DELAWARE RIVER
COMPREHENSIVE NAVIGATION STUDY

MAIN CHANNEL DEEPENING

FINAL INTERIM FEASIBILITY STUDY
AND ENVIRONMENTAL IMPACT STATEMENT

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
FEBRUARY 1992

SYLLABUS

This report is an interim feasibility study and is a partial response to a resolution adopted by the House Committee on Public Works authorizing the Delaware River Comprehensive Navigation Study (2 December 1970) as well as the 1 March 1954 resolution by the Committee on Public Works of the United States Senate regarding channel dimensions of the Delaware River, Philadelphia to the Sea project. In addition, the study responds to September 20, 1974 resolution by the Senate Committee on Public Works to develop a regional dredging disposal plan for the tidal Delaware River and its tributaries. The existing Delaware River, Philadelphia to the Sea project was adopted in 1910 and modified in 1930, 1935, 1938, 1954, and 1958. The project extends from Allegheny Avenue in Philadelphia to deep water in Delaware Bay. The channel widths range from 400 feet in Philadelphia Harbor to 1,000 feet in the bay. Through Philadelphia Harbor the channel is 40 feet deep on the west side and 37 feet deep on the east side. The project also provides for widening at critical bends. There are nineteen anchorages on the Delaware River; six are authorized under the Philadelphia to the Sea project (Mantua Creek, Marcus Hook, Deepwater Point, Reedy Point, Gloucester and Port Richmond) and the remaining thirteen are natural deep-water anchorages. The disposal of dredged material is a Federal responsibility. The project includes twelve training dikes to reduce shoaling in the channel and anchorages or minimize dredging and disposal costs.

Channel depths ranging up to 50' and channel widths to accommodate one-way and two-way traffic are analyzed in this feasibility study. In addition it examines anchorages and needs certain of tributary projects. Based on the findings of this study, the recommended plan of improvement includes a two-way full width channel of variable width and a depth of 45 feet from deep water in Delaware Bay into Philadelphia Harbor, bend widening, partial deepening of the Marcus Hook Anchorage, disposal areas, and navigation aids.

The ultimate cost of the project is $278,293,000 of which $184,456,000 is Federal and $93,837,000 is non-Federal. These figures are based on 75% Federal and 25% non-Federal cost sharing for the general navigation features (channel and anchorage) and provision of lands, easements, rights-of-way, relocations, and dredged material disposal areas by the non-Federal sponsor. Navigation aid costs of $856,000 are a Federal responsibility. Associated costs of $23,205,000 for berth dredging and bulkhead modifications are a non-Federal responsibility. The non-Federal sponsor is also responsible for an additional 10% of the GNF ($24,480,000) less credit for LERRD, however since LERRD exceeds 10% of the GNF, there is no additional contribution required. Based on the average annual project investment costs of $32,113,000 and average annual benefits of $42,776,000 the benefit cost ratio is 1.33 to 1. All operation and maintenance costs, exclusive of berth area dredging would be borne by the Federal government.

The requirements of Section 404(r) of Public Law 92-500, as amended, have been met.

DELAWARE RIVER
COMPREHENSIVE NAVIGATION STUDY
MAIN CHANNEL DEEPENING
FEASIBILITY REPORT

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DELAWARE RIVER COMPREHENSIVE NAVIGATION STUDY
MAIN CHANNEL INTERIM

INTRODUCTION

1. The Delaware River navigation system serves the Middle Atlantic region by providing a series of navigation channels maintained by the U.S. Army Corps of Engineers. The Delaware River Comprehensive Navigation Study is analyzing the ability of the various channels to respond to the demands of present and prospective waterborne commerce. This Interim Feasibility Report has been prepared to document the economic, environmental, social, institutional, and engineering feasibility of improving the main Delaware River channel for commercial navigation and to consider improvement of tributary channel projects as a result of main channel deepening.

STUDY AUTHORITY

2. STUDY RESOLUTIONS. This study is being conducted in partial response to a resolution by the Committee on Public Works of the United States Senate, dated 1 March 1954. The resolution reads as follows:

> "Resolved by the Committee on Public Works of the United States Senate, That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act, approved June 13, 1902, be, and is hereby, requested to review the reports on the Delaware River between Philadelphia and the Sea, submitted in House Document Numbered 340, Seventy-seventh Congress, First Session, and previous reports, with a view to determining whether any modification in the existing channel dimensions and anchorage areas is advisable at this time."

3. In addition, the study is addressing in part a resolution passed by the House Committee on Public Works on December 2, 1970 which is much more comprehensive and reads as follows:

> "Resolved by the Committee on Public Works of the House of Representatives, United States, that the Board of Engineers for River Harbors is hereby requested to review the reports on the Delaware River from Trenton, New Jersey, to the sea, contained in House Document Number 358, 83rd Congress and other reports with a view to promoting and encouraging the efficient, economic and logical development of the Delaware River Ports. The scope of such review shall encompass investigation of current shipping problems, adequacy of facilities, delays in intermodal transfers, channel dimensions, storage locations and capacities, and other physical aspects of affecting waterborne commerce, including the conduct of such model studies as may be necessary to establish an efficient layout of the port complex and the

design of navigation facilities. Such investigation shall also include, but not be limited to, the impact of waterborne commerce in the Delaware River region on the local, national and international economies, and its relation thereto: research into current and future markets for the import and export commerce of the region; evaluation of regional integrated approaches toward the opportunities and problems engendered thereby; an inventory of regional shipping facilities, capacity, and operating entities and evaluation thereof: a study of industrial and trade trends owing to new and improved technological advances, methods, improved vessel design, cargo handling facilities, extension of automation, and other cargo, vessels, and operating concepts; relationship of waterborne shipping to other modes of transportation with particular reference to intermodal transfer and facilitation of through shipments; comparison of the status and future of Delaware River ports and terminals with other national and international harbor complexes; recommendations for types, sizes, and locations of future facilities, and improvements and expansions of existing facilities,including deep-draft navigation channels; recommendations for improvements in port and industrial operations and development through improved coordination and programming, and long-term planning; determination of the adequacy of the region's shipping capacity in terms of its role and function of the port complex in Delaware River Basin development; presentation of guidelines for regional development to the extent required by navigational uses and potentials; determination of bulk movement projections, including estimated raw material requirements of the regional and national economy possible of shipment through the Delaware river ports, with particular reference to economies afforded by use of supersized bulk transport vessels and tankers; effects on the regional and national economy of new and expanded heavy industry and ancillary industries dependent thereon as a result of improved navigation and more efficient port operations; and desirability and extent of Federal participation in securing adequate bases for expansions and improvement of shipping facilities and further integration of regional planning for waterborne commerce. In carrying out this study the Secretary of the Army and the Chief of Engineers shall cooperate with and coordinate their efforts with all affected Federal departments, agencies and instrumentalities and all other interested parties, public and private."

4. OTHER RESOLUTIONS. It was determined during the course of the reconnaissance study that one other outstanding resolution could be addressed while responding to the two primary study resolutions. This is the resolution regarding dredged material disposal adopted by the U.S. Senate Committee on Public Works which was adopted on September 20, 1974 and reads as follows:

"Resolved by the Committee on Public Works of the United States Senate, That the Board of Engineers for Rivers and Harbors, created under the provisions of Section 3 of the River and Harbor Act approved June 13, 1902, be, and is hereby requested to review the report of the Chief of Engineers on the Delaware River between Philadelphia, Pennsylvania and Trenton, New Jersey, and Philadelphia to the Sea, printed as House Document 358, 83rd Congress, 2nd Session, and other reports with a view to developing a regional dredging spoil disposal plan for the tidal Delaware River, its tidal tributaries, and Delaware Bay."

STUDY AREA

5. The Delaware River Comprehensive Navigation Study is addressing the navigation related problems of all waterways which support commercial activity along the Delaware River and tributaries from Trenton, New Jersey to the Sea. Figure 1 shows the limitations of commercial navigation channels tributary to the Delaware River. This Interim study concerns itself only with navigation along the Delaware River and certain tributary projects which may be constrained by the main channel depth.

STUDY OBJECTIVES

6. The purpose of the interim study is to address and evaluate current problems, such as adequacy of facilities, delays in intermodel transfers, channel dimensions, storage locations and capacities, and other physical factors affecting waterborne commerce on the Delaware River and its deep draft tributaries. The goal is to determine an appropriate plan for the efficient use and development of the Delaware River channel system.

7. The study made the maximum use of previously developed data to evaluate and recommend measures for which there is Federal interest and local support.

8. THE REPORT AND THE PLANNING PROCESS. This report is organized into a main report, an environmental impact statement, an amendment to the environmental impact statement, a Correspondence Appendix, and an appendix evaluating the effects of dredged or fill material according to Section 404(b)(1) of the Clean Water Act. The main report explains the study methodology, accomplishments, conclusions and recommendations.

9. The main report proceeds from a profile of the natural, human, and economic resources through a description of the problems and needs of the study area to a discussion of the plan formulation process. Details of the alternative plans are then highlighted in a separate section. The main report ends with rationale and description for the recommended plan, study conclusions, and recommendations. The environmental impact statement is a self

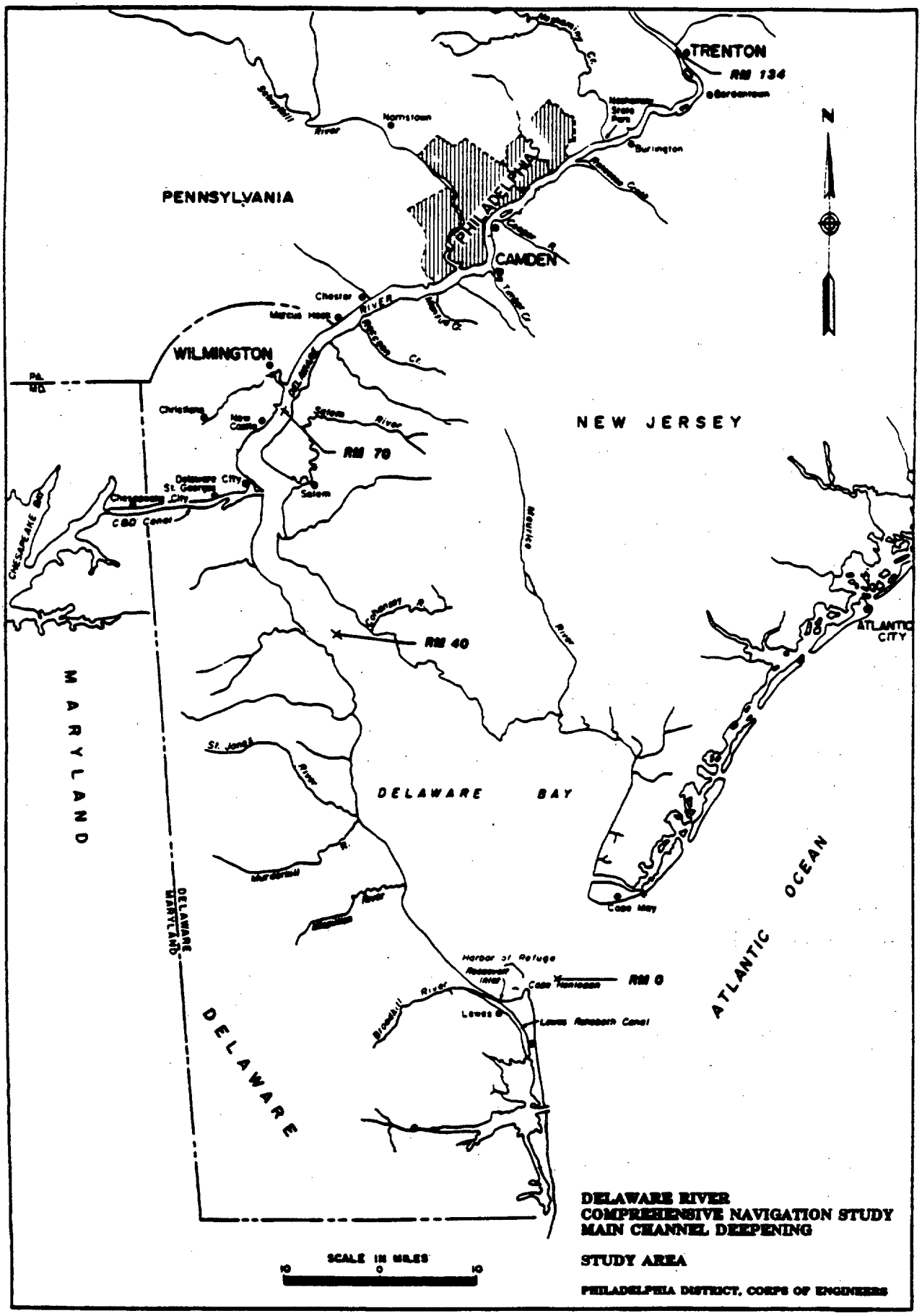

TRENTON
RM 134
Burlington
Norristown
PENNSYLVANIA
PHILADELPHIA
CAMDEN
Chester
WILMINGTON
PA
MD
Christiana
New Castle
Salem River
RM 70
Salem
Delaware City
St. George
Chesapeake City
C&D Canal
CHESAPEAKE BAY
NEW JERSEY
Maurice River
Cohansey R.
RM 40
ATLANTIC CITY
MARYLAND
St. Jones River
DELAWARE BAY
Mispillion River
Cape May
ATLANTIC OCEAN
DELAWARE
MARYLAND
Harbor of Refuge
Roosevelt Inlet
Cape Henlopen
RM 0
Broadkill River
Lewes
Lewes Rehoboth Canal
DELAWARE
N
SCALE IN MILES
10 0 10
DELAWARE RIVER
COMPREHENSIVE NAVIGATION STUDY
MAIN CHANNEL DEEPENING
STUDY AREA
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 1

supporting document which informs decision-makers and the public of project alternatives and their environmental effects. It analyzes measures which would avoid or minimize adverse impacts or enhance the quality of the human environment.

10. The planning process used in completing this report is a systematic, multi-objective procedure for analyzing problems and opportunities and culminates in the selection of a recommended plan of action. The process provides decision-makers and the interested public with information on the basic assumptions employed, the data and information analyzed, the areas of risk and uncertainty, the reasons and rationale used, and the significant implications of each alternative plan.

PRIOR REPORTS AND STUDIES

11. FEDERAL STUDIES. The following studies and reports completed by the Corps are related to waterborne transportation on the Delaware River. They represent only the most pertinent reports.

12. Delaware River Channel Dimensions Study. This study, initiated by the Corps of Engineers in response to the 1954 Resolution, analyzed existing channel dimensions in the Delaware River to determine the advisability of modifying existing channel dimensions and providing additional and improved anchorage facilities.

13. In 1964, a draft report on the existing channel dimensions was completed, which analyzed the feasibility of deepening the existing channel from Philadelphia to the Sea to 50 feet and widening it to 2000 feet. The study indicated that these modifications were feasible and that further detailed studies were warranted, however, these studies were deferred pending resolution of issues related to potential development of deepwater port facilities.

14. Long Range Spoil Disposal Study. This study program was conducted in response to the realization of the diminishing availability of suitable riparian land for use as disposal sites for Delaware River navigation projects. The study was completed in 1969. The goal of the study was to locate and obtain disposal areas which were within efficient pumping distance of the shoal areas for the Philadelphia to the Sea project. Achievement of these study goals, however, was limited by various physical, environmental and institutional constraints on location of the sites.

15. As a result of the study potential sites were identified, each with its own constraint or limitation, for disposal of material. The study also concluded that maintenance of the Delaware River channel from Philadelphia to the Sea would be possible for at least twenty years with existing disposal areas. If new disposal sites were not developed, any new work would shorten the life span of

existing disposal sites. Subsequent to completion of the study, new policies, such as the National Environmental Policy Act were enacted which invalidated the rationale used for identification of new disposal sites. However, the study remains an excellent technical reference on many aspects of dredging and disposal operations.

16. Atlantic Coast Deepwater Port Facilities Study. Completed in June 1973, the purpose of the study was to determine the most economic, efficient and logical means for developing facilities for handling dry and liquid bulk carriers, and consider methods to govern, finance and maintain these facilities while protecting and/or enhancing environmental values of the affected areas. The study was conducted by the Philadelphia District in cooperation with the Baltimore, Norfolk and New York Districts and New England Division.

17. In response to the purposes outlined, the study evaluated numerous candidate sites along the Atlantic Coast as well as several types of deepwater port facilities. These included local and regional islands both with and without on site storage as well as various types of mooring systems. Facilities to handle crude oil as well as grain, coal and iron ore were considered. The preliminary studies found that several sites were economically feasible for handling both dry and liquid bulk commodities, however a multi-purpose deepwater port was less attractive for dry bulk movements than channel deepening. Detailed studies found that the most economic locations for crude oil facilities were in the Atlantic Ocean off of New Jersey and off of Big Stone Beach in Delaware Bay. Institutionally, however, there was no single site which was not strongly opposed at the time by local interests and government officials. Therefore no recommendations were made for further studies of a deepwater port facility. Several of the economic assumptions underlying the study findings are no longer valid.

18. Delaware Estuary Salinity Intrusion Study. The Philadelphia District completed this study with the Division Engineer's Notice issued in January 1983. The study determined the probability for advance or retreat of salinity in the Delaware Estuary and the quantity of fresh water inflow needed to protect the various water users along the estuary.

19. Delaware River Shallows Study. This study, completed in March of 1979, was concerned with evaluating the shallow water resources of the Upper Delaware Estuary, from Reedy Point, Delaware to Trenton, New Jersey. Shallow water areas are defined as those areas from the mean low water line to the -10 foot mean low water contour. The study defined these areas, and developed a system by which their ecological value to the estuary can be evaluated. Such evaluations have assisted personnel of the Philadelphia District in processing permit applications involving encroachments within the

study area and provide a good reference for consideration of aquatic disposal.

20. Environmental Impact Statements (EIS). An EIS for project maintenance of the Delaware River, Trenton to the Sea, (including the Delaware River, Philadelphia to Sea; Delaware River, Philadelphia to Trenton; and Delaware River at Camden Projects) was prepared by the District in 1975.

21. Delaware River Dredging Disposal Study. The study was initiated in February 1978. The purposes of the study were to develop a regional dredging plan for the Delaware River and its tributaries, Delaware Bay, and Indian River Inlet and Bay for both Federal and private sectors; and to identify specific short and long term disposal sites, which minimize degradation of the natural environment.

22. Prior to consolidation into the Delaware River Comprehensive Navigation study, it defined the current and future needs for existing projects and private dredging. For such projects no new authorizations appear to be needed and an information report was issued in June 1984. For the alternative plans under consideration in the Comprehensive Navigation Study, additional demand for sites to dispose dredged material will be generated. In these cases, the identification and formulation of potential disposal sites required the input of data specific to each proposed new project. Therefore, the balance of the study is being completed as part of the Delaware River Comprehensive Navigation Study.

23. Interim Feasibility Report, Delaware River from Philadelphia to Wilmington: Delaware River Comprehensive Navigation Study. This study was completed in December 1984 as an interim feasibility study to the Delaware River Comprehensive Navigation Study Authority. It addressed current and potential future navigation problems of Federal interest at waterways tributaries to and constrained by the 40 foot main channel of the Delaware River.

24. The interim project areas included the lower Schuylkill River; a proposed auto terminal at Hog Island and Tioga Marine Terminals in Philadelphia; the Broadway/Holt and Beckett Street Terminals in Camden; and Wilmington Harbor in Delaware. This study recommended improvements at the lower Schuylkill River, and Beckett Street Terminals that were environmentally acceptable and technically and economically feasible. Based on the costs related to the Wilmington Harbor project, that plan was pursued under the Continuing Authorities Program. The recommended plans of improvement included deepening the existing Federal projects, in the Lower Schuylkill River from 33 foot to 40 foot, and at the Delaware River in the Vicinity of Camden, NJ (Beckett Street Terminal) from the authorized 37 foot project to 40 foot. The Chief of Engineers Report, dated 15 June 1986, was forwarded by the Assistant Secretary of the Army on 28 August 1987 for inclusion in

the Administration's 1988 legislative proposal. The projects contained in this report were authorized by Section (3a) of the Water Resources Development Act of 1988.

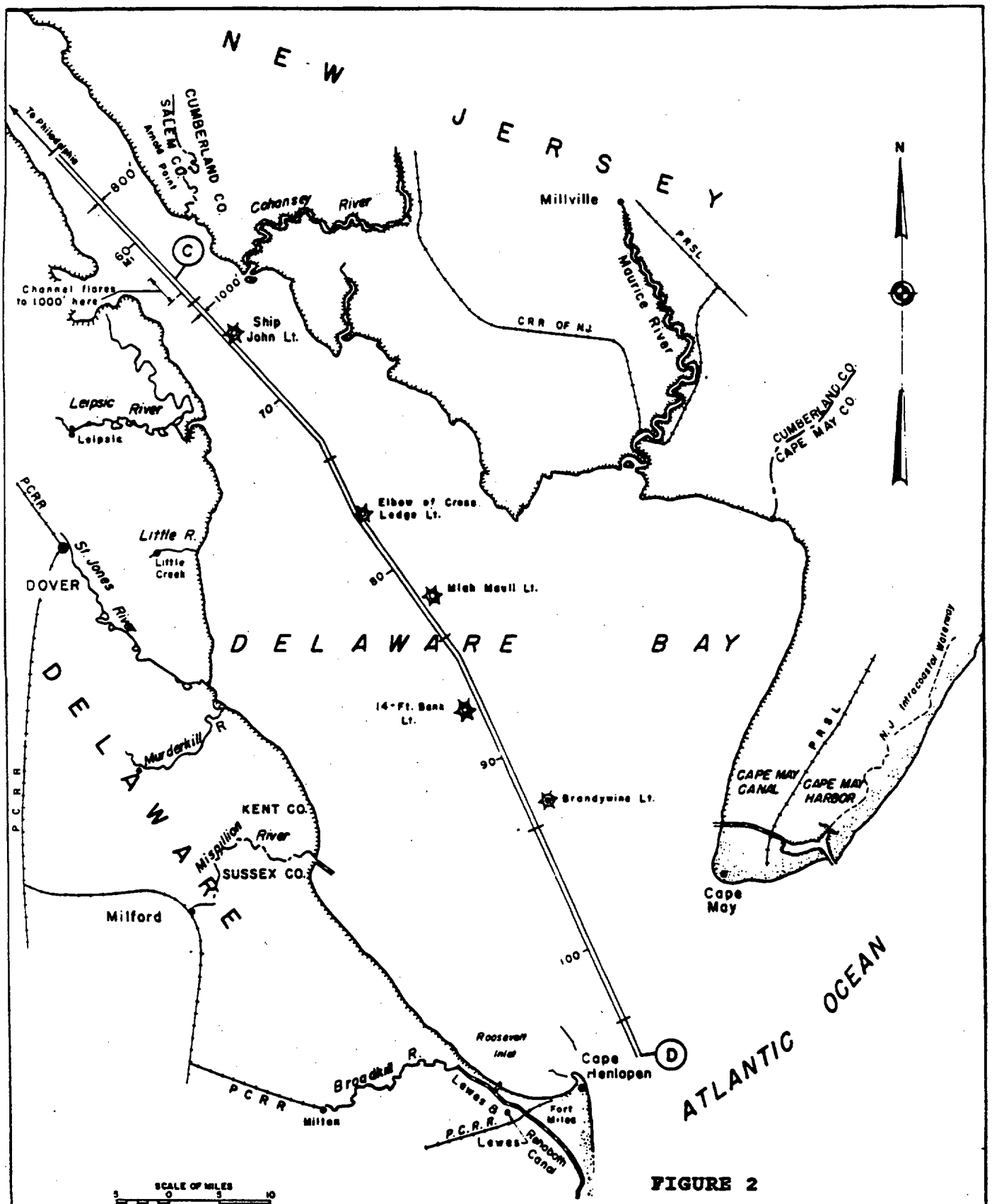
EXISTING PROJECTS

25. The Delaware River system includes six deep draft projects and 16 shallow draft projects which are Federally maintained. The deep draft projects are Delaware River, Philadelphia to the Sea; Delaware River in the Vicinity of Camden (Beckett St. Terminal); Delaware River, Philadelphia to Trenton; Wilmington Harbor (Christina River), Inland Waterway - Delaware River to Chesapeake Bay (C&D Canal); and Schuylkill River. The main Delaware River channel (Phila to the Sea) and the deep draft tributary channels which are the subject of this specific study are described in the following paragraphs.

26. DELAWARE RIVER, PHILADELPHIA TO THE SEA. The Philadelphia to the Sea project (adopted in 1910 and modified in 1930, '35, '38, '45, '54 and '58) provides for a 40 foot deep channel from Allegheny Avenue in Philadelphia to deep water in Delaware Bay. The channel widths range from 400 feet in Philadelphia Harbor to 1,000 feet in the bay. Through Philadelphia Harbor the channel is 40 feet deep on the west side and 37 feet deep on the east side. The project also provides for widening at critical bends. There are nineteen anchorages on the Delaware River; six are authorized under the Philadelphia to the Sea project (Mantua Creek, Marcus Hook, Deepwater Point, Reedy Point, Gloucester and Port Richmond) and the remaining thirteen are natural deep-water anchorages. The disposal of dredged material is solely a Federal responsibility. A number of training dikes were also constructed to reduce shoaling in the channel or anchorages, or to shift the shoaling from areas where disposal is expensive to areas where disposal areas are more readily available. Refer to Figures 2 and 3 for details.

27. DELAWARE RIVER, PHILADELPHIA TO TRENTON. The Philadelphia to Trenton project (adopted in 1930 and modified in 1935, '37, '46, '54, and '76) provides for a 40 foot deep, 400 foot wide channel from Allegheny Avenue, Philadelphia, to the upstream end of Newbold Island (a distance of 23.5 miles), a 35 foot deep channel from the upstream end of Newbold Island to the (former) Trenton Marine Terminal and a 12-foot deep channel upstream to the Penn Central Railroad bridge in Trenton. The total project length is 30.5 miles.

28. The project which was authorized in 1954, was completed in 1964 except for a 5.5 mile long segment dredged only to 35 feet between Newbold Island and the former Trenton Marine Terminal, a 1.5 mile segment along Trenton dredged only to 12 feet, and widening the turning basin at the Trenton Marine terminal. A modification at Tioga Marine Terminal, authorized in 1976, provides for dredging a turning area to a depth of 36 feet adjacent to the



LEGEND

Channel indicated thus: ═══

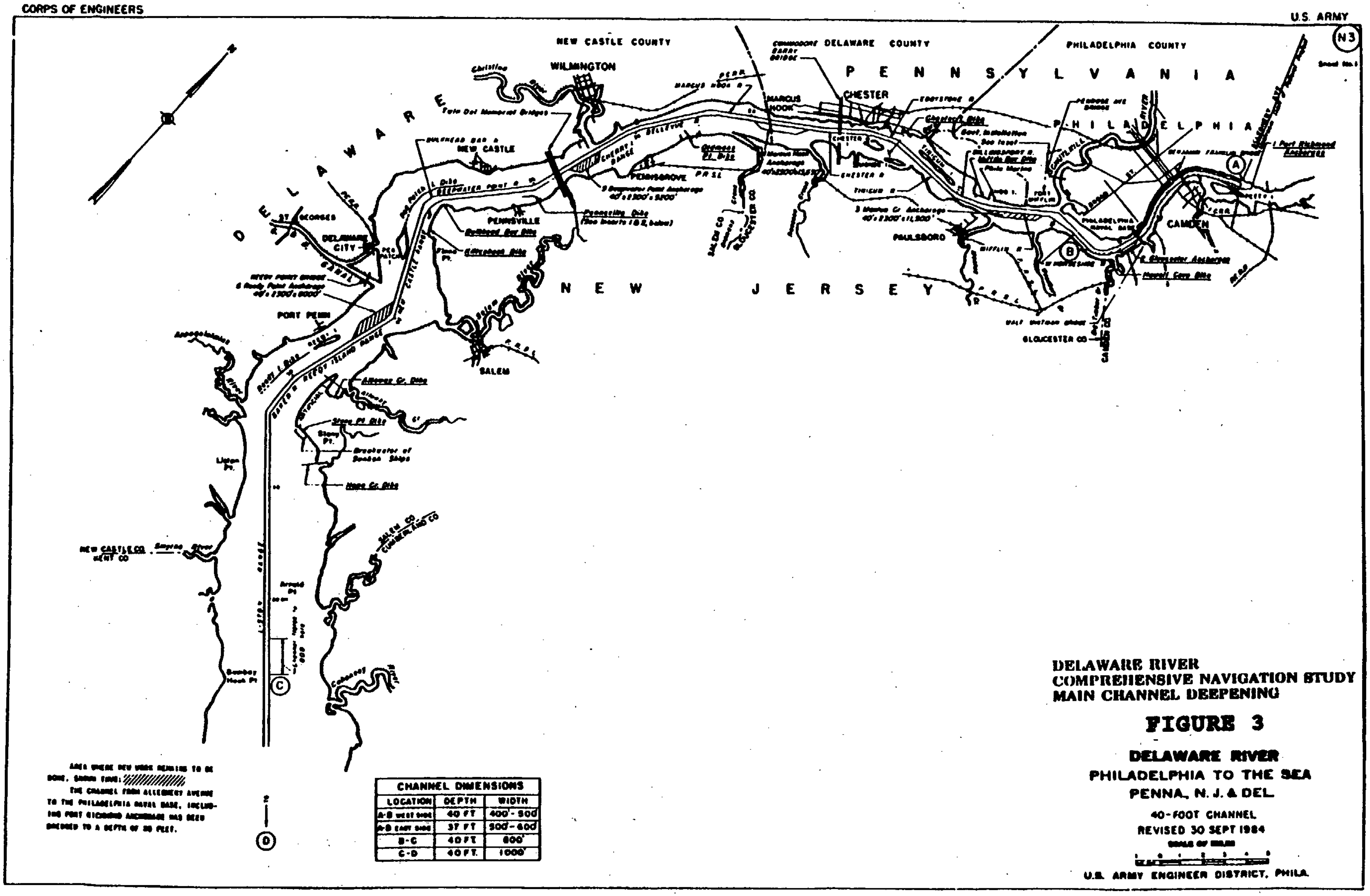
NOTE:
Distance in miles below Allegheny Ave., Phila., show along side of channel.

FIGURE 2

DELAWARE RIVER
COMPREHENSIVE NAVIGATION STUDY
MAIN CHANNEL DEEPENING

DELAWARE RIVER
PHILADELPHIA TO THE SEA

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS



DELAWARE RIVER
COMPREHENSIVE NAVIGATION STUDY
MAIN CHANNEL DEEPENING

FIGURE 3

DELAWARE RIVER
PHILADELPHIA TO THE SEA
PENNA., N. J. & DEL.
40-FOOT CHANNEL
REVISED 30 SEPT 1984
U.S. ARMY ENGINEER DISTRICT, PHILA.

CHANNEL DIMENSIONS		
LOCATION	DEPTH	WIDTH
A-B WEST SIDE	40 FT	400'-500'
A-B EAST SIDE	37 FT	500'-600'
B-C	40 FT	800'
C-D	40 FT.	1000'

existing Delaware River channel and maintenance dredging of a non-Federally constructed maneuvering area and the turning basin. Recently completed Preconstruction Engineering and Design (PED) studies have found no navigation problems presently exist which would require construction of the 1976 modification.

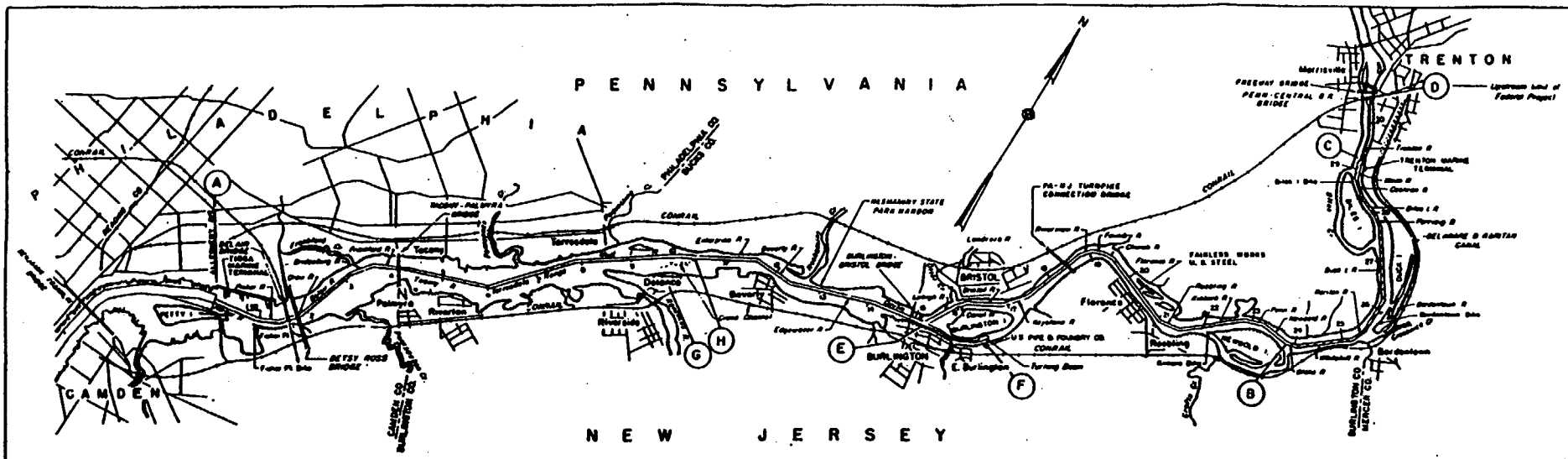
29. DELAWARE RIVER IN THE VICINITY OF CAMDEN. The Delaware River in the Vicinity of Camden project (adopted in 1919 and modified in 1930 and 1945) provides for a 30-foot-deep channel from Newton Creek at the Broadway terminal to Beckett Street Terminal and an 18 foot deep channel extending from Beckett Street terminal to Cooper Point. Also, the project provides for a depth of 37 feet in front of the Beckett Street terminal which was constructed in 1988. The project length is about four miles. The Water Resources Development Act of 1988 authorized deepening the access to berths 3 and 4 of Beckett Street terminal to 40 foot. A General Design Memorandum for the 40 foot project was completed in January 1990. Construction funds were appropriated in Fiscal Year 1991. Construction of this project is pending execution of the Local Cooperation Agreement. See Figure 5.

30. SCHUYLKILL RIVER. The Schuylkill River project provides for a channel from its confluence with the Delaware River upstream to University Avenue. The project (adopted in 1917 and modified in 1930 and 1946) has depths ranging from 33 to 22 feet. The project length is six miles. Disposal for the existing project is a Federal responsibility. The Water Resources Development Act of 1988 authorized deepening the lower Schuylkill River from 33' to 40'. Refer to Figure 6.

31. WILMINGTON HARBOR, CHRISTINA RIVER, DELAWARE. The Wilmington Harbor project (adopted in 1896 and modified in 1899, 1922, '30, '35, '40, '60 and '87) provides for a channel in the Christina River with depths of 38, 21, 10, and 7 feet from the Delaware River to Newport, Delaware, as shown in Figure 7. The project also provides for a turning basin opposite the Wilmington Marine Terminal, along with jetties at the mouths of the Christina and Brandywine Rivers. The project length is about 10 miles from the Delaware channel upstream to Newport. Deepening the lower 4240' of channel and widening the turning basin to 38' was completed in 1988 under the Corps of Engineers Continuing Authorities (Section 107) Program.

REPORT AND STUDY PROGRESS

32. This final interim report presents the results of feasibility studies for deepening the main channel of the Delaware River from 40' to 45'. After review and approval by Corps of Engineers Higher Authority it will be sent to Congress. Prior to construction, Preconstruction Engineering and Design Studies which includes initial Plans and Specifications will be necessary.



CHANNEL DIMENSIONS		
LOCATION	DEPTH	WIDTH
A-B	40 FT	400 FT.
B-C	35 FT	300 FT.
C-D	12 FT.	200 FT
E-F	20 FT.	200 FT
G-H	8 FT.	400 FT.

SCALE OF MILES

AREA WHERE NEW WORK REMAINS TO BE DONE, SHOWN THUS:

FIGURE 4

DELAWARE RIVER
COMPREHENSIVE NAVIGATION STUDY
MAIN CHANNEL DEEPENING

DELAWARE RIVER
PHILADELPHIA, PA TO TRENTON, NJ

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

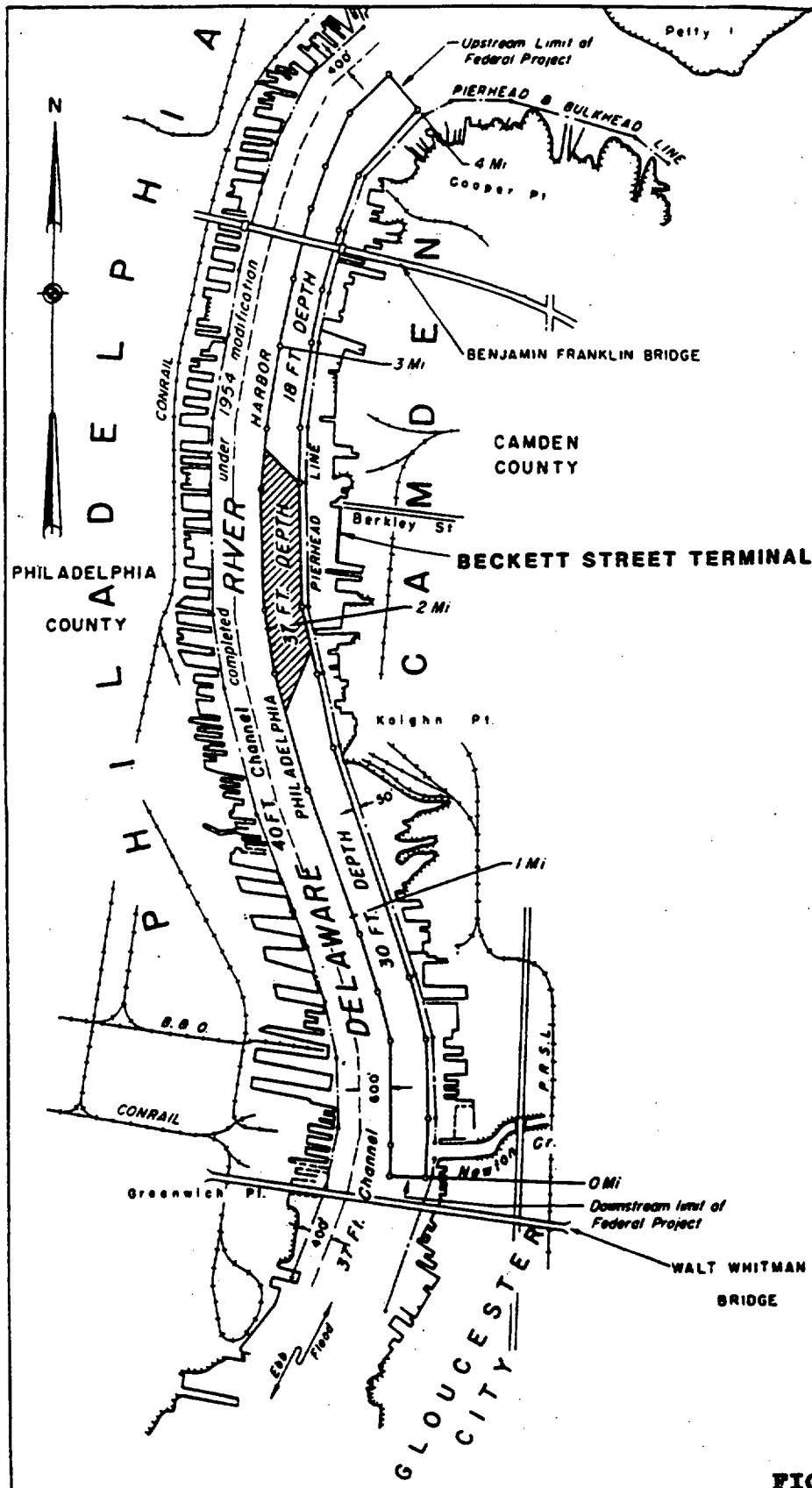


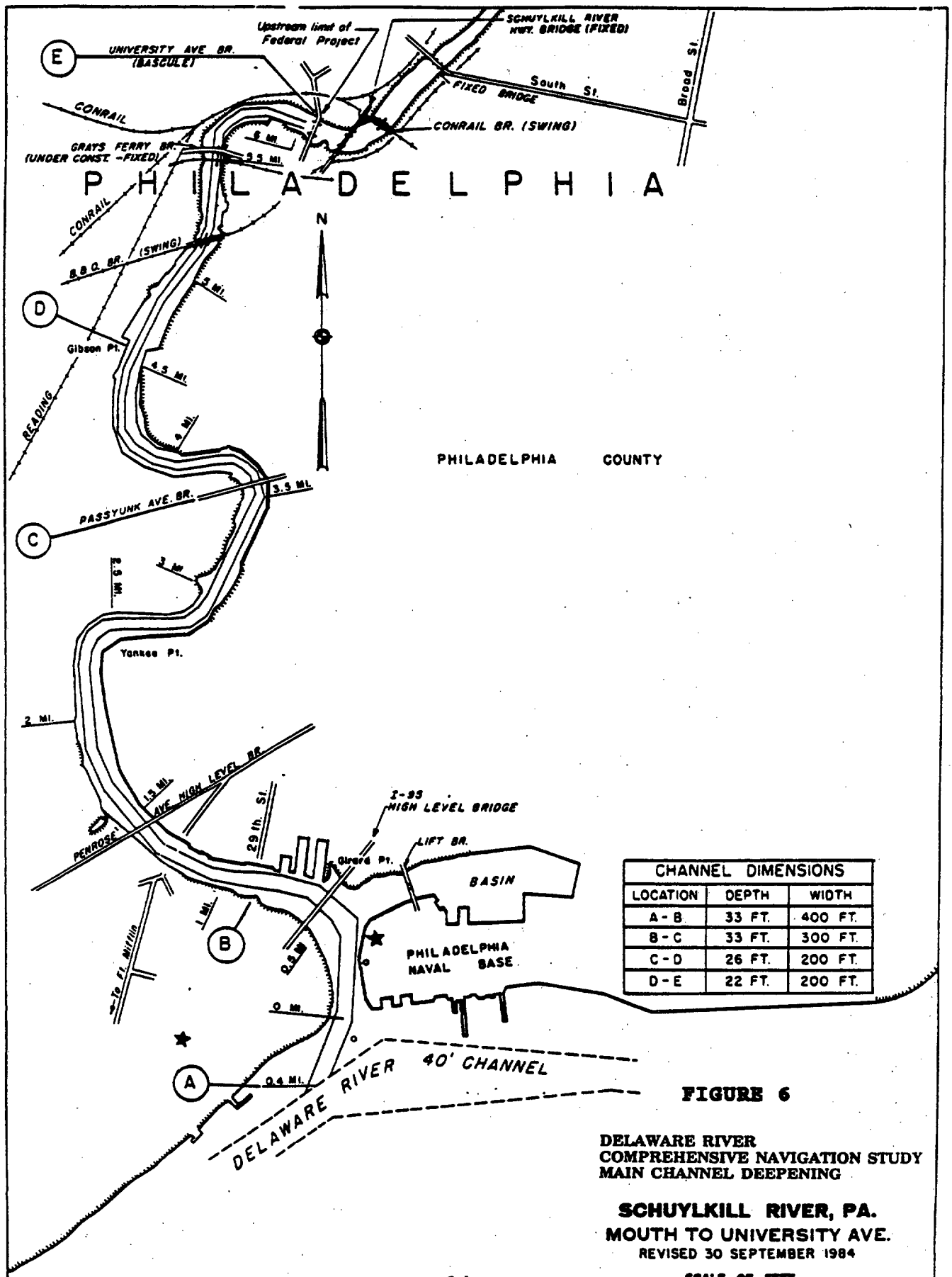
FIGURE 5

EXISTING PROJECT 37'
(CONSTRUCTION COMPLETED IN 1988)

DELAWARE RIVER
COMPREHENSIVE NAVIGATION STUDY
MAIN CHANNEL DEEPENING

DELAWARE RIVER IN THE VICINITY OF CAMDEN, NJ

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS



CHANNEL DIMENSIONS		
LOCATION	DEPTH	WIDTH
A - B	33 FT.	400 FT.
B - C	33 FT.	300 FT.
C - D	26 FT.	200 FT.
D - E	22 FT.	200 FT.

FIGURE 6

DELAWARE RIVER
COMPREHENSIVE NAVIGATION STUDY
MAIN CHANNEL DEEPENING

SCHUYLKILL RIVER, PA.
MOUTH TO UNIVERSITY AVE.
REVISED 30 SEPTEMBER 1984

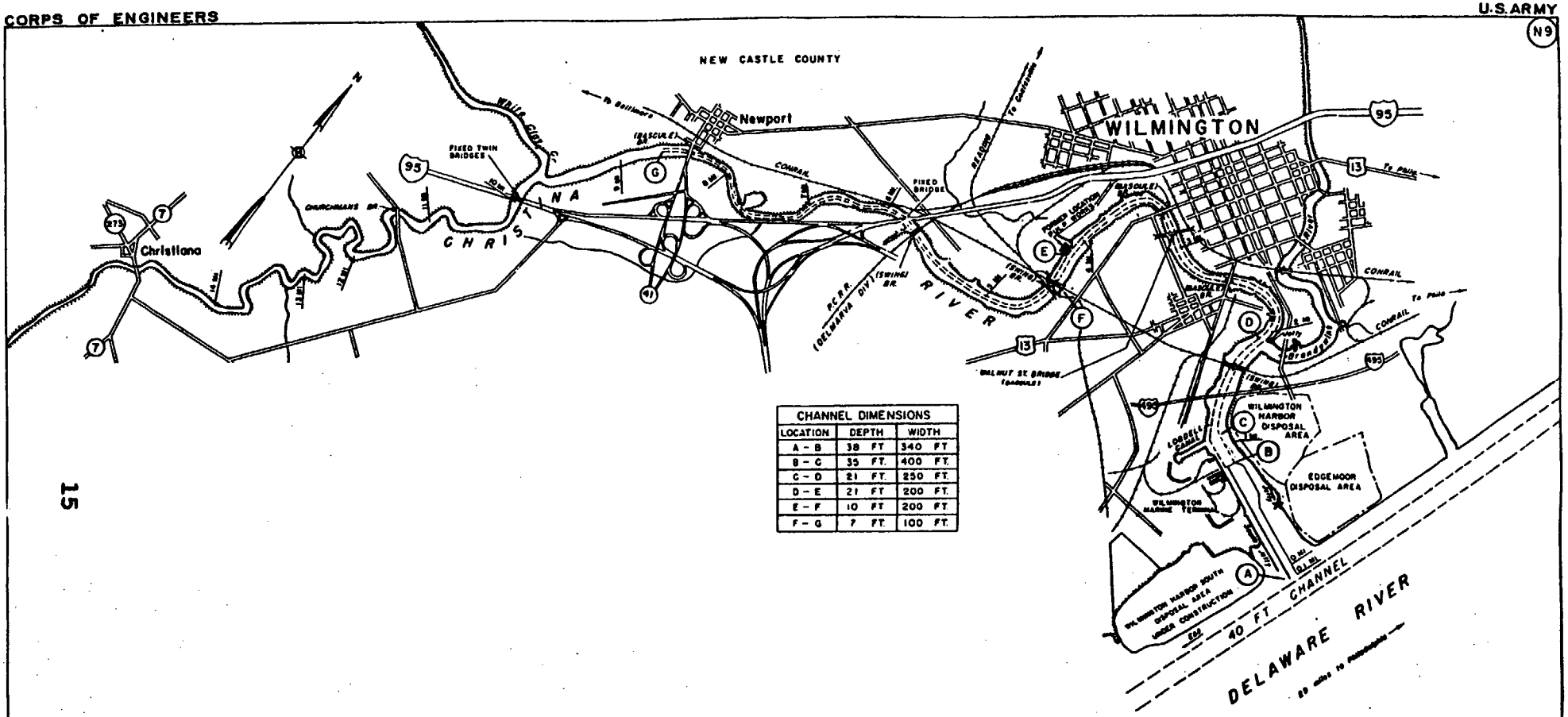
SCALE OF FEET
1000 0 1 2 3 4 5000

U.S. ARMY ENGINEER DISTRICT, PHILA.

CORPS OF ENGINEERS

U.S. ARMY

N9



CHANNEL DIMENSIONS		
LOCATION	DEPTH	WIDTH
A - B	38 FT	340 FT
B - C	35 FT.	400 FT.
C - D	21 FT.	250 FT.
D - E	21 FT	200 FT.
E - F	10 FT	200 FT.
F - G	7 FT.	100 FT.

FIGURE 7

WILMINGTON HARBOR

CHRISTINA RIVER, DELAWARE

REVISED 30 SEPTEMBER 1988

SCALE OF FEET

U.S. ARMY ENGINEER DISTRICT, PHILA.

EXISTING CONDITIONS

33. In seeking a solution to navigation and related problems of the study area, it is first necessary to understand the existing conditions along the waterway and the surrounding land area. It is important to examine the socio-economic and environmental parameters, that might impact or be impacted by the study. By then projecting these existing conditions into the future it is possible to identify future problems, needs and opportunities and to formulate planning objectives and planning constraints.

34. The Delaware River Basin contains an area of 12,757 square miles. Fifty percent of the basin lies in Pennsylvania, twenty three percent in New Jersey, nineteen percent in New York, and eight percent in Delaware. The Delaware River begins as two streams, the East and West Branches, on the western slopes of the Catskill Mountains. These branches meet at Hancock, New York, then flow in a general southward direction for 326 miles to the sea. In this distance the river acts as a boundary, first dividing New York from Pennsylvania, and finally New Jersey from Delaware and Pennsylvania.

NATURAL RESOURCES

35. LAND USE. The study area includes every classifiable type of land use, ranging from the highly urbanized metropolitan areas to highly rural areas. Inbetween are large suburban areas and extensive farmlands. Urban land uses, including residential, commercial, and industrial uses, are concentrated in the major cities and their suburbs and along the major ground transportation routes. Urbanization is continuing within the fringes of the urban areas and along the transportation routes.

36. The Philadelphia, Wilmington, Trenton Consolidated Metropolitan Statistical Area occupies the lower Delaware River Basin. It had the fifth largest population in the United States. Even so only about a third of the landmass was developed in 1970. Between 1970 and 1980 another 3% was subject to suburban and exurban development, a trend continuing in the 1980's.

37. CLIMATE. The study area is situated in the mid-Atlantic temperate zone. In general, the climate is mild with a few brief hot, humid periods in summer as well as cold, windy periods of similar duration and frequency during the winter. The yearly mean temperature is about 54 degrees F. Temperatures of 100 degrees or higher are comparatively rare. Readings as high as 90 degrees occur on the average of only 15 days in the summer, normally in two or three periods of excessive heat. Temperatures of zero degrees or below occur one winter in four. The normal annual precipitation is about 43 inches; rainfall is well distributed throughout the year with generally more than three inches per month. Temporary

droughts or periods of subnormal rainfall, however, are not uncommon for the area.

38. Light, southerly winds blowing up the Delaware Bay favor the formation of fog which occurs relatively frequently, especially from December to February when it often lasts two or three days. Such fog occurs about 50 days annually. Fog occurrence along the Delaware River itself happens less often. It averages roughly 30 times a year, though heavier fog occurs only about 7 days annually. Light north-northeasterly winds also bring in smoke from Philadelphia and the heavy industrial area located along the Delaware River north of Wilmington.

39. HYDROLOGY. The total drainage area tributary to the Delaware River estuary is 12,767 square miles, excluding 782 square miles of water surface in the estuary. The total average annual inflow of fresh water, head of tide to the mouth, is 20,000 cfs. Most of the fresh water inflow (88.9%) enters the estuary in its upper 70 miles. The discharge per square mile is greatest from that part of the watershed located above the head of tide at Trenton. There are substantial variations of the mean monthly discharges. The most discharge occurs in April, due to high precipitation and snow melt, and the least occurs in September, due to low precipitation and high evapotranspiration.

40. TIDAL HYDRAULICS. The tides of the Delaware Estuary are semidiurnal; there are two nearly equal high waters and two nearly equal low waters per lunar day. The mean range is about 4.2 feet at the mouth where the variation of elevation with time is approximately sinusoidal. As the tidal undulation propagates up the estuary, the tide range increases with the distance above the mouth, so that the mean range at the mouth of the Christina River is 5.6 feet, at the mouth of the Schuylkill River, 5.7 feet, and at the Benjamin Franklin Bridge in Philadelphia, 6.2 feet. Variations in water level are also highly dependent on wind speed and direction.

41. Based on tidal current charts compiled by the National Ocean Survey, maximum spring ebb and flood current velocities in the Delaware Bay range from 0.8 to 2.7 knots and from 0.9 to 2.4 knots, respectively depending on location. The Delaware River opposite Wilmington has peak tidal currents of 1.4 knots while 2.4 knots at Philadelphia opposite the Navy Yard is the highest predicted on the Delaware River below Trenton.

42. SALINITY. The salinity of the Delaware River is a function of freshwater outflow (from Delaware River headwaters, tributaries, runoff, and groundwater seepage) and saltwater inflow from the sea. Freshwater outflow varies with the seasons. Generally, it is greatest in March to April and least from June to October. The March to April discharge pushes saltwater seaward, and low flows from June to October allow saltwater to advance.

43. The Delaware River has an average freshwater discharge of about 12,000 cfs at Trenton, which increases to about 15,000 cfs at Artificial Island, New Jersey. Tidal flow, ranging from 448,000 to 472,000 cfs, at Artificial Island is far greater than freshwater discharge. During average weather and river flow conditions, tidal currents are the primary currents in the lower estuary and for the most part, determine normal estuarine circulation. Nontidal features such as freshwater runoff, weather and salinity gradients also effect currents.

44. Salinity in the Delaware estuary forms a gradient from less than 0.5 ppt in the tidal river to about 32 ppt at the mouth of the Delaware Bay. The estuary is generally polyhaline (18-30 ppt) from the mouth up to the vicinity of the Leipsic River, mesohaline (5-18 ppt) from the Leipsic River to around the Smyrna River, oligohaline (0.5-5 ppt) from the Smyrna River to around Marcus Hook, and fresh (0.0-0.5 ppt) from about Marcus Hook to Trenton. These zones are not static, but move in different directions depending upon freshwater outflow, tidal height and stage, weather conditions and morphologic alterations.

45. Delaware River salinity levels vary vertically as well as horizontally. For example, between Philadelphia and Reedy Point, Delaware, salinity is usually greater near the bottom than at the surface; however, the difference between surface and bottom is usually slight. Tide-induced mixing minimizes salinity stratification but generally, an essentially homogeneous vertical salinity profile is the case. Occasionally, gradients as high as 2 ppt per meter occur. The degree of stratification in the estuary is dependent on both location and tidal stage. The Delaware Bay is strongly stratified in winter and spring during high freshwater outflow, and well mixed in summer due to low outflow.

46. Saltwater inflow is associated with sea level (which rises with tidal stage), tidal elevation and seasons of the year. In a tidal cycle, salinity is at a maximum level near high slack water, and at a minimum level near low slack water. A small tidal range produces a small range in salinity and a large tidal range results in a greater range in salinity. Sea level is lower in December, January and February, and higher in August, September and October. Changing sea level favors upstream movement of saltwater most in summer and least in winter; the most favorable period for saltwater intrusion is from August to October when freshwater outflow is lowest and sea level is highest.

47. GEOLOGY AND GROUNDWATER. The study area lies within the coastal plain physiographic province and is underlain by unconsolidated sands and clays of Cretaceous, Tertiary, and Quaternary age. These sediments overlie bedrock which consists of metamorphic and igneous rocks of the upper Precambrian age. The unconsolidated formations dip to the southeast and generally thicken oceanward. The older formations are at or near the surface

of the Delaware River and are progressively deeper toward the Atlantic Ocean. Rock outcrops are located in the River Channel in the vicinity of Marcus Hook. The unconsolidated sediments consist of pervious and impervious layers which form a series of aquifers and aquicludes.

48. The primary aquifer units along the Delaware River are the Potomac-Raritan-Magothy formations and the Cape May and Columbia formations. The Potomac-Raritan-Magothy aquifers are exposed at various locations at or near the surface in a narrow band along both sides of the Delaware River between Trenton and Pennsville, New Jersey. The Cape May and Columbia formations cover practically all of Delaware and portions of Southern New Jersey. In many locations in or adjacent to the Delaware River, these aquifer units are mantled by sands and clays of recent alluvial deposits. The municipal water wells in southern New Jersey generally withdrawal their water from the Potomac-Raritan-Magothy formation. It is considered the sole source aquifer for the region and will be evaluated as such in determining the effects of any plans under consideration.

49. The Potomac-Raritan-Magothy formation contains the most important and productive aquifers in southern New Jersey and is referred to as the region's sole source aquifer. The thickness of the combined formations is as much as 500 feet. Many industries and public water companies in the region obtain groundwater from this formation. There are four major aquifers within the formation.

50. Groundwater flow is generally toward the main river in a typical river basin. However, the groundwater regime in the project area, specifically the New Jersey side of the river, has been disturbed by urbanization. This information has been documented in numerous reports. The U.S.G.S. Atlas HA-697 dated 1986 estimates a leakage of 70 MGD from the Delaware River into the Potomac-Raritan-Magothy aquifer system in the project area. A reversal of the natural groundwater flow due to overpumping of the aquifer has occurred. Prior to municipal and industrial pumping, water flow in the aquifer was towards the river. Where large groundwater withdrawals have locally reversed the original aquifer flow patterns, aquifer recharge by river water results. This is due to the fact that permeable sand and gravel in the river are in direct contact with the sediments which comprise the Potomac-Raritan-Magothy system. Although a large volume of river water is presently infiltrating the aquifer from the river, no contamination or salinity problems have been reported.

51. The groundwater regime in northern Delaware, as documented by the U.S. Geological Survey Water Resources Investigation Report 87-4185, is very similar to the situation in New Jersey. Brackish water is infiltrating the underlying Potomac Aquifers in the Cretaceous Potomac Formation in northern Delaware. The potential for infiltration of river water into the aquifers is suggested by

groundwater levels below sea level and removal by erosion of confining units overlying the aquifers near the river. Pumping from wells has lowered heads in the Potomac aquifers below sea level, which has created a hydraulic gradient from the Delaware River towards the underlying aquifers. There is a direct correlation between the rate of infiltration of river water and the total well-field pumpage. Evidence that infiltration is actually occurring in Delaware includes chloride concentrations in the aquifers that are above ambient levels and chemical characteristics of ground water and river water that are similar. The amount is controlled by the rate of pumping from municipal and private wells.

52. DELAWARE RIVER SUBSURFACE SEDIMENT CHARACTERISTICS. In order to better determine the type of material to be dredged from the channel and bends of the Delaware River, a series of 57 vibracore holes were recently taken throughout the project limits. Twenty foot of penetration was required at all locations, however the actual depth of penetration and amount of recovery varied. The 57 vibracore holes were spread throughout the project. Of the 29 holes taken in the channel, 16 were located in Reach E which is located in Delaware Bay. The remaining 28 holes were concentrated in the channel bends, where widening is planned.

53. Based on the findings of the vibracore explorations, bay sediments were divided into four subreaches. Reach E-1 and E-3 consist of fine-grained sediments; reaches E-2 and E-4 are predominantly coarse grained.

54. The gradation analysis of the channel bend sediments indicate predominantly fine grained characteristics. The materials consist of organic clays and silts with some fine sand layers. At bends H, PQ and S, (refer to Plate 2) the fine-grained sediments are underlain by coarser materials.

55. The channel vibracore samples contain varying amounts of sandy materials. The majority of reaches A and A-A (see Plate 1) contain sand and gravel with pockets of fine-grained materials. Rock was encountered in DRV 4, 5 and 7 at elevations -48.5, -50.6, -47.7 respectively (COE MLW datum), all below the maximum project depth. As previously mentioned, Reaches B, C, and D, predominantly consist of fine-grained silts and clays, with small pockets of sandy materials.

56. WATER AND SEDIMENT QUALITY. The water quality in the estuary is linked to the volume of flow. The Delaware is unable to assimilate as large a pollution load when flow is reduced as it can at normal volume. Even under normal flow conditions, water quality is degraded between Philadelphia and Wilmington. Dissolved oxygen and fecal coliform standards have been repeatedly violated, limiting use of the river for human contact and healthy aquatic communities.

57. Historically the Delaware Estuary has been one of the more polluted rivers in the world. Almost one hundred municipal and industrial discharges exist on or near the river. In addition, the river is subjected to pollution from tributaries, non-point sources, over 300 combined sewer overflows and other sources. Major water quality improvement has occurred as the result of a forty year cleanup program and the river currently has better water quality than any time in this century. In spite of this improvement, dissolved oxygen concentrations in the summer of 1987 were below 3 mg/1 in a portion of the estuary. Although dissolved oxygen and fecal coliform standards have been nearly attained as the result of federal, state and Delaware River Basin Commission abatement programs, the water quality reflected in these standards do not meet the fishable and swimmable goals of the Federal Clean Water Act.

58. A sediment testing program was conducted during the summer of 1991 to characterize the chemical quality of sediments in the existing, Philadelphia to the sea navigation channel. Chemical analyses were conducted on 18 sediment cores collected in the channel and 28 sediment cores collected in channel bend locations. Sediment samples were analyzed using both bulk and elutriate analysis procedures. Chemical parameters included metals, pesticides, polychlorinated biphenyls (PCB's) and polynuclear aromatic hydrocarbons (PAH's). Four sediment cores, collected in locations considered to have the greatest potential for contamination, were also tested for volatile organics, acid extractable organics and additional base neutral organics.

59. In order to evaluate the results of the chemical analyses, two sets of sediment criteria were considered. These criteria are currently used by the State of New Jersey, Department of Environmental Protection (NJDEP) to evaluate the potential hazard of soil contamination at project sites within New Jersey. It is recognized that these criteria have no regulatory authority behind them, and may not be used by other agencies for similar evaluations. The first set of criteria are Interim NJDEP Soil Action Levels. These criteria are not necessarily cleanup objectives, higher concentrations may be allowed at certain sites. The second set of criteria used by the NJDEP were initially developed to classify dredged sediments from the Great Lakes. The criteria provide non-polluted, moderately polluted and heavily polluted concentration ranges for various contaminants. The NJDEP uses these ranges to consider if special handling requirements are necessary for the disposal of sediments.

60. Two types of chemical quality concerns can be raised with respect to dredging and dredged material disposal operations. The first is potential water quality degradation arising from disturbance of bottom sediments, and ensuing impacts to aquatic biota. The second is long-term contamination problems associated with the dredged material disposal site. The sediment quality data

collected during the 1991 testing program do no indicate any significant problems relative to these concerns. Organic contaminants were found in few samples, at low concentrations. Bulk analyses of 46 sediment cores detected PCB's in one sample at a concentration of 1.72 parts per million (ppm), and pesticides in two samples at concentrations below 1 ppm. PCB's were not detected in any sediment elutriates, while pesticides were detected in only three elutriates at concentrations ranging between 0.0026 and 0.0063 ppm. All of these samples were collected in the river between Philadelphia, PA and Wilmington, DE. PAH's were detected in several channel bends throughout the project area. Concentrations were generally low, with only one reading above the Interim NJDEP Soil Action Level of 10 ppm. PAH's were detected at a concentration of 12.23 ppm at one sample located in the vicinity of Philadelphia, PA. This reading was from the upper 1.25 feet of the sediment core, with no PAH's detected below this strata. PAH's were only detected in one sediment elutriate at a concentration of 0.013 ppm. This sample was collected in Delaware Bay. Methylene chloride and phthalates were the only additional organic contaminants detected in cores analyzed for the full chemical parameter list. These contaminants were found in both bulk and elutriate samples at low concentrations. Based on these data it is concluded that organic contaminants would not degrade water quality during dredging operations, or cause long-term contamination problems at dredged material disposal sites.

61. Metals were found in channel sediments. While Interim NJDEP Soil Action Levels were exceeded for some metals, the overall metal content of channel sediments was within reasonable limits. The metal content of sediment elutriates was low throughout the project area. Concentrations of metals that were found were generally below 0.1 ppm. These observed concentrations suggest that the presence of metals in channel sediments would not significantly affect water quality during the dredging or disposal process. Total sediment concentrations of arsenic, cadmium, chromium and mercury each exceeded Soil Action Levels at one location throughout the project area. Zinc exceeded the Soil Action Level at two locations. All of these values, except arsenic, were found at the surface of sediment cores. Lower metal concentrations were found below the top strata. One channel bend sample had an arsenic concentration of 26.6 ppm, which was above the Soil Action Level of 20 ppm. There was no stratification in this sediment core, consequently no additional data is available. These few spot occurrences do not demonstrate contamination trends, and are not considered significant relative to the overall quality of channel sediments. Antimony, beryllium and thallium were not present in sediment elutriates. Beryllium was found in three elutriates at a concentration of 0.01 ppm in each. These metals would not cause water quality problems during the dredging process, or create hazardous conditions with disposal at confined, upland sites. Some sediment samples had metal concentrations within the moderately to heavily polluted range, relative to the sediment criteria utilized

by the NJDEP. As previously stated, the NJDEP use these classifications to determine disposal requirements. Disposal at confined, upland dredged material disposal sites, as is proposed for this project, is the preferred disposal alternative for this type of sediment. In the Delaware Bay, the sediments were found to be clean. There were no metals present above Soil Action Levels, or within the heavily polluted category. A more detailed discussion of the 1991 sediment testing program is provided in the Environmental Impact Statement.

62. FISH AND WILDLIFE RESOURCES. The ecological boundary of the study area consists of both banks of the Delaware River, its associated shallows and shoreline habitats, and the adjacent upland areas of potential dredged material disposal sites. The estuary is a dynamic mixing zone of fresh and salt water, the productivity of which is influenced by tidal action, water quality and temperature. Habitats are diverse and inter-dependent. Water depth is a major factor in productivity where the absence of sunlight and possibly oxygen is restrictive to abundant species populations.

63. The primary characteristics of the study area are its physical heterogeneity and its formerly degraded but greatly improved water quality. Variations exist in the quantity and types of wetlands associated with shallow water areas, the amounts of shoreline modification, the composition of the bottom sediments, and the sizes of the shallows. Each of the areas is, therefore, somewhat different from all others within the study area. Such differences are important because they affect the degree to which each area may be utilized by common basin species.

64. Since the physical characteristics vary throughout the study area, it follows that biological potentials also vary greatly. Any habitat, however, may support fewer organisms than its biological potential would indicate. This situation appears to occur frequently within the upper Delaware Estuary. While most sections of the study area are utilized by a variety of organisms, the data indicate that all sections could be utilized more intensely in the future with further improvements to water quality. This contention is based on the fact that suboptimal water quality exists within most of the study area. Much of the problem arises from the large amounts of organic material that are discharged into the estuary. This organic load results in the creation and maintenance of low dissolved oxygen levels in the upper portion of the study area.

65. Estuarine Habitats. Habitats in the study area are widely variable and diversified according to water depths, salinity, type of substrate and water quality fluctuations. Benthic diversity is greatest in Delaware Bay and diminishes upstream in the Delaware River. Most of the commercial fishery focuses on the bay where lobster, clams, crabs, weakfish, bluefish and menhaden populations are significant. The anadromous fishery, striped bass, shad and

shortnose sturgeon primarily, move to upstream fresh water areas to spawn.

66. Intertidal and Wetlands Habitats. Extensive wetland areas border Delaware Bay and, to a lesser and more intermittent extent, river edges from the bay to south of Philadelphia. The wetlands serve as valuable contributors to the food-web, as nurseries and spawning areas for the fisheries, and as a critical shallows/terrestrial interface for aquatic fowl and mammals. Intertidal habitats are abundant in both the bay and riverine environments. Aquatic vegetation is present on many bay and riverine shallows. Many saltwater, brackish water and fresh water plant species are represented and provide valuable fishery nursery and food-web sources. The bay and riverine system is utilized extensively for fish passage or habitat access. Anadromous species frequently use deep channels for access upstream or into major tributaries. Other species inhabit shallower waters and extensively use intertidal and wetland habitat areas.

67. Terrestrial Habitats. Upland vegetation ranges from extensively forested stands to grassy meadows and farm fields. This prolific and varied cover provides habitats supporting a great number of game and non-game species of mammals, waterfowl, terrestrial birds, rodents and insects. Even populated areas display a diversified number of smaller mammals and numerous birds. Downstream from Philadelphia to the bay mouth, both shorelines display extensive vegetation cover extending deep inland. Grassy fields, shrub-scrub, emerging forests and maturing forest habitats are represented.

68. Fisheries. An important aspect of the Delaware River estuary ecology is its capability to support a commercial and recreational fishery. The environment has been improved as a result of the implementation and enforcement of regulations by Federal and State agencies. The estuary fishery is slowly beginning to return to pre-industrialization levels. These efforts directly relate to primary jobs in fishing, processing and distribution, and secondary jobs in retail product sales, advertising, shipping and sales of complimentary items. The primary shellfish harvested are the oyster, hard clam and blue crab. The menhaden, weakfish, and blue fish are the predominant finfish caught in the bay. Over 250 species of finfish have been identified in the estuary including American shad, striped bass, bluefish, flounder, weakfish, sturgeon and menhaden.

69. The anadromous fishery is of particular importance as it reflects upon both fishing and dredging industries. The spring upriver shad spawning run is popular with recreational fishermen. These fish migrations are particularly sensitive to turbid water conditions during both spring and fall seasons of passage. This sensitivity is reflected in a bucket dredging and aquatic dredged material deposition moratorium during heavy fish migrations from

March through May and September through October. Overboard deposition is also environmentally unacceptable in the vicinity of turbidity-vulnerable oyster beds and in crab overwintering sites.

70. Recreational fishing in the bay and river is extremely popular, supporting numerous boats for hire and privately-owned craft. Associated services, usually dispensed from marina complexes, include provision of bait and tackle, food and beverage, petroleum products and ramp or other service fees. Clothing and boat sales, sightseeing and hotel rentals are also associated with these activities.

71. THREATENED AND ENDANGERED SPECIES. The Delaware estuary is within the range of 17 Federally designated threatened or endanged species. These include area transients such as sperm, fin, humpback, blue, sei and black right whales; and green loggerhead, Hawksbill, and Kemps Ridley leatherback turtles. Inhabitants under protection include the bald eagle, American peregrine falcon, Arctic peregrine falcon and the shortnose sturgeon. The American bald eagle has been successfully introduced to the New Jersey shore and is establishing itself in a preserve extending from Cape May along the New Jersey marshes westward.

72. CULTURAL RESOURCES. Much of the present topography of the Delaware Valley was formed during and after the last glacial advance. As the ice melted, large amounts of debris were washed downstream and out over the coastal plains of New Jersey and the Delmarva Peninsula. By 10,000 years ago, the estuary mouth was still some 10-40 miles offshore, and sea level was still rising at a rate of up to 6 feet every 100 years. It was sometime during this period that humans first entered the Delaware Valley. With the continued rise in sea level, the Delaware River and Bay eventually evolved into the present drowned estuary system.

73. The archaeological record of the prehistoric occupation of the Delaware Valley conforms to the generalized patterns of cultural development for the Middle Atlantic States. Three major periods are recognized: Paleoindian (15,000 years Before Present (B.P.) - 8,500 B.P.), Archaic (8,500 B.P. - 5,000 B.P.), and Woodland (5,000 B.P. - 400 B.P.). Few Paleoindian period sites have been found in the Delaware Valley, especially in the lower portion of the valley covered by the Philadelphia to the Sea project partly as a result of the low population density and nomadic lifestyle of the peoples from the period, and partly due to the inundation of sites by sea level rise, and the burial of sites under thick layers of alluvium and cultural deposits. Archaic period sites are known for the Upper Delaware but the lack of information from the lower estuary reflects site inundation and destruction due to flooding. Archaeological investigations have traditionally focused on Woodland period sites. Sites from the Woodland period are typically found in estuarine settings. By the 1600's, the Delaware Basin had been settled by the Lenape Indians.

Several National Register listed prehistoric sites have been found in the Delaware River and Bay area within one mile of shore.

74. European exploration of the Delaware Bay area began with Henry Hudson's voyage in 1609, for the Dutch East India Company. By the 1640s both the Dutch and the Swedes had established settlements as far upriver as Trenton, and battled each other for supremacy in the Delaware Valley. In 1654 the Dutch captured all Swedish posts, only to be conquered by an armed British fleet in 1664. By 1674, the British controlled all of the Dutch North American colonies, including Delaware Bay. In 1675, a settlement was established at Salem, New Jersey, which quickly became the center of government along the eastern banks of the Delaware. With the chartering of the Colony of Pennsylvania in the 1680's, and the establishment of Philadelphia as the colony's capital, development along the Delaware Estuary grew rapidly. Philadelphia soon became the principal port city on the Atlantic Coast, due in large measure to the region's rich grain harvest, ample water power for mills to convert the grain to flour, and quickly developing towns and roads to support the port city. The English maintained control of the region until the Revolutionary War. Several naval engagements between the British and the revolutionary forces took place along the Delaware River south of Philadelphia.

75. As the new country entered the nineteenth century, new commercial activities developed in the Delaware Valley. The thriving timber and tannery enterprises, and the mining and processing of rich mineral deposits in the region led to the creation of turnpikes, canals, and railroads throughout the area. In the lower estuary commercial fishing continued to thrive, as did agriculture. By the late nineteenth century, industrial development in the Delaware Valley was in full swing. Steel mills, locomotive works, canneries, chemical plants, and oil refineries dotted the shorelines. One Delaware Valley industry that deserves special mention is ship building. Shipbuilding has been one of the most important and most famous industries along the Delaware River for more than three centuries. During the Revolution, Philadelphia took the lead away from Boston as the shipbuilding capital of the colonies. Shipyards sprang up all along the Delaware River. John Fitch successfully operated the world's first steamboat along the Delaware River shoreline in the 1780's. In south Camden, the New York Shipbuilding Corporation's yard was the largest self-contained shipbuilding plant in the world in 1919, and the Philadelphia Navy Yard had become the largest navy yard with the largest drydock in the world. By World War I, Hog Island was the site of the largest shipbuilding plant in the world.

76. Ship building originally started along the Delaware River to enhance trade. Because the Delaware River/Bay is situated roughly halfway between New York Bay and the mouth of the Chesapeake Bay, and provides the only break in a dangerous 295 mile stretch of the Atlantic Coast, it was a natural site for port development. By the

colonial period, Delaware Valley port cities were engaged in trade with other colonies, Europe, and the Caribbean. Maritime commerce to and from the port cities along the Delaware River played a major role in the economic development of the entire Delaware Valley. The volume of shipping in this region, aggravated by the navigational hazards in the waterway, inevitably led to shipwrecks. Although the total number of wrecks will never be known, more than 145 documented shipwrecks have occurred in the Delaware River/Bay over the past three centuries. Most wrecks occurred in the first two centuries, before the development of regularly maintained channels, navigation aids, and harbor improvements.

77. Philadelphia District has undertaken several investigations of cultural resources within the project area. The Cultural Resources Overview and Sensitivity Analysis for the Delaware River and Shoreline (Gilbert/Commonwealth 1979) collected data for shoreline areas to assist in the development of suitable dredged material disposal areas. The study identified 162 historic sites and districts within one mile of the Delaware River and Bay area shoreline from Trenton, New Jersey to Lewes, Delaware. The Delaware River Comprehensive Navigation Study (Interim): Cultural Resources Sensitivity Reconnaissance (GAI 1983) assessed the potential for containing significant cultural resources of several proposed dredging and disposal sites between Wilmington and north of Philadelphia. This study added 30 new historic sites to the 1979 inventory. A Sensitivity Level Investigation of Cultural Resources in the Vicinity of the Main Navigational Channel, Delaware River, Wilmington to the Sea, and a Proposed Deepwater Port (Cox 1986) assigned cultural resource sensitivity designations of high, medium, or low to three segments of the waterway from Wilmington to the sea, to facilitate plans for deepening or widening the existing navigation channels and anchorages and creating a deepwater port. A "Preliminary Cultural Resource Reconnaissance Investigation of Thirteen Disposal Areas" (Heite and Heite 1986) assessed the potential for significant prehistoric or historic resources at thirteen proposed disposal areas along the Delaware River in New Jersey and Delaware. Finally, "Submerged Cultural Resources Investigations, Delaware River Main Navigational Channel, Philadelphia, PA to Artificial Island, NJ" (Cox 1988) presents the results of magnetometer and side scan sonar survey at fourteen locations, all found at the inside portion of the intersection of two ranges along the main channel, and each proposed for bend widening. This report documents sixty-six remotely sensed targets, six of which may represent potentially significant submerged cultural resources. The results of this report, and the others discussed above, are presented in greater detail, as appropriate, in the EIS.

HUMAN RESOURCES

78. There are 13 counties in the study area with a 1990 total population of 5,092,800. Information was extracted from Pennsylvania Facts and New Jersey Facts both from Clements Research Inc. plus Statistical Abstract of the U.S. Bureau of the Census. County totals range from the heavily urbanized 1,585,900 population in Philadelphia County to 65,300 in Salem County, New Jersey. Philadelphia, the major metropolitan center, is the most densely populated with 11,745 persons per square mile while Sussex County, Delaware has the least density with 121 persons per square mile (see Table 1).

79. The most heavily populated reach of the lower Delaware River Basin is the area bordering the estuary from Trenton, New Jersey, to Wilmington, Delaware. The principal municipalities are: Trenton, New Jersey; Camden, New Jersey; Philadelphia, Pennsylvania; Chester, Pennsylvania; and Wilmington, Delaware.

80. An extensive complex of industrial plants line both sides of the Delaware River. Industries produce goods such as chemicals and allied products, petroleum, primary metals, paper and allied products, processed foods, and electric power. The most heavily industrialized area is located in the Camden-Philadelphia-Chester reach of the river. In 1980 and beyond, the economic sector employing the most people in the area of consideration is the service industry followed by manufacturing. This is the reverse of the situation in 1970. Wholesale and retail trade remained a strong third throughout both 1970 and 1980.

81. The Ports of Philadelphia are a significant part of the regional economy. There are approximately 100,000 port related jobs in the Delaware Valley which generate one billion dollars of income annually. State and local taxes including income, profits and sale taxes, amounted to about 100 million dollars a year.

82. EMPLOYMENT. As shown in Table 2, the 1970 unemployment rates ranged from 2.1% in Chester County, Pennsylvania, to 6.5% in Cape May County, New Jersey. The 1980 figures show a dramatic increase throughout the study area ranging from 5.5% in Bucks County, Pennsylvania to 13.6% in Cape May County while 1990 figures are somewhat less. Per capita income approximately doubled in the 13 county study region from 1970-1980. The largest growth occurred in Kent County, Delaware and the smallest in Philadelphia County, Pennsylvania. Unemployment figures for 1991 range from 5.6% to 9.1%.

TABLE 1
POPULATION OF STUDY AREA BY COUNTIES
1970-1990 1/

COUNTY	1970	1980	1985	1990	1990 land area sq. mile	1990 density (per sq. mi.)
NEW JERSEY						
BURLINGTON	323,100	376,700	380,100	395,066	805	491
CAMDEN	456,400	483,200	488,100	502,824	222	2,265
CAPE MAY	59,600	85,900	90,600	95,089	255	373
CUMBERLAND	121,400	135,100	134,900	138,053	489	282
GLOUCESTER	172,700	201,300	207,100	230,082	325	708
MERCER	304,100	323,500	317,700	325,824	226	1,442
SALEM	60,300	62,900	65,200	65,294	338	193
PENNSYLVANIA						
BUCKS	416,700	453,000	512,700	541,174	608	890
DELAWARE	603,500	586,100	557,200	547,651	184	2,976
PHILA	1,950,000	1,876,500	1,637,400	1,585,877	135	11,745
DELAWARE						
KENT	81,900	98,700	101,200	110,993	591	188
NEW CASTLE	385,900	398,100	402,100	441,946	426	1,037
SUSSEX	80,400	93,900	103,800	113,229	938	121
STUDY AREA TOTAL	5,016,000	5,174,900	4,998,100	5,092,802	5542	1,747 (average)

1/ Bureau of Census

chemicals to other facilities in the region or domestic ports. Major dry and liquid bulk facilities are also found along the Delaware River at Wilmington, Delaware; Port Richmond in Northeast Philadelphia; Paulsboro, New Jersey; Greenwich Point in South Philadelphia; and along the Schuylkill River in Philadelphia. Development of an intermodal rail yard in south Philadelphia connected to the Packer Ave is underway. The numerous tributaries to the Delaware River support a variety of industries and the waterways are used primarily for delivery of fuel oils and raw materials or shipment of products.

WATERWAYS AND DISPOSAL AREAS

84. Six deep draft projects and 16 shallow draft projects serve commercial navigation in the Delaware River system. The following paragraphs discuss the existing conditions and disposal of dredged material for the five major deep draft, commercial channels which presently exist on the Delaware River or its tributaries and which could be impacted by the deepening of the Delaware River.

85. DELAWARE RIVER, PHILADELPHIA TO THE SEA. The 40 foot channel, Philadelphia Naval Base to the Sea and Philadelphia Naval Base to Allegheny Avenue, was completed in 1942 and 1962, respectively, and is maintained to authorized dimensions. The existing project provides for a channel from deep water in Delaware Bay to a point in the bay, near Ship John Light, 40 feet deep and 1,000 feet wide; thence to Philadelphia Naval Base, 40 feet deep and 800 feet wide, with 1,200-foot width at Bulkhead Bar and 1,000-foot width at other bends; thence to Allegheny Avenue, Philadelphia, PA, 40 feet deep and 500 feet wide through Horseshoe Bend and 40 feet deep and 400 feet wide through Philadelphia Harbor along the west side of the channel. The east side of the channel in Philadelphia Harbor has a depth of 37 feet and width of 600 feet. All depths refer to mean low water. The project also provides for construction of dikes and training works for regulation and control of tidal flow to reduce dredging. The 40-foot channel from the Naval Base to the Sea was completed in 1942. The dredging of the channel from the Naval Base to Allegheny Avenue to a 40 foot depth was completed in 1962. The enlarging of the anchorage at Marcus Hook was completed in 1967. Authorized but unconstructed features include constructing the new anchorages at Reedy Point and Deepwater Point, enlarging the Mantua Creek Anchorage, and deepening the Port Richmond Anchorage to 37 feet (see Figures 2 and 3). The authorized anchorage dimensions are:

TABLE 2

Employment and Income by County

	Total Employed			Total Unemployed			%Unemployed			Per Capital Income	
	1970	1980	1991	1970	1980	1991	1970	1980	1991	1970	1980
DELAWARE											
Kent	27,233	38,744	47,828	1,200	3,356	4,123	4.2	8.0	7.9	2,582	6,126
New Castle	151,125	181,132	226,116	6,097	11,525	14,398	3.9	6.0	6.0	3,557	8,067
Sussex	32,569	41,933	62,404	931	2,747	3,724	2.8	6.1	5.6	2,649	6,262
PENNSYLVANIA											
Bucks	164,602	223,939	281,286	5,090	12,993	18,596	3.0	5.5	6.2	3,417	8,048
Delaware	238,264	247,016	274,427	6,813	15,602	15,256	2.8	5.9	5.3	3,735	8,044
Phila.	763,520	624,706	674,861	26,806	80,599	59,764	4.6	11.4	8.1	3,041	6,053
NEW JERSEY											
Burlington	106,838	153,295	180,799	4,342	11,413	10,025	3.9	6.9	5.3	3,298	7,671
Camden	175,971	197,470	225,724	7,318	17,369	15,563	4.0	8.1	6.4	3,347	7,278
Cape May	18,667	28,561	47,827	1,288	4,484	2,795	6.5	13.6	5.5	3,157	7,079
Cumberland	46,942	52,866	56,967	2,831	5,522	5,730	5.7	9.5	9.1	2,902	6,032
Gloucester	64,034	84,758	99,903	2,661	6,935	7,179	4.0	7.6	6.7	3,032	6,939
Mercer	127,472	142,808	47,499	4,635	8,803	2,091	3.5	5.8	4.2	3,631	8,095
Salem	23,203	25,315	29,904	901	2,515	1,793	3.7	9.0	5.7	3,102	6,714

Source: U.S. Dept. of Labor, Bureau of Labor Statistics, LABSTAT Series Report, Local Area Employment and Unemployment Statistics.

Project	Authorized Dimensions
Mantua Creek:	40' x 2,300' x 11,500' (mean)
Marcus Hook:	40' x 2,300' x 13,650' (mean)
Deepwater Point:	40' x 2,300' x 5,200' (mean)
Reedy Point Point:	40' x 2,300' x 8,000' (mean)
Port Richmond:	37' x 500' (mean) x 6,400'
Gloucester:	30' x 400' (mean) x 3,500'

86. Mantua Creek Anchorage is currently maintained to about 60% of the authorized width and a 37 foot depth. The Marcus Hook Anchorage, enlarged in 1964, is maintained to authorized dimensions. The anchorage at Port Richmond is about 35 feet deep, as are the Reedy Point and Deepwater Point Anchorages. The Gloucester Anchorage requires no dredging and is currently deeper than authorized (35' MLW).

87. There are wide variations in the amount of dredging required to maintain the Philadelphia to the Sea project, depending on the ranges discussed; some are nearly self maintaining and others experience rapid shoaling. The 40 foot channel section requires annual maintenance dredging in the amount of 5,400,000 cubic yards including advance maintenance of 2 to 4 feet in rapid shoaling areas. Of this amount, the majority is required in the Marcus Hook Range (34%), Deepwater Point Range (26%), and New Castle Range (23%). The remaining 17 percent of the dredging is spread through the other 37 ranges. The historic annual maintenance dredging rates for the Marcus Hook and Mantua Creek Anchorages are 487,000 and 157,000 cubic yards, respectively.

88. During the 1970's vessel traffic patterns in the Delaware River moved toward utilization by deeper draft vessels, in order to maximize the utilization of the 40' channel. Vessel operations allowed ships to navigate the channel with drafts approaching the authorized depth provided that utilization of tide stages was maximized. Commitantly, shoaling began to increase within certain ranges to the point that controlling depths began to decrease. Subsequently, draft limitations were imposed since depths near the authorized depth could not be adequately maintained. During the six week period around September 1979 a loss of approximately $830,000 (September 1979 P.L.) in lightering costs were reported for 69 oil tankers. This figure did not include costs attributable to lost ship time, or additional fuel, pilotage or tug costs necessitated by the draft reduction. Accordingly, authorization for advance maintenance dredging was granted in June 1981 which stated that: "authority is granted to perform up to 4 foot overdepth dredging in the Delaware River, Philadelphia to the Sea project in those reaches which demonstrate an economic advantage to do so, as well as sufficient user need to maintain the authorized depth at all times". The "4 foot overdepth dredging" refers to

advance maintenance dredging rather than routine allowable overdepth dredging which is used to maintain a certain tolerance.

89. The Federal government has the sole responsibility for providing the necessary disposal areas and embankments for material dredged from this project. The disposal areas are listed below along with the acreage and ownership. In addition, a disposal site exists at Penns Grove, New Jersey. However, since Congress limited this site to a height of 10 feet in the Water Resources Development Act of 1986, and required approvals have not been obtained from the New Jersey Department of Environmental Protection, this site has not been utilized for disposal.

Name	Banked Area (acres)	Ownership
Artificial Island	305	Federal
Killcohook	1,229	Federal
Penns Neck	325	Federal
Pedricktown	1,089	Federal
National Park	120	Federal
Oldmans	270	Leased
Buoy 10	(subaqueous)	

90. DELAWARE RIVER, PHILADELPHIA, PA. TO TRENTON, N.J.. The existing 40' channel was completed in 1964 for a length of 23.5 miles. Uncompleted work includes dredging the 35-foot deep channel from Newbold Island to the former Trenton Marine Terminal and widening the turning basin at the terminal.

91. The historical dredging requirements for the project are as follows:

Channel Section (cy/yr)	Ranges	Historical Rate (cy/yr)	Rate to Maintain Authorized Project
40' x 400'	Harbor to Newbold Is.	518,300	518,300
35' x 400'	Blake to Trenton South	31,000	518,000
12' x 200'	Trenton North to Bridge	-	-
	Total	549,300	1,036,300

The Federal government has required the states of New Jersey and Pennsylvania to provide the necessary disposal areas and embankments for the disposal of material dredged from the channel. Current areas include:

#2 (Camden Site), Camden County, NJ
#4 (Palmyra Site), Burlington County, NJ
#12A (Hawk Island Site), Burlington County, NJ
#14 (Beverly Site), Burlington County, NJ

#20 (Tenneco Site), Burlington County, NJ
#22 (Burlington Island Site), Burlington County, NJ
*#28A (Former U.S. Steel Site), Bucks County, PA
*#28 (Biles Island Site), Bucks County, PA
* (Money Island Site), Bucks County, PA

* The State of PA is currently negotiating with Waste Management of North America to lease these sites for future Corps maintenance dredging activities.

92. DELAWARE RIVER IN THE VICINITY OF CAMDEN, NEW JERSEY. The 18 foot channel from Cooper Point to Kaighn Point and the 30 foot channel from Kaighn Point to Newton Creek were completed in 1924. Under the 1930 modification, the 30 foot channel was extended from Kaighn Point to the Camden Marine Terminal at Berkley Street.

93. In 1945, Congress recommended modification of the existing navigation project at Camden by dredging the channel in the vicinity of the Camden Marine Terminal to a depth of 37 feet. This new construction project was dredged during 1987 and 1988, excavating approximately 500,000 cubic yards. In the Water Resources Development Act of 1988, Congress authorized deepening of portions of the project adjacent to Beckett Street Terminal to a depth of 40 feet. Generally, the project area requires relatively little maintenance dredging with the last maintenance occurring in 1962; the annual volume is about 10,000 c.y. Any future disposal requirements are to be handled at a nearby Federal disposal area which is part of the Philadelphia to the Sea project. Disposal area costs were a non-Federal responsibility for the 37' access to the Beckett Street Terminal and would also be a local responsibility for any deepening project.

94. SCHUYLKILL RIVER. This project was initially authorized in 1917 and modified in 1930, 1946, and 1988. It provides for a navigation channel 33 feet deep with a 400 foot width near the mouth to 29th Street (see Figure 6). At this point the project narrows to 300 feet in the second reach to Passyunk Ave. Bridge. In the third reach from Passyunk Ave. to Gibson Point (approximately one mile) the dimensions are decreased to 26 by 200 feet. The last portion, from Gibson Pt. to University Ave. Bridge, has authorized dimensions of 22 by 200 feet.

95. Along the lower portion of the Schuylkill River (Reaches 1,2,&3) from the mouth to the Passyunk Ave. Bridge, the existing channel is currently maintained at 33 feet MLW. The third reach of the river, from Passyunk Ave. to Gibson Point is currently maintained at 26 feet MLW. The 22 foot depth portion of the project, from Gibson Point to University Ave. is not maintained to authorized depth and has not been dredged since before 1960. This section is currently at about natural depth.

96. Maintenance dredging and provision of disposal areas is a Federal responsibility. Currently, the 33 and 26 foot depth portions of the project are maintained by hydraulic pipeline dredge, with material being disposed at Fort Mifflin. The Fort Mifflin disposal area located at the confluence of the Schuylkill with the Delaware River is a 298 acre, Federally-owned disposal area.

97. The 33' deep section is dredged generally every two years. The 26' deep section is dredged generally every three years. Removal rates are as follows:

Reach	Historical Average Annual Removal Rate (1960 - Present)*	Average Annual Removal Rate to Authorized Depth*
1. Mouth to 29th St.	85,500	85,500
2. 29th to Passyunk	133,600	133,600
3. Passyunk to Gibson Pt.	90,000	90,500
4. Gibson Pt. to Univ. Ave.	0	86,000
Total	309,100	395,600

* gross place yardage

98. The Delaware River, Philadelphia to Wilmington Interim Feasibility report recommended deepening the lower reach (Penrose Avenue to the Delaware River) from 33' to 40' which was subsequently authorized in the Water Resources Development Act of 1988.

99. WILMINGTON HARBOR CHRISTINA RIVER. The existing project provides for a channel with depths of 38, 35, 21, 10, and 7 feet from the Delaware River to Newport. A turning basin is located opposite Wilmington Marine Terminal and jetties are provided at the mouths of the Christina and Brandywide Rivers. Channel widths vary from 400 feet to 100 feet, and the project extends a length of about 9.9 miles.

100. Until 1982 the reach accessing the Port of Wilmington had historically been maintenance dredged annually. However, due to the rapid shoaling rate at Wilmington Harbor, this cycle was changed to twice annually. Annual dredged quantities are similar under current dredging practice to those historically removed, approximately 1,108,000 cubic yards annually. It is estimated that the dredging rate to maintain authorized dimensions above the Wilmington Terminal would be about 88,700 cubic yards annually,

however these project reaches have historically not been maintenance dredged.

101. Under the Corps Continuing Authorities Program, a portion of the channel with a depth of 35 foot was deepened to 38 foot and a wider turning basin has been constructed to service the bulk berths at the Wilmington Terminal. It required initial disposal of 795,000 cubic yards but no measurable additional maintenance.

102. The Edgemore disposal area is being turned over to Delaware Solid Waste Authority. It is no longer available for dredged material disposal. Two Corps maintained upland disposal areas in the vicinity are available; Wilmington Harbor and Wilmington Harbor South. Wilmington Harbor is an existing site and Wilmington Harbor South is a new site recently constructed to provide additional disposal capacity.

103. OTHER WATERWAYS AND DISPOSAL AREAS. In addition to these major deep-draft projects the Federal government operates the Chesapeake and Delaware Canal, a 35' deep and 450' wide waterway which connects the Delaware and Chesapeake Bays. This project provides a valuable link which shortens the trip and travel time for vessels transiting between the Ports of Philadelphia and Baltimore and other Chesapeake Bay ports via connecting channels in upper Chesapeake Bay. Upland disposal areas line much of the Canal's length in Delaware, and two of these areas, Reedy Point North and South, are located at the eastern end of the Canal as it enters the Delaware River. Two disposal areas, Pierce Creek and Courthouse Point, are located in Maryland in the Upper Chesapeake Bay.

104. In this general vicinity near Delaware City, Delaware the Texaco Oil Refinery (formerly Getty) maintains a private 35 foot deep access channel for access of oil tankers and vessels to its refinery piers and berths. Material from this channel is dredged and disposed into a private disposal area adjacent to the refinery.

105. Much of the remainder of the non-Federal dredging at facilities and piers is done by private contract, who places this material at its upland contained disposal area.

HISTORIC WATERBORNE COMMERCE

106. Historic Commodity Movements. Over the past decade, traffic on the Delaware River has been dominated by liquid bulk commodities. As can be seen in Tables 3 and 4, import levels have historically comprised over 90% of foreign trade in the basin. Crude oil imports have particularly shown an increase, in tonnage terms, in 1985-1989. This dominance has caused changes in total tonnage to almost totally reflect changes in the petroleum market, which has masked some trends in tonnage levels for other commodities.

TABLE 3

TONNAGE AND DISTRIBUTION OF WATERBORNE IMPORTS BY MAJOR COMMODITY ON THE DELAWARE RIVER: TRENTON, NEW JERSEY TO THE SEA, 1973-1989

(thousands of short tons)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Total	69,253	69,340	68,275	67,969	70,160	67,122	70,784	56,039	56,433	49,548	46,490	52,458	53,841	59,989	61,728	64,046	64,093
	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Crude Oil	43,091	41,088	43,298	49,865	52,270	51,060	54,602	42,859	42,297	40,187	37,152	41,334	42,475	48,143	47,696	47,478	49,125
	62.00%	59.00%	63.00%	73.00%	75.00%	76.00%	77.00%	76.00%	75.00%	81.00%	80.00%	79.00%	79.00%	80.00%	77.00%	74.00%	77.00%
Iron Ore	13,135	14,617	15,037	10,789	7,335	6,833	6,760	6,715	7,934	3,833	2,818	3,646	3,574	3,574	3,824	5,116	4,396
	19.00%	21.00%	25.00%	16.00%	10.00%	10.00%	10.00%	12.00%	14.00%	8.00%	6.00%	7.00%	7.00%	6.00%	6.00%	7.80%	6.90%
Petroleum Products 1]	7,679	6,889	5,271	2,917	4,347	5,071	4,561	2,766	2,678	2,799	2,898	2,471	1,881	3,138	4,489	5,358	4,396
	11.00%	10.00%	5.00%	4.00%	6.00%	8.00%	6.00%	5.00%	5.00%	6.00%	6.00%	5.00%	3.00%	5.00%	7.00%	8.40%	6.90%
(Residual Fuel Oil) 2]	(6,589)	(4,727)	(2,194)	(2,793)	(3,433)	(3,828)	(2,803)	(2,120)	(1,746)	(1,635)	(2,103)	(1,746)	(1,186)	(2,129)	(2,777)	(2,819)	(2,673)
	(10.00%)	(7.00%)	(3.00%)	(4.00%)	(5.00%)	(6.00%)	(4.00%)	(4.00%)	(3.00%)	(3.00%)	(5.00%)	(3.00%)	(2.00%)	(4.00%)	(4.00%)	(4.40%)	(4.20%)
Iron & Steel Products 3]	1,470	2,672	1,803	1,229	2,060	1,507	1,220	714	773	642	835	1,307	1,217	1,092	932	1,139	908
	2.00%	4.00%	3.00%	2.00%	3.00%	2.00%	2.00%	1.00%	1.00%	1.00%	2.00%	2.00%	2.00%	2.00%	2.00%	1.80%	1.40%
Sugar	1,089	952	730	854	1,272	472	950	697	670	122	0	9	20	8	0	0	0
	2.00%	1.00%	1.00%	1.00%	2.00%	1.00%	1.00%	1.00%	1.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Limestone & Non-Ferrous Minerals	838	794	650	521	719	255	563	658	498	550	703	581	568	726	1	0	0
	1.00%	1.00%	1.00%	1.00%	1.00%	0.00%	1.00%	400.00%	1.00%	1.00%	2.00%	1.00%	1.00%	1.00%	0.00%	0.00%	0.00%
Other Commodities 4]	1,951	2,128	1,466	1,794	2,157	1,924	1,928	1,630	1,583	1,415	2,086	3,110	4,106	3,300	2,010	4,957	5,267
	3.00%	3.00%	2.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	4.00%	6.00%	8.00%	6.00%	3.00%	7.70%	8.20%

TABLE 4

TONNAGE AND DISTRIBUTION OF WATERBORNE EXPORTS BY MAJOR COMMODITY ON THE DELAWARE RIVER: TRENTON, NEW JERSEY TO THE SEA, 1973-1989

(thousands of short tons)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Total	4,205	5,822	4,151	3,541	2,471	4,034	4,975	6,684	5,604	4,117	3,108	2,661	6,047	5,758	3,766	4,676	5,226
Coal	602	1,947	1,197	812	576	772	1,133	2,875	3,314	2,077	1,282	1,153	4,390	3,976	1,939	2,326	2,456
	14.00%	33.00%	30.00%	23.00%	23.00%	19.00%	23.00%	43.00%	59.00%	50.00%	41.00%	43.00%	73.00%	6.00%	51.00%	50.00%	47.00%
Iron Ore & Steel Scrap	494	276	404	377	249	384	550	573	301	349	413	538	265	734	836	85	469
	13.00%	5.00%	10.00%	11.00%	10.00%	10.00%	11.00%	9.00%	5.00%	8.00%	13.00%	20.00%	4.00%	13.00%	22.00%	0.00%	0.00%
Corn	1058	1147	625	559	268	775	1303	1274	585	567	260	5	1	2	0	284	31
	25.00%	20.00%	15.00%	16.00%	11.00%	19.00%	25.00%	19.00%	10.00%	14.00%	9.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Wheat	133	186	631	130	0	269	4	254	70	22	0	1	0	0	0	0	0
	3.00%	3.00%	9.00%	4.00%	0.00%	7.00%	3.00%	4.00%	1.00%	1.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Soybeans	165	279	112	112	113	422	219	125	229	29	0	1	8	45	0	0	0
	4.00%	5.00%	3.00%	3.00%	5.00%	10.00%	4.00%	2.00%	4.00%	1.00%	0.00%	0.00%	0.00%	1.00%	0.00%	0.00%	0.00%
Chemicals 1]	325	289	212	223	181	280	271	240	232	227	213	259	203	221	251	406	466
	8.00%	5.00%	5.00%	6.00%	7.00%	7.00%	5.00%	4.00%	4.00%	6.00%	7.00%	10.00%	3.00%	4.00%	7.00%	8.00%	9.00%
Motor Vehicles, Parts and Equipment	45	159	279	172	120	155	160	167	178	125	71	64	28	6	19	29	28
	1.00%	3.00%	7.00%	5.00%	5.00%	4.00%	3.00%	2.00%	3.00%	3.00%	2.00%	2.00%	1.00%	0.00%	0.00%	0.62%	0.54%
Coke, Petroleum Coke	0	0	0	0	0	276	423	455	35	27	81	26	239	190	149	235	165
	0.00%	0.00%	0.00%	0.00%	0.00%	7.00%	9.00%	7.00%	1.00%	1.00%	3.00%	1.00%	4.00%	3.00%	4.00%	5.00%	3.20%
Other Commodities 2]	1,383	1,537	961	1,156	964	701	768	721	560	694	779	614	913	582	582	1,677	2,087
	33.00%	26.00%	23.00%	33.00%	39.00%	17.00%	15.00%	11.00%	10.00%	17.00%	25.00%	23.00%	15.00%	10.00%	15.00%	35.00%	40.00%

1] Chemicals includes all listings 2800-2899, mainly benzene and sodium hydroxide

2] Other Commodities includes remaining commodities such as Foodstuffs, Ores, Petroleum Products, and General Manufactured Items.

107. For imports, tonnage levels of iron ore have fallen from the 1975 high of 15 million tons to a 1989 level of 4.4 million tons. Associated with this decline has been a sharp drop in iron and steel imports to less than one-half of 1973 levels. Both of these declines reflect the depressed state of the U.S. steel industry. For exports, coal and grain have historically dominated traffic. Coal exports exhibited a general upward trend until 1982 when they declined by almost 40%, a reflection of the depressed international economy. However, the 1973-1989 period contains two trends. During the early and mid-70's, exports were primarily metallurgical coal. Export levels, during this period, exhibited large fluctuations, probably as a result of changes in the world economy. In 1979, steam coal exports began to dominate coal exports resulting in an upward trend. The 1985-1986 increase was principally due to rising shipments from Pier 124, which had undertaken significant capital investment to increase capacity. A dropoff in tonnage occurred in 1987, but a partial recovery was seen in 1988-1989. Also, scrap exports and containers have shown promising growth in recent years.

108. Shipments of grain, the other major export commodity, varied considerably during the 1973-1989 period. There were a variety of market factors that contributed to this fluctuation, such as the grain embargo in the late 70's, and the variation in world supply from year to year affecting the magnitude of U.S. export movements. A review of U.S. grain export levels and discussion with knowledgeable sources indicated that this variability also reflected that the Delaware River grain facilities were basically operating as a marginal port versus more successful ports. Of major importance, the export of significant grain movements essentially ceased in the port with the closing of the Tidewater Grain facility on the Schuylkill River in early 1986. No change is expected for the foreseeable future.

109. For the remaining imports and exports, coastal traffic (Table 5) and internal traffic (Table 6), there has been a general downward trend over the 1973-1989 time period. For example, the depressed state of the U.S. steel industry has influenced not only iron and steel imports, but also coastal movements of iron ore, iron and steel products, and various metallic and non-metallic ores. In combination with the generally depressed state of the world economy in the early-80's, this may have distorted the longer term growth trends for many commodities.

TABLE 5

COASTAL RECEIPTS AND SHIPMENTS BY MAJOR COMMONDITY GROUPS: TRENTON, NEW JERSEY TO THE SEA, 1973-1989

(thousands of short tons)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Total, Coastal Receipts	17,491	16,883	12,713	11,923	10438	10,352	11,567	10,848	9,423	7,841	7,725	6,649	5,718	5,205	4,720	5,430	4,800
Crude Petroleum	6,395	5,808	3,161	2,064	2,171	3,208	3,793	2,469	1,857	2,233	3,597	2,325	2,541	1,874	994	1,470	1,051
	37.00%	34.00%	25.00%	17.00%	21.00%	31.00%	33.00%	23.00%	20.00%	29.00%	47.00%	35.00%	44.00%	36.00%	21.00%	27.00%	21.90%
Chemicals & Plastics 1]	1,069	1,075	916	1,152	934	764	814	670	737	573	494	510	550	494	509	565	372
	5.00%	5.00%	7.00%	10.00%	9.00%	7.00%	7.00%	6.00%	8.00%	7.00%	6.00%	8.00%	10.00%	9.00%	11.00%	10.40%	7.70%
Petroleum Products 2]	9,558	9,513	8,440	8,506	7,198	6,266	6,870	7,467	6,681	4,746	3,527	3,746	2,565	2,724	3,082	3,305	3,213
	55.00%	55.00%	66.00%	71.00%	69.00%	61.00%	59.00%	69.00%	71.00%	62.00%	46.00%	56.00%	45.00%	52.00%	65.00%	60.00%	66.00%
All Other Commodities 3]	469	1,387	196	199	135	114	90	242	148	89	107	68	62	113	135	91	164
	3.00%	8.00%	2.00%	2.00%	1.00%	1.00%	1.00%	2.00%	2.00%	1.00%	1.00%	1.00%	1.00%	2.00%	3.00%	1.60%	3.40%
Total, Coastal Shipments	8,405	8,939	8,830	10,297	9,726	9,509	10,718	9,095	8,734	8,621	7,723	7,545	6,209	6,454	6,820	8,055	7,593
Crude Petroleum	73	206	417	334	9	74	356	243	129	60	59	9	49	78	327	568	645
	1.00%	2.00%	5.00%	3.00%	0.09%	1.00%	3.00%	3.00%	1.00%	1.00%	1.00%	0.00%	1.00%	1.00%	5.00%	7.00%	8.50%
Chemicals & Plastics 1]	169	220	169	177	217	158	131	144	155	77	100	189	136	159	126	159	151
	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	1.00%	2.00%	2.00%	1.00%	1.00%	3.00%	2.00%	2.00%	2.00%	1.90%	2.00%
Petroleum Products 2]	7,926	8,261	8,113	9,657	9,471	9,197	10,201	8,641	8,434	8,377	7,141	6,422	5,128	5,579	5,917	6,958	6,229
	94.00%	92.00%	92.00%	94.00%	97.00%	97.00%	95.00%	95.00%	97.00%	97.00%	92.00%	85.00%	83.00%	86.00%	87.00%	86.00%	82.00%
All Other Commodities 3]	237	250	131	129	29	80	30	67	16	107	423	925	896	638	448	370	567
	3.00%	3.00%	2.00%	1.00%	1.00%	1.00%	0.00%	1.00%	1.00%	1.00%	5.00%	12.00%	14.00%	10.00%	7.00%	4.60%	7.40%
Total, Coastal Traffic	25,896	25,822	21,543	22,220	20,164	19,861	22,265	19,943	18,157	16,262	15,448	14,194	11,927	11,659	115,540	13,485	12,394
Receipts as a Percent of Total	58.00%	65.00%	59.00%	53.00%	52.00%	51.00%	52.00%	54.00%	52.00%	47.00%	50.00%	47.00%	48.00%	45.00%	41.00%	40.00%	39.00%
Shipments as a Percent of Total	32.00%	35.00%	41.00%	46.00%	48.00%	49.00%	48.00%	46.00%	48.00%	53.00%	50.00%	53.00%	52.00%	55.00%	59.00%	60.00%	61.00%

1] Chemicals & Plastics includes all listings 2600-2699, mainly benzene and sodium hydroxide.

2] Petroleum Products includes all listings 2900-2999, mainly residual fuel oil and gasoline.

3] All other commodities includes remaining commodities such as Cereals and Grains, Foodstuffs, Ores and General Manufactured Items.

WORLD SHIPPING TRENDS/VESSEL USAGE.

110. A breakdown of vessels of the world fleet by draft was obtained using MARDATA Ship Library for dry bulk carriers, freighters, tankers, combination (oil, bulk ore) vessels and container vessels. The percent of fleet capacity (in deadweight tons) associated with design drafts in excess of 40 feet, 50 feet and 70 feet is as follows:

	Percent of Fleet Capacity			
Vessel Type	Draft 40' or more	Draft 50'	Draft 70'	No. of Vessels
Bulk Carriers	42.9	14.8	0.0	4,535
Freighters	0.3	0.1	0.0	13,103
Tankers	75.4	60.6	18.3	5,007
Combination Vessels	97.7	68.2	2.2	461
Container Vessels	9.9	0.0	0.0	1,104

111. U.S. FLEET. According to the July 1, 1983, inventory of the U.S. flag merchant fleet compiled by the Maritime Administration, the U.S. flag fleet consisted of 571 privately owned vessels of 22.0 million deadweight tons and 255 government owned vessels of 2.7 million deadweight. A detailed breakdown of the U.S. flag fleet by draft and deadweight was also complied by the Maritime Administration.

112. Dry Bulk Carriers. U.S. merchant-type dry bulk carriers are all privately owned. They all fit in the 20,000 to 30,000 DWT category, with drafts ranging from 30 to 36 feet, except for 2 vessels in the 80,000 to 90,000 DWT category (46 foot draft), and 1 vessel in the 30,000 to 40,000 DWT category (35 foot draft). The average draft for the entire fleet is 35 feet.

113. Tankers. Over 90 percent of U.S. flag tankers are privately owned. Fifty percent of the vessels concentrate in the 20,000 to 40,000 DWT category, with drafts ranging from 30 to 40 feet. Nearly 80 percent of the vessels have a draft lower than 40 feet. All government tankers are in the "under 20,000 DWT" category, with drafts ranging from 19 to 32 feet.

114. Freighters. There are about as many U.S. government owned freighters as there are privately owned freighters. However, the distribution of those vessels by draft and deadweight is different. About 65 percent of all government owned vessels fit in the 11,000 to 13,000 DWT category and all have a draft of 29 feet. Nearly 50 percent of the private fleet is composed of vessels of DWT exceeding 15,000 tons. The deepest draft for all U.S. flag freighters is 39 feet.

TABLE 6

TONNAGE AND DISTRIBUTION OF INTERNAL WATERBORNE COMMERCE ON THE DELAWARE RIVER:
TRENTON, NEW JERSEY TO THE SEA, 1973-1987

(thousands of short tons)

Commodity	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Total, Freight	29,219	31,432	28,862	29,185	29,693	30,303	31,218	25,403	22,647	19,052	17,430	19,780	20,472	22,421	23,913
Coal	1,736 6%	1,708 5%	1,525 5%	949 3%	843 3%	755 2%	845 3%	964 4%	1,014 4%	1,130 6%	1,219 7%	1,201 6%	1,068 5%	781 3%	772 3%
Crude Petroleum	6,796 23%	9,069 29%	9,993 35%	9,847 34%	11,045 37%	11,822 39%	12,318 39%	8,053 32%	4,542 20%	6,115 32%	4,809 28%	6,552 33%	8,932 44%	9,695 43%	10,876 45%
Chemicals & Fertilizers1	1,258 4%	1,089 3%	744 3%	981 3%	858 3%	866 3%	967 3%	938 4%	933 4%	479 3%	550 3%	642 3%	952 5%	1,091 5%	1,084 5%
Gasoline	2,977 10%	3,030 10%	2,329 8%	2,376 8%	1,946 7%	1,804 6%	2,192 7%	1,749 7%	1,411 6%	1,287 7%	991 6%	1,026 5%	1,694 8%	1,847 8%	1,802 8%
Distillate Fuel Oil	3,873 13%	4,815 15%	4,121 14%	3,342 11%	3,445 12%	3,621 12%	3,611 12%	3,971 16%	3,726 16%	2,692 14%	2,337 13%	2,517 13%	1,928 9%	1,975 9%	2,008 8%
Residual Fuel Oil	7,709 26%	7,263 23%	6,442 22%	8,635 30%	8,579 29%	9,153 30%	9,183 29%	8,010 32%	9,556 42%	5,920 31%	5,945 34%	5,959 30%	4,393 21%	5,313 24%	5,302 22%
Other Petroleum Products2	1,149 4%	1,845 6%	1,265 4%	1,211 4%	1,457 5%	1,473 5%	1,502 5%	1,281 5%	1,058 5%	963 5%	1,093 6%	1,442 7%	1,344 7%	1,197 5%	1,658 7%
Other Commodities3	3,727 13%	2,613 8%	2,443 8%	1,844 6%	1,520 5%	809 3%	600 2%	437 2%	407 2%	466 2%	485 3%	441 2%	161 1%	522 2%	2,211 9%

1 Chemicals & Fertilizers includes all listings 2800-2899, mainly benzene and sodium hydroxide.
2 Other Petroleum Products includes all 2900's listings except 2911, 2914, and 2915, mainly liquified gases and kerosene.
3 Other commodities includes remaining commodities such as Cereals and Grains, Foodstuffs, and General Manufactured Items.

SOURCE: Waterborne Commerce of the United States, Volume I, U.S. Amry Corps of Engineers.

115. REGIONAL FLEET. The regional fleet is defined as that portion of the world fleet servicing a particular coastal region of the United States. The most detailed information which includes the Port of Philadelphia comes from information about the Atlantic Coast region. The latest available document concerning the fleet servicing the Atlantic Coast is a 1978 Maritime Administrative report entitled, "Merchant Fleet Forecast of Vessels in U.S.-Foreign Trade." Based on this report, it is possible to compare the world, regional and U.S. flag fleets broken down by deadweight for dry bulk vessels, tankers and freighters.

116. Dry Bulk Carriers. The distribution of the regional and the world fleets is nearly identical for vessels of up to 60,000 DWT, composing 70 percent of the capacity of both fleets. Above 60,000 DWT, the regional fleet is much smaller than the world fleet as evidenced by the following breakdown:

DWT Range	Typ. Draft (ft.)	Percent of Fleet Capacity	
		World	Region
0 - 60,000	-	65	67
60,000 - 80,000	42	11	25
80,000 - 125,000	46	16	6
125,000 - above	58	8	2

117. Tankers. Major differences are observed between the world fleet and the part of the world fleet serving the Atlantic Coast. The composition of the regional fleet is extremely biased toward the 20,000 to 125,000 DWT range where over 90 percent of the fleet capacity can be found, evenly distributed inside this interval. Conversely, over 50 percent of the world fleet capacity is found in vessels of DWT higher than 125,000 tons. The composition of the world fleet is evenly distributed between 1,000 and 300,000 DWT. Vessels of DWT exceeding 300,000 tons account for 12 percent of the remaining capacity of the world fleet.

118. Freighters. The distributions of the regional and world freighter fleets are fairly similar. The major variation is a higher concentration of vessels ranging between 10,000 and 15,000 DWT, in the regional fleet, as opposed to the world fleet (47 percent and 34 percent respectively).

NAVIGATION PRACTICES

119. The purpose of this section is to describe how the Delaware River waterway system functions and to provide an overview of traffic movements, vessel operations, and the interrelationship of the component waterways in the system.

120. The Delaware River system can be entered or exited via the Delaware Bay entrance or through the Chesapeake and Delaware Canal. Two sets of ocean traffic lanes converge at a precautionary area at

the bay entrance. Each set of lanes has a separation zone for safety between inbound and outbound vessels. The northern Cape Henlopen - Five Fathom Bank lanes have minimum depths close to the 40 foot main channel depth and are used primarily by smaller vessels and those engaged in coastwise commerce. The southern Cape Henlopen - Delaware lanes are much deeper with minimum depths of about 55 feet outbound and 59 feet inbound. These lanes are used by most vessels engaged in foreign commerce including the large bulk carriers and tankers as well as for coastwise movements to the south. Each set of ocean lanes is marked by a series of buoys centrally located in each separation zone. Some vessels are piloted within the Delaware River system by members of the Pilot's Association for the Delaware River and Bay. They board incoming vessels in the pilot area at the bay entrance and at the Maryland/Delaware line in the C&D Canal.

121. From the bay entrance vessels can either proceed up the main Delaware River channel to the Philadelphia ports or through naturally deep waters to the Big Stone Beach Anchorage in lower Delaware Bay. This anchorage has been used for over 25 years by large tankers to lighter (primarily crude oil) onto barges. Maximum drafts for tankers entering the bay is 55 ft and lightering reduces the tankers operating drafts to those acceptable for the 40 ft channel. In 1983 this anchorage was reclassified by the U.S. Coast Guard as a general purpose anchorage, however lightering is still the dominant activity.

122. The 40 foot Delaware River channel provides for two-way traffic up to the Philadelphia Navy Yard where it transitions to a 400 ft width on the west side. Within Philadelphia Harbor the 37' east side of the channel allows two-way traffic with shallower vessels yielding the 40 foot channel to deeper vessels. The 40 foot channel continues upriver to the steel facility at Fairless, Pa. as the Philadelphia to Trenton segment of the Delaware River channel. The main channel serves numerous other tributary projects which provide both one-way and two-way access to facilities engaged in foreign, coastwise, and internal commerce. The main channel is connected to the Chesapeake Bay and Port of Baltimore by the C&D Canal. The canal is used by container liner services which call at Baltimore as well as by lesser draft domestic vessels, tug and barge traffic, and pleasure craft.

123. A series of six Federally authorized anchorages as well as thirteen naturally deep U.S. Coast Guard designated areas adjoin the Delaware River channel between Philadelphia and Delaware Bay. Included are general and special purpose anchorages. Vessels are permitted to anchor for a period up to 48 hours (or longer with a Coast Guard permit). Vessel usage is recorded by the U.S. Coast Guard only for the commonly used anchorages at Big Stone Beach, Mantua Creek, Marcus Hook, and Kaighn Point Gloucester in addition to the breakwater area at the bay entrance. Vessel length restrictions are enforced at Mantua Creek (700 feet) anchorage to void vessels swinging outside anchorage boundaries during a change of tide. Of the upriver anchorages, only Marcus Hook provides

depths compatible with the 40 foot channel. The most heavily used anchorages on the river are Marcus Hook and Mantua Creek. The dominant usage at those anchorages is by tankers for the refineries and bulk vessels, respectively. The anchorages are generally used to avoid accidents during foul weather and poor visibility; during lightering, bunkering, or repairs; or while awaiting berth space or favorable tide conditions.

124. The Pilot's Association and Mariner's Advisory Committee have established operating procedures for safe vessel movement. Vessel sailing drafts of up to 40 feet inbound and outbound can utilize the present Delaware River, Philadelphia to the Sea Project.

125. Traffic monitoring on the Delaware River system is accomplished by the U.S. Coast Guard, Philadelphia Maritime Exchange, and Pilot's Association. The U.S. Coast Guard is notified of vessel arrivals at least 48 hours ahead of time. The Maritime Exchange maintains a record of scheduled arrivals and departures. The pilots coordinate among themselves to assure safe and efficient vessel movements and they also communicate with the captains of other smaller vessels and tows operating on the river. Pilots also communicate with tug operators to arrange for docking assistance, if required. Tugs will accompany large vessels as they approach and depart port facilities for additional safety.

126. Vessel operations occur day or night on the major waterways using channel markers, range lights, and other physical references to guide navigation. Raycon (a radar transponder beacon, which emits a characteristic signal when triggered by the emissions of ship's radar) has been installed at selected locations at the bay entrance and Big Stone Beach Anchorage. It enhances the ability of vessel operators to determine vessel location during poor visibility conditions.

127. Typical vessel speeds in the Delaware River vary between 5 and 12 knots. Larger tankers (275,000 + DWT) operate with tug assistance during light traffic situations. Passing/meeting situations are limited at bends depending on vessel and traffic conditions. Traffic keep in touch with the Maritime Exchange.

128. Vessels with drafts of 37' or less can safely operate without use of the tides. Vessels with drafts in excess of 37' operating depth must rely on the tide. The critical area of concern for deep draft vessel operation in the Delaware River is the Marcus Hook Range with its rock outcroppings in the channel.

129. FACILITY/CAPACITY ANALYSIS. In this section, the capacity of potentially benefitting facilities in the Delaware River port system is estimated.

130. <u>Liquid Bulk.</u> The capacity of liquid bulk terminals is determined by the capacity of available storage tanks and pipelines from wharf to storage. The capacity from wharf to storage can

generally be expanded by increasing the number or diameter of pipelines, while the storage capacity is usually dependent upon the fixed plant/refinery consumption/production or transshipment rate.

131. Table 7 presents an inventory of deep-draft facilities for liquid bulk (crude oil, petroleum products, petrochemicals, and chemicals). In order to ensure no product contamination from intermixing, crude oil is handled by separate dedicated pipelines and tanks from those used for refined petroleum movements.

132. The total existing instantaneous storage capacity of liquid bulk terminals in the Delaware River is approximately 73 million barrels, or about 11 million tons.

133. The pump capacity of liquid bulk tankers is generally designed to unload vessels in 16 hours. However, a certain amount of time at berth is lost connecting pipes, adjusting valves, and other inefficiencies, so that 24 hours at berth would be a more reasonable estimate.

134. The annual capacity of a typical crude oil berth is very large, corresponding to the unloading of approximately 125 vessels per year. The U.S. Maritime Administration publication, Port Handbook for Estimating Marine Terminal Cargo Handling Capability, estimates typical annual throughput of a crude oil berth to be 6,000,000 short tons. For the six benefitting refineries, 16 total berths are utilized, equating to total berth capacity of 96 million short tons per year. Total current estimated annual throughput capacity for Delaware River facilities is approximately 60 million tons. The refineries anticipate expanding capacity as required, by technology changes and upgrading facilities, to meet the relatively low average annual growth of only 0.8% per year for crude oil imports projected from the study year to the final year of the project life, 2055. It is important to note that the refined product pipelines from the refineries in the Gulf Coast which extend to the Northeastern U.S. refined product market are not as cost-efficient as having crude oil refined at the Delaware River refineries and then transported to the Northeastern U.S. market.

Table 7

INVENTORY OF DEEP-DRAFT FACILITIES FOR CRUDE OIL/PETROLEUM PRODUCTS/PETROCHEMICALS AND CHEMICALS

COE Reference No.	Owner	Name	Commodities	Storage Capacity (000's) bbls	Berth Length (ft)	Alongside Depth (ft)	Pipelines from Wharf to Storage Tanks (# and diameter, inches) 36	30	24	20	18	16	14	12	10	8	6	4
					DELAWARE													
Philadelphia to the Sea - Christina River to Delaware Bay																		
5	Texaco Refining & Marketing Co. (R)	Pier No. 1	Crude Oil	4,975	1,100	38			1							1		
6	"	Pier No. 2	Petroleum Products	incl. above	1,000	34			1		3	1		4				
7	"	Pier No. 3	Petrol Prod/ Chemicals	incl. above	750	35					3		1	4	1			
Christina River - Port of Wilmington																		
10	Delaware Terminal Co. (S)	Tanker Berth	Petrol Prod/ Chemicals	1,200	1,000	35		1						2	1			
					PENNSYLVANIA													
Philadelphia to the Sea - Marcus Hook to Schuylkill River																		
23	Allied Chemical Co. (S)	Upper Pier	Chemicals	28	1,496	18-30									1		3	
24	Sun Refining & Marketing Co. (R)	Wharf 3C	Crude/Petrol. Prod./ Petrochem	16,240	1,000	38			1	2		1				1		
25	"	Wharf 3A	Crude/Petrol. Prod./ Petrochem	incl. above	1,500	12-32	1		1	1				1	3	6	4	2
26	"	Wharf No. 2	Crude/Petrol. Prod./ Petrochem	incl. above	650	32			1	1			1	3	5	6	5	4
27	"	Wharf No. 1	Petrol Prod.	incl. above	610	26				1				1	4	6	3	4
30	B.P. Oil Inc. (R)	Docks 1&2	Crude Oil	1,800	1,145	40			1		1			1		5	1	1
31	"	Barge Wharf	Petrol Prod.	920	1,210	20-34					1	2		2	1		2	3

Table 7 (Cont'd.)

INVENTORY OF DEEP-DRAFT FACILITIES FOR CRUDE OIL/PETROLEUM PRODUCTS/PETROCHEMICALS AND CHEMICALS

COE Reference No.	Owner	Name	Commodities	Storage Capacity (000's)	Berth Length (ft)	Alongside Depth (ft)	Pipelines from Wharf to Storage Tanks (# and diameter, inches) 36	30	24	20	18	16	14	12	10	8	6	4
				bbls														
32	Philadelphia Elec. Co. (S)	Chester Sta. Wharf	Fuel Oil[1]	67	407	25										1	1	
46	"	Eddystone Sta. Lower Wharf	Fuel Oil[1]	381	200	29										1		
47	"	Eddystone Sta. Upper Wharf	Fuel Oil[1]	incl. above	200	29										1		
49	Chevron Oil Corp. (R)	Hog Island Wharf	Crude Oil/ Naphtha	4,368	2,754	38			2	1								
51	Atlantic Pipeline Co. (S)	Fort Mifflin Berth A	Crude Oil	570	956	42		1				3			1			
52	"	Fort Mifflin Berth B	Crude Oil/ Petrol Prod.	incl. above	889	42		1			1							
Schuylkill River - Girard Point to Passyunk Ave.																		
58	Exxon Co. (S)	Barge Dock	Petrol. Prod.	908	180	33								3		5	9	
60	Swann Oil Inc. of Philadelphia (S)	Swann Oil Wharf	Petrol. Prod.	947	750	35									2		1	
61	Pioneer Oil Co. (S)	Triangle Term Pier	Petrol. Prod.	135	165	24-26											5	
62	Amoco Oil Co. (R)	West Yard Berth 4	Petrol. Prod.	565	430	26								3	1	1		1
63	Atlantic Pipeline Co. (S)	West Yard Berth 3	Petrol. Prod.	220	200	20-26									1	1		

Table 7 (Cont'd.)

INVENTORY OF DEEP-DRAFT FACILITIES FOR CRUDE OIL/PETROLEUM PRODUCTS/PETROCHEMICALS AND CHEMICALS

COE Reference No.	Owner	Name	Commodities	Storage Capacity (000's) bbls	Berth Length (ft)	Alongside Depth (ft)	Pipelines from Wharf to Storage Tanks (# and diameter, inches) 36	30	24	20	18	16	14	12	10	8	6	4
82	Atlantic Pipeline Co. (R)	Atlantic Wharf	Crude/Petrol Prod.	952,	888	25				1					2	4	1	
86	Chevron Oil Corp. (R)	Wharf No.2	Crude/Petrol Prod.	5,190	300	33								5		2	4	
87	" " "	Wharves 163	Petrol. Prod/ Petrochem	Incl. above	1,475	33								13	4	7	4	7
Philadelphia to the Sea - Schuylkill River to Allegheny Ave.																		
137	Namolco Inc. (S)	Pier G Port Richmond	Chemicals	238	1,423	30-36											1	
Philadelphia to Trenton - Allegheny Ave. to Newbold Island																		
140	Philadelphia Port Corp. (S)	Tioga II	Petrol. Prod/ Petrochem	1,000	620	34									2	8	3	
153	Philadelphia Elec. Co. (S)	Croyden Gen. Sta. Wharf	Fuel Oil[1]	611	500	30										1	1	
154	Meenan Oil Co. (S)	Meenan Oil Wharf	Petrol. Prod.	391	875	34						1			2			
159	U.S. Steel Corp. (S)	Mooring Wharf	Fuel Oil[1]	181	1,000	40				Not Available								
					NEW JERSEY													
Philadelphia to Trenton - Allegheny Ave. to Newbold Island																		
178	Amerada Hess Corp. (S)	Dock 1	Crude/Petrol. Prod.	2,100	285	39				1				4				
179	Texaco Inc. (R)	Tanker Dock Berths 1&2	Petrol. Prod.	1,193	197	29									1	2	2	1

Table 7 (Cont'd.)

INVENTORY OF DEEP-DRAFT FACILITIES FOR CRUDE OIL/PETROLEUM PRODUCTS/PETROCHEMICALS AND CHEMICALS

COE Reference No.	Owner	Name	Commodities	Storage Capacity (000's) bbls	Berth Length (ft)	Alongside Depth (ft)	Pipelines from Wharf to Storage Tanks (# and diameter, inches) 36	30	24	20	18	16	14	12	10	8	6	4
Philadelphia to the Sea - Port of Camden																		
181	Citgo Petroleum Corp. (S)	Petty's Island Term Dock	Petrol. Prod.	1,010	800	30						1		5				
Philadelphia to the Sea - Paulsboro to Delaware Bay																		
210	Koch Fuels Inc. (S)	Koch Fuels Dock	Petrol. Prod.	800	238	35						1			4	1		
214	Coastal Inc. (R)	Eagle Point Berth 1A	Crude Oil	8,620	650	35			1		1	1			4	3		1
215	"	Eagle Point Berth 1	Petrol. Prod.	incl. above	372	35										7	1	2
216	"	Eagle Point Berth 2	Crude/Petrol. Prod.	incl. above	800	40						3		3	4	1	4	1
217	"	Eagle Point Berth 3	Crude/Petrol. Prod.	incl. above	550	43						3		3	2	1	3	1
220	Mantua Chemical Term. (S)	Main Dock	Petrol. Prod/ Chemicals	4,300	1,000	40					Not Available (18 total)							
221	" " "	Barge Dock	Petrol. Prod/ Chemicals	1,300	600	30											2	
225	B.P. Oil Co. (R)	Paulsboro Term Pier 2 & Barge Berths 4&6	Petrol. Prod/ Petrochem	3,350	856	17-36						1		6		8	9	
226	" "	Paulsboro Term Pier 1 & Barge Berths 3, 5&7	Petrol. Prod/ Petrochem	incl. above	797	17-36					Not Available							

Table 7 (Cont'd.)

INVENTORY OF DEEP-DRAFT FACILITIES FOR CRUDE OIL/PETROLEUM PRODUCTS/PETROCHEMICALS AND CHEMICALS

COE Reference No.	Owner	Name	Commodities	Storage Capacity (000's) bbls	Berth Length (ft)	Alongside Depth (ft)	Pipelines from Wharf to Storage Tanks (# and diameter, inches) 36	30	24	20	18	16	14	12	10	8	6	4
228	Exxon Co. (S)	Paulsboro Wharf	Petrol. Prod.	1,621	1,320	25-40						1	1		1	5	1	
229	Sunmark Industries (S)	Paulsboro Term Pier	Petrol. Prod.	51[1]	90	35										1		
230	Mobil Oil Corp. (R)	Paulsboro Term Wharf & Berths 1, 2,3&5	Crude/Petrol. Prod.	6,200	2,388	34		1				1	1	3	2	1	1	
231	" "	Paulsboro Term Tanker Wharf	Crude/Petrol. Prod.	incl. above	822	40		1					1	1			1	
233	E.I. du Pont (S)	Repauno Plant Solvent & Sulpher Pier	Chemicals	106	840	20-35										2		
235	Monsanto Industrial Chemical Co. (S)	Delaware River Plant Dock	Chemicals	190	600	37									4			
237	E.I. du Pont (S)	Chamber Works Main Wharf	Petrol. Prod/ Petrochem/Chem	310	1,195	16-33			1					1				
			TOTAL	73,038			1	5	10	8	10	20	5	52	53	87	73	28

Note: 1 s. ton = 6.6 barrels of crude oil
1 s. ton = 7.1 barrels of refined petroleum
1 s. ton = 8.5 barels of gasoline

(R) - Refinery
(S) - Storage
[1] Fuel Oil for plant consumption

139. Coal Exports. The total estimated existing and planned coal loading (export) capacity of the Delaware River system is 19.7 million tons per year. This estimate is based on the reported existing and planned loading capacity of the individual facilities, and excludes South Jersey Port Corporation's Beckett Street Terminal which is discussed in a following section. At the present time, there is one primary export coal facility in operation, Conrail's Pier #124. This facility has been upgraded to provide an estimated capacity of 10 million tons per year. Conrail's Pier #18, Port Richmond, which once handled coal, has been closed due to obsolescence, in favor of expansion at pier #124. The north side of Conrail's Pier E, Port Richmond, has modified former grain spouts to handle coal from a new bottom dump car unloader and/or from a developed open storage/reclamation area. USX Corp.'s berthing is not currently equipped for coal export. Plans to achieve an annual throughput capacity of 8.2 million tons were developed in the early 1980's and, though not presently likely, could be implemented in the future. The estimated coal export capacity is broken down as follows:

Conrail Pier #124	10,000,000
Conrail Pier E	1,500,000
USX Corp.	8,200,000
Total	19,700,000

140. Iron Ore Imports. The total estimated iron ore import capacity of the Delaware River port system is 14.5 million tons per year at two existing terminals. This estimate is based on the reported shiploading capacity of existing equipment at the individual facilities and year-round three-shift operation. Conrail Pier #122 currently operates only 8 hours per day, 5 days a week, well below its capacity. With the decline in the U.S. steel industry, Conrail is actively restructuring Pier #122's material handling system to handle lighter materials, such as imports of fertilizer in relatively small vessel and shipment sizes. Conrail Pier #14, Port Richmond, which formerly handled iron ore, is currently inactive. USX Corp.'s berth operates on three shifts with a 4 million ton per year throughput capacity.

Conrail Pier #122	10,500,000
USX Corp.	4,000,000
Total	14,500,000

141. South Jersey Port Corporation (SJPC). The Beckett Street Terminal, operated by South Jersey Port Corporation, has experienced increased business in recent years. In the last decade, South Jersey Port has expended approximately $15,000,000 to modernize the bulk cargo handling facilities and marginal berths at Beckett Street, with the result that Beckett Street Terminal now has the capacity to handle large quantities of bulk cargo efficiently. With the present redevelopment of the Camden Waterfront, Beckett Street Terminal expansion can only occur towards the south. Plans are presently being advanced to extend the southernmost berth at Beckett Street Terminal 300 feet

southward by acquiring property from Domtar, Inc., the adjacent property owner. The land area currently owned by SJPC for Beckett Street Terminal is 74 acres. SJPC also has four berths, with 2300 L.F. of length. Expansion and development plans include additional land acreage of 260 acres and additional berthing length of 4100 L.F. Total tonnage throughput capacity projected by SJPC for Beckett Street Terminal, when fully developed by 1998 in accordance with their Long-Range Master Plan, will be in excess of 10 million tons annually.

142. Other Bulk and General Cargo. A significant number of projects are underway that would improve the capacity and efficiency of port facilities to handle the general cargo targeted by the ports of Philadelphia. The Greenwich Rail Yard in South Philadelphia will be developed into a $47 million intermodal regional transfer facility. This intermodal facility will enhance the port's ability to attract container cargo shipments. It will also allow the port to transfer ocean cargo directly to and from western destinations. Other port projects in Philadelphia include the following: (1) construction of a new warehouse for paper imports ($11.1 million), (2) expansion of the shed at Tioga I Marine Terminal ($6.9 million) (3) expansion of the fruit shed capacity at Piers 82-84 ($6.4 million).

143. Container Terminals. The Delaware River port system container facilities, in their totality, have capacity to handle over 900,000 TEUs (twenty-foot equivalent units) of containers per year based on existing infrastructure. For the potentially benefitting facilities, Packer Avenue Marine Terminal has a total container capacity of 311,000 TEUs and the Holt Cargo Systems' terminal a capacity of 156,000 TEUs annually. The Regional Intermodal Transfer Facility (RITF) being developed by the Delaware River Port Authority adjacent to the Packer Avenue Terminal could also benefit. Based on tonnage handled, capacity utilization is approximately 25% at the current time.

144. Breakbulk Facilities. The estimated maximum capacity to handle non-containerized breakbulk cargo is 4.2 million tons per year at 14 terminals. Five of the breakbulk facilities possess heavy lift cranes which can be used to load/discharge containers as well as breakbulk cargo: Holt Cargo Systems, South Jersey Port Corp.'s Broadway and Beckett Terminals, the Port of Wilmington, and Northern Shipping Co. These facilities have higher than average capacities since their heavy lift cranes have higher handling rates for containers than for conventional breakbulk. Using these cranes, the container loading/discharging capacity is estimated to be 2.2 million tons per year. Thus, total capacity at the breakbulk facilities is 6.4 million tons per year. Several assumptions were used to determine the capacity of existing breakbulk facilities. For container handling these were considering only existing heavy lift cranes, and open storage assuming 110 TEU's per acre. For non-containerized breakbulk handling these included average productivity of 20 tons per hour per gang, with 3 gangs per berth and covered storage density of 7.5 sq. ft. per ton. For all

cargoes it was assumed that there was 5 day a week operation with average of 12 hours/day and an average storage time of 15 days.

145. Dedicated Ro-Ro Facilities. The total estimated existing and planned dedicated Ro-Ro capacity in the Delaware River system is 2.8 million tons per year at six terminals. Assumptions used to determine the capacity included an loading/unloading rate of 140 tons/hour with seven day a week operation, 20 hours/day. There would be storage on chassis one unit high, 110 TEU's per acre, one TEU= 10 tons and an average storage time of 15 days.

TRADE ROUTES

146. Freight trade routes for imports and exports through Delaware River Basin ports generally reflect the industrial character of the northeastern United States. Over the past decade, exports have generally been to industrialized countries, with imports coming from the less developed countries. Except for the Canadian Atlantic coast, the three trade routes accounting for the largest tonnage have been from the less developed countries - in Africa, South America, the Caribbean, and Mexico.

147. Using 1985-1989 data, existing vessel movements were broken down into relative percentages by benefitting trade route for benefitting commodities as shown below:

CRUDE OIL	
West Africa	36.8%
North Europe	19.0%
Caribbean	16.5%
South Africa	10.3%
South America	6.6%
Southeast Asia	3.2%
China/North Korea	2.2%
Red Sea/Arabian Gulf	1.8%
Mediterranean	1.7%
South Europe	1.2%
Australia	0.4%
Canada	0.3%
COAL	
North Europe	43.0%
Mediterranean	22.3%
Canada	17.3%
South America	6.8%
South Europe	6.2%
Caribbean	3.1%
East Europe	1.2%
IRON ORE	
Atlantic Canada	67.6%
North Europe	29.6%
South Europe	1.4%
North Africa	0.7%

SOUTH JERSEY PORT CORPORATION	
Scrap to Turkey	100%
Bituminous Coal from S. Amer.	100%

CONTAINERS	
Europe	38%
Mediterranean	7%
East Coast-South America	20%
Australia/Europe/East U.S.	20%
Halifax	15%

Additional commodities by trade route are shown below:

IMPORTS	
Iron and Steel:	Orient, Europe, Brazil
Fruit and Vegetable:	South America
Paper:	Europe, South America
Wood, Lumber Cork:	Canada
Chemical:	Europe, Africa, South America, Canada
Meat:	Australia, South America
Cork and Wood MFRS:	Asia
Fish:	South America, New Zealand
Stone:	Scotland, Nova Scotia

EXPORTS	
Chemical:	Europe, England, Japan, South America
Chemical Materials:	Europe, South America, Middle East
Road Vehicles:	Middle East
Pulp and Waste Paper:	Asia
Iron and Steel:	Asia, South America, Europe
Steel Scrap:	Europe, South America, Asia
Silt Coal:	Asia
Petrocoke:	Asia

LANDSIDE TRANSPORTATION SYSTEMS

148. An integral part of the study area are the transportation systems servicing the project area and the associated hinterlands. The investigations incorporated all facets of the system: highway, rail, and pipeline.

149. The primary New Jersey highway serving the north-south corridor is the New Jersey Turnpike, a 118-mile toll road which runs from its southern terminus at the Delaware Memorial Bridge at Wilmington, Delaware to points northeast, northern New Jersey, New York and the Northeast Region (see Figure 9). East-west auto traffic is served by the Atlantic City Expressway, a 44 mile, four-lane toll road, which, in conjunction with N. J. 42/U.S. 322, provides direct access from New Jersey's eastern shore to Camden, New Jersey, and the remaining ports of the Delaware River.

150. Unlike the New Jersey side of the Delaware River which is primarily rural and suburban, the Pennsylvania side is urban represented by the Philadelphia area. The principal highway

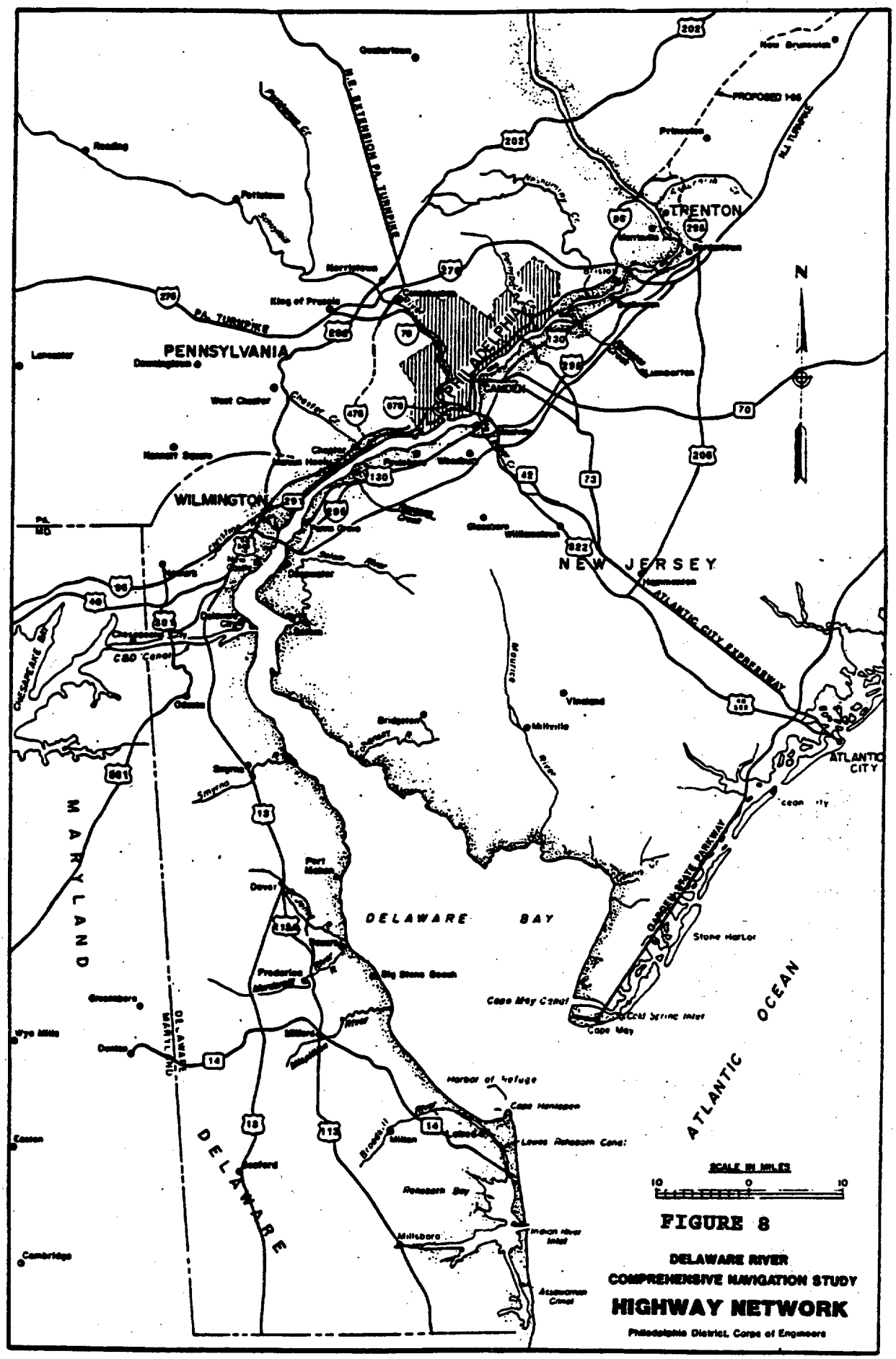


FIGURE 8

DELAWARE RIVER
COMPREHENSIVE NAVIGATION STUDY
HIGHWAY NETWORK
Philadelphia District, Corps of Engineers

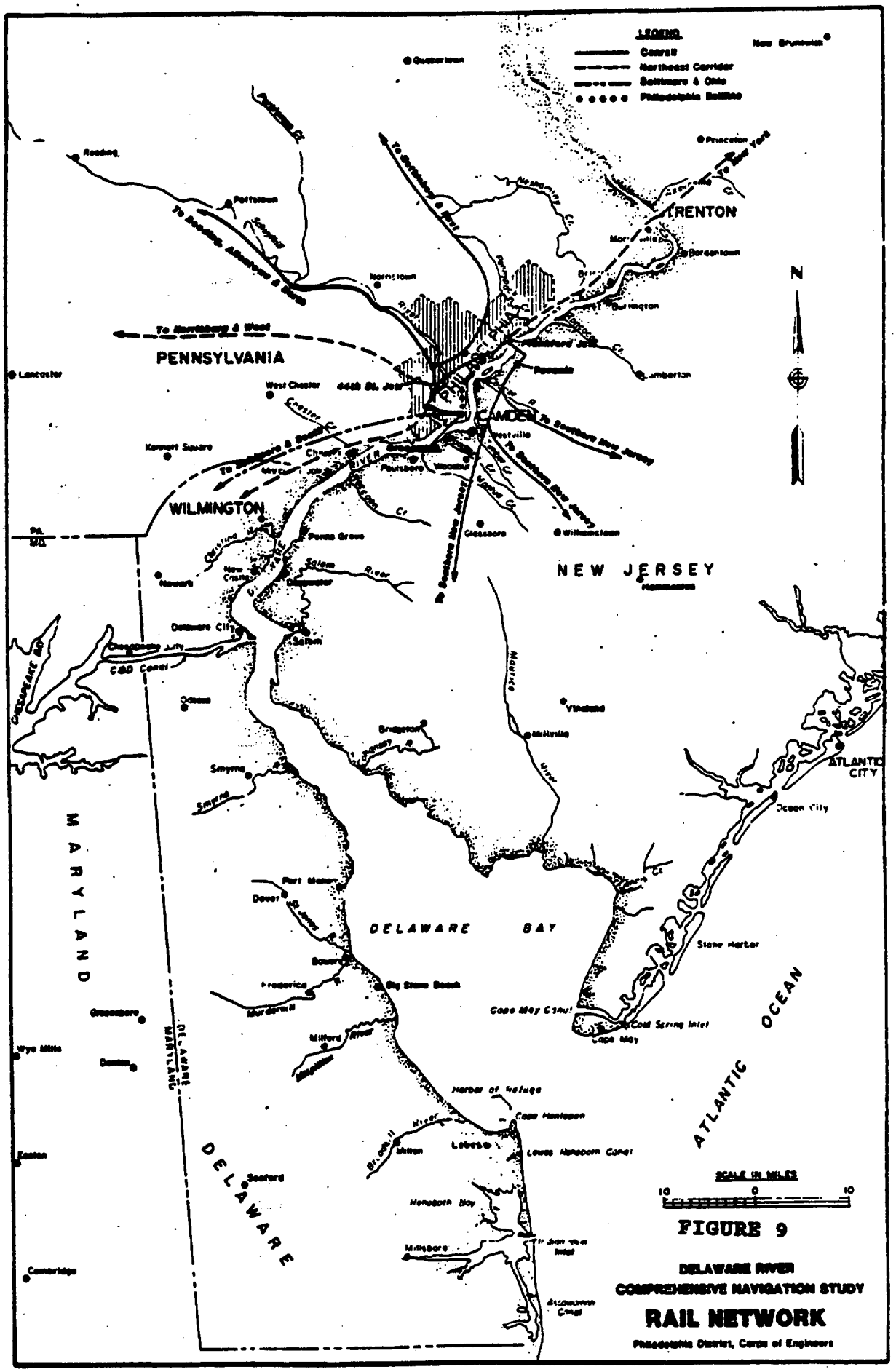


FIGURE 9

DELAWARE RIVER
COMPREHENSIVE NAVIGATION STUDY

RAIL NETWORK

Philadelphia District, Corps of Engineers

facility in the Northeast Corridor is I-95 which runs through Philadelphia, connects northern New Jersey, New York, and the New England states, and extends southwesterly to Wilmington, Delaware; Baltimore, Maryland, Washington, D.C., and points south. Primary service to the port community in Philadelphia is provided, with connection to I-95, by Delaware Avenue, a four lane road which runs parallel to I-95 and adjacent to the port facilities along the Delaware River. Major east-west movements to and from the Philadelphia ports are primarily carried by the Schuylkill Expressway (I-76). The Pennsylvania Turnpike and its Northeast Extension are 4-lane toll roads. The mainline turnpike provides for cross state movements from its eastern terminus at the New Jersey border to its western terminus at the Ohio border. The Northeast Extension provides access to northern Pennsylvania and western New York.

151. In Delaware, I-95 crosses the northern portion of the state between the Pennsylvania and Maryland state lines, a distance of 24 miles. North-south, traffic within Delaware is handled primarily by Routes 13 and 9.

152. The Delaware River port system was serviced by three trunkline railroads, the Conrail, Chessie, and Canadian Pacific Systems (see Figure 10). Conrail operates 17,700 miles of mainland track serving 16 states including the hinterland states of Delaware, Illinois, Kentucky, Maryland, New Jersey, New York, Ohio, Pennsylvania, Virginia, West Virginia, the District of Columbia, and portions of Canada. The Chessie System principal lines operate from New York City through Philadelphia, Baltimore, and Washington, D.C. Two lines operate westward from Maryland. In addition the Canadian Pacific Railroad has recently acquired the Delaware and Hudson Railroad which it will be using for Port access between Philadelphia and Canada. This will increase Philadelphia's potential market hinterland.

153. Regional Intermodal Container Transfer Facility. A major proposed plan by DRPA to improve container trade through Philadelphia involves the ongoing development of a rail intermodal yard at the Greenwich Rail terminal adjacent to the Packer Avenue Marine Terminal. The underlying purpose of the intermodal yard is to open the high cargo-generating area of the Midwest to Philadelphia through efficient rail operations near the port area. Contrail and CSX will have access to the yard, and the D&H Railway Division of Canadian Pacific Railways will also be open to the reach of Philadelphia. The intermodal yard will also open up the West Coast market, as well as the possibilities of landbridging Pacific Rim-European trade. The railyard is intended to serve as the key component to attract container lines to use Philadelphia as their load-center port. The intermodal yard is also designed to handle double-stack trains.

154. The intermodal yard is planned by DRPA to be built in two phases. The first phase will have a capacity of 270,000 lifts per year based on a conventional rail car system. Double stacking

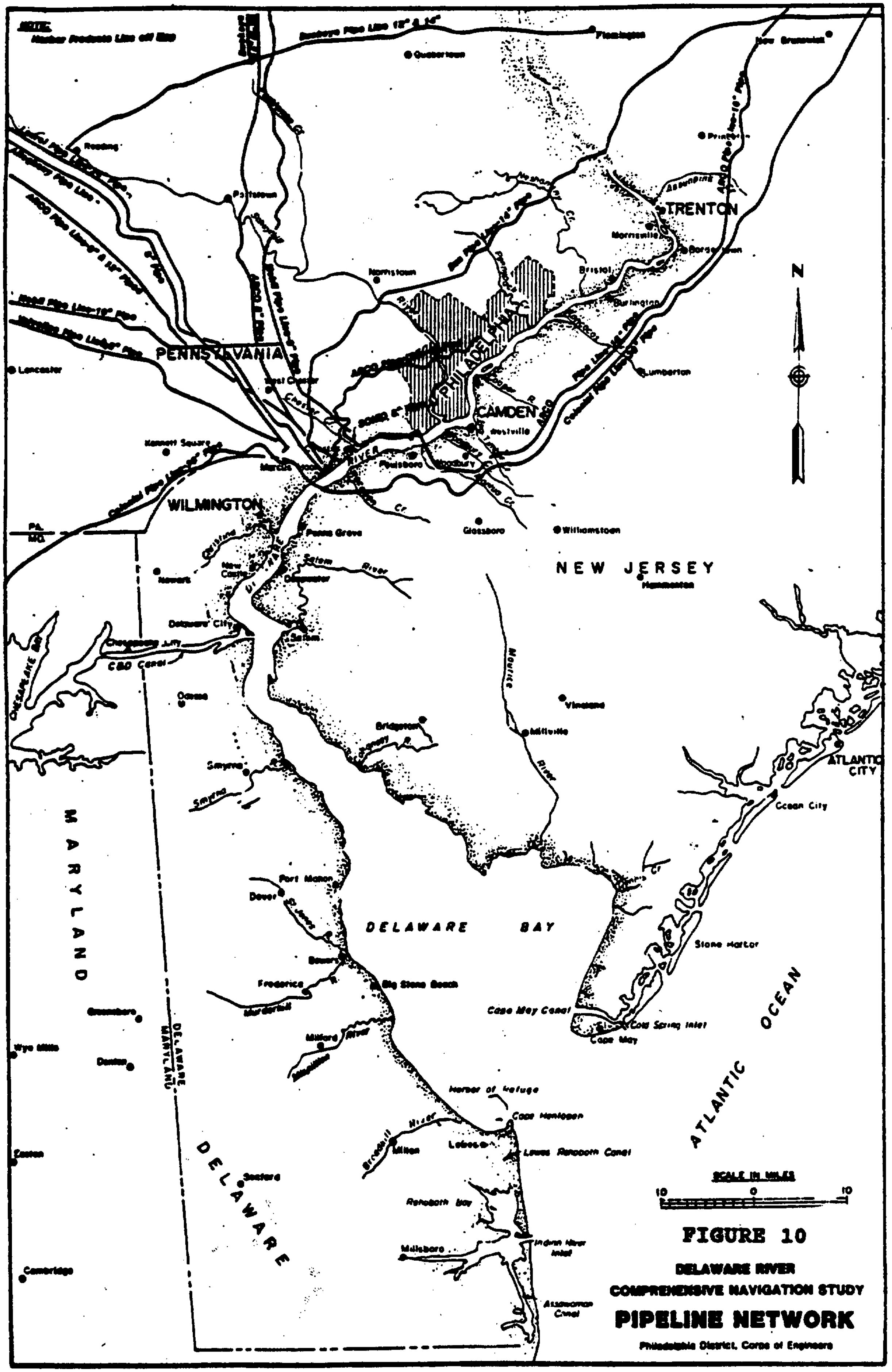


FIGURE 10

DELAWARE RIVER

COMPREHENSIVE NAVIGATION STUDY

PIPELINE NETWORK

Philadelphia District, Corps of Engineers

could boost capacity of 449,000 lifts per year. The yard will encompass four loading tracks of 3,600 feet in length and two storage tracks. The $2.3 million initial project outlay by DRPA represents approximately half the cost of opening the facility and involves laying new track, paving, building a gate complex and container-storage area, and installing overhead cranes for hoisting containers on and off trains. An additional amount of more than $2 million will be needed for equipment to load and unload rail cars. Eventually, DRPA anticipates spending more than $30 million on the project to accommodate future increases in business. The initial phase will involve 22 acres, with expansion possible for 44 additional acres. Close by, Railport, a private intermodal facility covering 10 acres, has laid track for its operations. The Railport facility was started in 1990 when it was uncertain if the DRPA would reach an agreement to lease a portion of Conrail's Greenwich yard. The Railport and DRPA facilities will be linked by rail to each other and to the CSX intermodal yard.

155. The North Atlantic coastal ports are served by a number of clean petroleum product pipelines (see Figure 11). The Colonial pipeline, originating in the Houston/Galveston refining territory, is the largest pipeline in the U.S. It passes through major refining centers in Louisiana, gathering products for delivery throughout the eastern U.S. The Plantation Pipeline is the second largest products line from the Gulf Coast and generally parallels the route of the Colonial line. At least six product pipelines cross Pennsylvania to serve the western part of the state, Ohio, and points west from the refining center on the Delaware River. Two lines continue to the New York area refineries. Locally, the Delaware River Basin is served by numerous small pipelines which provide for internal movements of petroleum products.

156. MARKET AREAS. This section addresses the market areas for Delaware River Ports and generally examines the major overseas trade areas for the shipments through the Delaware River Ports.

157. Export Market Areas. The predominant export through the Delaware River docks is coal. Both bituminous coal from Appalachia and Anthracite silt coal from eastern Pennsylvania are exported mainly to Europe with a significant amount also traveling to the Far East. Scrap metal which is shipped from the South Jersey Port Corporation's Beckett Street Terminal is produced within the Port's own metropolitan area and is exported to Turkey. Containers are exported and imported through the Regional Intermodal Transfer Facility and other facilities such as Packer Avenue and Holt terminals.

158. Import Market Area. Crude Oil, the largest bulk commodity shipped through the Ports of Philadelphia is imported from West Africa, North Sea, Middle East, Far East, Bahamas, Mexico and Venezuela. Crude Oil is received and refined by the regional refineries within the Philadelphia metropolitan area. Iron ore is imported from Atlantic Canada, Brazil, West Africa and Europe, and

supplies the eastern Pennsylvania steel industry with nearly all of its needs. Bituminous Steam Coal is imported from South America through Beckett Street Terminal.

159. Import Markets. The market area for most Delaware River Basin imports is predominantly within a relatively narrow band surrounding the basin. Crude oil and iron ore account for about 80-90% of imports annually. The level of crude oil and iron ore imports is largely determined by national and international trends that cannot be influenced by ports or firms within the basin. The result is that while having a locational advantage, national and international factors will determine the overall level of these imports and could, under some circumstances, terminate the flows.

160. General cargo imports are distributed over a somewhat wider geographical area than exports. However, about 80% of general cargo imports terminate in Delaware River Basin states. Meats, bananas, lumber and plywood are the main general cargo imports distributed over a wide area and are subject to extensive competition between ports. For imports and exports combined, the Delaware River Regional Port Study indicates that 98-99% of general cargo origins and destinations are in Pennsylvania and New Jersey. This result appears quite consistent with earlier Bureau of Census studies.

EXISTING INSTITUTIONS

161. A number of Government agencies both affect and are directly affected by Federal navigation activities in the study area. Some of these agencies are regulatory in nature and directly affect the conduct of dredging. Others are advisory and play a role in the formulation and development of project plans. Those that are affected by Federal project activities are consulted for input as plans are developed. A list of these agencies and a brief description of their role or mission as it relates to Federal dredging activities is provided below. It is not an all-inclusive list of agencies with which project plans are coordinated but rather a list which emphasizes key agencies in the institutional framework relative to Federal navigation projects.

162. FEDERAL GOVERNMENT. The Environmental Protection Agency (EPA) is generally responsible for the enforcement of Federal laws regarding air and water quality, solid waste, and hazardous materials. Relative to Federal navigational activities, the EPA and the Corps have established the guidelines for the evaluation of the water quality impacts associated with the disposal of dredged material as required by Section 404(b)(1) of the Clean Water Act (CWA). Similarly, the EPA and the Corps have developed the evaluative criteria for the specification of ocean dumping sites in accordance with the Marine Protection, Research, and Sanctuaries Act. EPA also maintains a veto authority over decisions made by the Corps regarding specification of disposal sites under Section 404(c) of the CWA. In the Clean Air Act (Section 309), EPA has been given the authority to review and comment on actions subject to the National Environmental Policy Act (NEPA) and to refer those actions to the Council on Environmental Quality (CEQ) if the agency finds the action to be unacceptable from an overall environmental standpoint.

163. The Fish and Wildlife Service (FWS) is responsible for evaluation of project impacts to Fish and Wildlife resources and recommendations concerning the conservation of those resources and mitigation of impacts. Those recommendations must be considered in project planning (Fish and Wildlife Coordination Act). Enforcement and coordination under the Endangered Species Act is primarily the responsibility of the FWS. The FWS also is the responsible agency for compliance with the coordination and consultation requirements under the Coastal Barrier Resources Act.

164. The National Marine Fisheries Service (NMFS) is similarly responsible for evaluation of project impacts on marine life and enforcement coordination under the Endangered Species Act for endangered species in the marine environment.

165. The National Park Service, Office of Archeological Services (OAS) is charged primarily with overseeing the historic

preservation program established as a result of the Archeological and Historic Preservation Act of 1974. A primary function is the review of historic preservation reports prepared by various Federal agencies.

166. Federal agencies are required to afford the Advisory Council on Historic Preservation (ACHP) an opportunity to comment on any Federally-funded or licensed activities that may have an effect on any District, building, site, structure, or object that is listed in or is eligible for inclusion in the National Register of Historic Places.

167. U.S. Coast Guard authority includes maritime law enforcement, placement and maintenance of aids to navigation supervision over the anchorage and movement of vessels, the handling of explosives and other dangerous vessel cargoes, and safeguarding life and property on the high seas. It also enforces laws relating to oil pollution, immigration, quarantine and numerous statutes under the jurisdiction of other Federal agencies that require marine personnel and facilities.

168. The responsibilities of the Federal Maritime Commission (FMC) embrace two broad areas of commercial navigation: regulating shipping practices and ensuring financial responsibility for water pollution cleanup. The FMC licenses ocean freight forwarders and maintains surveillance over services, practices, and agreements to assure equitable treatment to all segments of the maritime industry and the general public. The FMC also administers a provision of the Water Pollution Control Act of 1970 (PL 92-500) requiring the owner or operator of every vessel over three hundred gross tons to establish and maintain evidence of financial responsibility for assuming the cost of removing oil discharged into navigable waters.

169. The Maritime Administration (MARAD) administers Federal laws designed to promote and maintain a U.S. merchant marine fleet capable of meeting the Nation's shipping needs for both domestic and foreign commerce and national security. To carry out its mandate, MARAD assists the maritime community in the areas of ship design and construction, development of advanced transportation systems and equipment, and promotion of the use of U.S. flag vessels.

170. REGIONAL AGENCIES AND ORGANIZATIONS. The Delaware River Port Authority is a federally chartered bi-state authority governed by 16 commissioners, eight from Pennsylvania and eight from New Jersey. DRPA owns and operates four bridges between southeastern Pennsylvania and southern New Jersey which together carry more than 90 million vehicles annually. It also owns and operates, through subsidiary corporation, a 14-miles long commuter rail system know as the PATCO High-Speed Line. PATCO carries more than 11 million riders annually. All DRPA revenue is derived from bridge tolls and PATCO fares. In its charter, DRPA is charged with promoting

commerce for the public and private port facilities along the Delaware River. DRPA's World Trade Division provides international and domestic marketing services for these terminals, which collectively are known as "The Ports of Philadelphia."

171. In 1988 the governors of Pennsylvania and New Jersey proposed a program to unify the port facilities under DRPA's direction. That commitment was reinforced in 1991 by a joint letter signed by the two governors in which they publicly supported changes in DRPA's compact giving it broader authority over port enhancement and regional economic development.

172. Under direction by the governors, DRPA is preparing to open an intermodal rail terminal in Philadelphia which will provide services to three major railroads, Conrail, CSX and Canadian Pacific. It has also pledged $2.6 million to meet the local share obligation for the deepening of a section of the Delaware River channel serving the Beckett Street Terminal in Camden and has agreed to act as the local share sponsor for the proposed deepening of the main river channel.

173. In addition, DRPA is studying the development of a new headquarters building along the Camden waterfront and has expanded its planning and economic development roles in order to examine new transportation and job-creation projects that will benefit the Delaware Valley Region.

174. Developed as a mechanism for planning and cooperation between two States, the Delaware River and Bay Authority (DRBA) is responsible for transportation crossings between New Jersey and Delaware and has potential responsibilities with respect to port development. Each Governor appoints five commissioners to DRBA. The DRBA operates and maintains the Delaware Memorial Bridge and the Cape May-Lewes Ferry. Because bridge and ferry crossings have been determined to be adequate for the present, the DRBA has requested specific guidance from both Legislatures on the allowable extent of its future activities, including port or marine facility development which were originally included as permissible activities in its original charter.

175. The Delaware Valley Regional Planning Commission (DVRPC) was created by Pennsylvania and New Jersey in 1965 to provide continuing, comprehensive and coordinated planning for orderly growth and development throughout the Delaware Valley region. The DVRPC specializes in transportation planning and provides consulting services to local, county and state governments, as well as to the private sector.

176. The Delaware River Basin Commission (DRBC) was created in 1961 to plan, manage and protect the Delaware River basin's water resources. The basin encompasses parts of New York, Pennsylvania, New Jersey and Delaware. The Delaware River Basin Commission has five members acting as prime decision and policy makers for the organization. The Governors from the four states and the Secretary

of the Department of the Interior comprise the five members of the Commission. The Commission is charged with protecting the water resources of a 12,500 - square-mile watershed. All public and private projects proposed within the Delaware River basin that may affect water resources of the river must obtain Commission approval. The Delaware River Basin Commission's multipurpose scope emcompasses pollution control, water supply, flood control, water based recreation, fish and wildlife protection, and other aspects of water management. The DRBC's scope does not extend to navigation. The DRBC continually updates a Comprehensive Plan. The Comprehensive Plan is a master plan for the development of the water resources of the basin. All public or private water resources projects within the basin must comply with the goals of the Comprehensive Plan.

177. STATE GOVERNMENT AGENCIES. Several state agencies are involved with navigation:

Delaware Department of Natural Resources and Environmental Control.

New Jersey Department of Environmental Protection.

Pennsylvania Department of Environmental Resources.

Delaware Department of Transportation

New Jersey Department of Transportation

Pennsylvania Department of Transportation

South Jersey Port Corporation

Philadelphia Regional Port Authority

178. Each of the three state environmental agencies is tasked with the responsibility to conserve and maintain natural, scenic and aesthetic values of the environment and to assure its residents clean air and clean water. Each is responsible for the State's land and water management program and all aspects of environmental control. More specifically, they are the authority for environmental permits, monitoring and surveillance, enforcement, certification and training, planning and financial assistance. All three agencies are also responsible for their respective state's Coastal Zone Management Program. All issue Water Quality Certificates for disposal of dredged or fill material under Section 401 of the Clean Water Act.

179. All three State Departments of Transportation, have indirect navigational responsibility in planning and developing highway and rail access to port facilities. Only the Pennsylvania Department of Transportation, through its Water Facilities Loan Board, has

direct navigational involvement and only in providing loans for reconstruction and redevelopment, not for the new construction of any facilities.

180. The South Jersey Port Corporation (SJPC) was created as an agency of the New Jersey Department of Commerce and Economic Development in 1968. Its seven-member Board of Directors is appointed by the Governor. The South Jersey Port Corporation has jurisdiction over port facilities between Trenton and Cape May. Jurisdiction of the ports in the area is shared with the Delaware River Port Authority and the Delaware River and Bay Authority, but there have been no disputes over jurisdiction to date. The SJPC operates 2 terminal facilities under an agreement with the Camden Municipal Port Authority. It is a self-supporting agency, funded by the rents, rates and fees it charges the users of its facilities.

181. The Philadelphia Regional Port Authority was established in June 1989 by the General Assembly of the Commonwealth of Pennsylvania to increase coordination of port facilities and projects within an established regional port zone along the Delaware River. It has absorbed the function and property of the Philadelphia Port Corporation, including the Tioga and Packer Avenue Marine Terminals.

182. OTHER AGENCIES. There are also several city agencies directly involved in port development:

Wilmington, DE: Department of Commence
Camden, NJ: Camden Municipal Port Authority
Salem, NJ: City of Salem Port Authority
Philadelphia, PA: Philadelphia Commerce Department

Delaware County, PA: Delaware County Partnership for Economic Development

183. Private interests in port development have also joined ranks in two prominent area organizations. The Joint Executive Committee for the Improvement and Development of the Ports of Philadelphia is an organization primarily interested in channel and harbor development in the tri-State area. The Joint Executive Committee follows legislation, budget appropriations and project funding related to port and channel development in the Delaware River. The PENJERDEL Council seeks to promote port commerce as part of its concern for the region's economic prosperity. The Council is primarily a "watchdog" agency to ensure that legislation and budgets have adequate provisions for port development and viability.

PROBLEM IDENTIFICATION

MEANS BY WHICH PROBLEMS WERE IDENTIFIED

184. The identification of water and related land resource problems, needs, and opportunities in the study area has evolved from prior studies, current investigations, and continuing public coordination. Public concerns and desires have been elicited through a public involvement program in which public officials, interest groups, governmental agencies, and other segments of the public have been encouraged to become actively involved in the study process.

185. A formal public meeting was held during the reconnaissance studies and was used along with widespread distribution of initiation notices and newsletters, and agency coordination to fully identify the range of problems on the Delaware River channel and its tributaries that support commercial navigation. Coordinaiton has also been accomplished with project users and potential beneficiaries to identify problems and obtain economic data; Federal and state regulatory agencies to assess environmental concerns and views on impacts and mitigation; navigation interests regarding navigation practices and design criteria, and local sponsors to obtain views and discuss financing and local cooperation requirements. Numerous meetings have taken place which include the following:

- Mariners' Advisory Committee - to review design criteria and navigation practices.

- U.S. Coast Guard - to discuss design criteria (including one-way and asymmetric channels) and navigation aids.

- Dredging Committee for the Delaware River (established by the Delaware River Port Authority and Delaware River and Bay Authority) to discuss options for dredging disposal

- Environmental Scoping Meeting - to discuss environmental issues related to the proposed project, attended by a wide variety of public agencies concerned with environmental and cultural resources in the study area.

- Periodic meetings with PENJERDEL Council and Joint Executive Committee.

- Coordination meetings with navigation interests including oil refineries, Conrail, and public port agencies.

CONDITION IF NO FEDERAL ACTION IS TAKEN
(WITHOUT PROJECT PROFILE)

186. The without project condition is the most likely condition expected to exist over the planning period in the absence of implementing a plan of improvement. It provides the base line for estimating the benefits, costs and impacts for alternative with-project conditions. Each component is described in the following paragraphs.

187. NATURAL AND SOCIAL RESOURCES. Manmade activities will continue to affect both the waters and the ecology of the Delaware River Basin. Industrialization and urbanization along the Delaware River and its principal tributaries have caused severe alteration of the aquatic ecosystem. Gradual water quality improvements as a result of wastewater treatment improvements and improved land use controls should result in a gradual resurgence of the formerly diverse aquatic estuarine community. The extent of this improvement will however, not be as large as originally anticipated. While dissolved oxygen is no longer a limiting factor, concentrations of trace chemicals and the elimination of many prime habitat areas have become limiting factors in estuarine aquatic productivity.

188. While limited population growth in urban areas is expected, suburban and rural areas are projected to have up to a 0.5% annual population change. Industrial and commercial development along vacant land bordering the riverbanks is expected to continue, causing impacts to terrestrial and cultural resources.

189. More detailed estimates of long term area-wide future conditions relative to natural and social resources would be speculative, at best. It is reasonable to assume that changes will occur, however reliable forecasts are impossible. Such factors as economic conditions, social attitudes, human needs, resource availability, political influences, Government policies and regulations, international affairs, and natural forces such as weather cycles and biological adaptability would influence future without project conditions. In particular, sea level rise attributable to the Greenhouse Effect has the potential to affect salinity conditions in the Delaware River and Bay as well as wetlands and shoreline erosion. It is assumed based on historical tide gage records between 1912 and 1986 that sea level has been rising at an approximate average rate of 0.0129 feet per year (Hicks and Hickman, 1988). For the purposes of this study future natural and social conditions are considered to be comparable to existing conditions throughout the planning period, except where specifically noted.

190. WATERWAY CONDITIONS. It is anticipated that in the future waterways within the Delaware River system would be maintained to

the same degree as in the Existing Conditions section; i.e. the Delaware River channels maintained to current project dimensions. It is expected, however, that the deepening of the Delaware River in the Vicinity of Camden, N.J. (Beckett Street) project to 40 feet, authorized by the Water Resources Development Act of 1988 and currently undergoing Preconstruction Engineering and Design will be constructed.

191. DREDGING TECHNIQUES AND DISPOSAL AREAS. Existing dredging techniques and disposal methods will not change substantially in the future. Shoaling is expected to be concentrated in those areas where it has been in the past, requiring continued use of existing disposal areas and new areas in the future as capacity is reached. Use of hydraulic and hopper dredges under contract will continue to be the dominant method of dredging although bucket dredging will also be used. The use of hopper dredges, bottom dumping to an overboard disposal site in Delaware Bay, would also occur periodically.

192. Disposal Needs for 40 Ft. Maintenance Based on Current Conditions. As a result of new dredging practices introduced in 1955, material dredged from the river is now deposited solely within confined, upland disposal sites. Bucket dredging, which is rehandled in a diked basin, is the only method by which material is not pumped directly into upland sites along the river. The annual volume of dredged material has been reduced to approximately 5.4 million cubic yards a year. Formerly, open water disposal and agitation dredging led to shoaling and additional dredging requirements.

193. In order to maintain the full width channel to a depth of 40 feet, a minimum of two new disposal sites will be needed during the 50 year project life, depending on ultimate dike heights. One site will be needed in Reach A in the first half of the planning period and another in Reach B. The ultimate capacity of existing sites and the number of new sites required will depend on maximizing dike heights of existing disposal sites. Refer to Table 8.

TABLE 8
DISPOSAL AREA
MAINTENANCE REQUIREMENTS
FOR FULL WIDTH
40 FOOT CHANNEL
DURING THE 50 YEAR STUDY PERIOD
(2005-2055)

REACH	MAINTENANCE PLAN
REACH A	Up to year 2007 goes to National Park with dike raising could extend to year 2027. New site required to replace National Park.
REACH B	Replacement sites needed before year 2005 if dikes at existing Federal sites can not be raised and lease at Oldmans not be extended beyond current expiration in 1991. With further dike raising and extending use of Oldmans can defer new sites acquisition until year 2030. By acquiring a large new site earlier could limit the need for acquisition to a single site.
REACH C	Sufficient capacity at Killcohook and Penns Neck to handle project maintenance up to year 2014 with further dike raising, capacity Could be extended throughout the 50 year planning period. Replacement may be required.
REACH D	Sufficient capacity at Artificial Island for 50 years of project maintenance
REACH E	Sufficient capacity at Buoy 10 for 50 years of project maintenance

194. FUTURE FLEET TRENDS. The forecasts presented in this section are based on the John I. Jacobs, PLC, publication for crude oil vessels, the U.S. Maritime Administration (MARAD) projections for dry bulk, container, and general cargo vessels, and the March 1990 Institute for Water Resources (IWR) study, Fleet Forecasts For The United States to 2020 (conducted by DRI; Temple, Barker, and Sloane; and Lloyd's Maritime Information Services Ltd.). The benefit analysis incorporated no shifts in the vessel fleets over the project life with the proposed channel improvements. For example, the data base for crude oil vessels with sailing drafts greater than 40 feet has not incorporated any potential shift in the fleet since the naturally deep water in the lower Delaware Bay allows utilization of very large tankers that are lightered prior to navigating the 40 foot without project condition depth. Also, the users stated that a shift in the fleet was not expected in the foreseeable future. The operators of these vessels have made an economic decision to lighter tonnage at Big Stone Beach Anchorage on to barges until the point where the sailing draft is sufficiently reduced to allow the vessels to travel upriver to the pertinent facility. Even with a deepened main channel, they are expected to make the same economic decision and carry the equivalent amount of tonnage in the same vessels. If a shift in the distribution of the crude oil tanker fleet to a greater percentage of larger vessels as expected in the future in the Fleet Forecasts For The United States to 2020 was incorporated into the analysis, this would have the impact of increasing project benefits. The data bases for crude oil vessels with less than 40 foot sailing drafts, coal and iron ore have also not included a shift in the vessel fleet over the project life. Also, benefitting commodities using the SJPC terminal (scrap, and steam coal) are anticipated to continue the existing practice of chartering the most cost efficient vessel size as the channel is deepened. Container vessels will utilize larger post-Panamax vessels on four major trade routes.

195. Crude Oil Vessels. The data for the current tanker fleet mix, new tanker deliveries and orders, and scrapping of tankers has been obtained from World Tanker Fleet Review (John I. Jacobs, PLC). A comparison was made of the fleet mix of the world tanker fleet for 1983 and 1986 (Table 9). Although the total tanker fleet was reduced by approximately 3 percent during this period, the percent distribution of the fleet remained relatively unchanged. Significantly, vessel classes of importance to this study showed a percentage increase: 100,000-150,000 DWT=increase from 9.1% to 9.6%; 90,000-99,999 DWT=increase from 4.0% to 4.4%; and 40,000-89,999 DWT=increase from 21.3 % to 21.6%. The new tanker deliveries data showed that 114 vessels were delivered in 1986. The overall distribution for new deliveries was similar to the 1986 tanker fleet distributions. New tanker orders at the end of 1986 equaled 184 vessels and was also similar to the existing fleet distributions (see Table 9).

196. Table 9 also presents the number of tankers scrapped in 1984, 1985, and 1986. Vessels scrapped per year has decreased. A total of 526 vessels were scrapped over the 3-year period. The percent distribution shows that vessels less than 50,000 DWT comprised 42 percent of tankers scrapped. Tankers greater than 160,000 DWT represented another 28 percent. Only 4% of vessels were scrapped in the highly important vessel class, for this study, of 100,000-159,999 DWT. Overall, a trend towards more efficient vessels in the 100,000-159,999 DWT class at the expense of either smaller or larger vessel classes is being established in the world fleet. This trend will affect the size of tankers that will use the Delaware River port system main channel to transport crude oil to refineries in the study area.

197. Fleet Forecasts For The United States to 2020 projects that the tanker fleet will more than double total capacity by the year 2020. This projection makes the very strong case that the future fleet will be able to handle the total projected growth of crude oil imports through the Delaware River port system. Most of the vessel classes will maintain their relative percentage of the total fleet capacity over the projection period, resulting in each vessel class approximately doubling its capacity by 2020.

198. Dry Bulk Vessels. Recognizing the speculative nature of fleet forecasts and the difficulty of predicting far into the future, MARAD's year 2005 projections are assumed to continue to represent the estimate until the 50th year of the project life, 2055. According to the MARAD forecasts, the number of dry bulk vessels serving the Atlantic Coast is expected to rise from 327 in 1980 to 463 in 1995 and 833 in the 2005-2055 period. This increase in the number of vessels will be accompanied by a general shift towards larger bulk carriers. The share of vessels of 175,000 DWT or above serving the Atlantic coast is expected to increase from zero percent of fleet capacity to five percent in 1995 and to 15 percent for the 2005-2055 period. In the 125,000-175,000 DWT category, the percent of fleet capacity will also rise from zero to five and 15 percent, respectively. The shift will be less significant for medium-sized vessels with DWT ranging between 70,000 and 125,000 tons with shares of 12, 26, and 27 percent, respectively. Conversely, the proportion of vessels in "Handymax" size (30,000 to 50,000 DWT) will decrease from 24 to 20 and 14 percent, respectively.

199. In defining growth scenarios for the world fleet of dry bulk carriers, the construction trends used in the MARAD forecasts were compared with current trends in vessel construction. It was noted that the construction trends in 1976-1977 and 1980-1981 represented extreme outlooks on the future of large bulk carriers. Forty-nine percent of the capacity built in 1976-1977 were composed of vessels of DWT lower than 50,000 tons, as opposed to only 35 percent during 1980-81. Also, 26 percent of the vessels built in 1980-81 were

TABLE 9
COMPARISON OF FLEET MIX FOR 1983 AND 1986

Size Group DWT	Number of Vessels Dec. 31, 1983	Number of Vessels Dec. 31, 1986	Percent-Distribution 1983	Percent-Distribution 1986
10,000/39,999	1,409	1,336	47.1	49.0
40,000/89,999	638	589	21.3	21.6
90,000/99,999	119	120	4.0	4.4
100,000/159,999	272	262	9.1	9.6
160,000/249,999	193	133	6.5	4.9
250,000/399,999	331	265	11.1	9.7
400,000 +	27	22	0.9	0.8
	2,989	2,727		

COMBINATION OF NEWBUILD DELIVERIES AND NEW ORDERS
COMPARISON OF FLEET MIX WITH EXISTING FLEET MIX

Size Group DWT	Number of New Building Deliveries	New Orders At End of 1986	Total New Deliveries	Percent Distribution: Deliveries and Orders	Percent Distribution: 1986 Fleet
10,000/39,999	56	74	130	44	49
40,000/89,999	31	56	87	29	21
90,000/99,999	9	12	21	7	4
100,000/159,999	9	27	36	12	10
160,000/249,999	6	3	9	3	5
250,000/399,999	3	12	15	5	10
400,000 +	0	0	0	0	1
Total	114	184	298	100	100

NUMBER OF TANKERS SCRAPPED FROM 1984 TO 1986

Size Group DWT	Number of Tankers Scrapped 1984	1985	1986	Total	Percent Distribution
10,000/49,999	102	69	50	221	42
50,000/99,999	58	55	21	134	26
100,000/159,999	6	9	7	22	4
160,000 +	44	73	32	149	28
Total	210	206	110	526	100

larger than 125,000 tons, as opposed to only 15 percent for vessels built in 1976-77. Nevertheless, because so many other factors enter into consideration in fleet forecasting, the 2005 estimates were not significantly different in terms of fleet distribution. Thus, the 50,000 to 125,000 DWT category, which is a range of vessels of major importance in this study, is expected to make up approximately 50 percent of the total vessel fleet in the MARAD forecasts.

200. Fleet Forecast For The United States to 2020 expects the fleet to increase total capacity by 37% by the year 2020. All vessel classes are anticipated to maintain their relative percentage of the total fleet capacity over the projection period.

201. South Jersey Port Corporation. The without project condition vessel fleet assumed to be operating over the period of analysis was based on an analysis of past historical fleets during which changes in channel conditions occurred. This analysis showed that the fleet servicing the terminal assimilated a normal distribution with a mean sized vessel in the most cost efficient vessel deadweight class. Over time, as improvements to the channel and berthing areas have occurred at the terminal, the fleet distribution has maintained its normal tendencies with the mean sized vessel shifting into the most cost efficient vessel class in the fleet. Therefore, a comparable shift was applied to the existing fleet to estimate the fleet distribution in the 40 foot (MLW) without project condition.

202. Containerships. Containerships will continue to increase in size over the next decade based on trends in construction. A regression model developed by the DRPA for various vessel characteristics indicated that containerships built during the next decade should range between 4300 and 4500 TEUs versus the latest generation of containerships which averages 3200 TEUs. There also exists the reasonable probability of post-Panamax vessels reaching 5000 TEUs within the next decade if pertinent markets requiring this size vessel continue to expand. Currently, about 10 percent of the fleet has design drafts of at least 40 feet. We expect the trend toward deeper vessels to intensify.

203. COMMODITY PROJECTIONS. This section presents forecasts for each of the relevant commodities:

-The most likely forecasts for a commodity for the Delaware River ports. Forecasts were developed as being market driven (either by regional market demand for the imported commodities or by world markets for the exported commodities) from the study year to the final year of the project life.

204. Introduction. The DRI/McGraw-Hill/Temple, Barker, & Sloane (DRI/TBS) World Sea Trade Service was applied to develop commodity projections for crude oil, coal, and iron ore. International trade was modelled for the individual commodities over time. Specific

forecasts were developed showing inbound and outbound trade for 22 individual OECD member countries with 28 regional aggregates or countries worldwide.

205. This world trade forecasting methodology utilized both econometrically derived forecasts (when feasible and accurate) and less dynamic, propensity-based models. This resulted in models of commodity trade that were robust and yet relatively stable over time. Unlike many other attempts at modelling international trade flows, DRI's forecasts were developed using commodity specific models rather than sharing out total trade down to the individual product categories. Thus, commodity-specific factors were introduced both into the models and the final results. Imports and exports among the major developed market economy countries (22 OECD countries for which primary trade data was available) were balanced with exports dependent, in the case of intra-OECD trade flows, on import demand patterns.

206. Forecasts were based on estimates of macroeconomic variables drawn from DRI's extensive set of macroeconomic models (over 47 countries are modelled regularly as part of the DRI International Service). Trade models, while depending upon macroeconomic factors, were not directly lined up to country-specific trade forecasts drawn from DRI's macroeconomic services. The overall forecasts were checked by DRI against other projections of trade volumes to insure that they were reasonable.

207. Econometric Modelling Techniques. International trade was modelled both econometrically and using general propensity models driven by total trade estimates. Commodity trade balances were maintained and final forecasts integrated supply and demand by considering changes in market share as well as market demand. While solutions were not simultaneous, they did yield consistent OECD-wide forecasts of trade so that estimates of U.S. exports depended on European import demand as well as U.S. export competitiveness in European markets.

208. Compared to a typical macroeconomic model, each commodity model represented a mix of more than 500 structural equations, combined with an equal number of average relationships. By combining these past patterns with macroeconomic variables derived from DRI macroeconomic forecasts, robust estimates of world trade trends for specific commodities were generated. The integration of macroeconomic information with commodity-specific and region-specific trade data into a single forecast covered more than 40 commodities, 24 countries, and trade to and from 35 regions. Thus, the forecasts represented an overall picture for international trade characterizing direction of trade as well as total demand or supply.

209. Measuring Real Volume for Internationally Traded Products. Before discussing the structure of the world trade models in more detail, it was important to address the units of measurement that are being ultimately forecast. While for theoretical reasons it is important to forecast value of trade first rather than some quantity based measure, developing internationally consistent measures of real volume of trade when prices and exchange rates are constantly changing is difficult.

210. There is no simple method for deflating current dollar trade values into a measure of constant volume of trade. The method used was an attempt to develop a standardized methodology for deflating nominal trade values in order to allow cross country comparisons. Two principles guided the approach: 1) real changes in commodity prices should be captured; and 2) exchange rate changes should not be introduced mechanically, in order to avoid assuming the full effect of the change in international prices are passed onto buyers by sellers.

211. The lack of fully consistent, trade specific prices for commodities led DRI to develop a hybrid methodology using U.S. price statistics, exchange rates, and general export and import price indices. These synthetic measures were specific to OECD countries, specific to the commodities analyzed, and also specific to the direction of the trade.

212. U.S. Dept. of Labor price indices for U.S. imports and exports were applied. These indices are developed using survey data from U.S. importers and exporters and are commodity specific, but not specific to the direction of trade. So, to understand the effect of U.S. dollar changes on, for example, Japanese export volumes, it is necessary to abstract from these commodity-specific U.S. dollar price indices by including the impact of changes in exchange rates and general export price trends in Japan.

213. In general, for OECD country exporters, U.S. export commodity price indices for historical data and DRI price forecasts were used. For exports of LDC regions, U.S. import commodity price indices were used. For imports from OECD regions, DRI developed synthetic import price indices, specific to commodities, importing countries, and exporters; i.e., for the French imports of product k from Japan, DRI used Japanese export prices to the world for product k. When used in conjunction with the dollar denominated French exports, the result was a volume measure of French exports from Japan. These synthetic measures capture some of the dynamic movement in prices paid by importers, and are considered reasonable measures of price changes associated with commodity price trends and exchange rate adjustments.

214. Export prices for LDC's are the same as U.S. import price deflators for similar commodities based on the assumption that LDC's have kept their currency values consistent with U.S. prices

and that they have an ability to price for export consistent with developed country market developments. The only exceptions among the LDC regions are the three emerging Asian countries: Korea, Taiwan, and Hong Kong. Small adjustments in import prices for changes in these countries' exchange rates were introduced into the model's structure. The import price trends are regional and are based on export price trends of exporters. The aggregate price is the combination of export price trends weighted by actual levels of trade.

215. The advantages to the model, of having such a systematic method of measuring volume of trade across so many countries which use so many different definitions and statistical collection methods, outweigh the deficiencies of the system. The result is that estimates of the volume of trade are fully consistent with general price trends in the commodities represented and with changes in exchange rates among OECD member countries.

216. Structure of the Model. Each commodity specific trade route is constructed by DRI as a unique whole representing the exchange of products for that commodity between the major industialized countries and the world community. There are in excess of 200 countries trading in the world at present. To make the world trade model manageable, this number of countries has been subdivided into 28 partner regions.

217. The detail provided, however, is reasonable given the fact that a complete worldwide forecast is available for each of the 19 major OECD markets that account for fully 80% of world trade. Intra-developing country trade is not represented in the models structure due to the lack of reliable and timely reporter-partner country data on trade among the developing countries.

218. Reporter countries are those for which reliable detailed trade data and DRI macroeconomic forecasts are available regularly (see List A below). Listed industrialized countries account for approximately 95% or more of the trade of the OECD group (only Iceland is excluded).

List A: Major Industrialized Reporter Countries (Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Swizerland, United Kingdom, United States); Newly Industrializing Asian Developing (Hong Kong, South Korea, Taiwan)

List B: Partner Regions Used in the DRI World Trade Model
WORLD: All countries including Socialists
OECD: All 24 members of the OECD
NE: Northern European Countries
SEU: Southern European Countries
JAPAN: Japan

CANADA: Canada
U.S.: United States
AZ/NZ: Australia/New Zealand
LDC: Less Developed Countries
LATIN AMERICA
WLA: Western Latin America
ELA: Eastern Latin America
Argentina
Brazil
CLA: Carribean Basin (Central America, Mexico, and Caribbean Islands)
MEDITERREAN/PERSIAN GULF
MED: All countries bordering on the Mediterrean Sea including North Africa, Egypt, Middle East
PG: All countries bordering on the Persian Gulf
INDIAN SUBCONTINENT: India, Pakistan, Bangledesh, Afghanistan, Sri Lanka
FAR EAST
NICs (Newly Industrialized Countries in Asia)
Korea, Taiwan, Hong Kong
SEA: Southeast Asia (Singapore, Malaysia, Indonesia, Phillippines, Thailand)
AFRICA
SAF: Southern Africa, including Angola, Zambia, Zimbabwe, Malawi, and South Africa
EAF: East Africa including Kenya, Ethiopia, Uganda
WAF: West Africa including Ghana, Togo, Nigeria
EASTERN EUROPE: All countries in Eastern Europe including the Soviet Union and Yugoslavia

219. The Process: The Multistage Approach to Global Trade Forecasting. Trade for each commodity is first arranged in arrays representing the imports or exports for the reporters with each of the partner regions separately indicated. Thus, for each partner region, the export and import flows of the individual OECD reporters (see List A) for 10 years of history are arrayed in a single block of data. Within the same block, the data of the U.S. trade with the Northern European countries (summed together), and the French trade with its Northern European partners is included in the partner region sum.

220. All models are estimated using a pooled cross-sectional modelling technique. Pooled cross-sectional models combine information on many countries over a shorter time interval rather than relying upon country specific time series models over longer time periods. Because international trade data is consistently available only from 1978 at revision 2 of the UN's Standard International Trade Classification), and because pooled cross-sectional models of trade are capable, in theoretic literature, of identifying changing patterns of trade, this approach is both very practical and also theoretically justified. Thus, the econometric

models are jointly developed for 21 independent countries at the same time.

221. Cross country models are based on a theory that suggests patterns of future trade can be determined by observing the relationship between market size and economic wealth of more than a single country. Thus, the pattern of trade of an advanced, service dominated economy like the U.S. may serve as a template for future patterns of trade of other countries not as large or as wealthy.

222. The econometric relationships vary depending upon whether import or export data are used. Most of the variance explained, however, is explained by the more general economic variables for which the calculated coefficients are general to the entire set of OECD countries included in the estimating equation. To assure that non-economic factors that affect the propensity of a country to import or its ability to export a specific product are included, individual country intercepts are also calculated. The form that these intercept terms take, i.e., the independent variable that they modify, differs depending whether it is an export or import model used. Thus, for each country, the econometric equation is made up of two parts: 1) coefficients specific to that country, and 2) coefficients common to the set of countries:

223. Mikt= f(General Parameters) + bikt*Di, where i is the reporter country, k is the product type, and t is the trade direction; and where Di is the dummy variable (either 0 or 1) for each reporter country (this dummy variable has the same dimension as the trade data or the exogenous assumption data, and there is a 1 present where the country's own data is in the array and a zero where the other country's data is sequenced).

224. <u>Econometric Variables included in the DRI World Trade Models:</u>
Import equations may depend upon:
-Traded goods consumption as a share of GNP
-Import share of traded goods consumption
-Population size (market potential)
-Investment share of Gross Domestic Product
-Import prices (the adjusted local currency price after taking into account changes in local exchange rates, cross rates of exchange, and U.S. commodity price trends)
-Import prices for specific importing regions (U.S., Japan, and Northern Europe)
-Consumption of commodity (specific coefficients for U.S., Japan, Canada, Northern Europe, and Southern Europe)
-Ratio of Production of Commodity to Consumption (specific coefficients for U.S., Japan, Canada, Northern Europe, and Southern Europe)
-Country specific intercepts
-Country specific adjustment variables (for refining estimates using a two-stage estimation procedure)

Exports are a function of the following variables:
-Goods production share of Gross Domestic Product
-Exports of merchandise, adjusted for service component, as a share of production of goods
-Per capita Gross Domestic Product
-Population size
-Exchange rate adjusted wage rates
-Real growth in output relative to OECD real growth in output
-Relative wage rates (in U.S. dollars)
-Per capita GDP of exporter to importing region
-Exporter's price (includes adjustments for commodity prices, general export price trends relative to U.S. price trends and exchange rates) in importer's currency
-Investment share of GDP
-Production of Commodity (regional specific coefficients for U.S., Canada, Japan, Northern Europe, Southern Europe)
-Country specific variables measuring demand growth and relative prices in importing regions
-Country specific adjustment variables (developed using the iterative method of model adjustment)

225. The following regional variables are used in this sub-model:
-Population size (the market to be reached)
-Per capita GDP (the region's wealth)
-Relative prices: a combination term combining export prices and exchange rate movements
-Export share (a measure of regional success or trade intensity)
-Region specific coefficients for total imports
-Region specific consumption estimates for commodity
-Region specific production to consumption ratios for commodity
-Region specific intercepts (non-economic factors affecting imports from OECD)

226. To insure that the best estimation and forecasting approach is used whenever feasible, the model uses built-in software that measures the accuracy of any technique over the historical data period. It determines whether an alternative approach should be applied when their are doubts about the accuracy of the estimate of trade over the historical period.

227. Non-Econometric Approaches to Forecasting International Trade. In cases where the econometric approaches may not be sufficiently accurate (generally occurring when there is an insuficient number of observations), stable, non-econometric estimates of trade flows are developed by DRI using average patterns associated with historical periods. Such methods must, necessarily, choose criteria on which to base estimates, and such estimates are typically less volatile than the actual data they represent.

228. These non-econometric estimates are based on propensity models that use data from two macroeconomic variables rather than a single variable. The result is a forecast more accurate than simply applying proportional growth to total trade that would result from a single variable model.

229. For these non-econometric propensity models, parameters are developed. Each parameter relates for either imports or exports of a country reporter (i), and its trade with a regional group (d) of a single commodity (k). Each parameter is a function of the total demand for the commodity from the world.

230. As an example of this technique, the average import propensity against total imports of the product k from region d by country i would be calculated as follows:

APM(ikd)=M(ikd, 1985 to 1988)/M(ik,World, 1985 to 1988)

231. If the simple average technique were used exclusively, the resulting forecast would have only the variation inherent in the actual trade itself. A proportional model must yield an estimate of growth consistent with the pattern of trade of the independent variable used to forecast the model. To utilize variation in trade, period to period, for the non-econometric approach, a structure must be introduced to the simple proportional models.

232. To capture this historical variation, an approach was developed that mimics the change in the ratio over time and forecasts this change, assuming some limits on its growth rate, in the forecasting model. Thus imports, if forecast using a propensity model, reflect the changing share of the source market in total imports from the world of the commodity and the imports from the world reflect economic factors impacting on demand. This combination yields a unique forecast for each flow that will be different than the base forecast for the total trade with the world, as the following example equation shows:

GRAPM(ikd)=%Growth (APM(ikd,x-y)),where %Growth is the compound annual rate of growth for the period x-y, so that

M(ikd,t+1)=(APM(ikd,t)*(1+GRAPM(ikd))*M(ik,World,t+1)

where M is imports of country i, of product k, from region d, for time t; APM is the mean average propensity to import k from d over the period x-y relative to imports from the world of commodity k for the same time period; GRAPM is the growth rate of the APM, the market share; and M(ik,World) is the imports of the commodity from the world.

233. <u>Integration of Econometric Forecasts with Non-Econometric Model Results.</u> As discussed above, the DRI World Trade Model has to combine elements of both methods to insure that results are reasonable estimates of future patterns of growth. To do this, the

system uses a weighted distribution of estimates for trade from the stochastic propensity and econometric models.

234. Because of the huge number of trade flows forecasted and their interdependence, it is critical that the DRI World Trade Model incorporates internal tests and limits to insure that valid, reasonable forecasts are developed. With the logarithmic forms used in the econometric models, limits are imposed in the models assuring the quality of forecasts not singly, but rather for all countries and regions included in the modelling system.

235. A hierarchy of choice has been developed. If there are sufficient observations, then econometric models have been developed. If, however, there were insufficient degrees of freedom for accurate statistical models to be developed, then alternative, non-econometric approaches have been used. Or if the volume of trade was particularly small or erratic, then non-econometric approaches have again been used.

236. If an econometric model was sufficiently accurate, judged by the Standard Error as an initial test, then its forecasting accuracy was tested over the historical period in order to assess if individual country forecasts should depend upon the cross-country model results or whether they should depend, instead, upon forecasts derived from the propensity model approach (which is typically also based on the econometric model for imports from the world).

237. To do this, an average error over the period (the cumulative average percentage deviation of the forecast from the actual) for each reporter was estimated. The pooled cross-sectional model technique allowed the easy separation of each of the 19 reporters once the multi-country model was estimated. If the standard error for country i from region d for product k was over a maximum limit, MaxError, then the stochastic propensity method was used instead of the econometrically determined forecast for trade. When the standard error for the country was less than MaxError, but greater than MinError, then the non-econometrically determined estimate of trade was used. A formula was used to fix the weights:

ADJUST=(Standard Error-MinError)/(MaxError-MinError)

238. From this formula, if the Standard Error for the equation was close to the MinError, then the majority of the influence will be derived from the econometric specification. If, on the other hand, the Standard Error is closer to the MaxError then the opposite is the case.

239. If the standard error of the equation was less than the MinError, then only the forecast, adjusted by the estimated standard error for the flow (from the econometric model), is utilized.

240. Integration of Import and Export Estimates. At the end of the first stage of forecast development, preliminary forecasts of exports and imports were developed by DRI. In the second stage, these preliminary, independent estimates were merged to yield a jointly consistent forecast. The sum of the parts in the model, i.e., the demand by regions, was compared to the demand estimated by the model's equations from all sources (from the OECD, from the LDC, and from the World). For each commodity, these other estimates served as additional information and were averaged with the forecasts developed by summing the regional values. Moreover, the DRI model methodology calls for the merging of information on demand and supply from the export and import models. For intra-OECD trade, the import demand forecast serves as the template and the export supply models are used to measure market share among the export sources. Through a series of steps, the export and import estimates for countries and regions are merged together.

241. The DRI World Trade Modelling System fits together structurally, not through a set of interlocking bilateral relationships, but through a set of interrelated regional/country relationships. Thus imports of 21 reporters with the U.S. is one element in the model, as is imports of the 21 with Northern Europe taken as a single unit. Imports from the entire set of OECD countries for each of the 21 reporters is a third element. Thus, total trade of the U.S., for example, measured through reporter imports alone would be the sum of elements of each partner array for each trade direction.

242. Consistency then is gained through the integration of export and import data. American imports, from members of the Economic Community, are the exports of the individual countries in the EEC to the U.S.

243. Summary. The DRI World Trade Model is thus based on an integrated framework that analyzes data for 24 countries, exports and imports, with more than 28 major import or export regions/countries. This information is derived from a total data sample of 24 reporters with 200 countries.

244. Commodity specific forecasts are developed based on a combined econometric and average propensity framework where export and import flows are fully integrated to insure global consistency. All DRI forecasts are based on the latest econometric model variables related to patterns of trade appropriate to the individual commodity considered.

245. Crude Oil Forecast. Average annual growth of crude oil through the Delaware River system under the most likely scenario from the study year to the end of the project life is projected at the very modest rate of 0.8% per annum. The future projection was accomplished through the consideration of future growth trends in

population, economic activity, and refined petroleum product demand in the market area for the Delaware River refineries.

246. The impacts of volatility in world oil markets that occurred during the late 1970's through the 1980's are clearly reflected in historical cargo statistics for Delaware River crude imports. The "Second Oil Shock" of 1979-1980, resulting from the shut-off of Iranian crude to U.S. markets, played a critical role in shaping the profile of U.S. and Delaware River crude imports. U.S. imports of crude from alternative sources, including the newly commercialized Alaskan fields, surged in response to the supply curtailment; Delaware River imports of crude rose from 51 million short tons (MST) in 1978 to 55 MST in 1979. Sharp increases in world crude oil prices associated with the disruption of supply initiated a movement toward lower consumption levels and reduced economic growth (the recession of 1980-82). Delaware River crude imports dropped sharply from 55 MST to 43 MST between 1979 and 1980, before declining moderately over 1980 to 1983, reaching a trough of 38 MST by the end of the period. The steepness of the decline in world oil demand for crude oil during the early 1980's set the stage for the collapse of OPEC prices in 1985-1986 and contributed towards the current oversupply in world markets. Stronger economic growth in the U.S. and other industrial countries, together with the lower price of oil, has recently resulted in sharp increases in importation of both crude oil and refined petroleum products. Delaware River imports advanced from 38 MST in 1983 to 49 MST in 1989. Table 10 presents commodity projections by trade route.

247. Coal Exports. Coal has been a major export commodity in past years, although fluctuations have characterized the cargo flow. U.S. coal shipments have experienced significant competition from slow demand growth, intensive price competition, new foreign production, and excess export capacity. These problems have been magnified for the Ports of Philadelphia, as transport coal efficiencies and infrastructural development have been realized at the competing ports of Hampton Roads and Baltimore, resulting in recent erosion in Philadelphia's share of coal exports.

248. A long term decline in U.S. metallurgical coal shipments is tied, in part, to technological advances, greater availability of alternative sources of coal, and falling coal prices. Newly emerging nations are likely to pose the greatest threat, due to their practices of government subsidization and price support programs, together with large supplies of comparatively inexpensive labor. Thus, Philadelphia exports in the future are anticipated to be almost entirely bituminous steam coal and anthracite coal.

Table10. DRI Projected Growth in Crude Oil Coming Into the Port of Philadelphia by Trade Route
(Short tons)

Trade route	1989 Actual	1995 Forecast tonnage	1995 Percent growth 1989-1995	1995 Percent change 1989-1995	2000 Forecast tonnage	2000 Percent growth 1995-2000	2000 Percent change 1989-2000	2005 Forecast tonnage	2005 Percent growth 2000-2005	2005 Percent change 1989-2005
Canada	51576	0	-100.000	-100.0	0	0.000	-100.0	0	0.000	-100.0
Caribbean Basin	1983448	1439592	-5.201	-27.4	1064839	-5.852	-46.3	1039624	-0.478	-47.6
China & North Korea	859227	1080788	3.898	25.8	1407481	5.424	63.8	1619722	2.849	88.5
East Coast of South America	2030422	6470781	21.310	218.7	8643250	5.961	325.7	10286974	3.543	406.6
Far Eastern NIE	0	0	0.000	0.0	0	0.000	0.0	0	0.000	0.0
Japan	0	0	0.000	0.0	0	0.000	0.0	0	0.000	0.0
Northern Europe	2913204	979708	-16.609	-66.4	858833	-2.599	-70.5	699885	-4.011	-76.0
Other Mediterranean	663380	1063451	8.183	60.3	787335	-5.835	18.7	883765	2.338	33.2
Red Sea & Arabian Gulf	9517043	11861277	3.738	24.6	13868238	3.176	45.7	15566779	2.338	63.6
South Pacific (a)	36359 (b)	36560	0.092	0.6	39094	1.349	7.5	38361	-0.378	5.5
Southeast Asia	224430	149428	-6.554	-33.4	177548	3.509	-20.9	177080	-0.053	-21.1
Southern Africa	4339473	6226242	6.202	43.5	8344109	6.030	92.3	8146520	-0.478	87.7
West Coast of South America	2316120	1736886	-4.683	-25.0	2119066	4.058	-8.5	2407989	2.589	4.0
Southern Europe	1124018	472656	-13.444	-57.9	625678	5.770	-44.3	799767	5.032	-28.8
West Africa	19277552	25446265	4.736	32.0	27185918	1.331	41.0	28240679	0.764	46.5
Total	45336252	56963634	3.878	25.6	65121389	2.713	43.6	69907145	1.428	54.2

(Continued)

Table 10. (Continued)

Trade route	1989 Actual	Forecast tonnage	2015 Percent growth 2005-2015	Percent change 1989-2015	Forecast tonnage	2030 Percent growth 2015-2030	Percent change 1989-2030	Forecast tonnage	2055 Percent growth 2030-2055	Percent change 1989-2055
Canada	51576	0	0.000	-100.0	0	0.000	-100.0	0	0.000	-100.0
Caribbean Basin	1983448	1098888	0.556	-44.6	1175661	0.451	-40.7	1005207	-0.625	-49.3
China & North Korea	859227	2040765	2.338	137.5	2425346	1.158	182.3	2299701	-0.213	167.6
East Coast of South America	2030422	15124224	3.929	644.9	19662587	1.765	868.4	20298890	0.127	899.7
Far Eastern NIE	0	0	0.000	0.0	0	0.000	0.0	0	0.000	0.0
Japan	0	0	0.000	0.0	0	0.000	0.0	0	0.000	0.0
Northern Europe	2913204	412707	-5.145	-85.8	169716	-5.752	-94.2	31184	-6.552	-98.9
Other Mediterranean	663380	1064501	1.878	60.5	1194666	0.772	80.1	1035243	-0.571	56.1
Red Sea & Arabian Gulf	9517043	18750276	1.878	97.0	21043033	0.772	121.1	18234933	-0.571	91.6
South Pacific (a)	36359 (b)	32510	-1.641	-10.6	17737	-3.959	-51.2	4032	-5.753	-88.9
Southeast Asia	224430	204168	1.434	-9.0	242280	1.148	8.0	224389	-0.306	-0.0
Southern Africa	4339473	8610917	0.556	98.4	9212517	0.451	112.3	7876832	-0.625	81.5
West Coast of South America	2316120	2809311	1.553	21.3	2836276	0.064	22.5	2069321	-1.253	-10.7
Southern Europe	1124018	1246147	4.535	10.9	1937617	2.986	72.4	2569366	1.135	128.6
West Africa	19277552	28802590	0.197	49.4	28307376	-0.116	46.8	24203206	-0.625	25.6
Total	45336252	80197004	1.383	76.9	88224812	0.638	94.6	79852304	-0.398	76.1

249. 1987 was a down year for movements of export coal through Pier 124 as, in particular, the effect of the large 1986 drop in the price of a highly competitive fuel source, crude oil, from $28/barrel to as low as $10/barrel, was fully felt on Pier 124 coal exports. Total shipments dropped from 3.9 million tons in 1986 to 1.9 million tons in 1987. However, improved export years were seen in 1988 and 1989 with 2.3 and 2.6 million tons shipped, respectively, as crude oil prices settled at a more stable level of $16-$18/barrel and the world economy improved. The annualized growth rate from 1987 to 1989 was 15.4%. The outlook for continued movements of coal through Pier 124 is clouded because of the ongoing plan by the facility owner, Conrail, to shift movements to a terminal in Baltimore. However, by the base year, coal is expected to be moving through Philadelphia. Table 11 presents the coal export projections assuming movements through Pier 124.

250. Iron Ore Imports. Iron ore imports on the Delaware River serve as key raw material inputs to the manufacture of steel in the Eastern and Western Pennsylvania regions. Reflecting the decline of U.S. industry, especially output from older, low-technology facilities of the Eastern Seaboard states, imports of iron ore have dropped dramatically over the last decade. Flows of iron ore on the Delaware River declined from 7.3 MST in 1977 to a trough of 2.8 MST in 1983. The recession of 1980-82 served to reduce domestic demand for steel and steel-products, while the emergence of lower-cost competition from Asian producers resulted in a loss of market share for U.S. mills.

251. The import level of iron ore rebounded in 1984 to 3.6 MST, and has stabilized near that tonnage level over the recent past. For the most likely scenario, Delaware River imports of iron ore are projected in Table 12 by trade route.

252. South Jersey Port Corporation (Beckett Street Terminal). Total tonnage processed at the terminal has historically grown 67% for the time period for the last ten-year period. SJPC provided a short term forecast of tonnage which extrapolates a smoothed historical average annual growth rate. An examination of historical commodity movements have shown that the specific bulk commodities imported and exported through the terminal have changed over time as commodity markets have changed. However, as markets have changed the terminal has consistently maintained positive growth in tonnage regardless of the type of commodities handled. Based on this long term trend, one potentially benefitting commodity, the import of bituminous coal was assumed to grow at an annual rate equal to the long term growth rate. Scrap export projections to Turkey were developed using a Box-Jenkins ARIMA Time-Series Model applying historic data as input, and verified with projections developed by the WEFA Group. Tonnage for the project base year is estimated to be as follows:

Exports:	
Scrap	1,525,000
Imports:	
Bituminous Coal	244,000
TOTAL	1,769,000

253. Container Terminals. The Delaware River Port Authority has provided projections, developed by the WEFA Group, which anticipate average annual growth of 3.7% for container traffic through the Delaware River port system to the year 2005. This trend is expected to be representative of the growth which would occur during the first twenty years of the project life for purposes of this analysis, and then held constant over the remainder of the project life. Refer to Table 13

Table 11. DRI Projected Growth in Coal Leaving From the Port of Philadelphia by Trade Route
(Short tons)

Trade route	1989 Actual	Forecast tonnage	1995 Percent growth 1989-1995	Percent change 1989-1995	Forecast tonnage	2000 Percent growth 1995-2000	Percent change 1989-2000	Forecast tonnage	2005 Percent growth 2000-2005	Percent change 1989-2005
Canada	448680	522361	2.567	16.4	520184	-0.083	15.9	477913	-1.681	6.5
East Coast of South America	54826	5487	-31.862	-90.0	5683	0.704	-89.6	5216	-1.700	-90.5
Eastern Europe	57966	41492	-5.420	-28.4	32761	-4.615	-43.5	34371	0.964	-40.7
Northern Europe	854449	824242	-0.598	-3.5	846235	0.528	-1.0	820673	-0.612	-4.0
Other Mediterranean	582868	853353	6.560	46.4	586196	-7.235	0.6	291611	-13.033	-50.0
Southern Europe	197586	213465	1.297	8.0	197709	-1.522	0.1	187567	-1.048	-5.1
Total	2196375	2460400	1.910	12.0	2188768	-2.313	-0.3	1817351	-3.651	-17.3

Trade route	1989 Actual	Forecast tonnage	2015 Percent growth 2005-2015	Percent change 1989-2015	Forecast tonnage	2030 Percent growth 2015-2030	Percent change 1989-2030	Forecast tonnage	2055 Percent growth 2030-2055	Percent change 1989-2055
Canada	448680	394062	-1.911	-12.2	241196	-3.220	-46.2	60175	-5.402	-86.6
East Coast of South America	54826	4174	-2.204	-92.4	3411	-1.337	-93.8	2837	-0.734	-94.8
Eastern Europe	57966	37051	0.754	-36.1	42199	0.871	-27.2	37102	-0.514	-36.0
Northern Europe	854449	726945	-1.205	-14.9	674503	-0.498	-21.1	529430	-0.964	-38.0
Other Mediterranean	582868	40172	-17.981	-93.1	18632	-4.993	-96.8	52785	4.253	-90.9
Southern Europe	197586	197457	0.515	-0.1	210354	0.423	6.5	152665	-1.274	-22.7
Total	2196375	1399861	-2.576	-36.3	1190295	-1.075	-45.8	834994	-1.408	-62.0

Table 12. DRI Projected Growth in Iron Ore Coming Into the Port of Philadelphia by Trade Route
(Short tons)

Trade route	1989 Actual	1995 Forecast tonnage	1995 Percent growth 1989-1995	1995 Percent change 1989-1995	2000 Forecast tonnage	2000 Percent growth 1995-2000	2000 Percent change 1989-2000	2005 Forecast tonnage	2005 Percent growth 2000-2005	2005 Percent change 1989-2005
Canada	1481796	1767710	2.984	19.3	1811329	0.489	22.2	1711596	-1.126	15.5
East Coast of South America	2300036	3106570	5.138	35.1	4482764	7.610	94.9	5720694	4.998	148.7
Northern Europe	52714	55573	0.884	5.4	58215	0.933	10.4	51553	-2.401	-2.2
Western Africa	0	0	0.000	0.0	0	0.000	0.0	0	0.000	0.0
Total	3834546	4929853	4.277	28.6	6352308	5.201	65.7	7483843	3.333	95.2

Trade route	1989 Actual	2015 Forecast tonnage	2015 Percent growth 2005-2015	2015 Percent change 1989-2015	2030 Forecast tonnage	2030 Percent growth 2015-2030	2030 Percent change 1989-2030	2055 Forecast tonnage	2055 Percent growth 2030-2055	2055 Percent change 1989-2055
Canada	1481796	1396536	-2.014	-5.8	920571	-2.740	-37.9	340971	-3.895	-77.0
East Coast of South America	2300036	8480257	4.015	268.7	11766061	2.207	411.6	13119948	0.437	470.4
Northern Europe	52714	38187	-2.957	-27.6	11905	-7.476	-77.4	900	-9.814	-98.3
Western Africa	0	0	0.000	0.0	0	0.000	0.0	0	0.000	0.0
Total	3834546	9914980	2.853	158.6	12698537	1.663	231.2	13461819	0.234	251.1

TABLE 13

PROJECT CONTAINER CARGO
NORTH ATLANTIC PORTS
(000'S TEUs)

	1985	1990	2000	2005	MARKET SHARE
NEW YORK	2367	3035	3640	5235	64.9%
BALTIMORE	706	905	1086	1561	19.4%
NORFOLK	401	514	740	887	11.0%
PHILADELPHIA	171	219	315	378	4.7%
TOTAL	**3645**	**4674**	**5605**	**8061**	**100.0%**

PROBLEMS, NEEDS, AND OPPORTUNITIES

254. The following sections discuss the problems, needs, and opportunities for the region with regard to the adequacy of the waterways, facilities, and landside transportation systems to accommodate vessels and commodity movements.

255. NEED FOR WATERWAY IMPROVEMENTS. Waterway dimensions present problems in many of the project areas within the region. The following paragraphs include a summary of problems and needs as well as the potential for further study effort.

256. Philadelphia to the Sea. The major problem identified on the Philadelphia to the Sea project is the need for a deeper access in order to handle the present and future tankers, dry bulk carriers and container vessels more efficiently. Provision of a deeper channel would reduce the non-structural practices, such as lightering and light loading now in use by the restricted vessels. In addition, several users are likely to use larger vessels if a deeper channel is provided.

257. With channel deepening there will be a need to evaluate the deepening of anchorages, as well as tributary projects and access channels to the public terminals. The realignment of the channel under the Benjamin Franklin Bridge, as requested by local shippers, also warrants consideration, to provide more efficient movement to the upper channel.

258. Philadelphia to Trenton. Problems along the Philadelphia to Trenton project generally consist of the need for adequate channel maintenance to the Mercer County Generating Station and the need for maintenance of the 40 foot channel up to the USX Steel facility at Fairless. There is no identified need for deepening of the access to Tioga Marine Terminal beyond the authorized 36 feet. Problems related to maintenance of the channel project to Duck Island and adequate maintenance of the 40 foot channel are problems which should be handled by the Operations and Maintenance program. The USX plant is the only facility identified which is constrained by the 40' main channel. Therefore, in the absence of multiple beneficiaries further study does not appear to be in the Federal interest.

259. Christina River (Wilmington Harbor). No present interest for further deepening of the project has been identified. Subsequently facility expansion of the Port of Wilmington facility onto the Delaware River could be handled by Continuing Authorities efforts under Section 107.

260. Schuylkill River. The Water Resources Development Act of 1988 authorized deepening the lower Schuylkill River from 33' to 40'. No need for further deepening of the project has been identified.

261. Delaware River in the Vicinity of Camden. A need exists for additional depths at South Jersey Port Corporation's Beckett Street Terminal in Camden to efficiently handle the dry bulk vessels calling at that facility. Further study is warranted of deepening the main channel as well as the access to Beckett Street Terminal, since this is a public terminal and improvements would be within the Federal interest. South Jersey Port Corporation has plans to extend Beckett Street Terminal's southernmost berth and has recently adopted a Port masterplan for the development of new berth space to the south of the existing terminal. Bulk vessels calling at the existing facilities can benefit from main channel deepening and deeper access to the terminal.

262. NEED FOR DREDGED MATERIAL DISPOSAL. Dredging and associated disposal in the study area involves two distinct operations. Federal project dredged material is usually disposed of in Federally owned or leased sites. In many cases it is the responsibility of the Federal Government to provide the necessary disposal areas. Non-Federal dredging includes berth maintenance and dredging to provide access from berthing areas to one of the Federally maintained channels. Most of this associated material is placed in disposal areas that are provided by the dredging contractor or sites owned by the facilities.

263. Annual historic dredging quantities for the deep draft projects in the Delaware River System total about 11 million cubic yards annually including 8 million from the Federal projects and 3 million from non-Federal.

264. The problem of dredged material disposal is project specific. A description of the problems associated with each specific Federal deep draft project and the specific maintenance volumes follows:

265. Delaware River, Philadelphia to the Sea. Annual maintenance dredging volumes total about 5.4 million cubic yards for this project's features. Eight existing upland disposal sites are located along the project. In order to adequately handle dredged material from the existing Federal project through the study period at least two new upland dredged material disposal sites were projected to be needed in the upper river and possibly one in the middle river depending on ultimate dike heights. Any further deepening of the project would require additional site development with provision of disposal areas a non-Federal responsibility in accordance with the W.R.D.A. of 1986.

266. Delaware River, Philadelphia to Trenton. The upland dredged material disposal sites were leased by the local sponsor. During the study period two additional sites were projected to be needed by the year 2010 to handle the existing project maintenance, which averages 550,000 cy annually. Provision of additional sites is a non-Federal responsibility.

267. Christina River, Wilmington Harbor Project. Two existing Corps upland disposal areas and the additional disposal area under construction will provide sufficient disposal capacity through 2030 for existing project conditions. An additional site will be required beyond that for maintenance operations during the remainder of the study period, which average 1.2 million c.y. annually.

268. Schuylkill River. This project is hydraulically dredged and the material deposited in an upland disposal area with sufficient disposal capacity through the year 2030. An additional site will be required during the study period to accommodate maintenance dredging which average 310,000 c.y. annually unless the dike heights can be raised above 50 feet.

269. Delaware River in the Vicinity of Camden. The maintenance requirements of this project are limited and have been included with those for the Philadelphia to the Sea project since this project is geographically located within the latter's boundaries. Annual maintenance volumes are approximately 10,000 c.y,

270. Additional Requirements. Beyond the disposal areas established to sustain existing maintenance requirements, additional disposal capacity may be required. The construction and maintenance of waterway improvement resulting from this study will require additional disposal areas beyond that discussed above.

271. ADEQUACY OF TRANSPORTATION NETWORK. The capacity analysis examines the overall adequacy of the transportation systems with respect to the level of current usage and future requirements.

272. Highway Assessment. The primary regional access highways in New Jersey are the New Jersey Turnpike and I-295, serving the northshore corridor. In addition Route 55 was completed in 1989 which provides more direct access from the Philadelphia-Camden area to southeastern New Jersey. Regional access to and from the Delaware River ports from New Jersey appears adequate to sustain normal traffic growth through the 1990's and well past the year 2000 as presently planned construction and improvement projects are completed. Throughout the study period the highway system will continue to be maintained and upgraded as it has historically to provide adequate highway access to New Jersey.

273. The primary regional access highways in Pennsylvania are the mainline Pennsylvania Turnpike (I-276), the Northeast Extension of the Turnpike (Route 9), I-95, and the mainline Schuylkill Expressway (I-76) with its Vine Street extension. The recently constructed I-476 connects I-95 near Chester with the Pennsylvania Turnpike at its junction with the Northeast Extension. Now that the I-476 and the Vine Street extension are completed, the network provides adequate access to and from the Delaware River Ports and will sustain normal traffic growth through the 1990's and well past

the year 2000. Throughout the study period the highway system will continue to be maintained and upgraded as it has historically to provide adequate highway access to Pennsylvania.

274. The Delaware highways evaluated for adequacy were the Delaware Turnpike (I-95), US 40 in the Northeast Corridor, and US 13 and 301 on the Delmarva Peninsula. A new alternative north/south route which would reduce congestion on Route 13 is planned for construction in the early 1990's. These highways are adequate to sustain normal traffic growth through the 1990's and well past the year 2000.

275. The primary interstate and intrastate highway system serving the Delaware River Ports and its hinterlands is currently operating at less than full capacity. With the planned completion of such highway links as I-295, I-195, and I-287 in New Jersey, the widening of the Delaware Turnpike and I-95 in Pennsylvania, and other Pennsylvania and New Jersey improvements, it would appear the highway access to the region will be adequate into the future. Constraints to regional development and port operations are not expected to result from any regional highway access bottlenecks. There are no known problems related to highway access from port terminals.

276. Rail Transportation Assessment. Conrail and the Chessie railroads provide the primary rail service connection between the Philadelphia ports and the hinterland region they serve. Each of the two railroads operates at levels considerably below its stated capacity and present no constraint to project port development and commodity movements.

277. Both companies have made considerable investments in improving their systems in recent years, including rehabilitation of trackage and new rolling stock. Conrail has spent over $200 million on track rehabilitation in the northeast U.S. since 1976. An additional $42 million has been spent by Conrail to expand and upgrade its Pier 124 coal facility to handle upwards of 10 million tons of coal per year. In further support of its coal operation, Conrail has acquired more than 5000 additional hoppers, raising its fleet on serviceable hoppers to 35,000. Other investments have been made in the form of a rail container facility in Morrisville, which will also serve the Philadelphia Region. Another intermodal facility is planned for the Greenwich Rail Yard in South Philadelphia which will enhance the port's ability to attract containerized cargo and maintain its market share. In addition, the Canadian Pacific's acquisition of the Delaware and Hudson Railway in the $25 million dollar purchase in 1991 will add a third truckline with access throughout Canada and replace considerable international traffic now entering Canada via Halifax, Nova Scotia.

278. Overall, rail capacity is adequate, as is service to area shippers. Previous studies have found that Conrail's overall

service reliability and equipment supply have improved substantially in recent years. With its present utilization between 30-50% of capacity, the company can provide for substantial expansion in throughput as the need arises.

279. A similar ability exists for the Chessie system. Handling capacity on Chessie-operated lines are upwards of 50 trains daily into and out of the Philadelphia/Wilmington area. However, an average of only 10 trains operates daily.

280. A third railroad, Canadian Pacific via its D&H Railway subsidiary has recently gained access to the area and will service DRPA's regional intermodal transter facility.

281. Air Transport Assessment. Based on information provided by the Philadelphia International Airport, total plane movements appear to have remained relatively constant except for commuter (passenger) traffic. Four basic categories contribute to this movement: carrier, commuter, military, and general aviation. It appears, analyzing available data, that the trend toward movement of cargo by air is slowing. Area facilities are adequate for any increase in movements. At this time, it does not appear that air freight transport facilities will constrain any potential development of the ports in the study area.

282. Pipeline Transportation Assessment. The North Atlantic coastal ports are served by a number of clean petroleum products pipelines. The Colonial Pipeline, originating in the Houston/Galveston refining territory, is the largest pipeline in the United States. It passes through major refining centers in Louisiana, gathering products for delivery throughout the eastern United States. By connection to other pipelines, petroleum can be gathered from many major Texas and Louisiana refineries. Important delivery points include Norfolk and York River, VA: Baltimore, MD, Paulsboro and Trenton, NJ: Philadelphia and Marcus Hook, PA: and New York Harbor. A connection with the Buckeye pipeline extends service to Long Island, NY. The Colonial Line can deliver 732,000 barrels per day to the northeastern United States through its 32-inch pipe, with an ultimate capacity of 930,000 barrels per day. The Plantation Pipeline is the second largest products line from the Gulf Coast, and generally parallels the route of Colonial line. Although the line ends at Washington, D.C., it also serves a major section of the North Atlantic Coast and has a capacity of over 400,000 barrels per day.

283. At least six product pipelines cross Pennsylvania to serve the western part of the state, Ohio, and points west from the refining centers on the Delaware River. Two lines connects to New York-area refineries. The major Buckeye Pipeline connects to several other pipeline systems in the midwest, providing a continuous link to the Gulf Coast refineries. Part of the Buckeye system and the Texas Eastern Pipeline includes the famous Little

Big Inch Line, constructed during World War II to serve the East coast in an emergency. The Delaware River refineries are tied to the New York-area refineries by three pipelines besides the Colonial line: the Sun Oil Line (14-inch), the Buckeye line (16-inch), and the Harbor Projects line (16-inch). The present pipeline system operates below capacity and does not represent a constraint to future oil refinery production.

284. ADEQUACY OF PORT FACILITIES. It can be expected that adequate facilities will be available for the level of tonnage projected in the future for those commodities identified to benefit from a channel modification. As per ER 1105-2-100, in projecting commodity movements, sufficient capacity of hinterland transportation and related facilities, including port facilities, should be assumed unless there is substantive data to the contrary. No major throughput capacity problems in handling projected tonnage over the project life are anticipated. Port facilities are expected to be upgraded and replaced as the need arises. Landside transportation systems are also expected to keep pace with commerce requirements.

285. Crude Oil. The import level for crude oil is forecasted to be 79 million tons in 2055. The refineries will need to expand their current 60 million ton capacity modestly in order to process the tonnage projected. The refinery capacity is expected to increase in the future through technology changes, upgrading facilities, expansion, and new development in order to accomodate project commodity flow.

286. Coal. The maximum coal export forecast over the project life is 1.8 million tons. This volume will not require an increase in capacity, as current capacity is 10 million tons.

287. Iron Ore. Iron ore imports are forecast to be 13 million tons in the year 2055. This volume can be accomodated by a modest increase in capacity of existing facilities (10.5 million tons).

288. South Jersey Port Corporation. Benefitting tonnage is projected to be approximately 3.5 million tons in 2055. This volume can be accomodated by capacity to be available by 1998, based on the long-range Master Plan of the South Jersey Port Corporation.

289. Containers. Benefitting tonnage is projected to be 2 million tons in 2055, which can be handled by existing capacity.

290. The Beckett Street Terminal, operated by South Jersey Port Corporation, has experienced increased business in recent years. In the last decade, South Jersey Port has expended approximately $15,000,000 to modernize the bulk cargo handling facilities and marginal berths at Beckett Street, with the result that Beckett

Street Terminal now has the capacity to handle large quantities of bulk cargo efficiently.

291. South Jersey Port Corporation (SJPC). The Land area currently owned by SJPC for Beckett Street Terminal is 74 acres. SJPC also has four berths, with 2300 L.F. of length. Expansion and development plans include additional land acreage of 260 acres and additional berthing length of 4100 L.F. (to be completed by 1995). Throughput capacity projected by SJPC for Beckett Street Terminal for all commodities, when fully developed by 1998 in accordance with their Long-Range Master Plan, will be in excess of 10 million tons of bulk commodities annually.

292. Oil Pollution. The input of oil into the Delaware River results form several activities, including refinery and other industrial operations, urban runoff, municipal waste, and tanker traffic. In 1975, the input of oil from onshore operation (not including that resulting from tanker operations) was estimated at 59,000 gallons per day or about 21.5 million gallons per year. Following enactment of the Clean Water Act in 1977, this oil discharge decreased by over one-half.

293. The potential for oil spills and concern over the negative environmental impacts involved is very much a public concern. Any oil spill event in the Delaware River must be reported to the National Response Center. Under the National Oil Spill Contingency Plan (NCP), there are National, Regional, and Local Response Teams. The Region III and Region II Emergency Response Teams have jurisdiction in the Delaware River Comprehensive Navigation Study area. The Region III Response Team consists of representatives of the following:

- Environmental Protection Agency
- U.S. Coast Guard
- Department of Agriculture
- Department of Commerce
- Department of Defense
- Department of Energy
- Department of Health and Human Services
- Department of the Interior
- Department of Labor
- Federal Emergency Management Agency
- Commonwealths of Pennsylvania, Virginia, and District of Columbia
- States of Delaware, Maryland, and West Virginia

294. The Region II Response Team is composed of the same Federal agencies plus the States of New Jersey and New York. Under the Regional Contingency Plan (RCP) in the Delaware River Comprehensive Navigation Study Area the U.S. Coast Guard Captain of the Port, Philadelphia (COTP) is designated as the on scene cleanup coordinator (OSC). The OSC can call upon support for spill clean

up from the Atlantic Strike Team (located at Fort Dix, NJ), a specially trained and equipped contingent of NCP's National Strike Team; the Delaware Bay and River Cooperative (DB&RC), a consortium of oil, chemical, and petroleum transportation companies which operate two cleanup vessels and have an assortment of other kinds of cleanup equipment at their disposal; members of the Regional Response Team; and representatives of the Local Response Team such as the New Jersey State Police and the Philadelphia Fire Department. The Regional Contingency Plan is updated on a continual basis and would be updated to reflect any changes in current vessel traffic patterns due to a modified project.

295. U.S. Coast Guard data from 1973 to 1989 on vessel-related oil spills in the Delaware River revealed a gradual decline in both the number of spill incidents and the volume. Much of it can be attributed to the increase in tanker vessel size and the use of larger tank barges for lightering. Twenty-five percent of the spills analyzed involved residual fuel oil, 20 percent involved crude oil, and another 20 percent involved diesel fuel. Additional petroleum-related materials spilled in the river were gasoline, other distillate fuel oils, and waste oil. On a volume bases, crude oil comprised 44 percent of material spilled followed by residual fuel oil with 26 percent.

296. Lightering operations have occurred at the Big Stone Beach Anchorage since the 1960's. Transfer accidents in the Delaware River occur at a rate one-half that of the national average of 8 accidents per 1000 transfers. The average national lightering spill is about 32 gallons. For the Delaware such spills are immediately cleaned up using an oil skimmer which is permanently stationed at Lewes, Delaware and operated by the Delaware Bay and River Cooperative.

297. Most of the oil spilled into the Delaware River has been the result of tanker and barge accidents. Refer to Table 13 for a listing of the major oil spills which have occurred in the Delaware River since 1973. Major incidents such as these are usually the result of human error and structural or mechanical failures. After an oil spill event, a prompt and efficient oil spill cleanup can reduce many adverse impacts. An analysis of recent large spills in the Delaware River reveals that cleanup operations are generally very effective at removing the spilled oil from the water and protecting ecologically sensitive shoreline areas. Records show that the DB&RC vessels have been able to recover 60 to 70% of the spilled oil. In the aftermath of the catastrophic Exxon Valdez oil spill in Prince William Sound Alaska, several actions have been taken to lessen the chances and reduce the impacts from similar spills that may occur in the future. Since the enactment of the Oil Pollution Act of 1990, all vessels must have spill response plans to deal with the worst case oil spill that could occur.

Table 14 - Major Oil Spills in the Delaware River, 1973-1989

Year	Volume (gallons)	Vessel Source	Location	Accident Type
Spills Greater than 100,000 Gallons				
1973	126,000	Tanker	Marcus Hook	Grounding
1974	285,000	Tanker	Philadelphia/Camden	Collision
1975	500,000	Tanker	Marcus Hook	Collision
1976	134,000	Tank Barge	Marcus Hook	Grounding
1978	630,000	Tank Barge	New Castle-Reedy Island	Sinking
1979	189,000	Tank Barge	Marcus Hook	Collision
1985	525,000	Tank Barge	Philadelphia/Camden	Grounding
Spills Greater than 10,000 Gallons but less than 100,000				
1973	14,720	Tanker	Ocean Throughway to Delaware Bay	Grounding
1974	13,000	Tanker	Philadelphia/Camden	Fire/Explosion
1975	12,000	Tanker	Marcus Hook	Collision
1975	73,000	Tugboat	Philadelphia/Camden	Capsizing
1976	84,000	Tanker	Philadelphia/Camden	Collision
1979	16,800	Tanker	Philadelphia/Camden	Pipe Rupture

These plans must be in place by February 18, 1993. Also, the Marine Spill Response Corporation (MSRC) was created and incorporated in 1989. This not-for-profit corporation was created to assist in the cleanup of large oil spills using state of the art technology. Lastly, there is increasing public pressure to require vessels that transport oil to have double hulls, back-up steering and emergency back-up propulsion systems.

298. Although minor spills also occur periodically, the Delaware River has functioned safely considering the huge volume of oil that is transported on the river. Channel dimensions have not been identified as a contributing factor to the previous accidents or oil spills on the Delaware River. Through proper planning and design of waterway improvements and navigation aids, the potential for accidents can be minimized. There is potential to reduce oil pollution due to lightering operations by main channel deepening. This would alleviate the need for lightering vessels in the 40' to 45' range.

299. Summary of Problem Identification. In summary, this section has provided an assessment of the present and expected future problems within the study area that could have an effect on navigation.

300. The current authorized channel dimensions on the main stem and Delaware River in the Vicinity of Camden present a constraint to efficient vessel movement. The Delaware River main stem channel dimensions constrain dry and liquid bulk movements. Alternatives such as lightering, lightloading and waiting for tides are in themselves inadequate to solve the problem.

301. The facility adequacy assessment described above indicates that in the near term there are expected to be no problems related to the Delaware River regions facility or cargo handling capabilities. However, in the mid to long-term, beyond 2020, given the expected growths in commodity movements, it appears that there will be a need for general cargo and dry bulk facilities open for public use. It has been assumed, based on the historic and current trends and facility development plans, that facilities will be developed or utilized to the degree required to meet regional demands in the future. The capacity of the existing landside transportation network along with the proposed improvement is expected to be able to provide adequate service to and from the hinterlands, both now and in the future.

PLAN FORMULATION

302. Plan formulation is the process of establishing study objectives, identifying and developing alternative measures, evaluating and assessing alternative plans, and selecting the best plan. The purpose of this section is to provide the background process and procedures followed in this study.

PLANNING OBJECTIVES

303. The following planning objectives were established for formulation of plans to address the problems, needs and opportunities identified under the without project conditions over the study's 50 year period of analysis:

Provide adequate and safe navigation channels and appurtenances to accommodate vessels travelling along the Delaware River for which existing channel dimensions are a problem.

Identify and systematically examine alternatives available for increasing the efficiency of waterborne commerce.

Identify and evaluate acceptable disposal sites and techniques for disposal of material dredged within the study area, such that dredged material disposal capacity is sufficient for initial construction and maintenance requirements during the study period.

Protect fish and wildlife resources in the study area during initial construction and project maintenance.

PLANNING CONSTRAINTS

304. The formulation and evaluation of alternative plans must be constrained by technical and economic criteria. Further constraints are caused by environmental policies and institutional requirements.

Project features will be designed in accordance with criteria contained in Corps of Engineers' regulations for deep-draft navigation channels, with consideration to the views of pilots and the U.S. Coast Guard regarding safety of design.

Dredged material disposal areas should be capable of handling all types of material normally dredged in the Delaware River (silt, sand, rock).

Channel designs and projected vessel usage should be compatible with the vertical and horizontal clearances

provided by existing bridge or utility crossings which cannot be relocated at a reasonable cost.

Project vessel usage and channel depth requirements should not exceed limitations to vessel size presented by waterway dimensions both along the trade route and at the port of the trading partner.

305. ECONOMIC CONSTRAINTS

In accord with ER 1105-2-100, Chapter 6, Section VII, NED Benefit Evaluation Procedures: Transportation (Deep Draft Navigation), the estimation of deep-draft navigation benefits was accomplished. Economic constraints limit the range of alternatives considered based on principles of project optimization. The following items constitute the economic constraints foreseen to impact formulation of alternatives to be considered:

-Shippers are assumed to use the least cost mode of transportation if there are no overriding noneconomic factors influencing modal preference including shipment size and vessel availability.

-Shippers are expected to make maximum use of nonstructural measures in order to minimize transportation costs.

-Analyses of project benefits and costs are to be conducted in accordance with Corps of Engineers' regulations and must assure that any plan is complete within itself, efficient and safe, and economically feasible.

-Economic evaluations of project justifications must assume that authorized channel dimensions are maintained and will evaluate the incremental justification of channel modifications.

306. <u>ENVIRONMENTAL CONSTRAINTS.</u> Appropriate measures must be taken to ensure that resulting projects are consistent with local, regional, and state plans, and that the necessary permits and approvals are likely to be issued by the regulatory agencies. Identification of a viable NED plan necessitates likely approval for required permits and certificates.

The Coastal Zone Management Programs in the states of Pennsylvania, New Jersey and Delaware each prohibit certain activities as being contrary to fundamental coastal resource management goals, even with full mitigation. These activities are:

	Prohibited in		
Activity	PA	NJ	DE
Wetland destruction	*		
Stream relocation		*	

Stream modification resulting in increased flooding potential	*	*	*
Shellfish/oysterbed destruction		*	*

Compliance with numerous Environmental Quality Protection Statues and other Environmental Review Requirements will also be required. These include:

- Archaeological and Historical Preservation Act
- Clean Water Act, as amended
- Clean Air Act of 1977
- Coastal Zone Management Act of 1972, as amended
- Endangered Special Act of 1973, as amended
- Fish and Wildlife Coordination Act
- Marine Protection, Research and Sanctuaries Act
- National Historic Preservation Act, as amended
- National Environmental Policy Act, as amended
- Rivers and Harbors Act
- Executive Order 11988 Floodplain Management
- Executive Order 11990 Protection of Wetlands
- Executive Order 12114 Environmental Effects of Major Federal Actions

PLAN FORMULATION RATIONALE

307. The formulation process used to develop and evaluate alternative plans was based on the consideration of all possible alternatives with the potential for addressing the planning objectives and meeting the technical, economic and socio-environmental criteria. This process was accomplished in several different formulation iterations, or cycles. The first step included the preliminary screening of all possible structural and non-structural alternatives and their associated features. Based on technical and economic reasons, a number of these measures were subsequently evaluated in the formulation process, involving several iterative cycles, each with different emphasis.

MANAGEMENT MEASURES

308. The purpose of this portion of plan formulation, accomplished during the development of the reconnaissance portion of the study, was to screen alternative solutions to navigation problems of Federal interest. There are numerous measures which address the efficiency of waterborne commerce. These measures fall into the broad categories of waterway conditions, disposal of dredged material, and provision of adequate landside facilities and transportation. A variety of structural and non-structural measures are possible for these various components of the waterborne transportation system. Most of the non-structural waterway measures are currently in practice to make optimum use of the existing Delaware River projects. These management measures

include those which are within the authority of the Federal government to implement, as well as those which are within the authority of non-Federal governments, port authorities, corporations, and shippers.

309. WATERWAY IMPROVEMENTS. The waterway-related measures which could improve the safety or efficiency of waterborne commerce include:

Structural	Non-Structural
. Channel modification (widening, deepening, realignment, extension)	. Transshipment (lightering, topping off, or modal shifts)
. Anchorages	. Use of high tides for vessel movements, loading, unloading
. Breakwaters and Jetties	. Lightloading
. Aids to Navigation	. Modification to pilot regulations
	. Tug assistance
	. Modification of vessel design or operational characteristics
	. Scheduling/traffic management

310. DREDGED MATERIAL DISPOSAL. Measures to provide additional disposal area capacity and maximize capacity at new sites include the following:

- raising dikes
- dewatering
- reusing dredged material
- extending leases
- using sedimentation basins to reduce shoaling
- acquiring new upland sites
- ocean/bay disposal (filling holes, bottom dumping, and thin layering)
- island/wetland/upland creation

FORMULATION AND EVALUATION CRITERIA

311. GENERAL. All plans were formulated and evaluated on the basis of technical, economic, and socio-environmental criteria. These criteria, along with intangible considerations, permitted the development and tentative selection of plans which best responded to the planning objectives. The specific criteria are as follows:

312. TECHNICAL CRITERIA. The following technical criteria are used to develop and analyze alternative plans:

Each alternative is designed as a complete project that does not obligate the Federal government to future work, except for maintenance as provided by law.

Analyses of project benefits and costs are to be conducted in accordance with Corps of Engineers' regulations and must assure that any plan is complete, efficient, safe, and economically feasible in terms of current prices.

The formulation of disposal area sites will consider the effect that channel deepening could have on the existing Federal project and existing Federally provided disposal sites. These options varying the means the local sponsor provides for disposal capacity are:

a) Deposit all material (initial construction and increased maintenance) into an upland Federal disposal site and require local sponsors to reimburse the Federal government.

b) Deposit all material into a Federal upland disposal site but require local sponsors to transfer material to a locally provided final site.

c) Deposit all material into a disposal site provided by the local sponsors.

d) Deposit the required volume of material (initial construction and increased maintenance) into a locally provided disposal site while using a Federally provided site as economically practicable.

e) Deposit material at an aquatic site in Delaware Bay with consideration for beneficial uses such as wetland/island/upland creation, oyster seed bed creation, and sand stockpile.

313. Any use of Federal disposal areas on a reimbursement basis by local sponsors should make the government whole, have no significant impact on the remaining capacity of the Federal sites, and should not result in a short-term need for replacement sites by the Federal government which could impact the maintenance dredging capabilities.

314. Channel and turning basin designs are in accordance with design criteria contained in EM 1110-2-1613, titled "Engineering and Design-Hydraulic Design of Deep Draft Navigation Projects" dated 8 April 1983. Safe underkeel clearance is to be established through coordination with the appropriate pilots and vessel operators and the U.S. Coast Guard. For quantity computations, up to two (2) feet below the channel design depth (overdepth) is

allowed as a tolerance in the dredging operation, the present practice for dredging contracts.

315. Designs and layout of alternatives is to be coordinated with the appropriate pilots and vessel operators and the U.S. Coast Guard to assure safe design. Layout of suitable navigation aids is to be accomplished by the U.S. Coast Guard.

316. SOCIO-ENVIRONMENTAL CRITERIA. The following socio-environmental criteria and intangible effects were considered in the plan formulation and evaluation:

Protect public health, safety and well-being.

Avoid, where possible, detrimental environmental impacts and include features to prevent unavoidable adverse effects.

PRELIMINARY SCREENING OF ALTERNATIVE MEASURES

317. GENERAL. The following discussion describes the formulation and screening of alternative measures in the plan development of this study. Both structural and non-structural measures are addressed.

318. STRUCTURAL MEASURES. The formulation and screening of structural measures is discussed below.

319. Channel Modification. Channel modifications benefits existing or potential users by allowing use of larger vessels, reducing or eliminating more costly non-structural measures, preventing accidents and vessel damages, allowing a shift to waterborne movement from a more costly mode, or by lowering total transportation costs for commodities moving through other ports or to other origins and destinations. The problem identification section indicates that there is a significant amount of traffic in the Delaware River and Bay region which utilizes one or a combination of several non-structural measures due to channel limitations. Channel modification is addressed for all problem areas on the Delaware River where there appear to be problems with the depth, width, alignment or length of navigation channels.

320. Anchorages. Anchorages for general use are designated by the U.S. Coast Guard for short term anchoring (48 hours maximum without special permission). Ships may anchor while waiting for favorable tidal conditions, safe weather conditions for operation, repairs or for the availability of berth space. Lightering is conducted at some general anchorages. Special anchorages may be designated for specific purposes such as for tanker lightering, anchoring of ships carrying explosives and natural gas, or anchoring of naval vessels. Investigation of anchorage utilization is included as a necessary part of this study.

321. Breakwaters and Jetties. Breakwaters are used to protect a harbor or beach from the force of waves. As such breakwaters alleviate the effects of wave action, such as beach erosion or damages to vessels or harbor structures. Jetties are constructed at the entrance of restricted waterways to minimize the effect of cross currents on navigation as well as to reduce the amount of shoaling occurring in the channel. Neither would be a benefit to navigation along the main channel of the Delaware River.

322. Navigation Aids. Navigation aids include range lights, buoys, lightships, raycon beacons, maritime radio beacons, loran, fog signals, and sunken vessel markings, all of which are installed and maintained by the U.S. Coast Guard. These aids mark navigation channels and maneuvering areas for safe movement of vessels and provide reference points with which pilots can determine vessel position. Means to improve navigation aids will be investigated in conjunction with the Coast Guard.

323. Oil Pipeline. This alternative would require construction of a crude oil facility as a means of improving importing of crude oil into athe Delaware Estuary. A pipeline terminal would require continued use of larger tankers for transatlantic travel. Earlier Deepwater Port studied for Delaware Bay all predicted more imported oil and greater use of larger tankers than now thought reasonable. Delaware River tanker traffic would be reduced with construction of a crude oil pipreline but not eliminated since outbound chemicals and refined products will still need to travel by water.

323. Big Stone Beach Anchorage Terminal, Delaware Bay. An oil terminal and pipeline option from this location to the refineries was analyzed in detail as part of the North Atlantic Coast Deepwater Port Study done in the early 1970's. The corps concluded at that time that net benfits were marginal and potential ecological and social costs to the coastal zone were considerable. Without a project sponsor no recommendation for future studies was made. A group of oil multi-component artificial island port located here. While no formal recommendations were made interest was developed.

324. An updated analysis of an island terminal facility located in the lowaer Delaware Bay off Big Stone Beach Anchorage was reanalyzed by the Corps in 1984. Designed like the main channel deepening to handle coal and iron ore as well as crude oil, benefits could only offset 60% of the high construction cost of $1.4 billion assuming present commodity levels. Attempts to find an interested project sponsor for this alternative were unsuccessful. Reducing the size and providing only for a crude oil facility was less viable economically. The State of Delaware was opposed to this alternative due to the ecological and secondary development effects expected.

325. The environmental effects of constructing an oil pipeline are expected to be high. Even with maxing use of existing rights-of-ways-there would be sizable wetland and terrestrial impacts. The opposition on environmental grounds to a recent product pipeline proposal from the Delaware City Terminal to an existing pipeline at Marcus Hook was considerable. The potential for spills and long term leakage into the groundwater were both raised.

326. One other location off the mouth of the Maurice River on the New Jersey side of the bay was evaluated in detail as part of the Deepwater Port Study. This site was dismissed due to greater dredging quantities and higher costs than would occur with the Big Stone Beach site plus the resulting ecological impacts of terminal location in a more productive area, including oyster habitats.

327. There are no other locations in the Bay for a pipeline terminal which could be developed without at least double the amount of terminal dredging. The impacts of pipeline construction and operation would, like a pipeline with a terminal at Bid Stone

Beach, be considerable, although the amount of wetlands impact might be less for a terminal off the Maurice River.

328. Location in Lower Delaware River, Reach D Reach D extends from Bombay Hook to the Chesapeake and Delaware Canal. There are no locations found where a pipeline terminal facility could be developed without considerable berth dredging. Massive terminal dredging. Massive terminal dredging (over 10 million cubic yards) would be necessary in addition tot he 15 to 22 million cubic yards of river channel dredging needed to provide a 45 foot channel somewhere in this reach. This added cost would, couple with the economic and ecological costs of a 60 mile pipeline, make this option uneconomical. The loss in commercial fishery (finfish and shellfish) would be an additional negative factor. The effect on the oyster industry would likely be devasting.

329. Locations in the Lower Middle Delaware River, Reach C Like a terminal in reach D, dredging quantities would be substantial. Combined channel and berth yardage could range between 35 and 40 million cubic yards for initial dredging, even with the use of the Texaco terminal channel. This is 70 to 80% of the dredging quantities of deepening the entire channel. A channel only deepened to here would exclude coal, iron ore, and othr cargoes which account for 20% of the benefits of main channel deepening. Channel with the added cost of operating the pipeline is the additional maintenance dredging associated with locating in this heavily shoaled area. This option appears less economically viable than channel deepening. Also ther does not appear to be an environmental benefit from a terminal here and a 20 mile pipeline.

330. Marcus Hook Terminal, Reach B A terminal located here would serve the 4 remaining upstream terminals by providing a 15 mile pipeline. The least costly plan would likely involve modifying the Marcus Hook Anchorage. Initial dredging yardage for th channel deepening and terminal facility could be about 5 million cubic yards less than full channel deepening. The overall dredging saving might be less since channel realignment into rock outcrops would probably be necessary. The amount of annual maintenance will be even greater than the full length channel deepening since Marcus Hook is the most heavily shoaling segment in the river. The minimal reduction in intial yardage also assumes no compensation for lost anchorage capacity and minimal resultant reduction in safety. Other commodities which account for 20% of the project benefits could also not benefit from this scheme.

331. The need to expand the anchorage by even one or two of the three berthing areas required for a terminal would require destruction of shallows and probably freshwater wetlands which border the anchorage.

332. Other Locations in the Middle Delaware River, Reach B and Locations in the Upper Delaware River, Reach A There are no location whithin these 2 reaches which appear better thatn the Marcus Hook location. Elsewhere dredged yardages are likely to increase to 50 million cubic yards. This approximates the amount of dredging required to deepen the entire channel length and would result since partial use of an existing anchorage at alternative locations is not possible.

333. In conclusion of a crude oil pipeline alternatives has identified no alternative which appears to even approach the overall viability.

334. NON-STRUCTUAL MEASURES. The following non-structural measures were considered during preliminary planning for the study.

335. Transshipment. Transshipment means the transfer of cargo from one means of transport to another. Lightering and topping off generally refer to transfer of cargo between a large deep-draft vessel and a smaller vessel or barge in order to maximize the cargo tonnage carried over a long voyage. However, the term can also apply to intermodal shifts such as transfer of cargo from a vessel to rail car, truck, or pipeline enroute to its final destination. Lightering and topping off are practiced where vessel design drafts exceed available channel depths at the port and for years has been commonly practiced for liquid bulk commodity shipments due to the main channel depth of the Delaware River. This measure does not provide the opportunity to alleviate current problems for the Delaware River.

336. Use of High Tides. Movement of deep draft vessels at high tide in channels of restrictive depth is a means of increasing efficiency of commodity movements. Costs for tidal delays are generally small in comparison to transportation savings over a long voyage. Where channel depths are below the potential vessel operating draft, loading or unloading of vessels timed around peak tides can also maximize the tonnage of cargo carried per vessel. This practice has become standard for bulk shipments allowing up to three feet of additional loading for vessels using high tides. Therefore, it does not have the potential for alleviating current problems related to the depth of the main channel.

337. Split Deliveries. Where vessel design drafts exceed available depths at particular ports, trips can be made there when the vessel is partially loaded. By arranging vessel calling patterns so that initial offloading or final onloading occurs at the deeper ports of call, the vessels can still call at ports with lesser depths available. Such occurrences have occurred in the Delaware River with bulk commodities. However, this measure does not alleviate the current problems related to the depth of the main Delaware River channel.

338. Lightloading. Lightloading can reduce overall transportation cost per ton of cargo where channel depths are restrictive. A lightloaded larger vessel can often carry greater tonnage than a fully loaded smaller vessel of equal draft. Therefore, more tonnage can be carried per vessel trip and a cost savings might be achieved due to lower operating cost per ton over the overall trip if transfer costs to the second vessel are low. Lightloading for bulk commodities is a common practice and does not provide the opportunity for alleviating the identified navigation problems.

339. Pilot Regulations. The pilot regulations for safe movement of vessels for the Delaware River are published in the Code of Federal Regulations, Title 33, Subchapter D. The regulations are established through a rather lengthy process which includes public meetings and formal review and comment periods. The regulations govern port and waterway safety, use of anchorages, international navigation rules, aids to navigation, and other areas of concern. Modifications to these regulations is possible, though they have been established for safety and efficiency of operation. However, modifications to pilot regulations are difficult to implement and provide no opportunity for alleviating the identified navigation problems.

340. Tug Assistance. Using tugs for turning, docking, and navigating in restrictive waterways is a common way of minimizing the need for larger channel and maneuvering areas. In the Delaware River system, tugs are used as safety precautions in vessel docking at many locations. Also along the Delaware River, Philadelphia to Trenton Project where there are draw bridges, if a bridge failed to open or a vessel lost power and a collision was imminent, tugs could facilitate an emergency stop. Use of tugs in these instances is expected to continue under any future channel scheme and this measure does not provide the opportunity to alleviate current navigation problems of insufficient depth.

341. Modification of Vessels. Rather than modifying or enlarging channels due to vessel characteristics, the reverse is also possible. Vessels can be designed or modified to carry additional tonnage as an alternative to larger waterways. An example is the Panamax size vessel which is designed around the constraint of operation through the Panama Canal. Other examples include LASH vessels, extension of container ships, special barge designs to include loading equipment, or special vessel control features such as stern or bow thrusters to increase vessel maneuverability in restricted waterways. There is insufficient traffic to justify development and construction of a fleet solely for use in the Delaware River. Thrusters have become commonplace on larger vessels and this trend, which will aid vessel maneuverability especially with docking, is expected to continue.

342. Scheduling/Traffic Management. Where problems include traffic congestion or backlog, scheduling of arrivals and departures can minimize demurrage costs while vessels wait for berth space. Traffic management can be used to minimize accidents, to maximize the efficiency of vessel movements, to avoid vessel delays for through traffic due to vessels turning or docking, to avoid queuing problems, and to reduce transportation costs by minimizing fuel consumption. None of the problems identified could be rectified by scheduling/traffic management; berth utilization generally averages less than 25% at nearly all facilities, minimizing the potential benefits of this option. The Delaware River pilots coordinate between themselves to alleviate any problems with queuing delays as vessels perform docking maneuvers and to avoid passing at bends.

343. DREDGED MATERIAL DISPOSAL. The following measures were considered during preliminary planning for the study. Each of the measures considered was screened to identify those that had the greatest potential to satisfy the disposal needs for a channel deepening project. Those demonstrating potential were evaluated further.

344. Raising Dikes. Containment dikes are periodically raised to increase the useful capacity of a site. The maximum height of a containment dike is based on engineering considerations such as slope stability and existing subsurface conditions. The dike heights are periodically increased by stepping in or encroaching into the disposal area with successive lifts designed for one or more periods of filling. The actual height increase depends upon the characteristics and volume of material to be placed and an allowance for freeboard (usually 2 feet). The final dike elevation in Federally owned sites considers safety, lease agreements, effects on adjacent properties, and future land use in addition to the technical limitations. Conversely, final dike elevation in privately owned sites is usually controlled by easement, local ordinances and owner's future plans for the site. Based on technical considerations, the study generally considers the maximum elevations to be 70 feet above original ground for new disposal areas. This measure is an economical way to minimize the need for additional site acquisition and periodic dike raisings will be incorporated into disposal plans.

345. Dewatering of Dredged Material. Dewatering dredged material is a common practice that is employed to increase the useful life of any disposal area. Field tests which were conducted as part of the Dredged Material Research Program (DMRP) have proven that even some of the more difficult types of dredged material can be efficiently dewatered. Interior surface trenching and perimeter trenching by dragline and backhoe are effective ways to achieve a greater degree of dewatering than can be done through natural drainage. These methods have been utilized at existing Philadelphia District disposal areas, where capacity is at a

premium. Both methods appear to be cost effective and will be used to the maximum extent practical for new disposal areas. Other more complex methods exist, such as those involving under-drainage systems and vacuum pumping. However, these methods are extremely costly with variable results and consequently were not considered further in this study.

346. The study considered a variety of advanced equipment designed specifically for the purpose of improving the construction practices of digging dewatering trenches. In mid 1983, an amphibious rotary trencher was purchased by the Philadelphia District and has been used since. This vehicle has the capability to dig a trench between 18 to 48 inches in depth at a speed of about 2-3 miles per hour. The effect of the trenching on the shoal to disposal area (wet to dry) ratio is dependent upon the type of material, the network and depth of the trenching, the time elapsed between the placement of the dredge material and the initiation of trenching, and the length of time available for drainage and drying of the dredged material. The wet to dry ratio of 1.5 to 1 used for this disposal analysis includes the use of this rotary trencher and other dewatering techniques currently used.

347. Reusing Dredged Material. The sale of dredged material was initiated by the Philadelphia District in 1972 as a means of extending the useful life of existing disposal sites as well as providing a means of more efficiently utilizing the dredged material. The material is sold in quantity as excess government property directly from the disposal area. It has many productive uses, such as for landfill or construction activities. The future volume of material that can be reused in this manner depends on such factors as demand, type and quality of material, and distance between the disposal site and reuse site. Some of the varied uses of dredged material are discussed in the following paragraphs.

- Highway Fill. Although it is likely that there will always be a market for this purpose, indications are that it will be less than previously experienced. The interstate highway program in the vicinity of the study area is nearly completed thereby eliminating the long range need for this material. State and county highway officials have indicated that their future need (as highway fill) will also be limited.

- Shoreline Protection. Shoreline protection involves the deposition of dredged material onto eroding shoreline as direct beach placement, underwater berms, wetland creation, or offshore stockpiles. A major source of suitable (sandy) material could come from the dredging operations performed in the Delaware Bay. In some cases the added transportation and placement costs, might result in increased costs in comparison to other alternatives for disposal, however such measures can be recommended in accordance with applicable cost sharing

requirements, if local sponsors agree to finance the cost differential. This alternative has sufficient viability to be investigated further as part of this study.

- Land Reclamation. This concept involves the placement of dewatered dredged material in areas such as abandoned pits and quarries, strip mines, sanitary landfills, agricultural soil enrichment, and resource recovery. Following an inventory of abandoned pits and quarries and cost analyses of a selected typical location reclamation of this type proved to be unjustified and was eliminated from further consideration. Although there are no strip mines in the immediate vicinity of the study area, the concept was investigated based on data from the City of Philadelphia, which has used this method to dispose of sewage sludge. Assuming similar unit costs for dredged material, the cost of this method would be prohibitive. Use of dredged material in sanitary landfills to level the terrain or act as an impermeable cover has been performed on a small scale. It is anticipated that relatively small amounts of dredged material may be used for this purpose where fine grained material is available at disposal areas located within a short haul distance from sanitary landfill sites, however the concept has little potential as a solution given the large volumes of dredged material. The need for soil enrichment is being met by using sludge offered without charge from local sewage treatment plants and discourages the marketability of the dredged material for agricultural use which requires farm payments. Fine grained material contained in certain disposal areas could be used for construction materials such as lightweight aggregate and bricks. However, the success of a resource recovery operation would be difficult because continuous access to the raw material is not assured, the initial capital investment is high, and most importantly, favorable market conditions must be established and maintained. At the present time cheaper and better quality materials are available to the producers of these materials. Consequently, this alternative was eliminated from further consideration.

348. Extending Leases. Lease extension for disposal areas which the government does not own is a viable way to minimize the need for site acquisition. This is currently practiced to the maximum extent for the Delaware River Philadelphia to Trenton project and other tributary projects. However, the practical limit for this is controlled by planned uses for these sites and this does not represent a long-term solution for initial construction and project maintenance.

349. Using Sedimentation Basins to Reduce Shoaling. This measure considered the possibility of reducing the historical shoaling pattern by forcing sedimentation to occur in concentrated areas (deposition basins) or other locations more accessible to available

disposal sites. Consideration was also given to reducing the shoaling in the channel by forcing the sedimentation to occur outside the area being maintained. Prior studies were evaluated to determine the effectiveness of such measures as shoreline modifications, in-river training dikes and sedimentation traps. Shoreline modifications and training dikes are designed to streamline the channel and encourage transportation of shoal material. By increasing flow velocities or redirecting the current patterns shoal material can be transported upstream or downstream of a problem area. Sediment traps are pits dredged either in the main channel or adjacent to it. By decreasing the flow velocity, sediment is deposited at a concentrated pre-determined location. Studies to reduce or eliminate shoaling had been conducted in the past through the use of a hydraulic model of the Delaware River Estuary at WES. These analyses considered the existing system of twelve training dikes which had been constructed in the Delaware River to regulate and control tidal flow and sedimentation. Based on reviews of the model studies, it was concluded that the historic shoaling pattern cannot be further altered by additional measures and no new sediment traps or dikes should be developed. Therefore, further consideration is not warranted.

350. Site Management. Under this alternative, consideration was given to management practices (other than dewatering) that would extend the useful life of existing dredged material disposal areas. This measure would assure that the need for new dredged disposal areas were kept to a minimum. Management practices include baffle dikes, outflow facilities and use of optimal lift thickness to assure maximum drainage of dredged material. The current practice has been to construct as many interior baffle dikes and sluice gates as are needed in each disposal area so that the sediment particles are retained within the disposal site and, at the same time, the drying process is accelerated. Along with these measures, the District has normally used thin lift thicknesses to minimize the cost of dewatering. These management practices have been used in the past with good results and will continue to be used in the future.

351. Acquiring New Upland Sites. Consistent with past practice on the Delaware River and its tributaries, acquisition of new upland sites could potentially accommodate the dredged material associated with major channel deepening initial construction and maintenance. As documented in previous studies by the Tidal Hydraulics Committee and the Philadelphia District, disposal of dredged material in confined upland sites reduced the annual volume of maintenance dredging in the river from about 15 to 16 million cubic yards to about 6 million cubic yards since the 1950's. This reduction is attributable to positive removal of sediment from the river in comparison to agitation dredging and open water rehandling techniques previously practiced in the District. In addition, upland disposal techniques allowed effective maintenance of the authorized 40 foot channel depth, whereas previous methods resulted

in an effective depth of about 36 feet. Investigation of new upland sites warrants further consideration.

352. Ocean/Bay Disposal. Disposal of dredged material in aquatic areas can be accomplished by bottom dumping from hopper dredges or barges as well as through other techniques. Filling of deep holes can be a practical disposal technique to avoid impacts on more valuable shallow water aquatic habitat. In addition, thin layering of disposed material can be accomplished to limit impacts on the benthic organisms and minimize habitat destruction via burial. This methodology however impacts a much larger surface area.

- Bottom Dumping. Bottom dumping of dredged material at the Federal site near Buoy 10 in lower Delaware Bay has been practiced to a limited degree in the past for sandy materials from the lower bay channel segments which experience little shoaling and require less frequent maintenance. Such disposal sites are economically viable if they are close to dredging locations yet located significantly enough away so that the material is not reintroduced as a sediment source for shoaling. Ocean dumping would require further significant hauling costs and is not considered further.

- Filling Holes. Filling deep holes to create shallows or to create a more uniform bathymetry may have limited potential for material disposal. In the upper river the few holes that do exist are generally located parallel to the channel and behind islands or the training dikes which have been constructed in the river to train flows and maintain the channel depths to the maximum extent through natural scour due to focused currents. Most of the undredged holes have also resulted due to the scour which occurs on the landward side of training dikes and islands. As such it is apparent that any such filling of holes with dredged material would likely reintroduce the material back into the river to be redredged and placed in an upland site as part of maintenance operations. Any further consideration of this option should consider the increased O&M dredging which might result and may require evaluation of dikes to properly confine the material. In the lower river and bay filling of holes has been considered in previous studies but due to the uncertainty that exists about the currents which initially formed the holes. Re-suspending of dredged sediments placed in the deep hole could contribute to future shoaling problems. In addition many of the deep hole sites within the bay area are located in and around the Big Stone Anchorage, in the pilots area, or within the Cape May/Lewes Ferry route. By filling these holes the risk of adversely affecting navigational access to these areas could increase. Therefore, no deepholes identified within the project area could be used for dredged material disposal.

- Thin layering. Thin layering of dredged materials is a relatively new technique for disposal in aquatic environments which is designed to minimize the disturbance to benthic organisms by limiting material placement to a 1 foot layer or less. Primary considerations for this technique are type of material, proximity to the channel, and availability of equipment. Two techniques are employed; use of a barge mounted discharge pipe with a swiveling baffle to allow barge oscillation during disposal operations and also spray techniques. Barge operations would be limited to areas with a depth sufficient for barge draft, but this technique might be suitable for various material types. Spray techniques can be employed in shallower areas and have been tried in wetlands areas to gradually raise their level. That technique is not well suited to materials with high organics content or gravels and rocks. Both techniques require a reasonable offset from the channel so that material suspended by the surface discharge operations does not immediately return to the channel. The Mobile District has used an offset of about 2500 feet from its deep draft channels and 1000 feet from smaller projects, however considerations at other locations include the currents, material type, and the slope of the bottom. Due to the currents in the upper river, the fine/silty properties of the material, and the limited distance from the channel, this option does not warrant consideration. There is also insufficient area in the upper river beyond a 2000 foot distance from the channel and associated anchorages and access to berths to accommodate dredged quantities for a 45' channel deepening. In the lower Delaware River thin layering may be possible as the river widens, however consideration must be given to the turbidity and resuspension of fine materials as it effects the environment and requires more costly maintenance dredging operations. In the Delaware Bay this measure would be precluded by the abundance of oyster grounds which are protected under the respective CZM plans. Thin layering with fine sands would destroy the habitat in the oyster grounds by changing the hard bottom characteristics required for oysters.

353. Wetlands/Island/Upland Creation. Dredged material disposal in aquatic environments can also be used to create wetlands, islands, or uplands. U.S. Army Corps of Engineers regulation ER 1165-2-27 promotes the use of dredged material for creation of shallow water and wetland habitats. In certain cases this would require construction of dikes to contain material and protect it from erosive waves and currents. Several of the existing Federal disposal areas and islands in the river have been created using dredged material. These techniques generally involve filling water depths of 30 feet and less and present the opportunity to dispose of significant quantities of dredged material. Although the loss of medium and shallow water depth habitat would result from this option, the creation of an additional marsh or island habitat would

be created. Therefore, further consideration of these options is warranted.

354. RESULTS OF PRELIMINARY SCREENING. The preliminary screening concluded that there were no non-structural measures which would by themselves adequately address the planning objectives in a manner which would increase the safe and efficient movement of commerce through the Delaware River system. Many of these non-structural measures are widely used by Delaware River vessel pilots and shippers under the existing conditions. Dredged material disposal is a major element in any navigational analysis and it appears that the primary measures to be investigated further include new upland sites, development of aquatic sites as marshes or islands, and limited variations for aquatic disposal.

CYCLE 1 - GENERAL SCREENING FOR DREDGED MATERIAL DISPOSAL AREA POLYGONS

355. A computerized technique called Spatial Analysis Methodology (SAM) was used for the initial screening phase of this study. SAM can be defined in simple terms as a computerized data management and analysis tool designed specifically to handle "Spatial" or mapped data. SAM was originally developed by the Corps' Hydrologic Engineering Center (HEC) through a pilot study program for comprehensive watershed planning. In this study, SAM's specific application was to perform an automated suitability screening using various kinds of (spatial) data to determine the relative attractiveness of parcels for disposal activities. SAM is comprised of two main components:

1. A data bank of pertinent physiographic characteristics, and
2. A series of computer programs designed to perform utility or analysis functions.

356. Although seemingly complicated, the methodology is a rather straight-forward procedure of collecting and storing necessary mapped data in the computer, defining the criteria for screening polygons, instructing the computer to search the data bank for areas having the desired combination of characteristics, and then displaying the results in graphical or tabular form for further analysis or consideration (refer to Figure 13 for the schematic approach used in the attractiveness modeling).

357. The study area encompassed a 5 mile band on either side of the Delaware River channel. This area was subdivided by a uniform grid array into a data base of approximately 43,500 grid cells, each cell being about 18 acres in size. Each grid cell was identified by 13 distinct surface and sub-surface characteristics called "parameters". Each parameter was further subdivided into categories or "variables" (see Table 17 for a list of the parameters and variables).

358. The identification of parameters and variables was based on available mapping or, in some cases, maps specifically developed as part of the study. The data were transferred from the maps to the computer data base using a technique called polygon digitizing. Having identified the spatial distribution of each of the parameters and variables, the next step involved assigning a weighing factor to each data variable cell to describe its relative attractiveness for dredged material disposal. The weightings varied from 0 (least attractive) to 10 (most attractive). If for some reason, a particular feature rendered the area totally unacceptable, the cell was designated with values of "-1" for that variable. A "-1" would cause a variable to be excluded from further consideration. Finally, a relative index weighing was established to relate the importance of one parameter to another.

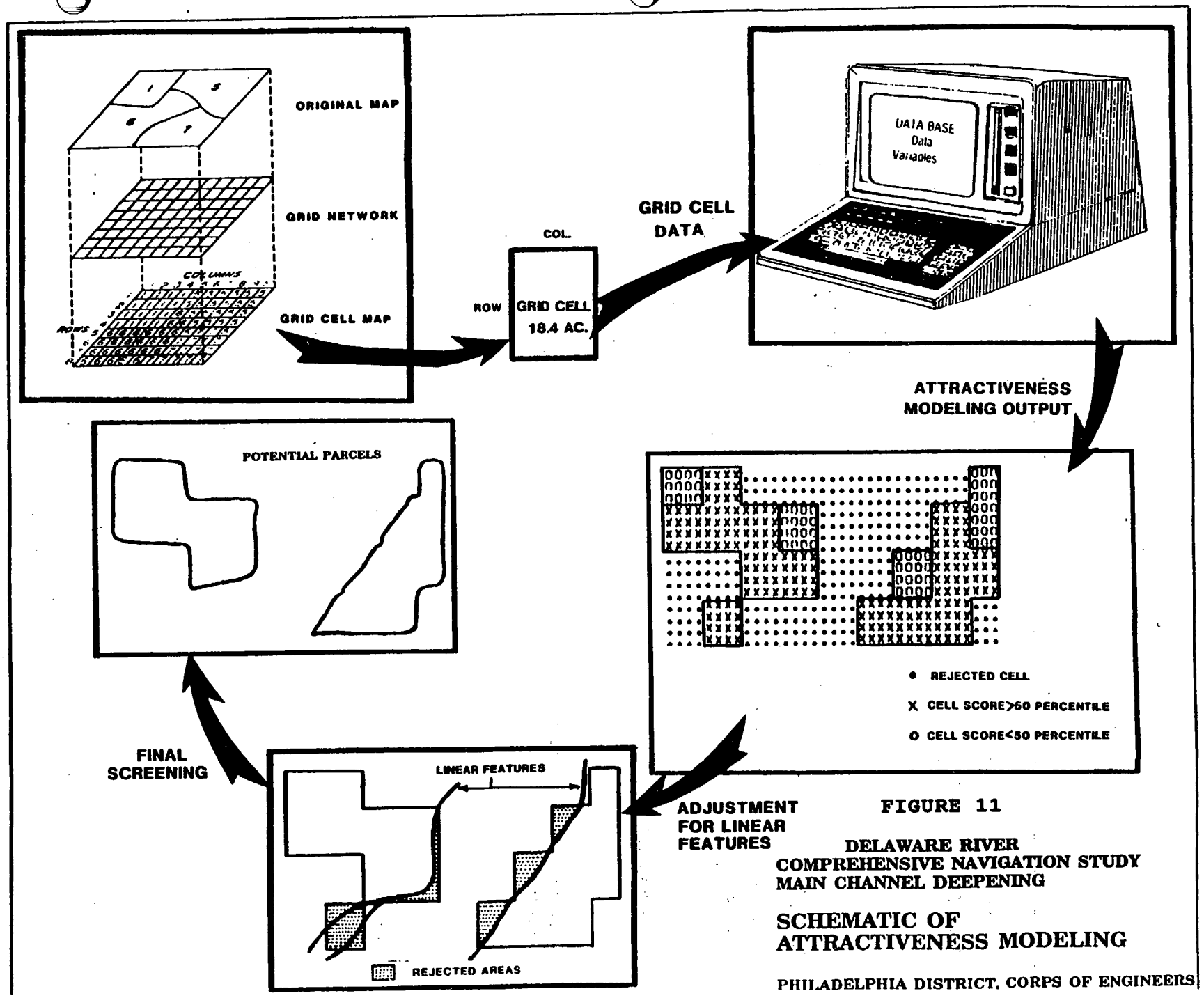


FIGURE 11

DELAWARE RIVER
COMPREHENSIVE NAVIGATION STUDY
MAIN CHANNEL DEEPENING

SCHEMATIC OF
ATTRACTIVENESS MODELING

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

TABLE 15

SCALE OF ACCEPTABILITY FOR WEIGHTING
POTENTIAL DISPOSAL SITES

-1	0	1	2	3	4	5	6	7	8	9	10
UNACCEPTABLE (EXCLUDED)		LEAST ACCEPTABLE				GENERALLY ACCEPTABLE				MOST ACCEPTABLE	

PARAMETER	VARIABLE	VARIABLE WEIGHTING FACTOR (RELATIVE ACCEPTABILITY) NED
1. Archaeological Sensitivity Zones	0 Other	10
	1 High Sensitivity	0
	2 Medium Sensitivity	5
	3 Low Sensitivity	10
2. Historic Sites	0 Other	10
	1 Historic Sites	0
	2 Historic Districts	0
3. Groundwater Recharge Zones	0 Other	10
	1 Zone I	10
	2 Zone II	8
	3 Zone III	6
	4 Zone IV	4
	5 Zone V	2
	6 Zone VI	0
4. Recreation	0 Other	10
	1 Federal Park	0
	2 State Parks, Forest & Wildlife Mgt. Areas	0
	3 County Parks	0
	4 Fairgrounds	0
	5 Local Parks	0
	6 Campgrounds	0
	7 Golf Courses	0
	8 Private Parks	0
	9 Marinas	0

TABLE 15 (Cont'd)

PARAMETER	VARIABLE	VARIABLE WEIGHTING FACTOR (RELATIVE ACCEPTABILITY) NED
5. Fish and Wildlife Sensitive Areas	0 Other	10
	1 (Reserved)	5
	2 Finfish	5
	3 Wading Bird and Seabird High Use Areas	5
	4 Major Waterfowl Areas	5
	5 Muskrat Areas	5
	6 (Reserved)	5
	7 Conservation/Natural Areas	5
	8 High Fishing Areas	5
	9 Exculsionary Trout Areas	0
	10 Trout Waters	5
	11 Shellfish	0
	12 (Reserved)	5
	13 Exclusionary Wading Bird & Seabird Colonies	0
	14 Exclusionary Waterfowl Areas	0
	15 Exclusionary Muskrat Areas	0
	16 (Reserved)	5
	17 Exclusionary Conservation/ Natural Areas	0
	18 (Reserved)	0
	19 Exclusionary Terrestrial Game Areas	0
	20 Combination of 2 and 3	0
	21 Combination of 2 and 4	0
	22 Combination of 2 and 5	0
	58 Combination of 2, 13, 15 and 17	0
6. Land Use and Land Cover	0 Other	10
	1 Urban and Built up	-1
	2 Normal Bottom (10'-42')	5
	3 Shallow (10')	5
	4 (Reserved)	5
	5 (Reserved)	5
	6 Forested Uplands	10
	7 Orchards	5
	8 Cropland	10
	9 Rangeland	10
	10 Other Agricultural Land	10
	11 Barren Land	10
	12 Strip Mining Land	10
	13 Active CE Disposal Site	10

TABLE 15 (Cont'd)

PARAMETER	VARIABLE	VARIABLE WEIGHTING FACTOR (RELATIVE ACCEPTABILITY NED
	14 Inactive CE Disposal Site	10
	15 Private, Industrial, Municipal Landfills	10
	16 Sewage Sludge Landfill	10
	17 Deep Water Bodies (42')	10
	18 Inland Water Bodies (Lakes/Ponds)	5
7. S.C.S. Important Farmlands	0 Other	10
	1 Unique Farmland	5
	2 Prime Farmland	5
	3 Additional Farmland of Statewide Importance	10
	4 Additional Farmland of Local Importance	10
8. D.O.I. Wetlands	0 Other	10
A. One Wetland Type 50% or Greater Cell Coverage	1 Palustrine	0
	2 Riverine (Intertidal Flats/Intermittent Streams)	0
	3 Estuarine	0
	4 Lacustrine	0
	5 Marine	0
B. One Wetland Type Less Than 50% Cell Coverage	6 Palustrine	0
	7 Riverine (Intertidal Flats/Intermittent Streams)	0
	8 Estuarine	0
	9 Lacustrine	0
	10 Marine	0
C. Mixed Wetland Types (Dominant Type Indicated 50% or Greater Cell Coverage)	11 Palustrine	0
	12 Riverine (Intertidal Flats/Intermittent Streams)	0
	13 Estuarine	0
	14 Lacustrine	0
	15 Marine	0
D. Mixed Wetlands Types (Dominant Type Indicated Less Than 50% Cell Coverage)	16 Palustrine	0
	17 Riverine (Intertidal Flats/Intermittent Streams)	0
	18 Estuarine	0
	19 Lacustrine	0
	20 Marine	0
E. Three or More Wetlands Types	21 Mixed Wetlands 50% or Greater Cell Coverage	0

TABLE 15 (Cont'd)

PARAMETER	VARIABLE	VARIABLE WEIGHTING FACTOR (RELATIVE ACCEPTABILITY NED
	22 Mixed Wetlands Less Than 50% Cell Coverage	0
9. Navigation Features	0 Other	10
	1 Main Channel	-1
	2 Entrance Channel	-1
	3 Anchorage Areas	-1
	4 Dredge Disposal Sites In Water	10
10. Groundwater Protection Zones	0 Other	10
	1 Zone I	10
	2 Zone II	7
	3 Zone III	5
	4 Zone IV	5
	5 Zone V	3
	6 Zone VI	0
11. Construction and Development	0 Other	10
	1 Urban and Built Up	-1
	2 Normal Bottom (10'-42')	0
	3 Shallow (10')	3
	4 (Reserved)	0
	5 (Reserved)	0
	6 Forested Upland	7
	7 Orchards	7
	8 Cropland	10
	9 Rangeland	10
	10 Other Agricultural Land	10
	11 Barren Land	10
	12 Strip Mining Land	10
	13 Active CE Disposal Site	7
	14 Inactive CE Disposal Site	7
	15 Private, Industrial, Municipal Landfills	5
	16 Sewage Sludge Landfill	5
	17 Deep Water Bodies (42')	0
	18 Inland Water Bodies (Lakes/Ponds)	7
12. Elevation Ranges	1 -30' Depth and Greater (Datum is Mean Low Water)	10
	2 -30' to 0' Depth (Datum is Mean Low Water)	9
	3 Mean Low Water to 20' NGVD	7
	4 20' to 40' NGVD	5
	5 40' to 60' NGVD	3

TABLE 15 (Cont'd)

FACTOR ACCEPTABILITY PARAMETER	VARIABLE WEIGHING (RELATIVE VARIABLE	NED
	6 60' NGVD	0
13. Distance Bands Philadelphia To Trenton: From Center of Channel	1 0' to 5000'	10
	2 5000' to 10000'	8
	3 10000' to 15000'	6
	4 15000' to 20000'	4
	5 20000'	0
Distance Bands - Philadelphia To Sea; From 30' Depth (Datum is Mean Low Water)	1 0' to 3000'	10
	2 3000' to 6000	8
	3 6000' to 9000'	6
	4 9000' to 12000'	4
	5 12000'	0

BLANK

TABLE 16

DISPOSAL SITE SELECTION BASED ON VARYING INDEX VALUES

(PARAMETER IMPORTANCE)

PARAMETER	NED
Archaeological Sensitivity Zones	1
Historic Sites	1
Groundwater Recharge Zones	1
Recreation	1
Fish and Wildlife Sensitive Areas	1
Land Use and Land Cover	1
S.C.S. Important Farmlands	1
DOI Wetlands	1
Navigation Features	1
Groundwater Protection Zones	3
Construction and Development	3
Elevation Ranges	3
Distance Bands - Philadelphia to Trenton	5
Distance Bands - Philadelphia to Sea	5

TABLE 16

DISPOSAL SITE SELECTION BASED ON VARYING INDEX VALUES

(PARAMETER IMPORTANCE)

PARAMETER	NED
Archaeological Sensitivity Zones	1
Historic Sites	1
Groundwater Recharge Zones	1
Recreation	1
Fish and Wildlife Sensitive Areas	1
Land Use and Land Cover	1
S.C.S. Important Farmlands	1
DOI Wetlands	1
Navigation Features	1
Groundwater Protection Zones	3
Construction and Development	3
Elevation Ranges	3
Distance Bands - Philadelphia to Trenton	5
Distance Bands - Philadelphia to Sea	5

359. The criteria defining the attractiveness of a cell for the disposal of dredged material incorporated the rationale involved in selecting potential disposal areas. These criteria assumed that the results would be technically feasible, cost effective and environmentally acceptable.

360. The NED screening, conducted with a view to reasonably maximize national economic development, consistent with protection of the environment, emphasized those parameters involving engineering feasibility and cost efficiency of dredging and dredged material disposal. Parameters such as surface and sub-surface features that would be indicative of construction suitability, topographic elevation, and distance to dredging reaches were all considered to be of prime importance.

361. Table 17 provides the relative index weightings, used for each parameter. A preliminary version of the weightings was coordinated with a Plan Formulation Committee for disposal studies which was comprised of a cross-section of environmental agencies and dredging interests. Comments resulting from this coordination were reflected in adjustments to the values or resolved through clarification to the originator of the comment. The values shown in Tables 13 and 17 were ultimately used in the data base.

362. Based on the attractiveness modelling, computer printouts were produced at a 1:24,000 scale for the purpose of overlaying the output directly on U.S.G.S. quadrangle sheets. Attractiveness of each cell was represented by the different densities of various typed characters and overprints to provide a readily distinguishable basis for identifying attractive cells. Where adjacent attractive cells could be identified which might be combined into a large polygon, they were outlined and plotted on the U.S.G.S. quadrangles. A total of 308 upland and aquatic polygons were identified in this manner. Table 19 shows the distribution of these new polygons according to state location and type. In addition, all Federal and private existing disposal areas were identified as attractive.

363. Within the Delaware Bay, potential disposal areas were identified through interviews with the local officials, review of previous correspondence and reports, and public notices, rather then using SAM. Aerial photographs, maps, U.S.G.S. quadrangle, and surveys were also obtained to identify other possible locations for dredged material disposal operations. Due to the size of the Delaware Bay, study area encompassed a 10 mile band on either side of the Delaware River channel, unlike the 5 mile band in the northern reaches. Table 20 shows 184 possible sites for te Delaware Bay. The site names are applicable to the U.S.G.S. quadrangle in which the site is located. In the case of overboard (OB) disposal, deep hole filling (DH), and some island creation (I) the site names are an abbreviation of the type of alternative.

TABLE 17

DISPOSAL POLYGON OUTPUT

Polygon Location (State/County)

Polygon Type	NJ Castle	DE Kent	DE Philadelphia	Total	PA DE Delaware	PA Camden	NJ Gloucester	NJ Salem	NJ Cumberland	New
Upland	9	2	270		5	0	52	90	16	96
Aquatic	2.5	1	23		0	0	5	3	3	8.5
Combination	1	0	15		3	2	0	1	1	7
Total	12.5	3	308		8	2	57	94	20	111.5

TABLE 18
DISPOSAL OPTIONS FOR DELAWARE BAY

Site	Size App	Type
Canton NJ C 1	165 Acres	Upland
C 2	100 Acres	Upland
C 3	165 Acres	Upland
C 4	150 Acres	Upland
C 5	250 Acres	Upland
C 6	140 Acres	Upland
C 7	100 Acres	Upland
C 8	140 Acres	Upland
C 9	100+Acres	Upland
C 10	240 Acres	Upland
C 11	100 Acres	Upland
C 12	120 Acres	Oyster seed bed creation
C 13	160 Acres	Island Creation

TABLE 18

DISPOSAL OPTIONS FOR DELAWARE BAY

Site	Size App.	Type
Bem David Point BD 1	190 Acres	Upland
BD 2	160 Acres	Upland
BD 3	140 Acres	Upland
BD 4	85 Acres	Upland
BD 5	200 Acres	Upland
BD 6	200 Acres	Wet land creation
BD 7	160 Acres	Oyster seed bed creation
BD 8	200 Acres	Wetland Creation
BD 9	200 Acres	Oyster seed bed creation
Cedarville CV 1	100 Acres	Beachfill
CV 2	175 Acres	Upland
CV 3	145 Acres	Upland
CV 4	105 Acres	Upland
CV 5	105 Acres	Upland
CV 6	200 Acres	Upland

TABLE 18
DISPOSAL SITE OPTIONS FOR DELAWARE BAY

Site	Size App	Type
CV 7	165 Acres	Upland
CV 8	185 Acres	Upland
CV 9	200 Acres	Upland
Fortescue F 1	200 Acres	Wetland Creation
F 2	215 Acres	Island Creation
F 3	100 Acres	Beachfill
Port Morris PN 1	200 Acres	Wetlands Restorations
PN 2	450 Acres	Oyster seed bed creation
PN 3	200 Acres	Wetland Creation/ Restoration
Heislerville H 1	100 Acres	Upland
H 2	200 Acres	Upland
H 3	680 Acres	Upland
H 4	440 Acres	Upland

TABLE 18

DISPOSAL SITE OPTIONS FOR DELAWARE BAY

Site	Size App	Type
H 5	150 Acres	Uplands
H 6	100 Acres	Sand stockpile
H 7	100 Acres	Beachfill
H 8	160 Acres	Island Creation
H 9	160 Acres	Island Creation
H 10	500 Acres	Thinlayering
H 11	500 Acres	Thinlayering
Rio Grande RD 1	120 Acres	Upland
RD 2	160 Acres	Upland
RD 3	130 Acres	Upland
RD 4	100 Acres	Beachfill
RD 5	100 Acres	Beachfill
RD 6	320 Acres	Oyster Seed Bed

TABLE 18

DISPOSAL OPTIONS FOR DELAWARE BAY

Site	Size App	Type
Cape May CM 1	170 Acres	Upland
CM 2	140 Acres	Upland
CM 3	130 Acres	Upland
CM 4	100 Acres	Beachfill
CM 5/6	200 Acres	Beachfill/ Shore Protection
Woodbine WB 1	160 Acres	Upland
WB 2	150 Acres	Upland
WB 3	175 Acres	Upland

TABLE 18
DISPOSAL OPTIONS FOR DELAWARE BAY

Site Name	Size App	Type
Taylors Bridge TB 1	110 Acres	Upland
TB 2	300 Acres	Upland
TB 3	120 Acres	Upland
TB 4	120 Acres	Upland

TABLE 18
DISPOSAL OPTIONS FOR DELAWARE BAY

Site Name	Size App	Type
Bombay Hook BB 1	120 Acres	Upland
BB 2	500 Acres	Thinlayering
Little Creek LC 1	380 Acres	Upland
LC 2	210 Acres	Upland
LC 3	225 Acres	Upland
LC 4	170 Acres	Upland
LC 5	160 Acres	Upland
LC 6	98 Acres	Upland
LC 7	314 Acres	Upland
LC 8	100 Acres	Island Creation
LC 9	200 Acres	Wetland Creation/Restoration
LC 10	100 Acres	Sand Stockpile
LC 11	200 Acres	Under water berms shore protection
LC 12	200 Acres	Under water berms shore protection
Frederica FR 1	115 Acres	Upland
FR 2	105 Acres	Upland
FR 3	135 Acres	Upland

TABLE 18
DISPOSAL OPTIONS FOR DELAWARE BAY

FR 4	160 Acres	Upland
FR 5	220 Acres	Upland
FR 6	240 Acres	Upland
FR 7	330 Acres	Upland
FR 8	150 Acres	Upland
FR 9	140 Acres	Upland
FR 10	160 Acres	Upland
FR 11	160 Acres	Upland
FR 12	200 Acres	Upland
FR 13	200 Acres	Upland
FR 14	285 Acres	Upland
FR 15	115 Acres	Upland
FR 16	250 Acres	Upland

TABLE 18
DISPOSAL OPTIONS FOR DELAWARE BAY

Site Name	Size App	Type
Frederica FR 17	130 Acres	Upland
FR 18	130 Acres	Upland
FR 19	170 Acres	Upland
FR 20	80 Acres	Upland
FR 21	160 Acres	Upland
FR 22	100 Acres	Upland
FR 23	130 Acres	Upland
FR 24	175 Acres	Upland
FR 25	120 Acres	Upland
FR 26	100 Acres	Beachfill
FR 27	200 Acres	Underwater berms/Shore protection
FR 28	100 Acres	Sand stockpile
FR 29	200 Acres	Underwater berms/Shore protection

TABLE 18
DISPOSAL OPTIONS FOR DELAWARE BAY

Bennetts Pier BP 1	160 Acres	Upland
BP 2	170 Acres	Upland
BP 3	150 Acres	Upland
BP 4	100 Acres	Beachfill
Mispillian River MS 1	400 Acres	Upland
MS 2	160 Acres	Upland
MS 3	250 Acres	Upland
MS 4	150 Acres	Upland
MS 5	125 Acres	Upland
MS 6	120 Acres	Upland
MS 7	200 Acres	Upland
MS 8	100 Acres	Upland
MS 9	120 Acres	Upland
MS 10	100 Acres	Upland
MS 11	150 Acres	Upland

TABLE 18
DISPOSAL OPTIONS FOR DELAWARE BAY

Site Name	Size App	Type
MS 12	230 Acres	Upland
MS 13	370 Acres	Upland
MS 14	350 Acres	Upland
MS 15	110 Acres	Upland
MS 16	160 Acres	Upland
MS 17	100 Acres	Beachfill
MS 18	200 Acres	Wetland Creation
MS 19	100 Acres	Beachfill
MS 20	110 Acres	Upland
MS 21	200 Acres	Shore protection off shore berms
MS 22	120 Acres	Upland

TABLE 18
DISPOSAL OPTIONS FOR DELAWARE BAY

Milton ML 1	190 Acres	Upland
ML 2	210 Acres	Upland
ML 3	105 Acres	Upland
ML 4	190 Acres	Upland
ML 5	470 Acres	Upland
ML 6	140 Acres	Upland
ML 7	190 Acres	Upland
ML 8	175 Acres	Upland
ML 9	160 Acres	Upland
ML 10	130 Acres	Upland
ML 11	290 Acres	Upland
ML 12	325 Acres	Upland
ML 13	310 Acres	Upland
ML 14	320 Acres	Upland
ML 15	450 Acres	Upland

TABLE 18
DISPOSAL OPTIONS FOR DELAWARE BAY

Site Name	Size App.	Type
Lewis L 1	160 Acres	Upland
L 2	135 Acres	Upland
L 3	100 Acres	Upland
L 4	100 Acres	Beachfill
L 5	200 Acres	Sand stockpile
L 6	100 Acres	Beachfill
L 7	100 Acres	Beachfill
CH 1	100 Acres	Beachfill
CH 2	100 Acres	Beachfill

TABLE 18
DISPOSAL OPTIONS FOR DELAWARE BAY

OB 1	100	Overboard
OB 2	120	Overboard
OB 3	80	Overboard
OB 4	170	Overboard
OB 5	120	Overboard
OB 6	160	Overboard
OB 7	100	Overboard
OB 8	95	Overboard
DH 1	100	Deep Hole
DH 2	100	Deep Hole
DH 3	100	Deep Hole
I1	200	Island Creation
I2	90	Island Creation
I3	110	Island Creation

CYCLE 2 - MANUAL SCREENING OF POLYGONS FOR DISPOSAL AREAS

364. Following the identification phase the polygons were manually screened to consider linear features (i.e. roads, streams) or isolated structures that the model was not as well suited to appraise and to redefine boundaries. Since the characteristics of an 18 acre cell were considered by the computer to be one variable for each parameter (based on the center of the cell primarily), there were numerous cells which appeared less attractive during this process. In the Delaware Bay a 100 acres cell was considered. Also, during this step, consideration was given to cost factors such as: minimum disposal area size requirements, man-made improvements or navigation channels/access, reasonable disposal pipeline routes to reach the polygon, reasonable effluent water courses to the river, and accessibility for construction and maintenance. Finally, the candidate upland polygons were field visited to assure that some feature that might render it unrealistic was not missed (such as new development subsequent to the land use mapping input to the spatial model).

365. Following this analysis the number of realistic Delaware River polygons was reduced from 308 to 74. In the Delaware Bay the number was reduced from 184 to 72. These locations then entered a third cycle of screening.

CYCLE 3 - INSTITUTIONAL/ENVIRONMENTAL SCREENING

366. In order for a candidate site to be considered viable for further study, it was considered necessary for it to pass a screening of institutional and environmental criteria. From an institutional standpoint it was considered necessary that a candidate site not include public park land or designated wildlife areas. In addition, sites were screened to assure that they had no significant affect on adjacent residential properties and communities. This rationale is clearly important, as is evidenced by the limitations imposed by Congress on the development of the Penns Grove Federal disposal area in Section 1131 of the W.R.D.A. of 1986 (PL 99-662), due to its proximity to residential properties.

367. From an environmental perspective candidate sites were also screened to eliminate those which would involve activities prohibited by a Federally approved Coastal Zone Management (CZM) Plan. Such candidate sites could not be considered implementable and did not warrant further study. The New Jersey CZM plan specifically prohibits the relocation of rivers, streams, and creeks and the filling of ponds. Therefore, any aquatic or upland sites which involved these activities was eliminated from further consideration. Both the Delaware and New Jersey CZM plans also prohibit the destruction of shellfish/oyster beds. The Pennsylvania CZM plan specifically prohibits the destruction of

wetlands. All three states prohibit actions which reduce flood flow capacity and thus increase flooding potential.

368. Based on the findings of geotechnical exploratives the Delaware River segment (Reach A-D) is predominantly fine-grained material. However, the Delaware Bay (Reach E) was divided into four subreaches, E-1 through E-4. Reach E-1 and E-3 consist of fine-grained sediments; reaches E-2 and E-4 are predominantly coarse grained. The coarse-grained sediments are suitable for beachfills, oyster bed creation, wetland creation, and offshore stockpiling, while the fine-grained sediments may be used for wetland creation or disposed of in an upland site. A summary of the gradation analysis is contained in Table 1 of the Geotechnical Appendix.

369. Table 17 shows the results of Cycle 3 screening which further reduced the number of candidate sites from 74 to 38 for the Delaware River. The remaining sites included, 24 upland and 9 aquatic (9 for creating islands/marsh and 5 for creating uplands) these are discussed further in Cycle 6. Table 17A shows a reduction from 72 sites to 34 sites in the Delaware Bay.

TABLE 19
DELAWARE RIVER
INSTITUTIONAL AND ENVIRONMENTAL SCREENING

Site Name	Institutional Location	Environmental Acceptability	Overall Acceptability	Acceptability
13 E	Moorestown, NJ	No, Borders large new suburban residential development	Yes	No
13 F	Cimmaminson, NJ	Yes	Yes	Yes
17A	East Greenwich/ Center City, NJ	Yes	Yes	Yes
17B	East Greenwich/ Center City, NJ	Yes	Yes	Yes
17C	New Jersey TurnPike/ Berkely Rd, NJ	Yes	Yes	Yes
17D	New Jersey TurnPike/ Berkely Rd, NJ	Yes	Yes	Yes
17G	Tennaco, NJ	Yes	Yes	Yes
17O	Gats, NJ	Yes	Yes	Yes
17P	Mantua Cr., NJ	No, Site borders 13 residents	No, Would fill Mantua Crk. channel	No
18B	Deptford, NJ	No, Recent residential development surrounds site	Yes	No
15D	Raccoon Cr, NJ	Yes	Yes	Yes

TABLE 19 (CONT'D)

Site Name	Location	Institutional Acceptability	Environmental Acceptability	Overall Acceptability
Raccoon Is	Raccoon Cr, NJ	Yes	Yes	Yes
15E	Sun Oil, Monuanto, NJ	Yes	Yes	Yes
15F	Sun Oil, Oldmans NJ	Yes	Yes	Yes
15G	Nortonville, Oldmans, NJ	Yes	Yes	Yes
15P	Harrisonville, Oldsman Cr, NJ NJ	Yes	No, 85% site wetlands - remaining site to small	No
16M	East Greenwick, NJ	Yes	Yes	Yes
16T	Centre Square Beckett, NJ	No, Congressional prohibition 1960's	Yes	No
16Y	Repanpo, NJ	Yes	Yes	Yes
16Z	Rt 322, NJ	Yes	No, Stream relocation required	No
16DD	Repaupo, NJ	Yes	No, 95% site wetlands stream relocation required	No
21E	Kay Gardens, NJ	Yes	Yes	Yes
21F	Pedricktown, Perkintown Rd. NJ	Yes	Yes	Yes

TABLE 19 (CONT'D)

Site Name	Location	Institutional Acceptability	Environmental Acceptability	Overall Acceptability
21T	Rt 40/Turnpike, NJ	Yes	No, Stream relocation required	No
21Y	Repaupo, NJ	Yes	Yes	Yes
21AA	Pedricktown, Rd. NJ	No, New residential development on lowerside and considerable residential disruption	Yes	No
22BB	Woolwick, NJ	Yes	Yes	Yes
15H Island	Claymount, DE	Yes, island compatible with adjacent waterfront park	Yes, but reduce by 100 access to prevent flow disruption of Neaman Creek	Yes
15H Upland	Claymount, DE	No, upland would not be compatible with adjacent waterfront park	Yes (report above)	No
15I Island	Oldmans Creek	Yes	Yes, but reduce 200 acres to present flow disruption	Yes
15I Island	Oldmans Cr. NJ	Yes	Yes, but reduce by 200 acres to prevent flow disruption	Yes

TABLE 19 (CONT'D)

Site Name	Location	Environmental Acceptability	Overall Acceptability	Acceptability
15J Upland	Oldmans Cr. NJ	Yes	Yes	Yes
16O Island	Chester Monds, NJ	Yes	Yes	Yes
16O/Upland	Chester Monds, NJ	No, In flight path-Phila., International Institutional Airport	No	No
16P Island	Greenwich, NJ	Yes	No, blocks Cromweed creek, Greenwick Lake	No
16P Upland	Greenwick, NJ	Yes	No, blocks Cromweed creek, Greenwick Lake	No
16R Island	Tinicum Island PA	No, State Wildlife	No, Site detailed special area/protected	No
16R Upland	Tinicum Island PA	No, State Wildlife	No, site detailed special area/protected	No
20H	Langollen Estate New Castle, DE	No, Eastern portion County park	Yes	No
20Q	Adjacent to Killcohook/Lehigh	Yes	Miles crk. through center/NJ CZM prohibits filling of Creek	No
21D	Mannington, NJ	Yes	Yes	Yes
21J	Haines Neck Rd./ Mannington, NJ	Yes	No, Stream relocation required	No

TABLE 19 (CONT'D)

Site Name	Location	Institutional Acceptability	Environmental Acceptability	Overall Acceptability
21L	Mannington, NJ	Yes	Yes	Yes
21M	Mannington, NJ	Yes	Yes	Yes
23C	Delaware City, DE	Yes	Yes	Yes
23D	Delaware City, DE	Yes	Yes	Yes
23E	Corbert, DE	Yes	Yes	Yes
23F	Corbert, DE	Yes	Yes	Yes
23G	Corbert, DE	Yes	Yes	Yes
23H	Corbert, DE	Yes	Yes	Yes
24T	Harrisonville, NJ	No, recently developed Wildlife refuge	Yes	
24U	Harrisonville, NJ	No, 25 homes adjacent/ community Pt. Pleasant	Yes	No
24CC	Harrisonville, NJ	Yes	No, 80% site wetlands (remaining sites too small)	No
25D	Harrisonville, NJ	No, Pipeline disruption	Yes	No
25G	Harrisonville, NJ	No, Adjacent development	Yes	No

TABLE 19 (CONT'D)

Site Name	Location	Institutional Acceptability	Environmental Acceptability	Overall Acceptability
25I	Salem, NJ	Yes	Yes	Yes
20A Island	Pea Patch, DE	Yes	Yes	Yes
20A Upland	Pea Patch, DE	Yes	Yes	Yes
24E/Island	Pea Patch, DE	Yes, but eliminate existing island	Yes	Yes
24E/Upland	Pea Patch, DE	No, upland disrupts Historic Park; Herony	Yes	No
24G Island	Reedy Island DE	Yes, but reduced size	Yes	Yes
24G/Upland	Reedy Island DE	No, disrupts State Wildlife area	Yes	No
24I Island	Salem Cove, NJ	Yes	No, Flow disruption/ Salem River/ Mill Creek	No

TABLE 19 (CONT'D)

Site Name	Location	Institutional Acceptability	Environmental Acceptability	Overall Acceptability
24I	Salem, Cove	Yes	No, Flow disruption/ Salem River/Mill Creek	No
24N	Elsinboro, NJ	Yes	No, 80% wetlands/ remaining site too small	No
24O	St. Georges, DE	Yes	Yes	Yes
25J	Salem, NJ	Yes	Yes	Yes
25K	Salem, N	Yes	Yes	Yes
27D	Appoquinink, NJ	No, Appoquinink wildlife area	No, 100% wetlands	No
24L Island	North of Artificial Island, NJ	Yes	No, Tidal flow blockage	No
24L Upland	North of Artificial Island, NJ	Yes	No, Tidal flow blockage	No
27C Island	Appoquinink, DE	Yes	No, Tidal flow blockage/185 acres wetland	No
27C Upland	Appoquinink, DE	Yes	No, Tidal flow blockage/185 acres wetland	No
27F Island	Appoquinink, DE	Yes	No, Tidal flow blockage/1900 acres wetland	No

TABLE 19 (CONT'D)

Site Name	Location	Institutional Acceptability	Environmental Acceptability	Overall Acceptability
27F Upland	Appoquinink, DE	Yes	No, Tidal flow blockage/1900 acres wetland	No
27H Island	Appoquinink, DE	Yes	Yes	Yes
27H Upland	Appoquinink, DE	Yes	Yes	Yes
27I Island	Appoquinink, DE	Yes	Yes	Yes
27I Upland	Appoquinink, DE	Yes	Yes	Yes
27J Island	Artificial Island/ Hope Cr., NJ	Yes	No, Tidal flow blockage/Hope Cr.	No
27J Upland	Artificial Island/ Hope Cr., NJ	Yes	No, Tidal flow blockage/Hope Cr.	No
27Q Island	Artificial Island/ Hope Cr., NJ	Yes	No, Tidal flow blockage	No
27Q Upland	Artificial Island/ Hope Cr., NJ	Yes	No, Tidal flow blockage	No
28A Island	Artificial Island/ Hope Cr., NJ	Yes	No Oyster Beds	No

TABLE 19 (CONT'D)

Site Name	Location	Institutional Acceptability	Environmental Acceptability	Overall Acceptability
28A Upland	Artificial Island/ Hope Cr., NJ	Yes	No Oyster Beds	No
28B Island	Artificial Island/ Hope Cr., NJ	Yes	No Oyster Beds	No
28B Upland	Artificial Island/ Hope Cr., NJ	Yes	No Oyster Beds	No
32C Island	Artificial Island/ Hope Cr., NJ	Yes	No Oyster Beds	No
32C Upland	Artificial Island/ Hope Cr., NJ	Yes	No Oyster Beds	No
32E Island	Artificial Island/ Hope Cr., NJ	Yes	No Oyster Beds	No
32E Upland	Artificial Island/ Hope Cr., NJ	Yes	No Oyster Beds	No

TABLE 19 (CONT'D)

Site Name	Location	Institutional Acceptability	Environmental Acceptability	Overall Acceptability
34F Island	Artificial Island/ Hope Cr., NJ	Yes	No Oyster Beds	No
34F Upland	Artificial Island/ Hope Cr., NJ	Yes	No Oyster Beds	No
33G Island	Artificial Island/ Hope Cr., NJ	Yes	No Oyster Beds	No
33G Upland	Artificial Island/ Hope Cr., NJ	Yes	No Oyster Beds	No
33F Island	Artificial Island/ Hope Cr., NJ	Yes	No Oyster Beds	No
33F Upland	Artificial Island/ Hope Cr., NJ	Yes	No Oyster Beds	No

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TABLE 20
DELAWARE BAY
CYCLE 3 - INSTITUTIONAL/ENVIRONMENTAL SCREENING

SITE NAME	TYPE	INSTITUTIONAL ACCEPTABILITY	ENVIRONMENTAL ACCEPTABILITY	OVERALL ACCEPTABILITY
Canton N.J. C1	Upland	No Schools Across Highway	No Stream within Area	N
C2	Upland	Y	Y	Y
C11	Upland	Y	Y	Y
C12	Oyster Bed Creation	Y	N Unsuitable Silty Material	N
C13	Island Creation	Y	Y*	Y
Ben Davis BD1	Upland	N Wildlife Management Area	Y	N
BD5	Upland	N Wildlife Management Area	Y	N
BD6	Wetland Creation	Y	N Oyster Bed within Area	N
BD8	Wetland Creation	Y	N Oyster Beds within Area	N
BD9	Oyster Seed Bed Creation	Y	N Unsuitable Silty Material	N
Cedarville CV1	Beachfill	Unsuitable Silty Material	Unsuitable Silty Material	N

* Pending Benthic Testing

TABLE 20
CYCLE 3 - INSTITUTIONAL/ENVIRONMENTAL SCREENING

SITE NAME	TYPE	INSTITUTIONAL ACCEPTABILITY	ENVIRONMENTAL ACCEPTABILITY	OVERALL ACCEPTABILITY
CV6	Upland	N Fish and Wildlife Management Area	Y	N
Fortescue F1	Wetland Creation	Y	Y *	Y
F2	Island Creation	Y	Y *	Y
F3	Beachfill	Y	Y	Y
PN1	Wetland Creation	Y	Y *	Y
PN2	Oyster Seed Bed Creation	Y	N Unsuitable Silty Material	N
Rio Grande RD1	Upland	Y	Y	Y
RD4	Beachfill	Y	Y	Y
RD5	Beachfill	Y	N Unsuitable Silty Material	N
RD6	Oyster Seed Bed Creation	Y	N Unsuitable Silty Material	N

*Pending Benthic Testing

TABLE 20
CYCLE 3 - INSTITUTIONAL/ENVIRONMENTAL SCREENING

SITE NAME	TYPE	INSTITUTIONAL ACCEPTABILITY	ENVIRONMENTAL ACCEPTABILITY	OVERALL ACCEPTABILITY
Cape May CM2	Upland	Y	Y	Y
CM4	Beachfill	Y	Y	Y
CM5/6	Beachfill/Shore Protection	Y	Y	Y
Delaware Taylors Bridge TB1	Upland	State Designated Wildlife Area	No Wetlands in Area/No Streams	N
Bombay BB2	Thin layering	Y	N Oyster Lease Bed	N
Little Creek LC8	Island Creation	N Bombay Hook, Natural Wildlife Area	N Oyster Lease Bed	N
LC9	Wetland Creation / Restoration	Y	Y *	Y

TABLE 20

SITE NAME	TYPE	INSTITUTIONAL ACCEPTABILITY	ENVIRONMENTAL ACCEPTABILITY	OVERALL ACCEPTABILITY
LC10	Sand stock pile	Y	Y *	Y
LC11	Under water berms/ shore protection	Y	N Oyster Beds	N
LC12	Under water berms / shore protection	Y	N Oyster Beds	N
Frederica FR18	Upland	Y	N Pond in Area	N
FR19	Upland	Y	Y	Y
FR26	Beachfill	Unsuitable Silty Material	Unsuitable Silty Material	N
FR27	Underwater berms/ shore protection	Y	N Oyster Bed	N
FR28	Sand stock pile	Y	Y *	Y
FR29	Under water berms/ Shore Protection	Y	N Oyster Bed	N

* Pending Benthic Testing

TABLE 20

CYCLE 3 - INSTITUTIONAL/ENVIRONMENTAL SCREENING

SITE NAME	TYPE	INSTITUTIONAL ACCEPTABILITY	ENVIRONMENTAL ACCEPTABILITY	OVERALL ACCEPTABILITY
Bennetts Pier BP1	Upland	Y	Y	Y
BP2	Upland	Y	Y	Y
BP4	Beach Fill	Y	N Unsuitable Silty Material	N
MS2	Upland	N Milford Neck Wildlife Area	Y	N
MS3	Upland	Y	Y	Y
MS12	Upland	Y	Y	Y
MS14	Upland	N State Park	N Stream/Wetlands	N
MS15	Upland	N State Park	Y Stream/Wetlands	N
MS16	Upland	N State Park	Y	N
MS17	Beachfill	Y	N Unsuitable Silty Material	Y
MS18	Wetland Creation	Y	Y *	Y
MS19	Sand Stock Pile	Y	Y *	Y

* Pending Benthic Testing

TABLE 20
CYCLE 3 - INSTITUTIONAL/ENVIRONMENTAL SCREENING

SITE NAME	TYPE	INSTITUTIONAL ACCEPTABILITY	ENVIRONMENTAL ACCEPTABILITY	OVERALL ACCEPTABILITY
MS20	Upland	N Historic Area	N Wetlands Border site	N
MS21	Underwater Berms/Shore Protection	Y	N Oyster Seed Beds in Area	N
Milton ML1	Upland	Y	N Wetlands	N
ML2	Upland	Y	Y	Y
ML4	Upland	Y	Y	Y
ML9	Upland	Y School grounds Residential Area	Y	Y
Lewis L1	Upland	Y	Y	Y
L2	Upland	Y	Y	Y
L3	Upland	N Historic Site University Del	Y	N
L4	Beachfill	Y	Y	Y
L5	Sand stock pile	Y	Y *	Y
L6	Beachfill	Y	Y	Y
L7	Beachfill	N	N	N
CH1	Beachfill	N National Park	N Shore Bird Nesting Area	N
CH2	Beachfill	N National Park	Y	N

TABLE 20
DELAWARE BAY
CYCLE 3 - INSTITUTION/ENVIRONMENTAL SCREENING

SITE NAME	TYPE	INSTITUTIONAL ACCEPTABILITY	ENVIRONMENTAL ACCEPTABILITY	OVERALL ACCEPTABILITY
OB4	Overboard	Y	Y *	Y
I 1	Island Creation	Y	Y *	Y
I 3	Island Creation	Y	Y *	Y

* Pending Benthic Testing

CYCLE 4 - INITIAL CHANNEL DEEPENING ANALYSIS

370. This analysis was conducted at a reconnaissance level of detail without indepth analysis of physical design conditions and navigation practices. Cycle 4 studies were initiated in April 1983 following the approval of the Plan of Study/Reconnaissance Study. This analysis is to address the main channel which was not analyzed in the Reconnaissance Study.

371. This analysis cycle used Waterborne Commerce statistics up to and including the year 1982 which were the latest available at that time. Total tonnage moved in 1982 on the main Delaware River channel between Philadelphia and the Sea was 81,618,754 tons. This total had percentage components of 62 percent foreign traffic, 18 percent coastwise traffic, and 20 percent internal and local traffic.

372. Cycle 4 formulation analyzed deepening the main Delaware River channel to depths of 42, 45 and 50 feet. Shoaling rates and dredging records were analyzed to determine suitable starting conditions (authorized depth, existing depth or natural depth). Dredged quantities and rock excavation quantities were calculated assuming bottom cut deepening along existing sideslopes. This would reduce existing bottom channel widths slightly. These quantities included a two foot overdepth. Disposal of dredged material was planned for disposal areas along each reach of the Delaware River, similar to the area distribution of the existing Federal sites which have been found to reasonably minimize the costs of dredging and disposal operations. No anchorage dredging was included for this analysis. No relocations or associated features were required for the 42 foot depth while the 45 foot plan was estimated to require two utility relocations and associated costs for bulkhead modification at six locations. The 50 foot plan was estimated to require six utility relocations and associated costs for the six bulkhead modifications. Costs were developed using the Dredged Material Disposal Management Model (D2M2) developed by the U.S. Army Corps of Engineers Hydrologic Engineering Center. This model can be used to estimate the total average annual cost of the least cost disposal scheme, considering such factors as dredging and disposal area diking costs, for initial construction and maintenance types of dredging plant, site acquisition costs, and annual site operations and maintenance. The computer solution is based on a present worth comparison of all dredging and disposal costs over the planning period for an iterative series of analyses which vary site selection and the timing of acquisition to arrive at a least cost solution.

373. For existing Delaware River traffic, crude oil was identified as the major commodity beneficiary. Coal, grain, iron ore, and scrap were also projected to accrue benefits. When this cycle of analysis was performed container fleet projections were unclear,

therefore, no benefits were claimed for containers. The potential benefits for diverted traffic were also estimated.

374. All the crude oil terminals except the Getty (now Texaco), Delaware City facility were projected to benefit from a deeper main channel. This facility maintains an access channel to its berth of only 35 feet and would not modify their access due to a deeper main channel. Tidewater Grain, Pier 122 (iron ore), Pier 124 (coal), and South Jersey Port Corporation's Beckett Street Terminal (scrap) were identified as beneficiaries in this cycle. A comparison of the project costs and benefits for this cycle is presented below in Table 18 using an September 1991 price level.

375. Based on the net benefits for the three depths, shown in Table 18, it was concluded that the 50 foot project would not be economically feasible under conditions occurring at that time and it was eliminated from further study. Further study of deepening the channel up to and including 45' was found warranted in order to determine the optimum channel.

CYCLE 5 - NAVIGATION SYSTEM ANALYSIS

376. The purpose of Cycle 5 formulation was to complete more detailed design studies and updated economic studies in order to conduct optimization of the regional waterway system. This required further analyses of the main Delaware River channel deepening including evaluation of further improvements at tributary projects consistent with main channel depths, studies of realigning the channel under Benjamin Franklin bridge realignment in the vicinity of Marcus Hook, and the Delaware River Anchorages.

TABLE 21

CYCLE 4 FORMULATION, MAIN CHANNEL DEEPENING
DELAWARE RIVER, PHILADELPHIA TO THE SEA

Project Costs	42 foot Project	45 foot Project	50 foot Project
Project First Cost	$60,941,000	$369,904,000	$761,782,000
Amortized First Cost	5,053,000	29,552,000	63,166,000
Operation & Maintenance	1,953,000	4,861,000	10,344,000
Total Ave. Annual Costs	7,006,000	34,413,000	73,510,000
Project Benefits			
Exist. & Future Commod.	13,437,000	29,397,000	47,914,000
North Atlantic Diversions	9,923,000	15,192,000	23,856,000
Total Annual Benefits	23,360,000	44,589,000	71,770,000
Benefit/Cost Ratio	3.33	1.29	0.98
Net Benefits	16,354,000	10,176,000	- (1,740,000)

377. Cycle 5 studies were conducted in the period between 1986 and 1988. Several important developments occurred during the period. The major regional gain elevator on the Schuylkill River ceased operation in December 1985 and remained closed, available for sale. The grain elevator at Port Richmond's Pier E which had been integrated with coal exports by Energy Terminals Incorporated was not functioning and not likely to resume in the near future. Grain, which was once thought to have major potential as a growth export from the Port of Philadelphia was considered to have a bleak future. On the other hand crude oil and petroleum products, the largest waterborne commodities increased their amount of annual tonnage during this timeframe. The region's refineries were streamlined insuring more efficient and competitive operations. Coal, the largest export commodity from the Port of Philadelphia, had almost a fourfold increase to 4.7 million tons

exported in 1985 compared to 1.2 million tons in 1984. General cargo tonnage increased during 1986 and the port captured the majority of tonnage into the region for particular commodities such as Chilean fruit and meats.

378. The selection of design vessels was made following a review of existing and future vessel distributions and coordination with pilots, ship captains, and the Coast Guard. More detailed consideration was given to the physical conditions as they impacted on design requirements.

379. In keeping with the recommendations of Cycle 4 to analyze channel depths of 41 to 45 feet, the initial analyses concentrated on the selected depths of 42' and 45' for several of the options under investigation. Then the main channel analysis was conducted using one foot increments up to 46 feet as a system analysis. The first evaluation was of realignment of the main channel in Philadelphia Harbor.

380. DELAWARE RIVER CHANNEL REALIGNMENT AND BENJAMIN FRANKLIN BRIDGE. The alignment of the 40 foot MLW deep draft channel under the Benjamin Franklin Bridge passes close to its west abutment where the minimum vertical clearance is only 129 feet (MHW), the least clearance of any bridge between Trenton and the Sea. The other bridges provide clearances of 135 (MHW) and greater as shown on Table 19. Figure 14 shows the current channel dimensions in the vicinity of the Benjamin Franklin Bridge and the vertical clearances. According to representatives of the Delaware River Pilots' Association and the Mariners' Advisory Committee, the 129' constraint causes both a safety hazard to vessels passing under the bridge and inefficient vessel operations. These inefficiencies were reported to include the cost of disassembling mast-mounted equipment on some vessels, delays due to tide conditions and ballasting requirements, and the use of smaller vessels than desired. These problems were experienced by the Navious Fleet which calls at the U.S.X. Steel plant in Fairless Hills.

a. The navigational depths considered ranged from 40' to 45'. An additional 2' was included for all depths to allow for overdepth dredging. Vessel depth allowance parameters were evaluated and found to require a total of five feet in order to allow for squat, trim and freshwater sinkage and safe underkeel clearance.

TABLE 22

Minimum Vertical Clearances at Delaware River Bridge Crossings

Vertical Bridge Name	Type	Location	Minimum Clearance (MHW)
Delaware Memorial Twin Bridges	Fixed	Wilmington, DE	188' (for 40' channel)
Commodore Barry Bridge	Fixed	Chester, PA/Bridgeport, NJ	181' (for 40' channel)
Walt Whitman Bridge	Fixed	Phila, PA/Gloucester, NJ	139'/150' (for 40/37 channel)
Benjamin Franklin Bridge	Fixed	Phila, PA/Camden, NJ	129'/135' (for 40/37 channel)
Conrail Bridge	Vertical Lift	Phila, PA/Delair, NJ	135' (40 channel)
Betsy Ross Bridge	Fixed	Phila, PA/Pennsauken, NJ	135' (for 40' channel)
Tacony-Palmyra Bridge	Bascule	Phila, PA/Palmyra, NJ	-
Burlington-Bristol Bridge	Lift	Burlington, NJ/Bristol, PA	134'
Turnpike Bridge	Fixed	Bristol, PA/Florence, NJ	135'

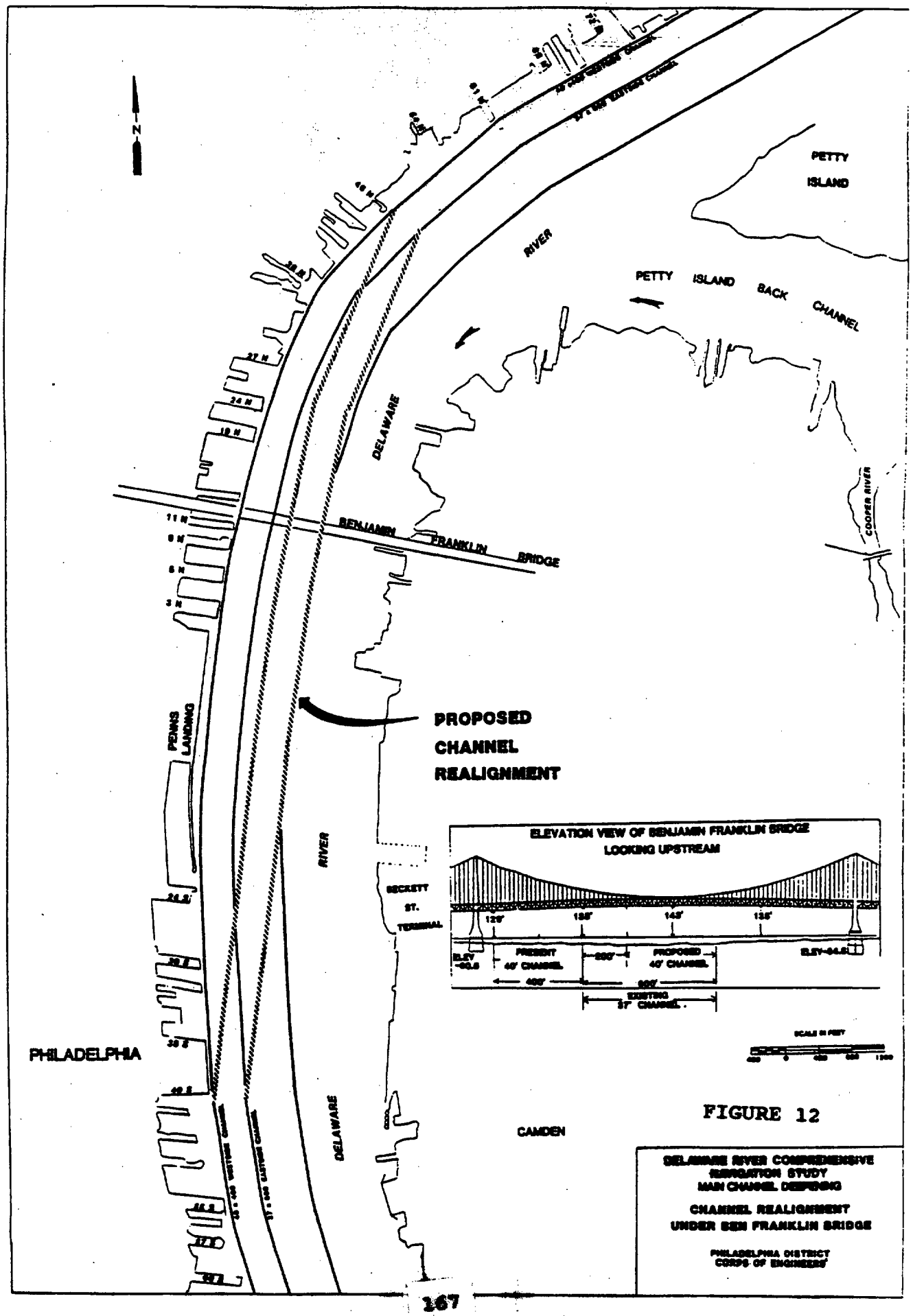


FIGURE 12

DELAWARE RIVER COMPREHENSIVE NAVIGATION STUDY
MAIN CHANNEL DEEPENING

CHANNEL REALIGNMENT
UNDER BEN FRANKLIN BRIDGE

PHILADELPHIA DISTRICT
CORPS OF ENGINEERS

Sample vessels that called at U.S.X. Steel are as follows:

Vessels Calling at U.S.X. Steel During 1984

Deadweight Tons	50,000	63,000	73,000
Design Draft	39'	42'	44'
Air Clearance (@ 39' Draft)	111'	118 '	132'

381. The vessel class which is restricted by the 129 ft. MLW clearance at the Ben Franklin Bridge during an inbound, cargo-laden passage is the 73,000 DWT vessel. With an air height of 132 feet it is necessary to disassemble the vessel's mast in order to pass with a sufficient margin of safety under the Ben Franklin Bridge. It is unlikely that a cargo-laden vessel of that size could add ballast to pass under the bridge because of the 40 foot depth restriction. The realignment would shift the 40 foot channel closer to the center of the bridge, thus providing a minimum of 135 ft. (MHW) vertical air clearance without prolonged tidal delays.

382. A benefit analysis showed that $43,000 per year could be saved by realigning the channel and quantifying the following benefits:

a) time saved in not having to disassemble the mast,
b) time saved in not having to take on ballast

The analysis assumed a 0.9% growth rate in tonnage shipped. Costs were analyzed using the D2M2 model. It should be noted that project costs are not high since this section of the Delaware River is deeper than authorized in many areas and is relatively stable, requiring little maintenance dredging.

383. Table 20 shows the results of the economic analysis. The resultant benefit/cost ratio of 0.14 showed that the realignment was economically unjustified for the existing channel depth of 40 feet. The economic analysis was also based on benefits to a single user. Further studies identified no other potential users. This portion of the study was suspended. Subsequently, a change in plan operation has curtailed iron ore shipment eliminating the need for any realignment.

384. DELAWARE RIVER CHANNEL REALIGNMENT AT MARCUS HOOK, PENNSYLVANIA. Cycle 5 evaluations of channel deepening included a realignment of the channel of Marcus Hook including the Marcus Hook, Chester and Eddystone Ranges. Figure 15 shows the dimensions of the existing projects and the realignment (40' x 800'). The adjacent Marcus Hook Anchorage is fully maintained to its authorized dimensions of 40' x 2300' x 13,650' (mean).

385. The numerous rock outcroppings along the Pennsylvania side of the channel represent a major channel deepening cost. The proposed realignment which was analyzed in an attempt to reduce channel deepening dredging of sediment in shallower areas outside the existing channel while avoiding expensive rock excavation. The cost of rock removal ranges from five to twenty times more expensive than that for sediment, depending upon the dredging technique employed. Table 21 lists the cubic yardage of sediment and rock excavation for the realigned channel and the existing configuration.

386. For the initial comparison of costs, the channel realignment was assumed to reduce the size of the anchorage. In effect the plan would cause some disbenefits unless the anchorage were shifted, however, these considerations were intentionally deferred to later cycles of formulation, if further study was indicated. Formulation of the alternatives was conducted on a least cost basis since benefits would remain constant regardless of alignment. It demonstrated that channel deepening along the existing alignment at Marcus Hook was more cost-effective than realigning the channel to avoid rock excavation. This realignment was not recommended for further investigation.

387. DELAWARE RIVER, PHILADELPHIA TO THE SEA ANCHORAGES. As discussed in earlier sections, the anchorages at Marcus Hook and Mantua Creek are the most heavily used of the Federally authorized anchorages. U.S. Coast Guard records on anchorage use revealed that investigations of anchorage modifications could be limited to these two locations. Usage at the other anchorages was so infrequent that it was obvious that no need existed to consider improvements.

388. Examination of vessel characteristics using the anchorage at Mantua Creek indicated that there were no significant problems and that the largest vessels calling there were usually in ballast. Vessels calling at Marcus Hook included a large percentage (60%) of tankers which are constrained by depths in the channel and anchorage. Analysis of historic anchorage usage data showed that Mantua Creek was more frequently used than Marcus Hook, but that both anchorages were empty a significant percentage of the time: 40 percent and 72 percent, respectively. For the period analyzed, no more than three vessels used the Marcus Hook Anchorage at one time and two or fewer vessels used the anchorage 98 percent of the time.

TABLE 23

Cycle 5, Analysis of Realignment of 40' channel at
Benjamin Franklin Bridge
(October 1991 Price Level)

Item	
Channel Width	400'
Initial Dredging	257,000 cy
Maint. Quantity (annual)	4,400 cy
Utility Relocations	None
Associated Features	None

Project Costs	
Project First Costs	$2,012,000
Amortized First Costs	$ 176,000
Operations & Maintenance	$ 123,000
Total Average Annual Cost	$ 299,000

Project Benefits	
Transport. Savings	$43,000 Average Annual Benefits

Benefit/Cost Ratio	0.14

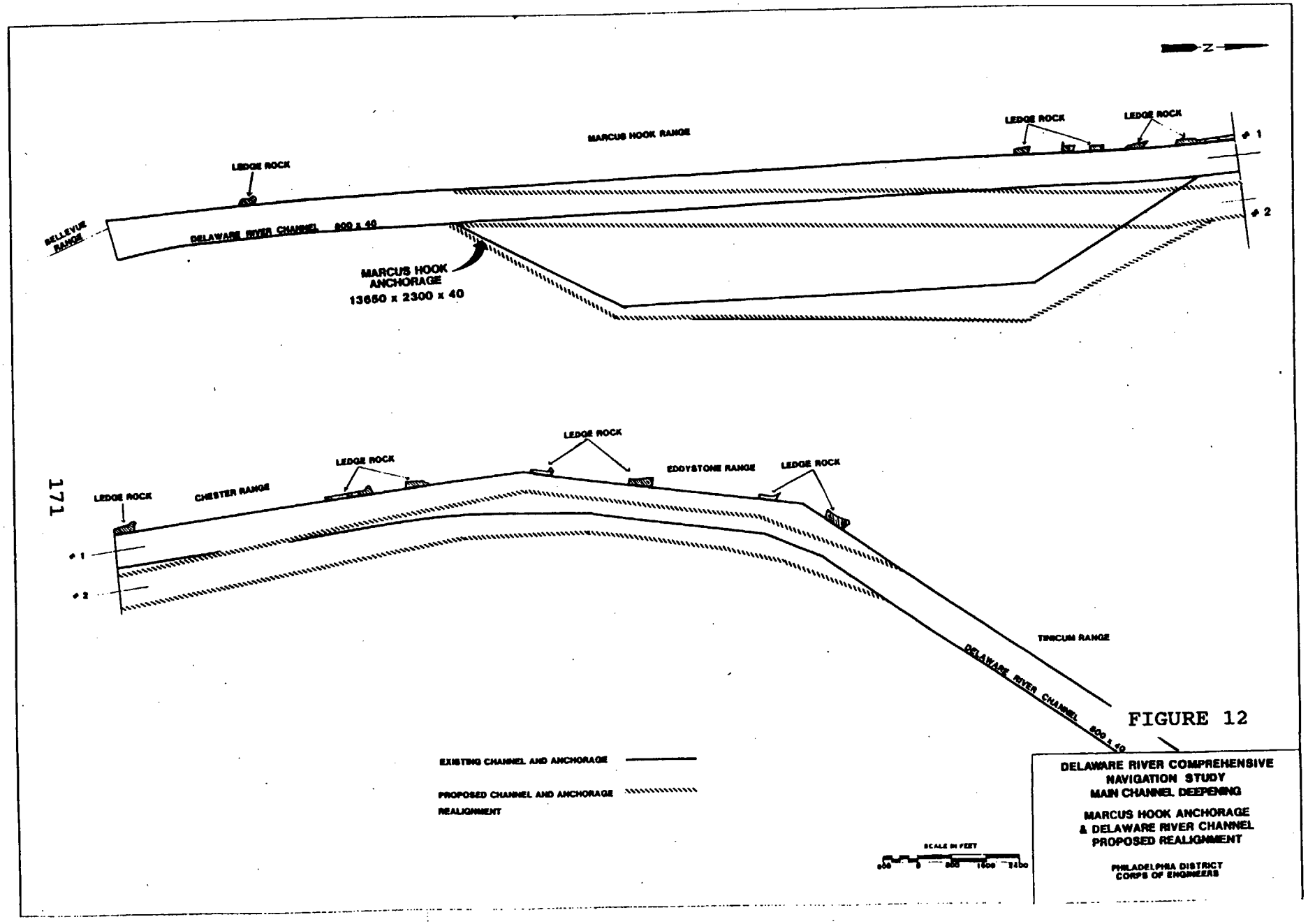

N
MARCUS HOOK RANGE
LEDGE ROCK
LEDGE ROCK
LEDGE ROCK
BELLEVUE RANGE
DELAWARE RIVER CHANNEL 800 x 40
MARCUS HOOK ANCHORAGE
13650 x 2300 x 40
1
2
LEDGE ROCK
LEDGE ROCK
LEDGE ROCK
CHESTER RANGE
EDDYSTONE RANGE
LEDGE ROCK
1
2
TINICUM RANGE
DELAWARE RIVER CHANNEL 800 x 40
EXISTING CHANNEL AND ANCHORAGE
PROPOSED CHANNEL AND ANCHORAGE REALIGNMENT
SCALE IN FEET
DELAWARE RIVER COMPREHENSIVE NAVIGATION STUDY
MAIN CHANNEL DEEPENING
MARCUS HOOK ANCHORAGE & DELAWARE RIVER CHANNEL PROPOSED REALIGNMENT
PHILADELPHIA DISTRICT
CORPS OF ENGINEERS

FIGURE 12

TABLE 24
Cycle 5, Analysis of Realignment of Delaware River Channel, Realignment of Marcus Hook
(October 1991 Price Level)

	Existing Alignment		Realigned Channel	
Project Costs ($thousands)	42'	45'	42'	45'
Project First Cost	$ 10,133	$ 24,723	$27,463	$29,541
Amortized First Cost	887	2,176	2,407	2,590
Operations & Maintenance	7,859	8,848	7,933	9,009
Total Ave. Annual Cost	8,746	11,024	10,340	11,599
Quantities of material removed:				
Sediment(cy)	145,000	5,222,000	6,394,000	8,831,000
Rock (cy)	15,000	45,100	0	0

Net Savings-
Existing Alignment 42' $(-1,594) Average Annual Costs
($thousands) 45' $(-575) Average Annual Costs

389. No improvements were considered for the Mantua Creek Anchorage since usage patterns suggested no serious problems with authorized or existing dimensions. In developing alternatives for analysis of Marcus Hook, consideration was given to deepening the entire anchorage to depths compatible with main channel depths (42 and 45 feet initially) as well as two schemes to reduce dredging requirements. The Marcus Hook Anchorage and Range area represents the largest single shoal location in the main channel project and plans to minimize dredging were expected to be much more efficient than dredging the entire anchorage. The first alternative reasonably minimized the number of free-swinging spaces to be provided. Although the available usage data did not permit queuing type analysis which related vessel draft and dimensions, duration of anchorage, and number of vessels at any given time, two spaces were considered to be adequate. A second option provided for deepening the entire anchorage for comparison even though no significant difference would result in benefits. Another option gave consideration to mooring dolphins or double anchoring (stern and bow) by vessels to further reduce the area required below that of free-swinging criteria.

390. However, coordination with the Mariners' Advisory Committee and Pilots' Association surfaced several concerns over the last option. Double anchoring systems were considered unreliable since they do not always hold the vessel in place. This would create a serious hazard and oil spill potential, particularly for frequent use by tankers in close proximity to each other. In addition, not all vessels are equipped with stern anchors. The non-structural approach was therefore eliminated. Mooring structures were also viewed as presenting collision potential. Massive, costly structures would be required to resist the mooring forces of river currents . In addition operational costs would be increased by the necessity for tug assistance to anchor and mooring crews. For these reasons the structural version of the option was considered impractical and the full size and two space anchorage plans were analyzed (see Figures 16 and 17).

391. An economic analysis of the Marcus Hook Anchorage showed that anchorage use had declined since the mid-1970's due to 1) a decline in Delaware River commerce, 2) a larger cargo carried per vessel, and 3) a shortening of queues due to an increase in cargo transfer capacity. Two types of benefits were studied:

(a) Improvements to navigation (accident cost prevention); and

(b) Improvements to operating efficiency (lightering and bunkering cost reduction).

392. The economics analysis identified no difference in benefits attributable to the full anchorage deepening plan. Costs were analyzed using the D2M2 model, reflecting the difference in initial and maintenance dredging costs as well as disposal area usage throughout the planning period. Results of the benefit/cost analysis are shown below in Table 22.

393. The analysis of deepening Marcus Hook Anchorage concluded that, when considered incrementally, provision of an anchorage depth compatible with a deeper channel was not economically justified. However, a question remained as to whether it was safe to design a deeper channel with no upstream anchorage of compatible depth (only berths would have suitable depth) or if a minimum capacity anchorage was a necessary, inseparable feature of a channel deepening plan. The District coordinated further with the Delaware River Pilots on this matter and it was concluded that further studies should include a minimum size anchorage area as part of the channel deepening plan.

394. TRIBUTARY PROJECTS. Only one deep-draft tributary project to the main channel, the Delaware River in the vicinity of Camden, was found to have potential to benefit from channel deepening.

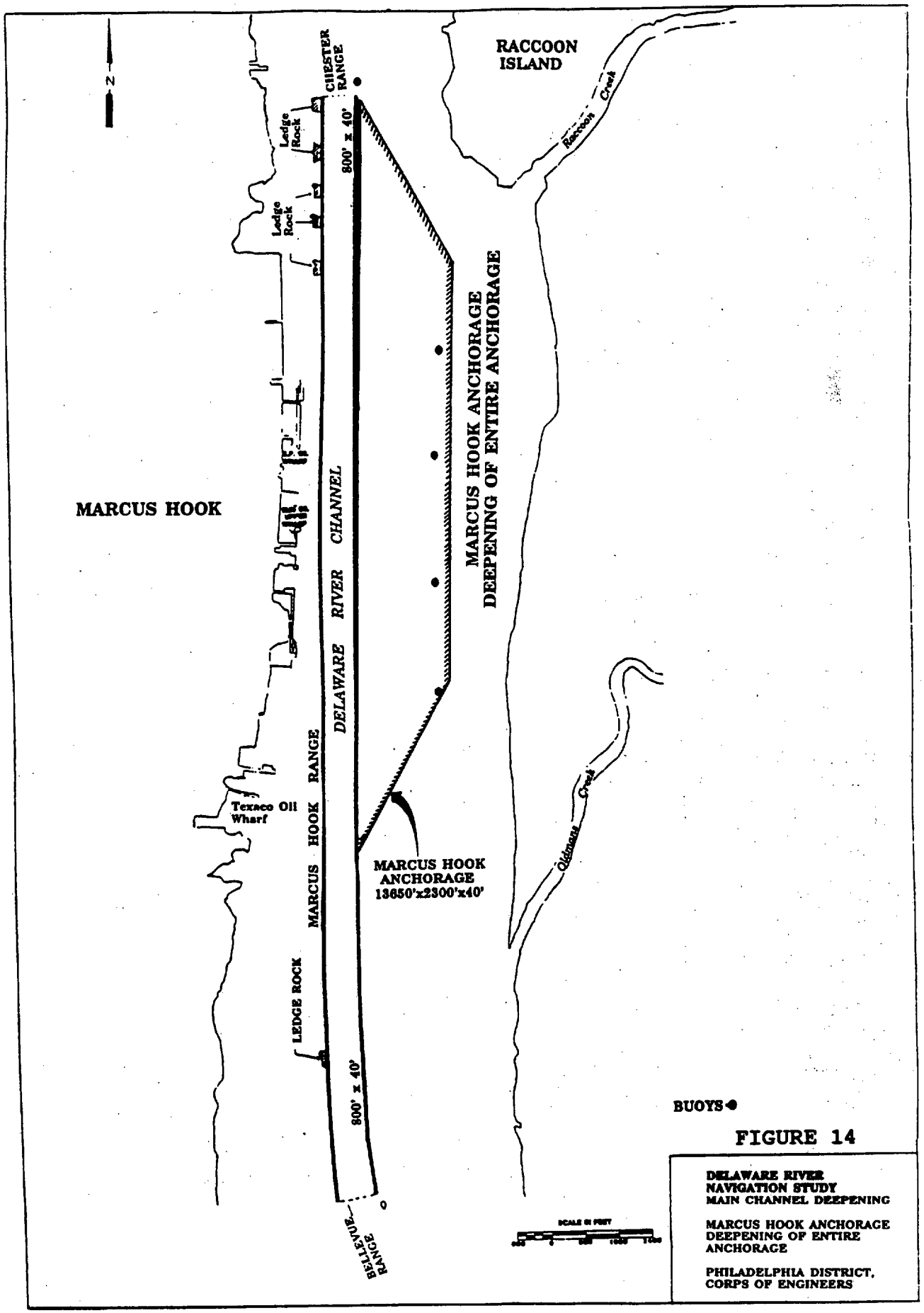


FIGURE 14

DELAWARE RIVER
NAVIGATION STUDY
MAIN CHANNEL DEEPENING

MARCUS HOOK ANCHORAGE
DEEPENING OF ENTIRE
ANCHORAGE

PHILADELPHIA DISTRICT,
CORPS OF ENGINEERS

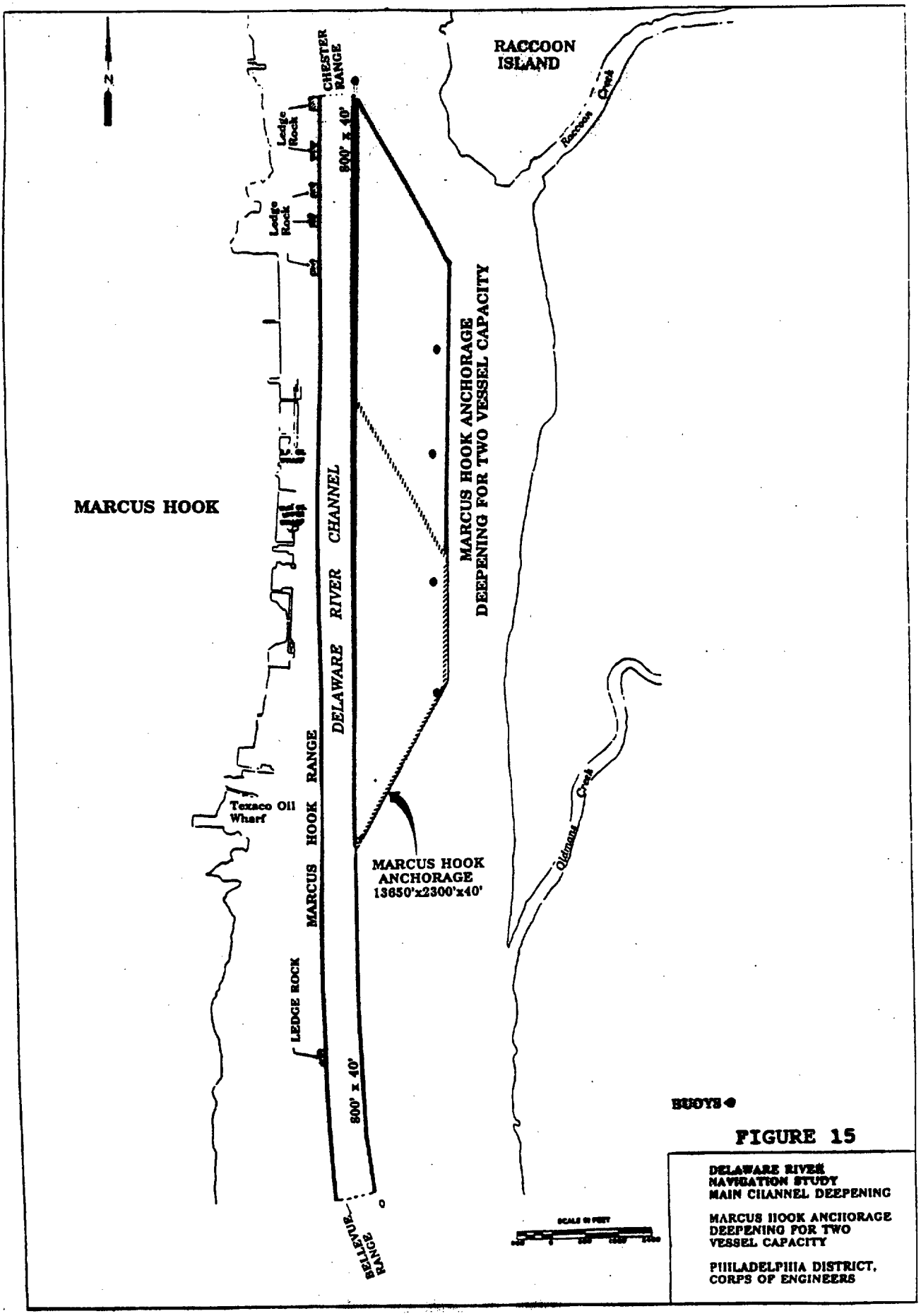


FIGURE 15

DELAWARE RIVER
NAVIGATION STUDY
MAIN CHANNEL DEEPENING

MARCUS HOOK ANCHORAGE
DEEPENING FOR TWO
VESSEL CAPACITY

PHILADELPHIA DISTRICT,
CORPS OF ENGINEERS

TABLE 25
Economic Analysis of Marcus Hook Anchorage Improvements
(October 1991 Price Level)

	Full Size ($thousands)		Partial Size ($thousands)	
	42 ft.	45 ft.42 ft	42 ft.	45ft.
Project First Cost	$12,671	$42,599	$6,624	$29,380
Amortized First Cost	1,101	4,204	581	2,575
Operations and Maintenance	734	2,103	651	1,882
Total Average Annual Cost	1,843	6,307	1,232	4,457
Total Average Annual Benefits	148	267	148	267
Net Benefits	(-1,695)	(-6,040)	(-1,084)	(-4,190)
Benefit/Cost Ratio	0.08	0.04	0.12	0.06

395. Delaware River in the Vicinity of Camden. Deepened access to the Beckett Street Terminal (40 feet) was authorized by Section 3a of the W.R.D.A. of 1988. The bulk berths at Beckett Street Terminal handle significant amounts of dry bulk cargo including scrap and coal which could benefit by further deepening consistent with the main channel. Deepening the trapezoidal access channel to berths 3 and 4 at the facility was included in the main channel deepening analyses.

396. MAIN CHANNEL DEEPENING DELAWARE RIVER, PHILADELPHIA TO THE SEA. Deepening of the entire channel was considered through Philadelphia Harbor up to the upper limit of the Philadelphia to Sea project at Allegheny Avenue. Benefits from channel deepening would accrue for crude oil imports to six of the seven major Delaware River refineries, ore imports to Pier 122 plus coal exports from Pier 124. Dredging through Philadelphia Harbor would also benefit scrap metal and bulk operations at Beckett Street Terminal in Camden. However, none were identified for facilities further upstream. Therefore, the channel deepening options stopped at that terminal.

397. Coordination with the Pilot's Association and Mariners Advisory Committee evaluated and discussed the adequacy of existing channel conditions, the need for modifications based on problems experienced, design parameters and physical conditions, and operational practices. Several key findings resulted from this coordination as discussed in the following paragraphs.

398. The existing channel widths varying from 1000' in Delaware Bay to 800' in the lower river up to the Philadelphia Navy Yard, were confirmed as being adequate and safe. These dimensions resulted from various authorizations through the years after consultation with pilots and vessel captains and no justification exists for deviating from these established widths for two-way traffic. A key concern expressed by the pilots was the need for additional widening at bends as part of the plan development.

399. Previous analyses found that deepening of the Federal anchorages to a depth compatible with a deepened main channel was not economically justified when considered incrementally. However, it was felt that as an integral feature of the plan there was a need to provide a minimal anchorage area at a compatible depth to the main channel so that a safe refuge was available for vessels experiencing mechanical problems or sudden fog. As a result, deepening of two spaces within the Marcus Hook Anchorage was included for all channel deepening plans.

400. Design physical conditions for operation in the Delaware were felt to include a 1.5 knot tidal current, visibility of 1 mile during the day or 2 miles at night, and 20-30 knot winds from the northwest. Thick fog and more severe physical conditions which inhibit vessel movements occur about seven days per year.

401. The pilots indicated that the largest vessels (275,000 DWT tankers) operate with tug assistance during light traffic conditions. No passing/meeting situations are permitted at turns for these vessels. Transits are restricted to daylight conditions.

402. The largest anticipated bulk carrier at that time was 190,000 DWT and proposed Pier 124 modifications would accommodate this vessel. Lesser size tankers and bulk carriers operate day or night with no tug assistance except for turning/docking maneuvers. Since the largest vessels operate infrequently and could be accommodated by restricting transits to daylight and milder physical conditions or through use of tug assistance, they were not considered for design under adverse conditions. The design vessel selected was a 160,000 DWT dry bulk carrier with a beam of 145 feet and a design draft of 58 feet. These vessels can be accommodated as a result of lightering and traversing on the high cycle of the tide.

403. The navigational depths considered ranged from 40' to 45'. An additional 2' was included for all depths to allow for overdepth dredging. Vessel depth allowance parameters were evaluated and found to require a total of five feet in order to allow for squat, trim and freshwater sinkage and safe underkeel clearance.

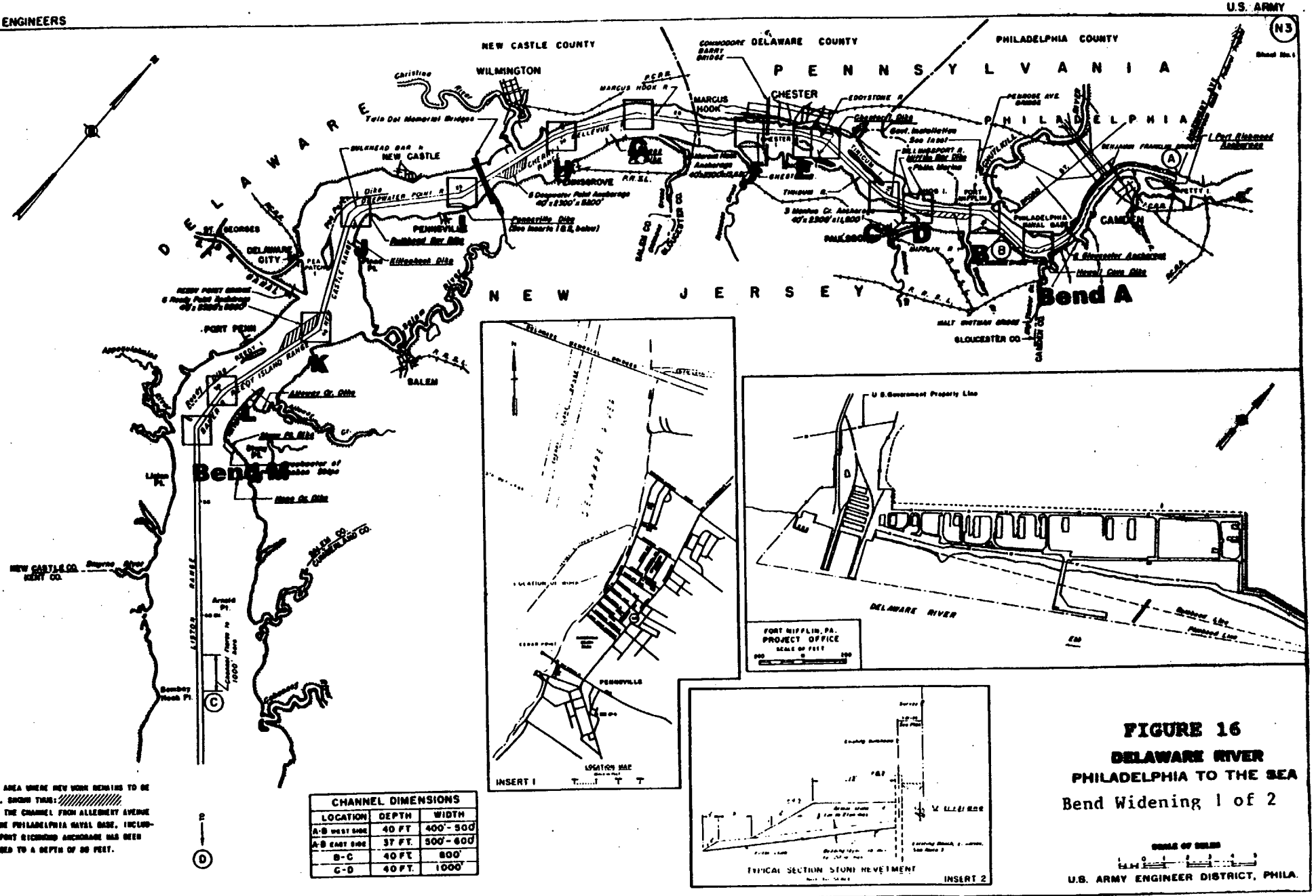
404. The existing channel alignment has 16 bend widenings in the channel between Delaware Bay and the Philadelphia Harbor. (See Figures 18 & 19). These bend widenings are required for turning

vessels. The width needed at each bend is dependent on the angle of the turn plus the beam, length, and maneuverability of the design vessel. Bend widening was not considered necessary for the Philadelphia Harbor itself due to reduced vessel speed. Vessels operate at speeds up to 12 knots elsewhere in the main channel and bay.

405. During Cycle 5 the D2M2 data files were modified to incorporate new information on shoaling rates, initial construction quantities, disposal area capacities, the acquisition costs and the annual costs for disposal site operation and maintenance, and dredging/transportation costs. Additional modifications were made to reflect changes in the status of disposal sites. Due to the large amount of data storage required to operate the D2M2 model, four major reaches were used to determine the most cost effective mode of transportation and disposal site usage. Table 23 shows the dredging yardage at various depths for the entire project from Brandywine Range in Delaware Bay up to Beckett Street Terminal over the 50 year planning period including initial construction and maintenance. The cubic yardage refers to unconsolidated material with a wet-to-dry ratio of 1.5.

TABLE 26
CYCLE 5, CHANNEL DEEPENING
DREDGED MATERIAL QUANTITIES
(DELAWWARE BAY TO BECKETT ST. TERMINAL)
(TOTAL) (MILLION CUBIC YARDS)

DEPTH	Initial Dredging	50 yr Maintenance Dredging Total
40'	0	298
41'	14	308
42'	23	318
43'	34	328
44'	45	339
45'	59	348



AREA WHERE NEW WORK REMAINS TO BE DONE, SHOWN THUS: ////////

THE CHANNEL FROM ALLEGHENY AVENUE TO THE PHILADELPHIA NAVAL BASE, INCLUDING FORT RICHMOND ANCHORAGE HAS BEEN DREDGED TO A DEPTH OF 30 FEET.

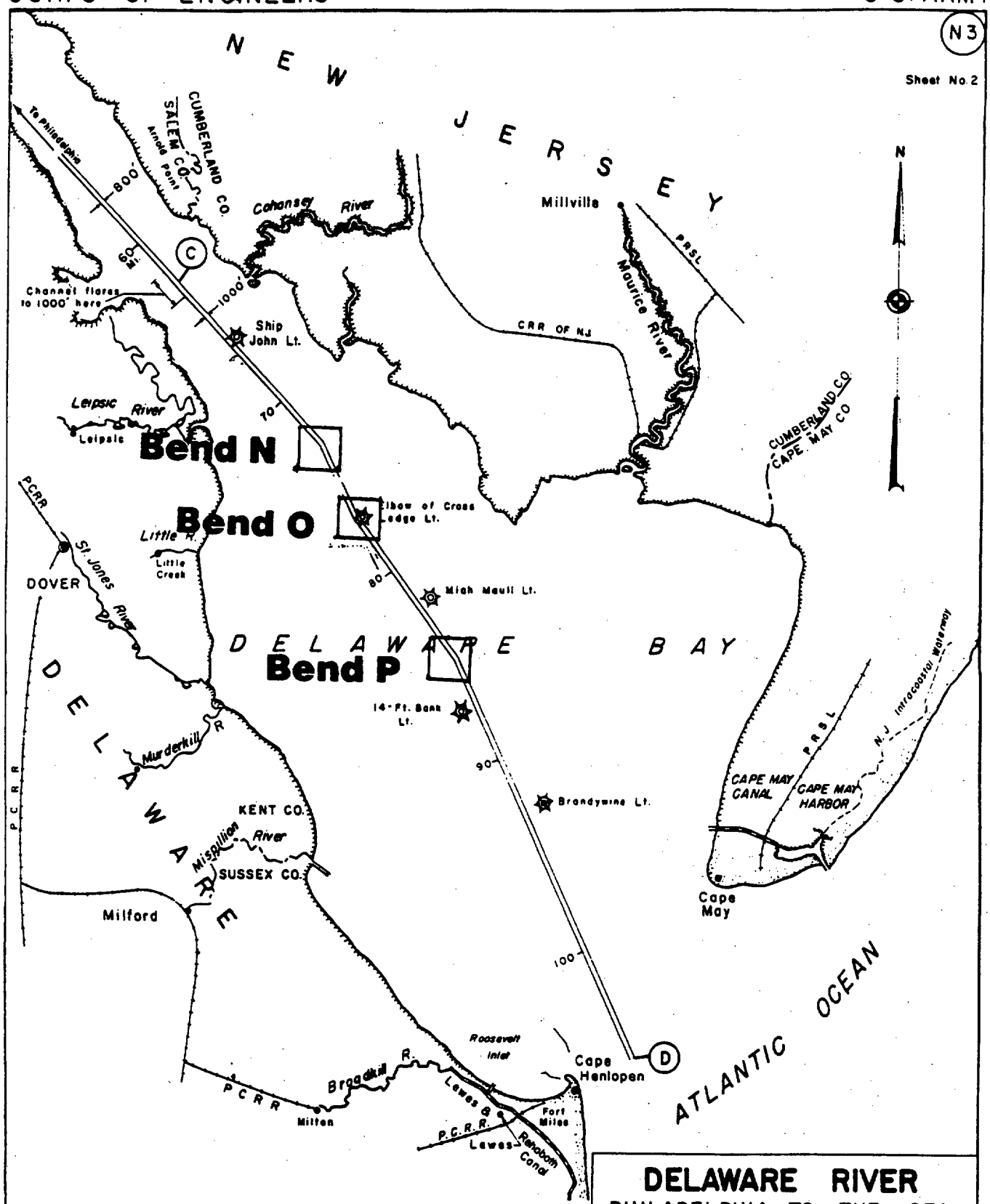
CHANNEL DIMENSIONS		
LOCATION	DEPTH	WIDTH
A-B WEST SIDE	40 FT	400'-500'
A-B EAST SIDE	37 FT.	500'-600'
B-C	40 FT.	800'
C-D	40 FT.	1000'

FIGURE 16

DELAWARE RIVER

PHILADELPHIA TO THE SEA

Bend Widening 1 of 2



LEGEND

Channel indicated thus: ═══

NOTE:

Distance in miles below Allegheny Ave., Phila., show along side of channel

DELAWARE RIVER

PHILADELPHIA TO THE SEA

PENNA., N.J. & DEL.

Bend Widening 2 of 2

FIGURE 17

SCALE OF MILES

5 0 5 10

U.S. ARMY ENGINEER DISTRICT, PHILA.

406. The D2M2 model used the most efficient means for the disposal of dredged material. The sites considered all passed both technical and ecological screenings accomplished previously.

407. The economic analysis involved the estimated value of potential project benefits based on transportation cost savings which would result from channel deepening. Transportation cost savings would accrue due to use of larger vessels, reduced costs for lightering, tidal delay reductions, and less tug usage requirements. Benefits were broken down into two categories: a) existing traffic (with future growth) through the Delaware River system, and b) potential diversions from competing ports.

408. Weighted average transportation costs per ton were developed for each of the relevant commodities and trade routes for the 40 ft. (MLW) without condition main channel depth, and with condition alternatives extending to a maximum 45 ft. (MLW) main channel depth.

409. A Multiport Analysis was conducted in accordance with EC 1105-2-129: Guidance on the applicability of the Principles and Guidelines to Deep Draft Navigation Benefit Evaluation which calls for "a systematic determination of routing possibilities, regional port analyses and intermodal networks." The goal of the multiport analysis was to estimate the volume of tonnage which might be diverted to the Delaware River port system from New York, Baltimore, Norfolk/Hampton Roads, New Orleans, and the Texas Gulf Coast ports (i.e., those ports identified as competing), and the resultant transportation cost savings from the diverted tonnage as a result of the Delaware River plan of improvements. The only estimated diversions from other ports was coal moving through Pier 124. Further studies were recommended over the entire depth range up to and including 46 feet, based on the expected change in benefits which were expected to occur with the changing world energy situation which would significantly increase the amount of crude oil imports both to the nation in general and the local refineries in particular.

CYCLE 6 - DISPOSAL COST AND IMPACT ASSESSMENT

410. ASSESSMENT OF DISPOSAL AREA IMPACT. The ultimate selection of a plan of improvement must give consideration to disposal options as well as channel depths, dimensions, and length. In order to further refine the disposal analyses, consideration was given to the effect channel deepening would have on the existing Federal project in general, and the existing Federal disposal areas in particular. Five disposal options were evaluated, which are described as follows:

a. Pumping all material from construction of the modified project and subsequent maintenance of the entire project into upland Federal sites, and allowing local sponsors to

reimburse the Federal government on an in-place volumetric basis.

b. Pumping all material into upland Federal sites, as above but requiring local sponsors to rehandle the required volumes of dried material to a final location provided by the sponsor.

c. Requiring local interests to provide suitable new disposal sites to accommodate the volumes of the initial construction and increased maintenance dredging associated with the project modification; and pumping the required volumes of dredged material into these sites during each dredging cycle.

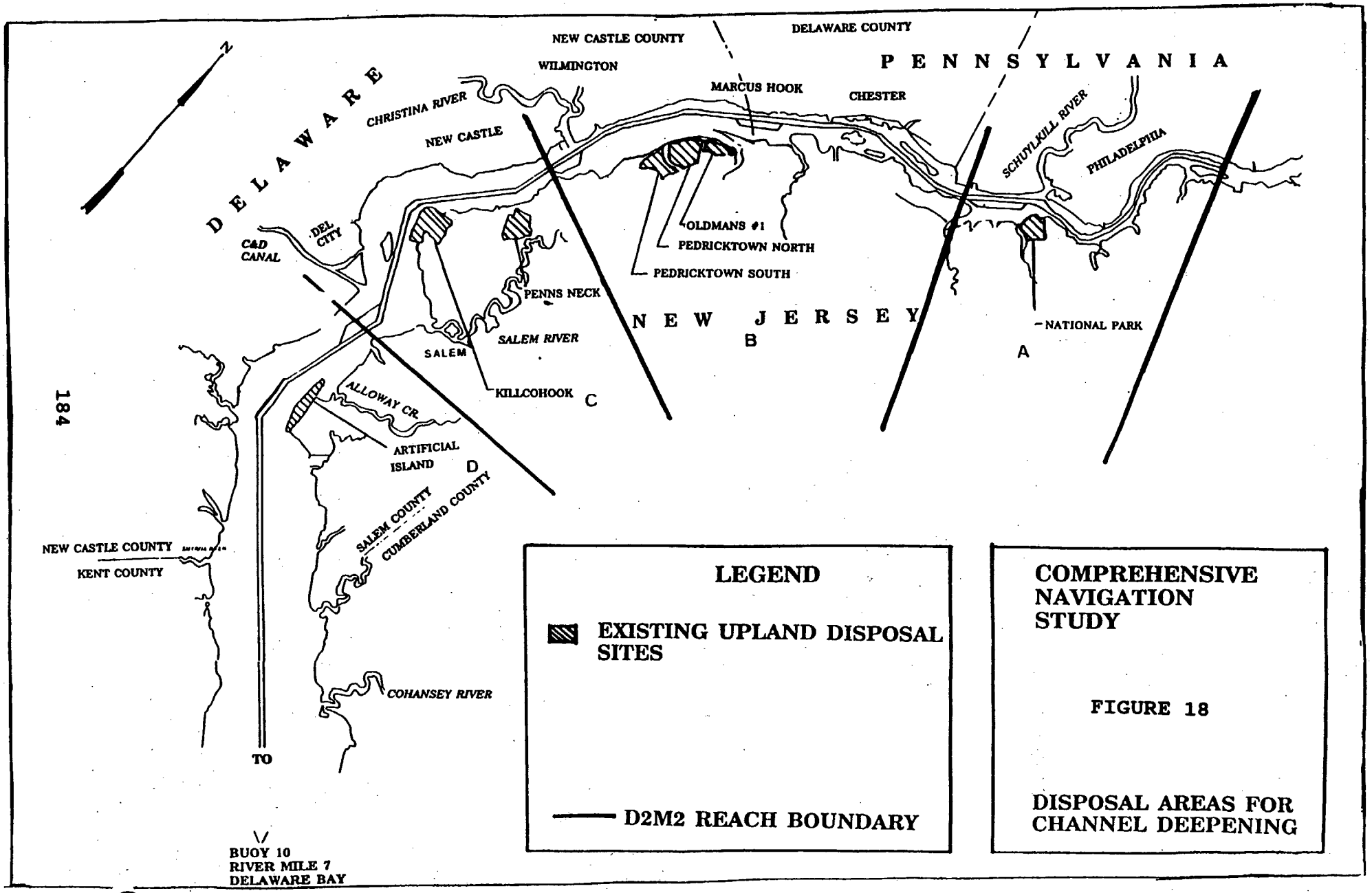
d. Requiring new sites to be provided by local interests for initial construction and increased maintenance as in (c), however, allowing pumping of material into either the Federal or local sites as appropriate to minimize dredging and mobilization costs, while ensuring the long term volume requirements are met by local sponsors.

e. Deposit material at an aquatic site Delaware Bay with is consideration for beneficial uses such as wetland/island/upland creation, oyster seed bed creation, and sand stockpile.

411. In screening these options it was considered necessary that local sponsors make the Federal government whole for any costs it incurred due to non-Federal use of a Federal disposal area. This includes consideration of costs for diking, maintenance, transportation and disposal and acquisition as affected by the local use. In addition, it was concluded that local use of a Federal site should cause no significant reduction in the remaining life of Federal sites, considering 10% or less to be an acceptable change. However, it was also concluded that local use could not result in an overall reduction in the expected life of a site such that a short-term (about 10 years or less) problem could result and jeopardize the government's ability to maintain the existing project.

412. Consideration was given to use of existing Federal upland disposal areas in option (a) since the sites are well distributed along the length of the main channel and had potential to minimize project costs. The analysis was broken down into 4 separate reaches (see figure 20). However, an analysis of initial construction and maintenance requirements showed that the potential impact on remaining capacities at Federal sites would be very significant, based on a 45' project as shown below:

Reach Reduction	Sites	Reduction in Useful Life	Percent
A.	National Park	21 years	45%
B.	Pedricktown N. Pedricktown S. Oldmans	10 years	24%
C.	Killcohook Penns Neck	11 years	18.5%
D.	Artificial Island	36 years	39%


N
DELAWARE
NEW CASTLE COUNTY
DELAWARE COUNTY
PENNSYLVANIA
WILMINGTON
CHRISTINA RIVER
NEW CASTLE
MARCUS HOOK
CHESTER
SCHUYLKILL RIVER
PHILADELPHIA
DEL CITY
C&D CANAL
OLDMANS #1
PEDRICKTOWN NORTH
PEDRICKTOWN SOUTH
PENNS NECK
NEW JERSEY
B
A
NATIONAL PARK
SALEM RIVER
SALEM
KILLCOHOOK
C
ALLOWAY CR.
ARTIFICIAL ISLAND
D
SALEM COUNTY
CUMBERLAND COUNTY
NEW CASTLE COUNTY
KENT COUNTY
COHANSEY RIVER
TO
BUOY 10
RIVER MILE 7
DELAWARE BAY
LEGEND
EXISTING UPLAND DISPOSAL SITES
D2M2 REACH BOUNDARY
COMPREHENSIVE NAVIGATION STUDY
FIGURE 18
DISPOSAL AREAS FOR CHANNEL DEEPENING

413. Based on this analysis it was evident that option (a) was not acceptable for the Delaware River disposal area and that other options should be considered. It was also concluded that use of this option could interfere with annual maintenance operations due to the large volumes of pumped slurry, limited degree of dike raising (lift) which could be accommodated, and difficulty in dewatering large lifts.

414. Option (b) calls for pumping all material into the upland Federal sites, but rehandling it, when dried, into final locations provided by the sponsors. This option is not well suited to the very large quantities generated by main channel deepening, since it would result in huge volumes of material being excavated and hauled to other locations. It would also interfere with maintenance operations at each site, since there is limited time for excavation after dewatering between annual maintenance pumping cycles. Current maintenance operation utilize low ground pressure equipment to accomplish ditching and dike raisings and are time constrained for these limited activities. This option would also appear to be inefficient, given the volumes of dredging, since large parcels would be needed as a final disposal location and these could likely be developed and pumped directly at less expense.

415. Option (c) requires local interests to provide new disposal sites to accommodate the volumes of initial construction and maintenance for which they are responsible and placement of the appropriate volumes in local sites during each dredging cycle.

416. This would appear to be a relatively inefficient option, given that during maintenance operations the local sponsor would be responsible for the incremental quantity associated with channel deepening. Use of this option could significantly increase mobilization, demobilization, and dredging costs by requiring use of multiple disposal areas in every maintenance cycle including pipeline, mooring barges, and site preparation expenses.

417. Option (d) requires local interests to acquire new sites to accommodate the volumes of initial construction and increased maintenance dredging, allowing operational efficiencies to occur by using Federal and non-Federal sites as appropriate, while ensuring that long-term volume requirements are met by local sponsors. This option has advantages over previous options and can result in an NED plan for the river channels since it provides for operational efficiencies while having little or no effect on ultimate Federal site capacities. There is also an opportunity to enhance site management by increasing the number of sites and allowing longer periods for rest, dewatering, and possibly reuse of material. Additionally, site capacity could be exchanged to result in overall efficiencies between the government and local sponsor and ensure the continued availability of disposal capacity distributed along the length of the river, which would continue to minimize future maintenance costs for the main channel.

418. As part of this consideration, the Reedy Point North and South disposal areas located in Reach C, were identified as having significant remaining capacity with little demand for use on the Chesapeake and Delaware Canal project. It was concluded that they could be considered for use by sponsors for the Delaware River main channel deepening, without any significant effect on project maintenance operations. The capacity at these locations could be exchanged for that in other areas such as Reach A where Federal capacity is more limited.

419. Option (e) to dispose of material at aquatic sites in Delaware Bay or in the Atlantic Ocean is unattractive in comparison to other options due to the haul cost, except for the material in the Delaware Bay channel. This was evident from D2M2 computerized cost analyses conducted in earlier studies. Beneficial use sites and the Buoy 10 site were made available for computer runs in each reach. Only in the bay channel were these options selected as less expensive, than alternative sites within the reach. Maintenance dredging operations have used the overboard disposal site at Buoy 10 on a limited basis for the bay channel since this is closer to the shoaling locations than upland sites or any potential ocean locations. However, based on agency coordination beneficial use options in the Delaware Bay, option (e), viewed as necessary alternatives to extensive use of Buoy 10 Delaware Bay.

420. In conclusion, options (d) and (e) were found to warrant further consideration in developing a disposal plan which reasonably maximized National Economic Development objectives. The impact of dredging volumes for channel deepening were too significant to allow use of the Federal disposal areas on the main channel. However, for the Delaware River use of excess capacity at C&D Canal disposal areas, trade offs between Federal and non-Federal site use and capacities, and beneficial uses in the Delaware Bay warrant consideration.

421. <u>DISPOSAL COST AND IMPACT ASSESSMENT.</u> For the new sites to be considered under option (d) of the previous discussion, an evaluation was made of critical cost factors and in each reach environmental and cultural resource concerns in order to rank and compare the remaining 33 potential disposal sites plus 2 Federal sites.

422. Using cost curves and data developed for the D2M2 model weighted dredging costs per cubic yard were developed for each area as a function of distance from dredging locations. Costs were also developed for diking and acquisition per cubic yard of ultimate site capacity as components of a site cost per cubic yard. This was used to rank sites as high, moderate or low cost based on the following ranges. In the Delaware River and Delaware Bay a low cost site was any site under $4.50 per cubic yard. In order for a site to be ranked moderate in the Delaware River the cost ranged

from $4.50 to $6.50 a cubic yard. Due to the large number of available and probably acceptable sites in the Delaware River ranges the price range was kept narrow. In the Delaware Bay the channel ranges from 5 to over 15 miles from the shore. This forced the moderate cost up between $4.50 to $10.00 in order to attract more environmentally desirable alternatives. Otherwise the cost prohibitive choice of hauling material upriver to a Delaware River site would have to be considered. High costs sites were greater than $6.50 for the Delaware River and greater than $10.00 for the Delaware Bay.

423. The habitat and land cover as well as other critical environmental and cultural values at each site were described and quantified in order to assess the significance of impacts and the probable need for mitigation at each site. Impacts were summarized as high, moderate, and low and mitigation requirements assessed citing acreage and habitat type. Using these comparisons of cost and impact the sites in each reach were classified and screened. All low cost sites in each reach regardless of environmental impact and moderate cost sites with low impact were carried forward. Table 24 and Table 24A shows the results of this analysis. Based on this analysis ten new upland and seven aquatic sites in the Delaware River and the Delaware Bay 19 remaining sites were recommended for consideration in detailed formulation analyses which passed the previous disposal cycle utilized a more detailed incremental costs analysis including incremental mitigation to prepare a final ranking of disposal based on the disposal requirements of the Delaware River Main Channel in the Delaware Bay. Variations of island/marsh creation and upland creation warrant consideration for the aquatic sites. No sites which may have been economically more advantageous were eliminated from consideration at any time in the screening process solely due to environmental factors. Where modification of site boundaries (avoidance) was possible by shifting a border and least costly, this environmentally preferred option was chose.

CYCLE 7 - DISPOSAL AREA SCHEME SELECTION

424. This final analysis of disposal areas utilized a more detailed incremental cost analysis including incremental mitigation to prepare a final ranking of disposal areas based on the disposal requirements of a 45 foot deep full width channel. This is in compliance with Corps Policy Guidance subject, Management of Material Dredged from Navigation Channels dated May 18, 1989. Both initial and ultimate disposal capacity requirements were used in determining the size and in some cases the number of disposal sites considered. Initial costs were evaluated using acquisition costs, mobilization and demobilization costs, and dredging and disposal costs for a given disposal area or areas. To these construction costs were added the costs associated with mitigation

of environmentally sensitive habitat. The total cost of initial construction was converted to an annualized cost and added to the average annual maintenance cost to determine total average annual cost.

425. In the Delaware River reaches 17 separate new sites which passed the previous disposal cycle analysis plus the two Federal disposal sites (Reedy Island North and South) and the 19 remaining bay sites were combined into 19 disposal scenarios. These scenarios are evaluated in Table 28. In addition thin layering was evaluated in Reaches C and D where sufficient river bottom exists beyond 2000 feet of a channel, to handle the disposal requirements of initial construction in these reaches.

426. The two scenarios in reach A, both involve use of a single upland disposal site. Site 17G is slightly less expensive (3%) than site 170; neither requires mitigation. However, during this time site 17G was being designed for a $1 billion waterfront project called Imperial Landing. Included on this project is a 1,500 slip marina, 4,700 housing units and 2.5 million square feet commercial space, plus a golf course, ferry service, and an equestrian center. The project is before the West Deptford Township planning board and township committee for final approval. Development is expected to begin shortly, and the site will not be available for use as a disposal site. As a result, site 170 would be the best site for use in Reach A.

427. There are six scenarios in Reach B, three involving upland sites and three aquatic. The three upland scenarios were less expensive than aquatic disposal, even without mitigation costs included.

TABLE 27
CYCLE 6 SCREENING OF DISPOSAL AREAS

SITE/ REACH	ACRES	CAPACITY	COST $/C.Y.	LAND USE AND COVER	FISH & WILDLIFE IMPACTS	MITIGATION REQUIREMENTS	CULTURAL RESOURCE IMPACTS	COST RANKING	ENV IMPACT	CONTINUE TO EVALUATE
13F UPLAND REACH A	140	4.9 MCY	7.70	20 ACRES WOODS 120 ACRES CULT. FIELD	MODERATE	NONE	NONE KNOWN	HIGH	MODERATE	NO
17A UPLAND REACH A	130	4.5 MCY	8.00	10 ACRES WOODS 120 ACRES CULT. FIELD	LOW	NONE	NONE KNOWN	HIGH	LOW	NO
17B UPLAND REACH A	120	4.2 MCY	8.00	20 ACRES WOODS 100 ACRES CULT. FIELD	LOW	NONE	NONE KNOWN	HIGH	LOW	NO
17C UPLAND REACH A	120	5.2 MCY	7.50	120 ACRES CULT. FIELD	LOW	NONE	NONE KNOWN	HIGH	LOW	NO
17D UPLAND REACH A	100	3.5 MCY	7.30	5 ACRES WOODS 95 ACRES CULT. FIELD	LOW	NONE	NAT REGISTER SITES	HIGH	MODERATE	NO
17G UPLAND REACH A	295	20.9 MCY	3.10	30 ACRES CULT. FIELD 265 ACRES OF FIELD	LOW	NONE	NONE KNOWN	LOW	LOW	YES
17O UPLAND REACH A	300	11 MCY	3.20	30 ACRES CULT. FIELD 210 ACRES WOODS 30 ACRES LAND FIELD 30 ACRES WETLANDS	MODERATE	30 ACRES WETLANDS	SEVERAL PREHIST. REGISTER SITES	LOW	MODERATE	YES

TABLE 27 (CONT'D)

CYCLE 6 SCREENING OF DISPOSAL AREAS
(Cont'd)

SITE/ REACH	ACRES	CAPACITY	COST $/C.Y.	LAND USE AND COVER	FISH & WILDLIFE IMPACTS	MITIGATION REQUIREMENTS	CULTURAL RESOURCE IMPACTS	COST RANKING	ENV IMPACT	CONTINUE TO EVALUATE
15D UPLAND REACH B	575	40.3 MCY	3.20	200 ACRES ABAN. FIELD 275 ACRES CULT FIELD	LOW	NONE	PREHISTORIC SITES KNOWN	LOW	MODERATE	YES
RACCOON UPLAND REACH B	600	40 MCY	2.40	600 ACRES ABAN. FIELD	LOW	NONE	NONE	LOW	LOW	YES
15E UPLAND REACH B	120	7.6 MCY	3.60	60 ACRES CULT. FIELD 40 ACRES ABAN. FIELD 20 ACRES WETLAND	MODERATE	20 ACRES WETLAND	POSSIBLE	LOW	MODERATE	YES
15F UPLAND REACH B	145	6.5 MCY	4.70	145 ACRES ABAN. FIELD	LOW	NONE	NONE KNOWN	MODERATE	LOW	YES
15G UPLAND REACH B	320	20.0 MCY	3.50	320 ACRES ABAN. FIELD	LOW	NONE	NONE KNOWN	LOW	LOW	YES
15H AQUATIC TO ISLAND (+15') REACH B	455	17 MCY	5.10	75 ACRES SHALLOWS 100 ACRES TIDAL FLATS 280 ACRES DEEP RIVER	MODERATE	75 ACRES SHALLOWS 100 ACRES TIDAL FLATS	NONE	MODERATE	MODERATE	NO
15I AQUATIC TO ISLAND (+15') REACH B	775	21 MCY	5.20	165 ACRES TIDAL FLATS 265 ACRES SHALLOWS 180 ACRES DEEP WATER 65 ACRES WETLANDS	HIGH	165 ACRES TIDAL FLATS 265 ACRES SHALLOWS 65 ACRES WETLANDS	NONE	MODERATE	HIGH	NO

TABLE 27 (CONT'D)

CYCLE 6 SCREENING OF DISPOSAL AREAS
(Cont'd)

SITE/ REACH	ACRES	CAPACITY	COST $/C.Y.	LAND USE AND COVER	FISH & WILDLIFE IMPACTS	MITIGATION REQUIREMENTS	CULTURAL RESOURCE IMPACTS	COST RANKING	ENV IMPACT	CONTINUE TO EVALUATE
15I AQUATIC TO UPLAND (+50') REACH B	775	50 MCY	3.70	165 ACRES TIDAL FLATS 265 ACRES SHALLOWS 180 ACRES DEEP WATER 65 ACRES WETLANDS	HIGH	165 ACRES TIDAL FLATS 265 ACRES SHALLOWS 65 ACRES WETLANDS	NONE	LOW	HIGH	YES
15J AQUATIC TO ISLAND (+15') REACH B	895	27 MCY	4.30	125 ACRES TIDAL FLATS 320 ACRES SHALLOWS 430 DEEP WATER	HIGH	125 ACRES TIDAL FLATS 320 ACRES SHALLOWS	NONE	LOW	HIGH	YES
15J AQUATIC TO UPLAND (+50') REACH B	895	60 MCY	3.70	125 ACRES TIDAL FLATS 320 ACRES SHALLOWS 430 DEEP WATER	HIGH	125 ACRES TIDAL FLATS 320 ACRES SHALLOWS	NONE	LOW	HIGH	YES
16O AQUATIC TO ISLAND (+15') REACH B	1400	50 MCY	4.30	460 ACRES INTERTIDAL 590 ACRES SHALLOWS 100 ACRES DEEP WATER 250 ACRES WETLAND	HIGH	460 ACRE INTERTIDAL 590 ACRES SHALLOWS 250 ACRES WETLAND	NONE	LOW	HIGH	YES
16M UPLAND REACH B	155	5.2 MCY	7.00	155 ACRES CULT. FIELD	LOW	NONE	NONE KNOWN	HIGH	LOW	NO
16Y UPLAND REACH B	220	9.4 MCY	6.90	145 ACRES CULT. FIELD 60 ACRES WOODS 15 ACRES WETLANDS 3000 STREAM	MODERATE	15 ACRES WETLAND	NONE KNOWN	HIGH	LOW	NO
21E UPLAND REACH B	150	5.0 MCY	6.70	150 ACRES CULT. FIELD	LOW	NONE	NONE KNOWN	HIGH	LOW	NO
21F UPLAND REACH B	100	3.7 MCY	7.00	100 ACRES CULT. FIELD	LOW	NONE	NONE KNOWN	HIGH	LOW	NO

TABLE 27 (CONT'D)

CYCLE 6 SCREENING OF DISPOSAL AREAS

SITE/ REACH	ACRES	CAPACITY	COST $/C.Y.	LAND USE AND COVER	FISH & WILDLIFE IMPACTS	MITIGATION REQUIREMENTS	CULTURAL RESOURCE IMPACTS	COST RANKING	ENV IMPACT	CONTINUE TO EVALUATE
21 Y UPLAND REACH B	130	4.5 MCY	7.30	130 ACRES CULT. FIELD	LOW	NONE	NONE KNOWN	HIGH	LOW	NO
22BB UPLAND REACH B	300	10.8 MCY	7.50	200 ACRES CULT. FIELD 40 ACRES WOODS 60 ACRES ABAN. FIELD	MODERATE	NONE	NONE KNOWN	HIGH	MODERATE	NO
21D UPLAND REACH C	100	3.9 MCY	6.80	90 ACRES CULT. FIELD 500' STREAM 10 ACRES WOODS	MODERATE	NONE	NONE KNOWN	HIGH	MODERATE	NO
23C UPLAND REACH C	200	6.9 MCY	6.20	200 ACRES CULT. FIELD	LOW	NONE	NONE KNOWN	MODERATE	LOW	YES
23D UPLAND REACH C	200	6.9 MCY	6.40	200 ACRES CULT. FIELD	LOW	NONE	NONE KNOWN	MODERATE	LOW	YES
25I UPLAND REACH C	140	6.5 MCY	5.70	140 ACRES CULT. FIELD	LOW	NONE	NAT. REGISTER DISTRICT	MODERATE	MODERATE	NO
20A AQUATIC TO ISLAND (+15') REACH C	1170	33 MCY	4.20	70 ACRES SHALLOWS 1100 ACRES DEEP WATER	MODERATE	70 ACRES SHALLOWS	NONE	LOW	MODERATE	YES

TABLE 27 (CONT'D)

CYCLE 6 SCREENING OF DISPOSAL AREAS

SITE/ REACH	ACRES	CAPACITY	COST $/C.Y.	LAND USE AND COVER	FISH & WILDLIFE IMPACTS	MITIGATION REQUIREMENTS	CULTURAL RESOURCE IMPACTS	COST RANKING	ENV IMPACT	CONTINUE TO EVALUATE
20A AQUATIC TO UPLAND (+50') REACH C	1170	98 MCY	3.10	70 ACRESS SHALLOWS 1100 ACRES DEEP WATER	MODERATE	70 ACRES SHALLOWS	NONE	LOW	MODERATE	YES
24E AQUATIC TO ISLAND (+15') REACH C	3535	72 MCY	3.90	3435 ACRES SHALLOWS 100 ACRES DEEP WATER	HIGH	3435 ACRES SHALLOWS	NONE	LOW	HIGH	YES
24G AQUATIC TO ISLAND (+15') REACH C	3500	72 MCY	4.50	3300 ACRES SHALLOWS 200 ACRES DEEP WATER	HIGH	3500 ACRES SHALLOWS	NONE	LOW	HIGH	YES
24O UPLAND REACH D	295	10.6 MCY	6.30	285 ACRES CULT. FIELD 10 ACRES WETLANDS	MODERATE	10 ACRES WETLANDS	NONE KNOWN	MODERATE	MODERATE	NO
25J UPLAND REACH D	145	6.6 MCY	6.40	145 ACRES CULT FIELD	LOW	NONE	NONE KNOWN	MODERATE	LOW	YES
27H AQUATIC TO ISLAND (+15') REACH D	470	5.7 MCY	8.30	460 ACRES SHALLOW 10 ACRES WETLAND	HIGH	460 ACRES SHALLOWS 10 ACRES WETLAND	NONE KNOWN	HIGH	HIGH	NO
27H AQUATIC TO UPLAND (+50') REACH D	470	18.1 MCY	6.10	460 ACRES SHALLOW 10 ACRES WETLAND	HIGH	460 ACRES SHALLOW 10 ACRES WETLAND	NONE KNOWN	MODERATE	HIGH	NO

TABLE 27 (CONT'D)

CYCLE 6 SCREENING OF DISPOSAL AREAS

SITE/ REACH	ACRES	CAPACITY	COST $/C.Y.	LAND USE AND COVER	FISH & WILDLIFE IMPACTS	MITIGATION REQUIREMENTS	CULTURAL RESOURCE IMPACTS	COST RANKING	ENV IMPACT	CONTINUE TO EVALUATE
271 AQUATIC TO ISLAND (+15') REACH D	700	14 MCY	5.50	700 ACRES SHALLOWS	HIGH	700 ACRES SHALLOWS	NONE KNOWN	MODERATE	HIGH	NO
271 AQUATIC TO UPLAND (+50') REACH D	700	45 MCY	4.10	700 ACRES SHALLOWS	HIGH	700 ACRES SHALLOWS	NONE KNOWN	LOW	HIGH	YES

TABLE 27 (CONT'D)
CYCLE 6 SCREENING OF DISPOSAL AREAS
LOWER MIAH MAULL/UPPER BRANDYWINE RANGE

SITE/REACH	ACRES	CAPACITY	COST $/C.Y.	LAND USE WILDLIFE IMPACTS	FISH & WILDLIFE IMPACTS	MITIGATION REQUIREMENTS	CULTURAL RESOURCE IMPACTS	COST RANKING	ENV IMPACT	CONTINUE TO EVALUATE
PN 1 Wetland Restoration Reach E	200	3.8 MCY	9.45	50 Acres of tidal flats 150 acres shallows	Moderate	Pending*	None Known	Moderate	Moderate	Yes
FR 19 Upland Reach E	170	3.3 MCY	20.25	170 Acres cult. filed	Low	None	None Known	High	Low	No
MS 3 Upland Reach E	250	4.8 MCY	20.25	50 Acres woods 200 Acres cult. filed	Low	None	None Known	High	Low	No
MS 12 Upland Reach E	230	4.4 MCY	20.65	160 Acres cult. filed 70 Acres woods	Low	None	None Known	High	Low	No
ML 1 Upland Reach E	190	3.6 MCY	20.00	190 Acres Cult. Field	Low	None	None Known	High	Low	No
ML 2 Upland Reach E	210	4.0 MCY	20.00	200 Acres cult. field 10 acres woods	Low	None	None Known	High	Low	No
ML 4 Upland Reach E	190	3.6 MCY	20.00	160 Acres cult. field 30 acres land field	Low	None	None Known	High	Low	No
I 3 Island Creation Reach E	110	2.1 MCY	7.10	110 Acres shallows	Moderate	Pending*	None Known	Moderate	Moderate	Yes
I 1 Island Creation Reach E	200	3.8 MCY	7.85	200 Acres deepwater	Moderate	Pending*	None Known	Moderate	Moderate	Yes
LC 2 Upland Reach E	210	4.0 MCY	21.35	190 Acres cult. field 20 Acres woods	Low	None	None Known	High	Low	No

* Pending Benthic Testing

TABLE 27 (CONT'D)
CYCLE 6 SCREENING OF DISPOSAL AREAS
LOWER BRANDYWINE RANGE

SITE/REACH	ACRES	CAPACITY	COST $/C.Y.	LAND USE AND COVER	FISH & WILDLIFE IMPACTS	MITIGATION REQUIREMENTS	CULTURAL RESOURCE IMPACTS	COST RANKING	ENV IMPACT	CONTINUE TO EVALUATE
RD 4 Beachfill Reach E	100	1.9 MCY	12.10	100 Acres Sandy Shore Line	Low	None	None Known	Moderate	Low	Yes
OB 4 Overboard Reach E	170	3.3 MCY	4.05	170 Acres Deepwater	Moderate	170 Acres deepwater	None Known	Low	Moderate	Yes
CM 2 Upland Reach E	140	2.7 MCY	13.50	70 Acres woods 40 Acres Cult. Field 30 Acres Filed	Low	None	None Known	Moderate	Low	Yes
CM 4 Beachfill Reach E	100	1.9 MCY	13.05	100 Acres Sandy Shore Line	Low	None	None Known	Moderate	Low	Yes
CM 5/6 Beachfill Reach E	200	3.8 MCY	10.35	200 Acres Sandy Shore Line	Low	None	None Known	Moderate	Low	Yes
MS 18 Wetland Creation Reach E	200	3.8 MCY	15.10	100 Acres of Tidal Flats 100 Acres Shallows	Moderate	Pending*	None Known	High	Moderate	No
MS 19 Sand Stock Pile Reach E	200	3.8 MCY	11.15	200 Acres Shallows	Low	Pending*	None Known	Moderate	Moderate	Yes
L 1 Upland Reach E	100	3.1 MCY	19.95	100 Acres Cult. Field 60 Acres wood	Low	None	None Known	High	Low	No
L 2 Upland Reach E	135	2.6 MCY	19.95	135 Acres Cult. Field	Low	None	None Known	High	Low	No

TABLE 27

CYCLE 6 SCREENING OF DISPOSAL AREAS
LOWER BRANDYWINE RANGE

SITE/REACH	ACRES	CAPACITY	COST $/C.Y.	LAND USE AND COVER	FISH & WILDLIFE IMPACTS	MITIGATION REQUIREMENTS	CULTURAL RESOURCE IMPACTS	COST RANKING	ENV IMPACT	CONTINUE TO EVALUATE
L 3 Upland Reach E	100	1.9 MCY	19.80	100 Acres Cult. Field	Low	None	Several Pre Hist. Reg Sites	High	Low	No
L 4 Overboard Reach E	100	1.9 MCY	14.75	100 Acres Sandy Shoreline	Low	None	None Known	High	Low	Yes
L 5 Sandrock Pile Reach E	200	3.8 MCY	11.10	200 Acres Shallows	Moderate	Pending*	None Known	Moderate	Moderate	Yes
L 6 Beachfill Reach E	100	1.9 MCY	16.85	100 Acres Sandy Shoreline	Low	Pending*	None Known	Moderate	Moderate	No
L 7 Beachfill Reach E	100	1.9 MCY	16.85	100 Acres Sandy Shore Line	Low	Pending*	None Known	High	Moderate	No

* Pending Benthic Testing

TABLE 27 (CONT'D)
CYCLE 6 SCREENING OF DISPOSAL AREAS
LOWER LISTON/UPPER CROSS LEDGE RANGE

SITE/REACH	ACRES	CAPACITY	COST $/C.Y.	LAND USE AND COVER	FISH & WILDLIFE IMPACTS	MITIGATION REQUIREMENTS	CULTURAL RESOURCE IMPACTS	COST RANKING	ENV IMPACT	CONTINUE TO EVALUATE
C 2 Upland Reach E	100	1.9 MCY	15.70	80 Acres Woods 20 Acres Cult. Field	Low	None	None Known	High	Low	No
C 11 Upland Reach E	100	1.9 MCY	10.30	10 Acres Woods 80 Acres Cult. Field	Low	None	None Known	Moderate	Low	Yes
C 13 Island Creation Reach E	160	3.1 MCY	7.50	160 Acres Field	Moderate	None	None Known	Moderate	Moderate	Yes
LC 9 Wetland Creation Restoration Reach E	200	3.8 MCY	7.35	200 Acres Shallows	Moderate	None	None Known	Moderate	Moderate	Yes

TABLE 27 (CONT'D)
CYCLE 6 SCREENING OF DISPOSAL AREAS
LOWER CROSS LEDGE/UPPER MIAH MAULL RANGE

SITE/REACH	ACRES	CAPACITY	COST $/C.Y.	LAND USE AND COVER	FISH & WILDLIFE IMPACTS	MITIGATION REQUIREMENTS	CULTURAL RESOURCE IMPACTS	COST RANKING	ENV IMPACT	CONTINUE TO EVALUATE
F 1 Wetland Creation Reach E	200	3.8 MCY	10.00	40 Acres of Tidal flats 160 Acres of shallows	Moderate	Pending*	None Known	Moderate	Moderate	Yes
F 2 Island Creation Reach E	215	4.1 MCY	9.25	215 Acres shallows	Low	Pending*	None Known	Moderate	Moderate	Yes
F 3 Beachfill Reach E	100	1.9 MCY	12.10	100 Acres Sandy Shoreline	Low	None	None Known	Moderate	Low	Yes
RD 1 Upland Reach E	120	2.32 MCY	31.75	80 Acres Cult. Field 20 Acres Residential 20 Acres wood	Low	None	None Known	High	Moderate	No
LC 10 Sand Stockpile Reach E	200	3.8 MCY	8.25	200 Acres shallows	Low	Pending*	None Known	High	Moderate	No
BP 1 Upland Reach E	160	3.1 MCY	20.75	100 Acres woods 20 Acres Land Field 40 Acres Woods	Moderate	None	None Known	High	Low	No
BP 2 Upland Reach E	170	3.3 MCY	19.75	150 Acres Woods 20 Acres Land Field	Moderate	None	None Known	High	Low	No
CV 1 Beachfill Reach E	100	1.9 MCY	30.00	100 Acres Sandy Shoreline	Low	None	None Known	High	Low	No

* Pending Benthic Testing

TABLE 28
CYCLE 7 DISPOSAL AREA SCHEME SELECTION
(COST IN THOUSANDS DOLLARS)

ITEM	REACH A 170	REACH A 17G	REACH B 15D	REACH B RACCON ISL.	REACH B COMBINATION 15E,F,&G	REACH B 15I/DIKED UPLAND	REACH B 15J/DIKED UPLAND	REACH B 160-ISLAND
ACREAGE (AC)	300	295	575	600	585	775	895	1400
INITIAL COST	$36,504	$35,472	$57,337	$58,976	$61,143	$162,677	$133,534	$236,249
FEDERAL SITE REPLACEMENT	$0	$0	$0	$0	$0	$0	$0	$0
ENVIRONMENTAL CONCERNS/CRITERIA	MINOR WETLANDS	NONE	NONE	NONE	MINOR WETLANDS	NURSERY, SPAWNING AND FORAGING HABITAL	NURSERY, SPAWNING AND FORAGING HABITAL	NURSERY, SPAWNING AND FORAGING HABITAL
FOR:	----	----	----	----	----	MODERATE WETLANDS SHALLOW WATER HABITAT INTERTIDAL HABITAT	SHALLOW WATER HABITAT INTERTIDAL HABITAT	SHALLOW WATER HABITAT INTERTIDAL HABITAT MAJOR WETLANDS
DISPOSAL AREA MITIGATION	30 ACRES WETLANDS AVOIDANCE	NONE	NONE	NONE	CREATE 20 ACRES OF WETLANDS	200 AC INTERTIDAL 310 AC SHALLOWS AVOID WETLANDS	125 AC INTERTIDAL 320 AC SHALLOWS	460 AC INTERTIDAL 390 AC SHALLOWS 250 AC WETLAND
DISPOSAL AREA MITIGATION COSTS	$0	$0	$0	$0	DIKE $132 PLACE MATERIAL $240	DIKE '$73,500 PLACE MATERIAL $6,120	DIKE $94,850 PLACE MATERIAL $5,340	DIKE $168,350 PLACE MATERIAL $13,200
TOTAL INITIAL COSTS	$36,504	$35,472	$57,337	$58,976	$61,515	$242,297	$233,724	$417,799
AMORTIZED FIRST COSTS	$ 3,286	$ 3,194	$ 5,162	$ 5,310	$ 5,538	$ 21,815	$ 21,043	$ 37,615
ANNUAL O&M REQUIREMENTS	40,000 cy.	40,000 cy.	820,000 cy.	820,000 cy.	820,000 cy.	820,000 cy.	820,000 cy.	820,000 cy.
AVG. ANNUAL MAINT. COST	$ 142	$ 142	$ 3,132	$ 3,222	$ 3,572	$ 2,113	$ 2,113	$ 2,113
TOTAL AVG. ANNUAL COST	$ 3,428	$ 3,336	$ 8,294	$ 8,532	$ 9,110	$ 23,928	$ 23,156	$ 39,728

TABLE 28 (CONT'D)

CYCLE 7 DISPOSAL AREA SCHEME SELECTION
(COSTS IN THOUSAND DOLLARS)

ITEM	REACH C 23C/23D AND 24I (REDUCED IS.)	REACH C 23C/23D AND READY IS. NORTH	REACH C 20A/DIKED ISLAND	REACH C 20A/DIKED UPLAND	REACH C 24E/DIKED ISLAND	REACH C 24G/DIKED ISLAND	REACH C TRANSFER TO RACCOON ISLAND	REACH C READY ISLAND NORTH AND SOUTH 23C
ACREAGE (AC)	650	520	1170	350	1450	1400	600	200
INITIAL COST	$132,294	$71,336	$165,305	$80,411	$208,721	$202,156	$52,873	$70,735
FEDERAL SITE REPLACEMENT	$0	$12,650	$0	$0	$0	$0	$0	$36,800
ENVIRONMENTAL CONCERNS/CRITERIA	NURSERY, SPAWNING AND FORAGING HABITAT	NONE	NURSERY, SPAWNING AND FORAGING HABITAT	NURSERY, SPAWNING AND FORAGING HABITAT	NURSERY, SPAWNING AND FORAGING HABITAT	NURSERY, SPAWNING AND FORAGING HABITAT	NONE	NONE
FOR:	SHALLOW WATER HABITAT	----	----	SHALLOW WATER HABITAT	SHALLOW WATER HABITAT	SHALLOW WATER HABITAT	----	----
DISPOSAL AREA MITIGATION	250 ACRES SHALLOWS	NONE	70 ACRES SHALLOWS	50 ACRES SHALLOWS	1450 ACRES SHALLOWS	1400 SHALLOWS AVOID WETLANDS	NONE	NONE
DISPOSAL AREA MITIGATION COSTS	DIKE $570 PLACE MATERIAL $3000	$0	DIKE $310 PLACE MATERIAL $840	DIKE $270 PLACE MATERIAL $600	DIKE $101,500 PLACE MATERIAL $1,740	DIKE $98,000 PLACE MATERIAL $1,680	$0	$0
TOTAL INITIAL COSTS	$135,864	$83,986	$166,455	$81,281	$311,961	$301,836	$52,873	$107,535
AMORTIZED FIRST COSTS	$ 12,232	$ 7,561	$14,986	$ 7,318	$ 28,086	$ 27,175	4,760	$9,682
ANNUAL O&M REQUIREMENTS	420,000 cy.	420,000 cy.	420,000 cy.	420,000 cy.	420,000 cy.	420,000 cy.	420,000 cy.	420,000 cy.
AVG. ANNUAL MAINT. COST	$ 1,704	$ 1,704	$ 1,432	$ 1,432	$ 1,432	$ 1,432	$ 1,704	$ 1,527
TOTAL AVG. ANNUAL COST	$ 13,936	$ 9,265	$16,418	$ 8,750	$ 29,518	$ 28,607	$ 6,464	$ 11,043

TABLE 28 (CONT'D)

CYCLE 7 DISPOSAL AREA SCHEME SELECTION
(COSTS IN THOUSAND DOLLARS)

ITEM	REACH C THIN LAYERING	REACH D READY ISLAND NORTH AND SOUTH	REACH D 271/ISLAND	REACH D 240	REACH D THIN LAYERING
ACREAGE (AC)	5000	0	0	295	5200
INITIAL COST	$ 29,867	$43,444	$ 93,699	$58,124	$ 51,183
FEDERAL SITE REPLACEMENT	$ 38,410	$14,250	$0	$0	$ 8,930
ENVIRONMENTAL CONCERNS/CRITERIA	TURBIDITY	NONE	NURSERY, SPAWNING AND FORAGING HABITAT	NONE	TURBIDITY
FOR:	----	----	SHALLOW WATER HABITAT	----	----
DISPOSAL AREA MITIGATION	NONE	NONE	415 ACRES SHALLOWS	NONE	NONE
DISPOSAL AREA MITIGATION COSTS	$0	$0	DIKE $1180 PLACE MATERIAL $4980	$0	$0
TOTAL INITIAL COSTS	$ 68,637	$57,694	$99,859	$58,124	$60,113
AMORTIZED FIRST COSTS	$ 6,180	$ 5,194	$ 8,990	$ 5,233	$ 5,412
ANNUAL O&M REQUIREMENTS	630,000 cy.	60,000 cy.	60,000 cy.	60,000 cy.	90,000 cy.
AVG. ANNUAL MAINT. COST	$ 2,143	$ 354	$ 354	$ 624	$ 531
TOTAL AVG. ANNUAL COST	$ 8,323	$ 5,548	$ 9,344	$ 5,857	$ 5,943

TABLE 28 (CONT'D)
CYCLE 7 DISPOSAL AREA SCHEME SELECTION
(COSTS IN THOUSAND DOLLARS)
FOR
LOWER LISTON/UPPER CROSS LEDGE RANGE

SITE NAME/ TYPE	C11 UPLAND	C13 ISLAND CREATION	LC9 WETLAND RESTORATION
ACREAGE (AC) INITIAL COST	100 $10,500	160 $8,900	200 $8,900
FEDERAL SITE REPLACEMENT	0	0	0
ENVIRONMENTAL CONCERNS/CRITERIA	None	Nursery, spawning and foraging habitat	Nursery, spawning and foraging habitat
FOR:	------	Shallow water habitat	Shallow water habitat
DISPOSAL AREA MITIGATION	None	None, site selection to avoid critical areas*	None, site selection to avoid critical areas*
DISPOSAL AREA MITIGATION COST	0	0	0
TOTAL INITIAL COSTS	$10,500	$8,900	$8,900
AMORTIZED FIRST COSTS	$932.8	$790.7	$790.7
ANNUAL O&M REQUIREMENTS	58,200cy	58,200cy	58,200cy
AVG. ANNUAL MAINT. COST	$145.5	$145.5	$145.5
TOTAL AVG. ANNUAL COST	$1,078	$936.2	$936.2

* Final site boundary will be based on detailed benthic testing in Preconstruction, Engineering and Design (PED) phase

TABLE 28 (CONT'D)
CYCLE 7 DISPOSAL AREA SCHEME SELECTION
(COSTS IN THOUSAND DOLLARS)
FOR
CROSS LEDGE/UPPER MIAH MAULL RANGE

SITE NAME/ TYPE	LC10/FR28 SAND STOCK PILE	F1 WETLAND CREATION	F2 ISLAND CREATION	F3 BEACHFILL
ACREAGE (AC) INITIAL COST	100 $13,120	280 $27,230	215 $28,030	100 $17,070
FEDERAL SITE REPLACEMENT	0	0	0	0
ENVIRONMENTAL CONCERNS/CRITERIA	Nursery, spawning and foraging habitat	Nursery, spawning and foraging habitat	Nursery, spawning and foraging habitat	NONE
FOR:	Shallow water habitat	Shallow water habitat	Shallow water habitat	-----
DISPOSAL AREA MITIGATION	None, site selection to avoid critical areas*	None, site selection to avoid critical areas*	None, site selection to avoid critical areas*	NONE
DISPOSAL AREA MITIGATION COST	---	---	---	---
TOTAL INITIAL COSTS	$13,120	$27,230	$28,030	$17,070
AMORTIZED FIRST COSTS	$1,165.6	$2,419.1	$2,490.2	$1,516.5
ANNUAL O&M REQUIREMENTS/	2,500cy	2,500cy	2,500cy	2,500cy
AVG. ANNUAL MAINT. COST	$6.3	$6.3	$6.3	$6.3
TOTAL AVG. ANNUAL COST	$1,171.9	$2,496.5	$2,496.5	$1,522.8

* Final site boundary will be based on detailed benthic testing in Preconstruction, Engineering and Design (PED) phase

TABLE 28 (CONT'D)
CYCLE 7 DISPOSAL AREA SCHEME SELECTION
(COSTS IN THOUSAND DOLLARS)
FOR
LOWER MIAM MAULL/UPPER BRANDY WINE RANGE

SITE NAME/ TYPE	I 1 ISLAND CREATION	PM1 WETLAND RESTORATION	I3 ISLAND CREATION
ACREAGE (AC) INITIAL COST	200 $14,800	200 $14,400	110 $14,400
FEDERAL SITE REPLACEMENT	0	0	0
ENVIRONMENTAL CONCERNS/CRITERIA	Nursery, spawning and foraging habitat	Nursery, spawning and foraging habitat	Nursery, spawning and foraging habitat
FOR:	Shallow water habitat	Shallow water habitat	Shallow water habitat
DISPOSAL AREA MITIGATION	None, site selection to avoid critical areas*	None, site selection to avoid critical areas*	None, site selection to avoid critical areas*
DISPOSAL AREA MITIGATION COSTS	0	0	0
TOTAL INITIAL COSTS	$14,800	$14,400	$14,400
AMORTIZED FIRST COSTS	$1,314.8	$1279.3	$1279.3
ANNUAL O&M REQUIREMENTS	900cy	900cy	900cy
AVG. ANNUAL MAINT. COST	$2.3	$2.3	$2.3
TOTAL AVG. ANNUAL COST	$1,317.2	$1,281.6	$1.281.6

* Final site boundary will be based on detailed benthic testing in Preconstruction, Engineering and Design (PED) phase

TABLE 28 (CONT'D)
CYCLE 7 DISPOSAL AREA SCHEME SELECTION
(COSTS IN THOUSAND DOLLARS)
FOR
LOWER BRANDYWINE RANGE

SITE NAME/ TYPE	RD4 BEACHFILL	OB4 OVERBOARD	CM2 UPLAND	MS19 SANDSTOCK PILE	CM4 BEACHFILL	CM5/6 BEACHFILL	L4 BEACHFILL	L5 SANDSTOCK PILE
ACREAGE (AC) INITIAL COST	100 $32,680	170 $33,855	140 $27,570	200 $25,080	100 $32,680	200 $ 32,680	100 $ 32,680	200 $25,080
FEDERAL SITE REPLACEMENT	0	0	0	0	0	0	0	0
ENVIRONMENTAL CONCERNS/CRITERIA	NONE	Blue crab wintering, critical fish wintering area	NONE	Nursery, spawning and foraging habitat	NONE	NONE	NONE	Nursery, spawning and foraging habitat
FOR:	-----	Deep water habitat	-----	Shallow water habitat	-----	-----	-----	Shallow water habitat
DISPOSAL AREA MITIGATION	NONE	Due to large quantities, mitigation by alternative deep water site improvement	NONE	None, site selection to avoid critical areas*	NONE	NONE	NONE	None, site selection to avoid critical areas*
DISPOSAL AREA MITIGATION COST	0	11,285	0	0	0	0	0	0
TOTAL INITIAL COSTS	$32,680	$33.855	$27,570	$25.080	$32,680	32,680	32,680	25,080
AMORTIZED FIRST COSTS	$2903.3	$3,007.7	$2449.3	$2,228.1	$2903.3	29022 0	29033 0	2,228.1 0
ANNUAL O&M REQUIREMENTS	6000cy	6000cy	6000cy	6000cy	6000cy	15.0 2918.3	15.0 2,918.3	15.0 2,243.1
AVG. ANNUAL MAINT. COST	$15.0	$15.0	$15.0	$15.0	$15.0			
TOTAL AVG. ANNUAL COST	$2,918.3	$3,022.7	$2,464.3	$2,243.1	$2918.3			

* Final site boundary will be based on detailed benthic testing in Preconstruction, Engineering and Design (PED) phase

428. There were 9 scenarios evaluated in Reach C. The 2 candidate upland sites, the 2 existing Federal sites, and 3 aquatic sites were evaluated in 6 combinations. In addition the use of one inexpensive site in Reach B, plus thin layering of initial construction was also evaluated. Transfer of material to the Raccoon Island disposal site was found to be the least expensive, with the added cost of farther transport more than offset by lower disposal area construction costs.

429. In Reach D, four scenarios were evaluated. Two looked at upland disposal, one considered creating an island, and one thin layering. Use of the existing Reedy Island North and Reedy Island South was the least expensive.

430. In conclusion, in the upper Reaches A,B,C, and D 5 upland disposal sites were determined to be the NED sites for disposal of dredged material associated with channel deepening for the Delaware River. These include three new upland sites, (17O, 15D, plus Raccoon Island), plus the existing Reedy Island North and Reedy Island South disposal sites. Only those sites which were most economically advantageous were selected, once environmental and cultural mitigation costs were included and engineering feasibility and institutional acceptability assured.

431. In Reach E, based on the costs shown in Table 25, LC 9 (Port Mahon) or C 13 (Alder Cove) were determined to be the NED disposal plans for the disposal of dredged material associated with Lower Liston/ Upper Cross Ledge Range. Due to the closeness of the cost comparisons, final selection will await the findings of the PED studies. FR 28/ LC 10 (sand stockpiles off of Kitts Hummock and Pickering Beach, shown in table 7-13) was determined to be the NED disposal plan for the disposal of dredged material associated with the Lower Cross Ledge/Upper Miah Maull Range. Table 7-14 shows island creation at I3 (lower Middle Shoal), and wetland restoration at PN 1 (Maurice River Cove area) were determined to be the NED disposal plan for the disposal of dredged material associated with the Lower Miah Maull/Upper Brandywine Range. Again the closeness of the cost comparison will force final selection to wait for the results of the PED studies. Sand stockpiles off of Lewis/ Broadkill, Beach (LS) and Slaughter Beach (MS-19) (Table 7-15) were determined to be the NED disposal plan for the disposal of dredged material associated with the Lower Brandywine Range. Final selection of these options will await completion of the detailed benthic studies to be conducted during the PED phase. If the studies reveal that significant mitigation is required for sand stockpile areas then the beachfill options could become the NED plan.

CYCLE 8 - ASSESSMENT AND EVALUATION OF DETAILED PLANS

432. The final cycle of formulation was accomplished to evaluate alternative channel deepening plans and conduct economic optimization of the project features including channel depth,

disposal area usage, project length, navigation aid requirements, and full width versus asymmetric channel plans. Provision of a two space anchorage was included in the planning. Consideration was also given to environmental and cultural impacts, the need for mitigation, and the potential for wetlands creation under Section 150 of Public Law 94-587.

433. CHANNEL FORMULATION. Three channel options were considered. All would follow the existing channel alignment and would extend from the bay mouth up to Philadelphia Harbor. They are presented in order of relative scope. The first option, a minimum width asymmetric channel, would minimize costs while accounting for predominant import commodities. Previous analyses concluded that only by including all of the oil refineries (except Texaco) can sufficient vessel traffic benefit to justify the costs of dredging a lengthy river channel. By extending the deepened channel about 2 miles upstream from Eagle Point (the uppermost refinery location) to near the Walt Whitman Bridge, Conrail's Pier 122 and the Packer Avenue Terminal could also benefit. The second option, a more efficient asymmetric channel, was suggested by the Delaware River Pilots. The same six refineries and Conrail's Pier 122 would benefit from reduced vessel travel time and operating costs compared to the narrower asymmetric. The third option, a full width channel, would provide for two way traffic. Besides further operating savings to vessels from the six refineries and Conrail's Pier 122, an adjacent Conrail Pier 124 which exports coal would be added as well as container traffic for Packer Avenue Terminal. The channel would be extended two miles further upstream to the Beckett Street, Camden Terminal where both dry bulk imports and exports could benefit. Extending the deepening further upriver to the Beckett Street Terminal was previously found to be the upper limit of the project. This facility would require deepening of the Federal project, Delaware River in the Vicinity of Camden, in order to fully benefit from the main channel deepening.

434. Channel Depths. A range of channel depths up to 46 feet were considered. Further depths have been previously shown to lack economic justification, and that range was considered likely to bracket the optimum depth.

435. Dredging Practices. The present channel is maintained primarily by the use of contracted hydraulic dredges which pump into confined upland disposal areas. When required, advanced maintenance dredging of up to 4 feet overdepth is performed, depending on the rate of shoaling. In addition to the advanced maintenance overdepth, a separate dredging overdepth of 2 feet may occur to account for dredging inaccuracies. High shoaling areas are dredged at least every year but areas of lower shoaling may go several years between dredging. The two foot overdepth allowance is standard practice on large dredging projects. An allowance for up to an including a two foot overdepth dredging takes into account dredging inaccuracies. The inclusion of the overdepth quantities in the total project cost provides for a conservative cost estimate.

436. Starting Conditions. The amount of initial dredging was determined by use of a design section in any location where periodic maintenance has occurred. The remaining locations are either naturally deeper or previously dredged below 40 feet (a common practice in the past for mining sand) and are now relatively stable. By this breakdown, one would not inadvertently bypass a location where a post-dredging survey shows a deep location, only to later require initial dredging due to subsequent shoaling in the period before channel deepening could occur. Disposal areas were developed based on maximizing usable disposal area size in order to minimize project costs. Real estate costs for a lesser sized disposal area would only be marginally reduced, since excess partial parcels would have limited use due to their being uneconomic remnants.

437. Shoaling Analysis. The shoaling analysis performed for the Philadelphia-to-Sea channel deepening utilized an empirical data base of historic hydrographic surveys and maintenance dredging records in order to estimate the incremental maintenance dredging quantities associated with the considered alternative channel depths and alignments. The incremental maintenance dredging quantities were then used to determine the estimated annual operation and maintenance cost component (in addition to the amortized first cost of project construction) of the total average annual cost of the considered alternative.

438. The detailed analysis of shoaling rates was performed for three of the ranges of the Philadelphia-to-Sea project which together require nearly 85 per cent of the total project by length. The period of record used in the analysis of shoaling with respect to channel deepening included 1969 through 1985. During this period there were a number of maintenance dredging contracts in which depths greater than the project depth of 40 feet were obtained either through intentional advance maintenance dredging or unintended dredging beyond "pay" depth. The record of depth as a function of time at representative index stations within each of the four navigation ranges evaluated was used to determine characteristic shoaling rates subsequent to dredging. The estimates of potential future shoaling rates within the Philadelphia-to-Sea channel for alternative depths greater than the existing 40 foot depth were based on the actual shoaling characteristics observed in the critical shoaling reached of the project for dredged depths in excess of 40 feet.

439. Design Vessel. The design vessel selected for the main channel was a 145 foot beam tanker with a length of 951 feet, based on an analysis of over 1,100 bulk vessel movements in 1985 and 1986 plus guidance found in EM 1110-2-1613. Crude oil tankers are the dominant vessel type both in size and numbers, both now and throughout the study period. No colliers or iron ore ships using the Delaware River had vessel beams of over 140 feet in that two year period. The limited number of larger vessels used the channel over that two year period (11 tankers making 29 trips) could still use any of the channel options but would require better weather or limited to daylight transit; this is the present practice for these

larger ships. There has been no subsequent change in tanker vessel size based on coordination with the pilots. For the channel segments above Eagle Point a dry bulk vessel with a length of 830 feet and beam of 128 feet is the selected design vessel. The largest containerized vessel anticipated to use the channel in the future is the post-Penamax vessel with the following approximate characteristics: 55,000 DWT, 4500-5000 TEV's, length of 950 feet and a beam width of 130 feet.

440. Bend Widening. Bend widening would be required for all schemes to facilitate turning of the longer vessels now using the river and to meet current Corps design criteria. Bend widening was accomplished using the Apex Method presented in EM 1110-2-1613.

441. Channel Widths. Channel widths were established using EM 1110-2-1613 for one-way and two-way channels. The factors chosen for design in each channel segment were established as a percentage of beam width as follows:

	Delaware River	Delaware Bay
Ship Clearance Lane	80%	100%
Maneuvering Lane	180%	200%
Bank Clearance Lane	60%	100%

442. Anchorage. Partial deepening of the Marcus Hook Anchorage is included in each plan to provide a safe navigation channel. The pilots have indicated that the risk of vessel accidents and major oil spills would probably double or triple if there was no upstream anchorage at compatible depth with the deepened channel. Given the level of crude oil traffic in the river and frequency of tanker transits, tanker traffic will encounter fog, foul weather, and emergency situations which could prevent completion of a trip using high tide and must have a safe anchorage as part of the project. It is estimated that $3 to $5 million in annual clean up costs might result from major oil spills (without adequate anchorage space) if environmental damage is included, an annual cost of $30 to $50 million is not unreasonable. Criteria in EM 1110-2-1613 for a free swinging anchorage was used in the design.

443. All facilities within the study area have been investigated with regard to the need for both a turning basin and anchorage. Corps design criteria for a turning basin require a circle diameter which is 1.5 times the vessel length. The turning area may include any of the following items: the Federal Navigation Channel including bends, the private berth area of the target dock, portions of the Marcus Hook Anchorage proposed for deepening, any adjacent areas that are naturally deep. A separate area is required only if sufficient turning space cannot be found within the above categories. The ten facilities which would benefit from channel deepening were evaluated. First, the longest vessels using each facility were identified and then the Corps criteria for a turning area were applied. For all of the facilities, existing space is sufficient for turning and maneuvering. Separate turning

areas are not required. Except in four cases, sufficient maneuvering area exists solely within the area in front of the berth and the adjacent Federal channel. The specific results of each evaluation are described below.

1. Sun Oil, Marcus Hook - The largest vessel using Marcus Hook facilities is a 935 foot tanker and requires a turning circle with a 2400 foot diameter. This circle includes the berth area and the 800 foot Federal channel, and extends 100 feet into the Marcus Hook Anchorage. The second largest vessel is an 872 foot tanker. It has a turning circle which can be accommodated without requiring use of the anchorage.

2. BP, Marcus Hook - The same vessels described in Sum Oil, Marcus Hook were evaluated for this facility. The only difference is a 50 foot rather than a 100 foot extension of the largest vessel into Marcus Hook Anchorage.

3. Mobil Oil, Paulsboro - The largest vessel using this facility is a 1445 long tanker. It can turn at any time within the combined channel, berthing area, and expanded bend. This situation allows for increased flexibility because the present practice is to dock the vessel facing upstream, and turn only when the vessel is empty and extends past the existing channel.

4. Chevron, Ft. Mifflin - The largest ship visiting this facility is a 1031 foot long tanker. This vessel can turn at any time within the combined channel and berthing area.

5. Atlantic, Ft. Mifflin - The largest vessel here is also the 1031 foot long tanker. There is insufficient combined channel and berthing area for turning at the dock. However, approximately 2 miles upstream at the Eagle Point Range, sufficient channel width (1150 feet) exists to turn the ship around.

6. Eagle Point, Westville, NJ - An 876 foot tanker is the largest vessel at this facility. The tanker can turn within the combined berth and channel.

7. Conrail - The largest ships at this facility are dry bulk vessels with a maximum length of 892 feet. These vessels can dock and back out within the existing channel with tug assistance.

8. Packer Avenue - The container design vessel for this facility can only turn outside the combined berth/channel area. However, suitable natural depths are available to accomplish the turning without extra dredging. The results summarized above are based on application of Corps criteria. Although Pilot coordination indicated a preference for more (maneuvering/turning) space, only those modifications justified by Corps criteria can be implemented.

444. Beckett Street Terminal Access Channel. The trapezoidal access channel for the bulk berths at Beckett Street Terminal were designed to be consistent with the criteria for the authorized 40'

project which includes approach and departure angles of 450° from the 40' west side of the Delaware River channel.

445. Operating Drafts. The Delaware River pilots establish through the Mariners' Advisory Committee the safe operating practices. Currently, the maximum acceptable ship draft in the 40 foot deep channel is also 40 feet for vessels using the tides. While the Delaware River, Philadelphia to Sea project is authorized to a depth of 40 feet MLW, the effective channel depth is somewhat deeper for several reasons. The river has been fully maintained to provide a 40 foot minimum depth. Additional depth at a given location could be different at a given time as a result of tolerances in the dredging process, natural scour due to currents, agitation of the sediments in the center of the channel due to vessel transits, and periodic sand mining operations. Advance maintenance of 2 to 4 feet is also practiced at selected locations with high shoaling rates. When a given river section does shoal, it does so the fastest along the edges, with the center channel depth (where in present practice ships generally navigate) considerably deeper. Rock outcrops, located in the Marcus Hook Range, cause additional concern over the actual channel depth.

446. In addition to the static vessel draft, four factors must be included to determine required channel depth for a given operating draft. The first, freshwater sinkage, results from the fact that the density of freshwater is 3% less than average ocean saltwater. This means that a vessel with a 39 foot draft in saltwater is one foot deeper in freshwater. The second factor concerns the amount of minimum clearance desired between a ship and the channel bottom. Corps vessel underkeel guidance for channel design calls for 2 feet of clearance for soft channel bottoms and 3 feet for hard/rock channels, a practice also adopted for use in the Delaware. The third factor in computing required channel depth, squat, results because a ship in motion will cause a lowering of the water surface because of the change in velocity and pressure about the vessel, causing it to be lowered with respect to the channel bottom. The amount of lowering depends on several factors, especially the speed of the vessel compared to that of the water and the cross section of the channel and the river itself. For the Delaware River the pilots travel faster in the lower river and bay where the greater channel cross section minimizes the squat and the absence of docks close to the channel minimizes vessel wave damage. Above Wilmington, vessel speeds are reduced. Overall the effect of squat is a 1 to 2 foot requirement in operating draft.

447. One remaining factor, trim is involved in determining channel depth. In the bay, where salinity levels are higher tankers operate with the stern 1 foot lower than the bow; this practice allows for better vessel maneuvering at higher speeds. Shifting of cargo between tanks allows for a return to an even keel upon entering the river.

448. BENEFIT ANALYSIS METHODOLOGY. The analysis quantified transportation benefits from the proposed channel improvements for vessel movements through the Delaware River port system by

comparing the incremental difference in transportation costs for the with and without project conditions. Transportation costs were computed by combining vessel operating costs, projections for commodities, and fleet shift impacts. A multiport analysis was also conducted, and concluded that deepening the Delaware River main channel would not divert traffic from the competing North Atlantic ports. A shift of Canadian container traffic from Halifax to Philadelphia is possible with the recent introduction of the Canada Pacific Railroad, via its subsidiary the D&H Railway, into the Philadelphia area. This would occur under both the without and with project conditions. The estimate of savings in ocean transportation costs from a Delaware River channel deepening proved to be insufficient to offset inland transportation cost advantages at the competing ports of New York, Baltimore, and Norfolk/Hampton Roads for potentially divertible commodity trade routes.

449. Vessel costs at sea and in port were derived from the data contained in OCE Economic Guidance Memorandum #91-4, Fiscal Year 1991, "Vessel Operating Costs", for foreign flag liquid bulk, dry bulk, and container vessels. Deep draft vessel operating costs in the Reference Handbook were compiled based on interviews with vessel operators, shipyards, fuel suppliers, and through research of secondary sources. Port charges, pilot fees, and tug boat costs were site specific to the Delaware River port system. Landside costs, such as the transportation costs of the commodities after leaving the destination port or prior to entering the origin port, were considered identical per ton under the with and without project conditions and were, thus, not included in the transportation cost estimation.

450. Data bases were separately analyzed to determine transportation costs and savings for vessel movements for the following commodities: crude oil greater than 40 foot sailing draft, crude oil less than or equal to 40 foot sailing draft, coal from Pier 124, iron ore, and South Jersey Port Corporation (SJPC) dry bulk commodities and container movements.

451. An analysis of the port depths of trade route partners for the benefitting commodities has incorporated the impact of any constraints at the other end of the trade route. Crude oil movements will not have a constraint at the pertinent foreign ports in West Africa, North Europe, the Caribbean, South Africa, South America, Southeast Asia, China/North Korea, Red Sea/Arabian Gulf, Mediterranean, South Europe, Australia, and Canada since depths are in excess of the maximum considered Delaware River channel depth of 46 feet. Coal movements are constrained by depths less than 40 feet at Pakistan and Venezuela and by the constraint of the Panama Canal for movements to China, Japan, and Australia. The benefitting coal trade routes based on vessel design characteristics and depths at the partner ports are North Europe, Mediterranean, Canada, South America, South Europe, and East Europe. Iron ore movements are unconstrained by the depth at the major beneficiary trade partner port, Seven Islands, in Atlantic Canada. Other, less important, iron ore trade routes without depth constraints are South America, North Europe, South Europe, and

North Africa. Scrap exports from the SJPC terminal to Turkey are provided with a depth of 72 feet at the trade route port. Bituminous steam coal from South America has trade route port depths in excess of 45 feet. Trade route port depths for potentially benefitting container movements (Europe, Mediterrean, East Coast of South America, and Australia/New Zealand) are also not a constraint.

452. The analysis utilized the Waterborne Commerce Statistics Center (WCSC) data base for the last five available years, 1985-1989 for actual historic vessel movements using the current 40 foot (MLW) main channel. An econometric framework using a two-stage least squares multiple regression model was applied to simulate expected cargo tonnage carried by vessels in the fleet if the Delaware River federal navigation channel were to be deepened from the current 40 feet to a maximum with project condition depth of 46 feet.

453. The theoretical basis for the econometric analysis incorporates the recognition that the economic goal of any firm is to maximize profits. The profit function is equal to revenues minus costs. The modelling of potential reductions in transportation costs caused by a navigation improvement is identical to analyzing the effect on a firm's cost function by changing its production function. The purpose of the statistical analysis applied in this report is to estimate a production function of vessel operations using actual voyage data. The production function, expressed as Q=f(K,L,M), represents the utilization of particular combinations of input resources to produce a specific level of quantity output. The output of the production function, Q, or quantity, is defined as the amount of cargo carried (i.e., sailing deadweight tonnage). The input, L, represents labor which is considered fixed in a capital-intensive industry such as shipping. The input, K, represents capital, and is defined as the vessels themselves and can be measured by cargo carrying capacity (design deadweight tonnage and design draft). The input, M, represents change in technology (specifically, a change in the channel constraint to vessels from a channel deepening). The production function model has been expanded to include sailing draft as an exogenous input variable directly related to sailing deadweight tonnage. The addition of this variable helped to reduce the potential problem of heteroscedasticity, which, when present, places more weight on observations which have larger error variances than on those with smaller error variances. The effort of developing an econometric model to represent a production function for ship operators involves estimating a technological process for individual ships. The individual ship's production process will represent the technical constraints faced by ship operators as well as their market constraints since the demand for ocean transportation services is a derived demand, meaning that the demand for other goods and services determines the demand for ocean transportation. Non-economic factors such as port depth adjustments are accomplished exogenous to the two-stage least squares multiple

regression model during the transferral of the predicted data to the transportation cost model evaluation.

454. The amount of tonnage which can be carried by a ship leaving or entering a harbor should be positively correlated to its size. The larger the ship, the greater its capacity for transporting tonnage will also be. Since ship operating firms are assumed to be profit maximizers faced with a demand for their services derived by other markets, their optimal behavior should be characterized by them providing a supply of transportation services at minimum cost. In other words, ship operators should be using the most economically efficient ship available to transport cargo. However, channel dimensions generally constrain ship operators by limiting the amount of cargo which can be loaded upon their vessels. This constraint results in operators using efficient ships at less than their optimal load or optimally using less efficient ships. Either way, ship operators are confronted by higher costs directly caused by these economic inefficiencies. The objective of the statistical analysis was to produce a model to be used as a tool to predict cargo tonnage carried by vessel classes, and, thus, simulate actual operating practices under different channel depths.

455. Exogenous input data from the WCSC data base and Lloyd's Register of Ships included the following: vessel name, design draft (DESDWT), actual sailing draft (SDRAFT), commodity, trade route, export or import classification, design deadweight tonnage (DESDWT), actual sailing deadweight tonnage (SDWT), and dockcode.

456. Predicted tonnage by vessel was estimated for three data bases: crude oil vessels with sailing drafts less than or equal to 40 feet, coal vessels, and iron ore vessels. Crude oil vessels with sailing drafts greater than 40 feet will not have an increase in tonnage carried due to a channel deepening. The operators of these vessels have made a decision currently to lighter at Big Stone Beach Anchorage until the vessel sailing draft is sufficiently reduced to allow for navigation upriver to the pertinent facility. Even with a deeper main channel they will continue to carry the same amount of tonnage, and benefits will be based on savings from reduced lightering requirements. Vessels using SJPC's Beckett Street Terminal are expected to behave optimally by utilizing vessel cargo carrying capacity to the maximum extent allowed by the channel as it is deepened.

457. The data bases were desegregated by trade route and design draft. Average sailing draft, average design deadweight tonnage, average sailing deadweight tonnage, and fleet distribution were computed for each vessel design draft class by trade route. Individual transportation cost models were developed for each design draft vessel class for each trade route.

458. For crude oil vessels with sailing drafts 40 feet, these cost models estimated tons lightered and transportation costs for each channel depth from 40 to 46 feet. By combining commodity projections with the fleet distribution, estimates of total tons lightered for each design draft class by trade route over the project life by decade were made. Total transportation costs,

including the costs of lightering, were then computed for design draft class, trade route, project life decade, and channel depth. Subtracting the total transportation costs of each with project channel depth from the total transportation costs for the without project channel depth resulted in cost savings as a result of the reduced lightering with a deeper channel. Finally, the tons lightered, transportation costs, and transportation savings associated with each channel depth were summed for all trade routes and annualized.

459. The data bases for crude oil <= 40 foot sailing draft, coal, and iron ore movements were analyzed in basically a similar manner to the crude oil >40 foot sailing draft data base. However, a key difference is that tonnage expected to be carried by each vessel for each channel depth was predicted by a two-stage least squares multiple regression statistical model. The very large tankers that are currently not lightering have made a decision, based on the relative shipment size purchased, to load to a sailing draft (i.e., 40 feet or less) that assures that lightering is not required in the Delaware Bay. Economically, the oil companies do not believe it cost-efficient to purchase slightly more crude oil for these shipments and load slightly deeper to, say, 41 or 42 feet, since this would require lightering of only a small amount of the crude into barges in the bay. With a deeper channel, under both current and future practice, these vessels will carry increased tonnage as predicted by the statistical model and will increase their sailing draft to take advantage of the channel improvement (while assuring that lightering of the vessel is still not required based on the sailing draft). A review of the data base for coal and iron ore vessels determined that less than 2% of outgoing Pier 124 vessels had arrived in the Delaware River system carrying iron ore to Pier 122. The infrequency of this type of operation is expected to continue in the future, and will have only a minimal impact on benefits.

460. Individual transportation cost models were developed for each design draft vessel class for each trade route. These cost models estimated the cost per ton based on predicted tonnage from the statistical model for each channel depth from 40 to 46 feet. By combining commodity projections with the fleet distribution, estimates of the total transportation cost for each design draft class by trade route over the project life by decade were made. Subtracting the total transportation costs of each with project channel depth from the total transportation costs for the without project depth results in cost savings from the more efficient movement of tonnage. Finally, the transportation savings for all trade routes were summed and annualized.

461. Two dry bulk commodities will benefit from a channel depth improvement in excess of forty feet at the South Jersey Port Corporation's Beckett Street Terminal. Container vessels also have the potential to benefit for five trade routes. Individual transportation cost models were developed for each design deadweight tonnage vessel class for each trade route. Ship operators are expected to continue to behave optimally by utilizing

chartered vessel cargo carrying capacity to the extent allowed by the channel as it is deepened, since these movements are economical within a small range of marginal costs. Containers incorporate average lightloading into the analysis. The cost models which were developed estimated the cost per ton for each channel depth from 40 to 46 feet. By combining commodity projections with the fleet distribution, estimates of the total transportation costs for each design deadweight tonnage vessel class by trade route was made. The subtraction of the total transportation costs of each with project channel depth from the total transportation costs for the without project channel depth resulted in an annualized estimate of savings from the more efficient movement of tonnage with the channel improvement.

462. MINIMUM WIDTH ASYMMETRIC INBOUND CHANNEL. An asymmetric inbound channel is considered as a separable feature since a majority of potential benefits are obtained from inbound traffic. Under this option only the inbound lane of the channel would be deepened up to the Philadelphia Navy Yard below Walt Whitman Bridge. (Refer to Figure 21.) Channel widths would be 400 feet from Pier 122 to the Navy Yard, 435 feet from the Navy Yard to Bombay Hook and 580 feet in the bay. As part of this option a new set of range lights would be required to mark the centerline of the asymmetric channel. Other features of this option included as part of the plan would be widening of bends to accommodate vessel crab in turns. A two space anchorage would be provided at Marcus Hook within its existing limits at the upstream end. The plan includes utility relocations at two locations for the 45' and 46' depth plans. Dredged material would be placed in the new sites identified as 170 in Reach A, 15 D in Reach B, and Raccoon Island for Reach C. Material from Reach D would be placed in the two Federal disposal sites (Reedy Point North and South) at the entrance to the C&D Canal, exchanging ultimate capacity for that in Reach A where Federal sites are most limited. Disposal of dredged material in Reach E, the bay channel, is to occur through wetland/island creation and sand stockpiling for subsequent use by the non-federal interests. Associated cost include berth dredging at each benefiting facility and bulkhead modifications for one facility at depths of 43 feet and greater.

463. Maintenance dredging would be accomplished according to the current intervals at Federal expense. Material would be placed in Federal and non-Federally provided sites in order to minimize mobilization and pumping costs, while maximizing the capabilities for site management and potential reuse of material. Ultimately the local sponsor would be responsible for the incremental site preparation and disposal area costs attributable to the channel deepening. Maintenance of associated features would be accomplished by the beneficiary facilities.

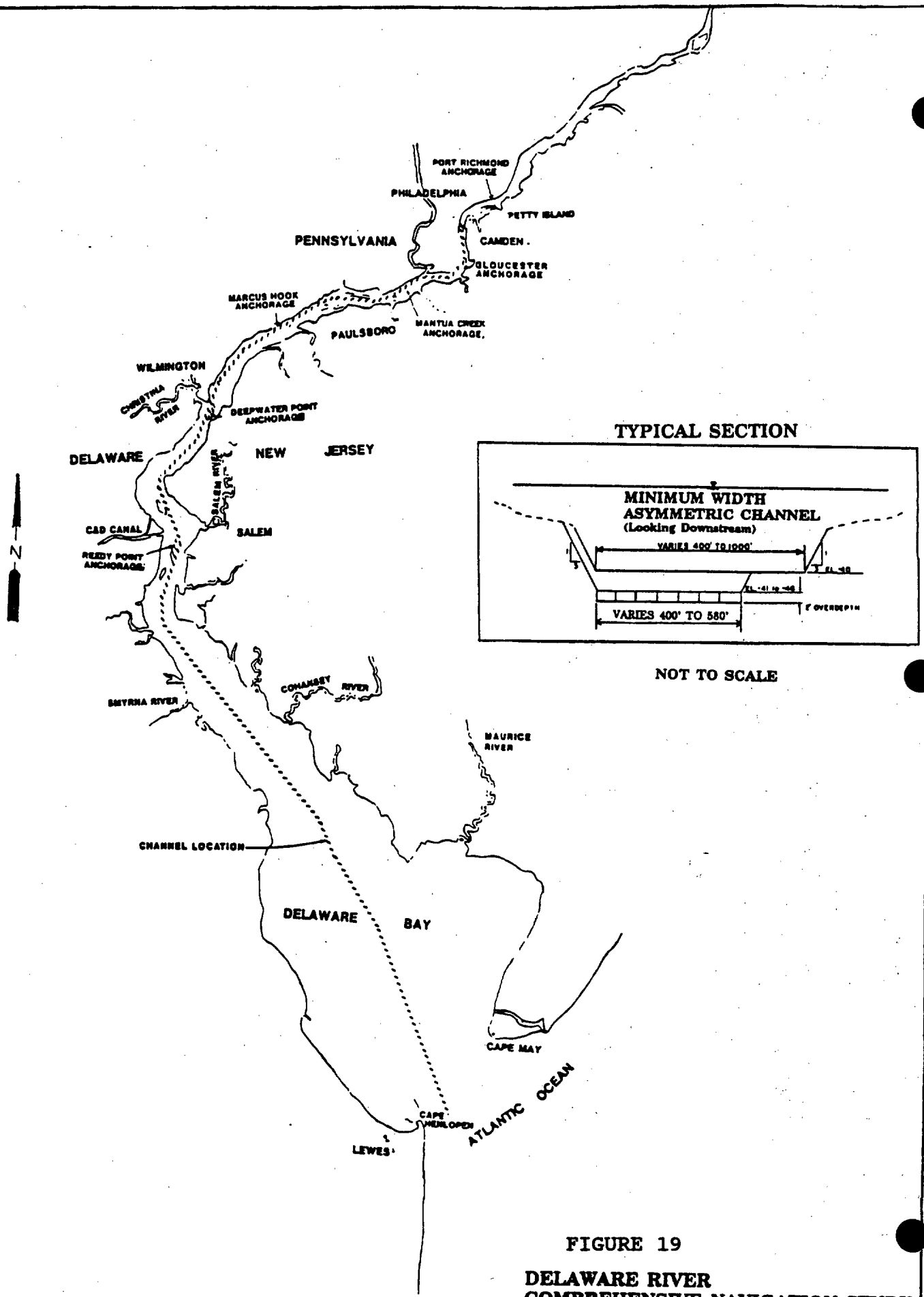


FIGURE 19

DELAWARE RIVER
COMPREHENSIVE NAVIGATION STUDY
MINIMUM WIDTH
ASYMMETRIC CHANNEL
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

464. Navigation Practice. With only the inbound lane deepened, vessel operating practices would be different from current practices. No longer could crude oil tankers and import dry bulk carriers (the only ships benefitting from an asymmetric inbound deepening option) normally travel in the channel center except to pass. They would be restricted to a channel 42% to 46% narrower and for safe navigation would travel much slower. This plan results in vessel steaming times of 11 1/2 hours at a minimum, which exceeds the time for running upriver with a single tide. Two measures to overcome this constraint are possible. Deeper draft vessels could be required to wait in the naturally deep upper Delaware Bay for about 3 hours for the return of higher tides, resulting in a 14 hour total trip. The second option would be to add two feet of channel depth to either the upper river or bay channels or portions of both to allow for a continuous 11 1/2 hour trip not hindered by the need to wait for the tide to return. Increasing vessel operating costs by about $3,000 ($1000/hr x 3 hrs.) for over 200 ships per year would be less expensive than the several million yards of added dredging. Therefore, the first option was analyzed.

465. While passing of ships with drafts over 40 feet could not occur, effective coordination between pilots should allow for limited impact on operations. Present practice in the asymmetric Philadelphia Harbor is for shallower vessels to use the 37' east channel irrespective of travel direction and deeper draft vessels use the 40' west channel. Similar practices could occur with this option. In keeping with current practice ships using the deeper channel could align themselves with the northernmost destination in front so that no vessels are delayed by turning and docking movements.

466. Beneficiaries. This option would benefit crude oil and dry bulk imports to Pier 122 only. The Delaware River channel is too long and too heavily used to allow for outbound vessels to alternately use the deeper channel, especially with the timing requirements associated with using the tides.

This option involves deepening for inbound traffic based on Corps design criteria for the channel with no access channel to SJPC's Beckett Street Terminal. With only the inbound traffic lane to be deepened, outgoing vessels would receive no benefits. Also, crude oil, and iron ore incoming vessels would be forced to stay within a narrower channel and travel at a slower speed. This would add, on average, approximately 7 hours additional travel time, plus additional tug and pilot costs, to each trip upriver for Option 2. Consequently, Option 2 would provide reduced transportation cost savings as compared to a full width option. Benefits are presented in Table 31.

TABLE 29

DELAWARE RIVER COMPREHENSIVE NAVIGATION STUDY FILE:BSUM2S1
MAIN CHANNEL DEEPENING INVESTIGATION
OPTION 2
SUMMARY OF AVG ANN BENEFITS
INCORPORATING FY91 OCE VESSEL OPERATING COSTS
& 3/4% DISCOUNT RATE

COMMODITY	41 FEET	42 FEET	43 FEET	44 FEET	45 FEET	46 FEET
CRUDE OIL						
TRANSPORTATION SAVINGS	$6,219,000	$12,129,000	$17,883,000	$23,203,000	$28,417,000	$33,468,000
IRON ORE						
TRANSPORTATION SAVINGS	$53,000	$102,000	$147,000	$183,000	$214,000	$233,000

COAL-ALL TRANSPORTATION SAVINGS ELIMINATED SINCE OUTBOUND CHANNEL WILL NOT BE DEEPENED

SOUTH JERSEY PORT CORPORATION-ALL TRANSPORTATION SAVINGS ELIMINATED SINCE ACCESS CHANNEL WILL NOT BE DEEPENED

CONTAINERS-ALL TRANSPORTATION SAVINGS ELIMINATED

TOTAL TRANSPORTATION SAVINGS (CUMULATIVE)	$6,272,000	$12,231,000	$18,030,000	$23,486,000	$28,631,000	$33,701,000

467. MORE EFFICIENT ASYMMETRIC INBOUND CHANNEL. Channel widths for this option are based on recommendations of the Delaware River and Bay Pilots. This channel allows for running with the tide and permits speeds sufficient to stay within a single tidal cycle. The deepened channel in Philadelphia Harbor would be 400' wide and between the Navy Yard and Wilmington would be 435' wide (see Figure 22). In the reach between Wilmington and the Bombay Hook, the deepened channel would be 600 feet wide while in the bay the channel would be 800 feet wide. River geometry and shore facilities are such that present practices are for the pilots to navigate this portion of the river and bay much faster in order to allow for inbound vessel transits to occur within a single tide cycle. Such a speed difference between upper river and the lower river plus bay allows for use of the tide within a single tidal cycle to increase effective channel depth. Similar to the minimum width asymmetric channel, this option requires a duplicate set of range lights to be installed for safe navigation of inbound vessels in order to follow the centerline of the asymmetric channel. Other features of this option would include bend widening, a two space anchorage at Marcus Hook and utility relocations for the 45 foot and 46 foot depth plan. Dredged material disposal would be accomplished similar to the first option. Associated costs for berth dredging and bulkheads would also be required as in the earlier option.

468. Navigation Practice. Vessel operating practice would only change slightly. Deeper vessels would be able to utilize 80% of the existing bay channel and 75% of the river channel below Wilmington. For every foot of increased channel depth a comparable increase in vessel draft could occur for inbound traffic. With a 45' deep channel, 42' draft inbound vessels (freshwater draft) could navigate without using the tide and vessels up to a 45' draft could do so with a tide. Inbound trips using the tide would take about 10 1/2 hours.

469. Beneficiaries. Like the minimum width asymmetric this option would benefit crude oil and dry bulk imports, but not coal vessels. This option developed at the request of the pilots, would deepen only the inbound traffic lane, but to a greater width than Option 2. Also like Option 2, Option 3 does not include an access channel to SJPC's Beckett Street Terminal. Additional travel time per vessel trip over the two-way channel for crude oil, and iron ore incoming vessels would be approximately three hours, thereby, providing transportation cost savings greater than Option 2 but less than Option 1. Benefits are presented in Table 32.

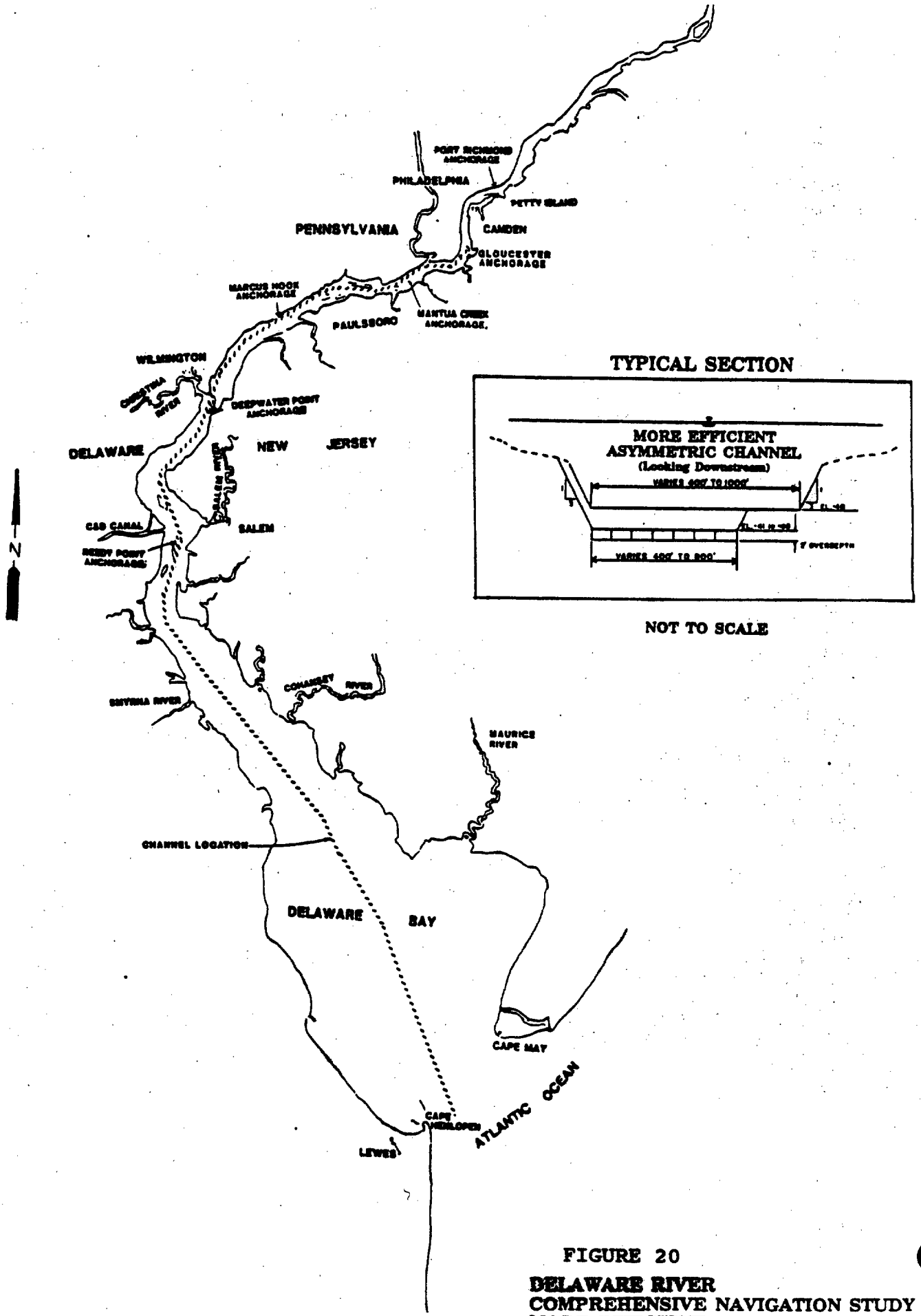


FIGURE 20

DELAWARE RIVER
COMPREHENSIVE NAVIGATION STUDY
MORE EFFICIENT
ASYMMETRIC CHANNEL
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

TABLE 30
DELAWARE RIVER COMPREHENSIVE NAVIGATION STUDY
MAIN CHANNEL DEEPENING INVESTIGATION
OPTION 3
SUMMARY OF AVG ANN BENEFITS
INCORPORATING FY91 OCE VESSEL OPERATING COSTS
8 3/4% DISCOUNT RATE

COMMODITY	41 FEET	42 FEET	43 FEET	44 FEET	45 FEET	46 FEET
CRUDE OIL TRANSPORTATION SAVINGS	$6,926,000	$13,509,000	$19,918,000	$25,844,000	$31,651,000	$37,276,000
IRON ORE TRANSPORTATION SAVINGS	$90,000	$174,000	$251,000	$312,000	$365,000	$397,000
COAL-ALL TRANSPORTATION SAVINGS ELIMINATED SINCE OUTBOUND CHANNEL WILL NOT BE DEEPENED						
SOUTH JERSEY PORT CORPORATION-ALL TRANSPORTATION SAVINGS ELIMINATED SINCE ACCESS CHANNEL WILL NOT BE DEEPENED						
CONTAINERS-ALL TRANSPORTATION SAVINGS ELIMINATED						
TOTAL TRANSPORTATION SAVINGS (CUMULATIVE)	$7,016,000	$13,683,000	$20,169,000	$26,156,000	$32,016,000	$37,673,000

470. FULL WIDTH CHANNEL. Under this option the inbound and outbound lanes would be deepened consistent with the existing project dimensions; 1000' from Delaware Bay to Bombay Hook and then 800' up to the Philadelphia Navy Yard below the Walt Whitman Bridge. Refer to Figure 23.

471. Through Philadelphia Harbor up to Beckett Street Terminal, the 400'-500' west side channel would be deepened from its current 40' depth. A trapezoidal access channel would be provided to the bulk berths at Beckett Street Terminal, modifying the 40' access channel authorized by the W.R.D.A. of 1988, which modified sections of the east side Delaware River channel and the Delaware River in the Vicinity of Camden project. Oil tanker movements are limited to the wider channel reaches, while the narrower channel accommodates the smaller dry bulk vessels calling at the Conrail facilities and Beckett Street Terminal, as well as container vessels at the intermodal transfer facility. The 400' channel is used by both inbound and outbound vessels in a one-way manner using communications among the vessel pilots and Philadelphia Maritime Exchange to avoid conflicts. Shallower draft traffic utilizes the parallel eastern channels to avoid conflicts with the deep draft vessels confined to the western channel. This practice would continue to be used in order to minimize dredging requirements, and one-way usage of the 400' wide channel is adequate for the level of traffic. The overall project length would be 102 miles.

472. Included as part of the plan would be widening of bends to accommodate vessel crab in turns. A two space anchorage would be provided at Marcus Hook within its existing limits at the upstream end. The plan includes utility relocations at two locations for the 45' and 46' depth plans. No navigation aids would require modification for this option. Dredged material would be placed in the new sites identified as 170 in Reach A, 15 D in Reach B, and Raccoon Island for Reach C. Material from Reach D would be placed in the two Federal disposal sites (Reedy Point North and South) at the entrance to the C&D Canal, exchanging ultimate capacity for that in Reach A where Federal sites are most limited. Disposal areas were developed based on maximizing usable disposal area size in order to minimize project costs. Real estate costs for a lesser sized disposal area would only be marginally reduced, since excess partial parcels would have limited use due to their being uneconomic remnants. Disposal of dredged material in Reach E, the bay channel, is to occur through wetland/island creation and sand stockpiling for subsequent use by the non-federal interests. Associated costs include berth dredging at each benefitting facility and bulkhead modifications for one facility at depths of 43 feet and greater.

473. Maintenance dredging would be accomplished according to the current intervals at Federal expense. Material would be placed in Federal and non-Federally provided sites in order to minimize mobilization and pumping costs, while maximizing the capabilities for site management and potential reuse of material. Ultimately the local sponsor would be responsible for the incremental site preparation and disposal area costs attributable to the channel

deepening. Maintenance of associated features would be accomplished by the beneficiary facilities.

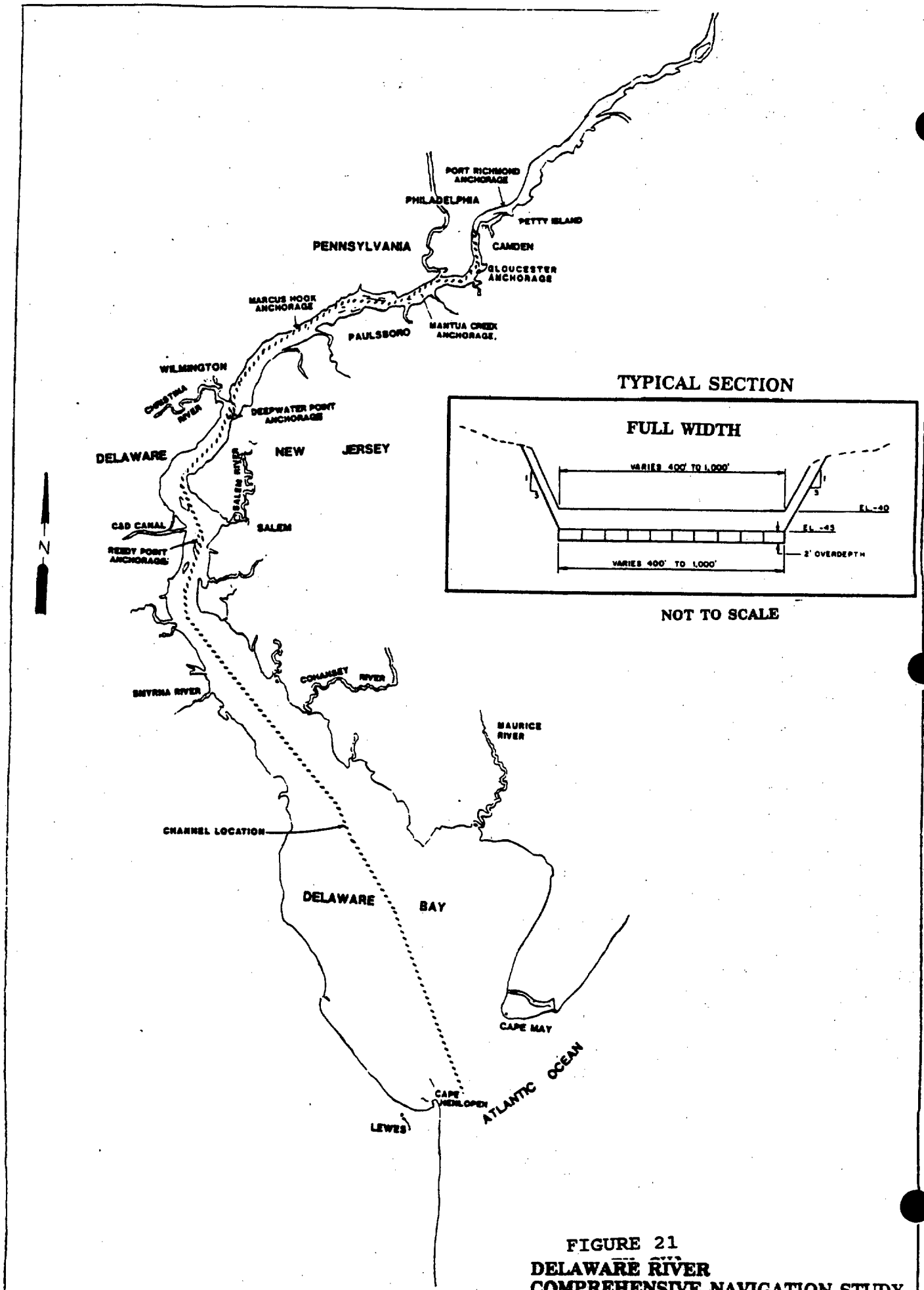


FIGURE 21
DELAWARE RIVER
COMPREHENSIVE NAVIGATION STUDY
FULL WIDTH CHANNEL
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

474. Navigation Practice. With both inbound and outbound lanes deepened, vessel operating practice would continue as it does now. Vessels would navigate in the center of the channel when possible to maximize speeds but could use both lanes in a passing situation. For every foot of increased channel depth, a comparable increase in maximum vessel operating drafts could occur for both inbound and outbound traffic. With a 45' deep channel, 42' (freshwater) draft vessels could navigate without using the tide and vessels up to a 45" draft could do so with a tide. Inbound trips using the tide would still take about 7 1/2 hours while outbound trips would take the same 10 1/2 hours.

475. Beneficiaries. The main beneficiary of channel deepening would be crude oil tankers docking at six refineries. In addition colliers and iron ore vessels using Piers 122 and 124 could also be loaded deeper. Scrap, and bituminous coal shipments at the Beckett Street Terminal are also expected to benefit as well as container vessels. The estimation of benefits for Option 1, the full width channel with an access channel to SJPC's Beckett Street Terminal, involved combining the transportation costs per ton by channel depth estimated for each pertinent vessel class by trade route by commodity with the annualized level of commodity projections. No induced tonnage will result from the proposed channel improvements. Benefits are presented in Table 33.

476. COMPARISON OF DETAILED PLANS. The following analyses were conducted to identify and measure the likely economic, environmental and social impacts expected to result from implementation of the alternative plans. The impacts were evaluated to determine the contributions, both beneficial and adverse, of the alternative plans. Interest during construction was computed using a schedule defining cost, by individual year over the total construction period, broken out by individual cost category, i.e., initial project costs, associated costs, real estate cost, relocations, navigation aids, and PED costs. All associated and PED costs as well as some real estate costs will not accrue interest during construction. The Single Payment Compound Amount Factor was applied to bring costs for each individual year forward to the project base year in order to place costs on an equal basis with the annualized project benefits. The analysis is structured incrementally, analyzing first the narrowest asymmetric channel, then the more efficient asymmetric channel and last the full width, longer channel.

477. Minimum Width Asymmetric Channel Inbound (Option II) A comparison of costs and benefits associated with constructing this option from depths of 41 feet to 46 feet is presented in Table 34. Project benefits come from crude oil imports to six refineries and iron ore imports to Pier 122. Net benefits are maximized with a 45 foot channel depth for this option.

Delaware River Comprehensive Navigation Study:
Main Channel Deepening

Table 31. Annualized Benefits For Option 1 (with Beckett Street Terminal)
September 1991 Price Level, 8 3/4% Discount rate

Commodity	Channel Depth: 41	42	43	44	45	46
	Average Annual Benefits					
Crude oil vessels with sailing drafts greater than 40 feet	$5,333,000	$10,533,000	$15,641,000	$20,525,000	$25,430,000	$30,244,000
Crude oil vessels with sailing drafts less than or equal to 40 feet	$2,068,000	$3,902,000	$5,642,000	$7,090,000	$8,390,000	$9,587,000
Subtotal-Crude Oil Imports	$7,401,000	$14,435,000	$21,283,000	$27,615,000	$33,820,000	$39,831,000
Coal vessels-Exports	$95,000	$176,000	$240,000	$284,000	$311,000	$321,000
Iron Ore vessels-Imports	$117,000	$226,000	$326,000	$406,000	$475,000	$517,000
SJPC:						
Scrap to Turkey	$1,488,000	$2,159,000	$3,096,000	$4,280,000	$4,917,000	$4,917,000
Coal from Colombia	$58,000	$64,000	$99,000	$134,000	$160,000	$160,000
Subtotal-SJPC	$1,546,000	$2,223,000	$3,195,000	$4,414,000	$5,077,000	$5,077,000
Containers	$871,000	$1,720,000	$2,032,000	$2,251,000	$2,895,000	$2,895,000
TOTAL-CUMULATIVE	$10,030,000	$18,780,000	$27,076,000	$34,970,000	$42,578,000	$48,641,000
INCREMENTAL	$10,030,000	$8,750,000	$8,296,000	$7,894,000	$7,608,000	$6,063,000

TABLE 32
DELAWARE RIVER COMPREHENSIVE NAVIGATION STUDY
MAIN CHANNEL DEEPENING INVESTIGATION
OPTION 3
SUMMARY OF AVG ANN BENEFITS
INCORPORATING FY91 OCE VESSEL OPERATING COSTS
8 3/4% DISCOUNT RATE

COMMODITY	41 FEET	42 FEET	43 FEET	44 FEET	45 FEET	46 FEET	
CRUDE OIL							
TRANSPORTATION SAVINGS	$6,926,000	$13,509,000	$19,918,000	$25,844,000	$31,651,000	$37,276,000	
IRON ORE							
TRANSPORTATION SAVINGS	$90,000	$174,000	$251,000	$312,000	$365,000	$397,000	
COAL-ALL TRANSPORTATION SAVINGS ELIMINATED SINCE OUTBOUND CHANNEL WILL NOT BE DEEPENED							
SOUTH JERSEY PORT CORPORATION-ALL TRANSPORTATION SAVINGS ELIMINATED SINCE ACCESS CHANNEL WILL NOT BE DEEPENED							
CONTAINERS-ALL TRANSPORTATION SAVINGS ELIMINATED							
TOTAL TRANSPORTATION SAVINGS (CUMULATIVE)	$7,016,000	$13,683,000	$20,169,000	$26,156,000	$32,016,000	$37,673,000	
TOTAL TRANSPORTATION SAVINGS (INCREMENTAL)	$7,016,000	$6,667,000	$6,486,000	$5,987,000	$5,860,000	$5,657,000	
OPTION 1:							
CRUDE OIL							
TRANSPORTATION SAVINGS	$7,401,000	$7,034,000	$6,848,000	$6,332,000	$6,205,000	$6,011,000	$39,831,000
IRON ORE							
TRANSPORTATION SAVINGS	$117,000	$109,000	$100,000	$80,000	$69,000	$42,000	$517,000

478. More Efficient Asymmetric Inbound Channel (Option III). A comparison of the costs and benefits associated with constructing and operating this option from depths of 41 feet to 46 feet is presented in Table 34. Project benefits come from increased navigational efficiencies to the same six refineries and one iron ore facility as in Option II. Net benefits are maximized with a 45 feet channel depth. In addition as shown on Table 35, for each proposed depth the net NED benefits for Option III exceed those for Option II therefore further formulation analysis will proceed with Option III as the inbound asymmetric plan.

479. Outbound Lane Optimization. Consistent with incremental plan formulation methodology, a comparison of the additional costs and benefits associated with constructing and operating a two-way channel (Option I) was developed as an incrementally added plan to the asymmetric inbound channel (Option III). This incremental optimization is presented as Table 36. Project benefits come from increased navigational efficiencies to the same six refineries and one iron ore facility as in Options II and III, from coal exports from Pier 122, from container benefits and from bulk imports and exports from the Beckett Street facility. Net benefits are maximized with a 45 foot channel depth.

480. Length Optimization. A sensitivity analysis was conducted for the optimum plan to assure that the last increment of channel length was justified. A shorter project ending at the Conrail Ore piers below the Walt Whitman Bridge (Table 37) was compared to the longer project which accesses Beckett Street Terminal (Table 38). The results are summarized in Table 39 which demonstrates that the project increment to Beckett Street Terminal is incrementally justified and optimizes at the 45' depth.

481. Continuation of Length Optimization. Another sensitivity analyses was performed for the increment between the most northern refinery and the Walt Whitman Bridge; facilities located in the channel segment include Conrail's Piers 122 and 124 and the Packer Avenue general cargo and container facility. This showed that this segment is also incrementally justified and optimizes at the 45' depth (Refer to tables 40 and 41).

TABLE 39
INCREMENTAL OPTIMIZATION OF ASYMMETRIC CHANNELS
OPTIONS II vs. III

CHANNEL DEPTH	ANNUAL COSTS ($000'S)			ANNUAL BENEFITS ($000'S)			NET
	#3	#2	DIFF.	#3	#2	DIFF.	
41 FT	9,919	9,805	114	7,016	6,272	744	630
42 FT	11,817	11,056	761	13,683	12,231	1,452	691
43 FT	15,079	14,109	970	20,169	18,030	2,139	1,169
44 FT	19,566	18,090	1,476	26,156	23,486	2,670	1,194
45 FT	24,525	22,450	2,075	32,016	28,631	3,385	1,310
46 FT	32,804	30,086	2,718	37,673	33,701	3,972	1,254

TABLE 34
OPTIMIZATION OF OUTBOUND CHANNEL

CHANNEL DEPTH	ANNUAL COSTS ($000'S)			ANNUAL BENEFITS ($000'S)			NET (6-3)
	#1 W/ BECKETT (1)	#3 (2)	DIFF. (1-2)	#1 W/ BECKETT (4)	#3 (5)	DIFF. (4-5)	
41 FT	11,119	9,919	1,200	10,030	7,016	3,014	1,814
42 FT	14,150	11,817	2,333	18,780	13,683	5,097	2,764
43 FT	19,161	15,079	4,082	27,076	20,169	6,907	2,825
44 FT	25,685	19,566	6,118	35,131	26,156	8,975	2,857
45 FT	32,113	24,525	7,587	42,776	32,016	10,760	3,173
46 FT	40,847	32,804	8,043	48,874	37,673	11,201	3,158

TABLE 35
OPTION 1 (FULL CHANNEL WIDTH, WITHOUT BECKETT STREET)
ANNUALIZATION OF COSTS AND ECONOMIC OPTIMIZATION
8 3/4% DISCOUNT RATE, SEPT 1991 P. L.

	41 FT	42 FT	43 FT	44 FT	45 FT	46 FT
INITIAL PROJECT COSTS	$74,790,000	$99,160,000	$135,640,000	$191,620,000	$243,460,000	$303,370,000
ASSOC. COSTS	$7,348,000	$9,238,000	$19,708,000	$21,193,000	$22,560,000	$23,892,000
REAL ESTATE	$19,827,000	$19,827,000	$19,827,000	$19,827,000	$19,827,000	$19,827,000
RELOCATIONS	$0	$0	$0	$0	$3,130,000	$5,760,000
NAVIGATION AIDS	$856,000	$856,000	$856,000	$856,000	$856,000	$856,000
PED COSTS	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$10,000,000
TOTAL FIRST COSTS	$112,821,000	$139,081,000	$186,031,000	$243,496,000	$299,833,000	$363,705,000
CRF, 50 YRS	0.0888400	0.0888400	0.0888400	0.0888400	0.0888400	0.0888400
AVG ANN FIRST COST	$10,023,000	$12,356,000	$16,527,000	$21,632,000	$26,637,000	$32,312,000
AVG ANN O&M (FROM W/O PROJECT DEPTH)	$220,000	$440,000	$670,000	$890,000	$1,110,000	$1,330,000
TOTAL AVG ANN COSTS (W/O IDC)	$10,243,000	$12,796,000	$17,197,000	$22,522,000	$27,747,000	$33,642,000
AVG ANN IDC COSTS	$599,000	$934,000	$1,376,000	$2,370,000	$3,481,000	$5,631,000
TOTAL AVG ANN COSTS	$10,842,000	$13,730,000	$18,573,000	$24,892,000	$31,228,000	$39,273,000
AVG ANN BENEFITS OVER PROJECT LIFE	$8,484,000	$16,557,000	$23,881,000	$30,556,000	$37,501,000	$43,564,000
AVG ANN BENEFITS DURING CONSTRUCTION	$0	$0	$0	$161,000	$198,000	$233,000
TOTAL AVG ANN BENEFITS	$8,484,000	$16,557,000	$23,881,000	$30,717,000	$37,699,000	$43,797,000
BENEFIT-COST RATIO	0.78	1.21	1.29	1.23	1.21	1.12
NET BENEFITS	($2,358,000)	$2,827,000	$5,308,000	$5,825,000	$6,471,000	$4,524,000

TABLE 36
OPTION 1 (FULL CHANNEL WIDTH, WITH BECKETT STREET)
ANNUALIZATION OF COSTS AND ECONOMIC OPTIMIZATION
8 3/4% DISCOUNT RATE, SEPT 1991 P. L.

	41 FT	42 FT	43 FT	44 FT	45 FT	46 FT
INITIAL PROJECT COSTS	$76,820,000	$101,910,000	$139,370,000	$195,690,000	$248,480,000	$314,540,000
ASSOC. COSTS	$7,781,000	$9,723,000	$20,247,000	$21,785,000	$23,205,000	$24,590,000
REAL ESTATE	$19,827,000	$19,827,000	$19,827,000	$19,827,000	$19,827,000	$19,827,000
RELOCATIONS	$0	$0	$0	$0	$3,130,000	$5,760,000
NAVIGATION AIDS	$856,000	$856,000	$856,000	$856,000	$856,000	$856,000
PED COSTS	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$10,000,000
TOTAL FIRST COSTS	$115,284,000	$142,316,000	$190,300,000	$248,158,000	$305,498,000	$375,573,000
CRF, 50 YRS	0.0888400	0.0888400	0.0888400	0.0888400	0.0888400	0.0888400
AVG ANN FIRST COST	$10,242,000	$12,643,000	$16,906,000	$22,046,000	$27,140,000	$33,366,000
AVG ANN O&M (FROM W/O PROJECT DEPTH)	$270,000	$540,000	$800,000	$1,070,000	$1,340,000	$1,610,000
TOTAL AVG ANN COSTS (W/O IDC)	$10,512,000	$13,183,000	$17,706,000	$23,116,000	$28,480,000	$34,976,000
AVG ANN IDC COSTS	$607,000	$967,000	$1,455,000	$2,569,000	$3,633,000	$5,871,000
TOTAL AVG ANN COSTS	$11,119,000	$14,150,000	$19,161,000	$25,685,000	$32,113,000	$40,847,000
AVG ANN BENEFITS OVER PROJECT LIFE	$10,030,000	$18,780,000	$27,076,000	$34,970,000	$42,578,000	$48,641,000
AVG ANN BENEFITS DURING CONSTRUCTION	$0	$0	$0	$161,000	$198,000	$233,000
TOTAL AVG ANN BENEFITS	$10,030,000	$18,780,000	$27,076,000	$35,131,000	$42,776,000	$48,874,000
BENEFIT-COST RATIO	0.90	1.33	1.41	1.37	1.33	1.20
NET BENEFITS	($1,089,000)	$4,630,000	$7,915,000	$9,446,000	$10,663,000	$8,027,000

TABLE 36 A
OPTION 2
ANNUALIZATION OF COSTS AND ECONOMIC OPTIMIZATION
8 3/4% DISCOUNT RATE, SEPT 1991 P. L.

	41 FT	42 FT	43 FT	44 FT	45 FT	46 FT
INITIAL PROJECT COSTS	$59,180,000	$68,970,000	$89,340,000	$124,310,000	$160,680,000	$225,970,000
ASSOC. COSTS	$7,862,000	$10,005,000	$20,536,000	$21,959,000	$23,830,000	$29,163,000
REAL ESTATE	$19,827,000	$19,827,000	$19,827,000	$19,827,000	$19,827,000	$19,827,000
RELOCATIONS	$0	$0	$0	$0	$3,130,000	$5,760,000
NAVIGATION AIDS	$6,837,300	$6,837,300	$6,837,300	$6,837,300	$6,837,300	$6,837,300
PED COSTS	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$10,000,000
TOTAL FIRST COSTS	$103,706,300	$115,639,300	$146,540,300	$182,933,300	$224,304,300	$297,557,300
CRF, 50 YRS	0.0888400	0.0888400	0.0888400	0.0888400	0.0888400	0.0888400
AVG ANN FIRST COST	$9,213,000	$10,273,000	$13,019,000	$16,252,000	$19,927,000	$26,435,000
AVG ANN O&M (FROM W/O PROJECT DEPTH)	$90,000	$190,000	$280,000	$380,000	$470,000	$560,000
TOTAL AVG ANN COSTS (W/O IDC)	$9,303,000	$10,463,000	$13,299,000	$16,632,000	$20,397,000	$26,995,000
AVG ANN IDC COSTS	$502,000	$593,000	$810,000	$1,458,000	$2,053,000	$3,091,000
TOTAL AVG ANN COSTS	$9,805,000	$11,056,000	$14,109,000	$18,090,000	$22,450,000	$30,086,000
AVG ANN BENEFITS OVER PROJECT LIFE	$6,272,000	$12,231,000	$18,030,000	$23,486,000	$28,631,000	$33,701,000
AVG ANN BENEFITS DURING CONSTRUCTION	$0	$0	$0	$0	$0	$0
TOTAL AVG ANN BENEFITS	$6,272,000	$12,231,000	$18,030,000	$23,486,000	$28,631,000	$33,701,000
BENEFIT-COST RATIO	0.64	1.11	1.28	1.30	1.28	1.12
NET BENEFITS	($3,533,000)	$1,175,000	$3,921,000	$5,396,000	$6,181,000	$3,615,000

TABLE 37
INCREMENTAL OPTIMIZATION OF
BECKETT REACH

CHANNEL DEPTH	ANNUAL COSTS ($000'S)			ANNUAL BENEFITS ($000'S)			NET (6-3)
	#1 W/ BECK. (1)	#1 W/ O BECK. (2)	DIFF. (1-2)	#1 W/ BECK. (4)	#1 W/O BECK. (5)	DIFF. (4-5)	
41 FT	11,119	10,842	277	10,030	8,484	1,546	1,269
42 FT	14,150	13,730	420	18,780	16,557	2,223	1,803
43 FT	19,161	18,573	588	27,076	23,881	3,195	2,607
44 FT	25,685	24,892	793	35,131	30,717	4,414	3,622
45 FT	32,113	31,228	885	42,776	37,699	5,077	4,193
46 FT	40,847	39,273	1,574	48,874	43,797	5,077	3,503

TABLE 38
LENGTH OPTIMIZATION: DREDGING ONLY TO COASTAL REFINERY
ANNUALIZATION OF COSTS
8 3/4% DISCOUNT RATE, SEPT 1991 P.L.

	41 FT	42 FT	43 FT	44 FT	45 FT	46 FT
INITIAL PROJECT COSTS	$74,100,000	$98,430,000	$134,690,000	$190,340,000	$241,790,000	$301,180,000
ASSOC. COSTS	$4,899,000	$6,457,000	$16,515,000	$17,502,000	$18,497,000	$19,479,000
REAL ESTATE	$19,827,000	$19,827,000	$19,827,000	$19,827,000	$19,827,000	$19,827,000
RELOCATIONS	$0	$0	$0	$0	$3,130,000	$5,760,000
NAVIGATION AIDS	$856,000	$856,000	$856,000	$856,000	$856,000	$856,000
PED COSTS	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$10,000,000
TOTAL FIRST COSTS	$109,682,000	$135,570,000	$181,888,000	$238,525,000	$294,100,000	$357,102,000
CRF, 50 YRS	0.0888400	0.0888400	0.0888400	0.0888400	0.0888400	0.0888400
AVG ANN FIRST COST	$9,744,000	$12,044,000	$16,159,000	$21,191,000	$26,128,000	$31,725,000
AVG ANN O&M (FROM W/O PROJECT DEPTH)	$214,000	$428,000	$652,000	$866,000	$1,080,000	$1,295,000
TOTAL AVG ANN COSTS (W/O IDC)	$9,958,000	$12,472,000	$16,811,000	$22,057,000	$27,208,000	$33,020,000
AVG ANN IDC COSTS	$593,400	$927,100	$1,366,400	$2,354,100	$3,457,100	$5,591,300
TOTAL AVG ANN COSTS	$10,551,400	$13,399,100	$18,177,400	$24,411,100	$30,665,100	$38,611,300

TABLE 39

LENGTH OPTIMIZATION - SEGMENT BETWEEN
NORTHERN MOST REFINERY & WALT WHITMAN BRIDGE

CHANNEL DEPTH	ANNUAL COSTS ($000's) #1 W/O BECK	NORTHERN MOST REFINERY	Diff	ANNUAL BENEFITS ($000's) #1 W/O BECK	NORTHERN MOST REFINERY	Diff	NET
41 FT	10,842	10,551	291	8,484	7,401	1,083	792
42 FT	13,730	13,399	331	16,557	14,435	2,122	1,791
43 FT	18,573	18,177	396	23,881	21,283	2,598	2,202
44 FT	24,892	24,410	482	30,717	27,615	3,102	2,620
45 FT	31,228	30,644	564	37,699	33,820	3,879	3,315
46 FT	39,273	38,611	622	43,797	39,831	3,966	3,304

TRADE OFF ANALYSIS

482. The information presented previously indicates that all depths have positive net National Economic Development (NED) benefits. Although adverse environmental impacts associated with dredging and disposal increase with both depths and width, the net difference in impacts between the smallest scale plan, and the largest scale plan is considered to be relatively small, when compared to that already occurring with the existing channel.

RATIONALE FOR SELECTED PLAN

483. The process used to determine the selected plan considered the degree of study objective fulfillment, economic justification, and environmental considerations. The main planning objectives were to provide adequate and safe navigation channels to accommodate vessels travelling along the Delaware River while satisfying the national objective of maximizing net benefits. Based on the comparison of alternatives presented, the 45 foot full-width plan with access to Beckett Street Terminal fulfills the planning objectives, is economically justified, maximizes net benefits and qualifies as the NED plan.

RISK AND UNCERTAINTY ANALYSIS

484. Situations of risk are conventionally defined as those in which the potential outcomes can be described in reasonably well known probability descriptions. In situations of uncertainty, potential outcomes cannot be described in objectively known probability distributions. Risk and uncertainty arise from measurement uncertainty or inaccuracies and from the underlying variability of complex natural, social, and economic situations. It is the purpose of this section to characterize to the extent possible the different degrees of risk and uncertainty.

485. A number of parameters were identified as having risk and uncertainty associated with the outcome of the planning analysis. A sensitivity analysis was conducted to vary these key parameters and determine what impact this would have on project justification and optimization. The parameters which were varied are discussed below.

486. DISCOUNT RATE. Table 42 is a summary for Option 1 (full width channel) of average annual benefits for three discount rates, 8 5/8%, 8 7/8%, and 10%. Benefits would be only 6% lower for the 10% discount rate in comparison to the 8 3/4% discount rate for the full range of improvements considered. The optimal depth would still be 45 feet, for 8 5/8% and 8 7/8% as shown on Table 43 and 44 and 44 feet for 10%, as shown on Table 45.

TABLE 40
OPTION 1 (WITH BECKETT STREET)
SENSITIVITY ANALYSIS:DISCOUNT RATES

8 3/4% DISCOUNT RATE:

	Channel Depth:					
Commodity	41	42	43	44	45	46
Crude Oil Imports	$7,401,000	$14,435,000	$21,283,000	$27,615,000	$33,820,000	$39,831,000
Coal vessels-Exports	$95,000	$176,000	$240,000	$284,000	$311,000	$321,000
Iron Ore vessels-Imports	$117,000	$226,000	$326,000	$406,000	$475,000	$517,000
SJPC	$1,546,000	$2,223,000	$3,195,000	$4,414,000	$5,077,000	$5,077,000
Containers	$871,000	$1,720,000	$2,032,000	$2,251,000	$2,895,000	$2,895,000
TOTAL-CUMULATIVE	$10,030,000	$18,780,000	$27,076,000	$34,970,000	$42,578,000	$48,641,000

8 5/8% DISCOUNT RATE:

	Channel Depth:					
Commodity	41	42	43	44	45	46
Crude Oil Imports	$7,505,000	$14,637,000	$21,581,000	$28,002,000	$34,294,000	$40,389,000
Coal vessels-Exports	$95,000	$176,000	$240,000	$284,000	$311,000	$321,000
Iron Ore vessels-Imports	$119,000	$229,000	$331,000	$412,000	$482,000	$525,000
SJPC	$1,548,000	$2,226,000	$3,200,000	$4,421,000	$5,085,000	$5,085,000
Containers	$874,000	$1,725,000	$2,038,000	$2,258,000	$2,904,000	$2,904,000
TOTAL-CUMULATIVE	$10,141,000	$18,993,000	$27,390,000	$35,377,000	$43,076,000	$49,224,000

8 7/8% DISCOUNT RATE:

	Channel Depth:					
Commodity	41	42	43	44	45	46
Crude Oil Imports	$7,299,000	$14,236,000	$20,989,000	$27,233,000	$33,353,000	$39,281,000
Coal vessels-Exports	$95,000	$176,000	$240,000	$284,000	$311,000	$321,000
Iron Ore vessels-Imports	$115,000	$223,000	$321,000	$400,000	$468,000	$509,000
SJPC	$1,544,000	$2,220,000	$3,190,000	$4,407,000	$5,069,000	$5,069,000
Containers	$868,000	$1,715,000	$2,026,000	$2,244,000	$2,886,000	$2,886,000
TOTAL-CUMULATIVE	$9,921,000	$18,570,000	$26,766,000	$34,568,000	$42,087,000	$48,066,000

10% DISCOUNT RATE:

	Channel Depth:					
Commodity	41	42	43	44	45	46
Crude Oil Imports	$6,881,000	$13,420,000	$19,786,000	$25,673,000	$31,442,000	$37,030,000
Coal vessels-Exports	$95,000	$176,000	$240,000	$284,000	$311,000	$321,000
Iron Ore vessels-Imports	$101,000	$196,000	$282,000	$352,000	$411,000	$448,000
SJPC	$1,511,000	$2,172,000	$3,122,000	$4,314,000	$4,962,000	$4,962,000
Containers	$839,000	$1,657,000	$1,958,000	$2,169,000	$2,789,000	$2,789,000
TOTAL-CUMULATIVE	$9,427,000	$17,621,000	$25,388,000	$32,792,000	$39,915,000	$45,550,000

TABLE 41
OPTION 1 (FULL CHANNEL WIDTH, WITH BECKETT STREET)
ANNUALIZATION OF COSTS AND ECONOMIC OPTIMIZATION
SENSITIVITY: 8 5/8% DISCOUNT RATE

F:AAC1W

	41 FT	42 FT	43 FT	44 FT	45 FT	46 FT
INITIAL PROJECT COSTS	$76,820,000	$101,910,000	$139,370,000	$195,690,000	$248,480,000	$314,540,000
ASSOC. COSTS	$7,781,000	$9,723,000	$20,247,000	$21,785,000	$23,205,000	$24,590,000
REAL ESTATE	$19,827,000	$19,827,000	$19,827,000	$19,827,000	$19,827,000	$19,827,000
RELOCATIONS	$0	$0	$0	$0	$3,130,000	$5,760,000
NAVIGATION AIDS	$856,000	$856,000	$856,000	$856,000	$856,000	$856,000
PED COSTS	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$10,000,000
TOTAL FIRST COSTS	$115,284,000	$142,316,000	$190,300,000	$248,158,000	$305,498,000	$375,573,000
CRF, 50 YRS	0.0876504	0.0876504	0.0876504	0.0876504	0.0876504	0.0876504
AVG ANN FIRST COST	$10,105,000	$12,474,000	$16,680,000	$21,751,000	$26,777,000	$32,919,000
AVG ANN O&M (FROM W/O PROJECT DEPTH)	$270,000	$540,000	$800,000	$1,070,000	$1,340,000	$1,610,000
TOTAL AVG ANN COSTS (W/O IDC)	$10,375,000	$13,014,000	$17,480,000	$22,821,000	$28,117,000	$34,529,000
AVG ANN IDC COSTS	$589,760	$937,990	$1,411,350	$2,490,960	$3,523,040	$5,694,870
TOTAL AVG ANN COSTS	$10,964,760	$13,951,990	$18,891,350	$25,311,960	$31,640,040	$40,223,870
AVG ANN BENEFITS OVER PROJECT LIFE	$10,141,000	$18,993,000	$27,390,000	$35,377,000	$43,076,000	$49,224,000
AVG ANN BENEFITS DURING CONSTRUCTION	$0	$0	$0	$163,000	$201,000	$236,000
TOTAL AVG ANN BENEFITS	$10,141,000	$18,993,000	$27,390,000	$35,540,000	$43,277,000	$49,460,000
BENEFIT-COST RATIO	0.92	1.36	1.45	1.40	1.37	1.23
NET BENEFITS	($824,000)	$5,041,000	$8,499,000	$10,228,000	$11,637,000	$9,236,000

TABLE 42
OPTION 1 (FULL CHANNEL WIDTH, WITH BECKETT STREET)
ANNUALIZATION OF COSTS AND ECONOMIC OPTIMIZATION
SENSITIVITY: 8 7/8% DISCOUNT RATE

F:AAC1W

	41 FT	42 FT	43 FT	44 FT	45 FT	46 FT
INITIAL PROJECT COSTS	$76,820,000	$101,910,000	$139,370,000	$195,690,000	$248,480,000	$314,540,000
ASSOC. COSTS	$7,781,000	$9,723,000	$20,247,000	$21,785,000	$23,205,000	$24,590,000
REAL ESTATE	$19,827,000	$19,827,000	$19,827,000	$19,827,000	$19,827,000	$19,827,000
RELOCATIONS	$0	$0	$0	$0	$3,130,000	$5,760,000
NAVIGATION AIDS	$856,000	$856,000	$856,000	$856,000	$856,000	$856,000
PED COSTS	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$10,000,000
TOTAL FIRST COSTS	$115,284,000	$142,316,000	$190,300,000	$248,158,000	$305,498,000	$375,573,000
CRF, 50 YRS	0.0900323	0.0900323	0.0900323	0.0900323	0.0900323	0.0900323
AVG ANN FIRST COST	$10,379,000	$12,813,000	$17,133,000	$22,342,000	$27,505,000	$33,814,000
AVG ANN O&M (FROM W/O PROJECT DEPTH)	$270,000	$540,000	$800,000	$1,070,000	$1,340,000	$1,610,000
TOTAL AVG ANN COSTS (W/O IDC)	$10,649,000	$13,353,000	$17,933,000	$23,412,000	$28,845,000	$35,424,000
AVG ANN IDC COSTS	$626,240	$996,010	$1,498,650	$2,645,040	$3,740,960	$6,047,130
TOTAL AVG ANN COSTS	$11,275,240	$14,349,010	$19,431,650	$26,057,040	$32,585,960	$41,471,130
AVG ANN BENEFITS OVER PROJECT LIFE	$9,921,000	$18,570,000	$26,766,000	$34,568,000	$42,087,000	$48,066,000
AVG ANN BENEFITS DURING CONSTRUCTION	$0	$0	$0	$159,000	$195,000	$230,000
TOTAL AVG ANN BENEFITS	$9,921,000	$18,570,000	$26,766,000	$34,727,000	$42,282,000	$48,296,000
BENEFIT-COST RATIO	0.88	1.29	1.38	1.33	1.30	1.16
NET BENEFITS	($1,354,000)	$4,221,000	$7,334,000	$8,670,000	$9,696,000	$6,825,000

TABLE 43
OPTION 1 (FULL CHANNEL WIDTH, WITH BECKETT STREET)
ANNUALIZATION OF COSTS AND ECONOMIC OPTIMIZATION
SENSITIVITY: 10% DISCOUNT RATE

F:AAC1W

	41 FT	42 FT	43 FT	44 FT	45 FT	46 FT
INITIAL PROJECT COSTS	$76,820,000	$101,910,000	$139,370,000	$195,690,000	$248,480,000	$314,540,000
ASSOC. COSTS	$7,781,000	$9,723,000	$20,247,000	$21,785,000	$23,205,000	$24,590,000
REAL ESTATE	$19,827,000	$19,827,000	$19,827,000	$19,827,000	$19,827,000	$19,827,000
RELOCATIONS	$0	$0	$0	$0	$3,130,000	$5,760,000
NAVIGATION AIDS	$856,000	$856,000	$856,000	$856,000	$856,000	$856,000
PED COSTS	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$10,000,000
TOTAL FIRST COSTS	$115,284,000	$142,316,000	$190,300,000	$248,158,000	$305,498,000	$375,573,000
CRF, 50 YRS	0.1008590	0.1008590	0.1008590	0.1008590	0.1008590	0.1008590
AVG ANN FIRST COST	$11,627,000	$14,354,000	$19,193,000	$25,029,000	$30,812,000	$37,880,000
AVG ANN O&M (FROM W/O PROJECT DEPTH)	$270,000	$540,000	$800,000	$1,070,000	$1,340,000	$1,610,000
TOTAL AVG ANN COSTS (W/O IDC)	$11,897,000	$14,894,000	$19,993,000	$26,099,000	$32,152,000	$39,490,000
AVG ANN IDC COSTS	$796,480	$1,266,770	$1,920,600	$3,364,080	$4,757,920	$7,691,010
TOTAL AVG ANN COSTS	$12,693,480	$16,160,770	$21,913,600	$29,463,080	$36,909,920	$47,181,010
AVG ANN BENEFITS OVER PROJECT LIFE	$9,427,000	$17,621,000	$25,388,000	$32,792,000	$39,915,000	$45,550,000
AVG ANN BENEFITS DURING CONSTRUCTION	$0	$0	$0	$150,000	$184,000	$217,000
TOTAL AVG ANN BENEFITS	$9,427,000	$17,621,000	$25,388,000	$32,942,000	$40,099,000	$45,767,000
BENEFIT-COST RATIO	0.74	1.09	1.16	1.12	1.09	0.97
NET BENEFITS	($3,266,000)	$1,460,000	$3,474,000	$3,479,000	$3,189,000	($1,414,000)

487. OPTIMISTIC AND PESSIMISTIC TONNAGE. Tables 46 and 47 bracket the average annual benefits with optimistic and pessimistic tonnage scenarios of plus and minus 25% of the most likely scenario. The optimal depth for the former scenario would be 46 feet, and for the latter scenario would be 43 feet, as shown on Tables 48 and 49, respectively.

488. BASE YEAR TONNAGE. Average annual benefits are presented in Table 50 for base year levels of tonnage. For Option 1, benefits would be 10% lower and the optional depth would still be 45 feet as shown in Table 51.

489. STUDY YEAR TONNAGE. Average annual benefits are presented in Table 52 for study year tonnage levels. Benefits would be 44% lower for that tonnage level and the channel improvement would not be justified, as shown in Table 53.

490. CLOSED OIL REFINERY. Assuming a scenario in which an average-sized benefitting refinery were to close, Table 54 shows the impact. For Option 1, benefits would be 13% lower than determined in the study analysis, but the optimal depth would remain at 45 feet, as shown in Table 55.

491. COAL SHIFT. Table 56 analyzes the impact of the coal exports moving through Pier 124 shifting to Baltimore. For Option 1, benefits would be only 0.7% lower and the optimal depth would be 45 feet, as shown in Table 57.

492. OPTION II vs OPTION I. As the result of agency concerns over the viability of Option III (wide asymmetric) an outbound lane optimization was analyzed as an increment over Option II (narrow asymmetric). This test, as shown in Table 58, also confirmed 45' full width as the NED plan.

TABLE 44
FULL WIDTH CHANNEL
OPTIMISTIC SCENARIO BENEFITS

COMMODITY	CHANNEL DEPTH: 41	42	43	44	45	46
Crude Oil Imports	$9,251,000	$18,044,000	$26,604,000	$34,519,000	$42,275,000	$49,789,000
Coal vessels-Imports	$119,000	$220,000	$300,000	$355,000	$389,000	$401,000
Iron Ore vessels-Imports	$146,000	$283,000	$408,000	$508,000	$594,000	$646,000
SJPC	$1,933,000	$ 2,779,000	$ 3,994,000	$ 5,518,000	$ 6,346,000	$ 6,346,000
Containers	$1,089,000	$ 2,150,000	$ 2,540,000	$ 2,814,000	$ 3,619,000	$ 3,619,000
TOTAL-CUMULATIVE	$12,538,000	$23,476,000	$33,846,000	$43,714,000	$53,223,000	$60,801,000

TABLE 45
FULL WIDTH CHANNEL
PESSIMISTIC SCENARIO BENEFITS

COMMODITY	CHANNEL DEPTH: 41	42	43	44	45	46
Crude Oil Imports	$5,551,000	$10,826,000	$15,962,000	$20,711,000	$25,365,000	$29,873,000
Coal vessels-Imports	$ 71,000	$132,000	$180,000	$213,000	$ 233,000	$ 241,000
Iron Ore vessels-Imports	$ 88,000	$170,000	$245,000	$305,000	$ 356,000	$ 388,000
SJPC	$1,160,000	$ 1,667,000	$ 2,396,000	$ 3,311,000	$ 3,808,000	$ 3,808,000
Containers	$ 653,000	$ 1,290,000	$ 1,524,000	$ 1,688,000	$ 2,171,000	$ 2,171,000
TOTAL-CUMULATIVE	$7,523,000	$14,085,000	$20,307,000	$26,228,000	$31,933,000	$36,481,000

TABLE 46
OPTION 1 (FULL CHANNEL WIDTH, WITH BECKETT STREET)
ANNUALIZATION OF COSTS AND ECONOMIC OPTIMIZATION
SENSITIVITY: OPTIMISTIC SCENARIO

F:AAC1W

	41 FT	42 FT	43 FT	44 FT	45 FT	46 FT
INITIAL PROJECT COSTS	$76,820,000	$101,910,000	$139,370,000	$195,690,000	$248,480,000	$314,540,000
ASSOC. COSTS	$7,781,000	$9,723,000	$20,247,000	$21,785,000	$23,205,000	$24,590,000
REAL ESTATE	$19,827,000	$19,827,000	$19,827,000	$19,827,000	$19,827,000	$19,827,000
RELOCATIONS	$0	$0	$0	$0	$3,130,000	$5,760,000
NAVIGATION AIDS	$856,000	$856,000	$856,000	$856,000	$856,000	$856,000
PED COSTS	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$10,000,000
TOTAL FIRST COSTS	$115,284,000	$142,316,000	$190,300,000	$248,158,000	$305,498,000	$375,573,000
CRF, 50 YRS	0.0888400	0.0888400	0.0888400	0.0888400	0.0888400	0.0888400
AVG ANN FIRST COST	$10,242,000	$12,643,000	$16,906,000	$22,046,000	$27,140,000	$33,366,000
AVG ANN O&M (FROM W/O PROJECT DEPTH)	$270,000	$540,000	$800,000	$1,070,000	$1,340,000	$1,610,000
TOTAL AVG ANN COSTS (W/O IDC)	$10,512,000	$13,183,000	$17,706,000	$23,116,000	$28,480,000	$34,976,000
AVG ANN IDC COSTS	$608,000	$967,000	$1,455,000	$2,568,000	$3,632,000	$5,871,000
TOTAL AVG ANN COSTS	$11,120,000	$14,150,000	$19,161,000	$25,684,000	$32,112,000	$40,847,000
AVG ANN BENEFITS OVER PROJECT LIFE	$12,538,000	$23,476,000	$33,846,000	$43,714,000	$53,223,000	$60,801,000
AVG ANN BENEFITS DURING CONSTRUCTION	$0	$0	$0	$201,000	$248,000	$291,000
TOTAL AVG ANN BENEFITS	$12,538,000	$23,476,000	$33,846,000	$43,915,000	$53,471,000	$61,092,000
BENEFIT-COST RATIO	1.13	1.66	1.77	1.71	1.67	1.50
NET BENEFITS	$1,418,000	$9,326,000	$14,685,000	$18,231,000	$21,359,000	$20,245,000

TABLE 47
OPTION 1 (FULL CHANNEL WIDTH, WITH BECKETT STREET)
ANNUALIZATION OF COSTS AND ECONOMIC OPTIMIZATION
SENSITIVITY: PESSIMISTIC SCENARIO

F:AAC1W

	41 FT	42 FT	43 FT	44 FT	45 FT	46 FT
INITIAL PROJECT COSTS	$76,820,000	$101,910,000	$139,370,000	$195,690,000	$248,480,000	$314,540,000
ASSOC. COSTS	$7,781,000	$9,723,000	$20,247,000	$21,785,000	$23,205,000	$24,590,000
REAL ESTATE	$19,827,000	$19,827,000	$19,827,000	$19,827,000	$19,827,000	$19,827,000
RELOCATIONS	$0	$0	$0	$0	$3,130,000	$5,760,000
NAVIGATION AIDS	$856,000	$856,000	$856,000	$856,000	$856,000	$856,000
PED COSTS	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$10,000,000
TOTAL FIRST COSTS	$115,284,000	$142,316,000	$190,300,000	$248,158,000	$305,498,000	$375,573,000
CRF, 50 YRS	0.0888400	0.0888400	0.0888400	0.0888400	0.0888400	0.0888400
AVG ANN FIRST COST	$10,242,000	$12,643,000	$16,906,000	$22,046,000	$27,140,000	$33,366,000
AVG ANN O&M (FROM W/O PROJECT DEPTH)	$270,000	$540,000	$800,000	$1,070,000	$1,340,000	$1,610,000
TOTAL AVG ANN COSTS (W/O IDC)	$10,512,000	$13,183,000	$17,706,000	$23,116,000	$28,480,000	$34,976,000
AVG ANN IDC COSTS	$608,000	$967,000	$1,455,000	$2,568,000	$3,632,000	$5,871,000
TOTAL AVG ANN COSTS	$11,120,000	$14,150,000	$19,161,000	$25,684,000	$32,112,000	$40,847,000
AVG ANN BENEFITS OVER PROJECT LIFE	$7,523,000	$14,085,000	$20,307,000	$26,228,000	$31,933,000	$36,481,000
AVG ANN BENEFITS DURING CONSTRUCTION	$0	$0	$0	$121,000	$149,000	$175,000
TOTAL AVG ANN BENEFITS	$7,523,000	$14,085,000	$20,307,000	$26,349,000	$32,082,000	$36,656,000
BENEFIT-COST RATIO	0.68	1.00	1.06	1.03	1.00	0.90
NET BENEFITS	($3,597,000)	($65,000)	$1,146,000	$665,000	($30,000)	($4,191,000)

TABLE 48
FULL WIDTH CHANNEL
BASE YEAR TONNAGE BENEFITS

COMMODITY	CHANNEL DEPTH: 41	42	43	44	45	46
Crude Oil Imports	$6,881,000	$13,422,000	$19,789,000	$25,676,000	$31,445,000	$37,034,000
Coal vessels-Imports	$ 95,000	$176,000	$240,000	$284,000	$ 311,000	$ 321,000
Iron Ore vessels-Imports	$ 94,000	$181,000	$261,000	$325,000	$ 380,000	$ 413,000
SJPC	$1,214,000	$ 1,746,000	$ 2,509,000	$ 3,466,000	$ 3,987,000	$ 3,987,000
Containers	$ 607,000	$ 1,198,000	$ 1,415,000	$ 1,568,000	$ 2,016,000	$ 2,016,000
TOTAL-CUMULATIVE	**$8,891,000**	**$16,723,000**	**$24,214,000**	**$31,319,000**	**$38,139,000**	**$43,771,000**

TABLE 49
OPTION 1 (FULL CHANNEL WIDTH, WITH BECKETT STREET)
ANNUALIZATION OF COSTS AND ECONOMIC OPTIMIZATION
SENSITIVITY: BASE YEAR TONNAGE

F:AAC1W

	41 FT	42 FT	43 FT	44 FT	45 FT	46 FT
INITIAL PROJECT COSTS	$76,820,000	$101,910,000	$139,370,000	$195,690,000	$248,480,000	$314,540,000
ASSOC. COSTS	$7,781,000	$9,723,000	$20,247,000	$21,785,000	$23,205,000	$24,590,000
REAL ESTATE	$19,827,000	$19,827,000	$19,827,000	$19,827,000	$19,827,000	$19,827,000
RELOCATIONS	$0	$0	$0	$0	$3,130,000	$5,760,000
NAVIGATION AIDS	$856,000	$856,000	$856,000	$856,000	$856,000	$856,000
PED COSTS	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$10,000,000
TOTAL FIRST COSTS	$115,284,000	$142,316,000	$190,300,000	$248,158,000	$305,498,000	$375,573,000
CRF, 50 YRS	0.0888400	0.0888400	0.0888400	0.0888400	0.0888400	0.0888400
AVG ANN FIRST COST	$10,242,000	$12,643,000	$16,906,000	$22,046,000	$27,140,000	$33,366,000
AVG ANN O&M (FROM W/O PROJECT DEPTH)	$270,000	$540,000	$800,000	$1,070,000	$1,340,000	$1,610,000
TOTAL AVG ANN COSTS (W/O IDC)	$10,512,000	$13,183,000	$17,706,000	$23,116,000	$28,480,000	$34,976,000
AVG ANN IDC COSTS	$608,000	$967,000	$1,455,000	$2,568,000	$3,632,000	$5,871,000
TOTAL AVG ANN COSTS	$11,120,000	$14,150,000	$19,161,000	$25,684,000	$32,112,000	$40,847,000
AVG ANN BENEFITS OVER PROJECT LIFE	$8,891,000	$16,723,000	$24,214,000	$31,319,000	$38,139,000	$43,771,000
AVG ANN BENEFITS DURING CONSTRUCTION	$0	$0	$0	$150,000	$184,000	$217,000
TOTAL AVG ANN BENEFITS	$8,891,000	$16,723,000	$24,214,000	$31,469,000	$38,323,000	$43,988,000
BENEFIT-COST RATIO	0.80	1.18	1.26	1.23	1.19	1.08
NET BENEFITS	($2,229,000)	$2,573,000	$5,053,000	$5,785,000	$6,211,000	$3,141,000

TABLE 50
FULL WIDTH CHANNEL
STUDY YEAR TONNAGE BENEFITS

COMMODITY	CHANNEL DEPTH: 41	42	43	44	45	46
Crude Oil Imports	$4,462,000	$ 8,703,000	$12,831,000	$16,648,000	$20,389,000	$24,013,000
Coal vessels-Imports	$ 110,000	$ 203,000	$ 277,000	$ 328,000	$ 359,000	$ 370,000
Iron Ore vessels-Imports	$ 48,000	$ 93,000	$ 134,000	$ 166,000	$ 195,000	$ 212,000
SJPC	$ 347,000	$ 499,000	$ 718,000	$ 992,000	$ 1,141,000	$ 1,141,000
Containers	$ 505,000	$ 997,000	$ 1,178,000	$ 1,305,000	$ 1,679,000	$ 1,679,000
TOTAL-CUMULATIVE	$5,472,000	$10,495,000	$15,138,000	$19,439,000	$23,763,000	$27,415,000

TABLE 51

OPTION 1 (FULL CHANNEL WIDTH, WITH BECKETT STREET)

ANNUALIZATION OF COSTS AND ECONOMIC OPTIMIZATION

SENSITIVITY: STUDY YEAR TONNAGE

F:AAC1W

	41 FT	42 FT	43 FT	44 FT	45 FT	46 FT
INITIAL PROJECT COSTS	$76,820,000	$101,910,000	$139,370,000	$195,690,000	$248,480,000	$314,540,000
ASSOC. COSTS	$7,781,000	$9,723,000	$20,247,000	$21,785,000	$23,205,000	$24,590,000
REAL ESTATE	$19,827,000	$19,827,000	$19,827,000	$19,827,000	$19,827,000	$19,827,000
RELOCATIONS	$0	$0	$0	$0	$3,130,000	$5,760,000
NAVIGATION AIDS	$856,000	$856,000	$856,000	$856,000	$856,000	$856,000
PED COSTS	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$10,000,000
TOTAL FIRST COSTS	$115,284,000	$142,316,000	$190,300,000	$248,158,000	$305,498,000	$375,573,000
CRF, 50 YRS	0.0888400	0.0888400	0.0888400	0.0888400	0.0888400	0.0888400
AVG ANN FIRST COST	$10,242,000	$12,643,000	$16,906,000	$22,046,000	$27,140,000	$33,366,000
AVG ANN O&M (FROM W/O PROJECT DEPTH)	$270,000	$540,000	$800,000	$1,070,000	$1,340,000	$1,610,000
TOTAL AVG ANN COSTS (W/O IDC)	$10,512,000	$13,183,000	$17,706,000	$23,116,000	$28,480,000	$34,976,000
AVG ANN IDC COSTS	$608,000	$967,000	$1,455,000	$2,568,000	$3,632,000	$5,871,000
TOTAL AVG ANN COSTS	$11,120,000	$14,150,000	$19,161,000	$25,684,000	$32,112,000	$40,847,000
AVG ANN BENEFITS OVER PROJECT LIFE	$5,472,000	$10,495,000	$15,138,000	$19,439,000	$23,763,000	$27,415,000
AVG ANN BENEFITS DURING CONSTRUCTION	$0	$0	$0	$97,000	$119,000	$140,000
TOTAL AVG ANN BENEFITS	$5,472,000	$10,495,000	$15,138,000	$19,536,000	$23,882,000	$27,555,000
BENEFIT-COST RATIO	0.49	0.74	0.79	0.76	0.74	0.67
NET BENEFITS	($5,648,000)	($3,655,000)	($4,023,000)	($6,148,000)	($8,230,000)	($13,292,000)

TABLE 52
FULL WIDTH CHANNEL
BENEFITS WITH AVERAGE SIZED REFINERY CLOSED

COMMODITY	CHANNEL DEPTH: 41	42	43	44	45	46
Crude Oil Imports	$6,167,000	$12,029,000	$17,736,000	$23,012,000	$28,183,000	$33,192,000
Coal vessels-Imports	$ 95,000	$ 176,000	$ 240,000	$ 284,000	$ 311,000	$ 321,000
Iron Ore vessels-Imports	$ 117,000	$ 226,000	$ 326,000	$ 406,000	$ 475,000	$ 517,000
SJPC	$1,546,000	$ 2,223,000	$ 3,195,000	$ 4,414,000	$ 5,077,000	$ 5,077,000
Containers	$ 871,000	$ 1,720,000	$ 2,032,000	$ 2,251,000	$ 2,895,000	$ 2,895,000
TOTAL-CUMULATIVE	**$8,796,000**	**$16,374,000**	**$23,529,000**	**$30,367,000**	**$36,941,000**	**$42,002,000**

TABLE 53
OPTION 1 (FULL CHANNEL WIDTH, WITH BECKETT STREET) F:AAC1W
ANNUALIZATION OF COSTS AND ECONOMIC OPTIMIZATION
SENSITIVITY: AVERAGE-SIZED REFINERY CLOSED

	41 FT	42 FT	43 FT	44 FT	45 FT	46 FT
INITIAL PROJECT COSTS	$76,820,000	$101,910,000	$139,370,000	$195,690,000	$248,480,000	$314,540,000
ASSOC. COSTS	$7,781,000	$9,723,000	$20,247,000	$21,785,000	$23,205,000	$24,590,000
REAL ESTATE	$19,827,000	$19,827,000	$19,827,000	$19,827,000	$19,827,000	$19,827,000
RELOCATIONS	$0	$0	$0	$0	$3,130,000	$5,760,000
NAVIGATION AIDS	$856,000	$856,000	$856,000	$856,000	$856,000	$856,000
PED COSTS	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$10,000,000
TOTAL FIRST COSTS	$115,284,000	$142,316,000	$190,300,000	$248,158,000	$305,498,000	$375,573,000
CRF, 50 YRS	0.0888400	0.0888400	0.0888400	0.0888400	0.0888400	0.0888400
AVG ANN FIRST COST	$10,242,000	$12,643,000	$16,906,000	$22,046,000	$27,140,000	$33,366,000
AVG ANN O&M (FROM W/O PROJECT DEPTH)	$270,000	$540,000	$800,000	$1,070,000	$1,340,000	$1,610,000
TOTAL AVG ANN COSTS (W/O IDC)	$10,512,000	$13,183,000	$17,706,000	$23,116,000	$28,480,000	$34,976,000
AVG ANN IDC COSTS	$608,000	$967,000	$1,455,000	$2,568,000	$3,632,000	$5,871,000
TOTAL AVG ANN COSTS	$11,120,000	$14,150,000	$19,161,000	$25,684,000	$32,112,000	$40,847,000
AVG ANN BENEFITS OVER PROJECT LIFE	$8,796,000	$16,374,000	$23,529,000	$30,367,000	$36,941,000	$42,002,000
AVG ANN BENEFITS DURING CONSTRUCTION	$0	$0	$0	$134,000	$165,000	$194,000
TOTAL AVG ANN BENEFITS	$8,796,000	$16,374,000	$23,529,000	$30,501,000	$37,106,000	$42,196,000
BENEFIT-COST RATIO	0.79	1.16	1.23	1.19	1.16	1.03
NET BENEFITS	($2,324,000)	$2,224,000	$4,368,000	$4,817,000	$4,994,000	$1,349,000

TABLE 54
FULL WIDTH CHANNEL
BENEFITS WITH COAL MOVED TO BALTIMORE

COMMODITY	CHANNEL DEPTH: 41	42	43	44	45	46
Crude Oil Imports	$7,401,000	$14,435,000	$21,283,000	$27,615,000	$33,820,000	$39,831,000
Coal vessels-Imports	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
Iron Ore vessels-Imports	$ 117,000	$ 226,000	$ 326,000	$ 406,000	$ 475,000	$ 517,000
SJPC	$1,546,000	$ 2,223,000	$ 3,195,000	$ 4,414,000	$ 5,077,000	$ 5,077,000
Containers	$ 871,000	$ 1,720,000	$ 2,032,000	$ 2,251,000	$ 2,895,000	$ 2,895,000
TOTAL-CUMULATIVE	**$9,935,000**	**$18,604,000**	**$26,836,000**	**$34,686,000**	**$42,267,000**	**$48,320,000**

TABLE 55
FULL WIDTH CHANNEL OPTIMIZATION WITH COAL

OPTION 1 (FULL CHANNEL WIDTH, WITH BECKETT STREET)
ANNUALIZATION OF COSTS AND ECONOMIC OPTIMIZATION
SENSITIVITY: COAL TO BALTIMORE

F:AAC1W

	41 FT	42 FT	43 FT	44 FT	45 FT	46 FT
INITIAL PROJECT COSTS	$76,820,000	$101,910,000	$139,370,000	$195,690,000	$248,480,000	$314,540,000
ASSOC. COSTS	$7,781,000	$9,723,000	$20,247,000	$21,785,000	$23,205,000	$24,590,000
REAL ESTATE	$19,827,000	$19,827,000	$19,827,000	$19,827,000	$19,827,000	$19,827,000
RELOCATIONS	$0	$0	$0	$0	$3,130,000	$5,760,000
NAVIGATION AIDS	$856,000	$856,000	$856,000	$856,000	$856,000	$856,000
PED COSTS	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$10,000,000	$10,000,000
TOTAL FIRST COSTS	$115,284,000	$142,316,000	$190,300,000	$248,158,000	$305,498,000	$375,573,000
CRF, 50 YRS	0.0888400	0.0888400	0.0888400	0.0888400	0.0888400	0.0888400
AVG ANN FIRST COST	$10,242,000	$12,643,000	$16,906,000	$22,046,000	$27,140,000	$33,366,000
AVG ANN O&M (FROM W/O PROJECT DEPTH)	$270,000	$540,000	$800,000	$1,070,000	$1,340,000	$1,610,000
TOTAL AVG ANN COSTS (W/O IDC)	$10,512,000	$13,183,000	$17,706,000	$23,116,000	$28,480,000	$34,976,000
AVG ANN IDC COSTS	$608,000	$967,000	$1,455,000	$2,568,000	$3,632,000	$5,871,000
TOTAL AVG ANN COSTS	$11,120,000	$14,150,000	$19,161,000	$25,684,000	$32,112,000	$40,847,000
AVG ANN BENEFITS OVER PROJECT LIFE	$9,935,000	$18,604,000	$26,836,000	$34,686,000	$42,267,000	$48,370,000
AVG ANN BENEFITS DURING CONSTRUCTION	$0	$0	$0	$134,000	$165,000	$194,000
TOTAL AVG ANN BENEFITS	$9,935,000	$18,604,000	$26,836,000	$34,820,000	$42,432,000	$48,564,000
BENEFIT-COST RATIO	0.89	1.31	1.40	1.36	1.32	1.19
NET BENEFITS	($1,185,000)	$4,454,000	$7,675,000	$9,136,000	$10,320,000	$7,717,000

TABLE 56
OPTIMIZATION OF OUTBOUND LANE
OPTION #1 vs ASYMMETRIC #2

CHANNEL DEPTH	ANNUAL COSTS ($000'S)			ANNUAL BENEFITS			NET
	#1	#2	DIFF.	#1	#2	DIFF.	
41 FT	11,119	9,805	1,314	10,030	6,272	3,758	2,444
42 FT	14,150	11,056	3,094	18,780	12,231	6,549	3,455
43 FT	19,161	14,109	5,052	27,076	18,030	9,046	3,994
44 FT	25,685	18,090	7,594	35,131	23,486	11,645	4,051
45 FT	32,113	22,450	9,662	42,776	28,631	14,145	4,483*
46 FT	40,847	30,086	10,761	48,874	33,701	15,173	4,412

482. Navigation Practice. Navigation practice has changed considerably since 1954, when the last channel modifications for the Delaware River, Philadelphia to Sea project occurred. Initially vessels did not use the tide and vessel operating drafts were limited to 30 feet, since the 40 foot channel could be effectively maintained to a depth of only 36 feet. At present the channel is fully maintained to a 40 foot depth. Vessels which do not use the tides are loaded up to a depth of 37 feet and by using tides vessel drafts can reach 40 feet. Maximum use of the channel in terms of vessel operating draft now occurs.

483. RIVER DEPTHS. Effective river depths vary as a result of tides and weather conditions. Low tides fall 2 feet or more below the plane of mean low water an average of five times a year and 1 foot or more below the plane of mean low water an average of 34 times a year. The extreme low tides occur in the Delaware River when strong northwest winds prevail for periods of from one to three days. Similar variations in high tide also occur. Tidal variations are monitored by the pilots and transit times adjusted accordingly to assure safe underkeel and overhead clearance. Although no changes in operating practice are anticipated, the level of project outputs is sensitive to navigation practice, as is

demonstrated by the variations in benefits for the alternative plans considered.

495. Shoaling Analysis The shoaling analysis performed for the channel deepening utilized an empirical data base of historic hydrographic surveys and maintenance dredging records in order to estimate the incremental maintenance dredging quantities associated with the considered alternative channel depths and alignments. Detailed analysis of shoaling rates was performed for four of the ranges of the project which together require nearly 90 per cent of the average annual maintenance dredging by volume along less than 10 per cent of the total project by length. The period of record used in the analysis of shoaling with respect to channel deepening included 1969 which is the earliest year with current dredging and disposal practices fully in place through 1985. During this period there were a number of maintenance dredging contracts in which depths greater than the project depth of 40 feet were obtained either through intentional advance maintenance dredging or unintended dredging beyond "pay" depth. The record of depth as a function of time at representative index stations was used to determine characteristic shoaling rates subsequent to dredging. The estimates of potential future shoaling rates within the Philadelphia-to-Sea channel for alternative depths greater than the existing 40 foot depth were based on the actual shoaling characteristics observed in the critical shoaling reaches of the project for dredged depths in excess of 40 feet.

496. The risk and uncertainty associated with the shoaling and maintenance dredging analysis is related to a number of factors, including the natural year-to-year variability of sedimentation rates within the dredged channel of the project, the frequency and depth of maintenance dredging performed in the period of record used in the analysis, and the approach of utilizing an empirical data base rather than a modeling approach. The risk and uncertainty involved in the shoaling rate estimates are potential problems only if the tentatively selected plan is constructed and subsequent shoaling rates are significantly greater than projected. This is considered unlikely based on the amount of data and records evaluated, including advance maintenance. If there is less or no increase in shoaling rate and required maintenance dredging, then actual dredging costs for the Federal government would be less than projected and disposal site usage and costs would also be less, resulting in extended site capacity. Since disposal site area requirements were developed based primarily on initial construction, there is little risk that less disposal area acquisition would be needed due to uncertainty in shoaling projections.

497. Disposal Site Selection. Analyses of existing Federal disposal area capacity indicated that, even assuming dike heights are raised, insufficient capacity exists to maintain the 40 foot channel throughout the study period using the existing sites in the

upper river. Either two new upland disposal sites will be needed for disposal of material from the channel between Philadelphia and Wilmington, or material will have to be transported to downriver sites at increased expense. Enough capacity exists in disposal areas along the lower river to last past the year 2055 if dike raising continues. Based on recent experience, about 10 years would be required to obtain all necessary environmental clearances, complete detailed designs, and prepare the sites for first use. With suburban expansion likely to continue, suitable replacement upland disposal sites will be more difficult to locate and more costly in the future. Any constraint of dike heights will make disposal a more critical problem. Provision of additional sites for the tentatively selected plan will accelerate the acquisition process compared to needs for the existing channel maintenance and minimize the uncertainty of future disposal costs for the existing Federal project as well as the modification, while maximizing the effectiveness of site management and potential for reuse.

498. Sea Level Rise. The National Research Council study (Responding to Changes in Sea Level Engineering Implications, 1987) considers the effects of sea level rise on various coastal and estuarine features including navigation channels. According to this study the present best estimates of local relative sea level changes is 2.0 mm per Year or about 4 inches over 50 Years. This level of change is insufficient to alter the recommended plan.

COORDINATION

499. Coordination has been conducted with various Federal, state, and local agencies from initiation through formulation. More intense coordination was conducted with the various port interests including the Mariners' Advisory Committee, the Delaware River Port Authority, the Delaware River and Bay Authority, and the Joint Executive Committee. Coordination has also been accomplished with project users and potential beneficiaries. Federal and state regulatory agencies were involved in the screening of potential disposal areas and were consulted to asses environmental concerns and views on impacts. A formal public meeting was held during reconnaissance studies and was used along with several newsletters to facilitate public input.

500. A notice of intent to prepare a Draft Environmental Impact Statement (DEIS) was published in the Federal Register on May 4, 1989. A notice of availability for that DEIS was published in the Federal Register on July 13, 1990. Based on comments received on the DEIS it was determined that an amendment was necessary to provide additional information regarding the environmental impacts of the proposed project. Significant issues addressed in that amendment included the chemical characteristics of the sediments proposed for dredging, potential changes in salinity patterns of the Delaware Estuary as a result of channel deepening, potential

impacts to groundwater resources in the project areas, the feasibility of an oil pipeline system to limit the need for a navigation channel within the Delaware River, the impact of rock blasting on fishery resources in the vicinity of Marcus Hook, PA, and an analysis of alternatives to the use of the existing open water disposal site in Delaware Bay. A notice of intent to prepare that DEIS amendment was published in the Federal Register on June 12, 1991. A notice of availability for that amendment was published in the Federal Register on December 6, 1991.

501. Several informational workshops have been held involving members of the Delaware River Estuary Committee and the Water Resource Association of the Delaware River Basin as well as other navigational interests. Correspondence on the staff along with responses to comments on the Draft Report/EIS can be found in Appendix A.

SELECTED PLAN

502. The preceding section summarized plan formulation and identified the best plan to resolve the navigation problems of the study area. The following paragraphs present a description of that plan, including its accomplishments, effects, design, construction, and operation and maintenance aspects.

PROJECT DESCRIPTION

503. The selected plan as shown on Plate 1 consists of a navigation project extending from deep water in the Delaware Bay to the Beckett Street Terminal in Philadelphia Harbor, a distance of about 102.5 miles. The selected plan provides for a full width channel with a 45 foot MLW depth and an allowable dredging overdepth of two feet. The channel side slopes are 3 horizontal to 1 vertical. Channel dimensions below Walt Whitman Bridge are based on a 160,000 D.W.T. tanker with a length of 931 feet, beam of 145 feet, and operating draft of 45 feet. The design vessel for Philadelphia Harbor and Beckett Street Terminal access is a 100,000 D.W.T. dry bulk vessel with a length of 830 feet and beam of 128 feet. The selected channel dimensions allow for navigation practices similar to existing conditions which allow full use of the tide range by inbound vessels. The channel width would range from 400 feet in Philadelphia Harbor to 800 feet from Philadelphia Navy Yard to Bombay Hook and then 1000 feet in the Delaware Bay. The plan includes all appropriate bend widening as well as provision of a two space anchorage of compatible depth at Marcus Hook anchorage. The project also includes utility relocations, aids to navigation, and lands, easements, rights-of-way and disposal areas as required for the initial construction and maintenance of the project. The main channel dimensions are summarized as follows:

Location	Length Miles	Width (feet)
Delaware Bay	44.3	1000
Delaware River, Bombay Hook to Phila. Navy Yard	55.7	800
Phila. Harbor	2.5	400

504. In addition, the plan includes deepening access at a 45' depth to the bulk berths at Beckett Street Terminal in Camden, a public terminal operated by the South Jersey Port Corporation.

505. DREDGED MATERIAL DISPOSAL PLAN. The initial dredging quantity necessary to increase channel depths from the currently authorized 40 foot channel has two components, Federal and non-Federal. The Federal project quantity refers to the channel and anchorage, the non-Federal or associated quantity refers to the berth areas. Quantities are listed in Table 59.

TABLE 57

DISPOSAL QUANTITIES
45 FOOT PLAN

Initial Dredging - cubic yards

Federal Channel	Non-Federal Berth Area	Total
50,100,000	2,423,300	52,523,300

Maintenance Dredging - An additional 756,000 cubic yards per year

506. The disposal plan selected includes use of Site 17-O for initial construction in the upper Delaware River (Reach A), use of site 15D for construction in Reach B, initial construction in Reach C using the Raccoon Island disposal area, use of the Reedy Island North and South Federal sites in Reach D with the remainder going to the Raccoon Island site. Beneficial use of initial dredge material from the bay channel is to occur through wetland/island creation and sand stockpiling for subsequent use by the locals. Dredged material from maintenance would be placed in both Federal and non-Federal sites to minimize dredging and disposal costs for both the present 40' project and additional maintenance with channel deepening. This is the NED plan for dredged material disposal and includes sufficient disposal area capacity by the non-Federal sponsor to fully accommodate initial and maintenance dredging quantities. When required, advanced maintenance dredging of the channel up to 49 feet below mean low water will occur depending on the rate of shoaling. This is a continuation of

existing project maintenance practice since benefits for the proposed deepening are based on maximum utilization of the 45' channel and utilization of high tide stages. Approval for Advance Maintenance was granted by NAD for the Delaware River, Philadelphia to the Sea Project on 19 June 1981. Advance maintenance dredging is needed in critical area to assure maintenance of the proposed depth. The high shoaling areas will continue to be dredged at least every year, where areas of less shoaling will go several years between dredging. In addition, due to dredging inaccuracies up to two feet of overdredging will also continue to occur. The two foot overdepth allowance is standard practice on large dredging projects. An allowance for up to and including a two foot overdepth dredging takes into account dredging inaccuracies. The inclusion of the overdepth quantities in the total project cost provides for a conservative cost estimate.

507. The selected plan requires the acquisition of 3 new upland disposal areas as discussed in the Geotechnical Appendix. Areas 17-0, 15-D, and Raccoon Island will be used for initial and maintenance dredged quantities of the Federal channel. All of the new upland sites have been used in the past as dredged material disposal areas and contain 5 to 15 feet of fine-grained sediment which acts as an impermeable blanket. All of the areas overlie the Potomac-Raritan-Magothy formation. Due to the limited pending time of water and minimum head in the disposal area, as well as the stratigraphy and nature of the sediments beneath the disposal areas, it is improbable that any substantial quantity of water will escape through the foundation into the sole source aquifer. Any water that does not flow directly back into the river through the sluice will reach the river via the shallow surface aquifers that underlie the areas. In addition, the drinking water aquifers of the Potomac-Raritan-Magothy are separated by multiple clay layers as mentioned previously.

PROJECT COSTS

508. Project costs are comprised of initial costs and future operation and maintenance costs as outlined below.

509. INITIAL CONSTRUCTION COSTS. Estimates were prepared for initial dredging of the Federal and Non-Federal associated portions of the recommended plan. Dredging of the Federal and Non-Federal associated portions of the project will be done independently of each other. The estimates assume that Reaches AA (between Beckett Street and Piers 122/124), A, B of the Federal portion of the project will be done by hydraulic dredge and pumping into disposal areas acquired for the project. Due to the long pumping distances, Reaches C, and D will be done by hopper dredges pumping into disposal areas. For Reach E the use of hydraulic dredge and pumping to Wetlands restoration and aquatic sand stockpiling was computed. Cost estimates developed for Reach E takes into account environmental windows that may be encountered during the bottom

dumping portion of the project. The estimates assumed the dredging of the associated portion of the project will be done by a local dredging contractor hauling the dredged material to a private disposal site consistent with long term history of such work and the quantity in the part of all required permits. Cost estimates were also prepared for disposal area preparation. The disposal area work consists of site clearing, raising or building dikes and constructing sluices. All disposal area work will be done prior to initial dredging. The total initial costs for channel improvements from the bay mouth to Philadelphia Harbor are estimated at $245,656,000 dollars excluding LERRD and associated costs. Dredging operations for initial construction would occur over five years and would be separate from maintenance operations for the presently authorized project. The summary of initial first costs is shown in Tables 60 to 61.

510. MAINTENANCE COSTS. Estimates were prepared for maintenance dredging of the recommended plan. The unit costs were developed based on cost data taken from the Maintenance Dredging, Philadelphia to the Sea Project which is currently bid every year. The cost estimates assume that reaches AA, A, and B will be done by hydraulic dredge while reaches C, D, and E will be done by hopper dredge. Disposal area cost estimates were developed to account for the miscellaneous dike raising during the life of the project. Maintenance costs reflect September 1991 price levels. The incremental maintenance costs for the channel deepening project is estimated at $1,340,000 annually. Costs include maintenance dredging for the 50 year project life, and disposal area preparation. The summary of maintenance costs for the 40' existing project and the total after constructed 45' selected plan are shown in Tables 65 and 66.

511. Maintenance of the Federal channel would be a Federal responsibility, and continue to occur on an annual basis. The difference between the two (40' vs 45') would be the net cost of maintenance for the selected plan.

512. DISPOSAL. The three upland disposal sites provided by the non-federal interests for initial construction would be used throughout the 50 year project life for maintenance dredging disposal, along with Federal disposal sites, used for maintenance of the existing 40 foot project plus Reedy Point north and south disposal sites. The proposed aquatic sites in Delaware Bay will be used for initial construction only. Any Federal disposal areas that are used by the Local sponsor must be reimburse on a like for like yearly basis. While ownership and operation would remain with the local sponsor, the decision on site utilization will be retained by the Corps of Engineers via a permanent easement. As part of the final project Local Cooperation Agreement, details will

TABLE 58

DELAWARE RIVER COMPREHENSIVE NAVIGATION STUDY

INITIAL DREDGING
(PRICE LEVEL SEPTEMBER 1991)

		ESTIMATED COST	CONTINGENCY	TOTAL COST
12.-.-.-	DREDGING			
12.0.A.-	MOBILIZATION, DEMOBILIZATION AND PREPARATORY WORK	$10,924,880	$571,293	$11,496,173
12.0.2.-	PIPELINE DREDGING	$91,682,696	$9,435,231	$101,117,927
12.0.3.-	HOPPER DREDGING	$64,113,679	$4,487,257	$68,600,936
12.0.4.-	WETLANDS, PLANTING	$5,200,000	$1,300,000	$6,500,000
12.0.5.-	MECHANICAL DREDGING	$18,043,800	$9,021,900	$27,065,700
	SUBTOTAL, DREDGING	$189,965,055	$24,815,681	$214,780,736
	TOTAL CONSTRUCTION COST	$189,965,055	$24,815,681	$214,780,736
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	$14,900,000	$2,235,000	$17,135,000
31.-.-.-	CONSTRUCTION MANAGEMENT	$6,000,000	$900,000	$6,900,000
	TOTAL PROJECT COSTS	$210,865,055	$27,950,681	$238,815,736
	(ROUNDED)			$238,800,000

TABLE 59

DELAWARE RIVER COMPREHENSIVE NAVIGATION STUDY

INITIAL DISPOSAL AREAS
(PRICE LEV EL SEPTEMBER 1991)

		ESTIMATED COST	CONTINGENCY	TOTAL COST
01.-.-.-	LAND AND DAMAGES			
01.M.-.-	REAL ESTATE RECEIPTS/PAYMENTS	$17,241,000	$2,586,150	$19,827,150
	SUBTOTAL, LANDS AND DAMAGES	$17,241,000	$2,586,150	$19,827,150
12.-.-.-	DREDGING			
12.0.A.-	MOBILIZATION, DEMOBILIZATION AND PREPARATORY WORK	$320,000	$16,000	$336,000
12.0.1.-	DISPOSAL AREAS	$5,849,135	$584,914	$6,434,049
	SUBTOTAL, DREDGING	$6,169,135	$600,914	$6,770,049
	TOTAL CONSTRUCTION COST	$23,090,135	$3,187,064	$26,597,199
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	$1,730,000	$259,500	$1,989,500
31.-.-.-	CONSTRUCTION MANAGEMENT	$800,000	$120,000	$920,000
	TOTAL PROJECT COSTS	$8,699,135	$980,414	$9,679,549
	(ROUNDED)	$8,699,000	$980,000	$9,680,000

TABLE 60

DELAWARE RIVER COMPREHENSIVE NAVIGATION STUDY

UTILITY RELOCATIONS
(PRICE LEVEL SEPTEMBER 1991)

		ESTIMATED COST	CONTINGENCY	TOTAL COST
02.- -.-	RELOCATIONS			
02.3.-	CEMENTERIES, UTILITIES & STRUCTURES, CONSTRUCTION ACTIVITIES			
02.3.A.-	MOBILIZATION, DEMOBILIZATION AND PREPARATORY WORK	$26,750	$6,688	$33,438
02.3.2.-	UTILITIES			
02.3.2.R	PRIMARY POWER LINES	$1,974,150	$493,538	$2,467,688
	SUBTOTAL, RELOCATIONS	$2,000,900	$500,225	$2,501,125
	TOTAL CONSTRUCTION COST	$2,000,900	$500,225	$2,501,125
30 -.-.-	PLANNING, ENGINEERING AND DESIGN	$300,135	$75,033	$375,168
31.-.-.-	CONSTRUCTION MANAGEMENT	$223,300	$26,812	$250,112
	TOTAL PROJECT COSTS	$2,524,335	$602,070	$3,126,405
	(ROUNDED)			$3,126,000

TABLE 61

DELAWARE RIVER COMPREHENSIVE NAVIGATION STUDY – ASSOCIATED COSTS

NAVIGATION AIDS
(PRICE LEVEL SEPTEMBER 1991)

		ESTIMATED COST	CONTINGENCY	TOTAL COST
12.– –.–	DREDGING			
12.0.6.–	NAVIGATION AIDS			
12.06.B	NAVIGATION AIDS	$722,250	$72,225	$794,475
	SUBTOTAL, DREDGING	$722,250	$72,225	$794,475
	TOTAL CONSTRUCTION COST	$722,250	$72,225	$794,475
30.–.–.–	PLANNING, ENGINEERING AND DESIGN	$36,400	$3,640	$40,040
31.–.–.–	CONSTRUCTION MANAGEMENT	$18,200	$2,730	$20,930
	TOTAL PROJECT COSTS	$776,850	$78,595	$855,445
	(ROUNDED)	$777,000	$79,000	$855,000

TABLE 2

DELAWARE RIVER COMPREHENSIVE NAVIGATION STUDY

ASSOCIATED COSTS
(PRICE LEVEL SEPTEMBER 1991)

		ESTIMATED COST	CONTINGENCY	TOTAL COST
02.-.-.-	RELOCATIONS			
	CEMENTERIES, UTILITIES & STRUCTURES,			
02.3.-	CONSTRUCTION ACTIVITIES			
02.3.3.-	STRUCTURES			
02.3.3.5	BULKHEADS	$7,908,700	$1,186,305	$9,095,005
	SUBTOTAL, RELOCATIONS	$7,908,700	$1,186,305	$9,095,005
12.-.-.-	DREDGING			
12.0.A.-	MOBILIZATION, DEMOBILIZATION AND PREPARATORY WORK	$1,177,423	$176,613	$1,354,036
12.0.3.-	HOPPER DREDGING	$8,614,235	$1,292,135	$9,906,370
	SUBTOTAL, DREDGING	$9,791,658	$1,468,749	$11,260,407
	TOTAL CONSTRUCTION COST	$17,700,358	$2,655,054	$20,355,412
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	$1,416,029	$212,404	$1,628,433
31.-.-.-	CONSTRUCTION MANAGEMENT	$1,062,021	$159,303	$1,221,325
	TOTAL PROJECT COSTS	$20,178,408	$3,026,761	$23,205,169
	(ROUNDED)			$23,205,000

TABLE 63

MAINTENANCE DREDGIN 45' FULL WIDT H CHANNEL
(ANN UAL COST)
(PRICE LEV EL SEPTEMBER 1991)

		ESTIMATED COST	CONTINGENC	TOTAL COST
12.-.-.-	DREDGING			
12.0.A.-	MOBILIZATION, DEMOBILIZATION AND PREPARATORY WORK	$1,152,000	$172,800	$1,324,800
12.0.1.-	DISPOSAL AREAS	$505,000	$75,750	$580,750
12.0.2.-	PIPELINE DREDGING	$6,038,800	$897,820	$6,936,620
12.0.3.-	HOPPER DREDGING	$4,419,200	$661,880	$5,081,080
		=========	=======	=========
	SUBTOTAL, DREDGING	$12,115,000	$1,808,250	$13,923,250
		=========	=======	=========
	TOTAL CONSTRUCTION COST	$12,115,000	$1,808,250	$13,923,250
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	$300,000	$45,000	$345,000
31.-.-.-	CONSTRUCTION MANAGEMENT	$150,000	$22,500	$172,500
		=========	=======	=========
	TOTAL PROJECT COSTS	$12,565,000	$1,884,750	$14,440,750
	(ROUNDED)			$14,441,000

TABLE 64

MAINTENANCE DREDGIN EXISTING 40' CHANNEL
(ANN UAL COST)
(PRICE LEV EL SEPTEMBER 1991)

		ESTIMATED COST	CONTINGENC	TOTAL COST
12.-.-.-	DREDGING			
12.0.A.-	MOBILIZATION, DEMOBILIZATION AND PREPARATORY WORK	$1,152,000	$172,800	$1,324,800
12.0.1.-	DISPOSAL AREAS	$415,000	$62,250	$477,250
12.0.2.-	PIPELINE DREDGING	$5,376,000	$802,400	$6,178,400
12.0.3.-	HOPPER DREDGING	$4,006,100	$596,915	$4,603,015
		=========	=======	=========
	SUBTOTAL, DREDGING	$10,949,100	$1,634,365	$12,583,465
		=========	=======	=========
	TOTAL CONSTRUCTION COST	$10,949,100	$1,634,365	$12,583,465
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	$300,000	$45,000	$345,000
31.-.-.-	CONSTRUCTION MANAGEMENT	$150,000	$22,500	$172,500
		=========	=======	=========
	TOTAL PROJECT COSTS			$13,100,965
	(ROUNDED)			$13,101,000

be specified to ensure both the project sponsor and the Federal Government incur equitable costs. Disposal of dredged material from berths would continue to be deposited at private rather than project disposal areas.

513. Real Estate studies involved coordination with the Corps of Engineers, Baltimore District, Real Estate Division (CENAB-RE). Integral to this work effort, as outlined in draft ER 405-1-12 dated January 1991, is the preparation of a Baseline Cost Estimate for Real Estate in M-Cases format and Real Estate Supplement. This involves a detailed accounting of property ownership and acquisition activities of impacted project lands, preparation of a Gross Appraisal, and assessment of LERRD requirements. CENAP-RE Cooperation Agreement (LCA) in cooperation with the local sponsor, study manager., project manager and all other affiliated or concerned agencies. The sponsor has been responsible for providing the pertinent data and information to assist Government personnel in the identification of all property and potentially impacted properties within the study area.

514. Contingencies: The estimated cost for each major subdivision or feature of the recommended project includes an item for "contingencies". The item for "contingencies" is an allowance against some adverse or unanticipated condition not susceptible to exact evaluation from the data at hand but which must be expressed or represented in the cost estimate. The contingency allowances used in the development of the cost estimates for the selected project were estimated as a lump sum or approximate percentage. The contingency allowances used in the cost estimates reflect the following uncertainties and concerns exposed during the feasibility study:

a. Mobilization, Demobilization and Preparatory Work: Contingencies in this line item reflect concerns about availability of dredges and locations of the available dredges. A contingency factor of 5% for dredges and for rock excavation a contingency factor of 15% was used to reflect in addition to the above mentioned concerns, the specialized rock blasting equipment required.

b. Pipeline Dredging: Contingencies for the line item reflect concerns about pumping distances and production rates when dredging new/undisturbed materials. In addition contingencies reflect concerns about the fluctuation of fuel prices, surveys and labor costs. Hence for Reaches AA, A and B a contingency factor of 7% of the initial dredging was used. In addition for Reach E a contingency factor of 15% of the initial dredging was used to reflect the uncertainty that may arise at the proposed disposal site.

c. Hopper Dredging: Contingencies for the line item reflect concerns about pumping distances and production rates when dredging

new/undisturbed materials. In addition environmental windows that may be encountered during the bottom dumping portion of the project. Hence for Reaches C and D a contingency allowance of 7% of the initial dredging was used.

d. Rock Excavation: Contingencies for this line item reflect concerns about the availability of the equipment; drill pattern and depth of drilling; type of material; and instrumentation and monitoring during blasting. A contingency factor of 50% was used for rock excavation.

e. Disposal Areas: Contingencies for this line item reflect the uncertainty whether all disposal areas will be available and ready for the initial construction stages of the project. A contingency factor of 10% was used.

515. Planning, Engineering, and Design: Preconstruction, Engineering and Design (P,E & D) related costs for the Federal portion of the recommended plan during the initial dredging stage were estimated as a lump sum item based on similar Corps of Engineers projects. P,E & D costs include local cooperative agreements, environmental and regulatory activities, design related engineering, general design memorandum, plans and specifications, engineering during construction, A/E liability actions, cost engineering, construction and supply contract award activities and Project management. P,E & D estimated lump sums for Reaches AA, A and B was $1,420,000; for Reaches C and D was $1,610,000; and for Reach E was $1,390,000. P,E & D for the associated portion of the recommended plan during the initial dredging project were estimated at 8% of the direct construction cost.

516. Construction Management. Construction Management (S & A) related costs for the Federal portion of the recommended plan during the initial dredging stage were estimated as a lump sum in the amount of $600,000 based on similar Corps of Engineers projects. S & A costs include contract administration, review of shop drawings, inspection and quality assurance, project office operation, contractor initiated claims and litigations, government initiated claims and litigations, and project management. S & A related costs for the associated portion of the project were estimated at 6% of the direct construction cost.

PROJECT OPERATION

517. The Philadelphia District, Corps of Engineers would maintain the Federal channels and anchorage in accordance with the project dimensions, providing advance maintenance in high shoaling areas as required. Dredging would be performed on an annual basis in the Delaware River and a 5 year cycle in Delaware Bay, similar to existing practice. The Delaware River Port Authority as sponsor would provide and operate the non-Federal disposal areas in

cooperation with the Philadelphia District, Corps of Engineers, in order to maximize the overall efficiency of dredging and disposal operations. Maintenance of navigation aids would continue to be performed by the U.S. Coast Guard.

518. Berth dredging and facility maintenance would be accomplished by each beneficiary facility. Berth dredging is now performed utilizing an existing Department of the Army Permit. Berth material is placed in an upland diked disposal area established by a private dredging concern for this purpose. State and Federal permit conditions in place are designed to minimize water quality effects from dredging, disposal, and bulkhead modifications. The use of hopper dredging will further limit water quality impacts. Deepened berths are all currently at depths of 40 feet and generally dredged on a regular basis; these facts taken together would limit benthic effects. Seasonal dredging restrictions on bucket dredging now occur and studies are being initiated in regards to hydrualic/hopper dredging to better determine what effects if any would occur to anadromous fish passage and finfish spawning/nursery development. Modification of this Departmenet of the Army permit has been handled in a routine manner, therefore based on past experiences no difficulties are anticipated in modifying this permit for 45 foot dredging nor obtaining appropriate state permits. Port facility operations would continue as currently conducted with individual facilities maximizing economic outputs through operations, expansion, or upgrading of facilities in response to economic conditions. The Pilots' Association for the Bay and River Pilot's Association for the Bay and Delaware River will continue to coordinate/monitor traffic in cooperation with the Philadelphia Maritime Exchange.

PLAN ACCOMPLISHMENTS

519. The selected plan would provide net benefits of $11,019,000 to national economic development. The degree to which the selected plan fulfilled planning objectives was evaluated by comparing the impacts of the alternative depths. Those items evaluated include the following:

- Provide Adequate and Safe Navigation Channels. Although there have been no reported damages related to the existing Federal project, the deeper channel, bend widening and anchorage improvements provided by this plan will provide for the safe transit of vessels. These changed improvements will lesson the chances of large oil spills occurring

- Increases the Efficiency of Movement of Waterborne Commerce. The measures provided by this plan would improve the efficiency of

vessel movements by reducing lightering and the need for lightloading, therefore reducing the possibility of oil spill occurring during lightering operations.

- Identify and Evaluate Acceptable Disposal Sites and Techniques. The disposal scheme selected for the plan of improvement represents the most cost effective method of disposal.

- Protection of Finfish and Wildlife Resources. By observing the seasonal restraints for dredging operations impacts to finfish and wildlife resources will be minimized.

PROJECT EFFECTS

520. Project effects can be separated into impacts associated with dredging and impacts associated with dredged material disposal. Impacts related to dredging can include water quality degradation, loss of benthic organisms, disturbance to fishery resources, and impacts to cultural resources.

521. Water quality impacts include increased turbidity, a potential decrease in dissolved oxygen, and release of chemical contaminants into the water column. The first two are localized, short-term impacts that generally do not cause irreversible ecological harm. A sediment testing program was conducted during the summer of 1991 to characterize the chemical quality of sediments in the existing, Philadelphia to the Sea navigation channel. A total of 46 sediment cores were collected in the channel and in channel bend widening locations throughout the project area, and analyzed for a variety of chemical constituents as specified by the U.S. Environmental Protection Agency. Chemical constituents included metals, pesticides, polychlorinated biphenyls (PCB's) and polynuclear aromatic hydrocarbons (PAH's). Sediment samples were analyzed using both bulk and elutriate analysis procedures. PCB's were only detected in one sample at a concentration of 1.72 parts per million (ppm). Pesticides were detected in two samples at concentrations below 1 ppm. PCB's were not detected in any sediment elutriates, while pesticides were detected in only three elutriates at concentrations ranging between 0.0026 and 0.0063 ppm. PAH's were detected in several channel bend locations throughout the project area. Concentrations of PAH's in sediments were low, ranging between less than 1 and 12.23 ppm. PAH's were only detected in one sediment elutriate at a concentration of 0.013 ppm. Metals were found, were widely distributed throughout the project area. While some high readings were observed, the overall metal content of channel sediments was within reasonable limits. Concentrations of metals in sediment elutriates were low throughout the project area. Concentrations of

metals that were found were generally below 0.1 ppm. These test results do not indicate any significant concerns relative to water quality during dredging or dredged material disposal operations. A more detailed discussion of the 1991 sediment testing program is provided in the Environmental Impact Statement Amendment. Testing would be continued throughout the life of the project to identify problems, if they should arise.

522. Another concern related to water quality is the upstream movement of salinity due to a change in channel geometry. To address this concern, the Delaware River Basin Commission (DRBC) employed their Transient Salinity Intrusion Model (TSIM). This model is used extensively by the DRBC for simulation of various scenarios for drought management and reservoir operation planning. For this effort, salinity distribution was modelled for two discrete navigation channel geometries, the existing 40-foot depth and the proposed 45-foot depth. A worst case analysis was run by using the hydrology observed during the 1960's drought of record (1961-1966), estimated depletive water use in 1986, and the current operation of Delaware River Basin reservoirs. Based on the results of the model runs, it is concluded that the predicted changes in Delaware Estuary salinity patterns, from a five-foot deepening of the existing navigation channel, would not result in a perceptible decline in estuarine productivity or adversely impact water supplies in the vicinity of Philadelphia, PA. The predicted upstream movement in salinity would be minor in comparison to yearly fluctuations in salinities resulting from variations in river flow. An average shift in salinities ranging from 250 yards in upper Delaware Bay to 800 yards in the vicinity of Marcus Hook, PA would not be sufficient to effect species distribution or reduce productivity. In the freshwater portion of the estuary, above Marcus Hook, a predicted shift ranging between 800 yards to as much as 1.5 miles could occur. Salinities in this area are too low to impact freshwater organisms. Because of the natural salinity cycle within the estuary, salinities would only intrude further up-river than under existing conditions during October or November, which is the time of year when salinities are highest. Significant biological functions such as spawning, nursery activities, and plant growth do not occur at this time of year. It is also likely that the predicted upstream movement in salinity is exaggerated because the hydrology of the drought of record was used to calculate the change. It is expected that salinity increases would be even less than predicted during normal water years. With respect to water supplies in the vicinity of the Philadelphia-Camden metropolitan area, the main concern is protection of the Potomac-Raritan-Magothy aquifer system in the Camden, NJ area. A maximum 30-day average chloride concentration of 180 mg/l at River Mile 98 is the current standard set for protecting this aquifer system from salinity intrusion. The predicted 30-day average chloride concentrations at River Mile 98 were well below this standard throughout the drought of record. The DRBC has indicated that they plan on lowering this standard to

150 mg/l when additional reservoir storage is available to insure that the standard can be maintained. This more restrictive salinity standard was also met with a deepened channel throughout the drought of record, except in the simulation for November 1964. The 30-day average chloride concentration at River Mile 98 for this month violated the proposed standard by two mg/l. This one violation in a worst case analysis was considered acceptable since this more restrictive standard is dependent on additional reservoir storage, which was not included in this effort. A more detailed discussion of these analyses is provided in the Environmental Impact Statement Amendment.

523. Dredging would also result in the loss of benthic organisms in the immediate path of the dredge. More mobile organisms, such as crabs, can escape the path of the dredge provided that dredging occurs during their active portion of the year. Sessile organisms, such as worms and mollusks, would not be able to leave the dredging area. These organisms would be removed with the sediments and would not be expected to survive. Benthic recolonization does begin to occur shortly after completion of dredging, however, periodic maintenance dredging requirements can continue to disrupt the area. The extent of recolonization subsequent to dredging depends on several factors including the resulting substrate type, the amount of light penetration due to depth and/or turbidity, frequency of dredging, and long-term changes in water quality. The existing navigation channel is currently maintained to a depth of 40 feet at mean low water (mlw) through periodic dredging of shoaling areas. Deepening this channel to 45 feet at mlw would not significantly alter substrate type, light penetration, long-term turbidity levels, or water quality. While initial construction of a 45-foot deep channel would impact benthic organisms in areas that are not now maintained through dredging, these areas would recolonize. Maintenance of the new channel is not expected to impact benthos significantly more than current maintenance dredging operations.

524. Dredging operations can also impact the seasonal migration of anadromous species of fish. Seasonal dredging restrictions have been developed and are employed to minimize impacts to migratory species at appropriate times of the year. No bucket dredging and/or overboard disposal would be conducted during spring and autumn migration. In addition coordination is continuing with the Delaware Basin Fish and Wildlife Management Cooperative over the potential additional requirements.

525. The removal of rock from the channel in the vicinity of Marcus Hook, PA. also has the potential to impact aquatic organisms. Explosive devices would be required to blast this rock out of the channel. Blasting would occur between December and mid-March, which is in accordance with the Delaware Basin Fish and Wildlife Management Cooperative's proposed seasonal restrictions on construction activities in that portion of the river. Blasting at

this time of the year would avoid impacts to spawning, nursery, and migrational periods. Blasting techniques that would be employed to minimize impact to fish would include the use of directional charges that focus the force of the blast down into the rock, the use of appropriately sized charges, and the use of scare charges to clear fish from the impact area prior to detonation.

526. The Potomac-Raritan-Magothy formation contain the most important and productive aquifers in southern New Jersey and is referred to as the regions ole source aquifer. The thickness of the combined formations is as much as 500 feet. Many industries and public water companies in the region obtain groundwater from this formation. There are four major aquifers within the formation. In the vicinity of the projects disposal areas the uppermost aquifer is 50 to 120 feet below the surface, the second ranges from 105 feet to 250 feet, the third from 300 feet to 390 feet, and the lowermost aquifer if 400 feet to 500 feet below the surface. The upper water bearing zone is usually artisan and is separated from the surface sediments by clay beds with a minimum ten-feet thickness in the vicinity of the disposal areas. Communities along the river obtain their water from the basal part of the lower aquifer. Impermeable clay layers separate all of the water bearing zones. There is no potential for intrusion from future disposal through the existing disposal areas sediments and all clay layers of the Potomac-Raritan-Magothy formation.

527. Groundwater flow is generally toward the main river in a typical river basin. However, the groundwater regime in the project area, specially the New Jersey side of the river, has been disturbed by urbanization. The information has been documented in numerous reports. The U.S.G.S. Atlas HA-697 dated 1986 estimates a leakage of 70 MDG from the Delaware River into the Potomac-Raritan-Magothy aquifer system in the project area. A reversal of the natural groundwater flow due to overpumping of the aquifer has occurred. Prior to municipal and industrial pumping, water flow in the aquifer was towards the river. Where large groundwater withdrawals have locally reversed the original aquifer flow patterns, aquifer recharge by river water results. This is due to the face that permeable sand and gravel in the river ar in direct contact with the sediments which comprise the Potomac-Raritan-Magothy system. Although a large volume of river water is presently infiltrating the aquifer from the river, no contamination or salinity problems have been reported. Since the amount of aquifer recharge from the river is largely maintained by the pumping rate of private and public wells, any deepening of the channel will not increase the intrusion.

528. Upland disposal areas will be utilized to provide 50 years of capacity for the selected plan in Reaches A through D. All of the sites other than Reedy Island North and South, are located in New Jersey. The sites are all situated near the river edge, have similar subsurface conditions, contain varied amounts of fine-

grained dredged materia, and overlie the sole source aquifer. A typical area is Pedricktown disposal area. The area is located in the northwestern corner of Oldmans Township, Salem County, approximately 3 miles south the site 15D. The 1000+ acre facility has ben used for disposal of dredged material from the Delaware River since 1960. Presently the original ground ;is overlain by 20 to 40 feet of dredged material. Groundwater, discharge water, river sediment, and dredged slurry, have been tested to determine what effect the operation has on the surrounding area. To date, no detrimental effects have been realized. The new disposal areas will operate in the same manner as Pedricktown and therefore will not become a future source of groundwater contamination.

529. An investigation of New Jersey municipal water supply wells was conducted in the project area. Wells within two miles of the Delaware River channel or the disposal areas were considered. Thirty municipal wells are in operation from Westville Boro south of Pennsville Township. A table containing, total depth, screen depth and length, and aquifer is provided for each will in the Geotechnical Appendix. Of the thirty wells, 25 area screened in the Potomac-Raritan-Magothy formation. The remaining five withdrawal from the shallower Cape May formation, 40' to 60' below the surface. These wells are located in Penns Grove approximately two miles from Pedricktown South disposal area, which will be used for the 45' project maintenance, and currently is being used for the contaminant levels established by EPA and NJDEP in any of the wells, with the exception of high iron and manganese concentrations in the Salem County Wells. Published reports on ground water characteristics of the Potomac-Raritan-Magothy system and analysis of public and private wells in the vicinity of the site indicate high concentrations of iron and manganese. The high concentrations are attributed to natural conditions resulting from geological formations.

530. The selected plan for the Delaware River includes the use of three new upland sites for the disposal of dredged material. These sites have all been previously used in whole or in part for disposal purposes, and are considered disturbed. The use of these sites would result in the initial loss of existing vegetation. Raccoon Island is predominantly vegetated with common reed. Site 15D, in addition to being vegetated with common reed, is planted with corn and soybeans. Loss of this vegetation is not considered significant as it provides low quality wildlife habitat. Site 170 is more diverse with forested, shrubland and oldfield habitats, along with areas dominated by common reed. This site does provide a variety of upland habitat types, but is still considered a disturbed area. Disposal sites typically revegetate between disposal operations. The dominant species is common reed, however, a variety of wetland species can be found in poorly drained wet areas or areas with ponded water. The value of this type of habitat to wildlife is similar to the value of the existing habitat at the selected sites.

531. Based on the analysis done in Delaware Bay, LC 9 (Port Mahon) or C 13 (Alder Cove) were determined to be the NED disposal plans for the disposal of dredged material associated with Lower Liston/Upper Cross Ledge Range. Due to the closeness of the cost comparisons, final selection will await the findings of the PED studies. FR 28/ LC 10 (sand stockpiles off the Kitts Hummock and Pickering Beach) was determined to be the NED disposal plan for the disposal of dredged material associated with the Lower Cross Ledge/Upper Miah Maull Range. If benthic studies, conducted during the PED phase, reveal that significant mitigation is required for sand stockpile areas then beachfill options could become the NED plan. The placement of similar material on ocean and bay beaches in the past has not resoluted in any long-term ecological or aesthetic impacts. Island creation at I 3 (lower Middle Shoal), and wetland restoration at PN 1 (Maurice River Cove area) were determined to be the NED disposal plan for the disposal of dredged material associated with the Lower Miah Maull/Upper Brandywine Range. Again the closeness of the cost comparison will force final selection to wait for the results of the PED studies. Sand stockpiles off of Lewis, Broadkill, and Slaughter Beach (LS, MS 19) were determined to be the NED disposal plan for the disposal of dredged material associated with the Lower Brandywine Range. Final selection of these options will await completion of the detailed benthic studies to be conducted during the PED phase. If the studies reveal that significant mitigation is required for sand stockpile areas then beachfill options could become the NED plan.

532. Impacts to significant cultural resources as a result of implementing the proposed project can occur as a result of either dredging activities or disposal activities. Of the three sites selected for the disposal of dredged material, two are previously used and do not contain cultural resources that would be adversely impacted by the placement of additional fill. The third site, 170, was investigated in 1976 and was found to contain potentially significant prehistoric and historic resources. Further investigation will be necessary to develop measures to avoid or minimize adverse impacts to these resources. Necessary funds to complete data inventory and recovery have been included for PED implementation. Dredging activities have the potential to impact significant historic resources (principally in the form of shipwrecks), primarily as a result of widening the bends at the intersections of some of the ranges, but also as a result of deepening the navigation channel in areas which have been naturally deep and which therefore might contain shipwrecks. Further investigations will be conducted in the next phase of study to address and resolve this issue. Based on the survey information collected to date, the cost of cultural resource mitigation for known sites within project boundaries is $225,000. This cost is for sites identified in the 170 dredged material disposal area. Additional cultural resource surveys are necessary, and will be conducted during the PED phase of planning. It will not be possible to determine the final cultural resource mitigation cost

until completion of this work.Further information can be found in Section 5 of the Environmental Impact Statement.

RELATIONSHIP TO ENVIRONMENTAL STATUTES

533. Preparation of this Final Environmental Imapct Statement has included numerous coordination/scoping meetings with appropriate Federal and State resource agencies. An interagency scoping meeting for preparation of the DEIS was held on June 22, 1989. That meeting was attended by personnel representing the U.S. Fish and Wildlife Service, the U.S. Environmental Protection Agency, the National Marine Fisheries Service, the Delaware River Basin Commission, the State environmental agencies of Pennsylvania, New Jersey and Delaware, and the State Historic Preservation Officers of these States. Scoping for the DEIS amendment included a series of meetings with Regions II and III of the U.S. Environmental Protection Agency, the New Jersey Department of Environmental Protection and Energy, the Delaware Department of Natural Resources and Environmental Control and the Delaware Estuary Program.

534. In accordance with the Fish and Wildlife Coordination Act, a planning aid report and a section 2(b) report were obtained from the U.S. Fish and Wildlife Service. Letters of comment were also obtained from the U.S. Environmental Protection Agency, the National Marine Fisheries Service and the State environmental agencies of Pennsylvania, New Jersey and Delaware. These reports and letters are included in the comment/response section of the main report.

535. Based on the information developed during preparation of this Environmental Impact Statement, and the application of appropriate measures to minimize project impacts, it was determined in accordance with Section 307(c) of the Coastal Zone Management Act of 1972 that the proposed project complies with an will be conducted in a manner that is consistent with the approved Coastal Zone Management Programs of Pennsylvania, New Jersey and Delaware. Letters of concurrence with our statement of Coastal Zone consistency have been provided by the three States, and are included in the comment/response section of the main report.

536. The Philadelphia District of the U.S. Army Corps of Engineers is involved with the on-going Delaware Estuary Program. District personnel serve on the Management Committee and the Science and Technical Advisory Committee (STAC). The District has made project presentations to the Management Committee, the STAC and the Citizens Advisory Committee (CAC). The Delaware Estuary Program is leading towards preparation of a Comprehensive Management Plan to efficiently manage the resources of the Delaware Estuary. While this plan has not yet been prepared, the Corps will remain involved to insure the Corps' activities are consistent and supportive of the program.

537. In order to implement the requirements of Section 404 of the Clean Water Act, an exemption is being sought under Section 404(r) as part of the Congressional authorization process. A Section 404(b)(1) evaluation has been prepared and is included in Appendix B of the main report. This evaluation concludes that the proposed action would not result in any significant environmental impacts relative to the areas of concern under Section 404 of the Clean Water Act.

538. Table 1-1 provides a list of Federal environmental quality statues applicable to this statement, and their compliance status relative to the current stage of project review. Compliance will be met for all environmental quality protection statutes and environmental review requirements with distribution of this Final Environmental Impact Statement for review and comment. Aside from the approvals discussed above, no other permits or approvals are required for implementation of the proposed plan of improvement.

Table 1. Compliance with Environmental Quality Protection Statues and Other Environmental Review Requirements.

Federal Statues	Proposed Plan
Archaeological and Historical Preservation Act, as amended	Full Compliance
Clean Air Act, as amended	Full Compliance
Clean Water Act of 1977	Full Compliance
Coastal Zone Management Act of 1972, as amended	Full Compliance
Endangered Species Act of 1973, as amended	Full Compliance
Estuary Protection Act	Full Compliance
Federal Water Project Recreation Act, as amended	N/A
Land and Water Conservation Fund Act, as amended	N/A
Fish and Wildlife Coordination Act	Full Compliance
Marine Protection, Research and Sanctuaries Act	Full Compliance
National Historic Preservation Act, as amended	Full Compliance

National Environmental Policy Act, as amended		Full Compliance
Rivers and Harbors Act		Full Compliance
Watershed Protection and Flood Prevention Act		N/A
Wild and Scenic Rivers Act, as amended		N/A
Executive Orders, Memorandum, etc.		
EO 11988	Floodplain Management	Full Compliance
EO 11990	Protection of Wetlands	Full Compliance
EO 12114	Environmental Effects of Major Federal Actions	Full Compliance
Analysis of Impacts on Prime and Unique Farmlands		N/A
<u>State and Local Policies</u>		
Coastal Area Management Amendments 1974		Full Compliance

NOTES: The compliance categories used in this table were assigned based on the following definitions:

Full - All requirements of the statute, E.O., or other policy and related regulations have been met for this stage of project review.

Partial - Some requirements of the statue, E.O., or other policy and related regulations remain to be met.

Noncompliance - None of the requirements of the statute, E.O., or other policy and related regulations have been met.

N/A - Statute, E.O., or other policy not applicable.

ECONOMIC EVALUATION

539. All costs for the construction, operation and maintenance of the tentatively selected plan are based on a September 1991 price level and 8-3/4 percent discount rate. Operation and maintenance dredging costs were calculated using a project life of 50 years. Benefits were based on projections of existing commodities. A

comparison of project benefits and costs for the selected plan is shown in Table 70.

540. Average Annual Benefits During Construction Period. As part of the selected plan, a smaller "temporary" channel (similar to the Option 2 asymmetric channel) will be constructed to provide access for incoming crude oil vessels to the two Marcus Hook, Pa. refineries prior to the project base year. Benefits will begin to accrue for the last 3 months of construction. Benefits for the two refineries, were reduced to allow for increased operating costs from additional travel time as well as increased tug and pilot costs which will result from the narrower channel to be temporarily provided. The benefits were brought forward to the project base year applying the Single Payment Compound Amount Factor in a comparable manner to the method applied to compute interest during construction for construction costs, and generated an average annual value of $198,000. The other project beneficiaries will not accrue benefits until full project construction is completed.

TABLE 65

COMPARISON OF BENEFITS AND COSTS
FOR SELECTED PLAN

	Delaware River, Philadelphia Harbor to the Sea
Total Project First Cost	$278,293,000
Associated First Cost	$ 23,205,000
Project Economic Cost	$305,498,000
Interest During Construction	$ 40,887,000
Total Investment Costs	$346,385,000
Interest and Amortization	$ 30,773,000
Annual Operations and Maintenance	$ 1,340,000
Total Average Annual Costs	$ 32,113,000
Average Annual Benefits Over Project Life	$ 42,578,000
Average Annual Benefits During Construction Period	$ 198,000
Total Average Annual Benefits	$ 42,776,000
Benefit Cost Ratio	1.33
Net Benefits	$ 10,663,000

COST APPORTIONMENT

541. Public Law 99-662 (Water Resource Development Act of 1986) has established the basis for the Federal and non-Federal sharing of responsibilities in the construction, and operation and maintenance of Federal water resources projects. Under the terms of Public Law 99-662, the non-Federal interests would pay at the outset of construction, 25 percent of the total costs of construction of General Navigation Features (GNF) which consists of

the access channel. In addition, the non-Federal interests are to provide any lands, easements, rights-of-way, relocations and dredged material disposal areas (LERRD) or the costs thereof. The non-Federal sponsor is responsible for the associated costs of the project. The sponsor is also responsible for an additional 10 percent of the cost of GNF, less credit for lands, easements, rights-of-way, relocations and dredged material disposal areas which can be repaid with interest over a period not to exceed 30 years. The sponsor will provide equivalent capacity at his Raccoon Island and 170 disposal sites to offset the dredged disposal quantities placed at the Federally owned Reedy North and South sites. This arrangement will minimize the number of new sites required for initial construction and postpone the need for acquisition by the Federal government of disposal sites for the existing project which remains solely a Federal responsibility.

542. The Federal government is responsible for 75 percent of the cost of GNF as well as the cost of navigation aids. Operation and maintenance costs for the access channel, and navigation aids are a Federal responsibility. Maintenance for associated features is a non-Federal responsibility. Cost sharing arrangements for the selected plan are displayed on Table 66.

543. The ultimate Total project cost, including LERRD is $278,193,000 as shown in the following table. This includes the Federal Channel and Anchorage, Aids to Navigation, Disposal Areas, and Relocation Costs. The Federal government is responsible for 75% of the Federal Channel and Anchorage which together comprise the General Navigation features (GNF). In addition the federal government is solely responsible for 25% of the costs for general navigation features and the full costs of lands, easements, rights-of-way, relocations and dredged material disposal areas (LERRD). In addition 10% of the GNF less credit for LERRD. However, since the LERRD exceeds 10% of the GNF no additional contribution is required. Associated costs are solely a non-Federal responsibility.

TABLE 66

COST SHARING FOR THE SELECTED PLAN
(45 ft. Channel)

PROJECT COSTS	
General Navigation Features: Federal Channel and Anchorage	$244,800,000 (A)
Aids to Navigation	856,000
LERRD (Disposal Area Costs Real Estate & Dike Construction)	29,507,000
LERRD (Relocation Costs)	3,130,000
TOTAL PROJECT COST	278,293,000
ASSOCIATED COSTS	23,205,000

COST SHARING

	FEDERAL COSTS	NON-FEDERAL COSTS	TOTAL
GNF	$183,600,000 (75% x A)	$ 61,200,000 (25% x A)	$244,800,000
Long Term Repayment	$-24,480,000 (-10% x A)	$+24,480,000 (+10% x A)	- -
Navigation Aids	856,000	N/A	856,000
LERRD (Relocation)	N/A	$ 3,130,000	$ 3,130,000
LERRD (Disposal Areas)	N/A	$ 29,507,000	$29,507,000
Credit of LERRD	+24,480,000	-24,480,000	-
ULTIMATE COSTS	$184,456,000	$ 93,837,000	$278,293,000

Note: September 1991 Price Level; Discount Rate = 8 3/4%

LOCAL COOPERATION

544. Federal participation in the proposed project is contingent upon provisions that the project sponsor furnish assurances that they will comply with Section 221 of the River and Flood Control Act (Public Law 91-611) and, prior to construction, enter into a Local Cooperation Agreement as per the Water Resources Act of 1986 (PL 99-662). Items of Local Cooperation to be satisfied by the time of construction include the following:

- Provide and maintain the associated features at local expense and adequate public terminal and transfer facilities open to all on equal terms and such depths from the Federal channel line to and between the wharves at the terminal (berthing areas) as may be required for the accommodation of vessels at the terminal, consistent with the Federal project;

- Provide without cost to the United States of all lands, easements, rights-of-way, and relocation necessary for the construction, and subsequent operation and maintenance of the project including suitable areas, determined by the Chief of Engineers to be required in the general public interest for initial and subsequent disposal of spoil and necessary retaining dikes, bulkheads, and embankments therefore, or the costs of such retaining works.

- Holding and saving the United States free from damages due to the construction or operation and maintenance of the project, except for damages due to the fault or negligence of the United States or its contractors

- Provide to the Federal Government the non-Federal share of all other costs of construction of such project

- Compliance with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1978 (P.L. 91-646) and implementing regulations.

- Compliance with Section 601 of the Civil Rights Act of 1964 (P.L. 83-352).

545. The Delaware River Port Authority is the agency empowered by law to provide the non-Federal cooperation required for the project.

546. The sponsor is aware of the above requirements. A sample model of the Local Cooperation Agreement was provided to the sponsor in a letter dated October 6, 1989. A letter of intent to enter into such an agreement was provided by the sponsor on November 1, 1991. (Refer to Appendix A).

FINANCIAL ANALYSIS.

547. Based on preliminary information, the deepening of the Delaware River channel would be funded as part of a larger plan supported by the governors and Legislatives of New Jersey and Pennsylvania to improve the overall management of the Delaware River Ports through unification, expanding the role of the Delaware River Port Authority. Port improvements would be financed through a combination of cash on hand, bonds, and user charges. The exact combination to be determined in a manner most advantageous to DRPA, laid on fianacial situation at the time of construction.

PLAN IMPLEMENTATION

548. The steps necessary to complete the selected plan are as follows:

- The Division Engineer issues a public notice announcing study recommendations and the report is sent to the Board of Engineers for Rivers and Harbors.

- The Board reviews the report and comments in response to the notice and sends its recommendations to the Chief of Engineers who solicits review and comment by the Governor and interested Federal and state agencies. The final report will then be forwarded by the Chief of Engineers to the Secretary of the Army.

- The Secretary of the Army will review the report and obtain the views of the Office of Management and Budget (OMB) to determine the relationship of the plan to the programs of the President. Upon approval, the Secretary will then transmit the report to Congress.

- Detailed engineering and design will begin if the review finds the project favorable and the plan of improvement is approved by the Secretary of the Army.

549. Funding for construction will be allocated from the general budget. At that time, the project sponsor will be called upon to satisfy the requirements of local cooperation, including execution of a contract stating the local cooperation requirements and their legal and financial capability to provide them. After all necessary financial requirements and local cooperation items have been met, a construction contract will be awarded and carried to completion.