REBUILDING "STRONGER THAN THE STORM" – ENHANCING RESILIENCE OF THE NEW JERSEY MARINE TRANSPORTATION SYSTEM

W.S. Douglas[1] , M. Marano[2] and G. Clifton[3]

ABSTRACT

The Marine Transportation System (MTS) of the State of New Jersey comprises some 930 km of engineered navigation channel ranging from 15 m Federal channels serving ultra large container vessels to 1.8 m State channels serving private recreational vessels and pretty much everything in between. Several million cubic meters (CM) of dredged material must be removed every year to maintain this system, ranging from contaminated Harbor silts to pristine sand suitable for use on public beaches. Since 1995, the New Jersey Department of Transportation's Office of Maritime Resources is the State's lead agency responsible for planning, improving, and maintaining this system in cooperation with Federal, State and local partners. In the months following Superstorm Sandy in October of 2012, New Jersey struggled, in part due to bifurcated responsibility, to evaluate and begin recovery from the devastation wrought from the record high storm surge. While upland damage was easily seen and evaluated, the full extent of damage to the MTS, particularly the navigation channels, was harder to gauge. Following a State-wide synoptic evaluation, it became apparent that more than half of the MTS had been significantly damaged by both storm debris and moderate to severe shoaling of the State's navigation channels. In addition to the widespread damage to shoreline infrastructure, more than 2.3 million cubic meters of dredged material would need to be removed to return the system to a "State of Good Repair". Given the longstanding inadequate capacity for managing dredged material, full recovery in a timely fashion was not only going to be expensive, but it would also require innovative approaches to permitting, contracting and implementation of the State's dredging program. The Office of Maritime Resources was tapped to develop a comprehensive dredging program that will not only provide full recovery of the MTS within the next five years, but will also continue to implement innovative asset management, dredged material management and coastal resiliency programs. Specific attention will be paid to the Waterway Linear Segmentation system, beneficial use case studies including the restoration of subaqueous borrow pits, renewable confined disposal facilities, sediment dewatering and marsh enhancement, as well as progress toward long term strategies for sediment reduction and coastal resiliency through regional sediment management partnerships.

Keywords: Dredged material management, maintenance dredging, beneficial use, Superstorm Sandy, coastal resilience.

INTRODUCTION

New Jersey's Marine Transportation System can be divided into three major regions: the NY/NJ Harbor, the Delaware River, and the Atlantic Shore. Within these three regions are over 930 km of engineered waterway, thousands of berths, docks and ramps, as well as two internationally significant port complexes with associated terminals and goods handling facilities (Fig 1). Overall, New Jersey's MTS supports an economic engine worth over $50 billion annually ranging in activity from tourism and recreation to commercial fishing to international trade. Millions of cubic meters of sand, silt and gravel are transported into this channel network by Mother Nature every year and must be removed

[1] Dredging Program Manager, New Jersey Department of Transportation Office of Maritime Resources, 1035 Parkway Avenue, Trenton, New Jersey 08625 USA T: 609-530-4770, Email scott.douglas@dot.nj.gov.

[2] Senior Supervising Civil Engineer, WSP | Parsons Brinckerhoff, 2000 Lenox Drive, Lawrenceville, New Jersey, 08527, USA, T: 609-512-3516, Email: Michael.marano@wsp.com.

[3] Manager, New Jersey Department of Transportation Office of Maritime Resources, 1035 Parkway Avenue, Trenton, New Jersey 08625 USA T: 609-530-4770, Email genevieve.clifton@dot.nj.gov.

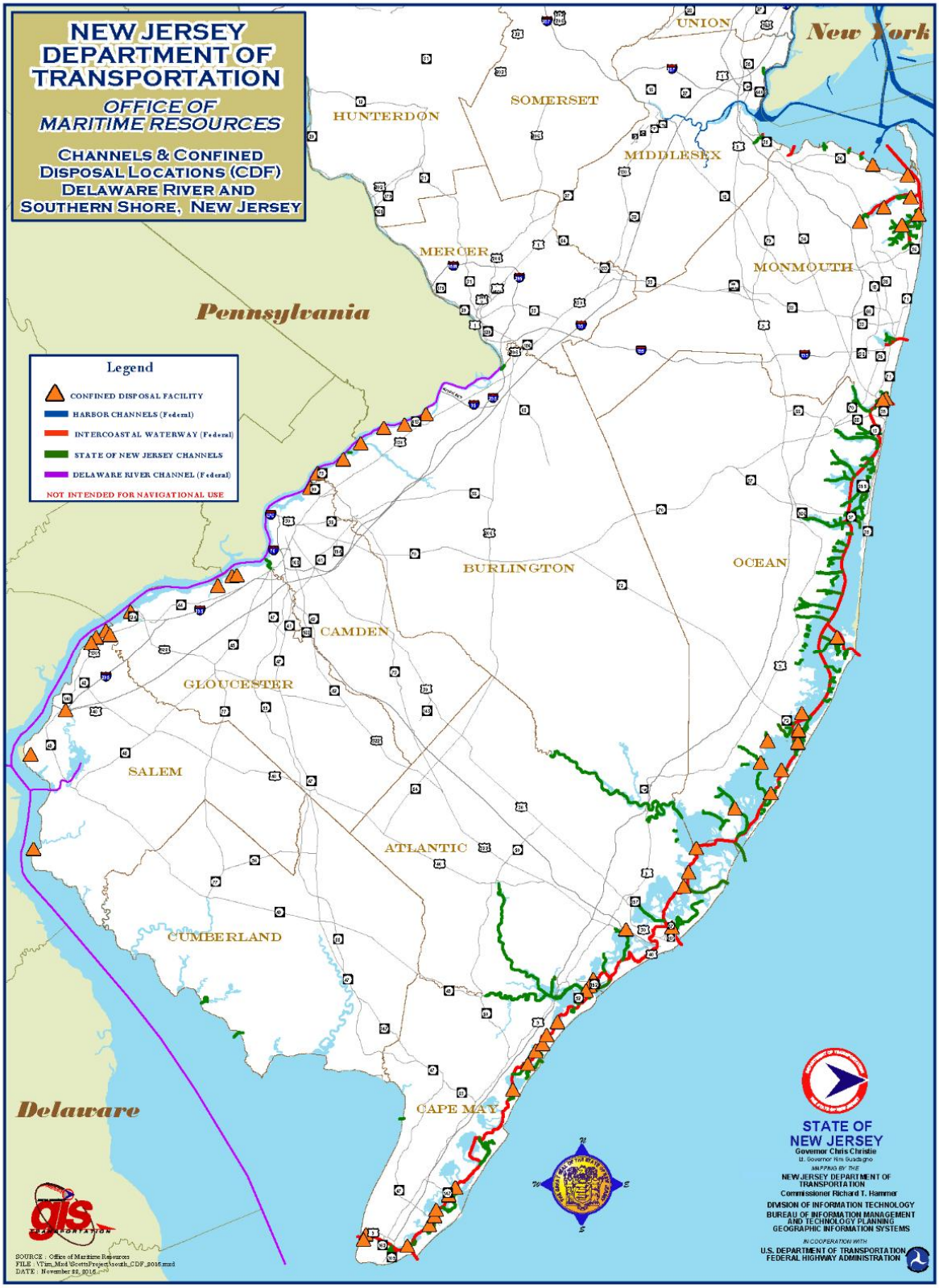

Figure 1. State and Federal navigation channel network and CDF locations in New Jersey

by maintenance dredging. Historically, dredged material was disposed of in the most convenient and cheapest way available, often without concern for environmental or aesthetic impact. There are numerous open water disposal sites that were used in New Jersey, and the coastline is littered with the remnants of past practice, disturbed uplands, and Confined Disposal Facility (CDF) islands, some used, some abandoned. Today, increased environmental awareness and competition for coastal land has made "disposal" unsustainable. The mantra is for reduction of dredging need wherever possible, reduction in contamination, and beneficial use. Most recently, discussion is turning toward opportunities to keep sediment in its natural system. For the past two decades, the Office of Maritime Resources of the New Jersey Department of Transportation (NJDOT/OMR) has been the agency charged with developing strategies for dredging and dredged material management statewide.

In October of 2012, Superstorm Sandy brought unprecedented storm surge and winds to shore communities and cities alike, spreading devastation across the region. The State completed a comprehensive side scan sonar and bathymetric channel survey to determine the locations of sunken debris and the extent of channel shoaling caused by the storm surge. Thousands of sunken targets were identified, ranging from cars and boats to pilings and crab pots. It was difficult to know which of this debris was storm related and which was already in place, but nonetheless, contractors were hired to remove as much of the Sandy-related debris as possible. Of course given the long maritime history of the area, the State Historic Preservation Office needed to review all of the data and approve its removal before the contractors could act.

Performing a comprehensive synoptic bathymetric survey had never been performed in the State's history. The first challenge was actually cataloging all of the navigation channels. While the New Jersey Department of Environmental Protection Bureau of Coastal Engineering (BCE) had been evaluating and marking safe passage for decades, full engineering level surveys had not been done, or were no longer available, on many channels. NJDOT/OMR gathered knowledgeable people together from throughout the state and eventually was able to map out the State's network from Liberty State Park, Hudson County, in the north to Spicer's Creek, Cape May County, in the south. In total, 209 channels were identified, covering some 370 km. Armed with this information, marine surveyors were dispatched to collect hydrographic data. Analysis of these data revealed over 2.3 million cubic meters of sediment was lying at the bottom of New Jersey's MTS. Ranking the data by severity showed that over half of the channels could be considered significantly shoaled, and 34 percent were severely shoaled or impassable.

As with the debris, it was not possible to determine from the surveys alone how much sediment was due to storm over-wash or a massive influx of offshore and eroded sediments into the system and how much of it was due to prior siltation. The State quickly negotiated with the Federal Emergency Management Agency (FEMA) to develop and agree upon a scientifically-based protocol that could be used. The Stockton University Coastal Research Center (CRC) was enlisted to devise and oversee the process of coring in all 209 Atlantic coast State channels. To make the determination as to what material had been present prior to the storm, and what had been deposited by the storm, an army of geologists were dispatched to collect, analyze and measure cores from the entire system. By observing the state of the material in the cores, coastal geologists led by the CRC were able to determine how much of the sediment in the channels had been recently deposited. The amount of Sandy impact varied widely from location to location, but on average was about 27% percent across the entire system, or 612,000 cubic meters. This information, along with as much historical data as was available on the channels was submitted to FEMA for reimbursement consideration. It became rapidly evident that a comprehensive program to restore the System to a "state of good repair" would be critically necessary. Eventually, 131 State channels impacted by Superstorm Sandy were determined to be eligible for the emergency response program.

TRADITIONAL SOLUTIONS

Confined Disposal Facilities

Confined Disposal Facilities, or CDFs, are passive dredged material dewatering facilities constructed using earthen berms and weir boxes for water level control. This approach has been used throughout the country as a low cost way

to manage dredged material. They range in size from a few hectares to over fifty hectares, and can be surrounded by berms as high as twelve to fifteen meters or more. The level of integrity of such structures varies widely, ranging in complexity from meeting or exceeding United States Army Corps of Engineers' (USACE) design standards to unconfined upland placement for one time use.

NJDOT/OMR has inventoried all of the historic upland sites in the state. Some of these sites were unconfined disposal sites for one time use during the initial construction of the MTS. Others are frequently used by the State, USACE or local municipalities, have fully engineered berms and water control structures, and are carefully managed. Many are at or nearing capacity, with few, if any, alternatives. For some facilities, it is practical to sell off the dried sand or gravel they contain, but for many, once they are filled as high as they can safely be filled, they are abandoned. This leaves the manager with no choice but to find another site or to cease maintaining nearby channels. Given that most shore communities have aggressively developed available land, leaving only environmentally sensitive and protected lands, there are few, if any sites available for construction of new CDFs.

Open water disposal

Open water disposal of dredged material has been practiced throughout the world for centuries. In many ports and harbors, it is the most cost effective solution to combat the millions of metric tons of silt and sand that annually clogs shipping channels. The sediment is dredged mechanically, placed into huge ocean going split hull scows, taken out to the ocean, and dumped on the bottom. Up until the mid-1990s, all of the material dredged out of the NY/NJ Harbor was disposed of either at various locations in the Harbor, or more recently, several miles off Sandy Hook. While new environmental regulations limit the amount of material suitable for placement in the ocean, open water disposal is still the method of choice for millions of cubic meters of sand, virgin clay, and silt from the Harbor. Rock from Harbor Deepening Project is also placed in open water, albeit beneficially used for the construction of fishing reefs off the Atlantic coast of NJ and Long Island. This method is limited to the Harbor region in New Jersey due to depth constraints on typical equipment and the high cost of sampling and testing.

Beach replenishment

One of the earliest and most widely beneficial uses of dredged material is beach replenishment. Clean sand, of similar size and texture as the receiving beach can be used to restore eroded beaches used for recreation or wildlife. The need for beach replenishment is so great in New Jersey that millions of cubic meters of sand are dredged from offshore borrow pits and pumped to receiving beaches up and down the Atlantic coast. The beneficial use of sand dredged from navigation channels is actually dwarfed by the need, tends to be localized and is small in scope compared to the larger beach restoration projects. Yet, it is still the most cost effective way to manage dredged sand and therefore an important part of the NJDOT/OMR's dredged material management strategy.

INNOVATIVE SOLUTIONS

Upland beneficial use (amended and CDF)

For the last decade or so the State's primary strategy for dredged material management is to beneficially use material wherever and whenever possible. Shifting from disposal to beneficial use was a direct result of the dredging crisis in NY/NJ Harbor and the lack of viable alternatives when the long-standing ocean disposal site was eliminated as an option. While clean sand, virgin clay/gravel and clean silt from the Harbor were used as a cap for the former ocean disposal site, now called the Historic Area Remediation Site (HARS), the lack of available options for placement of contaminated silt was problematic. Many ideas were proposed as solutions, but the one that proved to work the best was to amend the silt with Portland cement and use it as a cap material for landfills, brownfields and abandoned mines. To date, in excess of 15 million cubic meters of contaminated silt has been safely and effectively processed and placed upland (Figure 2), resulting in dozens of properties becoming available for use as warehouses, parks, golf courses and commercial space (Douglas et al., 2003; Maher et al., 2013). But what about the millions of cubic meters stored in CDFs throughout the state?

Figure 2. Illustrates the process of mixing dredged material with additives to manufacture useable fill.

Beneficial use of the relatively clean material stored in CDFs has had mixed success to date. While clean sand and gravel in large CDFs with direct landside access to the highway system has long been marketed as aggregate, it is more problematic when the CDFs contain silts and clays and are positioned far from highways or in environmentally sensitive areas. In this case, the cost of obtaining the material exceeds the benefit of its use or resale. Though, with quarry material as a finite resource, this cost-to-benefit ratio may change over time.

Regardless of their location, many of these CDFs statewide are at or near capacity. NJDOT/OMR has selected some sites that have the potential for a higher market value for rehabilitation. The material has been sampled and tested, and permits obtained that allow excavation of the accumulated material for beneficial use. After meeting with the construction and aggregate industry, NJDOT/OMR discovered that there is interest in using this material, regardless of its geotechnical properties, as engineered fill. In 2017, NJDOT/OMR intends to release the first procurement for one or two of these CDFs to be excavated and rebuilt.

Recently, NJDOT/OMR has been promoting the idea of Dredged Material Management Facilities, or DMMFs. A DMMF represents a new way of thinking about dredged material management in New Jersey. Rather than abandon sites when they become too full to use, it is becoming necessary to consider a more sustainable model. DMMFs need to be strategically located, have landside access to the extent feasible, contain staging or offloading facilities, be carefully managed for speed in dewatering and excavation for beneficial use, and be able to accommodate State, Federal and local needs. While the long term goal is to reduce the need for dredging by keeping material in the system, it will take time to develop methods to accomplish this reliably, making it logical to assume that DMMFs will be needed for some time to come. Given the practical limit of approximately 8 km for the hydraulic pumping of dredged material, NJDOT/OMR has determined that as many as eight new DMMFs will be needed to maintain the NJMTS

Restoration of subaqueous borrow pits

In years past, it was considered acceptable practice to dredge sand deposits out of the back bay areas in NJ and use that material to fill in tidal creeks and wetlands, or open water, and create "fast land" for development. While this practice has long been prohibited, "borrow pits" remain scattered throughout New Jersey's back bays. These "dredged holes" sometimes serve as habitat for fish, providing deep water refugia from summer high temperatures. But more often than not, the holes attract fine silt and debris, dead plants and animals, and the lack of circulation results in anoxic conditions and no natural benthic community. Since as early as the 1960s these holes have been identified as restoration targets, and possible repositories for dredged material from maintenance dredging projects.

Working with the Stockton CRC, the NJDOT/OMR inventoried 122 dredged holes and depressions from northern Ocean County to Cape May using historical data, aerial photography and GIS. Holes that appeared to have sufficient

capacity and close proximity to navigation channels were targeted for further evaluation as potential dredge material placement sites. A screening level check of bottom conditions, benthic community, and depth was

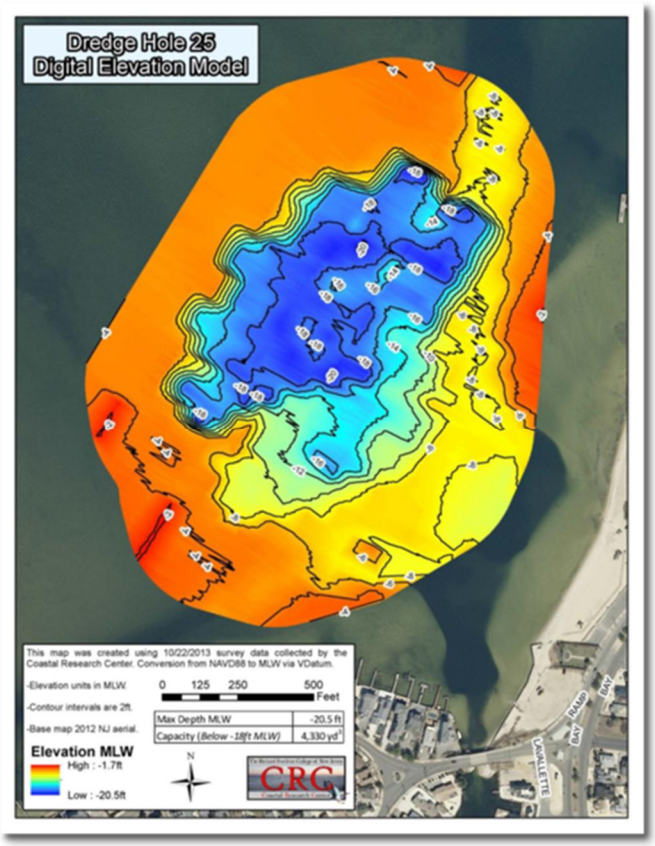

Figure 3. Plan view of Dredged Hole # 25 in Toms River Twp., NJ proposed for restoration of SAV habitat using dredged material.

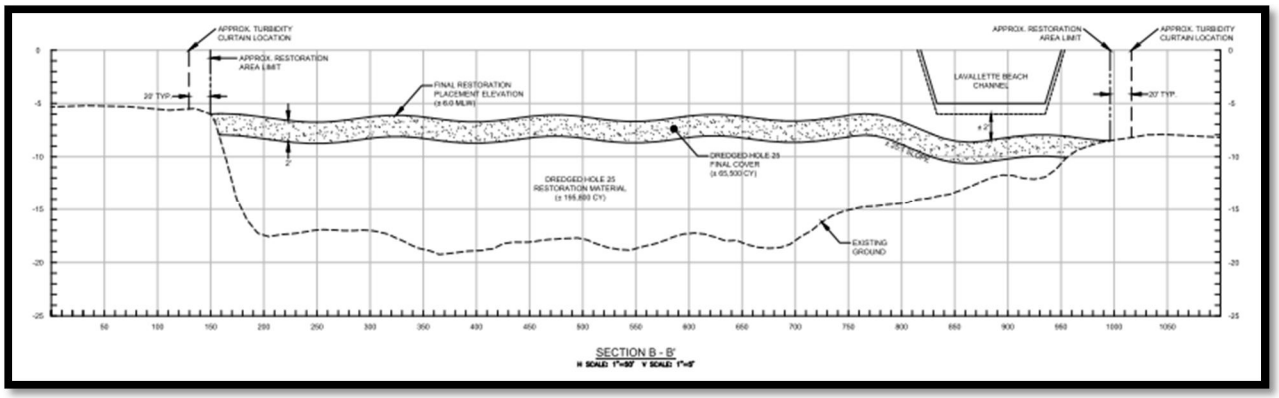

Figure 4. Typical Section Dredged Hole # 25 looking north in Toms River Twp., NJ proposed for restoration of SAV habitat using dredged material.

performed on these sites. Sites that had a healthy benthic community or were less than 5.5 m deep were considered unsuitable. This reduced the number of potential restoration sites to five. After consulting with resource agencies, two holes were selected for restoration of Sub-Aqueous Vegetation (SAV) habitat. Further evaluation of the SAV species present and their preferred substrate was performed, dredged material sources identified, and a restoration plan produced for each hole. Dredged Hole 18 will hold 134,000 cubic meters and Dredged Hole 25 will hold 200,000 cubic meters (Figures 3 & 4 show Dredged Hole 25). Material will be hydraulically dredged and transported by pipeline to a diffuser set in the middle of a silt curtain that extends to the bottom of the hole. This work is expected to commence in the fall of 2017 and take two construction seasons to complete.

Mechanical dewatering

In many places in New Jersey, there are simply no options for effective dredged material management. There is no better example of this than the Shark River channels in Monmouth County, NJ. The surrounding communities have developed almost all of the available shoreline, maintaining only parks and preserved natural areas. There are no available properties that can be used to feasibly host a confined disposal facility. While parking lots can and have been used to hold geotubes with small amounts of dredged material from a single berth, there was no place large enough, or available long enough, to host a channel maintenance project. Consequently, at the time of the storm, the Shark River channels, authorized to be 1.8 m deep, were as shallow as 0.3 m deep in many places. Sandy made matters much worse, depositing almost 33,000 cubic meters of new material in an already severely shoaled system.

Attempts to use a historic CDF in an adjacent natural area failed, as did proposals to create fast land and a containment island wildlife refuge, making it look increasingly unlikely that a workable solution would be presented. Complicating matters was a vanishingly small permitted dredging window of only four months, at the end of the calendar year. NJDOT/OMR advertised a solicitation looking for qualified and experienced dredgers who could use a combination of passive and mechanical dewatering to restore the channels. Mobile Dredging and Pumping Co. of Chester, PA won approval. Mobile proposed 2 mechanical dewatering systems for the project. Phase I featured a passive dewatering system that featured a piping system and geotube field in a contained parking lot area. Seven geotubes were used during phase I which held approximately 3,060 cubic meters of material (Figure 5). Phase II featured a rapid or active dewatering system which included a scalping operation that separated the sand and debris from the dredge slurry, and belt presses to force the water from the fine-grained material. Seven belt presses and two scalping systems were used in the active dewatering operation (Figure 6). Over the course of the two phases, much of which was too cold to operate efficiently, Mobile dredged 33,200 cubic meters and produced 43,460 metric tons of dewatered dredged sand and silt. 960 metric tons of coarse sand was considered suitable to replenish a local beach. The remaining 42,500 metric tons of dried material was trucked to the Monmouth County landfill for use as daily cover.

Marsh enhancement

Traditionally, marsh was considered a suitable place to put dredged material; either broadcast without consideration of containment, or with partial or full containment and controlled water return. As environmental regulation became more restricted, only fully controlled CDFs were allowed to be used for maintenance dredging projects, and it became very difficult to obtain, permit and construct new sites. In an ironic twist, it has been noted throughout the Atlantic coast that sea level rise is actually "drowning" salt marsh habitat. Failure to drain completely on each tide cycle has resulted in a gradual decrease in root mat density and a slow loss of sediment, with eventual reversion to open water. Healthy low marsh and high marsh habitat exists only within the daily tidal elevation range. It is essential for that habitat to experience the twice-daily tidal flushing that also naturally adds sediment and nutrients to the plant life in these zones. When that tidal cycle ceases to occur in specific areas of a salt marsh, the habitat will degrade until the biology can no longer support low marsh flora, eventually reverting to mud flat or open water. In many cases, this happens from the inside out, and it is often too late to save the marsh once the outer rim of the wetland is lost, thereby allowing intrusion of open ocean or bay into the interior of the marsh.

Figure 5. View of the passive dewatering operation for the maintenance dredging of the Shark River Channel and Shark River Channel Spur in the Borough of Belmar and Neptune Twp., Monmouth County, NJ. Phase I geotube field and associated piping network.

Figure 6. View of the active dewatering operation for the maintenance dredging of the Shark River Channel and Shark River Channel Spur in the Borough of Belmar and Neptune Twp., Monmouth County, NJ. Note the coarse grained material is being removed at the left of the picture and processed fine-grained material is shown at the center.

This effectively completes the destruction of the wetland. Many coastal scientists now feel that one way to combat these losses is to restore the natural accretion of sediment on the marsh, allowing it to keep pace with sea level rise and restore eroded sediment. The best way to accomplish this goal may be to use dredged material from maintenance dredging operations.

Working in conjunction with the NJ Division of Fish and Wildlife, NJDOT/OMR identified a section of salt marsh in a wildlife refuge in Cumberland County, NJ that was experiencing habitat degradation and in real risk of being converted to open water. Using a combination of dredge material comprised of silt and sand in the nearby Fortescue Channel, open water areas in the degraded marsh were filled and a water side dune was created to help protect the marsh from wave action. Using a double ring of compost-filled filter socks, an array of discharge pipes and valves, and daily monitoring of elevations, an adaptive management approach was used to restore the salt marsh habitat while simultaneously restoring navigability to an important fishing pier and USCG search and rescue station (Figures 7,8). The team is currently evaluating several more salt marshes in the Forsythe Wildlife Refuge for similar projects and hopes to develop a long term program of marsh enhancement with the Fish and Wildlife Service that could serve as a model for the Atlantic coast.

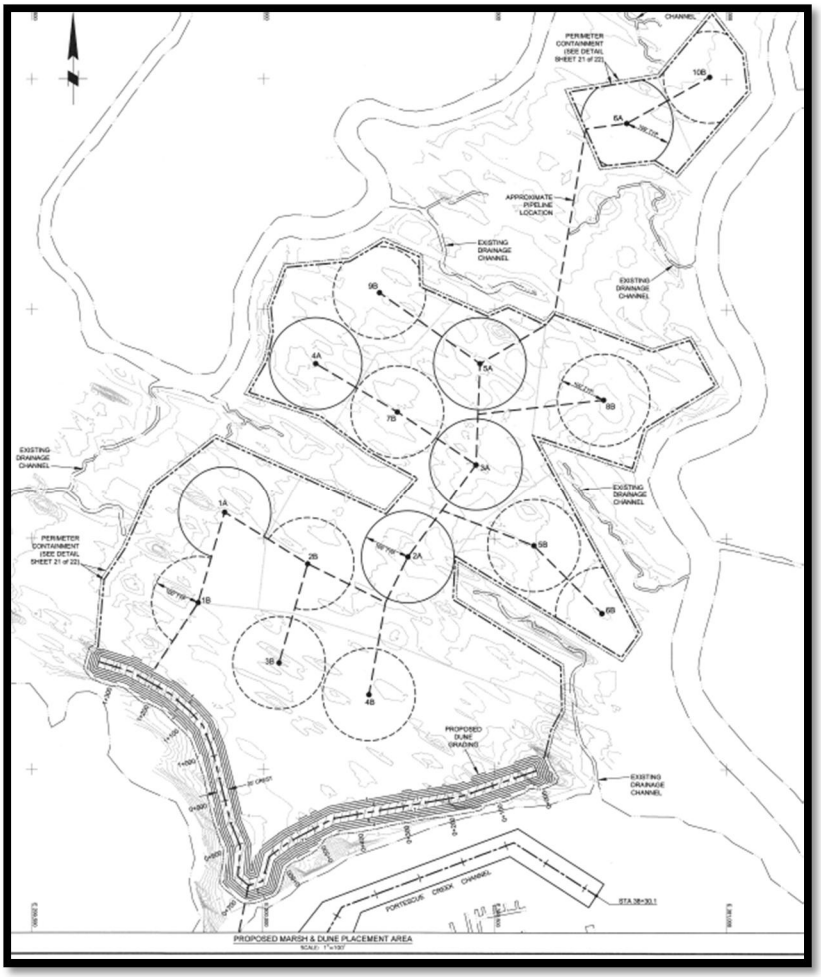

Figure 7. View of the proposed placement plan of the Fortescue Wildlife Refuge Habitat Enhancement using dredged material project in Downe Twp., Cumberland County, NJ.

Figure 8. Construction photos of inflow point 4A with flow being diverted by the excavator (left) and material settling out close to the fill limit near inflow point 4A (right) in the Fortescue Wildlife Refuge - Downe Twp., Cumberland County, NJ.

Coastal resiliency

One of the first projects that NJDOT/OMR performed after taking over the State channel network was in the Borough of Keansburg along the Raritan bay shore in Monmouth County, NJ. A small 2 Hectare CDF had long been used to hold sand and silt from the rapidly shoaling State channels serving three marinas. Because much of the Borough of Keansburg is actually below sea level, the entrance channel to the Raritan Bay is guarded by a robust tide gate that is operated very frequently. At the time the NJDOT/OMR team arrived to perform public outreach for the upcoming maintenance dredging project, the CDF was full in its current configuration (Figure 9). NJDOT/OMR proposed to remove a significant amount of sand and silt from the CDF and truck the material offsite for use at another Monmouth County, NJ CDF. The team also proposed to reconstruct the existing berms and refill the CDF to restore navigability to the channels.

Much to the surprise of the team, Keansburg actually wanted the material left in-place and requested that the existing berms be made higher. In fact, they educated us to the fact that the area behind the CDF was one of the only areas in the borough that had not flooded during Superstorm Sandy. Consequently, they not only wanted the existing CDF raised, but they wanted the State to consider building more CDFs adjacent to the existing facility and along their bay shore to help protect them from future storm surges. While many communities have sought sand to restore or create dunes for storm protection, rarely is it recognized that silty material, once dewatered, makes a stronger, more resilient core for a dune. The State is currently exploring the idea of using a string of CDFs in this area as a regional DMMF.

Figure 9. Project Map with Section A-A of the Keansburg CDF

ADMINISTRATIVE STRATEGIES

Bundling of channel contracts

Traditionally, maintenance dredging contracts have been permitted and contracted on a channel by channel basis. While this practice is acceptable for large deep-draft channels that include hundreds of thousands, if not millions of cubic meters, rarely does the maintenance dredging of State channels require the removal of more than tens of thousands of cubic meters. The inherent fixed costs of dredging, not to mention engineering and administration, make this singular approach expensive and inefficient. In order to improve efficiency and reduce costs, NJDOT/OMR logically bundles channel projects together, thereby increasing the pay volume of each contract while minimizing mobilization costs. While this practice makes permitting projects slightly more complex, the State feels the additional cost savings more than compensates for the additional effort, and it has resulted in a greater interest in the NJDOT/OMR program from the dredging industry.

Job order contracting

Job order contracting is a relatively new way for agencies to secure on-call contracts without resorting to force account or "time and materials" payment strategies. Essentially, the job order contract is a comprehensive listing of work items that can be requested by the owner with agreed upon prices that are typically paid for the work. The contracting industry bids on this listing and provides a multiplier. The company with the lowest multiplier of the listed work items is considered the "low bidder" and is awarded the on-call contract. Work scopes are developed by the owner and provided to the contractor on a task order basis. Proposals, budgets and schedules can be readily negotiated to achieve acceptable terms to both parties. This can reduce the time of procurement of services from three to six months to two to three weeks.

LONG TERM STRATEGIES

Modeling

NJDOT/OMR is performing regular synoptic bathymetric surveys of the NJ State Channel network in order to keep pace with what can be rapidly changing conditions. These surveys not only allow the State to reprioritize channel maintenance as needed, but will allow for calculation of sedimentation rates by channel and therefore predict the need for maintenance many years into the future. While imperfect, continual refinement of this system-wide model should allow the State to better predict funding needs and maintain a high level of system reliability.

Control structures

In several State channel systems we are faced with a near continuous need to dredge. This is mostly due to the high energy environment of our inlets and littoral drift of sand from replenished beaches, and most likely a combination of the two. Given the cost of work in these high energy environments, the State is beginning to investigate engineered solutions that either prevent sand from entering the channel or provide a relatively simple maintenance event. The State is working with the Stevens Institute of Technology and their Davidson Laboratory to evaluate several of these complexes and propose solutions. This investigation has just started and it is estimated to take a couple years for completion. In addition, the State is also exploring the use of re-profiling and near shore in-water placement for coarse grained, clean sand with the NJDEP and the National Marine Fisheries Service (NMFS). While open water placement is typically frowned upon by regulators in New Jersey, it may be that this technique, for small volumes, may actually be less intrusive on the environment than more traditional methods.

Regional Dredging Teams

New Jersey is unique in the country in that is has two very active regional dredging teams; one on the Delaware River and one in NY/NJ Harbor. The US Army Corps of Engineers hosts these regional teams composed of environmental resource and transportation agencies that are responsible for permitting and conducting dredging activities. In both cases, these bi-monthly or quarterly meetings ensure that the regulatory agencies and dredging project owners understand each other's concerns and needs. These collaborative meetings foster a sense of "team" among the members, streamlining permitting efforts and reducing environmental impacts for the projects at hand. These meetings also ensure that agency leadership will know in advance whether situations beyond the control of the group might result in a transportation or environmental crisis.

Regional Sediment Management Planning

One of the best tools that a Regional Dredging Team can have is a fully vetted and accepted Regional Sediment Management Plan (RSMP). This document outlines the need for dredging and the available options for dredged material management, environmental impacts, costs and research needs. The RSMP can also identify permitting difficulties and the management of sediment as a resource. Both the Delaware Estuary and the NY/NJ Harbor have approved Regional Sediment Management Plans that serve to direct the activities of the group and as a touchstone for research funding and regulatory reform.

NJDOT/OMR is beginning conversations with municipalities and volunteer ad hoc dredging groups to apply this concept on the local and county level. As the owner of a dredging project becomes more discrete (homeowner, marina, condo-association, municipality) it becomes even more critical for a comprehensive plan to guide the dredging and material management process. Planning, engineering and permitting for projects that are combined can ensure an economy of scale that allows a project to move forward, that otherwise might not. Further, dredged material is best managed on a larger scale. A variety of private contractors doing many small, uncoordinated projects introduces extreme inefficiency into the process. Moreover, from a planning, project and financial management and oversight standpoint, a single entity is best suited to ensure that project goals are met, on-schedule, within budget and in compliance with special project permit conditions.

Asset Management Systems

Transportation Departments across the country use asset management as a strong and effective tool for the management of the nation's vast and complex roadway and bridge system. Asset management systems include an inventory of the system, regular evaluations of system condition, repair needs and costs, as well as historical data. The purpose of the system is to allow program managers to identify advance maintenance needs in order to ensure reliability and minimize annual costs. The benefit of this approach is that regularly scheduled infrastructure maintenance will avoid system degradation to the point of replacement.

Ten years ago, NJDOT/OMR began thinking about an electronic "system" that could house information regarding the State's navigable waterways, and mirror the NJDOT's Straight Line Diagrams for cataloging the condition of maintained roadways. Developed in fits and starts, the initial product was called a Waterway Linear Segmentation system, or "WLS." After much discussion and development of business requirements, and as our society's use of technology exploded as a basis for management, the idea of managing both waterways and their resultant dredged material through an asset management system became feasible, and even preferred, from the standpoint of a transportation agency.

NJDOT/OMR will be rolling out a modern asset management system for the State Channel navigation system within the next few months. It will include an inventory of the system, condition of each channel, vessel use and facilities served. It will also include an inventory of dredged material management options, their condition, capacity, availability and cost of use. Parts of this system will be publically facing, with the ability to "crowd source" channel condition, particularly navigation hazards.

Dredged material marketplace

As part of the asset management system, NJDOT/OMR will also be rolling out a Dredged Material Marketplace. This system will not only allow NJDOT/OMR to track every cubic meter of dredged material and determine the most cost effective way to manage dredging needs, but will also provide the public with a way to "trade" dredged material and promote beneficial use. The system will geographically identify "users" and "takers" of material – those who want and those who need – and provide an information platform for enhanced beneficial use opportunities. The Marketplace will establish the use of dredged material beyond limited current industry practice and ideally will enable a more ubiquitous approach to its use.

Programmatic permits

When managing a system of over 200 channels, it is not practical for either the NJDOT or the permitting agencies to evaluate maintenance dredging projects on a channel by channel basis. NJDOT/OMR is preparing applications for programmatic permits from both the NJDEP and the USACE that will streamline the engineering process and provide for more effective use of available dredging time frames by eliminating the uncertainty of timing restrictions in the current process. The programmatic permits will identify the channels, authorized depths, current conditions and available dredged material management alternatives. NJDOT would provide details of each specific project prior to construction to ensure that each is compliant with the conditions of the programmatic permit and receive any conditions specific to the project. This would only be appropriate for dredging and dredged material management methods that are already well established and their impacts can be reasonably predicted.

SUMMARY

Since the start of the recovery effort, fifteen channels have been dredged and twenty more are in construction, representing 46.3 km and 545,000 cubic meters of sediment. Material management has ranged from beach placement to upland confined disposal to mechanical dewatering with upland beneficial use. Currently, an additional 19 channels are fully permitted and scheduled to be bid, representing another 46.3 km and 378,000 cubic meters of sediment. Another 32 channels are in various stages of design and permitting.

Table 1. Summary of dredging contracts, volumes, dredged material management and bids for projects awarded since Superstorm Sandy.

NJDOT Contract No.	Location	Advertised Pay Volume (CM)	Placement Method	Winning Bid	Status
005201401	Borough of Keansburg, Monmouth Co.	24,000	Beach Fill and Reconstructed CDF	$1,246,000	Complete
171201402	City of Brigantine, Atlantic Co.	31,000	Beach Fill	$603,000	Complete
205201403	Lower Twp. & City of Cape May, Cape May Co.	89,000	Existing CDF	$2,150,000	Complete
198201404	City of North Wildwood, Cape May Co.	30,000	Beach Fill	$1,712,000	Complete
004201502	Old Bridge Twp., Middlesex Co. Middletown Twp., Monmouth Co.	15,000	Beach Fill Existing CDF	$872,000	Complete
125201503	Twp of Barnegat, Ocean, Long Beach, Lacey, Borough of Barnegat Light, Ocean Co.	106,000	Reconstructed CDF and Beach Fill	$8,780,365	Ongoing
041201504	Brielle and Manasquan Boro, Monmouth Co., Point Pleasant and Point Pleasant Beach Boro, Ocean Co.	80,300	Beach Fill and existing CDF	$3,336,629.10	Ongoing
038201505	Neptune Twp., Neptune City and Borough of Belmar, Monmouth Co.	60,000	Passive and Active Mechanical Dewatering	$7,649,817.50	Complete
211201508	Downe Twp., Cumberland Co.	25,500	Marsh and dune enhancement, beach fill	$3,855,100	Complete

When all of this work is complete, a total of 135 km will have been cleared of 1.45 million cubic meters of sediment. In addition, six CDFs have been repaired or cleared of some or all of their stored material, and six more are in design for restoration. It is anticipated that it will take another 4 years to complete the dredging needed to bring New Jersey's MTS into a state of good repair. This effort includes maintaining the existing channels at their authorized depths through the application of modern asset management principles. In addition, emergency response will always be needed in a time of rising tides and increased storm activity on our State's coast. Since Superstorm Sandy, winter storm Jonas brought a significant storm surge with it and has resulted in the need to re-dredge three of our previously dredged channels in southern NJ. Finally, the NJDOT Office of Maritime Resources has been working with our coastal municipalities on advanced plans for dredging through our regional dredged material management planning efforts. NJDOT has entered into one agreement with the City of Avalon, Cape May County, NJ which assisted them in their efforts to clear local channels while simultaneously dredging the State channels in their area. The NJDOT/OMR is currently in negotiations with Ocean City, Cape May County, NJ on a similar agreement and they are beginning negotiations with another NJ coastal community.

In New Jersey, the NJDOT Office of Maritime Resources maintains an open viewpoint to new and innovative, and even unconventional ideas that may improve the dredging situation. Additional research into utilization of dredged materials for coastal resiliency on our marshes and beaches is currently underway. Better projects that improve storm protection for our homes and wetlands, as well as making it easier to maintain our channel network will both increase property values and decrease homeowner anxiety. While the initial costs of this program are high, the long term costs once the backlog is relieved are manageable. However, our state must remain vigilant against sliding into deferred maintenance. Another potential risk is the loss of Federal funding for shallow draft navigation, which has been recently voiced by some in Congress. The New Jersey network of State channels are branches off the trunk provided by the Intracoastal Waterway and inlets. Without strong commitment to the maintenance of this critical infrastructure and economic resource, our initial efforts to restore the State channels would be in vain.

REFERENCES

Douglas WS, Baier L.J, Gimello RJ, Lodge J. 2003. A comprehensive strategy for managing contaminated dredged material in the Port of NY and NJ. *J. Dredging Eng.* 5(3):1-12.

Maher A, Douglas WS, Jafari F, Pecchioli J. 2013. The Processing and Beneficial Use of Fine-grained Dredged Material; A Manual for Engineers. Center for Advanced Infrastructure and Transportation, Rutgers University, New Brunswick, NJ.

Douglas, W.S., Marano, M., Clifton, G., "Rebuilding "Stronger than the Storm" – Enhancing Resilience of the New Jersey Marine Transportation System" Proceedings of The Dredging Summit & Expo '17, Western Dredging Association, Vancouver, BC, June 26-29, 2017.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the outstanding contributions of the staff of the Office of Maritime Resources, NJDOT, WSP Parsons Brinckerhoff, Gahagan and Bryant Associates, Dewberry Engineers, the Office of Dredging and Sediment Technology, NJDEP and the Bureau of Coastal Engineering, NJDEP for the many years of hard work without which the efforts presented here would not have been impossible.