3.0 Proposed Plan of Improvement

3.1 Channel Design

3.1.1 Recommended Plan

The recommended plan as shown on Plates 1-4 consists of a navigation project extending from deep water in Delaware Bay to Philadelphia Harbor and to Beckett Street Terminal, Camden, New Jersey, a distance of about 102.5 miles. The plan provides for modifying the existing Delaware River Federal Navigation channel (Philadelphia to the Sea Project) from 40 to 45 feet below mean low water (MLW) with an allowable dredging overdepth of one foot. The channel side slopes are 3 horizontal to 1 vertical.

The channel width would range from 400 feet in Philadelphia Harbor, to 800 feet from the Philadelphia Navy Yard to Bombay Hook, and then 1,000 feet in Delaware Bay. The plan includes 12 bend widenings as well as provision of a two space anchorage of compatible depth at the Marcus Hook anchorage. The existing turning basin adjacent to the Naval Shipyard will not be deepened as part of the project.

The plan includes deepening access to a 45 foot depth at the bulk berths at Beckett Street Terminal in Camden, a public terminal operated by the South Jersey Port Corporation.

The project also includes the acquisition of four new upland disposal sites (17G, 15D, 15G and Raccoon Island), and relocation or placement of additional aids to navigation.

3.1.1.1 Bend Widening Details

The bends will be widened to accommodate the operating and handling characteristics of the design vessel operating at the 45 foot depth. The bends will be modified at the ranges listed below.

Horseshoe Bend-Eagle Point
Mifflin-Billingsport
Billingsport-Tinicum
Tinicum-Eddystone
Eddystone-Chester
Marcus Hook-Bellevue
Cherry Island-Deepwater
Deepwater-New Castle
New Castle-Reedy
Reedy-Baker
Baker-Liston
Cross Ledge-Miah Maull

The following is a summary of the modifications developed and recommended for each bend:

MIAH MAULL-CROSS LEDGE: 200 foot width increase at the apex of the west side of the bend.

LISTON-BAKER: Maximum width increase on the east edge of 250 feet, over a distance of 4500 feet south of the apex, and extending 3,900 feet north from the apex.

BAKER-REEDY ISLAND: 100 foot width increase at the west edge apex of the bend.

REEDY ISLAND-NEW CASTLE: Maximum widening of 400 feet at the west apex of the bend, tapering to zero over a distance of 3,200 feet south of the apex, and to zero over a distance of 4,000 feet north of the apex.

NEW CASTLE-BULKHEAD BAR, AND BULKHEAD BAR-DEEPWATER: The west edge of Bulkhead Bar range is extended by 300 feet to the south and 300 feet to the north; the widening tapers to zero at a distance of approximately 3,000 feet south of the south end of Bulkhead Bar, and 3,000 feet north of the north end of Bulkhead bar.

DEEPWATER-CHERRY ISLAND: A maximum channel widening of 375 feet is required at the eastern apex of the bend. The widening tapers to zero at a distance of about 2,000 feet both north and south of the apex.

BELLEVUE-MARCUS HOOK: The east apex of the bend requires a 150 foot widening over existing conditions, along a total length of approximately 4,000 feet.

CHESTER-EDDYSTONE: The southwest apex of the bend requires a maximum 225 foot widening, with a transition to zero at the northeast end of Eddystone range, over a linear distance of approximately 6,000 feet.

EDDYSTONE-TINICUM: The northeast apex of this bend requires a 200 foot widening, with a transition to zero at a distance of about 1,200 feet northeast and southwest of the bend apex.

TINICUM-BILLINGSPORT: The north channel edge of Billingsport was widened by 200 feet. At the northern apex of the Tinicum - Billingsport bend, this results in a maximum widening of approximately 400 feet, with a transition to zero at a distance of about 2,000 feet west of the apex.

BILLINGSPORT-MIFFLIN: The south apex of the bend was widened a maximum of 200 feet to the south, and transitioned to zero at a distance of approximately 3,000 feet northeast of the apex.

EAGLE POINT-HORSESHOE BEND: The northwest edge of Horseshoe Bend required a maximum widening of 490 feet to the north. The widening transitions to zero at a distance of approximately 4,000 linear feet west of the west end of Horseshoe Bend, and at a distance of 1,500 linear feet north of the north end of the bend.

3.1.2 Dredging

3.1.2.1 Initial Dredging

The total dredging quantity for initial project construction is estimated at 33 million cubic yards, and is distributed among the reaches as follows:

Reach AA	1,430,000 cy
Reach A	3,314,000 cy
Reach B *	8,624,000 cy
Reach C *	4,465,000 cy
Reach D	5,789,000 cy
Reach E	9,264,000 cy

* Includes rock (Reach B 211,000 cubic yards, and Reach C 18,000 cubic yards)

3.1.2.2 Maintenance Dredging

The required maintenance dredging of the 45 foot channel will increase to 6,007,000 cubic yards per year (cy/yr) from the current 4,888,000 cy/yr for the 40 foot channel, for a net increase of 1,119,000 cy/yr.

When required, advanced maintenance dredging of the channel up to 49 feet below mean low water will occur depending on the rate of shoaling. This is a continuation of the existing project maintenance practice, since benefits for the recommended project are based on maximum utilization of the 45 foot channel, and utilization of high tide stages. Approval for advanced maintenance was granted by the Corps of Engineers North Atlantic Office for the Delaware River, Philadelphia to the Sea Project on 19 June 1981.

Advanced maintenance dredging is required in critical areas to assure maintenance of the proposed depth. The high shoaling areas will continue to be dredged at least every year, where areas of less shoaling will go several years between dredging. In addition, due to dredging inaccuracies, one foot of overdredging will also continue to occur. The one foot overdepth allowance is standard practice on large dredging projects.

3.1.2.3 Dredging Techniques

The Main Channel Deepening Project will use two types of dredges (hopper dredge and pipeline dredge).

Typically, the Corps of Engineers does not specify the type of equipment that a contractor must use to dredge a channel. Each type of dredging equipment has different strengths and weaknesses. Some jobs can be accomplished by any type of dredge;

other projects require specialized equipment. Many times, one type of equipment will be more efficient than another. In these cases the bidding process usually results in the more efficient plant and equipment being used to accomplish the required dredging. Discussion of the different types of dredging equipment that would be suitable for dredging this project is provided below.

Self-Propelled Hopper Dredges: Hopper dredges are typically self-propelled seagoing vessels. They are equipped with propulsion machinery, sediment containers (i.e. hoppers), dredge pumps, and other specialized equipment required to perform their essential function of excavating sediments from the channel bottom. Hopper dredges have propulsion power adequate for required free-running speed and dredging against strong currents, and have excellent maneuverability. This allows hopper dredges to provide a safe working environment for crew and equipment to dredge bar channels or other areas subject to rough seas. This maneuverability also allows for safely dredging channels where interference with vessel traffic must be minimized.

A hopper dredge removes material from the bottom of the channel in thin layers, usually 2-12 inches, depending on the density and cohesiveness of the dredged material (Taylor, 1990). Pumps within the hull, but sometimes mounted on the dragarm, create a region of low pressure around the dragheads. This forces water and sediment up the dragarm and into the hopper. The more closely the draghead is maintained in contact with the sediment, the more efficient the dredging (i.e. the greater the concentration of sediment pumped into the hopper). Hopper dredges are most efficient for noncohesive sands and silts, and low density clay. Hopper dredges are not as efficient with medium to high density clays, or with dense sediments containing a significant clay fraction.

Dredging is usually done parallel to the centerline or axis of the channel. Sometimes, a waffle or crisscross pattern may be utilized to minimize trenching and produce a more level channel bottom (Taylor, 1990). This movement up and down the channel while dredging is called trailing, and may be accomplished at speeds of 1-6 knots depending on sediment type, sea conditions, and numerous other factors.

When an efficient load is achieved, the vessel suspends dredging, the dragarms are heaved aboard, and the dredge travels to the placement site. Because dredging stops during the trip to the placement site, the overall efficiency of a hopper dredge is dependent on the distance between the dredging and placement sites (i.e. the more distant the placement site, the less efficient the hopper dredge).

Cutterhead pipeline dredge: A cutterhead pipeline dredge is the most commonly used dredging plant in the United States. The cutterhead dredge is suitable for maintaining harbors, canals, and outlet channels, where wave heights are not excessive and suitable placement areas are nearby. It is essentially a barge hull with a moveable rotating cutter apparatus surrounding the intake of a suction pipe (Taylor, 1989; Hrabovsky, 1990). By combining the mechanical cutting action with the hydraulic suction, the hydraulic cutterhead has the capability of efficiently dredging a wide range of material, including clay, silt, sand, and gravel.

The largest hydraulic cutterhead dredges have 30 to 42 inch diameter pumps with 15,000 to 20,000 horsepower. These dredges are capable of pumping certain types of material through as much as 5-6 miles of pipeline, though up to 3 miles is more typical.

The attached pipeline also limits the maneuverability of the dredge. In addition, the cutterhead pipeline plant employs spuds and anchors in a manor similar to floating clamshell dredges. Accordingly, as with floating clamshell dredge plants, the hydraulic cutterhead should not be used in high traffic areas, and cannot be safely employed in rough seas. Cutterhead dredges are normally limited to operating in protected waterways where wave heights do not exceed 3 feet.

3.1.2.4 Dredging Schedule

Table 3-1 and Plates 24 and 25 detail the location and disposal destination of all of the initial dredged material for the project. The colors in the channel match the color of the disposal area where that material will be disposed.

Materials will be disposed at the closest available area in each range of the river. Dredged material from Reaches AA and A will be disposed at areas 17G and National Park. Reach B materials will be disposed at areas 15D, 15G, Raccoon Island, and Pedricktown North and South. Reach C materials will be disposed at Killcohook and Penns Neck, with some of the initial quantity from Reach C slated for the Reedy Point North disposal area. The material from Reach D will be disposed at Artificial Island, with a small portion of the initial quantity placed at the Reedy Point South disposal area. Reach E initial materials will be utilized to restore wetlands and create sand stockpiles.

Table 3-2 shows the quantities of material that will be dredged during the 50 year project life. A bar graph summary of each disposal area usage for the entire project is contained in Table 3-3. All operation and maintenance dredged material quantities would be placed into these areas in addition to the existing Federal sites which include National Park, Pedricktown North and South, Oldmans No. 1, Penns Neck, Killcohook and Artificial Island. Maintenance material from Reach E will be disposed at an existing subaqueous site (Buoy 10).

Due to the limited size of these proposed areas and the amount of material to be dredged, four years is required for the initial

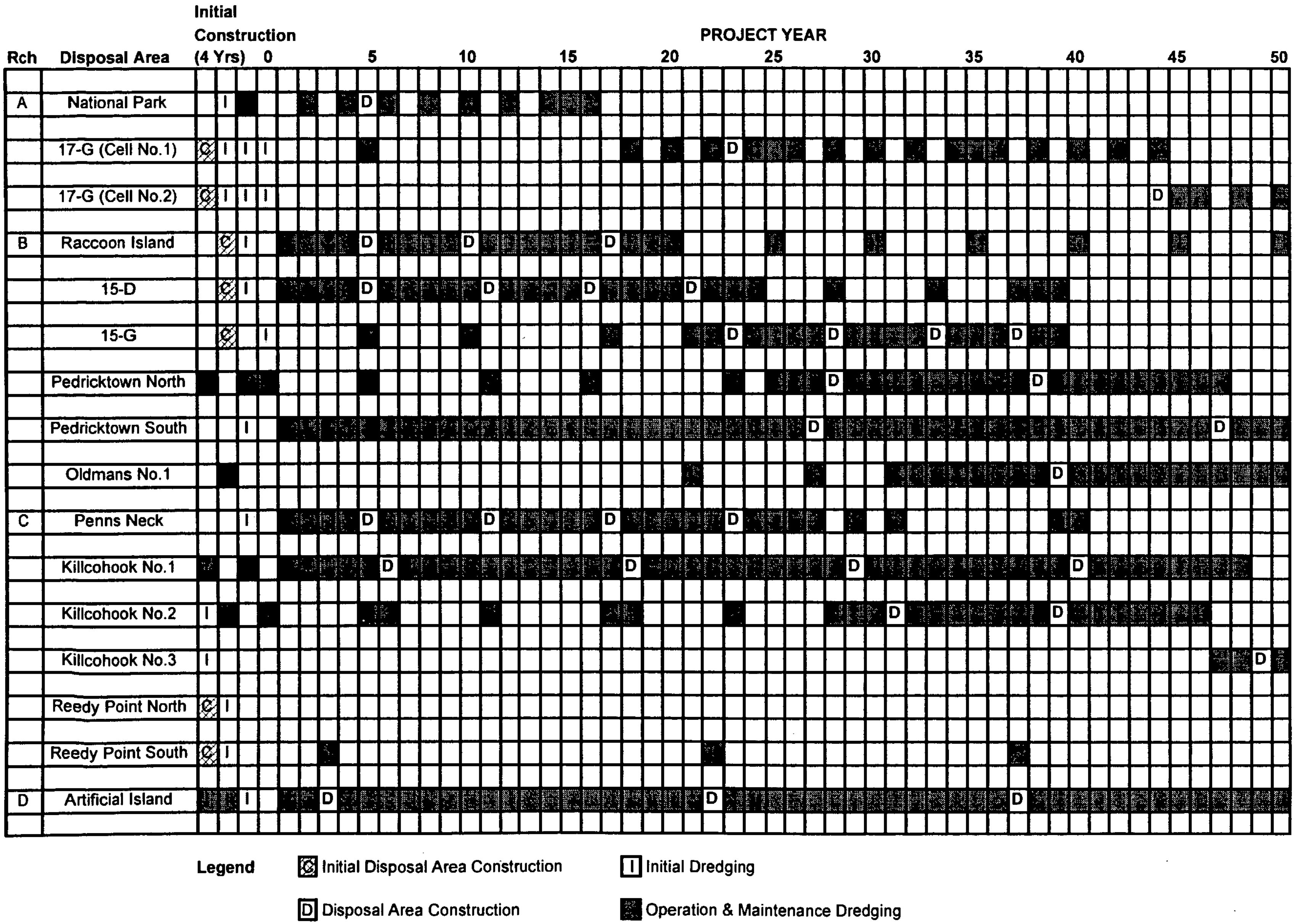
Table 3-1. Delaware River Main Channel Deepening Project
Dredging Quantities and Disposal Locations
Initial Dredging

Reach	Disposal Area	Quantity (cubic yards)
A-A	National Park	1,429,904
A	17-G	3,315,926
B	Raccoon Island	1,899,156
	15-D	581,413
	15-G	2,635,246
	Pedricktown North	1,674,958
	Pedricktown South	1,833,100
	subtotal	8,623,873
C	Penns Neck	753,568
	Killcohook No.1 via Lehigh Ave.	861,069
	Killcohook No.2 via shoreline	1,508,162
	Killcohook No.3 via shoreline	284,460
	Reedy Point North	1,057,597
	subtotal	4,464,856
D	Reedy Point South	1,009,641
	Artificial Island	4,779,220
	subtotal	5,788,861
E	Kelly Island	1,830,252
	Egg Island	2,600,148
	Slaughter Beach (MS-19)	2,858,300
	Broadkill Beach (L-5)	1,953,518
	subtotal	9,264,090
	TOTAL	32,887,510

Table 3-2. Delaware River Main Channel Deepening Project
Dredging Quantities - Maintenance (50 year period)

Reach	Disposal Area	Quantity (cubic yards)
A/AA	National Park	2,621,000
	17-G	5,729,000
	subtotal	8,350,000
B	Raccoon Island	24,350,000
	15-G	22,610,000
	15-D	28,560,000
	Pedricktown North	26,180,000
	Pedricktown South	25,950,000
	Oldmans No. 1	5,400,000
	subtotal	133,050,000
C	Penns Neck	28,269,000
	Killcohook No. 1	58,686,000
	Killcohook No. 2	19,893,000
	Killcohook No. 3	2,302,000
	subtotal	109,150,000
D	Artificial Island	19,146,000
E	Buoy 10	19,378,000
	TOTAL	289,074,000

TABLE 3-3
PROJECT DISPOSAL PLAN



project dredging. In order to assure that bulk dredging quantities do not overtop the disposal area dikes, and to ensure optimum lift thickness for drying and management of the areas, dredged quantities were efficiently distributed over the years of initial project dredging. Before beginning the actual project, a projection of disposal area capacities was made for the existing areas. Assuming a start date of year 2000, maintenance of the 40 foot project from the present to year 2000 was added to the existing disposal areas, thereby reducing their capacities. These maintenance quantities were also projected through the initial construction period of 3 years. After the initial construction was completed, the 45 foot project maintenance quantities were projected for 50 years.

3.1.3 Rock Blasting

Approximately 229,000 cubic yards of bedrock from the Delaware River near Marcus Hook would be removed to deepen the navigation channel to a depth of 45 feet mean low water. Approximately 70,000 cubic yards of bedrock will be removed by blasting. In order to remove this rock, holes drilled into the rock are packed with explosive to direct the force of the blast into the rock. The depth and placement of the holes and the size of the charges control the amount of rock that is broken. The project would be conducted by repeatedly drilling, blasting, and excavating relatively small areas until the required amount and area of bedrock is removed.

Adverse impacts to fish will be minimized by conducting blasting between 1 December and 15 March as recommended by the Delaware River Basin Fish and Wildlife Management Cooperative, and using techniques such as delayed blasting and "stemming" to reduce the amount of energy that would impact fish. Monitoring of impacts to fish from blasting will also be conducted to verify that impacts are minimal.

3.2 Delaware River, Upland Dredged Material Disposal Sites

3.2.1 Dredged Material Disposal Capacity Requirements

In order to determine the disposal needs of the project, potential disposal areas were screened as to their useful conversion to an active disposal area. After several field visits to new and existing areas, and using the most recent topographic information, a list of available disposal areas was developed. The areas include new sites 17-G, 15-D, 15-G and Raccoon Island, whose locations are shown on Plates 1 and 2. Preliminary plans called for use of the four aforementioned areas and the Federally owned Reedy Point North and South disposal areas for deposition of the initial construction dredged quantities from Reaches A through D (See Table 3-1). All operation and maintenance dredged material quantities would be placed into these areas in addition to the existing Federal sites which include National Park, Pedricktown North and South, Oldmans

No. 1, Penns Neck, Killcohook Areas 1, 2, and 3; Artificial Island Areas 1, 2, and 3 which are also shown on Plates 2 and 3, and quantities are shown on Table 3-2. Re-evaluation of the disposal scenario determined that the most efficient manner to dispose of the initial quantities would be to utilize the existing Federal disposal areas in combination with the four new areas.

All initial quantities from Reach E will be utilized for beneficial uses which are discussed in Section 3.3. Wetland restoration sites will be constructed from dredged material at Kelly Island, Delaware and Egg Island Point, New Jersey. Sand stockpiles will be created offshore of Broadkill and Slaughter Beaches in Delaware. Plates 24 and 25 detail the location and disposal destination of all of the initial dredged material for the project.

The disposal area scenario was computed for a 45 foot deep, full width navigation channel. A bar graph summary of each disposal area usage for the entire project is contained in Table 3-3, along with a summary of the dike raising years and associated cubic yards required for construction.

Materials were disposed at the closest available area in each reach of the river. Dredged material from Reaches AA and A will be disposed of in area 17-G and National Park. Reach B materials will be disposed at areas 15-D, 15-G, Raccoon Island, Pedricktown North and South, and Oldmans No. 1. Reach C materials will be disposed of at Killcohook and Penns Neck with some of the initial quantity from Reach C slated for Reedy Point North disposal area. The material from Reach D will be disposed of at Artificial Island with a small portion of the initial quantity to be pumped to Reedy Point South disposal area. As previously mentioned, Reach E initial materials will be utilized to restore wetlands and create sand stockpiles. The Reach E maintenance material will be disposed at the Buoy 10 disposal area.

3.2.2 Dredged Material Disposal Site Selection

The feasibility plan for disposal of river sediments from initial dredging called for use of two existing Federally owned upland disposal areas (Reedy Point North and South) and procurement of three additional sites by the sponsor, identified as 17G, 15D and Raccoon Island. The sponsor would reimburse the Government on the usage of the Federal sites.

As part of the PED study, the selected disposal plan was reviewed to see if existing conditions or usage of disposal areas changed from that analyzed in the Feasibility Study. That review indicated that disposal site 17G is now available, as plans for private development have been discontinued; and a portion of site 15D (about 200 acres) is not available.

Site 17G was evaluated during the feasibility study and was eliminated from selection due to the expectation that it would be developed prior to implementation of the proposed project. Site 17G is located upriver from site 17O. The two sites are physically similar and were ranked closely during the screening process. As a result, disposal site 17O which has some cultural concerns, was eliminated and site 17G was substituted.

To compensate for the 200 acre reduction in Site 15D, Site 15G was added. Similarly to Site 17G, Site 15G was evaluated during the Feasibility Study and was closely ranked with Site 15D. This substitution of the two sites (17G and 15G) had no impact on the previously estimated project construction costs. Based on coordination with the sponsor, the sponsor has the ability to acquire the selected candidate sites. Potential disposal sites identified as 17G, 15D, 15G and Raccoon Island were selected as the candidate sites for detailed engineering and environmental field testing.

3.2.3 Dredged Material Disposal Site Design and Operation

3.2.3.1 General Engineering Approach for Site Management

One of the primary goals and objectives for the four new confined disposal facilities (CDFs) is development, enhancement, and management of wildlife habitat in between dredged material disposal events. In the past, Delaware River CDFs have been managed with a primary goal of maximizing storage capacity. This normally requires that the sites be drained as quickly as possible following active placement operations, that they be trenched to hasten dewatering, and that the dried dredged material be borrowed from the interior of CDFs for upgrading dikes before the next dredging cycle. This overall management approach generally conflicts with management for wetlands and wildlife habitat.

An approach which would allow for both is tied to extended cycles between uses. With extended cycles, portions of the sites can be used for temporary wetland habitat for several years, prior to the need for draining, dewatering, and dike upgrading to be ready for the next placement episode. This would call for rotation of placement between subdivisions within each CDF. The CDF sites have total surface areas ranging from 275 to 350 acres. The CDFs are amenable to subdivision into cells, each with a surface area on the order of 125 to 175 acres. A 3- to 4-year cycle for use in any one site, and placement into one of the two cells for each cycle, means that each cell will be required for placement on a 6 to 8 year cycle. Assuming between 0.75 and 1.5 million cubic yards for each event, the bulked lift thickness will be on the order of 4 to 8 feet. Material could be left in a wet condition or ponded with water if desired for a period of 3 to 4 years. During that time period, the cell would be managed as wetlands. However, some self weight consolidation would be taking place, bringing the lift thickness down to around 3 to 6 feet. This would require periodic adjustment of weirs to maintain the desired ponded area and water depths.

The lift thickness following self weight consolidation can be managed for dewatering and borrow for dike upgrading over the next time period of 3 to 4 years. Using this engineering method, each of the four CDFs could have roughly half of the surface area managed for habitat at all times, with half the site being managed for dewatering and borrow for dike upgrading. The overall engineering approach to management is described in more detail under each CDF heading. Plates 20 to 23 indicate recommended dike alignments and locations of inflow points and weirs. It is assumed with this approach that some use of the other currently operating 4 CDFs in the vicinity will be necessary. Maintaining appropriate water levels during habitat cycles should be achievable by control of outfall weir elevations.

3.2.3.2 General Habitat Considerations

In the four new CDFs, which total more than 1,200 acres (Table 3-4), there are numerous possibilities for habitat development. However, while there are numerous possibilities, most will be eliminated from consideration due to infeasible engineering, excessive costs to the project, need for intensive long-term site management, and unforeseen changes in dredging schedules and plans.

Reach B of the Delaware River (See Plate 2) is south of the urban centers of Philadelphia, PA, and Camden, NJ, and much of the area is generally rural to suburban. Reach B is also an area requiring fairly intensive dredging to maintain navigation channels in the river, which has resulted in the current necessity for three CDF's along the Delaware River in Oldmans Township, New Jersey. Oldmans Township riverfront real estate lies entirely in Reach B. Some of these are currently intensively used for dredged material placement, while the ones that are proposed for this project have been used in the past, but have been left fallow for a number of years. As a result, landowners have put them to other uses, primarily agricultural crops and haying (685 acres). These manmade areas provide considerable habitat value as they are, due to field edges, isolation, small shrub and tree areas, and the availability of palatable, abundant food supplies for upland animals (corn, wheat, and soybeans).

Passive vs. Active Management

The four new CDFs will be divided into two cells each. Each of these will have two weirs, allowing considerable flexibility for passive management through control of water depths between dredging cycles. Allowing water to remain on sites after dredging, rather than allowing all freeboard and rainwater to flow off coupled with active dewatering, will provide for appropriate <u>Phragmites australis</u> control and waterfowl/waterbird habitat. While the U. S. Fish and Wildlife Service (1995a) has recommended active management using pumps to manipulate water

Table 3-4. Delaware River Channel Deepening Project
Upland Disposal Areas
Wildlife Habitat/Vegetation Impacts

Disposal Sites Area

Habitat Types	15G	17G	Raccoon Island	15D	Totals
Row Crops	246	191	-	248	685
Common Reed	24	65	320	60	469
Woodlands	-	21	20	7	48
Ruderal	5	18	6	5	34
Non-Tidal Marsh	-	-	4	-	4
Totals	275	295	350	320	1,240

levels, this can be expensive and labor intensive, and will require on-site personnel. Instead, site management will be by use of weir boards to maintain water levels, and not by seasonal pumping.

3.2.3.3 General Habitat Development

Within the four new CDFs, a wide range of development and management possibilities exist, but are also limited to coincidence with dredging cycles, number of cells constructed, and available land and water surface within cells. In the areas that have remained ponded on the currently used CDFs, shallow water and emergent marsh habitats have developed that provide year-round values for some animals, and migratory and nesting habitat for waterfowl and waterbirds. A large portion of the National Park CDF site supports shallow water interspersed with common reed and duck weed. Many species of birds were observed in this area including American coot (Fulica americana), scaup (Aythya spp.), bufflehead (Bucephala albeola), common merganser (Mergus merganser), mallard (Anas platyrhynchos), Canada goose (Branta canadensis), great egret (Casmerodius albus), and red-winged blackbird (Agelaius phoeniceus). Several species were observed on a large shallow water area on the Oldmans CDF including northern shoveler (Anas clypeata), approximately 100 scaup, ruddy duck (Oxyura jamaicensis), northern pintail (Anas acuta), Canada goose, greater yellowlegs (Tringa melanoleuca), and lesser yellowlegs (Tringa flavipes). Additionally, the following species were observed at a shallow ponded area adjacent to the Pedricktown North site: blue-winged teal (Anas discors), bufflehead, mallard, scaup, black-crowned night heron (Nycticorax nycticorax), green heron (Butorides striatus), and bank swallow (Riparia riparia) (U.S. Fish and Wildlife Service. 1995a).

The easiest habitat types to achieve will be non-forested, and will include primarily fresh water emergent and open water habitat. These wetlands will provide habitats for migratory and resident waterfowl, wading birds, as well as other birds, mammals, amphibians, and reptiles that utilize wetlands. This is in agreement with the U.S. Fish and Wildlife Service (1995a) recommendation to implement a water management strategy for each disposal site to allow the retention of standing water from 18 inches to three feet deep over as large an area as possible and for as long as possible between disposal episodes to enhance the habitat value.

3.2.3.4 Moist Soil Management Units

The four CDF sites will be isolated from both the river and the intertidal system, as they currently are. The closest concept to the types of habitats that will be developed on the four sites is that of moist soil management units. These generally consist of diked systems where water levels are intensively managed to provide selected habitat for target species. The target species are almost always waterfowl during migration, nesting, or overwintering, depending upon the units' location within North America. This concept is consistent with objectives of the U.S. Fish and Wildlife Service's North American Waterfowl Management Plan (NAWMP). The NAWMP, an international cooperative agreement between the United States and Canada, is being implemented to restore, protect, and enhance aquatic habitats and increase waterfowl populations. The proposed project is within the Middle-Upper Atlantic Coast Habitat Area, one of five Priority Habitat Ranges in the United States. A January 1989 joint agreement between the Department of the Interior and the Department of the Army is designed to further the goals of the NAWMP. Under this agreement, consideration of NAWMP goals should be incorporated into the planning, engineering and design, and construction phases of Corps projects (U.S. Fish and Wildlife Service. 1995a).

Within such a system, a full range of "impoundment" habitats could still exist, from uplands (dikes and higher areas), to high and low emergent marsh, to shallow water ponded areas. Under active management (using pumps and seasonal drainage), cells could be drawn down and planted in waterfowl food plants, then reflooded in autumn to provide abundant migratory and winter foods within reach of dabbling ducks. The U. S. Fish and Wildlife Service Refuge System, many state Wildlife Management Areas, and a number of private landowners rely on this approach to provide maximum habitat for certain species and coincidental habitat for other species. However, active management is not always necessary in order to provide some quality habitat, and pooled water over several years will still provide considerable habitat at a much lower cost.

3.2.3.5 Confined Disposal Facility Development and Management as Wetlands

An operations and maintenance manual will be developed for the new CDFs to insure that the goals of establishing temporary wetlands on portions of the sites is achieved. This manual will describe in detail a planting wetland vegetation, controlling nuisance vegetation, such as <u>phragmites</u>, and controling mosquitos, if necessary. The following paragraphs describe possible scenarios for achieving these goals; however, the final plans will be developed in Plans and Specifications.

Establish Desirable Vegetation

It is unlikely that desirable wetland vegetation will become established quickly unless the water in the wetland cell is drawn down to bare substrate. Under one possible scenario, the wetland cell would receive dredged material; no dredged material would be placed in the other cell. The water in the wetland cell would be drawn down after dredging is completed, and the area would be seeded with a combination of desirable wetland species. After the plants have become established (i.e. after one growing season), dredged material would be placed into the other (non-wetland) cell, and water would be diverted from the active dredged material disposal cell into the wetland cell, to levels of 1 to 2 feet deep . These species should become established during the first growing season and remain during the 3 to 4 year period until more dredged material is placed on the cell, this procedure would be repeated to establish wetland vegetation on the other cell.

<u>Phragmites</u> Control

The less productive areas of the new CDFs are all vegetated with <u>Phragmites australis</u>, the native common reed that aggressively proliferates on wet non-saline disturbed soils along the Atlantic coast (469 acres). Finding a way to deal with the reed has been a challenge for decades, and there are generally three accepted means of control: (a) manipulation of water levels, (b) introduction of salinity, and (c) selective herbicide applications. Common reed is an excellent species for dewatering wet sites and provides good forage for livestock; however, it has almost no wildlife value.

<u>Phragmites australis</u> will grow on all four sites. Planting of other species on dikes and uplands will not provide enough competition, and the species will out-compete any other species planted on the four sites if conditions are favorable for the reed. Therefore, dike colonization with common reed is generally a given condition. On some of the drier CDFs in New Jersey, farmers bale common reed into hay for their livestock. In the southern United States, two additional means are used, grazing to control reed on dikes, and building gently sloped dikes that can be mowed, not options in CDFs where capacity and dike heights are of prime importance. Therefore, habitat development, enhancement, and management should concentrate on the areas between the dikes. The most practical method for the control of common reed on these sites is through the control of water levels. Keeping ponded water on portions of the sites will help to limit the occurrence of the reed.

There is a risk that phragmites would become established during a drawdown by invading rhizomes from adjacent plants. To minimize this risk, impoundment berms would be sprayed with herbicide in the late summer, prior to the drawdown. Care would be taken to avoid spraying woody vegetation. Since phragmites' seeds will germinate on bare mud, and there is a large source of seed from nearby areas, this is another possible source of invasion. However, doing the drawdown and seeding in the spring and early summer, and reflooding before phragmites goes to seed in the late summer, will minimize this risk. In addition, phragmites will have difficulty germinating on the dredged material, which will most likely be wet enough to have anaerobic conditions. For Raccoon Island, which is presently covered with phragmites, the entire area may have to be sprayed with herbicide in the late summer/early fall prior to building the berms and covering the area with dredged material. The other dredged material disposal areas are presently, primarily farmlands, and will not need the herbicide treatment prior to construction. A herbicide treatment of the "active" disposal cell may have to be done prior to establishing a wetland on this cell in the next cycle. In addition, it is likely that the berms adjacent to the "new" wetland will have to be sprayed at the beginning of each new cycle.

Mosquito Control

After the area is reflooded, an appropriate fish species would be introduced to control mosquitos. The appropriate fish species would be selected by coordinating with the New Jersey Office of Mosquito Control Coordination and the appropriated County Mosquito Control District. The fish may have to introduced each year because of winter mortality. If fish could not adequately control the mosquitos, a pesticide would have to be used.

3.2.3.6 Site Specific Recommendations

CDF 15D

Engineering

<u>Cross and Spur Dikes.</u> This CDF has approximately 320 acres. There are presently interior drainage ditches, but no clear indication of usable cross dikes. The generally rounded configuration of the site is amenable to cross diking into two cells, each with a more favorable length to width ratio as shown in Plate 22.

<u>Inflow and Weir Locations.</u> Site 15D generally slopes from west to east. Inflow points will be located at the higher elevations to the west side as indicated on Plate 22. Two weir structures will be placed in each cell on the east end, at locations of lowest elevations and existing drainage ditches. The two weirs set apart in each cell will tend to counteract short circuiting if both are used during active management. Two or more weirs also provide more flexibility in operation if one develops problems.

<u>Operations and Management.</u> The large surface area of 15D should allow placement of approximately 1.5 million cubic yards on a 3 to 4 year cycle in each cell, assuming a 6 to 8 ft bulking thickness. The general slopes now existing can be maintained, and a large portion of the lower end of a cell could be retained as a shallow ponded area for 3 to 4 years following placement. After that period, the cell would be drained and actively dewatered, followed by dike upgrading using borrow material from within the cell.

Environmental

Site 15D is now almost exclusively agricultural fields of corn and soybeans, and has a 10-foot slope differential across the site, although it visually appears relatively flat (Plate 18). The perimeter dikes have already been designated to exclude the oak forest areas on the south side of the site, and a corner on the northwest side has also been excluded near Raccoon Creek because it does not provide efficient dike flow. The engineering placement of a cross dike from west to east across 15D will split the site into two long narrow cells. This configuration will provide two excellent cells for management as moist soil units or water impoundments because of the elevational differences.

Water depths for moist soil management units are generally from 0.5 to 3 ft deep (approximately 1/2 of the north cell and 2/3 of the south cell) and would provide more brood habitat and habitat for dabbling ducks and wading birds. By contrast, impoundments may be up to 10 ft deep (approximately covering the entire cell with varying water depths) and would provide for diving ducks. Since dabbling ducks are the species that are most likely to frequent these CDFs, the shallower ponded depth will be the goal. The most waterfowl production and use will come from the shallower water depths, as will any colonizing emergent fresh and floating marsh. Wading bird species will only use the shallow water depths.

A projected water depth of 0.5 to 3 ft will still leave room initially for high marsh and the development of a brief shrub and grass community on the west ends of both cells. However, over subsequent dredging cycles, the topography inside cells will flatten, causing the entire cell to pond. It should be noted that these could also become dense stands of common reed, and the best, least-expensive way to combat large stands of reed is with flooding. Common reed can be controlled easier if water is at least two feet deep on a long-term basis. Weirs will provide some management flexibility to adjust water depths to control common reed.

CDF 15G

Engineering

<u>Cross and Spur Dikes.</u> CDF 15G has approximately 275 acres. There are some interior drainage ditches and low areas, but the site is generally flat. A trace of an old cross dike runs diagonally across the site, but it would require a major reworking to be usable. As with 15D, the general shape of the CDF would be amenable to cross diking into two cells. The old cross dike alignment would result in an imbalance in size, so a new alignment is desirable (Plate 23).

<u>Inflow and Weir Locations.</u> Site 15G could be essentially level when dikes are upgraded, but the location of the creek to the northeast requires that inflow points be located on the west side. As with 15D, two weir structures will be placed in each cell toward the east end (Plate 23).

Operations and Management. The surface area of the CDF should allow placement of between 1.0 and 1.5 million cubic yards on a 3 to 4 year cycle in each cell. Most of the area of either of the cells could be retained as a wetland or ponded area for 3 to 4 years following placement. After that period, the cell would be drained and actively dewatered, then dike upgrading would take place.

Environmental

Site 15G only has a 3-5 foot differential in elevation, making the site almost flat for ponding purposes. Therefore, ponding water to depths of 0.5 to 3 feet will result in almost 100 percent water cover in either cell, both initially and after all subsequent dredging cycles. The option of providing deeper water here would not allow more than a narrow fringe of wetlands as would be found at 15D with the deeper water option, but would provide better *Phragmites australis* control. Weirs will provide some management flexibility to adjust water depths to control common reed. The approximately 15 acres of home site and forest remnants near U. S. Route 130 have already been excluded from the design of the perimeter dike, and the remainder of the CDF lends itself almost entirely to providing rotational ponded habitat.

CDF 17G

Engineering

Cross and Spur Dikes. This CDF has a total area of approximately 295 acres, and is visibly divided into four areas surrounding an old rehandling basin. There is currently a high cross dike separating the two westernmost areas from the two easternmost areas. There is an old remnant of a cross dike separating the northwest from the southwest area. The central area is a few feet lower than the northeast area. Furthermore, the entire southern end of the CDF has been purchased and will be developed as a forested wetland mitigation bank.

Maintenance of the four small cells at 17G would result in difficult rotation schedules for a 4 year frequency, and require much greater depths of material being placed. Using only two cells divided at the existing high roadway (Plate 20) is preferable, and the roadway should be built and maintained atop the cross dike. The dike alignment separating the resulting west cell from the mitigation bank area should be constructed to allow for a drainage ditch for flow from both cells. This would allow for placement of two weirs each within the cells, which would have more efficient hydraulic flow.

Inflow and Weir Locations. The CDF now slopes from north to south. Inflow points have historically been on the higher north side, and should continue to be located at the higher elevations to the north as indicated on Plate 20. Two weir structures should be placed in each cell at the locations indicated.

Operations and Management. The large surface area of 17G should easily accommodate placement of around 0.75 million cubic yards on a 3 to 4 year cycle to each cell in a thinner lift than the other three sites. Assuming the general slopes now existing are maintained, a large portion at the lower end of each cell could be retained as a ponded area for 3 to 4 years following placement. After that period, the cell would be drained and actively dewatered, followed by dike upgrading with interior borrow material.

Environmental

The CDF currently has over 10 feet of elevational differences, with the highest areas along the river. Construction of a new perimeter dike to exclude the mitigation bank lands will also require construction of a new drainage ditch for the entire CDF, and positioning of three of the weirs on the new ditch (Plate 20). The fourth weir is positioned to drain into the old turning basin. As indicated on Plate 20, the lowest point in the CDF is centered near the turning basin.

The CDF can easily be divided into two cells, with the design of the largest cell so that effluent will flow around and through the turning basin. This will temporarily allow the wetlands (common reed) in this area to remain, but will ultimately cause a change in wetland type from common reed to shallow ponded water fringed by emergent marsh. Both cells can be managed to hold shallow water between dredging cycles, and the larger cell especially lends itself to this type of management. The cells will eventually flatten in topography inside dikes with subsequent dredged material placement.

It is expected that as the cells are filled, the common reed in the CDF will migrate towards the river into the highest elevations. That area of reed now is baled as hay by the landowner because it becomes dry enough to support field equipment in summer months. Weirs will provide some management flexibility to adjust water depths to control common reed.

RACCOON ISLAND

Engineering

Cross and Spur Dikes. The Raccoon Island (RI) CDF is much more complex than the other three sites. It has approximately 350 acres, but the area will be much more difficult to utilize efficiently. A currently used highway and bridge approach, an abandoned highway, and a large powerline visually divide the CDF into three areas. The areas shown on Plate 21 should be managed as one large cell and one small cell. This would require diking across the abandoned highway and essentially making one cell of two existing cells. The remaining smaller cell is due to location of the existing powerline.

Inflow and Weir Locations. The RI CDF will require a major reworking to construct or rebuild cross dikes, and the site could be assumed essentially leveled when dikes are upgraded. The location of toll bridge facilities to the south and the river to the north requires more inflow points be located at the north side as indicated on Plate 21. As with the other CDFs, two weir structures will be placed in each cell toward Raccoon Creek.

Operations and Management. The two cells at the site would be roughly 100 to 200 acres in size. The smaller area of the cell in comparison to those in 15D and 15G will mean either a smaller volume of material placed for each cycle, shorter cycles, or higher lifts for that cell, all costing more than if the area was larger. Placement of 1.0 million cubic yards over a 100-acre cell would result in a bulked lift thickness of close to 10 feet.

Environmental

The RI CDF site presents a challenge for both engineers and biologists due to the infrastructure on the site. It is over 350 acres in size, but is artificially divided into four areas due to powerlines and roads. It is also almost entirely a solid stand of *Phragmites australis* in three areas. This area will become two cells of approximately 90 and 270 acres each (the abandoned highway will be included in the large cell).

The two cells are also almost uniformly flat, so that any water retention for wetlands and wildlife ponds will cover the entire cells. This effect will aid greatly in controlling common reed, and will result in a large shallow pond with very little plant material. Therefore, a rotational plan here is crucial to providing some habitat diversity. For optimal engineering, the larger cell of the two would be more efficient for draining and intensive dewatering. For optimal habitat, the larger cell of the two would be kept as ponded areas for wildlife habitat. Therefore, on a 50-year-life rotational basis, trade-offs will be included between dredging cycles where every other rotation will favor either engineering efficiency or habitat productivity. Using the approach of one small cell and one large cell, and the abandoned highway diked and filled over, the large cell will require thinner lifts and will provide more habitat during its rotation that the smaller cell.

3.2.4 Environmental Considerations

3.2.4.1 Coordination

The plan to manage the CDFs for wetlands and wildlife habitat was developed through extensive coordination with Federal resource agencies and the New Jersey Department of Environmental Protection (NJDEP). In order to determine the type and extent of natural resources on the 4 new upland dredged material disposal areas, the Corps of Engineers contracted for an environmental assessment for each of the sites. These assessments were coordinated with the New Jersey Department of Environmental Protection (NJDEP), U.S. Fish and Wildlife Service (FWS), and the U.S. Environmental Protection Agency (EPA). In addition, visits were conducted to each of the proposed sites, as well as to currently used Corps dredged material disposal areas with personnel from the resource agencies to develop ideas for managing the new CDFs for wetlands/wildlife, as well as for the disposal of dredged material. At the request of the Corps, the FWS prepared a report (See Appendix B) presenting recommendations for management of the CDFs for wildlife. Research scientists at the U.S. Army Waterways Experiment Station (WES) assisted the Philadelphia District in developing this plan.

3.2.4.2 Summary of Environmental Features

Listed below is a summary of the environmental features that are being incorporated into the design and operation of the upland, confined, dredged material disposal areas.

a. Sites will require cross diking to provide optimum wetland/wildlife habitat. Conversely, they should probably not be cross diked to achieve most efficient engineering capability. It is recommended that cross dikes be used sparingly and effectively as noted above, with one cross dike in 15D, 15G, 17G, and Raccoon Island.

b. The new CDFs will be optimized for wetland and wildlife habitat by establishing a rotational basis for disposing dredged material among cells within each new CDF and among 4 other nearby CDFs.

c. Weirs will be positioned to provide optimum ponding and water level manipulation, using structural designs that can be utilized and managed on a long-term basis.

d. Habitat options will focus on palustrine fresh marsh (both emergent and floating, shallow water). Fringe areas will be allowed to develop as transition zones and as uplands, and common reed stands will be discouraged using water level manipulation as its best control. This will provide the most waterfowl and waterbird habitat, while still providing for general habitat diversity.

e. Where possible, existing forested wetland should be allowed to remain, and within cells at highest points, upland forest should be encouraged, to provide maximum habitat diversity.

f. Dike construction and site leveling will be accomplished in a manner that minimizes impacts within environmental windows.

g. A fixed rotation for the disposal of dredged material will be established which will maximize years and seasons of ponding within selected cells. Rotation is for a 3 to 4 year cycle per CDF (6 to 8 year rotation per cell), which will allow each cell to lie fallow and provide habitat for at least 3 to 4 years before being required again in the rotation (longer spacing may be possible depending on the need to raise dikes).

h. Continued coordination, communication, and cooperation will be encouraged among State and Federal agencies on this project so that ways to accomplish all goals for these four sites within agency missions will be accomplished.

3.2.5 50-Year Maintenance Plan

All four sites lend themselves to some imaginative topographic relief for the sake of wildlife habitat during the life of the project, and especially after the project is completed. That is, the sculpting of ponds and islands within cells to provide more habitat diversity and varying water depths after dredged material has been placed in cells over several rotational cycles and higher overall elevations are achieved. This approach is also expensive, and would not be undertaken until the sites are no longer suitable for dredged material disposal, and the environmental features could be considered permanent. There are several transitional, more upland habitat features that can be planned for two to three decades into project life that include more moist forest, more insular features, and perched ponds.

These four sites, along with the other nine Federal CDFs adjacent to the Delaware River, will be developed and filled. The sites will progress, and at the end of the project life in 2050, the four sites will have become broad flat hills in the landscape and be uplands rather than wetlands. The material in these sites is suitable for beneficial uses, and does not require any remediation after project life. Upland habitat will develop on these sites regardless of whether they are planted or not; natural colonization takes longer but the results are the same over time. The detailed management of these areas should be determined by the needs and priorities of the people who are living at the end of the project. It can be stated at this time that this area will be committed to an open space/environmental uses.

3.3 Delaware Bay Beneficial Use Sites

3.3.1 Dredged Material Disposal Capacity Requirements

The authorized Delaware River Main Channel Deepening Project will require the removal of approximately ten million cubic yards (million cubic yards) from the Reach E channel (within the Delaware Bay Estuary), and placement in four beneficial use sites, including two wetland restorations (Kelly Island and Egg Island Point) and two sand stockpiles, Broadkill Beach(L-5) and Slaughter Beach (MS-19). Plate 4 shows the locations of the beneficial use sites. Design features of the beneficial use sites are given in the following sections.

Approximately eight million cubic yards is sand and one million cubic yards is primarily clay and silt, with a fraction of sand. The one million cubic yards of fine grained material (clay and silt) dredged from the main channel between Stations 360+000 to 381+000 and 455+000 to 460+000 (see Plate 25), will be placed at a confined dredged material facility (CDF) at Kelly Island. This CDF will also be a restored wetland of approximately 90 acres. In addition, 857,000 cy of sand dredged from between Stations 350+000 to 360+000 and 381+000 to 390+000, will be used at Kelly Island for foundation dikes, sand plugs and the filling of geotextile tubes.

Egg Island Point will be filled with approximately 2.13 million cubic yards of sand, with an additional 503,000 cy of sand being used for the foundation dikes and the filling of geotextile tubes. The sand will be dredged from the channel between Stations 390+000 and 440+000 (See Plate 25). An approximately 135 acre wetland restoration will be built.

The third and fourth beneficial use of dredged material sites are sand stockpiles. Approximately 2.8 million cubic yards of sand will be placed at site Slaughter Beach (MS-19) to elevation -3.0 feet mlw. The material will be dredged from the main channel between Stations 440+000 to 455+000 and Stations 460+000 and 472+000 (See Plate 25). Approximately 1.9 million cubic yards of sand will be placed to elevation -3.0 feet mlw at the Broadkill Beach (L-5) sand stockpile site. The material will be dredged from the main channel between Stations 472+000 to 485+000 and Stations 495+000 and 511+000 (See Plate 25).

Over the life of the project (50 years) approximately 19 million cubic yards of material will be dredged from the lower Delaware Estuary (Reach E) to maintain the channel. This material is sand and grandular, and will be deposited in the open water dredged material disposal site at Buoy 10 (see Plate 25). This existing site has been used for many years for the disposal of dredged material from the lower Delaware Bay.

3.3.2 Beneficial Use Site Selection

3.3.2.1 Previous Screening

Extensive screening for potential beneficial use sites was performed and is discussed in greater detail Section 3.4.4. An Analysis of Alternatives to the Buoy 10 Disposal Area in Delaware Bay (Reach E) is presented in the Final EIS (USACE. 1992). This analysis required 5 cycles to proceed from the identification of all reasonable disposal alternatives to the establishment of the most effective yet environmentally acceptable disposal plan. Cycle 1 evaluated disposal methods and identified potential disposal areas. The following disposal methods were evaluated: subaqueous (thinlayering, hole filling to create shallows, diked containment for wetland creation, diked containment for upland/island creation, deep water overboard disposal, beachfill, sand stock pile, oyster seed bed creation, and off shore berms/shore protection); placement of material in wetlands (diked containment) to create uplands; and placement of material on uplands (diked containment). Within each area of consideration, potential disposal areas were identified through interviews with local officials, review of previous correspondence and reports, and public notices. Aerial photographs, maps, and surveys were also obtained to identify other possible locations for dredged material disposal operations.

Following the identification phase, the potential disposal areas were then evaluated and manually screened for linear features (ie. roads, rail road tracks, etc.) that would preclude site development and engineering acceptability (Cycle 2). Only those options and sites which were feasible from and engineering perspective were allowed to advance onto further examination.

Cycle 3 analyzed the remaining disposal options from institutional and environmental viewpoints. The purpose of this screening was to eliminate sites which would violate the Federally approved regulations. Environmental concerns included adverse impacts to quality ecological habitats and disturbance of cultural resources.

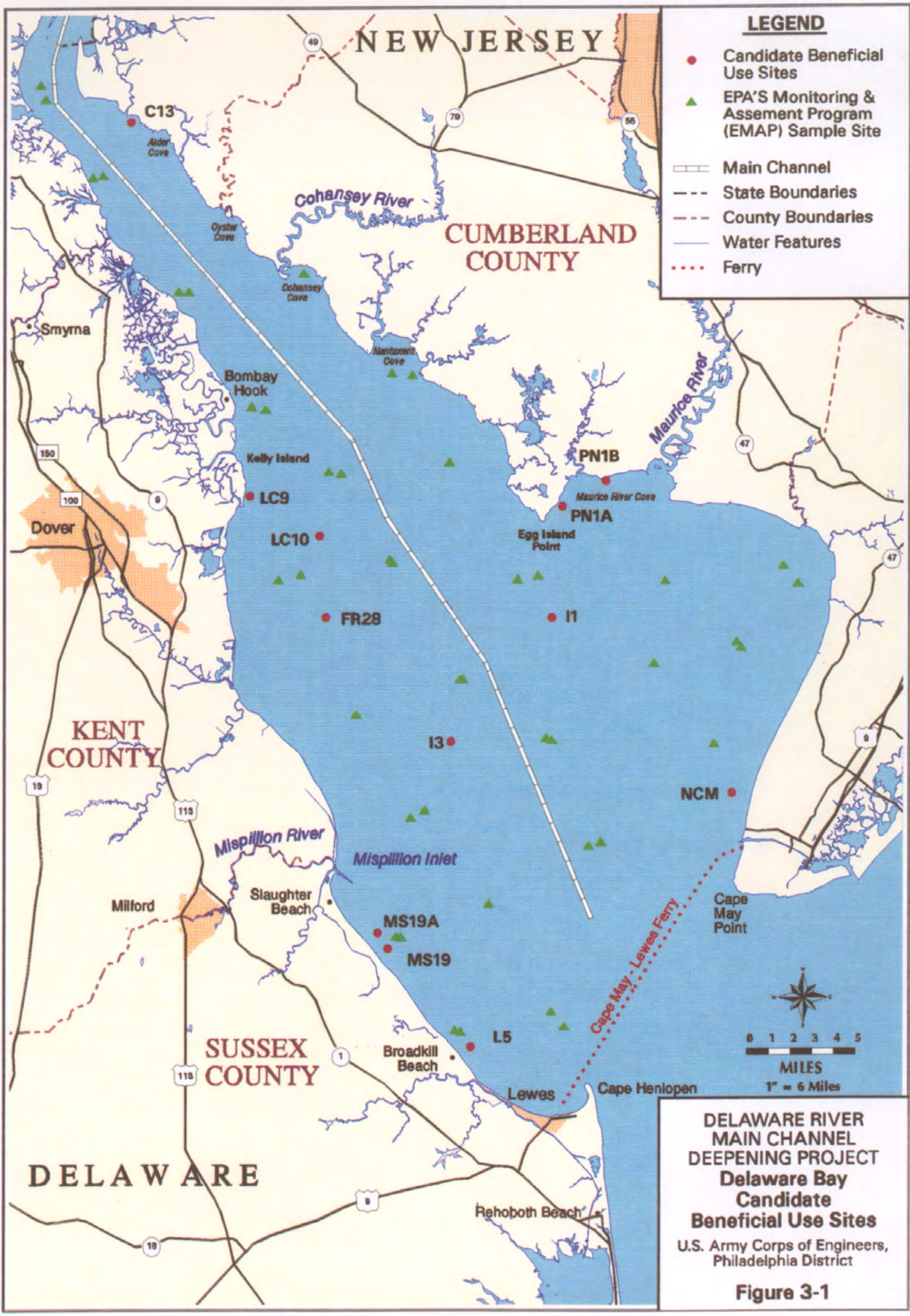
The sites that attained engineering, institutional, and environmental acceptability were then evaluated for critical cost factors and severity of impact to environmental and cultural resources (Cycle 4). The sites that remained after this screening were subjected to a more detailed incremental cost analysis, including incremental mitigation to prepare a final ranking of potential disposal sites (Cycle 5). These potential sites are listed on Table 3-5, and their locations are shown on Figure 3-1.

3.3.2.2 Benthic Screening

Benthic survey results are discussed in greater detail under Section 6.0, Benthic Habitat Investigations. Eleven proposed beneficial use sites were investigated in 1993 (Phase I). Four of these original sites were selected as beneficial use sites and were resampled in 1994 (Phase II). These sites were PNIA and LC-9 (Wetland Restoration); and LC-5 and LC-10 (Sand Stockpiles). Biological parameters that were measured included species composition, density of organisms, percent equilibrium taxa, biomass, numbers of large individuals, and commercially and/or recreationally important species. The result of these studies indicated that the significance of existing resources did not

Table 3-5. Delaware River Main Channel Deepening Project
Planning, Engineering and Design Study
Beneficial Use of Dredged Material
Disposal Alternatives for Reach E

RANGE	SITE NAME/LOCATION	TYPE
Lower Liston/ Upper Cross Ledge	LC-9/Port Mahon C-13/Alder Cove	Wetland Restoration Island Creation
Lower Cross Ledge/ Upper Miah Maull	FR-28/Offshore of Kitts Hummock Beach LC-10/Offshore of Pickering Beach	Sand Stockpile Sand Stockpile
Lower Brandywine	L-5/Offshore of Broadkill Beach MS-19/Offshore of Slaughter Beach	Sand Stockpile Sand Stockpile
Lower Miah Maull/ Upper Brandywine	PN-1/Maurice Cove Area I-3/Lower Middle Shoal	Wetland Restoration Island Creation



DELAWARE RIVER MAIN CHANNEL DEEPENING PROJECT
Delaware Bay Candidate Beneficial Use Sites
U.S. Army Corps of Engineers, Philadelphia District
Figure 3-1

preclude the use of any of these sites for beneficial uses.

As a result of coordination with the U.S. Fish and Wildlife Service and the State of Delaware, Site LC-10 was eliminated because it was in an oyster lease area, and Site MS-19B was substituted.

3.3.2.3 Chemical Screening

The results of chemical and biological testing of dredged material that would be placed at the beneficial use sites are discussed in greater detail under Section 4.0, Sediment Quality Investigations. Samples of sediment from the lower Delaware Bay channel (Reach E) were tested using bulk analysis procedures. Parameters included heavy metals, pesticides, PCBs, PAHs, phthalates, volatile organics, and semi-volatile organics. The mean channel sediment concentrations of detected chemicals were compared to the NJDEP Impact to Residential Soil Standards and the NJDEP Ground Water Standards. Comparison of the data to these criteria indicates that the dredged material from Reach E is acceptable for beneficial uses such as wetland creation and sand stockpiles for later beach nourishment.

To predict contaminant levels that would be liberated from sediment during dredging and disposal activities, which would then be biologically available to impact aquatic resources, 109 individual sediment strata were also evaluated through an elutriate analysis. The results of this analysis indicate that there would be no significant impacts to water quality.

In addition, bioassays and bioaccumulation tests have been run to directly test the potential toxic effects of Delaware River channel sediments on aquatic organisms. Water column and whole sediment bioassays exposed living organisms to sediment, to evaluate any differences in mortality between Delaware River channel sediment and clean laboratory sediment used as a control. Bioaccumulation tests were run with Delaware Bay sediment to evaluate the potential for bioaccumulation of contaminants by aquatic organisms that would reside in the sediment after placement in the beneficial use sites. All water column and whole sediment bioassays resulted in 100 percent survival of all test species. Test results also suggest that open water placement of Bay sediment is acceptable with regard to bioaccumulation concerns.

3.3.2.4 Cultural Screening

The results of screening beneficial use sites for cultural resources are discussed in greater detail under Section 11.0, Cultural Resource Investigations. All of the proposed beneficial use sites have been surveyed for cultural resources. None of the proposed beneficial uses of dredged material will adversely impact cultural resources.

3.3.2.5 Description of Selected Sites

As a result of all the screening processes described above, 4 sites were chosen for beneficial use of dredged material. Site locations are shown on Plate 4, and are described below:

EGG ISLAND POINT (PN1A): This 135 acre wetland restoration site is located in the Delaware Bay, adjacent to Egg Island Point, part of the Egg Island State Wildlife Management Area, Cumberland County, New Jersey.

KELLY ISLAND (LC-9): This 60 acre wetland restoration site is located in the Delaware Bay, adjacent to Kelly Island, part of the Bombay Hook National Wildlife Refuge, Port Mahon, Kent County, Delaware.

LC-5: This 230 acre sand stock pile is located about 0.33 miles offshore of Broadkill Beach, Delaware.

MS-19: This 500 acre sand stock pile is located about 0.5 miles offshore of Slaughter Beach, Delaware.

3.3.2.6 Coordination

Design of the selected beneficial use sites included extensive formal and informal coordination with Federal resource agencies including the U.S. Fish and Wildlife Service (FWS), the U.S. Environmental Protection Agency (EPA), and the National Marine Fisheries Service (NMFS), and state resource agencies including the New Jersey Department of Environmental Protection (NJDEP) and the Delaware Department of Natural Resources and Environmental Control (DDNREC). At the Corps' request, the FWS prepared a Planning Aid Report that summarized available data and information on the fish and wildlife resources of the Delaware Bay, with emphasis on those resources that would be most affected by plans being considered for the disposal of dredged material from the Main Channel deepening project (USFWS. 1995b).

A number of meetings were held with the resource agencies to coordinate the design of proposed beneficial use sites. In addition, numerous telephone conversations were held between members of the Corps' Study Team and members of the resource agencies. Additional information on coordination is given in Section 15.0, Public Involvement.

3.3.2.7 Fish and Wildlife Resources

General

The information presented in this section has been taken from the planning aid report prepared by the FWS (1995b). The Delaware Bay supports diverse and abundant fisheries and shellfisheries resources of high ecological, commercial and recreational value. Additionally, the extensive tidal marshes and shallow water areas bordering most of the Delaware Bay receives heavy use throughout the year by migratory shorebirds, waterfowl, raptors, and passerines. The interspersion of beach and marsh cover types annually hosts the second largest concentration of migrating shorebirds in the Western Hemisphere, including 80 percent of the hemispheric population of red knots (Calidris canutus).

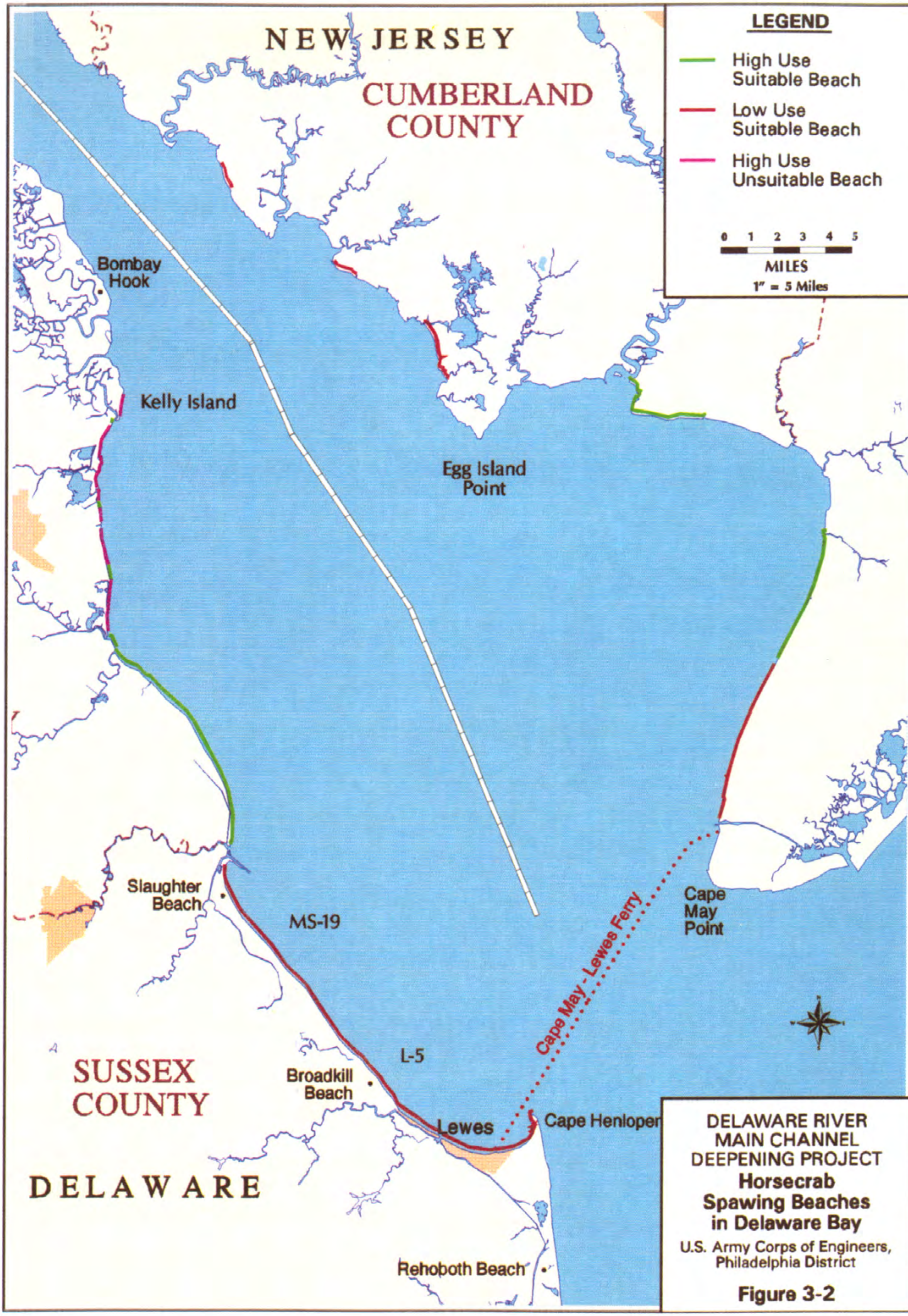
Macroinvertebrates

Horseshoe crabs. The largest population of spawning horseshoe crabs in the world is found in Delaware Bay (See Figure 3-2). Each spring, adult horseshoe crabs migrate from deep water in the Delaware Bay and the Atlantic continental shelf to spawn on Delaware Bay beaches. The minimal geologic shoreline development and smooth morphology of Delaware Bay's lower shoreline facilitates movement of horseshoe crabs and enables them to find suitable spawning beaches in large numbers. Spawning generally occurs from April to July, with the peak spawning activity occurring on full moon high tides in May and June. The average width of the intertidal area used by horseshoe crabs for spawning is about 45 feet on Delaware Bay beaches. Eggs are deposited in the upper portion of the intertidal zone in clusters approximately 6 to 8 inches below the surface. The average cluster contains between 3,000 and 4,000 eggs.

Horseshoe crab reproductive success is greatest under the following conditions: (1) the egg clusters are moistened by water with salinity of at least 8 parts per thousand; (2) the substrate around the egg clusters is well oxygenated; (3) the beach surface is exposed to direct sunlight to provide sufficient incubation; and, (4) the slope of the beach is adequate for larvae to orient and travel downslope to the water upon hatching. These conditions are found on sandy beaches along the lower portion of Delaware Bay.

The mechanism by which horseshoe crabs locate preferred spawning habitat is not completely understood. While horseshoe crabs spawn in greater numbers and with greater fecundity along sandy beaches, horseshoe crabs can tolerate a wide range of physical and chemical environmental conditions, and will spawn in less suitable habitats if ideal conditions are not encountered. Therefore, the presence of large numbers of horseshoe crabs on a beach is not necessarily an indicator of habitat suitability. It is known that shoreline areas with high concentrations of silt or peat are less favorable to horseshoe crabs, because the anaerobic conditions reduce egg survivability. It also appears that horseshoe crabs can detect hydrogen sulfide, which is produced in the anaerobic conditions of peat substrates, and that horseshoe crabs actively avoid such areas.

Beach slope is also thought to play an important role in determining the suitability of beaches for horseshoe crab spawning. Horseshoe crabs generally travel downslope after spawning and appear to become disoriented on flat areas.



DELAWARE RIVER MAIN CHANNEL DEEPENING PROJECT

Horsecrab Spawing Beaches in Delaware Bay

U.S. Army Corps of Engineers, Philadelphia District

Figure 3-2

Although the optimal beach slope is unknown, beaches visited by the FWS during February 1995 had slopes of between 3 and 7 degrees to seaward. As previously noted, beach conditions vary substantially from season to season, and these observations may not reflect beach conditions during the horseshoe crab spawning season.

In addition to the intertidal zone used for spawning, horseshoe crabs also use shallow water areas (less than two fathom depths) such as intertidal flats and shoal water as nursery habitat for juvenile life stages. Adult horseshoe crabs forage in deep water habitat during most of the year, except during the breeding season when they move into shallow and intertidal water.

The presence of offshore mud flats may also influence the use of certain beaches by spawning horseshoe crabs. Horseshoe crabs may congregate on mud flats to wait for full moon high tides, because these areas provide protection from wave energy. Female horseshoe crabs can carry over 88,000 eggs per animal. Therefore, several tidal cycles are required to complete spawning. Offshore mud flats may provide safe areas to rest between tide cycles.

Under normal conditions spawning mortality on beaches averages approximately 10 percent of the spawning individuals. Factors contributing to normal mortality include age, excessive energy expenditure during spawning, stranding, desiccation, or predation by gulls. Entrapment in man-made structures such as rip-rap, bulkheads, and jetties, and commercial harvest also account for significant additional mortality.

Annual beach surveys of Delaware Bay horseshoe crab spawning activity conducted by volunteers since 1990 appear to indicate an overall decline in the horseshoe crab population in recent years. Preliminary results from the 1995 beach surveys appear to further support the conclusion that horseshoe crab numbers are declining. Additionally, trawl surveys conducted by DDNREC appear to corroborate the findings of the beach surveys. Weather and other factors influence the timing and intensity of spawning; therefore, additional data are needed before valid conclusions can be drawn regarding population trends. Nonetheless, the observed downward trend in the existing data is reason for concern.

The beach surveys are also useful in documenting relative use of various shoreline segments by spawning horseshoe crabs. For example, the survey data indicate declining numbers of spawning horseshoe crabs on beaches experiencing the highest erosion; Kelly Island and Port Mahon, in particular. The most consistent spawning beaches in Delaware appear to be those between Kelly Island and South Bowers Beach, which have extensive mud flats offshore.

While horseshoe crabs have some commercial value, the primary importance of this species is food chain support, particularly for migratory shorebirds. Shorebirds congregate along the Delaware Bay shoreline during their northward migration each spring because the massive amounts of horseshoe crab eggs provide a food source unlike that in any other site in the Western Hemisphere. Shorebirds passing through Delaware Bay spend, on average, 15 days replenishing body fat reserves before continuing their migration to nesting areas in the Arctic. During that period, these shorebirds consume massive quantities of horseshoe crab eggs. For example, sanderling (Calidris alba) have been estimated to eat 9,000 eggs per individual per day.

The bills of most shorebirds are too short to allow them to dig up horseshoe crab egg clusters. Most shorebirds rely on successive waves of horseshoe crabs to come ashore and inadvertently dig up previously deposited egg clusters while attempting to deposit new egg clusters. Therefore, a large population of horseshoe crabs, laying many more eggs than are needed to maintain the population, is necessary to provide a sufficient food supply for migrating shorebirds. However, the minimum size of the population needed to sustain shorebird populations is unknown.

Other macroinvertebrate. Commercially and recreationally important macroinvertebrate species found in Delaware Bay include blue crab (Callinectes sapidus), American oyster (Crassostrea virginica) and hard clam (Mercenaria mercenaria). Blue crabs are abundant throughout the area, foraging in tidally influenced waters and wetlands from May through November. During the winter (December through April) blue crabs stay in water greater than 15 feet deep.

In waters within the State of Delaware, oysters occur in naturally reproducing seed beds offshore and north of Kelly Island, and in leased bed areas south of Kelly Island down to the Mispillion River area. In New Jersey waters, oyster seed beds occur from south of Artificial Island to Fortescue; lease beds occur from southwest of Egg Island Point throughout much of the lower Bay. Hard clams occur throughout the area, on soft sandy bottoms, in water with salinity greater than 12 ppt.

Maurer *et al.* (1978) found a total of 169 species of benthic macroinvertebrates in Delaware Bay over two summers of sampling (1972 and 1973). Maurer *et al.* (1978) noted that there are marked seasonal and annual fluctuations in the distributions of animal assemblages. The number of species and number of individuals increased with increasing salinity and increasing median sediment grain size.

The general composition of the benthic invertebrate community is similar to that of other temperate estuaries in the Northern Hemisphere (Maurer *et al.*, 1978). Dominant species include the polychaetes Glycera dibranchiata, Heteromustus filiformis, and Scoloplos fragilis; and mollusks such as Tellina agilis, Ensis directectus, Nucula proxima, Gemma gemma, Molina lateralis, and Mytilus edulis. These species are found in community assemblages throughout the Mid-Atlantic Bight.

Finfish

Delaware Bay supports substantial recreational and commercial fisheries. Weakfish (Cynoscion regalis), summer flounder (Paralichthys dentatus), and bluefish (Pomatomus saltatrix) are the most popular recreational species, but the recreational catch also includes striped bass (Morone saxatilis), scup (Stenotomus chrysops), tautog (Tautoga onitis), spot (Leiostomus xanthurus), Atlantic croaker (Micropogonias undulatus), red hake (Urophycis chuss), black sea bass (Centropristis striata), skates, and sharks. Delaware Bay also supports important anadromous fish species including American shad (Alosa sapidissima), alewife (Alosa pseudoharengus) and blueback herring (Alosa aestivalis). Stocks of several of these species, most notably weakfish, have declined in recent years due largely to over-fishing.

Weakfish are one of the most important species in Delaware Bay in terms of abundance and value to the recreational and commercial fisheries. Weakfish are seasonal residents of Delaware Bay from April through October and spawn throughout the project area. Spawning occurs throughout the summer, but peaks in June and July. The larvae are transported by currents to the middle and upper portions of the Bay where they develop into juveniles. During the fall, after juveniles have attained a length of 4 to 6 inches, weakfish migrate to wintering areas off Virginia and North Carolina.

Striped bass occur in all seasons, throughout the project area; although young-of-the-year use the project area only sporadically, concentrating primarily in the spawning area, which is in the Wilmington/Philadelphia area of the Delaware River.

Black sea bass, scup, and tautog stay in close proximity to reefs or other hard irregular structures. These species can be found throughout the project area, during any time of the year. American shad use the project area during two time periods. In the spring and early summer (April through July) the channel and other deep areas of the bay serve as a "multi-stock" staging area for adults as they wait for water temperatures to warm upstream in the Delaware River and further up the Atlantic coast. Fish from the north Atlantic then move back out to the coast, while the Susquehanna and Delaware River stocks migrate upstream to spawn. In the fall (September through November) the "young-of-the-year" move down into the Bay as the water temperatures decrease, and then leave the Bay for the open ocean.

Reptiles

The northern diamondback terrapin (Malaclemys t. terrapin) is relatively common throughout the study area. Estuarine emergent marshes and associated creeks and near shore waters are used for foraging (April through December). Salt marsh snails and fiddler crabs form the bulk of the diamondback terrapin diet. Egg laying occurs from early June through mid-July on sandy beaches with little or no vegetation, as well as on bayshore beaches surrounding the mouth of tidal marsh creeks. Hibernation occurs in mud banks and creek bottoms within the foraging areas, as well as within the nests themselves.

The northern diamondback terrapin is a candidate for inclusion on the Federal List of Endangered and Threatened Wildlife and Plants, pursuant to the Endangered Species Act of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.). Candidate species receive no protection under the Endangered Species Act; however, the FWS encourages Federal agencies and other planners to consider candidate species in project planning.

Avifauna

Waterfowl. Waterfowl are abundant in tidally influenced wetlands and shallow water areas throughout the study area, reaching peak numbers in the fall and winter months. The Little Creek Management Area south of Kelly Island and the Bombay Hook National Wildlife Refuge area are important concentration areas for snow goose (Chen caerulescens), Canada goose (Branta canadensis) and dabbling ducks such as mallard (Anas platyrhynchos), American black duck (Anas rubripes), northern pintail (Anas acuta), and green-winged teal (Anas crecca). Black ducks are known to concentrate in the scalloped, cut-out areas along Kelly Island, created as the shoreline erodes. In addition, diving ducks such as scaup (Aythya sp.) and canvasback (Aythya valisineria) use the Little Creek area of the Bay itself (generally within the oyster leasing area).

Shorebirds. As many as 1.5 million shorebirds may pass through the Delaware Bay each spring; the largest concentration of shorebirds on the east coast. As previously mentioned, the shorebird stopover coincides with the spawning period of horseshoe crabs. The most commonly occurring shorebird species that migrate through Delaware Bay are the red knot, ruddy turnstone (Arenaria interpres), semipalmated sandpiper (Calidris pusilla), sanderling, dunlin (Calidris alpina), and dowitchers (Limnodromus spp.). The first four species listed comprise 97 percent of all shorebirds observed in aerial surveys conducted since 1986.

Shorebirds are dependent on a mosaic of beach and salt marsh cover types to meet their requirements for foraging, roosting, and resting. While the horseshoe crab eggs found on Delaware Bay beaches are an essential food source for migrating shorebirds, other cover types are also used extensively by shorebirds. Shorebirds feed in salt marsh ponds and creeks during high tide when bayshore beaches are inaccessible, and shorebirds roost in protected areas of the salt marsh.

Little information exists on the historical use of the Delaware Bay by migrating shorebirds. Since 1985, the NJDFGW, Endangered and Nongame Species Program, and the DDNREC, Endangered and Nongame Species Program, have conducted annual shorebird surveys along Delaware Bay. Aerial surveys of approximately 50 miles of shoreline in both Delaware and New Jersey are conducted once per week for six weeks each May and June. The Delaware portion of the survey extends from Woodland Beach south to Cape Henlopen. The New Jersey portion of the survey extends from the Cohansey River to Cape May Canal. Estimates are made of total bird numbers, by species.

The survey data indicate that the beach areas from the Mispillion River north to Simons River are the most heavily used by shorebirds. In 1990, this area accounted for over 80 percent of all the shorebirds observed in the Delaware portion of the survey. The Mispillion River area, including the mud flats of the Mispillion jetty, experience the heaviest use, both in terms of total numbers of birds and species density. Survey data also indicate heavy shorebird use along the entire New Jersey shoreline, particularly near Dennis Creek, Moores Beach, Thompson Beach, Egg Island Point, and Fortescue.

Two trends in shorebird abundance are important to note from the surveys. First, the number of sanderlings using Delaware Bay has apparently declined markedly. In 1990, sanderling were observed at only 4 Delaware beaches, all south of Big Stone Beach. Second, there is also evidence that semipalmated sandpipers are declining significantly.

Site Specific Fish and Wildlife Resources

Kelly Island

While horseshoe crabs spawn in the adjacent Kent Island area, conditions are generally not conducive to egg development, and reproductive success is probably low (Figure 3-2). The value of horseshoe crab eggs at this site may be more as a food source for migrating shorebirds, than as a source for sustaining horseshoe crab populations.

Commercially important oyster seed beds exist in the area offshore of Kent Island and Kelly Island (Figure 3-2). There are also oyster beds inside the mouth of the Leipsic River. Additionally, hard clams and blue crabs are distributed throughout the Kelly Island area. Blue crabs in this area are commercially important.

The most frequently occurring species of benthic macroinvertebrates in samples taken in the vicinity of Kelly

Island area by Maurer *et al.* (1978) in 1972 and 1973 included polychaetes such as Nephtys picta, Glycera capitata, Glycera dibranchiata, and Heteromastus filiformis; mollusks such as Tellina agilis, Nassarius trivittatus, Ensis directus, Mulinia lateralis, and Nucula proxima; and, crustaceans including Cancer irroratus, Paraphoxus spinosus, Protohaustorius wigleyi, and Pagurus longicarpus.

The Greeley-Polhemus Group (1994) found 23 macroinvertebrate species at the Kelly site, in 1993. Crustaceans (11 species) and polychaetes (5 species) dominated the samples. Dominant species included mollusks such as Mulinia lateralis, and polychaetes including Glycera dibranchiata. Small horseshoe crabs were also collected. The Greeley-Polhemus Group (1994) reported sampling problems associated with the thick cohesive silt / clay substrate, which made it difficult to dredge for commercially or recreationally important species.

Striped bass use the mouth of the Leipsic River in all seasons. This area is also a spawning area in spring and summer for riverine and anadromous fish such as American shad, river herring, and white perch (Morone americana).

Kent Island marshes provide significant shelter, wintering and breeding habitat for American black duck and other waterfowl species. Gulls, terns, and large numbers of wading birds such as glossy ibis (Plegadis falcinellus) use the Kent Island and Kelly Island areas, especially in spring.

The beach on the southern tip of Kelly Island historically supported large numbers of spawning horseshoe crabs, with corresponding heavy use by shorebirds, particularly ruddy turnstones and semipalmated sandpipers. As the beach at the southern tip of Kelly Island has eroded, horseshoe crab spawning activity has declined. While horseshoe crabs still spawn here in large numbers, conditions are generally no longer suitable for egg survival. Although horseshoe crab spawning activity has declined, shorebird use of this area has remained high. In fact, the area between Kelly Island and South Bowers Beach still supports one of the largest springtime concentrations of shorebirds in the entire Delaware Bay. This could be due in part to the inaccessibility of this area to humans.

Egg Island Point

Egg Island Point receives moderate to heavy use by horseshoe crabs. However, the shoreline conditions are generally not conducive to high spawning success, except at the tip of Egg Island Point and along the small sandy beach segments on the northwestern shoreline.

Commercially important oyster lease beds are located throughout the offshore area around Egg Island Point. Most of these lease beds are located 500 to 800 feet offshore; but in some cases lease beds are located within close proximity to the shoreline. Oyster seed beds occur to the northwest of Straight Creek, and this area also supports a commercially important blue crab fishery. See Figure 3-3 for oyster seed beds and lease areas.

The Egg Island Point area receives heavy use each spring by migratory shorebirds. Shorebirds feed in large numbers along the shoreline and along the sandy deltas at creek mouths. Additionally, the numerous small tidal and non-tidal ponds on the adjacent salt marsh provide valuable shorebird feeding and roosting habitat. The most common species using this area include ruddy turnstone, red knot, and semipalmated sandpiper.

The wetlands and nearshore shallows of Egg Island Point also provide valuable habitat for a large number of migratory waterfowl. Species identified during mid-winter waterfowl surveys conducted between 1985 and 1989 include mallard, American black duck, green-winged teal, scaup, merganser (Mergus sp.), gadwall (Anas strepera), bufflehead (Bucephala albeola), American widgeon (Anas americana), Northern shoveler (Anas clypeata), Canada goose, and snow goose (FWS 1995b).

Sand Stockpiles

The most frequently occurring species of benthic macroinvertebrates in samples taken in the vicinity of Site L-5 by Maurer *et al*. (1978) in 1972 and 1973 included polychaetes such as Nephtys picta, Scoloplos fragilis, Glycera americana, Glycera capitata, Glycera dibranchiata, Aricidea cerruti, and Heteromastus filiformis; mollusks such as Tellina agilis, Nassarius trivittatus, Ensis directus, and Nucula proxima; and, crustaceans including Cancer irroratus, Paraphoxus spinosus, Protohaustorius wigleyi, and Pagurus longicarpus.

The Greeley-Polhemus Group (1994) found 51 macroinvertebrate species at Site L-5 in 1993. Crustaceans (19 species) and polychaetes (18 species) dominated the samples. Dominant species included crustaceans such as Ampelisca sp., and Cerapus tubularis; mollusks such as Mulinia lateralis, and Nucula proxima; and, polychaetes including Glycera americana and Nephtys incisa.

The area in the vicinity of Site MS-19 was sampled by Maurer *et al*. (1978) in 1972 and 1973. The dominant species included mollusks such as Ensis directus, Tellina agilis, and Nucula proxima; polychaetes including Glycera americana, Glycera capitata, Glycera dibranchiata, Nereis succinea, Nephtys picta, Capitella capitata, Aricidea cerruti, Polydora ligni, Sabellaria vulgaris, and Heteromastus filiformis; and, crustaceans including Protohaustorius wigleyi, Paraphoxus spinosus, Pagurus

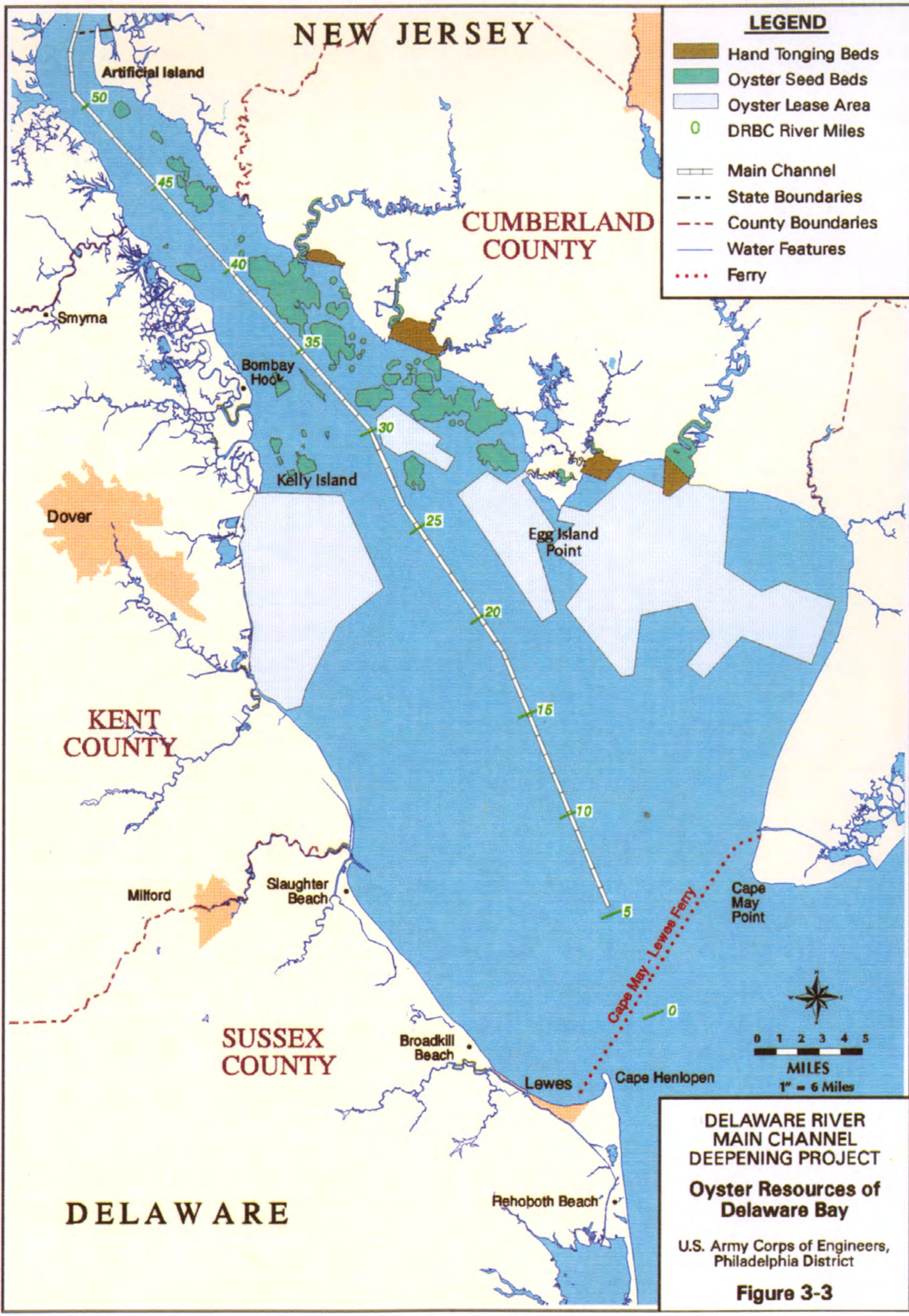

NEW JERSEY
CUMBERLAND COUNTY
KENT COUNTY
SUSSEX COUNTY
DELAWARE
Artificial Island
Smyrna
Bombay Hook
Kelly Island
Dover
Egg Island Point
Milford
Slaughter Beach
Cape May Point
Cape May - Lewes Ferry
Broadkill Beach
Lewes
Cape Henlopen
Rehoboth Beach
50
45
40
35
30
25
20
15
10
5
0
LEGEND
Hand Tonging Beds
Oyster Seed Beds
Oyster Lease Area
DRBC River Miles
Main Channel
State Boundaries
County Boundaries
Water Features
Ferry
0 1 2 3 4 5
MILES
1" = 6 Miles
DELAWARE RIVER MAIN CHANNEL DEEPENING PROJECT
Oyster Resources of Delaware Bay
U.S. Army Corps of Engineers, Philadelphia District

Figure 3-3

longicarpus, Cancer irroratus, Melita nitida, Neopanope sayi, Corophium simile, Paracaprella tenuis, and Eurypanopeus depressus.

The Greeley-Polhemus Group (1994) found a total of 62 species at Site MS-19 in samples collected in 1993. The mean density of individuals collected at this site (26,562.5 individuals per square meter) was much higher than that of any other proposed sand stockpile site. Most species were crustaceans (24 species) and polychaetes (20 species). Dominant species included crustaceans such as Ampelisca sp., Corophium sp., Cerapus tubularis, and Eurypanopeus depressus; and, mollusks such as Crepidula fornicata, and Ensis directus. Commercially and recreationally important species included knobbed whelk, horseshoe crab, blue crab, and hard clam.

3.3.3 Beneficial Use Site Design and Operation

3.3.3.1 Wave and Water Level Conditions for Delaware Bay

Information regarding water levels and waves in Delaware Bay indicate that construction of protective structures to allow for wetland restoration are challenging. The following is baseline information useful in the design of the project elements.

Water Levels. Maurmeyer (1978) found that the mean tide range is 5.5 feet MLW and the spring tide range is 6.2 feet MLW at Port Mahon, DE. The mean tide range is reasonably confirmed by the US Army Corps of Engineers (USACE 1986a) as 5.4 feet MLW. The water level that can be expected to occur once per year is about +7 feet MLW. Tables 1 & 2 provide estimates of other water levels for given return intervals based on calculations by Ocean & Coastal Technology, Inc. (OCTI) and USACE, 1986a. The values in the tables are not entirely consistent but still useful for reference.

Winds. Maurmeyer (1978) presented an analysis of the wind climate for Delaware Bay based on data from the Greater Wilmington, DE, Airport collected between 1951 and 1960. The mean annual wind speed was 11 mph and gale force winds (greater than 46 mph) occurred less than 0.3 percent of the time. Maurmeyer filtered the wind data by month and presented the data from January as representative of the winter season; April as representative of the spring; July for the summer; and October for the fall. In the winter, the mean wind speed was 12.8 mph with gale force winds occurring less than 0.7 percent of the time. Winter winds are typically from the northwest. In the summer, the winds were calmer with a mean of eight mph and with gale force winds occurring less than 0.1 percent of the time. Summer winds were usually from the southwest. Fall winds were variable with a tendency to occur from the north and northeast.

Waves. Maurmeyer discussed the wave climate for Delaware Bay based on shipboard observations. The ship observations were recorded off Slaughter Beach from 1961 to 1971. Most of the waves appear to be locally generated and not the result of waves propagating into the Bay from the Atlantic Ocean. Wave heights in the bay are generally less than two feet and exceed six feet only two percent of the time. Corresponding to the wind conditions, the highest waves occur during the winter and the smallest in the summer. However, the variability of the winds suggests that large waves may be generated from any quadrant in any season. Table 3-6 provides wave height and period for given return intervals for the Kelly Island locale based on the results of a wave hindcast conducted by Offshore and Coastal Technologies, Incorporated (OCTI).

Table 3-6. Storm event summary

Return Interval of Storm	Wave Height (feet)	Wave Period (s)	Water Level MLW (feet MLW)
2 year*	5.9	5.2	7.9
5 year	6.6	12.3	9.2
10 year	7.2	12.7	10.2
25 year	8.2	13.4	11.8

*Determined by evaluation of OCTI hindcast series.

3.3.3.2 Wetland Restorations

General

The structure designs and configurations at Kelly Island are based on ecological concerns, both in the immediate vicinity of the project and in Delaware Bay; containment of the fine-grained dredged material to be placed in the confined disposal facility (CDF), and shoreline protection. The following sections provide a description for the development of wetlands and other habitats at the project site and the associated structural designs and configurations needed to accommodate that development.

Kelly Island Wetland Restoration Design

Kelly Island has been eroding severely for many years, and has lost much of its shoreline, including almost all of its intertidal marsh (US Army Corps of Engineers. 1986a). The peat substrate that supported the ancient marsh has eroded back to remnants in many places. The loss of marsh on Kelly Island has exposed the navigation channel in the Mahon River to waves and the wetlands behind the island are threatened with overwash and loss. The loss of marsh is also adversely affecting existing habitats at the Bombay Hook National Wildlife Refuge (NWR) (USFWS. 1994).

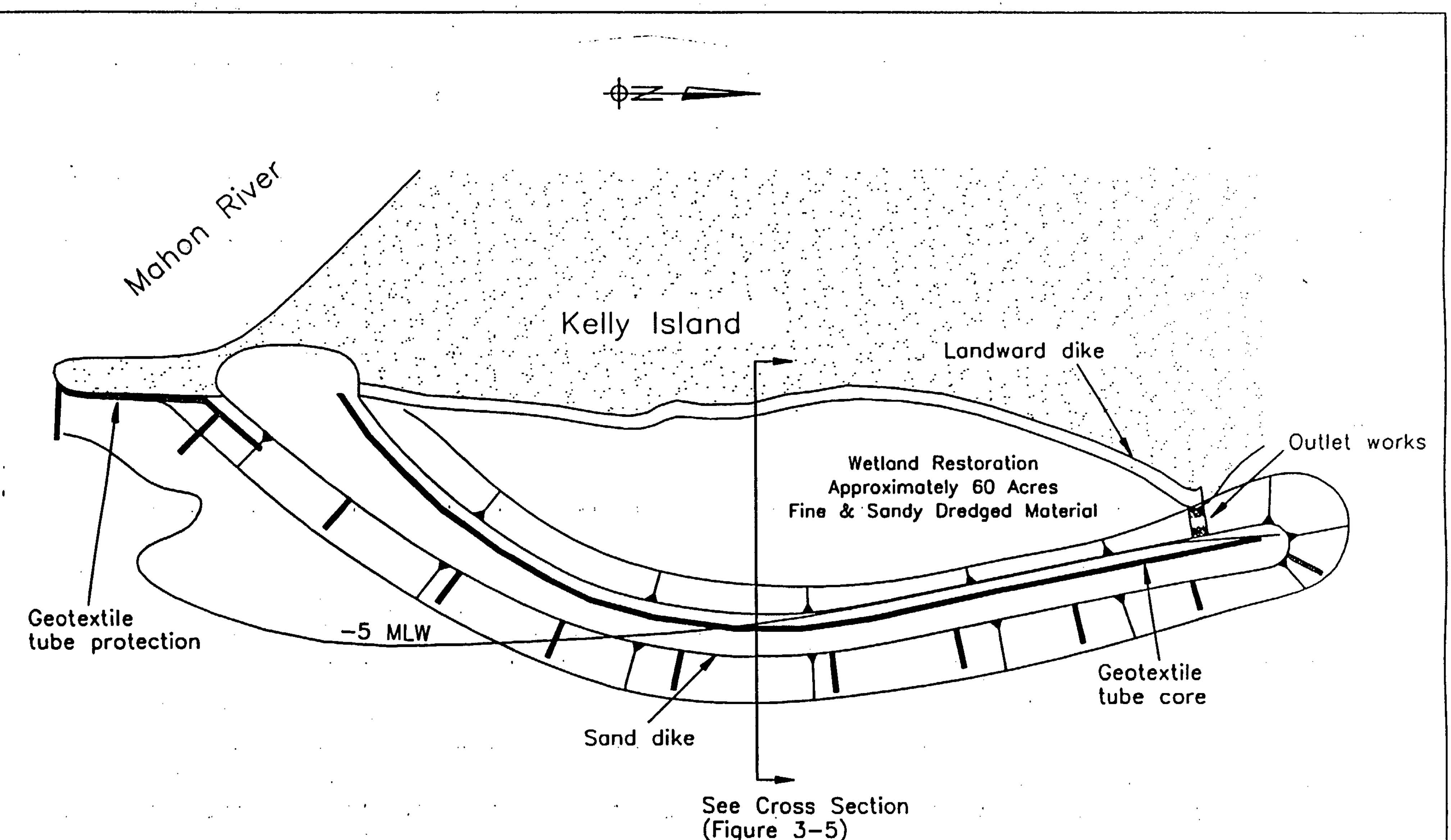
Bombay Hook NWR, including the Kelly Island area, provides considerable habitat diversity for fish and wildlife, and is one of the most important ecological areas in the Bay (USFWS. 1994). The greatest use of the eroding shoreline is by spawning horseshoe crabs at suitable beaches, feeding and resting migratory shorebirds which feed on the crab eggs, waterfowl, and occasional waterbirds such as herring gulls (Larus argentatus) and great blue herons (Ardea herodias). The wave energy and erosion has reduced feeding potential. Conditions are expected to greatly improve with construction of the project. The CDF to be built in front of Kelly Island (Figure 3-4) will provide protected waterbird feeding areas, sand beaches for crab spawning and shorebird feeding, resting areas for waterbird species, improved areas for juvenile fish within the restored salt marsh, and protection to the eroding existing marshes.

Timing of construction at Kelly Island will consider the current crab and shorebird use of the site to minimize impacts. The hydraulically-placed sand for the dikes is a limited-space effort, and only a small area will be affected at any given time during construction. The areas of construction are not currently used by crabs to spawn since they are below mean low water (MLW), and lack sand. Construction of the dikes will begin at the south end making use of access to the site from the Mahon River channel. Once the dikes are constructed, the interior of the CDF will be filled. Fine-grained material will be placed first (described below) followed by placement of sand to an elevation of +5 feet MLW. After construction, tidal channels and outlet-works adjustments will be made to aid intertidal connection. Intertidal connections are discussed in subsequent sections of this report. Optimal environmental windows will always be considered prior to and during construction to minimize impacts to the existing ecology.

Offshore Dike Design

In designing the offshore dike at Kelly Island, desired habitat and stability were examined. The offshore dike, as well as the landward dike and outlet works, must contain the dredged material during the filling process and control discharge from the site, and then continue to serve as protective structures with avenues for tidal exchange after the dredging is completed. The structures are described below.

The offshore dike will have a crest elevation of +10 feet MLW. This elevation is coincident with the water level for a return interval between 10 and 25 years (by Tables 3-6 and 3-7, respectively). It is only during rare events that this sand dike will be overtopped. The dike is expected to provide ample



NOT TO SCALE

DELAWARE RIVER
MAIN CHANNEL DEEPENING PROJECT

Kelly Island
Wetland Restoration Site
PLAN

U.S. Army Corps of Eng[illegible]
Philadelphia District

Figure 3-4

Table 3-7. Water levels at Kelly Island (from USACE, 1986).

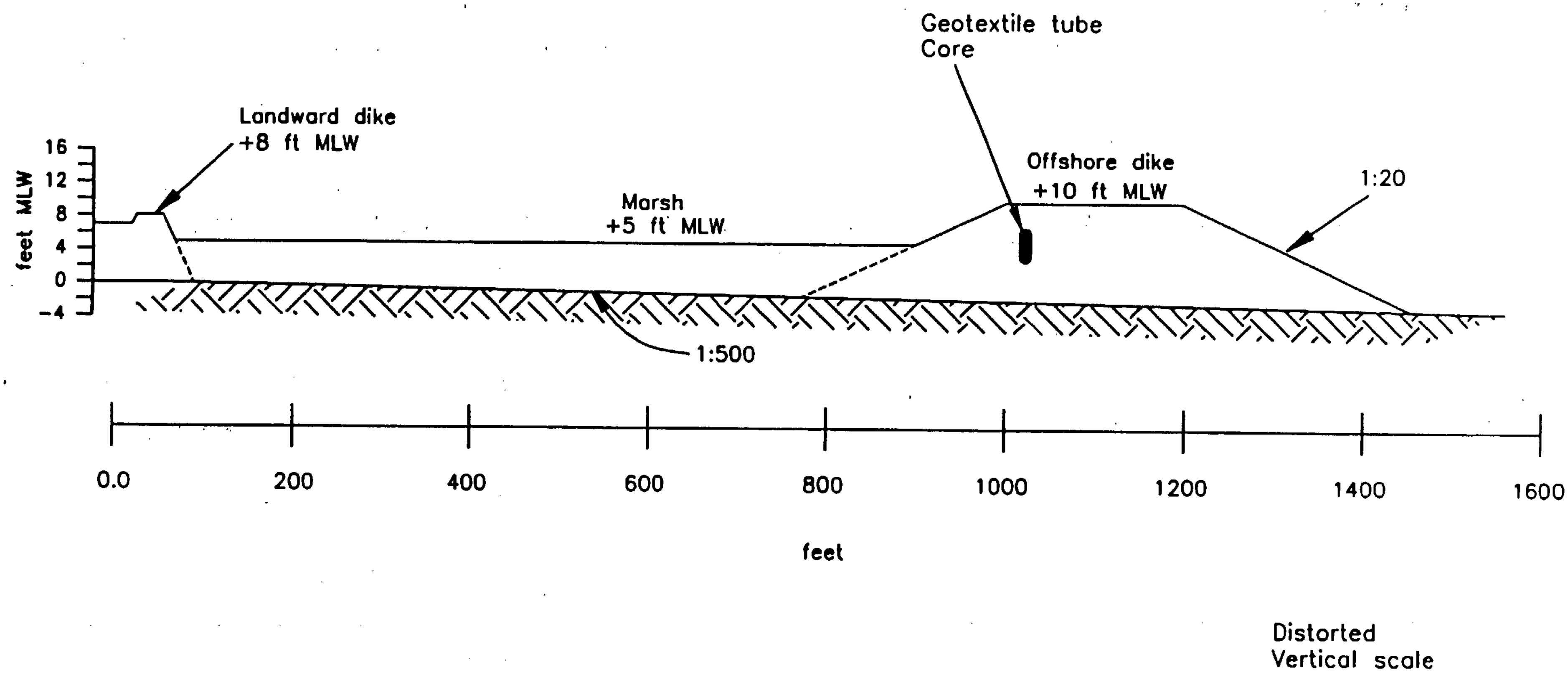
Recurrence Interval (yr)	Water Level (feet MLW)
1	7.2
2	7.7
10	8.8
50	10.6
100	11.4

spawning habitat for horseshoe crabs.

The crest width of the dike will be 200 feet at its narrowest. The volume of sand in the cross section of the dike will be constant, i.e. 845 cubic yards per yard. Therefore, the crest width of the dike in shallow water will be greater than in deeper water. The maximum crest width (at the southern intersection with the island) will be 350 feet. A representative cross-section of the project showing the offshore dike is provided in Figures 3-5. The total volume of sand required for the offshore dike is 1.7 million cubic yards (which includes a quantity sufficient to offset an estimated one foot of settlement). The offshore slopes for the dike are estimated to be 1:20 initially, and after the first year they should equilibrate to a milder 1:40 slope.

The crest-width for the dike was determined by considering the loss of 35,000 cubic yards of sand annually from the project as computed from net potential longshore sediment transport. Such losses are expected to result in a crest-width loss of about 13.5 feet per year. Additionally, a 20-foot loss of crest width was estimated due to initial equilibrium adjustment of the offshore slope, and a 30-foot loss of crest width due to a severe storm event with a 25-year return interval. Summing over a 10 year period, approximately 185 feet of crest width is needed to account for estimated losses. The value is rounded to 200 feet for the design. It is expected that after 10 years, maintenance of the offshore sand dike will be required.

The assumptions regarding the pathways taken by sand removed from the dike are that most transport will be northward and the sand will tend to stay close the shoreline as it is moves; some southerly transport will occur, eventually depositing in the Mahon River channel and will be dealt with through periodic maintenance; some of the sand will form offshore bars from time to time as the slope adjusts under different wave climates; and the sand is not expected to move into deeper bay waters. These



DELAWARE RIVER
MAIN CHANNEL DEEPENING PROJECT

Kelly Island
Wetland Restoration Site
Geotextile Tube/Berm CROSS SECTION

U.S. Army Corps of Engineers,
Philadelphia District

Figure 3-5

assumptions are based on general transport patterns observed along sandy shorelines.

It is worth noting that the existing marsh shoreline (composed mostly of organic peat) at Kelly Island is receding at a rate on the order of 20 feet per year. Sand should be more durable and erode at a lower rate than the existing marsh substrate. Therefore, the estimated recession of the sand crest at 13.5 feet per year appears reasonable.

The southern end of the offshore dike will terminate on the island. The elevation of the crest of the dike will transition from +10 feet MLW to the +7 feet MLW (approximate) elevation of the existing marsh. The dike will extend onto the island far enough to prevent southerly waves at high water from damaging any portion of the interior of the project. The dike will also extend beyond its connection with the landward dike (discussed below).

The northern end of the offshore dike will extend approximately 300 feet beyond Deepwater Point roughly parallel to the shoreline. The outlet works for the project (discussed below) will be placed at Deepwater Point, and so the offshore dike will protect that location.

A geotextile tube will be placed within the offshore dike as a factor of safety against a breach in the dike due to an extreme event and overwash. The crest of the tube will be placed to a crest elevation of +7 feet MLW. The tube will then be buried under an additional three feet of sand bringing the crest of the dike up to elevation +10 feet MLW. The protection that the tube provides should allow time for maintenance or repair work to be planned and executed if a breach should develop.

Design for the Geotextile Tube Core

Scour Blankets. In order to prevent scour from undermining the tubes if they are exposed, a scour blanket will be placed on the seaward side of the geotextile tube. The scour blanket width will be 10-13 feet. The scour blanket (geotextile fabric) will be anchored along its seaward edge with a factory- stitched anchor tube of one to two feet in diameter. The blanket will extend completely beneath the geotextile tube with another anchor tube on the leeward side.

Geotextile Tube Segments. To make manipulation of the tubes and their construction easier, geotextile tubes about 250-300 feet in length will be used. Experience has shown that deploying more than 300 feet of geotextile tube at any one time can be difficult to control (i.e. hold in place while filling), and it is more difficult to achieve desired height.

Geotextile Tube Fabric. The fabric mesh size will be selected based on the sediment grain sizes that will be used to fill the tube and on the expected strength needed during filling. Essentially, the fabric will be capable of retaining the sandy fill used inside the tube, but be permeable enough to allow the fill material to dewater.

Filling Ports. Filling ports will be factory-installed collared holes in the tube through which sand can be pumped via the dredge pipe. The fabric collars will be about three feet long and 18 inches in diameter and sewn around the filling holes. The dredge pipe slips into the collar and a rope or strap is tied around it to hold the collar on the pipe. The filling ports will be spaced about 25 to 50 feet apart.

Fill Material. Sand will be used as fill for the geotextile tubes. Sand settles quickly inside the tube and force excess water out. Very little consolidation of the sand inside the tube will occur after construction so the final crest elevation achieved during construction will remain.

Survivability. Geotextile tube material is very resistant to rupture due to tensile stresses, but does not resist cuts, punctures, or abrasion well. Since the tubes will be buried in core of the sand dike, only the tensile strength properties of material will be important.

Landward Dike

A dike will be constructed along the edge of the existing marsh to elevation +8 feet MLW. The dike will prevent dredged material from flowing across or settling in the existing marsh. The dike will be constructed by trucking sand from the larger offshore dike to the landward dike. The dike crest width will be 20-30 feet and between 1-3 feet high. The dike will not be constructed by hydraulic placement of sand. When the CDF is filled and all dredging is completed, the dike will be leveled to tie the existing marsh to the newly restored marsh elevations. A crest elevation of + 8 feet MLW is required to account for the final elevation of fill material (+5 feet MLW) with two feet of ponding required for efficient water control during placement and one foot of freeboard above that to accommodate water level variations and small waves within the site.

Groins

Groins will be placed along the perimeter of the offshore dike to help limit longshore transport. Although the cross-section of the dike is designed to sustain sediment losses for many years without losing any of its function, groins will increase the longevity of the project, reduce potential maintenance, and add a factor of safety against the risk that sand will be transported south along the project into the Mahon River entrance. Based on USACE (1992), the groins will be about 300 feet long extending seaward from the crest of the dike. The groins will be four to five feet high, and will be 600 feet apart along the shoreline.

Geotextile tubes will be used for the groins. The tubes will be placed during construction of the dike, the landward ends of the groins will be keyed into the dike to add to their stability. The design criteria provided above for the tubes in the core of the offshore dike will be applied here, as well.

Outlet Works

The outlet works will be placed through a cross-shore sand dike at the north end of the project extending from the tip of Deepwater Point to the offshore dike. The elevation of the crest of the cross-shore dike will be +8 feet MLW which is sufficient to prevent even the annual highest high-tide from overtopping the dike (Table 2). This elevation also provides sufficient freeboard so that water levels in the site can be held high if needed. The cross-shore dike does not need additional elevation to prevent wave overtopping because it is protected from waves by the offshore dike. A geotextile tube like the one described for the offshore sand dike will be placed in the core of the cross-shore dike. The flows through the outlet works during dredging depend on the depth of water above the weir crests and the depth of flow toward the weir.

The outlet works will have outflow pipes that pass through the core of the cross-shore dike. The cross-section of the cross-shore dike will be held to a minimum to minimize the length of outlet pipe required. The actual crest width of the dike will depend on the stability of the foundation upon which the dike is built. The dike will be filled until a stable cross-section is achieved. The dike will be constructed by moving sand from the offshore dike with heavy equipment so that steeper side slopes can be achieved which will minimize the dike cross-section.

The outlet works provided at the north end of the project will control release of water during dredging. Several drop inlets (e.g. `Delaware Trunks') are planned. The capacity of the outlet works will depend on the size of the dredge pump and discharge line and water control requirement for post-construction marsh management.

An outlet works at the southern end of the project will not be necessary for dredging purposes. However, tidal connection to the southern end of the site may be desired after the marsh develops and natural flow patterns emerge. Any additional tidal connection should be achieved, for example, by small tidal guts through the existing marsh to the Mahon River and not through the offshore dike, because greater wave action at this location would cause stability problems. A tidal gut presently exists near the south end of the project that would make an ideal connection with the Mahon River.

Construction of the Dikes

Construction will begin at the southern end of the project site. Sand will be hydraulically placed near the marsh shoreline. Heavy moving equipment off-loaded from a barge in the Mahon River will be moved across the narrow spit of marsh at the southern end of the island to the sand dike when the dike crest is sufficiently above high tide. The equipment will be used to spread the sand away from dredge pipe as the mound of sand forms. As the width of the dike increases, the placement of the discharge pipe will be toward the bay side of the dike and the construction equipment will be used to push the sand landward. This approach will create a steeper slope on the landward side of the offshore dike minimizing the volume of the containment site taken up by the offshore dike's cross section. The goal of this approach is to provide the maximum capacity possible in the site to accommodate the fine-grained dredged material. The silt will therefore form the minimum possible layer thickness.

Sand will be moved off the offshore dike to construct both the landward dike and the cross-shore dike at the north end of the project, as well.

Dredged Material Placement Inside the CDF

The inflow point for fine-grained dredged material to the site should be at the southern end of the project, far from the outlet works. This maximizes the distance between the inflow and outflow points allowing the maximum amount of time for sediment particles to fall out of suspension. The large ponding depth that will be present will result in low flow velocities within the site increasing the settling time for suspended sediments.

The 200,000 yd^3 of fine-grained dredged material will be placed first. Once placed, approximately one foot of sand will be placed over it. This initial sand layer will mix with the fine material without causing a mud wave to propagate across the site. After the first layer is placed, the remaining sand will be placed to +5 feet MLW over the site which is, the intertidal elevation needed for marsh restoration. Approximately 500,000 yd^3 of sand will be required. A floating dredge pipe with a directional baffle on the end will be used. The baffle can be used to force the floating pipe to move slowly in an arc across the ponded site, distributing a consistent thickness of sand over the site.

Geotextile Tube Protection for Southern Spit

Currently, the narrow, low crested southern spit of Kelly Island is all that remains for protection of the entrance to the Mahon River. Though it is outside the containment area discussed above, protection of the Mahon River entrance is important. Therefore, a geotextile tube revetment will be constructed along the spit. The design of the tube will generally follow the design criteria mentioned above for the geotextile tube core of the offshore dike. However, the condition of the spit at the time of construction is unknown, so detailed designs cannot be made at this time.

Habitat Characteristics and Considerations

The existing marsh and channels at Kelly island have been undergoing severe erosion for many years, and the shoreline has changed dramatically in recent years. The point that protects the mouth of the Mahon River has already lost all its salt marsh, and will probably be gone before this project is built. Inside the project (behind the CDF) there are two small intertidal channels that will be temporarily blocked during construction. The impacts resulting from such activities should be short-lived, and have almost no impact on ecological integrity of Kelly Island.

It is possible that by the time construction begins the eroded point at the southern end of Kelly Island may be gone due to continued erosion. In such a case, the southern end of the project may need redesign prior to construction.

The Kelly Island wetland restoration will initially require the construction of a closed area of about 60 acres using a sand berm with a geotextile tube core. A water control structure will allow tidal inundation of the area and access for aquatic organisms. The area will be completely enclosed before any fine grained dredge material is placed inside. The filled impoundment should be allowed to settle and consolidate for approximately one year from the last deposition of dredged material. During the consolidation period, common reed should be controlled with a herbicide, such as Rodeo, wherever it appears on the adjacent wetlands, dikes, or impounded area. Early control will facilitate a more effective re-vegetation process during year two.

Planting should occur during year two using native tidal wetland plants such as saltmarsh cordgrass (Spartina alternaflora, saltmeadow cordgrass (Spartina patens), salt marsh bulrush (Scirpus robustus), salt grass (Distichlis spicata), or three square (Scirpus pungens). The combination of species to be emphasized will depend upon soil and water salinities within the wetland restoration and water exchange. Plugs of vegetation taken from the adjacent marsh and seed collected from species in other areas should be inserted and/or broadcast over the impounded area. A reasonable estimate of the length of time required for vegetation to reach optimum density is two years.

During the third year after filling, water control structures similar to those used in the State of Delaware's Little Creek Wildlife Management Area should be installed at the north end of the restoration. The structures should be connected by a winding ditch 4 meters wide by 3 meters deep using an aquatic plant excavator (cookie cutter). Several shallow (0.5 - 1.0 meters) ponds ranging in size from 1 to 1.5 hectares should be selectively created throughout the impoundment and connected to the main ditch by smaller (2 meter width) ditches. Ponds and ditches should cover between 10 and 20 percent of the surface area of the restoration. Seeding open water areas with widgeon grass from surrounding impoundments will provide desirable submerged aquatic vegetation and a detritus base for aquatic invertebrates that are heavily used by shorebirds, wading birds and waterfowl.

Proper manipulation of the water control structures is vital to maintaining daily tidal exchange and ingress and egress of estuarine fishes and other organisms. All ditches and ponds should contain some permanent water to support mosquito-predaceous fish and submerged aquatic vegetation (SAV). Complete drawdowns should only be conducted to control nuisance algal blooms or aerate soils and should occur only for brief periods. A partial tidal exchange will occur through the water control structures twice daily, permitting oxygenation of the waters and exchange of nutrients and organisms. Exposed mudflats around the pond perimeters will be maintained during the shorebird migrations but the area will be maintained at full pool level during the winter months. Daily exchanges of sheet water over the emergent vegetation in the impoundment will occur on a regular basis.

After vegetation cover has become well established (3-4 years), a long term water management schedule must be implemented. The objectives of the water management plan will be to (1) facilitate important biological functions provided by normal tidal exchange; (2) encourage growth of the most desirable emergent vegetation permitted by soil and water conditions; (3) maintain fish populations in open water ponds and ditches to provide mosquito control; (4) ensure that all commercially and recreationally important fish species are able to enter and leave the area during critical periods; and (5) minimize the release of fine grained dredge material.

The importance of the movement of water into and throughout the wetland restoration cannot be over emphasized. The productivity and diversity are dependent upon the timing and magnitude of water exchange and flow. Water exchange controls soil and water salinities which, in turn, determine the kinds and productivity of the vegetation that can be maintained. Tidal waters salinity in the vicinity of Kelly Island normally range from a low of 5-10 ppt in the winter and spring to a high of 20-30 ppt during periods of extended low rainfall and high evaporation in the summer. Given these ranges of salinities, the most likely scenario for vegetation within the impoundment is composed of saltmarsh cordgrass (Spartina alterniflora) occurring in its long form along the ditches and pond edges and in its shorter forms in lower elevations of the marsh; saltmeadow cordgrass (Spartina patens) will dominate the higher elevations within the restoration that are less often flooded; (3) salt grass (Distichlis spicata) will appear irregularly in small patches where soil salinities area lowest; (4) Widgeon grass (Ruppia maritima) should occur in dense mats and dominate the ponds and ditches; and (5) nuisance vegetation, specifically common reed will aggressively pioneer into restoration and must be periodically controlled with herbicides. If water salinities within the restoration can be maintained between 15 and 25 ppt without substantially restricting organism exchange, the introduction of species such as salt marsh bulrush (Scirpus robustus) should be tried.

The ponds and ditches within the wetland restoration should produce and support substantially more resident fish species that in the open tide marsh (Whitman 1995). Mummichogs (Fundulus heteroclitus), sheepshead minnows (Cyprinodon variegatus) and silversides are among the resident species that are most abundant and serve to control mosquito production within the restoration. Anchovy (Anchoa mitchilli) and menhaden (Brevoortia tyrannus) typically enter the impoundment in July and remain until a total drawdown in the fall allows them to re-enter the estuary. Grass shrimp (Palaemonetes spp.), an important fish and waterfowl food should be abundant in the tidal ponds and blue crabs should enter the impoundment as young, mature, and provide abundant recreational crabbing opportunities.

Recreational and commercially important fish species that will use the impounded area included Atlantic croaker, spot, weakfish and white perch. These species do not appear to achieve significant growth to stay within these areas for long periods. In the case of these species, it is important to maintain water circulation throughout the summer months. Particularly important is the exit of these species during the total fall drawdown since it is unlikely that they can survive over winter with stabilized maximum water levels.

Ditches and ponds constructed inside of the restoration area within the deposited dredge material must also be allowed to settle and consolidate after construction before water can be released through the control structures. It is expected that once the dredged material is vegetated and ponds and ditches have been constructed, water can move in and out of the restoration without a measurable amount of fine grained material escaping.

To briefly summarize habitat considerations, all aspects of the Kelly Island design have been planned with fish and wildlife as the primary beneficiaries of the project, although shoreline erosion control is paramount to both protecting the refuge and accomplishing any quality habitat development. The recommended design still has enough flexibility so that prior to construction, a re-evaluation of design plans can be made to insure the best possible habitat combinations are achieved during construction.

Egg Island Point Wetland Restoration Design: Southeastern Shoreline

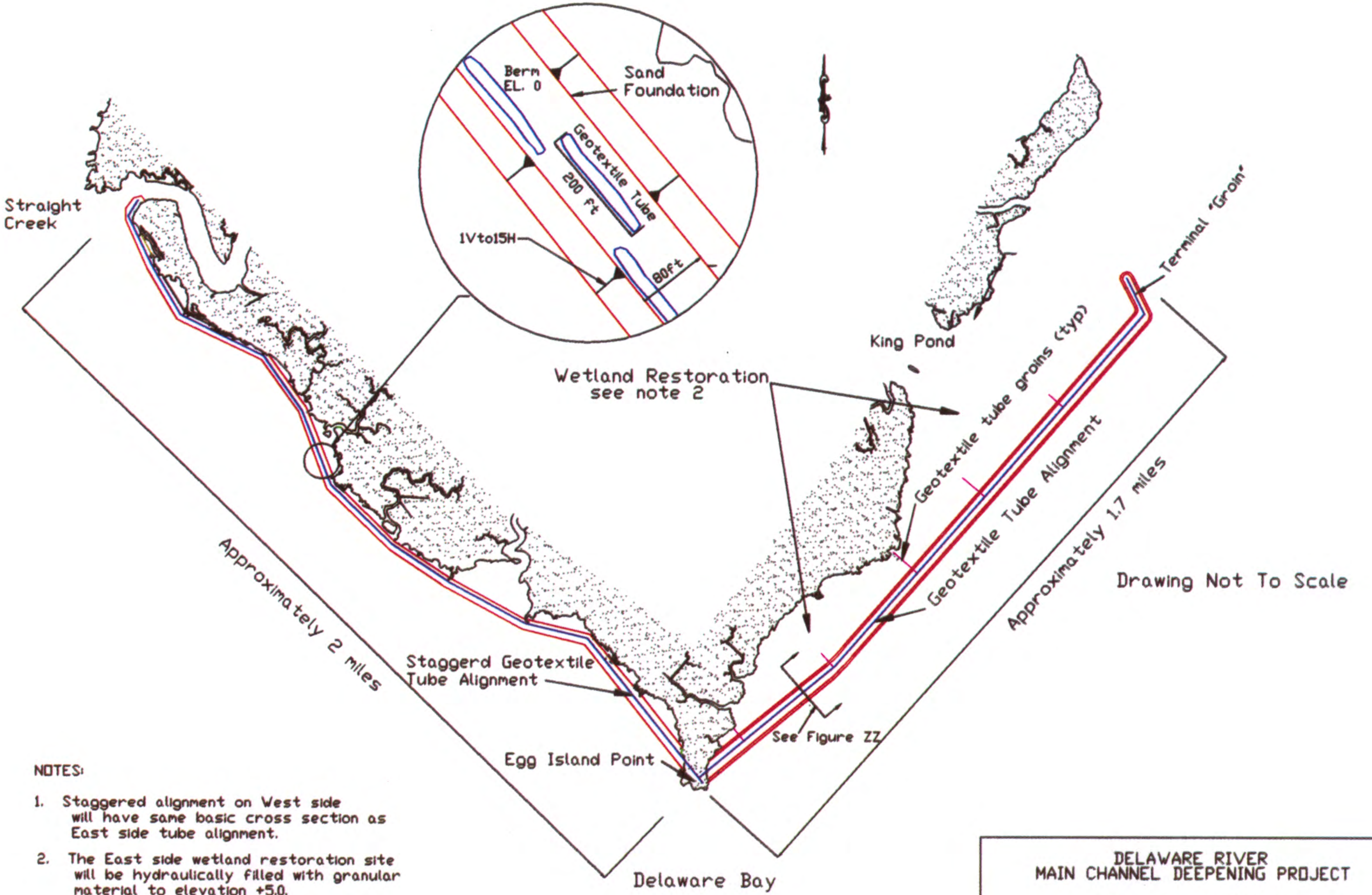
Structure Design of Geotextile Tubes

Much of the information for geotextile tubes and structures presented for Kelly Island is applicable to both shorelines of Egg Island Point. The northwest and southeast treatments, configurations, placements, and techniques differ considerably (Figure 3-6).

The southeastern side of the existing marsh at Egg Island Point will be protected by a single geotextile tube structure. The geotextile tube will be placed on top of a dredged material sand foundation built to elevation 0 feet MLW away from the eroding shoreline (Figure 3-7). The side slopes of the foundation are expected to reach 1:20. The crest elevation for the tube is expected to reach an elevation of +5 feet (±1) feet MLW. The area within the lee of the structure will be filled with sandy dredged material to an elevation of + 5 feet MLW. These elevations will be inundated daily during high tide periods which are expected to reach elevations of +5.5 feet MLW to +6.2 feet MLW (spring high tide). Consequently, waves will often overtop the project. The structure and the fill behind it should attenuate much of the wave energy.

Marsh protection structures generally extend at least a small distance above the high tide elevation to provide protection for a marsh. However, as mentioned in the sections for the Kelly Island design, observations of the local marshes and protection structures indicate that marsh vegetation may be adequately protected by structures that are between +5 feet MLW and +10 feet MLW. Since the single geotextile tube at Egg Island Point will be at +5 feet MLW with reaches of 0 to 1200 feet of very shallow water in its lee, wave energy over the structure should be attenuated sufficiently to protect the existing marsh and to support development of new marsh, especially near the existing marsh edge away from the geotextile tube.

If the structure foundation settles below 0 feet MLW or the



NOTES:

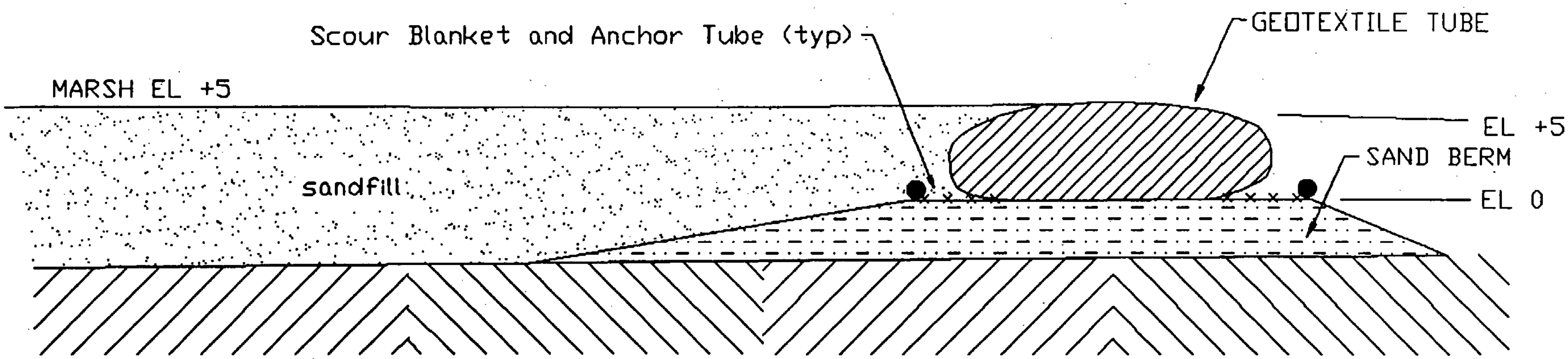
1. Staggered alignment on West side will have same basic cross section as East side tube alignment.
2. The East side wetland restoration site will be hydraulically filled with granular material to elevation +5.0.

DELAWARE RIVER
MAIN CHANNEL DEEPENING PROJECT

Egg Island Point
Wetland Restoration Site
PLAN

U.S. Army Corps of Engineers,
Philadelphia District

Figure 3-6



Drawing not to Scale

NOTES:

1. Geotextile Tube circumference is 30 feet.
2. Final in-place width of tube is approximately 8-10 feet.
3. Sand berm top width is 80 feet w/ 1V to 20H sideslopes.
4. Scour blanket to extend 15 feet from main tube.

DELAWARE RIVER
MAIN CHANNEL DEEPENING PROJECT

Egg Island Point
Wetland Restoration Site
Geotextile Tube/Berm CROSS SECTION

U.S. Army Corps of Engineers,
Philadelphia District

Figure 3-7

geotextile tube fails to achieve or maintain a crest elevation of +5 feet MLW after construction, then a contingency for construction of a second row of tubes will be planned. A higher structure in even a few locations will increase the wave attenuation performance of the overall structure. If only a few locations along the first row of tubes fail to achieve and maintain the desired elevation, then a second row of tubes might be placed only in those locations. If a second row of tubes is placed only in selected locations, then no influence on the tidal exchange would be expected. However, if the entire structure length is protected by a second row of tubes, then an alternate design for exchange may be needed.

Scour Blanket. Using the design wave height of 6.2 feet and a water depth at the structure of 6 feet, the recommended scour blanket width should be 13 feet. The scour blanket (geotextile fabric) will be anchored along its seaward edge with a factory-stitched anchor tube of one to two feet in diameter below 0 feet MLW, and it will be buried in the substrate.

As an added precaution, the scour blanket and anchor tube will be extended to either side of the tube. It is important to have the scour blanket on the leeward side of the tube to prevent overtopping wave scour from undermining the tube. Overtopping scour problems are more likely at this site than at the Kelly Island site due to the differences in breakwater heights.

Length of Geotextile Tube Segments. Geotextile tubes about 200 feet in length will be used. The use of tubes of this length improves the structure's integrity (i.e. should any particular tube be damaged, only a small section of the structure would suffer and could be more easily repaired). Experience has also shown that deploying more than 300 feet of geotextile tube at any one time can be difficult to control or hold in place while filling.

Geotextile Tube Fabric. Fabric needs for Egg Island Point are very similar to Kelly Island. Dredged material filling the tubes will be sandy, and the same wave and wind energies occur at both Egg Island Point and Kelly Island.

Planform Design

The region behind the structure on the southeastern shoreline of Egg Island Point will be filled with sandy dredged material to elevation of +5 feet MLW. This is equal to the elevation of the geotextile tube crest. The expected occurrence of events are that the area immediately behind the tubes will be scoured somewhat and, in general, material will be moved toward the existing marsh where a small berm or dune may form. Limited observations of a geotextile tube project at Smith Island in the Chesapeake Bay indicated that the sand in the lee of the tube (beyond the immediate scour area) maintained an elevation approximating that of the geotextile tube crest. The sand sloped very gradually upward toward the existing marsh. That project has been in place for only two years, and the planted marsh on the site is beginning to establish (Blama et al. 1995).

At the Egg Island Point project, as sand behind the breakwater (tubes) is pushed back toward the existing marsh, it may cover over some of the existing marsh. The amount of sand overwash will depend on the amount of wave energy exposure that the site receives before the project is densely colonized by marsh vegetation. The sand overwash may alter the existing marsh locally but should not be considered a long-term detriment.

Waves approaching the tubes obliquely will cause material within the project to move laterally across the project. No technique is available to determine how much transport will occur. However, any dominant wave direction will move the fill material in that direction. At Egg Island Point, waves are limited from the north and east due to land boundaries, but are fully exposed to waves from the south and west. Hence, the tendency should be for material to move north and east across the project. Initially, the adjustment of sand due to the wave climate may be dramatic, but as the sand achieves a more stable profile across the project area, the amount of sediment movement should diminish and then slow as vegetation colonizes the area.

If sand moves from behind the tube breakwater under the conditions described above, it should behave the same as the sand placed in the structure foundation. Sediment transport impacts are discussed in Section 9.0.

Tidal Exchange

Since the single row of tubes will be inundated by about 0.5 to 1.0 feet MHW along the entire length of the tube, additional measures are not necessary to ensure tidal flushing. In the event that a second row of tubes is needed as discussed above, then tidal flushing may be sufficiently accomplished by leaving a few gaps in the second row of tubes. The amount of such openings should be determined after the project is constructed, and natural exchange mechanisms have had time to develop.

Most of the concern for tidal exchange is for the region between the westernmost point of the island, and the marsh point that extends nearly to the breakwater line of tubes near the center of the project. It is assumed that regardless of the structure design, there will be sufficient tidal exchange through the easternmost open end of the tube breakwater (towards the Maurice River Cove).

Egg Island Point Wetland Restoration Design: Northwestern

Shoreline

The structures will consist of a staggered alignment of single geotextile tubes with one set of tubes close to the shoreline, and a second set of tubes about 50 feet offshore. A similar configuration has worked very well on the Louisiana Gulf Coast to protect eroding shoreline and to trap sediment to rebuild salt marsh (Davis, Irish, and Landin 1995). This configuration will help protect the shoreline without slowing ingress and egress for organisms. Openings between tubes will allow nearly full tidal access, while breaking waves that travel towards the shoreline.

Each geotextile tube will be placed on top of a dredged material sand foundation built to elevation 0 feet MLW away from the eroding shoreline. The sides of the foundation are expected to reach a 1:20 slope. The geotextile tubes in the staggered rows on the northwestern shoreline will also be 200 feet long, and achieve a projected height of five feet (MLW) after filling. Fabric tensile strength, tube and port design, placement, and filling will all be very similar to that of the southeastern shoreline of Egg Island Point and Kelly Island. No filling between the tubes and the shore will be carried out, and any sediment trapped behind the breakwater will be natural accretions.

3.3.3.3 Underwater Berm/Sand Stockpile

Broadkill Beach (LC-5): This 230 acre sand stock pile is located about 0.33 miles offshore of Broadkill Beach, Delaware (Plate 4). The average depth of the existing bottom is -8.0 feet MLW with a capacity of 1.9 million cubic yards of dredged material. This would raise the bottom depth to -3.0 feet MLW, including one foot of settlement. Sand will be placed at this site which will come from the main channel between Stations 472+000 to 485+000 and Stations 495+000 and 511+000 (Plate 25).

Slaughter Beach (MS-19): This 500 acre sand stock pile is located about 0.5 miles offshore of Slaughter Beach, Delaware (Plate 4). The average depth of the existing bottom is -8.0 feet MLW with a capacity of 2.8 million cubic yards of dredged material. This would raise the bottom depth to -3.0 feet MLW, including one foot of settlement. Sand will be placed at this site which will come from the main channel between Stations 440+000 to 455+000 and Stations 460+000 and 472+000 (Plate 25).

3.3.4 Environmental Considerations

3.3.4.1 Monitoring

Both environmental and engineering monitoring at Kelly Island and Egg Island Point are important. Monitoring gives a physical and biological baseline from which to plan and design the projects.

It provides documentation of events and project results, provides lessons learned to extrapolate to future similar projects, provides a success/failure track record, and gives needed information to determine if additional work or mid-course construction corrections are necessary (Landin 1992).

Most pre-construction data have been collected, and are available in a series of contract reports at the Philadelphia District office. These provide baseline biological information, contaminants assessments, construction feasibility, evaluation of potential beneficial uses of dredged material at a number of locations in the Bay, and engineering sediment and foundation data. While there is considerable information being compiled on the use of geotextile tubes as a substitute for more expensive riprap, some of the missing information specific to Delaware Bay can be obtained in the next two to three years prior to actual project construction. The Bodkin Island, Barren Island, and Smith Island projects in Chesapeake Bay, will be observed closely to determine final designs for both Kelly Island and Egg Island Point sites. Parameters to monitor for the overall project sites can be determined during evaluation of this information.

During project construction, there is a need to closely monitor construction techniques, and to allow for field flexibility should the contractor encounter difficulties with tubes, discharge channels and weirs, sand berms, and temporary dikes. It is important to monitor effluent run-off from the Kelly Island CDF in order to meet Delaware state water quality standards. It may also be necessary to make during-construction corrections to outfalls and filling rates, should any field problems be encountered. In addition, water quality will be monitored during construction and for 3-5 years following construction.

Post-construction monitoring is the most detailed and involves a number of requirements:

a. Surveys of as-built elevations to be sure that +5 feet MLW is achieved after consolidation and settling of dredged material at Kelly Island and southeast Egg Island Point.

b. Geotextile tube observations to maintain their integrity and profile, with mid-course corrections such as patches of rips, re-tying of ports, and other maintenance built into the process at all three locations (especially critical at Kelly Island and southeast Egg Island Point).

c. Physical and engineering evaluation of structures, marsh and berm soils, weirs, CDF entrances and tidal exchange at Kelly Island, and breakwater tidal exchange at Egg Island Point at southeast and northwest locations.

d. Biological evaluation of marsh vegetation, marsh soils, fish and wildlife colonization, survival and reproduction of any planted areas, and general ecological health of the two sites.

e. Comparison of the new marsh sites to nearby marshes (e.g. Kelly Island could be compared to a healthy marsh in the Mahon River and an eroding marsh on either side of the project; and Egg Island Point could be compared to a healthy marsh near Maurice River and an eroding marsh northeast or southwest of the Egg Island Point sites).

A detailed monitoring plan will be developed during the next study phase (Plans and Specifications), and will be completed prior to construction. The Philadelphia District will continue to closely coordinate work with the States of New Jersey and Delaware, the US Fish and Wildlife Service, the NOAA National Marine Fisheries Service, the US Environmental Protection Agency, and other concerned parties.

3.3.4.2 Operation and Maintenance of Kelly Island

An operation and maintenance plan will be developed that will include repairs to prevent any breach or potential breach from occurring. The innovative design of this facility will ensure that this area will successfully provide for the restoration of valuable wetland resources.

In light of the sensitivity of the oyster resources of the Kelly Island area certain contingency measures will be planned in the extremely unlikely event a breach occurs. These seed beds, existing under inherently low food supplies, do not have the reserves required to easily withstand increased turbidity levels that may result. Before the construction of the Kelly Island wetland restoration site, oyster populations will be measured to determine the status quo so that a comparison can be made in the unlikely event of a breach. Parameters to be measured include abundance, size (biomass) frequency, disease infection intensity, reproductive state, and recent mortality. If a breach occurs, the same parameters would be measured to determine the extent of impacts. If the impacts were significant, restoration of the bottom that was damaged by the release of silt would be done.

3.3.4.3 Environmental Windows

This effort is expected to be carried forward into actual construction and monitoring of both Kelly Island and Egg Island Point. For example, environmental windows will require a phased, timed approach to construction to avoid and minimize impacts on organisms, especially the horseshoe crabs and shorebirds. Placement of sand foundations would be accomplished prior to movement of crabs to the beaches for spawning. On-site observations would dictate work activities. It is not expected that crabs will move in great numbers into the eroded peaty areas at either site since they avoid reduced sediments smelling of hydrogen sulfide and greatly prefer sandy beaches.

While horseshoe crabs are spawning and the spring migration of shorebirds is occurring, geotextile tube breakwaters will be installed piecemeal. This type of construction only requires a small work area for the placement and filling of each tube, so that crabs and birds could be in the vicinity and not be impacted. Initially, tubes would be filled at points furthest from major spawning areas, the tubes would be filled at an expected rate of one to three per day. As construction moves closer to pertinent sandy beaches, spawning, hatching, and migration activities should be completed. After that point in time, the inside of the confined disposal facility (CDF) at Kelly Island would be filled with fine-grained material, and any additional "unconfined" material would be placed behind tubes at Egg Island Point. This back-filling work and placement of sand berms inside the breakwaters will coincide with the fall migration of shorebirds, but should not present a displacement problem. Shorebirds tend to feed on freshly placed dredged material in great numbers to take advantage of the food resources coming through the dredge pipes. The dredged material would then have about six months to sort and settle before crab spawning and spring migration recurred. Utilization of freshly pumped dredged material by numerous species of birds has been well documented for many years. This is especially so for Great Lakes, Gulf Coast, and Atlantic Coast shorebirds, seabirds, and wading birds, but has also been noted for geese, some duck species, and opportunistic feeding by such species as fish crows and bald eagles (Landin, Patin, and Allen 1989; Landin, Webb, and Knutson 1989).

There should be no impact on motile organisms such as finfish. There are many finfish species utilizing Delaware Bay, but most are accustomed to the natural turbidity of the Bay (US Fish and Wildlife Service 1980, 1994). While anecdotal reports indicate that shortnose sturgeons may have been caught in the bay in the past, no studies have been done to access their current use of this area The shortnose sturgeon is an endangered species that may be found in the Bay. Dredging activities in Delaware Bay are not known to have had an impact on this species.

From June to November, trained monitors are required on hopper dredges to record all sightings of sea turtles and marine mammals and other pertinent information.

3.3.5 50-Year Maintenance Plan

Maintenance material from the Delaware River Main Channel Deepening Project in Reach E will be disposed of at the existing Buoy 10 dredged material disposal site. If in the future, the wetland restoration areas become damaged or need more material, the use of dredged material from the maintenance of the main channel could be considered. The Corps of Engineers will maintain the Kelly Island wetland restoration, and remove any material that erodes from Kelly Island into the Mahon River navigation channel. Periodic surveys of the Mahon River channel will be done to determine the impacts of sediment eroding from Kelly Island.