BLOCK ISLAND HARBORS
SEA LEVEL RISE ADAPTATION STUDY

TOWN OF NEW SHOREHAM
AUGUST 1, 2013

New England Municipal Coastal Resilience Initiative Grant Program

Gulf of Maine Council on the Marine Environment

NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
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Block Island Harbors
Sea Level Rise Adaptation Study

New England Municipal Coastal Resilience Initiative Grant Program

Final Project Report

August 1, 2013

Prepared by:
Jane Weidman, AICP, New Shoreham Town Planner
Robert Fairbanks, PE, Fairbank Engineering Corporation
Richard St. Jean, PE, St. Jean Engineering, LLC
Martha Roldan, New Shoreham GIS Administrator

Technical Advisors:

Janet Freedman, RI Coastal Resources Management Council
Michael Oppenheimer, PhD, Professor of Geosciences and International Affairs, Princeton University

New Shoreham Advisory Committee:

Nancy Dodge, Town Manager
Shirlyne Gobern, Administrative Assistant
Stephen Land, Harbormaster
William McCombe, Interstate Navigation and EMA Director
Mary Anderson, Planning Board
Margie Comings, Old Harbor Task Force, Planning Board
Kevin Hoyt, Committee for the Great Salt Pond
Robert Gilpin, North Light Commission
Chris Littlefield, The Nature Conservancy
Sven Risom, Committee for the Great Salt Pond, Planning Board
Arlene Tunney, Harbors Committee, Old Harbor Task Force

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INTRODUCTION

US Gulf of Maine Association Grant /Project Goals

In December 2011, the Town of New Shoreham (Block Island) was a recipient of a grant from the Association of US Delegates to the Gulf of Maine Council on the Marine Environment (US Gulf of Maine Association) in coordination with the Gulf of Maine Council (GOMC) and Northeast Regional Ocean Council (NROC), with funding provided by the NOAA Climate Program Office. The grant was in response to a competitive Request for Proposals (RFP) from New England coastal communities for projects that would assist local efforts in adapting land use, infrastructure, policies and programs to reduce the vulnerability of both the built and natural environment from changing environmental conditions. Block Island's successful proposal sought funding to plan for and mitigate the impacts of flooding as a result of projected sea level rise and storm surges on its two harbors, as well as the island roadway system that connects the harbors to the commercial center of the island and to the outlying residential areas.

The project goals include the development of mapping that indicates the impact of various sea level rise and storm surge scenarios on the harbors and village areas, structural engineering concepts to address the impact of this rising sea level on the island's marine infrastructure, and contingency plans to respond to the potential inundation of the connecting roadways and bridges.

Project Area Description

Block Island, located twelve miles off the coast of Rhode Island, has unique challenges related to its geographic isolation, including vulnerability to natural hazards (hurricanes, coastal storms and nor'easters) and reliance on privately owned ferry and airline companies for transportation to and from the mainland. In addition, the village and two harbors, where development is densest and most of the commercial and hospitality activity takes place, is vulnerable to flooding due to its low elevation. The island's economy is heavily dependent upon tourism which in turn relies almost exclusively on the operations of its ferries.

Residents and visitors in the outlying areas depend on access to the village and harbors for a number of life's necessities and conveniences, including groceries and gas; mail, banking and religious services; and supplies and products shipped by ferry. The fire station, which also serves as the dispatch and response center for medical emergencies, and the police station next

door are located in a central site near one of the harbors, and public safety responders, in turn, require access to the remainder of the island. Access is also needed from the village and harbors to the Block Island Medical Center and the school, which also serves as an emergency shelter, both of which are located a half mile outside of the village. These critical aspects of island life depend on a functioning roadway system in and around the town center, some sections of which are vulnerable to storm erosion damage and flooding and eventually, sea level rise. See Figure A-1 Project Study Area.

Block Island Harbors:

For water-based transportation to and from the island, Block Island is served by two harbors, "Old Harbor" and "New Harbor". Old Harbor, in the village or downtown area, is the principal ferry terminal where the majority of passenger trips arrive and depart. In addition, all vehicles and goods, commercial and private, are moved on and off the island at Old Harbor.

This harbor, protected by a breakwater originally constructed by the Army Corp of Engineers in 1873, is a harbor of safe refuge. Marine facilities include the ferry terminal operated by the company, Interstate Navigation, and a town-managed dockage area known as the Inner Basin. The terminal facility includes two docking sites for the larger year-round passenger and vehicle ferries and a newly reconstructed dock which supports smaller seasonal (high-speed) passenger-only ferries, including one from New London, Ct operated by another ferry company, the Block Island Express. Landside it includes a large staging area for goods, supplies and equipment being moved off of or onto the ferry, a freight shed, a ticket office, a large queuing area for vehicles, and a parking area.

Old Harbor

The Inner Basin is formed by two town docks (West Dock and South Dock) and one along the inside of the breakwater owned by the Army Corp (East Dock). The Inner Basin is used for a limited number of commercial fishing and charter boats, as well as for public wharfage, with a high volume of transient boater use during the summer season. Facing the Inner Basin is the harbormaster's building, rebuilt in 2011. The Old Harbor landing area also includes a visitors' center operated seasonally by the BI Chamber of Commerce, and public restrooms. Old Harbor is the hub of the island, particularly during a typical summer day when the island welcomes 10,000 daily visitors, most of whom who travel from the Interstate's mainland facility, at the Port of Galilee in Narragansett.

Old Harbor marine and ferry support facilities; NS GIS Department

New Harbor, in the Great Salt Pond, is the location of the great majority of recreational boating activity, including most of the island's marinas. These include Payne's Dock, the Boat Basin, and Champlin's Marina. Payne's provides dockage for some small commercial cruise vessels, and Champlin's also supports a seasonal passenger-only ferry service from Montauk, NY. Inner Harbor, also referred to as the Hog Pen, located off the road approaching New Harbor, supports a couple of smaller marinas and a public boat launch. It is also the site of the Block Island Maritime Institute which provides maritime and marine science education programs for children. On the west side of the entrance to the Great Salt Pond, the "channel", includes a Coast Guard Station and dock. New Harbor is also extremely active during the summer season; it supports a number of restaurants and one major hotel, but it is not as critical in terms of supporting year-round island life as is Old Harbor.

New Harbor marine facilities; NS GIS Department

Background Efforts

2011 Hazard Mitigation Plan Update:

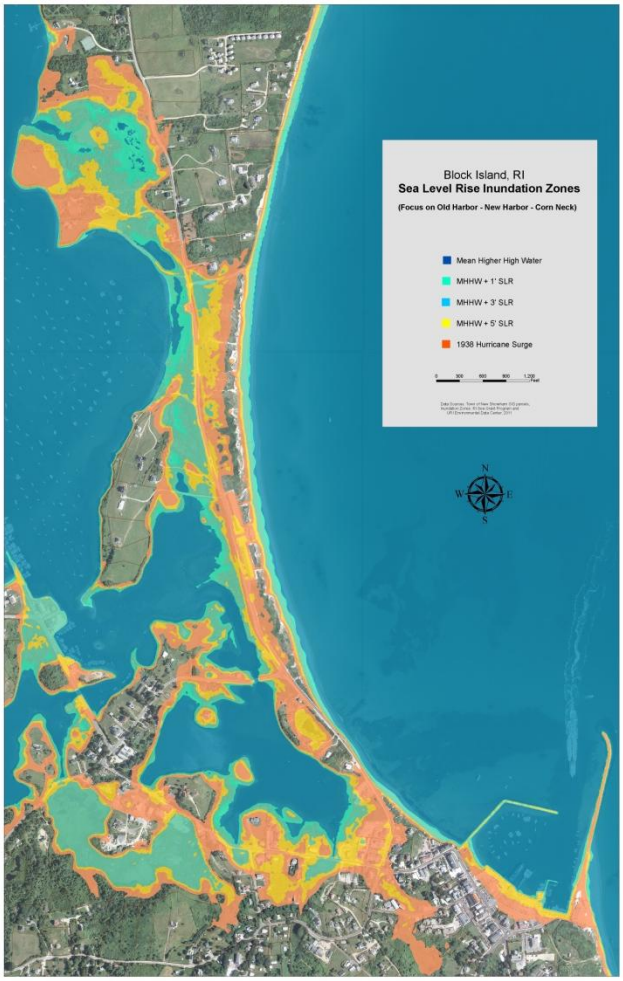
In 2011, the Town of New Shoreham updated its Hazard Mitigation Plan, originally prepared in 2006, with funding by the RI Emergency Management Agency. The plan describes the history of natural disaster events impacting the island – hurricanes (including as far back as the 1938 Hurricane), flooding, nor'easters, snowstorms and windstorms. It includes specific mitigation efforts related to vulnerable infrastructure, including certain roadways subject to hurricane and other storm damage, and a number of sewer pump stations located within the village and harbor areas subject to flooding and loss of power. The plan did make note of two additional potential natural hazards – climate change and sea level rise – but did not specifically address these hazards in terms of actual impacts or response needed by the community. The current study begins to address this critical issue by quantifying the degree of sea level rise expected in the future, and the impacts on the island's transportation infrastructure. The results of this study will be incorporated into the next update of the Hazard Mitigation Plan, scheduled for 2016.

Climate Change Session:

A public session, well attended by a cross-section of island residents, on climate change and the potential impact on the island in terms of flooding, storm surges and overall sea level rise was held on October 8, 2011, and sponsored by three island groups: Scenic Block Island, the

Committee for the Great Salt Pond and the Block Island office of The Nature Conservancy, with assistance from the Town Planning and GIS Departments.

Mapping prepared by the GIS Department using a digital elevation model of coastal Rhode Island made available through the Rhode Island Sea Grant Program, showed the impact on the island of various sea level rise scenarios and storm surges, including the inundation that occurred during the Hurricane of 1938. This preliminary mapping showed that while much of the island, including most of the residentially developed areas, will not be physically impacted by projected sea level rise, infrastructure in the village and harbor areas is vulnerable. Road access to the northern part of the island, Corn Neck, could eventually be severed, and lower lying roads and the land area around New Harbor inundated due to flooding associated with the Great Salt Pond and connecting water bodies. Among the issues brought up during the discussion period was that of the impact of sea level rise on the operation of the ferry terminal in Old Harbor.



Inundation mapping; NS GIS Department

CLIMATE CHANGE AND SEA LEVEL RISE

Impacts of Climate Change on Rhode Island

Changes in the climate, or alterations in the earth's overall weather trends, including air temperatures, length of seasons, annual precipitation and sea levels, is a scientifically documented fact. Governments at all levels will ultimately be forced to address the myriad negative impacts, particularly on the built environment.

In Rhode Island, as in the other New England states, there has been a documented increase in the average annual air temperature, as well as the temperature of Narragansett Bay. The amount of precipitation has increased gradually over the past 100 years, which has resulted in more intense storms with greater flooding, although there is less snow in the winter. The intensity of hurricanes has increased, and sea level rise is evident; as measured at tide gages in Newport, sea level has increased 8.7 inches since 1930.

Sea Level Rise:

Sea level rise, a result of thermal expansion and melting of the glaciers in Greenland and Antarctica, is occurring at an accelerating rate. In the northeast over the past half century, sea levels have been increasing three to four times faster than the global average rate, resulting in a 6 inch rise between 1970 and 2012. By 2050, sea level rise is Rhode Island is projected to increase by one foot or more above 1990 levels, and by 2100, by three to five feet.

Sea level rise, even if not immediately threatening in the form of inundation to a particular coastal site, has a negative impact in other ways. The elevation of a spring high tide today could be the equivalent of a daily high tide in the future, and surges during storms, especially in conjunction with a high tide, will be greater in intensity. The shoreline will also be subject to greater storm induced erosion.

Storm Surges:

Storm surges, waves or elevated water levels generated offshore by high winds associated with storms systems, will continue to increase in frequency due to the increased activity of extra-tropical (nor'easters) and tropical storms. When storms surges are associated with high tides they can be particularly threatening. With the impact of increasing sea levels, in some areas of the northeast storm surges associated with future hurricanes could be several feet higher than under present conditions. The higher storm surges also support larger waves on top of the elevated surge height. In the Atlantic Basin as a whole, there has been a shift toward category 4 and 5 storms, with fewer category 1 and 2 storms, although how this trend will impact hurricanes making landfall is uncertain, as the data is limited due to the rarity of these events.

The combination of these factors – higher sea levels and high tides, and the greater frequency of more severe storm surges – will result in greater coastal flooding and erosion, and more widespread property and infrastructure damage.

(Sources: RI Sea grant Program, URI Coastal Resources Center; University of Rhode Island).

Impacts of Storms on Block Island

Hurricane Irene, 2011:

In late August 2011, this destructive and costly hurricane, which made landfall in the Outer Banks of North Carolina, and in New Jersey and Brooklyn days later, and eventually became a tropical cyclone in New Hampshire and Vermont, caused widespread wind damage and power outage throughout much of Rhode Island, particularly Aquidneck Island (Newport). The storm passed Block Island which was spared power outage and only lost ferry service for a day. High winds did cause some tree damage and there was excitement from large waves rolling in from the south which swept over the east section of the breakwater in Old Harbor. However, there was no permanent damage to any roads or structures, nor to any vessels due to early preparation by the Harbors Department. The west side of the island was subjected to some erosion.

Super Storm Sandy, 2012:

Hurricane Sandy, also referred to as a "super storm", was the most destructive storm of the Atlantic 2012 season. It affected the entire eastern seaboard in the last days of October, most dramatically the New Jersey shore, which took a direct hit, and New York City, which experienced significant storm surges. In Rhode Island most of the damage was along the south coast where fifteen to thirty foot seas pounded the coast over two days, destroying dunes and causing significant flooding and property damage. The duration lasted through multiple tide cycles; storm surges of four to five feet on top of high tide resulted in a storm tide high of over eight feet above mean low tide, as recorded in Newport.

Rising sea level increased the impact of the storm. In New York and New Jersey, an increase in sea level over the past century resulted in a thirteen foot storm surge. Although the storm did not hit Rhode Island directly, it produced damage comparable to what a category 1 or 2 hurricane in an earlier era would have produced. Scientists predict that these impacts will be the new norm for storms in the future.

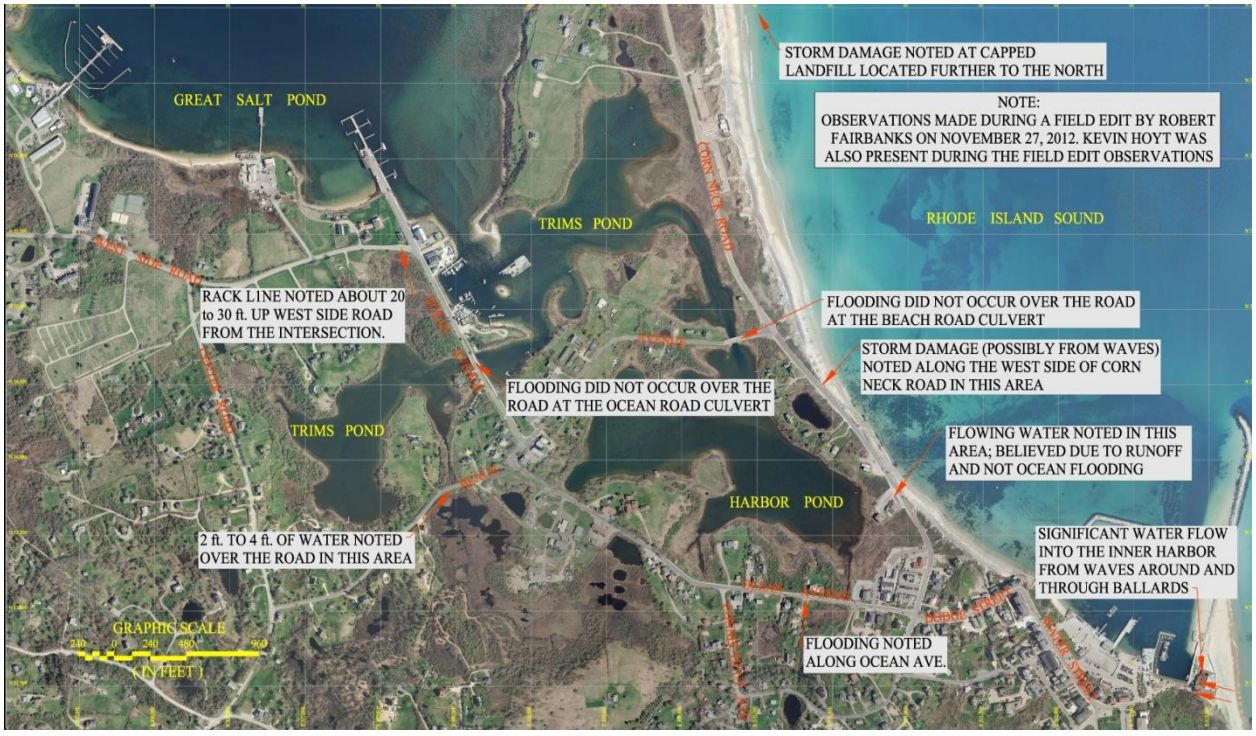
On Block Island, the storm pummeled the eastern side of the island, including Old Harbor and Crescent Beach. Corn Neck Road, which parallels the beach and connects the harbor and village area to the north part of the island, was destroyed for a length of 1,800 feet, isolating one business, restricting access to a number of residences and requiring travelers along the remainder of Corn Neck Road to use an alternate route (Ocean and Beach Avenues).

Corn Neck Road, along Crescent Beach; Alex Brady

A shorter section of Spring Street, leading out of town south of Old Harbor, and also paralleling close to the shore, was damaged. Both roads were rebuilt as part of a $3.1 million emergency repairs contract (funding by US DOT), with construction completed in March. The town beach pavilion also suffered damage, including structural, and had to be shuttered.

In Old Harbor, the bait dock on the east side of the Inner Basin was destroyed. The Army Corp East Dock sustained significant damage. The recently constructed town docks and the ferry dock withstood the storm. However, Ballard's, a large restaurant and bar located on what is essentially a coastal feature between the harbor and the beach, sustained significant damage; waves washed through the building, destroying the easterly wall and filling the first floor with sand.

In New Harbor, there was no structural damage, only localized flooding due to the storm surge that entered the Great Salt Pond. Under the direction of the harbormaster, the harbor had been almost entirely emptied of recreational boats in preparation for the storm. The marinas all took precautions to secure their facilities. The few boats that remained in New Harbor weathered the storm without damage, as they had been thoroughly secured in locations most favorable for the wind direction.



Field review of impacts from Super Storm Sandy; Fairbanks Engineering

Outside of the harbors area, there was considerable beach erosion and damage to the dune system, particularly along Crescent Beach. The Block Island Conservation Commission responded with a plan to install snow fencing to capture the sand, allowing the dunes to rebuild in a cost-effective and sustainable manner. The Conservation Commission, together with the BI Residents Association, purchased (with donations) 90 rolls of fencing and installed it along several access paths to the beach during three community work days in late March and early June 2013, events which attracted a total of over a hundred and fifty volunteers. Beach grass or beach roses are to be planted later as the dunes re-establish. Signs were installed to remind people to stay off the dunes.

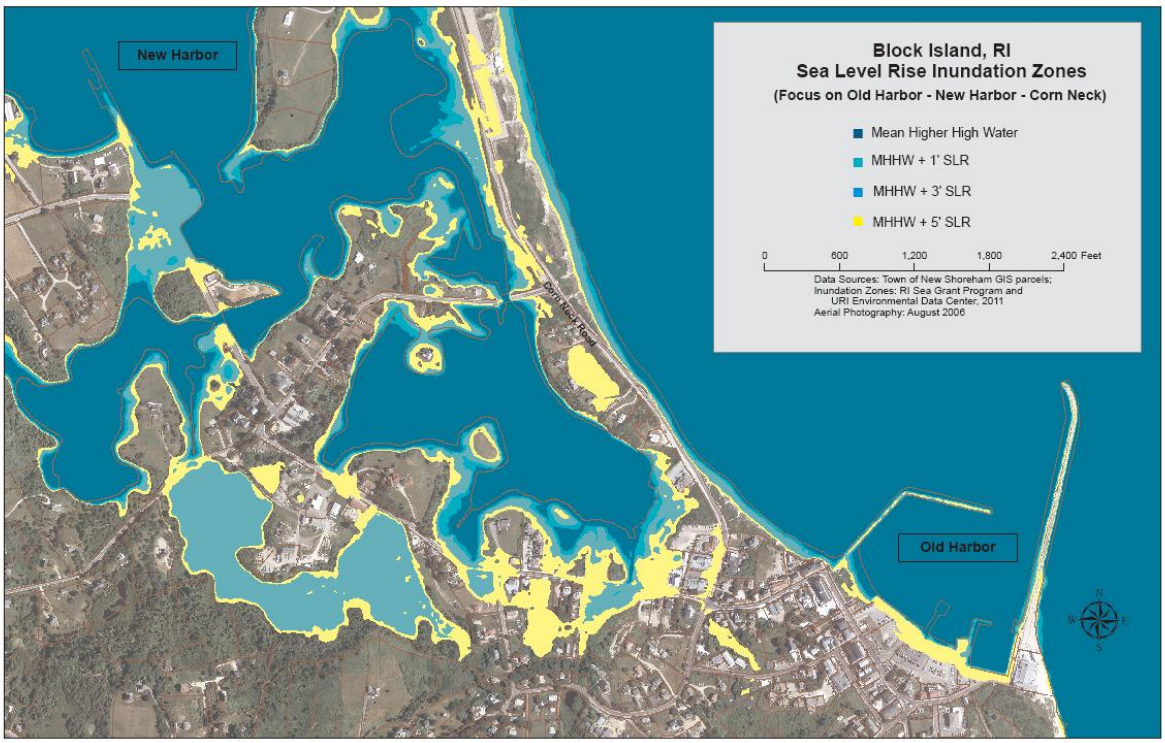
Dune protection sign along Corn Neck Road

SEA LEVEL RISE MAPPING FOR BLOCK ISLAND

Preliminary Mapping

Preliminary project mapping was prepared by the New Shoreham GIS Department applying the digital elevation model of coastal Rhode Island made available through the Rhode Island Sea Grant Program. These maps show the impact of one, three and five foot sea level rise, as well as the areas inundated by the Hurricane of 1938, on the entire island, with more detail focused on the area between Old Harbor and New Harbor. The model uses elevations of the coastal areas of the state based on the consolidation of a number of digital elevation data sources, including bathymetric data, and tidal conditions as measured by the Newport tide gage. This elevation model has been used around the state to show the dramatic impacts of various sea level rise scenarios on the landscape and built environment.

A goal of this project is to verify and improve the level of detail provided by these preliminary maps, and to show the various degrees of inundation that will occur under various sea level rise and storm surge scenarios. Of particular interest are impacts on the Old Harbor breakwater, the docks, the ferry landing and staging area, the land areas and adjoining docks at New Harbor, and many of the roadways in between and leading to other parts of the island.



Preliminary inundation mapping prepared by the New Shoreham GIS Department

Project Mapping and Methodology

New inundation maps were developed using a different elevation source, a statewide airborne LiDAR survey done in 2011[1]. The LiDAR consists of point data or "clouds" which contain every point visible at the time of survey, such as trees, buildings, cars and even people. On average, one point was collected on the ground surface for every meter of land surveyed (although coverage varied, with some areas where the point spacing was 20 meters or more apart). The result is a "bare earth" vertical accuracy of 15 centimeters (5.9 inches) RMSEz[2] or better, allowing for the generation of two foot contour lines. A bare earth version of the LiDAR survey was developed from the point data to create a digital elevation model (DEM) with one meter grid spacing. Surface water bodies were cut out of the grid and given a consistent elevation, allowing for better vertical accuracy. The details for the LiDAR collection and processing, also known as metadata, can be found at the RI Geographic Information Systems (RIGIS) website[3].

The mapping was generated by an Autocad 2013 Civil 3D Mapping and Planning software program based on 2011 orthophotos from RIGIS, using the 2011 LiDAR elevations. Some errors were noted in processing the bare earth file, most likely due to misinterpretation of objects just above the surface of the ground (curbs, low brush, barriers) as ground points. With consideration of the limitations of the LiDAR as described, the first effort was to create a digital terrain model using the bare earth file. Once the terrain model was completed, the data was converted into units of feet, using the elevations contained in the bare earth data. A topographic map was created with one foot contours. The higher resolution of the study mapping is considered artificial in that, similar to the original survey, it is only accurate in generating two foot contours. Nevertheless, the mapping is useful at the study level by showing general trends in topography in the project study area, and identifying the low lying areas prone to inundation during a storm event or sea level rise.

The datum for the project maps is NOAA bench mark data sheet for Station ID 8459338 in Old Harbor, Block Island. The mapping is referenced to Mean Low Water (MLW). NOAA's bench mark data sheet indicates that the Tidal Epoch is from 1983 to 2001, and the length of the series (one year) measurements were conducted from April 1988 to March 1989.[4]

[1] LiDAR, Airborne Light Detection and Ranging, is a remote sensing technology that uses an array of laser beams to collect high resolution elevation data across the landscape.

[2] RMSEz, Root Mean Square Error, is the statistical value equal to the square root of the average of the squares of the differences between known points and modeled points in the LiDAR surface.

[3] See Data Download/Elevation and Derived Products at the following link: http://www.edc.uri.edu/rigis/xslt/metadata.htm?xmlfile=/spfdata/elevation/2011RILiDAR_UTM.xml,xslfile=xsl/FGDC%20Plus.xsl

[4] Both the LiDAR and the benchmarks tidal data are tied to the North American Vertical Datum of 1988 (NAVD88).

Deriving the tidal elevations from station 8459338, the inundation surfaces are determined as follows, with MLW set at 0:

MLW = 0 ft (datum)
MSL = 1.35 ft
NAVD88 = 1.7 ft
MHW = 2.85 ft

MHHW = 3.10 ft
MHHW plus 1 foot SLR = 4.10 ft
MHHW plus 3 foot SLR = 6.10 ft
MHHW plus 1 foot SLR plus 3 ft storm surge = 7.10 ft
MHHW plus 5 foot SLR = 8.10 ft

FEMA 100 year flood elevation = 9.7 ft[5]

Given the lack of certainty of the accuracy of the elevation data, the resulting inundation maps are not suitable for design purposes. Some areas shown to be inundated may or may not be to the extent shown on the plans. Therefore, it is recommended that an actual field survey be conducted prior to undertaking any advance studies or design efforts to address the impacts of flooding. However, as stated above, the results provide a reasonably accurate picture of the vulnerable marine facilities and the landside support areas and roadways, and the impacts under both sea level rise and storm events. In evaluating the impacts of Sandy, it appears that the storm caused flood levels in the study area that align with the 3 foot sea level rise elevation limits, discussed in more detail below.

Impacts of Sea Level Rise as Mapped

The cumulative impacts of four inundation scenarios are indicated in Figure A-2. These are: the elevation of mean higher high water (MHHW) plus one foot sea level rise (SLR); three foot SLR; one foot plus three foot storm surge; and five foot SLR. These same scenarios are presented in additional maps breaking the project area into three sections for greater detail: Old Harbor, Village and Corn Neck Road (Figure A-3); Ocean and Beach Avenues (Figure A-4); and New Harbor (Figure A-5). For ease in understanding the cumulative impacts at each level of sea rise, the study area is shown as impacted by just one foot SLR (Figure A-6), three foot SLR (Figure A-7), and five foot SLR (Figure A-8).

The colors corresponding with a particular SLR scenario indicate the additional areas flooded beyond that expected under MHHW, or MHHW in combination with the lower SLR scenario(s). For example, the green shading shows only that area under one foot SLR impacted beyond the mean higher high water, while the yellow shading shows only that area under three foot SLR impacted beyond that under the one foot SLR scenario, and so on.

[5] The FEMA 100 year flood design elevation of 8 feet is based on NAVD88

Old Harbor and Marine Facilities:

Preliminary mapping showed that under the most extreme scenario, 5 foot SLR, the breakwater that forms the harbor of refuge would be partially inundated, along with up to half of the ferry landing area. The updated project mapping shows significant inundation impacts on the breakwater, particularly the west and north sections. Dramatic results will occur as sea level rise reaches three feet, when these sections of the breakwater will be entirely submerged. The eastern section of the breakwater will be narrowed under 3 foot SLR and significantly compromised under 5 foot SLR. A portion of the beach area between Ballard's and the south end of the eastern breakwater will be submerged under 5 foot SLR. These scenarios show that, as sea level rises, the breakwater as currently constructed would be expected to provide only marginal protection to the inner harbor area, and certainly would be breached by waves on top of storm surge generated by tropical and extra-tropical storms.

North and west sections of Old Harbor Breakwater

As sea level rise reaches three feet, some of the marine facilities and shore-side areas of Old Harbor will become flooded. The town dock and adjoining landside area, including the harbormaster's building, will all be inundated, as will the area alongside the ferry docks and the ferry office and ticket building. A three foot storm surge on top of 1 foot SLR will flood a significant portion of the area, impacting all of the buildings except the freight office. As sea level rise reaches five feet, Old Harbor will become a much different place than it is today, as most of the landing area will be inundated, including all the buildings and about half the parking and queuing area. The natural shoreline (small beach area) west of the ferry site will eventually loose area to inundation because of its lower elevation. Given the possibility of stronger storm surges, the impacts from rising sea level will be quite dramatic long before the five foot scenario occurs.

Roadways between Old Harbor and New Harbor:

Access out of Old Harbor includes a number of roads – Spring Street, High Street, Old Town Road – that lead to the central and southern parts of the island. These all rise in elevation and are not subject to any foreseeable inundation scenarios. However, as climate changes, some roads will be subject to more severe and frequent storm induced erosion damage. The section of Spring Street (not included in this study) damaged by Super Storm Sandy adjoins a bluff that was undercut by wave action. The narrow part of Corn Neck Road was damaged by waves accompanying the storm surges of Sandy. While the actual loss of the road to the rising sea appears to be many years away, it will be subject to storm erosion in the meantime.

For the village area road system, the impact of sea level rise will be increased flooding and the eventual submergence of some sections. The two bridges – Beach Avenue, near its intersection with Corn Neck Road, and Ocean Avenue, approaching New Harbor – are vulnerable as well. The roads and bridges connecting Old Harbor to New Harbor include many areas that are vulnerable to flooding from the large inland water bodies tidally connected to the Great Salt Pond – Harbor Pond and Trim's Pond. As sea level rises, the geography of the area connecting the harbors will be dramatically impacted, requiring that alternatives to the present roadway configuration be developed.

The impacts will be noticeable as sea level rise reaches three feet. Ocean Avenue, between the intersection with Corn Neck Road (Bridge Gate Square) and Beach Avenue, will be inundated in a couple of areas, including its intersection with Connecticut Avenue, which connects with Old Town Road to the south and is an access to the center of the island. Beach Avenue, west of its intersection with Ocean Avenue and another important access to the center of the island, will be inundated due to flooding associated with a large wetland system behind the Block Island power plant. Most dramatically, the section of Ocean Avenue between the Hog Pen and Payne's Dock, including its intersection with West Side Road, the major road connecting New Harbor with the outlying residential areas, will be completely flooded on an average high tide.

Ocean Avenue leading into New Harbor

As sea level rise reaches five feet, the flooded areas described above will be enlarged significantly; most of Ocean Avenue between Bridge Gate Square and Beach Avenue will be inundated, as will both approaches to the Beach Avenue Bridge, cutting off connection to Corn Neck Road. Corn Neck Road will be flooded along its west side from a rising Trim's Pond. At its present elevation, the Ocean Avenue Bridge will be lost, as will a small complex of buildings on the west side of Ocean Avenue just south of the bridge.

With no changes to infrastructure, the result of 3 foot SLR, and eventually 5 foot SLR, will be the isolation, in terms of public roadway access, of a number of areas in and around the village and New Harbor. This includes residential and commercial areas adjoining most of Ocean Avenue west of Bridge Gate Square. When the bridges are damaged or become impassable, the peninsula that separates the east portion of Trim's Pond from Harbor Pond, traversed east-west by Beach Avenue, will be cut off from both Corn Neck and New Harbor, and from the remainder of the island by flooding along Beach Avenue to the west and that described along Ocean Avenue. This area includes a number of residences and some inns, but most significantly, the public safety buildings – the police station, and next door, the fire station which also houses the island's ambulance services.

Police and fire station on Beach Avenue

New Harbor:

In New Harbor, all the marine facilities will eventually sustain impacts to some degree. The shoreline areas alongside the three dock structures will eventually succumb to higher sea levels, requiring adjustments. The buildings associated with Champlin's Marina, and with the Boat Basin, including a commercial building and a popular restaurant, appear to be protected by elevation. However, the dock at Champlin's, and more significantly, Payne's Dock, show inundation as sea level rise reaches three feet. A large wetland system lying between Champlin's and the Boat Basin can absorb a lot of the eventual flooding impact. However, as sea level rises, the impacts of storm surges will become more significant and as it reaches five feet, the Boat Basin complex will be cut off from West Side Road.

More significant is the permanent loss of a large low-lying area between Payne's Dock and the Hog Pen on both sides of Ocean Avenue, which as stated above, will be completely inundated at 3 foot SLR. On the west side it includes a cottage associated with the Narragansett Inn property, a mostly hilly parcel which lies between the Boat Basin and Payne's Dock and fronts a small beach (unaltered shoreline). On the east side of Ocean Avenue the doomed area supports a large restaurant, a small residence and the BI Maritime Institute building which also houses a restaurant. At 5 foot SLR more of this area will be inundated, as will the Ocean Avenue Bridge (at its present elevation).

This inundation scenario indicates an opening between two sections of Trim's Pond near its inlet with the Great Salt Pond by the submergence of a significant area of low-lying land. This will result in the creation of a small island in the middle of an enlarged Trim's Pond; if the Ocean Avenue Bridge is abandoned, it will have no roadway connection to the rest of the island. This small area is partially developed, used for marina and boat rental activities and the storage of individual oil tanks, but with no permanent structures. The complete inundation of the lower section of Ocean Avenue will mean that someday the only way to connect New Harbor with the rest of the island, including Beach Avenue, will be by West Side Road.

Ocean Avenue area vulnerable to sea level rise

Sewer Lines and Pump Stations:

The village area subjected to the impacts of climate change and sea level rise is also associated with the Town's water and sewer districts. The Town's sewage treatment processing facility is located just south of the Old Harbor village area on Spring Street and does not appear vulnerable to either storm surges or sea level rise. It also has two diesel generators, used to run the sewage treatment plant during the summer season as an alternative to the high cost of electricity on the island.

Sewer lines run along all of the streets in the village area and a short distance along Corn Neck Road. Ocean Avenue is sewered for its entire length; this line which continues along West Side Road, provides sewer services to all of the marine businesses – Payne's Dock, the Boat Basin and Champlin's Marina. There are a number of pump stations, five shown within the study area.

The locations of the sewer lines and pump stations are indicated on Figures A-2 through A-8 appended to this report. While the two along Ocean Avenue would be impacted by a 3 foot SLR, all but one of the pump stations (that closest to the treatment facility) would be impacted by a 5 foot SLR.

ADAPTATION STRATEGY

The adaptation strategy to address the impacts of sea level rise on the harbor and village areas of Block Island includes design concepts to retrofit the marine facilities, proposals regarding infrastructure – roads and the sewage pumping stations – and emergency planning to respond to major storm events that impact the operation of the ferry, the functioning of area roadways and the safety of the public, including visitors.

Engineering Solutions

Field Review:

Field inspection of the critical transportation infrastructure was undertaken. At Old Harbor this included the ferry terminal facility operated by Interstate Navigation, the town docks and the harbormaster's building, and the existing stone breakwater and revetment system. At New Harbor this included the docks and boat ramp. In addition, the impacts of sea level rise along the roadway and bridge sections of Ocean and Beach Avenues were reviewed.

Design Concepts:

With an understanding of the areas of the island and the specific facilities subject to the destructive impacts of sea level rise and storm surges, the next step is to identify engineering solutions, both temporary and long-term. These include design concepts to protect the marine facilities and infrastructure from both the inevitable sea level rise and the more current threat of storm surges. Typical methods to address the impacts of sea level rise on the infrastructure are summarized as follows:

Breakwaters at Old Harbor

Increase the elevation of these structures based on the sea level rise both experienced and predicted, and on increased design wave heights provided by revised FEMA flood studies.

Piers at Old and New Harbors

Raise the elevations of the piers as necessary to stay above the rising sea level. This is to be undertaken during normal maintenance re-construction work.

Roadways

Abandon the road
Re-align the road to a higher elevation
Provide fill to raise the road
Reconstruct the road as a causeway
Provide shoreline protection for the road as part of maintenance, such as a stone revetment or seawall structure.

Pump Stations

Provide back-up power
Flood-proof by use of submersible pumps and watertight casings for electrical equipment
Construct in-ground flood barriers
Add stabilizing structures to counter uplift forces
Raise the elevation

Cost for these modifications will vary greatly depending on the height of sea level rise and the structure or mitigation employed. Shoreline protection systems (revetments and seawalls) can range from $500 to greater than $10,000 per linear foot of shoreline protected. Road work costs will be highly dependent on the amount and cost of soil borrow fill material required to elevate the road and also the cost for asphalt pavement which fluctuates widely based on the price of crude oil.

Marine Facilities and Recommendations:

There are several marine related facilities on Block Island that will be impacted by sea level rise. At Old Harbor these include the breakwater system; the steel sheet-pile bulkhead structures that line much of the shoreline; the timber ferry dock; the Town's timber dock system at the Inner Basin; and the harbormaster's building. At New Harbor these include the timber dock system and the Town's boat ramp.

Stone Breakwater System

- Most of the existing stone breakwater system is in fair condition. The exception is the north end of the east breakwater which is in poor condition and has partially failed. The breakwater is shown to be inundated as sea level rises, requiring that its elevation be raised to provide adequate protection for the harbor.

- It is recommended that armor stone be added to an appropriate elevation, including use of larger stones where required. The stone size should be determined by the required design wave height as provided by updated FEMA flood studies.

- The cost to raise these structures about five feet is estimated to be $13,000,000. However, additional survey and bathymetry is required to verify quantities. The armor stone size, which will be a function of the design wave height, can significantly impact cost.

Sheet-Pile Bulkheads

- The existing steel sheet pile bulkheads along the shoreline within Old Harbor are in varying condition. The Town's bulkhead at the Inner Basin is relatively new and in good condition.

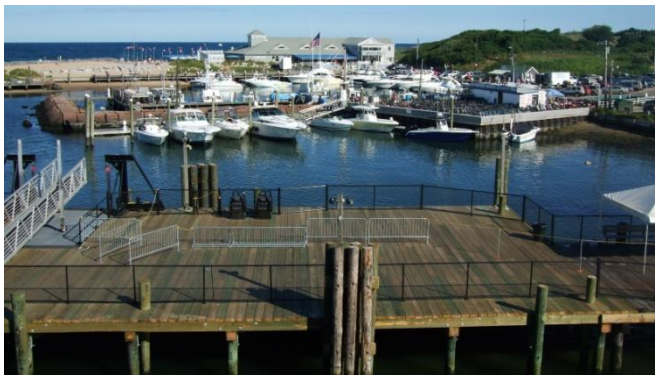
- The bulkheads along the shoreline within Old Harbor typically have a design life of about 20 to 30 years. The height of these structures should be re-evaluated according to the actual sea

level rise projections at the time these structures need maintenance. It may be beneficial to raise these bulkheads to provide better protection. The cost for steel sheet pile bulk head systems is anticipated to be $3,000 to $5,000 per lineal foot.

Timber Docks in Old Harbor

- The Town's timber dock system and Interstate Navigation's timber docks are all in good condition having been repaired or reconstructed within the last few years. They are expected to have a design life of about 20 to 30 years.

- Similar to the bulk heads, the elevation of the docks may be raised to accommodate sea level rise during the next maintenance cycle. New fixed timber dock construction is estimated to cost between $150 and $300 per square foot.



Timber docks in Old Harbor

Harbormaster's Building

- The harbormaster's building was rebuilt in the last few years and is in good condition. It was designed to allow flooding during storm events through the use of flood vents in the exterior walls of the building.

- Similar to the bulkhead systems and docks, an evaluation should be made to the harbormaster's building during its next maintenance phase. It is anticipated that if the docks and nearby roadways are elevated in the future to accommodate sea level rise, the building would also be raised in elevation.

Boat Ramp, New Harbor

- The Town's boat ramp at New Harbor is in poor condition and is in need of repair or replacement.

- Given the site and topographic restrictions, there is no viable way to accommodate sea level rise at the site of the boat ramp. It will need to be relocated in the future.

Boat ramp at New Harbor

Timber Docks in New Harbor

- The timber docks in New Pond are in fair to good condition and appear to be maintained as needed by their owners.

- Similar to the timber docks at Old Harbor, the docks at New Harbor, particularly Payne's Dock, should be evaluated and possibly raised to accommodate sea level rise during the next maintenance cycle.

The dock at the Boat Basin, New Harbor

Vulnerable Roadways and Recommendations:

As described previously in this report, many of the roadways between the two harbors are vulnerable to the impacts of sea level rise. These include sections of Ocean Avenue between Bridge Gate Square and the intersection with Beach Avenue, subject to flooding associated with Harbor Pond; an area of Beach Avenue west of its intersection with Ocean Avenue, subject to flooding from the east portion of Trim's Pond; and most dramatically Ocean Avenue at its low elevations between the Hog Pen and Payne's Dock, which will eventually become part of an enlarged Trim's Pond. The Ocean Avenue Bridge and the west and east approaches to the Beach Avenue Bridge are shown as inundated at 5 foot SLR, as is the section of Corn Neck Road which lies between Trim's Pond and Crescent Beach.

Ocean Avenue, South

- This is a state roadway in good condition and is a crucial connecting road between the harbors and the center part of the island.

- Near term impacts – flooding from storm surges – should be addressed by the development of a coastal model evaluating surges as impacted by sea level rise and tides. Infrastructure improvements or adjustments would be based on 100 year design waves and inundation levels.

- Long term impacts – due to sea level rise – will require raising the elevations of the impacted areas of the road.

Beach Avenue

- This is also a state roadway in good condition and serves to connect the northern part of the island (Corn Neck) to interior areas, and also serves as an alternate road connection to New Harbor (via Center Road and West Side Road).

- Near term impacts – flooding from storm surges – should also be addressed by a coastal model and study, with similar solutions as those for Ocean Avenue.

- Long term impacts – due to sea level rise – will require raising the elevations of the impacted areas of the road, or construction of a bridge.

Ocean Avenue, North

- This section of the state roadway leading into New Harbor is in good condition and includes a bridge over the narrow channel that connects the east and west sections of Trim's Pond. It provides the only access to the Hog Pen and is one of only two roadways providing access to Payne's Dock.

- Near term impacts – flooding from storm surges – should also be addressed by a coastal model and study, with similar solutions as those for the south section of Ocean Avenue and Beach Avenue.

- Long term impacts – due to sea level rise – will most likely involve abandonment and the use of Beach Avenue, Center Road and West Side Road as access to New Harbor. Access to Payne's Dock may require new road construction.

Corn Neck Road

- This is also a state roadway in generally good condition; the section damaged by Super Storm Sandy has been completely repaired. It serves as the only road access to the northern part of the island (referred to as "The Neck").

- Near term impacts – potential damage by storm surges from another tropical or semi-tropical storm – must be monitored by the State Department of Transportation and the Town.

- Long term impacts – due to sea level rise – will require raising the elevations of the impacted areas of the road, or possible dredging of the salt ponds to increase their storm surge capacity.

Sewer Lines and Pump Stations

- There are four pump stations in locations shown to be eventually impacted by inundation due to sea level rise. Two are located on Ocean Avenue, one near Bridge Gate Square and the second near the bridge over Trim's Pond. The others are at the Boat Basin and Champlin's Marina. As stated in the Hazard Mitigation Plan, the pump stations (five total) currently do not have a back-up power source. In the event of extended power outage, a sewage overflow could cause potential contamination of the groundwater and coastal ponds.

- The stability of the pump stations during flooding events, especially the wet well, will require evaluation and possible mitigation. In the meantime, portable generators are needed for rapid response during power failures.

- Long term impacts of inundation due to sea level rise will require retrofits to flood-proof the pumps and electrical components, such as casings and flood barriers, as well as a means of stabilizing them against the uplift forces of floodwaters. Eventually the elevations of the pump stations will have to be raised.

Emergency Contingency Planning

As stated in the Town's 2011 Hazard Mitigation Plan: *"Damage resulting from natural hazards to the harbors, docks, airports, ferries or planes would cripple the island in every way."*

In general, the emergency planning as part of the current project supplements the work done under the Hazard Mitigation Plan which deals more directly with the short term impacts of storm damage and power loss.

Ferry Operations:

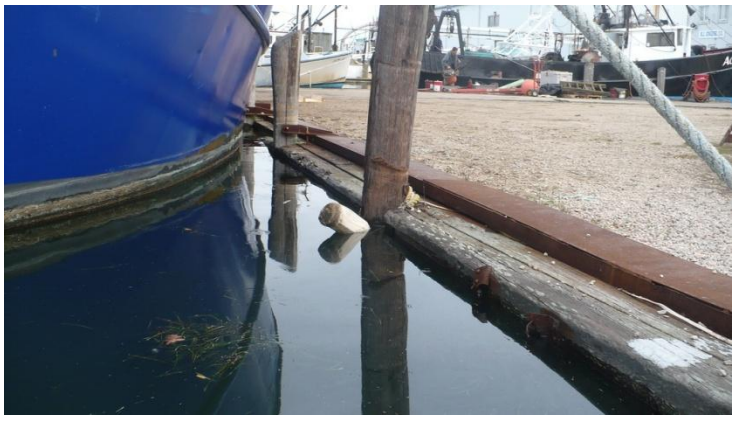
Well in advance of a hurricane or other major tropical storm event, the ferry company, Interstate Navigation, ceases its daily runs between Point Judith, Narragansett and Old Harbor and moves the ferry vessels to their more secure facility in New London, Ct. Vacationers and other overnight visitors are strongly encouraged to leave the island in advance of the storm and the ferry company makes every effort to move all persons off the island who desire to leave.

Block Island

In the event that use of Old Harbor is compromised, although unlikely, Payne's Dock in New Harbor could be used as an alternate ferry landing site, particularly important for bringing food, fuel and supplies onto the island. However, the dock is not structurally rated for trailer trucks so the transfer of supplies from the trucks onto the island would have to occur by forklift.

Galilee

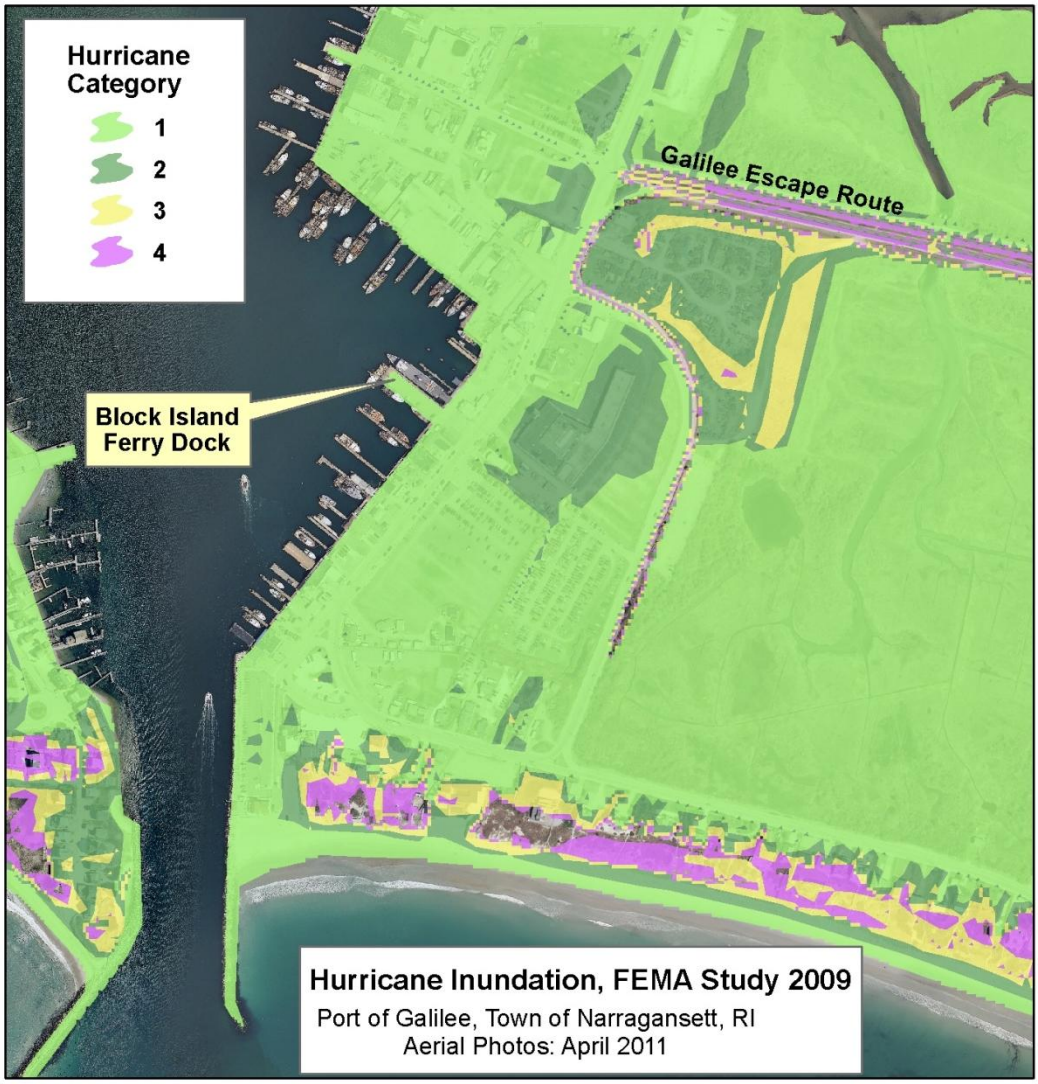
Alternative harbors on the mainland should also be identified as a location for temporary ferry service in the event that storm damage or inundation renders the terminal in the Port of Galilee (referred to on the ferry schedule as Point Judith) inoperable. Over the longer term, it appears that the ferry terminal facility in Narragansett, located on state property (RI Department of Environmental Management), is particularly vulnerable to sea level rise, as well as flooding due to coastal storms.



Ferry docking site in Galilee at high tide, 10/27/2011; Clara Rubin

Although sea level rise maps were not prepared for Galilee, a hurricane surge inundation map, available from the US Army Corps of Engineers through the Rhode Island Hurricane Evacuation Study, was modified to show the areas near the ferry landing that are vulnerable to hurricane surges. The maps were developed by overlaying the hurricane surge water surface elevations on

top of ground elevations from FEMA LiDAR data to show which areas would be inundated by hurricane storm surges. The model assumes a worst case scenario in terms of landfall location, wind speeds and direction, and in combination with mean high water.



Modified Hurricane Inundation Map for Galilee; NS GIS Department

As the mapping clearly shows, the Port and all of its associated marine related commercial and recreational areas, as well as numerous residences, are extremely vulnerable to even a category 1 hurricane. It is also expected that the dune system along the south shore would be damaged and that the breach would occur at a lower level intensity storm despite the map indicating that those areas would only be breached as a result of a category 3 or category 4 hurricane.

Public Safety/Emergency Response:

All overnight visitors are strongly encouraged to leave the island in advance of a major storm. Every year, as part of its free informational summer publication, the Block Island Times includes a prominent column called "Hurricane Planning for Residents and Visitors". Due to the lack of emergency shelter space for a large summer population, as well as the inability of the island to deal with large scale medical emergencies, the overriding emphasis of the column is on leaving the island when warned to do so. Because the ferries must move to safe harbor well in advance of a storm, the need to react to such directives is immediate.

Regarding the safety of recreational boaters, most of the work of the harbormaster occurs prior to a hurricane or major storm. In order to protect lives, and minimize or nearly eliminate the damage to recreational boats and potential collateral damage to other boats and infrastructure, visiting sailors and motor boaters are strongly directed to leave for their home ports. Use of town moorings is prohibited. To the extent possible, all local boats, including those belonging to the Town, are pulled out of the water. Those vessels remaining, particularly the commercial fleet in Old Harbor, are monitored by their owners and the harbormaster. Lines are adjusted during the storm in response to changing conditions.

Rough surf during Super Storm Sandy; Alex Brady

Public Outreach Program

The results of this study will be incorporated into the Hazard Mitigation Plan when it is updated in 2016. This project will also be referenced and summarized in the New Shoreham Comprehensive Plan, scheduled for update in 2014, under a new state required component "Natural Hazards".

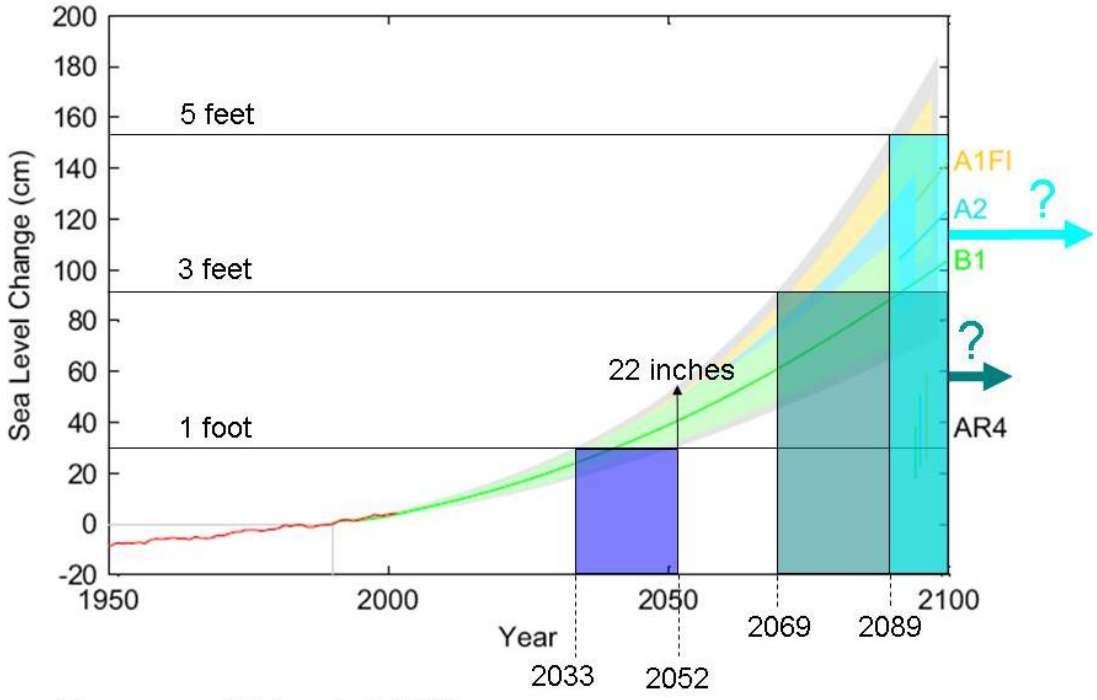
As part of the public education effort related to this project, a pamphlet was developed to provide islanders with information on what to expect from the impacts of a changing climate, particularly under emergency situations. To develop the pamphlet, the Old Harbor Task Force and the Committee for the Great Salt Pond partnered with the Town to undertake its preparation and distribution. As an attachment to this report, the pamphlet describes the sea level rise scenarios and storm events, and directs the community in responding to long term changes as well as to situations when transportation to and from the mainland is interrupted.

CONCLUSIONS AND NEXT STEPS

Time Frame for Sea Level Rise

The Vermeer and Rahmstorf[6] global sea level rise curve, reprinted below, shows the range of possibilities for sea level rise under various greenhouse gas scenarios identified by the Intergovernmental Panel on Climate Change. The sea level trend clearly shows acceleration over time. It also shows that the uncertainty of the projections is greater the further into the future the projections are made. In the worst case, sea levels could reach five feet above 1990 heights during the last decade of this century (around 2089). In the shorter term, 20 to 40 years from now, sea levels will be anywhere from 12 to 22 inches above the 1990 levels.

There have been various studies indicating that the relative sea level rise in the mid Atlantic and the Northeast is occurring at a higher rate than the global average. In Rhode Island, the average as measured in Newport over the last eighty years is approximately one inch every ten years (2.68 mm per year). However, in the last several years the rate has dramatically increased, as studied and graphed by State Geologist Jon Boothroyd at the University of Rhode Island.



Vermeer and Rahmstorf, 2009

[6] "Global sea level linked to global temperature", Martin Vermeer and Stefan Rahmstorf, Proceedings of the US National Academy of the Sciences, December 2009.

Impacts of Sea Level Rise and Increased Storm Intensities

While coastal properties, public infrastructure and natural resources will all be at eventual risk from rising sea level, there are a number of more immediate effects. These include the continued erosion of shorelines, possibly at faster rates due to higher storm surges; the potential saltwater contamination of freshwater, including drinking water supplies, especially wells located in low lying areas near the coast; and higher storm surge flooding with storm surges occurring further inland. It is important to note that, although temporary, the impacts of a two foot high storm surge, typical in a moderate extra-tropical storm, on top of a one foot rise in sea level is roughly equivalent to the impact of a three foot sea level rise. If the storm surge occurs at a high tide the impacts are even more pronounced.

Because hurricanes require warm sea surfaces to develop and maintain, the increase in sea surface temperatures can be linked to higher intensity hurricanes of a longer duration. Changing climate may also be responsible for the movement of major storm tracks northward. This will result in more property damage, flooding associated with increase rainfall, and greater risk to public health and safety.

State Planning Efforts

RI Climate Change Commission:

The Rhode Island Climate Change Commission, established under a 2010 state law, is a standing commission made up of legislators and representatives from state agencies and business, community and environmental organizations. The Commission's mandate is to study the projected impacts of climate change on Rhode Island and identify methods to protect both the natural and built environment. The eventual goal is to integrate climate change planning and adaptation into state and municipal programs and policies, including infrastructure development and maintenance.

The commission released a progress report in November 2012: *Adapting to Climate Change in the Ocean State: A Starting Point*. Of three working groups established by the commission is one to deal with infrastructure and the built environment; the others deal with natural resources and habitats, and with public health issues. The progress report describes the vulnerability of infrastructure located within river and coastal floodplains. These include wastewater treatment systems, energy infrastructure, and any number of transportation features including ports, roads, railroads and bridges. However the working group has not yet undertaken detailed risk assessments of specific infrastructure and the impacted populations that could eventually lead to identifiable initiatives or adaptation techniques.

RI Comprehensive Planning Act:

Another important state level legislative act was a set of amendments in 2011 to the RI Comprehensive Planning and Land Use Regulation Act, which included new content requirements for community comprehensive plans. One of these is a "Natural Hazards"

component identifying areas vulnerable to the effects of sea level rise, flooding and erosion, with policies and implementation techniques addressing these impacts. This addition, among others, including one to consider energy production and use, must be incorporated into local comprehensive plans by 2016.

RI Shoreline Change Special Area Management Plan:

The RI Coastal Resources Management Council is currently undertaking a Shoreline Change Special Area Management Plan, referred to as the Beach SAMP. It is a collaborative effort that includes the University of Rhode Island (URI) Coastal Resources Center/RI Sea Grant Program and the URI College of Environment and Life Sciences, as well as other state agencies and all of the coastal and bay communities. The goal is to prepare a state management plan that results in policies and regulations addressing both the short and long term changes to the shoreline from erosion, flooding and sea level rise, principally as it will affect the built environment. The project will involve extensive study and coastal modeling, and its initial phase will focus on the "South County" communities, including New Shoreham. The Block Island Harbors Sea Level Adaptation Study will be coordinated with the Beach SAMP.

Infrastructure Improvements and Building Code:

Both the mandate of the Climate Change Commission and a goal of the on-going Beach SAMP is to identify the vulnerable infrastructure along Rhode Island's coastlines, and the degree to which damage or loss of the infrastructure impacts the area population. This knowledge is to be used in long term planning for adaptation, including maintenance or replacement of vulnerable infrastructure.

This will aid Block Island as all of the roads in the village area, including those susceptible to flooding and sea level rise, are state owned and maintained, falling under the auspices of the Rhode Island Department of Transportation,. who is actively considering the impacts of climate change on vulnerable state roads under an recently established "infrastructure adaptation strategy".

Likewise, the State of Rhode Island Building Code regulates all construction at the local level (enforced by the building official). The state building code now requires a minimum one foot freeboard height in all Velocity (V) and Coastal A Zones. New and substantially rebuilt structures in the A Zone must be built to V Zone standards. There are also residential construction requirements for areas with high wind conditions, which includes Block Island.

Port of Galilee:

The Port of Galilee is owned by the State of Rhode Island and managed by the Department of Environmental Management. While its principal use is commercial fishing – it is the state's largest fishing port – year-round ferry transportation to and from Block Island is entirely reliant upon the ferry terminal and the large areas set aside for over-night and long-term parking. The future of the port as a commercial fishing hub and as a ferry terminal is protected to a large degree by its public ownership. However, the impact of sea level rise and storm surges on the

port should be thoroughly studied by the State, with input from both New Shoreham and the Town of Narragansett. To protect the operation of the ferry service, including roadway access to the terminal, plans should be developed to respond to damage from major storms. Eventually, adaptation techniques will need to be developed and implemented to respond to the inevitable rise of sea level.

Ferry boat and fishing vessel, Port of Galilee

Block Island Airport:

The Block Island Airport, owned and managed by the State of RI, is a very active airport, especially during the summer season. Aside from the ferry service and private boats, it provides the only other means of transport to and from the island. High winds and fog often shut down air traffic, and it is obviously not operational during a severe storm. The short runway cannot support larger planes. However, the airport may provide emergency access for supplies and transport in the event of extreme storm damage to the ferry terminal harbors on or off island for an extended time. Investigations should be undertaken to evaluate the runway length for landing and takeoff of cargo planes under such emergencies.

Local Planning and Regulatory Efforts

Planning and Zoning:

The Town will include the results of this study, as well as an evaluation of the impact of sea level rise on the island as a whole, in the update to the New Shoreham Comprehensive Plan scheduled for early 2014.

As a result of the dramatic impacts depicted by the sea level rise maps, the Town should evaluate its land use and building regulations to consider future development and redevelopment in the most critically impacted inundation areas. Presently, the Town has an established Coastal Zone, a highly restrictive district in terms of allowable uses, which consists of all landward area 100 feet from a delineated coastal feature, such as a bluff, dune, coastal pond or wetland. The Coastal Zone is not currently mapped as it depends upon field verification by the RI CRMC of these coastal features. It is important that this zone be mapped and that the 100 foot setback and restrictions on development be maintained in the zoning ordinance. The Town may also want to consider changes to building heights in areas susceptible to coastal flooding to accommodate additional freeboard.

Land Acquisition:

The Town and private conservation organizations should consider vulnerable areas in their land acquisition programs. As an example, in 2012, the Block Island Land Trust and the Block Island Conservancy purchased two parcels and received a conservation easement over a third, to protect a total of 1.3 acres of land along Corn Neck Road, in the area that sustained direct damage from Super Storm Sandy. They have since removed a dilapidated building located on one of the lots and are making plans for public use (with no permanent structures).

Corn Neck property acquired by the Block Island Land Trust

Dune Restoration/Shoreline Management:

Dunes serve as a vital barrier to protect against storm surges. Their loss or erosion can lead to greater risk to the properties lying behind. The Conservation Commission and other island groups should continue their program of fencing the dunes in order to build and stabilize them and to aid in beach replenishment, as needed. It is recommended that the town and private organizations on the island that deal with environmental issues work together, in conjunction with state agencies, to prepare for storms and sea level rise using natural systems and in a sustainable manner.

Emergency Management Procedures:

The inundation mapping indicates that under certain extreme storm conditions, much of the harbor and village area of Block Island will be flooded. For example, in the event of a major storm occurring at high tide and with a significant storm surge that together mimic the impact of three feet of sea level rise, parts of the island will be isolated. If Ocean Avenue is flooded in parts and Corn Neck Road is damaged as it was during Sandy in the area south of its intersection with Beach Avenue, road access between the public safety complex and most of the rest of the island will be cut off. The police, fire and rescue services must eventually prepare for such an event, including setting up a satellite public safety center and stationing fire engines and fully equipped ambulances at other island locations.

Hurricane planning involving summer visitors should also be strengthened. Block Island is a beloved vacation destination. Spending part of a summer on the island requires advance planning, particularly if one brings over a vehicle, and often involves a large expense, so there is a natural reluctance to cut short a vacation. Stronger policies requiring departure from the island, combined with incentives could be considered. Hotel and inn keepers and owners of vacation rentals should all play their part in terms of flexibility regarding the cost of vacation time lost to a storm. Travel insurance to be used specifically in the event of a hurricane or dangerous storm could be offered, even in a collective fashion, on Block Island. These issues will be more thoroughly addressed when the Town updates its Hazard Mitigation Plan in 2016.

Future Studies / Data Needs

In order to adequately prepare for the impacts of sea level rise and storm surges, both in terms of maintaining vulnerable infrastructure and providing for public safety, all levels of government must be actively involved. Efforts include acquiring and updating scientific information, developing solutions, creating programs and policies, and of course, communicating with each other and with the public. There are a number of studies which the Town of New Shoreham and the State of Rhode Island would benefit from.

Measuring, Modeling and Storm Tracking:

- Rhode Island and Block Island must continue to monitor actual regional and local sea level heights and update their own projections of sea level rise based on ongoing scientific studies.

- The sea level rise inundation mapping for Block Island should be refined and updated based on more accurate elevation data.

- To aid in determining the impacts of storm surges, as well as possible mitigation strategies, hydrologic studies of the Great Salt Pond and Trim's Harbor Ponds should be undertaken. These include tide and current measurements and dye tests to determine circulation patterns.

- Shoreline change and bluff erosion mapping of Block Island should be completed by the Coastal Resources Management Council with assistance from the Town.

- Due to the uncertainty of future hurricane activity in terms of frequency, size and tracking, the State of Rhode Island should undertake hurricane surge modeling for the Rhode Island coastal zone, as was done recently for New York City[7].

[7] "Physically based assessment of hurricane surge threat under climate change", Ning Lin, Kerry Emanuel, Michael Oppenheimer and Erik Vanmarcke, Nature Climate Change, June 2012

Maintaining Public Awareness:

Much has been written about the issue of climate change and the difficulty our culture and political system have in responding, in both addressing the man-made causes and dealing adequately with the impacts. As long as there is a small but loud minority challenging accepted science, an uncertainty of the role that climate change plays in recent extreme weather events, and the relative infrequency of very damaging coastal storms, addressing a problem that has both a long term cause and effect is a real challenge. Focusing on the sea level rise that will happen fifty or one hundred years from now is difficult for decision-makers, especially when the response may require great expense and there are urgent immediate needs for public resources. This is compounded by the fact that the actual impacts are and will be felt differently in different parts of the country and even differently within one region or one state.

Block Island must remain committed to studying and responding to the issues of climate change and sea level rise. This includes working with the State to continuously update the scientific data, and to keep adaptation always in mind when developing policies, planning for the future and regulating development in future inundation areas.

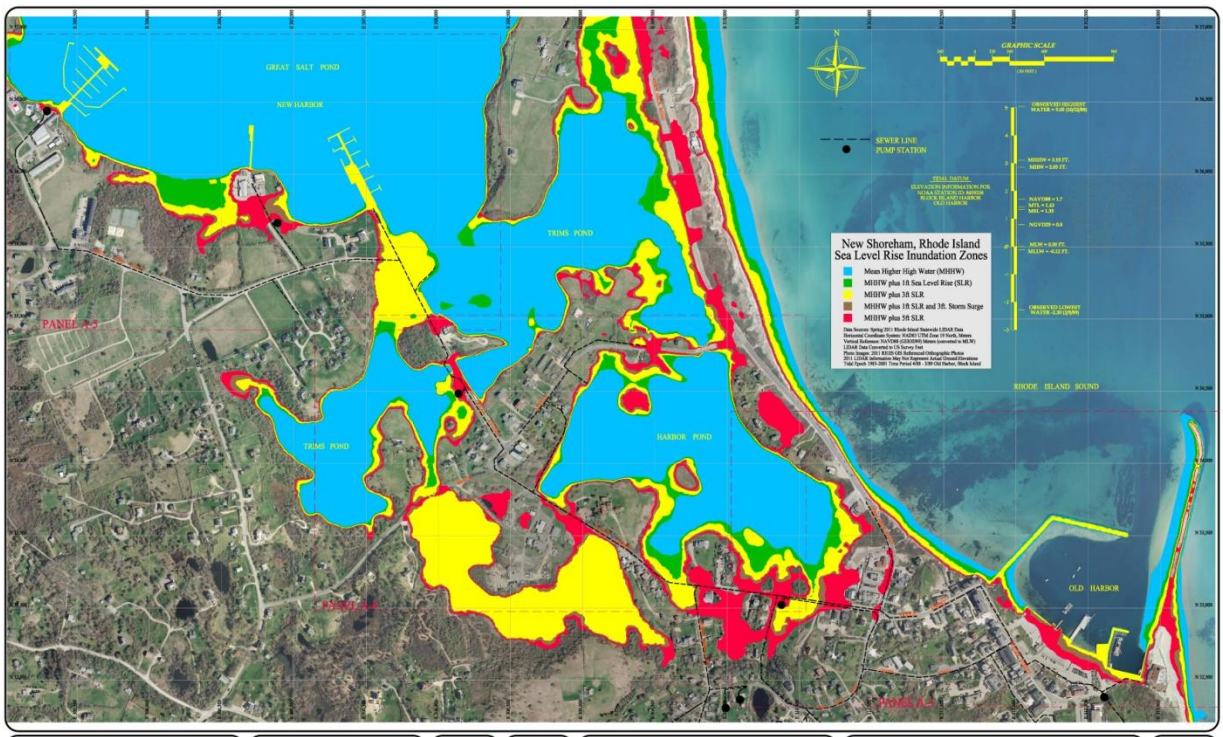
APPENDICIES

Maps

Figure A-1 Project Study Area
Figure A-2 Project Study Area with all SLR Inundation Zones
Figure A-3 Old Harbor, Village & Corn Neck Road Plan
Figure A-4 Ocean Avenue & Beach Avenue Plan
Figure A-5 New Harbor Plan
Figure A-6 Project Study Area with 1 foot SLR
Figure A-7 Project Study Area with 3 foot SLR
Figure A-8 Project Study Area with 5 foot SLR

Public Informational Pamphlet

New Shoreham, Rhode Island PREPARED FOR: Town of New Shoreham P.O. Drawer 220, Block Island, Rhode Island	PREPARED BY: FAIRBANKS ENGINEERING, CORP. 42 COBBLESTONE HILL ROAD EXETER, RI 02822			REVISIONS	SEA LEVEL RISE ADAPTATION STUDY Block Island Harbors - Project Study Area DESIGNED BY: R. ST. JEAN; DATE: 7/3/2013; CHECKED BY: R. FAIRBANKS; DATE: SCALE: 1 INCH = 2400 FEET; CONST. REV.; DATE:	SHT. NO. A-1 OF 2



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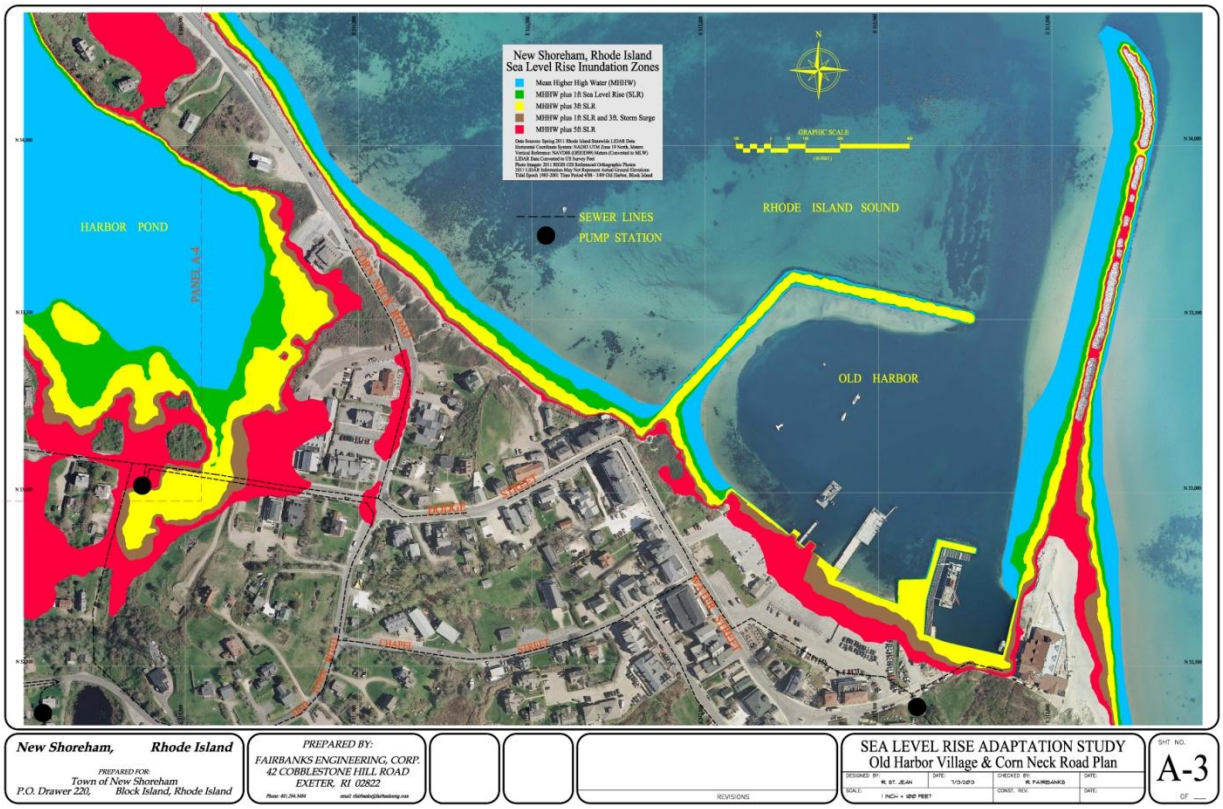
New Shoreham, Rhode Island
Sea Level Rise Inundation Zones
Mean Higher High Water (MHHW)
MHHW plus 1ft Sea Level Rise (SLR)
MHHW plus 3ft SLR
MHHW plus 1ft SLR and 3ft. Storm Surge
MHHW plus 5ft SLR
HARBOR POND
RHODE ISLAND SOUND
OLD HARBOR
SEWER LINES
PUMP STATION
PANEL A-4
GRAPHIC SCALE
New Shoreham, Rhode Island
Rhode Island
PREPARED FOR:
Town of New Shoreham
P.O. Drawer 220, Block Island, Rhode Island
PREPARED BY:
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SEA LEVEL RISE ADAPTATION STUDY
Old Harbor Village & Corn Neck Road Plan
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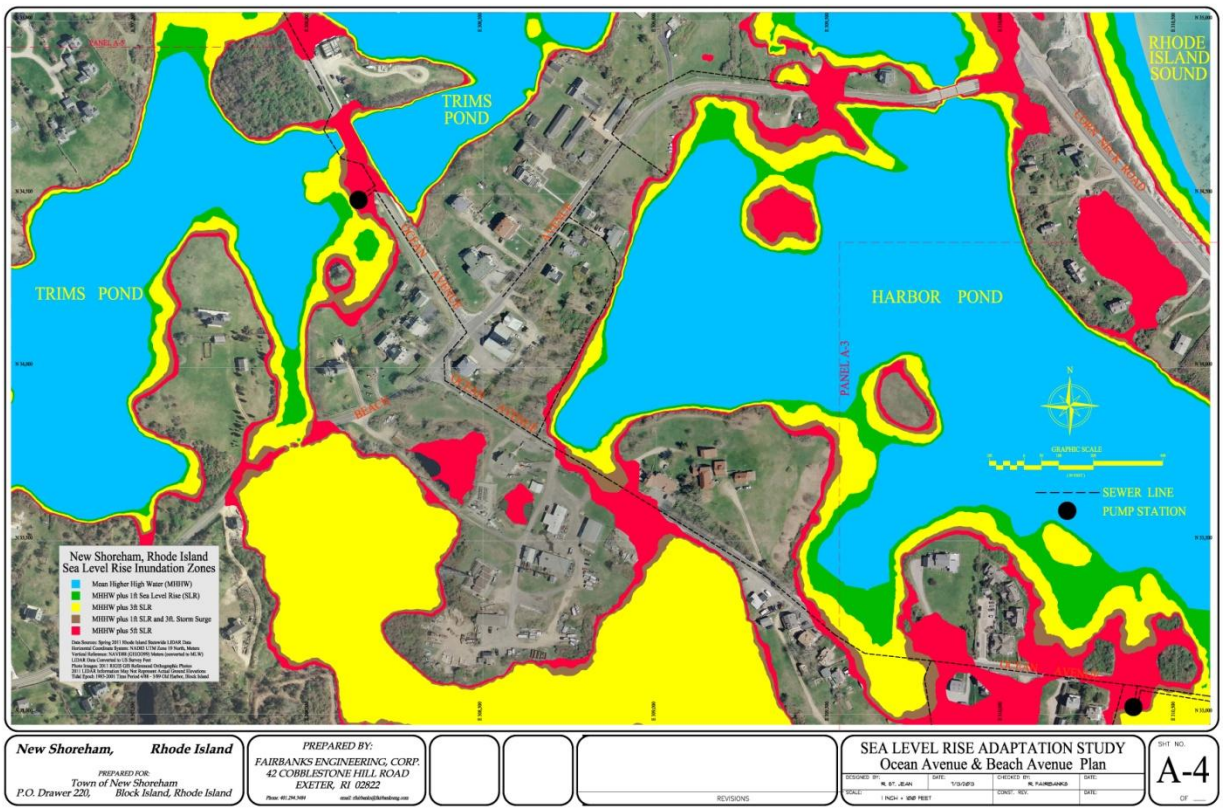
TRIMS POND
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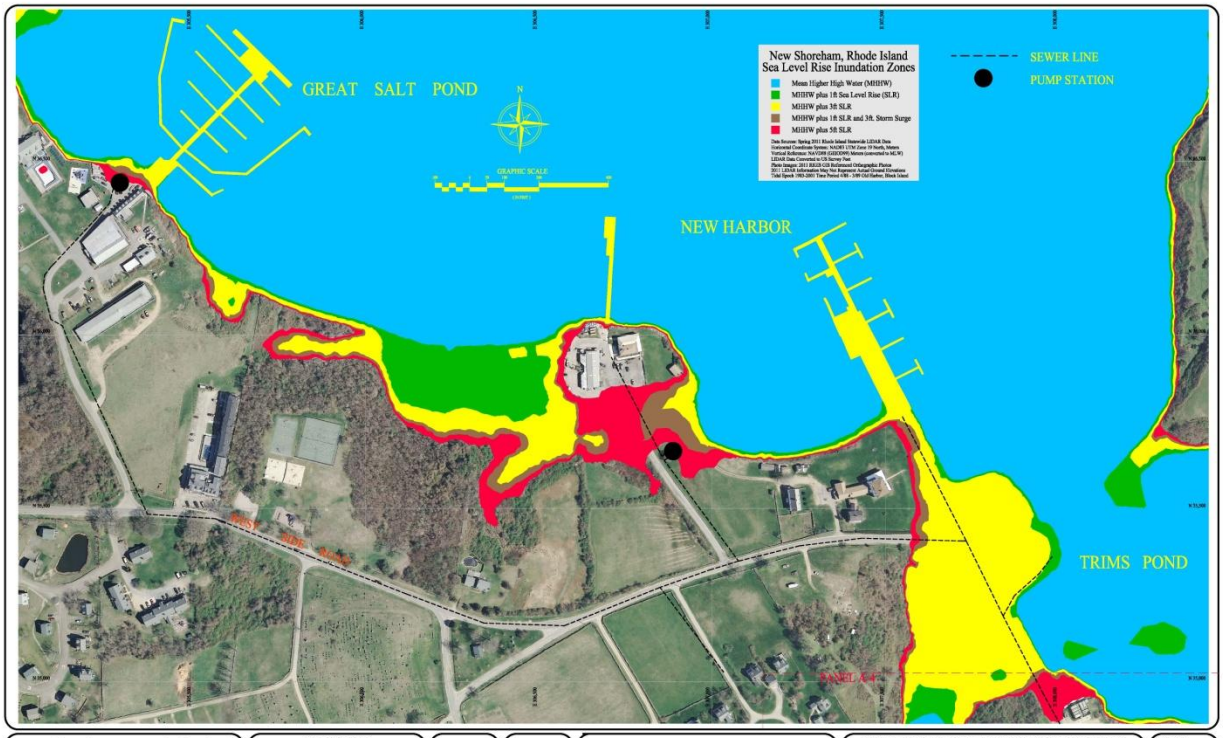
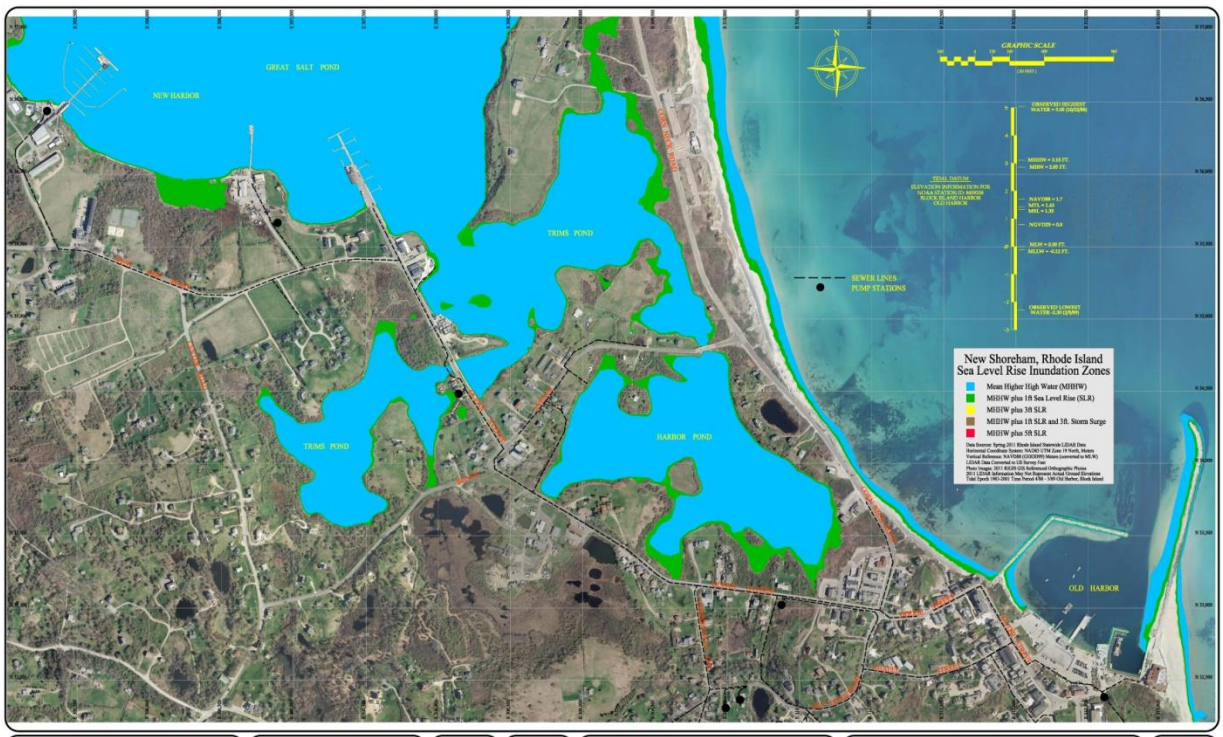
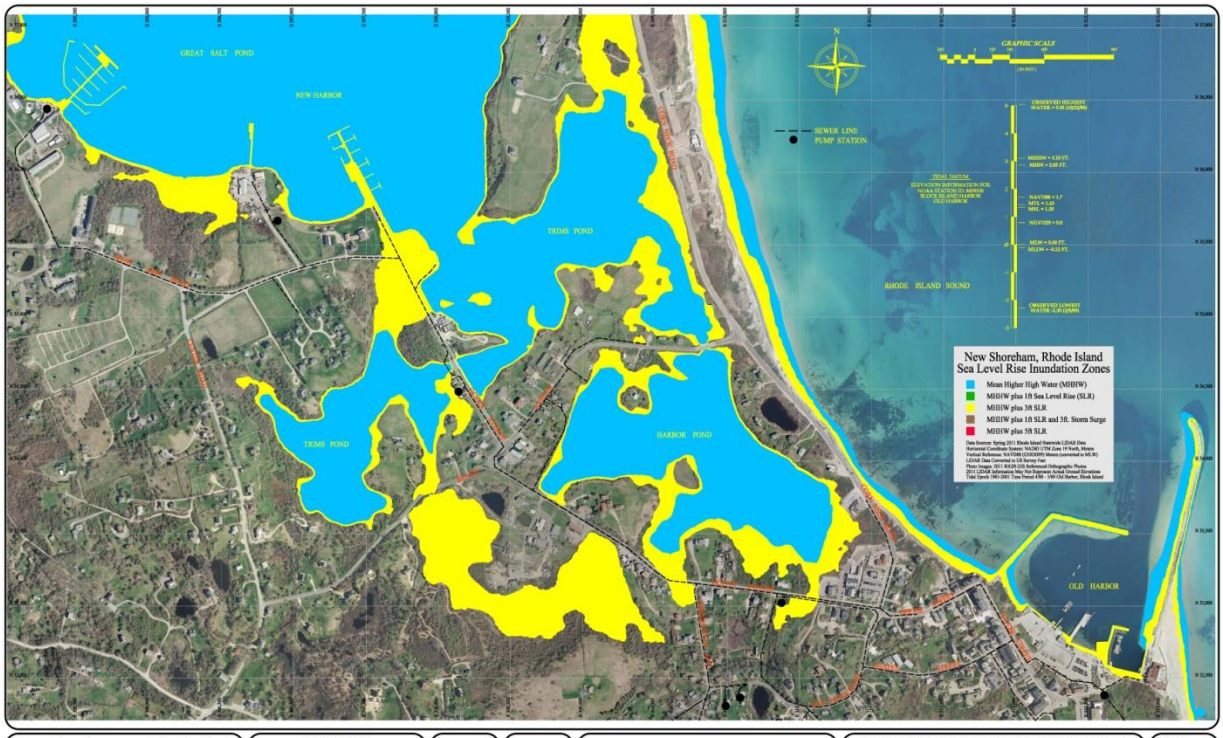
A-4



New Shoreham, Rhode Island PREPARED FOR: Town of New Shoreham P.O. Drawer 220, Block Island, Rhode Island	PREPARED BY: FAIRBANKS ENGINEERING, CORP. 42 COBBLESTONE HILL ROAD EXETER, RI 02822			REVISIONS	SEA LEVEL RISE ADAPTATION STUDY New Harbor Plan DESIGNED BY: R. ST. JEAN; DATE: 7/3/2013; CHECKED BY: R. FAIRBANKS; DATE: SCALE: 1 INCH = 1000 FEET; CONST. REV.; DATE:	SHT NO. A-5 OF ___



New Shoreham, Rhode Island PREPARED FOR: Town of New Shoreham P.O. Drawer 220, Block Island, Rhode Island	PREPARED BY: FAIRBANKS ENGINEERING, CORP. 42 COBBLESTONE HILL ROAD EXETER, RI 02822			REVISIONS	SEA LEVEL RISE ADAPTATION STUDY Project Study Area with 1 Foot SLR DESIGNED BY: R. ST. JEAN; DATE: 7/3/2013; CHECKED BY: R. FAIRBANKS; DATE: SCALE: 1 INCH = 2400 FEET; CONST. REV.; DATE:	SHT NO. A-6 OF ___



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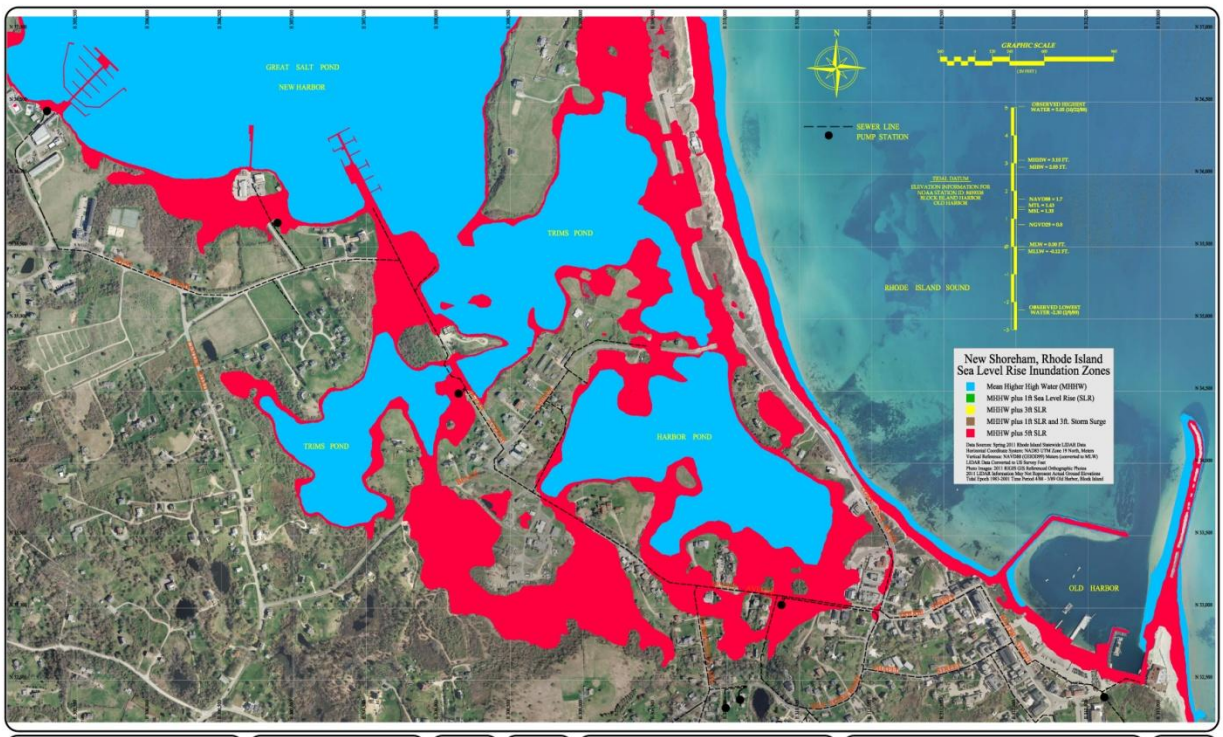
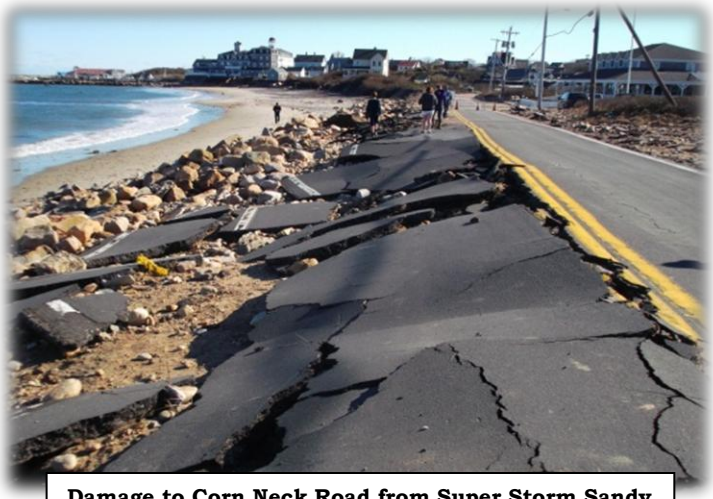


New Shoreham, Rhode Island PREPARED FOR: Town of New Shoreham P.O. Drawer 220, Block Island, Rhode Island	PREPARED BY: FAIRBANKS ENGINEERING, CORP. 42 COBBLESTONE HILL ROAD EXETER, RI 02822			REVISIONS	SEA LEVEL RISE ADAPTATION STUDY Project Study Area with 5 foot SLR DESIGNED BY: R. ST. JEAN DATE: 1/3/2013 CHECKED BY: R. FAIRBANKS DATE: SCALE: 1 INCH = 2400 FEET CONST. REV. DATE:	SHT NO. A-8 OF ___

SEA LEVEL RISE ON BLOCK ISLAND
HOW WILL IT AFFECT YOU?

Our climate is changing. Rhode Island is experiencing warmer air temperatures, increased Bay temperatures, more extreme weather events and accelerated sea level rise. Since 1930, sea level rise as measured by tide gages in Newport has risen at a rate of about 1 inch every 10 years, but this rate is increasing. In another 20 years it is probable the sea level will rise several more inches. This heightened sea level means higher high tides and greater storm surges. The result will be greater coastal flooding and erosion, and more widespread property damage.

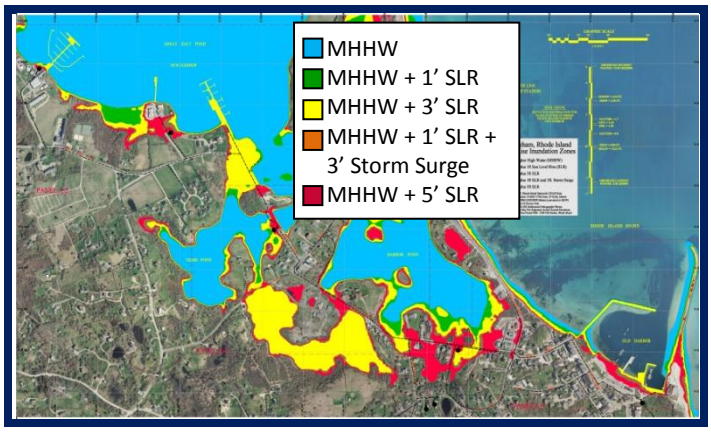
Owing to its geographical location, Block Island is vulnerable to hurricanes, coastal storms and nor'easters. The community is dependent on privately owned ferry and airline companies for transport to and from the mainland. The island's residents must plan for inevitable long term impacts that a rising sea will have on its two harbors and village roads. Residents and visitors alike must prepare for the next inevitable coastal storm on the scale of a Super Storm Sandy, which caused significant damage to roads, buildings and marine facilities due to wave action, storm induced erosion and flooding.



Damage to Corn Neck Road from Super Storm Sandy October 2012

A 2013 study* of the impact of sea level rise on the Block Island harbors and connecting roadways included preparation of maps illustrating areas predicted to be inundated under various scenarios. The maps demonstrate vulnerable flood damage areas that result as sea levels rise over the long term. Under extreme storm conditions in the near term, certain roads, bridges and marine areas, particularly Old Harbor and the ferry landing site and the roads leading into New Harbor, are also vulnerable to flooding and damage. This will result in some areas of the island becoming temporarily isolated. Ferry travel to and from the island may be disrupted beyond the anticipated normal storm duration. This information is important both for emergency planning purposes, and for scheduling and designing major infrastructure replacement.

* See *Block Island Harbors; Sea Level Rise Adaptation Study* at http://www.new-shoreham.com



Inundation zones depicted for sea level rise (SLR) scenarios

There are many things that Block Island officials, conservation organizations, residents, vacationers and visitors can do to prepare for climate change and sea level rise.

Maintaining public infrastructure:

* Plan for sea level rise and storm flooding when designing upgrades to marine facilities, roadways, bridges, and pump stations

Learning about and adapting to climate change impacts:

* Assist the organizations and agencies monitoring the impacts of climate change with efforts such as documenting and photographing high tide events, storm flooding impacts, bluff erosion and changes in species composition in the ocean and coastal pond, etc

* Be aware of vulnerable areas when using and developing property and designing buildings

* Focus land acquisition efforts on flood-prone areas most susceptible to damage

* Follow only pathways to the beach, and stay off the dunes, which serve to protect inland areas against wave erosion and flooding

Emergency procedures in advance of a major coastal storm or hurricane:

* Renters and visitors should leave the island when directed to do so

* Recreational boaters should leave for their home ports when instructed by the harbormaster

* Residents should follow the procedures for hurricane planning established by the emergency management director, and be aware of island roadways subject to temporary inundation