Appendix B

Description of the Project

B1 Thompsons Beach Marsh Restoration and Enhancement Project Description

American Littoral Society
18 Hartshorne Drive, Highlands, NJ 07732
732-291-0055

Thompsons Beach Marsh Restoration and Enhancement Project

Project Partners: U.S. Fish and Wildlife Service (Project Sponsor), Stockton University Coastal Research Center, LJ Niles and Associates

1.0 Introduction

The historical harvest and farming of salt hay (*Spartina patens*) in Delaware Bay has had a significant impact on the ecology and morphology of the marsh as well as its ability to compete with climate change and sea level rise. Salt hay farms were diked and the marsh transformed to lower elevations. The diking of marsh also led to changes in the natural hydrology, and as a consequence, changes in dominant plant and animal communities. Today, approximately 21.6% of formerly impounded marsh in Delaware Bay has not revegetated, has become open water or mud flat after impoundments were breached or dikes removed, and adjacent marsh is rapidly eroding due to those changes in elevation. Conversely, only 0.5% of marsh that was never impounded has converted to open water since 1930. This difference is likely due to dramatic elevation deficits caused by impoundment which caused oxidation-driven peat collapse and prevented normal vertical accretion. Surveys conducted for this project have shown that marsh elevations of current and formerly impounded areas (derived from Lidar and validated with RTK GPS) are significantly lower than the elevation of marsh areas that were never impounded. Supporting this finding, the frequency of high marsh vegetation (an indicator of higher elevation and greater marsh resiliency to sea level rise) in formerly impounded areas is half that of areas that were never impounded.

A key part of the American Littoral Society's (Society) National Fish and Wildlife Foundation (NFWF)-funded Delaware Bay Coastal Resiliency Restoration Program is the implementation of a saltmarsh restoration project adjacent to the once impounded Thompsons Beach in Maurice River Township (MRT). Partnering with the U.S. Fish and Wildlife Service (USFWS), the American Littoral Society is proposing to improve the resiliency and habitat value of the marsh at Thompsons Beach. This will be accomplished by dredging two existing creek channels and using the dredge sediment on two selected areas within the marsh. The Eastern project site will focus on raising the marsh elevation from mudflat to a level that can support low-marsh vegetation and the Southern project site will focus on using a small elevation change on low-marsh to develop specific high-marsh habitat. Additional details of the project are provided within this document and the Project Plans in **Appendix C**.

The marsh restoration and enhancement project proposes dredging approximately 6,800 linear feet of the East and West man-made creek channels located at the existing boat ramp. Dredging will cover approximately 4.77 acres in total area and produce approximately 20,000 cubic yards of sediment. Please note, that while dredging will improve navigation to and from the boat ramp this is not the goal of this

dredging activity, instead, dredging is being conducted for the sole purpose of beneficial reuse for marsh restoration. The sediment that will be used for this project was sampled and those collected samples were analyzed by an independent laboratory. The results from that analysis was sent to, and subsequently approved for use by NJDEP's Office of Dredging & Sediment Technology (**Appendix J**).

Dredge sediment will be placed on two project sites located within the marsh at Thompsons Beach.

The Eastern Area is 3.75 acres in size and primarily a mudflat, though 43% is vegetated with disassociated clumps of *Spartina alterniflora* (saltmarsh cordgrass). The site has an average elevation of 0.70', which is below the elevation at which *Spartina alterniflora* forms a continuous marsh with a stable marsh platform. We are proposing to raise the marsh plain to a target elevation range of 1.75' to 2.5' to restore a functioning low-marsh. An estimated 11,135 cubic yards of material are needed to reach the desired elevation. Coir logs will be placed along the perimeter of the placement area to contain sediments / runoff while the material dewaters. The project objective for this area is a fully vegetated marsh platform (target 80% cover) that will increase marsh resiliency to sea level rise.

The Southern Area is 9.95 acres of low-marsh. We are proposing to use a thin-layer application (up to 8 inches) of material to promote the growth of high marsh vegetation and improve the habitat availability for high marsh-specialist birds. A functioning marsh, with an appropriate mix of marsh elevations is essential to the continued success of resident marsh birds and migratory birds that travel the Atlantic Flyway. An estimated 9,160 cubic yards of material are needed to apply the 8" of sediment using a thin layer application. Staked hay bales and 8" coir logs will work with the natural topography to contain the sediment. The project objective for this area is to maximize resiliency of the salt marsh to sea level rise and increase habitat diversity to benefit tidal marsh obligate birds.

Thompsons Beach marsh offers an ideal venue for the actions proposed, as it is representative of other vulnerable marshes in our region. The actions proposed build upon the salt marsh restoration strategies undertaken by PSEG (initiated: 1996-1998) to restore a deficient tidal marsh, and aid the recovery of elevation deficits that are the result of decades of prior use as a salt hay farm.

The PSEG project dredged more than seven miles of new tidal channels across the area to simulate natural marsh hydrology. The new channels allowed for increased sediment transport into the area and today much of the former salt hay farm is a vegetated, functioning tidal marsh. Nonetheless, the sediment and elevation deficits that were the legacy of salt hay farming have not been fully recovered across some of the area. These marshes are unlikely to both fully recover their elevation and keep pace with sea level rise without the addition of sediment.

The approach in this proposal represents the range of strategies that must be pursued in an iterative process of marsh restoration in the Delaware Bay because marshes with a history of salt hay farming are in many cases are feet, not inches, below elevations that will be resilient to ongoing sea level rise.

With this proposed project, we hope to establish an effective and *cost-effective* way to address elevation issues throughout the Delaware Bay marshes.

1.1 Purpose and Need

Among New Jersey's tidal marshes, those in the Delaware Bay are in the greatest need of restoration and enhancement to ensure their long-term resiliency. Based on our assessment of the past and current land cover and condition of New Jersey's Delaware Estuary tidal marshes, we estimate that historically more than half the 89,547 acres of tidal marsh in this region were impounded for agriculture. While tidal flow has since returned to formerly diked areas, marsh recovery has been incomplete.

The current-day Delaware Bay marsh landscape is far less resilient to sea level rise as a result of these past management impacts. Beneficial use of sediment to offset these elevation deficits presents the only plausible solution to minimize vulnerability that threatens both the long term-persistence of these marshes as well as the coastal communities that these marshes buffer from storms.

This proposed project is significant because more than 10,000 acres of marsh along the Delaware Bay in New Jersey having been lost due to marsh diking; this represents 12% of N.J.'s Delaware Bay salt marsh, and clearly points to a highly vulnerable landscape for this part of the State. Furthermore, since 1930 the Delaware Bay has lost, on average, 224 acres of saltmarsh annually. To save this shrinking resource, more projects like this one need to be done to show cost-effective methodologies that ensure the future ecology, biodiversity, and resiliency of the marsh and its adjacent communities.

Luckily, because of their hydrological and geomorphic setting, once restored, Delaware Bay marshes are likely to be among the most resilient to sea level rise in the region because it has a moderate tidal range, high suspended sediment load, accretion rates that meet or exceed current rates of sea level rise and a large frontage of undeveloped transition zone between uplands and tidal marshes to allow for inland marsh migration. But these marshes cannot on their own recover feet of elevation deficits while also keeping pace with sea level rise. This project will address deficient elevation in two areas of salt marsh with the beneficial reuse of dredge sediment, with the intent to identify cost-effective and repeatable processes.

1.2 PSEG Previous Restoration Efforts

In the late 1990s, PSEG restored the hydrology of a bayfront salt hay farm that had experienced dike breaching. Prior to restoration, much of the formerly vegetated salt hay farm was open water and mudflats. This is because marsh elevations behind the dikes were far below surrounding undiked marshes due to many decades of tidal restriction. In addition, no natural tidal marsh creek hydrology remained in the area that would help move sediment back into the marsh with the tides to help marshes rebuild elevation and revegetate.

The PSEG project dredged more than seven miles of new tidal channels across the area to simulate natural marsh hydrology. The new channels allowed for increased sediment transport into the area and today much of the former salt hay farm is a vegetated, functioning tidal marsh.

Nonetheless, the sediment and elevation deficits that were the legacy of salt hay farming have not been recovered across some of the area. These marshes are unlikely to both fully recover their elevation *and* keep pace with sea level rise without the addition of sediment.

The designers of the PSEG project recognized this limitation and suggested that using dredge material to augment the sediment budgets of the marsh would improve restoration outcomes (Weinstein & Weishar, 2002).

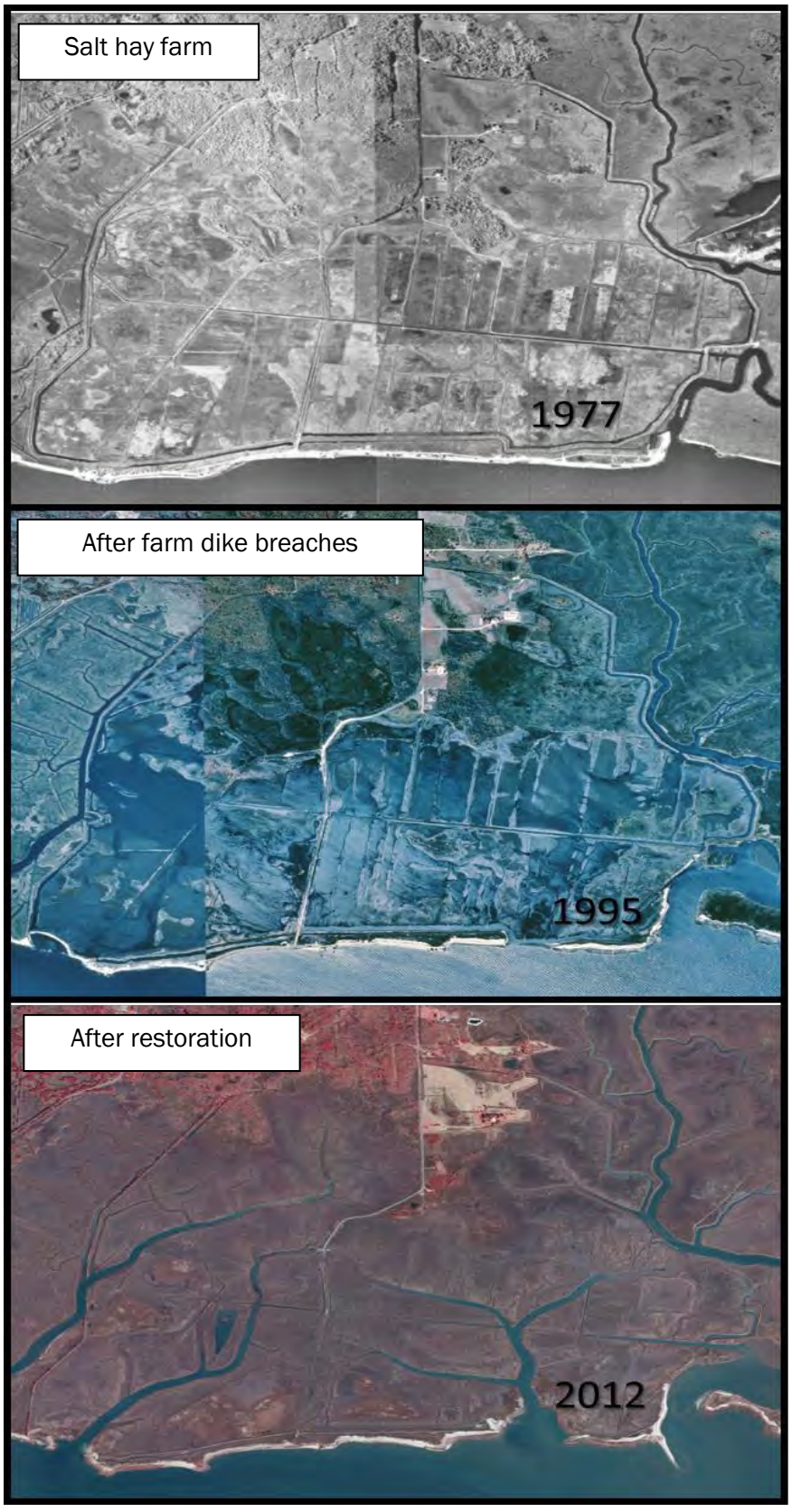

Figure 1 This series of photos demonstrates the process from maintained salt hay farm with dikes intact, abandonment with dikes breached, and after restoration by PSEG.

2.0 Regional Setting

The Thompsons Beach Marsh Restoration and Enhancement Project is located within a 1396-acre tidal marsh in Maurice River Township, Cumberland County. Portions of the project area exist on property owned by PSEG (Francis Corp) and property owned by NJDEP's Division of Fish and Wildlife (Heislerville Wildlife Management Area).

Thompsons Beach sits at the northeast end of the Delaware Bay, approximately 1.5 miles east of the mouth of the Maurice River. The closest town is Heislerville (unincorporated community in Maurice River Twp) which lies 1.5 miles north of the project sites. In the past, Thompsons Beach had a small community along the Bay, but those properties have since been demolished and converted to open space.

This site had historically been diked and farmed for salt hay, but as the salt hay operations ceased the dikes fell into disrepair and the area was inundated from tidal flow. In 1996 the PSEG Estuary Enhancement Program conducted a restoration project which achieved a functioning tidal marsh

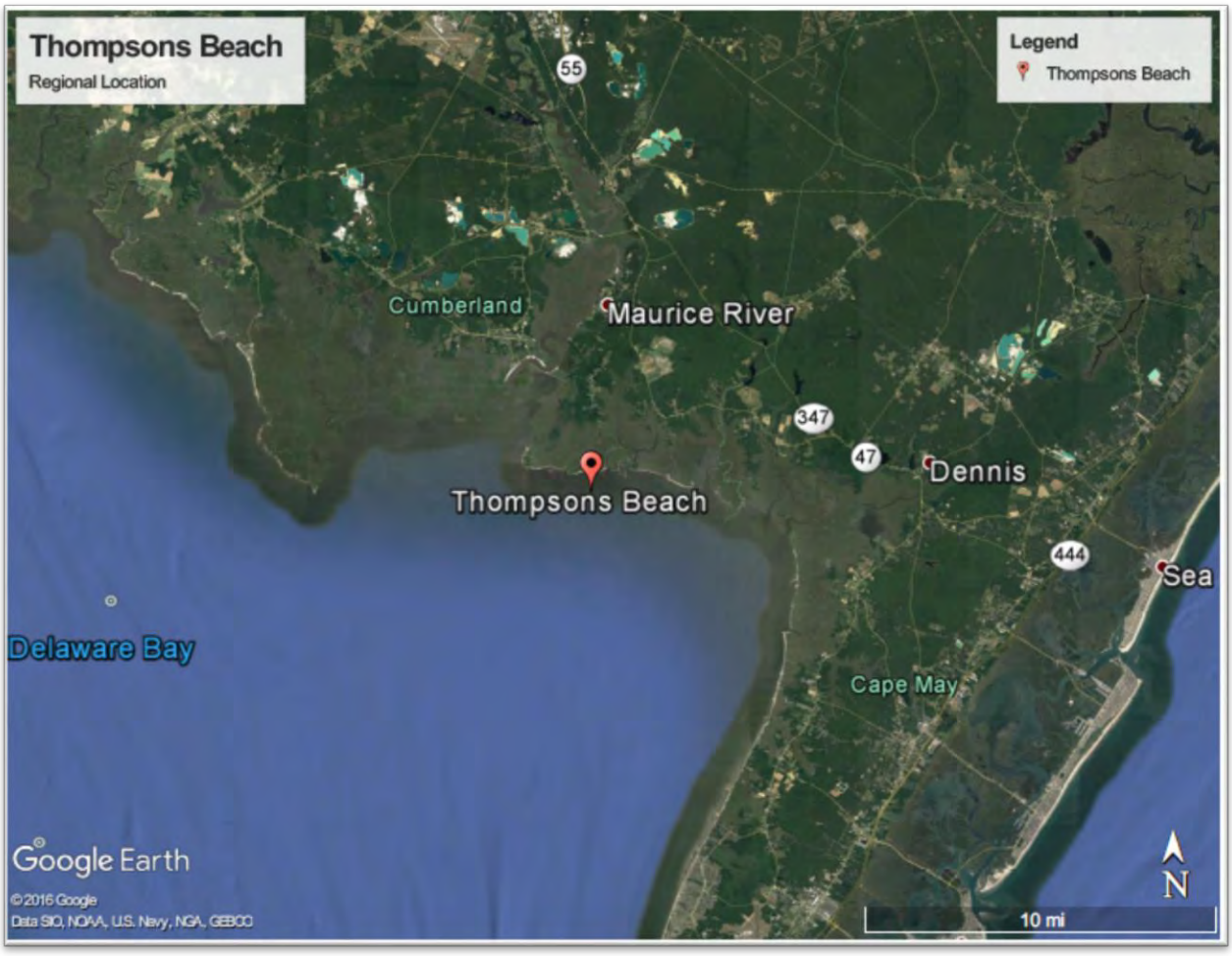

Figure 2 Aerial image showing regional location of Thompsons Beach.

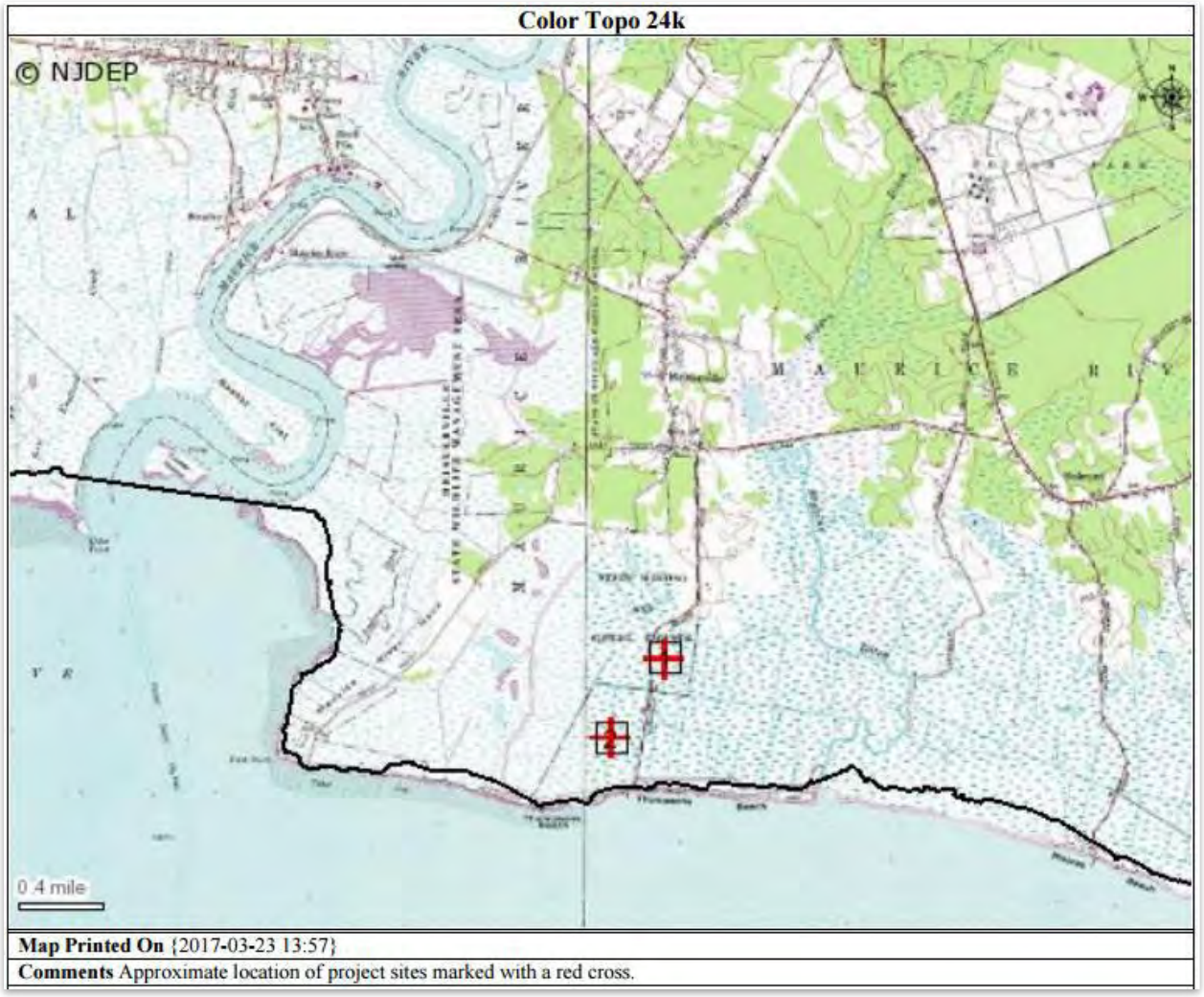

Figure 3 US Topographic Map image from NJ-GeoWeb showing project locations within the larger tidal saltmarsh.

3.0 Project Site Description

Each of the project sites are adjacent to Thompsons Beach in Maurice River Township, Cumberland County, New Jersey and were chosen because they are representative of typical elevation deficient marshes. As previously mentioned, the 1396-acre tidal marsh behind Thompsons Beach was part of the PSEG Estuary Enhancement Program (EEP) and through that program, a restoration project was initiated in the late 1990s which achieved a functioning tidal marsh where there had previously been low elevations and no remaining natural marsh hydrology. That project dredged a network of tidal creeks into the marsh interior that improved hydrology and allowed sediment to accrete providing an improved marsh platform with an elevation that could support more resilient vegetation and diverse marsh communities. We intend to build on the successful model PSEG had created and raise elevations of the marsh at two locations using dredge material from two adjacent creeks (East and West) and placing that dredged material on the marsh plain to raise elevation to a level that can support resilient vegetation and create an improved, more natural ratio between low and high marsh habitat.

Figure 4 Aerial image showing the dredging locations (in orange) and the marsh restoration areas (green outline).

The Society has selected two locations within the marsh and identified them as the Eastern and Southern sites. Site photos can be found in **Appendix D**.

3.1 Eastern Site – Marsh Restoration, 3.75 acres

The Eastern restoration area (near parking lot) has an average elevation of 0.70', which is below the elevation at which *Spartina alterniflora* forms a continuous marsh with a stable marsh platform. Current vegetation cover is 43%, composed of very tall clumped *Spartina alterniflora*, the remaining area is mudflat. The site is flooded at all high tides. Because of its low elevation and frequent flooding, ice scour tends to shear away above ground vegetation during winter which further impedes recovery.

An elevation survey was completed by Stockton University Coastal Research Center during low tide both through RTKGPS and laser scanning. As a result, the survey does represent the higher spectrum of elevations rather than the lower as minor channelized areas would contain more water, are more unconsolidated, and soft in nature and tend to fall in small shadow zones not easily scanned. The survey was conducted to extract and represent the typical existing conditions within the zone of soft and unconsolidated sediments and vegetated areas. Area volume calculations were done using ArcGIS using the survey data to create a DEM surface of the region and using tins to calculate the volumes.

An estimated 11,135 cubic yards of material are needed to reach the target elevation range of 1.75' to 2.5'. Coir logs will be located along the perimeter of the placement area to contain sediments / runoff while the material dewaters.

3.2 Southern Site - Habitat Enhancement, 9.95 acres

At the Southern site, we propose to use thin-layer application of material to promote the growth of high marsh vegetation and improve the habitat availability for high marsh-specialist birds. High marsh is among the first habitats to succumb to sea level rise because it occupies a razor-thin elevational range between upper elevations occupied by *Phragmites* and maritime shrubs and lower elevations occupied by *Spartina alterniflora* which has a much broader tidal tolerance. Furthermore, these marshes have less capacity to accrete upward due to the low frequency of tidal flooding characteristic of these habitats. Without management intervention, high marsh habitat and the species that depend on it may disappear and greatly impact high-marsh specialist birds (*Donnelly, 2001*). A functioning marsh, with an appropriate mix of marsh elevations is essential to the continued success of resident marsh birds and migratory birds that travel the Atlantic Flyway.

This 9.95-acre site is situated within a 45-acre section of marsh which received large amounts of dredge material from initial restoration in the late 1990s. The vegetation has naturally recovered across the 45-acre marsh and forms a mosaic of short-form *Spartina alterniflora* and *Spartina patens*, *Distichlis spicata* and *Juncus gerardii* which are indicators of higher marsh. With a thin layer application of sediment slurry, we will fine-tune the elevations in the lowest elevation portion of this area to promote greater coverage of *Spartina patens* and other high marsh species to benefit tidal marsh nesting birds.

High marsh vegetation cover throughout the bay has been drastically reduced as a result of salt hay farming. Thompsons Beach marsh has been a heavily managed landscape since at least the late 1800's. The natural creek hydrology was erased during this period, replaced by a grid work of farm ditches. The management of the landscape continued with the PSEG project, when tidal hydrology was restored with man-made channels. In this case, we propose to increase the diversity and sea level rise resiliency of the marsh by raising elevation using thin-layer application. The Southern site's current elevation is a direct result of management – the application of dredge material when the man-made channels were dug in the 1990s. There would be no opportunity to use the thin-layer technique on this marsh without the previous dredge deposition that recovered potentially two or more feet of elevation deficit caused by past management as a farm.

An estimated 9,160 cubic yards of material are needed to apply the 8" of sediment using a thin layer application. Staked hay bales and 8" or 10" coir logs will work with the natural topography to contain the sediment.

3.3 Waterways Proposed for Dredging

Sediment for the proposed marsh elevation increase will come from man-made channels constructed during the PSEG-led marsh restoration project in the late 1990s. That project dredged a network of tidal creeks into the marsh interior in order to bring tides and silt into the sediment-starved marsh. Portions of these creeks have since "silted-in" making them unnavigable during low tides.

An estimated 20,295 cubic yards of dredge sediment would be needed for the proposed projects. Analysis shows there is more sediment available than would be needed for the project. It is our intention to only use the amount of sediment needed to reach our target elevations, we will not dredge all available sediment.

West Creek
An estimated 13,635 cubic yards of material would be dredged.

A 10' wide channel with a slope ratio of 1V-4H will be dredged to a maximum depth of -5.5 NAVD88. For channel details please see **Appendix C, pages 5 and 8**. **(Creek "A")**

East Creek
An estimated 6,657 cubic yards of material would be dredged.

A 10' wide channel with a slope ratio of 1V-4H will be dredged to a maximum depth of -5.5 NAVD88.

For channel details please see **Appendix C, pages 4 and 9**. **(Creek "B")**

4.0 Topography

Elevations at our Eastern restoration site are far below normal while at the Southern restoration site elevation are higher than the surrounding area due to the sediment placed there during prior restoration work. Specific elevation data can be found in the Project Plans (**Appendix C**).

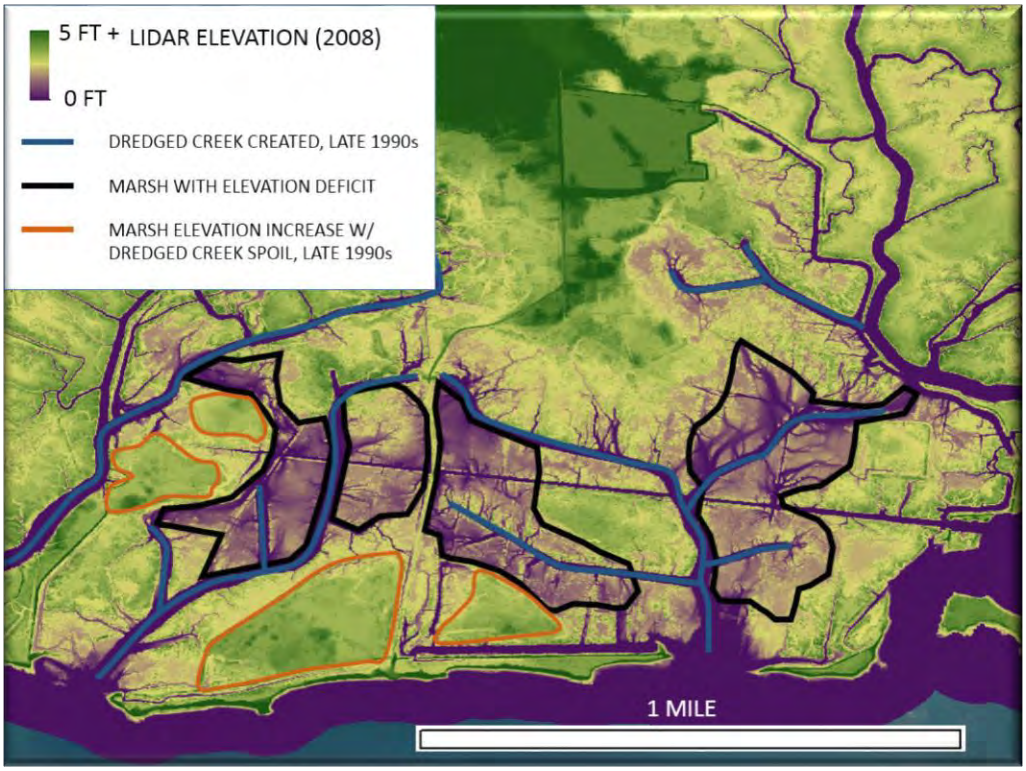

Figure 5 Aerial image showing the LIDAR based marsh elevations.

These sites allow for the demonstration of two restoration techniques. First, using dredged sediment to modify elevations which will create marsh from mudflat. This is a critical technique (distinct from the more common "thin layer" application technique) that must be developed, tested and eventually brought to scale in order to restore some portion of the 10,000 acres lost as a result of past impoundment.

Secondly, on marshes at higher elevations within the tidal frame, we seek to specifically manage for the rapid establishment of high marsh vegetation, another restoration technique that is critically needed to conserve species of conservation concern throughout the northeast.

The project sites are located within a tidal saltmarsh as shown in the topographic map below.

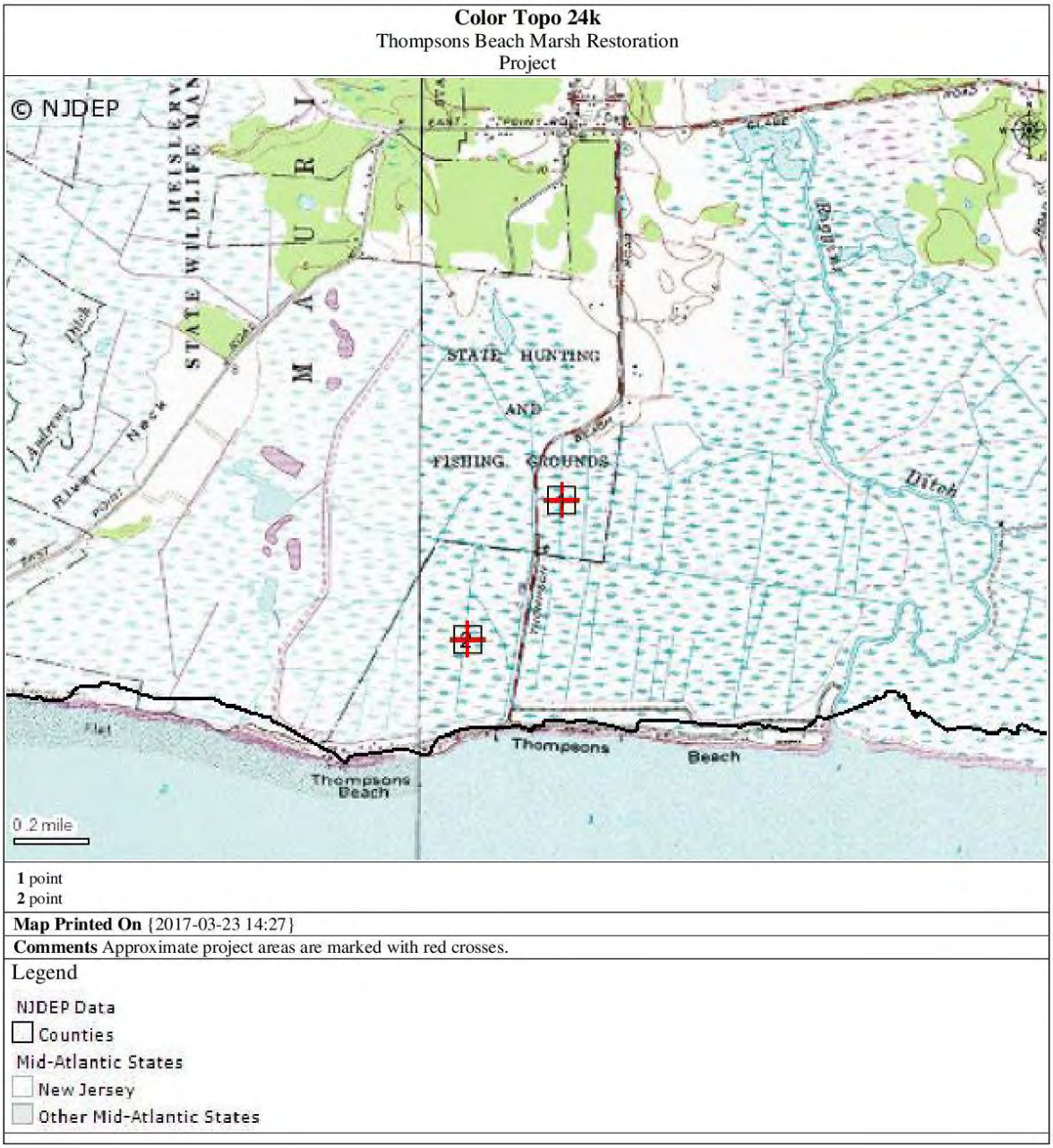

Figure 6 Image of topographic map from NJ-GeoWeb showing project locations.

5.0 Hydrology

In the late 1990s, PSEG restored the hydrology of the site which then was a former salt hay farm that had experienced dike breaching. Prior to restoration, much of the formerly vegetated salt hay farm was open water and mudflats. This is because marsh elevations behind the dikes were far below surrounding un-diked marshes due to many decades of tidal restriction. In addition, no natural tidal marsh creek hydrology remained in the area that would help move sediment back into the marsh with the tides and allow the marsh to rebuild elevation and revegetate. The PSEG project dredged more than seven miles of new tidal channels across the area to simulate natural marsh hydrology. The new channels allowed for increased sediment transport into the area and today much of the former salt hay farm is a vegetated, functioning tidal marsh. All of the current hydrologic features within the project area were created by, or are a result of, the PSEG project.

We do not expect noticeable change to the marsh hydrology resulting from the thin layer application in our Southern project area. The minor creeks shown on our plans were created using GIS files from the NJ GIS Warehouse, the creeks may not exist or do not exist specifically as displayed. We will ground-truth these creeks as part of our pre-construction survey.

This project will affect the hydrology of the marsh to a limited degree by changing the tidal inundation at the Eastern project area. This project area is small in comparison to the overall marsh plain and should not create any negative impacts.

The Engineering Report (**Appendix B**) further discusses effects on hydrology.

Tidal levels at the project site, derived from Vdatum, are listed below for reference.

Tidal Boundary	**Elevation (ft)**
High Tide Level (HTL)	+4.53
Mean Higher High Water (MHHW)	+2.94
Mean High Water (MHW)	+2.46
Mean Tide Level (MTL)	-0.3677
Mean Low Water (MLW)	-3.29
Mean Lower Low Water (MLLW)	-3.42
Mean Tide Range (MHW – MLW)	6.08

6.0 Vegetation

The Eastern project area has 42% vegetation cover with the remaining area a mudflat. All vegetation is very tall *Spartina alterniflora* that grows in clumps and is subject to shearing and disturbance from winter ice scour.

The Southern project area currently has 98% cover of *Spartina alterniflora*, with no other plant species present. Average vegetation height within this area is 2.9' and average elevation is 2.7'. Before 1992, a large portion of the site was vegetated with high-marsh species (*Spartina patens*, *Distichlis spicata* and

Juncus gerardii) and the northeastern portion of the site was vegetated with dense stands of *Phragmites australis*. However, during 1992, dike breaches flooded the area that had previously been farmed. With a lack of adequately sized drainage channels, the flooding covered much of the area eliminating much of the vegetative cover (*Hinkle & Mitsch, 2005*).

After PSEG's restoration plan to create four new or enlarged inlets and associated channels, the site was subject to normal daily tidal inundation and drainage. However, the site was still vulnerable with elevations dramatically lower than they should be. Currently, the marsh is predominantly covered by tall form *S. alterniflora* (*Hinkle & Mitsch, 2005*). At the Eastern site our goals is to increase vegetation coverage to 80%, following the same guidelines previously followed by PSEG (*Hinkle & Mitsch, 2005*). The current elevation of this site is either too low for natural vegetation or just high enough for tall form *S. alterniflora* to grow. By increasing the elevation, we expect to see a natural recovery of the vegetation to this site. For the Southern site, the goal is vegetation cover ratio 60% high marsh plant species with the remainder *Spartina alterniflora*.

Figure 7 The photo on the left is an area of marsh targeted for restoration at its lower elevational limit, with clumped tall-form Spartina alterniflora. On the right is a marsh area that received additional dredged sediment during restoration in the 1990s.

6.1 Elevation – Vegetation Relationships

RTK-GPS and vegetation data at the site guided our selection of elevation targets. Overall, *Spartina alterflora* plant height is negatively correlated with elevation (R^2=0.66, DF=1, p<0.0001). As elevation increases, plant height decreases (Figure 6).

At higher elevations, plant community diversity increases (Figure 7), with high marsh vegetation appearing elevations 3.2' and above (0.75' above MHW). Sparse *Phragmites australis* begins to appear at elevations 3.5' and above (1.04' above MHW), with monotypic stands forming at 3.7' and above.

Phragmites is salinity-limited in this region of estuary (Smith, 2013) and can only occur at higher elevations, typically on old spoil piles, dikes and at the marsh-upland interface.

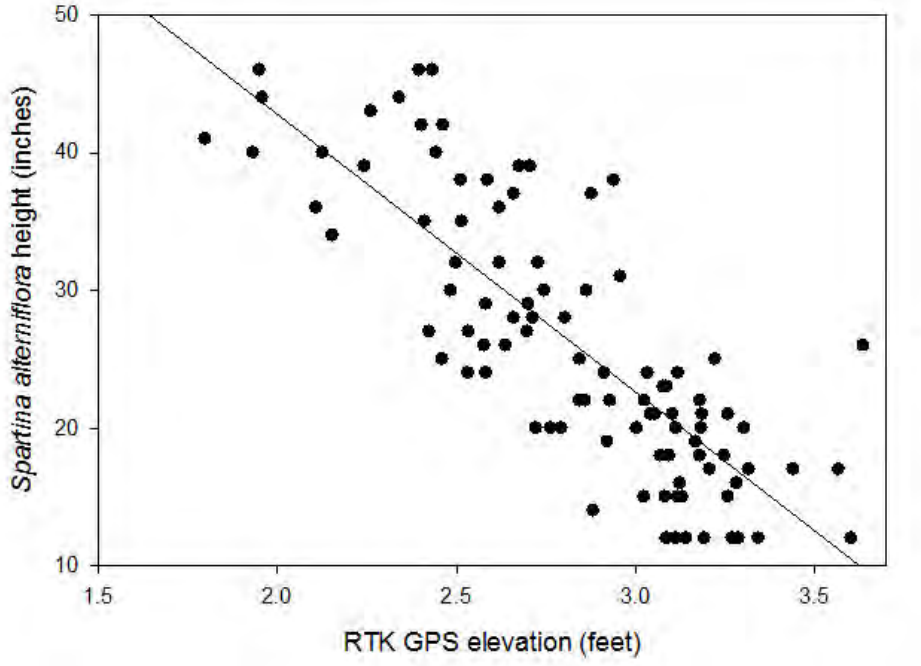

Figure 8 The relationship between Spartina alterniflora plant height and elevation.

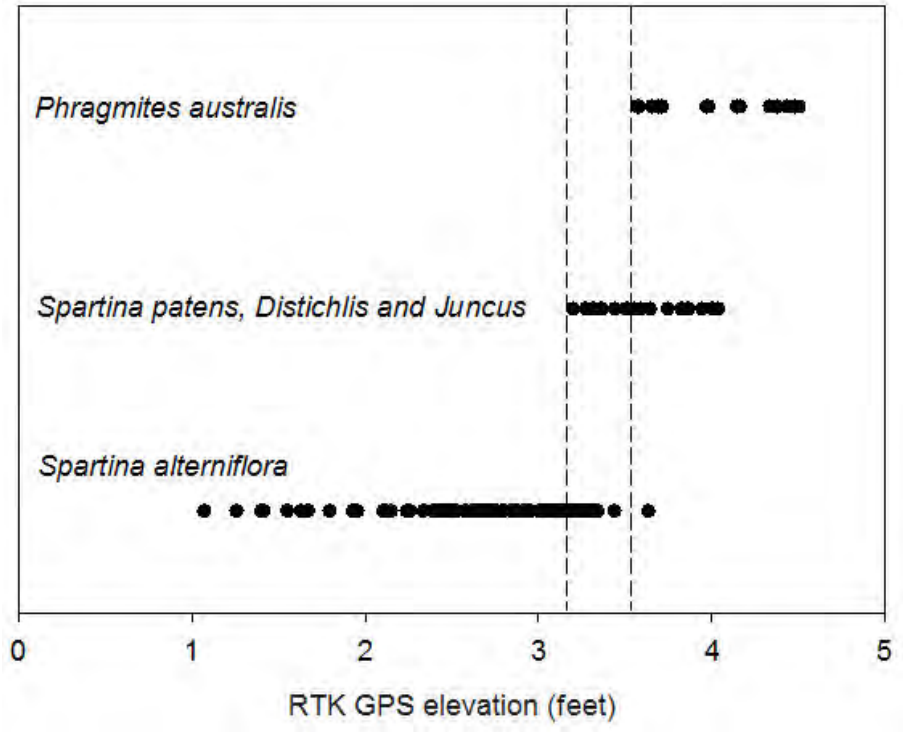

Figure 9 Elevation distribution of Spartina alterniflora, high marsh species and Phragmite australis at Thompsons beach southern site and adjacent reference marsh. Dotted lines depict 3.2' and 3.5' elevation thresholds where high marsh and Phragmites occur.

7.0 Wildlife

Opportunistic surveys of wildlife between 2014 and 2016 revealed the following species, all characteristic of salt marshes in the region.

Mammals observed in the project area include mink (*Neovison vison*), muskrat (*Ondatra zibethicus*), marsh rice rat (*Oryzomys palustris*), meadow vole (*Microtus pennsylvanicus*), Northern river otter (*Lontra canadensis*).

Diamondback terrapin (*Malaclemys terrapin*) are abundant throughout the site.

Invertebrates observed at the site include purple marsh crab (*Sesarma reticulatum*), fiddler crab (*Uca pugnax* and *Uca pugilator*), ribbed mussel (*Geukensia demissa*), salt marsh tiger beetle (*Ellipsoptera marginata*), Aaron's skipper (*Poanes aaroni*), salt marsh skipper (*Panoquina panoquin*), seaside dragonlet (*Erythrodiplax berenice*).

For birds, in addition to opportunistic surveys, we conducted targeted surveys for black rail as part of NJDEP and NJ Audubon's statewide surveys for this species in 2016.

Investigators from the Saltmarsh Habitat and Avian Research Program (SHARP) conducted surveys in 2015 and 2016 at the proposed restoration sites as well as a series of reference sites (described below).

During these surveys and other site visits, we observed the following bird species using the tidal marshes at the site:

American bittern	American black duck	Lesser yellowlegs	Short-eared owl
Great blue heron	Green-winged teal	Eastern willet	Marsh wren
Great egret	Hooded merganser	Semipalmated sandpiper	Nelson's sparrow
Snowy egret	Osprey	Least sandpiper	Saltmarsh sparrow
Little blue heron	Bald eagle	Short-billed dowitcher	Seaside sparrow
Tricolored heron	Northern harrier	Common tern	Eastern meadowlark
Black-crowned night heron	Clapper rail	Forsters tern	Red-winged blackbird
Glossy ibis	Virginia rail	Least tern	Boat-tailed grackle
Snow goose	Greater yellowlegs	Black skimmer	

The following table shows rare wildlife species or wildlife habitat may be located on the project site based on NJDEP Natural Heritage Program's Landscape Project 3.1 Species Based Patches. (all confirmed except black rail, which previously nested at the site when it was a salt hay farm).

Common Name	**Scientific Name**	**Feature Label**	**Federal Status**	**State Status**	**G Rank**	**S Rank**
Black-crowned Night-heron	*Nycticorax nycticorax*	Foraging	NA	State Threatened		3
Red Knot	*Calidris canutus*	Non-breeding Sighting	NA	State Endangered		4

Sanderling	*Calidris alba*	Non-breeding Sighting	NA	Special Concern		2
Semipalmated Sandpiper	*Calidris pusilla*	Non-breeding Sighting	NA	Special Concern		2
Least Tern	*Sternula antillarum*	Foraging	NA	State Endangered		4
Bald Eagle	*Haliaeetus leucocephalus*	Wintering	NA	State Threatened		3
Black Rail	*Laterallus jamaicensis*	Breeding Sighting Confirmed	NA	State Endangered		4
Northern Harrier	*Circus cyaneus*	Nest	NA	State Endangered		4
Osprey	*Pandion haliaetus*	Nest	NA	State Threatened		3
Bald Eagle	*Haliaeetus leucocephalus*	Nest	NA	State Endangered		4
Bald Eagle	*Haliaeetus leucocephalus*	Foraging	NA	State Endangered		4
Migratory Shorebird Concentration Site	Migratory Shorebird Concentration Area	Non-breeding Concentration - Major	NA	State Endangered		4

7.1 Impacts to Wildlife

The project is specifically designed to restore and enhance habitat for bird species that utilize marsh habitat during different life cycle stages, as well as increase overall biodiversity within the marsh system by restoring healthy marsh elevations/vegetation. The proposed activities are not anticipated to negatively impact bird or fish species. The American Littoral Society, and its partner are stewards for these species, and as such, highly sensitive to their unique life cycles and habitat needs.

Work will be conducted during periods that minimizes risks to threatened or endangered species. Construction activities will occur outside the breeding season of birds and no T&E bird species nest are within the project area boundaries. No threatened or endangered reptiles, amphibians, mammals, invertebrates or fish use habitat within the project area boundaries.

No impact to T/E species are anticipated. Continuous on-site monitoring of project execution will respond to any unanticipated issues that arise.

7.1.1 Anadromous Fish

An Essential Fish Habitat (EFH) evaluation has been prepared and submitted to the U.S. Fish & Wildlife Service, USACE, and NMFS. This EFH is included in this submission as **Appendix G**.

The Delaware River serves as one of the main migratory pathways for anadromous fish in New Jersey. However, the East and West creeks have not been listed as confirmed or rare use by anadromous river herring *(Locations of Anadromous American Shad and River Herring During Their Spawning Period in New Jersey's Freshwaters Including Known Migratory Impediments and Fish Ladders; NJDEP, 2005).* Since these species have not been identified in these waters, the proposed project will not have any adverse impacts on their habitat or migratory pathways.

In addition, the East and West creeks lack the upstream connectivity to potential spawning habitat and terminate at the Maurice River Township boat ramp and at the boundary of the Eastern project site. Habitat at the termination of the waterway, as well as towards the bay is not conducive for spawning.

Proposed dredging activities at the MRT site may temporarily affect the presence of such fish species if foraging because of noise or in-water disturbances; however, these disturbances will be minor and short-term in nature, and will not result in any permanent impacts or adverse effects to migratory finfish. Additionally, work will be performed from September through March, when river herring are not present.

7.1.2 Intra-Service Section 7 Biological Evaluation Form

The American Littoral Society is working collaboratively with USFWS, and the Division of Fish & Wildlife to further develop a monitoring protocol and adaptive management measures for ongoing use at regional marsh restoration sites. See **Appendix E** for the Monitoring Plan and **Appendix F** for the Adaptive Management Plan.

As part of that partnership, USFWS prepared an Intra-Service Section 7 Biological Evaluation Form (**Appendix H**).

For the Thompsons Beach Marsh project site USFWS identified the Northern Long Eared Bat and the Red Knot in the "Pertinent Species and Habitat" section of the Biological Evaluation Form.

The report states there is no suitable habitat in the project area for Northern Long Eared Bats. And that noise from construction could disturb migrating red knot if it takes place during migration seasons. If construction occurs from May 1 to June 7, red knot monitoring will take place to determine if construction could potentially impact the birds.

7.1.3 Natural & Historic Resources Land Management Policy Activity Review Form (ARF)

The comments received during the ARF process follows:
"*We have no objection to the proposal to raise mudflat elevation on the 3.75 ac. piece close to the eastern boat ramp access to Thompson's Beach marsh. However, the proposal provides no consideration of the value of the existing mudflat to migrating shorebirds. Mig shorebirds generally do not use vegetated salt marsh for roosting or foraging, and prefer the openness of unvegetated mudflats. The proposal states that "mudflats are not a limited resource in the bay," and thus, presumably, this project would have no negative effects. While open mudflats ARE a valuable resource for migrating shorebirds,*

we agree that the project area (the 3.75 ac parcel) is small enough as to have no appreciable negative impact, and that a more elevated salt marsh has a higher long-term value.

A TIMING RESTRICTION on dredging and fill placement is required for work within 1,000 feet of an osprey nest. There are two osprey nests within that distance of the maintenance dredging location, which will prohibit dredging during the April 1 through August 31 time period. On the chance that either of those osprey nests are occupied by nesting bald eagles (a condition which needs to be determined by March 1 of any year), the timing restriction would be adjusted accordingly."

The Natural & Historic Resources Land Management Policy Activity Review Form can be found in **Appendix O**.

8.0 Restoration Plan

The Monitoring Plan can be found under **Appendix E**.

The Adaptive Management Plan can be found under **Appendix F**.

The restoration approach we are proposing represents the range of strategies that must be pursued in an iterative process to achieve the goals of marsh recovery and increasing marsh habitat diversity because marshes with a history of salt hay farming are in many cases are feet, not inches, below elevations that will be resilient to ongoing sea level rise. This restoration process includes first recreating marsh from mudflats using dredge material and may include adding additional sediment at a later date to further increase marsh plain elevation. Once marshes are restored to adequate elevations to support a robust and diverse mosaic of tidal marsh plants, thin layer application of sediments can be used to fine-tune elevations to maximize habitat availability for rare and declining tidal marsh obligate species.

8.1 Restoration Project Objectives

1. Use dredge material from adjacent waterways and deposit in sediment containment settling basin to increase the elevation of former salt hay farm area with elevations that are currently too low in the tidal range to support robust vegetation. These areas did not recover a vegetated marsh platform after hydrological restoration in the late 1990s due of elevation deficits caused by salt hay farming. The restoration target elevation of 1.75'-2.5' NAVD88 at the Eastern project area will ensure that this area will recover a fully vegetated marsh platform (target 80% cover) that will increase marsh resiliency to sea level rise.

2. Use thin layer application of dredge material on the Southern project area to increase elevation of existing marsh platform with up to 8" of sediment to maximum height of 3.4' Navd88 and convert an area comprised of 100% low marsh (*Spartina alterniflora*) to a habitat mosaic composed of a target 60% cover of high marsh vegetation composed of *Spartina patens*, *Distichlis spicata* and *Juncus gerardii* and 40% cover *Spartina alterniflora*. This will maximize resiliency of the salt marsh to sea level rise and increase habitat diversity to benefit tidal marsh obligate birds.

8.2 Reference System

Our bay-wide analysis of agricultural impoundment of tidal marshes and its impacts allowed us to identify marsh areas that were never subject to impoundment and ditching. Portions of tidal marshes in the Back Creek Watershed stand out as among the least affected by direct human impacts. We selected 1,065-acre reference area within this region as exemplary of a marsh with high sea level rise resiliency and high habitat diversity. A useful means to evaluate the resiliency of a marsh to sea level rise is to consider the proportion of the marsh platform that exists at elevation above mean high water (*Raposa et al., 2016*). Tidal marshes achieve peak below-ground productivity at or slightly above mean high water (*Nyman et al., 1993; Turner et al., 2004*). Mean high water at Back Creek is 2.9'. Based on Lidar-derived elevation data, 72% of the marsh surface is above mean high water. The area is composed of an estimated 20% (215 acres) high marsh vegetation cover.

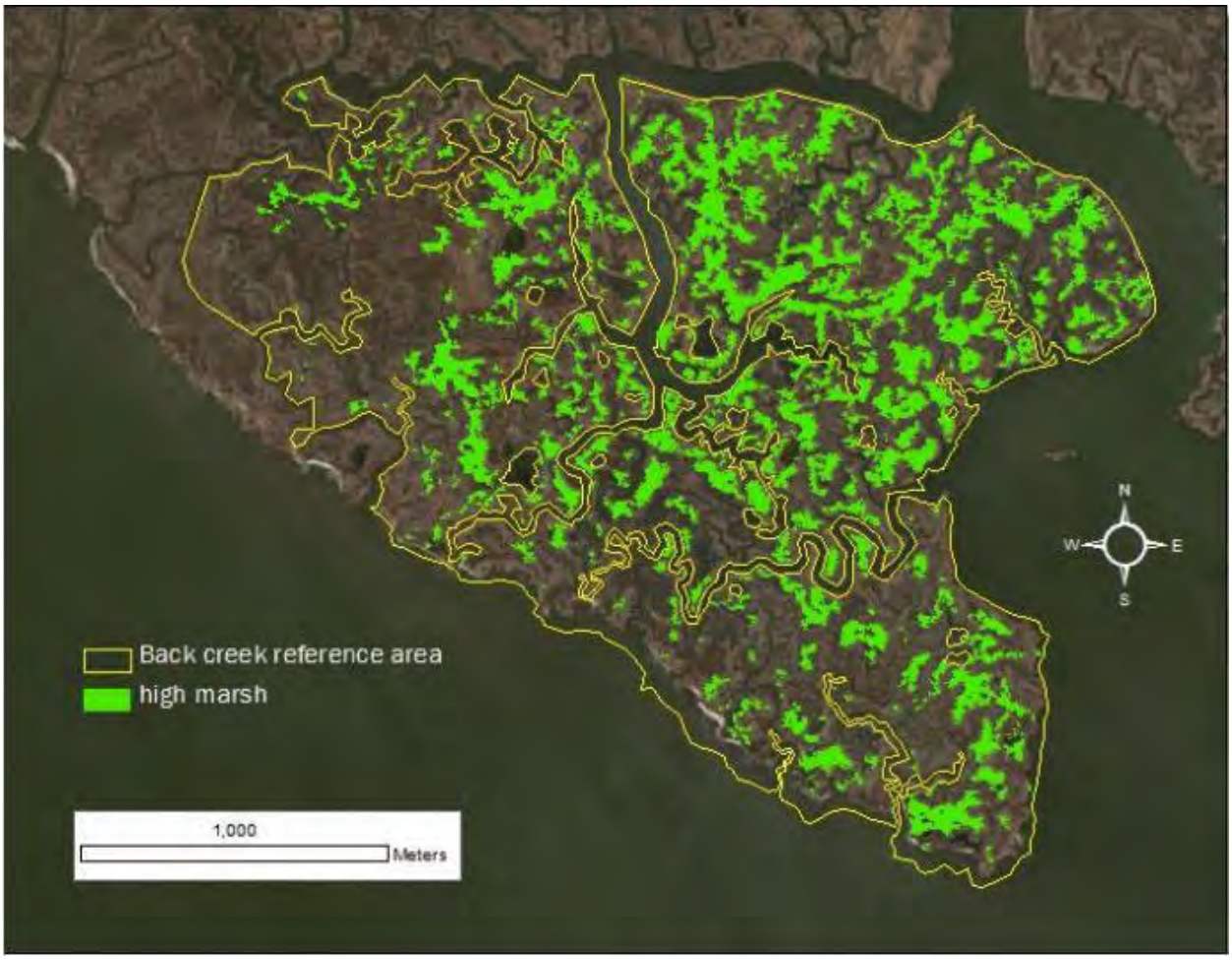

Figure 10 Aerial image showing areas of high marsh with in the Back Creek reference site.

In contrast, at the 1,112 acre Thompsons marsh, just 5% of the area is covered by high marsh and only 42% of the marsh area exists above mean high water (2.75'). This is despite the fact the area includes approximately 115 acres marsh that had elevations raised with dredged sediment to elevations above mean high water. This indicates that the areas that did not receive sediment addition are in even poorer condition with respect to elevation.

We do not anticipate conducting on the ground monitoring at the Back Creek site. The remotely sensed elevation and vegetation patterns that we have documented there, along with the site's lack of any history of hydrological modification, provides context for understanding salt marsh composition in the estuary and for understanding the fundamentally altered character of marshes with a past history of ditching and farming. The Back Creek site serves as template for designing restoration projects like ours.

In addition to the Back Creek reference site, within the Thompsons marsh project area we have identified an array of reference sites that represent the range of conditions at the site.

1. Reference site at similar elevations to our eastern restoration area to serve as control.

   The "very low elevation" reference site will be monitored for breeding birds (SHARP program) and vegetation coverage will be monitored over time.

2. Restoration site where dredge material was added by PSEG as part of maintenance dredging in 2013 that is now experiencing vegetation recovery.

   We have collected baseline elevation data at this site and will monitor the progress of vegetation recovery at this site for comparison with our eastern project area.

3. Three reference sites where dredge material was deposited to increase elevations during the initial late 1990s PSEG restoration.

   These "high elevation" reference sites will serve as references for the southern project area. These sites will be monitored for breeding birds (SHARP program).

4. A nearby example of a high marsh – low marsh habitat mosaic with average marsh elevations above MHW with no past history of restoration.

   This will serve as a reference for the southern project area. Baseline vegetation, elevation and breeding birds (SHARP program) will be monitored to determine similarities and differences between natural and restored high marsh mosaics.

Figure 11 Aerial image showing various reference sites.

9.0 Sediment Analysis

The complete sediment analysis report was provided to the Office of Dredging and Sediment Technology (ODST) and subsequently approved for use, a copy of this acceptance email can be found in **Appendix J**. The complete report is on file at ODST, but a complete copy of the sediment analysis can be provided upon request if needed.

Additionally, Stockton University's final report regarding sediment collection can be found under **Appendix I**. The report contains maps depicting the proposed vs. actual core locations, an excel data table displaying the sample coordinates and depths of penetrations obtained, and stratigraphic core logs, detailing the stratigraphy found at each core site.

Below is a summary of the sediment analysis findings provided by Stockton University's Coastal Research Center:

Marsh sediments were sampled on September 21 & 22, 2016 by the Stockton University Coastal Research Center (CRC) and were analyzed by ALS Environmental Laboratories. As part of that analysis grain size, percent moisture and total organic content (TOC) were determined. All of the samples taken in the creeks and eastern marsh placement area contained a gray to black organic silt consistent with lower energy creek environments and mud flats. The samples taken within the proposed southern marsh placement area contained saltmarsh with roots. An exception was sample PA-2 taken in the southern placement area in the southeast corner which contained an existing salt marsh component at the surface with a fine tan sand present 0.2 feet below the marsh surface. This anomaly may be due to the transport or storm overwash of sandy sediments from the nearby bay shoreline or through placement during previous restoration efforts by PSE&G in this region. The sediments that comprise the interior marsh substrate at these sites are predominantly fine-grained. All the samples taken within the eastern marsh placement and near tidal creek banks were <2% sand. This area represents the highest level of marsh degradation at the site these fine materials of the exposed marsh substrate are softer and more unconsolidated than the surrounding marsh. Samples taken in the southern interior marsh placement area were more variable but more consistent with salt marsh with two composited areas. Composite SA-1 samples were located closer to the road contained 37% sand, 4 of the 5 samples ranged from 5-18% sand with one anomaly PA-2 that contained 97% sand. Composite SA-2 samples located closer to the creek contained 6% sand with the five samples ranging from 3-15% sand.

ALS Environmental Laboratories evaluated the chemical and physical composition of the sediments samples to be dredged and placed on the project restoration areas. Those results indicated similar properties of the creek sediment to existing sediments in the adjacent marsh placement sites. The creek areas to be dredged are solely as a source of material for restoring the marsh and improving marsh hydrology, not for navigation. Both creeks are immediately adjacent to the site and the proposed dredge sediments are adequate for the intended restoration project. The sediments in both the western and eastern tidal creeks are heterogeneous and texture varies throughout the length of the channel. The upper reaches of both creeks consist of finer sediments (<10% sand) mostly silt with the percentage of fine sand increasing (30%-60%) towards the lower reach of the creeks. This restoration project has been designed to take advantage of the finer sediments in the upper reach of the creeks. Dredged channel material consisting predominantly of fine textured sediment will be used in a confined layer application of material over interior mudflats and very low marsh habitat to raise the existing elevation to a preferred target elevation. All dredged material placed on the marsh will act as a suitable medium for planted native material and will support the natural recolonization of native vegetation.

9.1 Bulking Factor

For this project, we are anticipating a 25% sediment bulking factor based on the professional experience of Stockton University's Coastal Research Center and the engineer's project review.

The bulking factor of sediment is due to structural disruption and entrainment of water during dredging, the amount of bulking varies with the type of sediment and method. Because of the uncertainty introduced by bulking, dredging quantities are most often determined by finding the difference between pre-and-post dredge surveys rather than rely on bulking estimates. The samples of the sediment to be dredged from the creek had a percent-moisture level already between 60-70%; to fluidize the sediment for transport hydraulically should not require a bulking factor greater than 25%.

Again, as this project is designed for restoration of marsh and not for navigation, no additional material will be placed in the confined area that would exceed containment during the dredging process. Unlike

typical dredging projects this will not be a 24 /7 operation. Dredging volumes will be limited and regulated to only daylight hours with progress closely monitored. Approximately 500 cubic yards of placement per day is expected and would cover a thin layer approximately 0.3 acres of area per day. within the 3.75-acre area. Time will be allowed for daily dewatering of sediment as placed thereby reducing the bulking factor. In addition, we do not expect this sediment to completely dewater in fact that would be contrary to the goals as we desire the sediment to remain wet to allow for vegetation growth and not become dried out often seen in typical CDF's after dewatering. Samples taken within the Eastern placement also showed percent-moisture of 60-70%, so this would be our minimum expectation for dewatering. If this proves inadequate the installation of additional coir logs to raise the containment berm is an option.

10.0 Construction Methodology

This project will address deficient elevation in two areas of salt marsh with the beneficial reuse of dredge sediment. For this project the Society will be utilizing two different dredge-sediment placement strategies to restore and enhance salt marsh at different elevations. The Society and its partners will design, construct, and monitor the performance of both a thin layer sediment application technique and the more conventional method of pumping dredge sediment to a dewatering containment area. Both techniques are proven effective in creating an ecologically healthy marsh by direct deposition of dredge sediment from the adjacent waterways. Dredged material flowing from the restoration areas into the tidal creeks will be controlled by using a combination of hay bales and coir logs. We will be placing small volumes of material only during daylight hours, 1000 cy daily max (expected to be closer to 500 cy/day), covering only a thin layer (0.3 acres) daily allowing for daily partial dewatering. For additional details please see the Engineering Report in **Appendix B** and the Project Plans in **Appendix C.**

10.1 Eastern Area

This restoration site will receive dredge material hydraulically to raise the marsh platform to a target elevation range between 1.75' and 2.5' NAVD88. This sediment placement would bring the marsh platform to an elevation range more consistent with a functioning low marsh and will increase marsh resiliency and restore biodiversity. An estimated 11,135 cubic yards of material are needed to reach 2.5 feet in elevation. Coir logs will be located along the perimeter of the placement area to contain sediments / runoff while the material dewaters. Their top elevation will be at +2.9 feet, or approximately 0.4 feet above the restored marsh level. Coir logs should be placed where existing elevation is 0.5 or greater and/or with coir mats to stabilize and raise elevation if needed. A pre-construction survey of the marsh will be conducted to determine existing surface elevations in the perimeter area and confined region to aid in placement of the logs to maximize elevation. A slope analysis using this survey will be conducted to assist in optimizing pipe placement areas to take advantage of natural terrain and in developing alternatives including grading and sloping since it is not a requirement of the project to meet a uniform consistent target elevation target throughout the placement area, some variation in elevation mimics natural systems and is an acceptable outcome to the restoration.

Primary control will use a 24-inch diameter log; secondary/back up control will be accomplished by a parallel 12-inch diameter log. To prevent uplift, the logs will be anchored using stakes on each side, spaced every 2' (3' for 12" coir log) along the log, with twine across the top. An 18 to 24-inch overlap will be provided where two logs meet (cribbing will be reduced to 12" spacing). Please see **page 7 of the**

Project Plans in Appendix C. Bulking fluidized sediment will be minimal due to slow placement and daily dewatering due to small volumes. The proposed coir logs should be of sufficient height to accommodate elevation target range between 1.75 to 2.5 feet. Coir log elevations are low enough to allow for overtopping and flooding of placement area during high tides. Additionally, the project area is located over 50 feet from the east tidal creek (150 feet to be more precise) which would also provide a natural buffer and transition zone.

Since the goal is to achieve moisture content in the placed sediments similar to that of the existing marsh conditions, for optimal plant growth, complete dewatering is not a goal nor is full compaction of sediments. A target range of elevations that supports targeted plant species growth is the primary objective.

Placement in the containment area will **not** be done within 1-1/2 hour of high tide. This will potentially create up to a three-hour window during which pumping should be suspended. This window will not always occur midday, so the contractor will adjust the work schedule accordingly.

Elevation markers will be used to assist with meeting elevation targets within the placement area.

A low-impact tracked machine will be used inside the project area to move coir logs and dredge pipe. The closed access road will be used as containment bank. We estimate dredge pipe to be 8" in diameter. Since there are no real navigation concerns, floating lines will be used within the creek with an emergent line placed along the closed access road. Containment routes will be from road and crossing the placement area to minimize temporary impact to adjacent marsh. Restoration would cover and repair temporary damage within the placement zone caused by installation of coir logs except on outer secondary perimeter.

Following the natural dewatering of the area and sediment consolidation, the Eastern project area containment berms may need to be lowered to an elevation near or below mean higher high water to ensure tidal exchange to the area to promote the revegetation by desirable species and to insure the containment area does not retain water or create mosquito breeding habitat. Coir logs will be left in place to biodegrade.

10.2 Southern Area

The Southern project area will receive a thin layer application of a maximum thickness of 8" of dredge material, not to exceed 3.4' in elevation. An estimated 9,160 cubic yards of material are needed to apply the 8" of sediment using a thin layer application.

Hay bales and coir logs will be used in combination to contain dredged sediment in the Southern area. Hay bales will be used along the northern (downslope) perimeter with 8" or 10" coir logs at the heads of six small tidal creeks. The hay bales will be center staked with a minimum of two stakes per bale. Coir logs will be anchored using stakes on each side, spaced every 3' along the log, with twine across the top. An 18 to 24-inch overlap will be provided where two logs meet (cribbing will be reduced to 12" spacing). Please see **page 7 of the Project Plans in Appendix C**.

From the Engineering Report (**Appendix B**): *in the southern area the top of the containment will be*

approximately 24 inches above the prevailing lowest elevation of about 2.1 feet and thus 9 inches above the proposed restored level of 3.4 feet. This is deemed sufficient to prevent dredged material from entering the creeks.

A pre-construction survey of the marsh will be used to create a slope analysis which will assist in optimizing pipe placement areas to take advantage of natural terrain and determine the best placement for containment structures. We plan to minimize containment to only to those areas immediately adjacent to streams and other areas identified in our slope analysis. We will closely monitor and adjust containment as needed.

On the Southern project area, we will be utilizing a pipe with diffuser for the distribution of sediment. An 8" polyethylene dredge pipe will emerge from the creek and traverse southeast for approximately 250' across the marsh to the project site. Less than 1000 cy /day will be dredged (expected to be closer to 500 cy/day) and placed on the project site (only during daylight hours). The pipe will be moved regularly using a low-impact tracked machine to ensure even placement.

The excavator will access the site either from the access road or the tidal creek across approximately 300' of tidal marsh. We will carefully monitor the impact of the vehicle to the marsh substrate and adjust movement paths and gauge the relative impact of using the same path multiple times vs using multiple single paths once. Depending on tidal conditions, weather and project execution timeline, the machine will likely only traverse the marsh twice, once to access the project site and once to leave.

Elevation markers will be used to help ensure target elevations are achieved.

Hay bales and coir logs will either be dismantled or removed post construction. This will be dependent on condition.

The minor creeks shown on our plans were created using GIS files from the NJ GIS Warehouse, the creeks may not exist or do not exist specifically as displayed. We will ground-truth these creeks as part of our pre-construction survey. Regardless, we will be placing coir logs around any minor streams to prevent effluent from getting into the waterways via creek mouths and banks.

Figure 12 Mitigation of impacts to the saltmarsh will be performed during restoration and will be a direct result of restoration activities. A single piece of heavy equipment will be used on the marsh surface, a low-pressure amphibious floating excavator with 4' wide tracks. The vehicle will move primarily within the footprint of dredge material application. The exception is the southern site where the excavator will access the site either from the road or the tidal creek across approximately 300' of tidal marsh.

We will carefully monitor the impact of the vehicle to the marsh substrate and adjust movement paths and gauge the relative impact of using the same path multiple times vs using multiple single paths once. Depending on tidal conditions, weather and project execution timeline, the machine will likely only traverse the marsh twice, once to access the project site and once to leave.

11.0 Dredging

First and foremost, this is a marsh restoration project, only the specific volume of sediment needed to meet the project objectives will be dredged. This project is ***not*** intended to improve navigation and therefore necessitate a way to dispose of excess sediment. It is expected, however, that navigation to and from the adjacent boat ramps will improve.

An estimated 20,295 cubic yards of dredge sediment would be needed for the proposed projects.

Dredging will be initiated at the south end of the cut where water is present in the creek even at low tide, cutting north into the creek allowing tidal flow to follow the cut, providing a greater work window. Work will be conducted during daylight hours and dredging and material placement within the containment areas will not be conducted one hour before, during or one hour after high tide (dependent on tide level) to maintain the necessary freeboard.

The Southern placement area will not be affected by tide as the elevations there are slightly above MHW and will not be restricted by the tide cycle.

We estimate needing 22 days for eastern placement and 18 days for the southern area. Estimates are based on daily pumping rate of 500 cy.

Dredging will be performed using 8" polyethylene pipe. Pipe will be in 40 foot lengths and water-tight fitted.

During construction, the contractor will minimize any disturbance of the existing marsh.

11.1 West Creek

Dredge material for the Southern enhancement area will come from the West creek to minimize the pumping distance. A floating pipeline will convey the material to the restoration area along the creek with a short traverse across the marsh where it will be applied by a diffused spray in thin layers. Multiple applications are anticipated which will allow each previous application to dewater before the next layer is applied.

An estimated 13,635 cubic yards of material would be dredged. A 10' wide channel with a slope ratio of 1V-4H will be dredged to a maximum depth of -5.5 NAVD88. For channel details please see **Project Plans, Appendix C, pages 5 and 8. (Creek "A")**

11.2 East Creek

The source of material for the Eastern restoration area is the East creek. A floating pipeline will convey the dredge material from the dredge to the Eastern restoration area along the creek, up the boat ramp, and down the side of the closed access road. Utilizing the closed access road is the preferred route for dredge material as it minimizes impacts to the marsh, however, a secondary route across the marsh is included on the project plans to allow for contingencies.

An estimated 6,657 cubic yards of material would be dredged. The dredge will cut a 10' wide channel with a slope ratio of 1V-4H, dredging to a maximum depth of -5.5 NAVD88. For channel details please see **Project Plans, Appendix C, pages 4 and 9. (Creek "B")**

12.0 Project Schedule

	Year 1				Year 2				Year 3			
	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
Permitting												
Marsh Construction *												
Year 1 M&AM												
Pre-Planting Assessment												
Marsh Planting						Phase 1		Phase 2				
As-Built Survey												
Year 2 M&AM												
End of Grant											Aug	

** includes continuous construction monitoring at placement sites*

Referenced Literature

Carey J.C., Raposa K.B., Wigand C., & Warren R.S. (2015) Contrasting Decadal-Scale Changes in Elevation and Vegetation in Two Long Island Sound Salt Marshes. *Estuaries and Coasts*, 1–11.

Donnelly J.P. & Bertness M.D. (2001) Rapid shoreward encroachment of salt marsh cordgrass in response to accelerated sea-level rise. *Proceedings of the National Academy of Sciences of the United States of America*, 98, 14218–14223.

Field C.R., Gjerdrum C., & Elphick C.S. (2016) Forest resistance to sea-level rise prevents landward migration of tidal marsh. *Biological Conservation*, 201, 363–369.

Hinkle R.L. & Mitsch W.J. (2005) Salt marsh vegetation recovery at salt hay farm wetland restoration sites on Delaware Bay. *Ecological Engineering*, 25, 240–251.

Lathrop R.G., Niles L.J., Merchant D., Farrell T., & Licitra C. (2013) Mapping the Critical Horseshoe Crab Spawning Habitats of Delaware Bay.

Nyman J., DeLaune R., Roberts H., & Patrick W. (1993) Relationship between vegetation and soil formation in a rapidly submerging coastal marsh. *Marine Ecology Progress Series*, 96, 269–279.

Raposa K.B., Wasson K., Smith E., Crooks J.A., Delgado P., Fernald S.H., Ferner M.C., Helms A., Hice L.A., Mora J.W., & others (2016) Assessing tidal marsh resiliency to sea-level rise at broad geographic scales with multi-metric indices. *Biological Conservation*.

Raposa K.B., Weber R.L.J., Ekberg M.C., & Ferguson W. (2015) Vegetation Dynamics in Rhode Island Salt Marshes During a Period of Accelerating Sea Level Rise and Extreme Sea Level Events. *Estuaries and Coasts*, 1–11.

Shriver W.G., O'Brien K.M., Ducey M.J., & Hodgman T.P. (2016) Population abundance and trends of Saltmarsh (Ammodramus caudacutus) and Nelson's (A. nelsoni) Sparrows: influence of sea levels and precipitation. *Journal of Ornithology*, 157, 189–200.

Smith J.A.., Hafner S., & Niles L.J. (In Review) The Impact of Past Management Practices on Tidal Marsh Resiliency to Sea Level Rise in the Delaware Estuary. *Ocean & Coastal Management*.

Smith J.A. (2013) The role of Phragmites australis in mediating inland salt marsh migration in a Mid-Atlantic estuary. *PloS one*, **8**, e65091.

Turner R.E., Swenson E.M., Milan C.S., Lee J.M., & Oswald T.A. (2004) Below-ground biomass in healthy and impaired salt marshes. *Ecological Research*, 19, 29–35.

Weinstein M.P., Teal J.M., Balletto J.H., & Strait K.A. (2001) Restoration principles emerging from one of the world's largest tidal marsh restoration projects. *Wetlands Ecology and Management*, 9, 387–407.

B2 Monitoring Framework

American Littoral Society

Thompsons Beach Marsh Restoration and Enhancement Project

March 2017

Monitoring Framework

MONITORING FOR ADAPTIVE MANAGEMENT PLAN

Restoration Rationale

Past management of Delaware Estuary marshes via impoundment for farming has caused considerable impacts to the diversity and sea level rise resilience of tidal marshes. These past practices have degraded marshes by creating elevation deficits that result in either uniformly low marsh dominated by *Spartina alterniflora* or conversion to open water and mudflat. This process has resulted in the loss of more than 10,000 acres of tidal marsh, making these past practices the single largest cause of marsh loss and degradation in the Delaware Estuary. Dredged sediment can be used to restore marsh elevations in order to convert mudflat back to vegetated marsh and increase habitat diversity by converting low marsh to high marsh.

The monitoring framework presented here is designed to evaluate whether management actions are achieving the desired result of increased marsh habitat diversity, extent and elevation by evaluating project implementation and effectiveness while gathering data critical for adaptive management actions if project goals are not being met over time.

Restoration Project Objectives

1. Use dredge material from adjacent waterway and deposit in sediment containment settling basin to increase the elevation of former salt hay farm area with elevations that are currently too low in the tidal range to support robust vegetation. These areas did not recover a vegetated marsh platform after hydrological restoration in the late 1990s because of elevation deficits caused by salt hay farming. The restoration target elevation of 1.75'-2.5' Navd88 will ensure that this area will recover a fully vegetated marsh platform (target 80% cover) that will increase marsh resilience to sea level rise.

2. Use thin layer application of dredge material to increase elevation of existing marsh platform with up to 8" of sediment to maximum height of 3.4' Navd88 and convert an area comprised of 100% low marsh (*Spartina alterniflora*) to a habitat mosaic composed of a target 60% cover of high marsh vegetation composed of *Spartina patens*, *Distichlis spicata* and *Juncus gerardii* and 40% cover *Spartina alterniflora*. This will maximize resilience of the salt marsh to sea level rise and increase habitat diversity to benefit tidal marsh obligate birds.

Monitoring and adaptive management approach

We seek to manage former salt hay farms to enhance sea level rise resilience and habitat diversity by increasing the elevation of the marsh platform through sediment addition to allow for **a)** the re-vegetation of former salt marsh areas that are now mudflat or **b)** to increase vegetation diversity in marshes that are now vegetated to maximize resilience and wildlife habitat value.

Monitoring data will provide the critical information needed to evaluate whether project design objectives are being met during the construction phase and, subsequently whether overall resilience project goals have been met. Data will be collected on those factors we are seeking to change, such as elevation and vegetation attributes as well as those factors (e.g. water levels) that may influence these ends results and can inform adaptive management strategies.

We intend to use monitoring data to document increases in elevation the project achieves and to document the changes in vegetation that we expect the increase in elevation to produce. Beyond the active restoration area, we will compare measures of the project site to reference sites that exhibit elevation and vegetation

characteristics similar to our project objectives. Elevation monitoring will occur at restoration sites before, and at regular intervals after restoration. Vegetation monitoring will occur at seasonal peak biomass (July-September) before and annually post-restoration. All monitoring will follow standard, peer-reviewed protocols.

Implementation monitoring – to determine whether project components meet or deviate from design criteria.

Question 1: ***Have marsh elevation goals been met?***

Approach: Pre and Post-sediment application elevation monitoring. Prior to, during and at regular intervals after application. Elevation will be recorded via RTK GPS, ground-based LIDAR or photogrammetry as appropriate given substrate conditions.

In addition, for the **southern site** we will place marker horizons (50 x 50 cm plot feldspar clay) at RTK GPS-referenced sites prior to sediment application for fine-scale measurements of realized marsh surface elevation gain.

Role in adaptive management: Elevation monitoring will determine if elevation targets were reached, allowing for adjustments in dredge material application and grading during construction. Post-construction, it will allow us to assess changes to elevation as settling, dewatering and revegetation progresses to inform future iterations of material application.

Question 2: ***Did dredging conform to the project design?***

Approach: Pre-and post-dredging bathymetric surveys of dredged areas to track changes in channel morphology over time.

Role in adaptive management: This will allow us to estimate the remaining inventory of sediment available for future dredging and allow use to measure channel sedimentation rate in order to assess availability of sediment for future dredging.

Question 3: Are sediment characteristics similar to surrounding area?

As part of our sediment sampling plan, we will test dredged sediment for use in restoration for nutrient composition, grain size and contaminants.

Role in adaptive management: This information will verify that sediment characteristics within the placement site are similar to the material being applied. Any differences in sediment characteristics at the time of placement or over time may help explain patterns of revegetation.

Effectiveness monitoring – To determine if the project objectives are being met.

Question 4: ***What is the rate of natural recruitment of salt marsh plant species in sediment addition areas?***

Species composition, vegetation percent cover and vegetation height: At a series of survey points, a line intercept survey oriented in a random direction will be conducted along a one meter transect. At each decimeter mark the plant species that the point intercepts or other cover (e.g. mud, open water) will be noted. Maximum height of vegetation along the one meter transect will be noted.

Vegetation horizontal density: Along the same one meter transect vegetation obstruction will be noted with a board marked with one decimeter intervals. Total intervals completely obstructed by vegetation observed at a distance of 3m at a viewing height of 1m will be noted.

Role in adaptive management: This monitoring will establish bounds of expectation for vegetation recovery for projects of this kind in relation to elevation, hydrology and sediment characteristics. It will inform decisions regarding supplemental planting.

Question 5: ***Does planting accelerate the achievement of vegetation cover objective?***

We will use the same metrics of species composition, vegetation percent cover, vegetation height and density in planted areas and compare results with unplanted areas to document the relative benefit of planting vs natural recruitment.

Role in adaptive management: This monitoring will establish whether planting alters the bounds of expectation for vegetation recovery timing and will inform decisions regarding supplemental planting.

Question 6: ***Is below-ground vegetation biomass of restored areas similar to reference areas with equivalent elevation and inundation regime?***

We will collect 15 cm wide by 30 cm deep cores of below ground plant material. We will wash sediments through 0.6 mm screen sieve until all loose organics and mud are removed. Root material will be sorted into live and dead components and dried at 75 degrees Celsius to a constant weight. Dried live and dead material will then be weighed.

Role in adaptive management: This monitoring will establish bounds of expectation for vegetation recovery timing and will help assess how vegetation characteristics of marsh managed as part of this project compares with reference sites regarding vegetation characteristics and function.

Question 7: ***Do plantings survive? What factors affect planting survival?***

We will track the fate of a sample of individually-marked plants over time (with at least three surveys per growing season) in relation to elevation, plant species type and tidal inundation patterns. At least 100 plants of each species will be tracked per elevation zone.

Role in adaptive management: It is critical to determine the factors that influence revegetation success. This experimental framework will allow us to better understand the interaction between elevation and the pace and trajectory of vegetation recovery to inform this and future projects.

Question 8: ***Were vegetation cover target goals achieved?***

Our vegetation cover target goals will be evaluated using the monitoring methods outlined under Question 3. These measures will be supplemented with aerial photography taken once per growing season, with cover estimated in GIS.

Role in adaptive management: Understanding the pace of recovery and the feasibility of the project goals are essential for adjusting the bounds of expectation for future projects and adjusting best management practices to increase the probability of achieving objectives.

Question 9: ***Do high marsh obligate birds respond to increased high marsh area?***

For the **southern area**, because our restoration goals are targeted specifically at increasing habitat for marsh-obligate birds, we will document use of the site by these species (and reference sites) before and after restoration.

Targeted surveys of salt marsh and seaside sparrows, rails and willet. Sparrows will be surveyed using standard point count methodology, black rail and clapper rail will be surveyed with nocturnal call back surveys.

Role in adaptive management: This is the ultimate goal of managing marsh to increase the extent of high marsh vegetation. The focus of this project is primarily to develop the technologies necessary to scale up efforts throughout the northeast to conserve and increase coverage of this critical habitat. Nonetheless, a key question is determining whether, if vegetation goals are achieved, the scale of the project is sufficient to attract birds species that nest in high marsh. If not, then future iterations may need to be carried out at a different scale.

Adaptive management monitoring – To provide additional information critical for adaptive management decision making.

Question 10: ***Is tide and inundation frequency similar inside and outside of the settling basin?***

For the **eastern site**, we will measure water and tide levels inside and outside the containment berm of the sediment settling basin using pressure sensors in order to determine whether interior water levels match exterior water levels. This is important because higher water levels inside the basin would translate to poorer vegetation recovery.

Role in adaptive management: It is important that tidal hydrology is not impacted by containment because over the long term this can negatively impact vegetation condition. If we determine that there is altered hydrology we can adjust containment to correct this.

Question 11: Is flood frequency conducive to high marsh vegetation? – flood frequency measurements at control and restoration site

For the **southern site**, we will measure tidal inundation frequency and depth in restored and reference areas in order to determine whether restored elevations achieve the hydrology necessary to meet goals for post-project vegetation composition.

Role in adaptive management: Although we have established site-specific elevation thresholds used to establish project targets, aspects of the flooding regime may not be conducive to high marsh vegetation establishment. Monitoring this factor will allow us to identify discrepancies and potentially correct them with additional management.

Question 12: Are containment structures maintaining their integrity through the dewatering and revegetation phase?

Although no issues are anticipated, the integrity of the containment berm will be checked regularly throughout construction and long term monitoring in order to rectify any issues that arise that will affect project goals.

Role in adaptive management: Containment must be monitored in order to ensure that no sediment loss occurs. If any breakdown or breaches occur that threatens to allow the discharge of sediment beyond the project footprint, we can install supplemental containment materials to prevent this.

Monitoring schedule

Prior to construction phase

- elevation
- marker horizons
- vegetation measurements
- creek bathymetry
- sediment sampling
- bird surveys
- tide level measurements

During construction

- elevation
- containment integrity

Post-construction, year 1

- elevation
- creek bathymetry
- containment integrity
- tide level measurements

Post-construction annual monitoring, years 1-5

- elevation
- marker horizons
- vegetation measurements
- bird surveys
- tide level measurements
- containment integrity

Discussion of other ecological factors potentially impacted by restoration.

Water column attributes

Because the project area is limited in extent and part of an open estuarine system, based on literature review and the project team's understanding of the site, we do not expect our project to measurably impact salinity, turbidity, nekton composition, water quality or suspended sediment concentrations at local or regional scales. These factors have little direct bearing on restoration objectives given the scale of the project and are do not play a role in adaptive management decision making.

Increasing marsh area through restoration has clear benefits for increasing ecosystem productivity and for functioning as a wave energy buffer for upland areas and human infrastructure. We do not intent to model wave energy reduction benefits of this project because it is not a specific goal of the project and the conceptual and empirical framework for this ecosystem service for tidal marshes has been well-established.

Marsh elevation dynamics

While Surface Elevation Tables (SETs) are useful for understanding the processes driving changes in marsh elevation, the key factor measured by SETs as opposed to marker horizons (described as part of our monitoring above) is subsidence. The network of SET tables in the Delaware Bay are adequate to inform our project and provide context regarding broader subsidence processes occurring within the system. Furthermore there are no restoration actions or adaptive management options can directly address subsidence patterns. Our actions can only address surface accretion/erosion patterns, which monitoring with marker horizons can document to inform adaptive management. Furthermore, it is not feasible to establish SET tables in unstable mudflat settings as at the NJDEP-owned portion of our restoration project (eastern area).

Benthic infauna and macro invertebrates

While not a restoration goal per se, we anticipate a shift of benthic infauna when we convert open mudflat to vegetated salt marsh. This is an acceptable tradeoff given the mudflats are not a limited resource in the bay and that the restoration area was a salt marsh before human activities degraded the area into a mudflat. For thin-layer application, we expect based on published literature, a full recovery of benthic infauna over time.

Likewise any impacts to epifaunal macroinvertebrates (e.g. ribbed mussel and marsh crabs) will be temporary, as evidenced by the complete recolonization of these species at the former salt hay farm site where our restoration project is being carried out. Temporary impacts to invertebrates are offset by increased resilience of the marsh itself that provides these species their fundamental habitat. The dredge material being placed at the site matches the grain size composition of the material on site. In situations where grain size deviates from native marsh sediment (e.g. coarser material) more consideration of this issue may be warranted given that using a different grain sizes may drive a more significant and longer term impact.

B3 Adaptive Management Plan

American Littoral Society

Thompsons Beach Marsh Restoration and Enhancement Project

March 2017

Adaptive Management Plan

Adaptive Management

Project monitoring is necessary for determining whether design and management objectives have been met and for identifying factors that influence the achievement of these objectives. Ongoing monitoring of project progress will provide information feedback to support adaptive management decision-making.

This iterative process not only applies to the current project, but also to future projects. With each successive project of this type, uncertainty regarding the outcomes of management actions will be reduced via the incorporation of adaptive management principles and the increased knowledge base resulting from this process. We have put these principles into practice during our previous projects to improve beach habitat for shorebirds and horseshoe crabs on the Delaware Bay. Over four successive years of restoration, we have refined our approach during each iteration based on monitoring results to maximize the habitat quality of restored beaches.

Adaptive management during project construction phase.

Dredging and material placement operations

All dredging and material application activities carried out by the contractor will be monitored by project staff at all times. This practice has been an integral part of this team's projects on both Delaware Bay and Atlantic coast working with the same contractor.

This approach will allow ongoing adjustment to activities if issues arise regarding material placement rates and depths, tidal constraints, placement elevation, dewatering, containment and project timeline.

Equipment impacts on surrounding marsh

Dredge pipe will be arranged along the road and/or waterways to the maximum extent possible to minimize impacts to surrounding marsh. A single piece of heavy equipment will be used on the marsh surface, a low-pressure amphibious floating excavator with 4' wide tracks. The vehicle will move primarily within the footprint of dredge material application. The exception is the southern site where the excavator will access the site either from the road or the tidal creek across approximately 300' of tidal marsh.

We will carefully monitor the impact of the vehicle to the marsh substrate and adjust movement paths and gauge the relative impact of using the same path multiple times vs using multiple single paths once. Depending on tidal conditions, weather and project execution timeline, the machine will likely only traverse the marsh twice, once to access the project site and once to leave.

Adaptive management to meet and maintain design objectives

Elevation targets

During construction, constant onsite monitoring of dredge material application, dewatering rates and spot elevations with RTK GPS will be made to ensure that target elevation windows are met, and most critically, not exceeded.

After construction, we will continue to monitor elevations to gauge settling rate. This will inform potential future activities at this site and future projects with similar management goals.

If long-term settling (after demobilization) allows final elevations to fall below the target elevation range, there will be no long term negative impact to the tidal marsh although this may affect project objectives regarding vegetation recovery.

Containment

Eastern site

During construction, containment structures will be carefully monitored for areas of breaching or excessive sediment leakage. The outer tier of containment structures are designed to capture moderate sediment leakage from the primary structure. We will monitor both structures during construction to ensure that no sediment overtopping occurs. We will have the materials onsite necessary to make spot-repairs of containment if necessary.

Subsequent to construction we will make frequent checks of containment to assess structural integrity and ensure that sediment remains contained. As necessary we will repair and improve containment to manage any issues that arise. Adjustments may include planting within and around containment structures to enhance stability and allow for containment resulting from vegetation re-growth to occur more rapidly.

We will monitor water levels inside and outside of containment in order to gauge the impact of containment on tidal hydrology. If necessary, we will make modifications to the structure to improve hydrology as settling and revegetation make the containment structure less integral to holding sediment in place.

Southern site

The need for containment is minimal at the southern site. Containment will be focused primarily around small drainages at the downslope end of the project site to minimize the potential loss of sediment into these lower areas. We will have materials on hand to expand containment if necessary as sediment placement proceeds.

Adaptive management to meet project objectives

Eastern site. Our goal for the eastern site is to achieve 80% coverage of *Spartina alterniflora*. Based on past restoration results at this site, we anticipate relatively rapid natural revegetation of the site with *Spartina alterniflora*. If necessary, seeding and planting remain an option if monitoring reveals that natural revegetation is not progressing.

Southern site. For the southern site, the goal is to achieve 60% coverage of high marsh vegetation. The factors affecting revegetation at this site are more complex, involving elevation, hydrology, climate and soil conditions. Our adaptive management response will be informed by measurements of these variables. Given this complexity, we will employ a mixture of natural recolonization and planting to examine pace and extent of vegetation recovery. If vegetation recovery stalls, we will consider an array of site treatments including additional planting to achieve project objectives. This process will build a knowledge-base of best practices for creating high marsh using sediment addition.

Given the strict controls placed on elevation during the construction phase and that target elevations are well below the threshold suitable for *Phragmites*, we do not anticipate establishment of this species at either site.

As unforeseen issues arise and new information comes to light, we may add additional metrics to our monitoring plan in order to improve adaptive management capacity.

Thompson Beach Marsh Restoration and Enhancement Project
Monitoring Plan

timeline	Phase	site	parameter	management objective	monitoring	prompt for adaptive management	adpative management options
year 1	construction	**eastern**	elevation	dredge within placement in primary containment to 1.75-2.5' range	RTK GPS spot elevations and/or grade stakes	placement exceeds 2.5'	grade to target elevation range
year 1	construction	**eastern**	elevation	dredge within placement in primary containment to 1.75-2.5' range	RTK GPS spot elevations and/or grade stakes	placement is less than 1.75'	add additional sediment
year 1	construction	**eastern**	sediment containment	ensure that dredge material remains within project footprint	Constant monitoring of containment during contruction operations	overtopping of secondary containment	Identify flow paths between primary and secondary containment structures, add additional containment materials to reduce flow from primary to secondary containment
year 1	construction	**eastern**	sediment containment	ensure that dredge material remains within project footprint	Constant monitoring of containment during contruction operations	breach or major flow of sediment from primary containment	halt placement operations and repair/augment containment structure
year 1	construction	**eastern**	surrounding marsh condition	minimize impacts to surrounding marsh from equipment	n/a	n/a: all equipment will be in water, on road or within project footprint with no impact on surrounding marsh	n/a
year 1	monitoring	**eastern**	elevation	dredge within placement in primary containment to 1.75-2.5' range	RTK GPS, Lidar, aerial photo-derived digital elevation model	At this point in time we do not anticipate that any observations made will prompt an adaptive management action	n/a
year 1	monitoring	**eastern**	occurrence of invasives	No phragmites coverage within project area	array of vegetation parameters outlined in monitoring plan	We do not anticipate Phragmites establishment as long as the elevation targets are not exceeded	n/a
year 1	monitoring	**eastern**	sediment containment	ensure that containment does not impact tidal hydrology	water level monitoring inside and outside of containment	altered tidal hydrology within containment	strategic breaching or removal of portion of containment to equalize hydrology inside and outside of containment - this action will be balances with the need to keep sediment contained until it is stablized.
year 1	monitoring	**eastern**	sediment containment	ensure that sediment does not expand beyond project footprint	vegetation and elevation monitoring will detect patterns of sediment discharge	sediment discharge detected that appreciably impacts surrounding vegetation or affects elevation within project footprint	install additional containment - coir logs and/or hay bales to control sediment movement
year 1	monitoring	**eastern**	vegetation	80% cover of Spartina alterniflora	array of vegetation parameters outlined in monitoring plan	At this point in time we do not anticipate that any observations made will prompt an adaptive management action	n/a
year 2-5	monitoring	**eastern**	elevation	dredge within placement in primary containment to 1.75-2.5' range	RTK GPS, Lidar, aerial photo-derived digital elevation model	At this point in time we do not anticipate that any observations made will prompt an adaptive management action	n/a
year 2-5	monitoring	**eastern**	occurrence of invasives	No phragmites coverage within project area	array of vegetation parameters outlined in monitoring plan	We do not anticipate Phragmites establishment as long as the elevation targets are not exceeded	n/a
year 2-5	monitoring	**eastern**	sediment containment	ensure that containment does not impact tidal hydrology	water level monitoring inside and outside of containment	altered tidal hydrology within containment	strategic breaching or removal of portion of containment to equalize hydrology inside and outside of containment - this action will be balances with the need to keep sediment contained until it is stablized.
year 2-5	monitoring	**eastern**	sediment containment	ensure that sediment does not expand beyond project footprint	vegetation and elevation monitoring will detect patterns of sediment discharge	sediment discharge detected that appreciably impacts surrounding vegetation or affects elevation within project footprint	install additional containment - coir logs and/or hay bales to control sediment movement
year 2-5	monitoring	**eastern**	vegetation	80% cover of Spartina alterniflora	array of vegetation parameters outlined in monitoring plan	If revegetation rate or composition is not on track to reach the objective we will consider planting as necessary	n/a