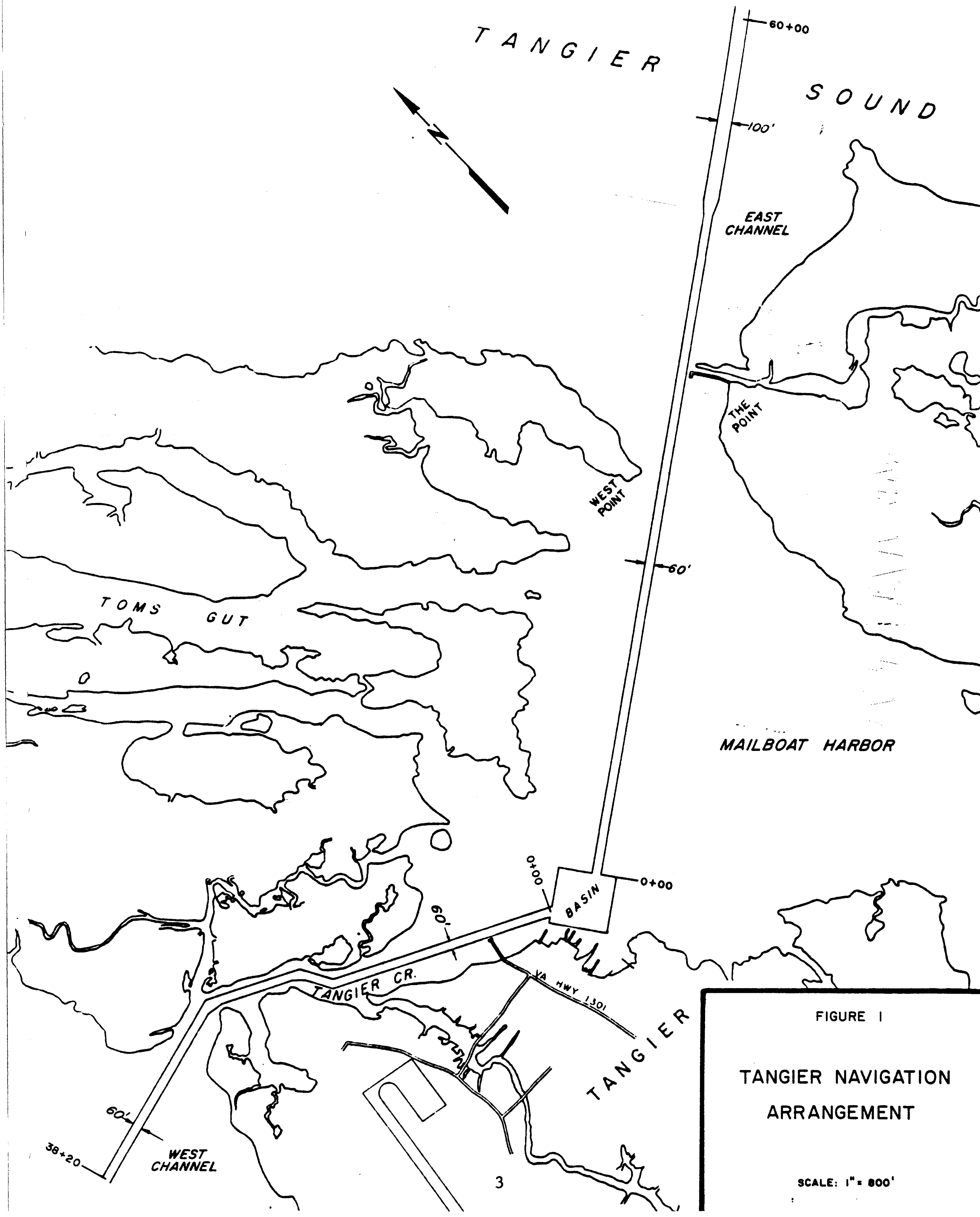


FIGURE 1

TANGIER NAVIGATION ARRANGEMENT

SCALE: 1" = 800'

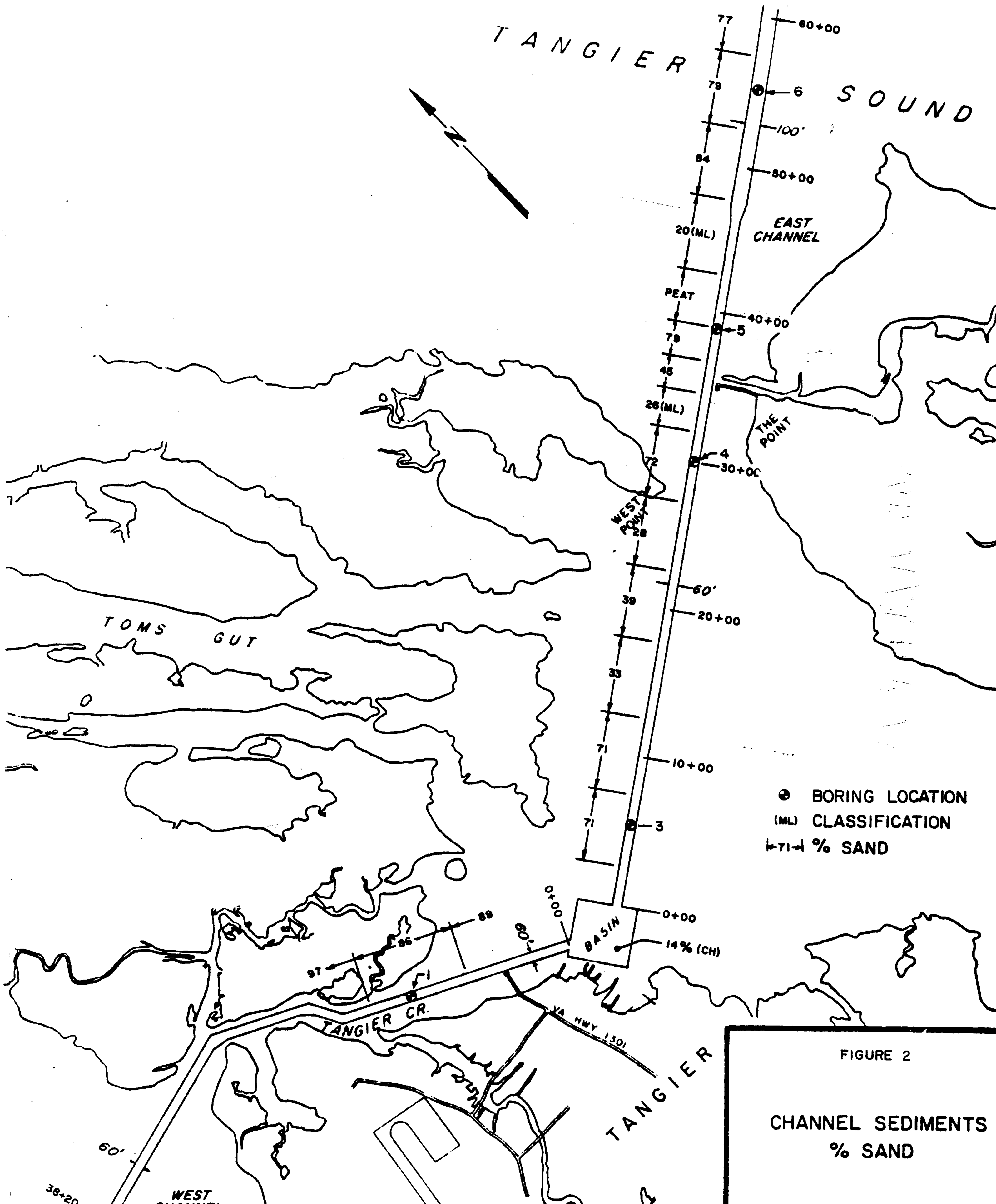


FIGURE 2

CHANNEL SEDIMENTS
% SAND

SCALE: 1" = 800'

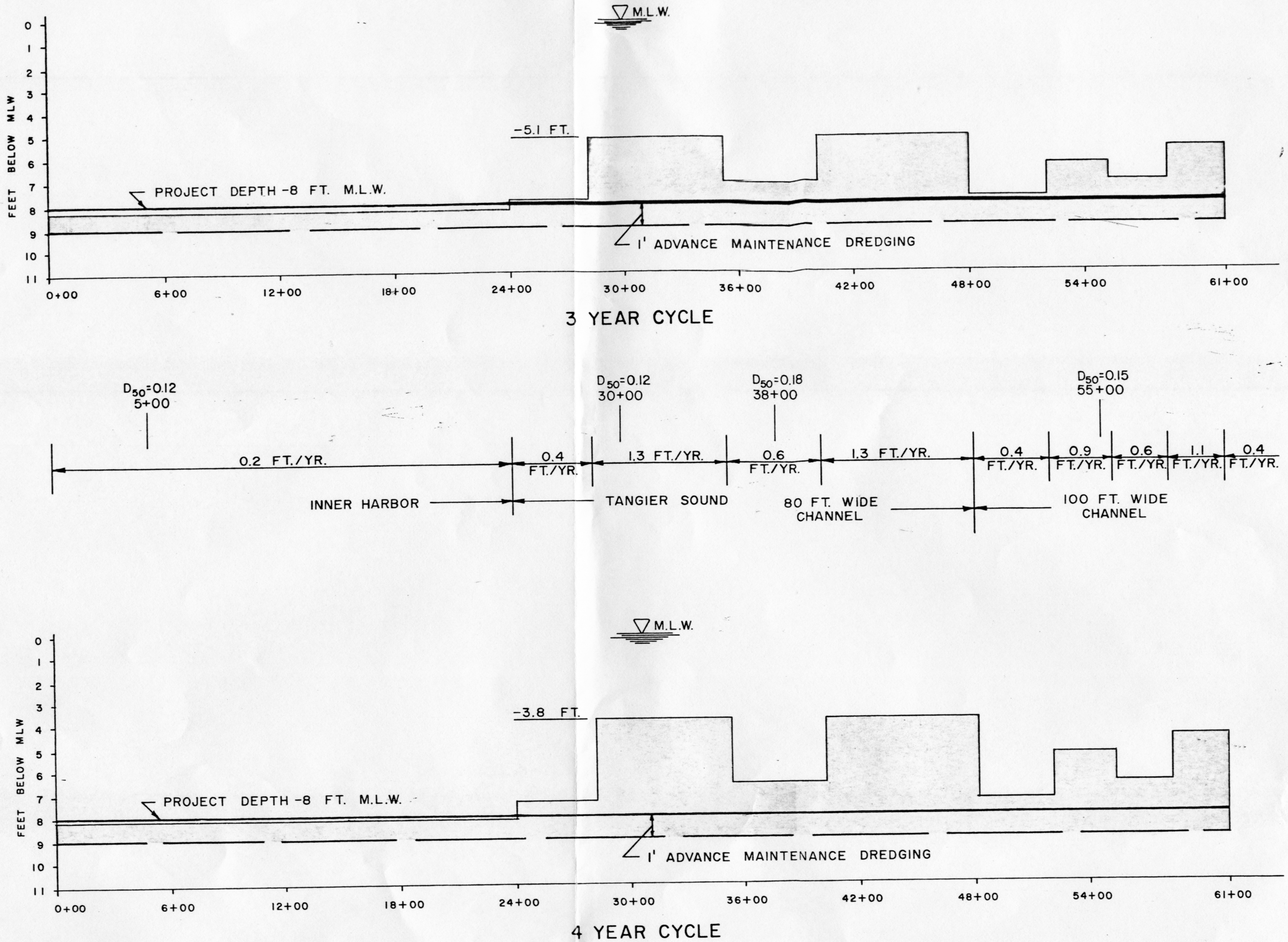
quantities involved. With this in mind, the term "shoaling rate" as used herein refers to the rate of channel depth reduction due to shoaling and is expressed in feet per year.

East Channel

The East Channel provides direct access to Tangier Sound and was first dredged in 1921. The East Channel consist of a channel 8 feet deep, 100 feet wide, and 1,300 feet long in Tangier Sound; thence, 8 feet deep, 60 feet wide, and 4,800 feet long to an anchorage basin 400 feet square and 7 feet deep adjacent to the town of Tangier, Virginia. Varied shoaling rates were found throughout this reach with the lower rates being in the inner harbor. Based on the computed shoaling rates an analysis of this channel was performed for a 3 year dredging cycle and a 4 year dredging cycle (Figure 3). From this analysis it is predicted that following dredging to the project depth plus 1 foot of advance maintenance, the usable depth would be 5.1 feet (MLW) in 3 years and 3.8 feet (MLW) in 4 years.

Shoaling rates in Tangier Sound varied widely with higher shoaling found in the 60 foot wide channel than in the 100 foot wide channel (Figure 3). The extra width provides additional capacity for sediment deposition. Widening of the 60 foot channel between stations 24+00 and 48+00 would provide additional bottom area, therefore, increase the channel capacity for sediment collection. This should have the affect of slowing the rate of channel depth reduction by shoaling in this area.

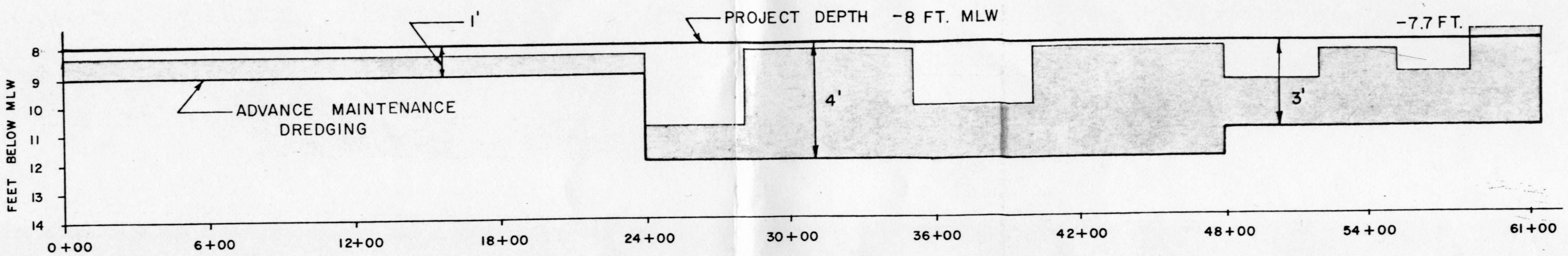
A minimum navigable depth of 8 feet should be provided to accommodate fuel barges. Advance maintenance dredging with variable depths is recommended to insure the required navigable depth and to decrease the maintenance dredging frequency. As shown on Figure 4, advance maintenance at depths (MLW) of 9 feet (Station 0+00 to Station 24+00), 12 feet (Station 24+00 to Station 48+00), and 11 feet (Station 48+00 to Station 61+00), would provide 8 feet of navigable water at the end of 3 years. For a 4 year maintenance dredging cycle depths (MLW) of 9 feet (Station 0+00), 13 feet (Station 24+00 to Station 48+00), and 12 feet (Station 48+00



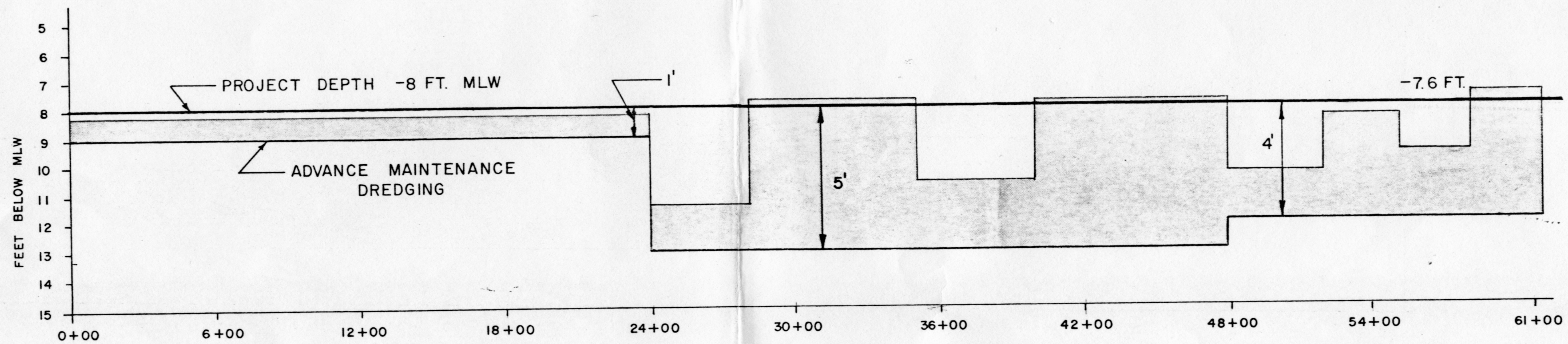
SHOALING RATES

FIGURE 3

EAST CHANNEL, TANGIER ISLAND



3 YEAR CYCLE



4 YEAR CYCLE

ADVANCE MAINTENANCE DREDGING

FIGURE 4

EAST CHANNEL, TANGIER ISLAND

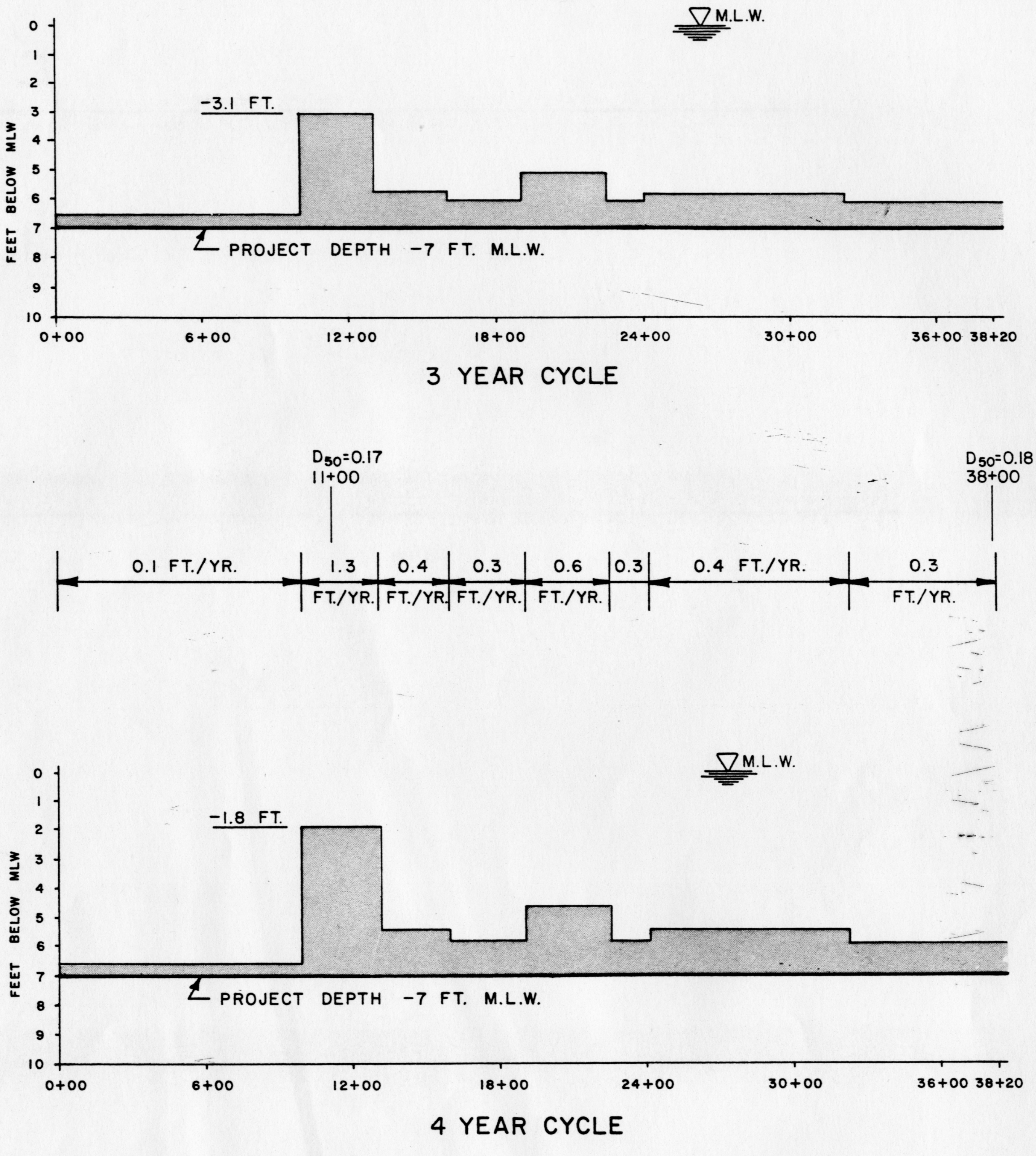
to Station 61+00) would be required. The shoaling rates existing between stations 24+00 and 28+00 do not justify the recommended dredging depth as shown on Figure 4, however, provision should be made for increased sediment deposition that possibly will occur due to the sudden increase in depth. If additional width were provided between Stations 24+00 and 48+00 it is predicted that the dredging depth in this area could be decreased by 1 foot for both dredging cycles.

West Channel

The West Channel was first dredged in 1965. This channel was cut through marsh to reach the Chesapeake Bay thereby causing considerable modification to the tidal hydraulic regime through the connecting channels. The West Channel is 7 feet deep and 60 feet wide from the anchorage basin at Tangier, Virginia, northwesterly through Tangier Creek to that depth in the Chesapeake Bay, a total length of approximately 3,820 feet.

Shoaling rates for the West Channel were developed by using project condition surveys performed by the Corps of Engineers. Shoaling rates throughout this reach were found to be low with the exception of the area between Stations 10+00 and 13+00 which contained a shoaling rate of 1.3 feet per year. Based on the computed shoaling rates an analysis of this reach was performed for a 3 year dredging cycle and a 4 year dredging cycle (Figure 5). From this analysis it is predicted that after dredging to the project depth the usable depth would be 3.1 feet (MLW) in 3 years and 1.8 feet (MLW) in 4 years.

As opposed to the East Channel, wider channels will not decrease the shoaling rate. The high shoaling rate between stations 10+00 and 13+00 is hypothesized to be caused by a flood tide delta and therefore only an increase in depth should be considered. A minimum navigable depth of 6 feet should be provided to accommodate vessels using the East Channel. Advance maintenance dredging should be concentrated in the region of delta formation. Variable depths (Figure 6) are recommended to insure the required navigable depth and to increase the maintenance dredging frequency. Advance maintenance dredging at depths (MLW) of 10 feet (Station 10+00 to Station



SHOALING RATES

FIGURE 5

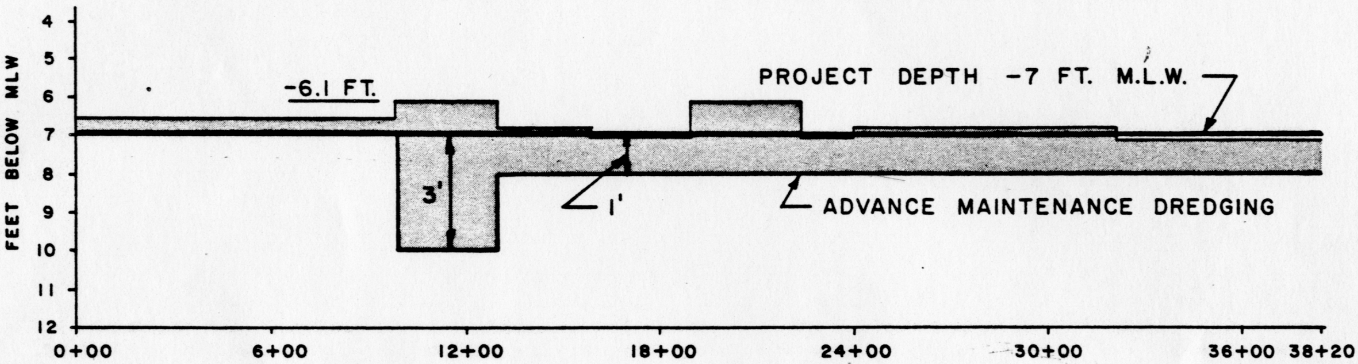
WEST CHANNEL, TANGIER ISLAND

13+00), and 8 feet (Station 13+00 to Station 38+20) would provide 6 feet of navigable water at the end of 3 years. For a 4 year maintenance dredging cycle, depths (MLW) of 11 feet (Station 10+00 to Station 13+00) and 8 feet (Station 13+00 to Station 38+20) would be required. Shoaling rates between stations 0+00 and 10+00 are so low that no advance maintenance dredging would be required for either cycle.

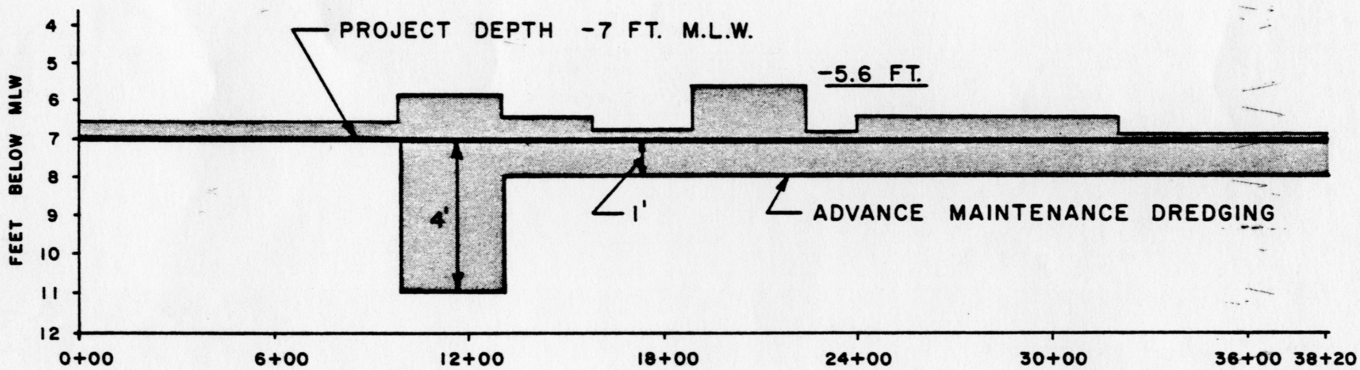
Economic Considerations

APPENDIX II contains a economic comparison between current dredging practice and advance maintenance dredging recommended by this report. The assumptions are made that the channels must be maintained at their project depth and that both the East and West Channels would be dredged under the same contract. Basic cost parameters used for the analysis were furnished by Sam McGee of the Dredging Management Branch.

The results ofthe economic comparison suggest that Alternative B Advance Maintenance would result in a savings of $1.2 million over nominal maintenance using 1 foot over-dredging during a 12 year period. Alternative A would result in a $1.0 million savings.



3 YEAR CYCLE



4 YEAR CYCLE

ADVANCE MAINTENANCE DREDGING

FIGURE 6

WEST CHANNEL, TANGIER ISLAND

PART III: TIDES AT TANGIER ISLAND

This section addresses the predicted astronomical tides available from the NOS tide tables and the tides measured on 6 and 8 November, 1981 by the staff of WS & E, Ltd. Tidal measurements were taken at three stations as shown in Figure 7.

Predicted Tides

The predicted tides for Tangier Island are typical of those found at two nearby subordinate stations at Tangier Sound Light and Watts Island. Tangier Sound Light is located approximately 1 mile south of the sand spit on Tangier Island and Watts Island is about 5 miles southeast of Mailboat Harbor.

The mean tide range at both Watts Island and Tangier Sound Light (1.6 feet) is less than the average mean tide given for 10 localities (2.2 feet) listed for the eastern shore of Chesapeake Bay in the NOS tide tables. The tide tables also predict that the tide at Tangier Sound Light leads Watts Island by 8 minutes on the high tide and 14 minutes on the low tide (see Table 2). Noting that Tangier Sound Light is located west of Watts Island, the direction of the surface gradient between these stations is from west to east for high tide and east to west for low tide. Consequently, at nearby Tangier Island, the channels should flow to the east during flood and to the west during the ebb in both West and East Channels.

The tides for Watts Island and Tangier Sound Light are computed on Hampton Roads, Virginia, which has mean and spring ranges of 2.5 feet and 3 feet, respectively.

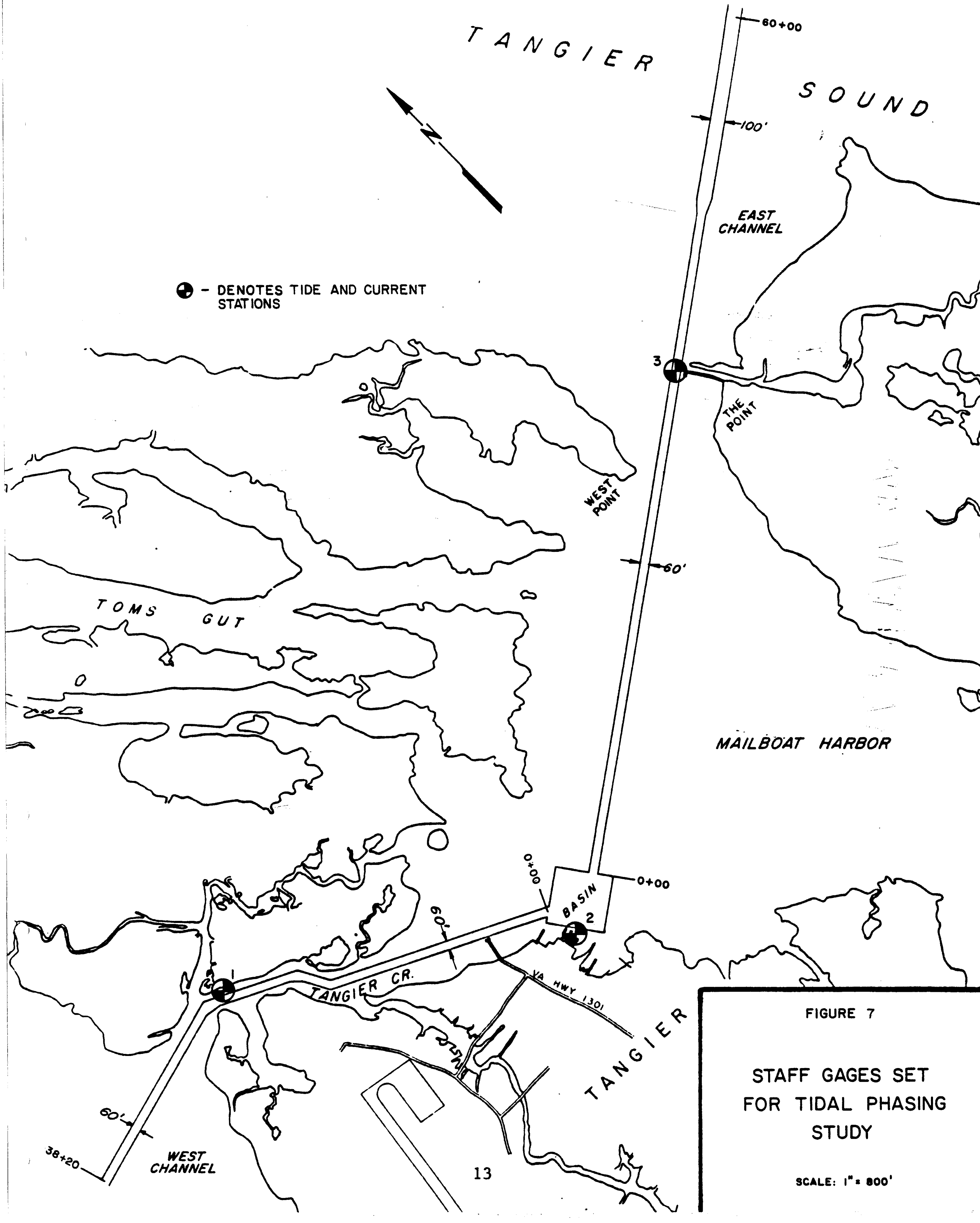


FIGURE 7

STAFF GAGES SET FOR TIDAL PHASING STUDY

SCALE: 1" = 800'

TABLE 2: TIDE CHARACTERISTICS IN THE VICINITY OF TANGIER ISLAND*

Station	Place	Time High h. m.	Time Low h. m.	Height High	Height Low	Ranges Mean	Ranges Spring
1965	Watts Island	+2 59	+3 02	-0.9	0.0	1.6	1.9
1967	Tangier Sound Light	+2 51	+2 48	0.64(1)	0.64(1)	1.6	1.9

*Reference Station is Hampton Roads; datum is Mean Low Water; time given in hours and minutes to be added to the time predicted for the Reference Station in the 1981 Tide Tables of National Ocean Survey.

(1) This factor must be multiplied by the heights given for the Reference Station, to find the corrected height for high and low water.

For 6 and 8 November 1981, the predicted daylight range at Hampton Roads is 2.0 and 2.5 feet respectively. Since the mean range at Hampton Roads is 2.5 feet, the tide tables suggest that the predicted daylight tides on these two days should have been near the mean range at Tangier Island. It is worth noting that perigean spring tides began on 12 November 1981 with predicted daylight ranges at Hampton Roads of 3.8 feet above the spring range.

Measured Tides

Visual observations of tidal current circulation patterns through the inner harbor and connecting channels revealed the need to conduct a tidal phasing study. Time allocated to the project did not allow for a complete investigation throughout full tidal cycles. However, portions of both the ebb and flood conditions were investigated. The gaging stations shown in Figure 7 were established and read by observers who recorded water levels and current directions. Gages 1 and 2 were referenced to MLW and Gage 3 was set by water surface transfer. Figures 8 and 9 report the findings in graphical form taken on 6 and 8 November 1981 respectively.

Table 3 shows the measured tides at Tangier Island as well as the predicted tides at Watts Island and Tangier Sound Light for 6 and 8 November 1981. The measured tides were extrapolated from the records shown in

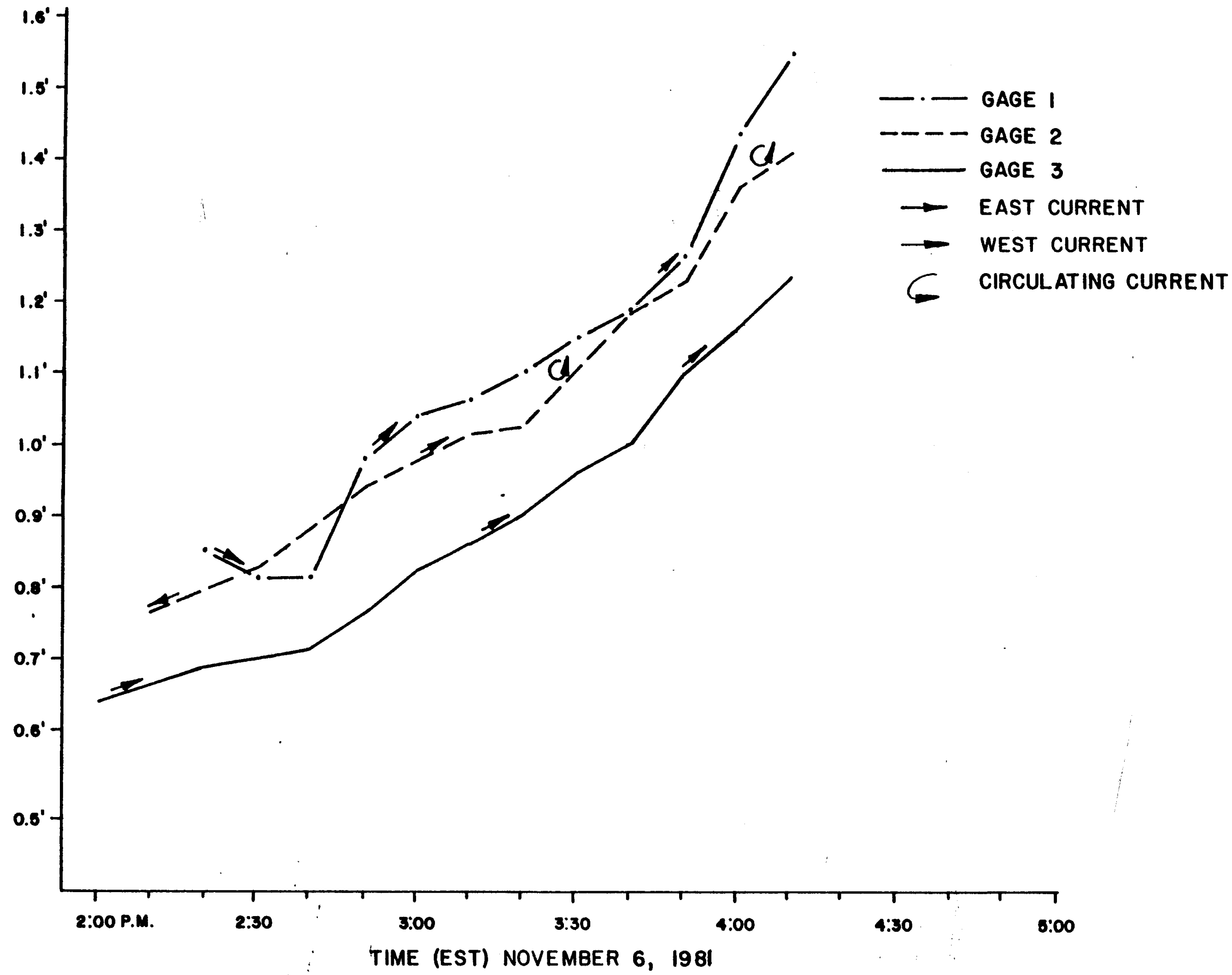


FIGURE 8

TIDAL PHASING
FLOOD CONDITION

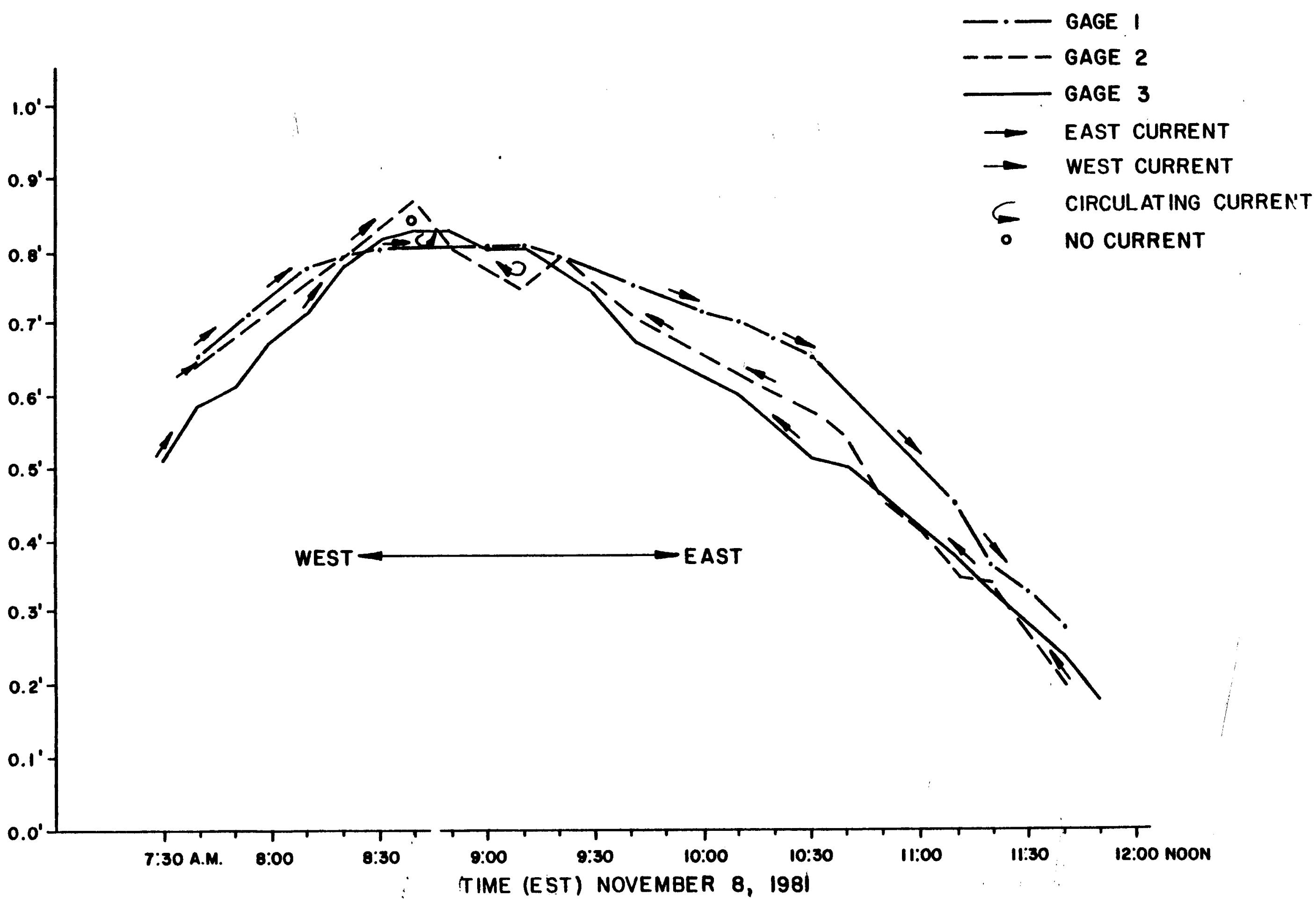


FIGURE 9

TIDAL PHASING
EBB CONDITION

TABLE 3: TIDES IN THE VICINITY OF TANGIER ISLAND DURING FIELD WORK

	Measured Tide Tangier Island		Predicted Tide Watts Island		Predicted Tide Tangier Sound Light	
Date	Time	Height (feet)	Time	Height (feet)	Time	Height (feet)
6 Nov 1981			0036	0.4	0022	0.3
			0644	1.3	0636	1.4
			1255	0.4	1241	0.3
			1906	1.5	1858	1.5
8 Nov 1981			0223	0.1	0209	0.6
	0830	0.8 H	0838	1.7	0830	1.7
			1455	0.1	1441	0.6
			2059	1.7	2051	1.7

Figure 8 and 9 while the predicted tides were computed using Table 2. As shown in Table 3, the time of high and low tides correspond between predicted and measured values. However, the high tide of 0.8 feet measured at 0830 on 8 November 1981 is lower than the predicted value of 1.7 feet at both Watts Island and Tangier Sound Light. This difference may be attributed in part to fluctuations in the water surface due to local storm activity.

Referring to Figure 9, a tidal head differential exists on the ebb tide between Gages 1 and 2, which would cause the current to flow west to east during that portion of the cycle mentioned. This is supported by the observed current at Gage 1 but not at Gage 2. It is likely that circulation patterns in the inner harbor influenced the observed current at Gage 2 as was also suggested by the observer at that station. The slight phase differential observed between Gages 2 and 3 is probably not significant because of the limiting accuracies in recording the tide levels and in the procedure used to set Gage 3.

Figure 8 reflects flood tide data over a greater tide range than Figure 9 and the data appears more consistant. The head differentials reported support the current directions observed.

In summary, Figure 9 indicates a convergence of the gage readings at all three gages suggesting that a reversal in the current direction at Gage 1 occurred shortly after the reporting period. Other evidence including visual observations on other days and local reports indicate that this switch does occur and the controlling hydraulic gradient is east to west on the ebb tide condition. Figure 8 and other visual information supports the fact that the hydraulic gradient is west to east on the flood tide condition. Figure 10 reflects the results of the above determination, which coincide with the flood and ebb directions predicted by the NOS Tide Tables as discussed in reference to Table 1.

Note that the tidal record length represented by Figures 8 and 9 is of short duration, thereby making the analysis more difficult. For future work at Tangier Island it is suggested that measurements be taken for a complete tidal cycle including the current velocities and directions.

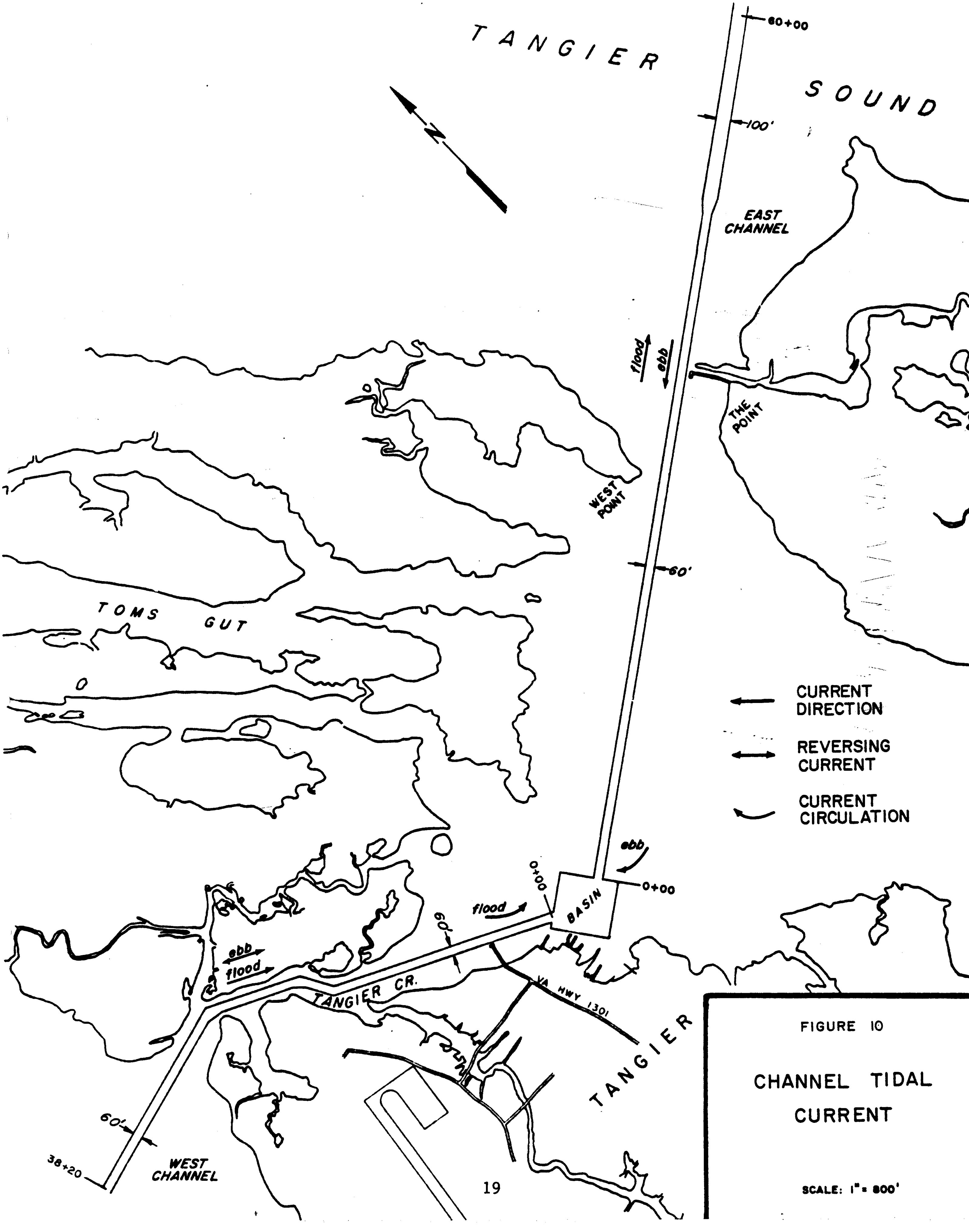


FIGURE 10

CHANNEL TIDAL CURRENT

SCALE: 1" = 800'

PART IV: COASTAL PROCESSES AFFECTING CHANNEL

Shoaling

The shoaling patterns in both East and West Channels were discussed briefly in Part II in reference to an advance maintenance dredging schedule (See Figures 3 and 5). This chapter explores the possible causes of the high shoaling rates at selected locations in both channels due to the coastal processes at Tangier Island.

Figure 11 shows the shoaling rates along both the East and West Channels, as well as the sand concentrations in the channels. Areas of the channel represented by white and wavey line segments in Figure 11 have among the highest shoaling rates ranging from 0.6 - 1.3 feet/year. Table 4 lists the location, the shoaling rates in feet/year, and our interpretation of the transport mechanisms creating heavy shoaling. As Table 4 suggests, the shoaling in East Channel is caused by longshore transport from wind-waves along the east shore of Tangier. In contrast, the heavy shoaling in west channel results from flood and ebb deltas, a tidal phenomenon.

The following paragraphs elaborate on specific areas of each channel including those given in Table 4. The discussion is broken down by channel segments lettered consecutively (a to k) starting at station 61 + 00 in East Channel and ending at Station 38 + 20 in West Channel as shown in Figure 11.

TABLE 4: LOCATIONS OF HIGH SHOALING RATES IN EAST AND WEST CHANNELS AT TANGIER ISLAND

Location	Shoaling Rate feet/year	Suggested Transport Mechanism causing shoaling	
20+00 - 24+00 West	0.6	Ebb Tidal delta	Deltas
10+00 - 13+00 West	1.3	Flood Tidal delta	Deltas
28+00 - 36+00 East	1.3	Waves from North, Northwest winds	Longshore Transport
36+00 - 40+00 East	0.6	Waves from Northwest, North Northeast winds*	Longshore Transport
40+00 - 48+00 East	1.3	Waves from Northwest, North Northeast winds*	Longshore Transport
54+00 - 58+00 East	0.6	Waves from Southeast winds	Longshore Transport
58+00 - 61+00 East	1.1	Waves from Southeast winds	Longshore Transport

*Longshore transport can occur along two shorelines in this area located on both sides of East Channel

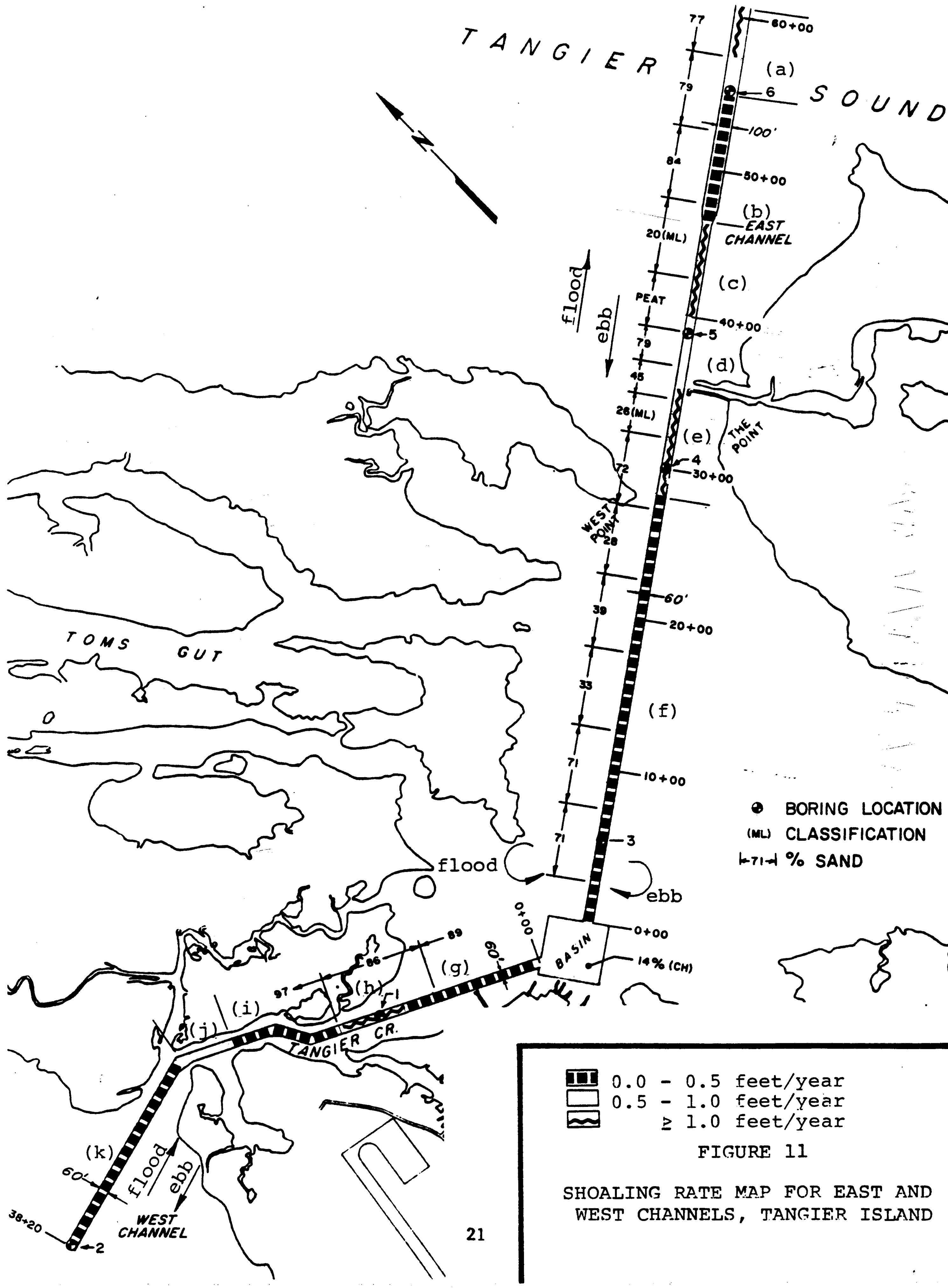


FIGURE 11

SHOALING RATE MAP FOR EAST AND WEST CHANNELS, TANGIER ISLAND

East Channel Hypotheses

Figure 12 summarizes the sediment characteristics and shoaling behavior for Stations 0+00 - 61+00 (Channel a-f segments) in East Channel. As shown at the top of Figure 12, the d_{50} sand size ranges in value from 0.11 - 0.18 mm. Bottom elevations in East Channel vary between 9 and 11 feet below MLW. The middle bar graph of Figure 12 indicates that the percentages of sand ranges from 0% - 84%. Finally, the lower bar graphs show the shoaling rate for both 3 and 4 year cycles taken from Figure 3. Figure 12 points out that the areas of heavy shoaling are not necessarily composed of all sands as might be expected initially.

The segments between 54+00 - 61+00 (segment a of Figure 11) have high shoaling rates (>0.6 feet/year) and a high percentage of fine sands (78%). The source of this sand is the eastern shore of Klinefelters Island. Southeast winds, which are common during the summer months, can set up longshore transport to the north carrying sediments across Tangier Sound to this segment of East Channel. This transport direction is evidenced by the existing shoreline which forms a nob at the north end of Klinefelters Island. This local shoreline feature may be the beginning of an accreting spit much like the one located at the south end of Tangier Island. The shoaling pattern established by the southeast winds is represented by black hatching in Figure 13.

Between Stations 48+00 and 54+00 (segment b) the shoaling rates are 0.4 feet/year. This low rate of shoaling can be attributed to a lack of sand transport to this area. The only readily available source of sand passes northeast of this segment of channel due to the shoreline extension on Klinefelters Island (nob). A contributing factor to the low shoaling rates may be the fact that the design width of the channel widens in this segment from 60 to 100 feet.

The next segment of channel, stations 40+00 - 48+00 (segment c) is the most vulnerable area to shoaling (shoaling rates are 1.3 feet/year). Northeast winds cause a longshore transport along the northern shore of Klinefelters Island which is carried into the channel. Transport in this direction was shown by the accretion behind the timber groin on the north

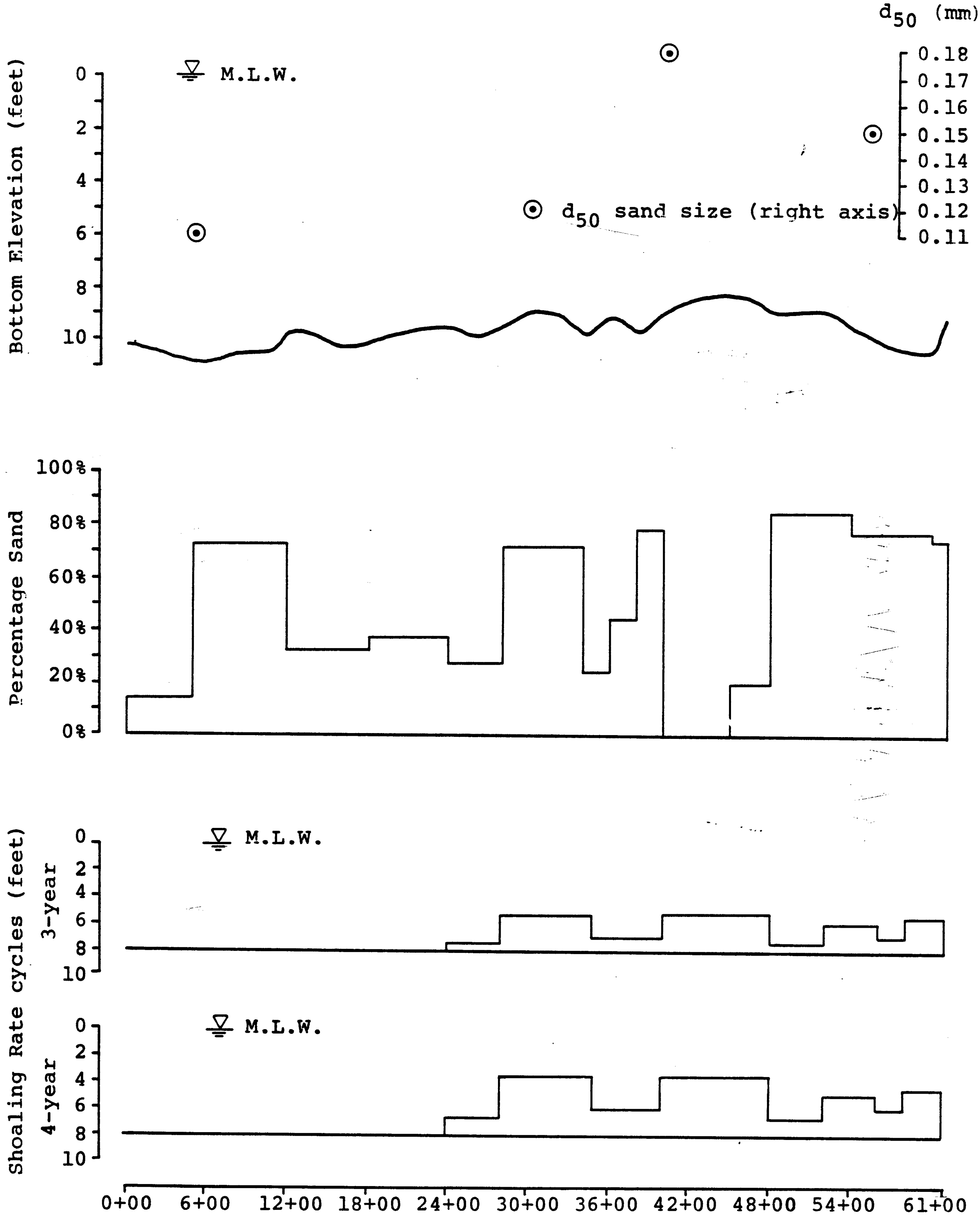


FIGURE 12

SEDIMENT CHARACTERISTICS AND SHOALING BEHAVIOR IN EAST CHANNEL

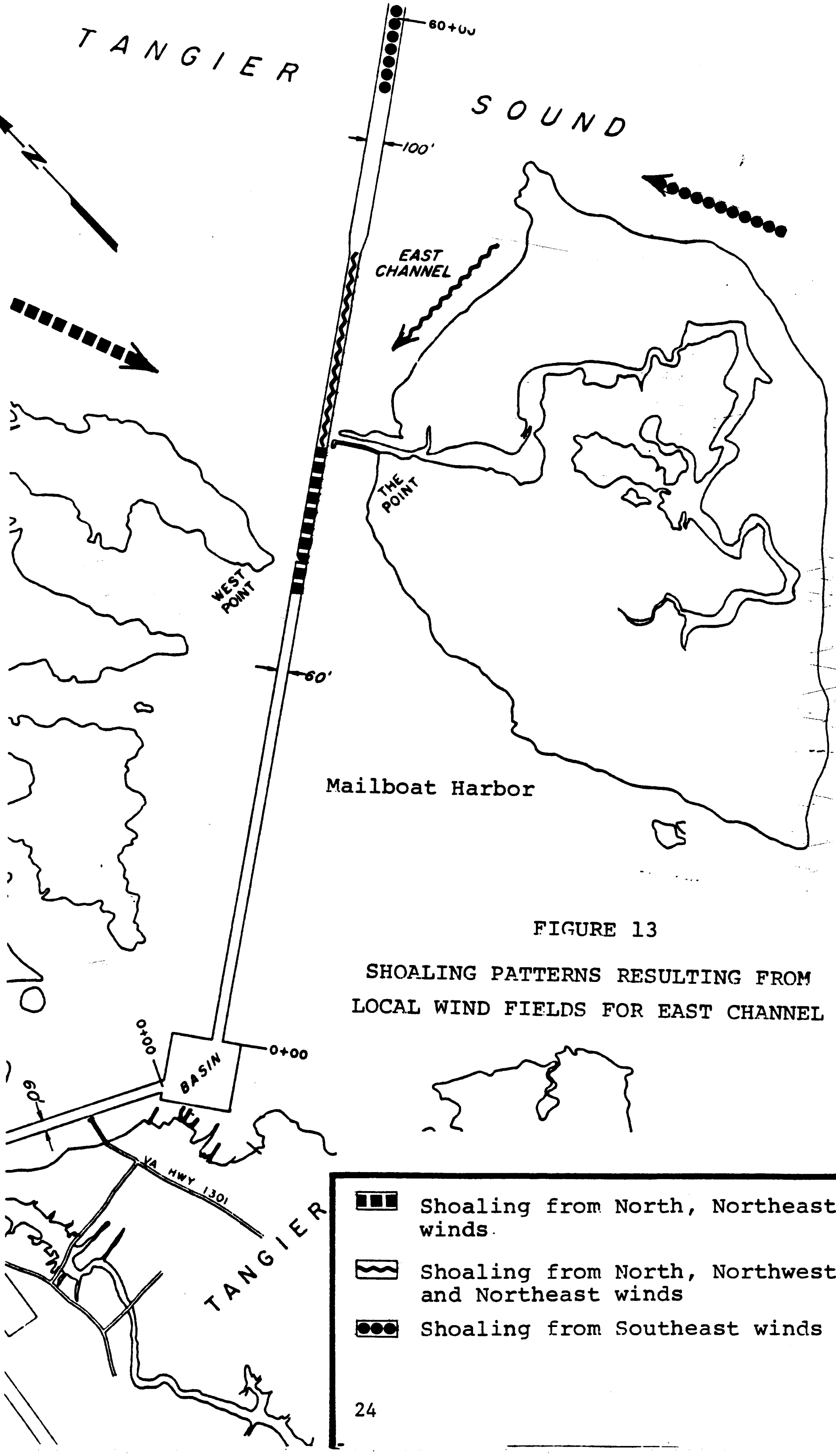


FIGURE 13

SHOALING PATTERNS RESULTING FROM LOCAL WIND FIELDS FOR EAST CHANNEL

▮▮▮	Shoaling from North, Northeast winds.
〰	Shoaling from North, Northwest and Northeast winds
●●●	Shoaling from Southeast winds

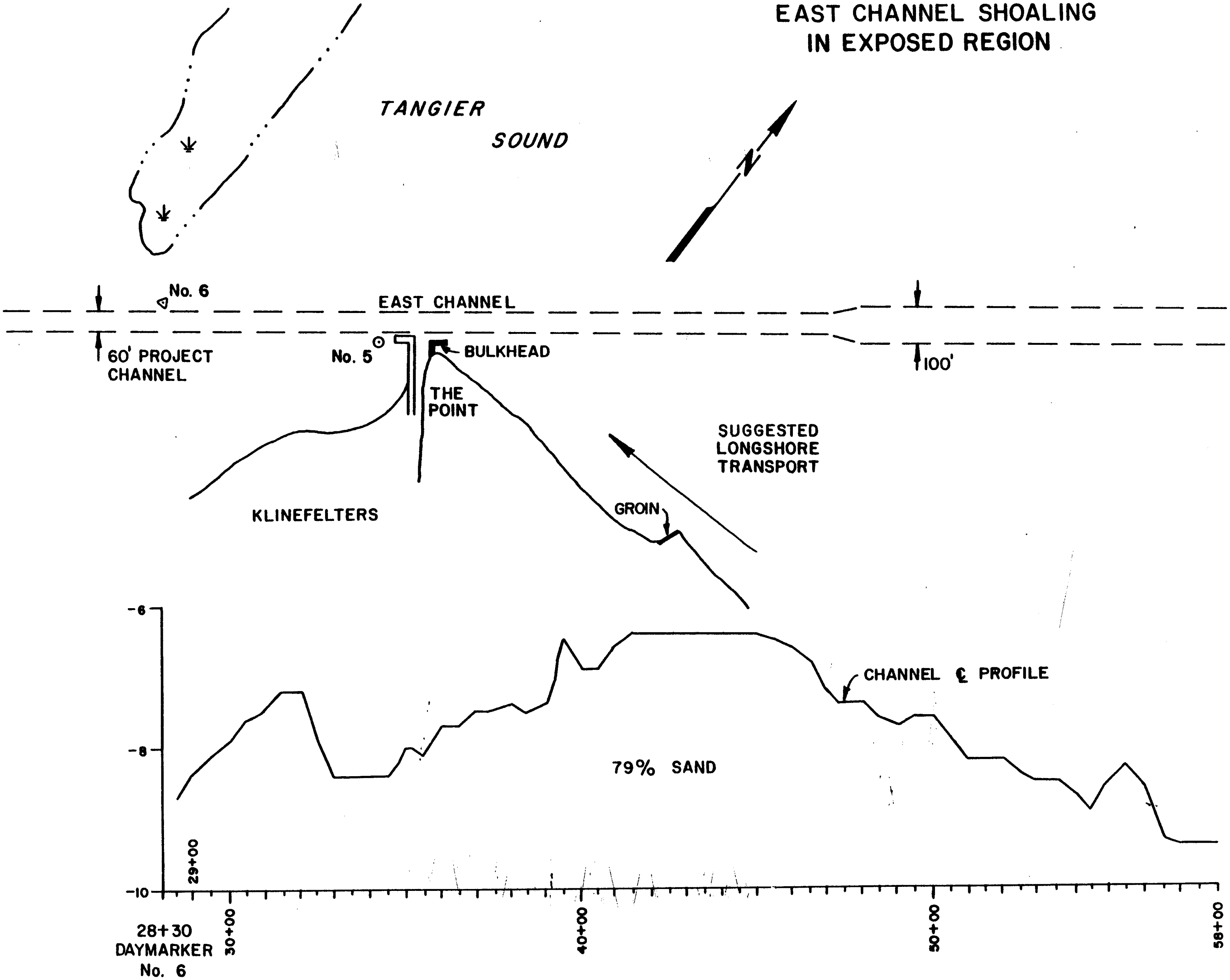
shoreline of Klinefelters Island. In addition, winds from the north, northwest can cause longshore transport along the western shore of the east channel which in turn can be directed into the channel. The wavey lines and bold square patterned areas on Figure 13 show the shoaling caused by these three predominant wind directions. One peculiarity of this area is high levels of silts, clays, and peat in the channel. The peat is most likely an outcrop of an old marsh. However, silts and clays generally accrete in channels that are within protected areas like Mailboat Harbor. Since this section of channel is relatively unprotected, the high levels of silt and clay may be due to a local feature in bottom topography such as a deep pit which resulted from previous maintenance dredging of the channel.

Stations 36+00 - 40+00 (segment d) are subject to the same set of wind and transport conditions as the previous section (c). However, the shoaling rate is only 0.6 feet/year compared to 1.3 feet/year for the previous section. One explanation for the lower rate may be attributed to the bar that was observed crossing the channel at Station 35+50 and shown in Figure 14. This bar decreases the flow area causing the velocities to increase, thereby increasing the transport capacity. The finest materials (silts and clays) are carried away first leaving the sands behind. As shown in Figures 11 and 12, the sediment in this area is composed mostly of sands (79%). Another reason for the lower shoaling rate may be the transport of sand away from the channel during periods of strong northwest winds. In this case, the sand would be carried east along the north shore of Klinefelters Island.

Stations 28+00 - 36+00 (segment e) represent another area of heavy shoaling. The rates were found to be 1.3 feet/per year. The major source of sediment in this section is due to north and northwest winds which cause longshore transport along the east shore of Tangier Island. This shoaling pattern is represented by the bold squares in Figure 13. High levels of sand (72%) are found in 28+00 - 32+00 with similar percentages of silts and clays (74%) between 32+00 - 36+00. The silts and clays are deposited just past the bar described previously (segment d) at Station 36+50. After passing the bar, the channel area increases thereby lowering the velocity

FIGURE 14

EAST CHANNEL SHOALING IN EXPOSED REGION



and allowing the fine material to settle out. The high levels of sand at the entrance into Mailboat Harbor are a result of the constriction of the flow area between West Point and Klinefelters Island. As in the case with the bar, located at 36+50, the velocities are increased, which in turn puts the silts and clays in suspension leaving the sand behind. The silts and clays are then deposited as the flow area widens into Mailboat Harbor. Silt and clay deposits in the channel just inside Mailboat Harbor are as high as 72%.

The inner portion of the East Channel between stations 0+00 - 28+00 (segment f) is bordered by very shallow, broad sandy flats which are against a marsh headland on the north and continue through Mailboat Harbor on the south. Channel sediments in this area range from 70% fine sand near the Basin to 30-40% fine sand beginning about 1200 feet from the basin. Natural processes appear to be transporting some sediments from the flats to the channel via wind wave action. Slow erosion of the surrounding marshes is contributing to the finer grained deposits. Boat wakes, particularly those of the large tour boats, may be a very significant factor in causing shoaling. The vessel displacement as the boat moves causes a significant draw down across the flats thereby agitating sediments and drawing them into the channel. As the wake wave reaches the flats, further agitation of sediments occurs which makes them available for transport via wind and tide generated currents.

West Channel Hypotheses

Figure 15 summarizes the sediment characteristics and shoaling behavior for West Channel in a form identical to Figure 12. The Stations in Figure 15 between 0+00 and 38+50 W are subdivided into segments g thru k on Figure 11.

Unlike East Channel, the West Channel is composed entirely of fine sands ($\geq$86%). West Channel also has a greater variation in bottom topography with elevations ranging between 6.5 to 18.0 feet below MLW. D_{50} sand sizes for West Channel are between 0.15 and 0.18 mm, which is similar to the sizes found in East Channel. Our interpretations of the West Channel segments is given in the following paragraphs.

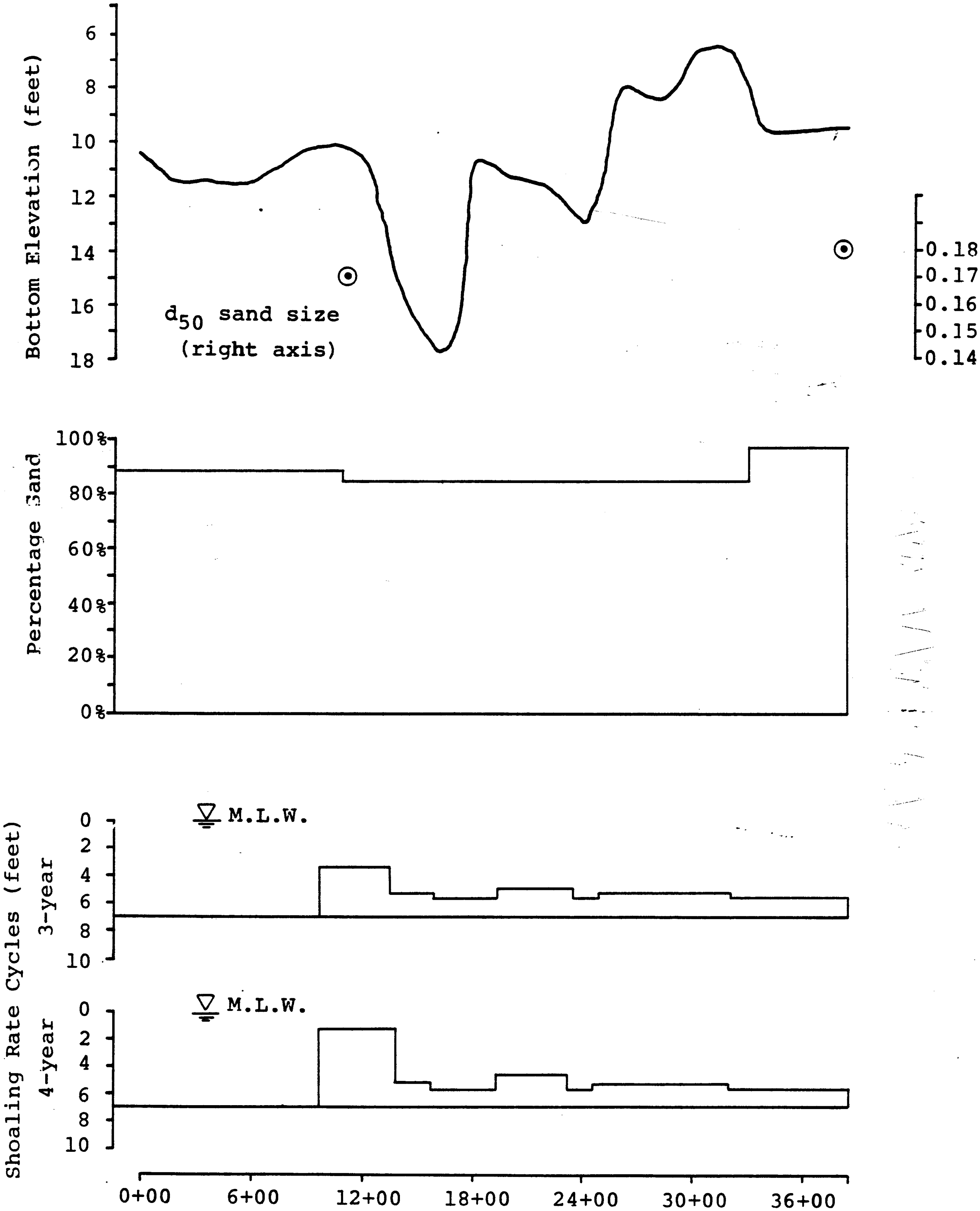


FIGURE 15

SEDIMENT CHARACTERISTICS AND SHOALING BEHAVIOR IN WEST CHANNEL

Stations 0+00 - 10+00 (segment g) is a low shoaling area with rates of 0.1 feet/year. This segment is protected much like segment f of East Channel which lies within Mailboat Harbor. Shoaling rates are low because of relatively small amounts of longshore transport in the area.

Stations 10+00 - 13+00 (segment h) have the highest shoaling rates of any channel segment in West Channel. The rates are 1.3 feet/year. The shoal in this area is most likely a flood tidal delta. Tidal flood currents flow southeast into Mailboat Harbor as shown in Figure 11. In this segment of channel, the flow area begins to widen thereby decreasing the velocities and causing the sands to be deposited. The most likely source of this sand comes from sediments scoured from the adjacent channel segment (Stations 13+00 to 20+00) discussed in the following paragraph. This shoaling pattern is shown in Figure 16.

The segment between Stations 13+00 - 20+00 (segment i) has shoaling rates averaging .35 feet/year. These low shoaling rates are probably due to the constricted channel cross section. The deepest part of West Channel is located in this segment with centerline depths as great as 18.0 feet below MLW as shown in Figure 15. These deep sections appear to correspond with narrow channel width, so that the greater depth, dominance of sand, and lower shoaling potential are assumed to be caused by the higher velocities in the constricted sections of this channel segment. The increase in bottom depth may also be partly caused by the bends in the channel setting up secondary currents which flow normal to the channel centerline and scour the bottom.

Stations 20+00 - 24+00 (segment j) have moderately high shoaling rates of 0.6 feet/year. The shoaling in this area is possibly due to an ebb tidal delta. The shoaling is less than in channel segment (h) (stations 10+00 - 13+00) because changes in flow area are not as great in this section. Shoaling could also be caused by sediment transport moving north or south along the west coast of Tangier Island and directed into the West Channel entrance. Note that this section of channel is also susceptible to winds from the west which could cause sediments to funnel into this area as shown by the arrows in Figure 16.

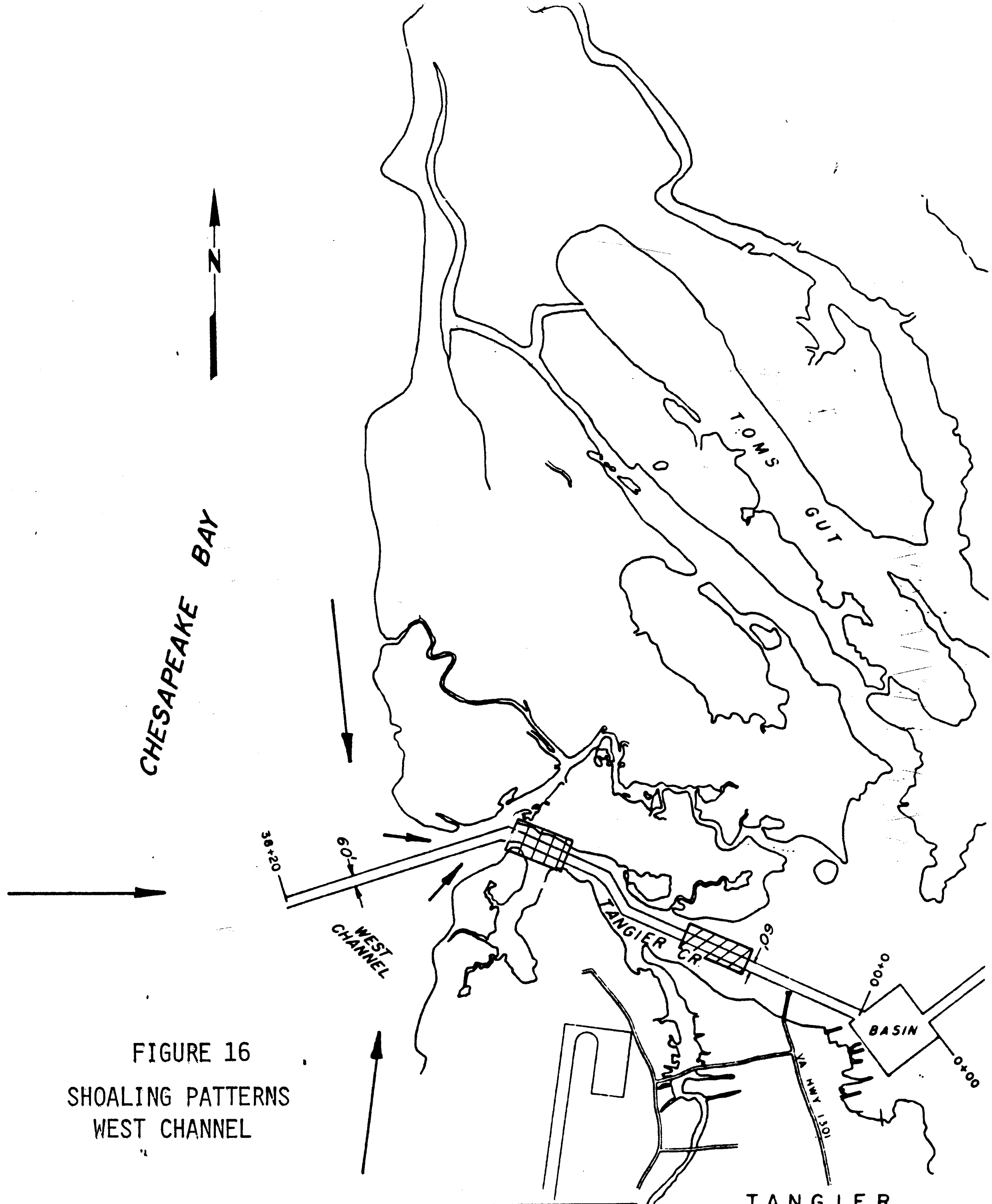


FIGURE 16
SHOALING PATTERNS
WEST CHANNEL

Shoaling from flood tidal delta
Shoaling from ebb delta or long-shore transport along west coast

The segment of West Channel (Stations 24+00 - 39+20) (segment k) extends out to the 6 foot contour west of Tangier Island. The shoaling rates are relatively low, averaging 0.35 feet/year. Most of the channel is beyond the longshore transport region along the west coast of Tangier Island. Sediments deposited in the channel closer to shore are carried into West Channel and deposited at section (h) (Station 10+00 - 13+00) and (j) (Stations 20+00 - 24+00) as discussed previously. Much of the sand within the littoral zone may very well bypass the channel entrance and continue moving along the coastline.

This concludes the discussion on the shoaling in East and West Channels of Tangier Island. It should be emphasized that the comments presented in this chapter are initial interpretations of limited bottom profile, sediment, and shoaling data. Obviously, more data is necessary to accurately assess the shoaling problems as discussed in the next chapter.

PART V: RECOMMENDED MODIFICATIONS

Long-Term Solutions

The advance maintenance dredging schedule shown in Figures 4 and 6 represent only temporary solutions to the shoaling in East and West Channels. After reviewing the coastal processes at Tangier Island, discussed in the previous chapter, it is possible to formulate potential long-term solutions for further investigation. Four alternatives to the shoaling problem are shown in Figure 17. A brief discussion is given for each of the alternatives ranked in order from (a) to (d), (a) being the most suitable solution.

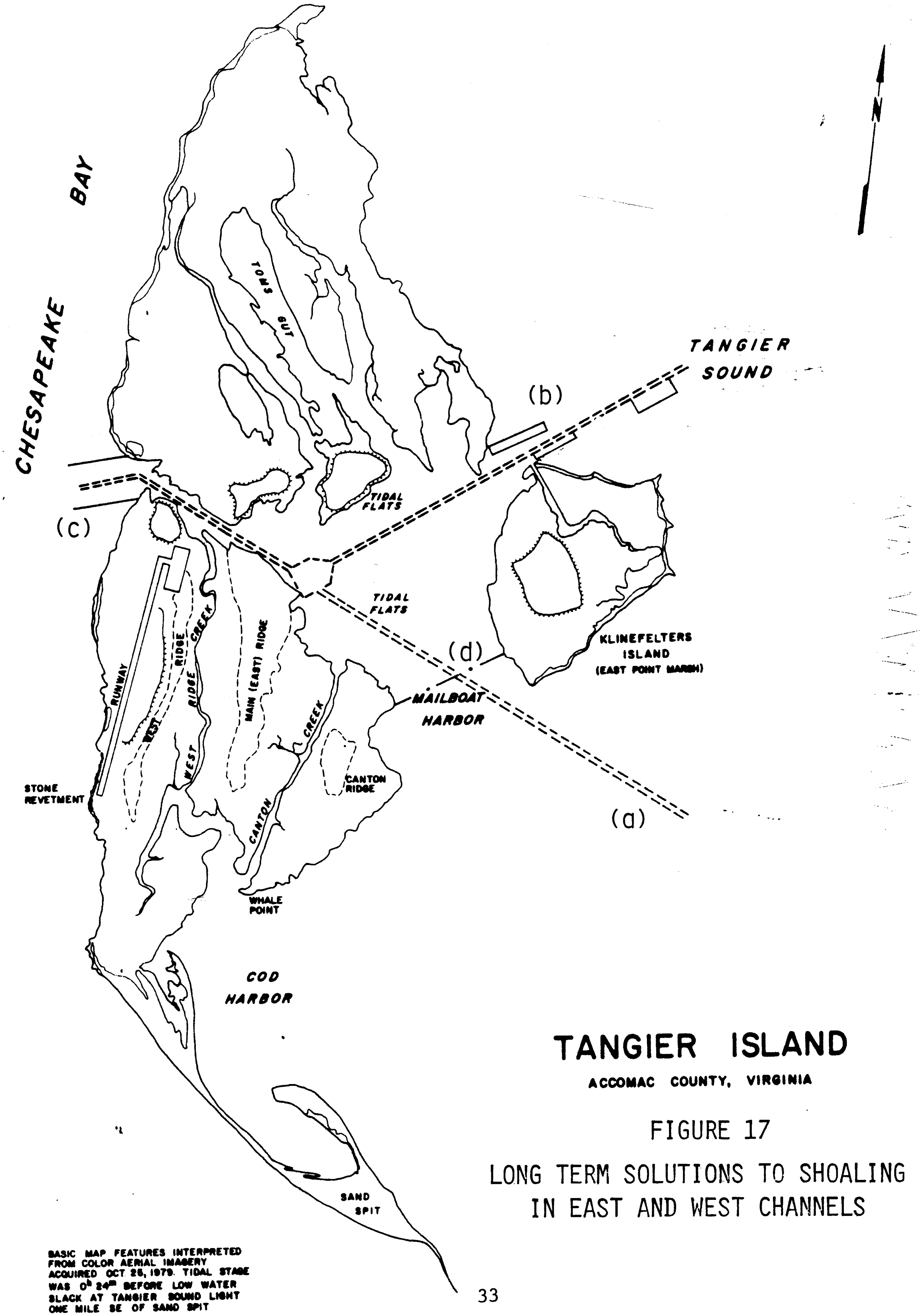
(a) Mailboat Harbor Channel

This new proposed channel as shown in Figure 17 represents perhaps the best water route out of the anchorage because it is sheltered from severe northwest winds. Shoaling in the proposed channel would be minimal since the southeast shore of Tangier Island is not a zone of active sand transport. The lengths of the channel from the anchorage to the 6 foot contour would be approximately 4800 feet, which is intermediate in length between the existing East and West Channels. It would also be sheltered from wind driven ice floes which have reportedly created ice jams in the East Channel.

The main disadvantage of the proposed channel is the length of time that would be required to design and obtain approvals for the construction. In addition, this alternative may not be suitable to Tangier Island residents using Mailboat Harbor for crab shedder operations. The impact of not maintaining the East Channel would also have to be addressed.

(b) Sediment Traps

This option involves dredging large pits to trap the longshore transport. Two sites are shown in Figure 17, one of which traps sand from northwest transport along Klinefelters Island while the other location traps sand traveling southeast along the western shore of Tangier Island. The sand would have to be removed periodically depending on the size of these pits.



TANGIER ISLAND

ACCOMAC COUNTY, VIRGINIA

FIGURE 17

LONG TERM SOLUTIONS TO SHOALING
IN EAST AND WEST CHANNELS

One drawback of this alternative is the fact that the dredged pit may change the wave refraction patterns in the area, thereby causing increased erosion of shoreline which may shoal in the channel.

(c) Jetties at West Channel Entrance

This alternative would help reduce the shoaling in West Channel particularly between Stations 20+00 and 24+00. As suggested in the report of Coastal Processes on the west shore of Tangier Island, the net longshore transport is about 18,600 cubic yards/year, to the south. This net value is a result of the potential transport of approximately 40,300 cubic yards of sand south and 21,700 cubic yards of sand north during the course of one year. Since the longshore transport can be from two directions, two jetties would be required, located north and south of the West Channel entrance as shown in Figure 17.

A sand by-passing program may have to be considered with this option. The jetties would stop the transport of sand along the west coast and cause erosion of shoreline. Since about 65% of the potential transport moves north to south along the west coast, the serious erosion would occur south of the jetties along the shoreline bordering the airport runway. Perhaps dredged material from East Channel and sand traps could be placed south of the jetties to compensate for this erosion.

(d) Mailboat Harbor Dike

By placing a dike across Mailboat Harbor, the entire tidal prism would be forced to pass through West and East Channel. This would increase velocities in those channels, and thus reduce shoaling.

However, this added flow is probably not sufficient to eliminate shoaling. Based on an area of 1.32×10^7 square feet and a spring range of 1.9 feet, the tidal prism of Mailboat Harbor is 2.4×10^7 ft^3.

The cross-sectional area of the inlet required for this tidal prism was found to be 377 ft^2. The total cross-sectional area of the narrowest inlet sections of East and West Harbor is approximately 3345 ft^2. Since the existing cross sectional area of both channels (3345 ft^2) is so much larger than the area required for the given tidal prism (377 ft^2), the channels will probably still shoal. The condition could be improved somewhat if it were found that the dike would cause an increase in head difference in the channels.

Other Hard Data Needed

In order to implement any of the long term solutions shown in Figure 17, the following data must be collected for use in a more detailed engineering analysis:

1. wind climate for Tangier Island
2. flow patterns in Mailboat Harbor
3. simultaneous tidal currents and ranges for complete spring and neap cycles
4. shoreline change map with documented details
5. bathymetry of channel entrances to Tangier Sound and Chesapeake Bay, and of Mailboat Harbor and approaches.

Summary

The shoaling rates and sand concentrations for East and West Channels are summarized in Figure 11. Based on the coastal processes (see Table 4) at Tangier Island, the shoaling in East Channel is most likely caused by longshore transport from waves traveling from the northwest, north, northeast, or southeast. On the other hand, the shoaling in West Channel is a result of flood and ebb tidal deltas.

Four options were proposed to the shoaling problem as alternatives to maintenance dredging. The most acceptable option is a new channel dredged from the anchorage through Mailboat Harbor. This proposed channel is more protected from wave attack and ice and is intermediate in length to the existing East and West Channels.

In order to evaluate any one of the four options, more data at Tangier Island will be necessary. This data includes the wind climate, flow patterns in Mailboat Harbor, tidal currents and ranges, documentation of the shoreline changes, and bathymetry.

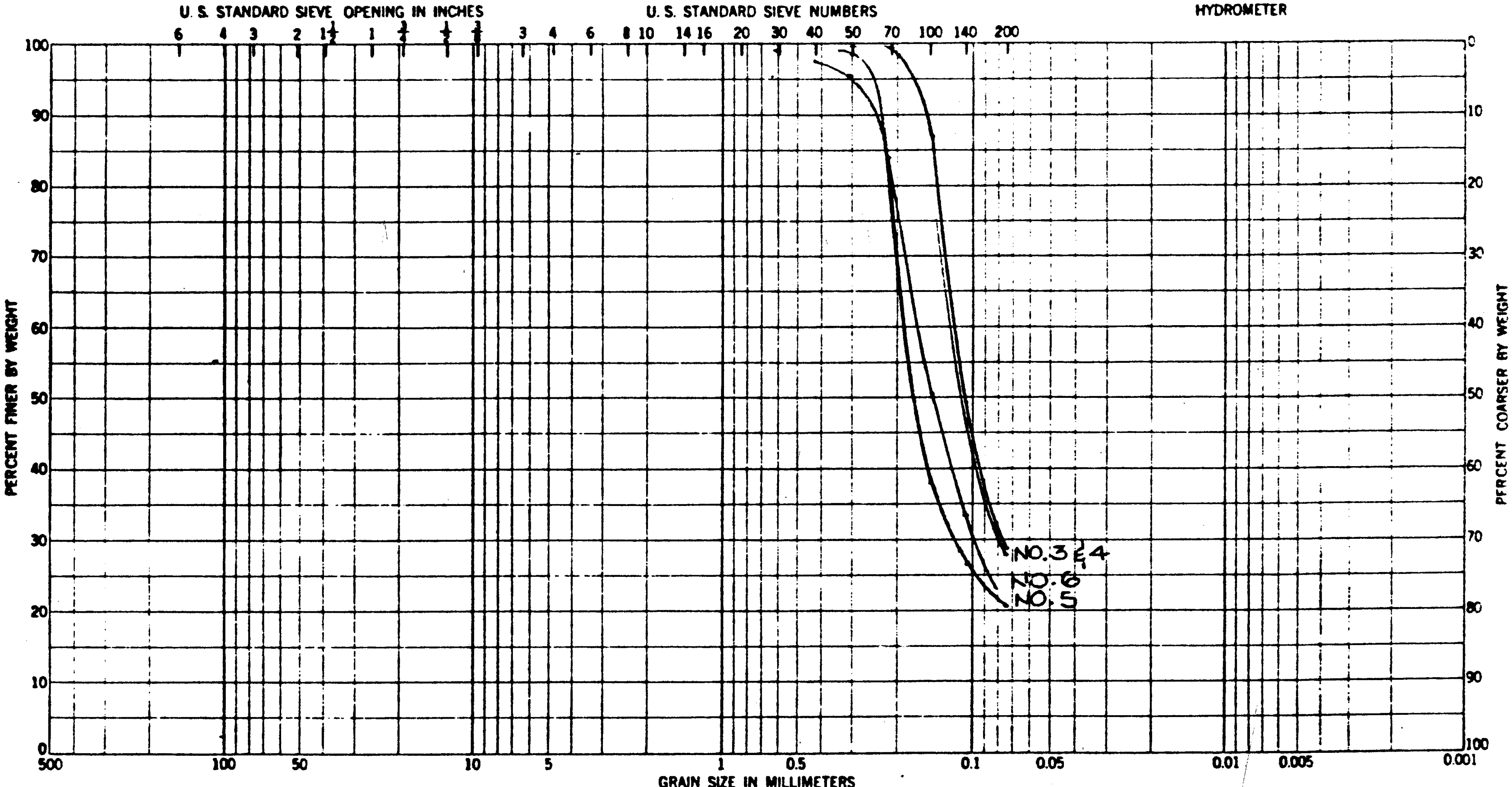
APPENDIX I

PROJECT CHANNEL SEDIMENTS

TANGIER CHANNEL

STA. NO	SAND	LL	PI	SYM	CLASSIFICATION
4+00 WEST	89%			(SP-SM)	fine SAND, little silt
11+00	86%			(SM)	fine SAND, little silt *
33+00	97%			(SP)	fine SAND *
38+00	97%				
-1+00 EAST	14%			(CH)	sl. org. CLAY & SILT, little fn. sand.
-3+00 EAST	13%				
5+00	71%			(SM)	fine SAND, some silt *
10+00	71%				
15+00	33%	36	7	(ML)	sl. org. SILT & CLAY w/ some to and sand.
20+00	39%				
25+00	28%				
30+00	72%			(SM)	fine SAND, some silt *
34+00	26%			(ML)	sl. org. SILT & CLAY some fn. sand
35+00	45%			(ML)	sl. org. SILT & CLAY and fn. sand
38+00	79%			(SM)	fine SAND, some silt *
40+00				(PT)	ROOT MATTER
45+00	20%			(ML)	sl. org. SILT & CLAY some fn. sand
50+00	84%			(SM)	fn. to med SAND, little silt
55+00	79%				fine SAND, some silt *
60+00	77%				

* SEE GRADATION CURVES.



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
3	5+00 E.	(SM) fine SAND				
4	30+00 E.	some silt				
5	38+00 E.					
6	55+00 E.					

Project TANGIER CHANNEL - EAST -

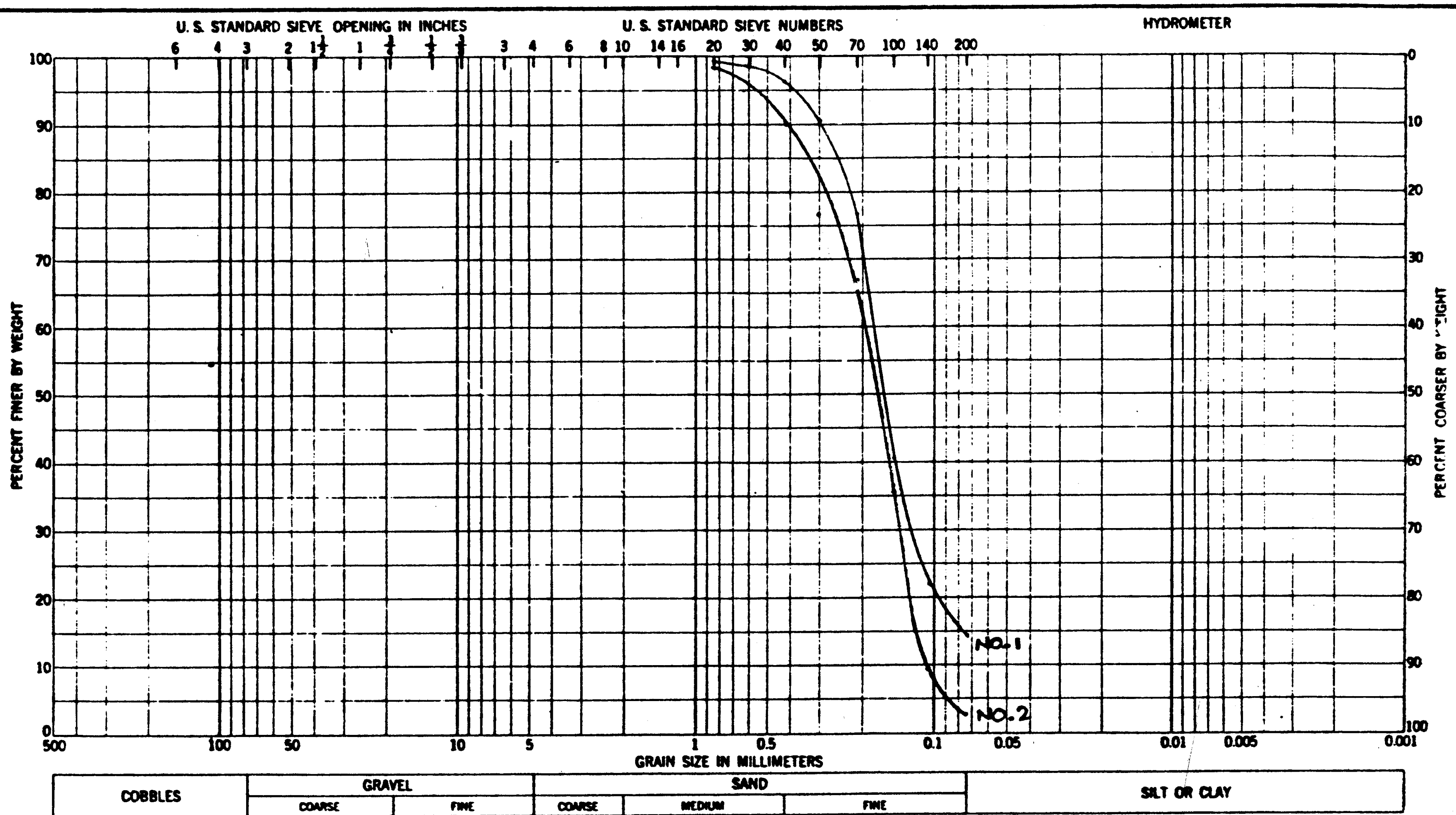
Area

Boring No.

Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087



Sample No.	~~Elev or Depth~~	Classification	Nat w %	LL	PL	PI
1	11+00 W	(SM) fn. SAND, little silt.				
2	38+00 W	(SP) fn. to med. SAND.				

Project TANGIER CHANNEL - WEST -

Area

Boring No.

Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087

APPENDIX II

ECONOMIC EVALUATION OF
ADVANCE MAINTENANCE DREDGING

WATERWAY SURVEYS & ENGINEERING, LTD.
5596 Greenwich Road
VIRGINIA BEACH, VIRGINIA 23462
(804) 490-1691

JOB TANGIER – SHOALING RATES
SHEET NO. 1 OF
CALCULATED BY J.L.O DATE 5-27-82
CHECKED BY DATE
SCALE

EAST CHANNEL

STATION	SHOALING RATES FT/YR	CY/YR	DREDGING TO – 8 MLW + 1' O.D. EXIST PROGRAM (1 YR)	ALT. A (3 YR CYCLE)	ALT B (4 YR CYCLE)
0+00 to 24+00	0.2	1070	1070	3210	4280
24+00 to 28+00	0.4	360	360	1080	1440
28+00 to 35+00	1.3	2030	2030	6090	8120
35+00 to 40+00	0.6	670	670	2010	2680
40+00 to 48+00	1.3	2320	2320	6960	9280
48+00 to 52+00	0.4	600	600	1800	2400
52+00 to 55+00	0.9	1000	1000	3000	4000
55+00 to 58+00	0.6	670	670	210	2680
58+00 to 61+00	1.1	1230	1230	3690	4920

TOTAL DREDGING: EAST CHANNEL — 9950 C.Y. — 29,850 C.Y — 39,800 C.Y.

WATERWAY SURVEYS & ENGINEERING, LTD.
5596 Greenwich Road
VIRGINIA BEACH, VIRGINIA 23462
(804) 490-1691

JOB
SHEET NO. 2 OF
CALCULATED BY DATE
CHECKED BY DATE
SCALE

WEST CHANNEL

STATION	SHOALING RATES FT/YR	SHOALING RATES C.Y./YR	DREDGING TO -7 MLW: EXIST PROGRAM (1 YR)	ALT A (3 YR CYCLE)	ALT B (4 YR CYCLE)
0+00 to 10+00	0.1	230	230	690	920
10+00 to 13+00	1.3	870	870	2610	3480
13+00 to 16+00	0.4	270	270	810	1080
16+00 to 19+00	0.3	200	200	600	800
19+00 + 22+50	0.6	470	470	1410	1880
22+50 + 24+00	0.3	100	100	300	400
24+00 to 32+00	0.4	720	720	2160	2880
32+00 to 38+00	0.3	400	400	1200	1600

TOTAL DREDGING : 3260 CY 9780 CY 13,040 CY.
WEST CHANNEL

WATERWAY SURVEYS
& ENGINEERING, LTD.
5596 Greenwich Road
VIRGINIA BEACH, VIRGINIA 23462
(804) 490-1691

JOB
SHEET NO. 3. OF
CALCULATED BY DATE
CHECKED BY DATE
SCALE

1982 DREDGING COST
furnished by Sam McGee, C of E.

0 to 50,000 C.Y	$2.00/C.Y.
50,000 to 75,000 C.Y	$1.85/C.Y.
75,000 to 100,000 C.Y.	$1.75/C.Y.
mob & demob	$115,000.

projected increase of 4% per year

EXIST PROGRAM (DREDGE TO -8'MLW + 1'O.D.)

DREDGING CYCLE OF 1 YR.

13,210 CY @ $2.00/C.Y. = $26,420

mob & demob = $115,000

COMMON CYCLE OF 12 YEARS

COST = $141,420 + $141,420 (F/A 4%, 12)

= $141,420 + $141,420 (15.026)

= $2,266,396.92

WATERWAY SURVEYS
& ENGINEERING, LTD.
5596 Greenwich Road
VIRGINIA BEACH, VIRGINIA 23462
(804) 490-1691

JOB ______
SHEET NO. 2 OF ______
CALCULATED BY ______ DATE ______
CHECKED BY ______ DATE ______
SCALE ______

ALTERINATIVE A (3 YR CYCLE)

39,630 CY @ $2.00 /C.Y. = $79,260

mob & demob = $115,000

COMMON CYCLE OF 12 YEARS

COST = 194,260 + 194,260 (F/P, 4%, 3)
+ 194,260 (F/P, 4%, 6) + 194,260 (F/P, 4%, 9)
+ 194,260 (F/P, 4%, 12)

= 194,260 + 194,260 (1.125) + 194,260 (1.265)
+ 194,260 (1.423) + 194,260 (1.601)

= $1,245,983.64

ALTERINATIVE B (4 YR CYCLE)

52,840 CY @ $1.85 /C.Y = $97,754

mob & demob = $115.000

COMMON CYCLE OF 12 YEARS

COST = $212,754 + 212,754 (F/P, 4%, 4) +
212,754 (F/P, 4%, 8) + 212,754 (F/P, 4%, 12)

= 212,754 + 212,754 (1.170) + 212,754 (1.369) + 212,754 (1.601)

= $1,093,555.56