BENEFICIAL USE OF DREDGE MATERIAL COASTAL RESTORATION CASE STUDY

Prime Hook National Wildlife Refuge

Partners

- Delaware Department of Natural Resources and Environmental Control (DNREC)
- Delaware Department of Transportation (DelDOT)
- National Oceanic and Atmospheric Administration (NOAA)
- U.S. Army Corps of Engineers (USACE)
- US Fish and Wildlife Service (USFWS)

Contractors

- AMEC Foster Wheeler
- Dredge America
- EA Engineering, Science, and Technology Inc
- ER&M
- Stantec, Inc.
- USACE
- Norfolk Dredging Company
- TI Coastal

Key Information

PROJECT LOCATION
Milton, DE

USACE DISTRICT
Philadelphia

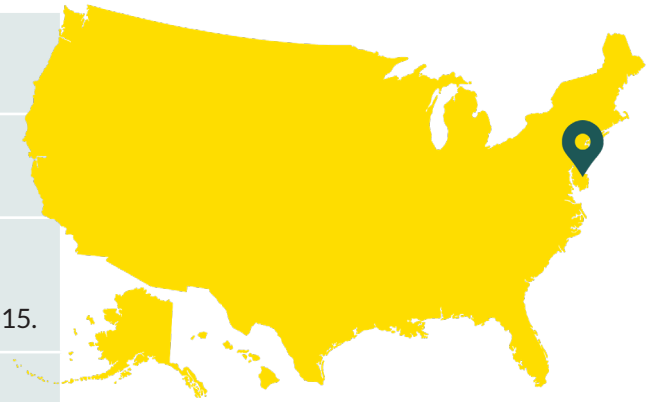
HABITAT
Beach, Dune, Tidal Marsh

LANDSCAPE
Back-barrier tidal marsh

PROJECT SIZE
4,000 acres, 8,900 linear feet of shoreline

PROJECT COMPLETED
Completed 2016. Early work started in 2008. Final model 2015.

PROJECT WEBSITE
https://www.doi.gov/hurricanesandy/more-resilient-prime-hook-national-wildlife-refuge https://www.stantec.com/en/projects/united-states-projects/p/prime-hook-marsh-restoration



ABSTRACT

A $38 million marsh restoration at Prime Hook National Wildlife Refuge in Delaware, completed in 2016, repaired damage caused by Hurricane Sandy in 2012 and added storm and sea-level rise resilience into the natural landscape.

The restoration repaired breached marshes, restored dunes and rebuilt the damaged shoreline. About 4,000 acres of back-barrier tidal marsh were restored, which will enhance and support a long stretch of barrier beach along the Delaware Bay.

The effort involved carving out miles of marsh drainage channels, mostly following historic drainage patterns, then pumping in 1.1 million cubic yards of sand along 8,900 feet of shoreline to fill the deep cuts left by Hurricane Sandy and other storms. The dunes and restored beach area were planted with native beach grasses and shrubs to hold the sand in place.

The restored marshes have created additional habitats for birds, including American oystercatchers and federally listed species such as rufa red knots and piping plovers. The restoration also provides enhanced storm protection for nearby residents.

Federal funding through the Hurricane Sandy Disaster Relief Act made the project possible. The project was the largest tidal marsh restoration project ever in the Eastern United States. The restoration is an example of a nature-based solution. Nature-based solutions are sustainable practices that use environmentally friendly features or processes to make landscapes more resilient to changes in climate and other conditions.

PROJECT GOALS

The overall goals of the project are to restore functional hydrology to the system, ecosystem function, and Horseshoe Crab considerations (beach face sand grain size). Note – if too fine of sand, Horseshoe Crab eggs won't develop.

Terrestrial restoration is likely to benefit other species — piping plover, rufa red knots (associated with Horseshoe Crab), terns, American oystercatcher, etc. Restoration work used a zig zag pattern for beach fencing to reduce impacts to shorebirds. Aquatic restoration benefited American eel, blue back herring, and other species such as stripers, drum, and bluecrabs.

What are the goals of the project:

- Restore tidal marsh habitats to support wildlife and vegetation.
- Improve coastal resilience against storms and sea-level rise.
- Restore natural hydrology and tidal flow.
- Enhance habitat quality for migratory birds, fish, and other wildlife.
- Ensure long-term ecological sustainability through monitoring and adaptive management.
- Mitigate future flooding and erosion through natural barriers.
- Enhance public access and education about wetland conservation and resilience.

PARTNERSHIP DEVELOPMENT AND MAINTENANCE

The partnership was formed based on a shared vision for restoring the Prime Hook National Wildlife Refuge, with key partners such as USFWS, DNREC, TNC, and USACE coming together around a common goal.

Some of the work was in process prior to Hurricane Sandy as part of Comprehensive Conservation Plan (CCP). Area experienced overwash events and marsh loss prior to the storm. Began working with DNREC Coastal programs early on, starting in 2008, as part of CCP planning and included radiometric cores, elevation data, Surface Elevation Table (SET) data, etc. Refuge aware of restoration need, and Sandy funding provided resources to focus on model and design. Multiple partners on the initiative including USACE ($38 million 1/2 each recovery & resiliency). AMEC Foster Wheeler / Wood were prime for resiliency. Stantec was prime for modeling.

Resiliency piece was directly conducted by US Fish and Wildlife Service (USFWS). Contracted AMEC to finalize design (based upon Stantec and Atkins modeling). Design was finished by EA Engineering. AMEC brought Dredge America on to conduct all marsh dredging. Recovery was conducted by USACE and USFWS. The Service brought on USACE to finish beach design and conduct beach restoration, with Service in partnership. Norfolk Dredging was contracted to conduct the breach and back-barrier restoration. ER&M was contracted by Norfolk to conduct all the dune fencing and dune planting. DelDOT worked with Service on aquatic conductivity along Prime Hook Road. DelDOT secured a Federal Highway Administration (FHWA) grant to design and install a bridge that would allow flow between unit 2 and 3. Later DelDOT installed 4 culvert crossings to increase conductivity.

Partner Contact: Bart Wilson, USFWS

Restoration Outcomes and Lessons Learned

RESTORATION OUTCOMES

- Target elevation, bird species response, plant response
- Project had relative goals and outcomes that looked at qualitative trends. Quantitative goals are challenging in a system like this and scale trends are a great means of evaluating recovery.

LESSONS LEARNED

- Would take a slower approach and phase implementation. Build beach and berm first, lower water levels of the systems before dredging channels of the interior.
- Having a 20% contingency was very helpful.
- Have regulators as part of the whole project. They were very honest about process and ecological response.
- Want to get the right contractors to do design and implementation. Lowest cost bidder may not have right skill set to do the work. Make sure to include past experience and references.
- Construction management / site management person is key. Appropriate staff with that skill set to oversee project work and make decisions. Adaptive management through construction based on true qualitative assessment.
- Clear communication of who is doing what and how things are being done among team members and contractors. When something comes up, address it as needed and not at a set communication point.
- Outreach was a challenge from the outset. Road to Prime Hook Beach flooding, salt water intrusion on ag lands, septic system failures, etc. Had focused message to community to do the restoration work. Was really focused on ecological benefits of the project. Was not focused on co-benefits of the project — i.e. flood attenuation on infrastructure and ag lands.

Advice for similar restoration projects

- Take ecosystem approach.
- Look for larger landscape aspects of what are stressors to systems, understand the impact of anthropogenic alterations, and cast a wide net in partners in design, implementation, and regulatory review.

Data sources and decision support tools used

- Utilized two to three years of field data to support model and design development.
- The comprehensive model (rich in hydrology and elevation) data was critical!! This was key in telling the story, and showing project direction and why (in a sense of what system could support).

PLANNING	
Overall cost	Approximately $38 million
Cost summary	• $38 million total — split: $19 million for resiliency and $19 million for recovery. » Stayed under budget with both aspects. • Resiliency » Final designs for restoration, planting, Phragmites australis (WCS) removal — $375,000, marsh dredging $14 million, planting of back barrier (low and high marsh) $962,500, removal of Fowler Beach Road — $175,000, initial phrag spraying during construction —$450,000. » Additional $3 million was spent by refuge on adaptive management (majority phragmites spraying for 5 years, aerial seeding of unit 3 post construction, monitoring, small scale channel construction by DNREC Mosquito control, modeling (which was ~ $650,000). • Recovery » $2.1 million for design and project management by USACE, $16.9 million — sediment placement for dune, berm and back-barrier; and planting of dune and dune fence. » Contingency — 10-20% built in. » Storm (Jonas) blew out a dune that project was to tie into and pumped additional material to build back that feature (came out of the contingency fund). Needed more material for the beach face. » Adaptive Management Plan — Phrag control. Had funds in contingency — 4 years of Phrag control.
Project championed by	USFWS—Comprehensive and deliberate at outset with full invitation. Some partners self-selected out. County Government wasn't brought in, but they did not have a large vested interest.
Link to USACE dredge project	Not linked to a regular navigation or Continuing Authorities Program (CAP) funded project. Specifically funded USACE Operations to do work. Not a normal process and required a lot of negotiating. Signed Memorandum of Understanding (MOU) with USACE Regulatory Section for guidance on regulations. Transferred portion of recovery funds to USACE for beach restoration.
Beneficial use	Indirectly as it uses 600,000 cu yards materials side cast from 25 miles of channels in refuge. 2.1 million cu yards total. 1.4 million cu yards for beach, berm, dune and back barrier was dredged from Delaware Bay (dredging for restoration) and 600,000 internal channels
Low cost / no cost alternative to ACOE	No
Funding sources	National Fish and Wildlife Foundation (NFWF) Sandy funds — Hurricane Disaster relief, recovery, and resiliency categories. These pots were considered separate, but balanced in how these projects dovetailed and complemented each other.
Cost estimate development	Educated estimate on the recovery. Resiliency was more thoughtful based on modeling and contractor input. Stantec and Atkins Global were part of the modeling team.
Placement coordination mechanism	The side casting and sediment placement areas were identified ahead of time. Project prioritized placement in areas that were lowest and avoided areas that were already "too high in elevation." Modeling showed that water levels would drop in system once restoration was completed (which occurred as planned), so areas that were going to be too high would be likely phragmites colonization areas.
Public outreach/ education efforts	Project plan included public meetings and communication with local reporters constantly. Project team conducted tours of project area (before, during, and after) for a variety of people (including reporters, regulators, practitioners, legislators, partners, etc.)
Public perception challenges	Numerous public perception challenges prior to and during construction. Project had to balance not working quickly enough vs doing too much and should let it all go. System modeling work indicated Prime Hook Road would flood every high tide and the marsh would not drain, prompting fish kills and algae blooms, and intensive saltwater intrusion in ag fields west of refuge — suboptimal water conditions. System dynamics during construction, especially back-barrier, the marsh had low water for long periods (as channels were being constructed and WCS were still in place) so mud flats were a concern, and it did not look like what people expected. At end (and over course of project) people started to see vision and actions and support grew. There was a local contingent that felt this restoration work was a waste of money, and preferred residential buy outs and let system go. Communicated message that the congressionally allocated funding was not allowed to be used for acquisition.

Figure 1. Hurricane Sandy impacts Prime Hook National Wildlife Refuge (DE). Prime Hook National Wildlife Refuge experienced extensive flooding during Hurricane Sandy. This photo shows a before and after of the beach between the Prime Hook Beach community and Slaughter Beach.

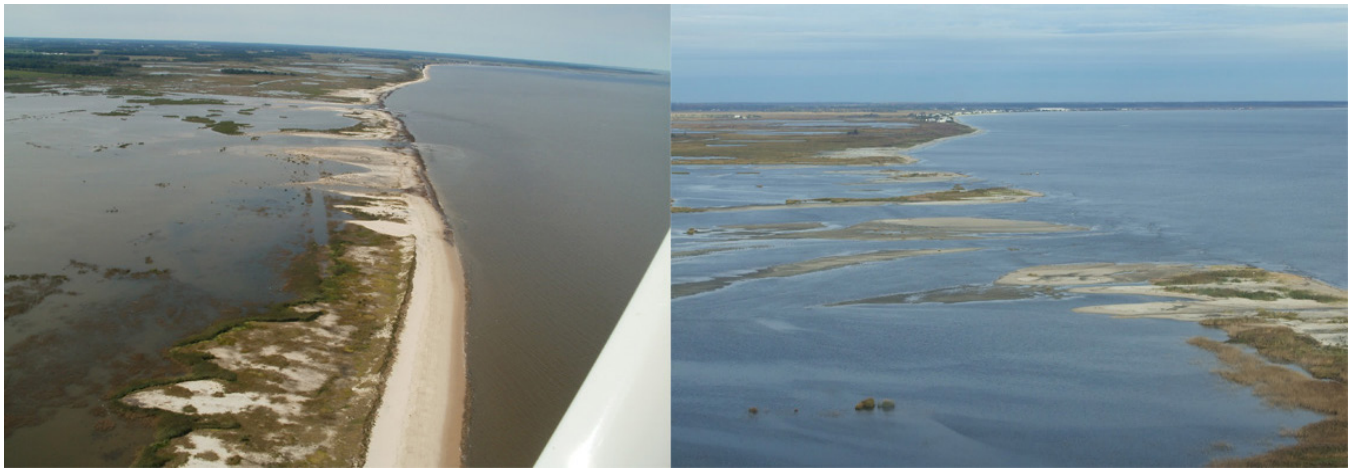


Photo Credit: USFWS

PERMITS

Public perception challenges	Numerous public perception challenges prior to and during construction. Project had to balance not working quickly enough vs doing too much and should let it all go. System modeling work indicated Prime Hook Road would flood every high tide and the marsh would not drain, prompting fish kills and algae blooms, and intensive saltwater intrusion in ag fields west of refuge — suboptimal water conditions. System dynamics during construction, especially back-barrier, the marsh had low water for long periods (as channels were being constructed and WCS were still in place) so mud flats were a concern, and it did not look like what people expected. At end (and over course of project) people started to see vision and actions and support grew. There was a local contingent that felt this restoration work was a waste of money, and preferred residential buy outs and let system go. Communicated message that the congressionally allocated funding was not allowed to be used for acquisition.
Required permits	• U.S. Army Corps of Engineers (USACE): Section 404 (Clean Water Act) and Section 10 (Rivers and Harbors Act). • Delaware DNREC: Tidal Wetlands Permit, Sediment and Stormwater Management Permit, Water Quality Certification. • U.S. Fish and Wildlife Service (USFWS): National Environmental Protection Act (NEPA) review and consultation. • Endangered Species Act (ESA): Section 7 Consultation with USFWS. • Coastal Zone Management Act (CZMA): Federal Consistency Determination. • Clean Water Act Section 401: Water Quality Certification from DNREC.
Responsible party	The responsibility for applying for the required permits for the Prime Hook National Wildlife Refuge Restoration project was shared primarily between USFWS and DNREC, with USFWS taking the lead in the application process, given its role as the managing agency of the refuge.
Impact on design or implementation	• Convened all regulators (Fed and State) in the room at outset for 4 hours to determine what permits were needed. Everyone agreed to approach, identified data needed to submit, frequency of updates, etc. Early coordination was key. • Individual USACE permit, state wetlands, beach permit, Federal Consistency via the Coastal Zone Management Act, Section 7 USFWS, Historic Preservation. Set the tone by having them all together. Relationships matter = trust. Scale of the project and local community pressure had non-ecological affects on project design and timing. Permitting timeline — about a year. Also doing a tiered EA for restoration at same time. • USACE helped with Environmental Assessment (EA) drafting. Project team stayed in constant communication with USACE and DNREC wetlands regulators. Constant updates to everyone in general, communicated constant changes being made (adaptive management in implementation) and open communication with regulators. Regulators supported changes, and then project team would modify as-built plans as they went along and at end of project turned in all changes to regulators who then updated permit. • Permit modifications as project construction occurred were not practical and regulators agreed as long as all changes were discussed with them and verbal approval granted.

MAINTENANCE AND MONITORING	
Ongoing maintenance	• Project plan included a monitoring plan. Initial Sandy Funding — kept some aside for monitoring. NFWF Monitoring Grant (2018-22) — hydrology, birds, vegetation response, Phrag, etc. • Did not have a formal adaptive management plan but had items identified: Phragmites control (spray lines in Geographic Information System (GIS) for future), hydrology — small scale areas that needed touch up — runnel work w/ DE Mosquito Control. Vegetation — watched. • Did not have a plan to do replanting. Conducted 1,000 acres of aerial seeding as part of restoration. • Beach/barrier/back-barrier — kept an eye on the vegetation to ensure no catastrophic issues. • 15,000 linear feet of runnels (30 inch wide) in 3 different areas to facilitate flushing. • Phrag treatments of 1000, 1000, 800, and 600 acres sprayed. Tried controlled burns. • Ghost forest areas — 2 years to remove Phrag cane. Some mechanical remove of Phrag to pull out fire danger near residential community. Phrag control and additional control burns still planned (to remove ghost forests for marsh transition). Discussed additional seeding of some mudflats in areas of center of unit 2 (could still happen if funding secured, major issue is securing seeds).
Dredging to provide future material	USFWS not considering additional sediment placement at this time. DNREC (state of Delaware) may do some placement in front of Prime Hook Beach community.
Monitoring funding	No monitoring funding from NFWF grant. Any maintenance and monitoring will be done with base USFWS funds or additional secured grants.
Monitoring includes	Bird nesting, roosting, foraging, vegetation, elevation, erosion etc. Refuge staff and partners spent the spring and summer of 2017 conducting continued monitoring of the restoration project. Water levels, salinity, nutrients, and flow continued to be monitored in partnership with the Delaware National Estuarine Research Reserve and the University of Delaware. This monitoring is ongoing year-round, and enables the refuge to track how the restored tidal hydrology in refuge wetlands translates into new patterns of water levels, sediment concentration, and salinity. In 2017, there were 6 nests that successfully fledged a total of 12 young plovers! In addition, there were nesting American oystercatchers and least terns. Between 2015 and 2017, there was a reduction of 700 acres of open water and an increase of over 500 acres of vegetated marsh in the project area.
Short- and long-term requirements	The project included the development of a long-term adaptive management plan that outlined how the U.S. Fish and Wildlife Service (USFWS) would continue to monitor, evaluate, and adapt the restoration efforts over time. Project completed in 2016. Adaptive management was very active in 2017–2020. Small scale hydrology work conducted to aid in drainage (reduce mosquito breeding in north part of unit 2 and southeast part of unit 3) and phrag control (mainly along western boundary of unit 2 and 3). This plan ensured that the refuge would be managed in a way that accounts for ongoing changes in the environment, such as rising sea levels, climate change, and evolving species needs. It provided a framework for making changes to the restoration approach as new information and environmental conditions emerged.
Flag end of project	Project is very successful. Every year it becomes more established, and biological response is increasing.

DESIGN/CONSTRUCTION ELEMENTS	
Lifespan of project	30 years as reasonable expectation. Hydrologic and Hydraulic (H&H) Modeling modeling used 30 year for slope and grain size. Used a Hurricane Sandy in the modeling and Sea Level Rise (SLR) forecasts.
Materials used	Sand, shell, rock. Beach face — 95% sand / coarse material. When dredging hit mud pockets, pumped into the marsh. Interior resiliency dredging — 90% was mud with some shell beds.
Volume of material used	2.1 million cu yards total. 650,000 cu yards in channel creation, and 1.41 million cu yards for beach creation.
Sediment volume and composition sufficient or augmented	Yes. Had design envelope and template for the beach. Forecast 1 million cu yards needed, pumped more for erosion and Hurricane Jonas replenishment. Interior was a little more than forecast.
Key design elements	Went through considerations with modeling — looking at keeping an inlet open, etc. Closed all breaches. The modeling looked at a variety of design considerations. For breach, there were 4 main openings, variety of options looking at keeping all open, 2 open, 1 open (with stabilization to maintain opening). For marsh, then variety of channels (just main channels, main channels and secondary, main, secondary and tertiary channels), keeping and removing 3 water control structures, and then tidal connections through Prime Hook Beach Road (which DelDOT implemented for us based upon our modeling) • Dredging and Sediment Placement: Used to rebuild marshes and elevate land. • Berm and Levee Reconstruction: Strengthened barriers to protect wetlands. • Tidal Flow Restoration: Modified water control structures to restore natural tidal dynamics. • Native Vegetation Planting: Reintroduced native plants to stabilize soil and enhance biodiversity. • Breach and Water Management: Enhanced water flow across marshes to improve hydrology. • Habitat Enhancement: Created or improved wildlife habitats within the refuge. • Flood Risk Reduction and Resilience Building: Focused on building resilience to future storms and improving coastal defenses.
Techniques to achieve design elements	Had beach face and speed bump of a berm. Seeded and planted. Left other areas open. Back barrier planting not uniform, leaving sand islands. Mosaic of habitats. Natural variability. Back barrier variability — shoals and features. A dune, beach, and back-barrier beach platform has been restored along nearly 8,900 feet of shoreline, including closure of 4 large breaches, using more than 1 million cubic yards of dredged material from the Delaware Bay. • The restored dune is 9 feet high with a 100- to 600-foot-wide back barrier platform extending into the marsh. • American beach grass was planted and 150,000 feet of fencing have been installed to stabilize the dune and back barrier. • Tidal marsh and dune grasses (Panicum and Spartina species) were planted in portions of the back barrier platform, to promote a return to vegetated salt marsh. • More than 25 miles of tidal channels have been dredged out in the marsh interior to restore flow of tidal water throughout the wetland complex. The channel network was designed in large part based on historic tidal channels present prior to conversion of the wetlands to freshwater impoundments. • Several man-made water-control structures were removed to improve tidal connection with the existing salt marshes to the north and south of the refuge. • Restoration has reduced water levels in much of the marsh interior, especially in unit 3. Tidal wetland grasses and other vegetation have already begun to recolonize many of the exposed mud flat areas, although full recovery will take some time. • Wild millet seed (as a carrier seed; with 18 other native species) was scattered from the air over 1,000 acres in the unit 3 impoundment, in order to give revegetation in that area a boost. • Asphalt pieces of what was left of the easternmost 1,800-foot section of Fowler Beach Road were removed. The refuge hopes to eventually construct a walkway to the beach. • Most of the restored wetlands will revert back to a saltwater marsh with some areas of fresher or brackish wetlands (especially western unit 3).

Containment actions	Site was former impoundments, considered the roads to north and south (and WCS) as containment or restriction of sediment from leaving system. Regulators liked this approach. No other containment required.
Protective measures	Avoided (where possible) placing material (from channel creation) on existing vegetated marsh. Did not want to make them any higher.
Equipment required	30 inch dredge in Bay and massive fleet of bulldozers / front end loaders. Had 2 splitters so 3 discharge pipes going 600 foot wide template. 3 10-in swing ladder cutter suction dredgers were used in channel dredging (with one pontoon mounted excavator)
Distance material was transported	1.5 miles offshore for the beach. Used mapping info to make sure we were not impacting Essential Fish Habitat (EFH). Different negotiations about dredge technique — lawnmower — thinner cut and wider area vs. deeper hole (anaerobic pockets). Work with regulators. Project had extensive benthic data used to avoid shellfish and other EFH areas.
Method of sediment sustability assessment	Remote acoustics — surface and subsurface sediments, in fauna of the area (previously mapped). DNREC water management section that manages all the offshore sites. They have State Historic Preservation Office (SHPO) surveys of their offshore sites. Sabellaria vulgaris and oyster beds.

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CONTACT

MIKE MOLNAR
Director, Coastal Zone Initiative
mmolnar@manomet.org
508.434.6364

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