ENVIRONMENTAL RESOURCES BR.

Delaware River Dredging Disposal Study

DEPARTMENT OF THE ARMY
Philadelphia District Corps of Engine
Custom House-2d & Chestnut Streets
Philadelphia Pennsylvania 19106

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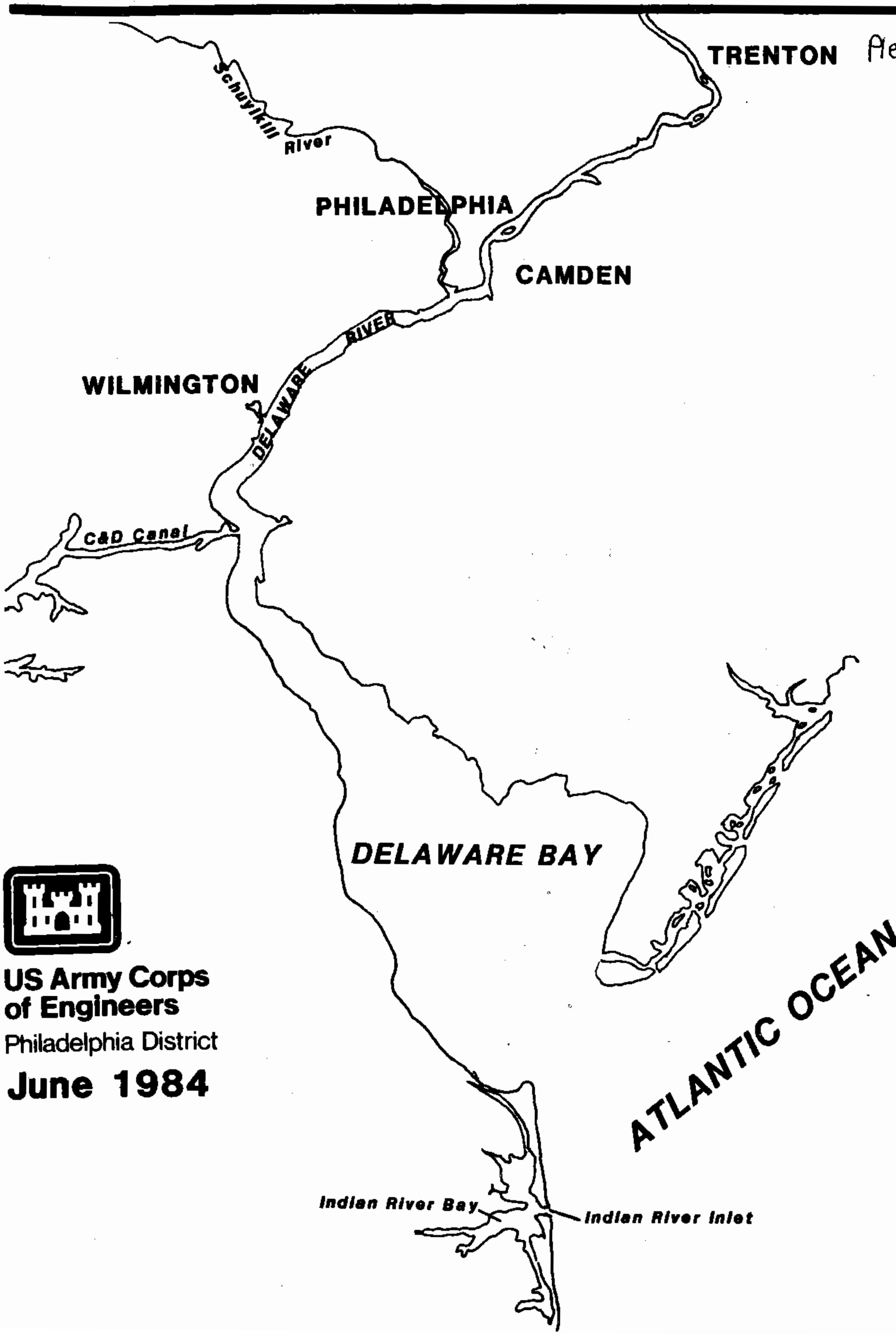


US Army Corps of Engineers
Philadelphia District
June 1984

DELAWARE RIVER DREDGING
DISPOSAL STUDY

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
JUNE 1984

SYLLABUS

This report was authorized by Congress at the request of the Delaware River Basin Commission. It presents a regional dredged material disposal plan for the Delaware River System for both Federal and Non-Federal sectors. The plan identifies specific disposal sites for both the short (10 year horizon) and long term (50 year horizon).

Over 11,000,000 cubic yards of material are dredged annually by the two sectors. In addition, needs for potential future projects were incorporated into the analysis. These disposal needs were used to identify two conditions to represent a wide range of potential future conditions. The first, termed the "worst case", represents an upper boundary and assumes that all identified existing authorized and future projects would be fully constructed and maintained during the study period (1980-2030). The second, the "most probable case", reflects a more realistic projection of future needs.

Each of these conditions reflect more volume than can be placed at existing disposal sites, with the shortfall being 335,000,000 and 78,300,000 cubic yards, respectively. Various alternative measures were assessed to determine the most viable means of resolving these shortfalls. Alternative measures were grouped into two general categories, management and identification of potential sites. Under management measures, those methods that would extend the useful life of an existing disposal site were considered. The second category, involved an extensive screening process including two computerized applications, one of which was developed as part of this study. The first, called Spatial Analysis Methodology, is a data management and analysis tool and was used to perform automated site suitability screening. Its output indicated relative attractiveness of potential sites for various scenarios ranging from a pro-dredging to a pro-environmental viewpoint. The second model, the systems model, evaluated the alternative measures based on dredging transportation and disposal site costs. The model results together with other related environmental and social factors were considered as part of the selection process.

The study concluded that for the short term period, the recommendations are: extend leases at existing sites, acquire and use advanced dewatering equipment, continue to make dredge material available for re-use and consider acquiring one additional site. Recommendations for the long term period are: continue past management practices and incorporate new development, as appropriate, as the state of art changes, acquire long term leases or land in fee where appropriate and consider acquiring five new disposal sites. It is anticipated that the added recommendations will emerge from the on-going Delaware River Comprehensive Navigation Study.

Regarding the short term recommendations, the advanced dewatering equipment was acquired during the latter stages of this study and is currently operating successfully in the District. Further, the District is already pursuing acquisition of the one additional site. The long term needs have also been presented but should be updated periodically as appropriate to reflect changing conditions.

The report will be distributed for information to those agencies having an interest in dredging and disposal of dredged material.

DELAWARE RIVER DREDGING
DISPOSAL STUDY

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (Cont'd)

LIST OF FIGURES

TABLE OF FIGURES (Cont'd)

LIST OF APPENDICES

INTRODUCTION

BACKGROUND AND AUTHORITY

The Delaware River, and particularly the Philadelphia Area, supports a major port complex. Over 130,000,000 tons of waterborne commerce move through the Delaware River system each year. This commerce relies, in large part, on maintenance of a 40 foot deep navigation channel in the Delaware River. Over 11,000,000 cubic yards of material are dredged annually from the Delaware River and its tributaries to support commerce. Some of the existing disposal sites for the dredged material should begin reaching capacity during the early 1990's.

Recognizing the potential disposal problem, the Delaware River Basin Commission adopted Resolution Number 74-8 on 26 June 1974. That resolution requested that the Corps of Engineers develop a regional dredging disposal plan for both public and private sectors and identify specific short term disposal sites and potential long term sites which minimize the degradation of the natural environment. Based on a request by Senators Roth and Biden of Delaware, the Senate Committee on Public Works adopted the study resolution on 20 September 1974. This resolution requested the development of a "regional dredging spoil disposal plan for the tidal Delaware River, its tidal tributaries, and Delaware Bay". In addition, on 24 July 1978 the Senate Committee on the Environment and Public Works adopted a resolution that increased the scope of the study to include Indian River Inlet and Bay. Copies of these resolutions are included in Appendix 4.

STUDY OBJECTIVE

In responding to the Congressional resolution, the objectives of the study are to:

a. Develop a regional dredging spoil disposal plan for the Delaware River, its tidal tributaries, Delaware Bay and Indian River Inlet and Bay.

b. Designate specific sites which may be used by Federal and Non-Federal sectors both in the short-term and long-term. In coming up with these sites, it is the intention to minimize degradation of the natural environment. For the purposes of this study, the planning periods are defined as 10 years (short term) and 50 years (long term).

STUDY AREA

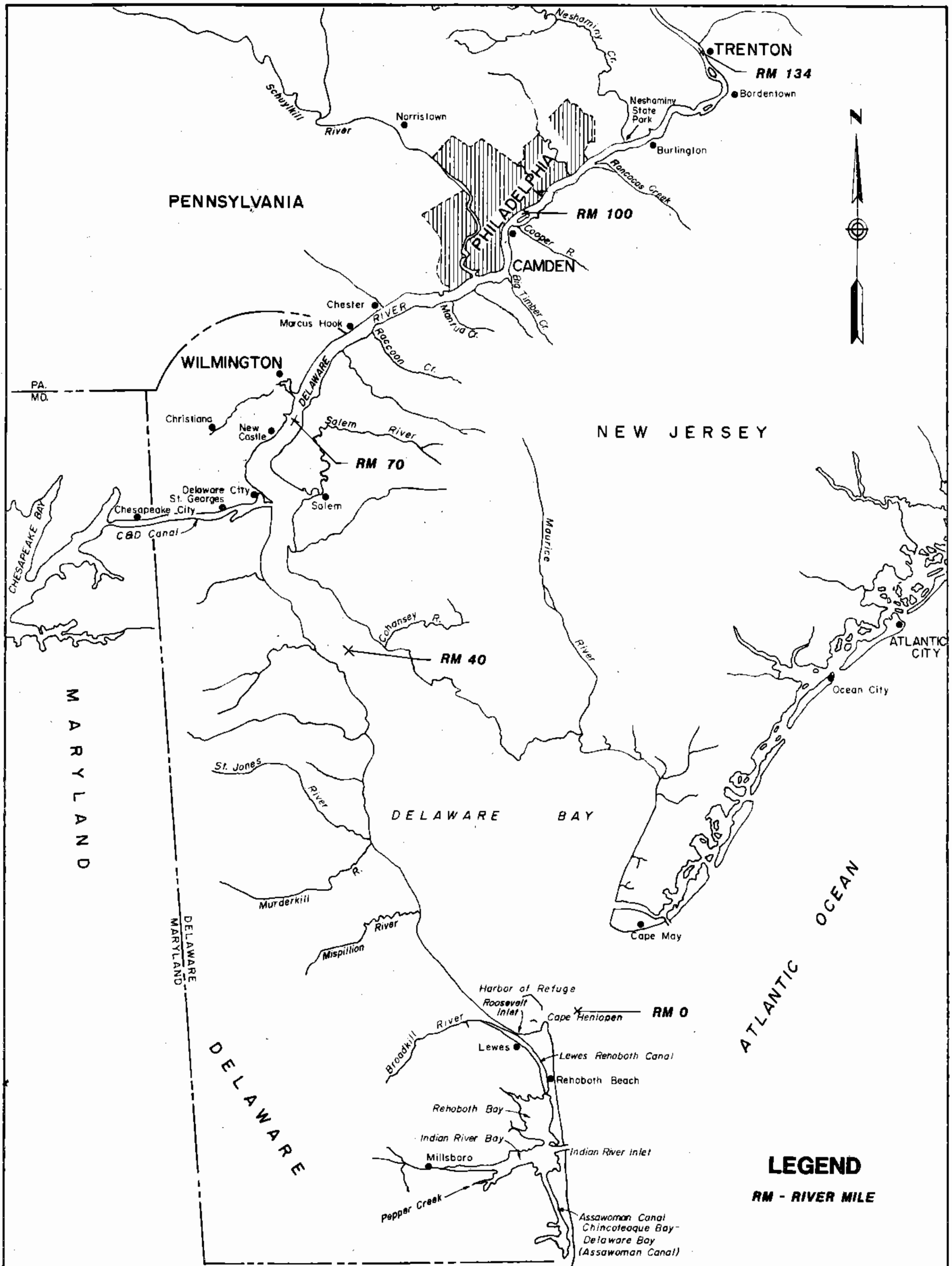
The study area (Figure 1) encompasses the Delaware River Estuary and Indian River Inlet and Bay. The estuary, which extends from the mouth of the Delaware Bay to Trenton, New Jersey, is bordered by Pennsylvania and Delaware on the western shore, and by New Jersey on the eastern shore. Indian River Inlet, located 12 miles south of Cape Henlopen, is the first opening in the barrier beach south of Delaware Bay. The Indian River Bay area is mostly marshland in private ownership.

There are 13 counties within the study area. These are listed below and shown on Figure 2:

NEW JERSEY
- BURLINGTON COUNTY
- CAMDEN COUNTY
- CAPE MAY COUNTY
- CUMBERLAND COUNTY
- GLOUCESTER COUNTY
- MERCER COUNTY
- SALEM COUNTY

PENNSYLVANIA
- BUCKS COUNTY
- DELAWARE COUNTY
- PHILADELPHIA COUNTY

DELAWARE
- KENT COUNTY
- NEW CASTLE COUNTY
- SUSSEX COUNTY

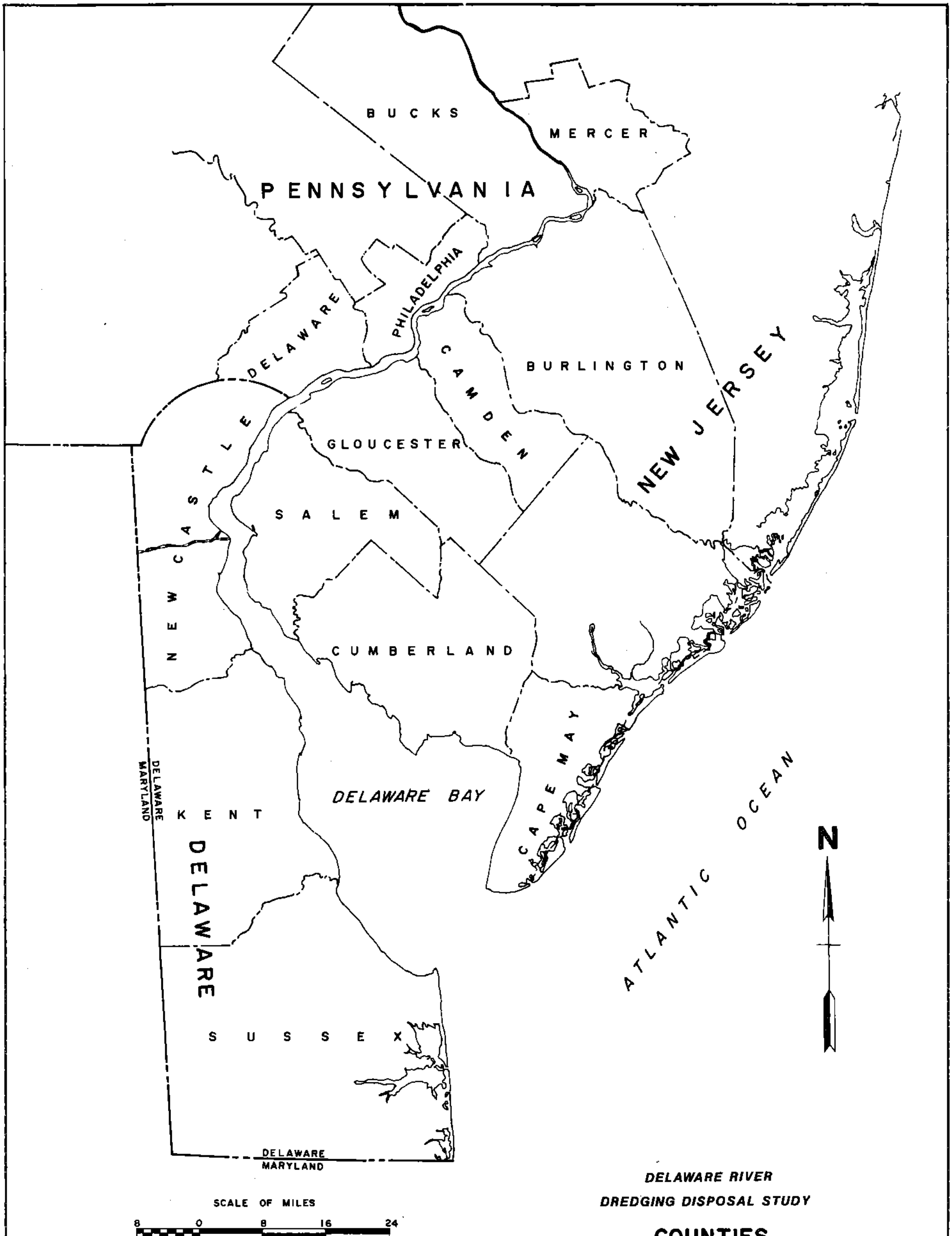


DELAWARE RIVER DREDGING DISPOSAL STUDY

STUDY AREA

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 1



DELAWARE RIVER

DREDGING DISPOSAL STUDY

COUNTIES

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

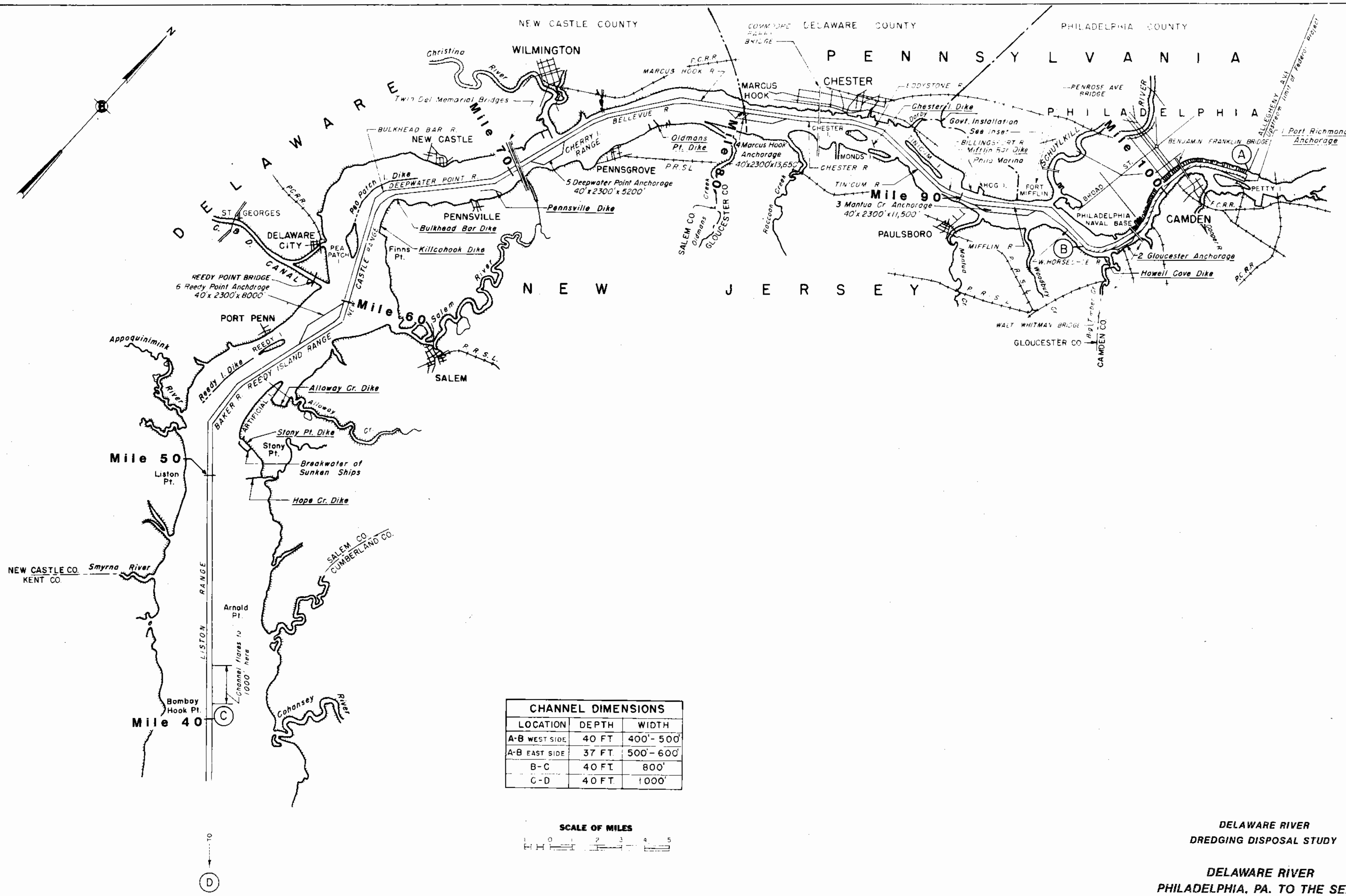
FIGURE 2

EXISTING FEDERAL PROJECTS

The study area includes five deep draft projects and 17 shallow draft projects (including Indian River Inlet and Bay) which are Federally maintained. The deep draft projects are Delaware River, Philadelphia to the Sea, Delaware River at Camden, Delaware River, Philadelphia to Trenton, Wilmington Harbor (Christina River), and Schuylkill River.

DEEP DRAFT PROJECTS. Delaware River, Philadelphia to the Sea. The Philadelphia to the Sea project (adopted in 1910 and modified in 1930, '33, '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 (Figures 3-4), 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 seventeen anchorages on the Delaware River; five are authorized under the Philadelphia to the Sea project (Mantua Creek, Marcus Hook, Port Richmond, Deepwater Point, and Reedy Point) and the remaining twelve are natural deep-water anchorages.

Delaware River at Camden. The Delaware River at Camden project (adopted in 1919 and modified in 1930 and 1945) provides for a 30-foot-deep channel from Newton Creek at Kaighn Point to the Berkley Street terminal and an 18 foot deep channel extending from Kaighn Point to Cooper Point. Also, the project provides for a depth of 37 feet within the project limits in front of the Camden Marine Terminal. The project construction has been completed except for the 37 foot deep portion, which is currently being analyzed as part of a separate study. The project length (Figure 5) is about four miles.



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'

DELAWARE RIVER
DREDGING DISPOSAL STUDY

DELAWARE RIVER
PHILADELPHIA, PA. TO THE SEA

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 3

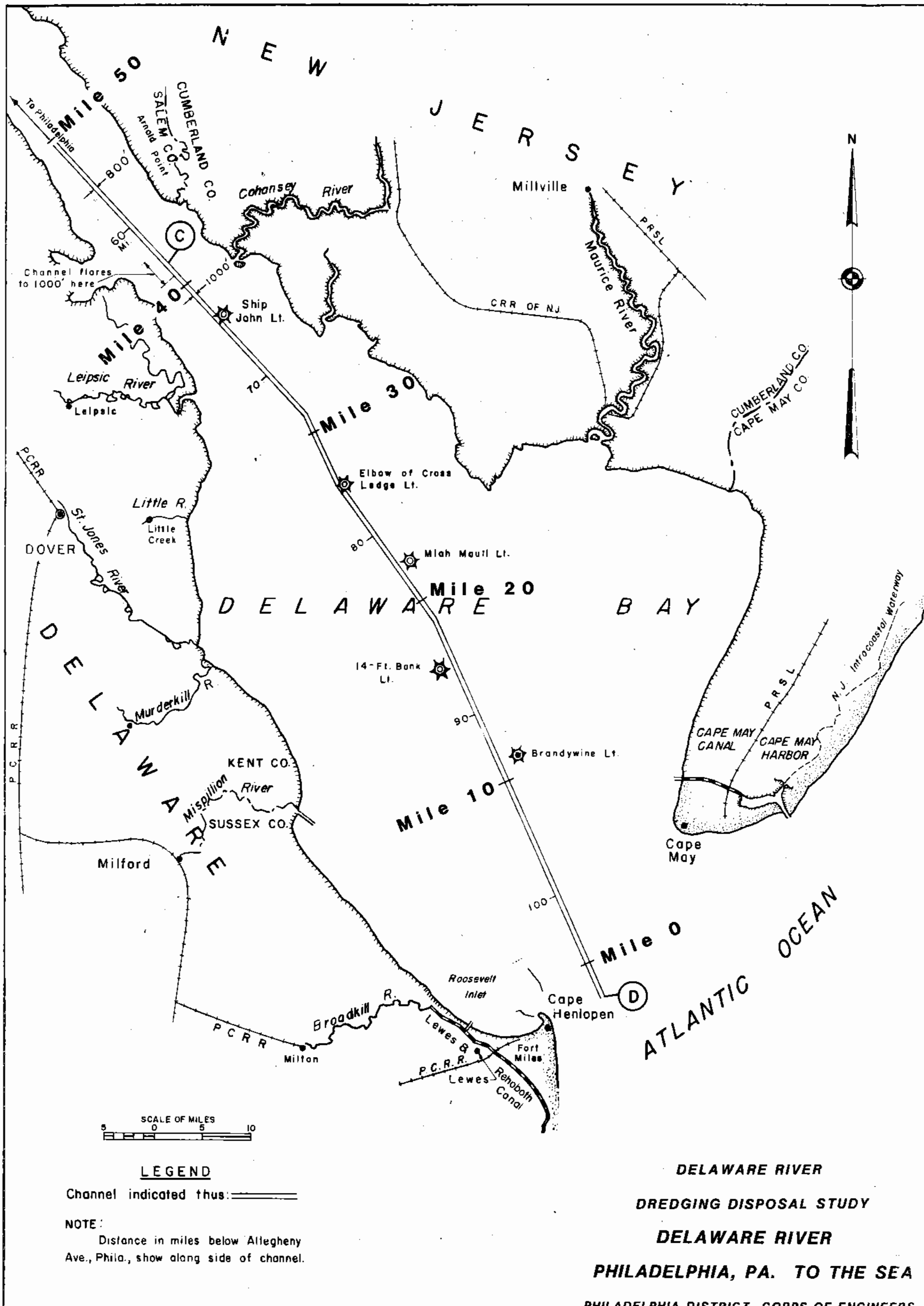
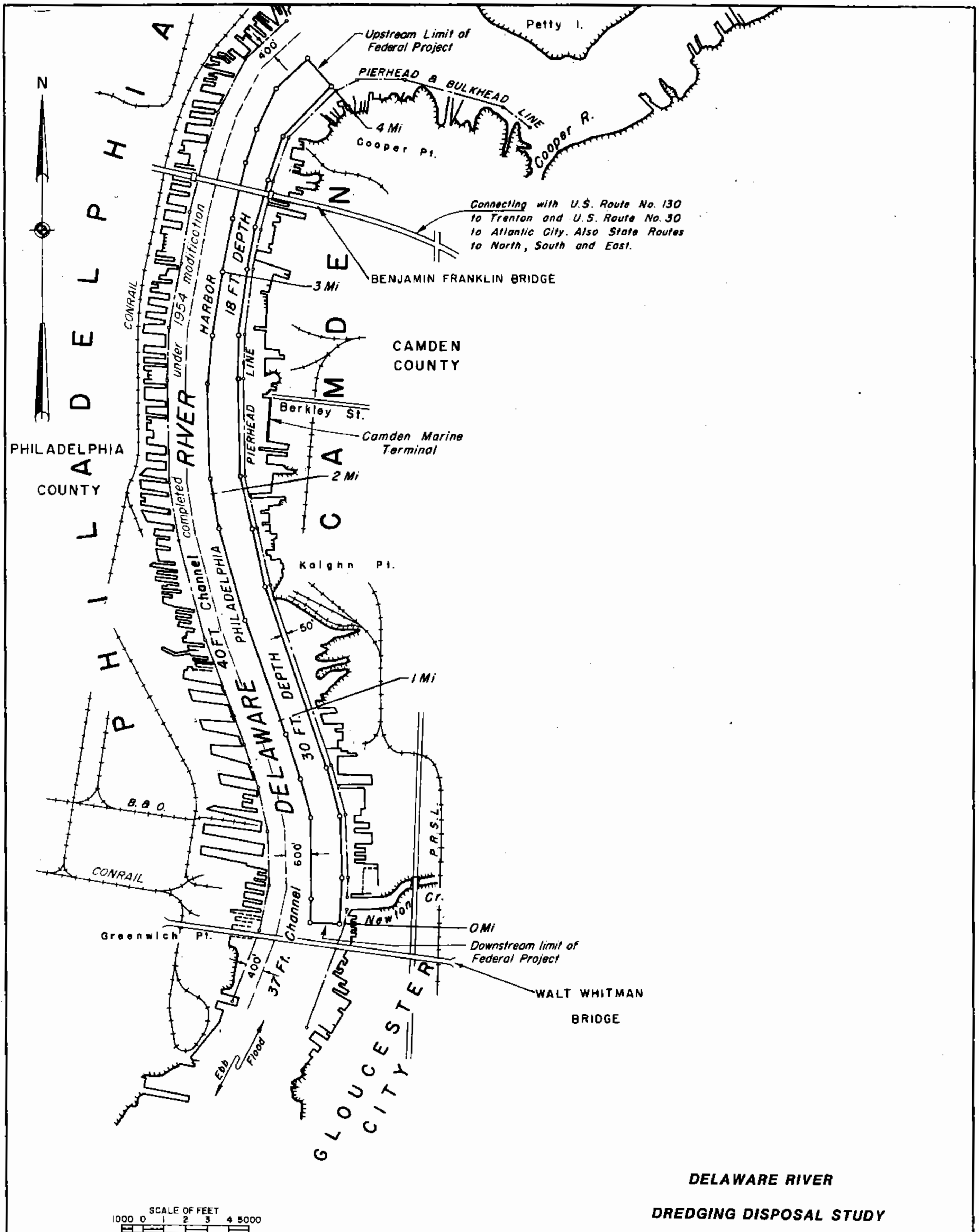

NEW JERSEY
Mile 50
To Philadelphia
CUMBERLAND CO.
SALEM CO.
Arnold Point
800'
60 Mi.
Cohansey River
Millville
PRSL
Maurice River
C
Channel flares to 1000' here
1000'
Mile 40
Ship John Lt.
CRR OF NJ
Mile
Leipsic River
Leipsic
70
Mile 30
CUMBERLAND CO.
CAPE MAY CO.
N
PCRR
Elbow of Cross Ledge Lt.
Little R.
Little Creek
DOVER
St. Jones River
80
Miah Maull Lt.
Mile 20
DELAWARE BAY
N.J. Intracoastal Waterway
DELAWARE
14-Ft. Bank Lt.
Murderkill R.
PRSL
PCRR
90
CAPE MAY CANAL
CAPE MAY HARBOR
Brandywine Lt.
KENT CO.
Mispillion River
Mile 10
SUSSEX CO.
Cape May
Milford
100
ATLANTIC OCEAN
Mile 0
Roosevelt Inlet
Cape Henlopen
D
Broadkill R.
PCRR
Milton
Lewes & Rehoboth Canal
P.C.R.R.
Lewes
Fort Miles
SCALE OF MILES
5 0 5 10
LEGEND
Channel indicated thus:
NOTE:
Distance in miles below Allegheny Ave., Phila., show along side of channel.
DELAWARE RIVER
DREDGING DISPOSAL STUDY
DELAWARE RIVER
PHILADELPHIA, PA. TO THE SEA
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Figure 4



DELAWARE RIVER

DREDGING DISPOSAL STUDY

DELAWARE RIVER AT CAMDEN

NEW JERSEY

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

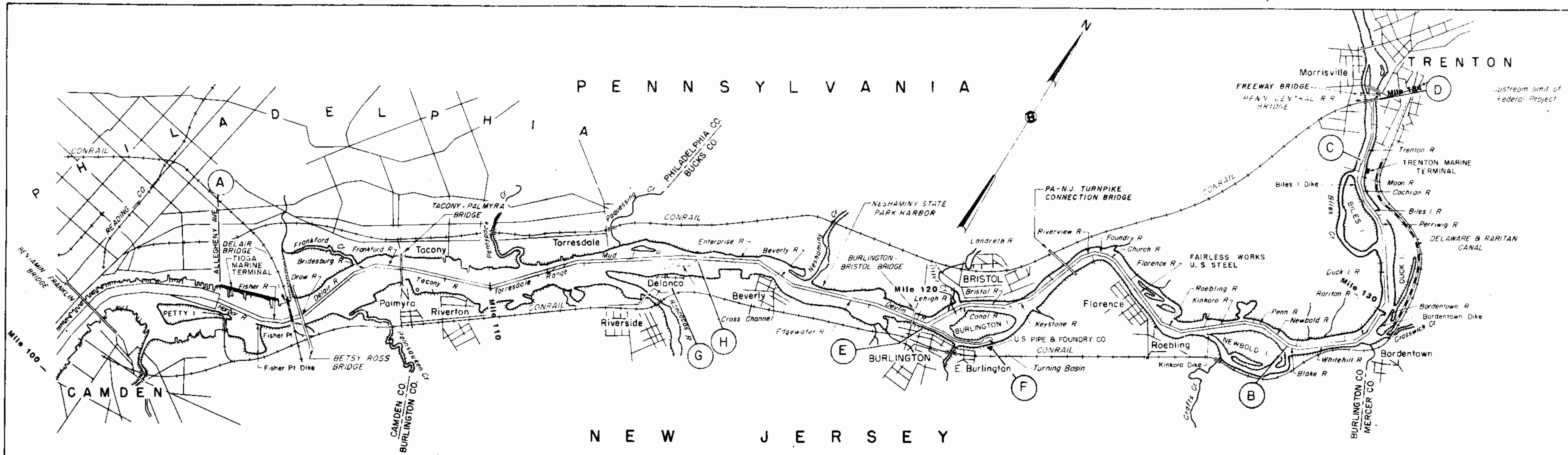
FIGURE 5

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 channel from Allegheny Avenue, Philadelphia, to Newbold Island (a distance of 24 miles), a 35-foot-deep channel from the upper end of Newbold Island to the Trenton Marine Terminal and a 12-foot-deep channel from Trenton Marine Terminal upstream to the Penn Central Railroad bridge in Trenton. The total project length (Figure 6) is 30.5 miles.

The project, as modified in 1954, was completed in 1964 to the previously authorized 25-foot depth, except for the 35-foot-deep channel (upper end of Newbold Island to the Trenton Marine Terminal) and widening the turning basin at the terminal. The 1976 modification provides for widening the Philadelphia side of the existing channel near the Tioga Marine Terminal to an average width of 1000 feet between Allegheny Avenue and the Delair Bridge an extent of 1.2 miles.

Wilmington Harbor. The Wilmington Harbor project (adopted in 1896 and modified in 1899, 1922, '30, '35, '40, and '60) provides for a channel in the Christina River with depths of 35, 21, 10, and 7 feet from the Delaware River to Newport, Delaware, as shown in Figure 7. The project also provides for a 35-foot deep turning basin opposite the Wilmington Marine Terminal, along with jetties at the mouths of the Christina and Brandywine Rivers. The project length is about 9 miles from the Delaware channel upstream to Newport.

Schuylkill River. The Schuylkill River project provides for a channel from its confluence with the Delaware River upstream to University Avenue (see Figure 8). The project (adopted in 1917 and modified in 1930 and 1946) has depths ranging from 22 to 33 feet. The project length is six miles. The latest modification was completed in 1962.



SCALE OF MILES

1 0 1 2 3

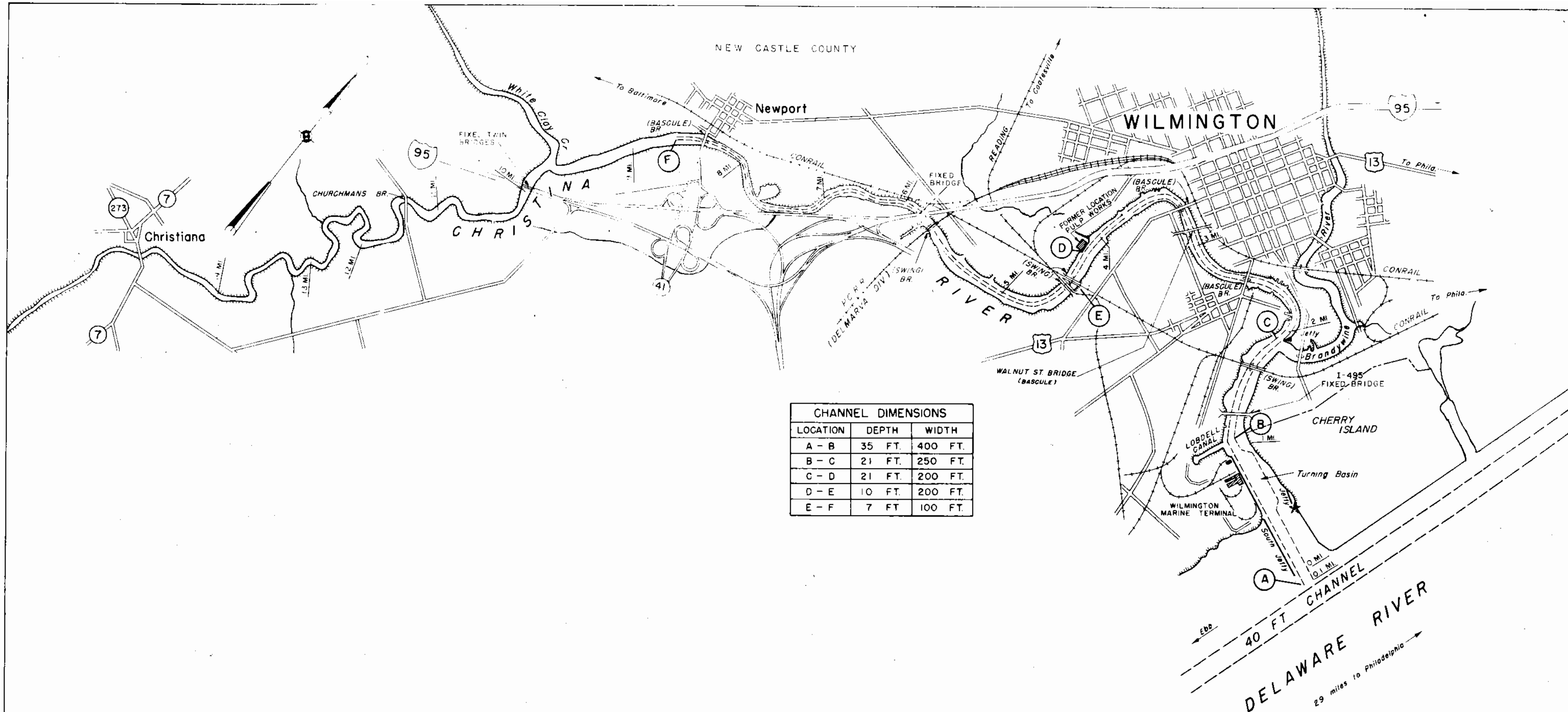
CHANNEL DIMENSIONS		
LOCATION	DEPTH	WIDTH
A - B	40 FT.	400 FT.
B - C	35 FT.	300 FT.
C - D	12 FT.	200 FT.
E - F	20 FT.	200 FT.
G - H	8 FT.	200 FT.

DELAWARE RIVER
DREDGING DISPOSAL STUDY

DELAWARE RIVER
PHILADELPHIA, PA. TO TRENTON, NJ

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 6



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

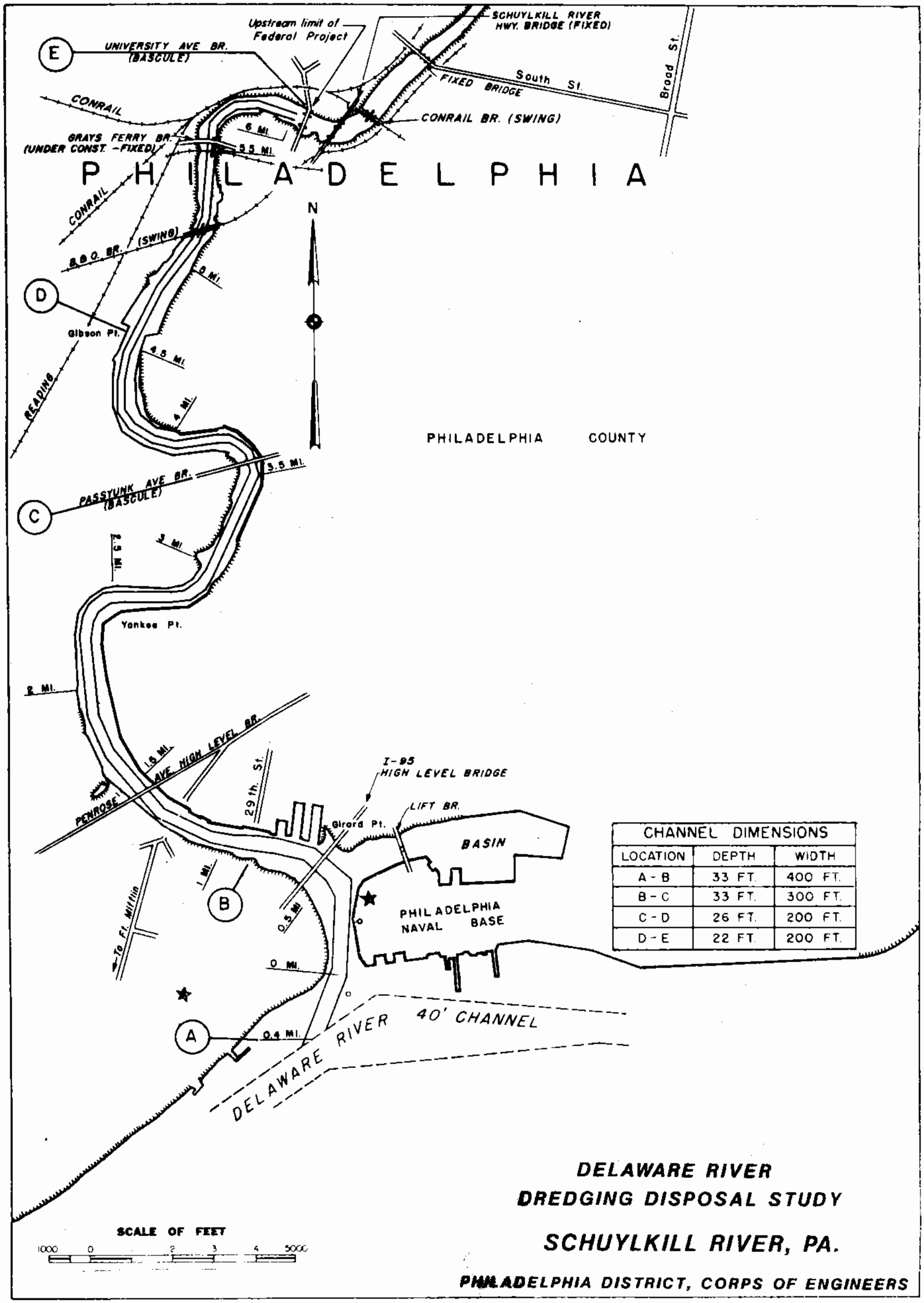
SCALE OF FEET
1000 0 1 2 3 4 5 6 7000

DELAWARE RIVER
DREDGING DISPOSAL STUDY

WILMINGTON HARBOR, CHRISTINA RIVER, DE

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 7



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.

DELAWARE RIVER
DREDGING DISPOSAL STUDY

SCHUYLKILL RIVER, PA.

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 8

SHALLOW DRAFT PROJECTS. The shallow draft projects considered are:

BIG TIMBER CREEK, NJ
BROADKILL RIVER, DE
COHANSEY RIVER, NJ
COOPER RIVER, NJ
HARBOR OF REFUGE, DE
INDIAN RIVER INLET AND BAY, DE
INLAND WATERWAY, REHOBOTH BAY TO DELAWARE BAY, DE
(LEWES AND REHOBOTH CANAL)
MANTUA CREEK, NJ
MAURICE RIVER, NJ
MISPILLION RIVER, DE
MURDERKILL RIVER, DE
NESHAMINY STATE PARK HARBOR, PA
PEPPER CREEK, DE
RACCOON CREEK, NJ
SALEM RIVER, NJ
ST. JONES RIVER, DE
WATERWAY FROM INDIAN RIVER INLET TO REHOBOTH BAY, DE

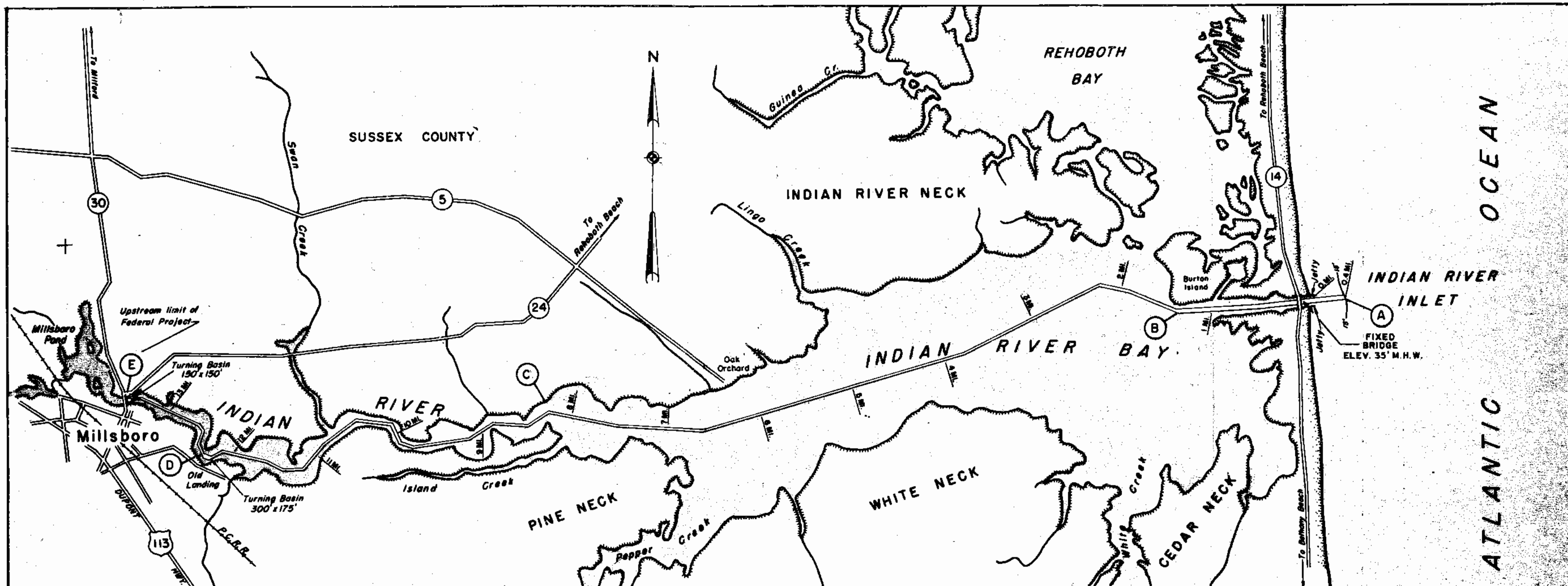
There are a number of additional authorized projects along the Delaware Estuary which are not actively maintained and therefore were not included in the study.

The Indian River Inlet and Bay, Pepper Creek, and the Waterway from Indian River Inlet to Rehoboth Bay are the only projects included in the study which lie outside of the Delaware Estuary.

The Indian River project (adopted in 1937 and modified in 1945) provides for a channel from Indian River Inlet to Millsboro, a distance of about 13 miles (see Figure 9).

NON-FEDERAL DREDGING

Along with the Federally maintained projects, there are a number of State, local and privately maintained areas. The majority of the dredging is performed to gain access to the Federal deep draft projects from piers and docks. American Dredging Company, the largest private dredging firm in the study area, performs maintenance dredging for approximately forty-five



CHANNEL DIMENSIONS		
LOCATION	DEPTH	WIDTH
A – B	15 FT.	200 FT.
B – C	9 FT.	100 FT.
C – D	9 FT.	80 FT.
D – E	4 FT.	60 FT.

SCALE OF MILES

1 0 1

DELAWARE RIVER
DREDGING DISPOSAL STUDY

INDIAN RIVER AND BAY, DE

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 9

companies under a "blanket" permit issued by the Philadelphia District. Other areas are maintained and operated in the vicinity of the private channel by individual companies and marinas.

COORDINATION AND STUDY PARTICIPANTS

In February 1978, an announcement of the study initiation was made to all known interested Federal, state, county, and local elected officials and agencies. Clearinghouses, special interest groups and interested individuals were also informed of the study. A copy of the announcement is included in Appendix 4. In early 1980, five public meetings were held to solicit views on problems and present the anticipated study efforts.

As the study progressed, a Plan Formulation Committee (PFC) was formed to provide advice to the study team during the critical decision making phases of the study. The committee was composed of representatives from the Corps of Engineers, Delaware River Basin Commission, Environmental Protection Agency, U.S. Fish and Wildlife Service, National Marine Fisheries Service, other Federal and State environmental agencies, the port interests, and local dredging and industrial representatives. The screening procedures used in selecting potential disposal sites incorporated the views of this committee to represent area-wide institutional concerns. Minutes of the PFC meetings are included in Appendix 4. In addition, the Corps of Engineers Waterways Experiment Station (WES) has played an active advisory role through their Dredged Material Research (DMRP) and Dredging Operations Technical Support (DOTS) Programs.

REPORT FORMAT

The results of the study are presented in five parts: the main report and four appendices. The main report presents an overview of the study and its findings. Appendix 1 provides the detail for the spatial analysis methodology data base screening process. Appendix 2 describes alternative dredging methods. Appendix 3 documents the systems model, and Appendix 4 includes pertinent correspondence relating to the study.

PRIOR AND CURRENT STUDIES

LONG RANGE SPOIL DISPOSAL STUDY. The goal of this study which was completed in 1973 was to locate and obtain disposal areas within efficient pumping distances of the known dredging reaches for the Philadelphia to the Sea project.

The study evaluated the remaining disposal area capacity, the nature, source and cause of shoaling, new dredging equipment and techniques and pumping of dredged material through long lines. The study identified three potential new disposal sites. It also concluded that continued maintenance of the Delaware River, Philadelphia to the Sea project under conditions of that period would not be possible after 1990.

ENVIRONMENTAL IMPACT STATEMENTS. The following is a summary of the Environmental Impact Statements (EIS) prepared for the maintenance of Federal navigation projects.

a. Delaware River, Trenton to the Sea, (including Schuylkill River and Wilmington Harbor) was prepared and filed with the Council on Environmental Quality (CEQ) in 1975.

b. Indian River Inlet was prepared and filed with CEQ in 1975.

Also, Environmental Assessments which resulted in Negative Declarations were prepared for the following projects as indicated:

DELAWARE	
MURDERKILL RIVER	1975
MISPILLION RIVER	1975
BROADKILL RIVER	1975

INLAND WATERWAY, REHOBOTH BAY TO DELAWARE BAY (LEWES AND REHOBOTH CANAL)	1974
HARBOR OF REFUGE	1975
WATERWAY FROM INDIAN RIVER INLET TO REHOBOTH BAY	1974
NEW JERSEY	
COOPER RIVER	1975
BIG TIMBER CREEK	1975
MANTUA CREEK	1975
RACCOON CREEK	1975
SALEM RIVER	1975
COHANSEY RIVER	1975
PENNSYLVANIA	
NESHAMINY STATE PARK HARBOR	1975

These reports give a brief description of the local environment, the projected dredging frequency, the potential impacts of dredging and disposal of dredged material.

DREDGED MATERIAL RESEARCH PROGRAM (DMRP). This program was conducted by the Environmental Effects Laboratory of the U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi.

The program sought answers to questions of why and under what circumstances would the disposal of dredged material produce adverse environmental impacts. The program produced generic knowledge of the processes and mechanisms involved in the creation of environmental impacts and methods for predicting these effects before a project is constructed or a permit issued. It has resulted in the development of methods of evaluating the relative impacts of alternatives for use by planners and design engineers. More significantly, it has produced tested, viable, cost-effective methods, and guidelines for reducing the impacts of conventional disposal alternatives, while pointing out the tradeoffs involved. It has also removed much of the uncertainty surrounding new disposal alternatives or possibilities.

As a result of this program, more than 200 technical reports have been published and widely distributed within and outside the Corps. These have been supplemented with synthesis reports, an index and retrieval system, a summary report, and special documents for Congress and the public. In addition, a technical advisory team has been established for the specific purpose of assisting Corps Districts and Divisions, agencies, and groups. This team is part of the Dredging Operations Technical Support (DOTS) and has assisted the Philadelphia District in the conduct of this study as mentioned in the section on coordination.

DELAWARE RIVER SHALLOWS STUDY. This study, prepared by the Philadelphia District, was completed in March 1979 and concerned the evaluation of the shallow water resources of the upper Delaware River Estuary, from Reedy Point, Delaware to Trenton, New Jersey. Shallow water is defined as those areas from the mean low water line to the -10 foot mean low water contour. The purpose of the study was to define those areas, and to develop a system by which their ecological value to the estuary could be evaluated.

DELAWARE RIVER COMPREHENSIVE NAVIGATION STUDY, NJ, PA, DE. The Philadelphia District is currently conducting this study which was authorized by a Senate Committee Resolution adopted on 2 December 1970. A Reconnaissance Report was completed in March 1983. The objective of the study is to define the Federal interest in navigation development especially with respect to future needs for navigational improvements. The study will address and evaluate current shipping problems, adequacy of facilities, delays in intermodal transfers, channel dimensions, storage locations and capacities, and other physical aspects affecting waterborne commerce in order to determine an appropriate plan for the efficient use and development of the Ports of

Philadelphia. In those areas where modifications are considered appropriate, it may be necessary to identify additional tentative disposal areas. Thus the two studies, the Dredging Disposal Study and the Comprehensive Navigation Study, are necessarily interrelated. This study has considered those certain prospective projects identified in an interim portion of the Comprehensive Study. Further studies and additional dredging needs associated with potential modifications will be conducted as part of the Comprehensive Study.

EXISTING CONDITIONS

NATURAL RESOURCES

CLIMATE. The entire 13 county study area lies within one broad climatic zone. In general the climate is mild with a few brief hot, humid periods in summer and cold, windy winter periods of similar duration and frequency. the yearly mean temperature is about 54°F and the normal annual precipitation is about 43 inches. The rainfall is well distributed throughout the year with generally more than 3 inches per month. Temporary droughts or periods of subnormal rainfall are not uncommon for the area.

TOPOGRAPHY AND GEOLOGY. Lands bordering the Delaware River Estuary from trenton to its mouth are generally flat. Along the lower part of the estuary, the elevation of the adjacent land ranges from 5 to 10 feet, about 20 feet at Wilmington, 20 to 30 feet at Philadelphia, and 40 to 50 feet near Trenton, NJ. Slopes near the lower estuary are generally less than 10 percent, while in the upper area, the slopes vary considerably with many steeper grades. The tributaries feeding the estuary below Trenton generally have a flat gradient with few rapids.

Geologically, the study area is situated near the border between two subdivisions, the Appalachian Piedmont Province and the Atlantic Coastal Plain Province. The Piedmont Plateau lies along the eastern edge of the Appalachian Mountains and runs from New Jersey to Alabama. The rocks of the Piedmont are old, hard, and crystalline. They extend downward and toward the Atlantic, forming a platform that supports the Coastal Plain. The rocks of the Coastal Plain are much younger, largely unconsolidated sediments forming a thick wedge. The Coastal Plain layers are composed mainly of clays, silts, sands, gravels and intermediate materials which slope to the southeast.

Some sandy layers form aquifers which are porous geologic formations that store or transmit groundwater in appreciable quantities. Significant aquifers underlying the study area include: The Raritan, Cape May, and Pennsauken in Pennsylvania; the Raritan-Magothy, Englishtown, Mount Laurel-Wenonah, and Kirkwood-Cohansey in New Jersey; and the Potomac, Magothy, Monmouth, Rancocas, Frederica, and Cheswold in Delaware. Of these, the Potomac and Raritan - Magothy aquifer systems are significant in that they represent the principal source of public water supplies for southern New Jersey. The aquifer beds outcrop along a path extending from Raritan Bay to New Castle County, Delaware, a major portion of which borders the Delaware River Estuary.

SURFACE WATER. The surface water resources of the study area include the Delaware River Estuary, its tributaries, and Indian River Inlet and Bay (including Pepper Creek). The Schuylkill River, a principal tributary of the estuary, enters at Philadelphia. The estuary is subject to semidiurnal tidal action from the Atlantic Ocean and has a mean tidal range increasing from 4.0 feet at the mouth to 6.9 feet at Trenton, NJ. The freshwater inflow to the Delaware River Estuary is primarily from the drainage area above the head of the estuary at Trenton, NJ. The long-term average flow at Trenton is 11,750 cfs (1913-1980). Comparable data for major gaged tributaries are presented in Table 1.

Indian River Bay is an Estuary fed by freshwater streams and tidal flushing from the Atlantic Ocean. Indian River Inlet connects the bay with the ocean. Freshwater inflow to the bay is primarily from three major tributaries which collectively represent only about 2 percent of the volume attributable to tidal flushing.

LAND USE. The Delaware River Estuary, from the sea to a point 67 miles from its mouth, (in the vicinity of New Castle, Delaware) is characterized by natural land with some industrial development. The adjacent land in this area is primarily wetlands and woodlands with some agricultural development and a few residential areas concentrated along the coast. From River Mile (RM) 67 to Trenton, NJ, which includes the major ports of Wilmington, Paulsboro, Marcus Hook, Camden and Philadelphia, the adjacent land includes both natural and highly industrialized areas with accompanying residential communities.

The Indian River Bay area is surrounded primarily by privately owned marshland. For this reason, land uses on the bay's developed portion of the shoreline are predominantly oriented toward recreation (seasonal housing, campgrounds, marinas, and marine services). The only industries on the bay are related to fish and shellfish harvesting. Some agricultural lands and poultry farms exist at the upstream portion of the Indian River. Also, a power plant is located on the river.

TABLE 1

MAJOR GAGED TRIBUTARIES

STREAM AND STATION LOCATION	GAGED DRAINAGE AREA (SQUARE MILES)	PERIOD OF RECORD	AVERAGE FLOW (CFS)
Assunpink Creek (Trenton, NJ)	89.4	1923-80	129
Crosswicks Creek (Extonville, NJ)	83.6	1940-51 1952-80	136
Neshaminy Creek (Langhorne, PA)	210.0	1934-79	291
North Branch Rancocas Creek (Pemberton, NJ)	111.0	1921-80	173
Pennypack Creek (Philadelphia, PA)	49.8	1965-70 1974-79	86
Schuylkill River (Philadelphia, PA)	1,893.0	1931-80	2,962
Chester Creek (Chester, PA)	61.1	1931-79	86
Christina River (Coochs Bridge, DE)	20.5	1943-79	29
Maurice River (Norma, NJ)	113	1932-81	168

WETLANDS. Historically, the Delaware River Estuary between Trenton and the Atlantic Ocean, and all tidal tributaries, were abundantly fringed with lush wetlands. The characteristic salt marsh vegetation of the bay merged with freshwater marshes in the vicinity of New Castle and Salem counties. The values of these ecosystems were largely unrecognized in the past, and most of the wetlands on both shores north of New Castle and Camden have been eliminated by dredging or filled for development. For example, the Philadelphia International Airport rests almost entirely on filled wetlands. Extensive tidal wetlands in a largely natural state are abundant south of Wilmington, DE and in Gloucester County, NJ.

Both tidal and non-tidal wetlands occur in the study area. Non-tidal marshes usually grow in freshwater along streams and in ponds. Bogs and swamps are also occasionally found in the study area. Tidal wetlands are flooded twice daily by tides, and it is this tidal fluctuation that maintains their high level of productivity. Tidal marshes thrive at all levels of salinity, which has been found to be the primary determinant of vegetational differences between fresh, brackish and saline marshes in the Delaware River Estuary. Disturbances, such as filling, ditching, and diking, induce changes in vegetation. Table 2 contains a list of representative plant species for each kind of marsh, and species characteristics of disturbed wetlands.[1]

Tidal wetlands, both fresh and saline, provide nutrients for estuarine and marine organisms. Those marine species that cannot migrate into the estuarine marshes are sustained by the regular tidal flushing of nutrients from the

TABLE 2 [1]

WETLANDS VEGETATION

TIDAL AND NON-TIDAL FRESHWATER MARSH (NATURAL)	
Common Threesquare	*Scirpus americanus*
Bullrush	*Scirpus olneyi*
Dotted Smartweed	*Polygonum punctatum*
Spikerush	*Eleocharis spp.*
Arrowhead	*Sagittaria spp.*
Wild Rice	*Zizania aquatica*
Arrow Arum	*Peltandra virginica*
Spatterdock	*Nuphar advena*
Pickerelweed	*Pontederia spp.*
Loosetrife	*Lythrum spp.*
TIDAL AND NON-TIDAL FRESHWATER MARSH (DISTURBED)	
Common Reed	*Phragmites australis*
BRACKISH MARSH	
Wild Rice	*Zizania aquatica*
Cattail	*Typha spp.*
SALTWATER MARSH	
Cordgrass	*Spartina alterniflora*
Salt Hay	*Spartina patens*
Spikegrass	*Distichlis spicata*
SALTWATER MARSH (DISTURBED)	
Common Reed	*Phragmites australis*
Groundsel Bush	*Baccharis halimifolia*
Marsh Elder	*Iva frutescens*

[1] Betz, Converse, Murdoch, Inc., 1979, Delaware River Dredging Disposal Study - Overview Inventory and Potential Impact Discussion. U.S.A.C.E., Philadelphia, Contract #DACW61-78-D-0018, 81pp.

marshes into the estuary and the Atlantic Ocean. Non-tidal wetlands are also valuable wildlife habitats and feeding grounds and perform the same roles as tidal marshes in maintaining water quality and supply. Such benefits, however, are generally only of local importance.

Wetlands with the least environmental value are those that have been disturbed. The plant species inhabiting these areas are far less attractive to wildlife for forage than natural wetlands vegetation. Filling and diking interrupts tidal flooding, therefore much of the productivity of the marsh is lost. Disturbed marshes are not without value, however. They provide shelter for wildlife and are still important recharge areas for groundwater supplies.

Shallows. The ecological cycles occurring in wetlands involve a wide variety of organisms interacting within several different wetland habitats. While important interactions occur within each of these habitats, it is within the shallow water areas that many of the critical interactions occur and in which much of the biological activity is concentrated.

Even as isolated environments, shallow water areas are often more productive than deeper waters. One reason for this difference is that shallow waters often have higher dissolved oxygen levels throughout the entire water column. Much oxygen enters water by diffusion from the atmosphere. Since subsurface water layers are constantly being brought to the surface by the force of the tides, river flow, wind and waves, and are exposed to the atmosphere, dissolved oxygen levels are evenly mixed throughout the water column. Oxygen is also produced by rooted aquatic plants and algae.

Besides benefiting from the oxygen production of rooted aquatic plants and algae, shallows are the direct recipients of organic materials produced by these groups. The large amounts of live and dead plant material (detritus) moving into or through shallows attract organisms which eat detritus and living plants which, in turn, attract organisms higher in the food chain. The eggs, larvae, juveniles, and adults of hundreds of species of invertebrates, fishes, birds, and mammals have been found within the shallow water zones of the study area. They are present in these areas in large part because of the availability of food.

In addition to being attracted by favorable food and oxygen conditions, organisms are also attracted by the variety of specific habitat types present in shallow water and shore zones. Due to the location of the shallows adjacent to different sediment sources, the bottoms of shallow water zones can be composed of substances varying from large stones and pebbles to very fine grained silts and muds. Conversely, deep water areas often have homogeneous bottom types composed mainly of the finer grained, lighter particles. Since the distribution and survival of benthic organisms is largely dependent on bottom type, greater variation within shallows promotes their colonization by a wider variety of benthic organisms than does the homogeneity of deeper areas. The open water areas and heavily vegetated zones, the quiet pools and swifter flowing riffle zones, and small isolated backwaters and unobstructed mainstream channels found in the shallows represent the variety of specific conditions that organisms require for their growth, shelter, feeding and reproduction.

It should be noted that some shallow areas are more productive than others. Natural differences in factors such as size, location, patterns of water circulation, shoreline configurations and characteristics of adjacent areas, all of which influence the biological structure of shallows, vary from area to area. Where these factors are optimal, production is high; where they are not, productivity may be reduced.

Intertidal Flats. Intertidal flats are those coastal environments between mean higher high water (MHHW) and mean lower low water (MLLW) in which no rooted aquatic plants grow. These areas provide two broad functional roles. First, they contribute substantial primary productivity in a highly nutritious form to estuaries. Second, intertidal flats serve as a primary locus wherein plant matter, derived from several estuarine habitats, is transformed into invertebrate animal tissue and ultimately into fishes, birds, and larger crustaceans.[2]

Primary productivity in intertidal areas is larger than in open waters because of the greater supply of light and nutrients available in very shallow areas. This primary productivity is the result of nonvascular plants (bottom-dwelling macro and microalgae and phytoplankton) that inhabit the intertidal zone. This productivity which occurs year-round is typically less than that of tidal marshes, but a greater proportion of it is passed to the estuarine food chain. Various herbivorous, deposit-feeding, or grazing invertebrates rapidly consume the benthic microalgae of mud flats. Thus the primary production of a mud flat is in a form (microalgae) that is directly usable by consumers. These organisms are in turn fed upon by their predators including shorebirds, crabs, and fishes.

BENTHOS. Living in close association with aquatic substrata are a variety of benthic invertebrates. The benthos are, for instance, a major link in the coastal detritus-based food web. Many species feed on detrital materials and associated microorganisms and, by so doing, accelerate the decomposition of organic materials deposited on the sediment surface.

2. Peterson, C.H., 1981, The Ecological Role of Mud Flats in Estuarine Systems, 184-192, In: P.S. Markoyits, E.D., Workshop on Coastal Ecosystems of the Southeastern U.S., USFWS - FWS/OES - 80/59 257.

At least 180 species of benthic invertebrates occur in Delaware Bay. A total of 109 and 125 species were collected in baywide sampling in 1972 and 1973, respectively. The most widespread species were Tellina agilis, Heteromastus filiformis, Glycera dibranchiata, Nephtys picta, Mulina lateralis, Protohaustorius wigleyi, Gemma gemma, and Nucla proxima.[3]

As has been reported for estuaries throughout the world, the number of benthic species in Delaware Bay increases with increasing salinity. A marked decline in species numbers occurs in the reach adjacent to Woodland Beach, Delaware.

A total of 57 benthic invertebrate taxa were collected in the upper bay and lower river during 1974-1976. Scolecolepides viridis, Polydora spp., Paranais litoralis, Balanus improvisus, and Cyathura polita were dominant, comprising 78 to 80 percent of annual mean density. These taxa are physiologically tolerant of the wide range of salinity in this part of the estuary.

A total of 70 benthic invertebrate taxa were collected in the Delaware River between Beverly and Burlington, New Jersey during 1970-1973. Limnodrilus spp., Procladius culiciformis, Corbicula manilensis, and Peloscolex ferox dominated the catch. These species do not appear in catches taken in the lower river and bay.

Crassostria virginiana - American oyster. A major commercial fishery exists in Delaware Bay. The fishery has existed since colonial times, but like so many other fisheries, is now a fraction of its former size. In 1880, the New Jersey fishery yielded 21.0 million pounds of meats worth 2.1 million dollars. From 1880 to 1931, the average annual harvest was 13.9 million pounds. From 1932 to 1956, it averaged 6.5 million pounds, and from 1957 to 1977, the average was 1.0 million pounds. Oyster landings in the State of

3 Delaware River Basin Commission, 1981, The Delaware River Basin - The Final Report and Environmental Impact Statement of the Level B Study, 140 pp.

Delaware underwent a similar decline and in Pennsylvania they stopped altogether in 1980. A decrease in the average annual harvest of oysters can be attributed to overfishing, an increase in harvesting efficiency, and MSX related mortalities.[4] MSX is a sporozoan parasite that first appeared in the Spring of 1957. It has since spread over the lower bay, and has killed oysters as far upbay as the Cohansey Bed. Oyster beds can be divided into three types: (1) the natural beds; (2) the planted beds in Delaware Bay; and (3) the adjacent river beds. The natural beds are seed areas from which oysters are dredged and normally placed on beds leased from the state, termed planted beds. Oysters occurring in the tributaries are called river beds and have been harvested or used as seed depending on their size and supply. In recent years river oysters have been exclusively transferred to planted beds for purposes of depuration.

Although the oysters range from the mouth of Delaware Bay to Hope Creek, NJ, the major beds (in terms of density and size of individuals) are located south of the Cohansey River on both sides of the bay, with extensive intertidal flats on the New Jersey side along Cape May. Distribution in the lower bay is in large part due to the hydraulic conditions that apparently favor settling on the Cape May flats. Circulation together with sub-marine topography (deep, elongate channels), predation, and the lack of a continuous shell bottom thus makes the west side of the bay a difficult site for oyster larvae to colonize.[5] Oysters only play a minor commercial role in Indian River Bay.

The Delaware Bay oyster industry has recently shown substantial improvement from the low point of the 1960's. The mean of reported landings has risen

[4] Haskin, H.H. and S.E. Ford, 1982, Haplosporidium nelsoni. (MSX) on Delaware Bay Seed Oyster Beds: A Host - Parasite Relationship along a Salinity Gradient. Journal of Invertebrate Pathology 40: 388-405.

[5] Maurer, D. and L. Watling, 1973, The Biology of the Oyster Community and its Associated Fauna in Delaware Bay, Delaware Bay Report Series, Vol. 6., 97 pp, University of Delaware, Newark.

from 1.1 million pounds during the 1958-1977 period to 1.5 million pounds during 1972-1977. During the same periods, and perhaps more indicative of the improvement, mean oyster plantings in New Jersey rose from 184,500 bushels to 299,000 bushels. In 1980, an estimated 434,000 bushels were tranferred to the leased grounds. Experts believe the bay may eventually yield 3.5 million pounds of oyster meats (0.5 million bushels) annually.

The oyster industry is almost entirely dependent on natural seed beds in the upper bay. The beds extend from the vicinity of Egg Island Point (RM 24) to Artificial Island (RM 48). The New Jersey side of the bay contains 24 distinct beds, totaling approximately 17,000 acres. The Delaware side has 11 beds totaling approximately 1000 acres.

Oystermen remove young oysters from the seed beds during a State-regulated, three to four week period in May and June each year and transfer them to leased grounds in the high salinity lower bay for faster growth. After one to four years, the oysters are harvested and shipped to market. New Jersey has approximately 29,000 acres in lower Delaware Bay leased for oyster harvest. Delaware has approximately 9,000 acres that are actively leased and an additonal 8,000 acres in inactive leases in the bay.

Mercenaria mercenaria - Hard Clam. This species is characterized by an extensive geographic range and inhabits sheltered bays and inlets. This species is important to the recreational clammer as well as the commercial clam industry, and is the largest commercial clam in the U.S. It has accounted for approximately 17 percent of the total volume and 53 percent of the total ex-vessel (i.e., dock side) value in the past ten years. Unfortunately, productive bottoms for these species are being impacted by dredging and filling operations in coastal states.

The hard clam was formerly an important commercial species in the Delaware Bay. Although hard clams are still available commercially, their importance as a commodity has drastically decreased in the last ten years. A survey in 1971 demonstrated the Delaware Bay clam population to be seriously depleted. This may be due in part to the increasing number of clammers since the oyster fishery has declined.

The hard clam is the most abundant shellfish in Indian River Bay and still supports a commercial operation. Both in the bay and rivers, the hard clam is commonly found in fine sands with clay, near and in, oyster bars. Local oystermen consider old, noncultivated oyster beds as productive sites for harvesting hard clams.

Hard clams constitute a valuable resource in Delaware Bay. The maintenance of this resource depends on a continuation of favorable environmental conditions necessary for the healthy development of the clams. Many areas of Delaware Bay have become contaminated with bacteria, rendering hard clams unsuitable for human consumption. Other modifications in the environment through human activities that have changed temperature, salinity, turbidity, or circulation patterns may have deleterious effects on the harvestable population by damaging the extremely vulnerable larval stages of the clam.

Callinectes sapidus - Blue Crab. A major commercial fishery exists in the bay for the blue crab (Callinectes sapidus). Commercial crabbing began in the 1870's and records have been maintained by individual States since 1880. Since 1929, the East Coast catch has steadily increased, reaching an annual average of 119 million pounds, with most of the crabs coming from Chesapeake Bay. During 1971-1977, the average annual catch and value in Delaware Bay was 4.0 million pounds.

FISHERIES. The Delaware River Estuary and Indian River Bay are recognized as important feeding and breeding grounds for many commercially and recreationally important species of fish.

The Delaware River Estuary is inhabited by at least 228 species of resident and migratory fishes. It is primarily important as a spawning and nursery ground. Early life stages of 112 species were detected in tidal waters and non-tidal waters near the tidal limit in the State of Delaware. The estuary is also used for summer and winter feeding.

At least 30 species of fish are commercially taken in the estuary. During the period 1960-1975, almost 58 million pounds of fish valued at 3.2 million dollars were harvested. The 10 most valuable species were Brevoortia tyrannus, Morone saxatilis, Cynoscion regalis, Anguilla rostrata, Alosa sapidissima, Morone americana, Cyprinus carpio, Pomatomus saltatrix, Paralichthys dentatus, and Ictalurus catus.
Recreational fishing is an important industry in the bay. Approximately 331,000 man-days of vessel fishing (1973 estimate) and 225,000 man-days of shore fishing (1976 estimate) occurred from the Delaware side. An estimated 300,000 to 650,000 man-days of sportfishing effort are expended annually on the New Jersey side. Weakfish, summer flounder, black sea bass, black drum and bluefish are the species most sought after.

Brevoortia tyrannus - Atlantic Menhaden. The Atlantic menhaden spawns in waters off the Atlantic coast. Hatching occurs at sea and in areas close to shore from late spring through early winter. After hatching, larvae move inshore to brackish and freshwater nursery grounds. The Delaware River from Wilmington to Artificial Island and the Chesapeake and Delaware Canal is an important nursery ground. Tidal creeks of the lower Delaware River are also important. Young fishes migrate to higher salinity and deeper waters as water temperature declines in fall; most migrate south and overwinter in offshore waters.

Cynoscion regalis - Weakfish. The weakfish has been the most important sportfish in the Delaware Estuary in recent years. Adults spawn in the lower bay from about May through September and eggs have been collected as far up-bay as Mad Horse Creek. After hatching, the larvae sink to the bottom of the water column to be carried upstream by subsurface flow. Larvae and young move up the estuary as far as Wilmington, Delaware but the upstream penetration may be limited by low dissolved oxygen concentrations in that area. Young also utilize the tidal creeks of the upper part of the estuary as nursery grounds. Young weakfish move to the lower estuary in the fall and eventually winter in nearshore areas along the coast.

Morone saxatilis - Striped Bass. The striped bass is an anadromous species that spawns in the lower reaches of large rivers. Its most important spawning grounds are the Roanoke River, certain tributaries to Chesapeake Bay, the Chesapeake and Delaware Canal and the Delaware River and Hudson River Estuaries. Stocks have been reduced in the Delaware River since 1940 for reasons probably related to lack of suitable spawning habitat.

Adults spend most of the year in the lower bay or offshore, entering the upper bay and lower river for spawning in April and May. Some eggs have been taken near Artificial Island, the product of local spawning and/or transport from more distant spawning areas (Chesapeake and Delaware Canals). Young utilize this area as a nursery ground during summer and fall, eventually moving to the lower bay to overwinter.

Alosa sapidissima - American Shad. The American shad is another anadromous species, but spawning occurs far upstream in the non-tidal portion of the Delaware River. Spawning adults normally pass through the estuary in early spring before the dissolved oxygen "barrier" establishes itself in the

Philadelphia area. The seaward migration of juveniles usually begins in September and peaks in October. Most adults die after spawning but some survive and return to the sea. Population of shad have increased in recent years due to improved water quality conditions in the Delaware River.

Morone americana - White Perch. The semi-anadromous white perch migrates from brackish waters (5-18 parts per thousand (ppt)) of Delaware Bay in spring, moving upriver to spawn in low salinity or fresh waters. Spawning is most common above Newbold Island, but also occurs from Lambertville, NJ to Artificial Island. After spawning, adults begin to move in prolonged stages back down the river. In summer they prefer low salinity or fresh waters and seem especially attracted to the saltwater-freshwater interface. Adults and young continue to move downriver in late summer and fall, ultimately wintering in the deep warmer waters of Delaware Bay.

Pomatomus saltatrix - Bluefish. The bluefish spawns in offshore waters of the Atlantic Ocean and in the lower reaches of some estuaries. However, eggs and larvae have not been collected in the Delaware River Estuary. Juveniles use the estuary as a nursery ground, occurring mostly between Woodland Beach and the Chesapeake and Delaware Canal from May through October. Young also occur in lesser numbers in the lower part of the Delaware River, Chesapeake and Delaware Canal and tidal creeks of the upper Delaware Bay. Adults use the estuary as a feeding ground.

Paralichthys dentatus - Summer Flounder. The summer flounder spawns in offshore waters of the Atlantic Ocean and the most important spawning grounds seem to be located off New York and New Jersey. Larvae move toward shore when they are able to swim. Young of the year were collected from September through early April throughout Delaware Bay as far up the estuary as the Chesapeake and Delaware Canal and at salinities as low as 1 ppt. Adults use higher salinity areas of the bay for feeding.

Anguilla rostrata - American Eel. The Amercian eel is a catadromous species, which means it lives in freshwater systems, but spawns at sea. Young, transparent "glass eels" are carried by the current and swim to the mouths of coastal estuaries where they develop further into elvers and eventually adults. Glass eels first appear in the Delaware River Estuary during December and continue to enter the estuary throughout the month of May. Most young move up the estuary to low salinity and freshwater areas, especially tidal tributaries.

Ictalurus catus - White Catfish. The white catfish is resident of the Delaware River and many of its lower tributaries. Although it is most commonly found in fresh water, specimens have been collected in salinities as high as 14.5 ppt. Numerous specimens were collected in tidal creeks of the lower Delaware River, most of which were in brackish water (salinity as high as 7.9 ppt).

Cyprinus carpio - Carp. The carp is an introduced resident of freshwater and brackish reaches of the Delaware River. In the Artificial Island area, specimens have been collected offshore, in the shore zone and from tributaries. Salinities ranged from 0.0 to 10.5 ppt. Spawning occurs in tidal freshwater creeks in the Delaware area from early May through early June.

WILDLIFE. It is only in relatively recent years that man has begun to comprehend the role of wetlands in the estuarine ecosystem. In particular, wetlands are said to be of utmost importance to the health and welfare of numerous fishes and shellfishes. Although this relationship is an extremely important and essential one, it must be kept in mind that the wetlands and marshes are also important to many other animals including song birds, ducks, geese, wading shore birds, birds of prey, fur-bearing mammals, plus some amphibians and reptiles.

The list of animals that are commonly found on wetlands of the study area is, indeed, a long one. Each of these animals play an important role in maintaining the ecological balance of the system as they interact with the wetlands by feeding, nesting, spawning and dying. Many of these animals spend their lives in particular zones or areas in the marsh. Yet, in many cases, it is difficult to determine specific ranges of certain wetland-dependent organisms.

Of the animals that do spend most of their lives in one part of the marsh, many are smaller forms such as the invertebrates, birds and small mammals. Invertebrates such as the marsh snail (*Melampus bidentatus*), the fiddler crab (*Uca* spp.) and the ribbed mussel (*Modiolus demissus*) are common low marsh inhabitants of tide lands.

The Delaware River Estuary is used by numerous species of herons, ibises and egrets, commonly known as large wading birds. The birds range throughout the estuary in saltwater, brackish and freshwater areas. Their food habits include a great variety of animal foods and only incidental use of plant materials. Fish, eels, frogs, toads, salamanders, lizards, snakes, crayfish and many kinds of insects are eaten. Some of the larger herons take mice, birds and young rats. In general, large wading birds are mobile, opportunistic feeders, adept at capturing prey under diverse conditions.

Two important heron rookeries or nesting sites occur in the Delaware River Estuary. Both are located in the brackish zone. Pea Patch Island provided nesting for nine species of wading birds in 1977, totaling over 6,000 pairs.

The J. Gordon Armstrong site near Delaware City, DE, supports over 100 pairs of great blue herons.

Shorebirds, in migration, frequent most of the habitat types found in the Delaware River Estuary, feeding on a variety of small marine and freshwater animals. Shorebirds in the study area include plovers, oyster catchers, gulls, terns, and skimmers. Included in their diet are insects, worms, mollusks, crustaceans, fish and small amounts of plant material. As the most productive feeding areas are large, tidal mudflats, shorebird concentrations are greatest in the lower estuary where large expanses of tidal mudflats are more common.

Some marsh birds can be found in low marsh areas where they remain for a large part of their lives. Clapper rails (Rallus longirostris) are typical low marsh residents that build their nests and raise their young among the stems of the tidal grasses. Both clapper rails and black ducks consume low marsh inhabitants, the crabs and snails. Seaside sparrows, red wing blackbirds and sharp-tailed sparrows principally consume cordgrass seeds. Cordgrass is also consumed by insects which form the base of the diet of many birds. Another common inhabitant is the willet (Cataptrophorous semipalmatus) whose noisy call usually precedes any strange visitor.

Among the small mammals who tend to remain in a fairly limited area are the meadow mouse (Microtus pennsylvanicus) and the muskrat (Ondatra zibethica). The meadow mouse is usually found in the landward edges of the wetlands near the salt hay (Spartina patens) zone. Mice range over large areas but still spend much time in the area of their nests. The nests represent safety and shelter and during adverse conditions, the mice seldom leave them. The muskrat is a very well known marsh inhabitant. It too, chooses a particular area in which to reside and tends to remain close by.

Animals that are essentially upland species occasionally roam into the marsh and wetland areas in search of food. Raccoons (Procyon lotor), oppossums (Didelphus marsupiala) and woodchucks (Marmota monax) often travel into the lower marsh to feed on shellfish and crabs. When conditions on the marsh are not too severe, as during neap tide periods, these animals may remain for several days at a time. Weasels (Mustela frenata), red and gray foxes (Vulpes fulva and Urocyon cineraoargenteus), deer (Odocoileus virginiana) and rabbits (Sylvilagus floridanus) also travel from upland to lower marsh areas on occasion.

Other extremely important users of marshes and wetlands are the transient species to whom the marshes represent feeding and resting sites. The most common of these are waterfowl. The study area is situated along one of the major flyways of the North American continent, and as a result, these wetlands are used extensively by many different migrating species. An estimated 300,000 ducks and geese, comprising 30 species, overwinter in the Delaware River Estuary, mostly in tidal wetlands, providing an estimated 320,000 man-days of hunting annually. Mallards (Anas platyrhynchos), pintails (A. acuta), blue and green-winged teals (A. carolinensis and A. discors), black ducks (A. rubripes), and gadwalls (A. strepera) are some of the duck species that can be found in the study area wetlands along with the magnificant Canadian Geese (Branta canadensis).

Waterfowl use the Delaware River Estuary as a staging area during migration as well as a wintering area. Most use is concentrated in and around the bay and lower river where much of the tidal marsh is located. Freshwater and brackish plant foods are favored, although certain waterfowl do consume saltmarsh plants or animal foods associated with salt marshes.

Predator-prey interactions also involve the top predatory species such as foxes, the otter (Lutra canadensis) and hawks. Foxes are sometimes seen in the upland margins stalking feeding ducks. Marsh hawks (Circus cyaneus), the most common bird of prey found in many wetlands, are often seen fringing wetland areas in search of mice, rats and young muskrats upon which they feed.

THREATENED AND ENDANGERED SPECIES. The lower Delaware River and Bay Region and Indian River Bay Region are within the historic range of 17 Federally threatened or endangered species as designated by the U.S. Department of the Interior (Table 3): seven species of whales, five species of marine turtles, four species of birds and one species of fish. The whales and turtles are primarily oceanic, but occasionally venture into Delaware Bay. Three of the birds are raptorial and migrate through the area. The other bird, the brown pelican, is a rare visitor. The shortnose sturgeon (Acipenser brevirostrum) was first discovered in the Delaware River in 1817, and was described as a new species based upon 4 specimens obtained that year. The species was apparently relatively common in the Delaware River until about 1910, but then it seemed to suffer a serious decline in numbers, and no documented captures were reported in the literature from 1913 through 1953. Because of its apparent scarcity throughout its range from Canada to Florida, the shortnose sturgeon was placed on the original Endangered Species list approved by Congress in 1973. The paucity of records of shortnose sturgeon in the Delaware River has continued up until the present, but may be attributed as much to a lack of proper sampling as to the scarcity of shortnose sturgeon.

Recent studies performed for the Philadelphia District have demonstated that shortnose sturgeon are found in the tidal Delaware River, but population size is unknown. Evidence available for the Delaware River and other similar river systems indicate that spawning occurs upstream of Trenton. Larvae and small

TABLE 3

THREATENED/ENDANGERED SPECIES
IN THE LOWER DELAWARE RIVER AND BAY REGION*

SPECIES	DELAWARE	NEW JERSEY	PENNSYLVANIA
Blue whale, *Balaenoptera Musculus* (E)	X	X	-
Bowhead whale, *Balaena mysticetus* (E)	X	X	-
Finback whale, *Balaenoptera physalus* (E)	X	X	-
Humpback whale, *Megaptera novaeangliae* (E)	X	X	-
Right whale, *Eubalaena* spp. (E)	X	X	-
Sei whale, *Balaenoptera borealis* (E)	X	X	-
Sperm whale, *Physeter catodon* (E)	X	X	-
Bald eagle, *Haliaeetus leucocephalus* (E)	X	X	X
American peregrine falcon, *Falco peregrinus anatum* (E)	X	X	X
Arctic peregrine falcon, *Falco peregrinus tundrius* (E)	X	X	X
Brown pelican, *Pelecanus occidentalis* (E)	X	X	-
Green sea turtle, *Chelonia myda* (T)**	X	X	-
Hawksbill sea turtle, *Eretmochelys imbricata* (E)	X	X	-
Atlantic Ridley sea turtle, *Lepidochelys coriacea* (E)	X	X	-
Leatherback sea turtle, *Dermochelys coriaced* (E)	X	X	-
Loggerhead sea turtle, *Caretia caretta* (T)	X	X	-
Shortnose sturgeon, *Acipenser brevirostrum* (E)	X	X	X

(E) Endangered
(T) Threatened
** Species is not found in Indian River Bay Area
* Source: Federal Register

juveniles then drift downstream and disperse in the freshwater tidal portion of the river, but remain primarily in deeper channel areas. Larger juveniles were rare in recent collections but apparently also live primarily in the tidal freshwater portion of the river, in deeper channel areas. Because of this preference for channel areas by larvae and juveniles, the possibility exists that dredging operations could affect this part of the sturgeon population, either by direct injury by the dredge or by increased turbidity generated by dredge operation. Adult shortnose sturgeon form aggregations at certain sites in the river channel between Trenton and Newbold Island from about March through October and at such times could be vulnerable to injury by dredges. At other times they should usually move away from areas being disturbed by an active dredge and should not be adversely affected. Additional studies will be performed to address these concerns.

SEDIMENTATION [6]

SOURCE OF SHOAL MATERIAL. The primary sources of shoal material in the Delaware River are from upland areas, tributaries, storm and sanitary sewer inflow, and from solids produced by organisms such as diatoms. The question of how much sediment enters the estuary from the ocean is unresolved. However, it has been observed that sediments entering from the ocean do not progress up the estuary beyond the head of the bay (RM 47). Estuary bank erosion is not considered significant as a source of sediment, because much of the shoreline is either bulkheaded, or marshland with erosion resistant vegetation.

SEDIMENT MOVEMENTS AND SHOALING. The rate of sediment transport into the estuary depends on the hydrology, which is extremely variable. The degree of shoaling varies throughout the estuary due to differences in freshwater inflow, tidal influence, predominant flow direction of near-bottom currents, salinity and cross-sectional area. However, it has been observed that annual shoaling quantities are nearly constant over time in dredged channels and anchorages.

[6] U.S. Army Corps of Engineers, North Atlantic Division. 1973. Long Range Spoil Disposal Study - Part III Sub-Study 2, Nature, Source, and Cause of the Shoal.

CHARACTERISTICS OF BED MATERIAL. From the mouth to about RM 40 (see Figure 1), the bed of the Delaware Estuary consists predominantly of fine grained materials with some fine to coarse sand. From RM 40 to about RM 95, the channel bottom consists largely of silt, although there are a few areas where granular material or rock outcrops are encountered. From RM 95 to RM 102, materials encountered include mostly compacted fine material interspersed with some sands and outcroppings of gneisses and schists near the upper end of the reach. From RM 102 to the head of tide, the channel bottom is composed of silt, clay, sand, gravel and bedrock.

For the Indian River Inlet and Bay, the bottom sediments range from shell, pebbles, coarse sand, silts and clays to clean fine sand. At the headwaters of the bay, the sediment is primarily silt and clay.

CHEMICAL QUALITY OF SEDIMENT

Sediment testing, conducted over the past four years, indicates that no serious pollution problems exist with respect to sediment quality in the study area. Testing has primarily been done on an as-needed basis for the purpose of obtaining state water quality certificates. Concentration ranges for various constituents are presented in Tables 4 and 5 for the Philadelphia to Trenton and Philadelphia to the Sea navigation projects, respectively. The parameters include heavy metals, sulfate, chloride, total Kjeldahl nitrogen, total organic carbon, oil and grease, suspended solids, fecal coliform,and total coliform. Heavy metals (As, Cd, Cr, Cu, Fe, Pb, Mn, Ni, Se, and Zn) were present in the sediments of most channel ranges with Iron and Manganese present in highest concentrations. Low concentrations of pesticides have also been found in the study area. These include N-aryl carbamates, O-aryl carbamates, organochlorine, organophosphorous, phenoxy acids, and triazines.

TABLE 4

CONCENTRATION RANGES OF SELECTED CONTAMINANTS PRESENT IN THE DELAWARE RIVER SEDIMENTS (PHILADELPHIA TO TRENTON) (all in mg/l except as noted)

HEAVY METALS ELEMENT			CONCENTRATION
Arsenic	(As)		<.001- .214
Cadmium	(Cd)		<.001- .018
Copper	(Cu)		.008-<.03
Chromium	(Cr)		<.001- .02
Iron	(Fe)		.050-3.36
Lead	(Pb)		<.001- .31
Mercury	(Hg)	(µg/l)	<.05-<1.2
Maganese	(Mn)		.38 -6.97
Nickel	(Ni)		<.02 - .219
Selenium	(Se)		<.001- .108
Zinc	(Zn)		<.004- .98
Volatile Organics			
Benzene	(µg/l)		ND - 120
Toluene	(µg/l		ND - 200
Non-Volatile Organics			
4,4' - DDT	(µg/l)		ND - .0351
4,4' - DDE	(µg/l)		ND - .00657
4,4' - DDD	(µg/l)		ND - .159
PCB's	(µg/l)		ND - 1.6
Total Cyanide			<.001 - .005
Sulfate			4.5 - 9.0
Chloride			<3.0
Nitrogen - Total Kjeldahl			.77 - 49.3
Carbon - Total Organic			<.10 - 27.0
Oil and Grease			.60 -27200
Suspended Solids			1 -10
Total Coliform (colonies/100 ml)			4 -2600
Fecal Coliform (colonies/100 ml)			ND -280

TABLE 5

CONCENTRATION RANGES OF SELECTED CONTAMINANTS PRESENT IN THE DELAWARE RIVER SEDIMENTS (PHILADELPHIA TO THE SEA)
(all measured in mg/l except as noted)

HEAVY METALS ELEMENT			CONCENTRATION
Arsenic	(As)		.001- .011
Cadmium	(Cd)		< .001- < .01
Copper	(Cu)		.007- .127
Chromium	(Cr)		.001- .19
Iron	(Fe)		.462-125.5
Lead	(Pb)		< .001- .36
Mercury	(Hg)	(µg/l)	< .0001-20
Maganese	(Mn)		< .012- 8.42
Nickel	(Ni)		< .01- .16
Selenium	(Se)		< .001- .193
Zinc	(Zn)		.005- .86
Volatile Organics			
Benzene	(µg/l)		ND -<1.0
Toluene	(µg/l)		ND -<1.0
Non-Volatile Organics			
4,4' - DDE	(µg/l)		ND -<1.0
4,4' - DDD	(µg/l)		ND -<1.0
PCB's			ND -< .10
PCB's	(µg/l)		ND -<9.0
Total Cyanide			< .001 - .011
Nitrogen - Total Kjeldahl			.39 - 55.0
Carbon - Total Organic			< .1 -1183
Oil and Grease			< .10 - 227.0
Suspended Solids			7.0 - 16.0
Total Coliform (colonies/100 ml)			3 -1440
Fecal Coliform (colonies/100 ml)			ND -380

ND - not detectable

A variety of volatile and non-volatile organic compounds have also been identified. To date, presence of these pollutants has not impeded dredging in the project area or the obtaining of required water quality certificates from the states of New Jersey, Pennsylvania or Delaware. Additional testing will be performed in the future in connection with solicitation of water quality certification for maintenance dredging as is appropriate. Sediment testing has also been conducted on Indian River Bay in conjunction with maintenance dredging. No serious water quality problems have been encountered in this area to date.

HUMAN RESOURCES

POPULATION. According to the 1980 U.S. Bureau of Census data, the population of the entire study area is 5,182,000. County totals range from 1,876,000 in Philadelphia County, Pennsylvania to 62,900 in Salem County, New Jersey. A more appropriate comparison is the difference in population density. In 1980, Philadelphia County had a density of 14,547 people per square mile while Sussex County, Delaware had a density of 99 people per square mile. This difference is indicative of the variations from urban areas to spacious rural areas.

According to Table 6, the population is increasing in most counties. However, Delaware and Philadelphia Counties in Pennsylvania showed a 2.9 percent and 3.8 percent decrease respectively from 1970 to 1980.

EMPLOYMENT. The classes of industry that employ the majority of persons in the study area are manufacturing, and wholesale and retail trade. Another important field of employment is service. The total labor force is 2,284,500 persons, ranging from 804,300 persons in Philadelphia County to 29,250 persons in Salem County. Estimates of labor force in the study area are shown by county in Table 7.

TABLE 6

POPULATION AND POPULATION DENSITY

COUNTY	AREA (SQ. MILES)	POPULATION 1970	POPULATION DENSITY 1970	POPULATION 1980	POPULATION DENSITY 1980	PERCENT CHANGE 1970-80
EW JERSEY						
Burlington	818	323,132	395	376,700	461	16.6
Camden	222	456,291	2,055	483,200	2,177	5.9
Cape May	263	59,554	226	85,900	327	44.2
Cumberland	502	121,374	242	135,100	269	11.3
Gloucester	328	172,681	526	201,300	614	16.6
Mercer	226	304,116	1,346	323,500	1,431	6.4
Salem	347	60,346	174	62,900	181	4.2
ENNSYLVANIA						
Bucks	614	416,728	679	453,000	738	8.7
Delaware	184	603,456	3,280	586,100	3,185	-2.9
Philadelphia	129	1,949,996	15,116	1,876,500	14,547	-3.8
ELAWARE						
Kent	595	81,892	138	98,700	166	20.5
New Castle	437	385,856	883	405,800	929	5.2
Sussex	946	80,356	35	93,900	99	16.9
OTAL STUDY AREA	5,611	5,015,778	894	5,182,600	924	3.3

TABLE 7

LABOR FORCE
IN THE STUDY AREA

COUNTY	LABOR FORCE
PENNSYLVANIA (a)	
Bucks	214,400
Philadelphia	804,300
Delaware	257,100
DELAWARE (b)	
New Castle	186,900
Kent and Sussex	90,000
NEW JERSEY (c)	
Mercer	159,900
Burlington	157,058
Camden	207,900
Gloucester	88,200
Salem	29,250
Cumberland	59,600
Cape May	40,000
STUDY AREA TOTAL	2,294,608

(a) Philadelphia Labor Area Annual Planning Report, May 1981

(b) State of Delaware Annual Planning Report June 1980

(c) New Jersey; Dept of Conservation and Economic Development, 1980

TABLE 8

SUMMARY OF TRAFFIC
DELAWARE RIVER AND TRIBUTARIES
TRENTON TO THE SEA
(short tons)

LOCALITY	TOTAL
Trenton Harbor, NJ	1,081,558
Burlington-Florence-Roebling, NJ	527,428
Penn Manor, PA, and Vicinity	4,196,192
Bristol, PA, and Vicinity	36,107
Philadelphia Harbor, PA	41,583,752
Camden-Gloucester, NJ	7,510,599
Chester, PA	663,091
Marcus Hook, PA, and Vicinity	24,550,791
Paulsboro, NJ, and Vicinity	20,581,505
Thompson Point, NJ and Vicinity	394,937
Wilmington Harbor, DE	3,128,230
Penns Grove-Carneys Point, NJ	427,003
New Castle, DE, and Vicinity	11,732,099
Artificial Island, NJ, and Vicinity	5,185
Lower Delaware Bay, NJ	18,889
Lower Delaware Bay, DE,	10,716,007
GROSS TOTAL	127,153,373

Source: Waterborne Commerce of the United States, 1981.

COMMERCE. There are 14 port areas and two open-bay areas which are significant handlers of waterborne commerce along Delaware River and Bay from Trenton to Cape May, New Jersey. Philadelphia Harbor handles the most traffic. Other large ports in the study area are Paulsboro, New Jersey, Marcus Hook, Pennsylvania, and New Castle, Delaware. Tonnage moving through each of the major ports along the Delaware River is shown in Table 8.

The ports along the Delaware River account for about 50 percent of the North Atlantic bulk traffic. The total gross volume of cargo which moved through the various port facilities in this region totaled more than 125 million short tons in 1981. Despite a 5 million decrease between 1980 and 1981, the net increase in import tonnage between 1965 and 1980 was about 7 million tons.

Though not a major center of commerce, the Indian River Inlet and Bay area serves as both an active recreational boating area and a thoroughfare for the passage of recreational vessels. Commerce is generally limited to commercial fishing vessels. These conditions also hold for Rehoboth Bay and the other inland waterways of Delaware's Atlantic Coast as the State of Delaware desires to maintain them as natural areas.

Other tidal tributaries in the study area which serve as active recreational boating areas and commercial fishing foci are the Neshaminy State Marina in Pennsylvania, Mispillion and Murderkill Rivers in Delaware and the Maurice River in New Jersey.

PROBLEM IDENTIFICATION

INTRODUCTION

As described in the previous section, a total of 5 deep draft and 17 shallow draft navigation projects are currently being maintained by the Philadelphia District in the study area. The dredging requirements for these projects along with the associated work performed by the private sector were projected over a 50 year period (1980-2030). In addition, the needs for potential future projects being pursued by the Federal and private sectors for implementation during the 50 year period were assessed. The resulting volume of dredged material for the current and future projects was compared to the remaining capacity at existing disposal sites. This comparison, as might be expected, produced a net deficit since the presently available capacity is insufficient to meet the long term dredging needs. As a result, the study attempted to satisfy the deficits for various levels of dredging through the alternative measures, presented in the Plan Formulation portion of this report.

FEDERAL AND NON-FEDERAL DREDGING

The dredging volumes were sub-divided into Federal and Non-Federal categories in order to accommodate the appropriate dredging mode and associated transportation costs. The Federal dredging involves the maintenance of projects authorized by Congress. The dredged material from the maintenance of the Federal projects is usually disposed in Federally owned or leased sites. In many cases, it is the responsibility of the Federal Government to provide the necessary disposal areas. Philadelphia to the Sea, Wilmington Harbor, Delaware River at Camden, Schuylkill River and some of the shallow projects are examples of projects where the enabling legislation requires the Federal Government to provide the disposal areas. For the remaining projects (Philadelphia to Trenton and the remaining shallow draft projects) the sponsor is required to provide the disposal area as an item of local cooperation.

Non-Federal dredging is performed by regional, State and local agencies as well as private dredging companies to provide access from berthing areas to one of the Federally maintained channels. Most of the associated material is placed either on-site or in disposal areas that are provided by the dredging contractor.

DREDGING LEVELS

HISTORIC DREDGING. This level of dredging represents the volume of dredged material that is currently being removed to maintain the 5 deep draft and 17 shallow-draft navigation projects and the accompanying private work. The Federal dredging quantities were based on data gathered from the Long Range Spoil Disposal Study, Environmental Impact Statements, and dredging construction files (years 1968 to 1980). Non-Federal dredging quantities were determined from Federal permit files, questionnaires and telephone interviews. Quantities for both sectors were averaged over a number of years of available dredging data. The resulting quantities are shown in Table 9.

TABLE 9

ANNUAL HISTORIC DREDGING QUANTITIES (CY)

	DEEP DRAFT	SHALLOW DRAFT	TOTAL
FEDERAL	7,980,000	210,000	8,190,000
NON-FEDERAL	3,033,000	30,000	3,063,000
TOTAL	11,013,000	240,000	11,253,000

POTENTIAL NEW PROJECTS. This level of dredging considers those new projects that may be implemented during the 50-year study period. The dredging volume associated with this level represents an additional increment to that shown for the historic level. It is emphasized that it is not the intention of this study to demonstrate the viability of these projects nor to recommend their implementation. However, it is anticipated that the dredging needs will tend to increase over the 50 year study period. By collectively considering both the historic dredging and those projects which have a reasonable likelihood of being constructed, it is anticipated that a more realistic dredging level can be approximated. This study assumed that potential new projects shown in Table 10 would be constructed by 1990.

These potential projects have been identified either through an interim portion of the on-going Delaware River Comprehensive Navigation Study or by an on-going study that has reached the advanced study stages. Other projects may be identified by the on-going Comprehensive Study or by other means and could be incorporated in the dredging plan shown later in this report, as appropriate.

TABLE 10

POTENTIAL NEW PROJECTS

PROJECT	SOURCE	DESCRIPTION
Beckett Street Terminal	On-going advanced study	Provide a 37' channel to the terminal.
Beckett Street Terminal	Delaware River Comprehensive Navigation Study	Provide a channel to the terminal with depth greater than 37'.
Tioga Marine Terminal	Delaware River Comprehensive Navigation Study	Deepen the existing channel to 40'.
Schuylkill River	Delaware River Comprehensive Navigation Study	Deepen the existing channel from its confluence with the Delaware River upstream to Passyunk Avenue to a depth as great as 37'.
Petty Island Back Channel	On-going study	Provide an 18' channel for a number of users in the Back Channel.

AUTHORIZED. The third dredging level is represented by the incremental volumes that would be required to reach authorized dimensions. The term "authorized refers to that established by Congress as part of the enabling legislation. In some cases, a particular portion of a project may either have never been constructed or may be maintained to a lesser depth or width. The departures from authorized dimensions are generally attributed to changes in conditions, changes in navigational needs, or budgetary constraints. This level of dredging therefore, represents a volume that has not been dredged but would be required (without advanced maintenance), if authorized projects were maintained.

ASSUMPTIONS FOR DETERMINING DEEP-DRAFT PROJECT NEEDS. The needs were determined for two conditions, namely; a worst case and a most probable case. These two conditions, defined a range of potential needs for disposal during the 50 year period of the study. The worst case assumed that all identified projects would be fully constructed and maintained during the study period. Also, it was assumed that there would be a minimum level of management at the disposal sites. It is emphasized that steps such as extending leases and improved site management practices have been taken to improve upon this condition. Consequently, the needs for the disposal capacity associated with the worst case condition scenario represent an extreme condition that would, in all likelihood, exceed that required. It is presented to represent an upper limit of the disposal capacity needed.

The most probable condition reflects reduced needs as it assumed that dredging associated with authorized but unconstructed projects would not be required. In addition, this condition considered that a number of improved site management practices would be implemented. These measures are designed to extend the useful capacity of existing or proposed disposal areas and are discussed under the Plan Formulation section of this report.

A definition of these conditions is shown below:

Worst Case Condition.

- Historic and Authorized dredging
- Anticipated new projects (These are assumed to be completed by 1990)
- Minimal Management of disposal sites (assumed a wet to dry ratio of 1.0 - i.e., one cubic yard of river bottom material would occupy one cubic yard disposal site capacity)
- Assumed present lease constraints would govern (i.e. leases would not be renegotiated)

Most Probable Case.

- Historic dredging
- Anticipated new projects (again assumed to be completed by 1990)
- Viable disposal management measures would be employed (wet to dry ratios - see above definition - would range from 1.3 to 2.0 depending on the site involved)
- Leases for continued use would be renegotiated where appropriate

PHILADELPHIA TO THE SEA PROJECT

HISTORIC. Of the nearly 8 million cubic yards of material dredged annually from Federal deep draft projects in the Delaware Estuary, approximately 6 million cubic yards are removed from the Philadelphia to the Sea project. Portions of the 40 foot deep channel and the Marcus Hook and Mantua anchorages require almost constant maintenance. The most significant shoaling areas are in the Marcus Hook, Deepwater Point, and New Castle reaches (see Figure 10). These areas represent approximately 75 percent (4,500,000 cy) of the maintenance dredging for the project. Most of the past dredging was performed by Corps hopper dredges with direct pumpout of the material to Federally-owned upland disposal sites. The current trend is to perform the bulk of the maintenance dredging by contracted hydraulic pipeline or hopper dredges. The existing disposal areas for this project are shown in Table 11 along with acreage and remaining disposal capacities.

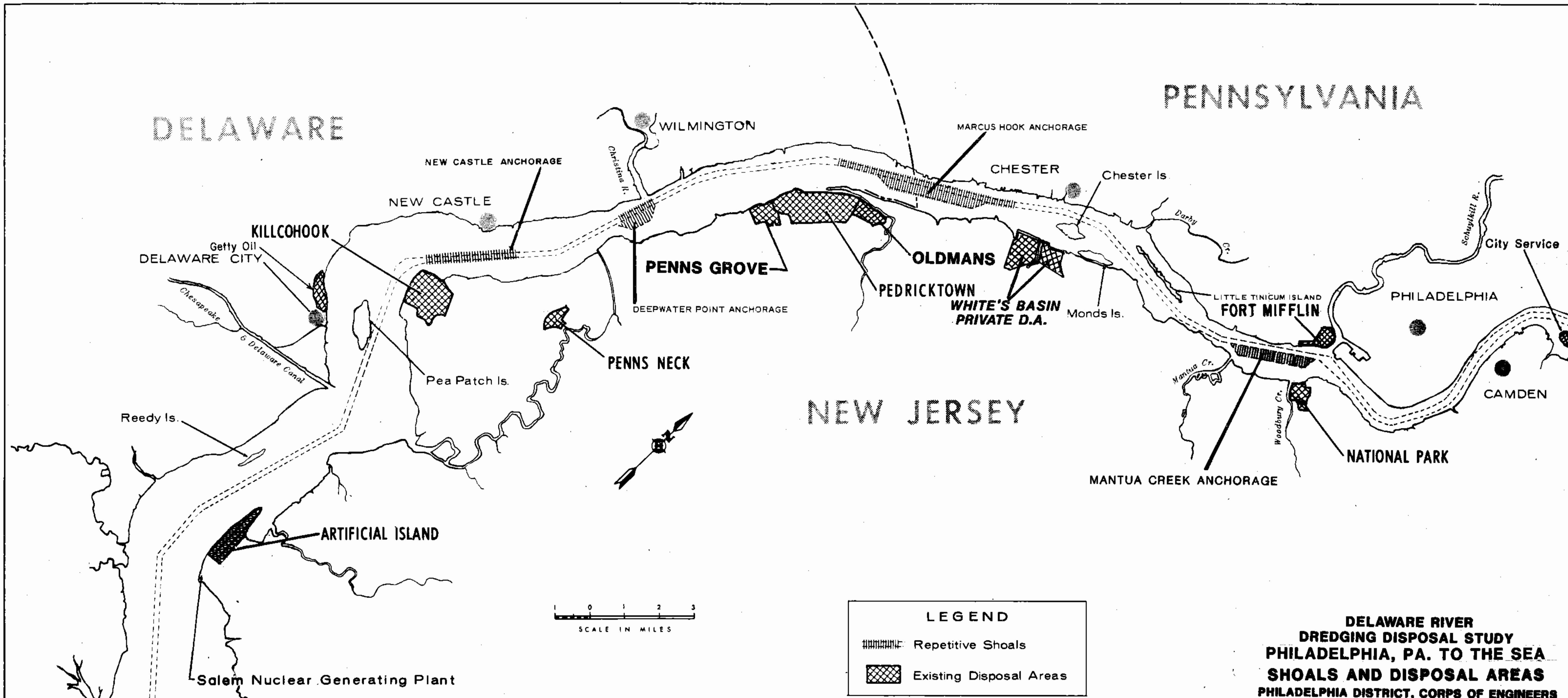

DELAWARE
PENNSYLVANIA
NEW JERSEY
WILMINGTON
MARCUS HOOK ANCHORAGE
NEW CASTLE ANCHORAGE
Christina R.
CHESTER
Chester Is.
NEW CASTLE
KILLCOHOOK
Getty Oil
DELAWARE CITY
PENNS GROVE
OLDMANS
PEDRICKTOWN
WHITE'S BASIN PRIVATE D.A.
Monds Is.
Darby Cr.
Schuylkill R.
City Service
PHILADELPHIA
LITTLE TINICUM ISLAND
FORT MIFFLIN
DEEPWATER POINT ANCHORAGE
Chesapeake & Delaware Canal
Pea Patch Is.
PENNS NECK
Mantua Cr.
Woodbury Cr.
CAMDEN
Reedy Is.
NATIONAL PARK
MANTUA CREEK ANCHORAGE
ARTIFICIAL ISLAND
Salem Nuclear Generating Plant
1 0 1 2 3
SCALE IN MILES
LEGEND
Repetitive Shoals
Existing Disposal Areas
DELAWARE RIVER
DREDGING DISPOSAL STUDY
PHILADELPHIA, PA. TO THE SEA
SHOALS AND DISPOSAL AREAS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 10

TABLE 11

REMAINING CAPACITY
OF FEDERAL DISPOSAL AREAS
PHILADELPHIA TO THE SEA PROJECT

DISPOSAL AREA	BANKED ACRES	ESTIMATED REMAINING CAPACITY (CY) TO MAXIMUM ELEVATION (a) AS OF 1980
National Park	120	4,100,000 to El. 50
Pedricktown		
North	567	21,700,000 to El. 50
South	522	21,700,000 to El. 35
Oldmans	189	6,000,000 to El. 35
Penns Neck	325	16,000,000 to El. 50
Penns Grove	253	13,180,000 to El. 35
Killcohook	1229	36,900,000 to El. 50
Artificial Island (Diked Area)	305	16,500,000 to EL. 50
Lower Delaware Bay	-	Open Water Site

(a) Corps of Engineers Delaware River Datum.

AUTHORIZED. Since no potential new projects were assumed in the Philadelphia to the Sea project, the next level of dredging to be investigated is the authorized level. As presented earlier, the Philadelphia to the Sea project includes 17 anchorages. Of these, 12 are located in deep water and, as such, require no dredging. Of the remaining five, only Marcus Hook anchorage is maintained to the authorized dimensions. Port Richmond and Mantua Creek have not been maintained to their authorized dimensions, while the Deepwater Point and Reedy Point anchorages have not been constructed. In addition, the authorized 37 foot channel on the east side is not maintained. The historic and the initial dredging requirements to obtain the authorized dimensions as well as that required to maintain the authorized dimensions are shown in Table 12.

TABLE 12

DREDGE VOLUMES FROM AUTHORIZED PROJECTS

PROJECT FEATURE	HISTORIC DREDGING (CY/YR)	INITIAL CONSTRUCTION (CY)	DREDGING REQUIRED TO MAINTAIN AUTHORIZED DIMENSIONS (CY/YR)
Port Richmond Anchorage	0	400,000	21,000
Mantua Creek Anchorage	157,000	12,100,000	256,000
Marcus Hook Anchorage	487,000	-	487,000
Deepwater Point Anchorage	0	3,176,000	102,000
Reedy Point Anchorage	0	2,950,000	0

NON-FEDERAL DREDGING. In addition to the Federal dredging, approximately 2,491,000 cubic yards of material are removed by Non-Federal interests each year in the vicinity of the Philadelphia to Sea project. Dredging to maintain access to the main channel from shore-based facilities is performed periodically by bucket and hydraulic pipeline dredges. Bucket dredging accounts for 1,950,000 cubic yards (78%) of the material and is disposed in White's Basin, a privately owned disposal site with an associated rehandling basin (see Figure 10). By raising the current dikes heights to a maximum elevation of 50 feet to increase capacity and opening of new compartments of the site, White's Basin will satisfy the 50 year bucket dredging disposal needs. The material removed by hydraulic pipeline dredges is disposed on-site or in privately owned areas such as those at City Service and Getty Oil (see Figure 10). The remaining capacity of these sites is approximately 13.5 million cubic yards. The capacity for these sites was determined assuming a maximum dredge material elevation of 25 feet. The dredge material elevation of these private sites (except for White's Basin) is constrained to 25 feet because the areas are generally small and are planned for future development by the land owners.

DELAWARE RIVER IN THE VICINITY OF CAMDEN, NJ PROJECT

HISTORIC. Most of the Delaware River in the vicinity of the Camden project has natural depths greater than that authorized and requires only occasional spot maintenance dredging.

POTENTIAL NEW PROJECTS. A potential new project in this area involves dredging in the vicinity of the Beckett Street Terminal. This project would be a modification of the current Delaware River in the vicinity of Camden project. The purpose of the dredging is to accomodate ship traffic in the area of the terminal. A recent engineering design study confirmed the feasibility of dredging a portion of the Camden project to its authorized depth (37 feet). It is presently anticipated that the dredged material will be placed in the National Park site.

A second analysis is being considered as part of the Delaware River Comprehensive Navigation Study to determine the viability of dredging beyond the authorized dimensions to a depth as great as 40 feet. The dredging volumes associated with each of these potential projects are presented in Table 13.

TABLE 13

BECKETT STREET TERMINAL
DREDGE VOLUMES

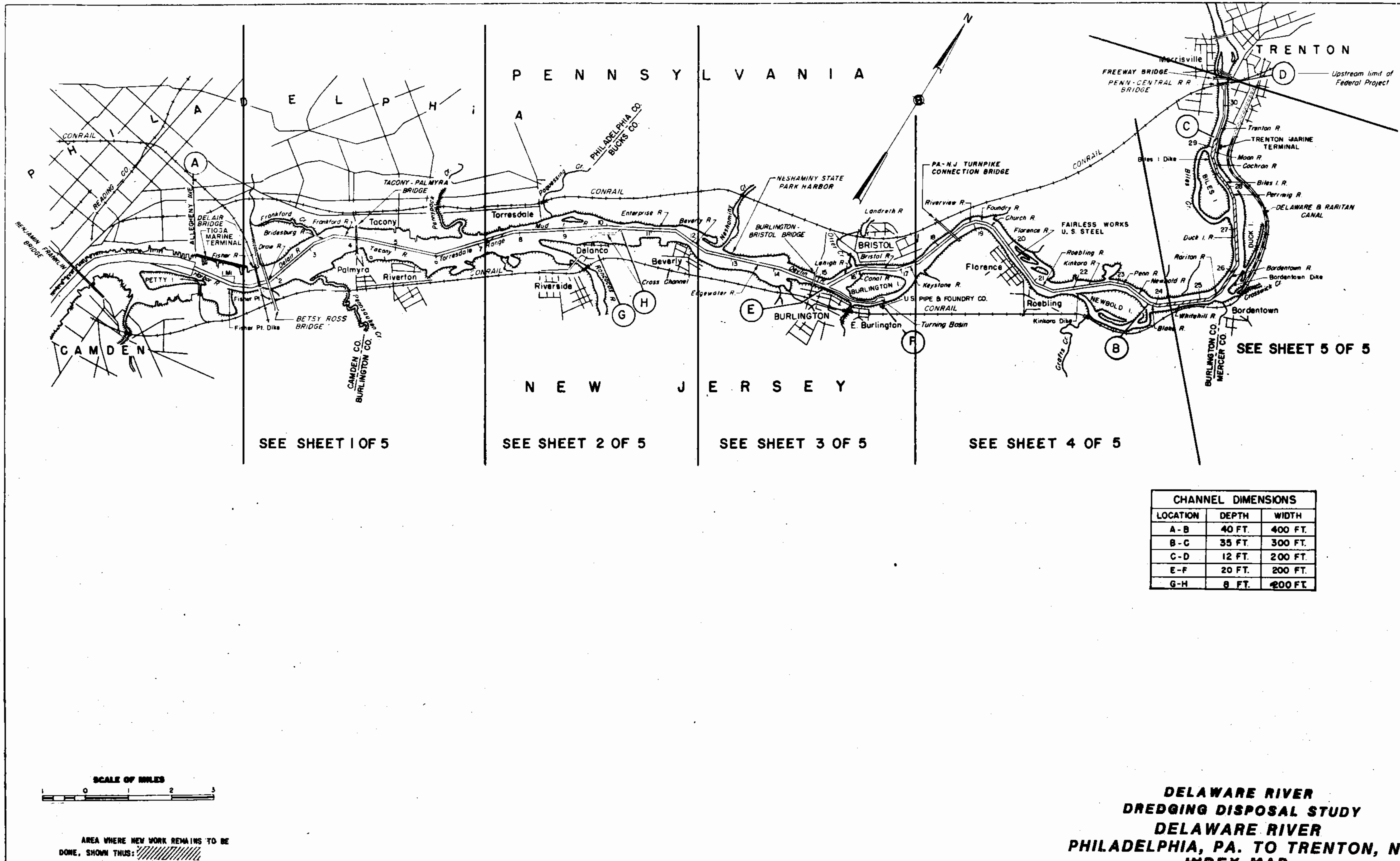
DEPTH (FT)	INITIAL CONSTRUCTION (CY)	ANNUAL MAINTENANCE (CY/YR)
37	441,900	9,900
40	678,900	11,800

NON-FEDERAL DREDGING. Approximately 23,000 cubic yards of material are removed privately by bucket dredges in order to maintain berthing areas for this project. Since this material is disposad in White's Basin, there is no deficit projected for the private sector.

The disposal requirements for the Delaware River at Camden project have been included with those for the Philadelphia to the Sea project for two reasons: First, the Camden project is located within the Philadelphia to the Sea limits; second, the study for the potential 37 foot channel has identified a site which is used for disposal for the Philadelphia to the Sea project. Consequently, jointly considering the needs of the two projects facilitates the analysis.

PHILADELPHIA TO TRENTON PROJECT

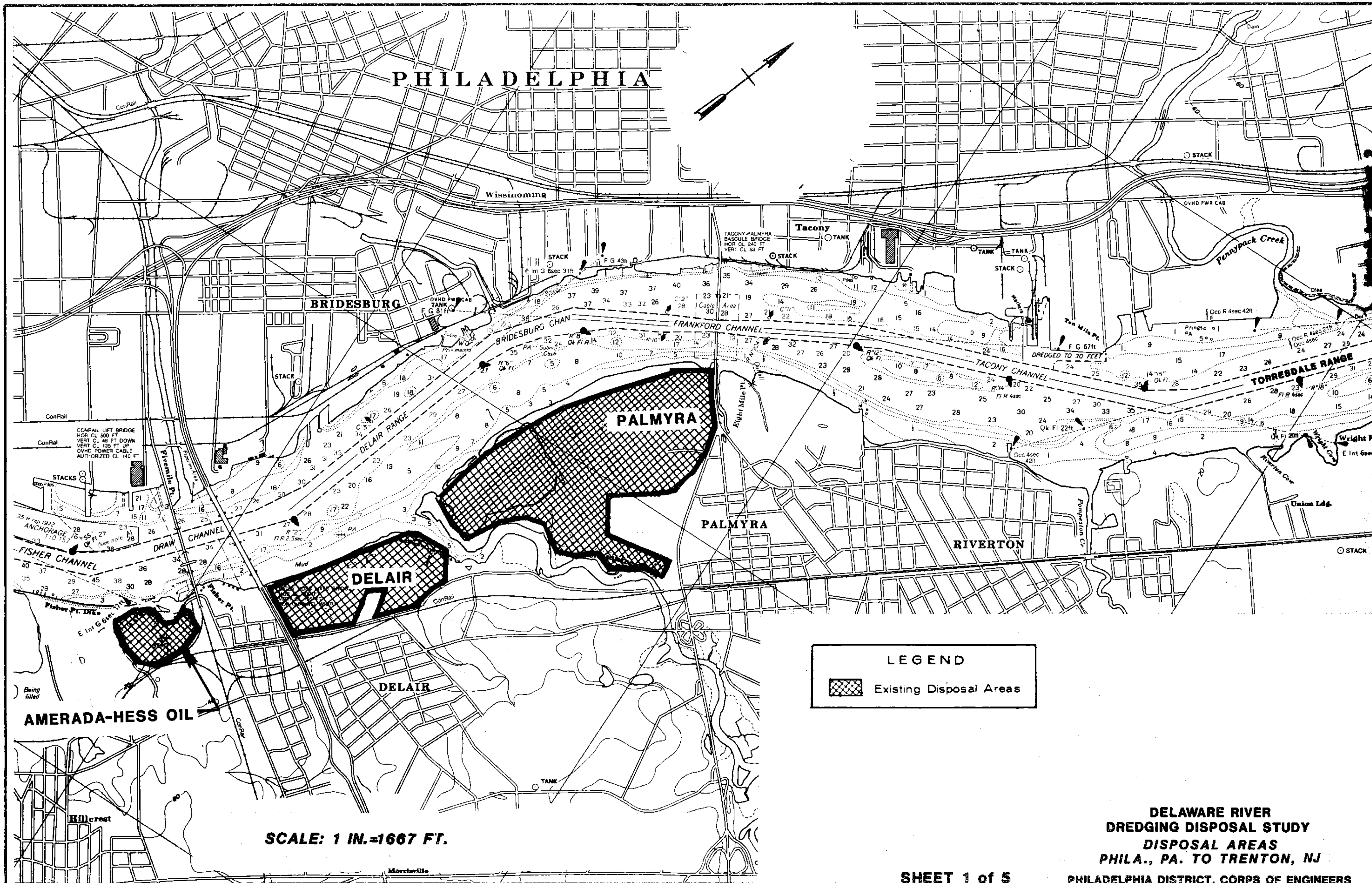
HISTORIC. Approximately 550,000 cubic yards of material are dredged annually from the Philadelphia to Trenton project. Nearly half of that amount is removed at the upper end of the project from the Newbold, Penn, Kinkora, Roebling, and Florence ranges. The Kinkora range is the most significant shoaling area. The Federal maintenance is performed by contractor-operated hydraulic pipeline dredges. The excavated material is placed in one of twelve upland disposal sites. These areas are not owned by the government but are provided by the Commonwealth of Pennsylavnia and the State of New Jersey as part of their local cooperation. Figures 11-16 show the locations of the existing disposal and significant shoal areas within the project. The remaining capacities of the disposal areas are shown in Table 14. Due to the time or fill height limit contained within each particular lease, the remaining capacity is currently constrained for some of these disposal areas. In the past, local interests have furnished disposal sites on an "as needed" basis to perform the required maintenance dredging. It is anticipated that this practice will continue. The District is in the process of attempting to renew the existing leases.



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.	200 FT.

DELAWARE RIVER
DREDGING DISPOSAL STUDY
DELAWARE RIVER
PHILADELPHIA, PA. TO TRENTON, NJ
INDEX MAP
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 11



SHEET 1 of 5

DELAWARE RIVER
DREDGING DISPOSAL STUDY
DISPOSAL AREAS
PHILA., PA. TO TRENTON, NJ
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 12

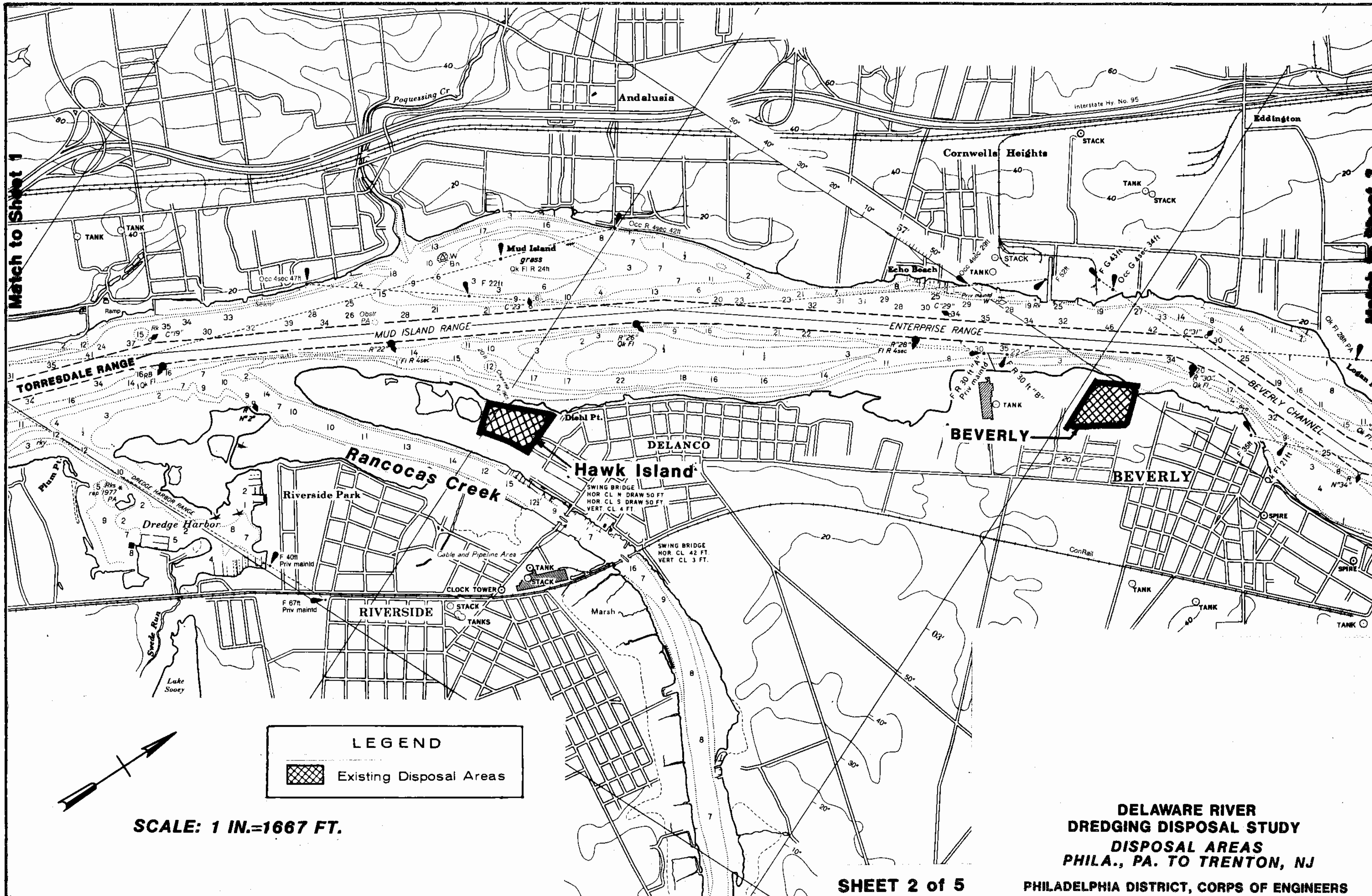

DELAWARE RIVER
DREDGING DISPOSAL STUDY
DISPOSAL AREAS
PHILA., PA. TO TRENTON, NJ
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SHEET 2 of 5
SCALE: 1 IN.=1667 FT.
LEGEND
Existing Disposal Areas
Match to Sheet 1
Match to Sheet 3
Hawk Island
BEVERLY
Rancocas Creek
DELANCO
RIVERSIDE
Riverside Park
Dredge Harbor
Andalusia
Cornwells Heights
Eddington
Echo Beach
Mud Island
TORRESDALE RANGE
MUD ISLAND RANGE
ENTERPRISE RANGE
BEVERLY CHANNEL
Interstate Hy. No. 95
Poquessing Cr
Diehl Pt.
Logan Pt
Plum Pt
Swede Run
Lake Sooey
ConRail
SWING BRIDGE HOR CL N DRAW 50 FT HOR CL S DRAW 50 FT VERT CL 4 FT
SWING BRIDGE HOR CL 42 FT. VERT CL 3 FT.
CLOCK TOWER
Cable and Pipeline Area
Marsh

FIGURE 13

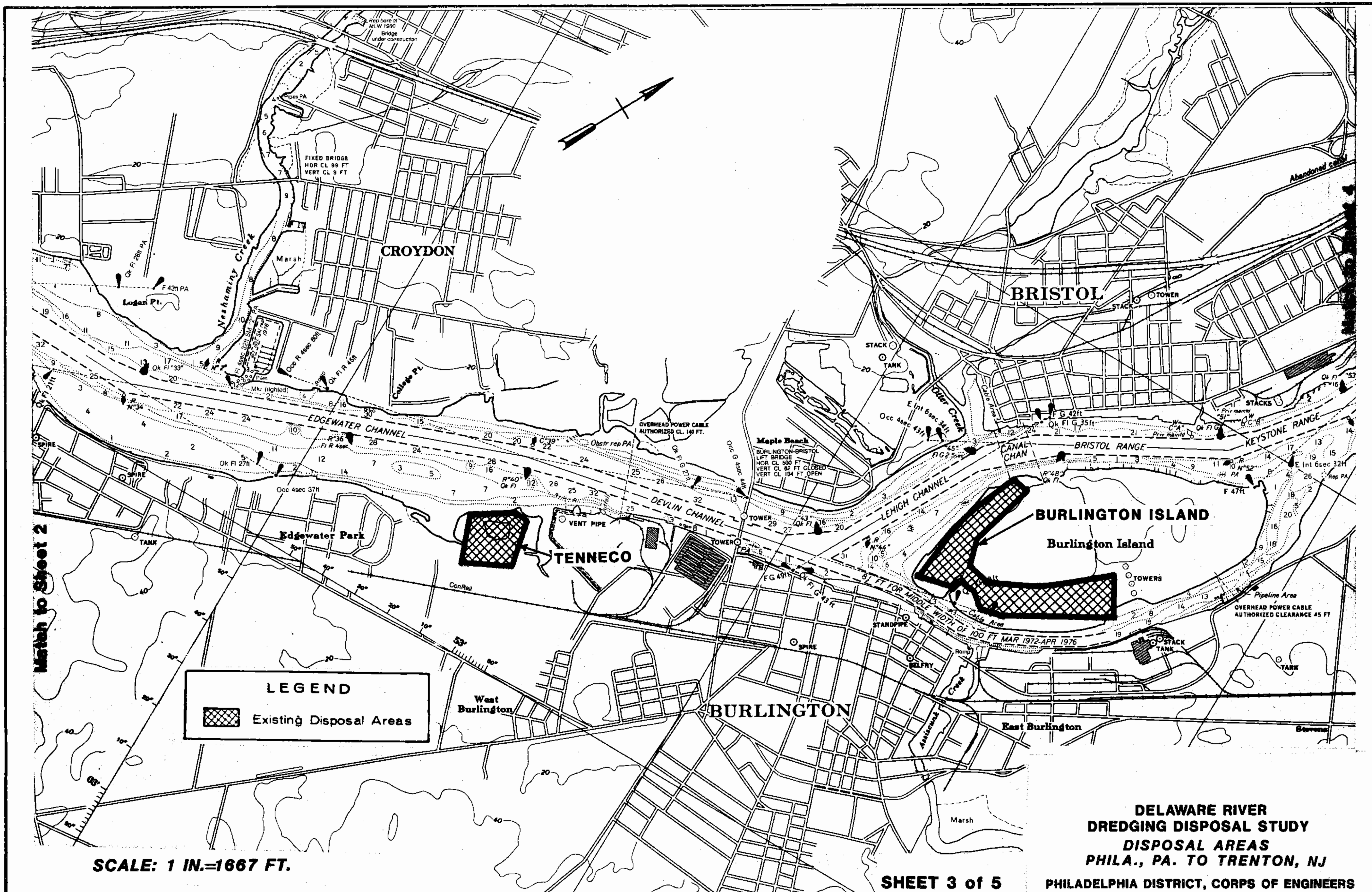
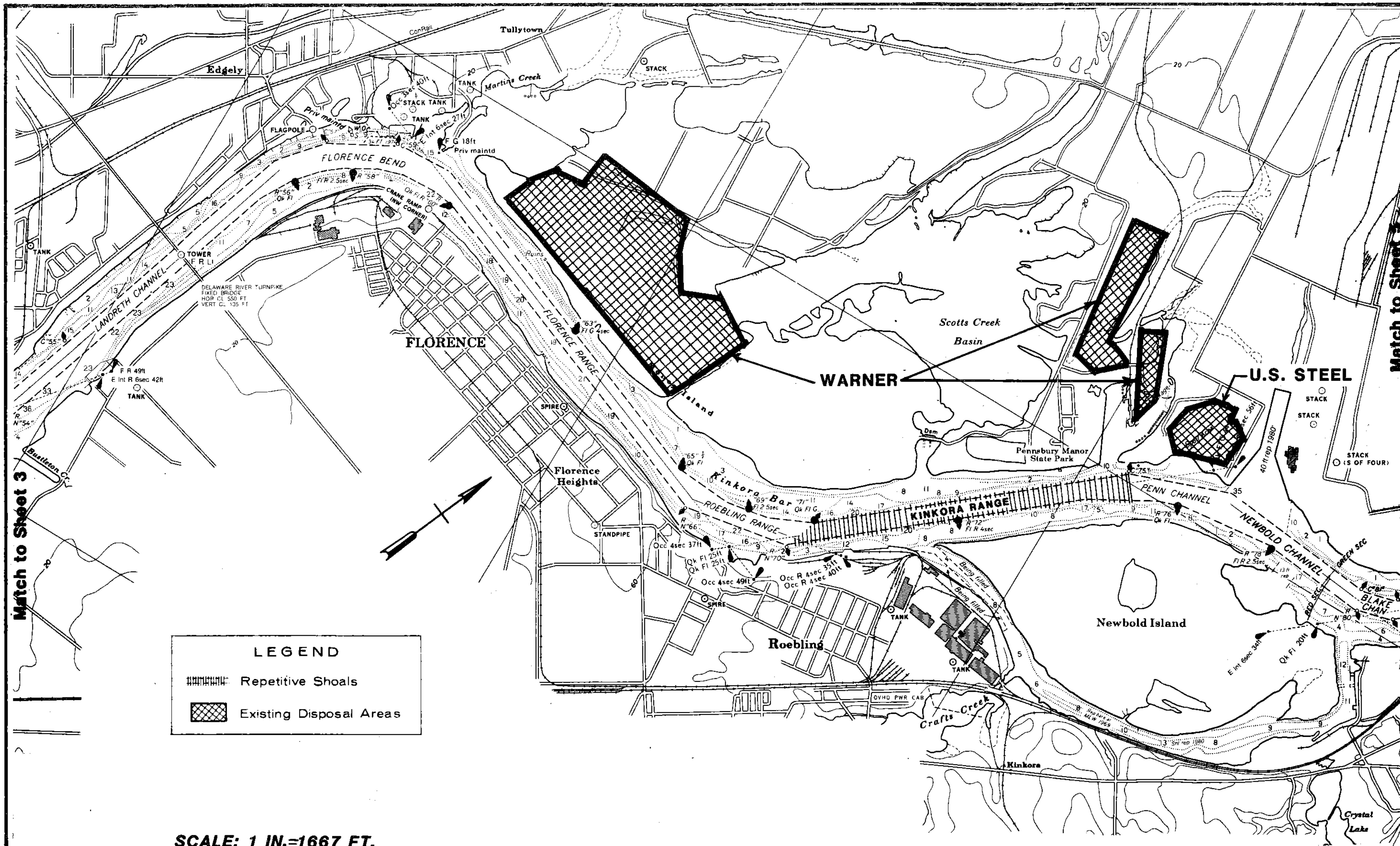

CROYDON
BRISTOL
BURLINGTON ISLAND
Burlington Island
TENNECO
BURLINGTON
West Burlington
East Burlington
Edgewater Park
Logan Pt.
College Pt.
Maple Beach
Neshaminy Creek
EDGEWATER CHANNEL
DEVLIN CHANNEL
LEHIGH CHANNEL
BRISTOL RANGE
KEYSTONE RANGE
CANAL CHAN
FIXED BRIDGE HOR CL 99 FT VERT CL 9 FT
OVERHEAD POWER CABLE AUTHORIZED CL. 140 FT.
BURLINGTON-BRISTOL LIFT BRIDGE HOR CL 500 FT VERT CL 62 FT CLOSED VERT CL 134 FT OPEN
OVERHEAD POWER CABLE AUTHORIZED CLEARANCE 45 FT
40 FT FOR MIDDLE WIDTH OF 100 FT MAR 1972-APR 1976
Match to Sheet 2
Match to Sheet 4
LEGEND
Existing Disposal Areas
SCALE: 1 IN.=1667 FT.
SHEET 3 of 5
DELAWARE RIVER
DREDGING DISPOSAL STUDY
DISPOSAL AREAS
PHILA., PA. TO TRENTON, NJ
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

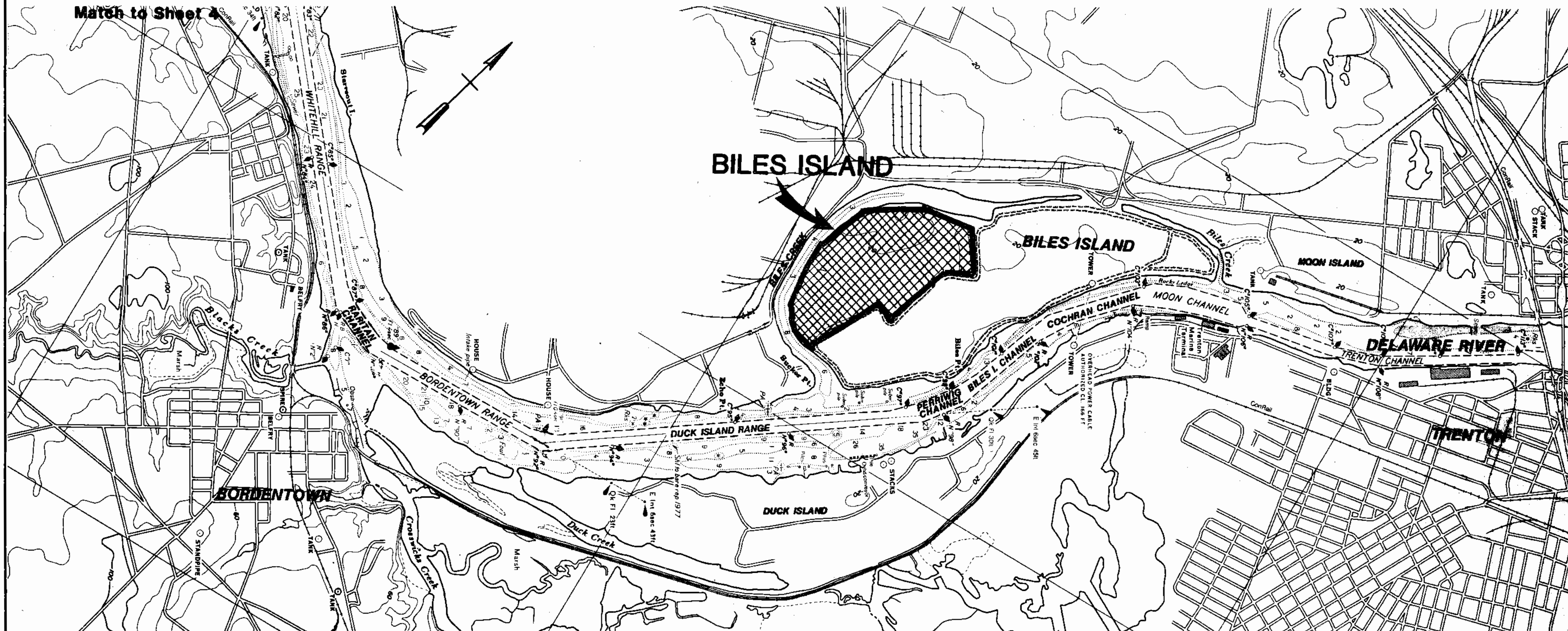
FIGURE 14



DELAWARE RIVER
DREDGING DISPOSAL STUDY
SHOALS AND DISPOSAL AREAS
PHILA., PA. TO TRENTON, NJ

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 15



SCALE: 1 IN.=1667 FT.

LEGEND
Existing Disposal Areas

DELAWARE RIVER
DREDGING DISPOSAL STUDY
DISPOSAL AREAS
PHILA., PA. TO TRENTON, NJ

SHEET 5 of 5

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 16

TABLE 14

REMAINING CAPACITY OF
DISPOSAL AREAS
PHILADELPHIA TO TRENTON PROJECT

DISPOSAL AREA	BANKED ACRES	LEASE CONSTRAINT TIME LIMIT	FILL HEIGHT LIMIT (ft.)	ESTIMATED REMAINING CAPACITY (CY) TO MAXIMUM ELEVATION (a) AS OF 1980
Delair	71	1984	21	4,067,000 to El. 50
Palmyra	163	1984	25	8,810,000 to El. 50
Hawk Island	20	1984	25	1,068,000 to El. 50
Beverly	23	1984	35	870,000 to El. 50
Tenneco	33	1983	25	1,969,000 to El. 50
Burlington Island	71	1984	35	2,370,000 to El. 50
Warner	234	1983	20	2,766,000 to El. 25
Warner	54	1983	30	551,000 to El. 30
Warner	15	1983	25	345,000 to El. 25
U.S. Steel	51	1986	20	400,000 to El. 20
Biles Island	156	1986	20	10,491,000 to El. 50
Amerada-Hess (b)	80	-	20	3,750,000 to El. 20

(a) Corps of Engineers, Philadelphia to Trenton Datum
(b) This site for private use only

POTENTIAL NEW PROJECTS. Tioga Marine Terminal is the only potential new project in the vicinity of the Philadelphia to Trenton project. A 1975 study identified the need for a 36 foot deep channel and turning basin to provide access to the terminal (see Figure 17). This study estimated that approximately 230,000 cubic yards of material would be removed initially for this project and about 102,000 cubic yards annually to maintain the 36' depth. Recent soundings, however, show only spot shoaling has taken place and minimal dredging is required to reach the authorized level. The Comprehensive Navigation Study will evaluate the potential of increasing the project depth to as great as 40 feet. Assuming a depth of 40 feet, initial construction would involve removing 500,000 cubic yards of material. Maintenance dredging for this depth would amount to about 8,300 cubic yards annually.

AUTHORIZED. The authorized work remaining to be done in the Philadelphia to Trenton project is the 35 foot deep channel from Newbold Island to the Trenton Marine Terminal and widening of the turning basin at the terminal. This construction would reduce tidal delays and the need for lightloading barge shipments to the Public Service Electric and Gas Company's Mercer Generating Station at Duck Island. It would also allow larger vessels to use the Trenton Marine Terminal. An estimated 6,200,000 cubic yards initially and 518,000 annually must be removed to construct and maintain the authorized dimensions of the channel and turning basin. This project has not been constructed due to lack of local support. Also, a 12 foot deep channel extending from the Trenton Marine Terminal upstream to Trenton is not maintained to the authorized dimensions. An initial dredging of 32,000 cubic yards is required to construct the channel, with minimal maintenance.

NON-FEDERAL DREDGING. The private sector removes an additional 171,000 cubic yards of material annually in the vicinity of this project, using both bucket and hydraulic pipeline dredges in a manner similar to the Non-Federal dredging for the Philadelphia to the Sea project. White's Basin has sufficient

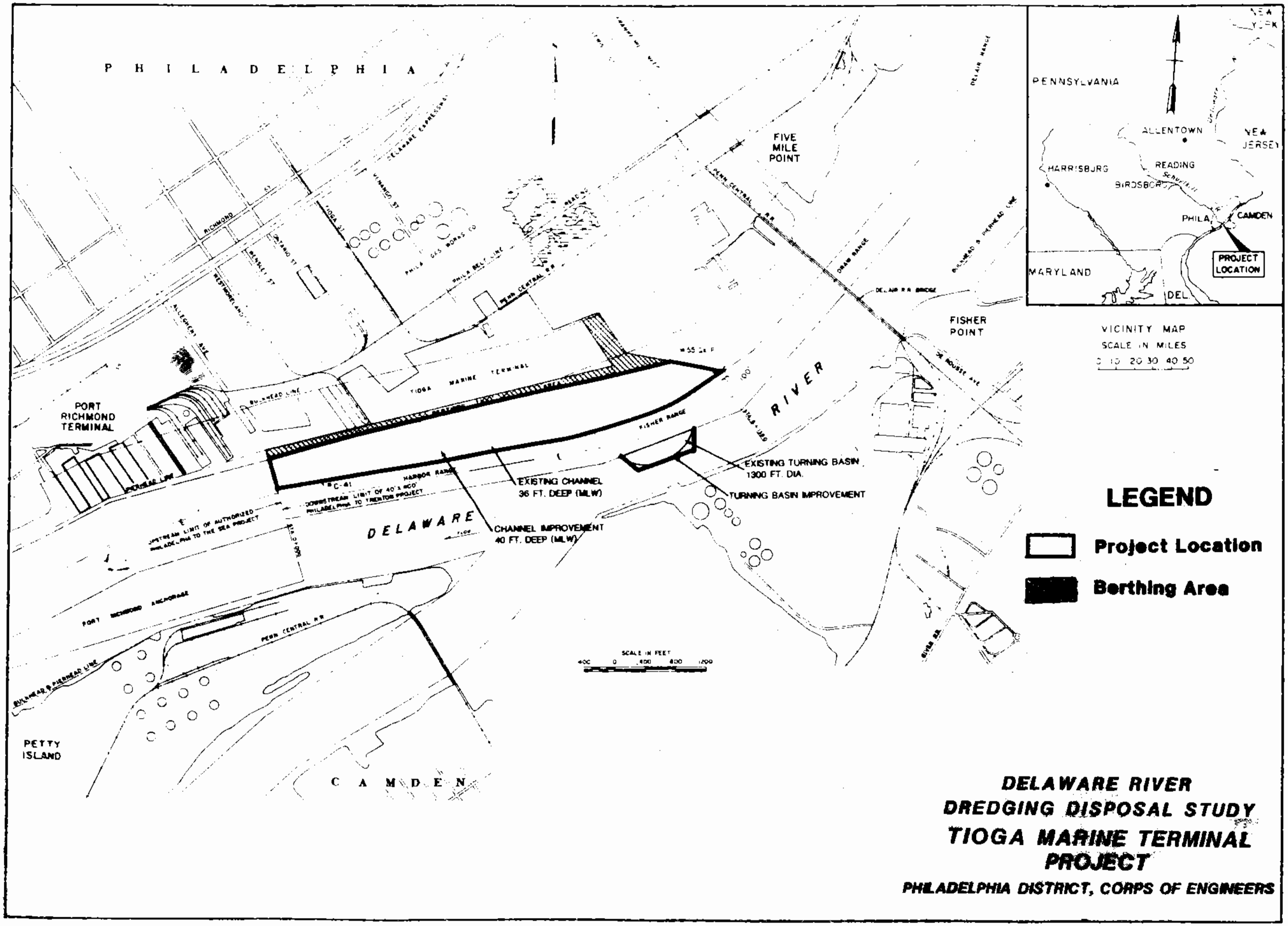

PHILADELPHIA
FIVE MILE POINT
FISHER POINT
PORT RICHMOND TERMINAL
TIOGA MARINE TERMINAL
DELAWARE RIVER
CAMDEN
PETTY ISLAND
EXISTING TURNING BASIN 1300 FT. DIA.
TURNING BASIN IMPROVEMENT
EXISTING CHANNEL 36 FT. DEEP (MLW)
CHANNEL IMPROVEMENT 40 FT. DEEP (MLW)
FISHER RANGE
HARBOR RANGE
PORT RICHMOND ANCHORAGE
PENN CENTRAL R.R.
DEL. AIR R.R. BRIDGE
ALLEGHENY AVE
TIOGA ST
VENANGO ST
RICHMOND
SCALE IN FEET
PENNSYLVANIA
NEW YORK
NEW JERSEY
ALLENTOWN
READING
HARRISBURG
BIRDSBORO
PHILA
CAMDEN
MARYLAND
DEL
PROJECT LOCATION
VICINITY MAP
SCALE IN MILES
0 10 20 30 40 50
LEGEND
Project Location
Berthing Area
DELAWARE RIVER
DREDGING DISPOSAL STUDY
TIOGA MARINE TERMINAL PROJECT
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 17

capacity for the 50 year period of this study for the 60,000 cubic yards removed each year by bucket dredges. The hydraulically dredged material, about 110,000 cubic yards annually, is disposed of in the Amerada-Hess and U.S. Steel sites (see Figure 12,15). The U.S. Steel site is also leased to the State for Federal use. These sites have about 4.2 million cubic yards of remaining capacity. This capacity is not sufficient to meet the 50 year need.

WILMINGTON HARBOR PROJECT

HISTORIC. Approximately 1.1 million cubic yards of material are removed annually from the Christina River by the Corps of Engineers in order to maintain depths necessary for ships using the Wilmington Marine Terminal. The Marine Terminal at the confluence of the Christina and Delaware Rivers is operated by the City of Wilmington. This dredging is performed by contracted hydraulic dredges and pumped to one of two upland confined disposal areas located on Cherry Island. The two Corps maintained areas, Wilmington Harbor and Edgemoor, are used on an alternating basis with each site normally being used for two consecutive years before a switch is made to the other site (see Figure 18). This allows time for drying and consolidation of material and to increase the height of embankments. Portions of these two areas are government owned and the balance is leased. The worst case condition assumed that the current lease constraints are imposed. As such, the remaining disposal capacity amounts to only 8,300,000 cubic yards.

For the most probable case the Wilmington Harbor and Edgemoor sites would be used until an elevation of +52 (Corps of Engineers, Christina River Datum) is reached. Once the elevation of +52 is reached, the sites will be combined as one to allow the deposition of dredged material to a final elevation of +70. The remaining capacity for the above conditions is 13,500,000 cubic yards.

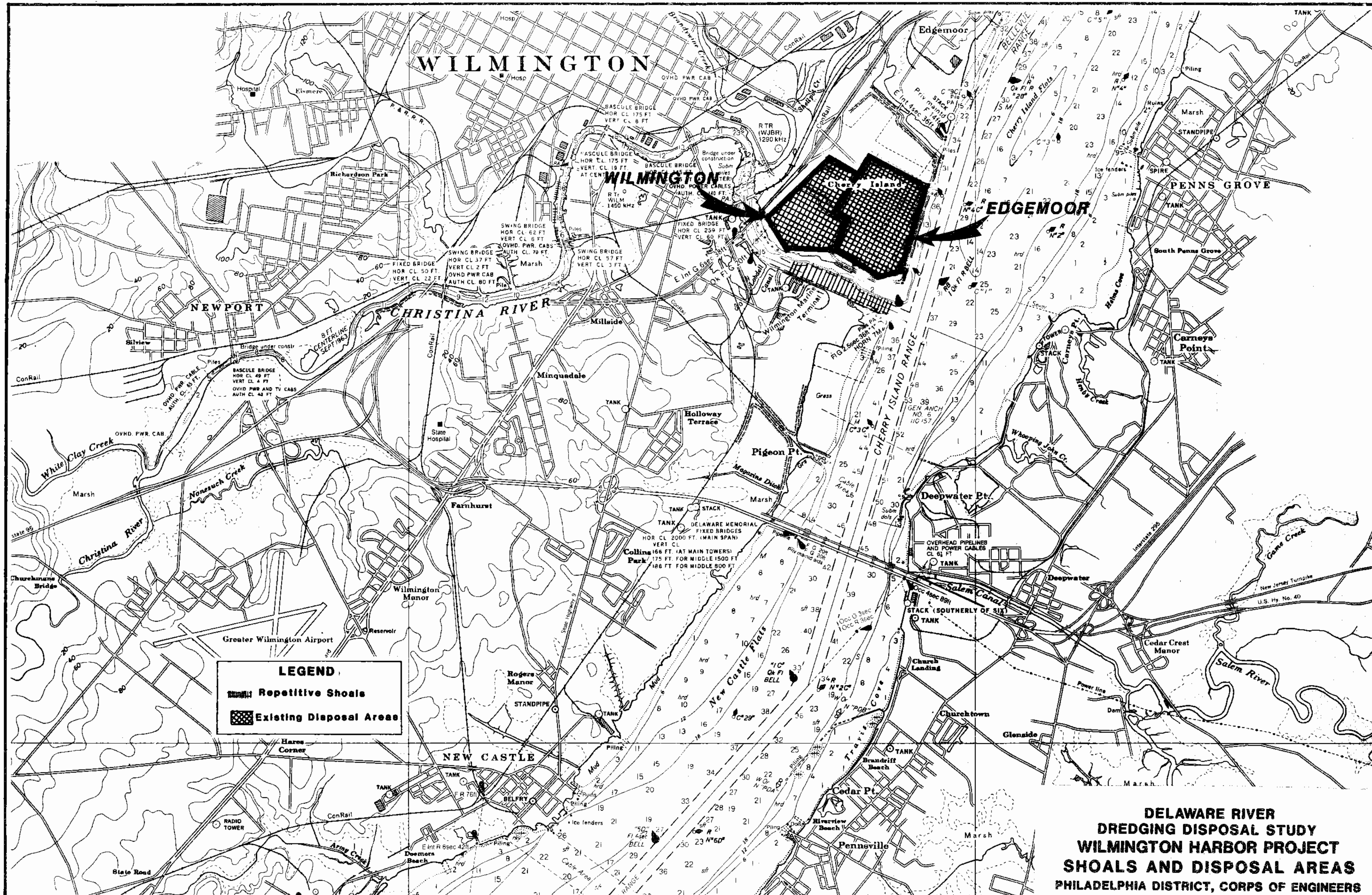

DELAWARE RIVER
DREDGING DISPOSAL STUDY
WILMINGTON HARBOR PROJECT
SHOALS AND DISPOSAL AREAS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
LEGEND
Repetitive Shoals
Existing Disposal Areas
WILMINGTON
EDGEMOOR
Cherry Island
CHRISTINA RIVER
NEWPORT
PENNS GROVE
Carneys Point
Deepwater Pt.
Pigeon Pt.
NEW CASTLE
Cedar Pt.
Pennsville
Salem Canal
Salem River
CHERRY ISLAND RANGE
New Castle Flats
Greater Wilmington Airport
Minquadale
Holloway Terrace
Farnhurst
Wilmington Manor
Rogers Manor
Collins Park
Richardson Park
Edgemoor
Deepwater
Churchtown
Cedar Crest Manor
Deemers Beach
Hares Corner
DELAWARE MEMORIAL FIXED BRIDGES

FIGURE 18

AUTHORIZED. Although there are no anticipated potential new projects, several upstream reaches in the Christina River have been authorized for dredging but have never been constructed. The total length of the reaches is over 8.5 miles and the authorized depths range from 7 to 21 feet. An estimated 887,000 cubic yards of material would be removed initally and about 89,000 annually to reach and maintain these authorized depths.

NON-FEDERAL DREDGING. The City of Wilmington dredges 67,000 cubic yards of material annually between the Federal channel and their docking facilities. This dredging, like the Federal work, is performed by hydraulic pipeline dredges and the material is pumped to the disposal areas on the Federal sites at Cherry Island. The City pays the Corps a fee for use of the Federal disposal areas.

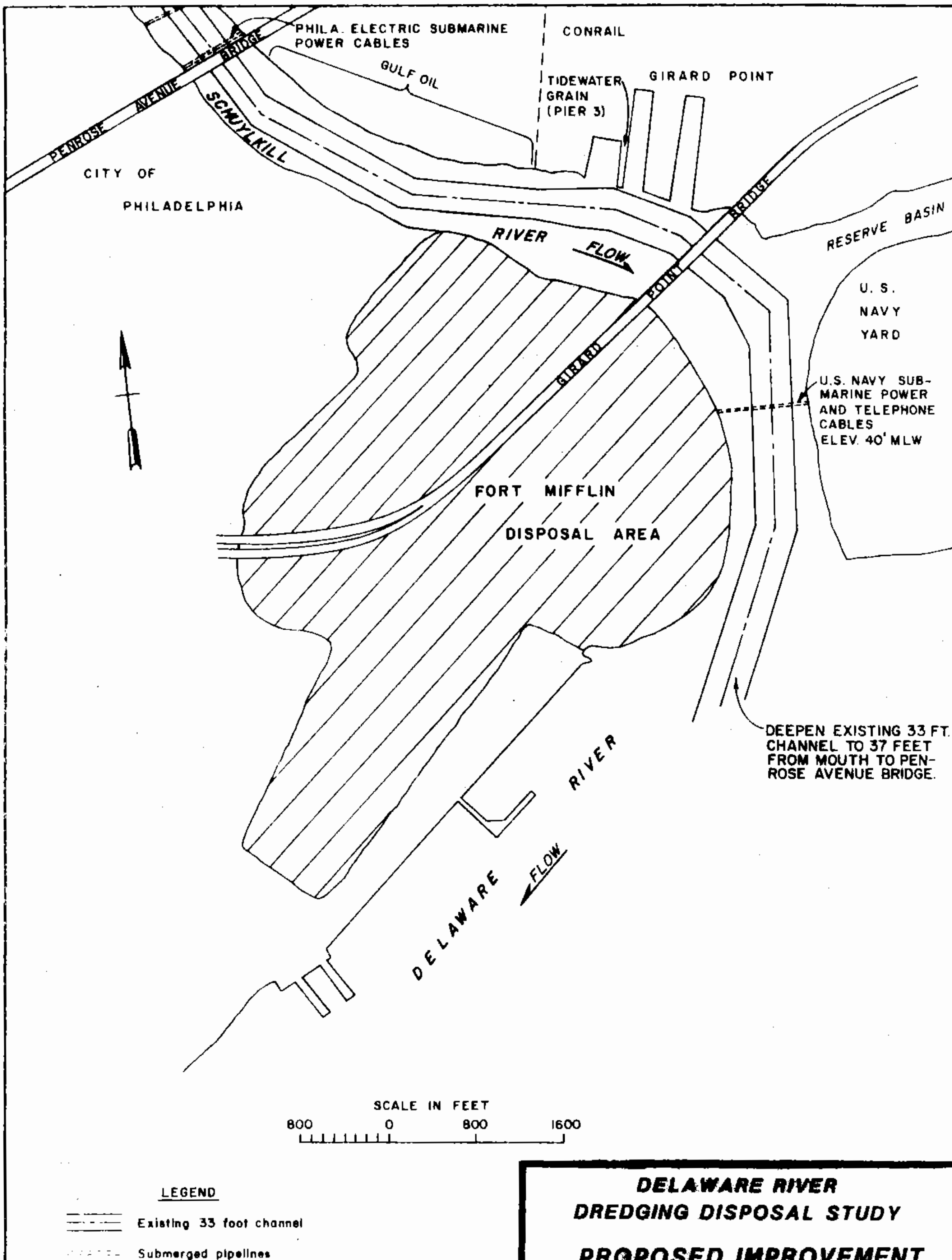
SCHUYLKILL RIVER PROJECT

HISTORIC. Maintenance dredging of the Schuylkill River is limited to the navigation channel from the Delaware River to Gibson Point in Philadelphia. The lower portion of the project, from the Delaware River to Passyunk Avenue, is dredged by contracted hydraulic pipeline dredge to a depth of 33 feet. Approximately 220,000 cubic yards of material are excavated annually to maintain this channel and deposited in the Fort Mifflin disposal area (see Figure 10). The remaining capacity (as of 1980, to 50 foot elevation) of this site is about 13 million cubic yards.

The upper reach of the dredged channel (Passyunk Avenue to Gibson Point) is maintained to a depth of 26 feet. The dredged material, which totals approximately 90,000 cubic yards annually, is removed by contracted bucket-type dredges. This material is placed into scows, deposited into a rehandling basin and then pumped to the National Park disposal area. Since this site is also used for the Philadelphia to the Sea project, the disposal requirements for this reach are included in that project.

POTENTIAL NEW PROJECTS. The Comprehensive Navigation Study is considering deepening part of the lower section of the project to 37 feet. A deeper channel from the Delaware River to Penrose Avenue would help to alleviate tidal delays currently being experienced and reduce the need to light load (see Figure 19). It would also allow shippers to use larger vessels and provide transportation savings. To deepen this project to 37 feet, about 500,000 cubic yards would be dredged initially with an additional 40,000 cubic yards required for annual maintenance.

AUTHORIZED WORK. The reach of the project between Gibson Point to University Avenue is authorized to a depth of 22 feet. This channel, however, has not been dredged since 1962 and is currently close to natural depth. The deepest barges in operation on this reach have 17 foot drafts. To reach authorized dimensions, about 250,000 cubic yards of material would have to be removed with the estimated annual maintenance being 86,000 cubic yards.



DELAWARE RIVER
DREDGING DISPOSAL STUDY

PROPOSED IMPROVEMENT
SCHUYLKILL RIVER

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 19

NON-FEDERAL DREDGING. In order to provide access to the Schuylkill project, the Non-Federal sector removes approximately 281,000 cubic yards annually by bucket dredge. All of this material is transported to White's Basin.

SHALLOW DRAFT PROJECTS

There are 17 active federal shallow draft projects in the study area. Most of the projects provide channels for recreational vessels. Disposal needs for the shallow draft projects were determined for two conditions, the worst case and most probable case using similar assumptions to that used for the deep-draft projects. The worst case condition considered both historic and authorized dredging where applicable (see Table 15) with minimal site management. The most probable condition considered only the historic dredging level with disposal site management. Table 15 lists the projects considered and their level of dredging.

HISTORIC. The total volume of material currently being removed from these projects collectively during a typical year is 210,000 cubic yards. Table 16 shows a breakdown of dredging rates for the four largest historically maintained projects which represent more than half of the total volume dredged annually. The majority of the dredging from shallow draft projects is accomplished using hydraulic dredges. The dredged material is disposed in upland sites or in open water in the vicinity of the project. Table 15 shows the party responsible for supplying the disposal area as defined in the project authorization. In the absence of a specific reference in the document, the federal government has assumed the responsibility for providing the site.

TABLE 15

SHALLOW DRAFT PROJECTS
LEVEL OF DREDGING
AND DISPOSAL RESPONSIBILITIES

PROJECT	LEVEL OF DREDGING	RESPONSIBILITY FOR DISPOSAL SITES
Big Timber Creek	Historic	Non-Federal
Broadkill River	Historic	None Stated*
Cohansey River	Historic	Non-Federal
Cooper River	Historic and Authorized	None Stated
Harbor of Refuge	Historic and Authorized	None Stated
Indian River Inlet and Bay	Historic and Authorized	Non-Federal
Inland Waterway, Rehoboth Bay to Delaware Bay (Lewes and Rehoboth Canal)	Historic	Non-Federal
Mantua Creek	Historic	Non-Federal
Maurice River	Historic and Authorized	None Stated
Mispillion River	Historic and Authorized	Non-Federal
Murderkill River	Historic and Authorized	None Stated
Neshaminy State Park Harbor	Historic	Non-Federal
Pepper Creek	Historic and Authorized	Non-Federal
Raccoon River	Historic	None Stated
Salem River	Historic and Authorized	None Stated
St. Jones River	Historic	Non-Federal
Waterway from Indian River Inlet to Rehoboth Bay	Historic	Non-Federal

* None Stated-Federal Government has assumed responsibility.

TABLE 16
SHALLOW DRAFT PROJECTS
HISTORIC DREDGING QUANTITIES (CY/YR)

PROJECT	FEDERAL	NON-FEDERAL
FOUR LARGEST PROJECTS (based on dredged volumes)		
HARBOR OF REFUGE, DE	43,000	0
LEWES TO REHOBOTH CANAL, DE	26,000	6,000
COHANSEY RIVER, NJ	26,000	0
INDIAN RIVER & BAY, DE	22,000	3,000
TOTAL	117,000	9,000

POTENTIAL NEW PROJECTS. The only potential new shallow draft project foreseen is the Petty Island Back Channel. This project would modify the presently authorized channel dimension of 70 feet wide and 12 feet deep to 150 feet wide and 18 feet deep (see Figure 20). A draft detailed project report was completed in March 1983 recommending the modified dimensions, and construction is tentatively planned for FY 85. The report recommended a local site (the Harrison Avenue disposal area which is owned by the project sponsor) as the potential disposal area for the life of the project. Since this site will be used exclusively for this project, both the site and the disposal needs were excluded from this analysis.

AUTHORIZED. In some of the projects the historically maintained level of dredging is less than that authorized (see Table 17). To reach authorized levels, a total of approximately 4 million cubic yards of material would have to be excavated initially. The increased annual maintenance would amount to 420,000 cubic yards. Table 16 gives the dredging volumes for the four largest projects, including authorized and historic maintenance.

TABLE 17

AUTHORIZED DREDGING VOLUMES
FOUR LARGEST SHALLOW DRAFT PROJECTS*
(CY)

PROJECT	INITIAL	MAINTENANCE
Harbor of Refuge	877,000	101,000
Indian River and Bay	620,000	46,000
Cohansey River	416,000	42,000
Maurice River	411,000	41,000
TOTAL	2,324,000	230,000

* based on dredge volumes

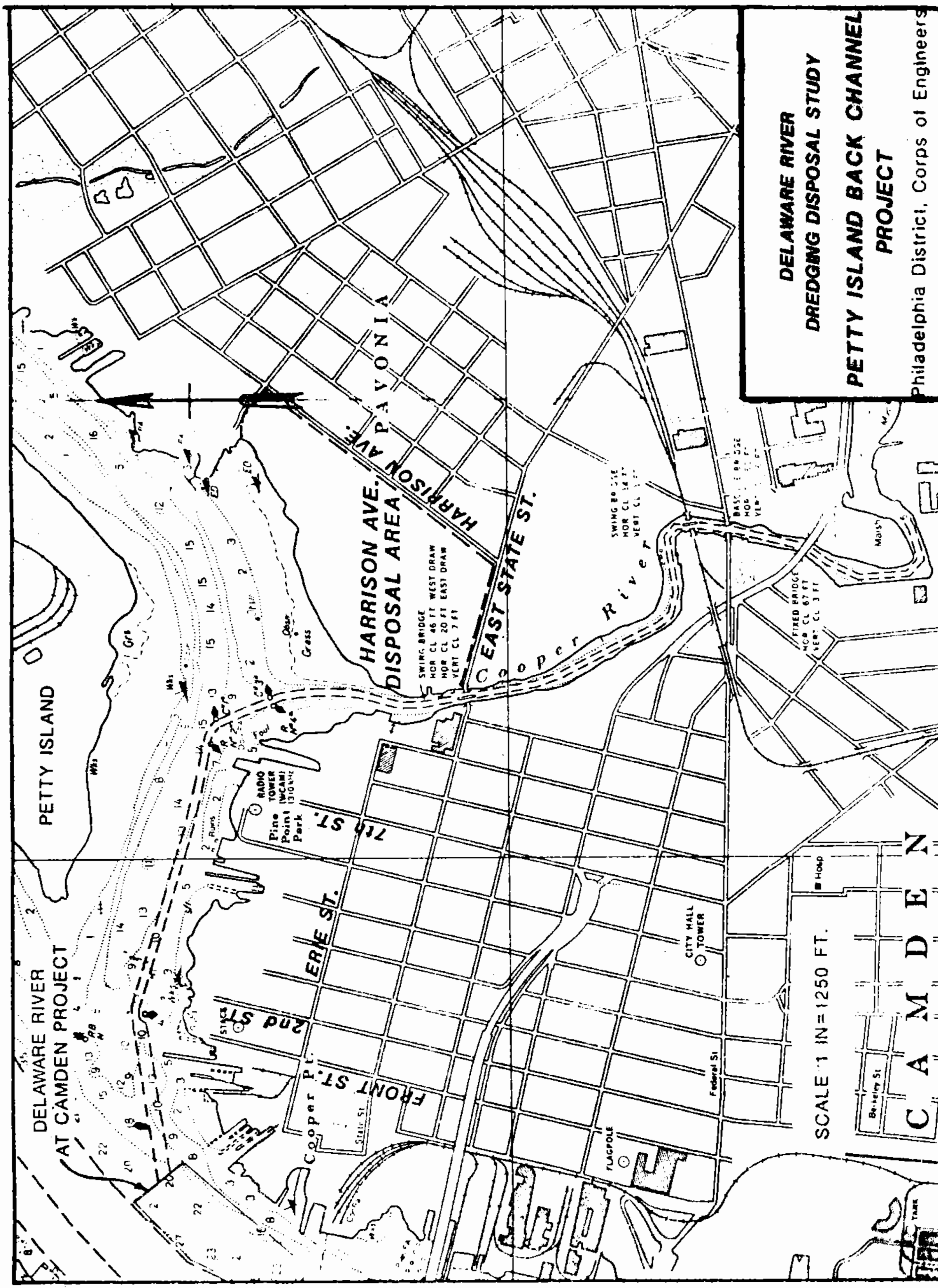

DELAWARE RIVER
DREDGING DISPOSAL STUDY
PETTY ISLAND BACK CHANNEL PROJECT
Philadelphia District, Corps of Engineers
PETTY ISLAND
DELAWARE RIVER AT CAMDEN PROJECT
HARRISON AVE. DISPOSAL AREA
HARRISON AVE.
PAVONIA
EAST STATE ST.
Cooper River
SWING BRIDGE HOR CL 46 FT WEST DRAW HOR CL 20 FT EAST DRAW VERT CL 7 FT
ERIE ST.
7th ST.
2nd ST.
FRONT ST.
RADIO TOWER
Pine Point Park
CITY HALL TOWER
FLAGPOLE
Cooper Pt.
Federal St
Berkeley St
SCALE 1 IN=1250 FT.
CAMDEN

FIGURE 20

NON-FEDERAL. Approximately 30,000 cubic yards per year is dredged by the States and marina owners to maintain access channels to the docking areas. The Lewes to Rehoboth Canal and Indian River and Bay projects account for 10,000 cubic yards, the balance is distributed among the remaining projects. The dredged material is usually placed on site.

SUMMARY OF DEFICITS

The following tables summarize the projected dredging requirements and disposal deficits for the two conditions over the 50 year study period. Deficits were estimated by considering the remaining capacity of existing sites (governed by lease (time or elevation limitation) or technical elevation).

TABLE 18

WORST CASE CONDITION
SUMMARY OF FIFTY YEAR DEFICITS
(Millon Cubic Yards)

	DREDGING REQUIREMENTS				
	HISTORIC	POTENTIAL NEW PROJECTS	AUTHORIZED	NON-FEDERAL	DISPOSAL AREA DEFICITS
Philadelphia to the Sea, including Delaware River at Camden, NJ	303.5	1.2	31.6	125.7	204.0
Philadelphia to Trenton	27.5	0.9	26.9	8.6	53.0
Wilmington Harbor	51.6	-	4.5	3.4	51.2
Schuylkill River	11.0	2.1	3.7	14.1	2.8
Shallow Draft Projects	10.5	-	20.8	1.5	24.0
TOTAL	404.1	4.2	87.5	153.3	335.0

TABLE 19

MOST PROBABLE CASE CONDITION
SUMMARY OF FIFTY YEAR DEFICITS
(Million Cubic Yards)

	DREDGING REQUIREMENTS			
	HISTORIC	POTENTIAL NEW PROJECTS	NON-FEDERAL	DISPOSAL AREA DEFICITS**
Philadelphia to the Sea including Delaware River at Camden, NJ	303.5	0.8*	125.7	62.0
Philadelphia to Trenton	27.5	0.9	8.6	2.3
Wilmington Harbor	51.6	-	3.4	14.0
Schuylkill River	11.0	2.1	14.1	None
Shallow Draft Projects	10.5	-	1.5	None
TOTAL	404.1	3.8	153.3	78.3

* Excludes the deepening of the Delaware River at Camden to 40'.
** Calculated based on appropriate wet/dry ratios

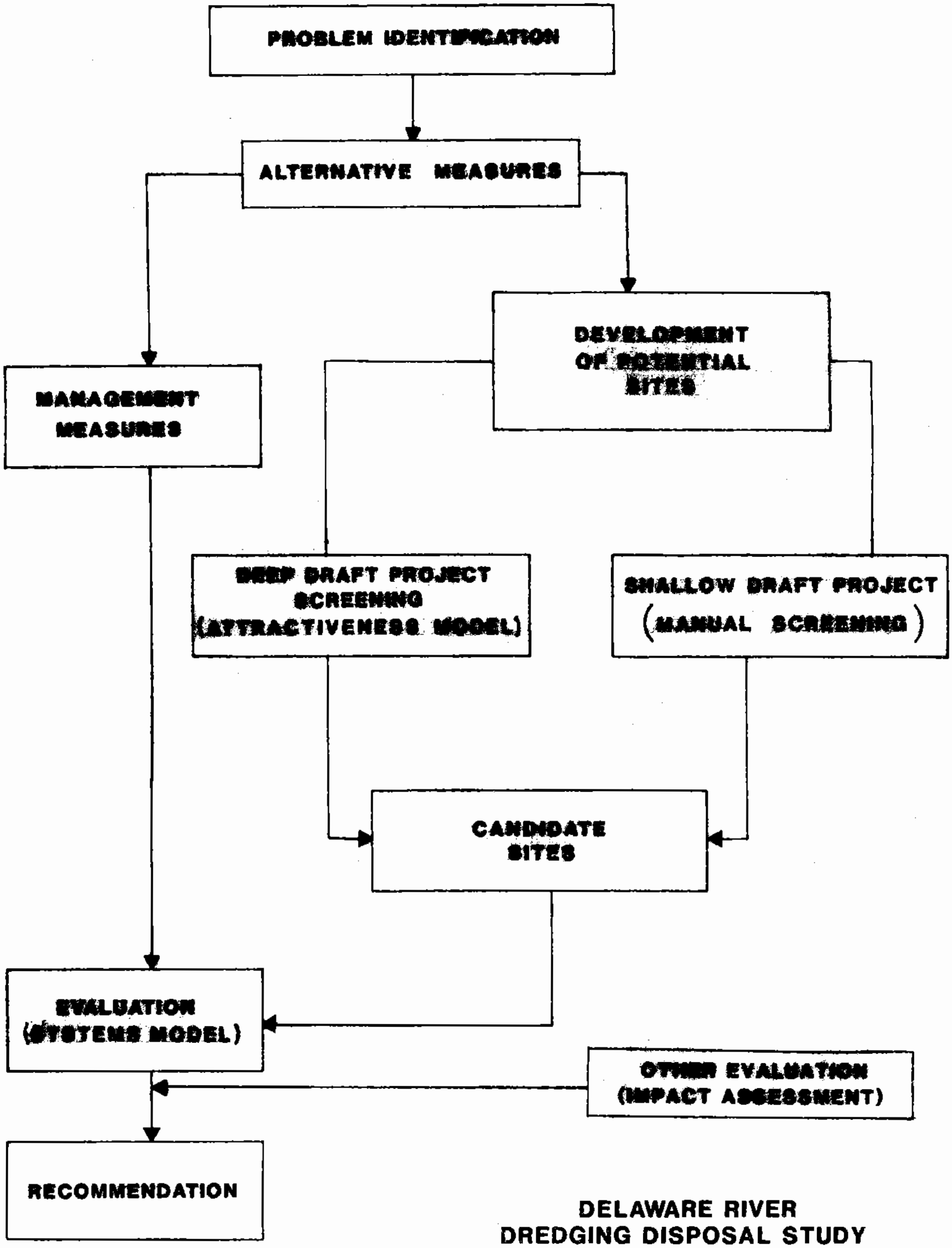
PLAN FORMULATION

INTRODUCTION

The sequence diagram shown in Figure 21, represents the formulation steps that were conducted as part of this study. The first step, Problem Identification, has been described in the previous section of the Report and presents the dredging requirements, available disposal capacities, and the deficits by project. The balance of the diagram represents those steps taken to determine the best way to resolve these deficits.

Those alternative measures described in the Reconnaissance Report were assessed to determine which offered the most potential to resolve the deficits both over the short term, defined as 10 years, and a long term period, defined as 50 years. The results of this assessment were coordinated with interested agencies through the Plan Formulation Committee and the Waterways Experiment Station (WES) to insure that all reasonable alternatives were evaluated.

Those alternative measures that emerged from this analysis were grouped into two general categories, management measures and development of potential sites. Under management measures, those methods that would extend the useful life of an existing disposal site were considered. The other category, development of potential sites, involved the selection of suitable sites for the disposal of dredged material. The selection process would have to satisfy a broad range of criteria if it were to result in sites that were technically feasible, cost-effective, and environmentally sound. The task of meeting these criteria is challenging since in some cases, they tend to be diametrically opposed.



DELAWARE RIVER
DREDGING DISPOSAL STUDY

SEQUENCE DIAGRAM

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 21

The problem of disposing of dredged material means different things to different people. To those who are responsible for dredging and disposal of dredged materials, the solution(s) must be feasible, cost-effective, environmentally sound, in accordance with regulations, and be implementable. To the water-borne commerce community, dredging of the Delaware River and the subsequent disposal of the dredged material is an absolute necessity. The process must occur whenever and wherever necessary in order to maintain or improve navigation in the river and provide for the uninterrupted flow of river traffic. To the environmental community and others not immediately dependent upon water-borne commerce, the problem of disposing of dredged material must still be solved, but, in terms that are environmentally and institutionally acceptable. Consequently, because of these sometimes opposing viewpoints, tradeoffs are necessary in coming up with an overall site selection plan.

In order to quantify the relative merits of various potential plans so that the tradeoffs could be displayed a methodology had to be developed that was objective in its approach and uniform in its application. Further, to meet changing needs over time, the methodology would have to be dynamic, and to meet regional objectives, it would have to be comprehensive enough to handle large volumes of diverse data over a large geographic area. To meet these objectives a computerized technique, Spatial Analysis Methodology (SAM), was selected as a means for considering the major portion of the site suitability screening phase of this study. SAM technology has been applied and tested in over thirty-five studies and investigations throughout the Corps. Its use for site-suitability screening for the selection of dredged material disposal sites was felt to be an innovative yet practical application of available computer modeling capabilities to traditional problem solving. Because SAM is computer based, it can support a systematic and objective approach to siting potential disposal areas with uniform application of criteria over the study area.

Computerization also allows for the storage and analysis of large volumes of data. This analysis, once computerized, can be performed quickly, consistently, and efficiently. The ability of the computer to perform repetitive or interactive analyses provides a superior tool for assessing potential impacts and determining the impact of any particular selection choice. This technique was used for screening of potential sites for the deep draft projects. A similar approach was applied manually for the small shallow draft projects as the individual needs were relatively small and diversified.

As part of the analysis, various scenarios ranging from a pro-dredging to a pro-environmental viewpoint were developed. The model output represented a list of potential candidate sites for each scenario. These sites were further screened for linear features (such as roads and streams) which are not easily adapted to the model.

A second mathematical model, the systems model, was used both to evaluate management measures and to refine the optimum sites within each particular scenario. This model determines the least costly plan for transporting material from a particular dredging site to an existing or potential disposal site. However, since this optimization was done for each scenario, the intent of that scenario, whether it was pro-dredging or pro-environmental, was preserved. The systems model output provides an optimal list of sites, the volume of material disposed, the overall cost for the optimum plan, and indicates when each site should be acquired. Numerous runs were made for each condition, scenario, and project. Other related factors (such as environmental and social aspects) were also considered for each plan as part of the impact assessment. The ultimate recommendation considered the relative costs and other related factors for each of the plans, as well as the views of the Plan Formulation Committee.

MANAGEMENT MEASURES

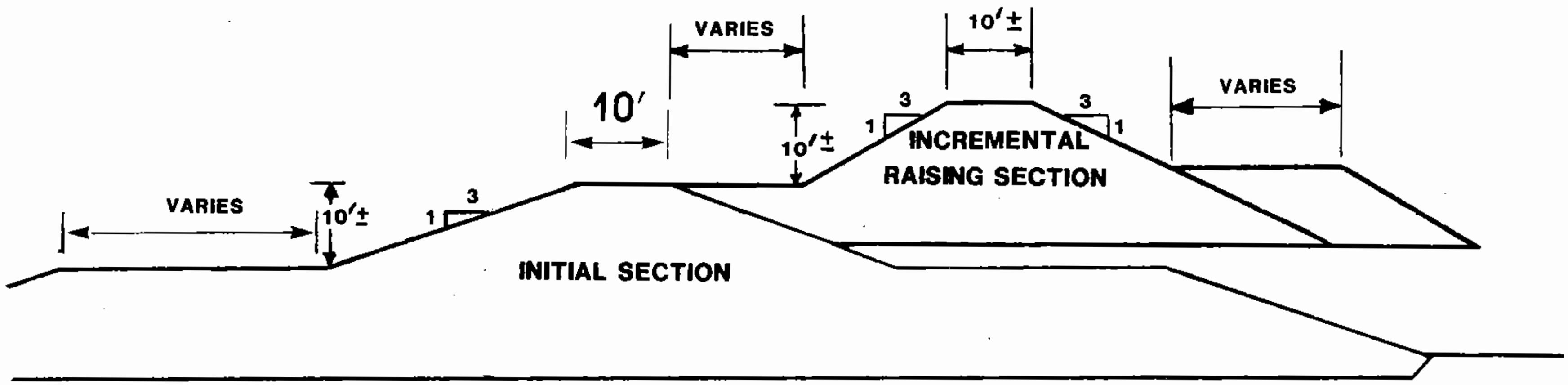
Each of the measures considered was screened to identify those that had the greatest potential to satisfy the disposal needs. Those demonstrating potential were evaluated further. The following is a discussion of the results of that screening.

DEWATERING OF DREDGED MATERIAL. Dewatering dredged material is a common practice that is employed to increase the useful life of an existing 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, particularly for those sites associated with the Wilmington Harbor project where capacity is at a premium. Both methods appear to be cost effective and have been incorporated into the mathematical systems model. Other more complex methods exist, such as those involving under-drainage systems and vacuum pumping. However, these methods are extremely costly and consequently were not considered further in this study.

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 is currently in use. 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 ratios used for the most probable case reflect the impact of this new equipment on a project by project basis.

INCREASED HEIGHT OF CONTAINMENT DIKES. Deep-Draft Projects. 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. This concept is shown on Figure 22. 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, 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 50 feet above original ground. In specific instances, elevations up to 70 feet above original ground are considered appropriate.

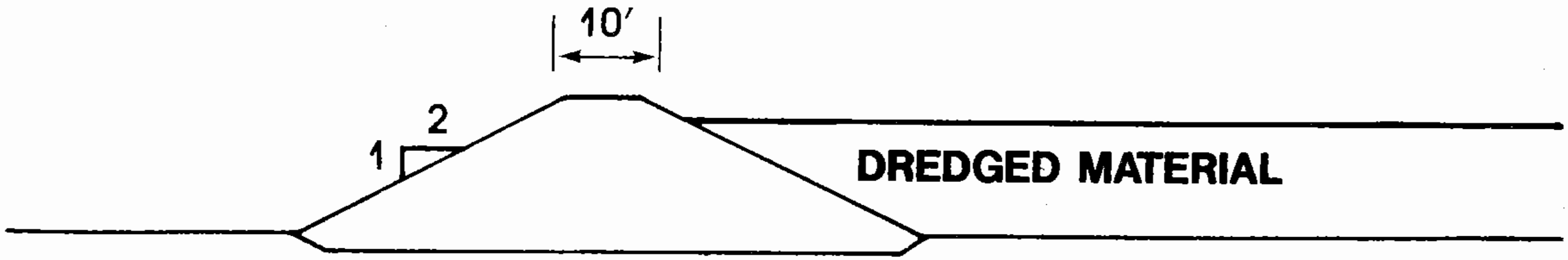
Shallow Draft Projects. In the case of shallow draft projects, the dredging volumes are considerably less than deep-draft projects, and the projects are spread out, requiring smaller dredges and disposal sites. Historically, disposal sites are usually 25 acres or less. Because of the relatively small size, the maximum practical height is generally 15 feet above existing ground elevation (see Figure 23).



Note: Berm widths and overall configuration shown are typical but will vary from site to site because of differences in dike foundation and dredged material characteristics

DELAWARE RIVER
DREDGING DISPOSAL STUDY
TYPICAL CONTAINMENT DIKE SECTION FOR DEEP DRAFT PROJECTS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 22



DELAWARE RIVER
DREDGING DISPOSAL STUDY
TYPICAL CONTAINMENT DIKE SECTION
FOR SHALLOW DRAFT PROJECTS

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 23

LEASE EXTENSION. In the Philadelphia to Trenton project and for some of the shallow draft projects, the disposal sites are provided by the project sponsor as an item of local cooperation. Most of the sites are leased from private owners often covering only a short period of time (such as a single dredging cycle). Usually, the leases are governed by either time duration or maximum filling elevation. Consideration of a longer period of time, based on the life of the project or the maximum dike elevation, are viable alternatives and will be considered, as appropriate. The two study conditions (the worst and most probable cases) bracket the range of impacts of extending leases on the disposal needs, with the worst case assuming current lease constraints and the most probable assuming site availability throughout the study period.

REUSE OF 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. Similar sales of existing foundation material have been made from newly acquired sites to increase potential storage capacity. Approximately 6 million cubic yards of material have been removed from disposal sites from 1972 through the present. 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 will be completed shortly 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 less than it has been in the recent past.

Beach Nourishment. Beach nourishment involves the deposition of suitable dredged materials onto beaches. The major source of available (sandy) material is from the dredging operations performed in the Philadelphia to Trenton project. However, the primary demand for this material is along the coastal beaches of New Jersey and Delaware. Transportation costs from the Philadelphia to Trenton project area to the coastal areas are prohibitive. As a result, this reuse alternative was not 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 and sanitary landfills.

- Abandoned Pits and Quarries - A survey was conducted to determine the potential future need for dredged material as fill for abandoned pits and quarries. The location and size of the pits and quarries were identified and one site was selected as "typical" for use in a cost analysis. Estimates of cost were developed for handling and transporting dredged material and compared to the costs of other methods of providing additional disposal area capacity. Evaluation of this method proved to be unjustified and this alternative was eliminated from further consideration.

- Strip Mines - Although there are no strip mines in the immediate vicinity of the study area, the concept was investigated in order to develop typical costs which would be associated with its use. The City of Philadelphia, presently using this method to dispose of sewage sludge, experience operating costs of $200 per dry ton ($220/cubic yard assuming 80 pounds per cubic foot). Assuming similar unit costs for dredged material, the cost of this method would be prohibitive.

- Sanitary Landfill - Use of dredged material in sanitary landfills to level the terrain or act as an impermeable cover has been performed on a small scale. Various State and local agencies were contacted to assess the potential future needs for dredged material. Those contacted indicated that the future need would be similar to that used in the past. 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. The volumes involved are believed to be insignificant compared to the overall volumes of dredged material.

Agricultural Soil Enrichment. The County agricultural agents were contacted for assistance in assessing the potential use of dredged material for soil enrichment. Information obtained indicated that most of the demand is for soil enrichment as a means of supplementing fertilizers. This need is being met by using sludge offered without charge from local sewage treatment plants. Thus, the marketability of the dredged material for agricultural use is hampered. Consequently, this alternative was not pursued any further.

Resource Recovery. Fine grained material contained in certain disposal areas in the Philadelphia to Trenton project can 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 considerations.

In summary, the Philadelphia District will monitor the changes in market trends and additional investigations will be made in the overall concept of dredged material reuse, if warranted. However, this concept in itself cannot be considered as a means of substantially reducing current and projected deficits.

REDUCED SHOALING BY USE OF DEPOSITION BASINS. 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. Based on reviews of the model studies, it was concluded that the historic shoaling pattern cannot be significantly altered by these measures. Therefore, further consideration is not warranted.

REDUCED SEDIMENT EROSION. Erosion control to reduce the sediment load carried by streams and rivers has been a continuous, long standing effort by the U.S. Department of Agriculture, Soil Conservation Service and other regional, State, and local organizations. Strict sediment control regulations are also in force for all construction activities. Check dams, sedimentation traps, vegetal cover on open lands, stream bank stabilization by revetment, vegetation or other bank stabilization controls, and other sedimentation control measures can be used. Additionally, erosion control of agricultural lands can be accomplished by terracing, contour plowing, strip cropping and similar techniques.

In view of the existing practices, enforcement of current erosion controls is encouraged and where appropriate, additional measures can be recommended. However, the current problem would not be reduced significantly by such actions, particularly over the near term future. This has been demonstrated by the fact that historical amounts have remained relatively stable over time despite changes in control measures. As a result, no further consideration of this alternative is warranted.

BETTER MANAGEMENT OF SITES. 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.

The District has kept abreast of efforts by others who are attempting to address similar problems. Both DMRP and DOTS have been particularly helpful in coordinating these endeavors. The costs of these measures have been incorporated into the systems model runs and have been reflected in the wet to dry ratio used in the most probable case condition. As a means of further considering this measure, the modeling tools developed as part of this study are being used to determine if further measures are warranted. The results of these efforts, which are being conducted separately from this study, will be incorporated as part of individual site management plans for specific disposal areas. In the event that significant improvements are achieved, these results would be incorporated in future reanalyses with the systems model.

DEVELOPMENT OF POTENTIAL SITES

As discussed in the introduction, the process used to select potential sites was performed separately for the deep draft and shallow draft projects. Although performed separately, the concept and considerations used in the screening processes were similar. This part of the study reflects a substantial work effort and consequently was initiated early in the study so as not to delay the final product. This approach was employed since, based on Reconnaissance Report results, it was obvious that a deficit in disposal volumes existed which was not anticipated to be entirely resolved by the management measures. Consequently, potential sites were identified either through a computerized screening phase (as in the case of the deep draft projects) or through the use of a manual process (as in the case of the shallow projects).

DEEP DRAFT PROJECT SCREENING. As described in the introduction to plan formulation, a computerized technique called Spatial Analysis Methodology (SAM) was used for the site 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" 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 automated site suitability screening among various kinds of (spatial) data to determine the relative attractiveness of alternate sites.

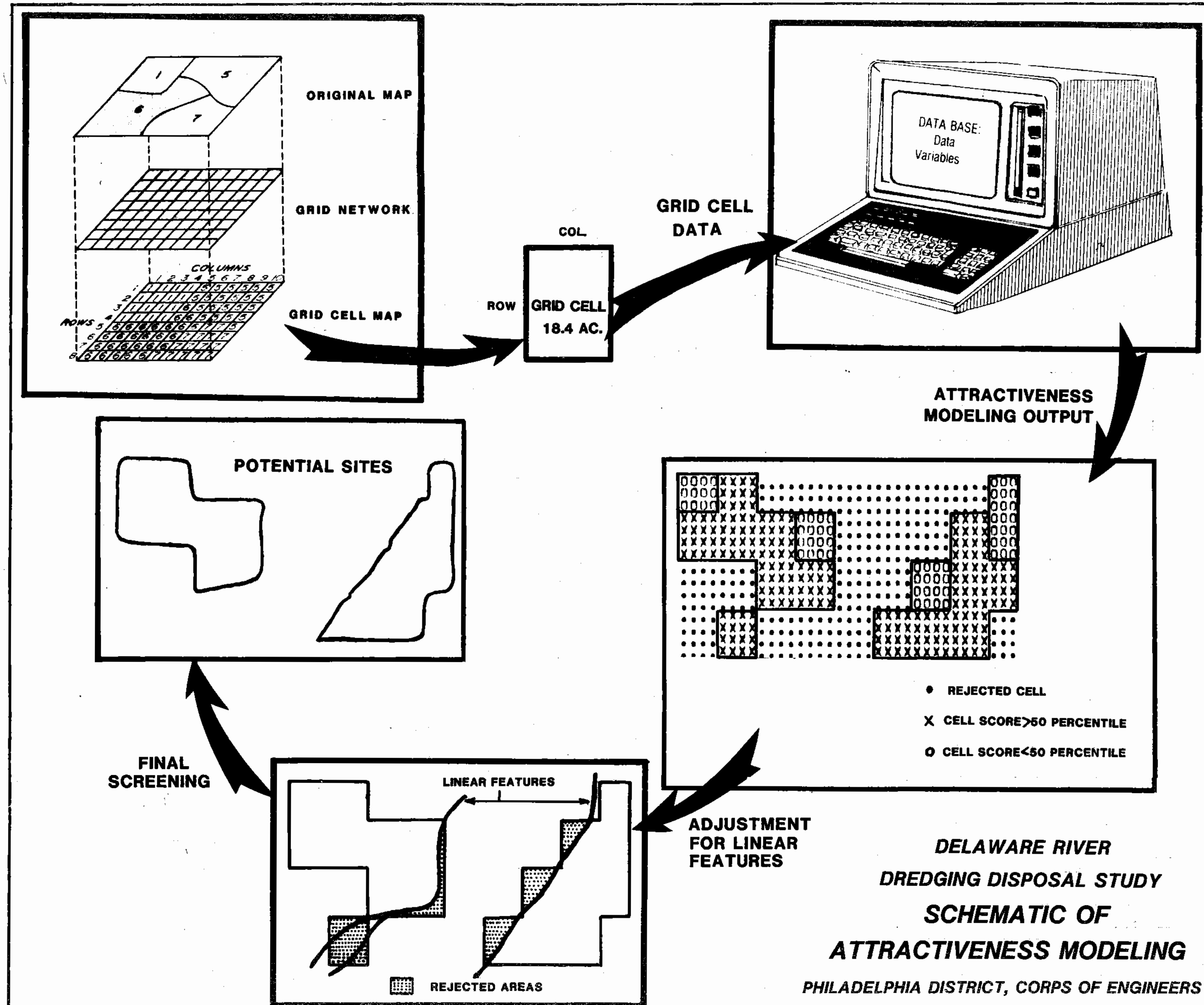
SAM is comprised of two main components:

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

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 selection of candidate disposal sites, instructing the computer to search the data bank for those 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 24 for the schematic approach used in the attractiveness modeling).

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 20 for a list of the parameters and variables).

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



DELAWARE RIVER

DREDGING DISPOSAL STUDY

SCHEMATIC OF ATTRACTIVENESS MODELING

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 24

was 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 weighting factor to each data variable cell to describe its relative attractiveness for use as a potential disposal site. 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 weighting was established to relate the importance of one parameter to another. Further details on the spatial model techniques are presented in Appendix 1.

The criteria defining the attractiveness of an area for the disposal of dredged material incorporated the competing pressures involved in selecting potential disposal areas. These critieria assumed that the results would be technically feasible, cost effective and environmentally acceptable. To reflect varying degrees of emphasis of each of these criteria, the interdisciplinary study team identified the following major alternative scenarios.

- National Economic Development (NED) Plan
- Environmental Quality (EQ) Plan

NED Plan. This scenario, while considering the environment, would emphasize those parameters involving engineering feasibility and cost efficiency of dredging and dredge 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 in this scenario.

EQ Plan. This scenario emphasized the preservation and protection of the environment over the ease or cost of construction of new disposal sites. Attributes such as natural water bodies (aquatic sites), wetlands, prime and unique agricultural lands, archaeological and historic sites, and ground water protection zones were factors of major importance to site selection as part of this plan.

Prior to selecting these scenarios, a number of alternate plans were also considered. However, each of these plans were eliminated. For example, one, identified as EQ-1, was intended to be less restrictive than the EQ sceanario in that it permitted disposal in aquatic or shallow water sites. Due to the close proximity of these sites to the shoaling areas, the transportation costs were negligible. Consequently, the associated costs for this scenario were relatively low. However, this plan was ultimately dropped due to environmental and hydraulic concerns. As discussed in the Existing Conditions Section, the environmental value of these aquatic and shallow regions is significant. The hydraulic concern is that the deposition of material would reduce cross-sectional flow areas which could change flow patterns and velocities, and in turn change the rate or location of channel shoaling.

Another scenario which was considered was a Mixed Objective (MO) plan. This plan was intended to be a compromise between the NED and EQ scenarios using weightings between these plans. However, after making computer runs, the results were found to closely approximate the EQ plan. Therefore, further analysis of the MO scenario was discontinued.

Table 20 lists data parameters, variables, and variable weightings including those identified as exclusionary variables for the NED and EQ scenario. Table 21 provides the relative index weightings used for each parameter. A

TABLE 20

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

TABLE 20 (Cont'd)

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

TABLE 20 (Cont'd)

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

TABLE 20 (Cont'd)

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

TABLE 20 (Cont'd)

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

TABLE 21

DISPOSAL SITE SELECTION BASED ON VARYING INDEX VALUES

(PARAMETER IMPORTANCE)

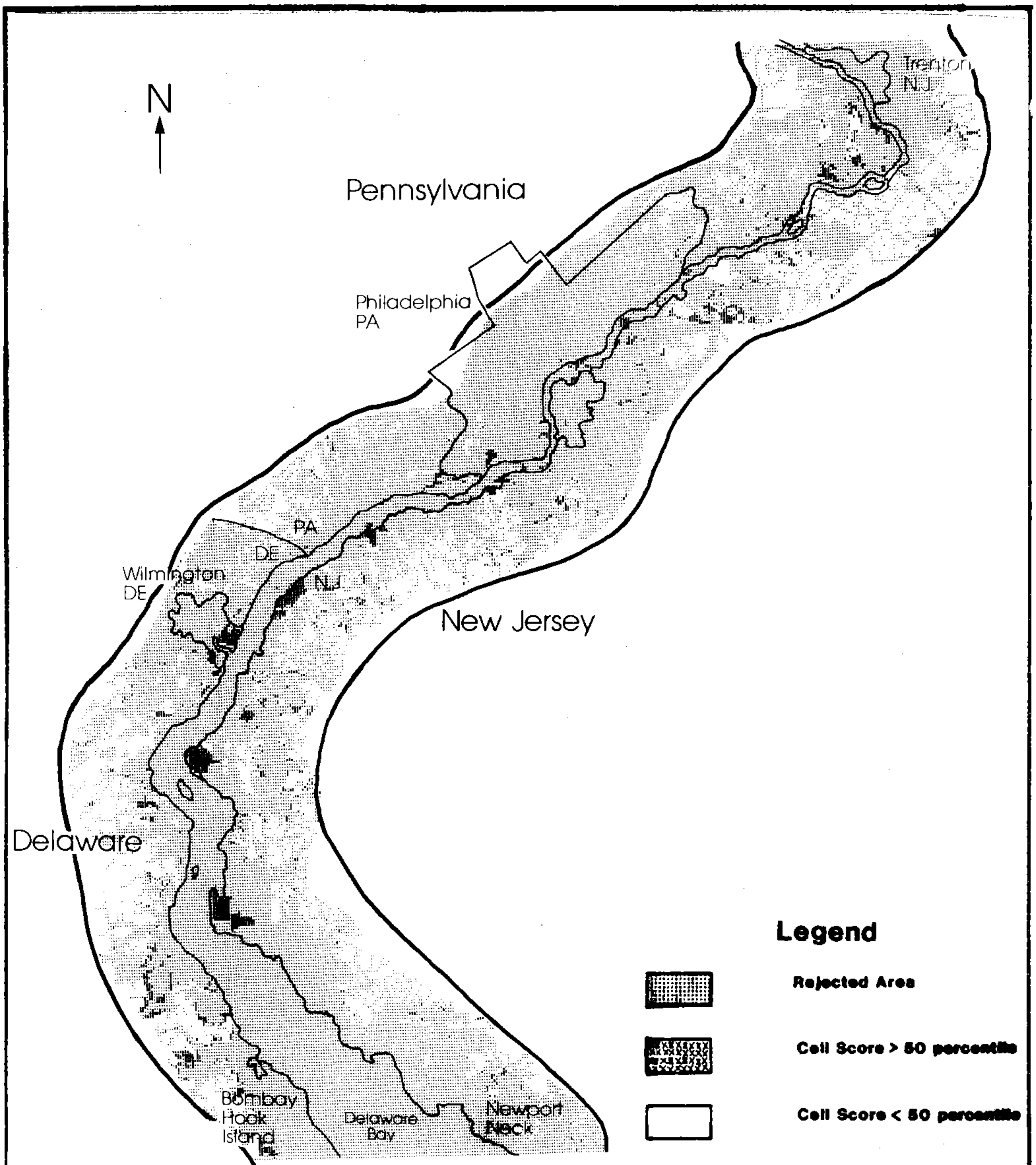
PARAMETER	NED	EQ
Archaeological Sensitivity Zones	1	1
Historic Sites	1	1
Groundwater Recharge Zones	1	5
Recreation	1	1
Fish and Wildlife Sensitive Areas	1	5
Land Use and Land Cover	1	5
S.C.S. Important Farmlands	1	1
DOI Wetlands	1	1
Navigation Features	1	1
Groundwater Protection Zones	3	1
Construction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

preliminary version of the weightings used coordinated with the Plan Formulation Committee. 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 20 and 21 reflect those that were ultimately used in the data base.

Model Output. Many options for displaying the model output were available. One option was the scale of the output, which was produced both on 1:24,000 scale (for the purpose of overlaying directly on USGS quandrangle sheets) and 1:96,000 scale (for illustration purposes). Also, the degree of attractiveness could easily be illustrated by using output display commands. Figures 25-26 provide reductions of the direct computer output (1:96,000 scale) showing potential sites for each scenario. These figures show the most attractive sites (those in the top 50 percentile category based on accumulated weightings), the least attractive sites (lower 50 percentile) and rejected cells. The EQ plan emphasized use of upland sites and offered the least number of potential sites. There is an increase in the number of potential sites for the NED plan as wetlands adjacent to the river were added to the portfolio of candidate sites.

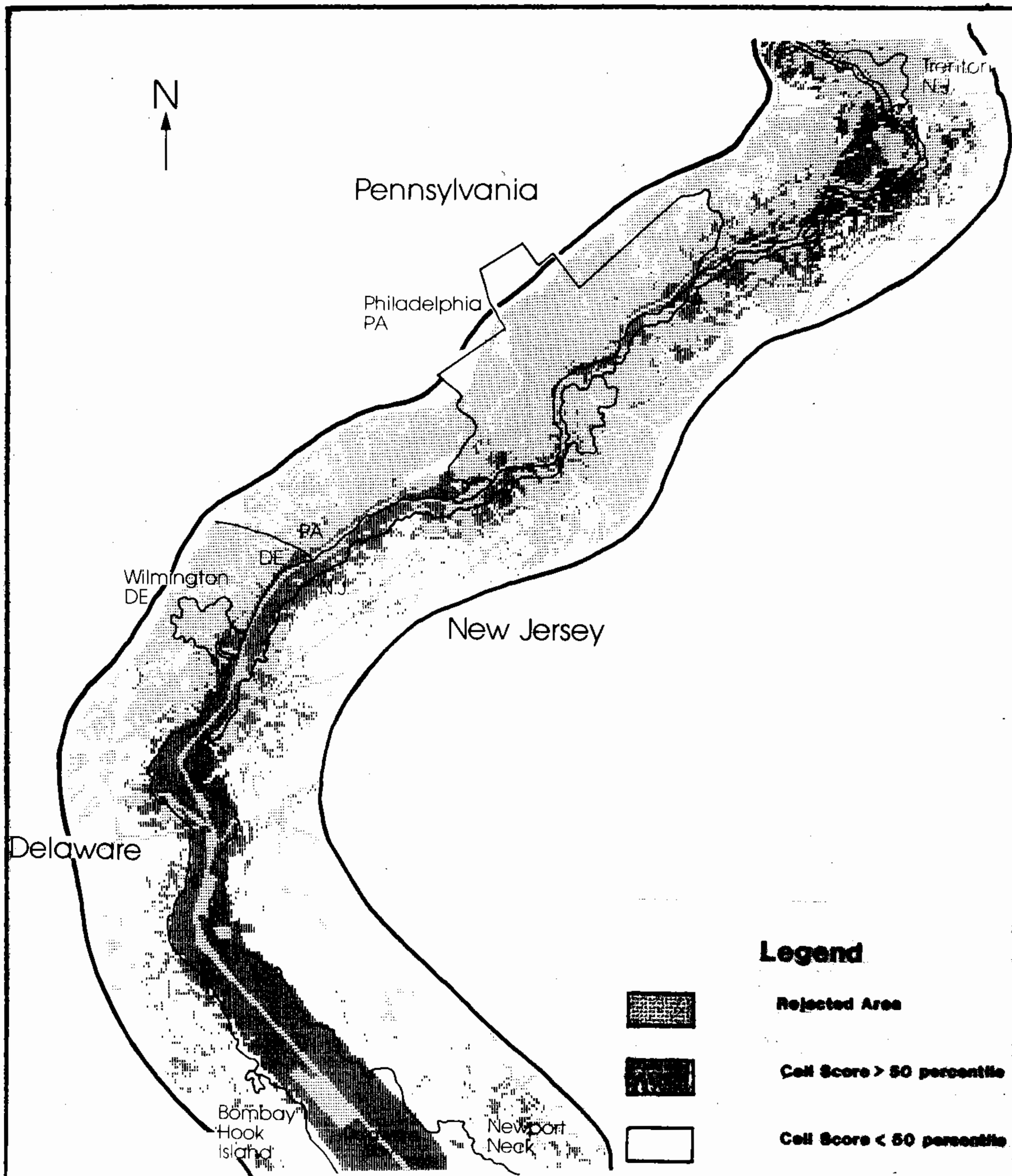
Following the screening of potential sites with the attractiveness model, two additional scenarios were developed. These plans emerged largely as a result of coordination with other agencies and comments from the Plan Formulation Committee. They are based primarily on the EQ sites but are generally more restrictive. These scenarios are referred to as:

- EQ Ranking
- Agency



DELAWARE RIVER
DREDGING DISPOSAL STUDY
EQ SCENARIO
ATTRACTIVENESS MODEL OUTPUT
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 25



DELAWARE RIVER
DREDGING DISPOSAL STUDY
NED SCENARIO
ATTRACTIVENESS MODEL OUTPUT
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 26

EQ Ranking. This scenario was designed to consider sites with minimal wetland involvement. Sites were placed in five categories that reflected the number of wetland and/or aquatic acres per site. Ranking categories included 0-5 acres, 6-25 acres, 26-50 acres, and 51-100 acres. Since a sufficient number of sites were in the 0-5 acre classification, the other four categories were not considered in the analysis.

Agency. This scenario was developed by a team composed of representatives from U.S. Fish and Wildlife Service (USFWS), Environmental Protection Agency (EPA), National Marine Fisheries Service (NMFS), and State Resource agencies after reviewing individual sites. Their combined efforts culminated in a Fish and Wildlife Report. This report is available in the District files. As part of this analysis, the sites were broken into four categories of increasing attractiveness. Potential sites in Categories I and II were classified as highly valuable environmental areas and consequently were not considered further. Those in Categories III and IV were included in the system model runs as potential candidate sites.

Manual Screening. Each of these scenarios resulted in sites which were manually screened to consider linear features (i.e. roads, streams) or isolated structures that the model is not as well suited to appraise. During this step, consideration was also given to the following items: minimum disposal area size requirements, man-made improvements, reasonable pipeline routes to the potential disposal areas, reasonable effluent water courses to the river, and accessibility for construction and maintenance. Finally, the candidate sites were field visited to assure that some feature that may render a site unrealistic was not missed.

SHALLOW-DRAFT PROJECT SCREENING. Potential sites for the small projects were screened manually using a similar process to that used for the deep draft analysis. The screening was conducted by the District with assistance from the U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency, State Environmental Agencies, and the National Marine Fisheries Service.

Worst Case. As indicated previously (Table 18), there is an estimated deficit of 24 million cubic yards over the 50 year study period. This volume is relatively small in contrast to the deficits associated with the deep draft projects. In addition, the volumes are disaggregated over 17 separate projects located throughout the study area. This condition also assumes that each of the 17 projects would be dredged and maintained to its authorized dimensions.

Because of the above reasons, particularly the low chance of each of the 17 projects being dredged to their authorized dimensions, a resolution of the individual project deficits was not pursued at length. However, in the event that a portion of this demand does materialize, several viable options are available as listed below:

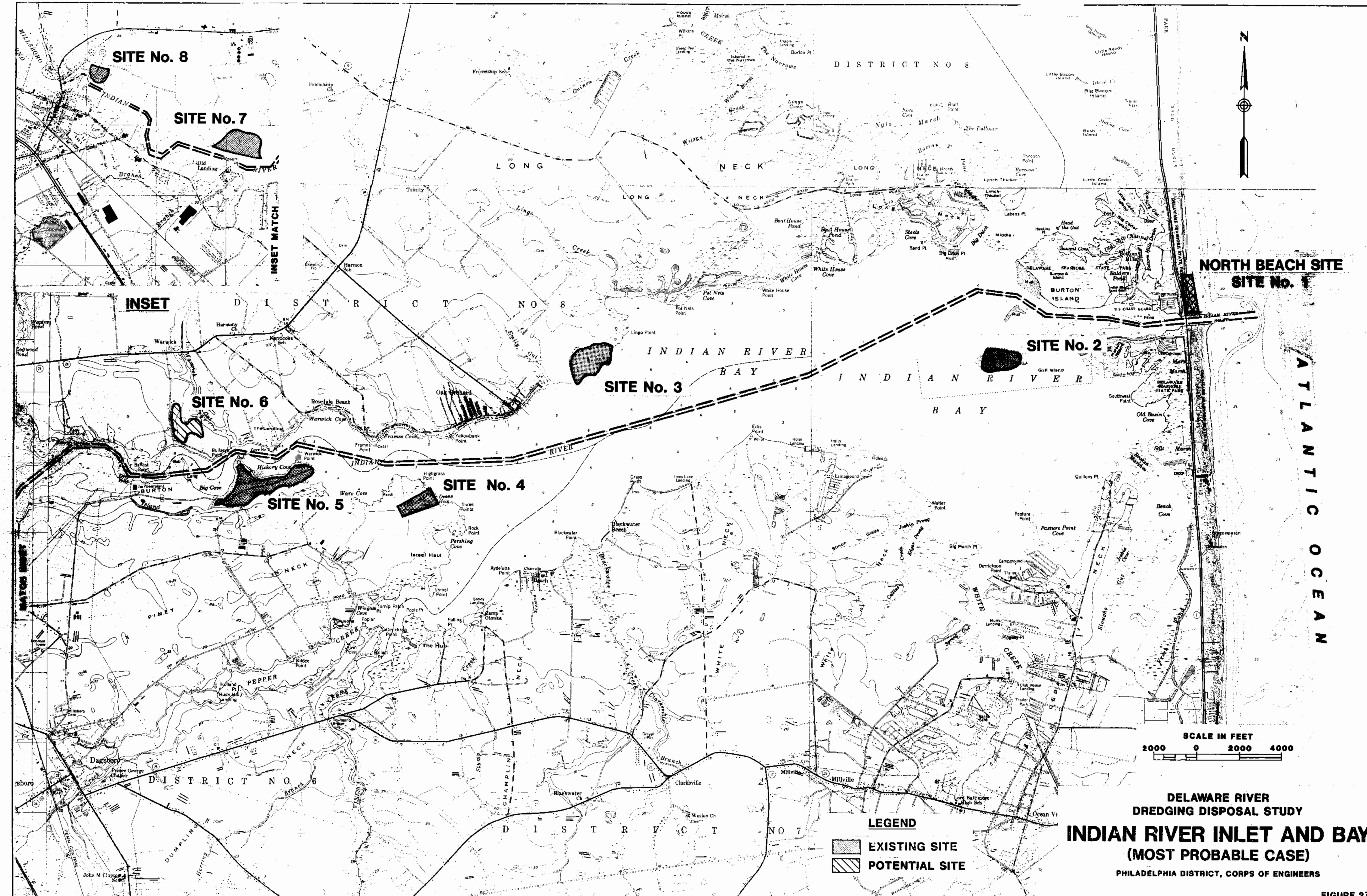
- Improved management of sites.
- Consideration of alternate sites such as those identified through the screening process.
- Filling to heights greater than 15 feet, which is the constraining elevation assumed for disposal sites associated with shallow-draft projects.

Most Probable. As indicated in Table 19, there is sufficient capacity to satisfy the disposal needs of shallow draft projects. These sites were reviewed to assure that the sites used historically were both technically viable and environmentally acceptable. The screening process (described previously) identified sites in addition to those used historically and resulted in those that would best meet the individual project disposal needs.

Despite there being no apparent disposal problem under the most probable case condition, this conclusion was based on the assumption that the identified sites would be available in the future. While this assumption is reasonable, there is no guarantee that this will, in fact, take place. In contrast to the deep draft projects where sites are generally acquired in fee or under longer term leases, disposal sites for shallow draft projects are normally acquired for a single maintenance cycle, usually immediately prior to the actual dredging. Further, many projects require the sponsor to provide the disposal site as a condition for performing the maintenance dredging. Despite the above uncertainties, the availability of disposal areas for small projects has not been a significant problem in the past. As such, no change in past practices is recommended.

Case Example. While it is unreasonable to model each of the 17 specific projects, one, Indian River Inlet and Bay, was modeled to see if any improvements could be recommended. The intention was that if it appeared warranted, additional projects would also be modeled. The results from the model supported the subjective analysis and therefore, no further efforts were made on other small projects. The existing sites for the Indian River Inlet and Bay project are shown on Figure 27. Site 5, however, is no longer in use due to foundation constraints. Site 6, which is the next best potential site will be used in its place.

POTENTIAL SITES. The candidate sites considered can be placed into two general groups, upland and open water (ocean or lower bay) areas. Upland disposal has traditionally been the more common method employed by the District and has been used rather heavily in the past. In this method, dredged material is disposed in confined, diked areas. The screening process described previously was used to search for potential new sites in this category.



DELAWARE RIVER
DREDGING DISPOSAL STUDY

INDIAN RIVER INLET AND BAY
(MOST PROBABLE CASE)

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 27

Open water areas include deep water areas at a location away from the navigation channel. Open water disposal has been a common practice in portions of the study area and involves either hopper or bucket dredging. In the latter case, the material would be loaded into a scow, and transported to the disposal site. The dredged material would then be released into the water and permitted to settle. At present, ocean disposal is not employed by the District for the projects under consideration in this study. The District does, however, utilize a disposal site in the lower Delaware Bay northwest of Cape May, New Jersey. One of the disadvantages of disposal in deepwater areas is that, when the distance from the shoal is great, the relative costs are high. Transportation costs are estimated to be $86 per mile per 1000 cubic yards of dredged material. Depending on the location of dredging, the total costs could vary from $6 to $12 per cubic yard. However, the total costs are offset by the fact that there are virtually no site preparation costs. Both upland and open water disposal have been considered in the systems analysis.

DREDGE PLANTS. In addition to the screening of disposal alternatives the study examined a variety of dredge plants that are currently available and their potential application in the study area. Where sites are sufficiently close to the shoal area, hopper and hydraulic pipeline dredges are the preferred dredging plants. These types of dredges minimize negative environmental effects as well as dredging costs, and are well suited for the study area sediment conditions. Where sites are not sufficiently close to the shoal, clamshell dredging with barge transport and either hydraulic or mechanical unloading systems are preferred. All three of the above dredging plants are readily available and are currently used by the District. Other types of dredges, pneumatic, oozer and pneuma, were evaluated and were determined to be unfeasible either because they were unavailable or not as efficient as the plants presently being used (refer to Appendix 2 for description and comparison of these dredge plants). However, the District will continue to evaluate new types of dredge plants as the state of the art is improved, thus insuring that the most cost effective means of dredging is employed. Dredging costs associated with each of the three plants (hopper, hydraulic, clamshell) have been included in the systems model.

SUMMARY OF ALTERNATIVE MEASURES ANALYSIS

The results of the screening process are presented in Table 22. Viable management measures have been incorporated in the most probable case condition using the systems model. Collectively, the measures which represent specific site management were considered by an improvement in the wet to dry ratio (which defines the relationship between the river bottom volume of material and the in-disposal site after drying volume). The specific wet to dry ratios used in the model varied by project based on past experience and anticipated improvements are shown below:

PHILADELPHIA TO THE SEA (INCLUDING DELAWARE RIVER AT CAMDEN)	1.8
WILMINGTON HARBOR	2.0
SCHUYLKILL RIVER	1.5
PHILADELPHIA TO TRENTON	1.3

As indicated previously, the wet to dry ratio for the worst case condition was assumed to be 1.0 and implies a minimum level of site management.

SYSTEMS MODEL

The systems model was used to evaluate those viable alternatives described previously. This model was developed by the Corps of Engineers as part of this study.

TABLE 22

RESULTS OF SCREENING OF ALTERNATIVE MEASURES

ALTERNATIVE	CONCLUSION	WORST CASE CONDITION	MOST PROBABLE CASE CONDITION
Dewatering	Viable - Continue past practices augmented by more effective trenching methods which can be achieved as a result of recently purchased equipment.	Use Wet to Dry ratio of 1.0	Use Wet to Dry ratio ranging from 1.3 - 2.0 depending on project
Increased Dike Height	Viable - Raise dikes to maximum allowable technical elevation.	Use maximum allowable technical elevations.	Same as Worst Case
Lease Extension	Viable - Renegotiate for extended time periods.	Assume renegotiation is unsuccessful and current constraints are imposed.	Assume renegotiation is successful.
Reuse	Viable - However, historical volumes are relatively small and negligible compared to disposal needs considered in this study. If this alternative becomes more attractive, a reanalysis can be made and would reduce deficits.	Continuation of past practices.	Same as Worst Case
Deposition Basins	Not Viable - Shoal areas cannot be moved out of present high shoal areas.	Not considered	Same as Worst Case

TABLE 22 (Cont'd)

ALTERNATIVE	CONCLUSION	WORST CASE CONDITION	MOST PROBABLE CASE CONDITION
Erosion Control	Viable - Enforcement of current erosion controls is encouraged. The disposal problem, however, cannot be significantly reduced by modifying current practices.	No change anticipated.	Same as Worst Case
Site Management	Viable - District has been using various practices (in addition to dewatering) which have produced good results. As the state of the art advances, even more effective measures may be realized and would be incorporated in future analysis. The District will employ modeling to develop specific site management plans.	Minimal management resulting in wet to day ratio of 1.0.	Considered in estimating wet to dry ratios shown above.
New Sites	Viable - Study has identified potential new sites.	Identified through modeling efforts.	Identified through modeling efforts.
Dredge Plants	Viable - Use present type of dredging plants and keep abreast of technological changes.	Costs for each type of plant incorporated in systems model.	Same as Worst Case

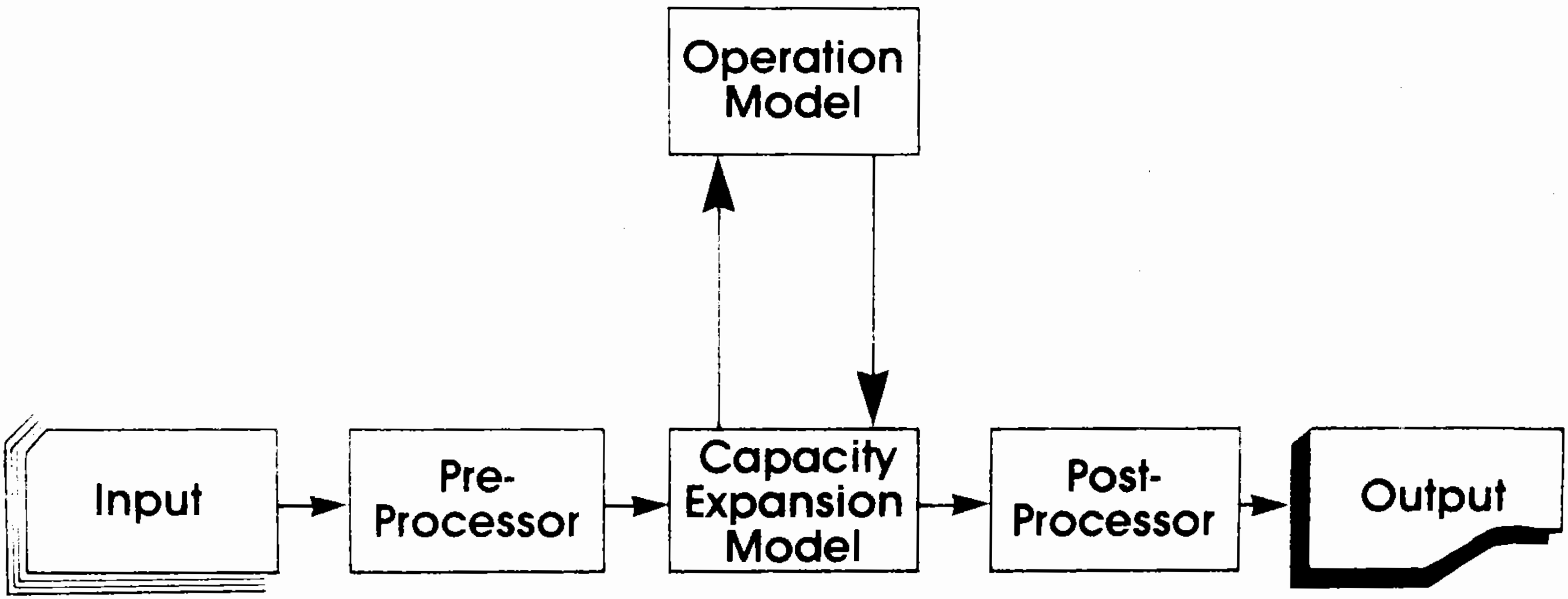
The systems model consists of four program components; a pre-processor, an operation, a capacity expansion, and a post-processor module. The relationship between these modules is shown in Figure 28.

PRE-PROCESSOR. The pre-processor reads the user-supplied input which describes the characteristics of the disposal system. The disposal site properties required include the location, initial storage, and operation and maintenance costs. The relationships between surface area, elevation, and remaining capacity are also needed. Additional data requirements are the wet to dry ratio, the maximum allowable rate of additional wet material, and the unit cost for additional material.

If capacity expansion is indicated, then more information must be supplied. In the case of leased sites whose lease termination date is within the period of study, costs for lease renegotiation must be provided. Acquisition costs along with site characteristics are included for potential new sites. The acquisition costs consist of the following:

- Real Estate
- Site clearing/utilities adjustment
- Foundation treatment/dikes
- Groundwater protection
- Sluice/discharge channel
- Access/obstacle passage

Input is also needed to describe the dredging and transport operations. This includes the volumes of material dredged from each site and the method used to accomplish this dredging. The dredge sites are specified in channel stationing and offset from the disposal area. By knowing the type of dredge transport, a unit cost of transportation is estimated from cost curves.



DELAWARE RIVER
DREDGING DISPOSAL STUDY

SYSTEMS MODULE COMPONENTS

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 28

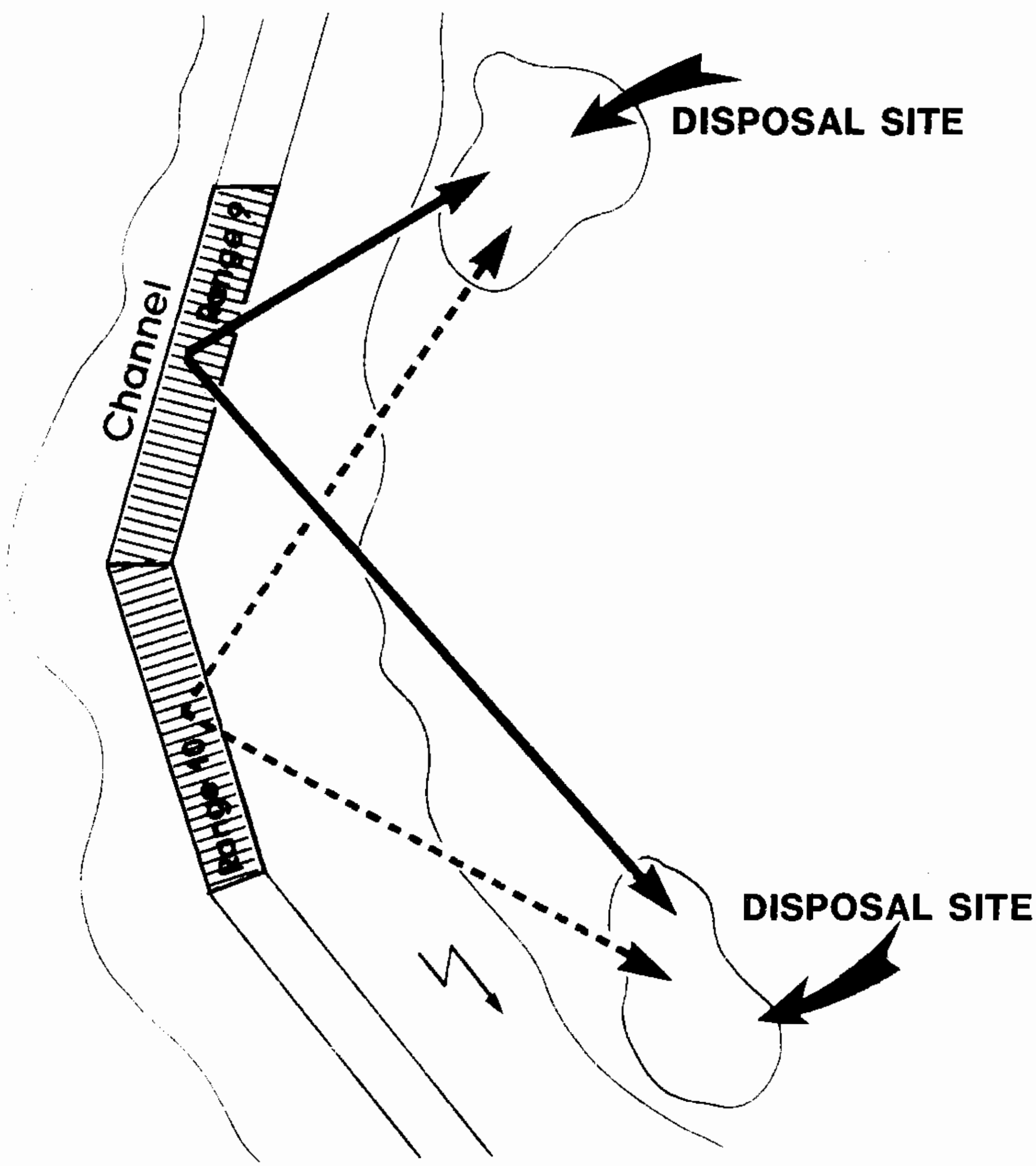
If new sites are to be considered or if site leases require negotiation within the period of analysis, the information is transferred to the capacity expansion module. When the operation of a specific disposal system is to be analyzed, the capacity expansion module is bypassed and the data is sent directly to the operation module.

OPERATION MODULE. The operation module determines the least costly dynamic scheme for routing dredged material from the dredging sites to disposal areas and for storing the material. A typical system is shown in Figure 29.

The operation problem is modeled as a multiperiod network. The least cost operation of a disposal system is determined by solving the network flow problem through an iterative approach using the out-of-kilter optimization algorithm.

CAPACITY EXPANSION. In cases where the capacity of existing disposal sites is insufficient to meet the dredging needs, the capacity expansion module is used to identify the least-costly manner to satisfy the demand given an array of potential sites and the costs and characteristics of each (see Figure 30).

The selection is accomplished using an enumeration technique (branch and bound) along with the operation module. The branch and bound algorithm identifies the time various sites should be added to the system. Once identified, the operation module calculates the corresponding operation cost. The additional associated costs for the selected sites, either acquisition or lease renegotiation, and the site operation and maintenance costs are included, with the system operation cost to yield a total cost for the expansion scheme. This cost is compared to the cost of alternative expansion schemes identified by the module and the least costly is selected.



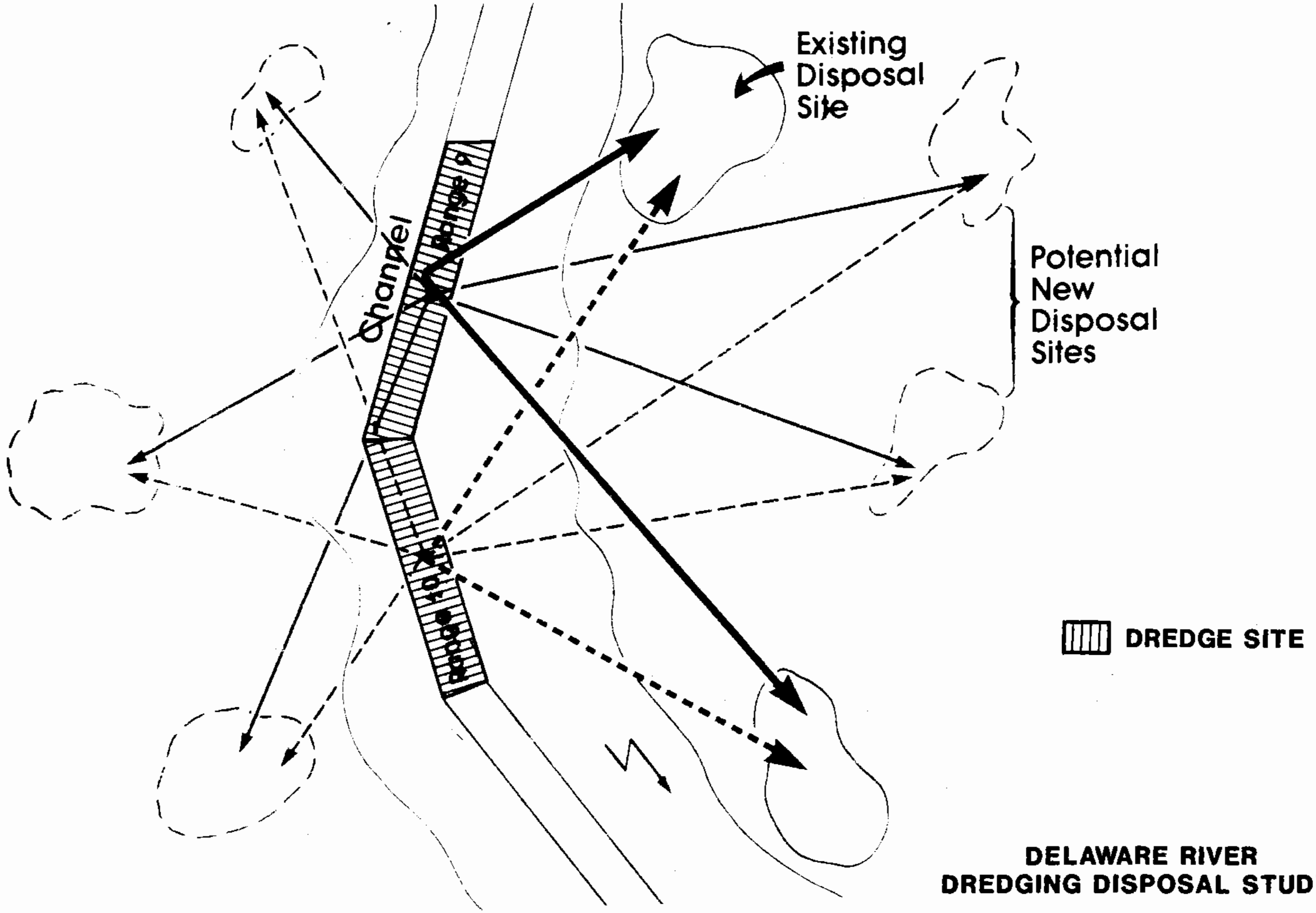
DREDGE SITE

DELAWARE RIVER
DREDGING DISPOSAL STUDY

OPERATIONS MODULE

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 29



DELAWARE RIVER
DREDGING DISPOSAL STUDY

CAPACITY EXPANSION MODULE

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 30

POST-PROCESSOR. The post-processor module interprets the results of the two previous modules. It provides a printed report of the least costly management scheme for the system, the volume of material transported and the corresponding cost. The disposal site status report shows the volume of material disposed in a particular site for each period. Also listed are the cost of disposal of this material and the resulting volume of material in the site at the end of each period. The elevation and surface area of the storage site are determined from the curves defined in the input module. The total volume of material sent to the disposal area during the period of analysis and the disposal cost are also shown in the output.

Additional details describing the systems model are provided in Appendix 3. In addition, a users manual is available for review at the District office (Dredged Material Disposal Management Model (D2M2)).

The systems model was used to evaluate potential sites for the two conditions presented in the Problem Identification Section. Model runs were performed for four scenarios (NED, EQ, EQ Ranking, and Agency). For each scenario the model was offered a list of potential sites and existing sites with remaining capacities as imposed by either a lease constraint (Worst Case) or a maximum technical elevation (Most Probable). The model selected sites based on least cost for each of the scenarios on a present worth basis. In addition, a next best site was selected to depict what would happen if any of the selected sites would become unavailable for some unforeseen reason. In order to relate the cost differental between the NED scenario, which in all cases was the most cost effective plan, and other scenarios, a relative cost index was developed. This index is a multiplier (in terms of present worth cost) using the NED scenario of the Most Probable Case Condition as a base.

MODEL RESULTS. A summary of the model results for each of the four deep draft projects is shown on the following pages for the two conditions. Because of the extensive amount of data in the summary, Table 23 has been included to index the model results.

TABLE 23

SYSTEMS MODEL RESULTS
REFERENCE TABLE

PROJECT	CONDITION	TABLE	FIGURE
Delaware River - Philadelphia to the Sea (Including Delaware River at Camden), Index Map.	-	-	31-32
Delaware River - Philadelphia to the Sea (Including Delaware River at Camden).	Worst Case	24	33-40
Delaware River - Philadelphia to the Sea (Including Delaware River at Camden)	Most Probable Case	25	41-48
Delaware River - Philadelphia to Trenton, Index Map	-	-	49
Delaware River - Philadelphia to Trenton	Worst Case	26	50-53
Delaware River - Philadelphia to Trenton	Most Probable Case	27	54-57
Wilmington Harbor	Worst Case	28	58-61
Wilmington Harbor	Most Probable Case	29	62-63
Schuylkill River	Worst Case	30	64
Schuylkill River	Most Probable Case	31	65

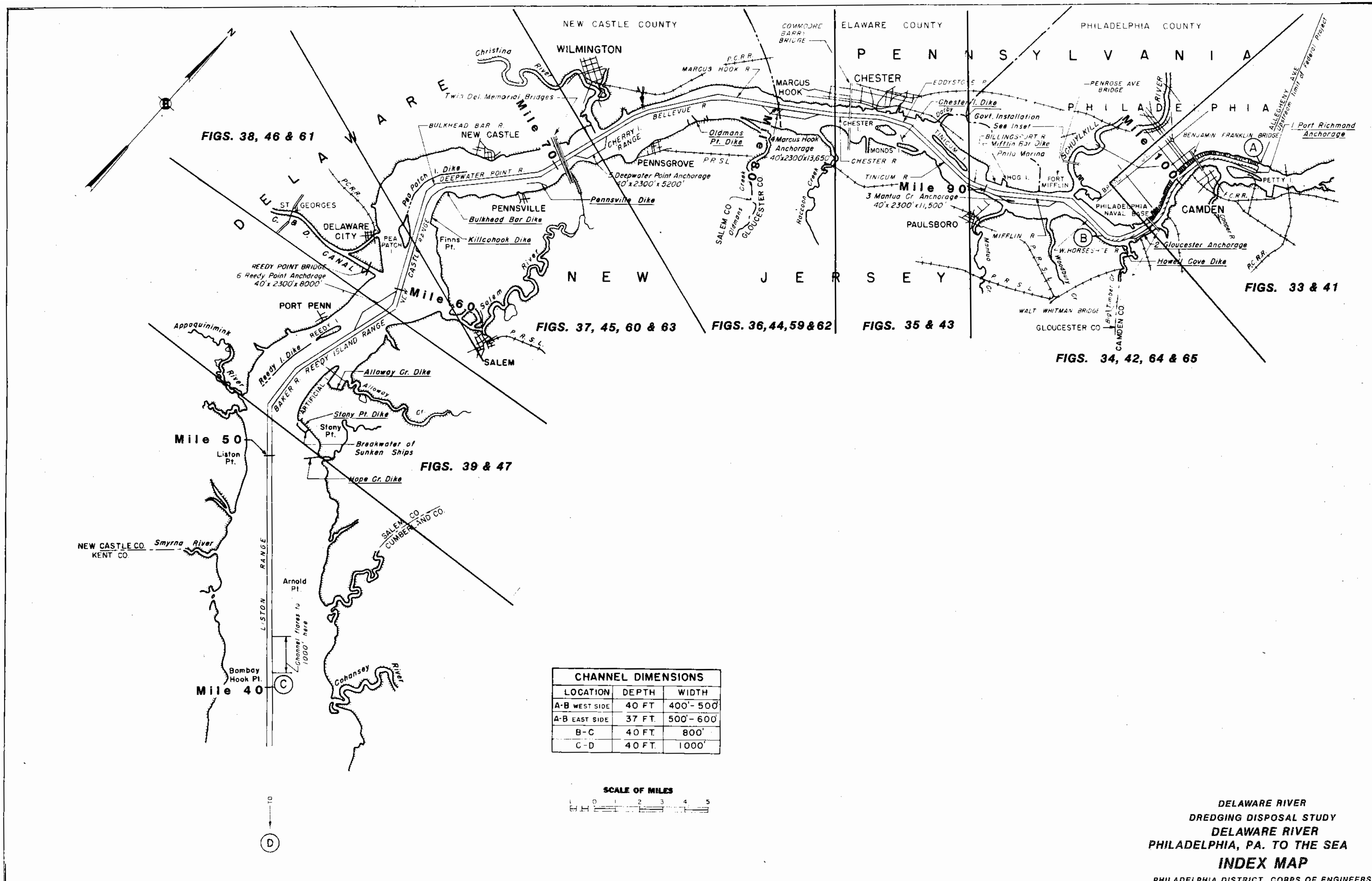
TABLE 24

DELAWARE RIVER, PHILADELPHIA TO THE SEA
WORST CASE CONDITION

SCENARIOS CONSIDERED

PLAN	DISPOSAL AREAS SELECTED SITES	DISPOSAL AREAS NEXT BEST (a)	RELATIVE COST INDEX (b)
NED	Existing Sites (c)		1.2
	11B, 12C		
	15D, 15E		
	15G, 15P		
	16DD, 17M		
	17O, 17P		
	20G, 20I		
	21AA, 24CC		
	24N, 27D		
		17N	
		20Q	
EQ	Existing Sites (c)		1.5
	13F, 15M		
	15R, 16G		
	16S, 16T		
	16V, 16Y		
	16Z, 17C		
	17G, 17I		
	18B, 20H		
	20J, 21D		
	21J, 21K		
	21L, 21T		
	21V, 21W		
	22B, 24U		
	25H, 25I		
	25J, 25K		
		16M	
		23C	
EQ Ranking	Existing Sites (c)		1.7
	15M, 15R		
	16M, 16X		
	17B, 17C		
	17D, 17F		
	18A, 20H		
	20J, 21D		
	21E, 21F		
	21V, 23C		
	23D, 23F		
	23H, 24O		
	24T, 25G		
	25H, 25I		
		16V	
		21L	
Agency	Existing Sites (c)		1.9
	11E, 13C		
	15M, 15R		
	16G, 16K		
	16M, 16N		
	16S, 16T		
	17A, 17B		
	17C, 20H		
	20J, 21F		
	21K, 21L		
	21M, 21V		
	23C, 23D		
	23E, 23F		
	23G, 23H		
	25D, 25G		
		13E	
		21Y	

(a) The site that would be chosen if the selected site becomes unavailable.
(b) This index is the multiplier in terms of cost using the cost of the NED scenario for the Most Probable plan as a base.
(c) As Shown in Table 11



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'

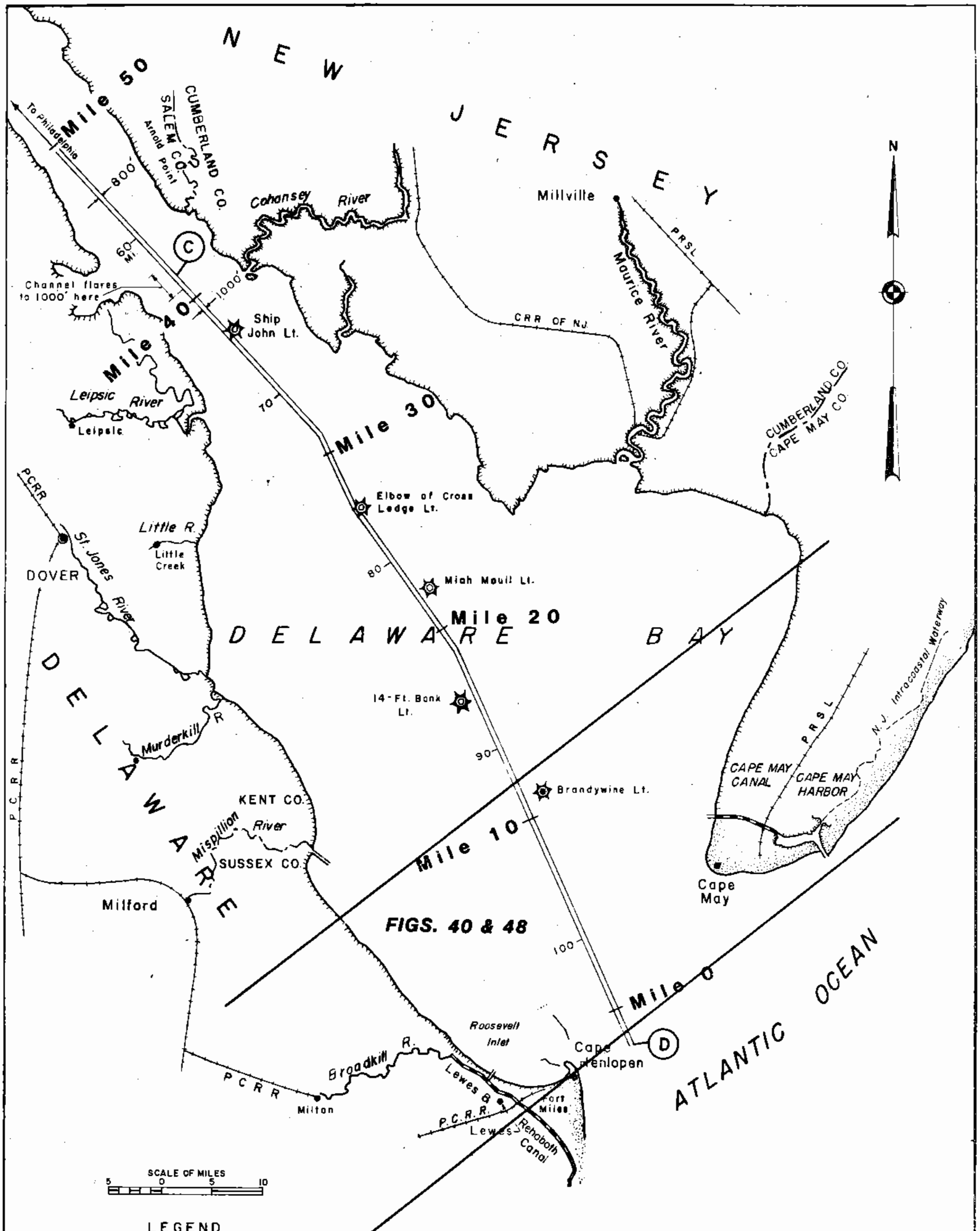
DELAWARE RIVER
DREDGING DISPOSAL STUDY

DELAWARE RIVER
PHILADELPHIA, PA. TO THE SEA

INDEX MAP

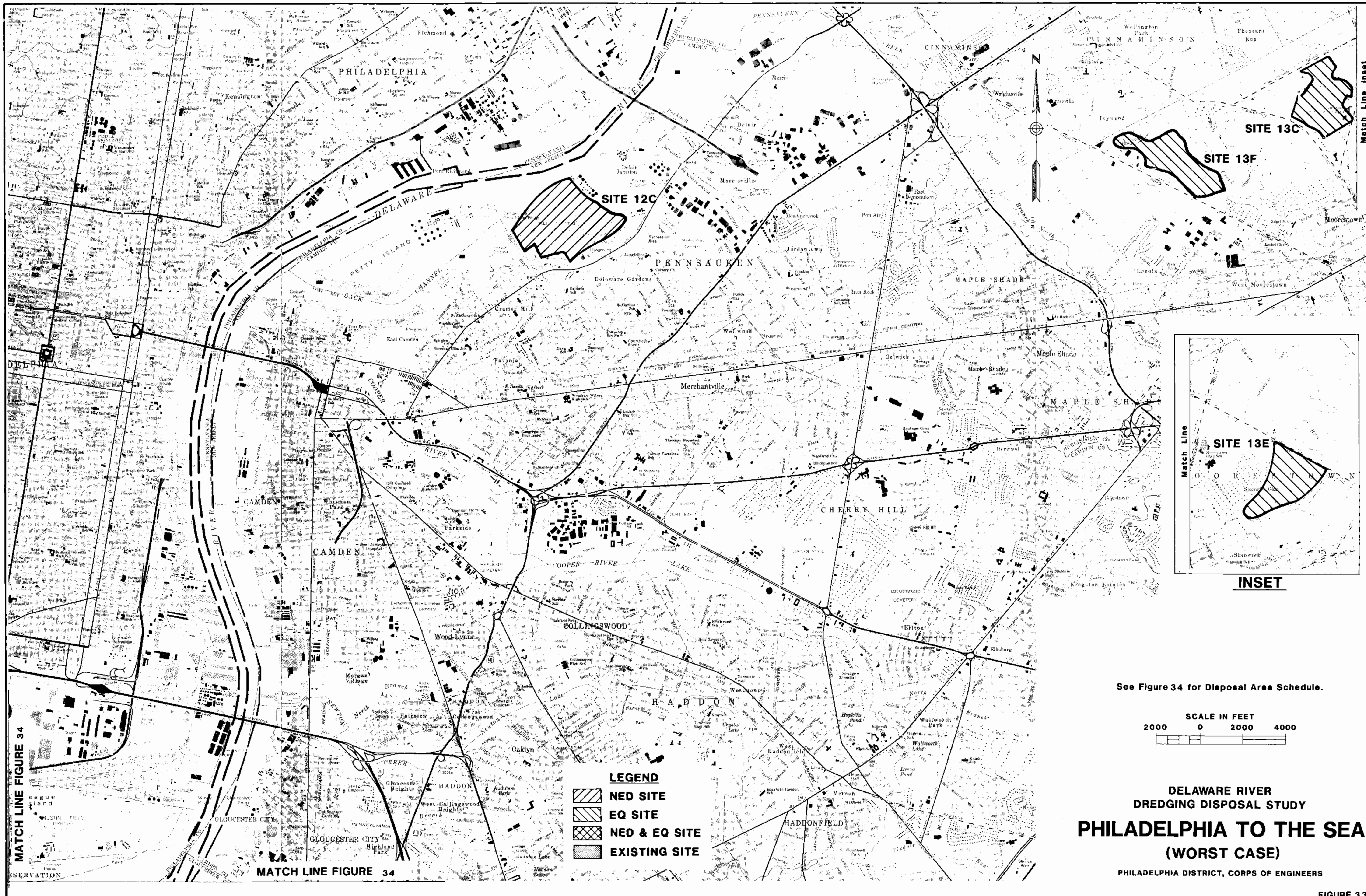
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 31



DELAWARE RIVER
DREDGING DISPOSAL STUDY
DELAWARE RIVER
PHILADELPHIA, PA. TO THE SEA
INDEX MAP
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 32

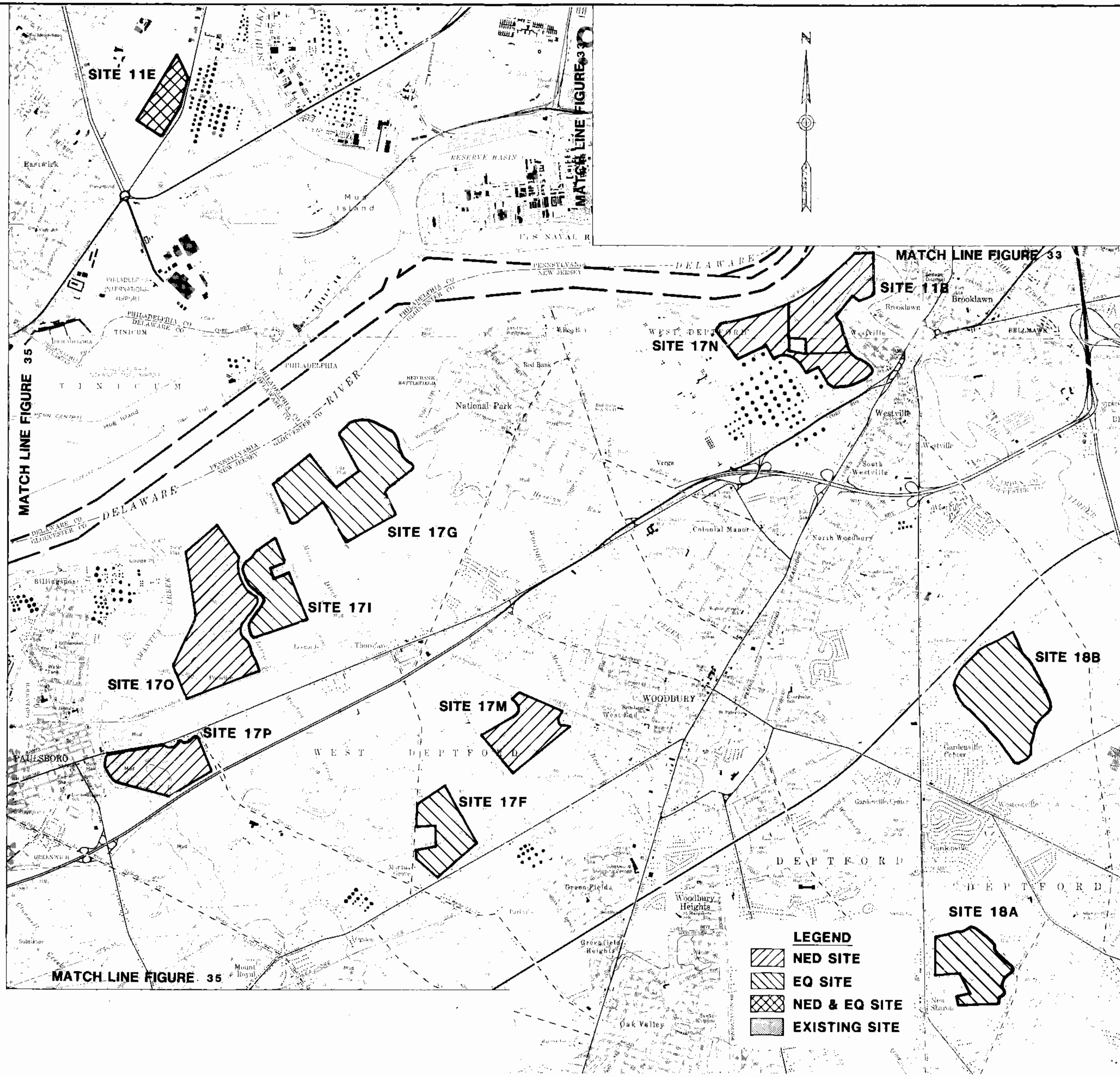


DELAWARE RIVER
DREDGING DISPOSAL STUDY

PHILADELPHIA TO THE SEA
(WORST CASE)

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 33



D.A. SELECTED CONT'D	NED	EQ	EQ RANKING	AGENCY
SITE 18A			X	
SITE 18B		X		
SITE 20G	X			
SITE 20H		X	X	X
SITE 20I	X			
SITE 20J		X	X	X
SITE 20Q	O			
SITE 21D		X	X	
SITE 21E			X	
SITE 21F			X	X
SITE 21J		X		
SITE 21K		X		X
SITE 21L		X	O	X
SITE 21M				X
SITE 21T		X		
SITE 21V		X	X	X
SITE 21W		X		
SITE 21Y				O
SITE 21AA	X			
SITE 22B		X		
SITE 23C		O	X	X
SITE 23D			X	X
SITE 23E				X
SITE 23F			X	X
SITE 23G				X
SITE 23H			X	X
SITE 24N	X			
SITE 24O			X	
SITE 24T			X	
SITE 24U		X		
SITE 24CC	X			
SITE 25D				X
SITE 25G			X	X
SITE 25H		X	X	
SITE 25I		X	X	
SITE 25J		X		
SITE 25K		X		
SITE 27D	X			

X = SELECTED SITE
O = NEXT BEST SITE

D.A. SELECTED	NED	EQ	EQ RANKING	AGENCY
OLDMANS	X	X	X	X
PEDRICKTOWN N.	X	X	X	X
PEDRICKTOWN S.	X	X	X	X
PENNS GROVE	X	X	X	X
PENNS NECK	X	X	X	X
KILLCOHOOK	X	X	X	X
ARTIFICIAL IS.	X	X	X	X
BUOY 10	X	X	X	X
SITE 11B	X			
SITE 11E				X
SITE 12C	X			
SITE 13C				X
SITE 13E				O
SITE 13F		X		
SITE 15D	X			
SITE 15E	X			
SITE 15G	X			
SITE 15M		X	X	X
SITE 15P	X			
SITE 15R		X	X	X
SITE 16G		X		
SITE 16K				X
SITE 16M		O	X	X
SITE 16N				X
SITE 16S		X		X
SITE 16T		X		X
SITE 16V		X	O	
SITE 16X			X	
SITE 16Y		X		
SITE 16Z		X		
SITE 16DD	X			
SITE 17A				X
SITE 17B			X	X
SITE 17C		X	X	X
SITE 17D			X	
SITE 17F			X	
SITE 17G		X		
SITE 17I		X		
SITE 17M	X			
SITE 17N	O			
SITE 17O	X			
SITE 17P	X			

CONTINUED

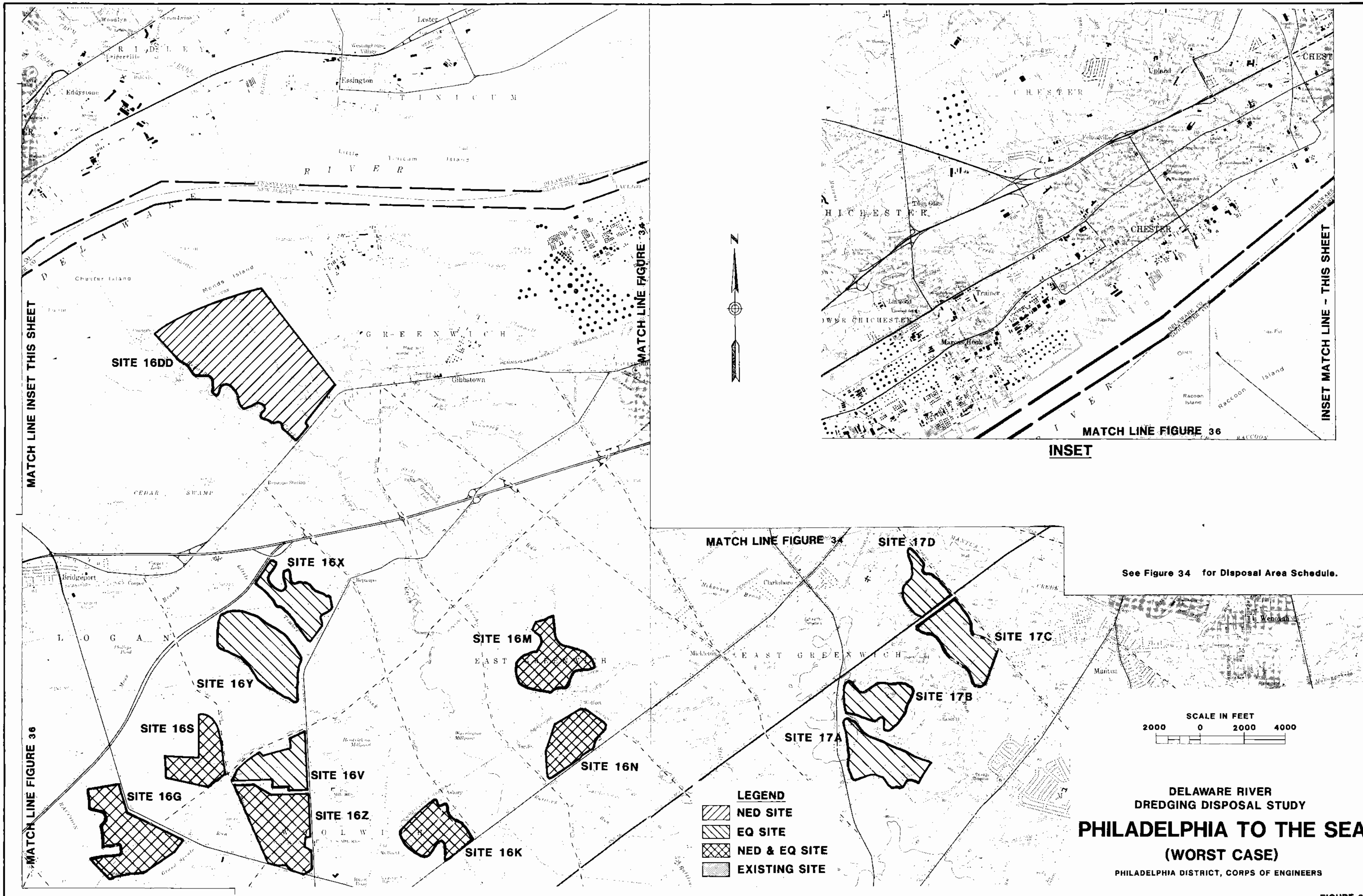
SCALE IN FEET
2000 0 2000 4000

DELAWARE RIVER
DREDGING DISPOSAL STUDY

PHILADELPHIA TO THE SEA
(WORST CASE)

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 34

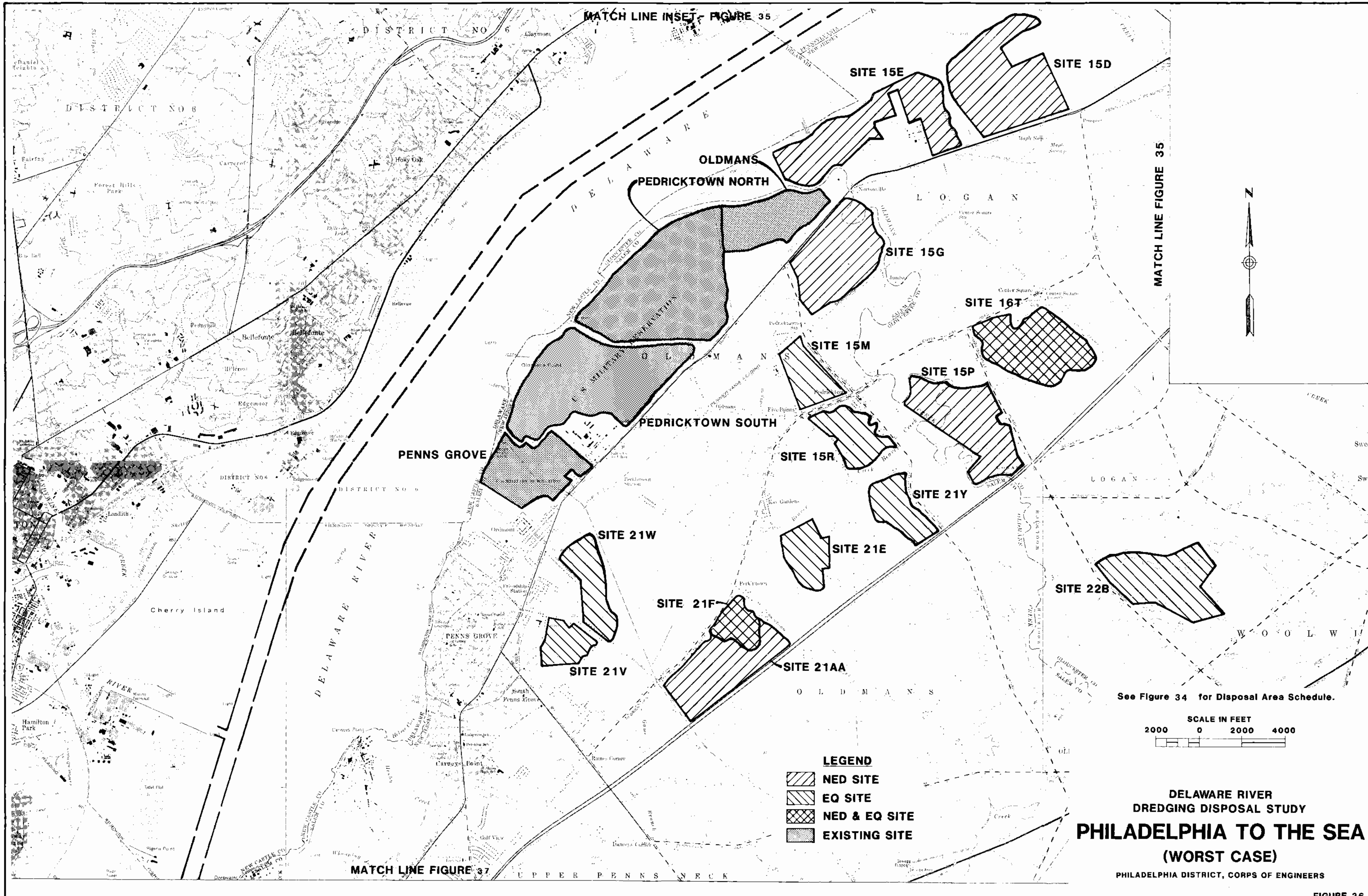


DELAWARE RIVER
DREDGING DISPOSAL STUDY

PHILADELPHIA TO THE SEA
(WORST CASE)

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 35



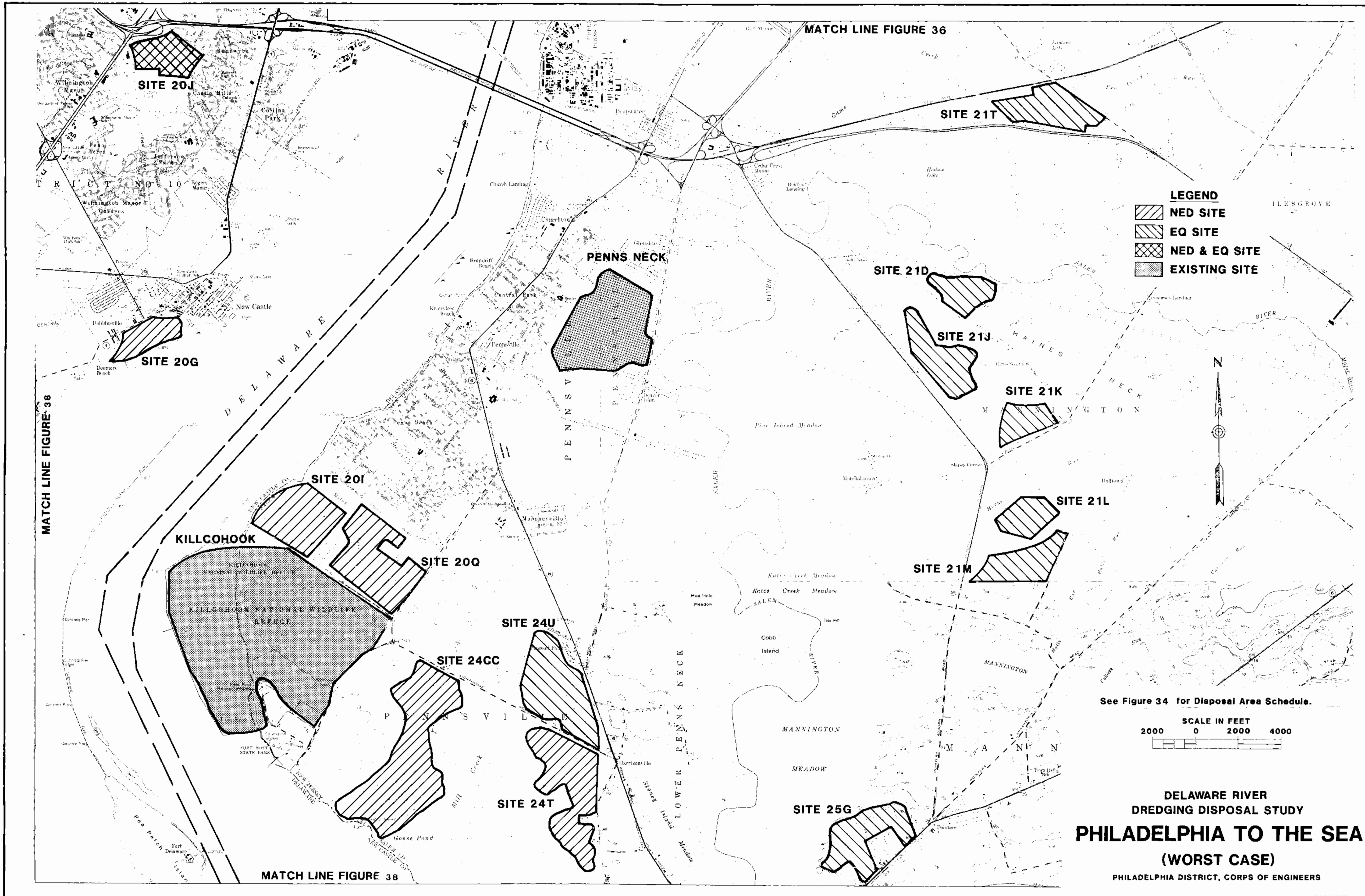
DELAWARE RIVER
DREDGING DISPOSAL STUDY

PHILADELPHIA TO THE SEA

(WORST CASE)

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 36

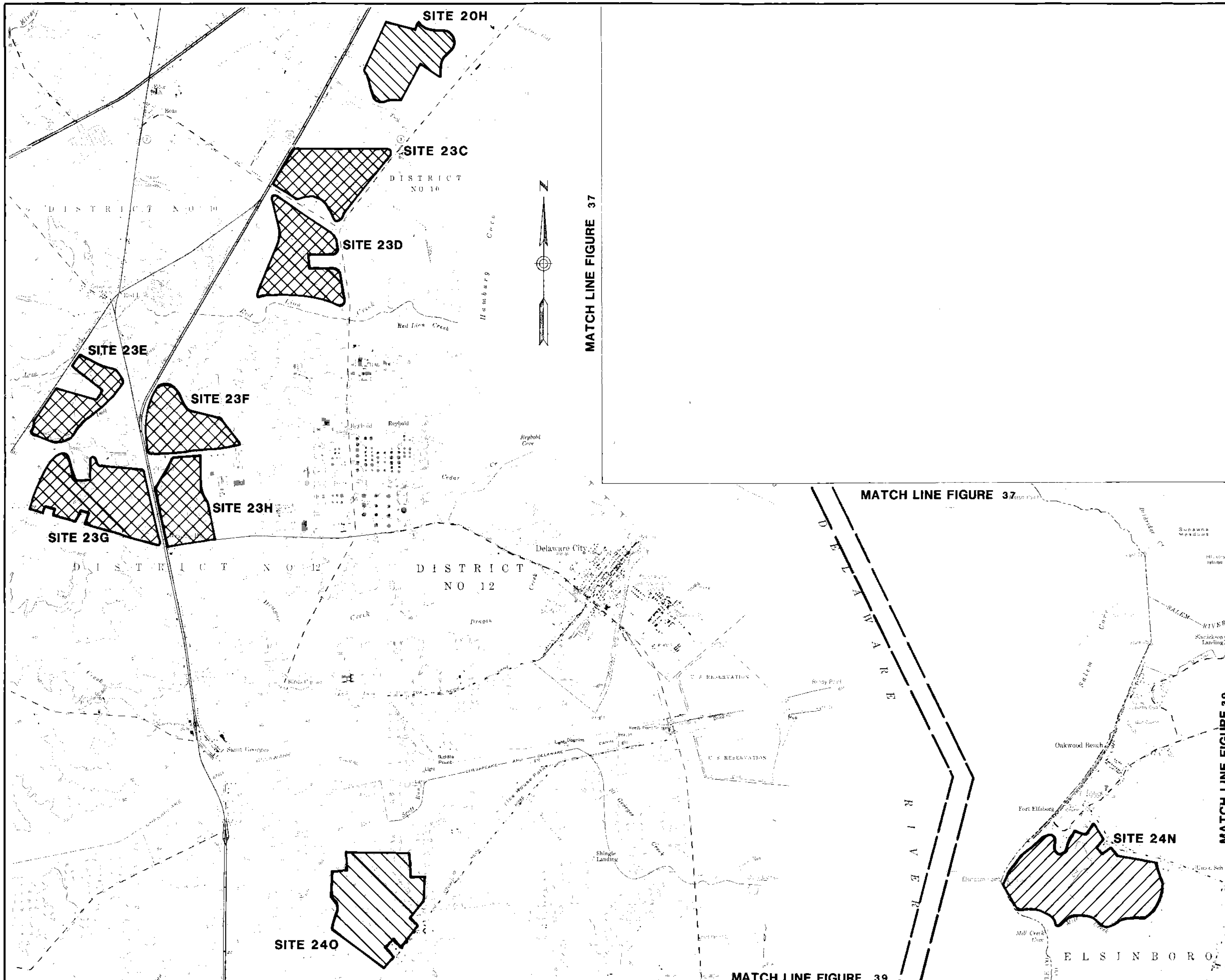


DELAWARE RIVER
DREDGING DISPOSAL STUDY

PHILADELPHIA TO THE SEA
(WORST CASE)

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 37



See Figure 34 for Disposal Area Schedule.

LEGEND

- NED SITE
- EQ SITE
- NED & EQ SITE
- EXISTING SITE

SCALE IN FEET
2000 0 2000 4000

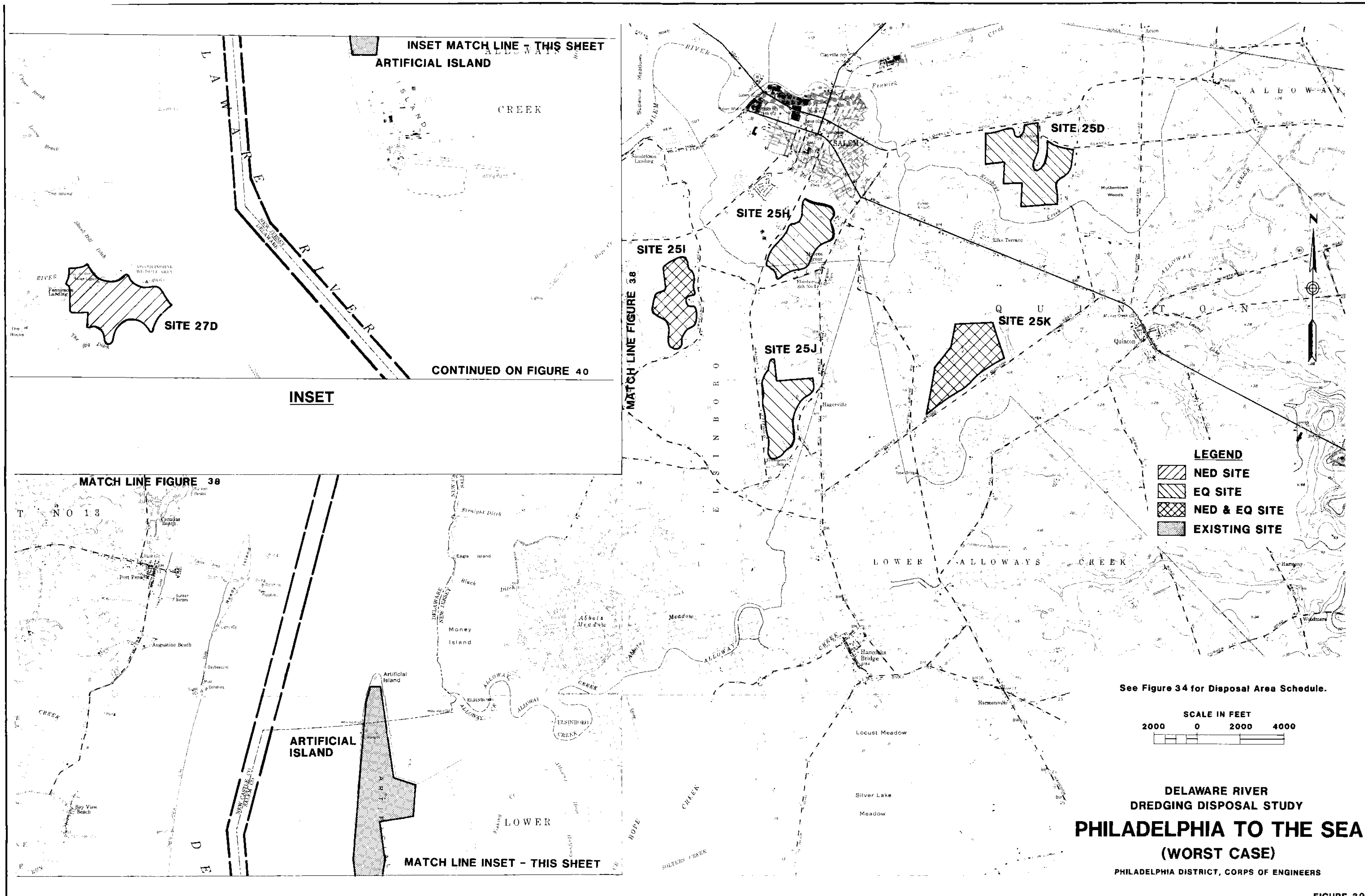
DELAWARE RIVER
DREDGING DISPOSAL STUDY

PHILADELPHIA TO THE SEA

(WORST CASE)

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 38

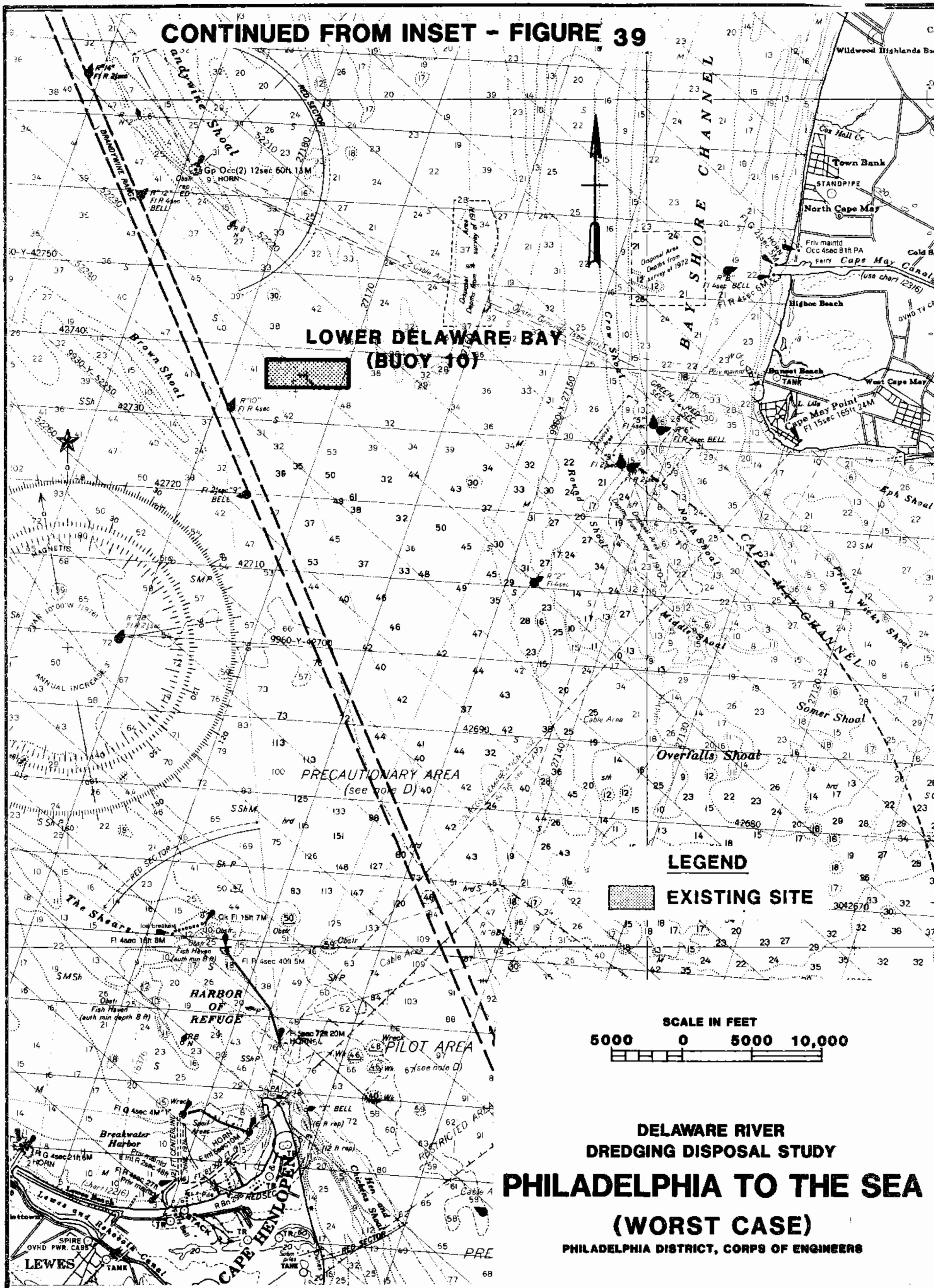


DELAWARE RIVER
DREDGING DISPOSAL STUDY

PHILADELPHIA TO THE SEA
(WORST CASE)

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 39



CONTINUED FROM INSET - FIGURE 39
LOWER DELAWARE BAY
(BUOY 10)
LEGEND
EXISTING SITE
SCALE IN FEET
5000 0 5000 10,000
DELAWARE RIVER
DREDGING DISPOSAL STUDY
PHILADELPHIA TO THE SEA
(WORST CASE)
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
BAYSHORE CHANNEL
CAPE MAY CHANNEL
PRECAUTIONARY AREA
PILOT AREA
HARBOR OF REFUGE
CAPE HENLOPEN
LEWES
Brandywine Shoal
Brown Shoal
Overfalls Shoal
Somer Shoal
Middle Shoal
North Shoal
Round Shoal
Crow Shoal
Eph Shoal
Prissy Wicks Shoal
Hen and Chickens Shoal
The Shears
Breakwater Harbor
Town Bank
North Cape May
Cape May Point
Sunset Beach
West Cape May
Higbee Beach
Cape May Canal
Wildwood Highlands Bch
Cox Hall Cr

FIGURE 40

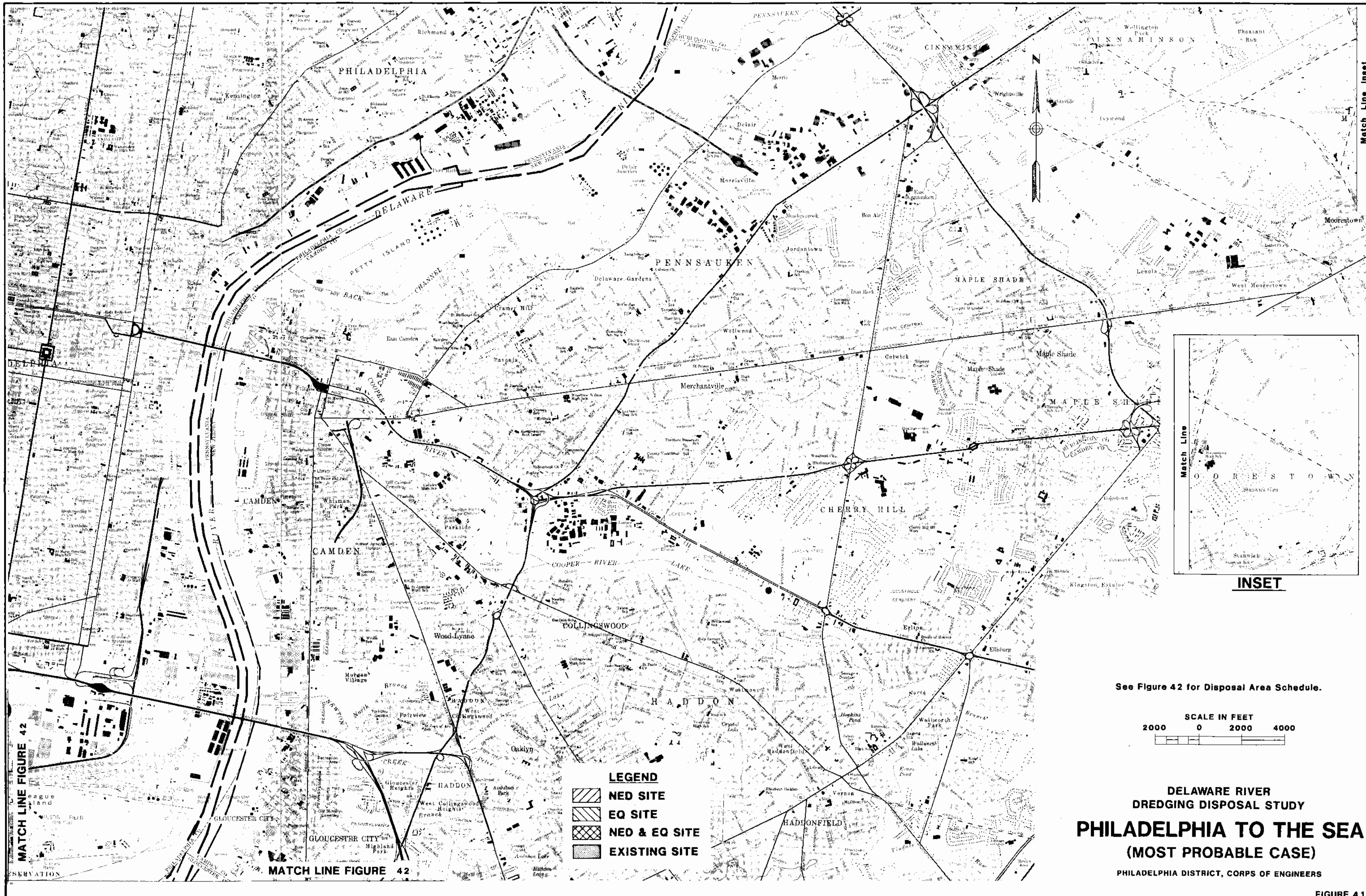
TABLE 25

DELAWARE RIVER, PHILADELPHIA TO THE SEA
MOST PROBABLE CASE CONDITION

SCENARIOS CONSIDERED

PLAN	DISPOSAL AREAS SELECTED SITES	DISPOSAL AREAS NEXT BEST (a)	RELATIVE COST INDEX (b)
NED	Existing Sites (c)		1.0
	11B		
	15D		
	16Q		
	17P		
	24CC		
		15G	
		20G	
EQ	Existing Sites (c)		1.1
	16T		
	16Y		
	17G		
		17I	
		21K	
EQ Ranking	Existing Sites (c)		1.1
	15M		
	16M		
	17I		
	20H		
	20J		
	21V		
		18A	
		24T	
Agency	Existing Sites (c)		1.1
	11D		
	11E		
	15M		
	16M		
	17C		
	20H		
	20J		
	21V		
		16N	
		23C	

(a) The site that would be chosen if the selected site becomes unavailable.
(b) This index is the multiplier in terms of cost using the cost of the NED scenario for the Most Probable plan as a base.
(c) As Shown in Table 11



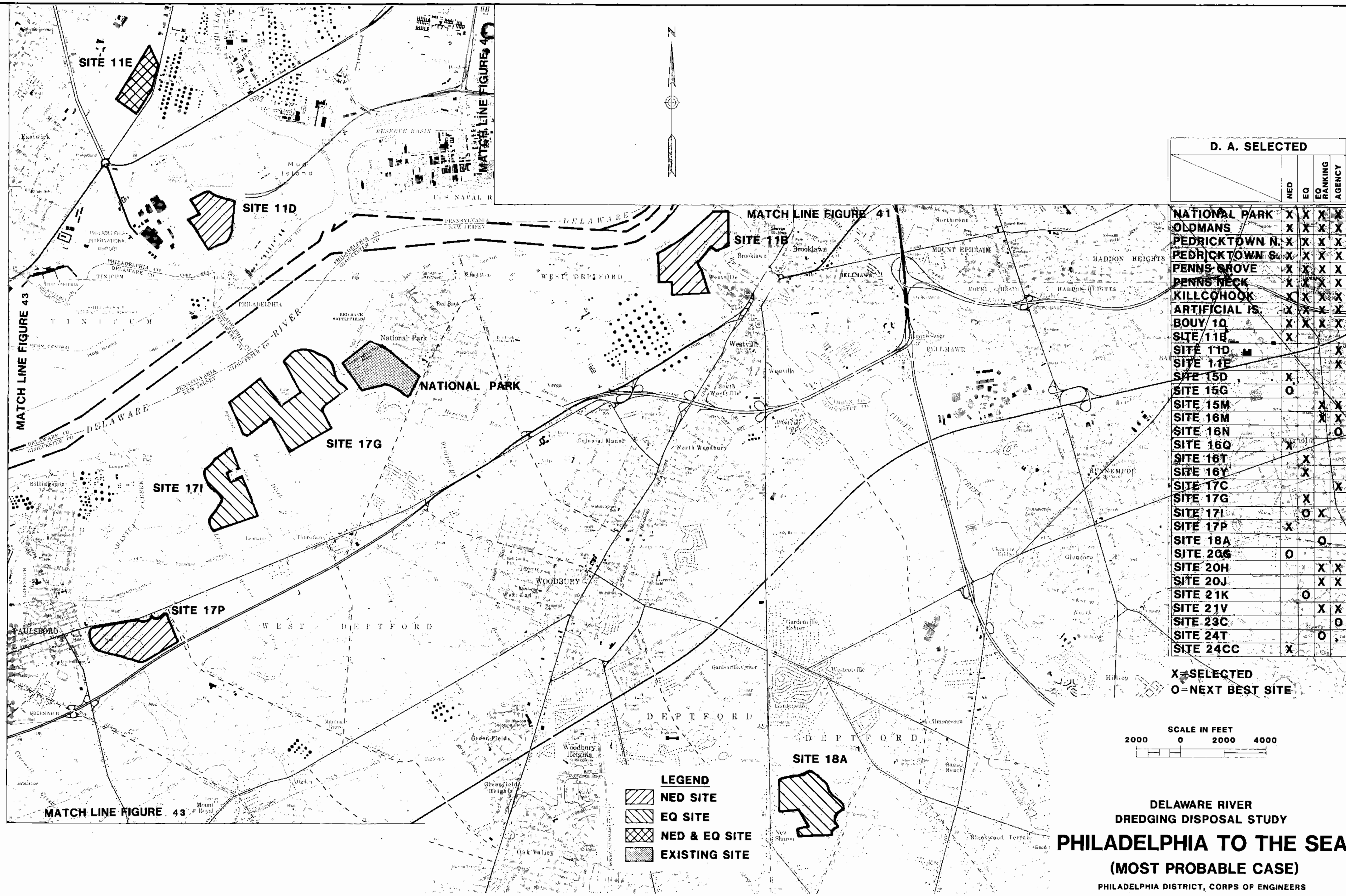
DELAWARE RIVER
DREDGING DISPOSAL STUDY

PHILADELPHIA TO THE SEA

(MOST PROBABLE CASE)

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 41



D. A. SELECTED	NED	EQ	EQ RANKING	AGENCY
NATIONAL PARK	X	X	X	X
OLDMANS	X	X	X	X
PEDRICKTOWN N.	X	X	X	X
PEDRICKTOWN S.	X	X	X	X
PENNS GROVE	X	X	X	X
PENNS NECK	X	X	X	X
KILLCOHOOK	X	X	X	X
ARTIFICIAL IS.	X	X	X	X
BOUY 10	X	X	X	X
SITE 11B	X			
SITE 11D				X
SITE 11E				X
SITE 15D	X			
SITE 15G	O			
SITE 15M			X	X
SITE 16M			X	X
SITE 16N				O
SITE 16Q	X			
SITE 16T		X		
SITE 16Y		X		
SITE 17C				X
SITE 17G		X		
SITE 17I		O	X	
SITE 17P	X			
SITE 18A			O	
SITE 20G	O			
SITE 20H			X	X
SITE 20J			X	X
SITE 21K		O		
SITE 21V			X	X
SITE 23C				O
SITE 24T			O	
SITE 24CC	X			

X=SELECTED
O=NEXT BEST SITE

DELAWARE RIVER
DREDGING DISPOSAL STUDY

PHILADELPHIA TO THE SEA

(MOST PROBABLE CASE)

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 42

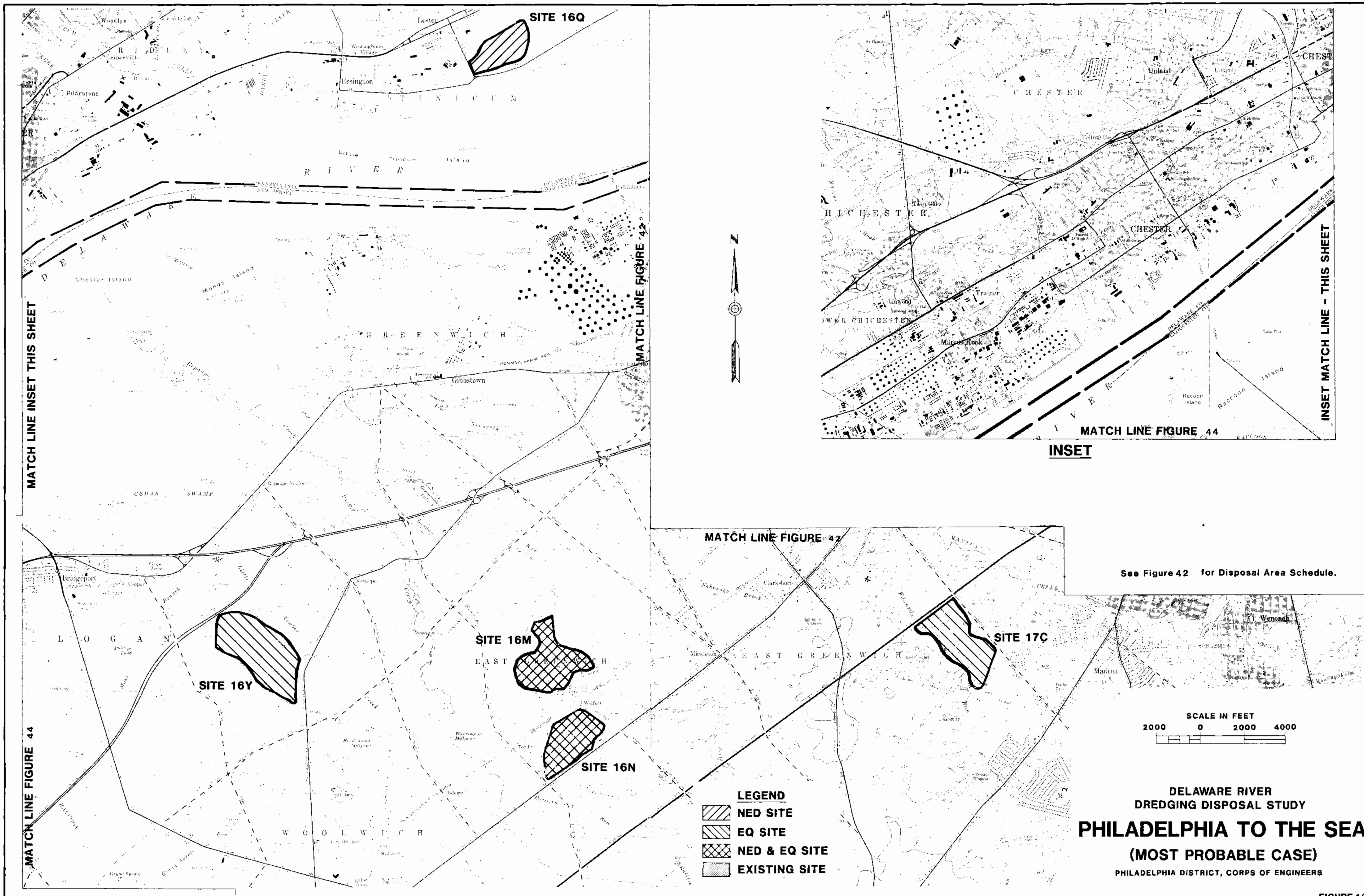
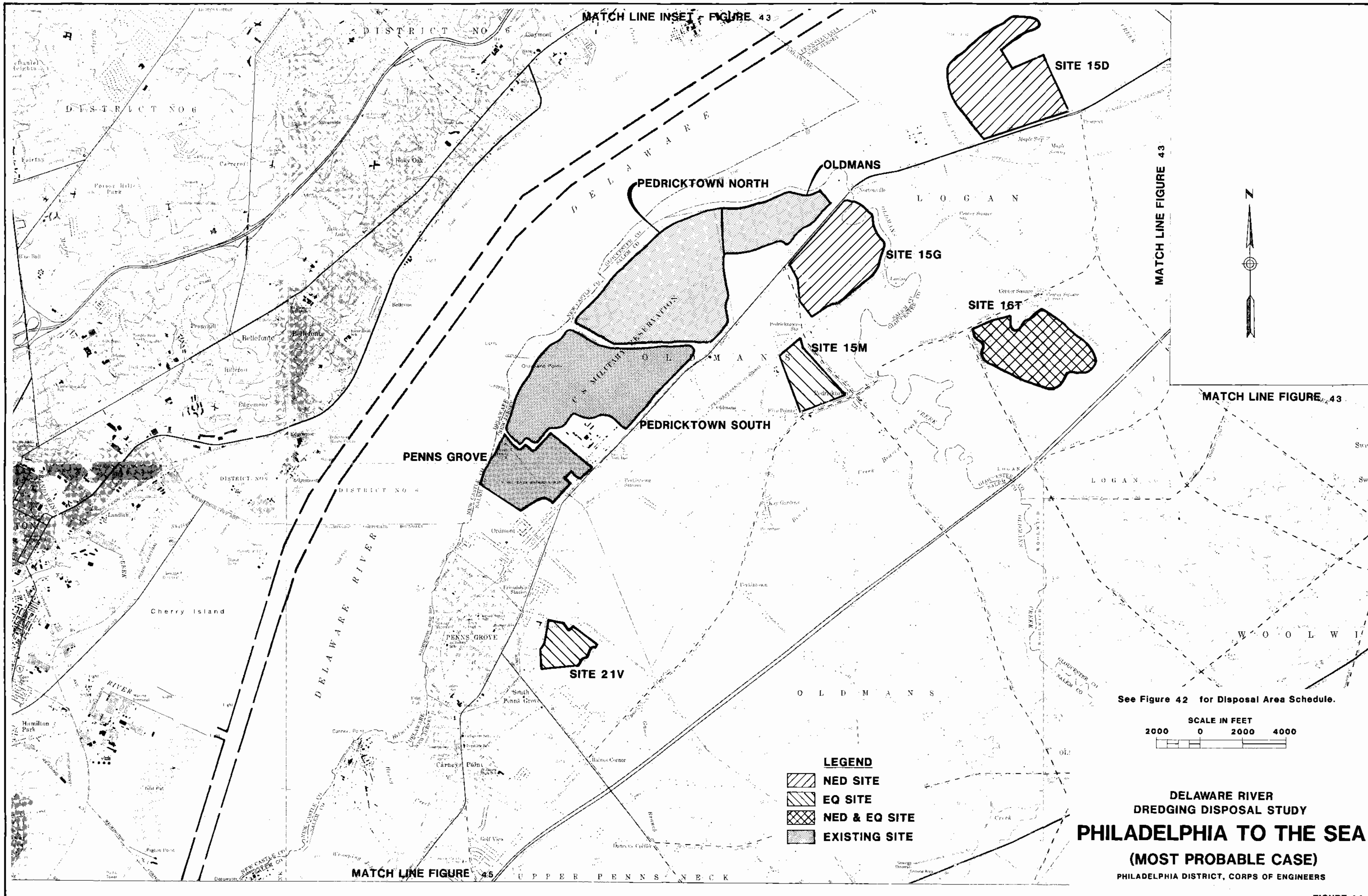

SITE 16Q
SITE 16M
SITE 16Y
SITE 16N
SITE 17C
MATCH LINE INSET THIS SHEET
MATCH LINE FIGURE 42
MATCH LINE FIGURE 44
INSET MATCH LINE - THIS SHEET
INSET
See Figure 42 for Disposal Area Schedule.
LEGEND
NED SITE
EQ SITE
NED & EQ SITE
EXISTING SITE
SCALE IN FEET
2000 0 2000 4000
DELAWARE RIVER
DREDGING DISPOSAL STUDY
PHILADELPHIA TO THE SEA
(MOST PROBABLE CASE)
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 43



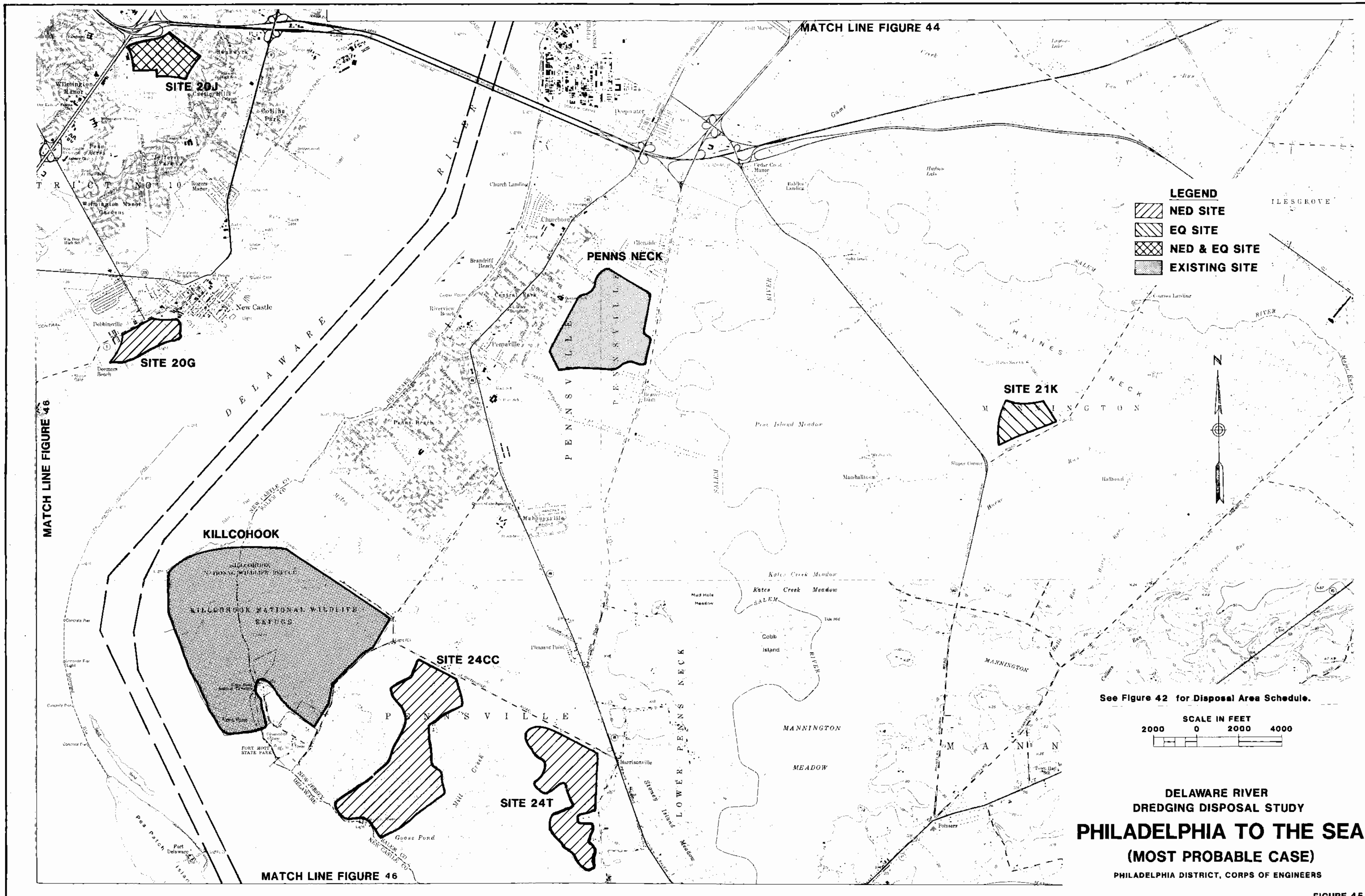
DELAWARE RIVER
DREDGING DISPOSAL STUDY

PHILADELPHIA TO THE SEA

(MOST PROBABLE CASE)

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 44



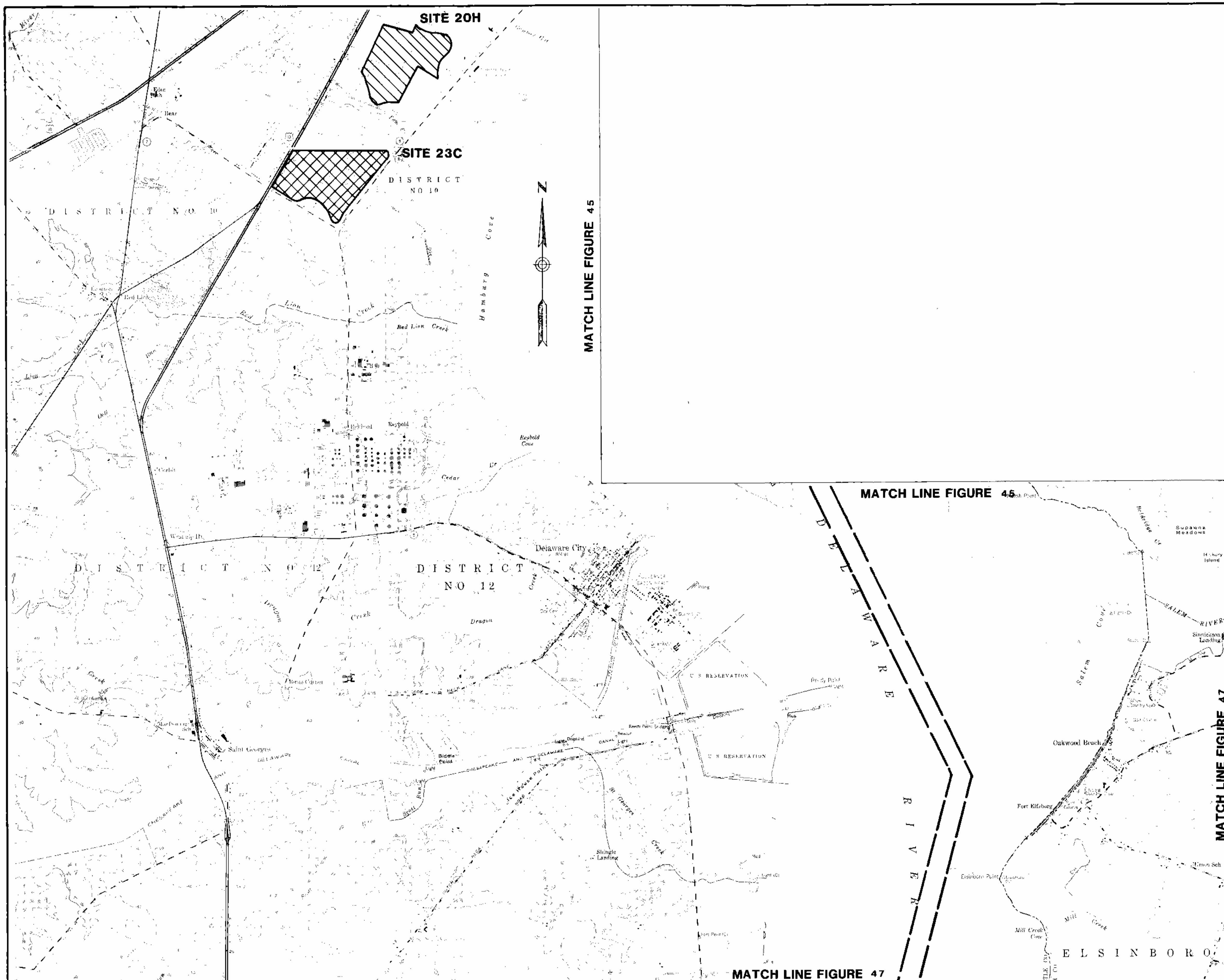
DELAWARE RIVER
DREDGING DISPOSAL STUDY

PHILADELPHIA TO THE SEA

(MOST PROBABLE CASE)

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 45



See Figure 42 for Disposal Area Schedule.

LEGEND

- NED SITE
- EQ SITE
- NED & EQ SITE
- EXISTING SITE

SCALE IN FEET

2000 0 2000 4000

DELAWARE RIVER
DREDGING DISPOSAL STUDY

PHILADELPHIA TO THE SEA

(MOST PROBABLE CASE)

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 46

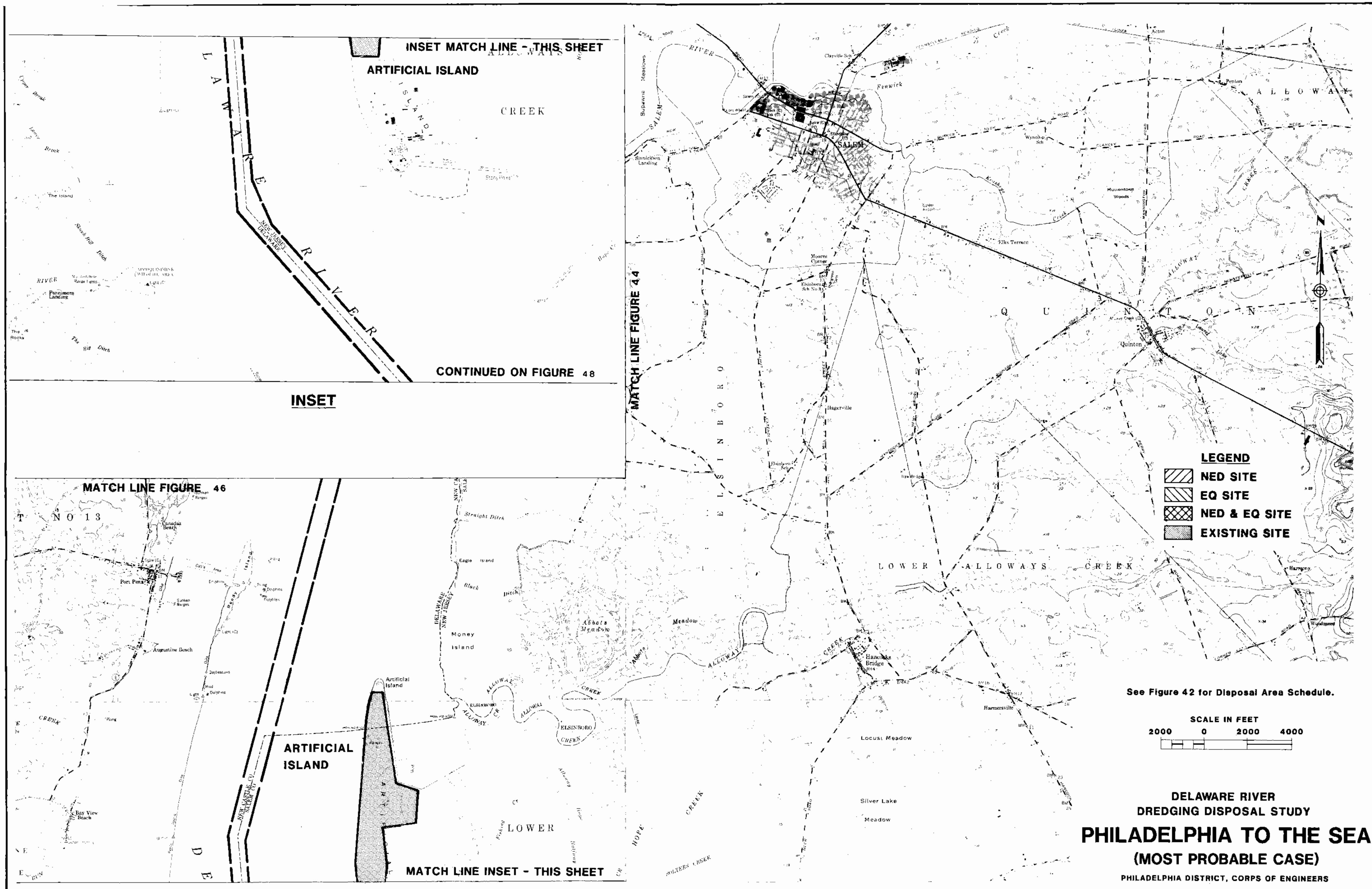

INSET MATCH LINE - THIS SHEET
ARTIFICIAL ISLAND
CREEK
DELAWARE RIVER
CONTINUED ON FIGURE 48
INSET
MATCH LINE FIGURE 46
MATCH LINE FIGURE 44
Port Penn
Augustine Beach
Bay View Beach
Money Island
ARTIFICIAL ISLAND
MATCH LINE INSET - THIS SHEET
SALEM
ELSINBORO
QUINTON
LOWER ALLOWAYS CREEK
ALLOWAYS
Hagerville
Hancocks Bridge
Harmersville
Locust Meadow
Silver Lake
LEGEND
NED SITE
EQ SITE
NED & EQ SITE
EXISTING SITE
See Figure 42 for Disposal Area Schedule.
SCALE IN FEET
2000 0 2000 4000
DELAWARE RIVER
DREDGING DISPOSAL STUDY
PHILADELPHIA TO THE SEA
(MOST PROBABLE CASE)
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 47

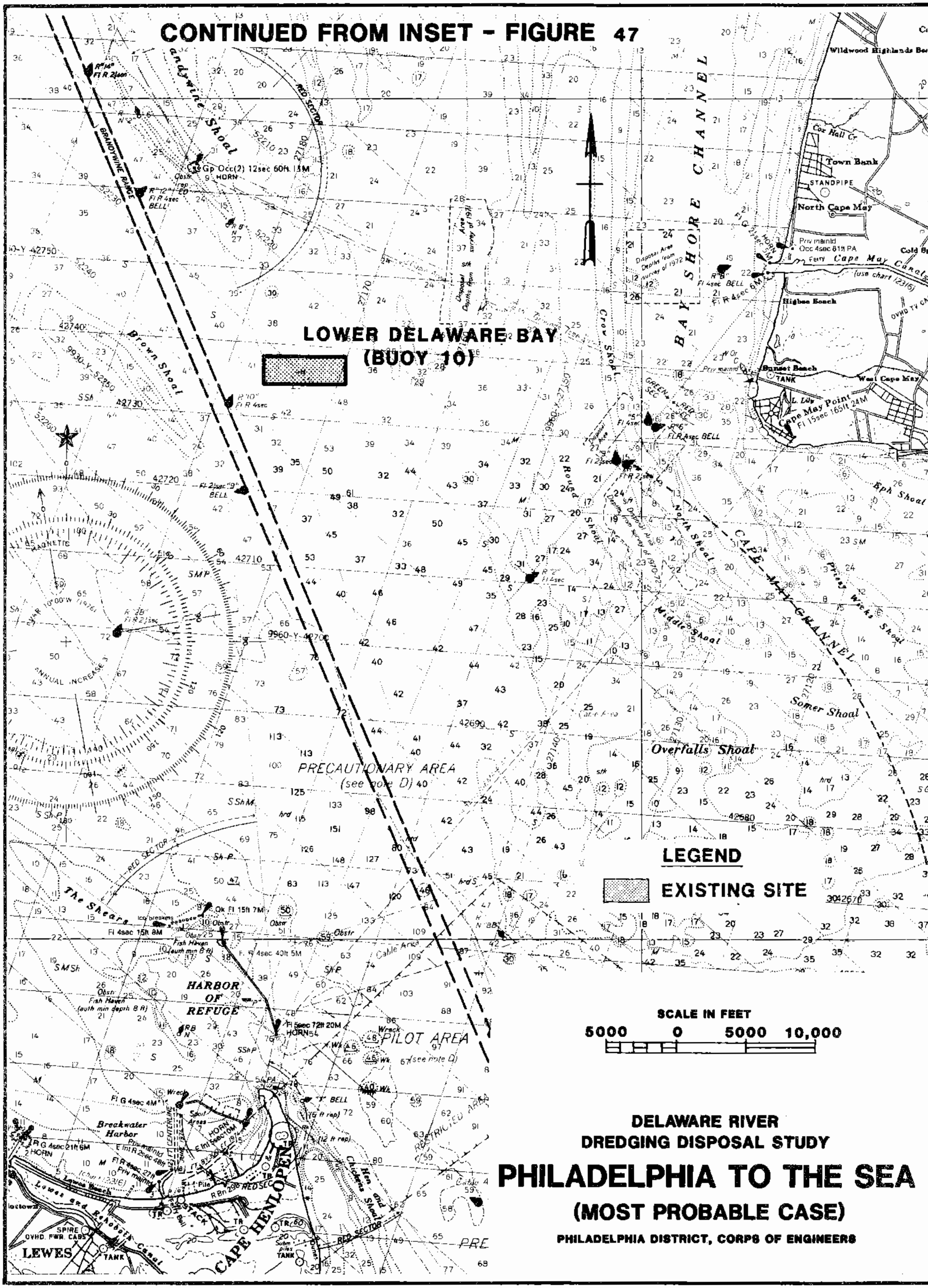

CONTINUED FROM INSET - FIGURE 47
LOWER DELAWARE BAY
(BUOY 10)
LEGEND
EXISTING SITE
SCALE IN FEET
5000 0 5000 10,000
DELAWARE RIVER
DREDGING DISPOSAL STUDY
PHILADELPHIA TO THE SEA
(MOST PROBABLE CASE)
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
Brandywine Shoal
BRANDYWINE RANGE
Brown Shoal
BAYSHORE CHANNEL
CAPE MAY CHANNEL
Crow Shoal
Round Shoal
North Shoal
Middle Shoal
Prissy Wicks Shoal
Somer Shoal
Overfalls Shoal
Eph Shoal
PRECAUTIONARY AREA
(see note D)
PILOT AREA
HARBOR OF REFUGE
The Shears
Breakwater Harbor
Hen and Chickens Shoal
CAPE HENLOPEN
LEWES
Lewes Beach
Lewes and Rehoboth Canal
Wildwood Highlands Beach
Cox Hall Cr
Town Bank
North Cape May
Cape May Canal
Higbee Beach
Sunset Beach
West Cape May
Cape May Point
RED SECTOR
RESTRICTED AREA

FIGURE 48

TABLE 26

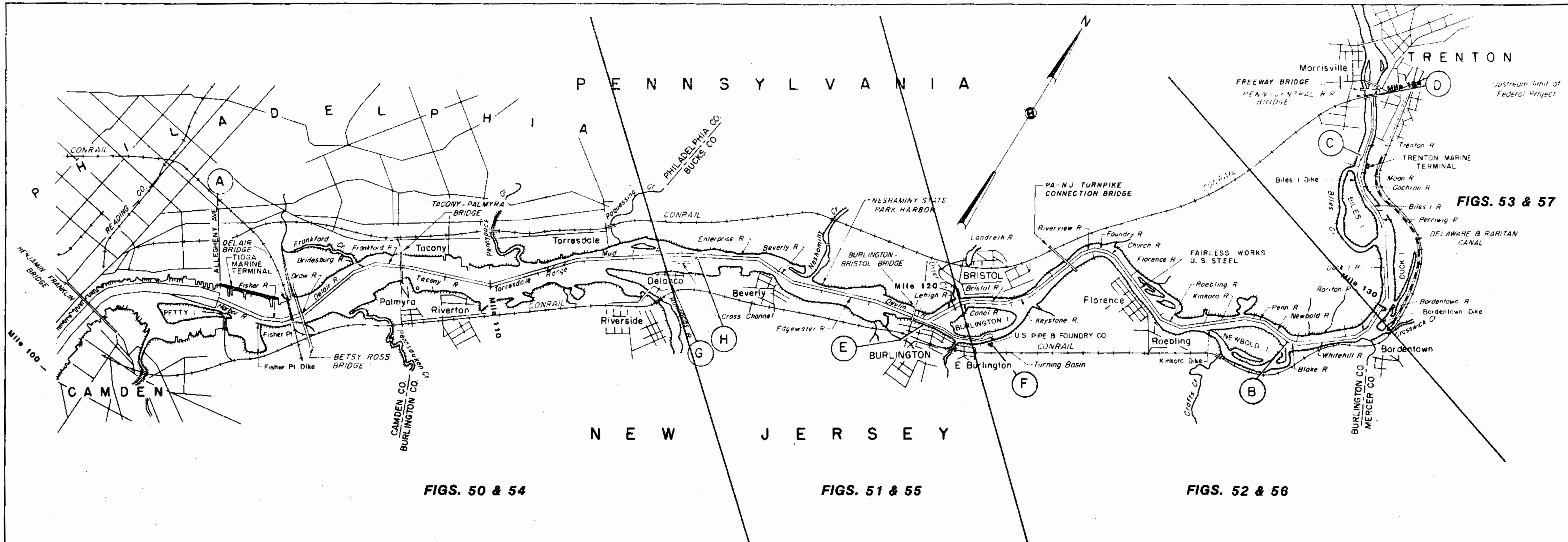
DELAWARE RIVER, PHILADELPHIA TO TRENTON
(Disposal sites to be provided by local sponsor)

WORST CASE CONDITION

SCENARIOS CONSIDERED

PLAN	DISPOSAL AREAS SELECTED SITES	NEXT BEST (a)	RELATIVE COST INDEX (b)
NED	Existing Sites (c)		2.4
	2K		
	3J		
	6C		
	6D		
	7A		
	12E		
		3M	
		7B	
EQ	Existing Sites (c)		4.9
	2C		
	2E		
	2K		
	3C		
	3F		
	6E		
	7B		
	7F		
	7N		
	8B		
	13B		
	13F		
		1C	
		13D	
EQ Ranking	Existing Sites (c)		5.0
	2K		
	3B		
	3C		
	3D		
	3M		
	7B		
	7M		
	8A		
	8B		
	13B		
	13F		
		7L	
Agency	Existing Sites (c)		5.2
	2A		
	2K		
	3A		
	3B		
	3C		
	7B		
	7M		
	8B		
	13B		
	13C		
		7L	

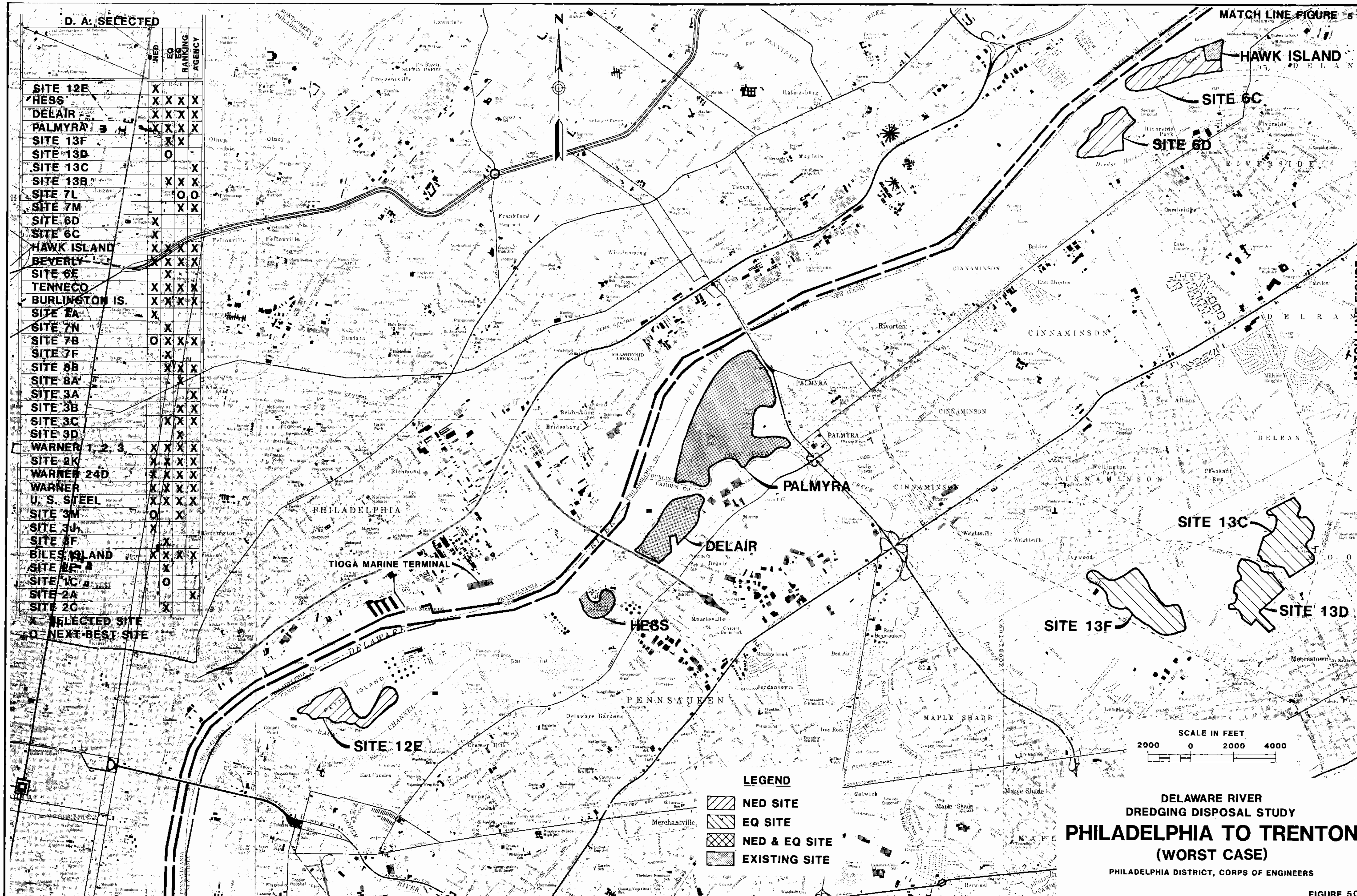
(a) The site that would be chosen if the selected site becomes unavailable.
(b) This index is the multiplier in terms of cost using the cost of the NED scenario for the Most Probable plan as a base.
(c) As Shown in Table 14



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.	200 FT.

DELAWARE RIVER
DREDGING DISPOSAL STUDY
DELAWARE RIVER
PHILADELPHIA, PA. TO TRENTON, NJ.
INDEX MAP
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 49



D. A. SELECTED

	NED	EQ	EQ RANKING	AGENCY
SITE 12E	X			
HESS	X	X	X	X
DELAIR	X	X	X	X
PALMYRA	X	X	X	X
SITE 13F		X	X	
SITE 13D		O		
SITE 13C				X
SITE 13B		X	X	X
SITE 7L			O	O
SITE 7M			X	X
SITE 6D	X			
SITE 6C	X			
HAWK ISLAND	X	X	X	X
BEVERLY	X	X	X	X
SITE 6E		X		
TENNECO	X	X	X	X
BURLINGTON IS.	X	X	X	X
SITE [illegible]A	X			
SITE 7N		X		
SITE 7B	O	X	X	X
SITE 7F		X		
SITE 8B		X	X	X
SITE 8A			X	
SITE 3A				X
SITE 3B			X	X
SITE 3C		X	X	X
SITE 3D			X	
WARNER 1, 2, 3	X	X	X	X
SITE 2K	X	X	X	X
WARNER 24D	X	X	X	X
WARNER	X	X	X	X
U. S. STEEL	X	X	X	X
SITE 3M	O		X	
SITE 3J	X			
SITE [illegible]F		X		
BILES ISLAND	X	X	X	X
SITE [illegible]		X		
SITE 1C		O		
SITE 2A				X
SITE 2C		X		

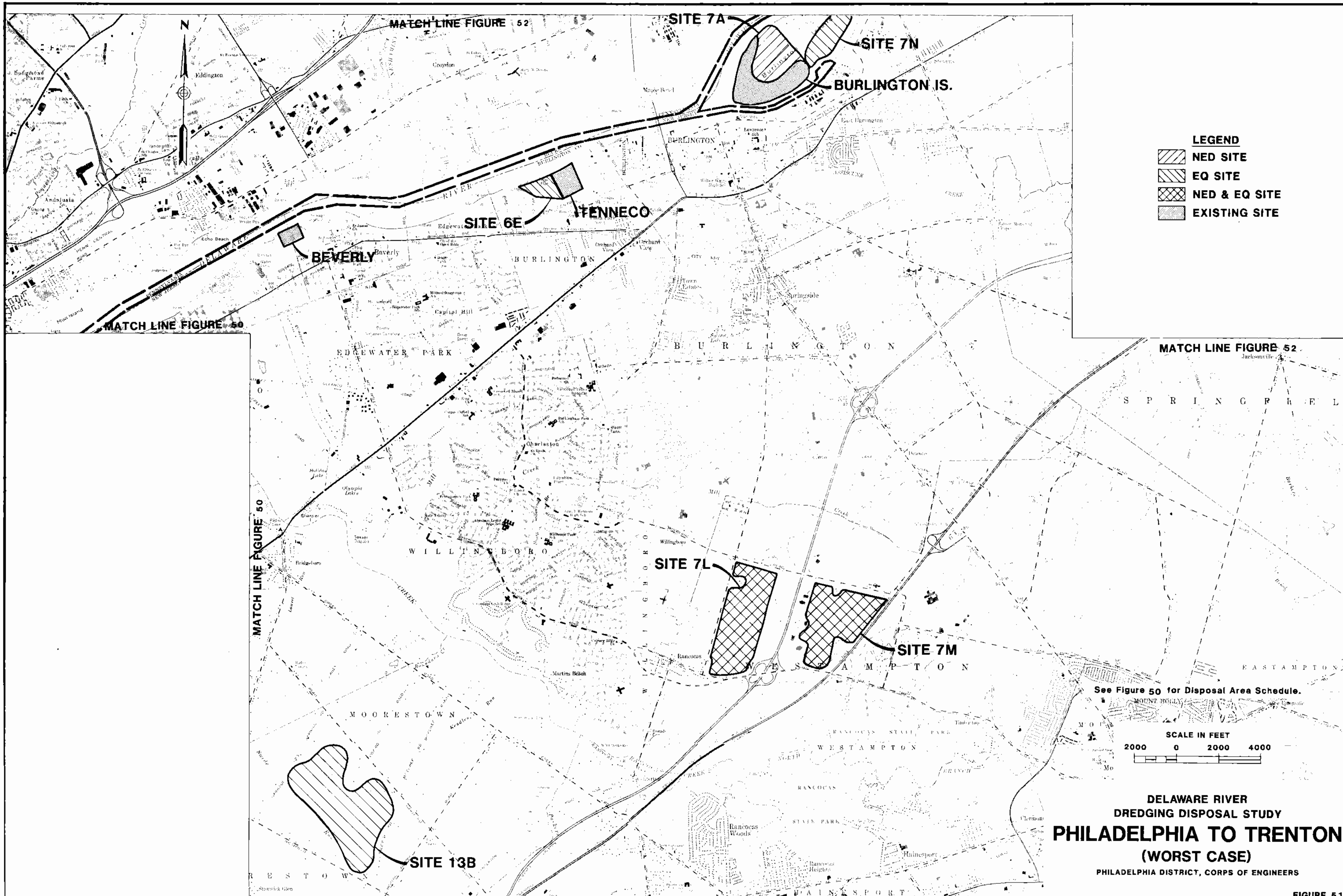
X = SELECTED SITE
O = NEXT-BEST SITE

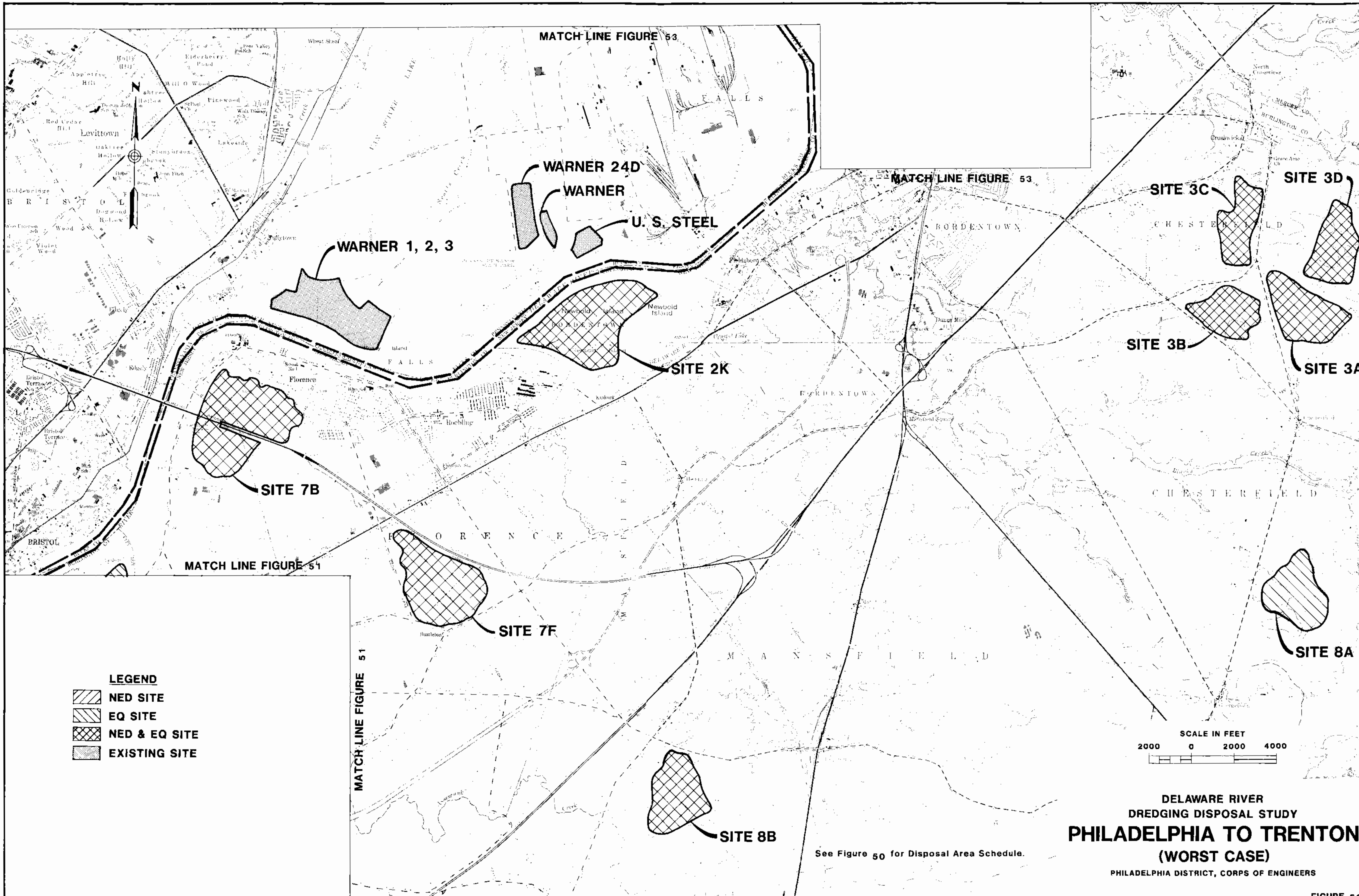
DELAWARE RIVER
DREDGING DISPOSAL STUDY

PHILADELPHIA TO TRENTON
(WORST CASE)

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

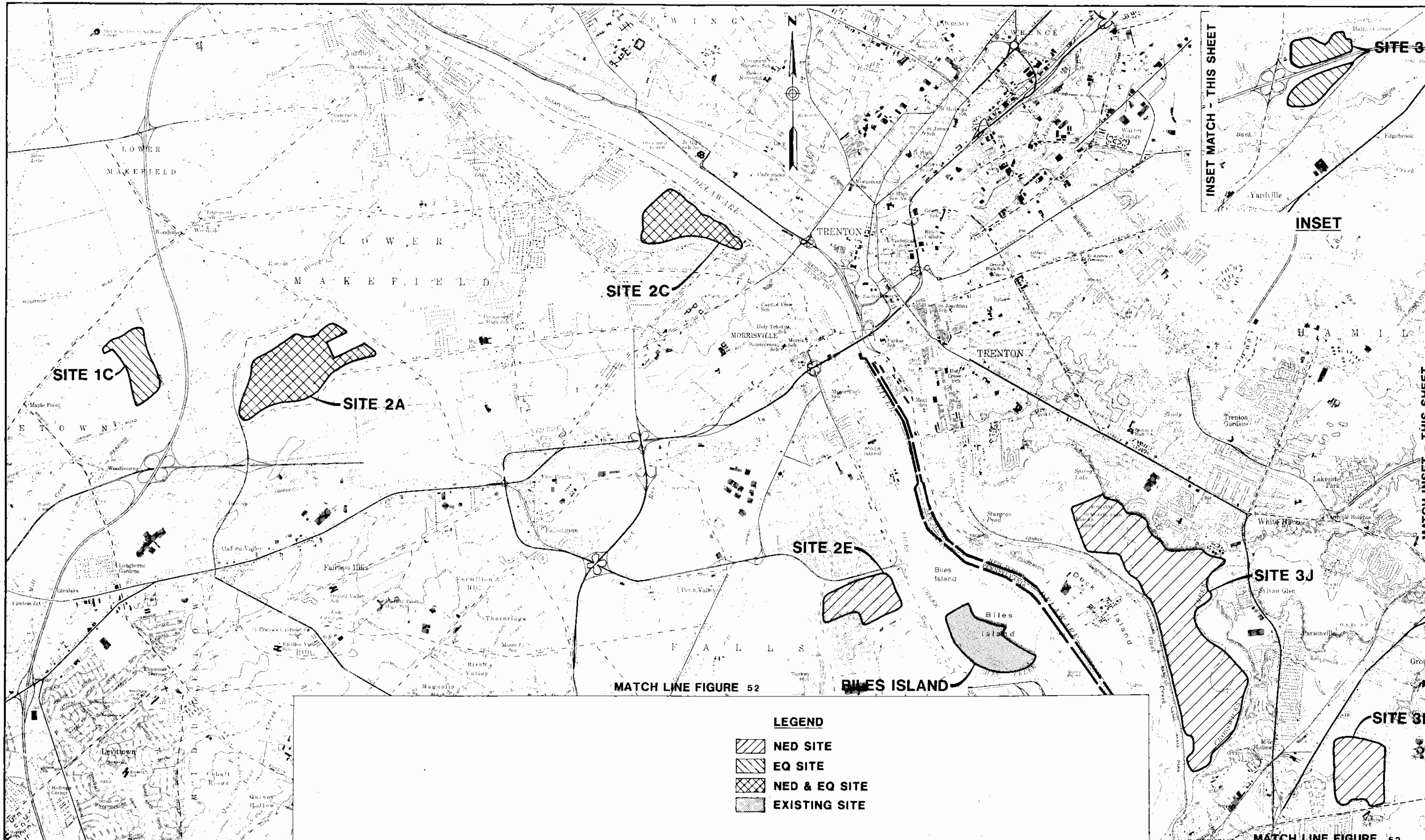
FIGURE 50


MATCH LINE FIGURE 52
SITE 7A
SITE 7N
BURLINGTON IS.
LEGEND
NED SITE
EQ SITE
NED & EQ SITE
EXISTING SITE
SITE 6E
TENNECO
BEVERLY
MATCH LINE FIGURE 50
MATCH LINE FIGURE 52
MATCH LINE FIGURE 50
SITE 7L
SITE 7M
SITE 13B
See Figure 50 for Disposal Area Schedule.
SCALE IN FEET
2000 0 2000 4000
DELAWARE RIVER
DREDGING DISPOSAL STUDY
PHILADELPHIA TO TRENTON
(WORST CASE)
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
FIGURE 51



DELAWARE RIVER
DREDGING DISPOSAL STUDY
PHILADELPHIA TO TRENTON
(WORST CASE)
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 52



DELAWARE RIVER
DREDGING DISPOSAL STUDY

PHILADELPHIA TO TRENTON
(WORST CASE)

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 53

TABLE 27

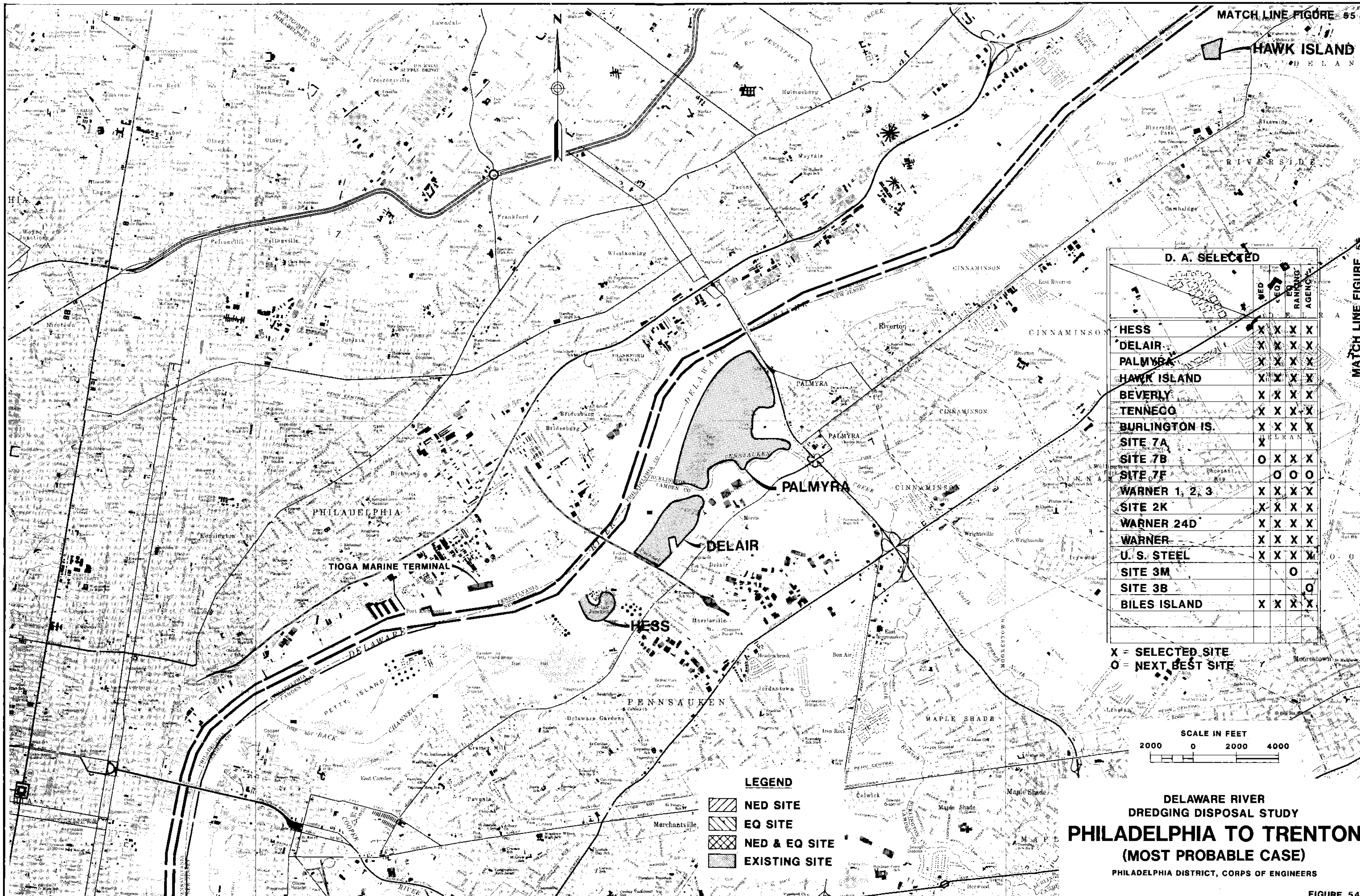
DELAWARE RIVER, PHILADELPHIA TO TRENTON
(Disposal sites to be provided by local sponsor)

MOST PROBABLE CASE CONDITION

SCENARIOS CONSIDERED

PLAN	DISPOSAL AREAS SELECTED SITES	DISPOSAL AREAS NEXT BEST (a)	RELATIVE COST INDEX (b)
NED	Existing Sites (c) 7A 2K	7B	1.0
EQ, EQ Ranking, Agency	Existing Sites (c) 7B 2K	7F (EQ, EQ Ranking, Agency) 3M (Ranking) 3B (Agency)	1.1

(a) The site that would be chosen if the selected site becomes unavailable.
(b) This index is the multiplier in terms of cost using the cost of the NED scenario for the Most Probable plan as a base.
(c) As shown in Table 14



D. A. SELECTED	NED	EQ	EQ RANKING	AGENCY
HESS	X	X	X	X
DELAIR	X	X	X	X
PALMYRA	X	X	X	X
HAWK ISLAND	X	X	X	X
BEVERLY	X	X	X	X
TENNECO	X	X	X	X
BURLINGTON IS.	X	X	X	X
SITE 7A	X			
SITE 7B	O	X	X	X
SITE 7F		O	O	O
WARNER 1, 2, 3	X	X	X	X
SITE 2K	X	X	X	X
WARNER 24D	X	X	X	X
WARNER	X	X	X	X
U. S. STEEL	X	X	X	X
SITE 3M			O	
SITE 3B				O
BILES ISLAND	X	X	X	X

X = SELECTED SITE
O = NEXT BEST SITE

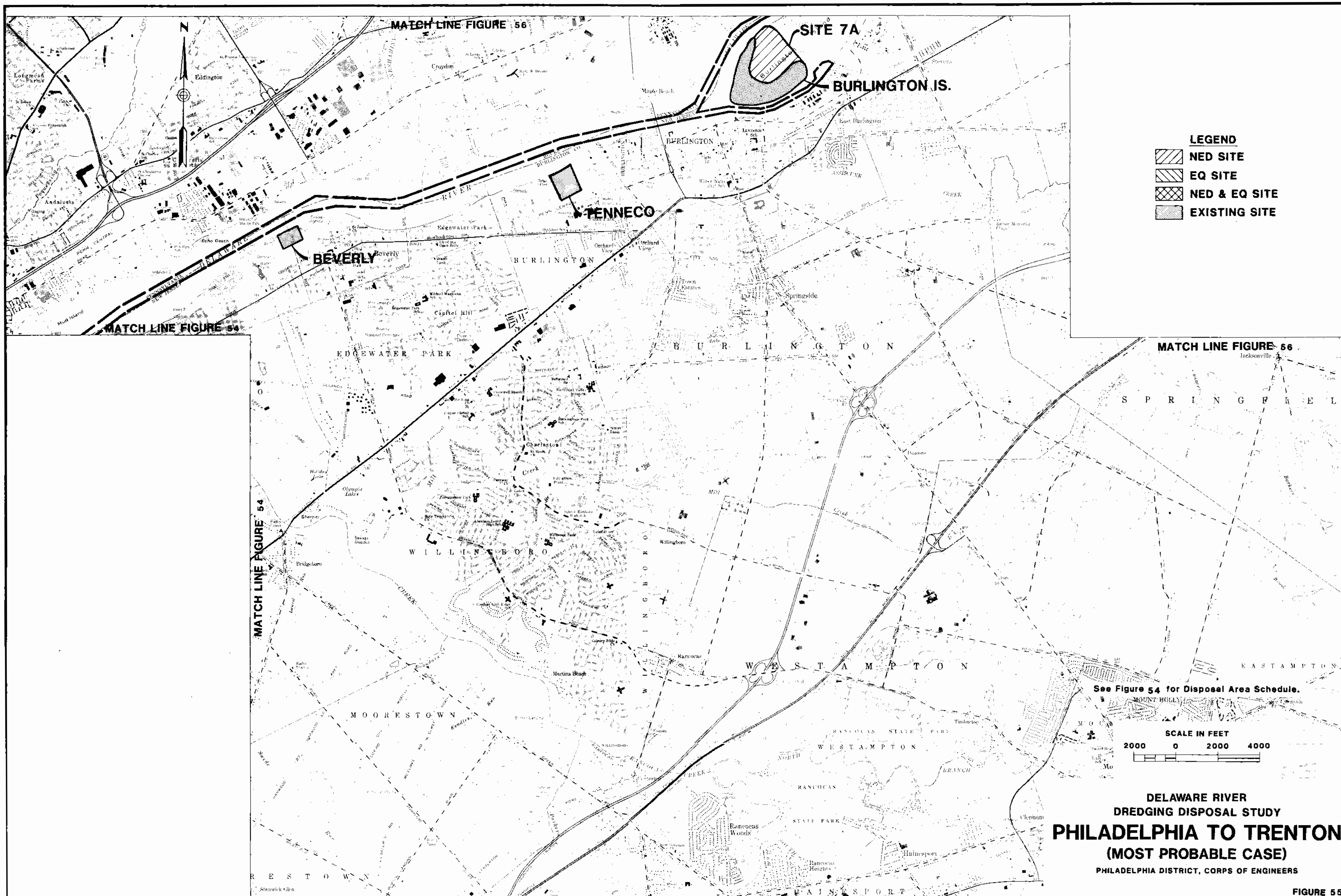
DELAWARE RIVER
DREDGING DISPOSAL STUDY

PHILADELPHIA TO TRENTON

(MOST PROBABLE CASE)

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 54

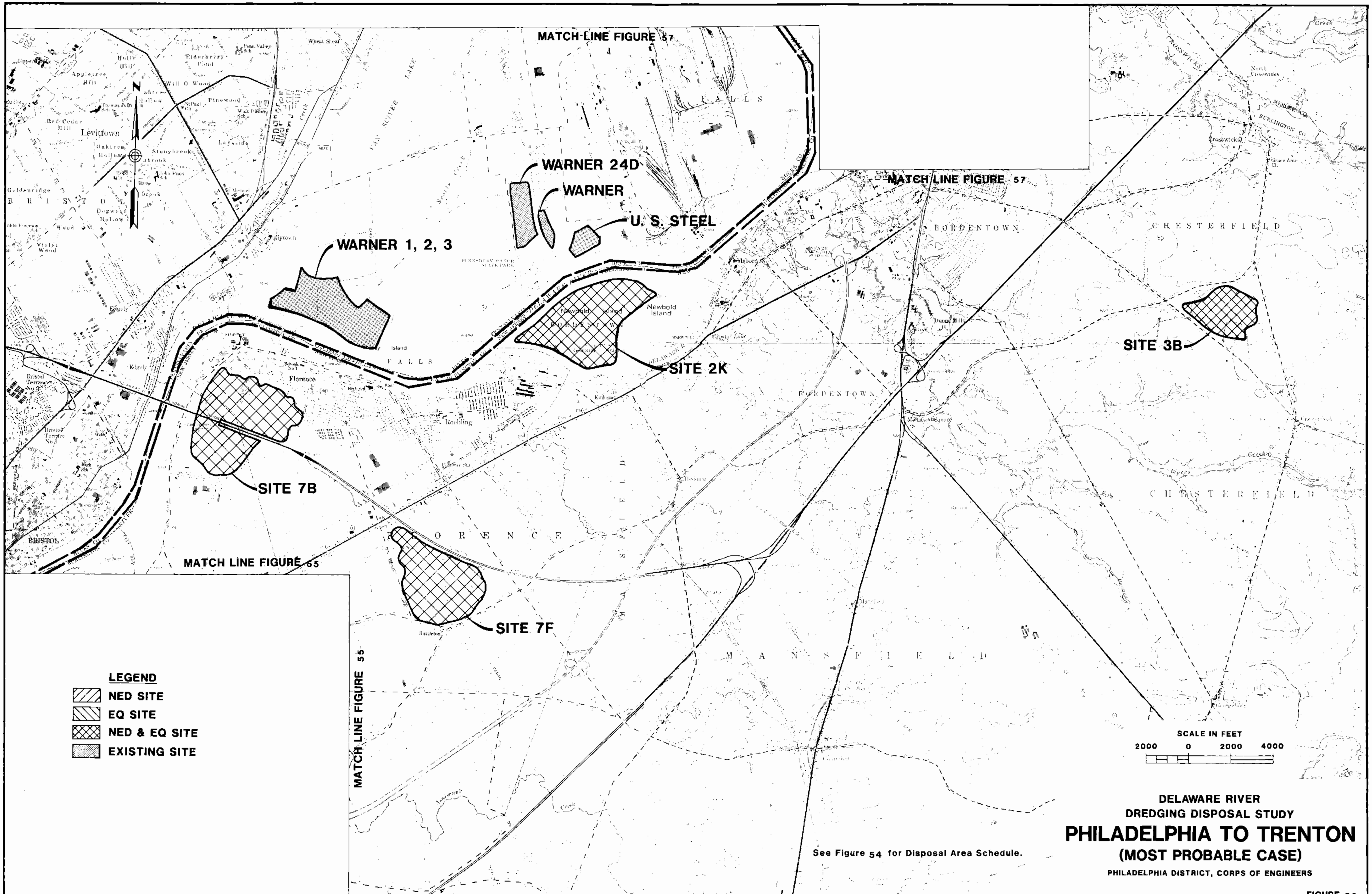


DELAWARE RIVER DREDGING DISPOSAL STUDY

PHILADELPHIA TO TRENTON (MOST PROBABLE CASE)

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 55



See Figure 54 for Disposal Area Schedule.

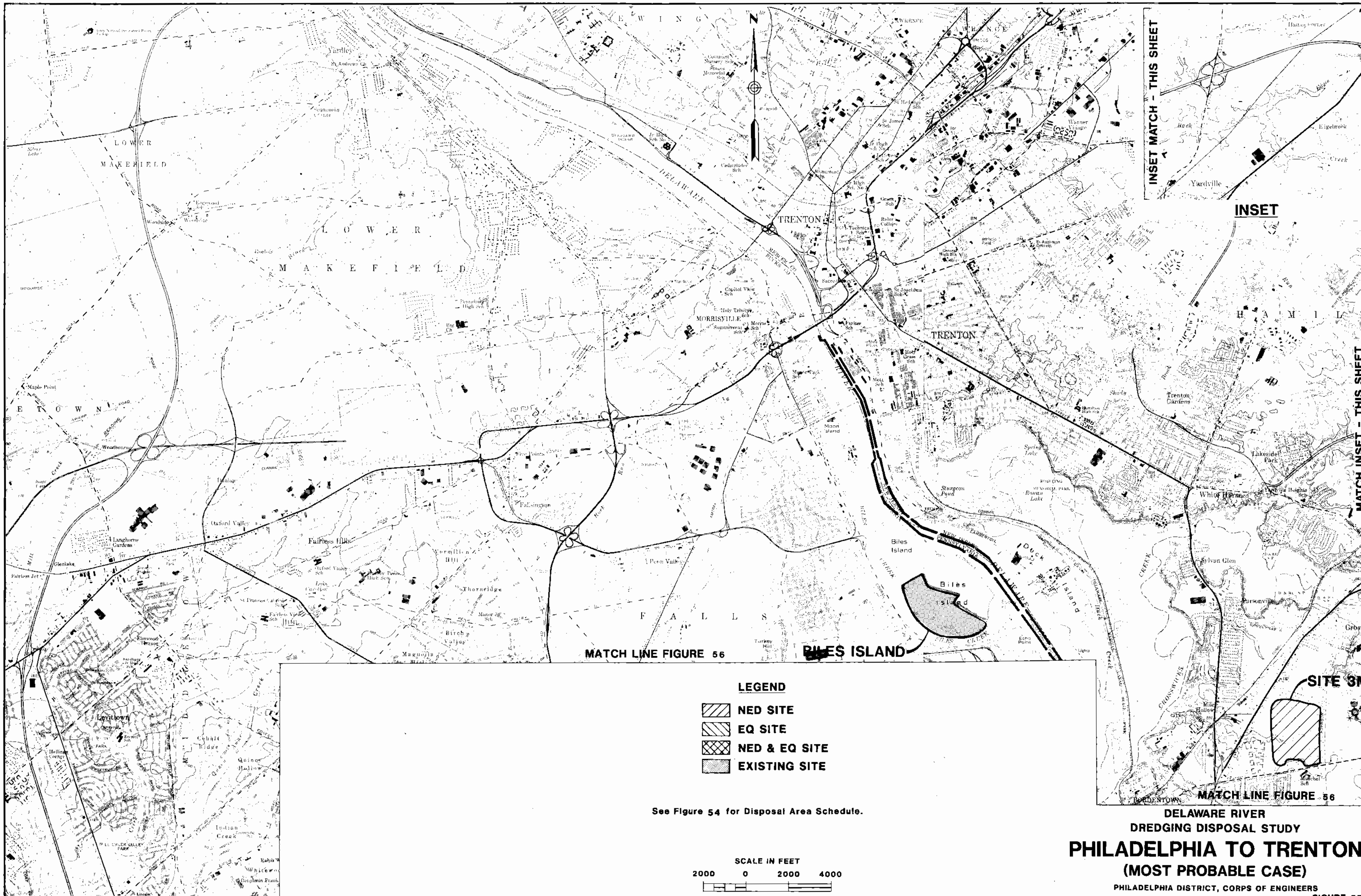
DELAWARE RIVER
DREDGING DISPOSAL STUDY

PHILADELPHIA TO TRENTON

(MOST PROBABLE CASE)

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 56



DELAWARE RIVER
DREDGING DISPOSAL STUDY

PHILADELPHIA TO TRENTON
(MOST PROBABLE CASE)

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 57

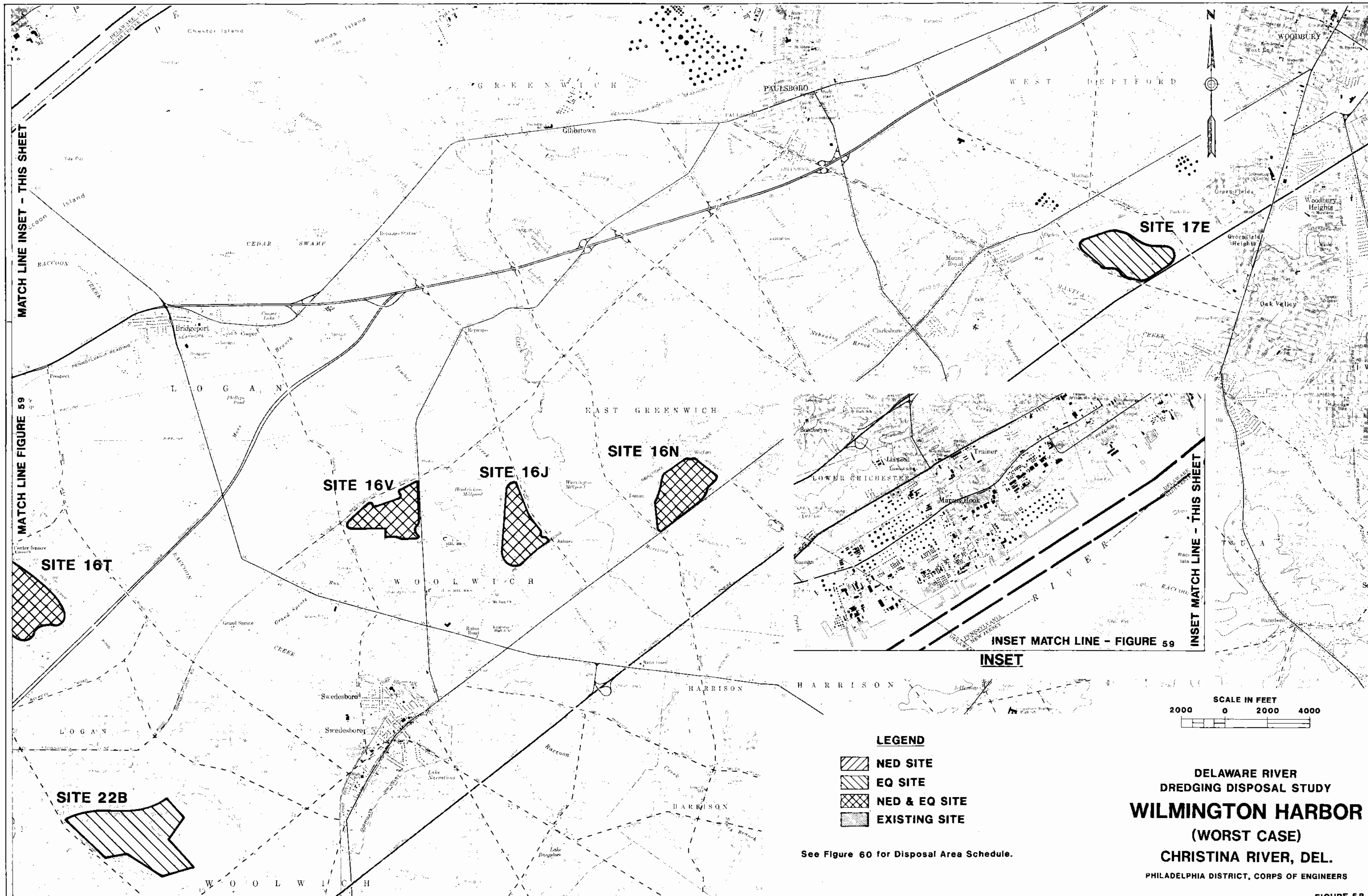
TABLE 28

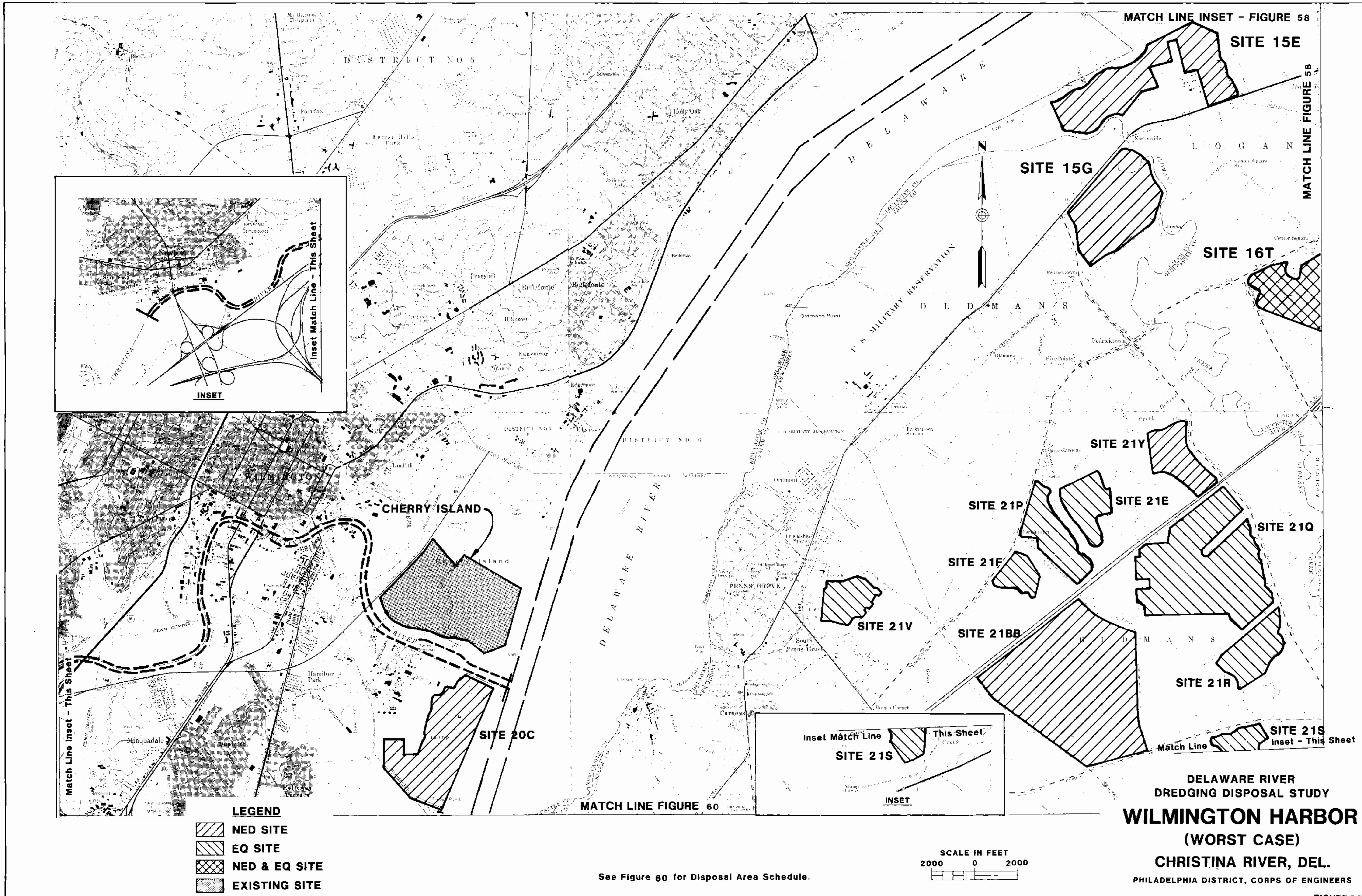
WILMINGTON HARBOR, CHRISTINA RIVER, DELAWARE
WORST CASE CONDITION

SCENARIOS CONSIDERED

PLAN	DISPOSAL AREAS SELECTED SITES	DISPOSAL AREAS NEXT BEST (a)	RELATIVE COST INDEX (b)
NED	Cherry Island		2.3
	20C		
	20E		
	21FF		
	21BB		
		20P	
EQ	Cherry Island		4.0
	21E		
	21Q		
	21R		
	21M		
	21F		
	21H		
	21P		
	21S		
	21V		
	21Y		
		(c)	
EQ Ranking	Cherry Island		4.0
	16N		
	16T		
	16V		
	17E		
	21K		
	21L		
	21M		
	22B		
	24P		
		16J	
Agency	Cherry Island		4.9
	15E		
	15G		
	21Y		
	23L		
		23A	

(a) The site that would be chosen if the selected site becomes unavailable.
(b) This index is the multiplier in terms of cost using the cost of the NED scenario for the Most Probable plan as a base.
(c) Not considered since the heavy demands of the Philadelphia to the Sea project selected most reasonable sites. Could be selected at a later date.


MATCH LINE INSET - THIS SHEET
MATCH LINE FIGURE 59
SITE 17E
SITE 16N
SITE 16J
SITE 16V
SITE 16T
SITE 22B
PAULSBORO
Gibbstown
Bridgeport
Swedesboro
WOODBURY
G R E E N W I C H
W E S T   D E P T F O R D
E A S T   G R E E N W I C H
L O G A N
W O O L W I C H
H A R R I S O N
CEDAR SWAMP
Chester Island
INSET MATCH LINE - FIGURE 59
INSET MATCH LINE - THIS SHEET
INSET
Marcus Hook
Trainer
Linwood
LOWER CHICHESTER
R I V E R
SCALE IN FEET
2000 0 2000 4000
LEGEND
NED SITE
EQ SITE
NED & EQ SITE
EXISTING SITE
See Figure 60 for Disposal Area Schedule.
DELAWARE RIVER
DREDGING DISPOSAL STUDY
WILMINGTON HARBOR
(WORST CASE)
CHRISTINA RIVER, DEL.
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
FIGURE 58



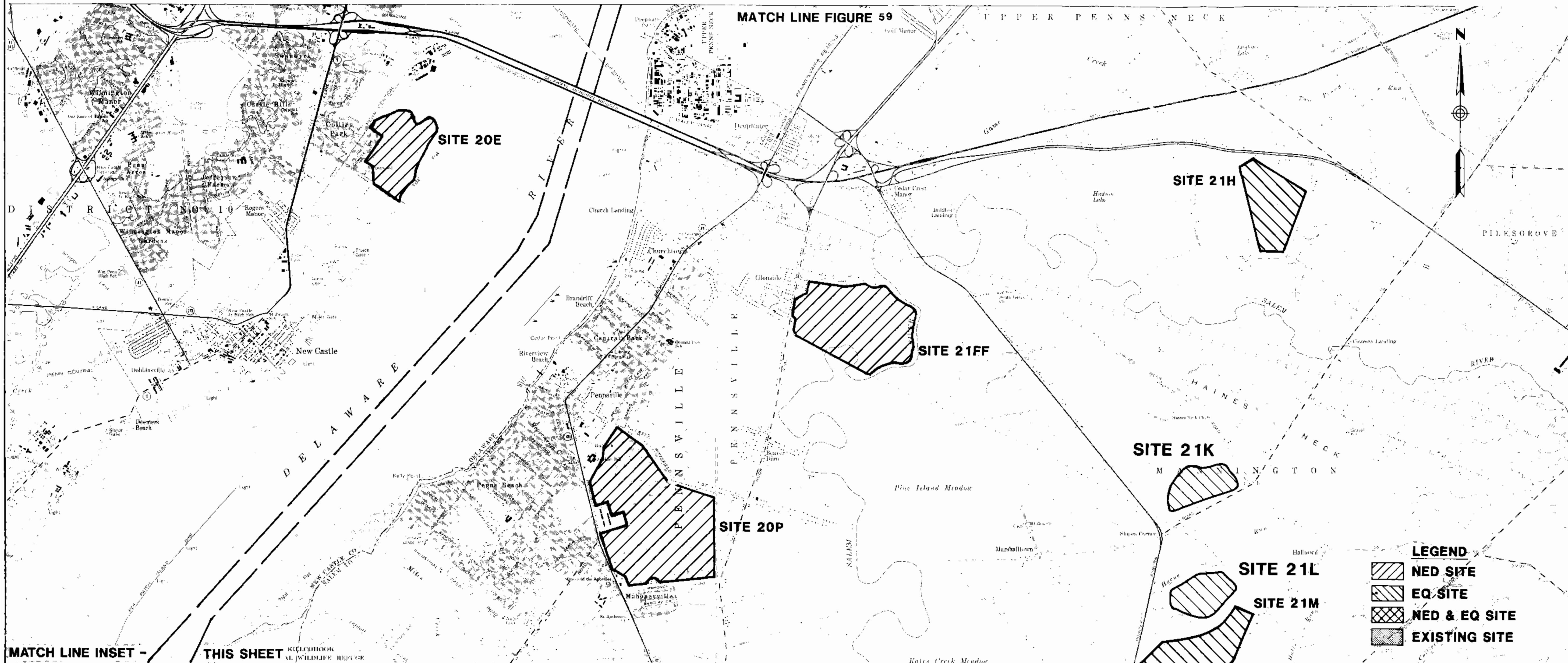
See Figure 60 for Disposal Area Schedule.

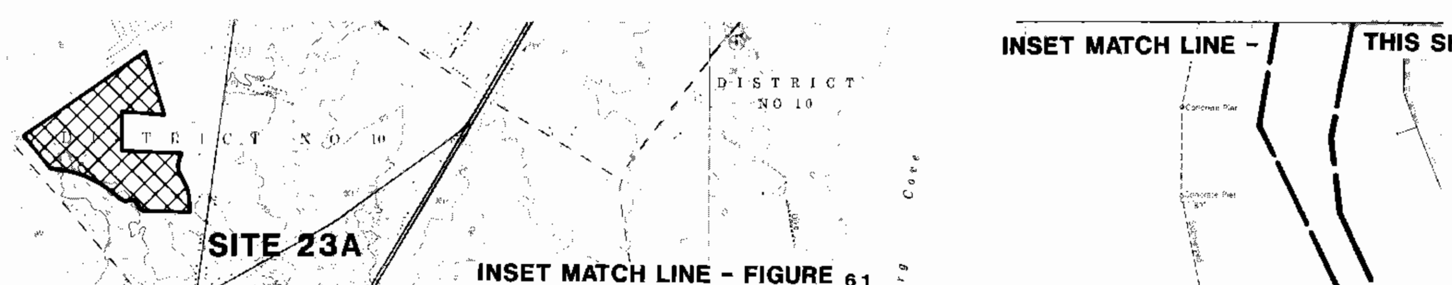
DELAWARE RIVER
DREDGING DISPOSAL STUDY

WILMINGTON HARBOR
(WORST CASE)
CHRISTINA RIVER, DEL.

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 59





INSET

D. A. SELECTED	NED	EQ	EQ RANKING	AGENCY
CHERRY IS.	X	X		
SITE 20C	X			
SITE 20E	X			
SITE 20P	O			
SITE 21E		X		
SITE 21F		X		
SITE 21H		X		
SITE 21M		X		
SITE 21P		X		
SITE 21Q		X		
SITE 21R		X		
SITE 21S		X		
SITE 21V		X		
SITE 21Y		X		
SITE 21BB	X	O		
SITE 21FF	X			

D. A. SELECTED	NED	EQ	EQ RANKING	AGENCY
SITE 15E				X
SITE 15G				X
SITE 16J			O	
SITE 16N			X	
SITE 16T			X	
SITE 16V			X	
SITE 17E			X	
SITE 21K			X	
SITE 21L			X	
SITE 22B			X	
SITE 23A				O
SITE 23L				X
SITE 24P			X	

X = SELECTED SITE
O = NEXT BEST SITE

SCALE IN FEET
2000 0 2000

DELAWARE RIVER
DREDGING DISPOSAL STUDY

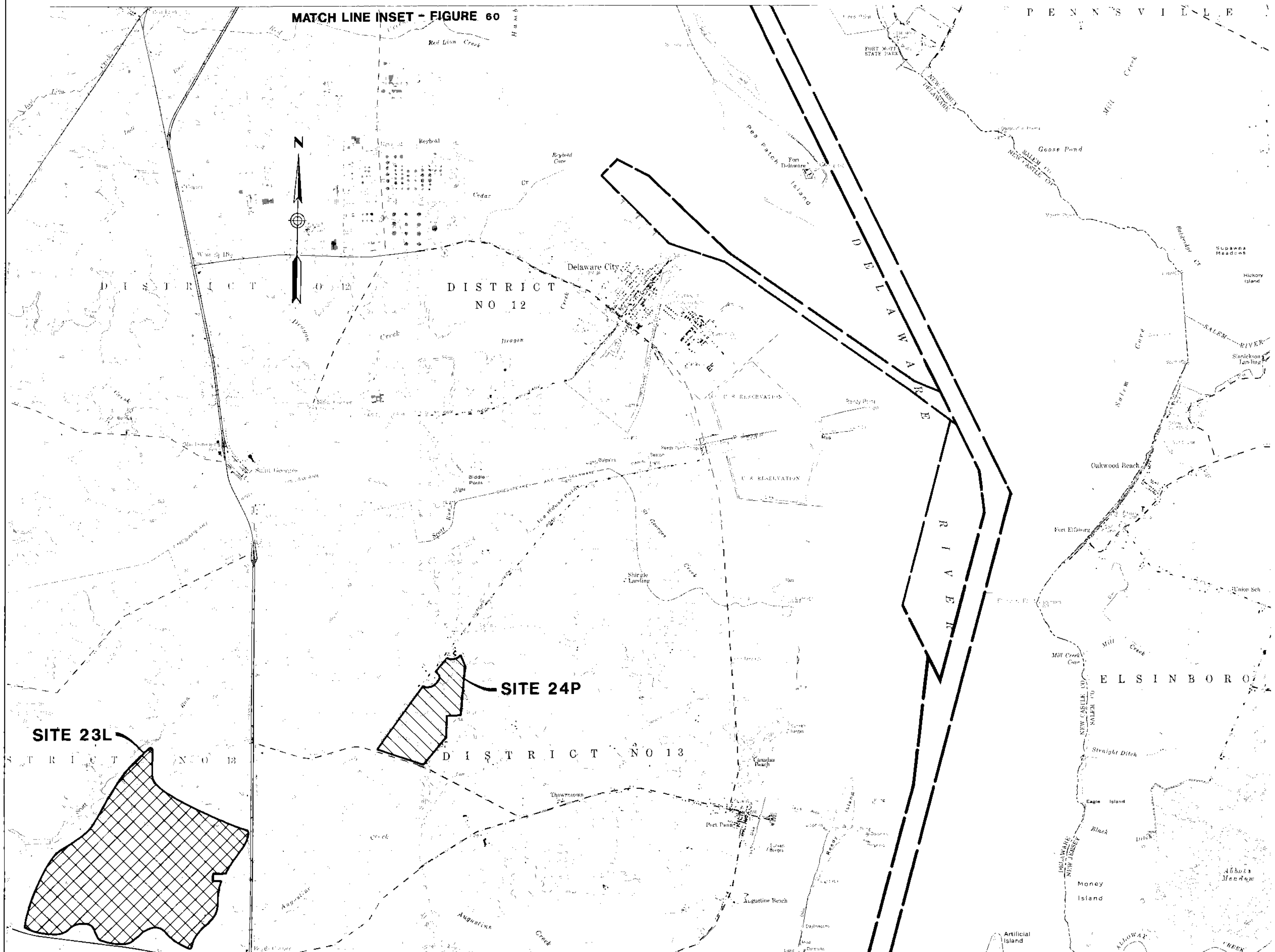
WILMINGTON HARBOR

(WORST CASE)

CHRISTINA RIVER, DEL.

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 60



See Figure 60 for Disposal Area Schedule.

LEGEND

- NED SITE
- EQ SITE
- NED & EQ SITE
- EXISTING SITE

SCALE IN FEET

2000 0 2000 4000

DELAWARE RIVER
DREDGING DISPOSAL STUDY

WILMINGTON HARBOR
(WORST CASE)
CHRISTINA RIVER, DEL.

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 61

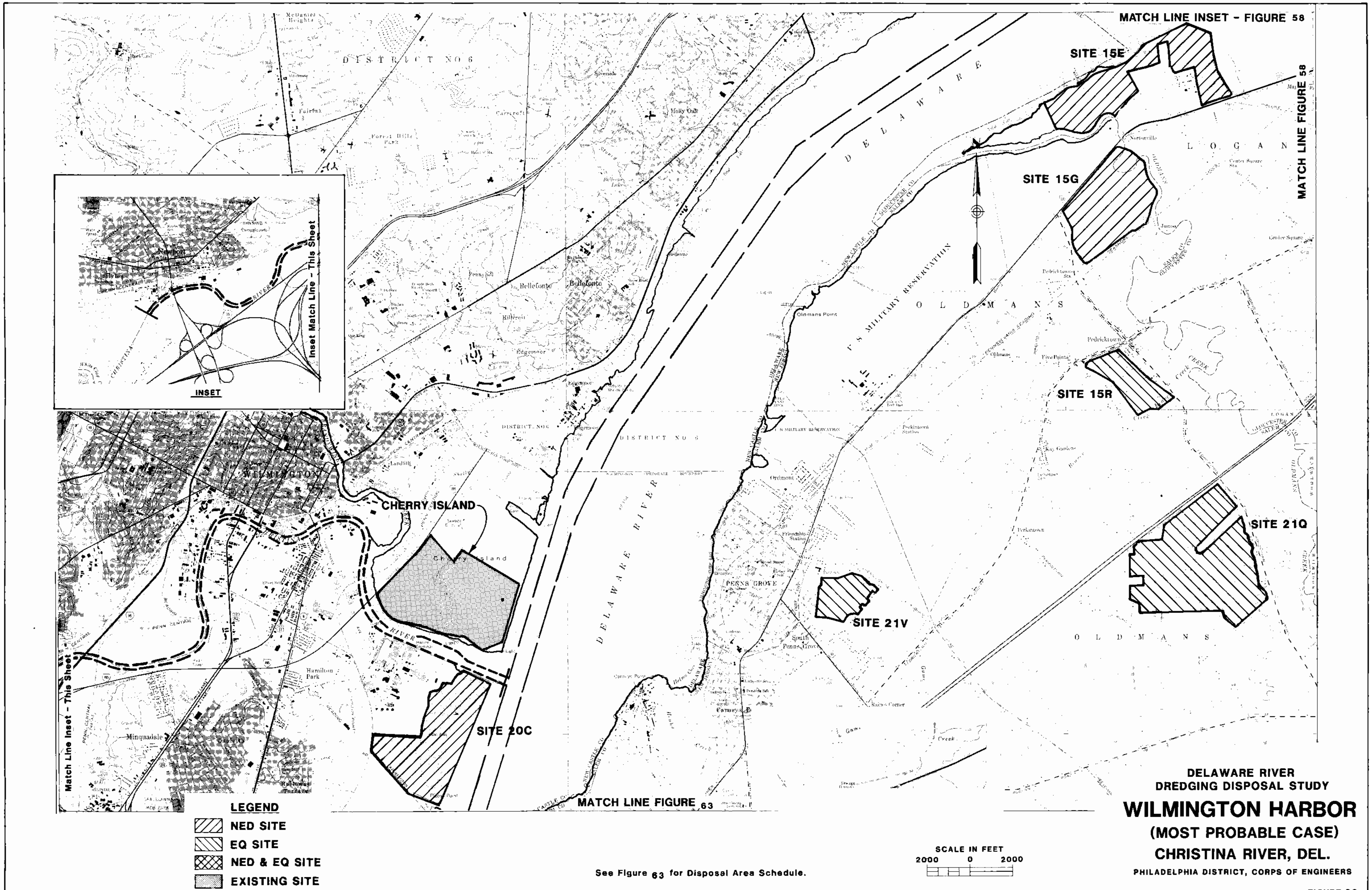
TABLE 29

WILMINGTON HARBOR, CHRISTINA RIVER, DELAWARE
MOST PROBABLE CASE CONDITION

SCENARIOS CONSIDERED

PLAN	DISPOSAL AREAS SELECTED SITES	DISPOSAL AREAS NEXT BEST (a)	RELATIVE COST INDEX (b)
NED	Cherry Island 20C 20E	15G	1.0
EQ	Cherry Island 21Q	21V	1.6
EQ Ranking	Cherry Island 20J 21D 21V	15R	1.7
Agency	Cherry Island 15E 15G	21K	1.6

(a) The site that would be chosen if the selected site becomes unavailable.
(b) This index is the multiplier in terms of cost using the cost of the NED scenario for the Most Probable plan as a base.



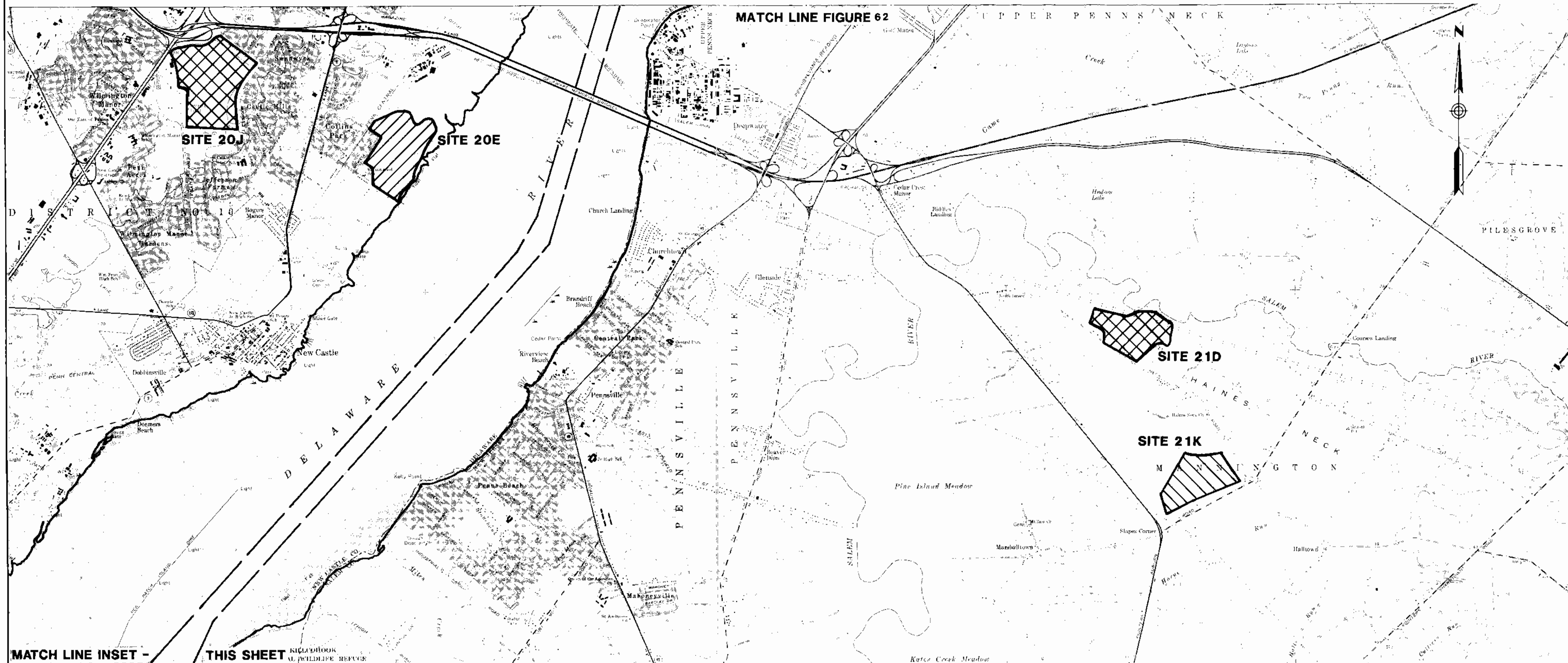
See Figure 63 for Disposal Area Schedule.

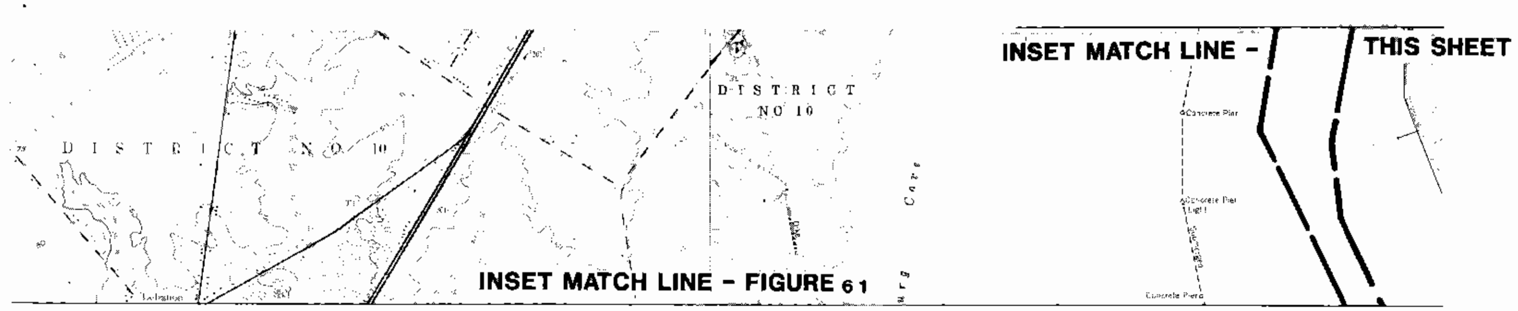
DELAWARE RIVER
DREDGING DISPOSAL STUDY

WILMINGTON HARBOR
(MOST PROBABLE CASE)
CHRISTINA RIVER, DEL.

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 62





INSET

D. A. SELECTED	NED	EQ	EQ RANKING	AGENCY
CHERRY IS.	X	X	X	X
SITE 15E				X
SITE 15G	O			X
SITE 15R			O	
SITE 20C	X			
SITE 20E	X			
SITE 20J			X	
SITE 21D			X	
SITE 21K				O
SITE 21Q		X		
SITE 21V		O	X	

X = SELECTED SITE
O = NEXT BEST SITE

LEGEND

- NED SITE
- EQ SITE
- NED & EQ SITE
- EXISTING SITE

SCALE IN FEET
2000 0 2000

DELAWARE RIVER
DREDGING DISPOSAL STUDY

WILMINGTON HARBOR
(MOST PROBABLE CASE)
CHRISTINA RIVER, DEL.

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 63

TABLE 30

SCHUYLKILL RIVER, MOUTH TO UNIVERSITY AVENUE
WORST CASE CONDITION

SCENARIOS CONSIDERED

PLAN	DISPOSAL AREAS SELECTED SITES	NEXT BEST (a)	RELATIVE COST INDEX (b)
All Plans (NED, EQ, EQ Ranking, Agency)	Fort Mifflin National Park 11D	11E	1.2

TABLE 31

SCHUYLKILL RIVER, MOUTH TO UNIVERSITY AVENUE
MOST PROBABLE CASE CONDITION

SCENARIOS CONSIDERED

PLAN	DISPOSAL AREAS SELECTED SITES	NEXT BEST (a)	RELATIVE COST INDEX (b)
All Plans (NED, EQ, EQ Ranking, Agency)	Fort Mifflin National Park	11E	1.0

(a) The site that would be chosen if the selected site becomes unavailable.
(b) This index is the multiplier in terms of cost using the cost of the NED scenario for the Most Probable plan as a base.

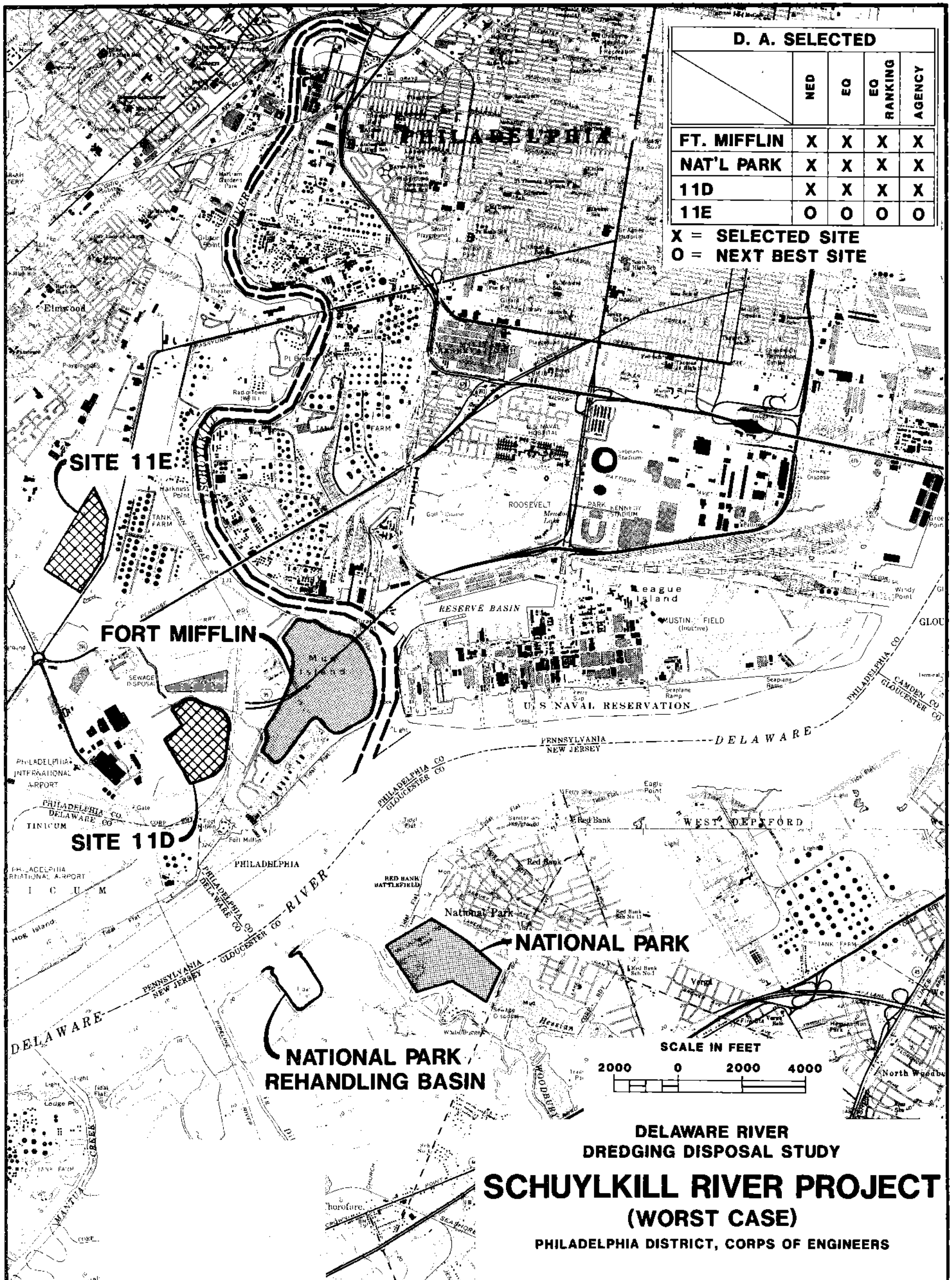
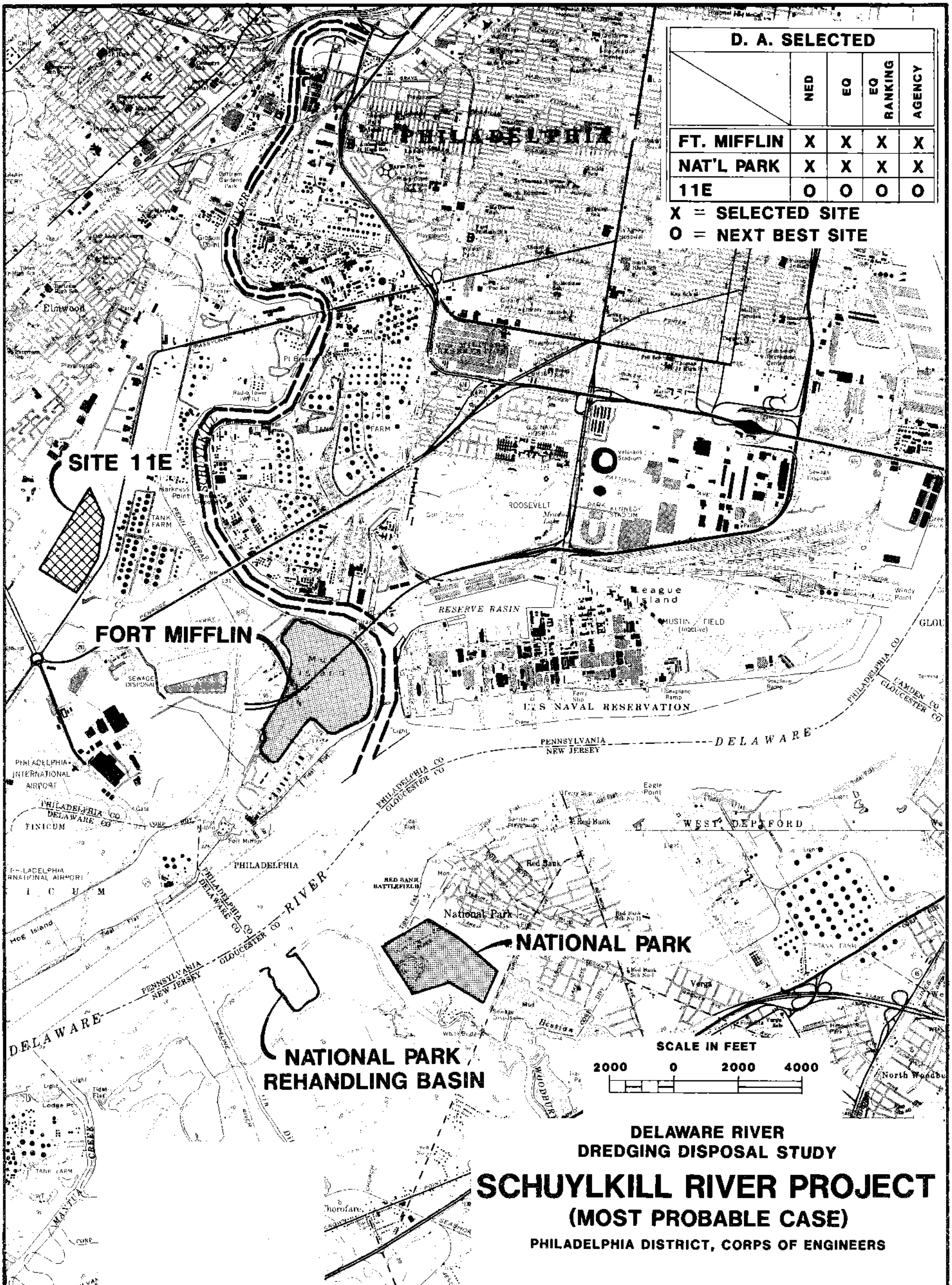

D. A. SELECTED
NED
EQ
EQ RANKING
AGENCY
FT. MIFFLIN X X X X
NAT'L PARK X X X X
11D X X X X
11E O O O O
X = SELECTED SITE
O = NEXT BEST SITE
PHILADELPHIA
SITE 11E
FORT MIFFLIN
SITE 11D
NATIONAL PARK
NATIONAL PARK REHANDLING BASIN
RESERVE BASIN
U.S. NAVAL RESERVATION
DELAWARE
RIVER
PENNSYLVANIA
NEW JERSEY
WEST DEPTFORD
SCALE IN FEET
2000 0 2000 4000
DELAWARE RIVER
DREDGING DISPOSAL STUDY
SCHUYLKILL RIVER PROJECT
(WORST CASE)
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 64



D. A. SELECTED	NED	EQ	EQ RANKING	AGENCY
FT. MIFFLIN	X	X	X	X
NAT'L PARK	X	X	X	X
11E	O	O	O	O

X = SELECTED SITE
O = NEXT BEST SITE

DELAWARE RIVER
DREDGING DISPOSAL STUDY

SCHUYLKILL RIVER PROJECT
(MOST PROBABLE CASE)

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 65

IMPACT ASSESSMENT

INTRODUCTION

The primary purpose of the systems model was to select disposal sites for each scenario based on least cost. In the development of the recommended plan other factors were considered. These included consideration of factors other than those that could be evaluated in terms of cost. These factors involve the environmental impact that would result from disposal area development, and are discussed below.

In general, candidate sites involve one or a combination of several habitat types that include agricultural, oldfield, shrubland, forested, and wetland areas. Upland disposal of dredged material is presently the most attractive alternative. Utilization of upland sites result in initial habitat loss due to clearing and diking of the area. Resident species are displaced and must relocate in other areas that contain similar habitat. In addition, species residing in adjacent areas may be disturbed by increased noise and activity levels resulting from site construction and disposal procedures. Although agricultural, oldfield, shrubland, and forested land provide habitat for many species of wildlife, these areas are relatively abundant within the region and selected sites could be developed for disposal purposes without significantly reducing the quality of fish and wildlife resources. Upland areas may also revegetate after disposal operations have been completed, thus restoring some form of upland habitat.

Historically, dredged material has been used extensively to fill low lying areas along the shoreline. In the past, wetland disposal was seen as a desirable practice that created dry land from areas that were considered useless. Wetlands are now recognized as biologically productive areas that offer essential habitat for many species of fish, mammals, and waterfowl. Disposal of dredged material in wetlands can effect the critical habitat determining factors which many organisms living in these areas depend on, including hydraulic flow, salinity, water quality, substrate, food, and cover. Filling of wetlands can also impact their natural flood storage and groundwater recharge capacities and their ability to remove suspended solids from water, to absorb and recycle mineral and organic constituents, and to generally contribute to improved water quality. Depending upon the quantity of material involved, habitat may be lost altogether through conversion to uplands.

Aquatic ecosystems concentrate pollutants such as heavy metals, pesticides, nutrients, and oil and grease compounds in bottom sediments. These contaminants are relatively insoluble in water, and tend to bind with suspended particulate material that ultimately settles out of the water column. Dredging of river sediments resuspends this material. The physical differences between the anaerobic environment of bottom sediments and the aerobic environment of surface water may temporarily release contaminants to surface waters making them available to aquatic organisms. This may be detrimental to the ecosystem depending upon concentrations and the length of exposure.

The potential for groundwater contamination as a result of upland disposal of dredged material is dependent upon the quality of material, soil and geologic characteristics of the site, and surface hydrology. Groundwater contamination can occur as a result of several events acting together or separately. These include: (1) leaching of contaminants by drainage of the liquids contained in the dredged material; (2) flushing of the dredged material by groundwater rising into the spoil then seeping out; and (3) leaching of contaminants by infiltration of water through cracks in the site surface. In general, the effects on groundwater from the disposal of clean dredged material should not pose serious problems.

The following sections give a brief description of sites listed for the NED, EQ, EQ Ranking and Agency plans under most probable case conditions. The text is divided by project and includes Delaware River, Philadelphia to the Sea, Delaware River Philadelphia to Trenton, Wilmington Harbor, and Schuylkill River. All plans include continued use of existing disposal areas. Environmental impacts of continued use of these areas are not included since they are minimal and their consideration is not part of the objective of this study. There are separate mechanisms to address concerns for existing sites.

PHILADELPHIA TO THE SEA. Philadelphia to the Sea project can be divided into two sections in terms of land use and natural resources. The upper section, from Allegheny Avenue, Philadelphia to Wilmington is a heavily populated residential and industrial area. The overall quality of fish and wildlife habitat is low due to reduced water quality in the river, and a lack of undeveloped land adjacent to the river. Open spaces are patchy and for the most part disturbed; however, this land is valuable to the preservation of existing resources. The situation improves downriver of Wilmington with much larger expanses of open land available for fish and wildlife habitat.

<u>NED Scenario</u>. The NED scenario involves development of sites 11B, 15D, 16Q, 17P, and 24CC. This plan involves the greatest amount of wetland/aquatic habitat, and would be the least desirable from an evironmental point of view. Sites 11B, 15D, 16Q, and 17P are all located within the highly developed Philadelphia to Wilmington corridor.

Site 11B is a 235 acre area located at the confluence of the Delaware River and Big Timber Creek in Gloucester County, New Jersey. Approximately 125 acres of the site consist of wetland, intertidal flat, and shallow water habitats. The remainder of the site is uplands.

Site 15D is east of Birch Creek at its confluence with the Delaware River in Gloucester County, New Jersey. It is comprised of 295 acres of uplands that include 115 acres of a previously used diked disposal area. This is a disturbed area that contains habitat of medium to low value for fish and wildlife species.

Site 16Q is a 115 acre area situated in a highly developed area southeast of Lester, Pennsylvania. This site is a previously used disposal area that contains a small area of palustrine emergent vegetation.

Site 17P is located along Mantua Creek west of Paulsboro, New Jersey. The site is 150 acres in size with approximately 35 acres of oldfield/forested uplands. The remainder of the site is tidal riverine emergent and palustrine forested wetlands. The site covers a section of the Mantua Creek channel, which would need to be realigned to maintain proper tidal flow and navigation.

Site 24CC is located adjacent to the Delaware River and Mill Creek. It is located in the Killcohook National Wildlife Refuge in Salem County, New Jersey. The site is approximately 460 acres in size with 360 acres of estuarine wetland/aquatic habitat. This area contains tidal streams, tidal and non-tidal wetlands, and open water habitat.

EQ Scenario. The EQ scenario includes development of sites 16T, 16Y, and 17G, which are all located between Philadelphia and Penns Grove in the State of New Jersey. This plan primarily considers utilization of uplands.

Site 16T is a 305 acre site located at the intersection of Center Square Road and Harrisonville Road in Gloucester County, New Jersey. The area is all uplands except for an isolated pond approximately 2 acres in size. This site contains forested and agricultural land.

Site 16Y is a 220 acre area adjacent to Little Timber Creek in Gloucester County, New Jersey. The site contains patches of palustrine forest habitat that cover approximately 35 acres and a intermittent stream that is a tributary of Little Timber Creek. The remainder of the site is uplands composed of forested and agricultural land.

Site 17G is a 295 acre area located downstream of the confluence of the Delaware River and Woodbury Creek. The site primarily contains uplands with two small (total of 17 acres) patches of non-tidal palustrine emergent wetlands.

EQ Ranking Scenario. The EQ Ranking scenario was an attempt to select disposal areas with a minimal amount of wetland involvment. All sites contain less than 5 acres of wetland habitat. This plan includes the use of sites 15M, 16M, 17I, 20H, 20J, and 21V, which are all located between Philadelphia and Wilmington.

Site 15M is a 120 acre area adjacent to Pedricktown, New Jersey. The site contains approximately 2 acres of palustrine emergent wetlands. The remainder of the site is uplands that may include agricultural or oldfield habitat.

Site 16M is a 155 acre area adjacent to Still Run in Gloucester County, New Jersey. This area is all uplands composed of forested and agricultural land.

Site 17I is a 125 acre area located at the confluence of the Delaware River and Little Mantua Creek in Gloucester County, New Jersey. The area is all uplands except for a non-tidal stream that branches off of Little Mantua Creek and follows a dike line to the Delaware River. The site contains agricultural, shrubland, and forested habitats.

Site 20H is 260 acre area located south of Llangollen Estates in New Castle County, Delaware. The site is all uplands composed of agricultural and oldfield habitat.

Site 20J is a 185 acre area located west of Castle Hills in New Castle County, Delaware. The site is located in the center of residential section and contains oldfield habitat.

Site 21V is a 100 acre upland area located east of Penns Grove, New Jersey. This site is composed of oldfield and agricultural land.

Agency Scenario. The Agency scenario includes the use of sites 15M, 16M, 20H, 20J, and 21V that were described under the EQ Ranking section. In addition, sites 11D, 11E, and 17C were also selected. All of these areas are located between Philadelphia and Wilmington.

Sites 11D and 11E are located west of the Schuylkill River near the Philadelphia International Airport. These sites are approximately 90 and 70 acres in size, respectively. This is a highly developed area with both sites composed of oldfield habitat.

Site 17C is a 150 acre upland area located adjacent to Edwards Run in Gloucester County, New Jersey. The site is composed of agricultural and forested land.

PHILADELPHIA TO TRENTON. NED Scenario. The NED scenario selected sites 2K and 7A. Site 2K is a 325 acre site located on a portion of Newbold Island.

The area has been disturbed by construction activities in conjunction with the one time proposed Newbold Island Nuclear Generating Station. The area consists of oldfield shrub/brush land, disturbed land that has begun to revegetate, and a pond that was excavated for the generating station. Although the site has been severely altered it is considered to have habitat value due to its isolated location. Filling of the man-made pond would result in the loss of aquatic habitat. The value of this pond to fish and wildlife is presently not known.

Site 7A is a 110 acre site located on Burlington Island adjacent to an existing dredged material disposal area. The site includes a clear water lake approximately 100 acres in size, which was excavated for sand between 1955-1969. The City of Burlington, New Jersey has conducted extensive testing and has considered using this lake as a raw water supply source. Eight wells have also been constructed and connected to the City's water distribution system. Filling of this man-made lake would curtail the future development of Burlington Island, and cause a significant loss in fish and wildlife habitat.

EQ, EQ Ranking, and Agency Scenarios. The EQ, EQ Ranking and Agency scenarios selected sites 2K and 7B. Site 7B is a 350 acre upland area located on the south side of Florence, New Jersey. The area is composed of oldfield, shrubland, forest, and cropland. Development of this area would involve loss of these habitats, which are relatively abundant on a regional basis. This area could be restored after disposal has been completed due to the involvement of uplands as opposed to aquatic or wetlands habitats.

WILMINGTON HARBOR. NED Scenario. The NED scenario selected sites 20C and 20E, which are located in New Castle County, Delaware. Site 20C is approximately 320 acres located adjacent to the Wilmington Harbor dredge

WHAT!?

site. The site is comprised of 260 acres of shallow water/intertidal mudflat, 40 acres of palustrine emergent wetlands, and 2 acres of uplands. This area is presently being considered under the Wilmington Harbor South Disposal Area Study.

Site 20E is a 150 acre upland area located between the Delaware River and Collins Park, Delaware. The site contains oldfield, scrub, and pockets of mature trees. This area is owned by the Lukens Steel Company.

EQ Scenario. The EQ scenario selected site 21Q, an area approximately 550 acres in size, located west of Oldmans Creek in Salem County, New Jersey. The site contains forested and scrub shrub non-tidal wetlands. Portions of 4 separate non-tidal streams are also included within this site. The remainder of the site is agricultural land.

EQ Ranking Scenario. The EQ Ranking scenario selected sites 20J and 21V, which were described for the Delaware River, Philadelphia to the Sea project. In addition, site 21D was also selected. This area is located adjacent to the Salem River in Salem County, New Jersey. The site is approximately 100 acres in size and includes 3 acres of forested non-tidal wetlands as well as a stretch of non-tidal stream.

Agency Scenario. The Agency scenario includes use of sites 15E and 15G. Site 15E is a 380 acre area located at the confluence of the Delaware River and Oldmans Creek in Gloucester County, New Jersey. The area is composed of agricultural, shrub, and developed land. The site contains a pond approximately 3 acres in size and a stretch of non-tidal stream. Site 15G is a 180 acre area located on the opposite side of Oldmans Creek in Salem County, New Jersey. This is a previously used diked disposal area that contains habitat of medium to low value for fish and wildlife species.

SCHUYLKILL RIVER. The Schuylkill River project requires no new disposal area to fill the 50 year need under most probable case conditions. All 4 planning scenarios (i.e., NED, EQ, EQ Ranking, and Agency) indicated that continued use of the existing Fort Mifflin and National Park disposal areas will be sufficient as well as most economical.

EVALUATION

BACKGROUND

The applicability of management measures such as dewatering, raising of dike heights, lease renegotiation and disposal site management were analyzed based on technical viability, cost and other related factors. The result of the analysis, shown on Table 22 indicated that many of these measures are reasonable.

To bracket the impact of adapting these measures, two conditions (the Worst Case and the Most Probable Case) were tested in the ensuing systems model runs. The model results were developed for four scenarios (NED, EQ, EQ Ranking and Agency) under each of these conditions. These results are shown in Tables 24-31. In view of the relatively large difference in cost and additional number of sites required for the Worst Case Condition, further analysis was confined to the Most Probable Case Condition.

Using the modeling results of the most probable case condition, a recommended plan was developed. The basis for this recommendation included consideration of the relative costs for each scenario, other related factors (such as those discussed under Impact Assessment) and views of the Plan Formulation Committee. The recommended plan, in some cases, is one of the four scenarios and in others represents a mix thereof. The following discussion is presented on a reach by reach basis. While these reaches follow the major Federal Projects, it should be recognized that the dredging volumes and deficits reflect both Federal and Non-Federal needs.

DEEP DRAFT PROJECTS

PHILADELPHIA TO SEA (INCLUDING DELAWARE RIVER AT CAMDEN). The existing upland disposal sites are estimated to begin reaching capacity by the year 2000. Table 25 shows the list of additional sites that would be needed to meet anticipated deficits through the year 2030 depending upon which scenario is assumed. The NED scenario is the least costly with the remaining three each being approximately ten percent higher. However, it should be kept in mind that this cost differential represents a considerable sum (approximately $27 million) since the base amount is in itself very large. In addition, the EQ Ranking and Agency scenarios would require 1-3 more sites than required under the NED and EQ scenarios since the potential sites in the former cases are relatively small. Examining the results further, the study attempted to minimize the number of new sites and at the same time retain the cost, engineering, and environmental impact criteria. After considering various other combinations, sites 15D and 16Q (from the NED scenario) and 17G (from the EQ scenario) were included in the recommended plan for this reach. The model results indicated that the costs for these sites were similar to the NED scenario. Sites 15D and 16Q are in close proximity to the bulk of the dredging while site 17G would be in the vicinity of the existing disposal areas. The U.S. Fish and Wildlife Service and Commonwealth of Pennsylvania have indicated some concerns for several of these sites. Letters expressing these concerns along with a District response are included in Appendix 4.

In the event that any of the existing or recommended sites become unavailable, the analysis indicated that site 15G would be the next best site. The recommended sites are shown on Figures 42, 43, and 44.

PHILADELPHIA TO TRENTON. With the adoption of the viable management measures, the existing sites are estimated to begin reaching capacity by the year 2010. As can be seen in Table 27, the least costly scenario is the NED plan with the remaining scenarios, again, each having a cost increase of about ten percent. Furthermore, site 2K is common for all scenarios, with 7A and 7B, in effect, being the next option. Considering the costs, engineering, and environmental impacts, sites 2K and 7B were selected (in lieu of 2K and 7A) for the recommended plan. The preference of 7B over 7A despite a cost increase of about $2 million involves a tradeoff of environmental concerns for site 7A (see Impact Assessment). The comments from the U.S. Fish and Wildlife Service also suggest a preference of site 7B to 7A.

In this case, site 7A would be the next best site. The acquisition of these sites is the responsibility of the State of New Jersey and Commonwealth of Pennsylvania as the Non-Federal sponsors of the project. The recommended sites are shown on Figure 56.

WILMINGTON HARBOR. The existing Cherry Island disposal area site contains two containment areas (Edgemoor and Wilmington) which are used alternately in cycles lasting about two years. These areas are estimated to have sufficient capacity to satisfy the disposal needs through 1993. At that time, additional new sites would be required to maintain the project. The systems model results shown on Table 29 identify the additional sites that would be required to meet the disposal needs through the year 2030 for each scenario. The least cost option is the NED scenario with the remaining scenarios costing between 60-70% more. The NED plan, sites 20C (220 acres) and 20E (120 acres) was selected because of the large cost difference. Moreover, since the environmental impacts are relatively minor (as discussed in the Impact Assessment), site 15G was selected as the next best site for this project. Refer to Figures 62 and 63 for the location of these sites.

SCHUYLKILL RIVER. As seen in Table 10, the existing disposal sites have sufficient remaining capacity to satisfy the disposal needs under the Most Probable Case Condition. Consequently, no new sites are required. In the event that there is a departure from this Most Probable Case Condition, the next best site is 11E. Refer to Figure 65 for the location of the existing and next best site.

SHALLOW DRAFT PROJECTS

The analysis showed that the anticipated needs for each of the 17 projects can be met by continued disposal at historically used sites. Again, this conclusion assumes the level of dredging reflects those associated with the Most Probable Case Condition. These sites are mapped and are available in the District Office files. One of the seventeen projects (Indian River Inlet and Bay) was analyzed in further detail with the systems model to determine if any further improvements could be recommended. The model results supported the subjective analysis and, therefore, no further efforts were made on other shallow draft projects.

SUMMARY AND CONCLUSIONS

This study has developed a dynamic planning model. This model is a tool that can be used for the preliminary screening of alternative sites and can be used to evaluate a regional dredging disposal system on a consistent basis. It is recognized that many factors can change over time and these changes could influence the decision making process. The methodology developed has been constructed in such a way that it can be updated to reflect virtually any change in conditions. The on-going Delaware River Comprehensive Navigation Study will update the qualitative data that was used in this study with specific data such as, real estate acquisition, groundwater and environmental protection costs, subsurface evaluations and site specific disposal area development and management costs.

The discussion throughout the report indicates how the results of the methodology are used to compare various options and ultimately arrive at a solution. Another feature of the results is that it presents an order of timing, indicating when new sites should be acquired. This order of timing allows the decision maker to distinguish between short term (within 10 years) and long term (within 50 years) disposal needs, thus meeting one of the objectives of the study.

The study analyzed two levels of disposal needs, one incorporating the "Most Probable" trends of the future and a second, higher level, the "Worst Case" condition. The Worst Case Condition incorporates projections of what could happen as an upper boundary if disposal demands were maximized. Through the automated methodology, many other conditions could be analyzed on a consistent basis. Both a Most Probable and a Worst Case Condition were analyzed to reflect various scenarios. Each scenario stressed one particular vantage point, ranging from a pro-dredging to a pro-environmental view. The results for these diverse views present a wide range of costs, impacts, and sites needed. The ability to analyze the scenarios and conditions demonstrates the power and flexibility of the methodology developed.

Since the assumptions upon which the Most Probable Case Condition are based represent our best judgement of what is expected to occur, further evaluation was limited to this case. Should the actual demand for disposal capacity be greater than that reflected in the Most Probable Case, a sufficient number of additional "Next Best" sites have been identified and could be used to satisfy the associated need. The on-going Delaware River Comprehensive Navigation Study is addressing the feasibility of new or additional projects, which for the most part, have not been included in the Most Probable Case. Should viable projects be recommended as part of that study, it is anticipated that the increased demand would either be so marginal as to require no new sites or the sites can be drawn from "Next Best" sites or from the unused portfolio of Worst Case sites. It is further anticipated that the overall impact associated with any such change in the demand for disposal sites would be relatively small with one possible exception. That exception, simply because of the volume of material involved, would be deepening of the Delaware River channel.

After considering each of the scenarios, a recommended plan was developed based on a composite of cost and other related factors. The recommended plans considered each of the four deep draft project reaches and the shallow draft projects for both the short and long term. These findings are presented in Table 32. Again, it is emphasized that while these reaches follow the major Federal projects, the dredging volumes and disposal deficits reflect both Federal and Non-Federal needs. The acquisition dates are based on remaining capacity limitations. In some cases, economics might be improved by using a site at an earlier date.

It is emphasized that the findings are those that would be made if one were to make a decision today. That decision would be appropriate if the condition upon which it was based actually takes place over the 50 year study period. While the trends and projections incorporated in the condition are the results of today's best judgement, it is recognized that conditions may change over time. Even more importantly, we now have developed a means of sensitizing virtually any such change. For these reasons, it is recommended that the emphasis be placed on the short term needs which can be estimated with greater confidence and demonstrate the specific actions that must be taken to avoid near term shortfalls in disposal capacity.

TABLE 32

SUMMARY OF STUDY FINDINGS

MANAGEMENT MEASURES

SHORT TERM

- Extend leases at existing sites for maximum use
- Acquire and use advanced dewatering equipment
- Continue to make dredge material available for re-use

LONG TERM

- Continue past management practices and incorporate new development, as appropriate, as the state of the art progresses
- Acquire long term leases or land in fee where appropriate

ACQUISITION OF NEW SITES

PERIOD	SITE	PROJECT	TENTATIVE ACQUISITION DATE(a)
SHORT TERM	20C	Wilmington Harbor	1993
LONG TERM	20E	Wilmington Harbor	2020
	7B	Philadelphia To Trenton	2010
	2K	Philadelphia To Trenton	2010
	15D	Philadelphia To Sea	2000
	16Q	Philadelphia To Sea	2000
	17G	Philadelphia To Sea	2000

(a) Acquisition date is defined as the year when a site is ready for disposal of dredged material.

Regarding the findings for the short term, action is already being taken by the District. The dewatering equipment discussed previously was acquired during the latter stages of this study and is currently operating successfully in the Cherry Island disposal areas. By using this equipment, the dewatering process at existing disposal areas can be accelerated with the net impact being more efficient use of existing and potential new disposal sites. Also, as indicated in Table 32, only one additional site is required in the short term. This site, identified as 20C and commonly known as Wilmington Harbor South, is needed for the continued maintenance of the Wilmington Harbor Project. The District is now in the process of preparing an Environmental Impact Statement and Design Memorandum for this site. Pending the outcome of these studies, authority already exists to implement specific recommendations thereof. The long term needs have also been presented but should be updated periodically as appropriate to reflect changing conditions. Implementation of the long range plans should be initiated at least 5 years prior to the exhaustion of disposal capacity to allow sufficient time to carry out the site acquisition and preparation phase.

Detailed engineering and environmental studies will be required for new sites identified for the long term period. The process would be similar to the studies that are being conducted for the Wilmington Harbor South site. These more detailed studies would include site specific real estate acquisition, groundwater and environmental protection costs, subsurface evaluations and site specific disposal area development and management costs. Finally, an environmental impact assessment would be prepared and coordinated with all affected agencies and local interests.

As noted previously the acquisition dates are dictated by a volumetric need. If the decision were, on the other hand, based instead on economics, the date of acquisition would be advanced. The reason for this is that the model results suggest a more economically attractive disposal plan if selected sites scheduled for eventual acquisition were available for use at some earlier date. The decision of whether to adopt a policy of advancing the acquisition phase to gain this economic advantage, as opposed to possibly acquiring a site before the actual need, is being considered as an operational question by the District. Comments from the Delaware River Basin Commission (see Appendix 4) suggest that we proceed as quickly as is reasonable in this regard. Should some of these sites (particularly those needed for the long term) become unavailable in the future due to some presently unforeseen reason, adjustments would be made on a site specific basis. Such revisions would be accomplished under the on-going Delaware River Comprehensive Navigation Study.

The study has served as a means of resolving some of the major issues concerning dredged material disposal. These issues include: the adequacy and remaining capacity of existing disposal sites; the availability of additional capacity at existing and new sites to accommodate projected disposal shortfall; the projections of when shortfalls are expected to occur; the alternatives available to efficiently solve the problem of dredged material disposal at existing sites; and the technical, economic, and environmental impacts of these alternatives.

RECOMMENDATIONS

There are no specific recommendations for construction of Federal projects as part of this study. The recommendations that have been made (see Table 32) can be pursued under the authority of existing legislation for each specific project.

The study recommendations are part of a dynamic and comprehensive plan that was prepared by an interdisciplinary District staff with input of interested agencies through the Plan Formulation Committee.

This report will serve as part of the basis for disposal site location and selection in formulating future projects in the Delaware River System conducted by the Corps of Engineers and considered during the review of Section 404 permits. It will also form a basis for evaluating other decisions involving potential disposal sites. Finally, this report will be distributed to those agencies and local port interests having an interest in dredging and disposal of dredged material for their consideration when making decisions concerning potential disposal sites.

It is recommended that this report be approved. Further studies, which primarily represent a refinement of the plan to reflect changed conditions including possible project modifications, will be accomplished as part of the Delaware River Comprehensive Navigation Study.

RALPH V. LOCURCIO
Lieutenant Colonel, Corps of Engineers
Commanding

APPENDIX 1

SPATIAL ANALYSIS METHODOLOGY FOR ATTRACTIVENESS MODELING

DELAWARE RIVER DREDGING
DISPOSAL STUDY

APPENDIX 1

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

The spatial modeling of the study area was conducted in the following three step process.

CONSTRUCTION OF THE DATA BANK

DATA COLLECTION. An interdisciplinary study team identified those data parameters which were considered to be important factors in the selection process for potential dredged material disposal sites. These parameters were generally found to be mapped, i.e. spatial, or could easily be converted to mapped format for subsequent inclusion in the data bank. Other types of pertinent data, i.e. non-spatial, were also identified for consideration in the decision making process by other means. Once identified, data was gathered and/or developed from the best available sources. Refer to Table 1 for the types of data parameters and variables that were assembled for the study area and their sources. Other spatial data parameters were also compiled for supplementary information. These included study area; community, county and state boundaries; 100-year tidal flood plain areas; and historic dredging reaches.

DATA CONVERSION

DIGITIZING. In order for the selected data parameters to be conveniently stored in the memory of the computer, the data was converted to digital form. To accomplish this, the entire 1250 square mile study area was subdivided by a two-dimensional grid system composed of 43,553 "cells". Each rectangular cell within the grid system represented an area of approximately 18 acres (18.4 acres). The selection of 18-acre grid cells was chosen as a practical lower limit of size for a "Federal" project disposal area. It was assumed that any feasible disposal site for major

TABLE 1

DATA PARAMETERS

DATA PARAMETER	VARIABLE	SOURCE
1. Archaeological Sensitivity Zones	0 Other 1 High Sensitivity 2 Medium Sensitivity 3 Low Sensitivity	The designation of archaeologically sensitive zones based on actual and expected site occurrences was derived primarily from a literature and records search.
2. Historic Sites	0 Other 1 Historic Sites 2 Historic Districts	Information was derived primarily from a literature, records search the National Register, State Register and State Preservation Office.
3. Groundwater Recharge Zones	0 Other 1 Zone I 2 Zone II 3 Zone III 4 Zone IV 5 Zone V 6 Zone VI	Information taken from State geologic maps.
4. Recreation	0 Other 1 Federal Park 2 State Parks, Forest and Wildlife Mgt. Areas 3 County Parks 4 Fairgrounds 5 Local Parks 6 Campgrounds 7 Golf Courses 8 Private Parks 9 Marinas	Information derived from State recreation plans, County maps, local maps and campground and boating guides.
5. Fish and Wildlife Sensitive Areas	0 Other 1 (Reserved) 2 Finfish 3 Wading Bird and Seabird	Information mapped by State offices of the U.S. Fish and Wildlife Services.

TABLE 1 (Cont'd)

DATA PARAMETER	VARIABLE	SOURCE
Fish and Wildlife Sensitive Areas (Cont'd)	4 Major Waterfowl Areas	
	5 Muskrat Areas	
	6 (Reserved)	
	7 Conservation/Natural Areas	
	8 High Fishing Areas	
	9 Exclusionary Trout Areas	
	10 Trout Waters	
	11 Shellfish	
	12 (Reserved)	
	13 Exclusionary Wading Bird and Seabird Colonies	
	14 Exclusionary Waterfowl Areas	
	15 Exclusionary Muskrat Areas	
	16 Reserved	
	17 Exclusionary Conservation/ Natural Areas	
	18 (Reserved)	
	19 Exclusionary Terrestrial Game Areas	
	20 Combination of 2 and 3	
	21 Combination of 2 and 4	
	22 Combination of 2 and 5	
	58 Combination of 2, 13, 15, and 17	
6. Land Use/Cover	0 Other	Data compiled from USGS quads, USGS land use/land cover maps, aerial photogaphy, State wetland maps, Pinelands vegetation maps, State maps and coastal zone data.
	1 Urban and Built Up	
	2 Normal Bottom (10'-42')	
	3 Shallow (10')	
	4 (Reserved)	
	5 (Reserved)	
	6 Forested Uplands	
	7 Orchards	
	8 Cropland	
	9 Rangeland	
	10 Other Agriculatural Land	
	11 Barren Land	

TABLE 1 (Cont'd)

DATA PARAMETER	VARIABLE	SOURCE
Land Use/Cover (Cont'd)	12 Strip Mining Land 13 Active CE Disposal Site 14 Inactive CE Disposal Site 15 Private, Industrial, Municiple Landfills 16 Sewage Sludge Landfill 17 Deep Water Bodies (42') 18 Inland Water Bodies (Lakes/Ponds)	
7. S.C.S. Important Farmlands	0 Other 1 Unique Farmland 2 Prime Farmland 3 Additional Farmland of Statewide Importance 4 Additional Farmland of Local Importance	Information obtained from State Soil Conservation Services Offices.
8. D.O.I Wetlands	0 Other	Department of the Interior Wetlands Maps.
A. One Wetland Type - 50% or Greater Cell Coverage	1 Palustrine 2 Riverine (Intertidal Flats/Intermittent Streams) 3 Estuarine 4 Lacustrine 5 Marine	
B. One Wetland Type - Less Than 50% Cell Coverage	6 Palustrine 7 Riverine (Intertidal Flats/ Intermittent Streams) 8 Estuarine 9 Lacustrine 10 Marine	
C. Mixed Wetlant Types (Dominant Type Indicated) -50% or Greater Cell Coverage	11 Palustrine 12 Riverine (Intertidal Flats/ Intermittent Streams) 13 Estuarine 14 Lacustrine 15 Marine	

TABLE 1 (Cont'd)

DATA PARAMETER	VARIABLE	SOURCE
D.O.I Wetlands (Cont'd)		
D. Mixed Wetlands Types (Dominant Type Indicated) Less Than 50% Cell Coverage	16 Palustrine 17 Riverine (Intertidal Flats/ Intermittent Streams) 18 Estuarine 19 Lacustrine 20 Marine	
E. Three or More Wetlands Typed	21 Mixed Wetlands - 50% or Greater Cell Coverage 22 Mixed Wetlands - Less Than 50% Cell Coverage	
9. Navigation Features	0 Other 1 Main Channel 2 Entrance Channel 3 Anchorage Areas 4 Dredge Disposal Sites in Water	Data taken from USGS quad sheets and NOAA maps.
10. Groundwater Protection	0 Other 1 Zone I 2 Zone II 3 Zone III 4 Zone IV 5 Zone V 6 Zone VI	Same as parameter #3
11. Construction and Devlopment	0 Other 1 Urban and Built Up 2 Normal Bottom (10'-42') 3 Shallow (10') 4 (Reserved) 5 (Reserved) 6 Forested Uplands 7 Orchards 8 Cropland 9 Rangeland 10 Other Agriculatural Land 11 Barren Land	Same as parameter #6

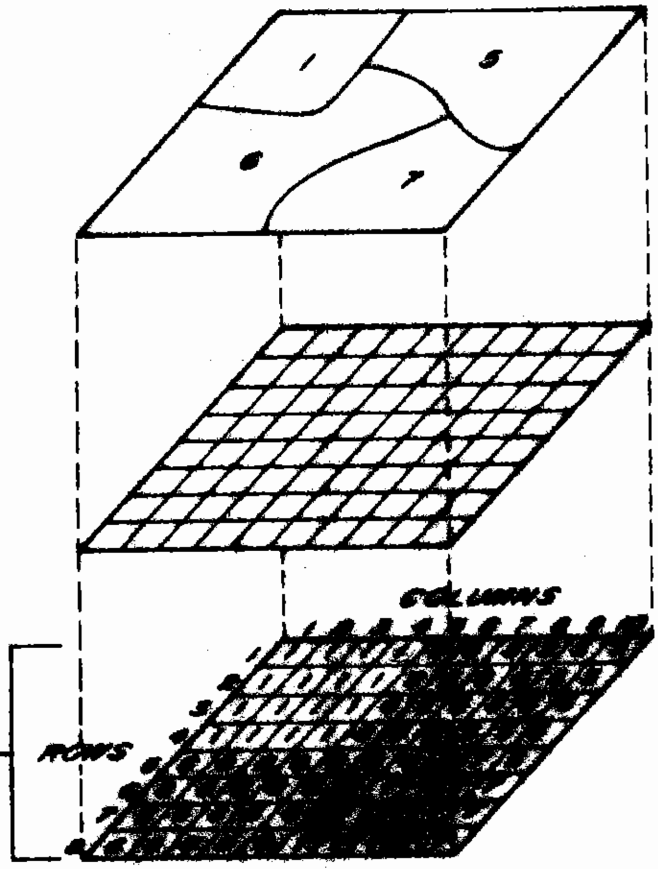
TABLE 1 (Cont'd)

DATA PARAMETER	VARIABLE	SOURCE
Construction and Development (Cont'd)	12 Strip Mining Land 13 Active CE Disposal Site 14 Inactive CE Disposal Site 15 Private, Industrial, Municiple Landfills 16 Sewage Sludge Landfill 17 Deep Water Bodies (42') 18 Inland Water Bodies (Lakes/Ponds)	
12. Elevation Ranges	1 -30' Depth and Greater (Datum is Mean Low Water) 2 -30' to 0'Depth (Datum is Mean Low Water) 3 Mean Low Water to 20' NGVD 4 20' to 40' NGVD 5 40' to 60' NGVD 6 60' NGVD	Data compiled from NOAA maps and USGS quad sheets.
13. Distance Bands - Philadelphia To Trenton: From Center of Channel	1 0' to 5000' 2 5000' to 10000' 3 10000' to 15000' 4 15000' to 20000' 5 20000'	Computer generated
14. Distance Bands - Philadelphia To Sea: From -30' Depth (Datum is Mean Low Water)	1 0' to 3000' 2 3000' to 6000' 3 6000' to 9000' 4 9000' to 12000' 5 12000'	

Federal dredging projects would be much larger and therefore, would be represented in the computer modeling by a group of 18-acre cells. Potential disposal areas for small or non-Federal projects requiring less than 25 acre sites would be identified by manual screening. Further, at the study base map scale of 1:48,000 (1"=4,000'), a single alpha-numeric character on the computer-mapped output would have a one-to-one correspondence with each grid cell in the data bank. The 18-acre grid cell was used as the common denominator for resolution of data and storage. Each grid cell was assigned a numerical value representing each of the data parameters and variables including a row/column identifier. For example, in the Land Use/Land Cover data parameter, a value of "1" assigned to a particular grid cell would represent that the 18-acre parcel of land was an "urban and built-up" area. A value of "8" would indicate that the area was "cropland", and so forth. By this process, the computer was able to store and later manipulate each of the data parameters in 18-acre units. The process of converting the original mapped (spatial) data to this digital form is called digitizing.

The process of digitizing was accomplished by data processing equipment which was used to trace the data from its original mapped form and automatically make appropriate numerical value assignments to each grid cell. Figure 1 shows the schematic of this digitizing process for converting original mapped data to digital form. This procedure was repeated for each parameter. Conceptually this process results in a series of maps stacked one on top of the other within the data base. However, the entire process is automated for ease and efficiency of data storage, retrieval, and analysis.

SINGLE PARAMETER DATA BANK



STORED DATA FILE (Single Parameter File)		
ROW	COLUMN	VARIABLE CATEGORY
1	1	1
1	2	1
1	3	1
1	4	1
1	5	5
1	6	5
.	.	.
.	.	.
	(etc.)	

DELAWARE RIVER
DREDGING DISPOSAL STUDY

SCHEMATIC OF DIGITIZING

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 1

COMPUTER MODELING ANALYSIS

GENERAL. HEC's basic SAM system contains a family of computer programs designed to access a data bank through individual cells or groups of cells, manipulate the data sets, perform required analyses and produce desired outputs. SAM's broad capabilities include hydrologic & hydraulic, economic and environmental analyses. For the purposes of this study, the "environmental" capabilities of SAM's Resource Information and Analysis (RIA) programs were selected as the site - suitability or "attractiveness" modeling tool for screening potential disposal areas. RIA can perform four basic functions:

1. Distance Determination: This option calculates the linear distance to/from each grid cell in the data bank to a cell containing a specific data parameter of interest. For example, grid cells having certain desirable characteristics for the placement of dredged material which are also within a certain distance from active dredging reaches can be readily identified and displayed.

2. Impact Assessment: This capability of RIA allows for the determination and display of areas potentially impacted by dredged disposal activities. The analysis is based on identifying relative impacts as either desirable or undesirable combinations of site characteristics.

3. Coincident Tabulation: This option is used to tabulate the coincidence of two or more data parameters which might be indicative of attractiveness or provide additional statistical information about prospective sites.

4. Locational Attractiveness: This modeling is a land attribute analysis technique that emphasizes identification of the combination of locational characteristics that make a site attractive for a particular activity. The modeling is a computational procedure that develops numerical attractiveness "scores" for each grid cell based on a particular set of criteria. In general, the higher the score, the more "attractive" an individual 18-acre cell would be for the disposal of dredged material. Different theories or conceptual approaches to the problem can be tested by re-running the analysis with different criteria thereby producing different attractiveness scores. It is this option of the RIA programs, along with distance determination, that was used as the primary attractiveness modeling tool.

MODELING TECHNIQUE. The basic computer modeling strategy was to use the locational attractiveness and distance determination options of RIA to interpret the logic of the selection criteria established by the study team, and then search the data bank for those areas satisfying that criteria. This was accomplished by having the study team assign "numerical-weighting factors" to each variable (or category) of each data parameter. These weighting factors represented the relative attractiveness or desirability of that data variable in a potential disposal site. A relative scale of acceptability was adapted as a uniform base from which to rank each data variable:

Scale of Acceptability for Weighting

Potential Disposal Site Attributes

-1	0	1	2	3	4	5	6	7	8	9	10
Unacceptable (Excluded)	Least Acceptable					Generally Acceptable					Most Acceptable

Assigning a weighting factor of value "10" to a particular data variable would signify that the presence of that attribute in any 18-acre grid cell would be "most attractive" for the disposal of dredge material. Conversely, a weighting factor of "0" would be the least acceptable. Further, an assigned value of "-1" would indicate that the presence of that particular attribute would be so unacceptable as to cause that cell to be excluded from further consideration. For example, under the Land Use/Land Cover parameter, barren land might be judged to be highly attractive and therefore assigned a weighting factor of "10", whereas urban and built-up land would be so unattractive as a potential disposal site as to warrant a "-1".

In this way, each data variable of each data parameter was assigned a numerical weighting factor to represent its relative acceptability. The assigned weighting factors reflected the collective judgement of the study team and were drawn from education and experience, statute, regulation, and professional practice related to dredging methods and options for disposing of dredged material.

Below is a list of references that were used in performing the spatial modeling analysis.

1. Technical Paper Number 47, Comprehensive Flood Plain Studies Using Spatial Data Management Techniques, Darryl W.Davis, U.S. Army Corps of Engineers, Hydrologic Engineering Center, Davis, California.

2. Guide Manual for the Creation of Grid Cell Data Banks, U.S. Army Corps of Engineers, Hydrologic Engineering Center, Davis, California, September 1978.

3. Generalized Computer Program, AUTOMAP II, Users Manual (Preliminary Draft), Environmental Systems Research Institute, Redlands, California, August 1974, prepared for U.S. Army Corps of Engineers, Hydrologic Engineering Center, Davis, California.

4. Generalized Computer Program, REGISTER, Users Manual (Preliminary Draft), U.S. Army Corps of Engineers, Hydrologic Engineering Center, Davis, California, January 1976.

5. Generalized Computer Program, BANK (Grid Cell Data Bank Update), Users Manual (Preliminary Draft), U.S. Army Corps of Engineers, Hydrologic Engineering Center, Davis, California, February, 1980.

6. Generalized Computer Program, RIA, Resource Information and Analysis Using Grid Cell Data Banks, Users Manual, 401-X6-L7590, U.S. Army Corps of Engineers, Hydrologic Engineering Center, Davis, California, September 1978.

APPENDIX 2

DREDGING METHODS

DELAWARE RIVER DREDGING
DISPOSAL STUDY

APPENDIX 2

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

DREDGING METHODS

INTRODUCTION

A dredge may be defined as a machine which removes materials from the bottom of waterways by means of scooping or suction devices. There are two primary dredging methods in use today, hydraulic and mechanical. In addition, modified systems or innovative systems, such as pneumatic, are being developed and have been used in limited cases. These new technologies are expected to increase removal efficiency and minimize the loss of fine-grained materials at the dredgehead.

This appendix describes the types of dredges that may be appropriate for use in the study area. Advantages and disadvantages in terms of cost, time, loss of material, depth requirements, and sediment types handled are also described herein.

HYDRAULIC DREDGING AND TRANSPORT

Dredges which operate hydraulically use water as a medium to convey the dredged material. The material to be excavated is mixed with water and pumped through the system by a centrifugal pump as a slurry (generally 10 to 20 percent solids content by weight). The material is transported to a confined area where the sediments are allowed to settle out. Owing to the large flows associated with this system, the disposal sites are designed to include areas for decanting the sediments, before discharge to the waterway or watercourse. In addition, certain types of sediment exhibit a phenomena known as "fluffing", wherein the dredged material occupies a greater volume in the disposal area than in the river bottom. This increase in volume results from the introduction of slurry water into the previously consolidated sediments. The fluff factor (cut to fill ratio) can range from 1 to 3 for bentonitic clays and organic silts to 1 to 1 for sands.

The following types of hydraulic dredges and their advantages and disadvantages are discussed below: (See also Table 1)

- Cutterhead Suction
- Plain Suction
- Hopper
- Dustpan
- Sidecasting

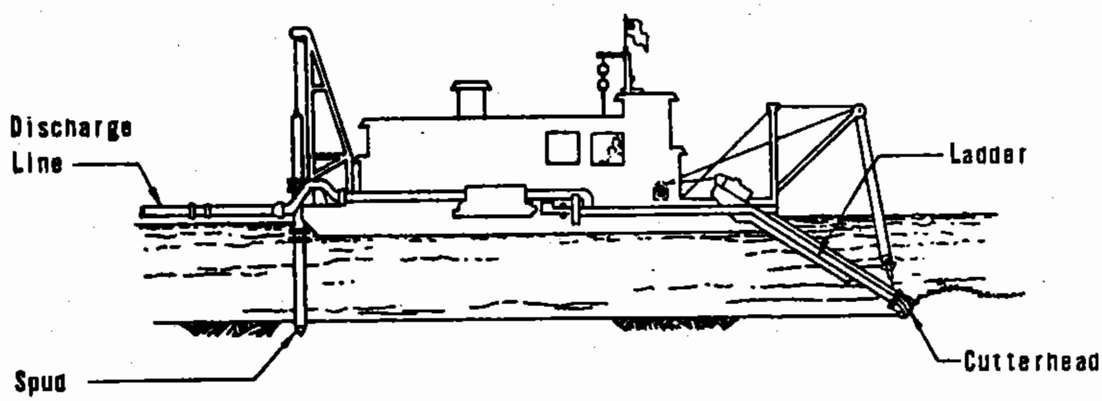
CUTTERHEAD SUCTION. This type of dredge excavates material by means of a rotating cutter at the end of a suction pipe. The cutter suspends material into a slurry which is then pumped hydraulically and discharged through a floating pipeline to shore. The dredge advances by swinging from side to side using spuds at the rear as pivots. Lateral movements are controlled by swing cables attached to anchors. The depth of cut is manually controlled by the operator, who may raise or lower the ladder cutterhead. This type of dredge is illustrated in Figure 1.

Dredge size is determined by the diameter of the discharge line. Sizes range from 6 to 42 in. with dredges in the 12 to 16 in. range suitable for dredging shallow draft Federal projects and some private projects. The deep draft Federal projects require dredges in the 16 to 30 in. range.

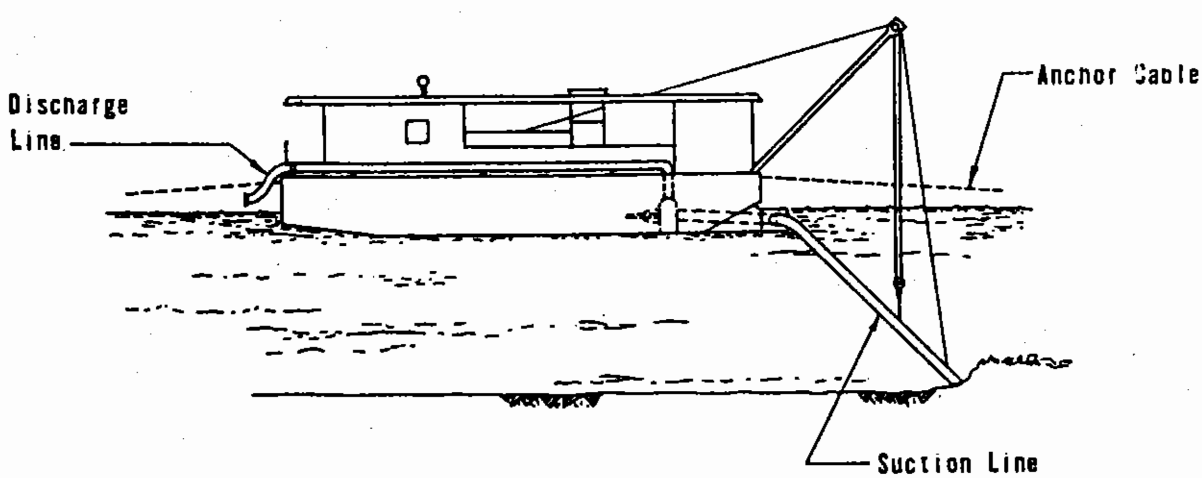
In general, 12 to 16 in. dredges are approximately 50 ft. in length, 20 ft. in width and require 3 to 4 ft. draft. Production varies considerably with dredged material characteristics and piping lengths, and typically range

Table 1
Hydraulic Dredges

Dredge type (1)	Cutterhead/Plain Suction dredge (2)	Hopper dredge (3)	Dustpan dredge (4)	Sidecasting dredge (5)
Dredging principle	Material is removed with a rotary cutter (or plain suction inlet in light material) picked up with dilution water by the suction pipe, and transported through the pump and the discharge line. While working, dredge swings around spud toward an anchor.	Material is removed and picked up together with dilution water by draghead sliding over bottom (or stationary) and flows through suction piping, pump, and discharge piping into hoppers of vessel.	Material is removed with water jets, picked up by a wide but shallow suction opening and transported through the pump and the discharge line. While working, dredge is slowly pulled toward two anchored spuds or anchors.	Material is removed and picked up together with dilution water by draghead sliding over bottom and flows through suction piping, pump, and discharge arm over side of vessel back into the water.
Horizontal working force on dredge	Medium intermittent force opposing swing to side.	Slight constant force opposing forward movement.	Medium constant force opposing forward movement.	Slight constant force opposing forward movement.
Anchoring while working	Two spuds and two swing anchors (one working spud and one walking spud).	Dredge moves under own power to dig a channel or is anchored to dig a hole.	Two spuds or anchors secured upstream while working.	Dredge moves under own power to dig a channel.
Effect of swells and waves	Very sensitive to swells and waves.	Little affected by swells and waves.	Very sensitive to swells and waves.	Little affected by swells and waves.
Material transport	Transport occurs in pipeline. Length of discharge line depends on available power, but can be extended with booster pump units to a total length of several miles.	After material is in hoppers, transport is over any suitable waterway. Material can be bottom dumped or pumped out. Booster pump units are not used with this plant.	Transport occurs in pontoon supported pipeline to side of dredge. Spoil discharges into water. pumped out (if so equipped). Pumpout is similar to pipeline dredge operation.	Transport occurs in pipeline on discharge boom over side of dredge. Material discharges into adjacent water.
Dredged material density	Diluted to an average of 1,200 g/l.	Diluted to an average of 1,200 g/l.	Diluted to an average of 1,200 g/l.	Diluted to an average of 1,200 g/l.
Comments	Highly developed machine with intricate horizontal moving procedure used throughout the world. Suitable for all but very hard materials. High production for size of plant.	Highly developed machine used throughout the world. Suitable for all but very hard materials. Production depends on traveling time to dump and mode of discharge.	Special sand dredge used only in United States in Mississippi River. Floating line is positioned with rudder in discharge stream. High production for size of plant.	Special sand dredge. Sand transport is limited to length of discharge boom. Used in coastal inlets or where material disharge into water is not objectionable. High production for size of plant.



CUTTERHEAD SUCTION DREDGE



PLAIN SUCTION DREDGE

DELAWARE RIVER
DREDGING DISPOSAL STUDY
CUTTERHEAD AND
PLAIN SUCTION DREDGES

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 1

from 150-850 cubic yards per hour (cu. yds./hr.). Twelve to 16 in. dredges will efficiently excavate medium clays, silt, sand, gravel and soft rock. Material loss at the cutterhead can be controlled to some extent by the operator by varying the rate of ladder swing and cutter rotation speed. These dredges generally have a maximum dredging depth of 30 to 35 ft.

In general, 18 to 30 in. dredges are approximately 130 to 200 ft. in length, 40 to 50 ft. in width and require 10 to 15 ft. draft. Production varies considerably with dredged material characteristics and piping lengths; typically ranging from 500-1200 cu. yds./hr.

Most of the turbidity generated by a cutterhead dredging operation (exclusive of disposal) is usually related to the type and quantity of material cut. The amount of material supplied to the suction is controlled primarily by the rate of cutter rotation. Although a properly designed cutter will efficiently cut and guide the bottom material toward the suction, the cutting action and turbulence associated with the rotation of the cutter will resuspend a portion of the bottom material being dredged. Excessive cutter rotation rates tend to propel the excavated material away from the suction pipe inlet. Residual material may remain in suspension or may settle into the existing cut where it again becomes susceptible to resuspension by ambient currents and turbulence generated during subsequent cuts.

The levels of turbidity in the vicinity of the cutter are not only dependent on the operation of the dredge during a particular cut, but are also related to the amount of material remaining in suspension from the previous cut(s).

In addition to the dredging equipment used and its mode of operation, turbidity may also be caused by sloughing of material from the sides of vertical cuts, inefficient operational techniques, and the prop wash from the tenders (tugboats) used to move pipeline, anchors, etc., in the shallow water areas outside the channel.

Advantages.

- Hydraulic dredges are readily available.
- Large volumes of material are moved economically because of a virtually continuous operating cycle.
- High production for size of plant.
- A wide range of materials, from light silts to heavy rock blasted to small sizes, can be excavated with a properly designed cutterhead.
- The use of booster pumps in the pipeline allows material transport over relatively long distances from the waterway to the disposal site.
- There is no rehandling of the sediment from the cutterhead to the disposal area.

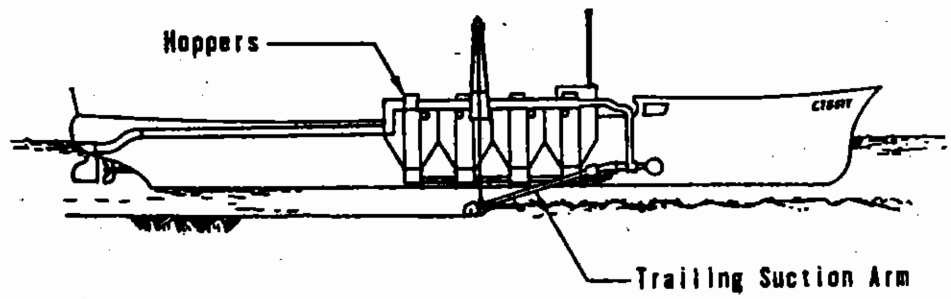
Disadvantages.

- The floating pipeline and swing wires can be an obstruction to navigation.
- There is agitation and disturbance of the bottom sediment. Materials loss is a function of operational procedures.
- Hydraulic pumping has reduced practicality at head losses exceeding 1200-1500 feet or total distances exceeding 2-4 miles. (Above this limitation, booster station would be used.)
- Large pipeline dredges can only pump mud up to 5 miles with minimum lift.
- The pipeline requires an easement.
- The hydraulic system generates large quantities of wastewater which must be controlled. This significantly increases the cost of a project.

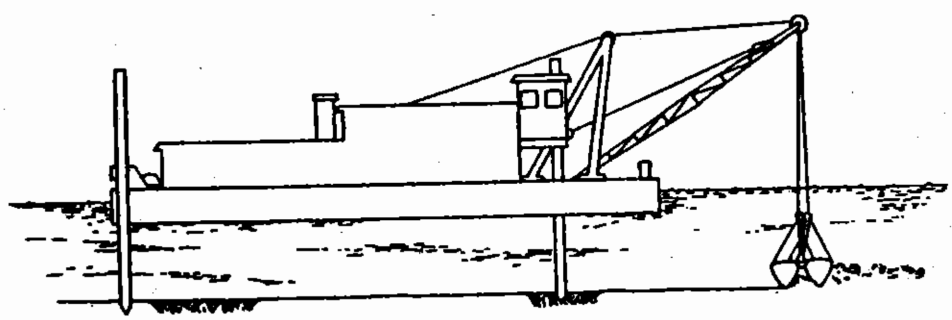
Conclusion. Based on extended historical use of cutterhead suction dredges in study area, this dredging method has been included in system model analysis. Sizes of dredges include 12", 16", 20" and 27" diameter due to material type channel depth and width, and available contractor plant.

PLAIN SUCTION. These are similar to standard cutterhead dredges, except for the absence of the cutter. Occasionally, these dredges are equipped with a special suction head which use water jets to loosen the material. The advantages and disadvantages are comparable, but the plain suction does not create as much turbidity. A disadvantage is that only loose and free-flowing sediments can be dredged using plain suction equipment (See Figure 1). A booster station is used where long lines and/or high lifts are required. A booster station plant can be located at any location in line, providing it has sufficient suction pressure. The plant can be located on a dredge, on a floating barge or ship, or on land. Booster stations vary in size and capacity, up to 30 inch and 3500 Horsepower (HP).

HOPPER. The hopper dredge is an ocean-going ship and functions like a plain suction dredge (See Figure 2). The dredging operation is accomplished by two trailing drag arms extending from both sides of the ship to the waterway bottom. The material is removed from the bottom by suction and pumped into hopper bins aboard the ship. In general, dredging is continued beyond the point where the bins overflow to increase the amount of solids contained in the hoppers. This method is not employed by the Philadelphia District. When the hoppers are filled, the dredge proceeds to deep water dumping grounds, where the bins are opened, and the material discharged. As an alternative, the bins may be pumped out, and the slurry discharged to upland disposal areas, as in conventional hydraulic dredging practice. The hopper dredge capacities can vary from 300 to 12,000 cu. yds., and a minimum draft



HOPPER DREDGE



CLAMSHELL DREDGE

DELAWARE RIVER
DREDGING DISPOSAL STUDY
HOPPER AND
CLAMSHELL DREDGES
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 2

of 15 ft. is usually required for operation. Shallow draft hopper dredges with 300 cu. yds. capacity are presently in use by the Corps to operate in as little as 8 ft. Production for a 3,500 cu. yds. hopper capacity ship is roughly 500,000 cu. yds. per month, assuming that the disposal site is a mile or less from the dredge reach. At a 20-mile distance to the disposal site, production would drop to approximately 300,000 cu. yds. per month as a result of transport time; at a 50 mile distance, to around 180,000 cu. yds. per month. Resuspension of fine-grained maintenance dredged material during hopper dredge operations is caused by the dragheads as they are pulled through the sediment, turbulence generated by the vessel and its prop wash, and overflow of turbid water during hopper filling operations. During the filling operation, dredged material slurry is often pumped into the hoppers after they have been filled in order to maximize the amount of higher density material in the hopper. The lower density, turbid water at the surface of the filled hoppers overflows and is usually discharged through ports located near the waterline of the dredge. Distributions of suspended solids in these overflow plumes are primarily dependent on the nature of the sediment being dredged; the design and operation of the dredge (such as forward speed and pumping rate); the nature, concentration, and volume of overflowed material; the locations of the overflow ports; and the hydraulic characteristics of the dredging site (such as water depth, salinity, and current direction and velocity).

Suspended solids concentrations may be as high as several tens of grams per liter (g/l) near the discharge port and as high as a few (g/l) near the draghead. Turbidity levels in the near-surface plume appear to decrease exponentially with increasing distance from the dredge due to settling and dispersion, quickly reaching concentrations less than 1 g/l.

Advantages.

- The dredge is self-propelled and removes material while underway with no moorings or cables.
- There is minimum interference with navigation because of the dredge's high mobility.
- Can operate in rough seas.
- Suitable for all but the hardest materials.

Disadvantages.

- The overflow of the hopper bins resuspends fines, as does the bottom dumping of the dredged material.

Conclusion. Based on extended historical use of hopper dredges in study area this dredging method has been included in system model analysis. The COMBER and DODGE ISLAND class dredges have been selected based on available plant and dredging conditions in the study area.

DUSTPAN DREDGE. A variation of the pipeline dredge, which at the present time is primarily used in the Mississippi River, is the dustpan hydraulic dredge. The name is derived from the shape of the suction pipe, which resembles a large dustpan 20 ft. or more in width and about 1 1/2 ft. in height. This dredge is extremely effective in removing sand bars that frequently exist in the navigation channel of the lower Mississipi River.

Advantages.

- High production for size of plant.
- Suitable for sand or mud.
- Reduced disturbance of the bottom sediment.

Disadvantages.

- Vary sensitive to swells and waves.
- Anchors can interfere with navigation.
- Used primarily in the Mississippi River at this time as a special dredge.

- Limited pumping distance.
- Booster stations are not used with this plant.

Conclusion. Based on above disadvantages and dredging conditions in study area, no additional consideration will be given to dustpan dredges in this study.

SIDE CASTING DREDGE. The side casting dredge evolved from use of hopper dredges to provide overboard discharge of dredged material. Under certain conditions this type of dredging is feasible and by far the most economical means of providing and maintaining channel depths.

These dredges can be designed for side casting only, or the conventional hopper dredge can be equipped to provide the capability for side cast dredging. All of this equipment is self-propelled with the discharge of the dredged material usually accomplished through a boom pipeline alongside the dredged channel.

Side casting dredges are particularly effective in locations where the currents do not return a significant amount of the dredged material to the navigation channel. The side caster can handle the same range of material that a hopper dredge can dredge successfully - clayey silt through sands. Its ability to maneuver in the channel makes this dredge particularly useful in maintaining shallow inlet channels to the ocean.

Side casting dredges range in discharge pipeline size from 12 in. to 57 in. They can excavate material from as deep as 60 ft. below the water level, but the smaller side casters can operate in as little as 4-1/2 ft. of water.

Advantages.

- The dredge is self-propelled and removes material while underway with no moorings or cables.
- There is minimum interference with navigation because of the dredge's high mobility.
- Can operate in rough water.
- Suitable for mud and sand.

Disadvantages

- Normal discharge is open water adjacent to dredge site.

Conclusion. Based on the historical development of hopper dredging methods, environmental consideration and location of and potential existing disposal areas, the sidecaster dredge will not be considered for future use in study area.

MECHANICAL DREDGES

Mechanical dredges remove the bottom material with excavation devices, but do not transport it to the disposal site. A fleet of barges and tugs are used for this purpose. All mechanical dredge types resemble dry land excavation equipment. In fact, in many cases surface equipment is floated on a barge and used for dredging.

The following types of mechanical dredges are discussed in this section. (see Table 2)

- Clamshell
- "Closed Bucket" Clamshell
- Dipper Dredge
- Dragline
- Endless Chain Bucket or Ladder Dredge

TABLE 2

Mechanical Dredges[1/]

Dredge type (1)	Dragline on barge (2)	Dipper dredge (3)	Clamshell or orange peel bucket dredge (4)	Endless chain bucket dredge (5)
Dredging principle	Scrapes off material by pulling single bucket over it toward stationary crane. Lifts bucket and deposits dredged material in a conveyance or on a bank.	Breaks off material by forcing cutting edge of single shovel into it while dredge is stationary. Lifts shovel and deposits dredged material in a a conveyance or on a bank.	Removes material by forcing opposing bucket edges into it while dredge is stationary. Lifts bucket and deposits dredged material in a conveyance or on a bank.	Removes material by forcing single cutting edge of successive buckets into material while dredge is slowly moved between anchors. Lifts buckets and deposits dredged material in a barge or own hopper.
Horizontal working force on dredge	Medium intermittent force toward bucket.	High very intermittent force away from bucket.	No forces.	Medium constant force away from bucket.
Anchoring while working	Dragline crane can be on shore or on barge. If on barge, latter can be secured with spuds or anchors.	Several heavy spuds.	Several spuds or anchors.	Several anchors.
Effect of swells and waves	Can work up to moderate swells and waves.	Very sensitive to swells and waves.	Can work up to moderate swells and waves.	Very sensitive to swells and waves.
Material transport	Transport occurs in barges, trucks, or cars. Crane does not transport material. Material disposal occurs in many ways.	Transport occurs in barges, trucks, or cars; dredge does not transport material. Material disposal occurs in many ways.	Transport occurs in barges, trucks, or cars; dredge does not transport material. Material disposal occurs in many ways.	Transport normally occurs in barges. Dredges equipped with hoppers are limited to material disposal by bottom dumping.
Dredged material density	Approaches in-place density in mud and silt. Approaches dry density in coarser material.	Approaches in-place density in mud and silt. Approaches dry density in coarser material.	Approaches in-place density in mud and silt. Approaches dry density in coarser material.	Approaches in-place density in mud and silt. Approaches dry density in coarser material.
Comments	The term "dredge" is questionable for this machine, since it is not exclusively built for underwater excavation and is frequently used for material removal above water. It is suitable for all but the hardest material and has a low production for its size.	Special hard material dredge of simple principle. Rudimentary machine can be assembled for temporary service by placing power shovel on spud barge. Low production for size of plant and investment.	This machine is simple in principle. It can be assembled in rudimentary form for temporary service by placing a crane on a barge. It is suitable for all but the hardest materials and has a low production for it size.	Highly developed machine. Not used in United States (other than as part of mining plant), but used extensively in other countries. It is suitable for all but the hardest materials and has a high production for its size.

1/ Mohr, Adolph, W., "Development and Future of Dredging", Journal of the Waterways, Harbors and Coastal Engineering Division, ASCE Vol. 100, No. WW2, Proc Paper 10513, May 1974, pp. 69-83.

The dredge excavates the sediment and places it on an adjacent barge, which, when filled, is towed by a tug to an unloading site. At the unloading site, the material is removed and transferred to the disposal site. The transfer from the barge to the disposal site may be performed either mechanically by clamshell buckets, or hydraulically by a pumpout system, or bottom dumped in a rehandling basin and then pumped hydraulically to a confined disposal area.

In the first case, the material would be moved to the disposal site by conveyor belt on other means. In the second case, the pump suction is lowered into the barge, water is added, a slurry formed, and the material pumped to the disposal site. The costs and operations from the unloading site to the disposal site are similar to the costs and operations of a pipeline system. The disposal costs are comparable to those experienced in the hydraulic dredging systems. In the study area, clamshell dredging and barge transport are employed in the vicinity of docks at major and minor port facilities. Dredged material is currently transported by barge to a rehandling basin, then pumped into a disposal area by a rehandling pipeline dredge, or the dredged material is transported by barge to bay or ocean sites and bottomed dumped.

CLAMSHELL. This dredge consists basically of a derrick mounted on a barge with a "clamshell" bucket for excavation (See Figure 2). The material is removed by forcing the opposing bucket edges into the sediment. The bucket is lifted out of the water and deposits the material on a barge or bank. The dredge itself remains stationary. This system works best in soft and cohesive materials. A wide variety of bucket and barge sizes is available.

Most of the turbidity generated by a typical clamshell operation is the result of sediment resuspension occurring when the bucket impacts on and is pulled off the bottom. Also, because most buckets are not covered, the "surface" material in the bucket and the material adhering to the outside of the bucket are exposed to the water column as the bucket is pulled up through the water column. When the bucket breaks the water surface, turbid water may spill out of the bucket or may leak through openings between the jaws. In addition to inadvertent spillage of material during the barge loading operation, turbid water in the barges is often intentionally overflowed (i.e., displaced by higher density material) to increase the barge's effective load.

Advantages.

- The dredge plant is readily available and easily assembled.
- Can work effectively in confined areas near docks and breakwaters.
- The density of the dredged material approaches the in-place density of mud and silt.
- Barge transportation is less expensive than hydraulic pipeline in conveying material over distances exceeding approximately 1 mile for shallow draft projects and 4 miles for large deep draft projects.

Disadvantages.

- In dredging very soft deposits, material washes out of the bucket. In dredging very hard materials, the bucket cannot penetrate the surface of the sediments, and little material is excavated.
- This system involves much equipment: tugs, tenders, unloading facilities, and transportation facilities from the unloading area to the final disposal site.
- The dredged material is rehandled several times. With each rehandling, material may be lost or spilled.
- Debris may not permit the full closure of the bucket jaws with attending material loss.
- Relatively low production.

Conclusion. Based on extended historical use in study area and readily available contractor plant, this dredge will be included in system model analysis. The size selected for consideration is the 8 and 12 cubic yard bucket.

"CLOSED BUCKET" CLAMSHELL. This is a recent modification of the clamshell dredge. Operation and design are similar as for a standard clamshell, except that the bucket itself is specially designed to be watertight, thus minimizing loss of material during the dredging process. This is achieved by the use of an upper cover closing the bucket top, and by the use of special seals along the bucket edges. Figure 3 shows two typical closed buckets, as manufactured by the Mitsubishi Seiko Co., Ldt., of Japan, and two types of seal mechanisms used for such a bucket.

Advantages.

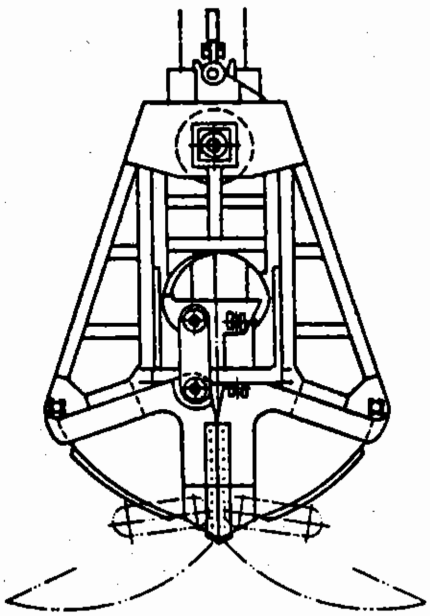
- Dredging in mud, the bucket can excavate with a minimum of sediment loss and turbidity.

Disadvantages.

- The bucket's sealing mechanism is unlikely to work well dredging in coarse and debris-laden material, which is found in some shallow draft projects.
- The bucket does not appear to be available in the USA at this time.

Conclusion. Based on the sediment conditions in the study area, this type of bucket will not be considered any further.

DIPPER DREDGE. The dipper dredge is basically a power shovel, such as is used for earth excavation, which has been mounted on a barge. It has the advantage of being capable of excavating hard materials that cannot easily be dredged by other types of dredges. The dipper dredge has the ability to remove blasted rock or loose boulders with its great digging power. The digging boom, or dipper stick, limits the depth of excavation generally to not more than 60 ft. Beyond this depth, the boom must be massive and presents a severe design problem.



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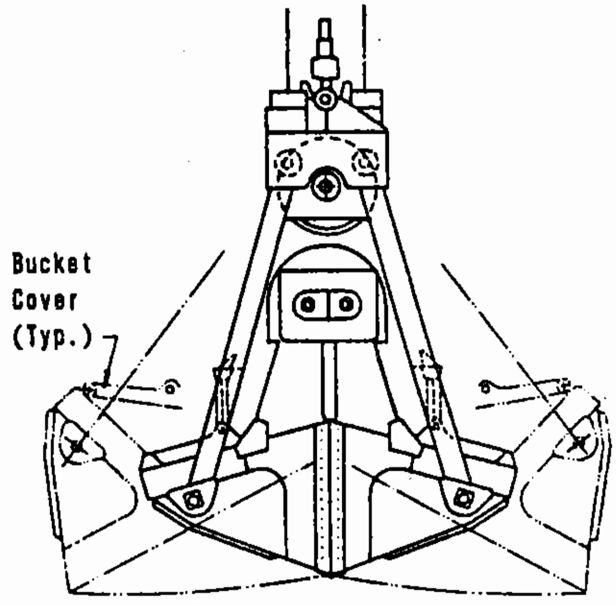
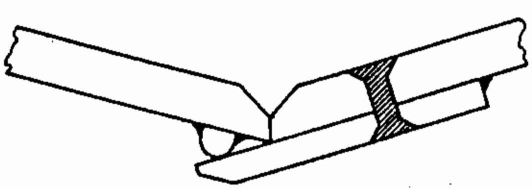
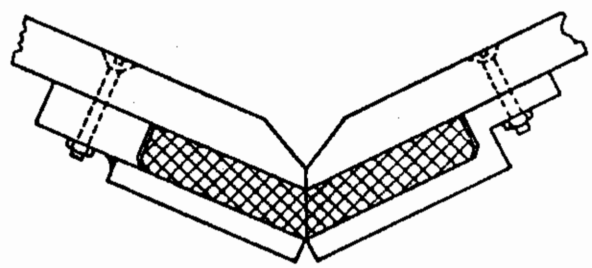


LATERAL DREDGING TYPE

MITSUBISHI CLOSED GRAB BUCKET



TWO-PLANE CONTACT METHOD



HARD RUBBER METHOD

LIP SEALING METHODS

DELAWARE RIVER
DREDGING DISPOSAL STUDY
CLOSED GRAB BUCKET AND
LIP SEALING METHODS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 3

The barge, which serves as the work platform for the power shovel, has spuds to anchor it in the work area while operating. Two spuds are used at the forward end to stabilize the dredge while working, and a single spud centered at the stern of the barge.

Advantages.

- Same advantages as clamshell.
- Very effective for removal of blasted rock or loose boulders.

Disadvantages.

- Same disadvantages as clamshell.

Conclusion. This special purpose dredge will only be considered for new work which involves rock removal. This type of dredge is not included in system model analysis.

DRAGLINE. Similar to clamshell dredge, except it is equipped with a dragline. The dragline scrapes off material by pulling the bucket towards the crane. The dragline can work from land and is more mobile for transport than clamshell dredge.

Advantages.

- Similar to clamshell dredge.

Disadvantages.

- Similar to clamshell dredge.
- Generally lower production than clamshell for channel dredging.

Conclusion. Since clamshell has higher production rates, no further consideration will be given.

ENDLESS CHAIN BUCKET DREDGE OR LADDER DREDGE. This dredge is so named because of its endless chain of buckets passing over and under a long steel frame or ladder. This ladder is usually mounted in the middle of the dredge and extends toward the front of the barge. The operating depth of the ladder can be altered to suit the channel depth being excavated, but is limited by design considerations.

The ladder dredge functions by forcing the buckets into the material to be excavated. The dredge is set up over the cut with an anchored cable set out ahead to pull on and side cables placed to either side to stabilize the barge while working.

The ladder dredge is best suited for dredging a varied type of material at great depths in a comparativey confined location. Quite often a ladder dredge is specifically built for a single project and the design is tailored to suit that job's requirements.

The size of the buckets and the speed of the bucket cycle is dependent upon the materials being dredged. Small buckets are preferred for rock and other hard materials; large buckets are generally used for soft digging. Bucket sizes vary between 5 and 55 cubic feet. In silts and muds the bucket-cycle will average 22 to 30 buckets per minute. In medium soils the rate may be 18 to 29 buckets per minute, but in hard or stiff clays the rate can drop to as low as 9 to 12 buckets per minute. An 85 per cent bucket-fill is considered average. Maximum digging depth for most of these dredges is around 40 feet, but 75 feet is not uncommon.

Generally speaking, in comparison with other types of dredges the ladder dredge has low efficiency. One of the main reasons for this is the extra power required to turn the bucket chain. Costs for dredging with this dredge are about twice that of clamshell dredging.

Advantages.

- Works well in soft clays and rocks.
- The dredged material density approaches the in-place density in mud.

Disadvantages.

- Moored with five or more lines and anchors.
- Hindrance to ship traffic.
- Normally poor mobility and not a rough weather dredge.
- Low efficiency/low production.
- Currently limited to production of gold in United States, none owned by commercial U.S. dredging firms.
- The dredged material is normally rehandled several times.
- This system involves much equipment: tugs, tenders, transport facilities (hopper or barge), and transportation facilities.

Conclusion. This dredge will not be considered further based on above stated disadvantages and nature of dredging in study area.

MODIFIED OR INNOVATIVE DREDGES

CLEAN-UP. The Clean-Up dredge is a hydraulic suction dredge modified by the replacement of a conventional cutterhead with a new suction design. The new suction head consists of an underwater pump and a shielded auger-like mixing device. There is also a moveable plate which deflects currents generated by the dredge suction and a device for collecting gases released during the dredging process. Sonar devices and an underwater television camera permit close monitoring of the dredging operation.

This equipment has been developed by the Toa Harbor Works of Japan and is used exclusively for the removal of highly contaminated material.

Advantages.

- Turbidity generation and resuspension of fine particles is held to a minimum by special suction devices and by giving the operator an accurate picture, through sensors, of the most suitable operation conditions.
- The use of sonar devices and television cameras allows accurate cutterhead positioning.
- The advantages listed under the cutterhead suction dredge also apply here.

Disadvantages.

- This dredge is not available in the United States at this time.
- It has a relatively low production rate and is therefore expensive. Trash and heavier materials would probably impede the successful operation of this machine.

Conclusion. Based on above disadvantages and nature of dredging operations in study area, this dredge will not be considered further.

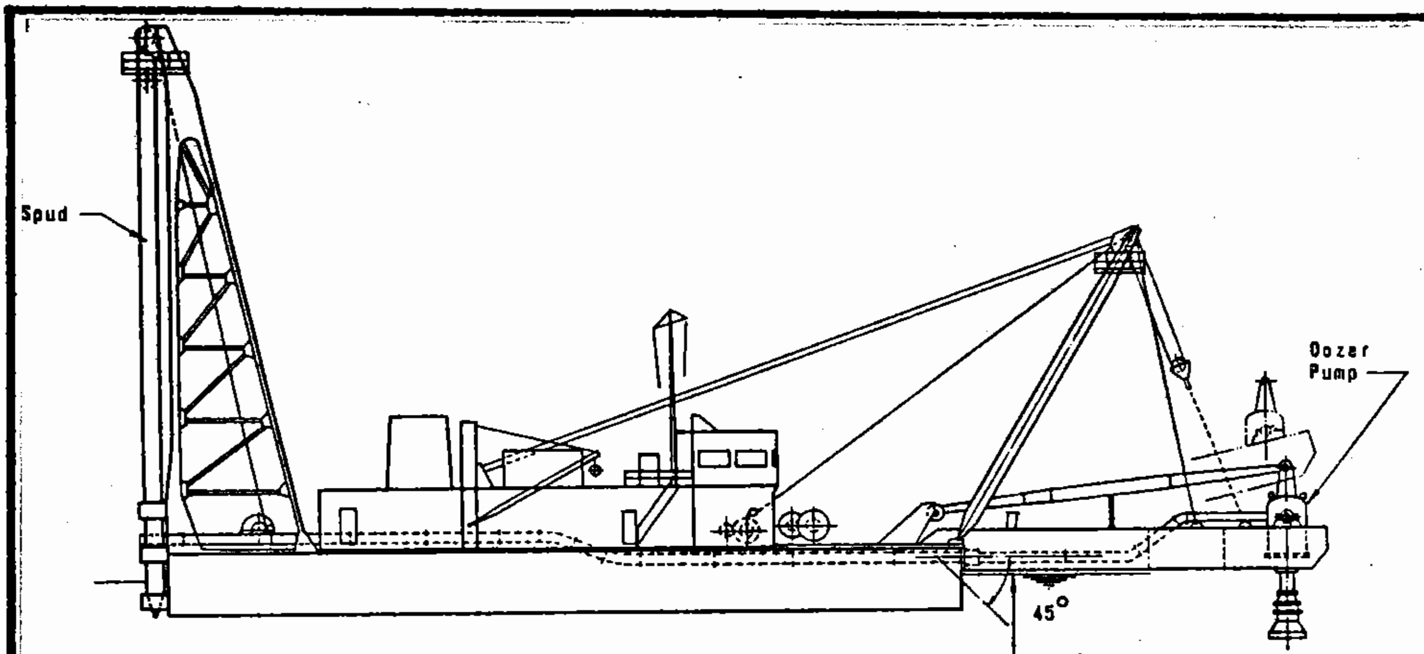
PNEUMATIC DREDGES. These systems are a recent innovation in the dredging field. Hydrostatic head is used to force sediment into the dredge head from which it is ejected by pneumatic pressure. There are few moving parts in contact with the dredged material and, as a result, little wear is experienced. Sludges, muds, and other loose and free-flowing materials can be removed at higher densities than generally experienced with hydraulic dredges. This material may be dumped in hopper barges or pumped to a suitable disposal site.

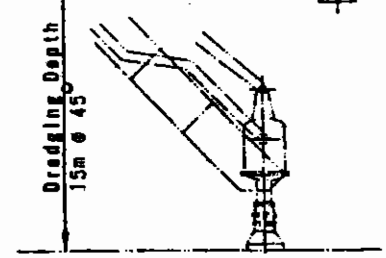
Two companies are known to manufacture pneumatic dredge heads: Pneuma International S.A. (Pneuma), and the Toyo Construction, Ltd. (Oozer). The method of operation of these two pneumatic devices is very similar and is described below.

The Oozer and Pneuma devices are operated by compressed air. Water pressure (hydrostatic head) at the dredge intake is used to load material into cylinders which are then evacuated by compressed air. To obtain a smooth flow of dredged material, two or three cylinders are used, their cycles set at different points so that material is always flowing through the delivery pipeline. The deeper the system is lowered, the greater the head and the production rate. The system includes a barge upon which the compressors, air distributing units and winches are mounted, and a submersible pneumatic device (dredge head) which is lowered for dredging purposes.

Oozer. The Oozer pump dredge consists of four components: an air compressor, a vacuum pump, a pump control valve, and a pump tank. Suction pressure is supplied by the positive water pressure on the sediment layer and the negative pressure generated inside the tank. The sediment in the tank is discharged by forcing in compressed air. The suction and discharge cycles are controlled by two level detectors. The dredge is operated in the same manner as a hydraulic dredge by swinging the craft from deadmen and using two spuds for control and propulsion.

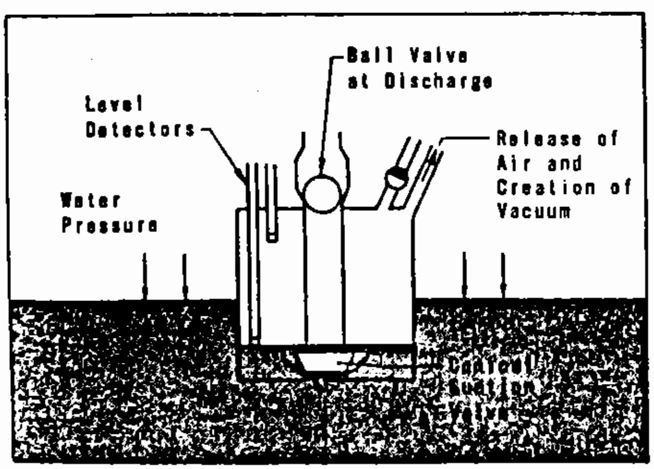
Figure 4 illustrates the operation of the Oozer pump, and shows the Taian Maru, an oozer-equipped dredge owned and operated by Toyo Construction.



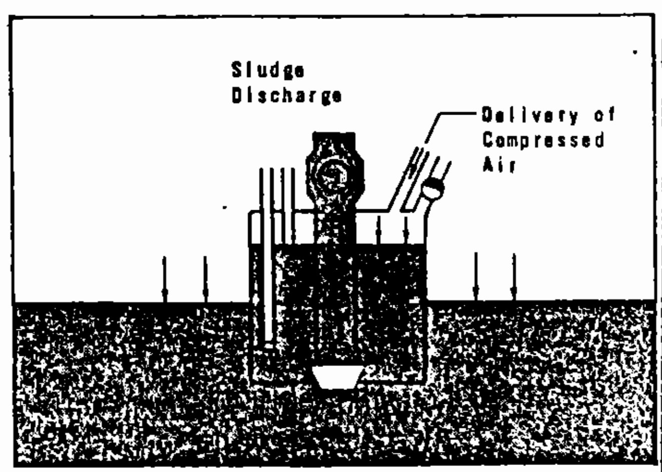


THE TAIAN MARU

Length	37m (121.4 ft)
Width	12m (39.4 ft)
Depth	3m (9.8 ft)
Draft	2.2m (7.2 ft)



SUCTION



DISCHARGE

OOZER PUMP OPERATION

DELAWARE RIVER
DREDGING DISPOSAL STUDY
THE TAIAN MARU AND
OOZER PUMP OPERATION
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 4

Advantages.

- This system generates very little turbidity and does not resuspend fines.

- Hazardous substances are less likely to be dissolved or suspended into the dilution water as compared to a centifugal pump.

- The system can be easily modified to dredge near breakwaters and docks. An underwater TV camera and a device which measures sediment thickness allow precise monitoring of the dredge cut.

Disadvantages.

- This system is not currently available in the United States.

- A wide variety of materials are to be dredged in the Delaware River, most of which are not suitable for removal by this system.

- Limited pumping distance for horsepower of dredge.

Pneuma. - This system is similar to the Oozer dredge with the following exception: after the sludge has been discharged and the compressed air vented, the tank pressure is allowed to return to atmospheric. No vacuum pump is used to create negative pressure as is done in the Oozer system. Therefore, the depth of submergence has a greater effect on production rates in the Pneuma system. This dredge is currently in production and may be available for use in the study area in future years.

Advantages.

- See those listed under the Oozer system. The monitoring capabilities are not as extensive, however.

Disadvantages.

- The dredge pump is not effective at depths less than 12 ft. because of low hydrostatic pressure.

- There is a possibility of trash becoming lodged in the cylinders. This would clog the control valves and impede the pumping cycle.

- Only soft and free-flowing materials can be effectively dredged.

Conclusion. Due to the above disadvantages and nature of dredging in study area the Oozer and Pnuema will not be considered any further.

APPENDIX 3

SYSTEMS MODEL

DELAWARE RIVER DREDGING
DISPOSAL STUDY

APPENDIX 3

TABLE OF CONTENTS

LIST OF FIGURES

DREDGED-MATERIAL DISPOSAL MODEL DESCRIPTION

PROGRAM CAPABILITIES

The (D2M2) model is a simulation-optimization model for analysis of long-term operation and expansion of a disposal system, given estimates of volumes dredged and descriptions of the existing and potential disposal sites. With the model, system disposal capacity expansion alternatives can be analyzed, and the minimum-cost combination and schedule can be determined for new site acquisition and lease extension. This is accomplished by evaluating automatically the present value of acquiring new sites and extending leases to identify the least-costly expansion policy. The cost of any alternative capacity expansion plan is considered to be the sum of site acquisition cost, operation, maintenance, and lease cost. To determine this, D2M2 includes the capability to identify the minimum-net-cost short-term operation policy for any specified system. This is accomplished for formulating and solving a mathematical programming model that represents the problem of allocating efficiently the available capacity. If desired, this portion of the program may be used without the capacity expansion evaluation portion.

Disposal-site consolidation rates, containment dike heights, and other characteristics of existing and proposed disposal system components are specified by the model user, so management schemes that involve changes in these parameters may be evaluated by systematic variation and re-execution of the model.

COMPUTATIONAL TECHNIQUES

Program D2M2 employs two optimization techniques to evaluate disposal system management alternatives: Network-flow programming and branch-and-bound enumeration. Network-flow programming is used for evaluation of the operation of a specified disposal system. Branch-and-bound enumeration is used for selection of the least-costly system capacity expansion scheme.

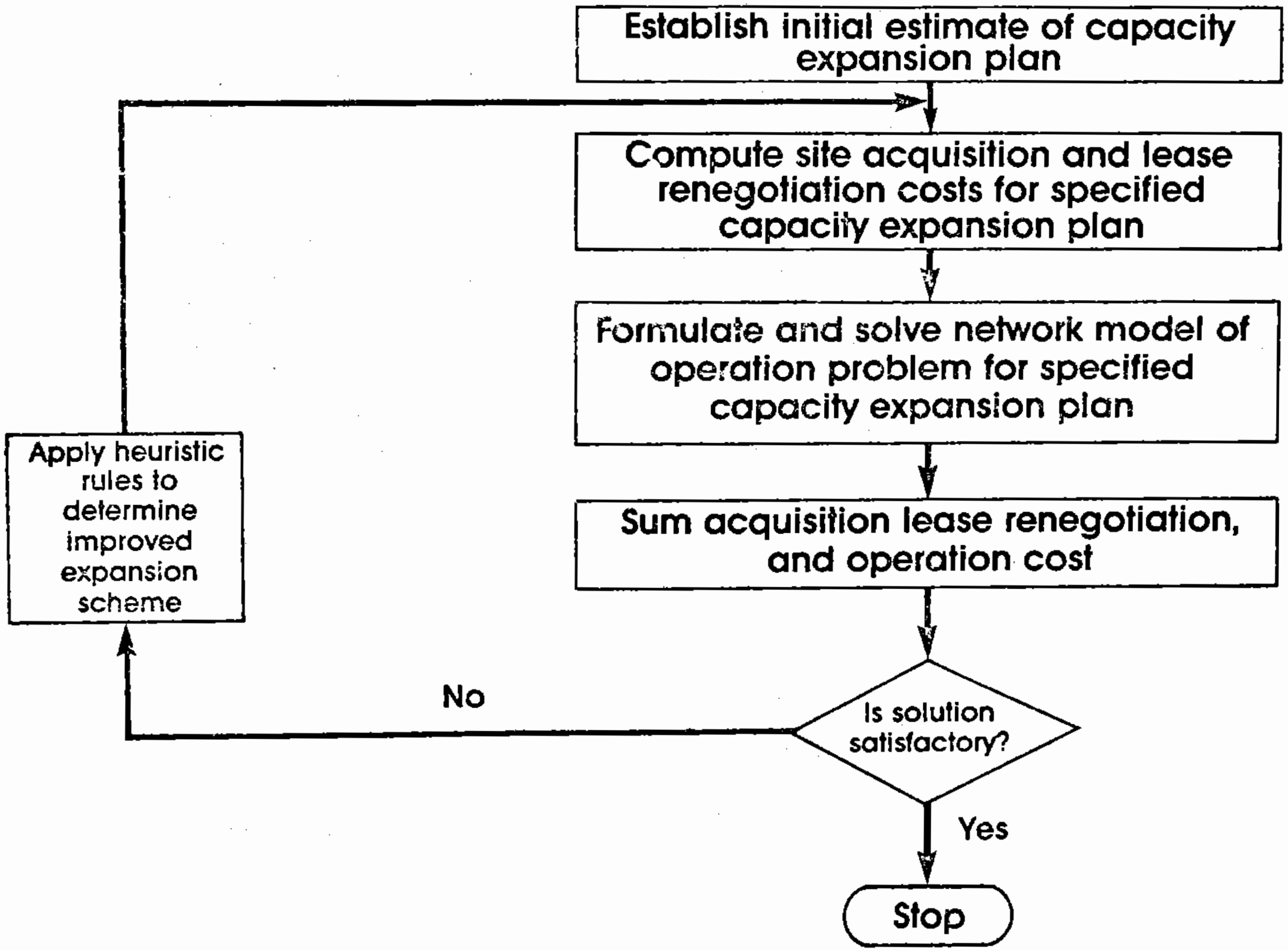
NETWORK-FLOW PROGRAMMING. Program D2M2 models the characteristics of dredged sites, disposal sites, and material transportation facilities as a network. This network includes nodes that represent the available disposal sites and the dredge sites. The nodes are connected by arcs that represent the transportation linkages, the disposal sites-to disposal site material transfer facilities, the material reuse capabilities, and the storage of material in the disposal sites. The "flow" of material through these arcs represents the transporting, transferring, or storing material within the disposal system. The flow may be limited, as appropriate, to represent restrictions on the maximum volume moved from a dredging site with a particular dredging technique, restrictions on the volumes transferred between sites, and limitations on the volume deposited in a disposal site. A cost per unit of flow is associated with each arc, representing the cost of dredging, transporting, and storing material.

The network-flow programming algorithm of D2M2 determines the least-costly assignment of flows to the arcs of the network, subject to the restrictions on those flows. The algorithm begins with an arbitrary set of flows for the arcs and iteratively adjusts the flows until the minimum-cost set which satisfies all restrictions is found.

BRANCH-AND-BOUND ENUMERATION. The least-costly scheme for acquisition of user-specified capability expansion options is determined in D2M2 by enumeration of the possible schedules. For example, if a site is considered for acquisition between 1985 and 1990, the enumeration scheme might evaluate the total cost if the site is added in each year 1985 to 1990 inclusive. From this evaluation, the least-costly alternative is selected as the optimal capacity expansion plan if this plan satisfies the capacity requirements and if the plan is less costly than operation of the existing system without expansion. Determination of the cost of each schedule is accomplished by computing the sum of the present value of the acquisition costs and lease renegotiation costs and the present value of operation cost of the disposal system with the expansion sites available. This operation cost is determined with the previously described network model of the disposal system.

The branch-and-bound enumeration procedure provides for a well-structured, systematic search of the site acquisition and lease renegotiation options. As implemented in D2M2, enumeration begins with evaluation of the total cost if all capacity expansion sites are acquired in the earliest period allowed and if all leases are renegotiated. A heuristic rule is used then to adjust this capacity expansion scheme, based on analysis of disposal site utilization during the period of analysis. After each adjustment, the network model of the disposal system is altered accordingly, and the least-costly operation policy is found. The cost of acquisition and lease renegotiation for the new expansion scheme is determined and is added to the operation cost. The heuristic rules are again applied and the process is repeated. This is illustrated by Figure 1. With careful application of this procedure, acceptable alternative capacity expansion schemes can be identified with reasonable computational effort.

Additional information on this model is available in the user's manual in the District Office.



**DELAWARE RIVER
DREDGING DISPOSAL STUDY**

**CAPACITY EXPANSION
ITERATION PROCEDURE**

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE 1

APPENDIX 4

PERTINENT CORRESPONDENCE

DELAWARE RIVER DREDGING
DISPOSAL STUDY

APPENDIX 4
PERTINENT CORRESPONDENCE

TABLE OF CONTENTS

Table of Contents (Cont'd)

INTRODUCTION

This appendix includes correspondence pertinent to the Delaware River Dredging Disposal Study. During the Reconnaissance Study coordination was initiated with regional, Federal, State, county agencies, special interest groups and interested individuals. Throughout the Stage 2, meetings were held with the Plan Formulation Committee to solicit comments on various completed work, efforts.

93rd Congress

2nd Session

United States Senate

COMMITTEE ON PUBLIC WORKS

COMMITTEE RESOLUTION

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.

Adopted: September 20, 1974

GPO 89-684-b

Jennings Randolph, Chairman.

(At the request of William Roth and Joseph Biden, Senators from Delaware)

95th Congress

2nd Session

United States Senate

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

COMMITTEE RESOLUTION

RESOLVED BY THE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS OF THE UNITED STATES SENATE, That the Board of Engineers for Rivers and Harbors, created under the provision 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 No. 330, Seventy-sixth Congress, 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, and Indian River Inlet and Bay.

Jennings Randolph, CHAIRMAN

Robert T. Stafford, RANKING MINORITY MEMBER

Adopted: July 24, 1978

GPO 88-717-b

(At the request of Senator William V. Roth, Jr., from Delaware)

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN-R

23 February 1978

Dear Sir:

I am pleased to inform you that we have initiated the Delaware River Dredging Disposal Study. The purpose of this Congressionally authorized study is to develop a regional dredging spoil disposal plan for the tidal portions of the Delaware River, its tidal tributaries, and Delaware Bay, extending from Trenton, New Jersey, to the sea. This study was authorized by the United States Senate Committee on Public Works on 20 September 1974. Efforts in the following year will concentrate on establishing a systematic program for conducting the study.

The study is expected to include investigations of the following: current and future dredging requirements of Federal, State and private interests; potential future spoil disposal sites; alternative dredged spoil disposal and utilization techniques; competing land use demands among agricultural, industrial, environmental and navigational interests; and economic, environmental and social impacts of all potential alternatives. The study will also assess the current and projected future problems associated with present dredging disposal methods and include an active public involvement and participation program.

We welcome any contribution you can make to this study. In particular, your views regarding the significance of the dredging disposal problem would be appreciated.

We look forward to your assistance. As the study progresses, we will inform you of major developments, so that your views may be obtained on all aspects.

Sincerely yours,

JOEL T. CALLAHAN
Lieutenant Colonel, Corps of Engineers
Acting District Engineer

MINUTES

INITIAL PLAN FORMULATION
COMMITTEE MEETING

1. Location: The meeting was held at the Philadelphia District on 2 July 1980.

2. Attendees: See the attached list.

3. Purpose:

a. Introduce the study, review its problems and needs and the possible alternative measures to solve them.

b. Introduce the Plan Formulation Committee and discuss their role.

c. Discuss the study area, parameters, and selection procedure.

4. Discussion: The meeting began with the introduction of all those in attendance. After some introductory remarks on the study, the role of the Committee and its future activities, as seen at this time, were discussed by Colonel Ton. Next, a review of alternate methods that could obtain additional sites as well as those that extend the useful life of existing sites were discussed by John Tunnell. The selection of the study area, the parameters that are being mapped, and the selection procedure to be used in the identification of suitable disposal areas were the last topics to be discussed by John Tunnell. The handouts prepared for this meeting included lists of the alternate measures, parameters, addresses of committee members, as well as a copy of the general study schedule.

The following section highlights or summarizes the comments made during the meeting:

A). The possibility of segregating any contaminated dredged material into selected sites was discussed. In response, it was stated that Delaware River material is generally of acceptable quality and that it is much easier to incorporate design techniques to handle any contaminants for new sites than for existing ones. The study will give consideration to this.

B). Concern was expressed that reduced dredging activities would affect the shipment of coal, grain, etc. and that certain considerations should be taken in doing an economic analysis of the potential impacts. It was pointed out that the authorized projects will be taken as a given, and that consideration will be given to changing the frequency of dredging (including advance maintenance), and not at changing the channel dimensions, as that is considered beyond the scope of this study.

As an informational follow-up to the concern about coal shipments, it should be mentioned that an Interagency Coal Export (ICE) Task Force has been established for the purpose of exploring the possibility of substantially increasing our nation's coal exports. The Task Force will compile information on present and projected levels of domestic and international supply and demand; identify actions required to increase exports; analyze the social, economic and environmental costs and benefits of such actions; and assess the role to be played by the private sector and, if desirable, by the government. They are expected to report to the President shortly.

C). Regarding the possible restoration of any fish and wildlife wetland habitats that may have been destroyed by past practices (prior to NEPA and other environmental legislation), a review of the study resolution has subsequently found that this is beyond the scope of the study. However, as pointed out at the meeting, the creation of marsh is an alternative disposal method that will be given serious consideration. This method, as well as island and upland development, could be coupled with habitat development techniques to provide suitable wildlife management areas.

D). Long-distance "satellite" areas for the disposal of dredged material will be considered but will be limited to the Philadelphia District's bounds. A good example of potential areas are the abandoned mines in northeastern Pennsylvania, that lie within the District's bounds. The approach for locating and analyzing these areas could be adopted from the New York District's Disposal Study which identified similar areas within their own bounds. Furthermore, the successful application of sludge in mines, as per a new pilot program, may be amenable to dredge spoil. This program, implemented by the Philadelphia Water Department, allows for the annual disposal of 50,000 dry tons of sludge onto approximately 1000 acres of abandoned strip mines located in northeastern Pennsylvania. Each operation is a one-shot deal.

E). The small quantities of sandy material dredged from the Ship John Light area of the Bay and the restrictions of the hopper dredge, make disposal onto beaches impractical. The material further upstream in the Philadelphia to Sea project is silty and therefore is not suitable for beach fill.

F). Concern was expressed that the sites that do "pop-up" from the initial suitability screening may not be available for use, and that real estate availability and zoning should also be considered initially. This was recognized but it is felt that this, being an institutional problem, would best be handled in later stages when more site specific. However, we do intend to develop general real estate costs for various land uses in various sections of the study area. These will be applied, as part of the initial screening, to those sites which are found suitable in the initial model analysis.

G). Concern was also expressed over the potential that all suitable sites might not, after the screening, be spread throughout the study area. A suggestion, which had already been considered, was to break the model into reaches with specific, known dredging rates. A "Distance from Shoaling" parameter could then be employed to consider dredging problems by reach. All sites will be screened even further when more site specific and a least cost analysis conducted.

H). New Jersey has formulated a policy on what areas may not be suitable for disposal material in New York District. New Jersey opposes disposal in wetlands, prime and unique farmlands, aquifer recharge areas, and in habitat for endangered or threatened species. This policy may also apply to the Philadelphia District.

I). It was mentioned that weightings could change based on the operational parameters that the Corps uses for site preparation, i.e. disposal of contaminated versus uncontaminated spoil. Naturally the Corps' objective is to minimize costs and time in our operations. However, as a result of environmental legislation and policies, monitoring and testing of our efforts is conducted.

DELAWARE RIVER DREDGING DISPOSAL STUDY
INITIAL PLAN FORMULATION COMMITTEE MEETING
ATTENDANCE LIST - 2 JULY 1980

Colonel James G. Ton	Philadelphia District, Corps of Engineers
Nicholas J. Barbieri	"
John Murphy	"
John Tunnell	"
Lee Ware	"
Don O'Neill	"
J. Jeffrey Radley	"
Stanley Snarski	"
Bob Schmidt	"
Herb Howlett	Delaware River Basin Commission
Seymour D. Selzer	"
Tim Goodger	National Marine Fisheries Service
Carl Montana	U.S.D.A., Soil Conservation Service
Charles Kulp	U. S. Fish and Wildlife Service
Mike Chezik	"
David A. Smith	"
Bill Muir	U. S. E.P.A., Region III
Raymond L. Montgomery	Waterways Experiment Station
William R. Ratledge	Delaware D.N.R.E.C.
Bernie Moore	N.J. D.E.P.
Lawrence Schmidt	N.J. D.E.P.
Norman Kapko	PA. D.E.R.
William Harrison	Joint Executive Council
Robert B. Biggs	University of Delaware
Gus Pistilli	American Dredging Company

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
112 West Foster Avenue
State College, PA 16801

July 10, 1980

Colonel James G. Ton
District Engineer
Philadelphia District, Corps of Engineers
Custom House, 2nd and Chestnut Streets
Philadelphia, PA 19106

Re: Delaware River Dredge Disposal Study - Initial Meeting of the Plan Formulation Committee

Dear Colonel Ton:

The Service supports the balanced approach that the Corps has initiated in attempting to solve the problem of dredge material disposal. Past disposal practices have been destructive of fish and wildlife habitats, particularly wetlands, and we are anxious to avoid or minimize further damages. Moreover, we look upon this study as an opportunity to restore or replace fish and wildlife habitats that were destroyed by past disposal operations. We urge you to give serious consideration to fish and wildlife habitat development, especially for the Philadelphia to Trenton Navigation Project.

We have reviewed the handouts given to us at the meeting and offer the following comments.

The Service has agreed to map "important fish and wildlife resource areas" as specified in our FY80 scope of work agreement. These areas will be selected on the basis of high value and criticality. Although we originally planned to include low and moderate value resource areas in the mapping, insufficient funding dictated that these habitats be dropped, leaving only the important or high value areas. Therefore, the Service has already employed a weighting system in providing input to the study. Essentially all areas that the Service maps are to be considered high value and potentially sensitive to dredged material disposal.

During the meeting, the representative from New Jersey indicated that some areas in his state would not be compatible with dredge material disposal. He cited wetlands as an example of areas that should be excluded from consideration as disposal sites. The Service fully supports this exclusion and recommends disposal activities in wetlands be likewise excluded in Pennsylvania and Delaware. Unfortunately our National Wetlands Inventory has not been completed for these states. However, we will make available to the Corps wetland maps covering the state of New Jersey and those areas mapped in Pennsylvania and Delaware. We suggest that these maps be used in lieu of wetland maps being prepared by your consultant, wherever possible.

There appears to be some overlap in the parameters and variables to be modeled. For example, under "land use and land cover," the variable "agricultural/low density residential" appears. How does "agricultural" differ from "cropland/pasture" under "vegetation"? Wouldn't it make more sense to lump "vegetation," wetlands" and "prime and unique farmland" under "land use and cover"? We recommend that the Corps re-evaluate the list of parameters and variables to eliminate potential overlap.

We note that the Plan Formulation Committee does not possess representation from the Pennsylvania Fish and Game Commissions. The bulk of the legislative responsibility for managing fish and wildlife resources in Pennsylvania belongs to these agencies and they should be consulted for possible representation. We recommend the Corps solicit their interest in the study and offer them the opporunity to participate on the Plan Formulation Committee.

We appreciate the opportunity to comment on this matter.

Sincerely,

Charles J. Kulp

Charles J. Kulp
Field Supervisor

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO

MINUTES

DELAWARE RIVER DREDGING DISPOSAL STUDY
SECOND PLAN FORMULATION COMMITTEE MEETING

A. Location: The meeting was held at the Philadelphia District on 26 March 1981.

B. Attendees: See the attached list.

C. Purpose:

1. Review the status of other efforts conducted since the last meeting.

2. To present the spacial attractiveness model being developed to screen the study area for potentially suitable dredged material disposal sites.

3. Discuss future study efforts.

D. Discussion:

1. The minutes of the initial meeting and the revised list of study parameters were approved by the committee.

2. The creation of an interdisciplinary study team in the District was discussed. In addition, it was recognized that the role of the plan formulation committee will change to meet the needs of the study as it progresses. It is anticipated that the committee will advise the District regarding decisions that guide the study.

3. The application of the computerized attractiveness model for the deep-draft projects was presented. In summation, the model provides a data management tool for use in screening a large geographic area to identify those locations which may have the best potential and least impact as dredge spoil disposal sites. The flexibility of the system will help to formulate selection criteria by displaying results of our assumptions. The output from the model will help to illustrate and support the study teams collective judgement. This process will undoubtedly reflect a compromise among alternative positions and should guide use toward those areas which warrant further, more detailed, site specific investigation. For the highlights of the presentation, see Inclosure #1.

4. Analysis of the shallow-draft navigation projects are also being conducted. As shown on the handout provided at the meeting, these projects are to be analyzed by a more traditional approach as the resolution of the attractiveness model is not appropriate for locating the smaller sites. Another study effort involves obtaining aerial topography of all active disposal sites serving the deep-draft projects. This will allow for an update of their remaining capacities and rates of fill. In addition, historic rates of dredging are being determined for Federal navigation projects and a questionnaire has been sent out to determine quantities of material that non-Federal interests have been dredging. Another major

ongoing effort involves the screening of numerous alternative measures or methods of disposal for further detailed studies. These measures include increasing the dike elevation and/or lease extension of existing sites, commercial reuse of dredged material, open water disposal, etc.

5. Prior to the next meeting, tentatively scheduled for summer, we will furnish available output from the attractiveness model to the committee members. Any comments or questions on the output can be raised at that meeting. In addition, the development of criteria for conducting site specific studies and field investigations will be addressed. This criteria is required prior to initiation of studies in Fiscal Year 1982.

6. The following section briefly highlights concerns and comments that the committee raised at the meeting:

a. Concern was raised regarding the source and degree of accuracy of the data developed as input for the model. In response, it was indicated that the data was based on literature searches conducted by various consultants including the the U.S. Fish and Wildlife Service (USF and WS). Our in-house, technical study team was deeply involved with the development of this data and felt that it was suitable for the initial screening stage. The USF & WS concurred with this view.

b. Social-political impacts will be considered at site specific stages of our investigations.

c. Members of the committee mentioned that the model could be helpful to community planners for industrial use applications. In fact, if desired, the States could also utilize the model.

d. Upon inquiry of anticipated documentation for the model, it was mentioned that the District already has a report available on the application of a computerized spatial model.

e. Since the states of Pennsylvania and New Jersey have the responsibility of furnishing disposal sites for the Delaware River, Philadelphia to Trenton project, the sites identified from our Stage 2 investigations will be furnished to the States for their consideration. Stage 3 work is not anticipated for this reach.

f. It was recommended that the respective State Coastal Zone Planners be made aware of the potential sites that are identified in the initial screening before conducting detailed studies.

g. Much discussion centered on a bill in Congress to deepen the ports of Philadelphia to 55 feet to accommodate the exportation of coal. Our study will not be considering deepening of the existing channel. We will concentrate on addressing disposal problems associated with the presently authorized depths.

h. Another item mentioned was the present administrations desire to employ "user fees", which would allow for the cost for maintenance dredging to be shared more by private interests. It was generally concluded that this approach would benefit this area and does not impact the study. The committee will be kept informed of this situation.

DELAWARE RIVER DREDGING DISPOSAL STUDY
COMPUTERIZED ATTRACTIVENESS MODEL
HIGHLIGHTS

1. Extensive efforts to develop the data bank for the model included mapping developed by the U.S. Fish and Wildlife Service (USF & WS) as well as specialized consultants.

2. The Corps has experience in this type of model; the application to this study is new.

3. The advantages of spatial analysis methodology are that it is systematic, dynamic and updateable.

4. There are two major components to this methodology. One being the computerized data bank of pertinent geographic and resource characteristics. The other, a series of utility and analysis programs which access the data bank and perform desired analyses and produce selected outputs.

5. The revised parameter list reflects an interdisciplinary study team approach by the District. The study team has identified 12 data parameters for inclusion in the data bank, eight of which will be assigned weighted sensitivity values and analyzed directly. The remaining four will be used indirectly in the computer analyses for supplemental information or as data overlays.

6. The grid cell data bank is being constructed by a technique known as polygon digitizing.

7. The total 5000 sq. mi. study area has been subdivided by the computer into approximately 180,000 grid cells, each of which covers approximately 18 acres.

8. The four basic analytical applications of the model are "distance determination", "impact assessment", "coincident tabulation" and "locational attractiveness".

9. In order to familiarize the study team with the application of the model and develop a technical approach for analyzing the entire study area, a pilot study was conducted. The area selected was in Bucks County, Pennsylvania, adjacent to Biles Island and the Delaware River.

10. Three trial runs were made of the pilot area, to show the effects that a variation in acceptance criteria would have on the output.

Delaware River Dredging Disposal Study

Second Plan Formulation Committee Meeting

Attendees

Seymour Selzer	Delaware River Basin Commission
Lawrence Schmidt	N. J. Dept. of Environmental Protection
Fred Schultz	N. J. Dept. of Environmental Protection
William C. Muir	U. S. Environmental Protection Agency
Charles Kulp	U. S. Fish & Wildlife Service
Mike Chezik	U. S. Fish & Wildlife Service
Carl Montana	U.S.D.A. Soil Conservation Service (N.J.)
Edward Bender	Pa. Dept. of Environmental Resources
W. R. Ratledge	Delaware DNR&EC
Don Roeder	American Dredging Company
John J. Malone	Phila. Port Corp.
H. R. Kreh	Corps of Engineers
Stanley Snarski	Corps of Engineers
Thomas Schina	" "
Sue Kasper	" "
John Burnes	" "
J. Jeffrey Radley	" "
Jeffrey Steen	" "
Gary Rohn	" "
Frank Schaefer	" "
John Murphy	" "
George Steinrock	" "
Stan Lulewicz	" "
Don O'Neill	" "

Attachment #1

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

DIVISION OF ECOLOGICAL SERVICES
1825B Virginia Street
Annapolis, Maryland 21401

September 16, 1981

District Engineer
Philadelphia District, Corps of Engineers
Custom House - 2nd and Chestnut Sts.
Philadelphia, PA 19106

Dear Sir:

In accordance with the scope of work for the Delaware River Dredging Disposal Study, the final section of our planning aid report entitled "Small Navigation Projects - Indian River Bay and Rehoboth Bay" is enclosed. As previously requested, other sections of this report were sent to you as they were completed.

This report is of a reconnaissance nature and does not constitute the report of the Secretary of the Interior on the project within the meaning of Section 2(b) of the Fish and Wildlife Coordination Act. The list of preparers noted in this report is not to be used to satisfy Section 1502.17 of the Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act. You may, however, feel free to use the report or parts thereof as a routine bibiographical citation. The report was prepared by Ms. P. Suzanne Nair under the supervision of Dr. Glenn Kinser, Ecological Services, U.S. Fish and Wildlife Service, Annapolis, Maryland. It has been coordinated with the Delaware Department of Natural Resources and Environmental Control.

If you have any questions concerning any aspect of the report, please contact Mr. Robert Folker of my staff or Ms. Nair.

Sincerely yours,

Glenn Kinser
Supervisor
Annapolis Field Office

* SIMILAR LETTERS WERE RECEIVED ON OTHER COMPLETED SMALL PROJECTS.

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
Suite 322
315 South Allen Street
State College, PA 16801

October 20, 1981

Lt. Colonel Roger L. Baldwin
District Engineer, Philadelphia District
U.S. Army Corps of Engineers
Custom House, 2nd and Chestnut Streets
Philadelphia, PA 19106

Dear Colonel Baldwin:

We are transmitting our planning aid report, "Delaware River Dredging Disposal Study - Small Navigation Projects." The report fulfills our 1981 agreement with the Corps for the Delaware River Dredging Disposal Study. Information in our report was coordinated with the New Jersey Division of Fish, Game and Wildlife; the Pennsylvania Fish and Game Commissions; and the National Marine Fisheries Service. The report was prepared in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.), but does not constitute the report of the Secretary of the Interior within the meaning of Section 2(b) of the Act, nor does it constitute consultation required under Section 7 of the Endangered Species Act (87 Stat. 884, as amended).

If you have any questions concerning any aspect of the report, please contact us.

Sincerely,

Charles J. Kulp
Field Supervisor

Attachment

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO

MINUTES

DELAWARE RIVER DREDGING DISPOSAL STUDY
THIRD PLAN FORMULATION COMMITTEE MEETING

A. Location: The meeting was held at the Philadelphia District on 27 April 1982.

B. Attendees: See the attached list.

C. Purpose:

1. To present the revised study plan.

2. To present suggested input (including parameters, weighting, relative weightings) for the spatial attractiveness model and to obtain views of committee members regarding the subject.

3. To present the results of the spacial attractiveness model for a sample area.

4. To discuss the development of a systems model and present the results of a sample area.

5. To duscuss the alternative analysis and the federal and non-federal dredging needs.

D. Discussion;

1. The attached handouts were provided at the meeting and were used as the basis of discussion.

2. The revised study plan was presented. Refer to page 2 of the inclosure. The study schedule shows a delay of 13 months, which is attributed to delays experienced in the creation of the data bank for the attractiveness model and a funding cut-back in fiscal year 1983. The work efforts for current fiscal year were highlighted as well as expected end products at the end of Stage 2 and 3. At the end of Stage 2, the study will identify the optimal plans for disposal of material for a 10-50 year time frame. Stage 3 studies will refine or supplement the environmental work produced in Stage 2.

3. The data base for the computerized attractiveness model and its application for a sample area was presented. The input data consists of environmental and engineering considerations (parameters). For each parameter, various variables have been identified, mapped, digitized and assigned weighting factors on a scale of 0 to 10 or excluded (A -1 denotes that a particular variable is excluded from further consideration). A relative index value has been assigned to represent the relative importance of a particular parameter. Refer to pages 6-14 the handout.

4. Numerous sensitivity runs were made for a sample area, identified as the Kinkora Range. These sensitivity runs took into account the objectives of the Environmental Quality and National Economic Development. The various outputs (see pages 15-20) showed an ordering of preference for potential disposal sites under multiple scenarios. The committee members were asked to provide any additional combinations of scenarios.

5. A systems analysis technique will be utilized to assess the numerous plans that will be developed in the plan formulation phase of the study. A computerized model will be developed by the Corps of Engineers' Hydrologic Engineering Center (HEC) to assist the study team in determining the cost-volume estimates. The systems model consists of four program modules; a pre-processor, a capacity expansion model, an operation model and a post-processor. The relationship of these modules is shown on page 24 of the attached inclosure. An existing operation model that is currently available was exercised for the Kinkora Range. This model is less sophisticated than the one that will be ultimately developed by HEC. Numerous "what if" scenarios were used to simulate costs to transport the dredged material during a single year. Refer to pages 27-30 of the handout for the assumptions, the input data and results of the sample runs.

6. The potential alternative measures are shown on pages 39-40 and will be assessed by the systems model. Also, the annual dredging needs shown on page 41 will serve as input to the systems model.

7. The committee was requested to provide comments and feedback on the topics discussed.

8. The following section briefly highlights concerns and comments that were raised at the meeting.

a. Concern was raised regarding the inconsistency in treating wetlands by this study and the on-going district notice of intent for Chester-Monds. It was pointed out that the district is aware of the environmental quality value of this area, and that we are reconsidering recommendations proposed in the late 1960's, to see if we can "design around" the concerns regarding wetlands. The Marcus Hook range is a heavily shoaled area and the district did not want to dismiss this area prematurally.

b. A discussion was centered on the size of the attractiveness model grid. The selection of the grid size (18.4 acres) was based on that would be considered for the existing federal projects (25 acres).

c. In response to a concern for potential quality (of the dredged material) that was raised, it was pointed out that available data indicates the quality is not a problem. In this regard, the Corps of Engineers currently obtains annual certificates from each state involved to assure consistency and compliance with regulations.

d. In order to meet EPA's regulations, a significant lead time would be required to adequately consider ocean dumping.

e. It was pointed out that the future private dredging quantities should take into account the urban water front developments or changes. If this data can be made available, the quantities of dredged material will be included.

f. The recharge areas that were mapped and digitized into the attractiveness model are based on the permeability of the soil. The mapping of these areas was requested by DRBC, their request was accommodated.

9. A tour of the Corps of Engineers computer center was conducted. Its purpose was to show the interested members the computer hardware that is utilized in the creation of the data bank and generation of output for the attractiveness model.

Delaware River Dredging Disposal Study

Third Plan Formulation Committee Meeting

Attendees

Page Fielding	Delaware River Basin Commission
Tim Goodger	National Marine Fishing Service
Lawrence Schmidt	N. J. Dept. of Environmental Protection
Fred Schultz	N. J. Dept. of Environmental Protection
Charles Kulp	U. S. Fish & Wildlife Service (Pa, NJ)
Mike Chezik	U. S. Fish & Wildlife Service (Pa, NJ)
Suzanne Nair	U. S. Fish & Wildlife Service (Del)
Bob Folker	U. S. Fish & Wildlife Service (Del)
Carl Montana	U.S.D.A. Soil Conservation Service (NJ)
Wendell Kirkham	U.S.D.A. Soil Conservation Service (NJ)
Tom Patin	Waterways Exp. Station (WES)
Edward Bender	Pa. Dept. of Environmental Resources
Lawrence Irelan	Delaware DNR&EC
Don Roeder	American Dredging Company
James Charlton	Phila. Maritime Exchange
Michael Wolf	Delaware Valley Regional Planning Commission
Col. Roger Baldwin	Corps of Engineers
Nicholas Barbieri	Corps of Engineers
H. R. Kreh	Corps of Engineers
Stanley Snarski	Corps of Engineers
Thomas Schina	Corps of Engineers
John Burnes	Corps of Engineers
Frank Vinci	Corps of Engineers
Brian Heverin	Corps of Engineers
John Murphy	Corps of Engineers
George Steinrock	Corps of Engineers

Attachment #1

Delaware River Dredging Disposal Study

Third Plan Formulation Committee Meeting

Attendees

Jeffrey Steen	Corps of Engineers
Gary Rohn	Corps of Engineers
Frank Schaefer	Corps of Engineers
Bob Anastasia	Corps of Engineers
Stan Lulewicz	Corps of Engineers
Bruce Uibel	Corps of Engineers
Len Lipski	Corps of Engineers
Jacqueline Winkler	Corps of Engineers

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

MAY 6 1982

Mr. Nicholas J. Barbieri, P.E.
Acting Chief, Planning/Engineering Division
Philadelphia District
Corps of Engineers
Custom House-2nd & Chestnut Sts.
Philadelphia, PA 19106

Re: Delaware River Dredging Disposal Study: PFC

Dear Mr. Barbieri:

The Corps presentation of the Delaware River Dredging Disposal Study at the Plan Formulation Committee meeting held on April 27, 1982 was outstanding. We foresee the computerized disposal site model as a valuable tool for this project. Several issues were discussed at the meeting that we would like to comment upon. First, the 18 acre cell size used in the computer model was quite sufficient for gross approximation. However, we believe the cell should be better described than by the categories exceeding 50%. We suggest that each cell be described by both major and minor use categories. Table 1 was confusing in this regard. In place of a single descriptive parameter, such as wetlands greater or less than 50%, two classifications could be used. The second would identify the minor use. This may reveal some special consideration for its use or possibly eliminate secondary use completely.

As a second item, there was no mention of mitigation potential of the model. In addition to the identification of disposal areas, the model could also be used in the identification of potential mitigation sites where compensation might be required as a condition of site selection. This might be the case where a site was considered acceptable except for a minor portion of the area containing wetlands or other valuable resources.

Finally, we believe the potential to use less than 18 acres for the grid sizes, would be very useful. An example, is Rehoboth Bay, or in areas around the ports, where large areas may not be available for spoil disposal. The States or the ports may have supplemental data on land use planning, port expansion, or related projects that could be coordinated into the overall proposal.

During the meeting, the issue of the Delaware River channel expansion was not mentioned or have we heard of plans to deepen or widen the channels. Channel modification is often discussed in association with other channel projects so this model should be capable of responding to changing conditions without major model modification.

The use of ocean dumping was mentioned as a possible alternative. If any consideration is to be given to this alternative, a meeting, involving all interested parties, should precede any final decision.

You may be aware that we are coordinating with the Norfolk and Baltimore Districts to develop similar long-range disposal plans. We recommend that the Districts coordinate their findings. This is especially true with the rehandling/reuse study being done in Baltimore.

Thank you for the opportunity to comment on this project and we look forward to our next meeting in the Fall.

Sincerely yours,

S. F. Thoumsin
Acting Chief
EIS & Wetlands Review Section

UNITED STATES DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

1370 Hamilton Street, Somerset, New Jersey 08873

May 24, 1982

John F. Murphy, Chief
Planning Branch
Philadelphia District Corps of Engineers
Custom House - 2D and Chestnut Streets
Philadelphia, PA 19106

Dear John:

As requested at the last meeting of the Delaware River Dredge Disposal Study Committee, we offer the following comments on the attractiveness model:

We believe the assumptions on the attractiveness model screening are sound and appear to be inclusive. There appears to be considerable overlap or duplication of variables in the land use/land cover and construction and development parameters. The variables carry different weighting factors. An explanation of the various parameters would be helpful to understand why identical variables are listed for more than one parameter and are given different weighting factors.

It is obvious that the preservation of wildlife habitat, such as muskrat areas, wading birds, and seagull areas, is given much more emphasis than areas for the production of domesticated animals producing milk, cheese, butter, meat, poultry, and eggs. The conversion of some wetland types or wildlife sensitive areas to productive farmland capable of growing desirable plants and animals would seem to be justified. You will find some additional comments on the attached copy of Table 1.

If you have any comments, please feel free to contact either me or Wendell Kirkham at FTS 342-5341.

Sincerely,

CARL MONTANA, P.E.
State Conservation Engineer

Enclosure

cc: Wendell Kirkham

TABLE 1

SCALE OF ACCEPTABILITY FOR WEIGHTING
POTENTIAL DISPOSAL SITES

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

PARAMETER	VARIABLE	VARIABLE WEIGHTING FACTOR (RELATIVE ACCEPTABILITY) OPTION 1	OPTION 2 . . . .
ARCHAEOLOGICAL SENSITIVITY ZONES	Ø OTHER	1Ø	.
	1 HIGH SENSITIVITY	-1	.
	2 MEDIUM SENSITIVITY	Ø	.
	3 LOW SENSITIVITY	5	.
HISTORIC SITES	Ø OTHER	1Ø	
	1 HISTORIC SITES	-1	
	2 HISTORIC DISTRICTS	-1	
GROUNDWATER RECHARGE ZONES	Ø OTHER	1Ø	
	1 ZONE I	1Ø	
	2 ZONE II	8	
	3 ZONE III	6	
	4 ZONE IV	4	
	5 ZONE V	2	
	6 ZONE VI	Ø	

US Army Corps of Engineers
Philadelphia District

TABLE 1
(CONTINUED)

PARAMETER	VARIABLE	VARIABLE WEIGHTING FACTOR (RELATIVE ACCEPTABILITY) OPTION 1	OPTION 2	. . . .
RECREATION	Ø OTHER	Ø	.	
	1 FEDERAL PARK	-1	.	
	2 STATE PARKS, FOREST AND WILDLIFE MGT. AREAS	-1	.	
	3 COUNTY PARKS	-1	.	
	4 FAIRGROUNDS	-1		
	5 LOCAL PARKS	-1		
	6 CAMPGROUNDS	-1		
	7 GOLF COURSES	-1		
	8 PRIVATE PARKS	-1		
	9 MARINAS	-1		
FISH AND WILDLIFE SENSITIVE AREAS	Ø OTHER	1Ø		
	1 (RESERVED)			
	2 FINFISH	Ø		
	3 WADING BIRD AND SEABIRD HIGH USE AREAS	Ø		
	4 MAJOR WATERFOWL AREAS	Ø		
	5 MUSKRAT AREAS	Ø		
	6 (RESERVED)			
	7 CONSERVATION/NATURAL AREAS	Ø		
	8 HIGH FISHING AREAS	Ø		
	9 EXCLUSIONARY TROUT AREAS	-1		
	1Ø TROUT WATERS	Ø		
	11 SHELLFISH	-1		
	12 (RESERVED)			
	13 EXCLUSIONARY WADING BIRD AND SEABIRD COLONIES	-1		
	14 EXCLUSIONARY WATERFOWL AREAS	-1		
	15 EXCLUSIONARY MUSKRAT AREAS	-1		
	16 (RESERVED)			

US Army Corps of Engineers
Philadelphia District

TABLE 1
(CONTINUED)

PARAMETER	VARIABLE	VARIABLE WEIGHTING FACTOR (RELATIVE ACCEPTABILITY) OPTION 1	OPTION 2 . . . .
	17 EXCLUSIONARY CONSERVATION/ NATURAL AREAS	-1	.
	18 (RESERVED)		.
	19 EXCLUSIONARY TERRESTRIAL GAME AREAS	-1	.
	20 COMBINATION OF 2 AND 3	-1	
	21 COMBINATION OF 2 AND 4	-1	
	22 COMBINATION OF 2 AND 5	-1	
	58 COMBINATION OF 2, 13, 15, AND 17	-1	
LAND USE/LAND COVER	Ø OTHER	1Ø	
	1 URBAN AND BUILT UP	-1	
	2 NORMAL BOTTOM (10'-42')	Ø	
	3 SHALLOW (10')	Ø	
	4 (RESERVED)		
	5 (RESERVED)		
	6 FORESTED UPLANDS (this could be Prime Farmland)	5	
	7 ORCHARDS	Ø	
	8 CROPLAND (other than unique & Prime farmland)	5	
	9 RANGELAND	6	
	1Ø OTHER AGRICULTURAL LAND	1Ø	
	11 BARREN LAND	1Ø	
	12 STRIP MINING LAND	5	
	13 ACTIVE CE DISPOSAL SITE	1Ø	
	14 INACTIVE CE DISPOSAL SITE	1Ø	
	15 PRIVATE, INDUSTRIAL, MUNICIPLE LANDFILLS	1Ø	
	16 SEWAGE SLUDGE LANDFILL	1Ø	

- (beside variables 0–10) are these the same
- (beside 2 and 3) are these water areas?
- (beside 6) - it could also be Prime Forestland
- (beside 9) — Rangeland not identified in New Jersey
- (beside 12) — why not 10?

US Army Corps
of Engineers
Philadelphia District

TABLE 1
(CONTINUED)

PARAMETER	VARIABLE	VARIABLE WEIGHTING FACTOR (RELATIVE ACCEPTABILITY) OPTION 1	OPTION 2 . . . .
	17 DEEP WATER BODIES (42')	5	
	18 INLAND WATER BODIES (LAKES/PONDS)	Ø	Secretary's memorandum 9500-2 Statement on Land Use Policy March 10, 1982
S.C.S. IMPORTANT FARMLANDS	Ø OTHER	1Ø	Policy
	1 UNIQUE FARMLAND	Ø	3b. Agencies within the Department of Agriculture will discourage the unwarranted conversion to other uses of Prime and unique farmlands, farmlands of statewide or local importance prime forest land and those of statewide or local importance and prime rangeland.
	2 PRIME FARMLAND	Ø	
	3 ADDITIONAL FARMLAND OF STATEWIDE IMPORTANCE	5	
	4 ADDITIONAL FARMLAND OF LOCAL IMPORTANCE	5	
D.O.I. WETLANDS	Ø OTHER	Ø	
A. ONE WETLAND TYPE - 50% OR GREATER CELL COVERAGE	1 PALUSTRINE	-1	3g. Advocate among Federal agencies
	2 RIVERINE (INTERTIDAL FLATS/ INTERMITTENT STREAMS)	-1	1. The retention of important farmlands, rangelands, forest lands & wetlands - - - - - - - -
	3 ESTUARINE	-1	
	4 LACUSTRINE	-1	
	5 MARINE	-1	
B. ONE WETLAND TYPE - LESS THAN 50% CELL COVERAGE	6 PALUSTRINE	-1	
	7 RIVERINE (INTERTIDAL FLATS/ INTERMITTENT STREAMS)	-1	
	8 ESTUARINE	-1	
	9 LACUSTRINE	-1	
	1Ø MARINE	-1	

US Army Corps of Engineers
Philadelphia District

TABLE 1
(CONTINUED)

PARAMETER	VARIABLE	VARIABLE WEIGHTING FACTOR (RELATIVE ACCEPTABILITY OPTION 1	OPTION 2	. . . .
C. MIXED WETLAND TYPES (DOMINANT TYPE INDICATED) - 50% OR GREATER CELL COVERAGE	11 PALUSTRINE	-1	.	
	12 RIVERINE (INTERTIDAL FLATS/ INTERMITTENT STREAMS)	-1	.	
	13 ESTUARINE	-1	.	
	14 LACUSTRINE	-1	.	
	15 MARINE	-1		
D. MIXED WETLANDS TYPES (DOMINANT TYPE INDICATED) LESS THAN 50% CELL COVERAGE	16 PALUSTRINE	-1		
	17 RIVERINE (INTERTIDAL FLATS/ INTERMITTENT STREAMS)	-1		
	18 ESTUARINE	-1		
	19 LACUSTRINE	-1		
	20 MARINE	-1		
E. THREE OR MORE WETLANDS TYPES	21 MIXED WETLANDS - 50% OR GREATER CELL COVERAGE	-1		
	22 MIXED WETLANDS - LESS THAN 50% CELL COVERAGE	-1		
NAVIGATION FEATURES	0 OTHER	0		
	1 MAIN CHANNEL	-1		
	2 ENTRANCE CHANNEL	-1		
	3 ANCHORAGE AREAS	-1		
	4 DREDGE DISPOSAL SITES IN WATER	+10		

US Army Corps of Engineers
Philadelphia District

TABLE 1
(CONTINUED)

PARAMETER	VARIABLE	VARIABLE WEIGHTING FACTOR (RELATIVE ACCEPTABILITY) OPTION 1	OPTION 2 . . . .
GROUNDWATER PROTECTION ZONES	Ø OTHER	1Ø	.
	1 ZONE I	1Ø	.
	2 ZONE II	7	.
	3 ZONE III	5	.
	4 ZONE IV	5	
	5 ZONE V	3	
	6 ZONE VI	Ø	
CONSTRUCTION AND DVELOPMENT	Ø OTHER	1Ø	
	1 URBAN AND BUILT UP	-1	
	2 NORMAL BOTTOM (10'-42')	Ø	
	3 SHALLOW (10')	3	How does this differ with shallow listed under "Land use/Land cover" - shallow is listed Ø?
	4 (RESERVED)		
	5 (RESERVED)		
	6 FORESTED UPLAND	7	Why are these catagories rated differently than those under Land use/Land cover
	7 ORCHARDS	7	
	8 CROPLAND	1Ø	
	9 RANGELAND	1Ø	
	10 OTHER AGRICULTURAL LAND	1Ø	
	11 BARREN LAND	1Ø	
	12 STRIP MINING LAND	1Ø	
	13 ACTIVE CE DISPOSAL SITE	7	
	14 INACTIVE CE DISPOSAL SITE	7	
	15 PRIVATE, INDUSTRIAL, MUNICIPLE LANDFILLS	5	
	16 SEWAGE SLUDGE LANDFILL	5	
	17 DEEP WATER BODIES (42')	Ø	
	18 INLAND WATER BODIES (LAKES/PONDS)	7	

US Army Corps of Engineers
Philadelphia District

TABLE 1
(CONTINUED)

PARAMETER	VARIABLE	VARIABLE WEIGHTING FACTOR (RELATIVE ACCEPTABILITY) OPTION 1	OPTION 2 . . . .
ELEVATION RANGES	1 -30' DEPTH AND GREATER (DATUM IS MEAN LOW WATER)	1Ø	. .
	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	
	6 60' NGVD	Ø	
DISTANCE BANDS - PHILADELPHIA TO TRENTON: FROM CENTER OF CHANNEL	1 0' TO 5000'	1Ø	
	2 5000' TO 10000'	8	
	3 10000' TO 15000'	6	
	4 15000' TO 20000'	4	
	5 20000'	Ø	
DISTANCE BANDS - PHILADELPHIA TO SEA; FROM -30' DEPTH (DATUM IS MEAN LOW WATER)	1 0' TO 3000'	1Ø	
	2 3000' TO 6000'	8	
	3 6000' TO 9000'	6	
	4 9000' TO 12000'	4	
	5 12000'	Ø	

US Army Corps of Engineers
Philadelphia District

TABLE 2

DISPOSAL SITE SELECTION BASED ON VARYING INDEX VALUES

(PARAMETER IMPORTANCE)

SCALE OF PARAMETER IMPORTANCE

INDEX VALUE	DEFINITION
1	BASE CONDITIONS
2	THIS PARAMETER IS TWICE (2X) AS IMPORTANT TO SITE SELECTION FOR THIS ANALYSIS AS THOSE WITH AN INDEX VALUE OF 1.
3	THIS PARAMETER IS THREE TIMES (3X) AS IMPORTANT.
4	THIS PARAMETER IS FOUR TIMES (4X) AS IMPORTANT.
. . .	. . .
Etc.	Etc.

US Army Corps of Engineers
Philadelphia District

TABLE 3

DISPOSAL SITE SELECTION BASED ON VARYING INDEX VALUES

(PARAMETER IMPORTANCE)

PARAMETER	INDEX VALUES RUN #1	RUN #2	RUN #3	. . . .
ARCHAEOLOGICAL SENSITIVITY ZONES	1	3	1	
HISTORIC SITES	1	3	1	
GROUNDWATER RECHARGE ZONES	1	3	1	
RECREATION	1	3	1	
FISH AND WILDLIFE SENSITIVE AREAS	1	9	1	
LAND USE AND LAND COVER	1	3	1	
S.C.S. IMPORTANT FARMLANDS	1	3	1	
DOI WETLANDS	1	9	1	
NAVIGATION FEATURES	1	1	1	
GROUNDWATER PROTECTION ZONES	1	1	2	
CONSTRUCTION AND DEVELOPMENT	1	1	2	
ELEVATION RANGES	1	1	3	
DISTANCE - PHILADELPHIA TO TRENTON	1	1	6	
DISTANCE - PHILADELPHIA TO SEA	1	1	6	

US Army Corps of Engineers
Philadelphia District

Edward J. Desher, *President*
Henry F. Corry, *Vice-President*
William A. Harrison, *Executive Director and Secretary*
Charles E. Mather III, *Treasurer*
James F. Young, Esq., *Solicitor*

THE PHILADELPHIA MARITIME EXCHANGE

620 LAFAYETTE BUILDING, PHILADELPHIA, PA. 19106-2488
(215) 925-1522

June 3, 1982

Mr. John F. Murphy
Chief, Planning Branch
Department of the Army
Philadelphia District, Corps of Engineers
Custom House - Second & Chestnut Streets
Philadelphia, PA 19106

Dear Mr. Murphy:

Thank you for the copy of the minutes of the Third Plan Formulation Committee meeting held on April 28, 1982 for the ongoing Delaware River Dredging Disposal Study. I find the minutes an accurate transcription of the meeting and would like to take this opportunity to express our continued support of the Disposal Study.

Sincerely yours,

James C. Charlton

James C. Charlton
Assistant to the Executive Director

JCC:cam

STATE OF NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OFFICE OF THE COMMISSIONER
CN 402
TRENTON, N.J. 08625
609 - 292 - 2885

June 30, 1982

Mr. James Murphy, Chief
Planning Branch
Philadelphia District Corps of Engineers
Custom House - 2D & Chestnut Streets
Philadelphia, PA 19106

Dear Mr. Murphy:

This concerns your request for comment on the Delaware River Dredging Disposal Study following the third Plan Formulation Committee Meeting held April 28, 1982.

Our Division of Coastal Resources has reviewed the information provided at the meeting and has determined that the computer program chosen by the Corps of Engineers compares closely with the Harvard University IMGRID program.

In general, our comments deal primarily with the parameters and the variable weighting factors used in the computer program. We would also suggest that the weighting factors be consistent with the policies of the enclosed New Jersey Coastal Zone Management Plan.

Our detailed comments are as follows:

1. High Fishing Areas which are defined in our program as Prime Fishing Areas and should be classified as unacceptable (-1) according to our policies, rather than least acceptable.

2. Add submerged vegetation as a parameter and assign -1 unacceptable.

3. Add the following navigation channels as an additional parameter: canals -1, inlets -1, marina moorings -1, ports -1, submerged shipwrecks and artificial reefs -1.

4. Add Wet Borrow Pit parameter with rating 8.

5. Add the Intertidal Flats parameter with scale -1.

6. Add the Filled Water's Edge parameter with scale -1.

7. Add the Natural Water's Edge-Floodplains parameter with scale -1.

100% Recycled

8. Add the Beaches parameter with scale 10 for clean sand. (beach nourishment), and -1 for contaminated sand.

9. Add Erosion Hazard Areas parameter with scale 5.

10. Add the Wetlands Buffer parameter with scale 0.

11. Add the Cranberry Bogs parameter with scale -1.

12. Add the Coastal Bluffs parameter with scale -1.

13. Add the Intermittent Stream Corridors parameter with scale -1.

14. The Farmland Conservation Areas which may overlap with some of variables listed in the study, should have scale 0.

Should you have any questions concerning these comments please let me know.

Sincerely,

Fred Schultz for

Lawrence Schmidt, Chief
Office of Environmental Review

Enclosure
cc: John Weingart

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO

MINUTES

DELAWARE RIVER DREDGING DISPOSAL STUDY
FOURTH PLAN FORMULATION COMMITTEE MEETING

A. Location: The meeting was held at the Philadelphia District on 15 February 1983.

B. Attendees: See the attached list.

C. Purpose:

1. To present the study status and results to date.

2. To present the output of the spatial attractiveness model for the study area.

3. To discuss the application of the systems model.

4. To discuss the current schedule.

D. Discussion: It was pointed out that the study is on schedule. Furthermore, the District has taken various steps to close the five month gap that existed between May and September of this year. As a result, the draft Stage 2 report is scheduled for completion by the end of this fiscal year.

A schematic diagram shown in Inclosure #1 served as a means of conveying the study concept and presentations at the meeting.

A needs analysis was performed for a 50-year period that considered the disposal needs for deep-draft dredging for both the federal and non-federal sectors. Small project dredging disposal needs were considered separately since they are of less magnitude and were discussed later.

The needs analysis considered the following levels of project development:

a. Historical dredging
b. Authorized project dredging
c. Immediate future project dredging
d. Long-term future project dredging

Please refer to Inclosure #2 for the specific projects.

Taking into account the various levels of project development and the remaining disposal capacity at existing sites various deficits were projected. To meet these deficits, the study assessed various alternative measures that had been presented at earlier meetings. Those still being considered are improved disposal site management measures and acquisition of new sites. Management measures (such as increasing the dike heights, lease extension, dewatering and reuse) primarily deal with increasing the remaining capacity of existing sites.

As was discussed at the previous meetings, the screening of new sites was accomplished through the application of the attractiveness (spatial) model and subsequent manual screening. At the last meeting, members were asked to provide comments or suggestions in establishing weightings for spatial runs. The comments received consisted of addition of new variables, alternation of specific variable weightings, modification of grid cell size and consideration of mitigation. In all cases the originators were contacted to discuss how their comments would be addressed. Generally, the responses to the comments were either incorporated into the study or resolved by clarification to the originator.

After making a number of sensitivity runs, two polar extremes were identified, a National Economic Development Plan (NED) and an Environmental Quality Plan (EQ). The EQ plan was represented as two boundary scenarios, namely an EQ-2 run which prohibited disposal on all wetland or aquatic areas and an EQ-1 run that excluded only wetlands. At the last meeting, it was indicated that a Mixed Objective Plan would be developed. After making a run with weightings between those for EQ-1 and NED, the computer results were found to be similar to that for EQ-1. Consequently, further analysis was discontinued since results were not sensitive to the weightings used.

A copy of the parameters, variables and weights for the three plans was provided at the meeting. The EQ-2 plan offers the least sites. There is a gradual increase in the number of sites in the EQ-1 and NED plans and, in particular, to sites adjacent to the river. Each of the three plans produced a list of candidate sites which were screened to correct for the fact that the model is not well suited to treat linear features (i.e. roads, pipelines) or isolated structures. Consideration was also given to the following items: minimum size requirements, man-made improvements, reasonable pipeline routes to potential disposal areas, reasonable effluent water courses to the river and accessibility for construction and maintenance. Finally, the candidate sites were field visited.

The systems model was constructed in a manner that would permit consideration of dredging volumes, different types of dredge plants, various modes of transportation, capacity of existing and new disposal sites, disposal site development costs, mitigation costs and management measures. Also, the model has the capability of optimizing the time horizon of acquiring new sites. A number of handouts were provided on the application of the systems model. The systems model runs will be conducted in three phases (see Inclosure #3) and the results will be presented to the committee for review.

Due to the relatively small dredging quantities (less than one percent of the amount of material dredged annually) and the diversity of projects, Federal and non-federal small navigation projects were considered separately from deep-draft projects. Potential new sites were screened manually. The screening was conducted by the study team with the assistance of the U.S. Fish and Wildlife Service considering environmental and engineering parameters. The analysis showed that the anticipated disposal needs for the most part can be met by using a combination of existing and identified new sites. Systems model runs will be conducted for two sample projects, Indian River and Bay and Maurice River to sensitize various options and will be used to assure the study team that intuitative judgement of site selection is reasonable.

As previously stated, the needs analysis considered the private deep-draft dredging along with the Federal deep-draft. Historically, about 68 percent of the private dredging material is rehandled in White's Basin and pumped to adjacent disposal areas. Because of the extensive reuse of material from this site (both historically and anticipated in the future), and by increasing dike heights and opening of new parts of the site, White's Basin will continue to be the main source of private disposal for the next 50-years.

The current schedule was briefly discussed. The main features of this year's work are the systems runs, coordination of selected plans, and completion of the Stage 2 report in September. A copy of this schedule was provided at the meeting. Comments and suggestions on the proposed systems runs (Inclosure #3) were requested.

The following concerns and comments were expressed at the meeting:

a. Concern was raised regarding filling wetlands and Federal refuges and state wildlife management areas. This option was only considered in the NED scenario. The study will attempt to minimize the impacts of filling these areas by considering mitigation measures and other available sites. At this point, a preliminary list of candidate sites has been identified. Through the application of the systems model, specific sites will be selected. These sites will be presented to the committee for review.

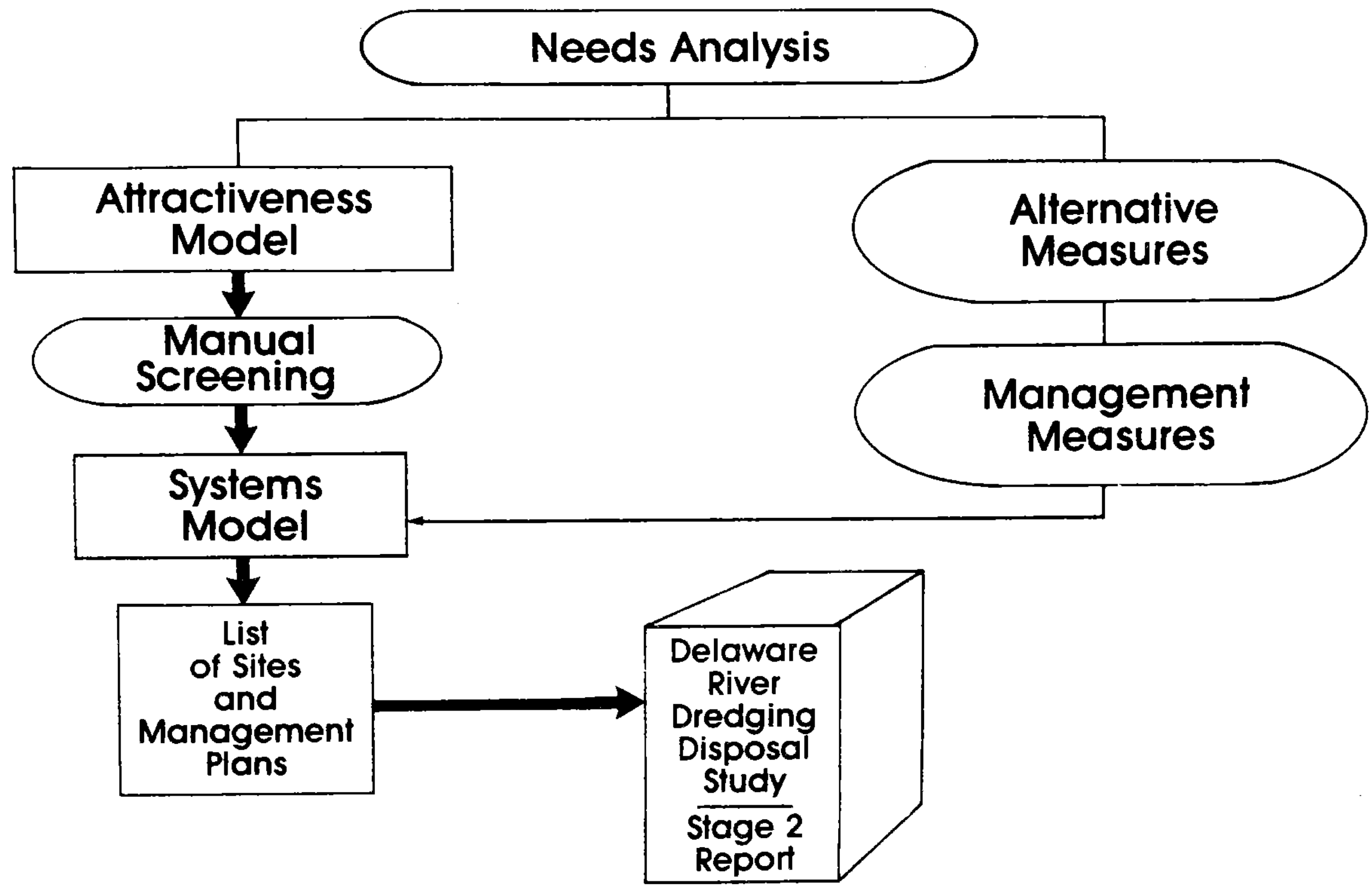
b. It was suggested that ownership of candidate sites be investigated prior to the systems runs. Due to the large number of candidate sites and the effort involved, consideration of ownership will be done after the sites are selected.

At an afternoon session attended by interested members, the systems model was demonstrated by making two sample runs. These runs were reviewed in detail.

Delaware River Dredging Disposal Study

Fourth Plan Formulation Committee Meeting

	Attendees
Deirdre C. Taylor	PA Dept. of Environ. Res.-Coastal Zone Mgmt.
Page Fielding	Delaware River Basin Commission
Tim Goodger	National Marine Fishing Service
Lawrence Schmidt	N.J. Dept. of Environmental Protection
Mike Chezik	U.S. Fish and Wildlife Service (PA, NJ)
Wendell Kirkham	U.S.D.A. Soil Conservation Service (NJ)
Emil Washko	PA Dept. of Environmental Resources
Kristina Patel	Delaware DNR&EC
Don Roeder	American Dredging Company
James Charlton	Philadelphia Maritime Exchange
Michael Wolf	Delaware Valley Regional Planning Commission
Lieutenant Colonel Roger Baldwin	Corps of Engineers; District Engineer
Nicholas Barbieri	Corps of Engineers; Chief, Planning/ Engineering Division
H. R. Kreh	Corps of Engineers; Chief, Operations Division
Stanley Snarski	Corps of Engineers; Ass't Chief, Operation Division
Roy Denmark	Corps of Engineers; Acting Chief Environmental Resources Branch
Vincent Calvarese	Corps of Engineers; Acting Chief, Engineering Branch
Salvatore Bucolo	Corps of Engineers; Acting Chief, Planning Branch
George Steinrock	Corps of Engineers; Project Manager
Gary Rohn	Corps of Engineers; Chief, Flood Plain Management Services
Leonard Lipski	Corps of Engineers; Chief, Hydrology and Hydraulics Branch
Bruce Uibel	Corps of Engineers; Chief, Foundation and Materials
Brian Heverin	Corps of Engineers; Chief, General Design


Needs Analysis
Attractiveness Model
Manual Screening
Systems Model
List of Sites and Management Plans
Alternative Measures
Management Measures
Delaware River Dredging Disposal Study
Stage 2 Report

Inclosure #1

LEVELS OF PROJECT DEVELOPMENT

1. Historical Dredging

   - Delaware River, Philadelphia to Sea, Philadelphia to Trenton
   - Schuylkill River
   - Wilmington Harbor
   - Delaware River Anchorages

2. Authorized Dredging (not constructed)

   - Upper portion of Schuylkill River project (Penrose Avenue to project limit)
   - Upper portion of Delaware River, Philadelphia to Trenton project (Newbold Island to Trenton, NJ)
   - Christina River (upstream of Lobdell Canal to project limit)
   - Delaware River Anchorages

3. Immediate Future Project Dredging (Pre-construction stages)

   - Schuylkill River Deepening to 37' (mouth to Penrose Avenue)
   - Delaware River at Camden to 37'
   - Tioga Marine Terminal
   - Petty Island Back Channel

4. Long-Term Future Project Dredging (Planning Stage)

   - Projects forthcoming from the on-going Corps of Engineers Delaware River Comprehensive Navigation Study.

Inclosure #2

Delaware River Dredging Disposal Study

SYSTEMS RUNS

The systems model runs will be conducted in three phases. The following is a brief summary of the proposed runs.

PHASE I - EXISTING/FUTURE CONDITIONS

LEVEL OF PROJECT DEVELOPMENT

1. Historical Dredging

   - Delaware River, Philadelphia to Sea, Philadelphia to Trenton
   - Schuylkill River
   - Wilmington Harbor
   - Delaware River Anchorages

2. Authorized Dredging (not constructed)

   - Upper portion of Schuylkill River project (Penrose Avenue to project limit)
   - Upper portion of Delaware River, Philadelphia to Trenton project (Newbold Island to Trenton, NJ)
   - Christina River (upstream of Lobdell Canal to project limit)
   - Delaware River Anchorages

3. Immediate Future Project Dredging

   - Schuylkill River Deepening to 37' (mouth of Penrose Avenue)
   - Delaware River at Camden to 37'
   - Tioga Marine Terminal
   - Petty Island Back Channel

LIMIATIONS

1. Use current pipeline, bucket and hopper dredging methods and procedures.

2. Use only existing disposal areas.

3. No transfer to reuse.

4. Lease limits (time and/or elevation).

5. Use existing management methods.

Inclosure #3

PHASE II - IMPROVED MANAGEMENT METHODS

Select Management Methods and Apply to Phase I Disposal Capacity Deficits

1. Dewatering Methods.

   - multi drying periods
   - sub-division

2. Fill height limitation.

3. Transfer of material.

4. Reuse.

5. Rehandling basins.

PHASE III - SELECTION OF NEW SITES AND MANAGEMENT PLANS

Based on Phase II deficits incorporate new sites for each project from the list of EQ-2, EQ-1 and NED sites.

LIMITATIONS

1. Incorporate new sites by specified ranking order.

   - cost
   - environmental quality

2. Consider transfer or reuse.

3. Fill proposed sites to greater of Elevation 50 ft. or 25 ft. above existing ground.

4. Apply cost efficient management methods.

5. Full term leases/fee ownership.

STATE OF NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OFFICE OF THE COMMISSIONER
PLANNING GROUP
DAVID N. KINSEY, DIRECTOR
CN 402
TRENTON, N.J. 08625
(609) 292-2662

February 15, 1983

Mr. George Steinrock, Project Manager
Delaware River Dredging Disposal Study
US Army Corps of Engineers
Custom House, Second & Chestnut Streets
Philadelphia, PA 19106

Dear Mr. Steinrock:

At today's meeting of the Plan Formulation Committee, you requested the comments of the members regarding the progress of your Study. I wish to reiterate my comment at the meeting regarding the preliminary screening of potential disposal sites under the National Economic Development (NED) plan alternative. Simply stated, the NED should be modified to categorically exclude wetlands delineated by the State of New Jersey under the Wetlands Act of 1970, national wildlife refuges, and State wildlife management areas. I fully understand the planning process to date is considered preliminary in terms of screening for the NED plan. However, if the Corps is to maintain credibility in the planning process, it is important to provide realistic alternatives that can be further analyzed in the context of a supplement to the Delaware River EIS.

In my judgement the Philadelphia District is doing an excellent job in developing the Delaware River Dredging Study. The results of the Study will hopefully address the long term need for new disposal sites and the improvement in management procedures at the existing sites. I appreciate the opportunity to participate on the Plan Formulation Committee.

Sincerely,

Lawrence Schmidt
Assistant Director
Planning Group

LS/ss
cc: Director Cookingham
Director Weingart

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Services Division
Habitat Protection Branch
7 Pleasant Street
Gloucester, Massachusetts 01930

MAR 23 1983

Lt. Colonel Roger L. Baldwin
District Engineer
Philadelphia District, Corps of Engineers
Custom House - 2nd & Chestnut Streets
Philadelphia, Pennsylvania 19106

Dear Colonel Baldwin:

Reference is made to the Delaware River Dredging Disposal Study presently conducted by your office.

We can appreciate the need for new disposal sites, especially since so many existing sites have limited capacity and may be approaching saturation. However, we have recently spent some time in your office reviewing many of the proposed sites and are disturbed to find that important, biologically productive habitats are seriously considered for site disposal. Some of these areas include: 1) tidal wetlands which provide nutrients to the aquatic food web. 2) Riverine shallows which provide spawning and nursery habitat for fish and invertebrates and a migration corridor for anadromous fish including American shad, blueback herring and alewife. 3) Overboard disposal sites near leased oyster seed beds. A small amount of spoil will smother and kill seed oysters. 4)Non-tidal streams which provide spawning and nursery habitat for blueback herring and alewife. 5) Some palustrine forested wetlands which could create undesirable downstream turbidity levels in tidal and non-tidal streams.

All of these habitat have been lost to some degree but nonetheless are needed by the River's living aquatic community. We urge that such sites be removed from consideration.

Sincerely yours,

for Ruth Rehfus
Branch Chief

DEPARTMENT OF THE ARMY
Philadelphia District, Corps of Engineers
Custom House - 2d & Chestnut Streets
Philadelphia, Pennsylvania 19106

28 MAR 1983

Environmental Resources Branch

Mr. Lawrence Schmidt, Assistant Director
Planning Group
New Jersey Department of Environmental Protection
CN-402
Trenton, New Jersey 08625

Dear Mr. Schmidt:

This is in regard to you February 15, 1983 letter to Mr. George Steinrock concerning the Delaware River Dredging Disposal Study in which you recommend that the NED plan be modified to categorically exclude wetlands delineated by the State of New Jersey under the Wetlands Act of 1970, national wildlife refuges and state wildlife management areas.

The Philadelphia District recognizes the importance of these types of areas and as a result, has excluded them from the EQ-1 and EQ-2 plans. However, to allow for complete flexibility in this preliminary review of future disposal sites the NED plan considers all areas except urban and built-up sites and navigation channels.

The inclusion of the wetland areas in the NED plan has been done with the understanding that in general, development of all kinds is prohibited in wetlands unless the Department of Environmental Protection can find that the proposed development meets certain specific conditions, and comparisons of disposal areas against these conditions can only be done on a site specific basis. Therefore, exclusion of wetlands at this time would be premature. In addition, a review of the N.J. DEP Coastal Resource and Development Policies indicates no categorical prohibition of development in public open space which includes wildlife refuges and state wildlife management areas (NJSA 7:7E-3.39). Therefore exclusion of these areas at this time would also be premature.

We recognize that the disposal areas selected during this phase of the study will be subject to state regulation and may require Federal Consistancy Certification Groundwater Discharge Permits and/or a Water Quality Certificate. Only at that time can the proposed sites be compared against the appropriate coastal policies and water quality criteria.

At this point, we hope to keep our options open for analysis through our systems model so that all reasonable alternatives can be considered.

We appreciate your interest in the Dredging Disposal Study and trust that we have sufficiently addressed your concerns. If you have any additional questions please contact Mr. Roy E. Denmark, Jr. at 215-597-4833.

Sincerely,

Nicholas J. Barbieri, P.E.
Chief, Planning/Engineering Division

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION II
26 FEDERAL PLAZA
NEW YORK, NEW YORK 10278

3 1 MAR 1983

Lt. Colonel Roger L. Baldwin
District Engineer
U.S. Army Corps of Engineers
Custom House
2nd and Chestnut Streets
Philadelphia, Pennsylvania 19106

Dear Colonel Baldwin:

On March 2nd and 3rd, 1983 Richard Coleates of my staff participated in a preliminary review of alternative dredged material disposal sites identified as part of the Corps' Delaware River Dredged Material Disposal Study. The number of alternative sites identified in New Jersey is in excess of 200. Alternative sites include tidal and freshwater wetlands, shallow and deep water aquatic habitat, and upland. Due to the large number of alternative sites, it was not possible to review all sites, nor to provide more than a cursory review of those sites which were examined. It is the U.S. Environmental Protection Agency's (EPA) understanding that only a small proportion of the alternative sites will actually be needed. Undoubtedly, a great many of the most environmentally sensitive sites will be eliminated by the Corps' own internal review, as the study progresses. At this point, it may be helpful to summarize the criteria which will be used by the EPA to review proposed dredged material disposal sites.

As you know, the substantive criteria used in evaluating discharges of dredged or fill material are the 404(b)(1) guidelines (40 CFR part 230). The guidelines place great weight on the evaluation of alternatives. The guidelines discourage the discharge of dredged material to the aquatic environment, including wetlands, except where there are no other practicable alternatives of lesser environmental harm. In general, upland sites are considered to be less environmentally sensitive than aquatic sites. Therefore, EPA would recommend that proposals for the use of aquatic sites not be seriously considered unless it has been demonstrated that upland sites are unavailable or not practicable.

With respect to aquatic sites, EPA views tidal wetlands to be the most environmentally sensitive habitat type due to their role in the maintenance of water quality and their contribution to the aquatic food chain. Freshwater wetlands also play an important role in the maintenance of water quality and their use as disposal areas is discouraged. Tidal streams, non-tidal streams, lakes and ponds, are important for maintaining aquatic ecosystem productivity and diversity. Shallow water aquatic habitats provide important habitat for aquatic life including anadramous fish, and help to maintain dissolved oxygen levels through support of primary productivity. Of all aquatic habitat types, deep water is generally the least sensitive. However, I should emphasize that the above discussion is, of necessity, generalized. Selection of any aquatic disposal site must take into account site specific conditions. For example, the proximity of oyster seed beds to a deep water site would likely make that site unacceptable due to the adverse effects of sedimentation and turbidity on these resources.

The consideration of any aquatic disposal site, assumming that less damaging alternatives are not practicable, should include proposals for mitigation. Ideally mitigation would include the creation of new aquatic habitat in compensation for that which would be lost. Alternatively habitat enhancement may be an option. It is recommended that projected costs for development and use of an aquatic disposal site include anticipated mitigation costs.

The criteria which are summarized above are identical to the criteria used by EPA and the Corps to evaluate permit applications from the public.

My staff and I appreciate the opportunity to provide input to this important study.

Sincerely yours,

Peter W. Anderson, Ph.D., Chief
Marine & Wetlands Protection Branch

cc: USFWS, State College
NMFS, Sandy Hook

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

DIVISION OF ECOLOGICAL SERVICES
1825B Virginia Street
Annapolis, Maryland 21401

April 6, 1983

District Engineer
Philadelphia District, Corps of Engineers
Custom House - 2nd and Chestnut Streets
Philadelphia, PA 19106

Dear Sir:

This report was prepared under provisions of the FY83 Scope of Work agreement for the Delaware River Dredging Disposal Study. The agreement called for: 1) preparation and discussion of criteria for evaluating the acceptability, from a Service standpoint, of candidate disposal sites selected by the Corps; 2) discussion of mitigation requirements; 3) evaluation of potential disposal sites using the above criteria and coordinating the evaluation effort with EPA, NMFS, and the State of Delaware; and 4) commenting on the possibility of disposing of dredged material in the Delaware Bay and Atlantic Ocean.

The evaluation criteria are listed in Attachment 1. There are five main categories: habitat type, shellfish, finfish, wildlife and public use. Under Habitat Type the sub-category "Open Water" includes Delaware river and Bay, its tidal and non-tidal tributaries, lakes and ponds. "Wetlands" includes estuarine, riverine and palustrine wetlands. "Developed" areas include active disposal sites as well as urban and industrial areas. Under "Finfish" the "Other" sub-category was used to designate estuarine/marine finfish. For "Wildlife" the "Other" sub-category was used to designate the diamondback terrapin, formerly rare throughout the State but now becoming stabilized. Under "Public Use" the "Commercial" sub-category designates commercial shellfishing and finfishing. "Other" refers to natural areas, parks, wildlife management areas, etc.

Each potential disposal site was evaluated in terms of the habitat types it contains and the value of these types for other resource categories. The value of each site was indicated by designating a mitigation category required for each one.

The mitigation categories are listed in Attachment 2. They were derived from the Service's mitigation policy. According to this policy, the term "mitigation" includes: "a) avoiding the impact altogether by not taking a certain action or parts of an action; b) minimizing impacts by limiting the degree or magnitude of the action and its implementation; c) rectifying the impact by repairing, rehabilitating or restoring the affected environment; d) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and e) compensating for the impact by replacing or providing substitute resources or environments." The Service's mitigation recommendations may include, but are not limited to, any of the above actions.

In the Service's policy, four resource categories have been set up to indicate which level of mitigation is recommended according to the fish and wildlife resource values involved. The policy covers impacts to fish and wildlife populations, their habitat and the human uses thereof. However, the primary focus is on recommendations related to habitat value losses. The four resource categories and mitigation goals are as follows: 1) Habitat to be impacted is of high value for evaluation species and is unique and irreplaceable on a national basis or in the ecoregion section. No loss of existing habitat value should occur; 2) Habitat to be impacted is of high value for evaluation species and is relatively scarce on a national basis or in the ecoregion section. No net loss of in-kind habitat value should occur; 3) Habitat to be impacted is of high to medium value for evaluation species and is relatively abundant on a national basis. There should be no net loss of habitat value while minimizing loss of in-kind habitat value; 4) Habitat to be impacted is of medium to low value for evaluation species. Loss of habitat value should be minimized. A fifth category has been added for this study to accommodate sites lacking sufficient information for evaluation.

On March 9, 1983, the Service met with representatives of EPA, NMFS, Delaware Division of Fish and Wildlife, Delaware Wetlands Division, Corps of Engineers and New Castle County Department of Planning to review the candidate sites. Generally, the review forms and associated comments reflect a concensus of opinion among the review agencies with the following exceptions. EPA and NMFS did not comment on upland sites. The Delaware Division of Fish and Wildlife representative felt that cropland should be placed in Mitigation Category 3 if such areas could be reclaimed within several years, or Category 2 if reclamation would take longer. The Service placed such areas in Category 4 unless special circumstances existed for a specific site.

For open water sites in Delaware River and Bay, it was agreed that if active shellfish beds are present, the area should be placed in Category 1. Otherwise such areas were placed in Category 2. It was also generally agreed that tidal tributaries of Delaware River and Bay would be placed in Category 1 since these areas are used to a greater extent as spawning and nursery areas.

Comments on potential disposal sites for the Small Navigation Projects are solely those of the Service since there was not time to review them at the interagency meeting.

It should be stressed that this evaluation is a very preliminary assessment using general information. The Service reserves the right to modify its comments and recommendations as additional information becomes available.

Before launching into a discussion of individual sites, the subject of ocean and bay disposal should be covered. The Service generally does not favor open water disposal because there are so many uncertainties associated with it. The impacts which overboarding has on the ecosystem depend on such things as consistency and toxic content of the spoil, water depth, currents, benthic organisms present, existing hydrologic patterns, etc. Without extensive monitoring studies, there is no way of knowing if spoil deposited in a particular area will remain there, nor how such deposition will affect circulation patterns and resources of the area. Potential impacts of overboarding include smothering and burial of organisms, long-term changes in species diversity and biomass, uptake of toxic organic compounds and heavy metals, changes in water circulation and changes in sediment size and movement.

This is not to say that the Service categorically rejects all proposals of open water disposal. There may be instances where open water disposal is preferable to disposal elsewhere in terms of the impacts upon resources. However, such instances will have to be addressed on a site by site basis.

The following are comments on individual candidate sites by quadrangle.

Bombay Hook (Quad. 32)

32A This site consists of open water. It is used by waterfowl as a resting area and is also used for commercial blue crab and eel fishing and recreational fishing for striped bass. It is recommended that the area be maintained as open water with a depth of at least -5 ft. MLW, primarily because of the waterfowl and blue crab use. Therefore it is placed in Mitigation Category 2.

32B This is also an open water site. Resources present include oyster, blue crab, anadromous, catadromous and estuarine/marine fish and waterfowl. The waterfowl use it as a resting and feeding ground. Active oyster beds present in the area are placed in Category 1 and should not be considered for spoil disposal. The rest of the site was placed in Category 2 for the same reasons as listed for 32A. The representative from Delaware Division of Fish and Game stated that if the Category 2 area was considered for spoil disposal, the Corps would be asked to remove any inactive shell beds present, fill to a depth of no less than -5 ft. MLW, and replace the shell.

32C This site consists of open water, wetlands, forest, shrubland, old field and cropland. Comments on the open water portion are the same as those for Site 32B. In addition, the site contains wetlands and a mature forest stand that support the highest concentration of waterfowl and deer in the State. There are also muskrat present in the area. The "Other Wildlife" category for this site is composed of diamondback terrapins, which nest in the sandy beach areas along the coast. Once very rare, the species is making a comeback. Therefore, wetlands and forest were placed in Category 1 and the remaining areas in Category 3.

32F&G Both sites are cropland. However, their proximity to Bombay Hook NWR make them exceptionally valuable to waterfowl and for hunting. Both sites were placed in Category 1.

Smyrna (Quad. 31)

31A, 31C, 31N-S All of these sites consist of cropland. They are used by waterfowl for feeding and are also of moderate value to big and small game and nongame species. Other members of the evaluation team ranked the waterfowl and hunting criteria under Category 2. However, the Service placed all sites in Category 4.

31B, 31G, 31H, 31J-M These sites consist of wetlands, forest and cropland. In most cases the sites barely nick the edge of wetlands, but these wetlands are included in the evaluation anyway. The sites received Category 3 ratings for wetlands and forest and a Category 4 rating for cropland. Other members of the evaluation team rated them slightly higher for their waterfowl and hunting value.

31D The site contains open water, wetland, forest and cropland. The open water, wetland and forest areas comprise a very small portion of the site where it extends into Taylor's Gut. This small section was placed in Category 2 due to its value for waterfowl. The site is very near the Woodland Beach Wildlife Area. The rest of the site is cropland which received a Category 4 rating.

31E&F Both sites are open water and are rated the same as site 32A--Category 2.

31I This site consists of forest and cropland. It received a moderate value rating for big game, small game and non-game and a slightly higher rating (Division of Fish and Game) for waterfowl and hunting. The Service placed forest in Category 3 and cropland in Category 4.

Taylor's Bridge (Quad. 27)

27A&B All of these sites are open water areas. They received the same ratings as Site 32A and were all placed in Category 2.

27C 27D 27F 27O These sites contain open water, wetland and cropland. Resources present include blue crab, anadromous, catadromous and estuarine/marine fish, waterfowl, muskrat, big game, small game, and nongame and the diamondback terrapin. Portions of each site are designated Natural Areas. These portions received a Category 1 rating. Wetlands also fall under Category 1. Open water areas were broken into two types: 1) open water in Delaware River or Bay received the same rating as that in Site 32A, and was placed in Category 2; 2) open water in tidal tributaries was placed in Category 1 due to its value as a spawning and nursery area. Cropland was placed in Category 3.

27H, 27Q — These two sites are composed of open water (tidal tributaries and Delaware River) and tidal wetlands. The tidal tributaries were placed in Category 1 and the Delaware River portion in Category 2. The tidal wetland areas were placed in Category 1.

27K — This site is all cropland. It was given a Category 4 rating.

27L, 27M, 27P — All three of these sites contain open water (tributaries), wetlands, forest and cropland. The only difference in the areas is that site 27M is used for mooring commercial fishing boats and 27L and P are not. Both sites contain portions of a Natural Area, and these portions were placed in Category 1. The open water and wetlands are also Category 1 due to their high value for waterfowl and furbearers. The sections of forest fall under Category 3 and cropland under Category 4.

27N — This is an impounded area near Augustine Creek. It contains open water, wetlands, forest and cropland. Portions of the site are located in a Natural Area and were placed in Category 1. There is also a great blue heron rookery on the site. The area is very important for waterfowl and furbearers as well. For these reasons the open water, wetlands, and forest were all placed in Category 1 and cropland in Category 3.

27R — Composed primarily of cropland, the site barely nicks a few wetland and forest areas. The wetlands were placed in Category 2. Any portions of a Natural Area within the site were placed in Category 1. Other sections fell under Category 4.

27S — The boundaries of this site were not clear on the map, but the site appears to contain open water, wetlands, forest and cropland. The open water (tributary) and wetland areas and portions of a Natural Area were all placed in Category 1. Forest and cropland were given a Category 3 rating, and cropland was placed in Category 4.

Middleton (Quad. 26)

26A, 26D-F, 26H-J,N — These sites all contain forest and cropland. They are of moderate value to wildlife and for hunting and trapping. Forests were placed in Category 3 and cropland in Category 4.

26B, 26C, 26G — These three sites were rated the same as 26A except where a natural area occurs. Natural areas were given a Category 1 rating.

26L This site consists entirely of cropland. It is of moderate value to big and small game and non-game species and was placed in Category 4.

26M The site contains forest and cropland and appears to include small portions of wetlands as well. Part of the site contains a Natural Area and was placed in Category 1. Wetlands were placed in Category 2, forest in Category 3 and cropland in Category 4.

Delaware City (Quad. 24)

24A This site contains open water, wetlands and old fields. The open water and wetlands are both tidal and received a Category 1 rating. They are of high value to finfish and wildlife. The old field area was placed in Category 3 because it has moderate value for wildlife.

24B, 24C, 24V, 24II These sites contain open water, wetlands, and cropland. Resources present include various warmwater fish species, waterfowl (particularly wood ducks), muskrats, big and small game species. These sites receive especially high use for birdwatching. Portions of the area are also a Natural Area. Open water and wetlands were placed in Category 1. Cropland fell under Category 4.

24D, 24F, 24H-L These are all open water sites in the Delaware River. They are all of relatively high value for blue crab and finfish and were placed in Category 2.

24E This is an open water Delaware River site that includes most of Pea Patch Island as well. A forested area on the island supports a heron rookery and was placed in Category 1. Most of the island is a State Park and falls under Category 1. Wetlands were placed in Category 1 and open water in Category 2.

24G This site consists primarily of open water in the Delaware River, but encompasses Reedy Island as well. The wetlands on Reedy Island, including mudflats, were placed in Category 1. A cottonwood forest on the island was once used by ospreys for nesting. It was rated Category 3. Open water in the site received a Category 2 rating.

24O-R These sites consist of open water, wetlands, forest, and cropland. The area is of relatively high value for big and small game and non-game species, and moderate value for warmwater fish species, waterfowl and furbearers. Open water and wetlands were placed in Category 2. Forest and cropland fell under Category 3 and cropland Category 4.

24S This site consists of open water (tidal tributaries), wetlands, forests and cropland. Portions of the site are located in a Natural Area and were placed in Category 1. Open water and wetlands were also placed in Category 1. Forests fell under Category 3 and cropland Category 4.

24W This site contains open water (impounded), wetlands and cropland. The area receives high concentrations of overwintering waterfowl. It is also of relatively high value for muskrats and is used for trapping as well as hunting. Open water and wetlands were placed in Category 1 and cropland in Category 3.

24X This site contains tidal tributaries and wetlands and a small patch of forest. A portion of the site is a Natural Area, designated Category 1. The tributaries are used by some anadromous fish for spawning. The area is close to 1000 Acre Marsh and is of relatively high value for waterfowl and furbearers. Open water and wetlands were placed in Category 1 and the forest in Category 3.

24Y This site is very similar to 24X, except that there is no Natural Area and no forest on the site. The open water and wetlands were both placed in Category 1.

24Z This site contains open water (tidal tributaries), wetlands, forest and cropland. It also contains portions of a Natural Area which were designated Category 1. The area is of high value to waterfowl and furbearers because it contains freshwater marsh. There is also a heron rookery on the site. Open water and wetlands were placed in Category 1. The forest was rated Category 2 and the cropland Category 3.

24HH The site consists of open water, wetlands and cropland. A portion of the site is a County Park and was rated Category 1. The tidal tributaries are used by white perch as a nursery area. The site is of relatively high value to all wildlife species. Open water and wetlands were placed in Category 1 and cropland in Category 4.

St. Georges (Quad. 23)

23A,E 23G, 23I-M These sites all consists of forest and cropland and are of moderate value to most wildlife species. Forests were placed in Category 3 and cropland in Category 4.

23B, 23N-S, 23V These sites contain open water (non-tidal), forest and cropland. The open water was placed in Category 2, being of relatively high value for wildlife species in the area. Forest was placed in Category 3 and cropland in Category 4.

23C,D 23F,H 23K — These sites consist entirely of cropland. They are of moderate value to furbearers, big and small game and non-game species, and for hunting and trapping. All sites were placed in Category 4.

23T,U — These two sites consist of cropland and an active spoil disposal area (developed). Both sites were placed in Category 4.

23W — This site consists of forest and cropland. A portion of the site is a Natural Area and was designated Category 1. The forest was placed in Category 3 and cropland in Category 4.

Wilmington South (Quad. 20)

20A,B — Both sites are open water areas in the Delaware River. The sites are of relatively high value to anadromous and catadromous species and moderate value to blue crabs, warmwater finfish and waterfowl. Both areas were rated as Category 2.

20C — This site contains open water, wetlands and developed areas. The open water area has value similar to 20A and was given the same rating: Category 2. Wetlands were placed in Category 1 and developed areas in Category 4.

20D,L — Both sites consist of developed areas and were placed in Category 4.

20E,F — All three sites consist of open water, wetlands, forest and developed areas. They are of relatively high value to anadromous and catadromous finfish and moderate value to blue crabs and waterfowl. Open water was placed in Category 2, wetlands in Category 1, forest in Category 3 and developed areas in Category 4.

20H — This site consists of open water (tidal tributary), forest and cropland. Open water was placed in Category 2, forest in Category 3 and cropland in Category 4.

20J — This site consists entirely of old fields and was placed in Category 4. It is in such a developed area that it has very little value.

20M — This site was placed in Category 5 because there was not enough information available to evaluate it.

20N — This site consists of forest and developed areas. Both types were placed in Category 4.

20O — This site contains open water (tidal), wetland, and forest. It is of relatively high value for anadromous, catadromous and warmwater finfish and waterfowl. Open water and wetlands were placed in Category 2 and forest in Category 3.

Newark East (Quad. 19)

19A-N All sites on this quadrangle contained forest, cropland and developed areas. Many of the currently undeveloped areas are scheduled for development. All sites were placed in Category 4 with the exception of 19J and 19K which lacked enough information for evaluation and were placed in Category 5.

Marcus Hook (Quad. 15)

15A-C All three sites are open water areas in the Delaware River. They are of high value to anadromous finfish and moderate value to blue crab, catadromous, warmwater and estuarine/marine finfish and waterfowl, especially ruddy ducks and black ducks. All three sites were placed in Category 2.

15H-J All three sites contain open water and wetlands. Wetlands were placed in Category 1. Open water areas have similar value to those in 15A and were placed in Category 2.

Wilmington North (Quad. 14)

14A-C There was not enough information available to evaluate these sites. They were all placed in Category 5.

Small Navigation Projects

There are approximately nine project areas and 85 candidate sites included in this effort. Due to time constraints none of these areas were evaluated by the interagency team that reviewed the previous sites. Therefore, the comments included in this section are solely those of the Service. We reserve the right to modify our comments upon receipt of additional information.

St. Jones River (Frederica Quad.)

Seven of the ten sites (4-10) designated for the St. Jones River are cropland. While such areas are of moderate value to waterfowl and other wildlife species, cropland is fairly abundant in the area and was placed in Category 4. This is based on the assumption that additional site-specific information will not indicate higher values for particular sites.

Sites 1-3 are primarily open water areas near the mouth of the river. While all three are already active disposal areas and were placed in Category 4, it is recommended that these sites not be filled above mean high water.

Murderkill River (Frederica Quad.)

As with the St. Jones River, sites 4-10 on the Murderkill River are cropland and were given a Category 4 rating. Sites 1-3 are the same areas discussed for the St. Jones River.

Mispillion River (Milford and Mispillion River Quads)

There are several discrepancies with the candidate sites for the Mispillion River. The first is with site 4 indicated as an historical disposal area on an island at the mouth of the river. Our records show that an historical site designated D2 was located in the breach between the island and the main shoreline. A December 5, 1980 letter from the Corps to the Service indicated that this site had been dropped from consideration due to environmental concerns. Another discrepancy exists with sites 22 and 23, indicated as historical and active sites, respectively. In the same letter mentioned above, these two sites (D7 and D8) were also listed as being dropped from consideration due to environmental concerns. Site 20 (D11) was selected as an alternate area in place of these two sites. The last discrepancy is with site 21, indicated as an historical site. The Service has no record of a previously considered disposal site in this area.

The evaluation of these sites is as follows. If site 4 is located on the island and used for sand disposal only, an indicated, the Service has no problem with this area and places it in Category 4. For sites 22 and 23 the Service reiterates its previous position that these areas contain wetlands and other valuable habitat and should not be considered for disposal. Both sites have been placed in Category 2. Site 21 appears to be cropland and has been placed in Category 4.

Site 1 is an open water area south of the south jetty at the river mouth. The area also contains an intertidal flat. The site, which receives use by waterfowl and finfish, was placed in Category 2. It is recommended that if this area is considered for spoil disposal, that spoil elevation be no higher than mean high water.

Sites 2 and 3 are active disposal areas and were placed in Category 4. Sites 5-9, 12-15, 17, 18 and 25 are all cropland and were placed in Category 4. Sites 10 and 11 are cropland designated as historical disposal areas. Both were placed in Category 4. Sites 20, 24 and 26 are active disposal areas and were placed in Category 4. Sites 16 and 19 are historical disposal sites and were also placed in Category 4. The Service has previously commented on these active and historical disposal areas. However, we would like to reiterate that disposal sites near the river should be diked with a 30-40 foot setback from all palustrine wetlands.

Indian River (Millsboro Quad.)

There are three sites on this quad: 7-9. Sites 8 and 9 are active disposal areas, and both sites have been placed in Category 4. Site 7, a cropland area, was also placed in Category 4.

Indian River Bay (Frankford Quad.)

Sites 3-6 are located on this quad. Sites 3-5 are active disposal areas placed in Category 4. Site 4 should be diked to keep spoil out of surrounding tidal wetlands. Site 6 is a cropland area and has been placed in Category 4 as well.

Pepper Creek (Frankford Quad.)

There are seven sites along Pepper Creek, most of which are cropland and have been placed in Category 4. Portions of site 1 infringe upon estuarine wetlands, and these portions have been placed in Category 1. The rest of the area falls under Category 4.

Indian River Bay (Bethany Beach Quad.)

There are three disposal areas indicated on this quad, but only two are numbered. Two of these sites are active disposal areas and fall under Category 4. Site 2 is primarily cropland, but it also infringes upon estuarine wetlands. Wetland areas are placed in Category 1, the remainder of the site in Category 4.

Rehoboth Bay (Rehoboth Beach Quad.)

Of the three sites shown only two are numbered (3 and 4), but the third is indicated as an active disposal area and falls under Category 4. Site 3 contains wetlands, forest and shrub/scrub areas. The wetlands were placed in Category 1. The remainder of the site was placed in Category 3. Site 4 is cropland and was placed in Category 4.

Lewes and Rehoboth Canal (Rehoboth Beach Quad.)

Sites 7-9 are located on this quad. All three sites are cropland and were placed in Category 4.

Lewes and Rehoboth Canal (Cape Henlopen Quad.)

Sites 5 and 6 are located on this map. Both are cropland and fall in Category 4.

Lewes and Rehoboth Canal (Lewes Quad.)

Sites 1-4 are on the Lewes quad. Site 1 is indicated as an historical disposal area for sand only. It was placed in Category 4. Site 2 is an active disposal area and was also placed in Category 4. Sites 3 and 4 are upland areas and were placed in Category 4.

Harbor of Refuge (Cape Henlopen Quad.)

There are six sites for the Harbor of Refuge. Sites 1 and 2 are both active areas located adjacent to the breakwater. Both were placed in Category 4. Site 3 is an intertidal area west of the ferry landing. This site was placed in Category 3. Sites 4-6 are primarily upland although sites 4 and 6 infringe to a minor extent upon palustrine wetlands. The wetland areas were placed in Category 3 and the remainder of the areas in Category 4.

Broadkill River (Lewes and Milton Quads)

Sites 1-8 are all cropland, and all were placed in Category 4.

This completes the discussion of individual candidate areas. If there are questions on the contents of this report, please contact Suzanne Nair of this office.

Sincerely yours,

Glenn Kinser
Supervisor
Annapolis Field Office

DELAWARE RIVER BASIN COMMISSION
P.O. BOX 7360
WEST TRENTON, NEW JERSEY 08628
(609) 883-9500

GERALD M. HANSLER
EXECUTIVE DIRECTOR

HEADQUARTERS LOCATION
25 STATE POLICE DRIVE
WEST TRENTON, N.J.

April 21, 1983

Mr. S. J. Bucolo, P.E.
Acting Chief, Planning Branch
U. S. Army Corps of Engineers
Custom House - 2 D and Chestnut Streets
Philadelphia, Pennsylvania 19106

Dear Mr. Bucolo:

I have reviewed the minutes of the fourth meeting of the Plan Formulation Committee of the Delaware River Dredging Disposal Study and I am pleased to note that the study is on schedule and, further, that the five-month hiatus in the schedule has been closed.

The minutes state that the Needs Analysis considered long-term future project dredging, yet it is noted that these projects are not included in Phase I of the Systems Model runs. I assume that these projects will be added as they become available from the Delaware River Comprehensive Navigation Study.

We look forward to receiving the results of the Systems Model runs and the completion of the Stage 2 report this fall.

Sincerely,

Robert L. Goodell
Chief Engineer

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
Suite 322
315 South Allen Street
State College, PA 16801

April 25, 1983

Lt. Colonel Roger L. Baldwin
District Engineer, Philadelphia District
U.S. Army Corps of Engineers
Custom House, 2nd and Chestnut Streets
Philadelphia, PA 19106

Dear Colonel Baldwin:

This transmits our planning aid report entitled "Preliminary Assessment of 270 Candidate Disposal Sites in Pennsylvania and New Jersey for the Delaware River Dredging Disposal Study." The report partially fulfills our 1983 agreement with your District for the Delaware River Dredging Disposal Study. Information in our report was coordinated with the Pennsylvania Fish and Game Commissions; the New Jersey Division of Fish, Game and Wildlife; the Environmental Protection Agency; and the National Marine Fisheries Service. This report was prepared in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.), but does not constitute the report of the Secretary of the Interior within the meaning of Section 2(b) of the Act, nor does it constitute consultation required under Section 7 of the Endangered Species Act (87 Stat. 884, as amended).

If you have any questions concerning any aspect of the report, please contact us.

Sincerely,

Charles J. Kulp
Field Supervisor

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES

May 12, 1983

(717) 787-2869

In reply refer to
RM
6-A.6

S. J. Bucolo, Acting Chief
Planning Branch
Philadelphia District - Corps of Engineers
Custom House - Second and Chestnut Sts.
Philadelphia, PA 19106

Dear Mr. Bucolo:

This is in response to your letter of March 31, 1983, to Mr. Norman G. Kapko, of my staff, requesting comments on the minutes of the Fourth Plan Formulation Committee Meeting, held on February 15, 1983, for the on-going Delaware River Dredging Disposal Study.

Our major concern regards this study's integration with the Corps' ongoing Delaware River Comprehensive Navigation Study. The purpose of the navigation study is to define the Federal interest in navigation development, especially with respect to the future needs for navigation improvements. The major navigational restrictions currently evident in the Delaware Estuary include inadequate channel depth and turning basin widths, both crucial to the maintenance of the Port of Philadelphia as a major, deep water regional port. The navigation study has only recently been initiated and has certainly not estimated the dredged volume necessary to maintain "adequate channel depth" no defined what "adequate channel depth" will be required to accommodate the new and emerging technology of deep draft ocean colliers. Our question, therefore, centers on whether the estimates of dredged disposal needs for the area for a 50 year time span are adequate, especially since an analysis of volumes dredged for navigation channel improvements has yet to be undertaken. It should be noted that a similar question on this issue was also raised at the meeting by Michael Wolf of the Delaware Valley Regional Planning Commission.

Finally, we also wish to call your attention to the fact that Ms. Deirdre C. Taylor, of our Division of Coastal Zone Management, was in attendance at the Dredging Disposal Study Meeting. Her name, however, was omitted from the attendance list. We request that her name be added to the list of attendees and also be placed on the mailing list for future minutes and other appropriate correspondence relating to the study.

Your courtesy in giving us this opportunity to comment on this matter is very much appreciated.

Sincerely,

Patrick J. Solano
Deputy Secretary
for Resources Management

Enclosure

MINUTES

DELAWARE RIVER DREDGING DISPOSAL STUDY
FIFTH PLAN FORMULATION COMMITTEE MEETING

A. Location: The meeting was held at the Philadelphia District on 2 November 1983.

B. Attendees: See Inclosure #1.

C. Purpose:

1. To present adjustments in the study process from that discussed at the last meeting.

2. To discuss the environmental agency coordination and results.

3. To present the results of the systems model runs and list of potential recommendations.

D. Discussion: It was pointed out that since the original objectives of the study have been satisfied, this is anticipated to be the final meeting of the committee. A package of handouts (see list on inclosure #2) were provided to summarize the study results and comments on them or the meeting discussion are requested.

The schematic diagram shown on page 6 of the handouts was used to recap the major components of the study, many of which were presented at the previous meetings.

It was emphasized that one of the main products of the study is the development of a methodology to evaluate the disposal system plan(s) on a consistent basis. The methodology addresses, among many other items, an order of timing, i.e. when new sites should be acquired. This order of timing allows us to distinguish between short term (within 10 years) and long term (within 50 years) disposal needs. As the handouts show, the bulk of the recommendations do not pertain to the short term. So that acquisition will incorporate changes which may occur in the future, it is anticipated that the input would be adjusted to reflect any such changes and the methodology reapplied. This updating would be done as often as needed, but at least 5-10 years prior to acquisition to allow sufficient time to complete the acquisition process. The recommendations in the handouts represent those that we would suggest if we were forced to make a decision on disposal sites today. Since the short term needs are relatively small, we would suggest taking care of those needs now and reapplying the methodology at the appropriate time.

Several comments on the minutes of the last meeting were received. These were categorized into two types, namely; suggestions to integrate this study with the Corps' on-going Delaware River Comprehensive Navigation

Study and environmental comments on specific sites. Concerning the former, close coordination has occurred throughout the two studies, and at this point they have been joined with the Delaware River Dredging Disposal Study being an interim product of the Comprehensive Navigation Study. The Stage 3 studies for the Disposal Study will be incorporated with the Comprehensive Study. Comments on potential sites were resolved by contacting the various agencies or incorporated in the environmental and agency run scenarios considered as part of this study.

Since the last meeting there were three areas where the study process was adjusted. These are: 1) the deletion of the EQ-1 scenario, 2) the manner in which mitigation was treated and 3) conduct of the systems model runs.

The EQ-1 scenario which considered aquatic sites was eliminated due to environmental (the location of highly sensitive shallow water and wetland habitat in aquatic areas) and hydraulic concerns (reductions in the cross-sectional area and its effect on the deposition of shoaling material). With the deletion of the EQ-1 scenario, the previous term EQ-2 was referred to as EQ.

Regarding mitigation, the study is no longer considering the compensation costs within the systems model. These costs are too general to be applied across the board at this time and will be applied as appropriate prior to implementation. However, the study did not eliminate the concept of mitigation as consideration was given in "EQ Ranking" and "Agency" runs scenarios.

In lieu of conducting the systems model runs in three phases presented at the last meeting (see handouts on pages 7-9), the runs were made to reflect two conditions identified as Most Probable and Worst Case. These two conditions represent a range of potential disposal needs. These conditions are defined specifically for each project in the handouts. The net disposal deficits for the entire study area for each of these conditions over the 50 year study period are estimated to be 74 million cubic yards and 335 million cubic yards respectively.

In addition to the two previously discussed scenarios (NED and EQ), two additional scenarios were modeled for each of the above conditions. The first of these is the "EQ Ranking" which was a variation of the EQ run that ranked sites for consideration by their amount of wetlands contained in each site. The second scenario is the "Agency" run and was the result of extensive coordination with Federal (USFWS, EPA, NMFS) and State resource agencies. These sites were the result of a screening process by these agencies using the output of the attractiveness model. Their combined efforts culminated in a Fish and Wildlife report which broke down all the sites into four categories (see page 10 of handouts). Potential sites in Categories I and II were classified as highly valuable environmental areas and were not considered, while Categories III and IV were included in the systems model runs as potential candidate sites.

A summary of the results for each of these four scenarios (NED, EQ, EQ Ranking and Agency) is shown on handouts 11-57 for each of the two conditions (Most Probable and Worst Case) and for each of the four project reaches. Also, a recommended plan was suggested for the most probable case condition. The basis for the recommendation was a composite of cost and other factors such as environmental considerations. The recommended plan in some cases is one of the four scenarios and in other cases a mix thereof.

In summary, the study has developed a dynamic tool that can be utilized to provide a common basis for making decisions. The methodology that is used by the tool can easily be updated to reflect changing conditions. This tool can be beneficial to sensitize future concepts and will be used in all future studies by the District. The approach is being considered by other Districts as a means of evaluating their needs.

Only one of the seven sites recommended for acquisition on page 11B is needed in the short term (Site 20C in the Wilmington Harbor project). The District is already in the process of conducting detailed engineering studies for this site. In addition, the study recommended that certain aspects of site management be improved. One of these aspects involves improved trenching techniques. Toward this end, the District has purchased an amphibious ditcher to accelerate the drying process, and this vehicle is already in use at existing disposal sites. Finally, the systems model is being used at specific disposal sites to develop site management plans.

The completion schedule of the study has been slightly delayed, as indicated in our letter of 12 July 1983. However, we anticipate the following sequence. First, the record will be open during a 30 day review period culminating on 2 December. Committee comments received by that time will be incorporated into a Draft Stage 2 Report and will be distributed to the committee in early 1984. The draft report with committee comments would then be submitted to our higher authority with the final version available in the spring. It was pointed out that the committee provided valuable guidance and review throughout the study.

The following concerns and comments were expressed at the meeting:

a. A question was raised regarding the difference between the EQ and Agency scenarios. The environmental concerns were addressed by both scenarios but the Agency scenario represents a more stringent condition.

b. Concern was raised on real estate ownership of the screened sites. Real estate ownership of individual sites was not addressed, however the cost of acquisition on an area basis was included in the systems model runs. The ownership of specific sites will be addressed during the acquisition process.

c. Concern was raised on how current the information on the potential sites is. The sites were checked against 1980 aerials and, in addition, helicopter flights to field check the majority of the sites were made in Spring of 1983.

DELAWARE RIVER DREDGING DISPOSAL STUDY
FIFTH PLAN FORMULATION COMMITTEE MEETING

Attendees

Tim Goodger	National Marine Fisheries Service
Page Fielding	Delaware River Basin Commission
Scott Anderson	Philadelphia Maritime Exchange
Don Roeder	American Dredging Company
Michael Wolf	Delaware Valley Regional Planning Commission
William C. Muir	U.S. Environmental Protection Agency
Shamus Malone	PA Dept. of Environmental Resources - Coastal Zone Management
Susan Scotto	University of Delaware Sea Grant College Program
Suzanne Nair	U.S. Fish & Wildlife Service (Del)
Bob Folker	U.S. Fish & Wildlife Service (Del)
Lewis Caccese	Joint Executive Committee
Lieutenant Colonel Roger Baldwin	Corps of Engineers; District Engineer
Nicholas Barbieri	Corps of Engineers; Chief, Planning/ Engineering Division
John Burnes	Corps of Engineers; Chief, Planning Branch
Stanley Snarski	Corps of Engineers; Ass't Chief, Operation Division
Vincent Calvarese	Corps of Engineers; Acting Chief, Engineering Branch
Salvatore Bucolo	Corps of Engineers; Ass't Chief, Planning/ Engineering Division
Roy Denmark	Corps of Engineers; Acting Chief Environmental Resources Branch
Brian Heverin	Corps of Engineers; Chief, General Design
George Steinrock	Corps of Engineers; Project Manager, Delaware River Dredging Disposal Study
John Tunnell	Corps of Engineers; Project Manager, Delaware River Comprehensive Navigation Study

Inclosure #1

DELAWARE RIVER DREDGING DISPOSAL STUDY
FIFTH PLAN FORMULATION COMMITTEE MEETING

Attendees

Tom Schina	Corps of Engineers; Chief, Programs Navigation & Maintaince Branch, Operations Division
Jerry Pasquale	Corps of Engineers; Environmental Resources Branch
Stan Lulewicz	Corps of Engineers; Planning Branch

Inclosure #1

SUMMARY OF HANDOUTS
FIFTH PLAN FORMULATION COMMITTEE MEETING

Inclosure #2

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
Suite 322
315 South Allen Street
State College, PA 16801

November 29, 1983

Lt. Colonel Roger L. Baldwin
District Engineer, Philadelphia District
U.S. Army Corps of Engineers
Custom House, 2nd and Chestnut Streets
Philadelphia, PA 19106

Dear Colonel Baldwin:

This responds to Mr. John Burnes' letter, dated November 16, 1983, enclosing minutes of the fifth and final plan formulation committee meeting of November 2, 1983, for the ongoing Delaware River Disposal Study. We are also commenting on the package of material that was distributed at the meeting and later furnished to us by Mr. George Steinrock.

These comments provide technical assistance only and do not constitute the report of the Secretary of the Interior on the project within the meaning of Section 2(b) of the Fish and Wildlife Coordination Act, nor do they represent the review comments of the Department of the Interior on any forthcoming environmental statement.

The Service concurs with the Corps' decision to eliminate the EQ-1 scenario which considered "aquatic sites" for disposal of dredged material. We believe this action is justified considering the serious damage such activities would have had on fish and wildlife resources, particularly tidal wetlands and shallow water areas.

We are concerned about the Corps' decision to delete compensation costs within the systems model. Fish and wildlife resource damages for many remaining disposal sites are significant, as are the costs of replacement. Applying compensation costs later or "prior to implementation" will favor sites closest to the dredging area and which usually have the highest resource value and replacement cost. We recommend that compensation costs be factored into the system's model, despite their general nature, in order to provide the public a truer picture of the economic and environmental suitability of each site.

Although deleting the EQ-1 scenario appreciably reduced the number of potentially controversial disposal sites, many remaining sites present significant fish and wildlife conflicts. Our review of potential disposal sites shown on handouts 11 through 57 reveals that many non-tidal and tidal wetlands would be affected. For example, under the Philadelphia to the Sea project, most probable case condition, 11 of 28 sites listed in PA & NJ contain non-tidal or tidal wetlands. Under the worst case condition, 35 of 69 sites contain non-tidal or tidal wetlands. Therefore, of 97 sites listed for this project, 46 or nearly half would adversely affect wetlands, the majority being non-tidal. Use of such sites are a concern to the Service and we again urge the Corps avoid using wetlands as potential disposal sites. To further assist the Corps in this regard, we are providing a complete listing of the potential disposal sites and their categorization (Table 1) based on the "Fish and Wildlife Habitat Categories" shown on page 10 of the November 2 meeting handout. By way of general explanation, Category I resources are usually tidal wetlands which should not be used for disposal of dredged material. Category II resources are generally non-tidal wetlands where disposal is strongly discouraged and inkind habitat replacement is required. Category III resources are terrestrial habitats where disposal is discouraged and inkind or out-of-kind habitat replacement is required. Category IV habitats are suitable for dredged material disposal with mitigation a possible requirement.

Sites 20I and 24CC, as well as the Killcohook site contain lands administered by the Service as National Wildlife Refuges. These sites are being managed to promote fish and wildlife resources and public uses, a goal which is not compatible with disposal of dredged material. We, therefore, recommend that the Corps delete these sites from further consideration.

Please include a copy of this letter in your Stage 2 report along with a response to our recommendations.

Sincerely,

Charles J. Kulp
Field Supervisor

Attachment

Table 1. Fish and Wildlife Resource Categories for Potential Disposal Sites Identified in the Delaware River Dredging Disposal Study (**Pennsylvania** and New Jersey).

SCHUYLKILL RIVER PROJECT

Most Probable Case	Categories I	II	III	IV
Ft. Mifflin				X
National Park				X
11E			X	X
Worst Case				
Ft. Mifflin				X
National Park				X
11E			X	X
11D			X	X

WILMINGTON HARBOR PROJECT

Most Probable Case	I	II	III	IV
15E			X	X
15G				X
15R			X	X
21D		X		X
21K				X
21Q		X	X	X
21V			X	X
Worst Case				
20P		X	X	
21E		Not evaluated		
21F			X	
21H		X	X	X
21M				X
21P		Not evaluated		
21Q		X	X	X
21R		X	X	X
21S		X	X	X
21V			X	X
21Y			X	X
21BB		X	X	X
21FF	X	X	X	X
15E			X	X
15G				X
16J		X	X	X
16N			X	X
16T			X	X
16V		X	X	X
17E		X	X	X

	Categories I	II	III	IV
21K				X
21L				X
22B		X	X	

PHILADELPHIA TO TRENTON

<u>Most Probable Case</u>

	I	II	III	IV
Hess				X
Delair (Holt Mitigation Site)	X			X
Palmyra	X	X	X	X
Hawk Island				X
Beverly				X
Tenneco		X	X	X
Burlington Island				X
7A		X		
7B			X	X
7F		X	X	X
Warner 1, 2, 3				X
2K			X	X
Warner 24D				X
Warner				X
U.S. Steel				X
3M		X	X	X
3B			X	X
Biles Island	X		X	X

<u>Worst Case</u>

	I	II	III	IV
12E		X	X	X
Hess				X
Delair (Holt Mitigation Site)	X			X
Palmyra	X	X	X	X
13F		X	X	X
13D		X	X	X
13C			X	X
13B			X	X
7L				X
7M			X	X
6D		X	X	X
6C		X	X	X
Hawk Island				X
Beverly				X
6E	X	X	X	X
Tenneco				X
Burlington Island				X
7A		X		
7N		Not evaluated		
7B			X	X

Categories	I	II	III	IV
7F		X	X	X
8B			X	X
8A			X	X
3A			X	X
3B			X	X
3C			X	X
3D			X	X
Warner 1, 2, 3				X
2K			X	X
Warner 24D				X
Warner				X
U.S. Steel				X
3M		X	X	X
3J	X			
3F		Not evaluated		
Biles Island	X		X	X
2E		X	X	X
1C			X	X
2A			X	X
2C		X		

PHILADELPHIA TO THE SEA

<u>Most Probable Case</u>

	I	II	III	IV
National Park				X
Oldmans				X
Pedricktown N				X
Pedricktown S				X
Penns Grove				X
Penns Neck				X
Killcohook (National Wildlife Refuge)	X			
Artificial Island				X
Buoy 10		Not evaluated		
11B	X	X	X	X
11D			X	X
11E			X	X
15D				X
15G				X
15M				X
16N			X	X
16Q		X	X	X
16T			X	X
16Y		X	X	X
17C			X	X

Categories	I	II	III	IV
17G			X	X
17I		X	X	X
17P	X	X	X	X
18A		X	X	X
21K				X
21V			X	X
24T		X	X	X
24CC (National Wildlife Refuge)	X			
<u>Worst Case</u>				
Oldmans				X
Pedricktown N				X
Pedricktown S				X
Penns Grove				X
Penns Neck				X
Killcohook (National Wildlife Refuge)	X			
Artificial Island				X
Buoy 10		Not evaluated		
11B	X	X	X	X
11E			X	X
12C	X	X		
13C			X	X
13E				X
13F		X	X	X
15D	X			X
15E			X	X
15M				X
15P	X		X	X
15R			X	X
16G			X	X
16K				X
16M			X	X
16N			X	X
16S			X	X
16T			X	X
16V		X	X	X
16X		X	X	X
16Y		X	X	X
16Z		X	X	X
16DD	X	X	X	X
17A			X	X
17B			X	X
17C			X	X
17D			X	X
17F		X	X	X

Categories	I	II	III	IV
17G	X		X	X
17I		X	X	X
17M		X	X	X
17N	X		X	X
17D		X	X	X
17P	X	X	X	X
18A		X	X	X
18B		X	X	X
20I (National Wildlife Refuge)	X			
20Q	X	X	X	
21D		X		X
21E		Not evaluated		
21F				X
21J		X	X	X
21K				X
21L				X
21M				X
21T		X	X	X
21V			X	X
21W		X	X	X
21Y			X	X
21AA		X	X	X
22B		X	X	

DELAWARE RIVER BASIN COMMISSION
P.O. BOX 7360
WEST TRENTON, NEW JERSEY 08628
(609) 883-9500

GERALD M. HANSLER
EXECUTIVE DIRECTOR

HEADQUARTERS LOCATION
25 STATE POLICE DRIVE
WEST TRENTON, N.J.

December 1, 1983

Dr. John A. Burnes, P.E.
Chief, Planning Branch
U. S. Army Corps of Engineers
Philadelphia District
Custom House - Second & Chestnut Streets
Philadelphia, Pennsylvania 19106

Dear John:

SUBJECT: Delaware River Dredging Disposal Study

We have reviewed the preliminary draft report for the subject study and find it to be a good presentation of the results from the model for the scenarios considered. The review draft report distributed November 2 contains no text which we assume is being prepared and may answer our questions. Were existing sites with remaining capacity included in the model analysis with the new sites so that all sites were compared and rated on the same basis?

While we are encouraged to see the report nearing completion, what action does the Corps plan to take to obtain the recommended sites? Site acquisition should not be held pending completion of the comprehensive navigation study.

Sincerely,

Robert L. Goodell
Chief Engineer

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
P. O. Box 1467, Harrisburg, Pennsylvania 17120

In reply refer to
RM-WR

(717) 783-9500

December 2, 1983

John A. Burnes, P.E.
Chief, Planning Branch
Philadelphia District - Corps of Engineers
Custom House - 2 D & Chestnut Streets
Philadelphia, PA 19106

Dear Mr. Burnes:

We have reviewed the Delaware River Dredging Disposal Study system model results and have discerned potential problems with Recommended Site 16Q, the only site located in Pennsylvania's coastal zone and therefore the only site which we analyzed. Site 16Q is the subject of a CZM funded study which looks at the development potential of this area. The study shows it has potential for development and the Henderson Group, owners of the site, are pursuing development plans here. Therefore, we believe that this is not a good site for future dredge disposal. We have enclosed a copy of this three volume CZM funded study for your review. The section most pertinent to Recommended Site 16Q is in Volume 3, Final Reuse Concepts, Page III 52, "Little Tinicum Island Road".

Thank you for the opportunity to review this document; and if you have any questions concerning our comments, please contact us at the above listed number.

Sincerely,

William Johnson

for

E. James Tabor, Chief
Division of Coastal Zone Management
Bureau of Water Resources Management

Enclosures

STATE OF NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OFFICE OF THE COMMISSIONER
CN 402
TRENTON, N.J. 08625
609 - 292 - 2885

December 8, 1983

Mr. John Burns
Chief, Planning Branch
Philadelphia District
Corps of Engineers
Custom House - Second & Chestnut
Philadelphia, PA 19106

Dear Mr. Burns:

ATTENTION: George Steinrock

The New Jersey Department of Environmental Protection has had an opportunity to review the package of information that was distributed at the fifth Plan Formulation Committee Meeting on November 2, 1983. I regret that I could not attend the meeting due to a prior commitment.

At this point in time we have no major objections to the plan of study or the preliminary results of the ongoing Delaware River Dredging Disposal Study. The Department of Environmental Protection obviously favors continued disposal site planning following the Environmental Quality (EQ) scenarios. We look forward to reviewing the draft Stage 2 Report. In order to coordinate a departmental response, please send me at least six copies of the report when it becomes available.

The Division of Coastal Resources has provided me with technical and policy related comments on the preliminary results of the systems model results. I am herewith attaching a copy of the Division's comments for your consideration. On behalf of the Department I wish to thank you for the opportunity to participate on the steering committee.

Sincerely,

Lawrence Schmidt
Acting Director
Planning Group

LS/ss
cc: Allan Campbell
Bernie Moore
Attachment

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State of New Jersey
DEPARTMENT OF ENVIRONMENTAL PROTECTION
TRENTON

DIVISION OF COASTAL RESOURCES

PLEASE ADDRESS REPLY TO:
CN 401
TRENTON, N. J. 08625

November 18, 1983

MEMORANDUM

TO: Mr. Lawrence Schmidt
Planning Group

FROM: Mr. Allan B. Campbell, Chief
Bureau of Coastal Planning & Development

SUBJECT: Delaware River Dredging Disposal Study

We have reviewed the U. S. Army Corps of Engineers' preliminary Delaware River Dredging Disposal Study you submitted to us on November 3, 1983. The following are our main concerns:

1. The National Development Plan (NDP) scenario considers filling wetlands. Such activity is prohibited under our coastal policies. However, in case of isolated wetlands areas, mitigation measures could be considered.

2. The Environmental Quality (EQ) scenario should, in addition to prohibition of disposal on all wetlands or aquatic areas, utilize factors outlined in our memorandum of June 22, 1982. These factors are consistent and compatible with all policies of New Jersey's approved and adopted Coastal Management Program.

3. Site 2K is shown as having the best opportunity and the least environmental constraints. There are some wetlands, however, that should not be filled.

4. Site 7B, which is outside of the coastal area, should address the compatibility of uses aspect since it may adversely affect adjacent residential area. This could be mitigated by an adequate buffer.

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5. Sites 15D and 17G are acceptable since these sites are already connected with dredging activities serving as rehandling basins.

jl

Attachment

M E M O R A N D U M

June 22, 1982

TO: Larry Schmidt

FROM: John R. Weingart

SUBJECT: Delaware River Dredging Disposal Study

My staff have reviewed the Delaware River Dredging Disposal Study prepared by the Philadelphia District Corps of Engineers. This study uses computer programs developed by Harvard University called IMGRID.

The only comment that I would like to make is in relation to the parameters chosen and the variable weighting factors. I suggest that parameters should be consistent with the Coastal Management Program definitions of special areas and resource policies.

The weighting factors reflecting the constraints and opportunities should also be consistent and compatable with all policies of New Jersey's approved & adopted Coastal Management Program:

1. High Fishing Areas which are defined in our program as Prime Fishing Areas and should be classified as unacceptable (-1) according to our policies, rather than least acceptable.

2. Add submerged vegetation as a parameter and assign -1 unacceptable.

3. Add the following navigation channels as an additional parameter: canals -1, inlets -1, marina moorings -1, ports -1, submerged shipwrecks and artificial reefs -1.

4. Add Wet Borrow Pit parameter with rating 8.

5. Add the Intertidal Flats parameter with scale -1.

6. Add the Filled Water's Edge parameter with scale -1.

7. Add the Natural Water's Edge-Floodplains parameter with scale -1.

8. Add the Beaches parameter with scale 10 for clean sand. (beach nourishment), and -1 for contaminated sand.

9. Add Erosion Hazard Areas parameter with scale 5.

10. Add the Wetlands Buffer parameter with scale 0.

11. Add the Cranberry Bogs parameter with scale -1.

12. Add the Coastal Bluffs parameter with scale -1.

13. Add the Intermittent Stream Corridors parameter with scale -1.

14. The Farmland Conservation Areas which may overlap with some of variables listed in the study, should have scale 0.

The scale of parameter importance should be identical in any of the test runs for all of the environmental parameters, and in comformance with the New Jersey Coastal Management Program.

cc: Mr. Fred Schultz
Mr. Michael Hochman

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO Environmental Resources Branch

DEC 12 1983

Mr. Charles J. Kulp
Field Supervisor
U. S. Fish and Wildlife Service
315 South Allen Street, Suite 322
State College, Pennsylvania 16801

Dear Mr. Kulp:

This is in response to your letter dated November 29, 1983, concerning results of the Delaware River Disposal Study. Your letter and this response will be included in the Correspondence Appendix of the Stage 2 report.

Our decision to defer consideration of mitigation was reached after initial attempts to factor costs into the systems model. The site-specific nature of mitigation precludes an accurate representation of the costs involved through the application of a uniform rate per acre. After attempting this and because of the problems experienced we decided to defer this issue until the plan implementation stage when more appropriate mitigation plans and associated costs can be developed.

Your letter also expressed concerns over the number of potential disposal areas that contain tidal and non-tidal wetlands. Most of those sites noted (11 of 28 for the most probable case and 35 of 69 for the worst case) are in the NED scenario, which considered all but built up areas as potential disposal sites. Furthermore, these wetland sites are those that were considered in the analysis, but not necessarily those selected for the recommended plan. In fact, of the sites recommended 15D is category IV; 2K, 7B, and 17G are combinations of categories III and IV; and 16Q is a combination of categories II, III, and IV. Selected sites for the Wilmington Harbor project, 20C (Wilmington Harbor South) and 20E (Lukens Steel), were not rated in your letter.

You indicated in your letter that a portion of site 17G contained category I habitat. The site was reduced in size after completion of your planning aid report dated April 25, 1983, resulting in the elimination of the category I portion of the site. This information was conveyed to Mr. Michael Chezik of your office during a recent telephone conversation with Mr. Jerry Pasquale of this office. In addition, it should also be noted that the portion of 16Q rated as category II is a perched wetland in a former disposal area, which represents a small portion (less than 10%) of the site.

Concerning sites 20I and 24CC, neither have been recommended for use, and accordingly there is no conflict with your suggestion to delete these from further consideration. Killcohook is an existing disposal area. Although this area was designated as a migratory bird refuge by a Presidential Executive Order in February of 1934, a provision was included for its continued use in connection with future maintenance work on the Delaware River. Since the purpose of this study is to suggest additional sites or better management of existing sites to fill the projected 50 year deficit, we are recommending continued use of existing disposal areas.

We appreciate your concern with the disposal of dredged material in the Philadelphia District and thank you for your participation in the Plan Formulation Committee of the Dredged Material Disposal Study. If you have any additional questions concerning this matter please contact Mr. Roy E. Denmark, Jr., Acting Chief, Environmental Resources Branch at FTS: 597-4833.

Sincerely,
Signed by: Nicholas J. Barbieri

Nicholas J. Barbieri, P.E.
Chief, Planning/Engineering Division

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO Planning Branch

Mr. Robert L. Goodell
Chief Engineer
Delaware River Basin Commission
P. O. Box 7360
West Trenton, New Jersey 08628

DEC 14 1983

Dear Mr. Goodell:

Thank you for your letter of December 1, 1983 regarding the Delaware River Dredging Disposal Study.

For clarification the handouts provided at the recent Plan Formulation Committee Meeting are being incorporated into a text, the draft Stage 2 Report for the study. This report will be distributed early next year and we believe, as you suggest, it will answer your questions. Also, in regard to your question concerning existing disposal sites, both their remaining capacities and those of new sites were included in the model analysis. These were evaluated on equal basis from all aspects.

Concerning your comment on site acquisition, it is emphasized that only one site of the seven suggested in the handouts is required in the short term (next 10 years). For that one site, 20C (Wilmington Harbor South), the District is already in the process of conducting the detailed engineering studies that are required for acquisition. The balance or long term needs would be addressed in sufficient time to assure that there is no disposal shortfall. Because these additional sites are not required until year 2000 or thereafter, the incorporation with the Comprehensive Navigation Study would not delay the acquisition process as we see it now. Should the disposal problem become more critical in the future, I assure you that similiarly to the Wilmington Harbor South site, action would be initiated.

The above discussion is being documented in the draft report. Again, thank you for your continued involvement in the study. Should you have any further questions, please do not hesitate to contact us again.

Sincerely,

Nicholas J. Barbieri, P. E.
Chief, Planning/Engineering Division

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT. CORPS OF ENGINEERS
CUSTOM HOUSE—2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
Planning Branch

DEC 15 1983

Mr. E. James Tabor
Chief, Division of Coastal Zone Management
Commonwealth of Pennsylvania
Department of Environmental Resources
P. O. Box 1467
Harrisburg, Pennsylvania 17120

Dear Mr. Tabor:

This is in response to your letter dated December 2, 1983 which addresses possible problems with a potential disposal site, 16Q, being considered under the Corps' Delaware River Dredging Disposal Study.

Upon reviewing the results of the Delaware County Planning Department Study, it was noted that specific development plans have not been finalized that would preclude the use of site 16Q for disposal. In addition, the study presented various key issues that needed to be resolved prior to development by interested parties. As a result, we feel that this area is a potential candidate for use as a disposal site and should still receive consideration to satisfy the long-term disposal needs (within 50 years) for the Philadelphia to the Sea reach of the study.

As discussed at the Plan Formulation Committee Meeting, we recognize that conditions, such as the availability of site 16Q may change over time and that adjustments may be necessary to reflect these changes.

Your letter and this response will be incorporated in the draft report which will be provided to you early next year. Also, I want to thank you for your continued involvement in this study. Should you have any further questions, please do not hesitate to contact us again.

Sincerely,

Nicholas J. Barbieri, P. E.
Chief, Planning/Engineering Division

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

DEC 27 1983

IN REPLY REFER TO
Environmental Resources Branch

Mr. Lawrence Schmidt, Acting Director
Planning Group
New Jersey Department of
Environmental Protection
CN 402
Trenton, New Jersey 08625

Dear Mr. Schmidt:

This is in response to your letter dated December 8, 1983, concerning the results of the Delaware River Dredging Disposal Study. We are pleased to hear that you have no major objections to the plans presented at the fifth Plan Formulation Committee meeting on November 2, 1983. Information addressing the specific concerns provided in the enclosure to your letter is presented below.

Paragraphs 1 and 2 of the enclosure expressed concern about the NED and EQ Scenarios. The study viewed the selection of new dredged material disposal areas from a number of perspectives including economic, engineering, and environmental. The Environmental Quality (EQ), EQ Ranking, and Agency scenarios were designed to address environmental concerns. These concerns included wetlands, important fish and wildlife habitats, groundwater, recreation, archaeological, and historic parameters. The National Economic Development (NED) scenario considered all land except built up areas and navigational features. Although wetlands were included under the NED scenario, this was done to facilitate a thorough analysis of the project area and develop implementation costs for this option. An attempt was made to minimize wetland involvement while selecting sites for the recommended plan. A recent Fish and Wildlife Service evaluation of recommended sites in the state of New Jersey indicated that no unique or relatively scarce habitat types would be impacted if this plan were implemented.

Paragraphs 3 and 4 of the enclosure expressed concerns over sites selected for the Philadelphia to Trenton project (i.e. 2K and 7B). These sites were recommended due to the dredging requirements in that section of the Delaware River. Based on available information, site 2K contains a man-made pond that was excavated in conjunction with the one time proposed Newbold Island Nuclear Generating Station. The remainder of the site is disturbed shrub/brush land that has begun to revegetate. Site 7B is an upland area that is composed of shrubland, forest, and agricultural land. This site was selected in lieu of site 7A, which contains a lake approximately 100 acres in size. These sites would be studied more extensively in the future if it is decided to proceed with plan implementation. Site modifications would be considered at that time to satisfy public concerns.

We appreciate your participation in the Plan Formulation Committee of the Delaware River Dredging Disposal Study. If you have any additional concerns please contact Mr. Roy E. Denmark, Jr., Acting Chief, Environmental Resources Branch at FTS: 597-4833.

Sincerely,

Signed by: S. J. BUCOLO

Nicholas J. Barbieri, P.E.
Chief, Planning/Engineering Division