U.S. Fish and Wildlife Service
Rhode Island National Wildlife Refuge Complex

ENVIRONMENTAL ASSESSMENT

NARROW RIVER ESTUARY RESILIENCY RESTORATION PROGRAM

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ENVIRONMENTAL ASSESSMENT - NARROW RIVER ESTUARY RESILIENCY RESTORATION

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1.0 INTRODUCTION

In October, 2012, Hurricane Sandy made landfall on the Eastern Seaboard, making apparent the need to enhance the resiliency of coastlines and estuarine habitat against future storms. In July, 2013, the U. S. Fish and Wildlife Service (Service) was awarded funding under the Disaster Relief Appropriations Act of 2013 (Public Law 113-2) to enhance habitats, resource values, and ecological resiliency in the Narrow River Estuary (estuary), located in the towns of South Kingstown and Narragansett, Washington County, Rhode Island (Figure 1).

To generate ideas for improving estuarine health, the public was invited to submit issues, concerns, and opportunities. The Service also received the assistance of over a dozen people knowledgeable about restoration and natural resource values from a variety of federal and state agencies, local municipalities, and conservation organizations to formulate restoration strategies. Since that time, the Service has been conducting field inventories and assessments to identify restoration actions. The result has been the development of an integrated set of actions designed to prevent and reduce the ongoing degradation of key estuarine values and to increase ecological health by improving resilience, biological productivity, and social value in the context of climate change and other anthropogenic impacts.

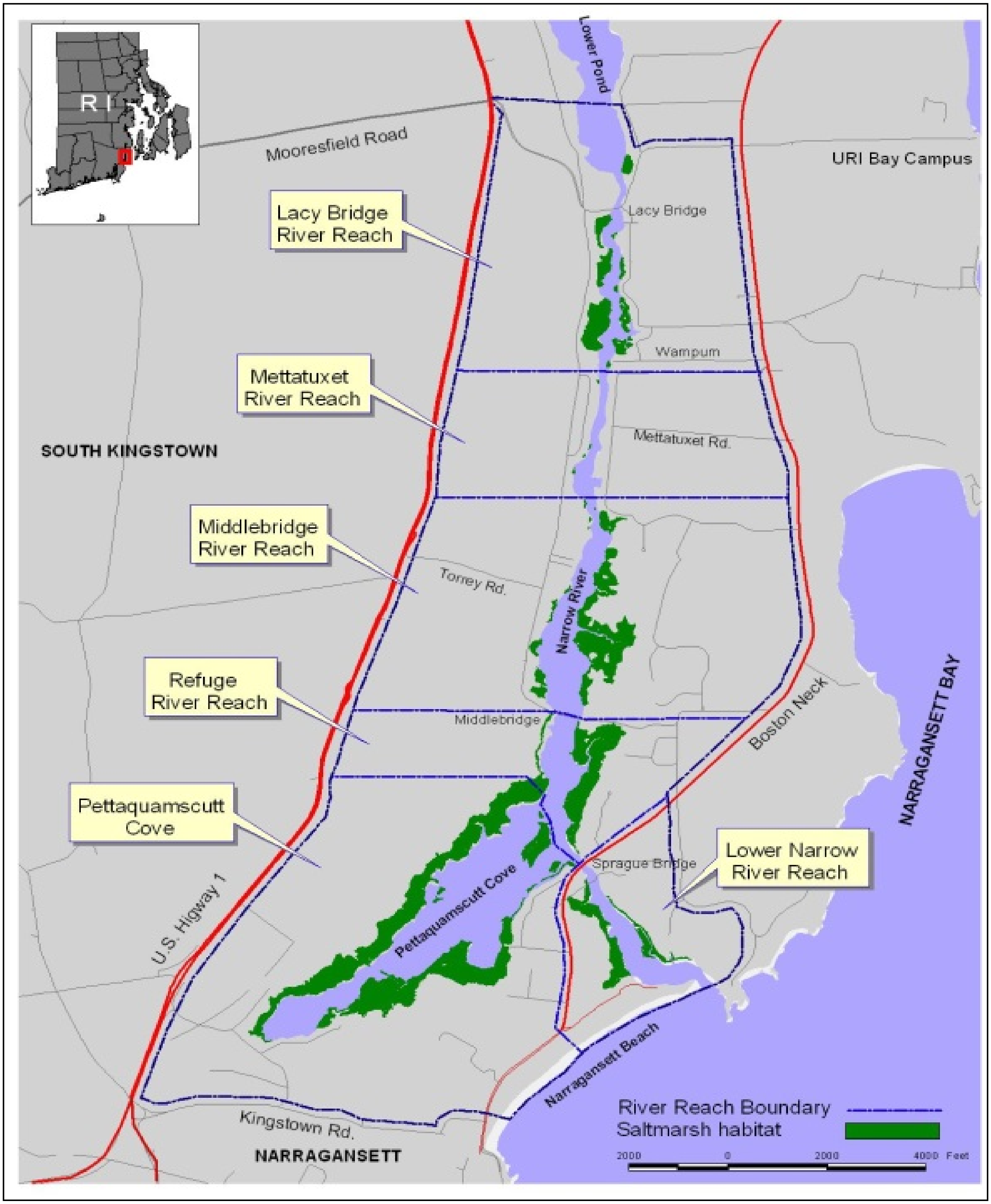
The Service is completing this Environmental Assessment (EA) consistent with the National Environmental Policy Act of 1969 (P.L. 91-190; 42 U.S.C. 4321 *et. seq.*) to describe and evaluate potential environmental impacts of the alternatives considered for this proposed action.

2.0 PURPOSE AND NEED FOR ACTION

The purpose of this resiliency restoration program is to abate degradation of fish and wildlife habitat and to increase the ecological health of the Narrow River Estuary. Enhancing the health of system components now will allow the estuary to become more resilient to changes brought about by sea level rise, climate change, and future storm events. Enhancement of estuarine conditions will also help achieve the mission of the National Wildlife Refuge System, and the purposes for which the John H. Chafee National Wildlife Refuge was established.

Estuaries and estuarine habitats are among the productive ecosystems known, serving as critical transitional areas between land and sea, and providing a wealth of values to society, including fish and wildlife production, pollution attenuation, and socioeconomic values such as flood control and recreation (NHDES 2004; RAE 2007; Tiner 1989). Estuarine habitats are important to numerous life stages of many fish species (Stevenson *et al.* 2014); indeed 75% of commercial fish species depend on estuaries for their feeding habitat, spawning grounds, and nurseries (RAE 2007).

Figure 1. Narrow River Resiliency Restoration Project Area



Salt marshes are some of the most ecologically important wetland habitats on Narragansett Bay (Schwartz 2009). These wetlands support the coastal estuarine ecosystem because of their role in providing food, space, and refugia for a wide variety of terrestrial and aquatic species (Teal *et al.* 1999). Salt marshes buffer and protect estuarine waters and habitats from land-based pollutants (USEPA 1993). The location of salt marshes between river and upland sites provides a buffer during storm events, and aid in reducing nitrogen inputs from uplands into estuaries (Wigand *et al.* 2004). Salt marshes provide habitat to wildlife species of highly restricted range, such as the salt marsh sparrow (*Ammodramus caudacutus*), a salt marsh obligate species of high conservation concern (USFWS 2008). Salt marshes are also valued as open space and provide scenic vistas.

The Narrow River drains a watershed approximately 14 square miles in size, and provides estuarine habitat in roughly half of the river's length. The estuary supports a variety of diverse habitats, including eelgrass *(Zostera marina)* beds, estuarine channels and basins, shallow water habitats, intertidal shoals (tide flats), and extensive salt marshes. Despite the important biological, economic, and social values this area provides, these estuarine habitats are threatened from a variety of natural and anthropogenic influences; and several characteristics of this estuary suggest key components are in decline. There is a need to act.

The estuary is susceptible to increased rates of sea level rise. The RI Coastal Resource Management Council (RICRMC) predicts a one foot sea level rise over 1990 levels by 2050 (URI 2013). Salt marsh habitats occur at elevations less than two feet above mean sea level, therefore only modest increases in sea level rise can have a marked change in the amount, type, distribution, and quality of salt marsh habitats. Locations where salt marsh vegetation can migrate inland in response to sea level rise is limited and will accommodate less than half of the current marsh acreage, with remaining marsh having a much patchier fragmented distribution (USFWS 2014). Relatively flat elevations on some marsh surfaces suggest that with only slight increases in sea level, large expanses of salt marsh will be lost at one time.

Changes in climate will also influence the estuary. If current predictions hold true, increased precipitation can increase freshwater input onto salt marsh surfaces, further degrading marsh conditions. Shifts in wind directions can make now stable shorelines more susceptible to wind driven waves. Increased frequency of storm events could limit recovery times and make some habitats less resilient to future storm events.

Despite ongoing efforts of the State, local municipalities, and the Narrow River Preservation Association (NRPA) to improve water quality, the estuary suffers from low water quality in the form of excess nitrogen influx and the presence of coliform bacteria, particularly after rainfall events (NRPA 2012). Excessive nitrogen loading can limit production of roots and rhizomes which help bind and stabilize salt marsh banks (Deegan *et al.* 2012), and make above ground vegetation more susceptible to grazing (Ramnarine *et al.* 2008). Poor water quality can reduce the diversity of aquatic insects, and protracted flushing rates such as in Pettaquamscutt Cove limit the system's ability to abate water quality issues (RICRMC 1999).

Salt marsh habitats have declined over time in both abundance and health. We estimate that over 12 acres have been lost to development of bare pans and mud flats on the salt marsh surface, caused by "waterlogging," the continued saturation of marsh soils attributed to poor drainage, creating conditions unsuitable for survival of marsh plants. Shoreline erosion continues at a rapid pace in some portions of the estuary. In combination with the natural undercutting of banks and accelerated erosion from boat wakes in some areas, large lengths of shoreline are failing, with little, if any recruitment of salt marsh areas apparent in the watershed (USFWS 2009; 2012). In 2014, most of Sedge Island's eastern shore has failed with two feet or more of the marsh bank lost due to channel erosion.

Over 39% of current salt marsh habitat is dominated by a mixture of stressed vegetation and bare pans, typical of degraded marsh conditions. Vegetated high marsh surfaces and permanent marsh pools provide important habitat for marine fish during higher tidal periods (MacKenzie and Dionne 2008), yet access to these marshes has declined over time. Clogging of channels in the estuary limits access to 17 acres of otherwise suitable habitat except during lunar or higher tides than average.

Historic changes in channels draining the estuary are likely due both to natural and anthropogenic factors, with once clear secondary river channels transformed into growing flood and ebb tidal deltas. Increasing sediment deposition has resulted in a loss of deeper habitat areas that provide feeding areas and thermal refuge for estuarine fish. Channel braiding as a result of sediment loads in excess of the river's ability to carry them has caused channels to migrate against salt marsh shorelines, causing deteriorating salt marsh and shallow-water habitats.

Important marine habitats such as eelgrass beds appear to have recently expanded in the estuary south of Middlebridge, although this increase has been located in shallow areas, making the bed susceptible to elevated summer temperatures and prop scarring from motorized vessels. High summertime water temperatures, reduced biomass on marsh surfaces, limited access to the salt marsh surface by fish species, and the limited availability of cold water refugia all likely limit fish production.

In short, estuarine habitats in the Narrow River are threatened and declining due to a number of anthropogenic and natural factors. These include climate-change-driven factors such as sea level rise, as well as use-driven factors such as shoreline erosion as aggravated by motorboat wakes, and lingering effects of historic alterations (ditching, berm construction, etc.). As a result, the estuary is losing the mosaic of healthy habitats that supports its diverse ecosystem. Salt marsh vegetation is dying, transforming formerly healthy marsh areas into hypersaline pans of low habitat value. Salt marsh edges are eroding, causing net loss of marsh habitat. Marsh erosion transports sediments into sub-tidal areas of the estuary, aggravating shoaling. This anthropogenic shoaling combines with natural shoaling trends caused by the expansion of flood-tide deltas in the estuary, increasing the area of tidal flats, and eliminating deeper areas that formerly provided important essential fish habitat and shallow-water habitats.

The cumulative impact of these changes is a loss of habitat diversity in the estuary and a "leveling" trend towards more uniform habitats. Where the estuary once supported high marsh, some low marsh, tidal flats, and deeper estuarine areas including eelgrass beds, it is losing habitats at both the higher and lower ends of the elevational range. As deeper areas of the estuary are lost, areas of passage, feeding and thermal refuge are lost for a variety of marine fish species. Benthic and estuarine habitat diversity is declining in the estuary.

This trend is expected to negatively impact estuarine fish and wildlife resources. Larger fish species such as striped bass *(Morone saxatilis)* and bluefish *(Pomatomus saltatrix)* that require deeper areas to feed, and species such as winter flounder *(Pseudopleuronectes americanus)* that utilize deeper areas for spawning and thermal refuge will likely see further declines in habitat quality. Wildlife species such as salt marsh sparrows, which require high marsh habitat for nesting, are expected to decline. Lacking restorative actions, the salt marsh sparrow is likely to require protection under the Endangered Species Act within a few years, and faces the possibility of extinction by 2050 (Paton 2014, pers. comm.).

Reversing these trends and restoring key estuarine components, preventing the loss of habitat diversity, and increasing the resiliency of fish and wildlife habitats will allow us to achieve the goals and objectives of the John H. Chafee National Wildlife Refuge, and the National Wildlife Refuge System.

3.0 THE JOHN H. CHAFEE NATIONAL WILDLIFE REFUGE

Much of the estuary is located within the John H. Chafee National Wildlife Refuge, managed by the U.S. Fish and Wildlife Service (USFWS) consistent with the goals of the National Wildlife Refuge System, and the Comprehensive Conservation Plan for this refuge (USFWS 2001). The purposes for which this refuge was established are:

(1) to protect and enhance the populations of black ducks and other waterfowl, geese, shorebirds, terns, wading birds, and other wildlife using the refuge; (2) to provide for the conservation and management of fish and wildlife within the refuge; (3) to fulfill the international treaty obligations of the United States respecting fish and wildlife; and (4) to provide opportunities for scientific research, environmental education, and fish and wildlife-oriented recreation" (102 Stat. 3177).

The National Wildlife Refuge System is administered according to the National Wildlife Refuge System Administration Act of 1966 (16 U.S.C. 668dd-668ee) as amended by the National Wildlife Refuge System Improvement Act of 1997 (Public Law 105-57). The mission of the National Wildlife Refuge System is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans.

4.0 ISSUES AND CONCERNS

In order to help guide development of the restoration plan, the public was asked to identify any issues or opportunities they may have regarding the restoration project during a 30 day public comment period held from March 4, 2014 through March 25, 2014. The public was notified via an article printed in the Narragansett Times, and a news release was published on the Rhode Island National Wildlife Refuge Complex website (http://www.fws.gov/refuge/Ninigret/About_the_Complex/) and Facebook page (https://www.facebook.com/rinwrc). The following issues were received:

What can be done to improve Narragansett Beach and the health of the Narrow River?

> Increased deposition of sand in the River has altered the channel in the area downstream of Sprague Bridge. Continuing discussions over the years question the potential of using sand deposited in a large flood tidal delta at the river mouth to replenish Narragansett Town Beach.

A retention pond near North River Drive lies within the 100 year flood plain, is in need of maintenance, and has poor water flow during winter storms. Can these conditions be addressed?

> This area has been developed for stormwater runoff abatement with maintenance completed by the local municipality. Maintenance of this particular stormwater structure is beyond the scope of this project.

In addition to these public issues, the Service has identified the following concerns and opportunities:

How can estuarine values be enhanced to make them more resilient to climate change and sea level rise?

Sea level in Rhode Island has been increasing at least since measurements began in 1920. The rate of rise has increased in recent years, with State projections placing the rate at a one foot rise over 1990 levels by the year 2050 (URI 2003). The climate is projected to become wetter and warmer, with the frequency of storm events increasing. Potential shifts in long term wind directions, which can alter ambient wind driven waves and storm surge (McInnes *et al.* 2011) also pose a threat to the Narrow River's health. Most estuarine habitats lie within two feet or less of mean sea level, and therefore are highly susceptible to rapid changes in sea level rise.

What impact will the project have on recreational uses (fishing, boating, and aesthetics)?

The Narrow River Estuary is an extremely popular location for recreational pursuits particularly fishing, boating, environmental education, and wildlife observation. Project activities have the potential to temporarily disrupt some of these uses, but also have the opportunity to improve them following construction. This includes reducing mosquito production from degraded wetlands, maintaining channels and access for boats while improving safety and reducing navigation hazards, maintaining aesthetics, and enhancing fish and wildlife habitat.

How can water quality impacts on estuarine health be abated?

Water quality in the Narrow River is impaired from pollution and excess nitrogen influx resulting from stormwater runoff, abandoned developments within Pettaquamscutt Cove, and sediment deposition in historic channels and tidal shoaling may influence flushing rates. The River has been closed to shellfishing since 1992 due to high levels of fecal coliform bacteria. The Service is concerned with improving water quality in the Narrow River estuary.

How will the proposed action affect tidal flows and volumes?

The Narrow River Estuary is a tidal system connected to Narragansett Bay via the Narrow River Inlet. Tidal flow is restricted in the inlet and at Sprague Bridge, causing attenuated tidal ranges in the estuary. Sprague Bridge was first constructed in 1867, with a concrete bridge replacing the original wooden covered bridge in 1920, which has restricted flows between the bridge abutments. The salt marshes and habitats of the estuary have evolved with this tidal restriction for over 140 years. The Service is concerned with avoiding any changes to tidal flow or volume that would adversely impact public or private lands, salt marshes and other habitats of the estuary.

How can the downward trend in salt marsh conditions be improved?

The extent and health of salt marshes is declining. Vegetated marsh is being replaced by un-vegetated bare areas, including new pools and pans, and new intertidal or open water areas. This trend is caused by accelerated sea level rise and climate change, poor marsh drainage, boat wakes, prop scarring and other anthropogenic impacts. Continued loss of salt marsh will cause loss of habitat diversity in the estuary, with corresponding declines in biodiversity—particularly for those species which are dependent on vegetated salt marsh habitat, such as salt marsh sparrows and other birds. Finally, declines in vegetated salt marsh will reduce the estuary's ecological resilience—its ability to adapt to climate change impacts such as warming temperatures and rising tides. The Service seeks to identify actions that can be undertaken to preserve the ecological value and resilience of the estuary.

How can marine fish and Essential Fish Habitat (EFH) be enhanced by the project?

The Narrow River is an important spawning and feeding area for numerous marine and diadromous fish species. The estuary supports a diversity of estuarine and shallow-water habitats, including eelgrass (*Zoestra marina*) beds, salt marsh, a variety of benthic habitats, and deeper water areas. But increased shoaling, reductions in marsh creeks limiting fish access, warm water temperatures, and degradation of marsh surfaces can hamper habitat quality and the productiveness of the estuary for marine fish. Protected embayments such as the Narrow River help support Rhode Island's recreational and commercial fisheries by serving as spawning, refuge and forage areas for commercial and recreational fish and shellfish species. The Narrow River Inlet and estuary are popular recreational fishing areas for striped bass and other species. The Service is concerned with maintaining fishery values in the estuary

How will habitat diversity and wildlife use of the estuary salt marshes, tidal flats, and pools be affected?

The Narrow River Estuary is a mosaic of estuarine habitat types, including salt marshes, tidal flats, and pools (shallow ponded areas) on the surface of the marsh. The high biological diversity is dependent on this mix of habitats. Some species require one specific habitat type, while others may use multiple habitat types or may be habitat generalists. Some species, such as the salt marsh sparrow are of high conservation concern, and identifying actions to help conserve these species are a high priority. The Service is concerned with maintaining a diversity of habitat, in order to support a wide diversity of fish and wildlife species.

How will cultural and historic resources be impacted by the project?

Cultural resources such as historic and prehistoric artifacts are important for understanding human uses and social context at landscape scale. The Service is concerned with preserving and protecting cultural resources.

A Draft Environmental Assessment (EA) for this project was published on the Service's website (http://www.fws.gov/refuge/john_h_chafee) and Facebook page (https://www.facebook.com/rinwrc) on October 30, 2014, and made available for a 30-day public comment period from October 30, 2014, through November 30, 2014. Printed copies of the Draft EA were placed at the Kettle Pond Visitor Center in Charlestown, RI, and on November 4, 2014, additional printed copies of the Draft EA were made available at the Maury Loontgens Memorial Library in Narragansett, RI, and at the Peacedale Public Library in South Kingstown, RI. On November 7, 2014, the Narragansett Times published a story regarding the availability of the Draft EA for public comment; a legal advertisement also ran in the Narragansett Times that day indicating the availability of the Draft EA for public comment (Narragansett Times, Vol. 151, No. 90). On Friday, November 12, 2014, The South County Independent published a legal advertisement that provided notice of the availability of the Draft EA for public comment. A Draft Finding of No Significant Impact for this project was published on the Refuge Complex website for public comment.

A total of 45 comments were received from two respondents on the Draft Environmental Assessment. Most of the comments were specific technical comments, requests for source information, or editorial comments. No public comment was received on the Draft Finding of No Significant Impact. All comments received are addressed in Appendix H.

5.0 AFFECTED ENVIRONMENT

5.1 OVERVIEW OF THE NARROW RIVER ESTUARY

The Narrow River is a 9.5 mile long river/estuarine system comprised of a tidal inlet, coastal estuary, and two fjord-like ponds, located in the towns of Narragansett, North Kingstown, and South Kingstown in southern Rhode Island. The watershed of the Narrow River is about 14 square miles in area, and is classed as 35% developed by the R.I. Dept. of Environmental Management (RIDEM 2001). The watershed includes freshwater ponds and wetlands; forests and other upland habitats.

The lower or southern portion of the Narrow River system is the Narrow River Estuary (estuary), a large habitat complex. The estuary is tidally connected to the West passage of Narragansett Bay via the Narrow River Inlet, the largest remaining unmanaged inlet or "breachway" in Rhode Island, and includes Pettaquamscutt Cove, a large, shallow lagoon.

Over time, channels in the estuary have shifted significantly in size and location (Appendix A). While Pettaquamscutt Cove appears to have been flushed by channels to the east of Sedge Island in the 1800's, much of the flow appears to have been diverted to the West of the Island. The main river channel to the north of Sedge Island has changed from being more centrally located to its current position against the east salt marsh shoreline bank.

South of Middlebridge and above Sprague Bridge, the estuary is shallow with depths throughout most of the area less than 2 feet below mean sea level (MSL) (Figure 2). Channels range as deep as 8 feet MSL but are more commonly less than 4 feet. Deeper areas (approximately 12 feet) are present only as scour areas under Middlebridge and Sprague Bridge. Intertidal and sub-tidal sand flats, including flood tide deltas are common in the vicinity of Sedge Island. Bottom habitats range from mud to coarse sand and fluid silt (Figure 3). Tidal range averages 2.3 feet, and displays a 1.5-hour lag time from the Narragansett Pier Tidal data (ACOE 2009).

Within the estuary are salt marshes, intertidal shoals (tidal flats), and shallow-water estuarine habitats, including eelgrass beds. The estuary supports several rare species, contributes to the survival of many migratory species of fish and birds, and provides habitat and forage for commercial and recreational fish species at multiple life stages.

These ecological functions support diverse human uses, including fishing, birding and recreational boating. Rhode Island's commercial fisheries generate more than $75 million in annual revenue (NOAA 2011); the state's recreational fisheries produce more than $130 million in annual economic activity; and wildlife watching produces more than $200 million in economic activity annually (USFWS 2011).

Figure 2. Bathymetry and Elevations in the Central Portion of the Estuary. Map compiled by TNC from various data sources: elevations from RIGIS LIDAR data (2011); bathymetry from Boothroyd and Oakley (2007), etc.

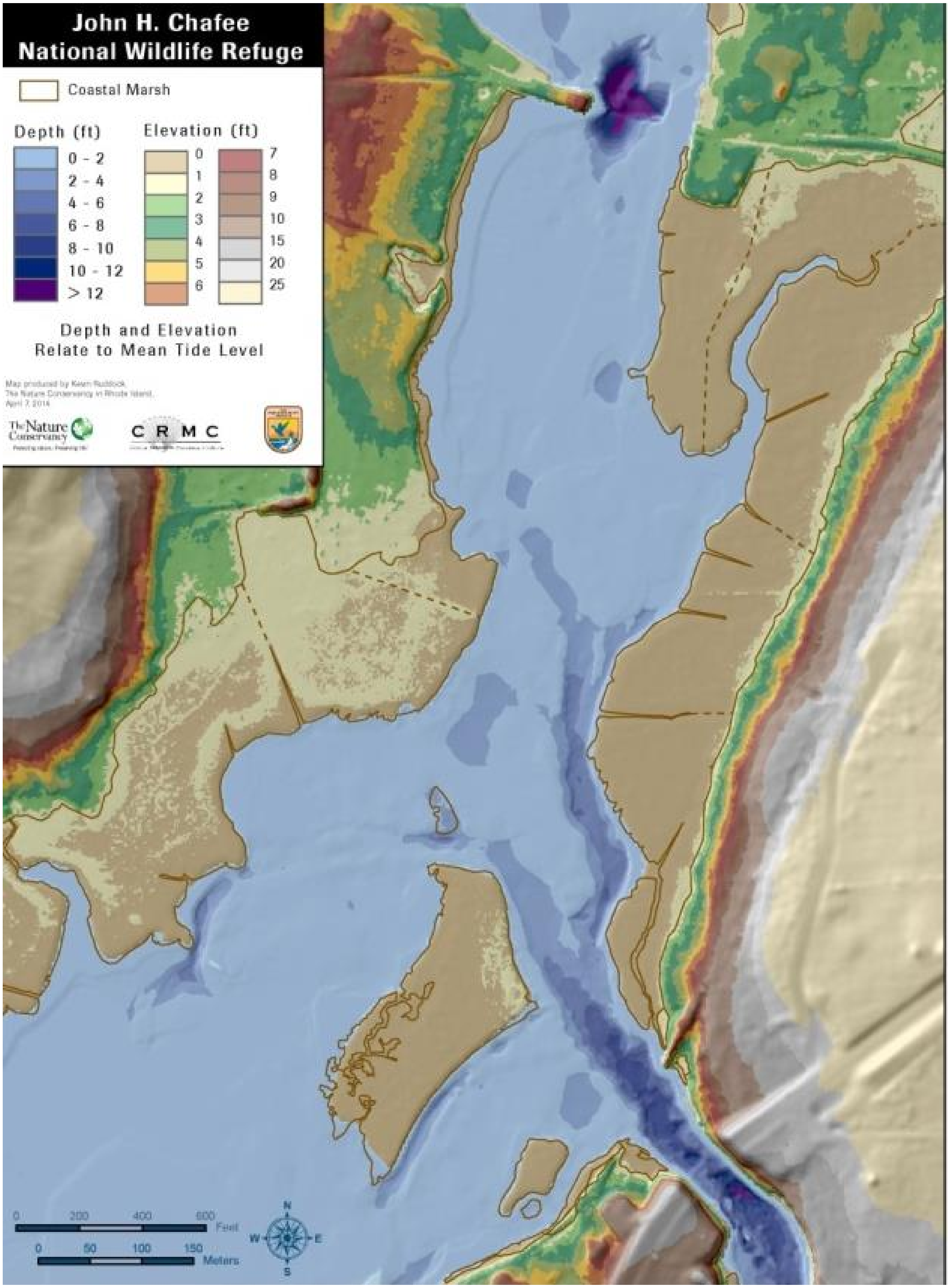
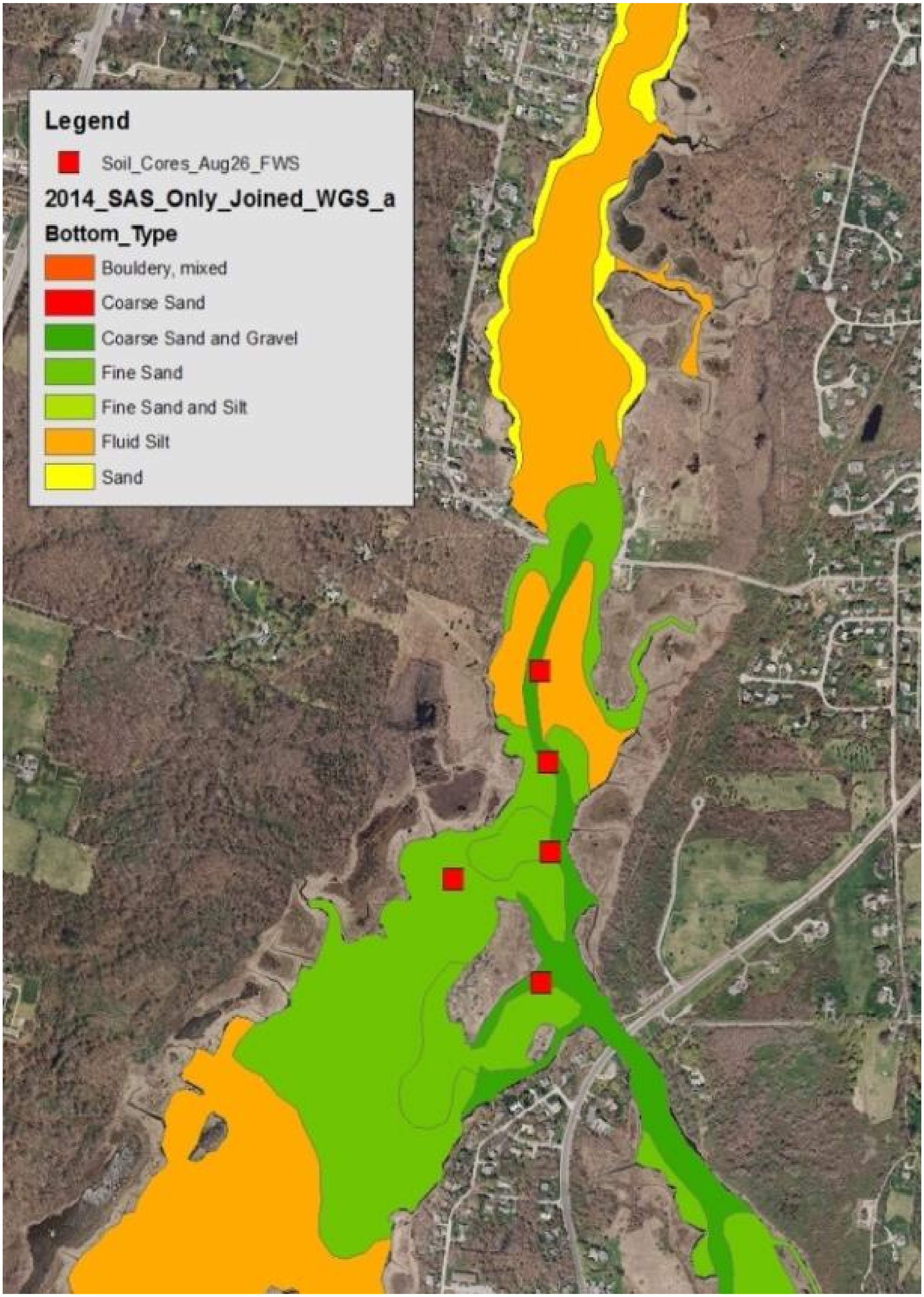


Figure 3. Benthic Habitats in the Central Portion of the Estuary (NRCS 2007).



5.2 PUBLIC USE AND RECREATION

The estuary supports many recreational uses and is an aesthetic amenity to southern Rhode Island, where summer tourism is a principal economic activity. Much of the land base is conserved as open space and for natural resource values by a variety of owners including the National Wildlife Refuge, the Narrow River Land Trust, The Nature Conservancy, and the Audubon Society of Rhode Island. NRPA and others provide the public with interpretive tours and environmental education opportunities.

The marshes are an important visual asset, adding to the desirability and popularity of the area as a recreational destination spot. The marshes and open waters are also visible from Boston Neck Road, Middlebridge Road and other local roads, adding to the scenic qualities and open space values that tourists and residents appreciate in southern Rhode Island.

The waters of the river are a popular location for recreational boating, including kayaking, canoeing and other paddle craft. A public boat ramp at Pollock Avenue in South Kingstown, a fee based public marina and parking area at Middlebridge, a kayak and paddleboard commercial operation at Middlebridge, and free access points on both sides of Sprague Bridge combine to provide ready public access to the water. Access near Sprague Bridge includes access provided by the Service on the northwest side of the Bridge, with limited parking accommodating 12 vehicles. The area is used primarily for fishing and kayaking.

A large portion of recreational boating is geared towards access to the beaches at the mouth of the Narrow River. During the 2009 boating season, the Service undertook field surveys to characterize the extent and level of recreational boat use. A total of 1,256 boat passes were recorded during 39 boat surveys in the vicinity of Sprague Bridge. On average, 33 vessels per hour passed through the study area, comprised nearly equally of motorized and non-motorized vessels. During busy periods, total (motor and non-motorized) vessel passes ranged from 40 to 72 boat passes per hour (USFWS 2009). There has been a large increase in non-motorized boat traffic since 2009.

The majority of boating use on the Narrow River is from June - September; July and August are the most intense periods of use. There is some off-season use, such as early-season and late-season fishing in May and October. Because of shallow water, motor boats must pass within 65 feet of the salt marsh shoreline just upriver from Sprague Bridge. This channel restriction also constrains other boat traffic including canoes, kayaks, and paddleboards, which during heavy use periods presents a safety and navigation hazard.

Fishing, both from shore and by boat, is popular in the Narrow River. Most fishing from shore takes place from Sedge Island downstream to the mouth of the River, and at Middlebridge. Recreational shell fishing has been closed in the River since the 1990's due to high levels of fecal coliform bacteria.

5.3 WATER QUALITY

The RI Department of Environmental Management (RIDEM) monitors water parameters as part of its fisheries monitoring program, and reports the following water quality characteristics in the River (Lake 2014):

Table 1. Narrow River Water Parameters 1994 – 2013 (May – Oct.)	
Near Lacy (Bridgetown) Bridge	
Average Temperature:	21.2 +/- 4.6 ^{o}C
Average Salinity:	17.2 +/- 5.3 ppt
Average Dissolved Oxygen:	7.7 +/- 1.7 mg/l
At Middlebridge	
Average Temperature:	20.3 +/- 4.2 ^{o}C
Average Salinity:	26.9 +/- 5.3 ppt
Average Dissolved Oxygen:	7.6 +/- 1.3 mg/l
At Refuge Reach (South of Middlebridge)	
Average Temperature:	19.9 +/- 4.0 ^{o}C
Average Salinity:	27.4 +/- 4.7 ppt
Average Dissolved Oxygen:	7.6 +/- 1.3 mg/l

NRPA has been monitoring water quality in the Narrow River for over two decades. The estuary suffers from low water quality in the form of excess nitrogen influx and the presence of coliform bacteria, particularly after rainfall events. High levels of pollution enter the estuary in many areas, but most notably in Mumford Brook and Mettatuxet Brook (NRPA 2012).

5.4 TIDAL FLOWS

The Narrow River Estuary's small watershed contributes relatively small amounts of fresh water to the system; as a result, the estuary is dominated by tidal dynamics. Tidal flows into and out of the estuary are restricted by the cross section of the Narrow River Inlet and restrictions at Sprague Bridge. As a result, the tide is greatly attenuated relative to Narragansett Bay. The high tide is slightly lower, low tide is higher; and as a result, the mean tide level is higher (Watson *et al.* 2014).

In 2007-2009 the U.S. Army Corps of Engineers collected tide data and developed hydrodynamic models to better understand tidal dynamics. The study found that the normal tide range at Narragansett Pier of approximately four feet during spring tides was attenuated to less than three feet in the estuary. Attenuation was greatest at the low end of the tidal cycle, with the lowest (ebb) tide elevation increased by more than one foot compared with the ocean, while the high tide elevation was reduced by approximately 0.7 feet. Attenuation was greatest upriver; during the measured cycle, maximum tidal elevations ranged from 3.3 feet at the Inlet to less than 2.3 feet north of Bridgetown Road (NGVD). This compares with an ocean maximum elevation of 3.5 feet NGVD. During the same tidal cycle, minimum tidal elevations ranged from -0.2 feet at the inlet to +1 foot north of Bridgetown Road, as compared with a minimum elevation of -0.8 feet in the ocean. The tidal cycle was also temporally retarded due to the restricted inlet; with high and low tide lagging the ocean cycle by 1.5 and 2 hours, respectively (ACOE 2009).

The ACOE study also modeled tidal prism and flushing times, estimating the Narrow River tidal prism at about 1000 acre-feet. The idealized flushing time was modeled at approximately 1.5 days. Flushing was higher in Pettaquamscutt Cove at approximately 0.26 days and lower upriver, at 3.0 - 7.5 days depending on location. The slow flushing times have contributed to water quality problems, such as high fecal coliform counts (ACOE 2009).

Currents are relatively strong into and out of the Inlet. The ACOE study measured peak spring current speeds in the Inlet at 2.08 ft/sec on the ebb tide, and 2.15 ft./sec on the flood. Current velocities are lower upriver, where the estuary is wider and less restricted. ACOE measured peak spring current speeds at 0.58 ft/sec (ebb) and 0.85 ft/sec (flood) south of Middlebridge (ACOE 2009).

5.5 SALT MARSH HABITAT

The salt marshes of the Narrow River were formed beginning about 18,000 years ago with the retreat of the Pleistocene ice sheets and rising sea level (RICRMC 1999). Salt marsh habitat currently occurs from just north of Lacy Bridge downriver to the mouth of the River (Figure 1). Appendix B provides detailed maps and information related to current salt marsh conditions in the area by river reach.

Salt marsh in the middle and upper reaches of the river occurs in widely dispersed small patches. In middle sections of the river where development is most concentrated, salt marsh is limited to fringing marsh patches less than one acre in size lying adjacent to residential properties. Most salt marsh occurs from Mettatuxet Brook downriver to the Mouth and into Pettaquamscutt Cove.

The amount and distribution of salt marsh has declined over time. Review of historical coastal survey maps and aerial photography (Appendix C) suggests a loss of 12 acres since 1869. The U.S. Environmental Protection Agency (USEPA) analyzed historic maps and aerial photographs, finding a long-term trend of marsh habitat degradation and loss. In Littleneck Cove, along the southeast shore of Pettaquamscutt Cove, the USEPA report found that marsh vegetation declined by 18% between 1869 and 2011, a rate of decline of 1.5% per decade (Watson *et al.* 2014).

The salt marsh surface is comprised of a variety of vegetative communities, many of which are adapted to saltwater inundation (Table 1 and Appendix B). At the upper elevations where freshwater seeps onto the surface, brackish (non-tidal) wetlands dominated in varying degrees by cattail *(Typha spp.),* phragmites *(Phragmites australis),* and bulrush *(Scirpus spp.)* are present throughout the estuary. Salt-marsh bulrush (*Bolboschoenus maritimus*), an indicator of the upper brackish border, is present along with marsh mallow (*Kosteletzkya virginica*), the brackish form of chairmaker's rush (*Schoenoplectus americanus*), and other plants characteristic of this community. Mock bishop's-weed (*Ptilimnium capillaceum*), a species of conservation concern, was found in a few patches in a brackish marsh below Middlebridge (RINHS 2014). Where freshwater inputs are minor at upper elevations, estuarine shrub wetlands dominated by high tide bush *(Iva frutescens)* occurs, but primarily from Middlebridge upriver.

Just below the brackish marsh and high tide bush communities, salt marsh vegetation dominates down to the riverbanks. Upper elevations and well drained sites include species such a salt marsh hay (*Spartina patens*), rushes (*Juncus spp*.), and saltgrass *(Distichlis spicata).* The majority of salt marsh is considered to be a high marsh community, typically located on higher elevations above mean high water, which are not regularly flooded by tides (Montague and Wiegert 1990). A survey in 2009 found the mean high tide line to occur within two feet of the riverbank edge (Appendix D).

Table 2. Salt Marsh Habitat Summary in the Narrow River Estuary, John H. Chafee National Wildlife Refuge (USFWS 2013a)

RIVER REACH	TOTAL ACRES	MARSH SURFACE (ACRES)						MARSH DRAINAGE (FT)			CONDITION OF MARSH SURFACE			
		SALT MARSH HABITAT (2)	NEW POOLS and PANS (3)	OLD POOLS and PANS (4)	BRACK-ISH MARSH (5)	ESTURINE SHRUB WETLAND (IVA)	TOTAL	RIVER / MARSH SHORE LINE	DITCHES and SLOUGHS (6)		WELL DRAINED SALT MARSH HABITAT		POORLY DRAINED SALT MARSH HABITAT (7)	
									FUNC - TIONAL	NON-FUNC - TIONAL	ACRES	%	ACRES	%
LACY BRIDGE	31.7	15.2	4.3	0.9	5.3	0.2	25.9	8,628	6,003	2,281	11.4	75	3.8	25
LOWER RIVER	21.4	14.0	0.0	0.5	0.0	0.0	14.5	6,414	7,972	58	11.3	81	2.7	19
MIDDLE-BRIDGE	83.3	31.6	3.2	4.9	9.2	2.1	51.1	8,542	12,366	1,887	17.5	56	14	44
METTA-TUXET	2.0	1.6	0.0	0.5	0.1	0.0	2.3	401	0	0	0.2	12	1.4	88
PET COVE	169.0	86.8	5.7	14.2	12.6	0.6	119.9	27,497	18,427	3,984	52.8	1	34	39
REFUGE	36.9	24.8	1.0	0.5	1.6	1.3	29.1	5,640	7,035	1,810	12.1	49	12.7	51
TOTAL	344.2	174.0	14.3	21.5	28.8	4.2	242.7	57,122	51,803	10,020	105.4	61	68.6	39

Footnotes:

1. Salt marsh habitat are those areas vegetated with *spartina spp., salicornia spp., juncus spp, distichlis spp.* in some combination.

2. New pools and pans have developed on marsh surface since 1939 (based on aerial photo interpretation). These pools and pans frequently dry up in the summertime, and could trap nekton such as small fish in summer. Depths are shallow with no developed banks. It is anticipated that with restoration of these areas, 25% will remain in *S. alterniflora* dominated stands.

3. Old pools and pans have occupied the marsh surface at least since 1939 (based on aerial photo interpretation). Pools are typically perennial, have established banks, and range in depth from 8" to over two feet. These pools are occupied by fish and other nekton.

4. Brackish marsh is dominated in some combination by *Typha spp., Scirpus spp.* and *Phragmites*.

5. The length of sloughs are double counted here, mostly affects MB05 and PC09.

6. Includes acreage poorly drained from clogging of channels. Based on vegetation mapping and field assessments, poorly drained salt marsh habitat is considered to be in a degraded condition, dominated by the short form variant of *S. alterniflora* and *Salicornia* in low density.

Low marsh, typified by the presence of the tall form variant of cordgrass (*Spartina alterniflora*), is inherently limited in availability because of the relatively high elevations of salt marsh in the estuary. This species, which typifies low marsh, primarily occurs at elevations of 0.90 feet NAVD88 or lower along drainage ways in the marshes. *S. alterniflora* is generally limited to the sides of the channels, within 10-20 feet or less of the bank. Based on the length of ditch and sloughs shown in Table 2, we estimate that approximately 24 acres, or 14% of salt marsh in the estuary is in a healthy, low marsh condition. Other species typically associated with low marsh include glasswort *(Salicornia spp.)* and *D. spicata*.

Within salt marshes, pools and pans dominate a significant portion of the surface, and many have been present at least since 1939. Historical pools can be distinguished from those recently established by the presence of fish species, well-developed banks, and depths ranging from eight inches to over two feet. The amount of pools and pans has increased by 40% since 1939, resulting in a loss of 14.3 acres of salt marsh (from Table 2). Newer pools and pans are typically shallower (less than 4 inches), and dry up during the summer, yielding bare mud and peat. Many of these sites contain remnant roots of *S. patens* (Ferguson 2014, pers. comm.).

The attenuated tidal range within the estuary causes the elevation of the salt marshes here to be, on average, lower than those elsewhere in Rhode Island. As a result, these marshes have less “elevational capital" or capacity to adapt to rapid sea level rise than other marshes in southern New England (Watson *et al.* 2014). By analyzing rates of radioactive decay in marsh peat, this study found marsh accretion rates in Littleneck Cove to average 2.1 mm/year since the 1960's. This compares with an average rate of sea level rise in southern New England of approximately 3.5 mm/year (Boon 2012), leading to the conclusion that the estuary salt marshes, already lacking in "elevational capital," are unable to adequately adapt to current sea level trends. Appendix E contains sea level rise modeling completed for the estuary by RICRMC and The Nature Conservancy.

Areas where salt marshes can "migrate" inland—expand into adjacent upland sites in response to moderate sea level rise—are limited, and can only accommodate less than half of the current salt marsh acreage (from Appendix B). Remaining salt marshes would occur in smaller, highly fragmented patches primarily on non-federal lands.

Throughout the Northeast, salt marshes are losing vegetated habitat due to natural and anthropogenic impacts. On Narragansett Bay, long-term monitoring shows rapid decline of high marsh or salt meadow, replaced by stressed vegetation and un-vegetated areas. This trend is more pronounced in marshes with lower elevations such as in the Narrow River. A recent comparative study attributes "excessive waterlogging, vegetation shifts, and dieback" in Narragansett Bay salt marshes to accelerated sea level rise, and suggests that fish and wildlife habitat will be impacted by these changes. The study also suggests that "management actions…to augment marsh elevations" can mitigate some of these impacts (Raposa *et al*. 2014).

A substantial amount of salt marsh habitat (39%) in the Narrow River Estuary is in a degraded condition due to expansion of bare pans and mud flats on the salt marsh surface, caused by "waterlogging," the continued saturation of marsh soils attributed to poor drainage, creating conditions unsuitable for survival of marsh plants. Interpretation of aerial photographs, validated by limited field assessments, show that areas more than 50 feet from sloughs, ditches and channels are dominated by degraded salt marsh vegetation. In these poorly drained areas, vegetation is dominated by *Salicornia spp.* and *S. alterniflora*. Vegetation tends to be at low densities, interspersed with bare peat where vegetation has been lost altogether.

In contrast, well-drained salt marshes are dominated by the tall form variant of *S. alterniflora* along channels, with stands dominated by *S. patens* or a mixture of *Spartina spp.* and *D. spicata* farther away from channels. These sites include habitat for species of concern, including seaside gerardia (*Agalinis maritima*), which is typically only found in larger marshes, but was found during limited surveys (RINHS 2014).

As shown in Table 3, 17 acres of salt marsh habitat is in a degraded condition from clogging of drainages. In some locations, stone walls along the western side of Pettaquamscutt Cove have altered freshwater flows, increasing the volume of fresh water entering upon salt marsh surfaces. While marshes show less hydrologic alteration than some other Rhode Island marshes, ditches and channels are common. Most of these features were dug in the early part of the 20th century and have since filled in with estuarine sediment. Findings by Watson and others (2014) suggest that this sedimentation and reduction of drainage features may be a significant contributor to the decline of salt marsh habitat, particularly high marsh or salt meadow habitat. This study also found the distribution of *S. patens* to be more dependent on proximity to marsh channels and edges—and thus the presence of well-drained soils—rather than elevation. This is not to suggest that elevation is not important to the presence of this species, as *S. patens* can only exist in intertidal conditions—rather that within the narrow range of vegetated marsh elevations, drainage is the most important factor influencing *S. patens* distribution.

Table 3. Salt Marsh Drainage Conditions in the Narrow River Estuary

RIVER REACH	TOTAL ACRES	MARSH DRAINAGE (FT)			CONDITION OF MARSH SURFACE				SALT MARSH IMPACTED - CLOGGED DRAINAGE
		RIVER / MARSH SHORE LINE	DITCHES and SLOUGHS		WELL DRAINED SALT MARSH HABITAT		POORLY DRAINED SALT MARSH HABITAT		
			FUNCTIONAL	NON-FNCT.	ACRES	%	ACRES	%	ACRES
LACY BRIDGE	15.2	8,628	6,003	2,281	11.4	75	3.8	25	4.1
LOWER RIVER	14.0	6,414	7,972	58	11.3	81	2.7	19	0.1
MIDDLE-BRIDGE	31.6	8,542	12,366	1,887	17.5	56	14	44	3.4
METTATUXET	1.6	401	0	0	0.2	12	1.4	88	0.0
PET COVE	86.8	27,497	18,427	3,984	52.8	61	34	39	8
REFUGE	24.8	5,640	7,035	1,810	12.1	49	12.7	51	1.8
TOTAL	174.0	57,122	51,803	10,020	105.4	61	68.6	39	17.4*

* Subset of poorly drained total acres.

Salt marsh loss as a result of shoreline erosion represents a continuing loss of habitat in the estuary. Shoreline surveys (USFWS 2012) found that most salt marsh banks on the river are undercut, and therefore inherently unstable. Undercut banks occur in all river reaches, and appears to be a typical, or natural bank feature in this riverine system (Table 4).

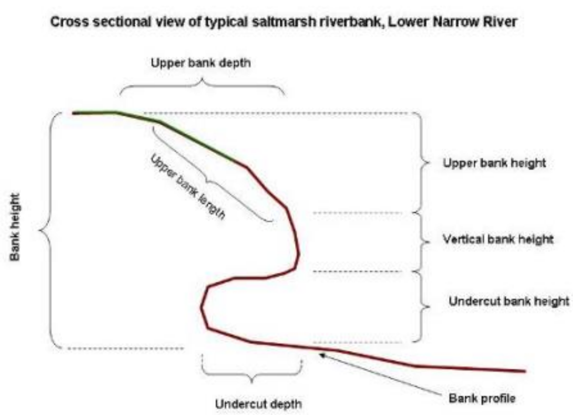
Salt marsh shoreline loss tends to occur as a catastrophic loss of bank segments as undercut banks fail and slump into the water. Most of the eastern shoreline of Sedge Island suffered a catastrophic failure of undercut salt marsh banks in 2014. The rate of shoreline loss is significant. As part of a Mean High Tide Line survey in 2009, metal rods were placed every 200 feet along the length of the shoreline. Of the rods placed within two feet of salt marsh banks along the shoreline, 20% were found in the water or are now below the mean high tide line (Appendix D).

A variety of causative agents are influencing loss of salt marsh shorelines. Ambient, or wind driven waves, river channels now flowing against salt marsh banks, and storm events help to weaken banks. Herbivory by green crab *(Carcinus spp*.) has been shown to reduce bank vegetation, with burrowing creating holes in the salt marsh bank.

Waves generated by boat wakes have been demonstrated to cause bank erosion in tidal rivers and other water bodies, and are believed to aggravate natural factors here by causing accelerated erosion rates. Klein (1977) conducted a literature review on the effects of boating in tidal creeks, and concluded that wakes produced by boats within 152 meters (500 feet) of a shoreline cause a significant force against the bank. Zabawa and Ostrem (1988) found that four factors were necessary in order for a shoreline to have a high potential for erosion from boat wakes, all of which are present in the lower Narrow River:

- Presence of exposed points in a narrow creek or cove;
- Uplands consisting of easily erodible material;
- Steep near-shore gradient on the shoreline profile; and
- Location adjacent to a high rate of boating, with boats passing relatively close to the shoreline.

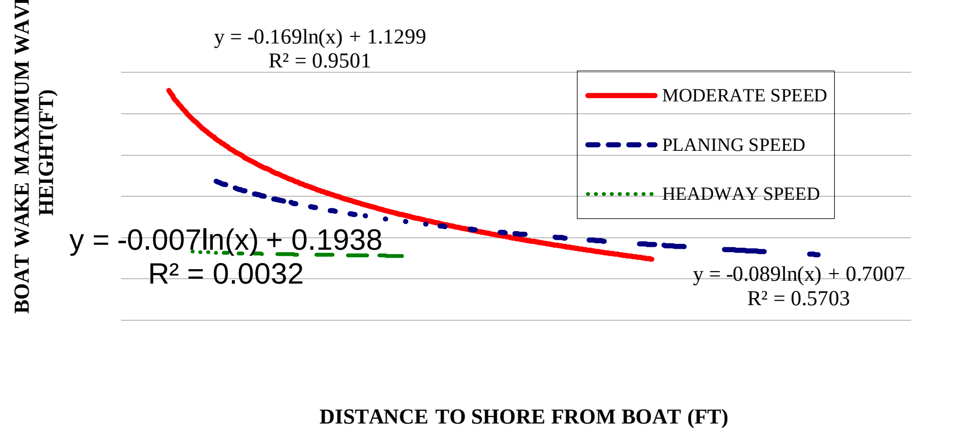
Table 4. Characteristics of Salt Marsh Shorelines in the Narrow River Estuary, John H. Chafee National Wildlife Refuge (USFWS 2012).																
RIVER REACH	NO. OF SAMPLES	MEASURE MENT	CHANNEL WIDTH (yds)	BANK HEIGHT (in)	UPPER BANK DEPTH (in)	HEIGHT OF UNDERCUT (in)	DEPTH OF UNDERCUT (in)	VERTICAL BANK HEIGHT (in)	UPPER BANK HEIGHT (in)	UPPER BANK LENGTH (in)	% BANK VEG.	% FUCUS COVER	No. MUSSELS	MUSSEL DENSITY (PER SQ ft)	MUSSEL HABITAT (SQ ft)	MUSSELS EXP : VEG.
Middle - bridge	22	AVE.	331	26.8	36.2	9.5	15.4	8.2	9.0	37.4	25	9	44	0.61	6.3	0.21
		SDEV	92	5.6	5.4	5.9	7.4	5.8	3.1	5.3	16	6	27	0.15	0.9	0.17
Upper Refuge	20	AVE.	235	26.8	26.6	8.2	14.9	7.9	10.8	29.2	17	1	7	0.51	5.1	0.22
		SDEV	95	2.3	14.6	5.2	6.7	5.0	3.9	14.0	7	3	7	0.18	1.9	0.30
Lower Refuge	43	AVE.	202	25.7	31.7	11.0	14.2	4.2	10.5	33.7	24	2	4	0.40	5.2	0.17
		SDEV	135	6.1	6.6	5.1	5.9	2.3	4.4	6.8	15	3	7	0.20	1.1	0.29
Lower River	18	AVE.	116	31.7	37.9	12.4	11.8	6.7	12.7	40.4	40	1	2	0.24	6.5	0.13
		SDEV	37	7.1	6.3	6.2	5.4	5.9	6.6	6.6	17	3	3	0.17	0.9	0.33
All Reaches	103	AVE.	222	27.2	32.7	10.4	14.2	6.2	10.6	34.7	26	3	13	0.44	5.6	0.18
		SDEV	126	5.9	9.3	5.6	6.4	4.8	4.6	9.1	16	5	21	0.22	1.4	0.28



The need for protection of salt marsh in the Narrow River was identified in the 1990's by the State and the Service (RICRMC 1999; USFWS 2001). The Service evaluated motorized vessels and their wakes in the Narrow River, and concluded that in some portions of the estuary, boat wake waves were likely casing the accelerated erosion of salt marsh banks (USFWS 2009). The amount of wave energy reaching the salt marsh shoreline was dependent on the size of the vessel, loading of the vessel (e.g. number of passengers), vessel speed, and proximity to the shoreline. Larger boats with a number of passengers travelling at moderate speed close to salt marsh shorelines tended to through the largest wakes. In those portions of the River where the channel was wider, boat wake waves attenuated and therefore impacts were minor (Figure 4). In some portions of the River, boats pass within just a few feet of salt marsh banks due to restricted channels. Prop scarring of salt marsh banks is apparent and has also caused loss of salt marsh shorelines.

Cumulatively, shoreline erosion, degradation of the salt marsh surface, and poor drainage is continuing to reduce salt marsh availability. Because of the general lack of significant salt marsh recruitment in the estuary (USFWS 2012), these losses are not being compensated for.

Figure 4. Predicted Boat Wake Maximum Wave Height Attenuation for vessels Traveling Above Headway Speed (N=60)



5.6 MARINE FISH AND ESSENTIAL FISH HABITAT

To identify how this proposal might enhance fish habitat, to evaluate important habitat components for fish, and to evaluate consequences, a thorough Essential Fish Habitat (EFH) Assessment was completed for the project, which is included in its entirety as an Appendix to this Environmental Assessment (Appendix F). A summary of findings resulting from the EFH assessment is provided here and in other sections of this report.

The Narrow River estuary contains an important recreational fishery and supports a variety of habitats important to marine and estuarine fish and shellfish. A number of salt water and brackish fish species occur. More than 75 species of fish are present throughout the fresh, salt and brackish water habitats of the River (RICRMC 1999). Some of the most abundant species in the estuary are Atlantic silverside (*Menidia menidia*), mummichog (*Fundulus heteroclitus*), winter flounder (*Psuedopleuronectes americanus*), sheepshead minnow (*Cyprinodon variegatus*), striped killifish (*Fundulus majalis*), four-spine stickleback (*Apeltes quadracas*), northern pipefish (*Syngnathus fuscus*) and Atlantic menhaden (*Brevoortia tyrannus*). All of these species are of ecological importance, providing forage for larger fish species as well as piscivorous birds. Fish species of commercial and recreational importance include bluefish, tautog (*Tautoga onitis*), black sea bass (*Centropristis striata*) and striped bass (RIDEM 2014). The Service's species of concern include American eel (*Anguilla rostrata*), striped bass and winter flounder.

Diadromous species present include alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), American shad (*Alosa sapidissima)* and American eel. Gilbert Stuart Brook in North Kingstown supports one of Narragansett Bay's most important river herring runs; all of these fish pass through the estuary while migrating between salt and fresh water habitats (RICRMC 1999).

Winter flounder were an abundant recreational and commercial fishery species on Narragansett Bay as late as the 1970's. The species declined significantly over the past several decades due to ecological and anthropogenic factors (Gibson 2013), leading to increased recreational and commercial fishery restrictions. Juvenile winter flounder are abundant here, indicating the high value of the estuary as spawning habitat for this species and its ecological importance in maintaining Narragansett Bay's fish populations.

According to RIDEM, alewife, blueback herring, winter flounder and American eel are regionally declining or vulnerable to decline. Fishing bans are in effect on alewives, blueback herring, and American shad due to regional population declines. However local populations of alewives and blueback herring are stable, due in part to the Narrow River runs (Lake 2014).

During the 1950's the estuary supported a commercial fishery for striped bass (RICRMC 1999). Today the estuary remains an important feeding area for the species. The Narrow River Inlet, as well as deeper open-water areas are popular recreational fishing spots for this species. Striped bass is among the most important fishery species on the U.S. Atlantic Coast. This species experienced a period of rebuilding following fishery restrictions during the 1980's, but has declined somewhat in abundance over the past decade (ASMFC 2014). Juvenile river herring migrate out of the Narrow River in early winter, while winter flounder spawn during the coldest months.

Shellfish presence is varied but most species occur in relatively low densities. Shoreline surveys conducted in 2012 found the density of ribbed mussel (*Geukensia demissa*) increases with increased distance from the mouth of the river, likely due to a salinity gradient (USFWS 2012). Oyster (*Ostrea virginica)* occur throughout the estuary, but are generally limited because of unfavorable substrates. Razor clam (*Siliqua patula*), quahog (*Mercenaria mercenaria*), and soft shell clams (*Mya arenaria)* all occur, but quahog and soft shell clams, at least in the tidal flats near Sedge Island, occur in very low density (less than one per square meter; RICRMC data 2014). Shellfishing was closed in the 1990's due to water quality impairments (RICRMC 1999). Blue crabs (*Callinectes sapidus*), are present throughout the Narrow River Estuary, while fiddler crabs (*Uca spp.)* and green crabs (*Carcinus spp*.) are common along marsh edges.

While all components of the estuary combine to provide important fish habitat, a shallow water habitat analysis (Appendix F) for the estuary determined that eelgrass beds and coarse sand beds at depth likely have the highest value for managed fish species. Eelgrass is a species of submerged aquatic vegetation present in the estuary whose distribution has varied widely over time. Once present in most river reaches in the 1940's, eelgrass has consistently been found only north of Middlebridge in moderate to high density. Eelgrass has recently expanded to areas south of Middlebridge and upriver of Sedge Island (figure 5), but is absent from areas downriver of Sprague Bridge (USFWS 2014).

Much of the estuary is too shallow to support this seagrass, which requires approximately 2 feet depth at MLW to survive in Narragansett Bay (Candal, 2005). Eelgrass beds are very important to many fish and shellfish species, and help to improve water clarity by trapping suspended sediments, and providing food for waterfowl (RICRMC 1999). Coarse sand bottoms are primarily associated with the deeper channels in the estuary, with fine sands located within flood and ebb tidal flats in lower portions of the estuary. High water temperatures and a limited availability of cool water refugia limit habitat values, and likely cause fish, such as winter flounder to leave the estuary from high water temperatures (Lake 2014).

Salt marsh habitats and the channels which drain them provide foraging habitat for marine fish, and habitat for a number of important prey species. Low marsh is generally considered of greater value to fish, as these low elevation marshes are inundated during most tide cycles and are therefore easily accessed by fish. The availability of low marsh (as typified by the presence of tall form variants of cordgrass) is limited primarily to areas along channels in the marshes, and is currently estimated to occupy 24 acres. The distribution of low marsh is inherently limited by elevations, since the bulk of salt marsh occurs above the mean high tide line (Appendix D).

Figure 5. Distribution of Eelgrass in the Narrow River Below Middlebridge (USFWS 2014)

High marsh is also important as fish habitat; many of the smaller fish species and other nekton provide important forage for marine fish. Research indicates the value of intertidal and high marsh habitat to feeding, growth and production of *Fundulus spp.* Weisberg and Lotrich (1982) and Weisberg (1986) show that “growth rates were significantly higher for mummichogs allowed access to the marsh surface.” MacKenzie and Dionne (2008) showed that high marsh habitat, in particular, stimulates mummichog growth and productivity. Studies by Butner and Brattstrom (1960), Meyer and Posey (2009), and Banikas and Thompson (2012) indicate that this is likely a function both of food availability and predator protection provided by high marsh, and that interior marsh surfaces are preferred when accessible, with tidal creeks serving as access pathways when high marsh surfaces are not flooded. Over time, the number of channels and drainages providing access to high marsh has declined over time, as sediments have clogged channels, reducing ready access to the marsh surface on 17.3 acres in the estuary. Healthy high marsh is an important estuarine feature for marine fish.

The Service conducts extensive nekton surveys in the creeks of the marsh with the most common species being salt marsh killifish, sheepshead minnow (*Cyprinodon variegatus*), and grass shrimp (*Palaemonetes spp.*), but young diadromous alewife and American eel have also been documented in the estuary and are known to utilize the saline and freshwater reaches of the watershed (see Appendix F).

Pools on the marsh surface provide important habitat for smaller species of fish and other nekton. Most historic pools (pools which have been present on the marsh since 1939) have well-developed banks, and adequate depths to make them persistent through the summer. Fish density is high. Most wading birds for example congregate at the deeper pools at low tide because prey species, including mummichog, are concentrated at these sites. Newer pools and pans, which have recently become established, are typically very shallow and dry up during the summer months.

Salt marsh shorelines are typically comprised of marsh peat with undercut banks generally two feet in depth. Below Middlebridge, these undercuts tend to be exposed at low tide, while those above Middlebridge tend to remain submerged except during lowest tides. Undercut banks provide some protection from predators, but lack vegetative or varied components. Given that most salt marsh banks (96%) are in this condition, habitat diversity is considered low along salt marsh shorelines.

5.7 WILDLIFE RESOURCES

More than 100 bird species are known to use the habitats of the Narrow River Estuary, including 35 species identified as “Species of Greatest Conservation Need” in the 2015 RI State Wildlife Action Plan Revision (RIDEM 2014). All of these species utilize the open water, tidal mudflats, creeks, pans, pools and vegetated marsh habitats for some portion of their life history. At any season, species diversity, abundance and distribution varies with both migratory and resident species represented.

Shorebirds:

During both the spring and fall migration the estuary receives an influx of migratory shorebirds and waterbirds (Table 5). Least and semipalmated sandpipers utilize exposed pans and mud and tidal flats, while larger shorebird including black-bellied plover, dunlin and short-billed dowitcher use the larger sandbars in the River when they are exposed at low tide.

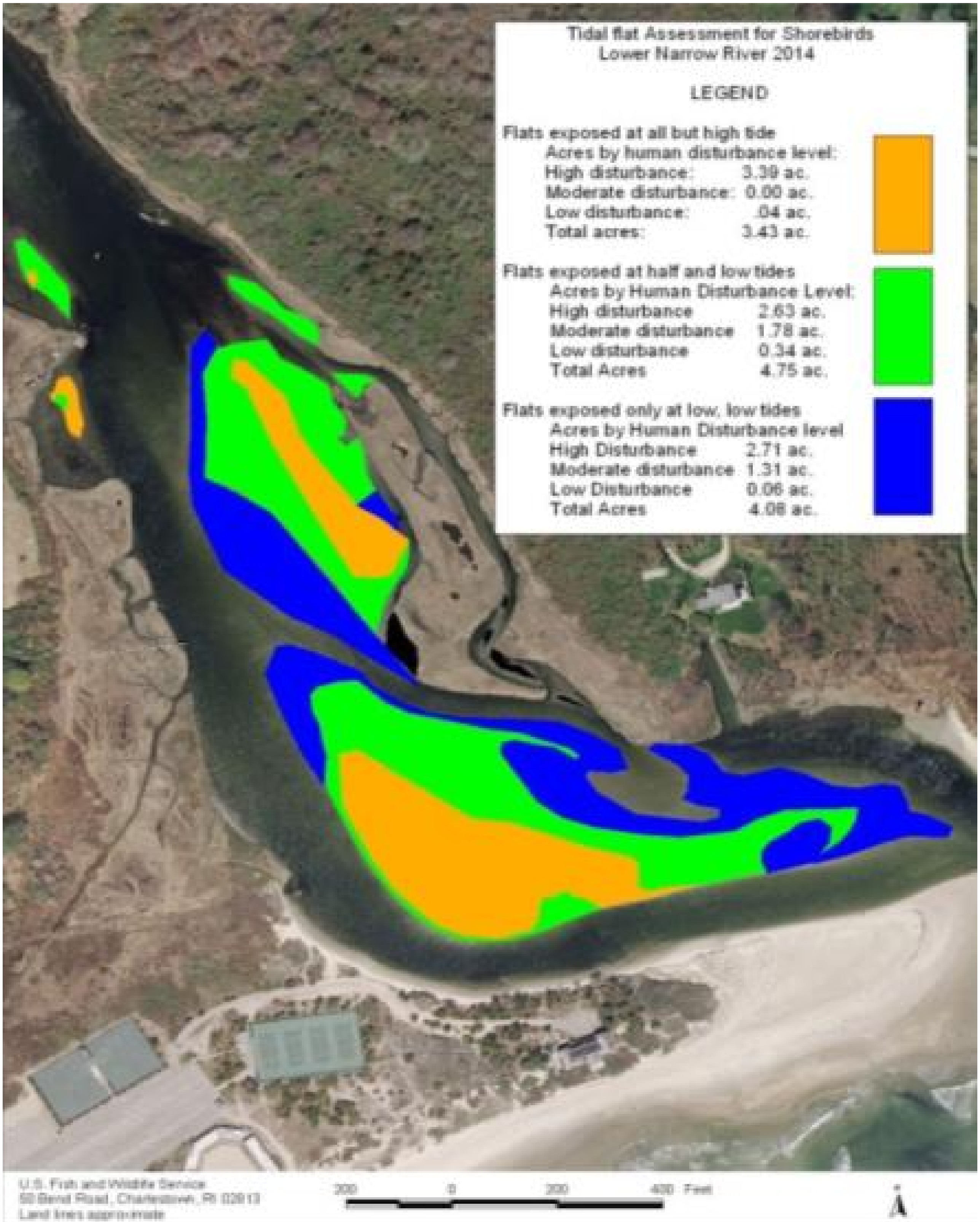
Spring shorebird migration takes place from May through mid-June in Rhode Island. Shorebirds are present at the Narrow River during this time, but not nearly to the extent as they are found in the fall. Willets are common in the salt marshes of the Narrow River from May-August and are the only shorebird species regularly found breeding. Fall migrants will begin arriving at the Narrow River as early as mid-July, but the peak of migration occurs in August. To maintain energy for their long migrations, shorebirds will stop over at the Narrow River where they can rest and forage on aquatic invertebrates that live in exposed and shallowly flooded mudflats. By October, the vast majority of shorebirds have passed south of the Narrow River. Broad mudflats and sandbars occur throughout the lower Narrow River and are most extensive south of Sprague Bridge, near the mouth of the Narrow River, and around Sedge Island located at the mouth of Pettaquamscutt Cove (Figure 6). A total of 12 acres of tidal flat is estimated to occur near the mouth of the Narrow River. Approximately 3 acres are exposed during all but high tide, 4 acres are exposed during mid to low tides, and 5 acres are exposed only at the lowest tidal ranges. At Sedge Island, an estimated 19 acres of tidal flat exists. Of the total acreage of tidal flat at Sedge Island, approximately 2 acres are exposed at all but high tide, and 6 acres are exposed during mid to low tidal conditions. The remaining 11 acres are only exposed during lowest low tides.

Piping plover (*Charadrius melodus*) are a federally endangered species which nests at the mouth of the Narrow River Inlet; least tern (*Sternula antillarum*), a state-listed threatened species, is also present in this area, approximately 0.6 miles from the estuary salt marshes proposed for restoration. Plovers are in the area from the end of March to mid September while least tern arrive in early May and leave by late August. While these two species occasionally feed in the area below Sprague Bridge, the marsh restoration project is far from nesting and resting habitat for these birds.

Shore and wading birds make significant use of tidal and salt marsh habitats. In the Narrow River, human disturbance may be a factor affecting the distribution of shorebirds and waterbirds. Research has shown that migrant shorebirds, wading birds, and waterfowl are particularly sensitive to human disturbance (Pfister *et al.* 1992; Klein 1993; Burger and Gochfeld 1998). Frequent disturbances can reduce the amount of time birds spend foraging, and increase energy expenditures as birds react to perceived threats (Fitzpatrick and Benedicte 1998). Peters and Otis (2007) documented the avoidance of roost sites by shorebirds in areas of high boat activity. Burger (1981) found some evidence to suggest that gulls and terns were less impacted by human disturbance as they usually flew away and re-landed where they had been. By contrast, herons, egrets, and shorebirds were most disturbed and flushed to distant marshes.

Ninety percent of the shorebirds documented in the Narrow River by Trocki and Paton (2007) were semipalmated plovers, semipalmated sandpipers, and least sandpipers. These species have relatively short legs and bills and as a result, tend to forage on exposed mud flats for their invertebrate prey. Wading birds with their longer bills and legs specialize in foraging for fish and invertebrates in deeper water, and were found foraging almost exclusively on immersed sand flats. Roughly the same amount of foraging

Figure 6 a. and b. Occurrence of Tidal Flats in the Lower Estuary (Based on aerial photos)



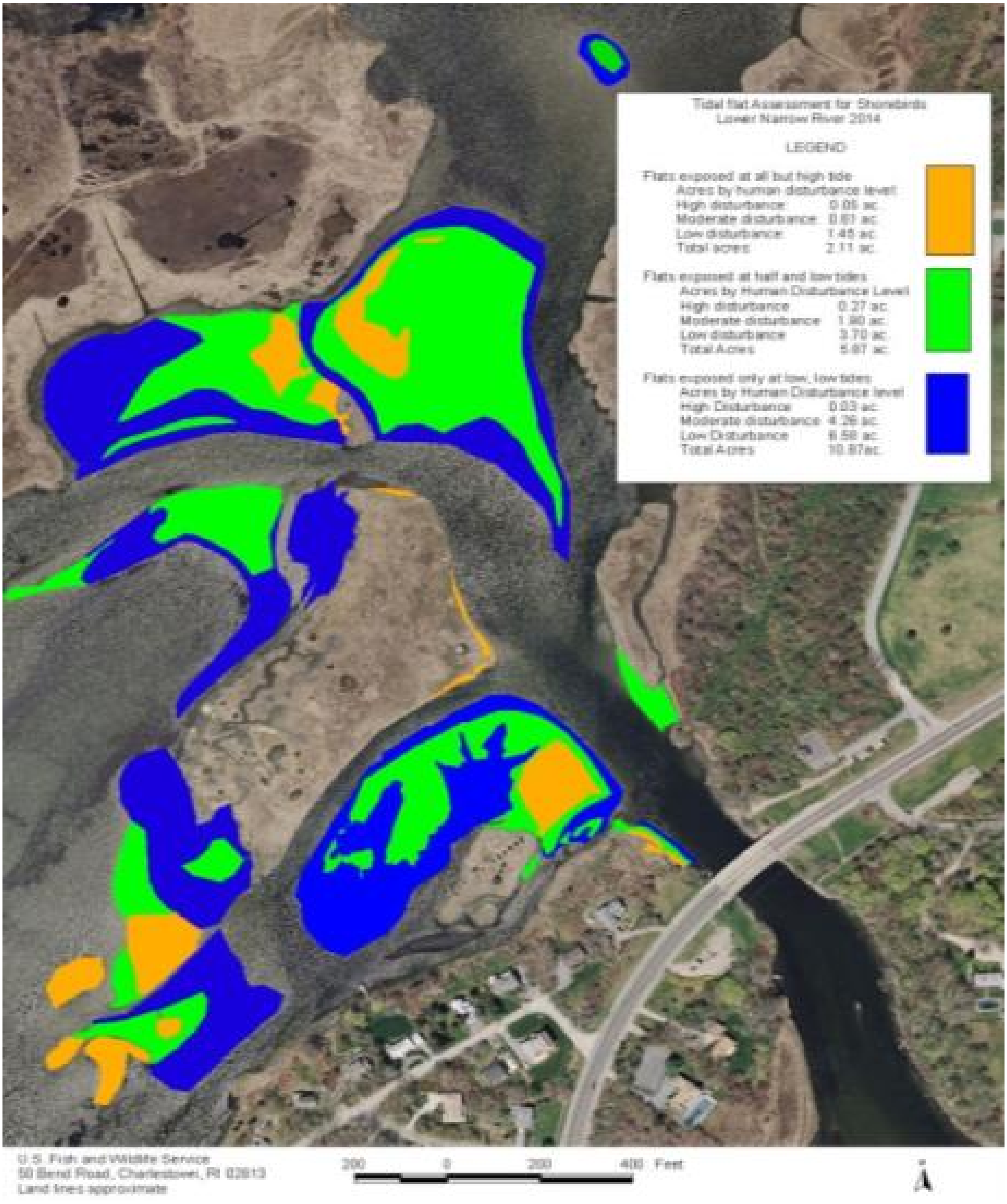

Tidal flat Assessment for Shorebirds
Lower Narrow River 2014
LEGEND
Flats exposed at all but high tide
Acres by human disturbance level
High disturbance 0.05 ac
Moderate disturbance 0.61 ac
Low disturbance 1.45 ac
Total acres 2.11 ac
Flats exposed at half and low tides
Acres by Human Disturbance Level
High disturbance 0.27 ac
Moderate disturbance 1.90 ac
Low disturbance 3.70 ac
Total Acres 5.87 ac
Flats exposed only at low, low tides
Acres by Human Disturbance level
High Disturbance 0.03 ac
Moderate disturbance 4.26 ac
Low Disturbance 6.58 ac
Total Acres 10.87ac
U.S. Fish and Wildlife Service
50 Bend Road, Charlestown, RI 02813
Land lines approximate
200 0 200 400 Feet

Table 5. Conservation Status of Shorebird Species Occurring at the Lower Narrow River			
Shorebirds*	**Scientific Name**	**Conservation Status***	**Alpha Code**
Black-bellied Plover	*Pluvialis squatarola*	3	BBPL
Semipalmated Plover	*Charadrius semipalmatus*	2	SEPL
Killdeer	*Charadrius vociferus*	3	KILL
Greater Yellowlegs	*Tringa melanoleuca*	3	GRYE
Lesser Yellowlegs	*Tringa flavipes*	3	LEYE
Willet	*Catoptrophorus semipalmatus*	3	WILL
Spotted Sandpiper	*Actitis macularius*	2	SPSA
Ruddy Turnstone	*Arenaria interpres*	4	RUTU
Sanderling	*Calidris alba*	4	SAND
Semipalmated Sandpiper	*Calidris pusilla*	3	SESA
Least Sandpiper	*Calidris minutilla*	3	LESA
Dunlin	*Calidris alpina*	3	DUNL
Short-billed Dowitcher	*Limnodromus griseus*	4	SBDO

*Species list from Trocki and Paton 2007.
** Conservation Status: 1) Species Not at Risk; 2) Species of Low Concern; 3) Species of Moderate Concern; 4) Species of High Concern; and 5) Highly Imperiled. Shorebird Conservation Plan, Clark 2000

habitat is available during regular low to high tide conditions for these species at Sedge Island and the mouth of the river; however disturbance levels are lower at the tidal flats near Sedge Island. The higher concentrations of shorebirds and wading birds documented near Sedge Island could be result of lower disturbance levels to these sensitive species.

Fall surveys conducted by Trocki and Paton (2007) documented that shorebirds and waterbirds are abundant on tidal flat habitat located around Sedge Island and the mouth of the Narrow River; however species abundance varied between areas. Shorebirds, wading birds (herons and egrets), and cormorants were detected most frequently foraging and resting on the flats around Sedge Island. By contrast, gulls and terns were most abundant during the fall surveys at the mouth of the river.

Waterbirds:
Cormorants, herons, egrets, gulls, terns, and marsh birds belong to a guild of species collectively known as waterbirds. The salt marshes, tidal flats, and open water habitats of the Narrow River estuary provides important foraging and resting habitat for at least 35 species of waterbirds (Table 6). Of these species, the least tern and snowy egret are considered species of high conservation concern by the North American Waterbird Conservation Plan; and two species, the Bonaparte's gull and Forster's tern, are listed as moderate concern (Kushlan *et al.* 2002). Because of the values the estuary has for waterbirds, the Narrow River has been identified as a waterbird focus area in the North American Waterbird Conservation Plan.

The estuary is highlighted as important to waterfowl and designated as the "Pettaquamscutt Cove Waterfowl Focus Area" in the North American Waterfowl Management (2004) and Implementation (2005) Plan. Winter waterfowl surveys conducted by the Service between November and March each year from 2004-2011 documented a total of 27 species of waterfowl in the Estuary with the most common species being American black duck (AMBD), ruddy duck, Canada goose (CAGO), mallard (MALL) and red-breasted merganser.

Three of these species have been documented breeding in low numbers in the estuary (AMBD, CAGO, MALL) but numbers peak for these species during January and February, with other migrants peaking during the spring and fall migration. The AMBD and other dabblers prefer the shallow water pools and channels while the diving species utilize the coves and embayments. Of these species, American black duck are a high regional conservation priority (BCR 30 plan), while 8 other species, including the ruddy duck, are listed as species of greatest conservation need by the State of Rhode Island. Three species of waterfowl breed along the Narrow River, including mallard, black duck, and Canada goose. The Narrow River estuary has been identified by the American Black Duck Atlantic Coast Joint Venture Strategic Plan (2008) as vital wintering habitat for black ducks, and as important migratory stopover habitat for several species of waterfowl in the Atlantic Flyway. The Service conducted annual winter waterfowl surveys (November-March) at the John H. Chafee NWR from 2004 to 2011. The surveys have documented the importance of the Narrow River estuary to a number of wintering waterfowl species.

Table 6. Conservation status and occurrence of waterbirds in the lower Narrow River.
[1]North American Waterbird Conservation Plan (Kushlan *et al*. 2002); [2]Rhode Island Natural Heritage Program (2006); [3] International Union for Conservation of Nature (IUCN 2014); [4] Black Duck Joint Venture Strategic Plan 2008-2012.

Waterbirds	Scientific Name	Alpha Code	Occurrence	Conservation Status
Cormorants				
Double-crested Cormorant	*Phalacrocorax auritus*	DCCO	Sp, Su, Fa	[1]Not Currently at Risk
Wading Birds				
Great Blue Heron	*Ardea herodias*	GBHE	Sp, Su, Fa, Wi	[1]Not Currently at Risk; [2]State Concern
Green Heron	*Butorides virescens*	GRHE	Sp, Su, Fa	[1]Low Concern
Great Egret	*Ardea alba*	GREG	Sp, Su, Fa	[1]Not Currently at Risk; [2]State Concern
Snowy Egret	*Egretta thula*	SNEG	Sp, Su, Fa	[1]High Concern; [2]State Concern
Glossy Ibis	*Plegadis falcinellus*	GLIB	Sp, Su, Fa	[1]Low Concern, [2]State Concern
Waterfowl				
Snow Goose	*Chen caerulescens*	SNGO	Wi	[3]Least Concern
Canada Goose	*Branta canadensis*	CAGO	Sp, Su, Fa, Wi	[3]Least Concern
Mute Swan	*Cygnus olor*	MUSW	Sp, Su, Fa, Wi	Invasive
American Black Duck	*Anas rubripes*	ABDU	Sp, Su, Fa, Wi	[3]Least Concern
Mallard	*Anas platyrhynchos*	MALL	Sp, Su, Fa, Wi	[3]Least Concern
Gadwall	*Anas strepera*	GADW	Wi	[2]State Concern
American Wigeon	*Abas americana*	AMWI	Wi	[3]Least Concern
Green-winged Teal	*Anas crecca*	GWTE	Fa, Wi	[2]State Concern
Blue-winged Teal	*Anas discors*	BWTE	Fa	[2]State Concern
Northern Pintail	*Anas acuta*	NOPI	Wi	[3]Least Concern
Canvasback	*Aythya valisineria*	CANV	Wi	[3]Least Concern
Greater Scaup	*Aythya affinis*	GRSC	Wi	[3]Least Concern
Lesser Scaup	*Aythya marila*	LESC	Wi	[3]Least Concern
Bufflehead	*Bucephala albeola*	BUFF	Wi	[3]Least Concern
Common Goldenye	*Bucephala clangula*	COGO	Wi	[3]Least Concern
Hooded Merganser	*Lophodytes cucullatus*	HOME	Wi	[2]State Concern
Red-breasted Merganser	*Mergus serrator*	RBME	Wi	[3]Least Concern
Common Merganser	*Mergus mergansor*	COME	Wi	[3]Least Concern
Ruddy Duck	*Nomonyx dominicus*	RUDU	Wi	[3]Least Concern
Gulls				
Laughing Gull	*Larus atricilla*	LAGU	Fa, Wi	[1]Not Currently at Risk
Bonaparte's Gull	*Larus philadelphia*	*BOGU*	Fa, Wi	[1]Moderate Concern
Ring-billed Gull	*Larus delawarensis*	*RGBU*	Sp, Su, Fa, Wi	[1]Not Currently at Risk
Herring Gull	*Larus argentatus*	*HEGU*	Sp, Su, Fa, Wi	[1]Low Concern
Great Black-backed Gull	*Larus marinus*	*GBBG*	Sp, Su, Fa, Wi	[1]Not Currently at Risk
Terns				
Common Tern	*Sterna hirundo*	*COTE*	Su, Fa	[1]Low Concern
Forster's Tern	*Sterna fosteri*	*FOTE*	Su, Fa	[1]Moderate Concern
Least Tern	*Sterna antillarum*	*LETE*	Su, Fa	[1]High Concern
Secretive Marsh Birds				
Virginia Rail	*Rallus limicola*	*VIRA*	Su, Fa	[3]Least Concern
Least Bittern	*Ixobrychus exilis*	*LEBI*	Su, Fa	[3]Least Concern

Species most frequently observed wintering on the Narrow River include: American black duck, bufflehead, Canada goose, mallard, red-breasted merganser, mute swan, hooded merganser, and gadwall.

Of these species, the gadwall and hooded merganser are listed as species of concern by the State of Rhode Island (Rhode Island Natural Heritage Program 2006); and American black duck is listed as a species of greatest conservation need in the Black Duck Joint Venture Strategic Plan 2008-2012. Blue-winged teal and green-winged teal were observed periodically and in small numbers during these surveys, both species are listed as a species of concern (Rhode Island Natural Heritage Program 2006).

The tern and gull species forage in shallow water habitats, but utilize the mudflats to rest. During the summer months the mudflats, creeks, and pools also support long legged waders, including great and snowy egret and great blue heron that nest in the Narragansett Bay area and forage in the marshes. Numbers increase dramatically during the post-breeding season prior to migration in the fall. Within salt marshes, these species tend to concentrate around the historic pools of the marsh, where nekton, including small fish species, are concentrated. All of these waders are listed as Species of Concern by the State of Rhode Island, while snowy egret is experiencing continental-scale declines (Trocki and Paton, 2007).

Secretive Marsh Birds:
Marsh birds are a group of waterbirds including rails, bitterns, grebes, gallinules and snipe that typically inhabit dense, emergent wetlands. These species are known for their secretive nature; they are seldom seen or heard because they vocalize infrequently and prefer wetland habitat that is inaccessible to humans. The Rhode Island National Wildlife Refuge has conducted avian point count surveys during the breeding season at the John H. Chafee National Wildlife Refuge annually since 2009. Virginia rail was the only species of secretive marsh bird detected during these surveys, and is a confirmed breeding species (in low numbers) on Refuge salt marshes.

Least bitterns (*Ixobrychus exilis*) are listed as threatened in Rhode Island (Rhode Island Natural Heritage Program 2006). Based on observations by USFWS Refuge Personnel, a sighting of a least bittern occurred at the John H. Chafee National Wildlife Refuge in June 2014, and this species may occasionally breed in the area, although nesting has not been confirmed.

Salt marsh Sparrow:
The vegetated surface of the tidal marsh supports the obligate nesting salt marsh sparrow and Virginia rail as well as migratory populations of Nelson's sparrow and seaside sparrow. All of these species are of highest conservation concern due to their dependence on salt marsh habitats and their limited worldwide distribution.

Current estimates project that 50% of the worldwide distribution of salt marsh sparrow occur in Connecticut and Rhode Island where they are restricted to salt marsh habitat, making them exceedingly vulnerable to loss of marsh habitat. The estuary salt marshes provide important nesting habitat for the salt marsh sparrow. These birds nest on the ground and require high marsh for nesting habitat; nests typically occur near the high tide line at the base of *S. patens*, saltmeadow rush *(Juncus gerardii)* and *S. alterniflora*. The salt marsh sparrow is declining in population; the species is listed as "vulnerable" by the International Union for the Conservation of Nature, and as a species in need of immediate conservation action by Partners in Flight. The species is particularly susceptible to anthropogenic impacts such as sea level rise, which floods the sparrows' nests, and predator introduction due to suburbanization (cats, raccoons, etc.). The abundance of salt meadow in the estuary has historically provided extensive nesting habitat for the salt marsh sparrow; however the relatively low elevations of the estuary marshes, degraded salt marsh, and expanding pools and pans, have reduced the amount of suitable nesting habitat and increased vulnerability to tidal flooding, causing reduced reproductive success.

The Service has been monitoring salt marsh sparrow breeding populations on the Narrow River marshes since 2008. Between 2008 and 2012, 288 sparrows were caught and banded. The study found that 95% of sparrow nests occurred in areas with at least 30% high marsh vegetation, and determined that 66% of nesting sites exhibited reproductive success. Tidal flooding during storm events or spring high tides was the principal cause of nest failure among salt marsh sparrows. Research throughout the range of this species has documented a steady decline in nesting habitat and reproductive success. Population viability analyses currently underway predict that sparrows will be unable to breed in tidal marsh habitats without intervention by approximately 2050 given current predictions for sea level rise and assuming that marsh elevations remain stable. (Field and Elphick 2014 pers. comm.).

Other Rare Species:
Additional species nest in the marsh, including willet and marsh wren that are also able to utilize freshwater habitats. Piscivorous birds also frequent the area, with osprey being the most common nester. In recent years, bald eagles have begun nesting near the salt marshes of the estuary (Trocki and Paton 2007; NRPA 2011; RICRMC 1999).

Additional rare species that may be present in the estuary include the diamondback terrapin (*Malaclemys terrapin*). This species is known to utilize brackish estuaries in Barrington and along the south shore of RI, but has not been documented in this estuary. The Rhode Island Natural History Survey conducted surveys for tiger beetle (*Cicindela marginata*), a State listed threatened species in portions of the estuary; however, none were found (RINHS 2014).

Other Species:
Mammals present in salt marshes are typical of those utilizing Rhode Island salt marshes, including white-tailed deer, salt marsh meadow vole, mink, raccoon, fox, and otter. All mammal species are common, and none of these are obligate salt marsh species.

5.8 CULTURAL RESOURCES

Coastal Rhode Island lies within the area occupied by the Narragansett Indian Tribe, who made and continue to make frequent use of coastal resources for hunting, fishing, and shellfishing. Artifacts and evidence of previous uses provide important information on native use of these areas, including ceremonial uses, providing an important window into the past. Specific patterns of use in the estuary are unknown, but sediment core samples showed cedar swamp remnants approximately three feet below the surface. It may be that this area was primarily used for securing food resources.

The presence of stone walls along the western shore of Pettaquamscutt Cove attest to former agricultural uses along the salt marshes, and remnants of an old road crossing and embankment can still be seen in the southern portion of Pettaquamscutt Cove, and running northward along the eastern shore.

6.0 ALTERNATIVES CONSIDERED

Initially, five different approaches, or alternatives, were considered to address the purpose and need for the restoration project. After further review, it was determined that three of the alternatives were not feasible, and therefore eliminated from further consideration.

6.1 ALTERNATIVES CONSIDERED BUT ELIMINATED FROM FURTHER STUDY

1. Use of hardened structures for salt marsh shoreline and channel restoration

To reduce salt marsh shoreline erosion and to modify channel flows, structural techniques, including sheet piles, rock armoring, revetments, and bulkheads have been successfully used in other areas. However, RICRMC has determined, through the Narrow River Special Area Management Plan, that such hardened structures are an inappropriate application in the Narrow River (RICRMC 1999). Therefore, shoreline restoration actions are limited to the use of natural, or "living shoreline" techniques.

2. Dredging of flood tidal delta in the Lower Narrow River below Sprague Bridge for restoration

Beneficial use of dredge materials could include reducing erosive flows against salt marsh shorelines, and clearing a partial channel could allow for further reducing low tide levels in the River, aiding in draining of degraded and waterlogged salt marsh. However, dredging could also increase tidal flows at high tide, not only threatening salt marsh habitat with increased water levels, but also private lands upriver of Middlebridge. If done improperly, dredging below Sprague Bridge could also place private lands at the mouth of the river in jeopardy from channel realignment and loss. The interaction between the flood tidal delta at the mouth of the river, channel restrictions at Sprague Bridge, and flow attractions is a complex issue which would require intensive modeling and detailed engineering. The Service determined that the potential benefits to restoration in this river reach were outweighed by the potential adverse impacts and the planning detail and execution costs necessary to address the complexity of the situation, in light of the limited timeframe which this project has for execution.

3. Acquire properties where salt marsh is likely to migrate inland in response to sea level rise

One of the most effective strategies to accommodate sea level rise is to ensure adjacent upland sites are available, and suitable for migration of salt marsh habitats. However, suitable areas for migration (low lying, undeveloped areas of little relief adjacent to salt marshes) are limited in the area, this strategy would not address other estuarine components in need of attention. Other funding sources would be required, since current funding is not intended for land acquisition.

6.2 ALTERNATIVES RECEIVING FURTHER ANALYSIS

Two alternatives were considered for further detailed analysis. Alternative A, No Action, represents conditions resulting from taking no action to improve estuarine conditions. Alternative B, the Proposed Action, would implement an integrated restoration/resiliency plan. Each alternative is described below.

6.3 FACTORS COMMON TO ALL ALTERNATIVES

Appropriate Federal and State permits required to meet applicable federal law will be secured prior to implementation of ground-disturbing activities. All permit requirements and conditions will be met during implementation of all actions. Regulatory agencies issuing permits and authorizations include the US Army Corps of Engineers, RI Coastal Resource Management Council, and RI Dept. of Environmental Management, with additional review by the National Oceanic and Atmospheric Administration and US Environmental Protection Agency. Cultural resource clearance pursuant to Section 106 of the Historic Preservation Act, including consultation with the RI Historical Preservation and Heritage Commission and the Narragansett Indian Tribe, will be concluded prior to implementation of ground-disturbing activities.

Where restoration actions are identified on non-federal lands, written landowner permission to complete the work will be secured prior to conducting any restoration action.

To minimize impacts to recreational uses of the river, actions which could significantly hamper recreational use of the river will be timed, where possible, to occur outside of the heavily used summer season (May – September).

6.4 ALTERNATIVE 1: NO ACTION

Under the no-action alternative, the Service will take no action to restore salt marshes, shorelines or estuarine conditions in the Narrow River Estuary. Present conditions and trends in public use and recreation, water quality, tidal flows, salt marsh habitat, estuarine conditions, and fish and wildlife habitat would continue as described in the Affected Environment section of this assessment.

6.5 ALTERNATIVE 2: PROPOSED ACTION: RESTORE ESTUARINE HABITAT AND SALT MARSHES

This is the Service's preferred Alternative and proposed action which would implement an integrated set of strategies (actions) designed to enhance key estuary components with the goal of restoring conditions and to improve resilience to sea level rise, climate change, and future storm events. These actions would be implemented over approximately the next three years. Details related to implementation of the various actions, including mitigation measures, management controls, project timing, maps, and tables are shown in Appendix G. The actions as described are conceptual in nature and subject to refinement as more information becomes available; however, the Service has endeavored to assess the maximum potential impact for purposes of this EA and environmental permitting.

Action A. Watershed and Water Quality Restoration

The intent of this action is to improve water quality and flushing. Appendix G provides a more detailed description of the action, including management controls, maps, profiles and mitigation. Proposed activities include:

1. In collaboration with NRPA, intensify ongoing, long-term water quality monitoring to enhance knowledge of non-point source pollution, in order to locate priority sites for water quality abatement actions. Further investigate the source of pollution in the Mumford Brook using such techniques as trained canines. Monitoring entails the sampling of water column parameters, including temperature, clarity, salinity, and location from sample sites. Water samples are taken and evaluated for various

constituent elements including nitrogen compounds and the presence of bacteria. Access to sample sites is by boat or on foot.

2. In collaboration with RIDEM, survey, design, and install (additional funding dependent) best management practice (BMP) sites in the Mettatuxet drainage in Narragansett and at Kimberly Drive in South Kingstown. The BMPs will remove excess nutrients and pathogens from storm water runoff in order to reduce anthropogenic sources of fecal coliform as well as nutrients and sediments, which impair water quality.

   All BMP work will be conducted in upland areas, with the final designs subject to approval by RIDEM, Division of Water Resources. Generally this work entails creation of basins where runoff is captured and treated naturally prior to flowing into surface waters. Construction would include the use of excavators, dump trucks, and backhoes. Construction traffic (trucks, light trucks cars, tractor trailers) would occur intermittently along Kimberly Drive and Mettatuxet Ave. Temporary one lane detours may be needed on Mettauxett Avenue during construction. Construction scheduling would attempt to avoid the summer season, and would only occur during daylight hours and on weekdays. Construction may last 30 days to 60 days. Once constructed, periodic inspections would occur, and periodic maintenance, once every five years, may be needed to place fresh gravel or other materials in the basins.

3. Improve flushing and water circulation in Upper Pettaquamscutt Cove by removing remnants of an old road crossing. The crossing has restricted the channel to 129 feet wide and reduced depths by two to three feet. The nearest natural restriction just to the south of the crossing is 273 feet wide and 2.5 feet deeper.

   Material will be excavated to the depth of typical bottom elevations northeast and southwest of the crossing. The crossing would not be widened, only deepened, to prevent loss of salt marsh. An area 150 feet long, 75 feet wide and 2 feet deep (-3 feet NAVD) would be excavated (dredged), yielding 1,120 cubic yards of material. Material removed will be transported to an upland disposal site outside of the project area.

   Excavation and placement of materials would likely be accomplished with the use of an excavator on a barge. Material would be removed from the bottom, placed on the barge or in containers on adjacent barges, and then transported to the staging area for removal. Activities would only occur during the winter dredging window of November 15 through January 31. A staging area would be temporarily constructed at the northwest corner of Sprague Bridge on National Wildlife Refuge Lands. Traffic associated with both construction of the staging area, transportation of personnel, supplies, equipment (barges, excavators, etc.) and materials for the dredging operation will increase traffic and fuel emissions near the bridge. This impact will occur outside of the busy summer season. See Appendix G for more information on this proposed action.

4. Enhance flushing potential by removing excess materials from historic channels as part of efforts to restore eelgrass habitat. See description under Action B.

Action B. Eelgrass Management, Estuarine Channel and Basin Restoration

This action takes advantage of the opportunity to enhance marine fisheries habitat by creating habitat conducive to eelgrass establishment and creation of thermal refugia. Basins and channels will be deepened by removing existing sediments to a depth of approximately -5 feet NAVD88. Areas where excavation will occur are channels which have been present historically (Appendix A). All treatment areas are where deposition of flood and ebb tidal deltas has formed over time, shifting channel flow to less favorable locations.

This action will establish approximately 7 acres of deeper estuarine areas, suitable for eelgrass habitat and serving as thermal refugia and passage for important estuarine fish species. The depth is anticipated to provide ideal habitat for existing eelgrass beds to expand, will ensure they are at a depth not susceptible to prop scarring, and will provide for cooler temperatures for growth and production.

To ensure no significant loss of *upper* tidal flat habitat for important shore and wading birds and shellfish, over three acres of tidal flat will be created or enhanced in areas less prone to disturbance compared to current locations. Sand bottom habitat will be maintained on side slopes, remaining tidal flats, and at the bottom of excavated areas.

As shown in Appendix G, 35,629 cubic yards of material will be excavated. As existing eelgrass beds provide a ready seed source, no planting or seeding of eelgrass is proposed. Sediments removed from restoration areas will be repurposed for beneficial re-use in restoring degraded and lost salt marshes (Actions D and E, below). Sediments in proposed restoration areas are generally sandy, with fines ranging from 2-60%, but less than 25% in 78% of the units analyzed. All strata were tested for potential chemical contaminants, including TPH, PCBs, SVOCs and metals. All parameters are within EPA and state criteria for beneficial use of dredged material.

All areas to be excavated will be surveyed with final engineering designs showing elevations, lengths, widths, and any operational constraints. Engineering designs will be subject to approval by RICRMC. Excavation and placement of materials would likely be accomplished with the use of an excavator on a barge, with other barges holding large containers to be used to hold materials. The excavator will be used to excavate the area, placing material in the containers and moved to different sites for eventual use in other restoration actions. Boats and other equipment would be used to move equipment, and to transport materials and personnel. Activities would only occur during the winter dredging window of November 15 through January 31. A staging area would be temporarily constructed at the northwest corner of Sprague Bridge on National Wildlife Refuge Lands. Traffic associated with both construction of the staging area, transportation of personnel, supplies, equipment (barges, excavators, etc.) and materials for the dredging operation will increase traffic and fuel emissions near the bridge. This impact will occur outside of the busy summer season. A temporary dock, consisting of barges tethered together, would be temporarily placed at Sprague Bridge in the water. Adequate space in the channel will be preserved to allow vessels to pass.

Because of the changes in channel conditions used by boaters, the Service will mark the channel during construction and for a minimum of two years following treatments. Appendix G provides a more detailed description of the action, including management controls, maps, profiles and mitigation.

Action C: Restore Salt Marsh Shorelines

This action builds upon the existing installation of living shoreline techniques in the river and the associated monitoring which is taking place to expand a variety of applications of living shoreline treatments to shorelines with serious bank stability issues, where such application is expected to be effective and possible. Collapse of undercut banks appears to be the primary causal factor of salt marsh shoreline loss, and frequently occurs as a mass, or catastrophic loss along several feet of shoreline. Living shoreline applications are generally not suited in areas of deeper water or in very high-energy locations. This action is intended to reduce marsh erosion using a variety of designs using a combination of biodegradable erosion control materials (bank stabilizer) and shell reefs (wave attenuator) that have been proven successful in protecting eroding shorelines and enhancing important estuarine processes and services elsewhere (O'Brien 2014, pers. comm.).

Fiber (coir) logs and bagged oyster shell will be placed in a variety of formations along eroding marsh edges. In 2014, RICRMC and The Nature Conservancy completed a pilot-scale test of this approach that is demonstrating its effectiveness to enhance marsh edge habitat through re-vegetation and colonization. Shell bags were stacked to a set height to attenuate waves and wakes. A sill which approximates a rectangle (20 x 5 x 2.5-ft) with a set gap (approximately 10-ft) was placed between units.

Other, simpler arrangements will be used to retard undercut erosion and failure by placing coir logs within the undercut area of the banks. Providing further protection of undercuts is anticipated to (a) retard bank failure; and (b) maximize lateral growth from the salt marsh, rather than having this horizontal extension of salt marsh lost due to bank failure from undercuts.

Installation requires transportation of materials, typically on a pontoon boat to the site from river access points. A crew or workers place the materials by hand along the bank, with rope and stakes placed to secure the materials in the arrangements needed. Installation could take place anytime during the warmer seasons, however we will attempt to avoid the busiest summer months. Use of the Pollock Avenue boat ramp would be required for loading and offloading small vessels.

Approximately 7% of all marsh shoreline in the estuary will be treated using living shoreline techniques, all of which would be applied to salt marsh shorelines from Pollock Avenue downstream. Appendix G provides a more detailed description of the action, including management controls, maps, and mitigation.

Action D: Restore Salt Marsh Surface Hydrology through Drainage Restoration/Runnels

Degraded salt marshes will be restored by improving surface drainage using the "runnel" method—excavating shallow (generally 8" to 12" or less in depth, and two feet wide) channels on the surface of the marsh to provide surface drainage. This action is intended to help restore growing conditions for marsh vegetation while improving habitat and productivity of small estuarine fish such as mummichog, striped killifish, and other fish and invertebrates that utilize high marsh surfaces and permanent marsh pools. The minimum number and lengths of runnels will be created, with the density based on site-specific analysis.

The combination of freshwater flow and seepage onto salt marsh shorelines, and entrapment of tidal flows due to a lack of adequate drainage has resulted in degraded salt marsh conditions on 39% of salt marshes in the estuary. As shown in Appendix B, pools and pans have expanded significantly on salt marsh surfaces over the past 75 years. Most historical pools have high value for fish production, wildlife habitat, and biological diversity and will not receive treatment; however newer pools and pans are shallow, dry up in the summer, and are devoid of vegetation and fish. In some cases, existing pans and pools will be connected to tidal waters, but only recently developed pans will be drained. Connections to historic pools would be with the intent of providing relief channels, so that as water elevations rise, water will drain off the salt marsh surface, while retaining the integrity of the pool.

In addition, some clogged existing ditches which have filled with sediments will be cleared, but only to the extent surface drainage can be achieved (generally a foot in depth or less). In all cases, both the minimum number and minimum depths and width will be used to enhance drainage. The purpose is to allow drainage while minimizing any increased volume of flow onto the surface.

Runnels will be constructed using hand tools such as pulaskis and shovels. Materials removed will be placed back on the marsh surface where they will not impede drainage and would continue growth. In some areas, a small low ground pressure excavator typically used for mosquito control pool creation will be used to create runnels and clear drainages. This approach has been used successfully to restore salt marshes on Narragansett Bay and in the South Shore salt ponds of Rhode Island by Save The Bay (Ferguson 2014, pers. comm.).

Some stone walls along the western side of Pettaquamscutt Cove have altered stream flows and seepage onto marsh surfaces. If trenching near stone walls to divert water into stream channels is inadequate, some walls may be modified to allow drainage. Only the minimum amount of disturbance to stone walls necessary to restore stream channel integrity will be done.

This action will be implemented on 46.9 acres, or 27% of the total salt marsh, and will be undertaken through an adaptive approach—beginning small scale in the first year, and then evaluating the need and opportunity for continued hydrologic restoration. Appendix G provides a more detailed description of the action, including management controls and mitigation.

Action E: Restore Lost Low Marsh, Restore Degraded Marsh, and Enhance Resiliency to Sea Level Rise through Restoration of Intertidal Elevations

The objectives for this action are to increase the availability of low marsh habitat, to restore degraded salt marsh, and to increase salt marsh elevations to enhance resiliency in the face of sea level rise.
This will be accomplished by repurposing sediments dredged under Action B (Eelgrass Restoration), for beneficial use through thin layer deposition (TLD) of dredged sediments.

The material excavated for eelgrass and channel enhancements (Action B) will be moved and temporarily stored at the staging area at Sprague Bridge, then moved to salt marsh creation or thin layer deposition areas by barge. Material within the containers will be re-slurried and pumped onto salt marsh surfaces, or the excavator will place material directly into areas designated for low marsh creation. Material placed on the marsh surface will be retained using a series of small coir logs or similar retaining methods until it settles. Once target elevations are met, material will be pumped into the next compartment. A series of straw bale fences will be installed within the drainage channels in order to keep sediments on site. Following placement of material, elevations will be retaken to determine whether additional placement of material will be needed.

TLD work will occur after dredging but prior to summer work restrictions, thereby avoiding impacts to fish and the busy summer boating season. During the winter, navigation through the river will be difficult with all of the equipment and barges, but it is likely boat traffic will be able to pass through the area. Appendix G provides a more detailed description of the action, including management controls and mitigation.

Low Marsh Restoration:
The availability of low marsh in the estuary is inherently limited by the relatively high elevations of the salt marsh surface. Survey of the mean high tide line in 2009 found that the high tide line lies within 1 foot of the salt marsh bank with the river (Appendix D). Subsequent surveys of salt marshes between Middlebridge and Sprague Bridge has also shown that most areas of the salt marsh lie above MHW (NAVD 88; Appendix G).

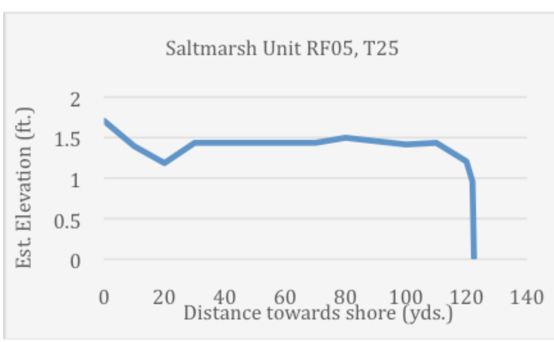
A total of 1.2 acres in areas of historical marsh occurrence will be designated for low marsh creation. Target elevations will be 0.850 feet NAVD88, with gentle (20:1 or greater) slopes to provide drainage. Coir logs, 12 inches in diameter or less, will be installed along the periphery of the salt marsh units to contain the material. Material will be transported to the site on the barges (as described under Action B) and offloaded using the excavator to design required elevations.

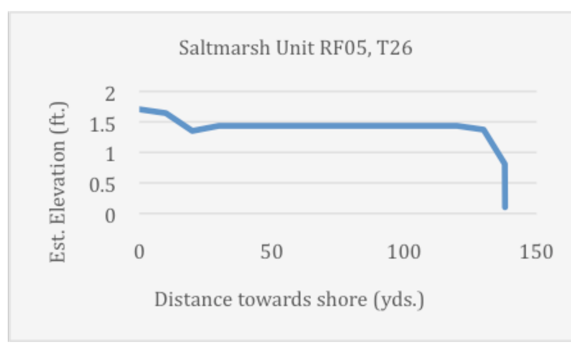
All sites will be planted with salt marsh plugs (*S. alterniflora* and *D. spicata*) on a 30” x 30” spacing or less once the material has settled and growing conditions are suitable. This approach to marsh restoration has been used successfully in Jamaica Bay, NY, Chesapeake Bay, MD, and elsewhere (ACOE 2014; Frame *et al.* 2006; Frame 2007; Wilson 2014).

Elevation Capital and Restoration of Degraded Marsh:
The intent of this action is to restore degraded marsh where tidal water entrapment on the salt marsh surface has resulted in reduced productivity and expanding bare pans on the marsh surface (see description under Action B, above); and to provide elevation capital so that treated areas are more resilient to sea level rise.

As shown in the surface profiles below taken on the eastern bank of the river (Unit 8 from Appendix G), elevations across the marsh surface are relatively uniform:

Figures 7 A. And B. Salt Marsh Elevation Relative to Distance Towards Shore





In the case of T25 (left) lower elevations in the back of the marsh and the presence of higher areas in the middle show that water flowing onto the marsh has a high likelihood of entrapment, resulting in degraded salt marsh conditions. Application of materials can aide in development of better drainage.

Examination of the profile at T26 shows that the surface profile is essentially flat. As sea level rise progresses to the point it reaches the upper bank, the entire length of the marsh surface will be inundated at once, potentially causing an expansive loss of salt marsh habitat in a short period of time. Applying material to the salt marsh surface on an incremental basis (higher to the back of the marsh, lower closest to the riverbank) will allow a more gradual loss of salt marsh over a longer period of time. Based on RICRMC's estimated sea level rise average rate of 0.2 inches per year, this catastrophic loss of salt marsh at Unit 8 would be expected to occur within decades without treatment.

This action applies a thin layer of locally sourced sediment to the surface of the marsh (TLD), raising intertidal elevations in order to mimic and augment natural accretion processes. This method has been successfully used on Delaware Bay, DE, Chesapeake Bay, MD, and Jamaica Bay, NY, to restore marshes adversely affected by accelerated sea level rise (ACOE 2014; Frame *et al.* 2006; Frame 2007; Wilson 2014).

TLD will be used to restore approximately 14 acres of degraded marsh by applying sediments to recently degraded marsh areas. Marsh elevational restoration will target degraded and ponded areas, particularly areas of new or increasing pans and stressed/low density vegetation, and will seek to restore high marsh habitat and vegetation such as *S. patens* and *J. gerardii.* Areas adjacent to the existing banks containing *S. alterniflora,* or stands of *S. patens* will not receive treatment. Target areas will include those with the potential to restore nesting habitat for salt marsh sparrows while attempting to avoiding areas of present value to this species. Appendix G provides the rational for target elevation creation.

Action F: Test Treatments to Enhance Conditions for Marsh Migration

In developed areas, the landward migration of marshes is often impeded by anthropogenic features such as roadbeds that prevent the tide from inundating upland areas. In a system that is losing marsh habitat at the seaward edges of the marsh, anthropogenic obstacles to marsh migration place further pressure on the marsh, leading to greater net loss rates than would otherwise be the case.

In order to facilitate natural marsh migration, the Service is proposing to girdle about 24 trees to release understory plants in the vicinity of Starr Drive, Narragansett on National Wildlife Refuge lands. The girdling will kill the trees and allow nearby salt marsh to migrate landward with sea level rise, thereby reducing net loss rates of salt marsh. Trees will be girdled using hand equipment such as chainsaws. Monitoring will require visits to the area (by foot) on a regular basis.

Adjacent control sites in untreated oak forest near the salt marsh transition zone will be evaluated and compared to determine whether this treatment has the potential to enhance conditions for salt marsh migration. This action will occur in upland sites.

6.6 MONITORING

A series of monitoring efforts will take place to provide a feedback loop in helping to determine whether actions taken result in anticipated effects, whether alteration in management actions are needed to avoid unanticipated effects, and to evaluate whether these techniques can be applied elsewhere for restoration.

Fisheries:
Finfish are monitored at three sites in the Narrow River Estuary on an ongoing basis by RIDEM Division of Fish and Wildlife. Fish samples are collected using a seine 130 ft. long (39.62m), 5.5 ft. deep (1.67m) with ¼" mesh (6.4mm). The seine has a bag at its midpoint, a weighted footrope and floats on the head rope. The area swept by the seine net is estimated to be between 2000 and 2400 square feet. The beach seine is set in a semi-circle, away from the shoreline and back again using an outboard-powered 16' Lund aluminum boat. The net is then hauled toward the beach by hand and the bag is emptied into a large water-filled tote. All fish collected are identified by species, measured, enumerated, and sub-samples are taken when appropriate. Water quality parameters (temperature, salinity and dissolved oxygen) are measured at each station. Seining at each station is conducted once a month for 6 months of the year between May and October.

Table 7. The coordinates of the RIDEM fishery monitoring stations in Narrow River

Station	Latitude (Degrees)	Longitude (Degrees)	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)
NR1:	41 29' 09.6"	71 26' 53.3"	41.486	-71.448139
NR2:	41 27' 28.6"	71 27' 06.9"	41.457944	-71.451917
NR3:	41 27' 17.1"	71 27' 10.0"	41.45475	-71.452778

Nekton:
As part of the Regional Salt marsh Integrity Monitoring Program (SMI), *t*he Service monitors salt marsh nekton at 20 randomly chosen stations within the estuary. Additional sample locations will be established within TLD treatment units. Nekton are sampled from pools, pans, ditches and creeks in the salt marsh using either a ditch net or throw trap depending on the type of water body. Salinity data are also collected at each sampling location. The results of this survey were used to monitor nekton use over time.

Both the fisheries and nekton monitoring programs will be used to track ongoing status and trends of fish and invertebrate communities in the estuary, including any changes resulting from the proposed action.

Water Quality:
The Narrow River Preservation Association will monitor nutrients and bacteria using methodologies approved by RIDEM and EPA for water quality monitoring in compliance with Clean Water Act reporting requirements throughout Rhode Island.

Tidal Flow and Volumes:
Water level data loggers and water volume loggers have been installed at five sites within the estuary: from just north of Middlebridge, just south of Sprague Bridge, two at Sedge Island, and one at Gooseberry Island. These data loggers have been operating continuously since July of 2014, and will be run over the next two years. This data will be used to determine how treatments applied in the estuary have influenced

flows. Additional loggers will be installed at the crossing in Upper Pettaquamscutt Cove should the crossing remnant be removed.

Living Shorelines:
Salt marsh shoreline condition surveys (USFWS 2012) will be re-run in 2015 and in 2016 to determine trends in salt marsh shoreline conditions within and outside of treatment areas. The Nature Conservancy has developed monitoring protocols to evaluate response to shoreline treatments completed in 2014. This same protocol will be continued over the next two years.

Shoreline condition surveys (USFWS 2012) will be completed before and immediately after installation of additional shoreline treatments. Inspections will be completed in all shoreline treatment areas three times per year and after any significant storm event to monitor structure integrity.

Boat Wakes:
Shorelines, including those with and without living shoreline treatments, will be monitored for erosion. Erosion rates will be compared to data collected in 2009 (USFWS 2009). Boating use and boat wake impacts on restored and non-restored shorelines will be evaluated, and if additional measures are warranted to protect National Wildlife Refuge shorelines, they will be evaluated at that time.

Salt Marsh Elevations and Drainage:
A total of 16 Surface Elevation Tables (SETs) have been installed within the estuary on salt marsh surfaces to monitor salt marsh elevations and compare them to rates of sea level rise. SETs have been installed both within and outside of treatment units.

Within TLD units, elevations before and after applications will be completed at levels sufficient to determine salt marsh elevations both within and adjacent to treated sites. Surveys will be re-run at 6 month intervals for a period of two years. Monitoring protocol developed for the Pepper Creek TLD project in Delaware will be modified for application here.

Save the Bay has developed protocols for intensive monitoring of two sites where runnels treatments will be applied (STB 2014). In other areas, elevation profiles will be completed along with establishment of photo plots at each site. Monitoring will occur at 6 month intervals following treatment. General inspections of all runnel treatment areas will be made three times per year to determine whether the treatments are trending towards achievement of goals, and to identify any modifications necessary to abate any unintended results, for example, unanticipated levels of erosion.

Low Marsh Creation:
Elevation surveys will be undertaken before and immediately after creation. Standard planting success surveys will be implemented to determine whether salt marsh plug planting is successful. Sites will be inspected three times per year over two years to determine whether objectives are being met, and to determine whether erosion or drainage issues appear so as to rectify them.

Degraded Salt Marsh Restoration with Elevation Capital (TLD):
Elevation surveys will be completed prior to application, and immediately afterward. Target elevations will be staked throughout the units to guide application. Pre- and post-restoration vegetation surveys will be undertaken and repeated at yearly intervals for three years. Prior vegetation monitoring (USFWS 2013) in combination with unit wide vegetation surveys will help determine vegetation response. Both within and

outside units, bulk density and estimates of above and below ground biomass will be completed. Monitoring protocols developed for the Pepper Creek TLD project in Delaware will be modified for application here.

Marsh Migration Treatments:
Surveys for vegetation composition will be completed on a yearly basis for three years.

7.0 ENVIRONMENTAL CONSEQUENCES

7.1 ALTERNATIVE 1: NO ACTION

7.1.1 PUBLIC USE AND RECREATION

Public use of the estuary will continue to expand. The popularity of boating, and the presence of commercial kayak and paddleboard rentals, and public access points at Pollock Avenue and in the vicinity of Sprague Bridge will likely receive expanded use. Motorized vessels will continue to use the estuary, and there appears to be an increasing trend in the number of larger vessels.

Continued shoaling and expansion of flood and ebb tidal deltas may aggravate present navigation, safety, and user conflict issues. Increased sedimentation and shoaling will continue to constrain both motorized and non-motorized vessels into channels restricted in width.

By reducing fish and wildlife habitat, diversity, and populations, the no-action alternative will affect many of the values that bring some recreational users to the Narrow River, particularly fishing and wildlife-watching. Mosquito production may increase as a result of new formations of pools and pans devoid of fish species.

Persistent water quality problems will continue to require suspension of shellfishing opportunities. Degradation of deep water channels used by foraging striped bass may limit recreational fishing quality.

Aesthetic values of the estuary will change—for example, the historic view of the Narrow River Estuary from Sprague Bridge in Narragansett—will be affected with evidence of salt marsh degradation and shoreline erosion becoming more evident. Long-standing uses such as fishing and wildlife observation may decline as a result of reduce abundance of some species. Tidal shoals are likely to expand, with recreational use of them unchanged. The no-action alternative is not expected to impact educational uses of the Narrow River Estuary.

7.1.2 WATER QUALITY

Poor water quality will continue in the estuary, primarily resulting from non-point source pollution. Delayed flushing rates in Pettaquamscutt Cove combined with high levels of pollution entering the system from Mumford Brook will cause water quality problems to persist.

7.1.3 TIDAL FLOW

The no-action alternative will have no near-term impacts on tidal flow in the Narrow River Estuary. Current trends would continue—i.e., the estuary gradually filling in with sediments, leading to reduced tidal prism with reduced tidal flushing over the long term.

7.1.4 SALT MARSH CONDITIONS

Salt marshes will continue to deteriorate and be reduced in extent, reducing ecological health, loss of biological diversity, and reduction in some fish and wildlife species. Watson and others (2014) describes the long-term trend of declining high marsh habitat in the southeast portion of the estuary and showed that the rate of sea level rise is outpacing marsh accretion. The study concluded that the deterioration of the marshes is caused by a trend of loss of marsh elevation relative to sea level rise. This study also observed that drainage is an important factor in the distribution of *S. patens*, leading to the conclusion that poor drainage is one cause of loss of high marsh habitat in the Narrow River Estuary. This work is consistent with the findings of Raposa and others (2014), which demonstrate a rapid loss of high marsh habitat in response to sea level rise in Narragansett Bay. Under the no-action alternative, high marsh plant species such as *S. patens* will continue to decline and be represented by small, highly fragmented patches.

With persistent drainage problems and sea level rise, historical and newer pools are likely to expand, with some in the Middlebridge and Pettaquamscutt Cove reaches eventually overtaking the salt marsh banks, leading to relatively large losses of salt marsh.

Watson and others (2014) estimated the rate of marsh loss in the estuary since 1869 at 1.5% per decade. Applied to the estuary's current inventory of 174 acres of salt marsh, it can be concluded that the estuary is losing approximately 2.6 acres of salt marsh per decade. At current rates, if no action is taken, the high marsh habitats of the Narrow River Estuary would virtually disappear in less than a century. Certainly, some marsh will persist in estuary for the foreseeable future. However, under the no-action alternative, the high marsh habitat that provides nesting habitat for salt marsh sparrows, and habitat for dozens of other species, will decline and fragment, no longer providing the ecological functions and values now provided by this habitat type.

Salt marsh shoreline stability will continue to decline, as will river channels remaining along salt marsh shorelines. Losses of salt marsh will occur most notably in the refuge river reach, on Sedge Island, and in the lower River. Given the rate of shoreline loss over the past five years (Appendix D), 3.6 acres of salt marsh loss per decade resulting from shoreline erosion could occur.

7.1.5 MARINE FISH AND ESSENTIAL FISH HABITAT

Flood and ebb tidal deltas are likely to continue their expansion, resulting in some loss of deeper areas which provide cool water refugia for winter flounder and foraging habitat for larger species such as striped bass. Similarly, habitat available for eelgrass will decline commensurate with loss of deeper channels.

Salt marsh habitat will continue to decline in extent by an estimated 6.2 acres per decade, eventually succumbing to sea level rise, and turning into mudflats with eventual loss. Continued entrapment of water on the salt marsh surface will further degrade vegetation, which will become less dense with open bare pans becoming prevalent. This will hamper the marshes' ability to keep pace with sea level rise, hastening the time period before loss. Marsh channels and creeks will continue to fill with sediments, limiting fish access to the upper marsh surfaces for foraging.

Under the no-action alternative, as deeper estuarine habitats and eelgrass beds are lost in the estuary, smaller estuarine fish and diadromous species will become more vulnerable to predators, with potential local and regional impacts. These species are important components of the diet of striped bass, the most important and valuable recreational fishing species on Narragansett Bay, which also tend to utilize deeper areas of the estuary. The no-action alternative is expected to allow further declines in diadromous fish and striped bass in the estuary and Narragansett Bay; this, in turn, will affect the fishing and recreational values of the estuary and Rhode Island.

The overall loss of estuarine habitat diversity caused by the no-action alternative will lead to reduced fish diversity in the estuary, with consequences for many other kinds of fish and wildlife, both within and beyond the Narrow River Estuary.

7.1.6 WILDLIFE RESOURCES

Under the no-action alternative, the salt marshes of the estuary, particularly high marsh or salt meadow habitat, will continue to deteriorate and disappear. The estuary will lose ecological complexity, diversity and resilience, with negative impacts on a wide variety of fish and wildlife species that utilize these habitats.

Tide flat habitat will expand under the no-action alternative, benefitting some shorebird species of moderate to high conservation need. Loss of older, historic pools and pans and salt marsh channels as they are inundated will create a loss of important foraging habitat. Marsh creek habitat will be lost as high marshes degrade and disappear, with commensurate losses expected of fish and shellfish that utilize the creeks.

Species that utilize the surface of the high marsh, from rodents to foxes to white-tailed deer, will be displaced, as high marsh habitat is lost. Species that forage on high marsh species, such as hawks, owls and bald eagles, which feed on rodents on the marsh, will decline in the estuary due to a loss of habitat and be displaced elsewhere.

The no-action alternative is expected to have negative consequences for rare species, particularly the salt marsh sparrow. As high marsh habitat is lost, populations of nesting salt marsh sparrows are expected to decline, with regional impacts on this species of concern.

The no-action alternative is expected to have no consequences on nearby populations of piping plover and least tern.

7.1.7 CULTURAL RESOURCES

No ground-disturbing actions will take place therefore there is no potential to impact cultural resources.

7.2 ALTERNATIVE 2: PROPOSED ACTION – RESTORE ESTUARINE HABITAT AND SALT MARSHES

To restore salt marsh habitat and estuarine conditions to the Narrow River Estuary, an integrated set of restoration actions would be undertaken to enhance estuarine conditions so as to make the area more resilient to climate change and sea level rise.

7.2.1 PUBLIC USE AND RECREATION

Public use of the estuary will continue to expand. The popularity of non-motorized vessels, and the presence of commercial kayak and paddleboard rentals, and public access points at Pollock Avenue and in the vicinity of Sprague Bridge will likely receive expanded use. Motorized vessels will continue to use the estuary, and there appears to be an increasing trend in the number of larger vessels.

The proposed action will have long-term positive effects on recreational boating and other forms of recreation on the Narrow River Estuary, and short-term negative consequences on these uses. In undertaking the proposed action, the Service will undertake all practicable measures to minimize these temporary, negative impacts.

Public use of the Service's access point to the River at Sprague Bridge will be curtailed during winter construction operations because of use by this site for staging construction equipment. The Service will work to minimize impacts on recreational use of this site during the summer season; however some impacts will be unavoidable and the closure of the access site for the entire construction period may be necessary. Closure of the Sprague Bridge site would result in the temporary loss of 12 parking spaces; however, parking for recreational access will continue to be available on the east side of Boston Neck Road. Construction operations will cause minor environmental impacts (noise, diesel exhaust). However these impacts are not expected to be significant in the context of the affected environment, which is impacted to use by a major state road (Route 1A/Boston Neck Road), several local roads, and heavy motor boat traffic during the summer.

Boat traffic during the winter dredging period (November 15 – January 31) may be altered, with slower speeds and a more restricted channel for navigation present between Middlebridge and Sprague Bridge, as dredging operations are underway. Both recreational use of the river and the access point are at their lowest levels during this season, minimizing the disruption to use of the river and adjacent environs.

Dredging operations will only occur from November 15 to January 31, so that spring, summer, and early fall recreational use of the River will not be impaired. While work will continue along shorelines and on the marsh surface as supported by small skiff and pontoon boats, added traffic on the river will be largely inconsequential.

Changes in the main river channel (increased width of deeper areas) will reduce navigational hazards and reduce safety issues arising between motorized and non-motorized vessels by providing a much wider area for boats to pass each other. Marking of the channel will aid in relocating boat traffic away from salt marsh shorelines, reducing impacts of accelerated shoreline loss and prop scarring.

Tidal flats in the estuary near Sedge Island will decline in size. These areas support occasional short-term recreational use. The larger tidal shoals in the lower part of the river will remain intact, which receive high recreational use. The shoals near Sedge Island are likely to rebuild over time.

A short-term decline in aesthetic values will occur during the first two seasons following application of repurposed dredge material onto the salt marsh surface. This impact is expected to be short lived, since the areas will be planted with salt marsh vegetation which is likely to rapidly recolonize the site. Some may object to the short term presence of equipment needed to implement the action, but this will be short lived. Marking of the river channel will require the presence of man-made materials, which may detract from the mostly natural setting of the river.

Some fine sediments have the potential to exude a strong sulfur odor when they are exposed to air and oxidize when they are first dredged. Both the type of material being dredged, and the method of handling this material (mixing) is likely to alleviate the potential for creating a nuisance. If the smell of fine sediments becomes an issue, mitigation, such as liming of the material, will be implemented. There are no permanent residences within or near the TLD areas, therefore issues related to sediment odors are not anticipated to be significant.

The long-term positive impacts of the proposed action stem from restoration and preservation of the Narrow River's estuarine ecology and resilience. By restoring and preserving salt marsh habitat, restoring and enhancing fish habitat and populations; and restoring and enhancing wildlife, rare species and biodiversity, the proposed action will maintain and enhance many of the values and uses that bring recreational users to the Narrow River.

Improvements to marine fish, including eelgrass habitat expansion, development of cool water refugia, enhanced foraging and access to salt marsh surfaces and creation of low marsh is expected to result in increased fish production and hence fishing opportunity.

While actions undertaken to improve water quality will not improve conditions enough to allow recreational shellfishing to resume in the near term, they will contribute to long-term improvement and it will aide in efforts to improve water quality in the watershed as a whole.

The proposed action will enhance and improve such recreational uses as fishing and wildlife watching, environmental education, and will preserve aesthetic values which are important to recreational uses such as boating, or simple visual appreciation.

7.2.2 WATER QUALITY

Flushing rates would be enhanced in Upper Pettaquamscutt Cove from removal of portions of the old crossing underwater, if deemed needed. Above ground portions of the crossing and embankment remnants would remain intact, therefore no change in visual quality would occur. Overall flushing in the Cove may improve with the enhancement of some channels near Sedge Island.

Temporary minor impairment of water quality during winter dredging operations will occur, but will be short-lived, and limited to the time period of dredging operations and a few days following. Some suspension of sediments from those areas where the material is placed on salt marsh surfaces may also occur; however mitigation measures applied will reduce this impact. Materials to be dredged have been tested and determined to be clear of any contaminants. Additional testing of sediments at the former road crossing will be completed and analyzed prior to any ground disturbing activity.

Design of the BMP's and possible construction of same at Mettatuxet Brook and Kimberly Drive would aid in reducing stormwater runoff directly entering the estuary, thereby improving water quality. Expanded monitoring of water quality by NRPA will help inform future management of water quality in the watershed, potentially leading to additional improvement actions.

7.2.3 TIDAL FLOWS

The proposed action will not significantly change tidal flow (volume) or tide levels, as the action does not include dredging below Sprague Bridge or alter the Narrow River Inlet. The Inlet is the principal tidal restriction into the Narrow River Estuary, along with the Sprague Bridge abutments which causes the estuary's attenuated tidal ranges (ACOE 2009). In other words, the actions taken will not increase flows or tidal height because there is a limited amount of water which can pass through the inlet and the Sprague Bridge abutments. The project will not change that condition.

While some improvement in flushing of Pettaquamscutt Cove may occur from deepening of channels, this enhancement may be small because dredged channels will not be connected to the Cove. Removal of the remnant fill from the crossing will improve water quality through enhanced flushing in that part of Pettaquamscutt Cove.

7.2.4 SALT MARSH CONDITIONS

Under the proposed alternative, the decline and loss of marsh habitat in the estuary will be reduced, vegetative and shoreline conditions improved, and marsh resiliency to future storms and sea level rise enhanced. The project will offset the 6.2 acre projected loss of salt marsh per decade projected under the no-action alternative.

Water quality enhancements (Action A) may reduce nitrogen levels in local areas, helping both above and below ground biomass production on salt marsh shorelines. Reductions in nitrogen entering the aquatic system can beneficially influence salt marsh shoreline stability and improve both above ground and below ground biomass accumulation to allow salt marshes to keep pace with sea level rise and make them less susceptible to pressure from green crabs and other grazers.

Deegan and others (2012) found that taller salt marsh grasses also produced fewer roots and rhizomes, which normally help stabilize the edge of the marsh creek. Over time, wide cracks began forming in the grassy banks of the tidal creeks, which eventually slumped down and collapsed into the muddy creek. Taller grass also produced fewer roots and rhizomes, which normally help stabilize the edge of the marsh creek. Excessive nitrogen loading can adversely impact below ground biomass production in salt marshes, in addition to making above ground production more susceptible to grazing (Ramnarine *et al.* 2008). Maximizing above and below-ground biomass production on salt marsh surfaces through water quality improvement will help rates of elevation gain on the salt marsh as a whole.

Dredging associated with eelgrass and channel improvements (Action B) will substantially reduce salt marsh loss along the eastern side of Sedge Island, and will also allow motorized vessels to operate farther away from salt marsh shorelines, reducing the impacts of accelerated bank erosion caused by boat wakes.

Applying living shoreline bank techniques (Action C) along seven percent of salt marsh banks in the estuary which are currently highly unstable will greatly improve bank stability and help prevent the further loss of salt marsh along treated banks. Salt marsh grows both vertically and horizontally. Gains in horizontal salt marsh growth are typically lost due to collapse of undercut shoreline banks. Reducing the rate of undercutting could reasonably be expected to allow the marsh to expand, rather than being continually lost from undercut bank failure. Applying a variety of designs coupled with monitoring will inform future management decisions regarding the effectiveness of applying these techniques in the future.

Salt marsh drainage restoration actions (Action D) will enhance growing conditions for salt marsh vegetation, enhancing vertical growth of the marsh by improving the productivity of above and below ground biomass.

In most areas treated (46.9 acres), we expect that in the short-term (1-3 years) *salicornia spp.* and *S. alterniflora* will re-colonize and dominate the sites, followed by eventual dominance by high marsh species such as *S. patens* and *J. gerardii*.

The amount of vegetated salt marsh will increase over current levels on the 14.3 acres of transient pools and pans that have recently developed on the marsh surface. In those areas, the lower elevation sites will likely limit production of high marsh species, and become dominated by tall forms of *S. alterniflora*, more typical of low marsh sites. Of the 14.3 acres treated, roughly 25%, or four acres, will likely support newly created habitat more indicative of low marsh habitat.

Degraded marsh treated with deposition of thin layers of re-purposed sediments (15.3 ac, Action E, TLD) will eventually respond with regrowth of vegetation, but may be bare or sparse for the first one or two growing seasons. Planting of *S. alterniflora* and *D. spicata* will help stabilize the sites and provide a rapid vegetative cover. *S. alterniflora*, *Salicornia*, and *D. spicata* will rapidly recolonize the site over a two year period. It is anticipated that high marsh vegetation will eventually dominate these sites.

The TLD process will replicate a natural “blow over” of beach sand on the marsh, much as occurs during hurricanes. Resiliency to future storms and to sea level rise will be enhanced by providing “elevational capital” or greater topographical relief to the units. As sea level rises to the banks for example, greater relief will allow for retention of at least portions of the marsh surface. Restoring low marsh along existing salt marsh banks where they were historically present will increase a habitat in relatively short supply in the estuary.

Increased rates of sea level rise will eventually outpace the ability of salt marshes ability to maintain intertidal elevations; however these treatments will allow the marshes to keep up over a longer time period than without action.

Providing for the migration of salt marsh habitats into adjacent low-lying uplands may be the best long-term solution for marsh preservation. Testing of vegetation treatments designed to enhance salt marsh migration (Action F) will inform future management by assessing the effectiveness of this technique.

Dredging under the proposed action will allow motorized vessels to pass further from salt marsh shorelines. Currently, motorized vessels must, due to shallow water, pass within 65 feet of salt marsh shorelines in the vicinity of Sedge Island. Boat wake wave attenuation modeling (USFWS 2009) indicates that the closer vessels travel to a shoreline, the greater the wave energy (synonymous with maximum wave height) and hence erosive potential these boat wakes will have (Figure 4). Applying this model, this action could result in reducing boat wake wave energy on salt marsh shorelines by 65%. Allowing motorized vessels to pass farther from salt marsh shorelines may also enhance vegetative growth on some banks. Table 8 summarizes the lineal feet of marsh shoreline and acres of salt marsh to be restored under the proposed action.

Under the proposed action, the unique morphology and ecology of the Narrow River salt marshes will be preserved. Brackish marshes, estuarine shrublands, natural tidal creeks and historic pools and pans will be preserved. Areas of marsh that are currently well-drained or which are particularly valuable as habitat in their present condition will not be targeted for any treatment.

Taken together, the proposed action will improve salt marsh conditions in the Narrow River Estuary by arresting current trends of salt marsh degradation and loss, while enhancing and preserving existing habitat values.

As a result, the proposed action will increase ecological resilience—the marshes' ability to adapt and survive sea level rise, climate change and other anthropogenic impacts. Actions to restore natural marsh hydrology, specifically by improving drainage of the marsh surface and increasing intertidal elevations, and to replace lost marsh areas, will improve the condition of the marshes, increase ecological resiliency, improve the estuary's capacity to adapt to climate change, and maintain a mosaic of wetland and estuarine habitats that support a diversity of native species.

Table 8. Summary of Proposed Action Effects on Salt Marsh Resources

River Reach	Current Salt Marsh (acres)	**Action A Water Quality Improvement** Reduce Nitrogen along salt marsh shorelines 1,000ft; stabilize shoreline 1,500ft (feet)	**Action B Eelgrass Enhancement** Restore shorelines by reducing boat wakes, moving channels away from salt marsh shorelines (feet)	**Action C Salt marsh Shoreline Stability** Apply living shoreline treatments (feet)	**Action D Surface Drainage Improvement** (1) Clear channels, runnel development (acres)	**Action D Recovered Salt marsh** (2) New salt marsh created from new pool/pan restoration (acres)	**Action E TLD** Low marsh and elevation capital (acres)	**Action F Marsh Migration enhancement** Girdle oak trees near salt marsh transition zone (acres)
Lacy Bridge	15.2			0	3 (3.8)*	4.3		
Mettatuxet	1.6	800		0	2.7	0		
Middlebridge	31.6			951	12 (14)*	3.2		
Refuge	24.8		1,600	343	1.4	1	9	
Pet. Cove	86.8	2500	950	1140	27.8(34)*	5.7	6.3	2
Lower River	14.0			1,391	0 (12.7)*	0		
Total	174	3,300	2,550	3,825	46.9(68.6)	14.3	15.3	2

1. Treatment likely to increase low marsh (fringing) as a result of sediment entrapment and establishment of cordgrass.
* Non-treated in parenthesis.
2. Of the 14.3 acres of new marsh created, 4 acres are anticipated to become low marsh.

7.2.5 MARINE FISH AND ESSENTIAL FISH HABITAT

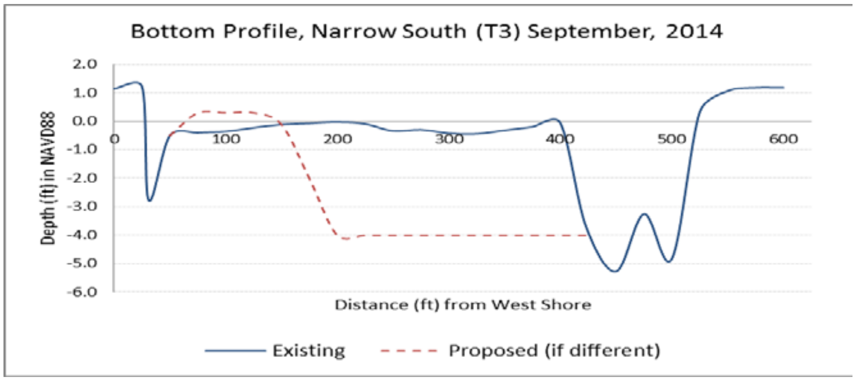
Proposed water quality improvements (Action A) will benefit marine fish; while these actions will not allow for near-term re-opening of shellfish harvest in the estuary, they will contribute to long-term efforts to restore this fishery..

Removal of portions of the former road crossing in Upper Pettaquamscutt Cove may cause short term disruption of benthic habitats, but will similarly provide long-term habitat improvement through improved flushing. Water quality actions will also benefit marine fish by enhancing salt marsh shoreline stability (3,300 ft) through reductions in nitrogen inputs.

Deepening estuarine channels and basins (Action B) will increase the availability of cool water refugia for winter flounder and enhance foraging habitat for bluefish and striped bass by 7 acres. Finfish surveys have demonstrated that in summer, the deeper, cooler waters support greater fish abundance and diversity than shallower, warmer areas; winter flounder are absent from areas of the estuary once water temperature reaches 26 - 28 degrees C (Lake, 2014 pers. comm.). Bluefish and striped bass forage in deeper channels of the estuary, and this action will increase the amount of available foraging habitat.

Eelgrass is considered the most important benthic habitat in the estuary (Appendix F), and occurs at depths greater than -2 feet MSL. By increasing areas at or below this depth, the proposed action is expected to result in an expansion of approximately 7 acres of eelgrass habitat and deeper estuarine areas, benefiting managed species and EFH. Re-alignment of the channel southeast of Sedge Island will improve eelgrass

Figure 8. Bottom profile of Narrow River South, Transect 3.



habitat availability by creating a channel shallower than current depths of -8 feet, which may be deeper than ideal for eelgrass. In Ninigret Pond, Charlestown, RI, a similar project to deepen flood-tide shoals within a coastal pond resulted in significant colonization by eelgrass (ACOE 2011).

In areas of eelgrass restoration, 7 acres of existing shallow-water coarse sand and tide flat habitat will be affected; however the amount of surface area, or wetted area of this habitat available to fish will be reduced by only one acre. As shown in the sample excavation profile, the primary change in surface area available to fish is in the distribution of habitat by depth. Currently within areas proposed for deepening, 90% of the wetted surface area lies above -2NAVD88. Implementing the proposed action would essentially reverse this distribution, providing more course sand at greater depth, where cooler and deeper water favors fish habitat use. The excavated bottom will remain as sand habitat until eelgrass colonizes the area, further improving habitat value. Areas targeted for creation of sand bottom habitats by excavation are in areas of low biological value, based on the results of eelgrass and shellfish/infauna surveys (RICRMC 2014; USFWS 2014). The larger tidal flats in the lower river will remain available, and likely expand over time. Under the proposed action, minor loss of tide flat habitat will be more than compensated by the restoration of valuable, declining habitats such as low marsh, high marsh, fringing marsh, and deeper estuarine areas suitable for the expansion of eelgrass beds and thermal refugia. The wetted surface of coarse sand benthic habitats will change little over existing conditions. This change in tidal flat habitat will be offset by 3.3 acres of tide flat enhancement.

Action B will also improve salt marsh stability, thereby reducing rates of low and high marsh loss. Providing deep and wide channels to the north of Sedge Island will allow motorized vessels to pass farther away from salt marsh banks, reducing accelerated erosion as well as prop scarring of the surface. Re-alignment of the channel on the east side of Sedge Island will improve salt marsh shoreline stability.

Application of living shoreline treatments (Action C) to undercut salt marsh shorelines will improve habitat diversity along the shoreline for marine species and provide increased suitable substrates for shellfish on 7% of salt marsh shorelines. This action will improve marsh shoreline complexity, stability and habitat value by interspersing the undercut areas with fringing marsh. The fringing marsh created by the living shoreline treatment will provide similar habitat value as the low marsh created under Action E, including colonization and feeding areas for invertebrates, feeding and refuge for small fish and nekton, and food web support to larger estuarine and marine fish. More stable marsh shorelines will support higher trophic level epifauna than the current eroding banks, improving biodiversity throughout the estuary. Like other marsh restoration actions proposed, marsh shoreline restoration will help protect estuarine water quality by reducing or reversing the rate of marsh loss.

The proposed Action D will have marked improvement in salt marsh conditions (see previous section on salt marsh impacts). Action D will restore marsh creeks and channels and create access through runnels, which as shown by the shallow-water habitat analysis (Appendix F), provide significant value to estuarine fish, including winter flounder. Habitat connectivity will be increased, allowing fish and invertebrates access and egress to and from pans and pools on the marsh surface. This is expected to improve production of small fish and other nekton adapted to the harsh conditions of these shallow water features, such as mummichog, striped killifish, ninespine stickleback (*Pungitius pungitius*), fourspine stickleback (*Apeltes quadracas*), and daggerblade grass shrimp (*Palemontes pugio*). By enhancing conditions for these important prey species, this action will improve EFH for larger, managed species such as winter flounder that feed on these and other marsh surface users. Enhanced access from clearing clogged channels and creation of small runnels to the marsh surface is expected to occur over 46.9 acres.

This action will also improve fish habitat on the surface of the marsh by improving habitat structure and condition. High marsh surfaces, marsh creeks, and permanent marsh pools provide highly productive habitat for many small estuarine fish and other nekton (USFWS Nekton Survey data; MacKenzie and Dionne 2008). By restoring vegetative complexity to the surface of the marsh, this action will improve habitat for many small fish and invertebrates, particularly during spring high tides when the surface of the marsh is flooded. Historical pools and pans, which provide important habitat for marine fish, will be protected.

Restoring 14.3 acres of salt marsh habitat lost to development of newer, shallow pools and pans, which dry up in the summertime will improve salt marsh conditions. Of these acres, we estimate 4 acres of newly created, low marsh dominated by the tall form variant of *S. alterniflora* will occur. This would be an important contribution to managed species, given the minimal amount of low marsh currently available in the estuary. Protection of historical pools and pans within treated areas will retain habitat diversity and the important values to fish.

Thin layer deposition (TLD) of dredged sediments (Action E) will be applied to narrowly targeted areas of degraded marshes, in order to prevent and reduce estuarine habitat loss, improve habitat resiliency and aid in preventing catastrophic loss of salt marsh with incremental sea level rise. TLD applications are expected to establish conditions to restore and maintain vegetated marsh in areas of vegetation die-back, water-logging, and rapidly expanding new pools and pans. This action will restore approximately 15.3 acres of degraded high marsh; approximately 1.2 acres of lost low marsh areas; and approximately 3.3 acres of tide flat habitat. Providing increased resiliency to sea level rise, these habitats will continue to be present for a longer period of time than without treatment, and will help prevent the large-scale loss of salt marsh by enhancing relief. TLD would not be applied next to the salt marsh creeks, thereby retaining existing low marsh values, and areas where tall form *S. alterniflora* occurs in a mix with other species.

Like Action D, this measure will improve fish habitat on the surface of marshes by improving habitat structure and condition, particularly during spring high tides when the surface of the marsh is flooded. Also like Action D, it will restore vegetative complexity to the surface of the marsh, improving habitat for many small fish and invertebrates. MacKenzie and Dionne (2008) demonstrate that even high marsh surfaces are important estuarine fish habitat. The literature review in Appendix F provides further studies of the importance of high marsh habitat to estuarine fish.

Restoration of lost low marsh habitat (Actions C, D, and E) will greatly increase habitat complexity and value for estuarine fish, invertebrates and epifauna. Low marshes provide valuable colonization and feeding areas for invertebrates such as ribbed mussel, fiddler crab, and snails such as *Littorina littorea* and *Melampus bidentatus*. During mid-high tides when covered with water, *S. alterniflora* low marshes provide valuable feeding and refuge for fish and nekton such as mummichogs, killifish, sticklebacks and shrimp which, in turn, provide food web support to fish species of commercial and recreational values, including winter flounder, bluefish and striped bass.

This restoration action will help restore the historic balance of estuarine habitats, restoring valuable marsh habitat for estuarine fish and nekton, including areas of feeding and refuge. By restoring and improving estuarine habitat complexity, diversity and value for fish and invertebrates, restoration of marsh and tide flat habitat is expected to provide significant benefit to EFH and managed species. Further, this action will help improve and protect estuarine water quality, with benefits to EFH, shallow-water habitats, and managed species in the Narrow River Estuary.

Management controls, including limiting dredging operations during seasons where minimal impact to managed species will occur (November 15-January 31), application of best management practices to control erosion, protecting key habitats such as pools and pans, and minimizing channel clearing and runnel development to the minimum level needed will help ensure that short term impacts are minimized (Appendix G).

7.2.6 WILDLIFE RESOURCES

As noted in Section 5.7, above, more than 100 bird species are known to use the habitats of the Narrow River Estuary, including migratory and resident species. Some species will benefit substantially from the proposed action, such as salt marsh sparrow, a species of high conservation concern, which is entirely dependant upon the availability of productive salt marsh for nesting, and a species with a highly restricted range. Other guilds of species, such as shorebirds, will experience slight reduction in foraging habitat in the central portions of the estuary, offset by enhancement of remaining tidal flats. Overall, wildlife resources will benefit from the improved health and resilience of the estuary.

Shorebirds:
Trocki and Paton (2007) documented the occurrence of 14 species of shorebirds in the Narrow River during fall migration. A disproportionate number of shorebirds were detected foraging on exposed and slightly immersed sand flats located around Sedge Island. Approximately 50% of shorebird detections in their study occurred within proposed dredge Areas 2 and 10 of the project area (see Appendix G). Thus, shorebirds

could potentially be affected by loss of foraging habitat from dredging activities at this location, although other tidal flats below Sprague Bridge will remain.

Steps would be taken to limit the impact on shorebirds and foraging habitat. Dredging activities would occur at a time when shorebirds are not present on the Narrow River (November – January). Additionally, upper tidal flat foraging habitat removed through dredging would be re-created and enhanced, so that there is no net loss of prime (upper tidal flat) shorebird habitat. The project would result in a net increase of approximately 1 acre of prime mudflat foraging habitat in areas of lower human disturbance, but balanced by declines in mid and lower tidal flat habitat.

Seasonal restrictions on dredging operations and runnel work will limit the disturbance in nesting habitats for willets. While a short-term decline in foraging habitat within TLD units is likely, planting of salt marsh vegetation along with natural re-establishment will limit this impact. The availability of untreated foraging habitat both within TLD units and throughout the estuary will limit short-term losses in foraging habitat to minimal levels. In summary, this project may affect, but is not likely to adversely affect shorebird species.

Wading Birds:
The pools on the salt marsh surface provide high quality foraging habitat for these species. Historical pools on the salt marsh would be conserved, and the runnels and drainages would enhance foraging habitat values. Living shoreline work along the shoreline banks will enhance habitat diversity and fish abundance, which will favorably impact these species.

Immersed tidal flat habitat around Sedge Island also provides foraging habitat for snowy egrets, great egrets, and great blue herons. The majority of wading bird detections (93%) observed during Trocki and Paton's study (2007) of tidal flats (not the entire estuary) occurred in the vicinity of Sedge Island. Approximately 33% of wading bird detections in their study occurred within proposed dredge Areas 2 and 10 of the project area (see Appendix G). Wading birds use exposed sand flat habitat for loafing and preening and forage on immersed flats. Steps would be taken to limit the potential impact to wading birds and their habitat within the tidal areas. Additionally, foraging and roosting habitat temporarily lost through dredging would be re-created and enhanced, so that there is no net loss in prime wading bird tidal habitat. The project would result in a net increase of approximately one acre of prime wading bird tidal habitat, the majority of which would be located in areas of low human disturbance.

Snowy egrets and great egrets would not be present in the project area during the proposed dredging window, from November to March. Great blue herons could occur in the project area during dredging activities, although disturbance to this species is anticipated to be minimal. Great blue herons could temporarily be displaced during restoration operations, but there will be areas where birds can seek refuge from temporary disturbances and forage without harassment.

Given the wide range of habitats available throughout the estuary, enhancements to salt marsh habitats including channel cleaning and runnel development which will provide new foraging habitat, and conservation of other key habitats such as brackish marsh and historical pools, the proposed action may affect, but is not likely to adversely affect wading bird species.

Cormorants:
The double-crested cormorant is a common species found on the Narrow River throughout the year, with the greatest concentrations occurring during late September and October. Cormorants primarily use

exposed tidal flats around Sedge Island for loafing and preening. The highest numbers documented by Trocki and Paton (2007) occurred on the flats south of Sedge Island. These flats would not be directly affected by dredging activity. Cormorants should benefit from the increase in exposed mudflats created by this project, which could serve as additional roosting habitat. The increased channel from dredging may degrade some foraging habitat in the vicinity of Sedge Island, however there is an abundance of foraging habitat throughout the estuary and these effects are anticipated to be negligible. Double-crested cormorants will likely be present in the project area, in small numbers, when dredging activities are occurring. These activities could temporarily displace loafing or foraging birds, but there are many areas along the Narrow River for cormorants to seek refuge from disturbance and to forage without harassment during the time of the proposed dredging. It is anticipated that this project may affect, but is not likely to adversely affect this species.

Gulls:
Gull species commonly found along the Narrow River include the herring gull, great-black-backed gull, ring-billed gull, laughing gull, and Bonaparte's gull. Gulls are present on the Narrow River throughout the year, with the highest concentrations occurring in late summer and early fall. Surveys conducted by Trocki and Paton (2007) detected the highest concentrations of gulls on the sand flats near the mouth of the narrow River, although they also occurred, but to a lesser extent, on sand flats around Sedge Island. Gulls primarily use the sand flats for loafing and preening. Small numbers of gulls will likely occur in the project area when dredging operations are taking place. Gulls may be temporarily displaced from restoration efforts, but they will be able to seek refuge on the exposed mudflats near the mouth of the river. It is also anticipated that gulls will benefit from the increase in exposed mudflats in areas of low disturbance where they could potentially roost. The restoration project may affect, but it is not likely to adversely affect gull species.

Terns:
Least terns nest on the sandy beach near the mouth of the Narrow River from May-August. Common terns are abundant along the mouth of the Narrow River during mid-July-September. Both, species have been observed by USFWS Refuge personnel foraging along the shallow waters of Pettaquamscutt Cove, and resting along tidal flats by Sedge Island, although the majority of observations were near the mouth of the River. Dredging activities would occur at a time when terns are not present on the Narrow River. Terns utilize exposed mudflats for loafing and preening, and forage for small fish in shallow water. It is not anticipated that dredging activities will significantly alter foraging habitat for this species. Terns could benefit from the creation of exposed mudflats in areas receiving less human disturbance. It is anticipated that the proposed project may affect, but is not likely to adversely affect tern species.

Waterfowl:
Nineteen species of waterfowl have been documented on the Narrow River from November through March. The most commonly observed species include: American black duck, bufflehead, Canada goose, mallard, red-breasted merganser, mute swan, hooded merganser, and gadwall. The Narrow River is of particular importance to wintering black duck. Shallow open water habitats and immersed flats are the most valuable foraging habitat for wintering waterfowl, and exposed mud flats are occasionally used for resting and preening. It is anticipated that these species will be abundant in the project area during the proposed dredging activities, as waterfowl use of the Narrow River reaches its peak from November to March. Waterfowl may be displaced from foraging and resting in the immediate vicinity of Sedge Island during restoration efforts. However, the project area represents a small percentage of the habitat available to wintering waterfowl in the Narrow River, and temporarily displaced birds will likely find refuge in other areas

of Pettaquamscutt Cover or along the River, where they can forage and rest without harassment. No long-term affects are anticipated as a result of the project. This project may affect, but is not likely to adversely waterfowl species.

The proposed action will reduce newly developed pools and pans while protecting the older, well-developed pools and pans—areas of open water on the surface of Narrow River marshes. These habitats are utilized by waterfowl such as black ducks, as well as wading birds such as herons and egrets. Most use is concentrated on the older (historical) pools and pans which contain aquatic vegetation and fish. During low tides, virtually all species are concentrated around the older historic pools, rather than newer ones. The newer pools and pans for the most part do not contain these habitat components. Therefore, the higher quality, more important pools and pans will be protected, and enhancing drainage and salt marsh conditions will help these habitats be sustained on the landscape for the future. The proposed action will benefit these species' food sources by maintaining tide creek species which are important prey for herons and egrets, and by maintaining eelgrass, an important food source for black ducks, brant and other waterfowl species (Seymour *et al.* 2002).

Secretive Marsh Birds:
Virginia rails are the only species of secretive marsh birds regularly occurring near the restoration areas. Rails inhabit dense, emergent wetland habitat and do not typically occur on tidal mud flat habitat. Brackish marshes will not be impacted by the project. Rails would not be present during at the time of dredging. Thus, modifications to tidal mudflats or salt marshes resulting from this project are not likely to adversely affect Virginia rails.

Threatened and Endangered Species:
Piping plovers are the only known federally threatened species using the Narrow River. Plovers nest on the beach near the mouth of the Narrow River from April-August. Dredging and other activities would not occur during the nesting or migration season, and therefore potential disturbances to foraging birds would not be expected. This project will have no effect on piping plovers.

Roseate terns have not been documented in the Narrow River but they are known to regularly occur along the southern coast of Rhode Island during fall migration. Roseate terns have been documented by USFWS Refuge personnel in mixed flocks of common terns at fall staging sites in other locations in Rhode Island and could potentially occur at the Narrow River in July and August. It is anticipated that roseate terns would occur at the mouth of the Narrow River, where common terns are known to stage before migrating south. Dredging activities would not occur during July or August when roseate terns could potentially occur at the Narrow River. The shallow waters at the mouth of the river where the majority of terns rest and forage would not be altered. The project will have no effect on roseate terns.

Salt marsh Sparrow:
Salt marsh sparrows are habitat specialists, found in salt marshes during the breeding and non-breeding season. Salt marshes along the Narrow River provide important nesting and foraging habitat for this species typically occupied from May through August.

Short Term (1 – 2 year) Impacts:
Salt marsh sparrows occur almost exclusively in salt marsh habitat and alterations to tidal flats from dredging operations are not anticipated to directly impact this species. A small number of sparrows may still be present in Narrow River salt marshes in early November, when potential dredging activity could occur;

however, disturbances to this species from dredging operations would be minimal at this time of year. Planting of TLD units would occur either in the early spring or fall near nesting habitat, therefore disturbance related to this activity would not disturb nesting activities. Seasonal restrictions on the use of runnel development actions including those using mechanical equipment on the marsh will prevent disturbance during the nesting season. Application of living shoreline treatments along the immediate shoreline will not disrupt nesting activities.

Dredging would not occur during the nesting season, but it is anticipated that the placement of thin layer deposition on the salt marsh would temporarily reduce foraging habitat (degraded salt marsh) in some areas until vegetation is reestablished. Vegetation would likely return to areas receiving 1 – 4 inches of deposition after 1 – 2 growing seasons, and planting of plugs in the area will hasten recovery over a shorter time period.

All of the larger, existing stands of *S. patens*, a preferred nesting habitat, would be protected and not treated as part of the TLD application. However, small tufts of *S. patens*, which may occur within degraded habitats, would be lost in the short term for 1 – 2 nesting seasons. To minimize the short-term impacts to nesting habitat, not all of the marsh habitat in the project area would receive thin layer deposition (less than 17% of estuary salt marshes). Only degraded salt marsh habitats are targeted where nesting sparrows have not been observed to nest, or where nesting activity is very low, and TLD applications will be spread over two seasons.

Long Term (2 – 3+ years) Benefits:
The combination of actions implemented under the preferred alternative will have significant positive consequences for salt marsh sparrows. Salt marsh habitats (see discussion in previous section) will expand in availability and increase in productivity and resilience.

Runnel treatments will prevent the entrapment of water on salt marsh surfaces leading to vegetative recovery of salt marsh surfaces. Vegetation is expected to respond, initially with tall forms of *S. alterniflora*, eventual reductions in *Salicornia*, and increases in *S. patens* and *Juncus*, both of which provide preferred nesting habitat. This enhancement will provide an increase the quality of nesting habitat by 46.9 acres, and create an additional 14 acres of habitat recovered from regrowth of salt marsh vegetation in areas currently occupied by newer pools and pans. Salt marsh sparrows will forage along channels and small creeks; therefore clearing of channels and creation of runnels will provide enhanced foraging habitats.

Widened channels (Action B) will help reduce salt marsh loss and impacts from accelerated erosion associated with boat wakes, and help stabilize other shorelines, reducing the loss of nesting habitat.

Providing elevation capital to areas of degraded habitat in TLD units will increase the resiliency of these areas to sea level rise, including prevention of catastrophic loss with just slight increases in sea level rise. This positive influence will occur over 15.3 acres. USFWS will monitor sparrow usage and nesting on the Narrow River marshes for at least two years following the restoration in order to document results of the restoration and, if necessary, undertake adaptive management to improve nesting success.

On the Narrow River, 95% of sparrow nests occur in areas with at least 30% high marsh vegetation. A recent study by USFWS determined that tidal flooding during storm events or spring high tides was the principal cause of nest failure among salt marsh sparrows, with a nesting failure rate of 34%. These actions will promote establishment of nesting habitat and enhance foraging habitat availability.

Testing mechanisms by which marsh migration can be enhanced will promote both understanding of the processes of marsh migration, and may also hasten development of nesting habitat for this species. Given the importance of this area in the limited range of this species, this action will have a substantial and beneficial impact on conservation efforts for this species within its range.

Given the restricted range of this species and its highly vulnerable status, this proposed action will result in a significant and substantial improvement of habitat and conservation for this species' population as a whole.

Osprey:
Osprey nest and forage along the Narrow River and are present within the project area from May through September. The proposed dredging activity would occur from November to March, when ospreys do not occur on the Narrow River.

The proposed action will benefit osprey, bald eagles and other piscivorous birds by maintaining abundant and diverse populations of alewives, juvenile bluefish, juvenile winter flounder and other small fish in the Narrow River Estuary.

Mammals that utilize the estuary, such as raccoon, fox, otter, fisher, coyote and white-tailed deer will not be significantly affected by the project, as most are habitat generalists.

7.2.7 CULTURAL RESOURCES

No significant impacts to cultural resources are anticipated from the proposed action. Consultation with the RI Historical Preservation and Heritage Commission and the Narragansett Indian Tribe will help guide the level of assessments and surveys required to determine whether significant archaeological or historical sites are present, and how best to protect them. Only after this consultation is completed will ground-disturbing activities commence.

Should management activities uncover unanticipated artifacts of cultural resource values of significance, the level of protection and documentation will be addressed at that time, in order to preserve the articles and prevent degradation of the site.

7.2.8 INDIRECT AND CUMULATIVE IMPACTS

Water quality in the Narrow River will remain in a degraded condition or slightly improve. While the project will help improve conditions in some portions of the watershed, storm runoff and persistent non-point sources will continue to inhibit water quality in the watershed as a whole. The action is not expected to have a significant effect outside of the watershed.

While the project is expected to improve salt marsh habitat conditions in the estuary, areas remaining untreated will continue at current levels or decline. While treatments to enhance elevation capital will help prevent catastrophic loss of salt marsh in the near term, sea level rise will continue to add stress on salt marsh and estuarine habitats not only in the Narrow River, but also in Narragansett Bay and along the entire Eastern Seaboard. Conservation of habitat within this estuary, while extremely important, will not in itself result in long-term conservation of this habitat overall. While projects located on the South Coast of

Rhode Island in Ninigret, Quonochontaug, and Winnapaug Ponds will aid in "buying time" against the full consequences of sea level rise and climate change, current trends and projections suggest that the health and availability of salt marsh habitats will decline markedly in the region, whether or not this project is implemented. Only in areas where salt marsh has the opportunity to migrate inland, or where treatments are applied for elevation capital will salt marsh communities be maintained in the long-term.

The health of managed fish species will likely improve in the estuary. Expected expansion of eelgrass and cold water refugia will have a marked benefit on habitat conditions for managed species. However long-term habitat trends influenced by sea level rise and climate change, as well as fishery trends, will ultimately determine the stability of managed fish species.

Carbon emissions resulting from the use of heavy equipment, vehicles, boats and emissions associated with creation and transportation of the materials used in the restoration will contribute to greenhouse gas emissions. However, given the reductions in emissions from buildings and facilities on the Wildlife Refuge Complex from use of geothermal heating, solar power, and fuel efficient vehicles in combination with the carbon sequestered on the largely undeveloped lands of the National Wildlife Refuges, it is unlikely this contribution will be significant in light of regional, national, and worldwide emissions.

While this project will provide a significant positive impact on conservation of the salt marsh sparrow, it is unlikely to cause a reversal in the species' declining population trend and vulnerability to sea level rise range-wide.

8.0 CONSULTATION AND COORDINATION

The following entities were consulted during preparation of the restoration and resiliency plan, and in preparation of this Environmental Assessment:

- Audubon Society of Rhode Island
- Narragansett Indian Tribe, Tribal Historic Preservation Office
- Narrow River Land Trust
- Narrow River Preservation Association
- Salt Ponds Coalition
- Rhode Island Natural History Survey
- State of Rhode Island, Department of Environmental Management
  - Office of Water Resources (Restoration Branch, Regulatory Branch)
  - Division of Fish and Wildlife (Restoration Branch, Regulatory Branch)
  - Office of Technical and Customer Assistance
- State of Rhode Island, Coastal Resources Management Council (Restoration/Regulatory)
- The Nature Conservancy, Rhode Island Chapter
- Town of Narragansett, Department of Public Works
- Town of South Kingstown, Department of Public Works
- University of Rhode Island (Dr. Jon Boothroyd; Dr. John King; Dr. Laura Meyerson)
- U.S. Environmental Protection Agency (Restoration Branch, Regulatory Branch)
- U.S. Army Corps of Engineers (Restoration Branch, Regulatory Branch)
- U. S. National Oceanic and Atmospheric Administration (Restoration/Regulatory Branches)

9.0 LEAD AGENCY CONTACT

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11.0 APPENDICES

APPENDIX A
MIGRATION OF ESTUARINE CHANNELS OVER TIME

APPENDIX B
SALT MARSH HABITATS IN THE NARROW RIVER ESTUARY

APPENDIX C
CHANGE IN SALT MARSH ABUNDANCE

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