Delaware Estuary
Regional Sediment Management Plan
White Paper

DREDGING AND DREDGED MATERIAL MANAGEMENT

August 2013

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Acronyms and Abbreviations

BMPS	Best Management Practices
C&D Canal	Chesapeake and Delaware Canal
CDF	Confined Disposal Facility
Co-op	Delaware River Basin Fish and Wildlife Management Cooperative
CY	Cubic yards
DMMP	Dredge Material Management Plans
DOTS	Dredging Operations Technical Support Program
Estuary/Basin	Delaware River Estuary/Basin
NEPA	National Environmental Policy Act
NJDEP	New Jersey Department of Environmental Protection
O&M	Operations and Maintenance
ODST	Office of Dredging and Sediment Technology (New Jersey)
RDT	Regional Dredging Team
RSM	Regional Sediment Management
RSMP	Regional Sediment Management Plan
RSMW	Regional Sediment Management Workgroup
USACE/Corps	U.S. Army Corps of Engineers

Introduction

Summary

This white paper on Dredging and Dredged Material Management in the Delaware Estuary was completed in support of the Delaware Estuary Regional Sediment Management Plan (RSMP). It is one of several white papers prepared in support of the RSMP.

The white paper is based on data collected from a variety of sources, primarily the U.S. Army Corps of Engineers (USACE/Corps), State agencies, and member groups from the Regional Sediment Management Workgroup (RSMW) and Regional Dredging Team (RDT) for the Delaware Estuary. Much of the data were provided by RDT, who is charged with tracking statistics on dredging in the Delaware River Estuary/Basin (Estuary/Basin).

The information contained in this document is meant to aid the RSMW in developing the RSMP, which will provide recommendations for sediment-related management in the Estuary/Basin. It is anticipated that the RDT will continue to update dredging-related data for use in evaluating trends, future needs and successes of recommendations implemented as a result of the RSMP. The RDT will also be integral to the team implementing dredged material management options related to beneficial use and restoration projects that result from the RSMP.

The white paper focuses on the following topics regarding dredging and dredged material management for all dredging projects in the Delaware River Basin/Estuary (Federal/private, maintenance/new improvements):

> Dredging Methods/Procedures

> Dredge Material Management/Disposal (Placement) Alternatives/Options

Peer Review

This white paper was reviewed by the RSMW committee members as well as other representatives from the USACE Philadelphia District not serving on the RSMW. The white paper was also reviewed by members of the Delaware Estuary RDT.

Purpose

The purpose of this white paper is to provide support information and recommendations to the RSMW regarding dredging operations (methods) and dredged material management (disposal, beneficial use) for maintaining navigation channels and berths (Federal and non-Federal) within the Delaware Estuary/River and its tributaries (Schuylkill, Christina, Salem, Maurice Rivers, and others) for use in preparing a RSMP. It will address all dredging interests in the Delaware Estuary: Federal and private (non-Federal).

Goals/Objectives

The RSMW has developed goals and objectives for each of the four white paper topic. For dredging and dredged material management, the goals and objectives include:

> *Evaluate and continually improve dredging and dredged material management activities such that navigational (commerce) and recreational needs are met while meeting environmental protection/restoration/enhancement goals.*

At the root of these goals is that maintenance of navigation channels and berthing areas/facilities is a priority, and that dredging and dredged material management methods meet environmental standards. Both sediment and dredged material should be promoted as a resource for ecosystem needs.

Data Sources

Data sources are primarily the RDT and USACE Philadelphia District. The RDT has been charged with inventorying and reporting on data collected from the Federal activities in the basin as well as private activities, which include those undertaken by State, municipal, and private operations/entities. Included in Appendix A and B are tables summarizing data collected and inventoried by the USACE on behalf of the RDT. Additional historical data is included as Appendix D and Appendix E (information from the Environmental Assessment for the Delaware River Main Channel Deepening project).

For several decades, the Philadelphia District has compiled data on volumes and quality of material dredged from the Delaware River/Estuary navigation channels and berthing areas. The USACE has also inventoried the volumes of dredged material used from Federal projects/facilities for various types of beneficial use within the basin. Material has also been used beneficially by private dredging operations, but the volumes have not been quantified for this paper. The historical information shows trends that are useful in projecting future sediment management needs in the basin.

The Delaware Estuary/Delaware River Basin – Boundaries

The Delaware Estuary extends from Trenton, New Jersey to the Delaware Bay entrance (transect line between Cape May, New Jersey and Cape Henlopen, Delaware), covers an area of approximately 800 square miles, and encompasses land in the States of New Jersey, Delaware and the Commonwealth of Pennsylvania (Figure 1). The watershed of the Delaware River Basin encompasses a much larger area, and originates in headwaters in the State of New York. The Delaware River is situated in one of the most densely populated areas in the country while simultaneously hosting some of the country's most unique ecosystems and natural resources.

Federal Dredging Interests

Background

The Delaware River provides a commercial navigation route from Trenton, New Jersey, to the Atlantic Ocean. There are major ports at Philadelphia, Pennsylvania; Camden, New Jersey; and Wilmington, Delaware. There are also smaller commercial navigation facilities along the river as far south as Delaware City, DE and Salem, NJ. The navigation channel extends 133 miles from the mouth of the Delaware Bay to the marine terminal at Trenton, New Jersey (Figure 1). The Port of Philadelphia and associated regional ports and industries on the Delaware River (such as the Port of Wilmington in Delaware, and the Beckett and Broadway Terminals in New Jersey) support one of the busiest navigation corridors in the U.S.

Dredging activities along the Delaware River are dominated by the USACE, which needs to maintain Federal navigation channels and berths. Federal channels for the Delaware Estuary are shown in Table 1. Navigation improvements to the river were first authorized by Congress in 1836. Deep- draft navigation projects in the estuary include: (1) Delaware River, Philadelphia, Pennsylvania, to Trenton, New Jersey; (2) Delaware River, Philadelphia to the Sea; (3) Delaware River at Camden, New Jersey; (4) Schuylkill River, Philadelphia; and (5) Wilmington Harbor, Christina River, Delaware. Figure 1 shows the Authorized Channel Alignment.

21 April 2011

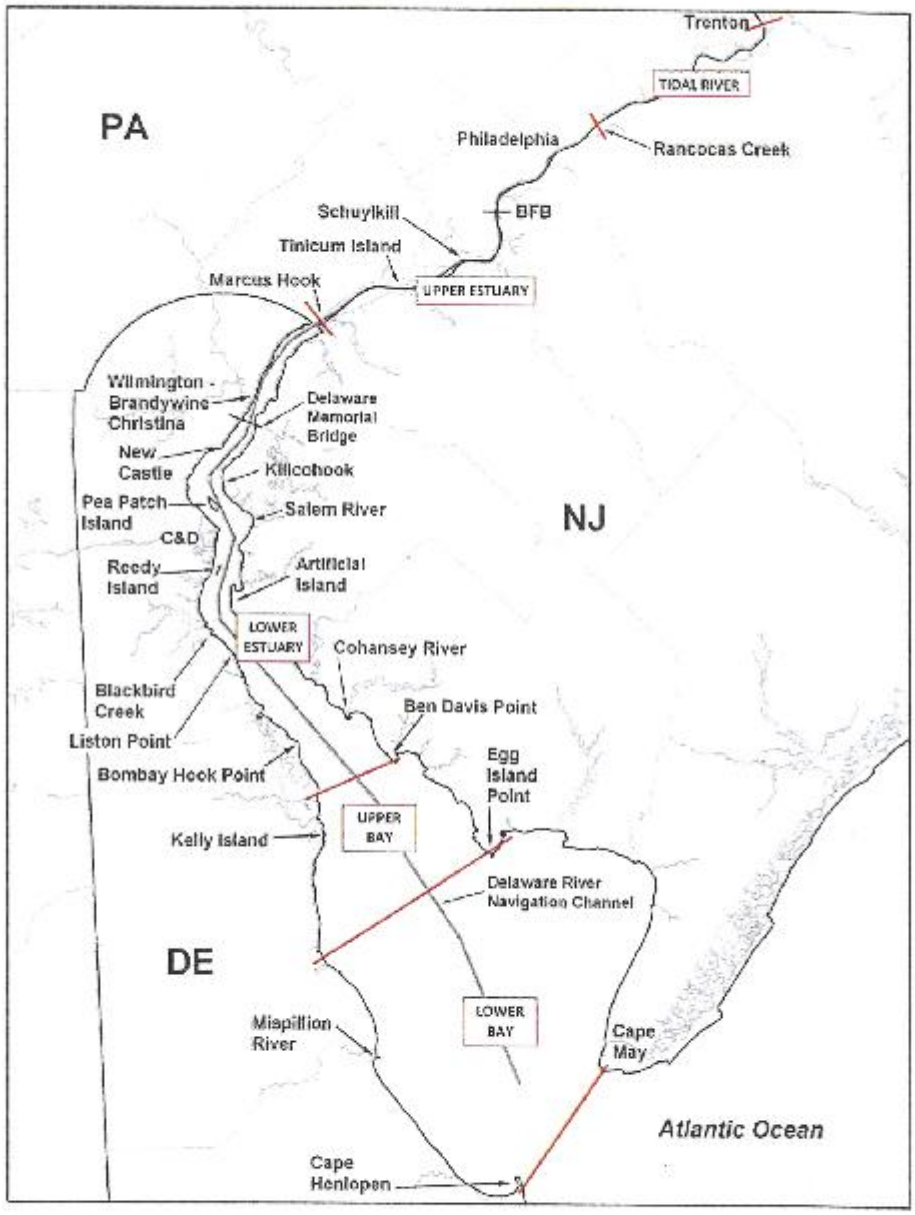

Figure 1 - Location Map

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Figure 1: Federal Project/Ranges Locations Map

Table 1: Authorized Federal Channels for the Delaware Estuary

Project Description	Distance in Miles	Depth in Feet	Width in Feet
Delaware River	24	40	400
Philadelphia to Trenton	5	35	300
	1	varies	200
		(20-8)	
Delaware River	55	40	1000
Philadelphia to the Sea	43	40	800
	9	40	800 to 400
Delaware River	4	varies	800
At Camden		40 to 18	
Schuylkill River	3.5	33	300 to 400
	1	26	200
	2.5	22	200
Christiana River	1	38	340
Wilmington Harbor	0.5	35	400
	4	21	250 to 200
	4	10 to 7	200 to 100

There are also 17 anchorage areas between Delaware Bay and Philadelphia. Six of the anchorages are authorized under the Philadelphia to the Sea project; the remaining eleven are natural deep water areas. The authorized anchorages are located at Port Richmond, Gloucester, Mantua Creek, Marcus Hook, Reedy Point, and Deepwater Point.

Dredging in the Delaware Estuary has primarily been dominated by maintenance dredging over the last several decades (since the deepening of the main navigation channel to 40 feet). There are several proposals for new dredging activities in the Delaware River Basin/Estuary that include deepening of the Philadelphia to the Sea main channel to 45 feet, deepening of existing berths in this portion of the Delaware River, and several new berths (Southport Marine Terminal and the Port of Paulsboro) for commercial operations. Each is in a different stage in the process of approval/implementation or regulatory review.

Due to the physical dynamics of the Delaware River (described in detail in the *Sediment Quantity and Dynamics White Paper*), there are locations where sediment accumulates rapidly and must be frequently removed by dredging. These sediment “depo-centers” include the Marcus Hook, Deepwater, and New Castle Ranges of the Philadelphia to the Sea project, and the Wilmington Harbor project on the Christina River.

The USACE is responsible for maintaining Federal navigation channels and anchorages. Maintenance dredging removes sediment that has accumulated in navigation channels and port berthing areas, reducing available depth and hindering navigation. Most of the present dredging in the Delaware Estuary is performed to maintain existing navigation channels, although some new dredging has been performed in the past two years as part of the plan to deepen the Philadelphia to the Sea project to 45 feet. Because the Delaware River continuously transports sediment from upland areas in its watershed to the

estuary, maintenance dredging is a near continuous process. Maintenance dredging of Federal navigation projects within the estuary has averaged about 4 million cubic yards (CY) per year over the last decade, at a cost of approximately $8 million annually (averaging $2.00 – $5.00/CY). Material from maintenance dredging is almost exclusively placed onshore in diked areas called upland Confined Disposal Facilities (CDFs).

While approximately 95% of the maintenance dredged material within the Delaware Estuary comes from Federal activities, dredging of private berth and access channels is also required periodically to maintain access between the main navigation channel and shore-based commercial/industrial and small craft harbor facilities (Section I-G). An average of about 350,000 cubic yards per year (5% of the total annual dredged material volume) is dredged from private facilities.

The principal types of dredges used on the Delaware River and its tributaries include (1) hydraulic cutter-head, (2) hopper, and (3) bucket. Appendix C is a summary of the types of dredging equipment traditionally used by the USACE Philadelphia District in the Delaware Estuary.

The majority of the maintenance dredging is performed by private contractors under USACE that use hydraulic cutter-head dredges. The hydraulic cutter-head rotates against the bottom sediment and a mixture of sediment solids and water is drawn in by suction. The dredged material slurry is then pumped through a pipeline and discharged into an upland CDF. The swing speed of the dredge is monitored and controlled to minimize turbidity at the cutterhead. Some of the Delaware River dredging is done by the Hopper Dredge *McFarland*, which is managed by the Philadelphia District, USACE.

In the Philadelphia to Trenton project, most dredging is performed with contractor-operated hydraulic pipeline dredges, although the *McFarland* has been employed on several occasions over the past decade. The hydraulic pipeline dredges are of the cutter-head type.

The USACE hopper dredge *McFarland* is a seagoing vessel equipped with centrifugal pumps that draw in a mixture of water and excavated material through vacuum suction. The material is discharged into hoppers contained in the hull of the vessel, without overflow. During loading, economics dictate close controls of the suction depths and the speed of the vessel, which results in minimal turbidity at the suction head. When full, the *McFarland* proceeds to a mooring barge and discharges its loaded hoppers through a pipeline to an upland CDF. Prior to about 1955, dredged material was typically bottom dumped into subaqueous basins from which it was later pumped ashore by a pipeline dredge. At present, essentially all dredged material is discharged directly into CDFs.

Dredging of private berth and access channels is also periodically required to maintain access between the main channel and shore-based commercial/industrial facilities. An average of about 350,000 cubic yards per year is dredged from private facilities. Although not a Federal maintenance activity, private birth and access channel dredging is controlled and regulated by both Federal and State permits and includes both industrial/commercial maintenance and small craft harbor maintenance. The permit process requires compliance with current environmental statutes including the National Environmental Policy Act (NEPA).

The USACE initiated a program several decades ago to develop a cost-effective and sustainable long range dredged material disposal plan that resulted in the development of a series of Federally-owned upland CDFs for the Philadelphia to the Sea project. Historically, these facilities have been able to handle the maintenance needs for the Federal activities at a reasonable cost. However, despite these planning efforts, the capacity of some of the currently active upland CDFs within the estuary is potentially limited. To date, the USACE has regenerated capacity in some upland CDFs by raising the berm heights and through limited beneficial use practices. The beneficial use of dredged material excavated from these upland CDFs creates renewable capacity. Projections (detailed in the *Sediment Quantity and Dynamics White Paper*) indicate CDFs have the capacity to manage expected needs for Federal dredging for maintenance and potential new projects provided capacity continues to be regenerated in some of the priority use CDFs. Information on the projections for capacity is included as Appendix A.

In selecting dredged material disposal sites, the USACE coordinates with the various agencies charged with protecting the environment. Potential new disposal locations that are key fish and wildlife areas have been removed from consideration. Factors taken into consideration for disposal area selection focus on the effect of the disposal area on the local environment. These factors include the potential impact of the disposal area on fish and wildlife, water pollution, estuary ecology, recreation, economics, and planning requirements/needs of the local community. The selection of a proposed disposal area is coordinated with local and regional planning commissions, the Delaware River Basin Commission, and Federal and State environmental protection/resource agencies. The USACE has not constructed any disposal areas in wetlands for the Philadelphia to the Sea project in the last 65 years; likewise, no disposal areas have been constructed in wetlands along the Philadelphia to Trenton channel in the last 50 years. Similar disposal area selection criteria and considerations have been evaluated historically for private sector solutions to the disposal of dredged material.

These practices have directed disposal activities that would have negative impacts on habitat away from wetlands and other vital habitats in the estuary. However, the site selection process has also directed dredging managers away from disposal projects that could potentially improve wetlands or other habitats through beneficial use.

The USACE has tracked dredge material volumes/statistics from the navigation channels and berth areas for years. Trend data are included in Appendix A and details described in the *Sediment Quantity and Dynamics White Paper*. Appendix F is a table from the April 2009 Environmental Assessment for the Delaware River Channel Deepening Project that provides additional data on dredged material volumes.

Projections for the Main Stem Channel Maintenance include approximately 3 million cubic yards of material to be dredged each year over the 5- to 10-year planning period. Theoretically, future maintenance dredged material volumes are anticipated to remain the same. During the 5 to 10 year planning window as in the last few years, maintenance dredged material volumes are projected to increase once the Main Channel Deepening project is completed. In the absence of other dredging projects, almost all existing upland CDFs have the capacity to manage the projected need for the Philadelphia to Sea reach (exceptions include Wilmington South); especially if materials contained in the upland CDFs can be beneficially used in an appropriate time period. From a planning perspective, any beneficial use projects that upland CDF managers are able to implement will only add to the available capacity for future activities.

Philadelphia to the Sea

The Philadelphia to the Sea project is currently maintained at a depth of 40 feet, with proposed deepening to 45 feet. There is over 100 million tons of waterborne freight travel on this important route annually. The regional economy is highly dependent on maintenance of the Philadelphia to the Sea navigation channel to depths sufficient to support deep draft vessels.

The Philadelphia to the Sea project requires the largest portion of maintenance dredging in the estuary, typically between 2 and 3 million cubic yards annually. The cost of dredging using current approaches/operations depends on the distance between the dredging operation and the disposal site. Disposal areas nearest to a dredging site are used most frequently. The repetitive and frequent use of these facilities requires more frequent management of the material at the site. In recent years, beneficial re-use of dredged material dewatered in upland CDFs has helped keep operation and maintenance costs down.

Dredged material from Federal activities in the Philadelphia to the Sea project is disposed of in a series of Federally-owned upland CDFs (Figure 2). The active Federal government-owned disposal sites for maintenance dredging in the estuary, listed in down-river order from Philadelphia, are: Fort Mifflin, National Park, Pedricktown, Penns Grove, Penns Neck, Killcohook, and Artificial Island. Artificial Island is presently used only when dredging is performed in the Reedy Island Range area. Figure 2 shows that the largest Federally-owned CDFs, representing most of the available dredged material disposal capacity in the estuary, are located in close proximity to the Delaware River main navigation channel reaches where most of the dredging is conducted.

One open-water disposal area, located near Buoy 10 west of Cape May, NJ, is maintained in the lower Delaware Bay to permit disposal of a small amount of material resulting from shoaling near that location. The amount of shoaling in this range varies so dredging does not occur on a regular basis. Approximately 500,000 cubic yards are dredged every 5 years in the lower Delaware Bay, all of which goes to Buoy 10.

The USACE dredged material managers indicate that under current procedures/economics/policies/ infrastructure, the most critical problem for dredged material management is to locate disposal sites close to the areas of greatest shoaling. Four high shoaling-rate locations within the navigation channel (sediment “depo-centers”), all of which lie in a 30 km reach from the Chesapeake and Delaware Canal (C&D Canal) upstream to Marcus Hook, require about 80% of the maintenance dredging within the entire estuary.

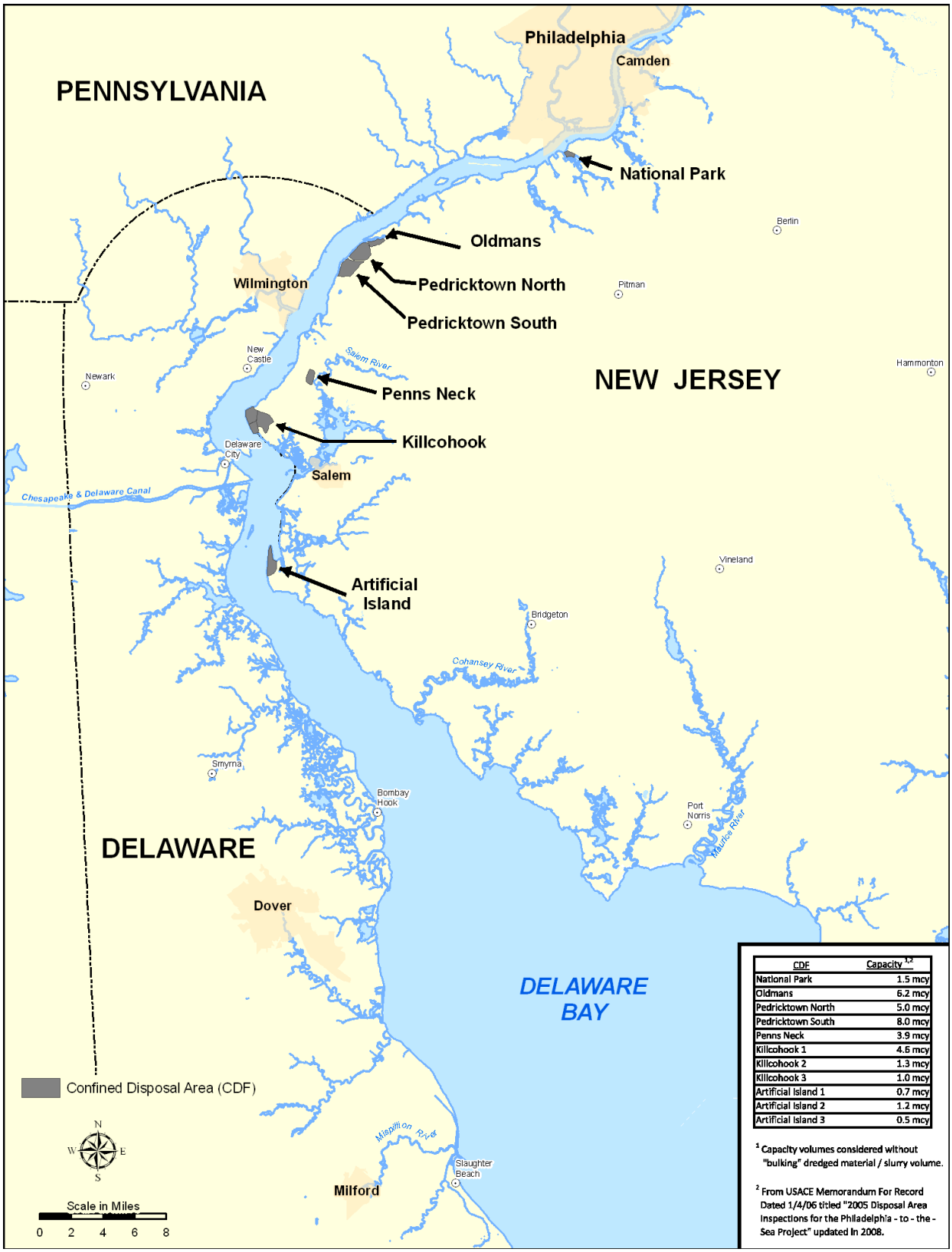
Philadelphia to Trenton

The Philadelphia District is required to maintain the Delaware River Federal navigation channel from Allegheny Avenue in Philadelphia to Trenton, New Jersey. The table in 1F shows required depths of the reaches. The majority of the reach is maintained to 40 feet. The Philadelphia to Trenton section of the Delaware River was last dredged in 1993, which equates to approximately 900,000 CY of material each dredging cycle. However, emergency dredging of critical shoals was performed in 2007.

Pennsylvania and New Jersey are required to provide the disposal sites for their respective portions of the river (Figure 2). New Jersey, under Chapter 18, Laws of 1956, agreed to furnish, free of cost, all lands, easements, rights of way, and dredged material disposal areas within the State. The portion of the Delaware River in which New Jersey has provided upland CDFs extends from Allegheny Avenue, Philadelphia, PA to the New Jersey Turnpike Bridge over the Delaware River in Florence, New Jersey. Pennsylvania provides suitable disposal capacity to support USACE maintenance dredging operations along both the upper reach of the 40-foot channel and in the 25-foot project channel, which is intended solely for use by New Jersey port facilities. In addition, a partnership between Pennsylvania, Waste Management Inc., and the USACE aimed at the beneficial use of dredged material removed from the upper reach of the 40-foot channel continues to be managed successfully, resulting in the annual placement (beneficial use) of approximately 500,000 CY on nearby landfills for use as daily cover.

There are nine dredged material upland CDFs located on the Delaware River between Philadelphia and Trenton. These facilities are not Federally owned, but are provided by lease from the Commonwealth of Pennsylvania and the State of New Jersey. All (100%) of the dredged material placed at the Money Island site is beneficially used for daily cover at a nearby landfill managed by Waste Management, Inc. Seven existing locations that were previously used for dredged material disposal have not been maintained by the New Jersey Department of Environmental Protection (NJDEP). In 2008, NJDEP agreed to implement a dredged material management plan for the New Jersey section of the Delaware River to facilitate the re-establishment of the upland CDFs.

Figure 2: USACE Owned CDF Locations and Capacity



CDF	Capacity [1,2]
National Park	1.5 mcy
Oldmans	6.2 mcy
Pedricktown North	5.0 mcy
Pedricktown South	8.0 mcy
Penns Neck	3.9 mcy
Killcohook 1	4.6 mcy
Killcohook 2	1.3 mcy
Killcohook 3	1.0 mcy
Artificial Island 1	0.7 mcy
Artificial Island 2	1.2 mcy
Artificial Island 3	0.5 mcy

[1] Capacity volumes considered without "bulking" dredged material / slurry volume.

[2] From USACE Memorandum For Record Dated 1/4/06 titled "2005 Disposal Area Inspections for the Philadelphia - to - the - Sea Project" updated in 2008.

Recently, the NJDEP Office of Dredging and Sediment Technology (ODST) initiated an evaluation of the seven existing upland CDFs, as well as other potential dredged material disposal sites proximate to the Delaware River. The ODST coordinated with various natural resource agencies, and determined that the following four upland CDFs appear to be most promising for use as disposal sites for the Philadelphia to Trenton project, while also meeting the USACE dredging equipment specifications (Figure 2):

- Delanco/Beverly CDF (#3)
- Cinnaminson CDF (#5)
- Burlington Island CDF (#2)
- Palymra Cove CDF (#6)

The ODST performed a title search of each of the above referenced disposal sites, and it appears that portions of a particular site(s) may not be entirely owned by the State of New Jersey. Specifically, certain portions may be owned by a municipality or deeded to other persons and still show unresolved tideland conveyances present on the property.

Wilmington Harbor

Approximately 750,000 cubic yards of dredged material are removed yearly from the Wilmington Harbor Federal channel and associated private berth area. In recent years, the removal of one million cubic yards of dredged material has been a challenge due to funding issues.

Wilmington Harbor is dredged by contractor-operated hydraulic cutter-head dredges, using Corps-furnished dredged material disposal areas. These disposal sites include the Wilmington Harbor North and Wilmington Harbor South disposal areas at the mouth of the Christina River. These upland CDFs may not have capacity for projected maintenance needs, and alternatives are being evaluated.

Schuylkill River

Maintenance dredging of the Schuylkill River, by the USACE, is limited to the navigation channel from the Delaware River to University Avenue, Philadelphia. Before the 1970s, a coal culm removal project continued to remove deposits resulting from upstream coal mining activity. The Schuylkill River project is maintained by contractor-operated hydraulic cutter-head dredges. The typical maintenance cycle is about two years, with a dredged material quantity of 200,000 to 300,000 cubic yards. The dredge material is placed in the Fort Mifflin CDF. In recent years, dredging has not occurred every two years due to lack of funding.

Salem and Maurice Rivers

Although the Salem River and Maurice River are authorized Federal navigation channels, the USACE has not conducted maintenance dredging of these two projects for some time. In the past, when the Salem River was dredged, material was sent to the USACE Killcohook Upland CDF for disposal.

Private/Non-Federal Interests

In addition to the Federal navigation channels and anchorages in the Delaware River, there are a number of private/non-Federal interests that are an important component of the economy along the river and require routine maintenance dredging. These entities include private industrial berths for off-loading oil/gas products, marinas for recreational boating or commercial fishing, and municipal and State-owned marinas and berths.

Maintenance dredging for these activities totals approximately 350,000 cubic yards of dredged material a year, a small fraction of the total dredged from the estuary. The maintenance of these private areas has a significant impact on the economy along the river. Private/non-Federal interests have been responsible

for providing their own dredged material disposal sites, or have collaborated in certain reaches of the river to use a centralized disposal area. Due to the relatively small volumes of dredged material, the private/non-Federal entities often rely on cooperation and coordinating dredging activities to reduce the cost of dredged material management.

Many of the private/non-Federal interests have contracted dredges that historically disposed of dredged material at a private disposal facility called White's Basin. This facility has not been available for a few years as the property owner, America Atlantic, addresses local and county issues and explores potential sale of the property. Recently, the site was made temporarily available for private users.

Multiple viable alternatives for private sector dredged material disposal and/or beneficial use are needed. The USACE is working with private/non-Federal interests to develop a short term plan that will allow them to use the Federal disposal facilities contingent on the removal of existing dredged material from the upland CDFs prior to the disposal of dredged material from the private berths.

The USACE has tracked dredge material volumes/statistics from the private berths for years and analyzed for trends (Appendix A). Details are described in the *Sediment Quantity and Dynamics White Paper*.

Projections are for approximately 350,000 cubic yards of dredged material a year over the 5- to 10-year planning period. The private berths need a plan for disposal. Maintenance dredging has not been completed for several years (except at sites that have a private disposal facility) due to the temporary closure of White's Basin. Efforts are under way on several fronts to find options for these private entities. Some of the efforts include:

> Temporary use of Federal facilities based on a commitment to remove an equal quantity of material for beneficial use prior to disposal.

> NJDOT is conducting a study to inventory previously approved disposal facilities for potential use by the State or other entities. The re-establishment of these disposal facilities has presented challenges due to the State permitting criteria and opposition by local municipalities.

> Searches for beneficial use projects.

> Searches for multiple disposal facilities and/or beneficial use sites in addition to White's Basin.

There is an effort underway by NJDOT to evaluate the potential use of abandoned/formerly used upland CDF sites. These sites were developed by various entities over the years prior to the USACE upland CDF site development program and the use of White's Basin. The NJDOT is evaluating former CDFs owned/maintained by the State of New Jersey or private entities that have been abandoned for retrofit potential. The potential for retrofits is being assessed specifically for maintenance dredging activities for private/non-Federal berths. The assessment is also inventorying available dredged material for the beneficial use market. New Jersey has indicated that retrofitting presents several challenges, the primary one regulatory. The current approach to wetlands delineation on these managed sites, and in some instances the use of these managed sites by protected species, presents challenges. Other challenges include retrofit construction costs and testing of the dredged material.

Private/non-Federal interests are required to obtain permits from the USACE and appropriate State agencies for their dredging and dredged material management activities. The permitting process ensures the projects comply with current environmental statutes and NEPA. The permits include conditions on the activities, dredging methods specifications, disposal area(s), dredging windows (seasonal restrictions), and other management requirements to address environmental protection concerns.

Sediment as a Resource

The RSMW considers sediment/dredged material to be a resource, which is integral to planning dredging and dredged material management activities. This view of sediments as a resource raises interesting considerations concerning the current assessment, regulations, potential markets for, and uses of dredged material. As described in the *Sediment Quantity and Dynamics White Paper*, sediment dynamics are an important process for maintaining the health of the Delaware River/Estuary ecosystem. A formal integrated sediment management program would facilitate the selection of location and determination of volume and frequency required to dredge and maintain navigation channels and berths. A sediment transport model has not been developed. If completed, it could present a great step forward in understanding these processes and refining recommendations made by the RSMW.

While it is recommended that sediment be considered a resource, historical activities have long affected sediment distribution or quality/composition through upland disposal/sequestration or due to contamination. Each of these activities affects potential use of some sediment as a viable resource. The *Sediment Quality White Paper* has conducted a planning-level evaluation of the suitability of sediments for aquatic habitat and potential upland beneficial uses of dredged material. Specific potential beneficial uses of sediment resulting from dredging operations are considered in the *Restoration and Beneficial Use White Paper*.

Currently, various Federal regulatory and resource agencies, and their equivalents in each of the three States bordering the Delaware River/Estuary (DE/NJ/PA), have independent regulatory programs to manage dredged material that differ from one another in some significant ways. These differences can present challenges for the USACE and other organizations that perform dredging making it difficult to develop a single consistent program for the comprehensive management of sediment and dredged material in the Delaware Estuary/River Basin. In particular, some regulatory agencies consider sediments to be pollutants or solid waste, and manage them accordingly. Overcoming these challenges, and developing a common vision of sediment and dredged material as a valuable resource, will facilitate many opportunities for dredged material management.

Advocacy

The RSMW is encouraging continued support of the economic vitality of the region through maintenance of navigation channels and berthing areas, and promoting the use of dredged material as a resource to be employed for environmental restoration and beneficial use projects. The RSMW also supports the use of dredging and dredged material management activities that consider the effects of sediment dynamics on the Delaware River/Estuary ecosystem.

In order to realize increased dredged material beneficial uses and sediment reduction strategies in the Delaware Estuary/Basin, and to positively impact dredging operations in the Estuary/Basin, an advocate like the RSMW or Partnership for the Delaware Estuary will be needed to facilitate such policy and programmatic changes.

RSMP Workgroup/Regional Dredging Team

Dredging and dredged material management are being evaluated in the Delaware Estuary by the RSMW and the RDT. The USACE has established these groups as part of a strategic plan to address not only regional sediment management, but also the beneficial use of dredged material within the Delaware Basin/Estuary. The RSMW is looking at long term planning for dredging operations and management of the resultant sediments, as well as sediment sources in general in the estuary/basin. The RDT is primarily focusing on day-to-day operations and activities, tracking dredging projects and disposal facilities, and monitoring permit actions to ensure navigation needs are met.

The RDT has, and will continue to provide, data to the RSMW regarding dredging activities/statistics in the Delaware Basin/Estuary. Throughout their projected life span, the two groups will continue to meeting to discuss dredging activities in the basin.

Upon completion of the RSMP, RSMW anticipates conducting an implementation workshop to identify the strategies, programmatic approaches, funding framework, and preliminary types of projects to consider during the initial planning phases of RSMP implementation. The RSMP implementation workshop is intended to provide opportunities for collaboration and inclusion of various entities throughout the Basin/Estuary. The RDT will serve a significant role in promoting and tracking dredging and dredged material management components of the RSMP implementation.

Background – Estuary/River Basin Sediments

Sources of Sediment in the Delaware

Sources of sediment and sediment processes/dynamics within the Delaware River Estuary/Basin are discussed in the *Sediment Quantity and Dynamics White Paper*. To understand the dredging regime in the Delaware River, the source and quality of the sediments in the channel needs to be understood. The following summary provides context to the sources of sediments which affect the dredged material management approaches discussed in this paper.

Sediment sources in the Delaware River affecting navigation channels/berths include:

- Upland sources from exposed soils in the upper watershed
  - Non-point sources such as agriculture or construction sites
  - Point sources such as combined sewer outfalls
- Erosion of stream banks from contributing waters
- Erosion from the banks of the Delaware River, including fringing marshes
- Scouring of the river bottom.

Sediments entering the basin originate from sites of varying land cover/uses such as: agriculture, residential/commercial development, silviculture, urban centers, industrial sites, and others.

Information developed by the USACE indicates the sources of new sediment in the basin primarily originate from the Delaware River above Trenton (59%), with 14% from the Schuylkill River, and 4% from the Christina River.

General Sediment Characteristics

Characteristics of the sediment in the Delaware River Basin/Estuary are described in the *Sediment Quantity and Dynamics White Paper* and the *Sediment Quality White Paper*. In general, the Delaware Estuary is a muddy (fine particulate) system in its upper reaches. Sediment entering the aquatic ecosystem comes from a variety of soil associations. The mechanics of transport within the basin tend to affect the distribution and types of sediments found in any given location in the navigation channels and berth areas. The character and composition of the sediments varies depending on the location in the basin. There are some pollutants of concern at elevated levels at specific locales that may require targeted management approaches. Material dredged from the navigation channels is generally of suitable character for various uses including: construction; beach nourishment; fill for development; ecological restoration; and others.

The quality of the sediments in the estuary is generally suitable for a variety of beneficial uses. The *Sediment Quality White Paper* contains a planning-level discussion of the characteristics/quality of the sediment within the estuary. The data evaluated in the *Sediment Quality White Paper* indicates that almost all of the sediments may be suitable for some type of upland use, while a significant portion of the sediment appears to be suitable for aquatic habitat uses. There are significant opportunities for alternative beneficial use/restoration projects within the basin, which could affect future dredged material management strategies. Potential upland and aquatic uses for sediment are discussed in the *Restoration and Beneficial Use White Paper*. Large volumes of dredged material from the navigation channels are potentially suitable for various uses, including construction; beach nourishment; fill for development; ecological restoration; and others.

Matching Material and Use

There is currently a significant inventory of sediments available for use in the Federally-owned and operated upland CDFs. There is an inventory of abandoned and currently serviceable State and private disposal facilities along the Delaware River Estuary with a significant volume of sediments available for use. Additionally, maintenance dredging for both Federal and private sector needs will generate significant volumes of material for disposal/use in the near term, and likely in the long term. Under current practices, dredged material is disposed in upland CDFs. If beneficial use is contemplated, for the most part it will result in of removal of dredged material from the CDFs after dewatering. The disposal facilities were sited initially so as to optimize dredging operations – they are the most efficient locations for known maintenance or improvement activities - and are not necessarily optimized in locations for ease of the beneficial use of dredged material. Although the original siting of the upland CDFs was not based on beneficial use considerations, many of these facilities, such as Fort Mifflin and Money Island, have provided dredged material for beneficial use projects.

As described in the *Restoration and Beneficial Use White Paper*, there are a variety of opportunities for the beneficial use of dredged materials to restore ecosystems, to be used as construction materials, and other potential uses. Matching the materials dredged to appropriate uses (both from a physical character and chemical quality perspective) is not always easy, especially considering the locations of disposal facilities and dredging operations compared to the areas of potential need for sediment (dredged material). *The Sediment Quality White Paper* discusses the results of a planning-level approach evaluating the suitability of sediments for potential types of beneficial uses. The *Restoration and Beneficial Use White Paper* discusses potential restoration opportunities and beneficial use strategies for various locations within the Delaware River Basin/Estuary.

The Dredged Material Management System (DMMS), under development by the NJDOT, is intended to offer a marketplace for matching potential beneficial use projects with available and suitable dredged material. The State of New Jersey is currently undertaking an extensive effort to characterize and quantify the dredged material in upland CDFs and to evaluate their potential for beneficial use.

Planning

Policy/Program Considerations

For USACE directed operations, the USACE is required to meet Federal standards for identifying *the most* environmentally acceptable least cost option (33 CFR Part 335). Private entities are required to obtain dredging permits from the USACE Regulatory Branch (Section 404/401 and 10 authorizations), as well as applicable State regulatory programs. Private/non-Federal entities are required to evaluate potential alternatives and identify least environmental impact solutions. The States in the Delaware Estuary/Basin (Pennsylvania, Delaware and New Jersey) each have programs regulating activities,

including dredging, in their waterways and programs for the disposal of sediments generated from these dredging activities. Each State evaluates sediment differently and each has different standards for defining sediment quality for potential use.

Dredged Material Management Plans (DMMP)

Dredged Material Management Plans a Federal term based in legislation are typically required if a Federal navigation project does not have the projected/planned capacity to meet 20 years of dredging activities pursuant to navigation mandates for Federal channels/berths. The Delaware River/Estuary is unique in that existing upland CDFs are projected to be able to manage the 20 year projection for the Philadelphia to the Sea projects/reach. The USACE Philadelphia District has developed a long range disposal plan through construction of upland CDFs of sufficient size and location to meet needs. This has created challenges for beneficial use options within the Delaware Basin/Estuary.

The USACE has disposal site capacity issues for the Christina River. A DMMP is being prepared by the USACE for this navigation project and should be finalized in the future.

Although a DMMP is not required for the Delaware Estuary, agencies involved in the RSM Plan preparation and RDT have identified the need for a DMMP for the upper basin (Philadelphia to Trenton). Section IF-3 has a detailed discussion of the factors contributing to the need for a DMMP in this location.

Scheduling/Coordination – Logistics

A challenge facing dredge material management program managers is scheduling projects to optimize dredging "windows" (time periods without environmental restrictions on dredging), equipment mobilization/demobilization, and beneficial use projects. In addition to direct cost savings benefits from piggy backing private projects onto Federal projects for operational efficiency, there are benefits in the minimization of disruptions to the environment and in the optimization of potential beneficial use.

Another potential benefit of "piggy backing" may be the indirect ability to justify what have generally been described as additional costs associated with conducting beneficial use/restoration projects. These costs are typically not considered feasible when completed solely by the USACE due to the Federal standard for determining/using least cost options.

A long range plan connecting dredging with beneficial needs will facilitate some of the logistical challenges identified.

Potential Dredging Projects

The stakeholders recognize that there may be the need for new dredging (beyond current/historical maintenance activities) within the Delaware Estuary. While the RSMW can neither identify all of these projects nor attempt to inventory them, there is a recognition that the RSMP needs to take into account approaches for managing future dredging needs. It is important to consider facility capacity and alternatives for disposal in the Delaware River/Estuary.

Some potential major projects have been identified and are discussed below (for this paper, no position has been taken on these projects – rather recognition of the types of projects and the magnitude of sediments that could potentially require management are considered).

Main Channel Deepening

One potential Federal project that could have significant impact on the dredge material management within the Delaware Estuary is the proposed deepening of the Delaware River Main Channel from the current 40 foot depth to 45 feet. Based on current data, this project could generate an additional 16

million cubic yards of material for the initial deepening and 3.6 million cubic yards for maintenance annually (total projected future maintenance volumes). Appendix D contains additional details.

Dredge material managers from the USACE indicate that there is sufficient capacity at the existing facilities to dispose of new material. Alternative options such as beneficial use and direct disposal options/alternatives for beneficial uses should be explored.

New/Expanded/Retrofit Berths

Several private projects that may affect dredged material management in the near term have been identified based on inquiries to the USACE Regulatory Branch and the Operations Division. Some of the larger projects include:

- Philadelphia Airport, which runway expansion may require partial removal of an existing CDF. The eliminated capacity will be replaced with equal or more capacity for maintenance material. The final location has not been secured.
- Hess LNG facility (former BP site) that may generate approximately 800K to 1M CY of material for disposal/beneficial use.
- Existing refinery/port berth deepening may be required to accommodate larger vessels.
- New dredging for port terminal development (Southport and Port of Paulsboro).
- Other undefined needs.

The total amount required by these projects is undetermined, but will be tracked by the RDT. The RSMW, in conjunction with the RDT, will provide strategies for dealing with increased dredge volumes beyond those required for maintenance of the Federal navigation channels.

Operations

Historical/Current Operations

Figures 1 and 2 depict the major maintenance dredging projects and navigation ranges for the Federal navigation program, and the locations of private/non-Federal berths within the Delaware Estuary. Historic operational dredging methods and dredged material disposal procedures are described below.

Dredging Methods

Current Federal methods for dredging are summarized in Appendix C.

Private sector methods vary and are based on sediment quantity, disposal location, ability to piggy back with other private projects, etc. State and Federal permit requirements usually stipulate the type of dredging methods acceptable for private actions.

Best Management Practices (BMPs)

For current Federal actions, BMPs such as turtle excluders, on board water handling, transport storage practices, etc., which have been developed in conjunction with the Federal and State resource agencies, are used for dredging. BMPs are typically specific to the individual dredging method/equipment being employed and type of disposal facility.

Private/non-Federal entities are required to incorporate BMPs into their dredging plan through the regulatory approvals from the Federal and State agencies with jurisdiction over dredging.

The USACE is evaluating alternative BMPs for dredging operations. These same technologies are also being evaluated by the USACE Philadelphia District for inclusion into their dredging operational plans. The USACE has an agreement with the Dredging Operations Technical Support Program (DOTS) to evaluate current operations and provide recommendations on alternative BMPs. The DOTS effort may be supplemented with additional evaluations, pending results from the DOTS study (anticipated end of 2012 fiscal year). Results of the DOTS study will be shared with the RDT and RSMW for inclusion/consideration in the development of recommendations for the RSMP.

Equipment

Appendix C describes in detail the type of equipment that is needed to conduct Federal navigation channel dredging. This is often the same equipment that is used for private/non-Federal actions. Alternatives for private dredging on a smaller scale include bucket, clamshell buckets, and environmental closed clamshell buckets.

The USACE owns and operates the Federal Hopper Dredge *McFarland* which is used for various maintenance activities in all coastal environments within the U.S. *McFarland* is mandated for use on the Delaware River for 70 days per year for training purposes. Training activities are funded annually on the Delaware River/Estuary from Philadelphia to the Sea if sufficient funds are appropriated to the Delaware River – Philadelphia to Sea project.

Disposal Options

Disposal options have historically varied and been different in the basin for Federal and private dredging operations. As described earlier, Federal maintenance of navigation channels has traditionally used Federally owned CDFs for disposal with limited beneficial uses opportunities. These facilities have a significant capacity, especially when the existing sediment inventory can be used beneficially. Private sector operations, except for limited small scale operations that dispose of material on site in uplands, have used White's Basin for disposal. Multiple disposal and beneficial use alternatives are needed for the private sector.

Best Management Practices – Water Quality

By regulation, operations at Federal upland CDFs implement best management practices for water quality. Some innovative BMPs have been used in other locations for small scale upland CDFs that can provide additional water quality benefits. BMPs for water quality will be evaluated by DOTS. The DOTS study will help USACE determine technologies that may be appropriate for use at the existing upland CDFs in the Delaware Estuary.

Private disposal permittees operate under permits from the USACE and the States. Water quality BMPs are conditional in these permits. Inspection and enforcement requirements are included in the permits. Pennsylvania's Standard Operating Procedure 2005, for use of disposal areas, captures details on water quality requirements, effluent limits, and BMP practices.

Material Segregation

For most upland CDFs, dredged material is blended during disposal operations. Pilot projects have begun to intentionally segregate materials generated from different sources so as to deliberately separate material based on sediment chemical quality, physical characteristics, and composition to facilitate beneficial reuse.

Regulatory Considerations

Federal dredging operations are statutorily required to satisfy the Federal acts and orders pertaining to dredging and dredged material disposal, management, and beneficial use. The Federal agencies have to

demonstrate compliance with NEPA, the Clean Waters Act, the Rivers and Harbors Act, and the Coastal Zone Management Act. Private/non-Federal operations must also comply with Section 404 and 401 of the Clean Waters Act, and Section 10 of the Rivers and Harbors Act. They must also comply with State laws and regulations for the State in which the material is being dredged and disposed of, or beneficially used.

The regulatory programs set standards for dredging methods, seasonal restrictions, location of disposal, and the BMPs for operating the disposal sites. Generally, the private entities use existing upland CDF sites or upland disposal sites, which limit their permitting requirements. The development of any new upland CDFs requires permits from the Federal and State regulatory agencies, in particular for water quality certification.

Potential Alternatives/Opportunities

This section discusses potential innovative alternatives/opportunities for dredging methods and dredged material management in the Delaware Estuary. Sediment quality, particularly in reference to the dredged materials' chemical composition (i.e., contamination), can affect the dredging methods and ultimately, the dredged material management options. Methods to limit the re-suspension of sediments and any associated contaminants into the water column after disposal vary and are dependent on the type and concentration of the contaminants. Testing of dredged material following standard protocols is required to determine contaminant concentrations, and will ultimately determine management options.

Dredging Methods

Equipment

Dredging equipment is limited and only certain dredging technologies are currently practical for use in the estuary. The transport distance to upland CDFs from dredging locations influences the types of equipment that can be used. As a practical matter, there is also a market constraining factor: at this time, commercial dredging operators only have certain types of equipment, which is usually in high demand.

The USACE owns the Hopper Dredge *McFarland,* which could perform up to 70 days of navigation maintenance dredging in the Delaware River. Those 70 days of dredging have been legislated to maintain *McFarland*'s Ready Reserve Status in the event of a national emergency (for example, berm construction associated with the B.P. Gulf of Mexico Oil Spill). Maintaining *McFarland*'s Ready Reserve Status allows this piece of equipment to conduct various types of dredging and disposal operations in the estuary.

There are alternative methods of dredging that have not been tried in the Delaware River/Estuary. Water injection dredging is appropriate for streams with distinct hydraulic dynamics, morphology, and sediment characteristics. Dredging managers from the USACE indicate water injection dredging would likely only be appropriate within the Delaware Estuary for the Christina River (based on initial assessments and understanding of the various locations typically requiring routine dredging). Further evaluation of the potential use of this method in the Delaware Estuary/Basin is recommended.

Another non-traditional alternative is to reduce dredging volumes by limiting the amount of sediment reaching areas traditionally in need of maintenance dredging. Alternatives include bypassing sediments from the water column to locations downstream of areas where large volumes of sediments typically deposit over short time periods (i.e. sediment depo-centers). This alternative requires further evaluation, but a demonstration project using *McFarland* could potentially be implemented. Sediment bypassing presents some challenges, including a requirement for continuous year round application, permitting for appropriate discharge locations, and cost relative to other methods.

Another alternative is to pump sediments directly from the zone of maximum turbidity in the Delaware River to downstream marshes through thin layer application. This beneficial use/restoration alternative is

being evaluated by the RSMW and member organizations for applicability/feasibility in the Delaware Estuary/Basin. Challenges include reducing the energy needed to pump long distances appropriate for thin layer placement of dredged material, and not eroding the marshes (USACE, 2011). This alternative is being evaluated by the RSMW for a demonstration project.

Each of these alternatives assumes larger benefits for all navigation channels/berths. There are a variety of methods currently being used by the private/non-Federal sector. There appears to be an opportunity to realize these broader benefits for private actions as well. Efforts to connect private dredging operations with Federal activities could broaden the benefits to be realized by Federal alternatives. Alternatives for the private dredging operations would need to be evaluated on a case by case basis absent this coordination.

Dredged Material Management Options

Disposal alternatives/opportunities primarily consist of beneficial use/restoration or methods described above.

Innovative Technologies

Innovative technologies include the pumping of sediments directly to restoration/beneficial uses, thus eliminating the need for upland CDFs or other intermediate dredged material management strategies (USACOE, 2011). Another innovative approach is to reduce the amount of sediment entering the system to reduce the need for dredging. For example, stabilizing upstream banks on the Delaware River and its tributaries, channel geometry changes, and upper watershed controls. Although it is recognized that these sources are only part of the sediment contribution to the estuary system, as dredge material managers recognize that the Delaware River bottom provides a significant amount of the sediment that is suspended in the water column (albeit sediments that originated from upstream sources), a combination of innovative technologies for reducing sediment loads in the upper watershed and redirecting sediments to starving locations may provide significant benefits.

Other innovative technologies include either directly pumping sediments out of the system (such as thin layer applications on agricultural fields or wetlands) or through habitat creation, flood control, island development, etc. Thin layer dredged material placement applications have been implemented in tidal marsh ecosystems in several coastal U.S. States which demonstrates the efficacy of the method as an appropriate alternative for serious consideration in the region. Further evaluation of this technology and its merit for application within the Delaware Estuary is recommended.

Best Management Practices

BMPs at dredged material disposal sites vary depending on the type of disposal site. For traditional upland CDFs, there are innovative technologies to improve water quality from disposal site discharge outfalls, such as flocculants and the use of created treatment wetlands. BMPs used at these facilities could also be adapted to fit with other dredged material management alternatives, such as segregated cells at the upland CDF. Some of these practices may be appropriate for smaller CDFs, but may not be effective for some of the larger Federally owned CDFs.

BMP alternatives for beneficial use projects will be required to be tailored to the activity. It is also recommended that potential alternative BMPs be vetted with the various Federal and State regulatory programs to determine their potential feasibility and permitability. Such a process would also facilitate inter-agency consistency in the review of such alternative BMPs in the Delaware Estuary/Basin.

Other Considerations

Multi-State Locations – Criteria

Opportunities for improving dredging methods and materials management require multi-State coordination. Dredging projects often occur in waters of more than one State, disposal facilities are located in several States, and executing beneficial use alternatives for a single project may involve several States, including States outside the basin.

Criteria for testing sediments, methods of dredging, and disposal vary within the multiple jurisdictions. Managers have difficulty navigating these various criteria especially to a beneficial end for sediments. The development of multi-State criteria is needed.

Seasonal Restrictions

Seasonal restrictions within the entire Delaware River Basin have been evaluated on a project-by-project basis since 1992. In that year, the Delaware River Basin Fish and Wildlife Management Cooperative (Co-op) began addressing both site- and project-specific impacts to watershed resources in relation to proposed operational activities. A re-evaluation of seasonal restrictions is presently underway. Co-op members will review each activity with its corresponding restriction. Inter-State consistency regarding duration of seasonal dredging windows is needed.

Seasonal time-of-year-restrictions (i.e., dredging windows) are typically recommended by both Federal and State resource agencies so as to prevent direct, indirect, and cumulative impacts on both critical (i.e., forage, spawning, nursery) terrestrial or aquatic habitat and key resident or migratory species. In many instances, the preferred timing sequence (as dictated by prescribed project schedules) of both the dredging and/or disposal phases of an individual project coincides with seasonal restrictions. Regular planning through project pre-coordination/pre-consultation with the respective resource agency (-ies) is recommended.

Seasonal restrictions can affect dredging operations. There are also seasonal restrictions for potential activities proposed in disposal areas, and often these seasonal restrictions are in conflict with proposed dredging/disposal activities. An evaluation is needed to determine if the predicted benefits of the seasonal restrictions typically applied to certain activities are commensurate with the ultimate/realized environmental gains for the activities. Consistency across the Federal and State programs that determine the need for these restrictions is also needed.

Retrofitting "Old" CDF Sites

There is an effort underway to evaluate the potential use of abandoned/formerly used ("old") CDF sites that had been developed by various entities over the years prior to the USACE CDF program and use of White's Basin. The NJDOT is evaluating former CDFs owned/maintained by the State of New Jersey or private entities that have been abandoned for their retrofit potential. New Jersey has indicated that retrofitting these sites presents several challenges; the primary one is regulatory. Current approaches to wetlands delineations on these managed sites, and in some instances the use of these managed sites by protected species, presents challenges. Other challenges include retrofit construction costs and testing of the materials in these facilities.

Factors Affecting Dredge Material Management/ Dredging Methods/Opportunities

Several factors affect the range of potential opportunities for improving dredging methods and dredged material management in the Delaware Estuary/Basin.

Sediment – Quantity/Characteristics

The type of sediment (sand, silt, gravel), and the volume to be removed/dredged, affects dredging methods. Appendix C contains a description of the dredging methods typically used for the Delaware Estuary/Basin.

The methods used in the basin for the Federal projects tend to be consistent across projects due to the large quantities of sediment that need to be dredged. Methods for private berths vary due to several factors including the sediment characteristics and varied volumes.

Sediment quantities and characteristics as they affect dredging operations are discussed in detail in the *Sediment Quantity and Dynamics White Paper*.

Sediment Quality

Sediment quality, particularly in reference to the materials' chemical composition (i.e., contamination), can affect dredging methods and disposal options. Methods to limit re-suspension of sediments and associated contaminants into the water column after disposal vary and are dependent on the type and concentration of the contaminants. Testing of the dredged material following standard protocols is required and intended to determine contaminant concentrations and management options. Quality characteristics that could affect dredged material management approaches are discussed in detail in the *Sediment Quality White Paper*.

Regulatory Approvals

Regulatory approval affects dredging methods permitted in certain locations. In the Delaware Estuary, Federal permits as well as State approval is required for private/non-Federal dredging operations. Each State has a different application approval process as well as a specific set of permit conditions and management approaches desired for each dredge material type and dredge material management method.

Finances

The Federal navigation program in the Delaware Estuary has historically received annual funding, but not always for the needs identified by program managers; funding for private entities, including municipalities/authorities, is limited. Sources to generate a funding stream are also limited. Alternative funding mechanisms should be evaluated. The RSMP will include an appendix identifying various potential funding sources for RSM and dredging related actions.

Beneficial Use/Restoration

A primary RSMW and USACE goal of dredged material management is to promote/expand dredged material beneficial use practices, including ecosystem restoration. The beneficial use of dredged material for construction applications/purposes within the USACE Philadelphia District Operations Division is a commonly accepted practice; for ecosystem restoration there is no steady/predictable funding source to accomplish these types of restoration/beneficial use projects. In a separate white paper *on Restoration and Beneficial Use*, the premises and types of opportunities for beneficial use/restoration using dredged material are discussed in detail.

Beneficial use include using dredged material for upland related projects such as building materials, elevating properties, etc. and for restoration projects such as beaches/dunes, wetlands, mud flats, bi-valve habitat, landfill capping, etc.

Proposed dredging projects should include an evaluation of opportunities for beneficial use/restoration of the dredged material. A coordinated effort between resource managers on potential beneficial uses, project location, permit processing, and dredged material characteristics is essential as well as a full accounting of all of the broader benefits and cost reductions - these efforts will likely fail (in particular for private/non-Federal sector projects). There are many considerations, including project timing, dredged material volumes, dredging methods, and funding that need to be addressed under a long range regional dredged material beneficial use plan. The benefits attributed and therefore, cost savings with these approaches, and/or a predictable and steady source of funding outside of the USACE Operations and Maintenance (O&M) business line needs to be realized. Through the Planning Division of Philadelphia District or outside the USACE, general permits/authorizations with appropriate conditions to support these types of projects should be developed.

Financial Challenges/Opportunities – Economics of Dredging

The economics of dredging is typically fairly straight forward. Within the Delaware Estuary, the Philadelphia District has some unique challenges concerning economic evaluations due to historical investments/programming made to plan for dredged material disposal in large upland CDFs.

The Federal navigation dredging program in the Delaware Estuary has historically received annual funding, but not always for the needs identified by district program managers. Funding for private entities, including municipalities/authorities, is usually limited. Additional sources are also limited. Alternative funding mechanisms should be evaluated. The RSMP will include an appendix identifying the various potential funding sources identified by the RSMW for funding RSM and dredging related actions.

Costs

Several decades ago, the Philadelphia District created an extremely cost effective approach to disposing of sediments from maintenance dredging activities from navigation channels and berthing areas. Due to the availability and capacity of the upland CDFs, the comparative costs associated with implementation of other alternatives (on a direct cubic yards-dredged vs. cubic yards-disposed basis), presents challenges for the implementation of beneficial use and ecosystem restoration actions that would normally incur additional costs. Opportunities for developing strategic funding partners or alternative cost: benefit evaluation methods should be explored. Evaluating costs and benefits for alternative dredged material management alternatives, including beneficial use, should be “re-engineered” to reflect broader Federal interests for Federal projects and the indirect overall savings associated with beneficial reuse.

For private/non-Federal projects, costs tend to be more variable and higher due to the small scale of some operations, the location of the disposal facilities relative to the operation, and limited options for disposal as well as other factors.

Benefits

For Federal projects, the models/programs used for evaluating benefits and the cost savings associated with them are very draconian and limited. There are many benefits to be derived from alternative dredged material management options such as beneficial use or restoration. The USACE Institute for Water Resources (IWR) has started to inventory/organize those benefits for various types of projects. Applying these benefits and methods of determining their value for dredging projects will be integral to the success of the plan to use alternative approaches for managing sediment on a systems basis.

"Creative" Partnerships

Until long term funding is secured, creative partnerships may be the appropriate mechanism for completing innovative dredging and dredged material management beneficial use projects.

Federal

There may be opportunities to leverage funds through a cost-sharing agreement with other Federal agencies responsible for resource management, such as the U.S. Fish and Wildlife Service, National Oceanic and Atmospheric Administration, U.S. Geological Survey, and the Natural Resources Conservation Service. These entities may be able to partner to provide the added financial backing or in-kind services cost share above the least cost Federal standard to permit restoration or beneficial use if the proposed activities fit within their plans/programs.

State/Local

State and local agencies provide another source for sharing the cost of dredged material beneficial use projects. These entities may be able to provide matching funds proportionate to the difference between the traditional approach and the preferred approach. Land, as an in-kind service, is a viable option as well. Examples where cost share opportunities with State/local entities may be feasible (as for these types of projects other sources of funding may be available and beneficial use could provide cost savings) could include use of dredged material for elevating a park or school ball field or constructing levees to protect facilities or natural systems from flooding in their jurisdiction.

Commerce

Another potential partner could be commerce agencies: Federal, regional, and State. There may be funds available from these entities to supplement Federal navigation dollars so as to ensure that existing or proposed navigation related commerce facilities will remain sustainable.

Private

Private berth areas, in particular those where maintenance and improvement dredging needs exist, have in the past, and will continue to be in the future, a source of partnerships. Often the magnitude of dredging required at these smaller facilities versus the costs associated with alternative dredged material management practices is not equivalent. Private contributions to broader programs, or collecting funds from several private entities that will ultimately benefit from a coordinated dredged material management project, may be a practical option in some locations.

Examples

Examples of partnerships that have been successful in this region and others include:

> Mining companies – using dredged material from the Delaware River and NY-NJ Harbor to fill subsurface mines, or as caps on surface mines, in Central Pennsylvania.

> Island/shoreline stabilization/creation, such as projects completed by the Baltimore and New York Districts of the USACE.

> Use of dredged material as landscaping material/soil completed in several regions.

Recommendations

Recommendations according to policy, programmatic, operational, research/study, and fiscal considerations related to dredging and dredged material management within the Delaware Estuary/River Basin are evaluated as follow:

Policy

The RSMW and RDT have recognized that long term success of implementing alternative approaches to dredging operations and dredged material management are outside (cost share) funding sources (non-Federal or other Federal business lines – such as Ecosystem Restoration and Flood Risk Management in addition to the traditional Navigation Business Line of the USACE) to offset the low cost of disposing maintenance material in the Federally owned upland CDFs using Navigation Funds. Unlike the NY/NJ Harbor area, which does not have Federally owned upland CDFs adjacent to Federal channels, the current cost of disposal is considered economical on the order of $2-$5 per cubic yard (Philadelphia District), not $50-$100 per cubic yard (NY District). It is critical for the managers in the Delaware Estuary to find creative dredged material management solutions through strategic partnerships, and to evaluate alternative policies regarding reasonable cost: benefit assessments. Presently, local companies who need materials suitable for construction purposes have taken advantage of this potential for partnerships.

Specific policy recommendations include:

> Recycle sediment through beneficial use to keep sediment in the watershed. This goal considers the beneficial use of 15% of all dredged material by 2015 and 5% more per year towards an ultimate goal of 50% by 2022 and increase the number and type of beneficial use projects.

> Modify existing sediment/dredged material management programs to facilitate implementation of the RSM paradigm.

> Promote consistency with State programs to new Federal guidelines for benefit cost analyses (Principles and Standards) that provide for broader spectrum of benefits in analysis of cost justification.

Programmatic

Current Federal and State regulatory programs within the Delaware Estuary/River Basin should be re-evaluated for consistency and modified to facilitate implementation of the recommendations in this White Paper. Effective dredged material management solutions require the ability to work across State lines by developing consistent regulatory standards to facilitate the management processes. It is also recommended that the USACE Regulatory Branch revisit with their Federal partners regulatory processes and permit conditions to further facilitate implementation ideas generated as part of this study. Several regional studies are currently being conducted by others concurrent with this RSMP planning initiative that should be considered in RSMP development.

Specific programmatic recommendations include:

> Facilitate regional coordination of dredging and dredged material disposal/management, with the goal of reducing annual O&M dredging costs and the volume of sediment to be dredged over time.

> Identify potential alternative dredged material beneficial use and management/disposal options for private and Federal navigation dredging projects.

> Strive for consistency in State standards for best management practices for dredging methodologies, particularly with respect to minimizing environmental effects. Develop one multi-State protocol for seasonal dredging restrictions (i.e. dredging windows).

- Solicit assistance from a broad spectrum of interests in changing the sediment paradigm/myths – sediment should be considered to be a resource, not a waste material.
- Continue to collaborate and develop/implement a long term dredged material disposal/management program for dredged material from private berth facilities.
- Identify and collaborate with potential partners to implement dredged material beneficial use projects. Such potential partners include Federal resource agencies, the States, municipalities, non-profit organizations, and the private sector (ports/maritime industry).
- Conduct a cost-benefit analysis that compares the full range of effects/benefits (ecological, social, etc.) associated with disposal/management of dredged material for various alternatives, including beneficial use. The potential for green jobs creation should be included in the analysis.
- Continue with the Regional Dredging Team (RDT) meetings to monitor and facilitate dredging operations in the basin.
- Develop and implement a public education/outreach program to explain the options for dredging and the beneficial uses of the sediments in the basin.
- Support and collaborate with entities developing regional restoration plans and project registries to identify potential beneficial uses of dredged material for restoration projects.

Operational

Current operations in the basin can be categorized as either Federally or privately/non-Federally directed. Changes in the types of dredging equipment or their operations have limited opportunity. Further evaluating the potential to reduce sediment loads reaching the channels and berth areas (potentially through creative sediment dynamics-engineered alternatives or tributary contribution reductions) is of greatest interest. Opportunities to identify and implement upland CDF water quality management improvements are also recommended for further evaluation.

Although private/non-Federal sector maintenance dredging contributions to dredge material volumes are small compared to the Federal contributions, it is recommended that priority be given to developing a sustainable 5- to 10- year plan addressing effective disposal/management alternatives for these private sector activities.

Specific operational recommendations include:

- Conduct pilot projects for treatment of wetlands to provide water quality enhancements to the discharges from existing upland CDFs.
- Conduct pilot projects to evaluate the use of thin layer application of dredged materials on wetlands in strategic areas subject to subsidence and/or sea level rise.
- Conduct pilot projects to evaluate the use of living shoreline and other ecologically beneficial approaches (oyster reefs, etc.) to control shoreline erosion problems.
- Conduct pilot projects to reduce sediment loads from upstream tributaries, such as stream restoration/bank stabilization projects.
- Implement appropriate recommendations from DOTS study of existing upland CDF best management practices.
- Investigate application of nautical depth (active and passive) for Wilmington Harbor and possible other areas if significant amounts of fluid mud exists.

Research/Study

Significant research has been conducted to understand the sediment characteristics and dynamics in the Delaware Estuary/Basin. While these efforts have provided a baseline for preparing this document, further studies are recommended in order to understand the most appropriate alternatives for reducing the need to dredge the navigation channels and private berths, the most appropriate best management practices for ensuring water quality, and the most appropriate locations to beneficially use dredged material within the estuary.

Specific research/study recommendations include:

> Evaluate the need/options for modified/longer "windows" for dredging and dredged material management operations to take advantage of alternative dredged material management options.

> Evaluate alternative dredging methods (technical and management solutions) to reduce dredging needs (e.g. see Richard Price and Bob Blama's recommendations) and reduce sediment transfer to the disposal of dredged material in upland CDFs.

> Evaluate bedload collectors to reduce depo-centers.

> Evaluate programs to reduce the sediment being transported to depo-centers through technical/engineered and management solutions.

> Evaluate the potential for dredged material segregation at existing upland CDFs and conduct pilot projects to demonstrate this process.

> Evaluate feasibility of long distance pumping (http://el.erdc.usace.army.mil/elpubs/pdf/tr11-2.pdf and NAP Report, U.S. Army Engineer District, Philadelphia. 1969. Long range spoil disposal study, Part V, Substudy 4, pumping through long lines. 19 June. Philadelphia, PA.)

Fiscal

The RDT and RSMW have recognized that critical to the long term success of implementing alternative and creative approaches to dredged material management, in particular beneficial uses and ecosystem restoration, are outside funding sources (non-Federal or other Federal business lines) to offset the low cost of disposing maintenance material in the Federally owned upland CDFs using Navigation Funds. Further evaluation of potential Federal, State, local, commerce, and private partner joint-funding strategies is also recommended.

Specific fiscal recommendations include:

> Identify, evaluate and pursue/secure creative funding mechanisms to provide alternative dredged material management, upper watershed sediment loading reduction, and beneficial use options. Explore options alternative funding approaches.

> Recommend to Congress that USACE Federal Standard/least cost disposal option for dredging projects reflect a more accurate accounting of the full range of economic, environmental, and other relevant costs and benefits for options that reuse dredged material.

> Continue to work with commercial entities to find markets for dredged material currently contained in upland CDFs throughout the basin.

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Dredging and Dredged Materials Management White Paper Committee

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Appendix A

Historical Dredging Quantities
(Tables Completed through 2010)

Appendix B

Historical Beneficial Uses – by Quantity
(Tables Completed through 2010)

Appendix C

Philadelphia District Historical Dredging Equipment/Methods and Available Alternatives

Appendix C: Philadelphia District Historical Dredging Equipment/Methods and Available Alternatives

USACE Philadelphia District

Dredging Operations – Background Information

Dredging Methods – Equipment

The following summarizes dredging methods/equipment historically used in the Delaware River Basin/Estuary.

Overview

Dredging of the Delaware River/Estuary Federal navigation channels conducted by the USACE is done by using both Government-owned equipment and through the work of contractors (primary method). Currently, methods/equipment available for dredging the Delaware Estuary/River are limited, in particular for the Main Channel maintenance dredging operations. There are a limited number of contractors with limited types of equipment that affect the available methods for dredging in the Delaware River/Estuary. The USACE owns equipment (the Hopper Dredge *McFarland*) and also contracts out to private dredging contractors. Private berths primarily use private contractors, while the State of Delaware also owns dredging equipment.

Dredging contractors employ several types of dredges in their operations. The type of dredging equipment used is generally dictated by the volumes of material to be dredged, the water depths, the size of the water body, and the distance to the disposal facilities. The actual dredging plant is a complex system comprised of numerous modules, each performing a particular operational function so as to excavate and remove sediments from a distinct area (i.e., navigation channel or berthing area) and ultimately transport and /or discharge the material in or at a prescribed disposal area/location. Dredging equipment generally consists of the dredge (equipment for removing the sediment from channel floor), transport mechanisms (equipment for transporting sediments to disposal area – barge, pipe or other), and discharge/dumping equipment at the disposal location.

Dredges designed primarily for open-ocean dredging or dredges intended for small channel/berth dredging vary and the Philadelphia District and private operators in the Delaware River Basin/Estuary have used various methods depending on location, scope and breadth of the project. However, Delaware River dredging conducted by the USACE has typically been accomplished by hydraulic means. Basically, for hydraulic dredging the contractor uses a hydraulic dredge, which will consist of a hopper, cutter head, or dustpan mechanisms. Historically, mechanical bucket dredges (dipper and clamshells) have not been used efficiently in the construction of beach projects; however, they are used on navigable waterway (channels/berths) projects on the Delaware River/Estuary and associated tributaries. Current methods often employ the use of dredging plants that pump dredged material through pipelines to disposal areas. Every type of dredge has specifications/parameters on how much material can be pumped per hour, the minimum pipe widths and maximum pipe lengths associated with various sediment characteristics.

The following discussion will focus on the methods used on the larger dredging projects in the Delaware River/Estuary and its tributaries: the hopper, cutter head, and dustpan type dredges. Their capabilities and differences will be briefly described to familiarize the reader with this specialized equipment. Private berths, which conduct smaller scale dredging operations use mechanical/bucket dredges. These methods are not described in detail in this section.

Hopper Dredges

Hopper Dredges, also known as Trailing Suction Hopper Dredges, are capable of placing on the order of 15-20K cubic yards of sand per day. Hopper dredges are used when the area to be dredged is 20 to 100 feet deep and the area to be dredged is 10+ miles away from a placement location.

The plant (dredge) moves to and from the borrow site under its own power and it has a self- contained crew (crew lives on board). Therefore, it requires no pipe set-up or booster pumps, and less attendant vessels during the operation, with no crew boat required for crew changes during 24 hour operations.

The illustration shows the dredge with drag arms down and the photograph shows the belly of the vessel being filled during the actual dredging operation (with the drag arms down). The intake is by drag arm, and the sand is then stored in the belly of the vessel. Once the dredge is filled, the operator will raise the drag arms and the captain will head to the discharge location. Depending on the project, there are various discharge methods. There is split hull bottom discharge (from the bow of the vessel). Should split hull bottom dump not be the choice of discharge, the sand must be re-liquefied in order to pump the sand out of the hull. In some cases booster pumps may be used, depending on the distance of the pipeline from the location of discharge to the beach/disposal facility.

On past projects within the Philadelphia District where a hopper dredge was utilized during the construction phase, several special conditions, coordinated with the District's Environmental Branch, were required that necessitated additional steps to be taken during the dredging operation. During the months of June through November in any given year, turtle excluder screens are mandatory and have been installed on the drag arm intakes. The dredging contractor is obligated to provide a formal written plan for review by the District. In addition , a National Marine Fisheries Service-certified inspector/observer is required to be on board at all times during dredging, and in some cases disposal operations so as to document evidence of the presence or absence of turtles and/or other aquatic (marine) life that may be caught in the drag arm intake. The inspector is expected to file/record through official documentation daily trip/incident reports.

Hydraulic Cutter Head Dredges

Hydraulic cutter head dredges are capable of placing on the order of 25-35K cubic yards of sand per day on average. These plants are flat bottom barges mounted with "giant" engine(s). The hull shape does not allow the dredge to tolerate high seas as well as the hopper dredge. As a result, the dredging contractor is responsible for monitoring weather patterns/conditions closely to ensure that ample time is allocated to bring the dredge into a sheltered harbor in the event that inclement weather events cause high seas. Generally, this is not an issue for dredging operations in the upper Delaware River but can be in the lower estuary.

Cutter head dredges use a spiral cutter head to dig into the water body floor. The cutter head is located at the end of what is known as the ladder. This ladder is lowered and raised via cable lines that are suspended from an "A" frame at the bow of the dredge. The cutter head spins and creates a sediment "cloud of" slurry, which is pumped through pipelines to the disposal area. This is the only form of discharge for the cutter head dredges. These cutter heads are capable of drilling rock and have been known to go right through ship wrecks (with the only evidence of the wreck being deposited at the disposal site). Therefore, all prohibited zones within the borrow site need be clearly marked.

The cutter head dredges are not mobile under their own power. Therefore, they require attendant vessels during the operation (such as tugs to reach the borrow site). Hence, a crew boat is needed for crew changes (the crew does not live on board).

Once the dredge is at the borrow site, the dredge is "spudded" down on spuds that are located at the stern of the dredge. The dredge can then swing in an arc like motion on the spud. Several anchors and associated cables enable the dredge to swing its arc and pull it forward within the borrow area when the spud is lifted.

Dustpan Dredges

Dustpan dredges are capable of placing up to 50K cubic yards of sand per day. Dredged material volumes rates of that magnitude were recorded when the "Beach Builder" was working the Ocean City New Jersey beach fill project. Similar in hull design to the cutter head dredge, the dustpan dredges are flat bottom barges mounted with "giant" engine(s). The Beach Builder is all engine. They are extremely powerful, which enables them to pump several miles without booster pumps.

The dustpan dredges are not mobile under their own power. Therefore, they require the aid of tugs to reach the borrow site. Hence, it requires attendant vessels during the operation, including a crew boat for crew changes (the crew does not live on board).

The dust pan dredge uses a spider configuration of six anchor cables to pull itself within the borrow site. The tugboats and other attendant vessels move the anchors into position. Once the dustpan dredge is into position, the "A" frame lowers the ladder and a wall of jet nozzles loosens the sediment. A suction pump then transfers the slurry to the desired location.

Similar to the cutter head dredge, the dustpan dredge cannot tolerate high seas. As a result, the dredging contractor is responsible for monitoring weather conditions closely to ensure that ample time is allocated to bring the dredge into a sheltered harbor in the event that inclement weather causes high seas.

Associated Equipment

Booster Pumps

Booster pumps in various configurations can be used in situations where the distance to the beach/disposal site is much greater than the capacity of the dredge's pumps. Booster pumps can be used on floating barges, jack-up barges, buoys, or simply land based.

Cranes and Derricks

Cranes and derricks also need to be inspected with the floating plant.

Boat Fleet and Barges

The boat fleet and barges are essential to an effective dredging operation. The typical boat fleet consists of tugboats, workboats, crew boats, and survey boats. For instance, the dredge Illinois has successfully worked the Ocean City Beach Fill Project several times. The photograph depicts a workboat, tugboat, work barge, and an anchor barge preparing for a beach fill. As you can see there are many mechanical devices associated with the floating plant. It is essential to inspect all forms of the plant at the beginning of the project. This includes the work barges and anchor barges, which sometimes get over-looked during the project.

Floating and Submerged Pipelines

Another key element to the floating plant is the pipeline. There are many types of pipelines that the contractor can use for any given project. The pipe is extremely dangerous to work with during mobilization and demobilization. The floating pipeline is typically located between the dredge and the riser pipe. Typically, the submerged pipe travels the majority of the distance to the beach/disposal site. The submerged pipeline comes in 500 to 1000 foot sections of seamless pipe. As per U.S. Coast Guard regulation, proper lighting needs to be in place, on riser pipes offshore and onshore and on all floating pipelines over the course of the entire project. Buoys are required along the submerged line so as to properly locate and identify it.

Appendix D

Table: Dredged Material Volumes April 2009 Environmental Assessment for Delaware River Channel Deepening

Appendix E

Philadelphia to Sea CDF Inventory Table

Table E.1: PROJECT: Maintenance Dredging, Delaware River, Philadelphia-to-the-Sea **9/22/2010**

Summary Table - Disposal Area Features

Disposal Site	Sub Area	Latest Survey		Acres Diked (a)	Inspection Date	Last Date Inspected	Average Dike Elevation NAVD88 (FT)	Average Floor Elevation NAVD88 (FT)	Estimated Current Capacity (b) (MCY)	Estimated Current Cap. w/Bulking (c) (MCY)
		Aerial	Land							
1. National Park		5/2007		101		27 Jul 05	32	21	1.5	0.8
2. Oldmans #1		5/2007	6/2005	295		11 Aug 05	38	23	6.2	3.4
3. Pedricktown	N	11/1998	8/2009	517		11 Aug 05	42	34	5.0	2.8
	S	5/2007	8/2009	497		25-Feb-03	48	36	8.0	4.5
4. Penns Neck		5/2007		321		22 Sep 05	23	13	3.9	2.2
5. Killcohook	1	5/2007	7/2008	714		20 Jul 05	36	30	4.6	2.6
	2	5/2007	12/2003	276		20 Jul 05	52	47	1.3	0.7
	3	5/2007	6/2005	181		20 Jul 05	45	39	1.0	0.6
6. Artificial	1	5/2007		94		21 Jul 05	18	11	0.7	0.6
Island	2	5/2007	6/01	107		21 Jul 05	24	15	1.2	0.7
	3	5/2007	6/01	89		21 Jul 05	12	6	0.4	0.2
TOTALS:				**3,192**					**33.9**	**19.1**