



**CITY OF OCEAN CITY**  
**POST-SANDY PLANNING ASSISTANCE GRANT**



**COMMUNITY RESILIENCE PLAN**

A handwritten signature in black ink that reads "Randall E. Scheule".

Randall E. Scheule, PP/AICP

The original of this document has been signed  
and sealed as required by NJS 45:14A-12.



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## **Introduction**

Throughout history, humans have been drawn to coastal areas, running the risks of storms and inundation for the great benefits these areas provide: rich food resources, building materials and transport routes. Recent population growth has also been disproportionately represented in the coastal zone, with immigration adding to natural growth, leading to rapid expansion of coastal settlements, aquaculture and agriculture. Unfortunately, the vulnerability of coastal peoples has also risen disproportionately.

State, local and Federal decision makers throughout New Jersey are working to enhance the resilience of coastal communities and responses to hazards – including flooding driven by sea-level rise and coastal storms – that are increasing as a result of climate change. This Community Resilience Plan documents Ocean City’s pro-active approach to address the many challenges to sustaining a vibrant community on a coastal barrier island.

As time passes and our collective understanding of sea level rise is refined, Ocean City will update this Plan to more appropriately reflect the community’s evolving approaches to building resilience.

This Plan has been prepared in response to recommendations contained in the Ocean City Strategic Recovery Planning Report (October 7, 2015). Preparation of this “Community Resilience Plan” has been made possible with funding provided by a Post-Sandy Planning Assistance Grant administered by the New Jersey Department of Community Affairs.

## **What is Community Resilience?**

Community resilience in Ocean City also referred to herein as *coastal resilience* is the ability to resist, absorb, recover from, or adapt to coastal hazards such as sea level rise, increased flooding, and more frequent and intense storm surges. The primary goal of this Community Resilience Plan is to address the current and future social, economic and ecological resilience of the City of Ocean City to the impacts of sea level rise and anticipated increases in the frequency and severity of storm surge, coastal flooding, and erosion.

The four basic steps inherent in the development of this Community Resilience Plan are:

1. Generate awareness of coastal risk (already underway and largely complete);
2. Assess coastal risks and opportunities (complete);
3. Identify choices for addressing priority risks and vulnerabilities (current effort); and



4. Develop and implement an action plan to put selected choices into place (future effort).

The coastal resilience approach addresses four critical areas of climate adaptation planning:

1. Assess Risk and Vulnerability to coastal hazards including current and future storms and sea level rise scenarios;
2. Identify Solutions for reducing risk across social-ecological systems;
3. Take Action to help communities develop and implement nature-based solutions where appropriate; and
4. Measure Effectiveness to ensure that our efforts to reduce risk through restoration and adaptation are successful.

TNC - The decision support tool is an important component of coastal resilience that supports each step of this approach. The tool platform and web apps are customized for different geographies and planning processes while also being replicated and modified across a network of coastal resilience projects. Explore the [Coastal Resilience Tool](#) here.

Coastal resilience is fundamentally about mitigating the vulnerability for human communities and natural resources simultaneously. Local vulnerability can come from many sources, including flooding from storms, king tides, oil spills and other coastal hazards. Climate change and sea level rise are important because they will change the landscape impacted by these sources of vulnerability and exacerbate future risk.

Currently coastal resilience focuses on (a) the resources at risk from coastal hazards including flooding and inundation and (b) the options for protecting coastlines and people from these hazards, including engineered and natural solutions. Coastal resilience identifies that these natural solutions may offer additional co-benefits.

Coastal Resilience promotes advance planning to mitigate disaster vulnerability, and encourages the use of nature-based approaches where appropriate. While no amount of either natural or built infrastructure will provide protection from the biggest coastal hazards there is substantial evidence that coastal natural habitats can effectively protect coastlines and reduce human vulnerability to more typical annual and decadal coastal hazard events. Moreover, forward-thinking development plans that seek to reduce the number of people and structures (or at least do not continue to increase that risk) have huge social, economic and ecological benefits.



Natural, technological, and human-caused hazards take a high toll on communities, but the costs in lives, livelihoods and quality of life can be reduced by better managing disaster risks. Planning and implementing prioritized measures can strengthen resilience and improve a community's abilities to continue or restore vital services in a more timely way, and to build back better after damaging events. That makes them better prepared for future events and more attractive to businesses and residents alike.

### **Sandy's Effects on the Coastline**

Generally, Sandy's coastal inundation took one of three forms. First, floodwaters came directly from the ocean, as water surged over beaches and bulkheads, flooding neighborhoods and critical infrastructure such as tunnels. Extreme water levels were seen citywide as the storm peaked in the evening of October 29, 2012. In many cases, in ocean-facing areas, the surge brought with it not just large volumes of water but also powerful waves that wreaked havoc on buildings and infrastructure alike. Another impact of the wave action along the city's ocean-facing coastline was massive beach erosion.

The second way Sandy's surge impacted the city was via less direct routes. In these cases, bays, inlets, and creeks functioned as "backdoor" channels, funneling ocean waters inland.

The third way Sandy's surge impacted coastal communities was by overtopping shoreline drainage infrastructure, and in some cases infiltrating the roadway drainage and sewer system through catch basins, manholes, and storm drains in the streets, especially in low-lying areas. This network of pipes and other features is designed to drain rainwater away from land and into the area's waterways and is generally not designed to protect against storm surge.

### **Performance of Existing Coastal Defenses**

Though Sandy's surge generally devastated areas that it touched, some coastal features and strategies – such as beaches nourished with sand, dunes, site elevation, and bulkheads – did offer some protection. Fortified beaches and dunes absorbed the destructive energy of waves and floodwaters, in many cases buffering adjacent neighborhoods.

Looking ahead, Ocean City's coastline and waterfront infrastructure face significant climate risks, chief among them are risks associated with storm surge and wave action. The NJ Climate Adaptation Alliance concluded that for now, ". . . planning and decision



making in New Jersey should be guided by the Intergovernmental Panel on Climate Change (IPCC)'s conclusions regarding changes in future storms, including:

- The global frequency of tropical cyclones (i.e., hurricanes) is not likely to increase, while maximum wind speeds are likely to increase;
- Precipitation intensity during tropical cyclones is likely to increase; and
- The global frequency of extratropical cyclones (i.e., nor'easters) is not likely to change substantially; however precipitation associated with winter storms is likely to increase.”<sup>1</sup>

All of this is expected to result in inundation, destructive waves, and erosion of the coastline on a more regular basis. At the same time, as sea levels rise, this in and of itself could pose threats to low-lying areas of the City, even in the absence of storm conditions.

## Major Risks

In the context of hazards, risk is the sum of vulnerability and frequency. In the context of coastal hazards, risk will change over time because coastal storms are believed to be increasing in frequency, and flooding will increase in frequency as sea level rises.

Vulnerabilities can remain static and risk can increase, or vulnerabilities can be reduced through adaptation to hold risk at bay. If vulnerabilities can be reduced even further, then risks could be lowered in the face of rising sea level and increased coastal storms, leading to increased resilience.

## Hurricanes and Storm Surge

The greatest risk to coastal areas in New Jersey is storm surge. Like most other barrier islands in New Jersey and the US Atlantic coast, Ocean City is at significant risk of tidal surge flooding from hurricanes and other large storms. Reflecting this storm surge risk, all of Ocean City has been designated as a Special Flood Hazard Area (SFHA) by the Federal Emergency Management Agency (FEMA).

The FIRMs represent the Federal government's assessment of coastal flood risk. They serve multiple purposes, including helping to determine premiums under the National Flood Insurance Program (NFIP) and triggering certain flood insurance requirements on Federally-backed mortgages. These maps divide coastal areas into several zones of vulnerability:

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<sup>1</sup> Integrating Climate Science into Coastal Resilience Planning and Decision Making in New Jersey, Rutgers University, October 2016

- A Zones: the 100-year floodplain – an area that has a 1 percent or greater chance of flooding in any given year;
- V Zones: the portion of the 100-year floodplain subject to high-velocity wave action (defined as a 3 foot or greater breaking wave);
- Coastal A Zones: the portion of the 100-year floodplain subject to breaking waves between 1.5 and 3 feet; and
- Shaded X Zones: the 500-year floodplain – an area that has a 0.2 percent or greater chance of flooding in any given year.

The following profile depicts the relative locations of these flood zones.

**Figure 1**

**Floodplain Zone Diagram**

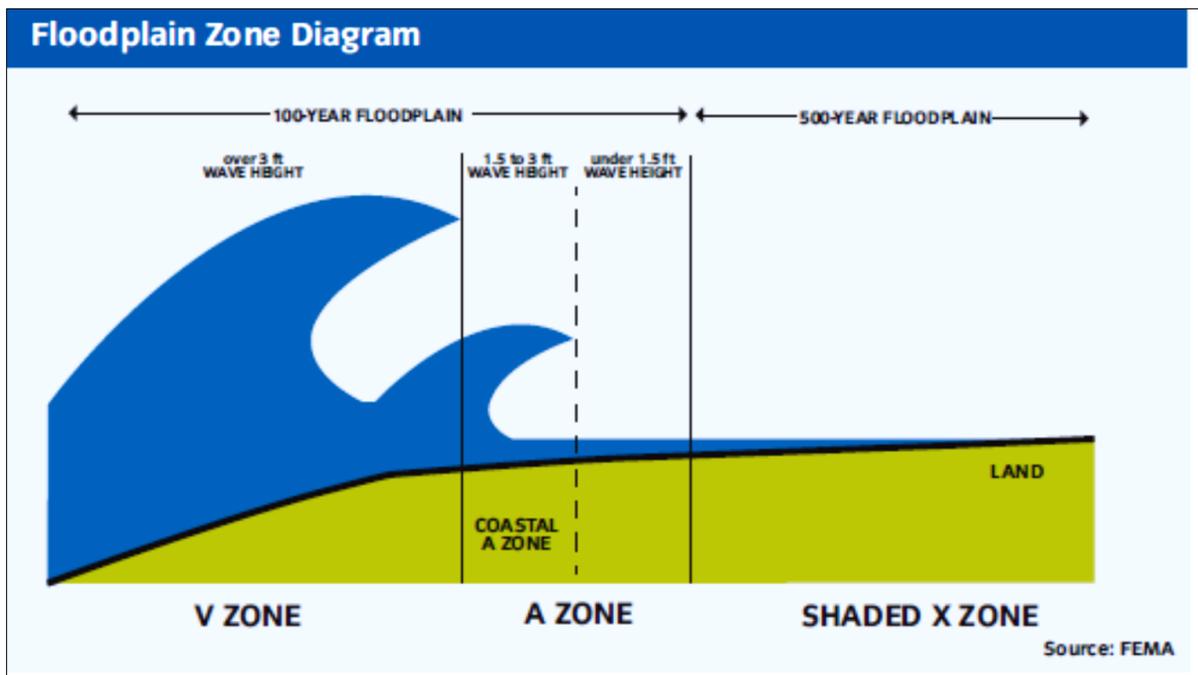
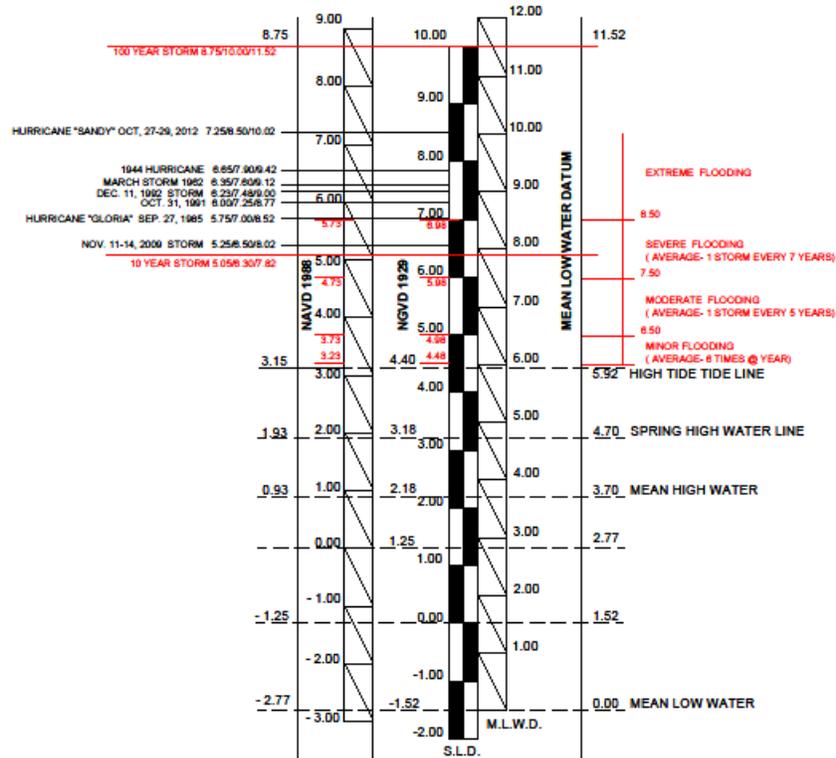


Figure 2 compares the tide heights of major storm events with minor to severe flood levels, typical tides and high water lines.

**Figure 2**  
**Historic Tides in Ocean City (1944 - 2012)**



**TIDE HEIGHTS**  
**RELATIVE TO N.A.V.D. 1988, N.G.V.D. 1929 & M.L.W. DATUM**  
**OCEAN CITY, NJ**  
HISTORIC TIDE INFORMATION FROM 520 BAY AVENUE TIDE STATION AND  
WALLACE HARDWARE STORE

## Sea Level Rise

### Sea Level Rise and Climate Change

Global sea level rise (SLR) has been a persistent trend for decades. It is expected to continue beyond the end of this century, which will cause significant impacts in the United States. Over eight million people live in areas at risk to coastal flooding, and



many of the nation's assets related to military readiness, energy, commerce, and ecosystems are already located at or near the ocean.<sup>2</sup>

The Community Rating System (CRS) incorporates the consideration of sea level rise into a number of elements, including Higher Study Standards (HSS) under Activity 410 (Flood Hazard Mapping); Coastal A Zone (CAZ) credit under Activity 430 (Higher Regulatory Standards); and Watershed Master Plan (WMP) under Activity 450 (Stormwater Management). Including sea level rise in WMP is required for coastal communities to meet the Class 4 prerequisite, and HSS credit for future-conditions hydrology is a Class 1 prerequisite.

Recognizing that there is uncertainty inherent in estimating future sea levels, the CRS has adopted a base minimum projection for sea level rise for the purposes of CRS credit and meeting CRS prerequisites. The "intermediate-high" projection for 2100, as included in the report *Global Sea Level Rise Scenarios for the United States National Climate Assessment* (National Oceanic and Atmospheric Administration, 2012, [https://scenarios.globalchange.gov/sites/default/files/NOAA\\_SLR\\_r3\\_0.pdf](https://scenarios.globalchange.gov/sites/default/files/NOAA_SLR_r3_0.pdf)), is the minimum projection that must be used for CRS purposes. Communities may use other projections provided that they are equal to or greater to NOAA's "intermediate-high" projection for 2100.

Because sea levels are changing at different rates in different parts of the country, global projections must be adjusted to take local conditions into consideration. For this, the CRS uses and recommends the U.S. Army Corps of Engineers "Sea-Level Change Curve Calculator," an online-tool available at <http://www.corpsclimate.us/ccaceslcurves.cfm>. The CRS anticipates that updates to the National Climate Assessment report will be incorporated into the Sea-Level Change Curve Calculator. If not, then the CRS will provide further guidance to communities, as needed.

Ocean City is currently rated as a CRS Class 5 community. In order to advance to Class 4 the City must receive credit for managing the impacts of sea level rise, based on a watershed master plan. The impacts of a median projected sea level rise (based on the National Oceanic and Atmospheric Administration's (NOAA's) "intermediate-high" projection for the year 2100) on the local drainage system during multiple rainfall events, including the 100-year rainfall event are described in the Watershed Master Plan chapter of this Plan.

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<sup>2</sup> Global SLR Supporting the US National Climate Assessment, November 2012, page 1.



Estuarine systems are particularly vulnerable to many of the projected effects of climate change, such as:

- Sea level rise
- Increased temperatures
- Changes in precipitation and storm intensity
- Ocean acidification

Examples of specific impacts that may occur in estuaries and other coastal areas include:

- Salt-water intrusion into aquifers as the sea rises
- Flooding of coastal wetlands and marshes
- Changes to water availability and quality
- Changes in habitat and species distributions
- Lower oxygen levels in wetlands
- Ocean acidification (due to higher concentrations of carbon dioxide in the atmosphere)
- A range of impacts from more severe coastal storms

These impacts may occur in tandem with other existing stressors, such as coastal population growth, presenting new and different challenges to National Estuary Programs and coastal communities.

Coastal resource managers can reduce risks and improve resiliency by:

- Proactively identifying areas that are particularly vulnerable
- Monitoring for changes, and developing and implementing adaptation plans

These adaptation plans may contain a wide range of adaptation actions that are designed to reduce impacts or exploit beneficial opportunities resulting from climate change. Adaptation strategies identified in this Plan are linked to management goals including maintenance of municipal infrastructure, access, and wetlands, protection of coastal development, and habitat preservation.

Reasons why coastal managers should focus their efforts on adapting to climate change include:



- Vulnerability
  - Coastal zones are highly vulnerable to climate change.
  - Climate-driven impacts will be further exacerbated by other human-induced pressures (IPCC 2007<sup>3</sup>).
- Timing
  - Coasts are already experiencing climate change impacts.
  - The Earth is committed to additional impacts due to past and current greenhouse gas emissions. Adaptation planning is necessary to address these already unavoidable impacts.
- Opportunity
  - Adaptation can help reduce the long-term costs of climate change impacts (IPCC 2007). See Adaptation Planning for the National Estuary Program.

### **Beach Erosion and Shoreline Protection**

Around the world, coastal recreation has become a major economic activity. Most coastal recreation centers are around beaches. For example, in the United States, on the Atlantic and Gulf coast, barrier islands which are fragile landforms due to their low-lying nature and a shortage of sediment supply are highly developed. They are both vulnerable to erosion and, in the case of beaches, to flooding during storms. In these regions, beachfront property has become some of the most valuable real estate in the country. Generally speaking, "cities on the beach" are directly threatened all over the world by the projected sea-level rise.

The beach is the backbone of the recreational and tourist economy in Ocean City as well as the protection for the development on the island. The on-going beach fill, a commitment by the City, the state and the federal government for 50 years from 1991, is a critical element to the economy and lifestyle of Ocean City. With sea level rise it can be expected that the beachfront will be more vulnerable to storm damage as waves build on an ever-higher level of water. Pursuit of methods to reduce wave impact and therefore wave damage to the vulnerable renourished beach will allow the beach to function longer than might otherwise be expected.

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<sup>3</sup> IPCC, 2007: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Parry, Martin L., Canziani, Osvaldo F., Palutikof, Jean P., van der Linden, Paul J., and Hanson, Clair E. (eds.)]. Cambridge University Press, Cambridge, United Kingdom, 1000 pp.



The beaches and shorelines of Ocean City are subject to the natural forces of erosion (removal of sediments that leads to loss of land) and accretion (deposit of sediments that leads to the building of land). Ocean City's beaches, like most barrier islands of the southeast US Atlantic coast, tend to erode sands from the island's northern end, while sands tend to deposit and accrete on the southern end of the island. Much of this natural sand movement process, known as the longshore drift, is driven by prevailing winds and associated wave angles. Hurricanes and other large storms can also have very large and sometimes quite different, impacts on the local erosion and accretion of beach sediments.

Natural beach erosion and accretion processes in Ocean City have been substantially altered by human activities for well over a century. In 1992, after years of eroding beaches and local efforts to renourish the beachfront using back bay dredging, the Federal Government, through the Army Corps of Engineers, and the State of New Jersey began a 50-year beach renourishment program on the beaches from the northernmost groin to 36th Street. The south end beach fill project extending from 36<sup>th</sup> Street to 59<sup>th</sup> Street was a result of Sandy and is now be part of a scheduled beach fill program. These two programs will provide an entire beach front dune system and template to provide added protection provided that funding remains solvent.

Both the north and south ends of Ocean City are now part of a three-year cycle for Army Corps of Engineers beach renourishment projects to restore eroded beaches and dunes. The next projects are due in 2018. Sand renourishment involves the use of mechanical dredges to capture suitable sediments from offshore areas and subsequent deposit of these sediments onto the beach and near shore coastal waters.

A fundamental goal of the Ocean City shore protection effort is to manage and renourish the City's beaches in a way that provides "flood control protection from hurricanes and storm damage." Consistent with this goal, a long-term partnership between the City and the NJ Department of Environmental Protection has resulted in the restoration of large expanses of vegetated sand dunes along most of the City's beachfront. These dune restoration activities have provided significant flood protection benefits for residents, while also further reducing the impacts of beach erosion and improving habitat conditions for several shore-dependent wildlife species. The City's Beach Management Plan provides a framework for cooperation among the City, NJ Division of Fish and Wildlife and the US Fish and Wildlife Service in the stewardship of



federally and State-listed endangered and threatened species occurring on the City's beaches.

## Current and On-going Initiatives

### Army Corps Beach Fill

On November 10, 2014, the U.S. Army Corps of Engineers awarded a \$57.6-million contract to the Great Lakes Dredge and Dock Company to complete the coastal storm damage reduction project from the southern end of Ocean City to Strathmere and Sea Isle. The project, which entails the construction of a dune and a berm, or beach, in front of each community, is a joint effort of the Army Corps' Philadelphia District and the New Jersey Department of Environmental Protection. The initial construction project was completed in the spring of 2016.

Work in the southern end of Ocean City, from 34<sup>th</sup> Street to Corson's Inlet state Park, involved the construction of a dune approximately 13 feet above sea level, with a width at the top of 25 feet, and a berm or beach extending 100 feet from the seaward base of the dune. On Ludlum Island, which includes Strathmere and Sea Isle, the dune will be about 15 feet high and the berm 50 feet wide.

This project consists of providing initial beach fill, with subsequent periodic nourishment, with a minimum berm width of 100 feet at an elevation of +8.0 National Geodetic Vertical Datum (NGVD). The beach fill extends from Surf Road southwest to 34th Street with a 1,000-foot taper south of 34th Street. This plan required the initial placement of approximately 6.2 million cubic yards of material and subsequent periodic nourishment of approximately 1.1 million cubic yards every 3 years. The material for the initial construction and periodic nourishment is being taken from the ebb shoal area located approximately 5,000 feet offshore of the Great Egg Harbor Inlet. This periodic dredging of the ebb shoal area will help alleviate the navigation difficulties in the inlet. Additionally, the initial construction of the project required the extension of 38 storm drain pipes.

Between October 27 and 30, 2012, Hurricane Sandy caused significant damage to the New Jersey coast from Sandy Hook to Cape May and up the Delaware Bay. Flood Control and Coastal Emergencies (FCCE) funds under Public Law 84-99 were utilized to complete a Project Information Report (PIR). The results of the PIR determined that the project was eligible for FCCE funds to repair the project to pre-storm conditions. The PIR was approved, funding provided and the previously awarded renourishment contract was modified to complete the repairs and renourishment



concurrently. Physical construction was completed in May 2013. The repairs and renourishment brought the project back to the design template. FY15 funds were used to complete the 7<sup>th</sup> renourishment cycle. FY16 funds will be used for project monitoring. Target completion date is 2041, with a total estimated cost of \$431.3M.

For the purpose of hurricane and storm damage reduction, this project provides a beach fill with periodic nourishment, and a berm along Surf Road southwest to 34<sup>th</sup> Street in Great Egg Harbor and Peck Beach.

**Table 1**  
**Ocean City Beachfill Program**

<u>Phase</u>	<u>Quantity of Sand (CY)</u>	<u>Costs (\$1,000)</u>	<u>Complete</u>	<u>Comments</u>
Initial Construction (Ph. I)	2,618,000	\$10,952	Oct 1992	
Initial Construction (Ph. II)	2,727,000	\$14,572	Mar 1993	
Storm Rehab	846,000	\$2,915	Jul 1993	
1 <sup>st</sup> Periodic Nourishment (Ph. I)	606,000	\$3,218	Dec 1994	
1 <sup>st</sup> Periodic Nourishment (Ph. II)	1,411,000	\$5,750	Aug 1995	
2 <sup>nd</sup> Periodic Nourishment	800,000	\$4,945	Oct 1997	
3 <sup>rd</sup> Periodic Nourishment	1,351,000	\$6,943	Dec 2000	
4 <sup>th</sup> Periodic Nourishment	1,600,000	\$8,314	Feb 2004	
5 <sup>th</sup> Periodic Nourishment	1,400,000	\$13,824	Mar 2010	
6 <sup>th</sup> Periodic Nourishment	1,000,000	\$11,993	May 2013	
FCCE Emergency (Sandy)	800,000		May 2013	
7 <sup>th</sup> Periodic Nourishment	1,000,000		Dec 2015	
8 <sup>th</sup> Periodic Nourishment	TBD			Sched. FY 18



## New Jersey Back Bay (NJBB) Focus Area

The New Jersey Back Bay (NJBB) Focus Area is located behind the New Jersey barrier islands of Monmouth, Ocean, Atlantic and Cape May Counties and includes the set of interconnected water bodies and coastal lakes that are separated from the Atlantic Ocean. The authority for the NJBB Study (Resolutions adopted by U.S. House of Representatives and U.S. Senate Committees in December 1987) support NACCS outcomes, are broad in scope and application and address the development of a coastal processes database, monitoring and related actions as the basis for actions and programs to prevent the harmful effects of shoreline erosion and storm damage. The authority also recommends that site specific studies for beach erosion control and hurricane protection be undertaken in areas with a Federal project, action, or response.

The NJBB Study is being performed to align with the goals of the North Atlantic Coast Comprehensive Study (NACCS), which are to:

- Provide a risk management framework, consistent with and NOAA/USACE Infrastructure Systems Rebuilding Principles; and
- Support resilient coastal communities and robust, sustainable coastal landscape systems, considering future sea level and climate change scenarios, to reduce risk to vulnerable populations, property, ecosystems, and infrastructure

The objective of the NJBB CSRM Study is to investigate coastal storm risk management problems and solutions to reduce damages from coastal flooding affecting population, critical infrastructure, critical facilities, property, and ecosystems. The study will consider past, current, and future coastal storm risk management and resilience planning initiatives and projects underway by the USACE and other Federal, State, and local agencies. Three overarching efforts will be performed:

- Assess the study area's problems, opportunities and future without project conditions;
- Assess the feasibility of implementing system-wide coastal storm risk management solutions such as policy/programmatic strategies, storm surge barriers at selected inlet entrances, or tidal gates at selected lagoon entrances; and



- If system-wide solutions are not feasible, assess the feasibility of implementing site-specific solutions, such as a combination of structural, non-structural, and natural and nature-based features.

The end product of this study will be a decision document in the form of a Chief's Report authorizing comprehensive USACE design and construction opportunities using the full array of CSRM strategies and measures for community-based solutions within a watershed-based, systems framework. Also included in the report would be recommendations of actionable and policy implementable items for non-USACE entities, including floodplain management, landscape architecture, hurricane evacuation plans, and Community Rating System enhancement opportunities. Additional recommendations will be provided for incorporating existing USACE and external programs, projects, plans and actions, as well as public-private partnership opportunities into the NACCS NJBB study umbrella. A programmatic NEPA document will be developed identifying a range of impacts. The PED Phase will include detailed design with a detailed fully compliant programmatic NEPA document which evaluates impacts for specific solutions.

### The Protective Role of Coastal Wetlands

Salt marshes lie between many human communities and the coast and have been presumed to protect these communities from coastal hazards by providing important ecosystem services. A report from the University of California found that “. . . salt marsh vegetation had a significant positive effect on wave attenuation as measured by reductions in wave height per unit distance across marsh vegetation. Salt marsh vegetation also had a significant positive effect on shoreline stabilization as measured by accretion, lateral erosion reduction, and marsh surface elevation change. Salt marsh characteristics that were positively correlated to both wave attenuation and shoreline stabilization were vegetation density, biomass production, and marsh size.”<sup>4</sup>

Ocean City was awarded a National Fish and Wildlife Foundation - Hurricane Sandy Coastal Resiliency Competition Grant in 2015. This grant will enable the use of sediment traps and beneficial reuse of dredge materials to reclaim previously existing wetlands, and thin-layer application of dredge materials to restore and enhance deteriorating wetlands in the Great Egg Harbor Bay. The creation and restoration of

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<sup>4</sup> Department of Ocean Sciences, University of California, Santa Cruz, California, United States of America, 2 Department of Ecology and Evolutionary Biology, University of California, Santa Cruz, California, United States of America, 3 The Nature Conservancy, Institute of Marine Sciences, University of California, Santa Cruz, United States of America



wetlands resulting from this project is expected to reduce impacts from future storms and enhance habitats for numerous fish and wildlife species.

### State-Sponsored Resiliency Initiatives

New Jersey State Departments and Agencies have incorporated strategy and planning in every aspect of the recovery process in an effort to rebuild back better and more resilient than before. In January 2013, the State established by emergency rule the best available data from FEMA's latest flood maps, plus one foot of freeboard, as the general rebuilding standard to adapt to changing flood hazard risks and corresponding federal flood insurance rates. Federal agencies subsequently adopted this standard for all reconstruction activities funded by the Sandy Supplemental Appropriation.

Early in the post-Sandy recovery, the New Jersey Office of Emergency Management's Disaster Recovery Bureau began providing technical assistance to local communities to help navigate FEMA's Public Assistance program, particularly focusing on "406 mitigation" design opportunities to rebuild more resiliently. The New Jersey Department of Community Affairs also launched the Post Sandy Planning Assistance Grant Program, which provides communities with planning grants to enable the development of strategic recovery plans, preparation of community design standards specific to flood hazard areas, and analyses of local land use practices to facilitate a smart and efficient rebuilding process at the local level. As part of the program, communities have also been encouraged to combine resources to pursue regional projects and solutions where feasible.

The New Jersey Office of Emergency Management also launched a planning initiative under FEMA's Hazard Mitigation Grant Program to provide eligible counties with grants to develop multi-jurisdictional hazard mitigation plans, incorporating municipal perspective to address regional vulnerabilities. As part of the State's hazard mitigation planning efforts, a cross-agency effort was initiated to identify regional resiliency opportunities by examining the locations and characteristics of critical infrastructure including drinking water, wastewater, transportation, transit, energy and communication systems. Studying where multiple infrastructure systems intersect and overlap enables the State to highlight and implement synergistic mitigation initiatives.

To examine energy resiliency, the New Jersey Board of Public Utilities, the New Jersey Department of Environmental Protection, the New Jersey Office of Homeland Security and Preparedness, and the New Jersey Office of Emergency Management have been collaborating with the U.S. Department of Energy and the National Renewable Energy



Laboratory to study the State's energy vulnerabilities, and identify opportunities to leverage commercially available technologies to address back-up power generation needs at critical facilities. New Jersey is encouraging the use of innovative technologies – including combined heat and power, fuel cells, and solar power with storage capability – which combine energy efficiency and greater resiliency.

Additional information on some of the State's resiliency initiatives is described in Appendix A.

### **Evolution of Options for Coastal Resilience**

Responses to climate change can be categorized, in a broad sense, as involving either "mitigation" or "adaptation" strategies.

Mitigation strategies focus on policies aimed at reducing the emission of greenhouse gasses in order to slow or ultimately halt the effects of climate change. These include, for example, the promotion of alternate fuel sources or improvements in energy efficiency.

Adaptation strategies, in contrast, focus on adjustments to the effects of climate change. In the case of coastal communities, this might include changes to land use policies, infrastructure location, or coastal protective measures. At the core of both adaptation and mitigation strategies is the idea of resilience – the ability to withstand and respond to the effects of climate change.

By their very nature, government agencies and non-government organizations (NGO) will concentrate their efforts on mitigation or adaptation strategies that are consistent with their role or mission.

*The Intergovernmental Panel on Climate Change (IPCC)* published the landmark paper “Strategies for Adaptation to Sea Level Rise” in 1990. The preface states that, “This report represents the first survey on a global scale of adaptive options for coastal areas in response to a possible acceleration of sea level rise and the implications of these options.” This was one of the earliest reports to list the three traditional categories of adaptation “to protect human life and property.” Three basic types of adaptation were presented in the report. The following descriptions of these three types of adaptation are taken from the report:

- Retreat involves no effort to protect the land from the sea. The coastal zone is abandoned and ecosystems shift landward. This choice can be motivated by



excessive economic or environmental impacts of protection. In the extreme case, an entire area may be abandoned.

- Accommodation implies that people continue to use the land at risk but do not attempt to prevent the land from being flooded. This option includes erecting emergency flood shelters, elevating buildings on piles, converting agriculture to fish farming, or growing flood or salt tolerant crops.
- Protection involves hard structures such as sea walls and dikes, as well as soft solutions such as dunes and vegetation, to protect the land from the sea so that existing land uses can continue.

In 2010, NOAA's Office of Ocean and Coastal Resource Management published the manual "Adapting to Climate Change: A Planning Guide for State Coastal Managers." Chapter 5 is dedicated to a discussion of adaptation strategies and methods. According to the manual, NOAA's seven categories of "Climate Change Adaptation Measures" and their sub-categories are:

#### Impact Identification and Assessment

- Research and Data Collection – Predict possible social and economic effects of climate change on communities. Calculate cost-to-benefit ratios of possible adaptation measures. Encourage adaptation plans that are tailored to specific industries.
- Monitoring – A comprehensive monitoring program that incorporates multiple tools and considers a variety of systems and processes can provide input to the vulnerability assessment and adaptation strategy.
- Modeling and Mapping – Map which areas are more or less susceptible to sea level rise in order to prioritize management efforts.

#### Awareness and Assistance

- Outreach and Education – Create scientific fact sheets about climate change addressing community members, visitors, elected officials, businesses and industries. Use multiple forms of communication such as news media, radio, brochures, community meetings, social networks, blogs and websites.
- Real Estate Disclosure – The disclosure of a property's vulnerability to coastal hazards enables potential buyers to make informed decisions reflecting the level of impacts they are willing and able to accept.
- Financial and Technical Assistance – Provide flood insurance discounts for properties that exceed floodproofing standards by one or two feet. Encourage hazard mitigation by providing grants to areas that implement adaptation measures.



## Growth and Development Management

- Zoning – Zoning can be used to regulate parcel use, density of development, building dimensions, setbacks, type of construction, shore protection structures, landscaping, etc. It can also be used to regulate where development can and cannot take place, making it an invaluable tool in efforts to protect natural resources and environmentally sensitive areas and guide development away from hazard-prone areas.
- Redevelopment Restrictions – Combining restrictions with acquisition/demolition/relocation programs provides safer options to property owners in the wake of the loss of or damage to their homes or businesses.
- Conservation Easements – A conservation easement is a legal agreement between a landowner and a land trust or government agency that can be used to restrict development in sensitive and hazard-prone areas.
- Compact Community Design – The high density development suggested by compact community design can allow for more opportunities to guide development away from sensitive and hazard-prone areas.

## Loss Reduction

- Acquisition, Demolition, and Relocation – The most effective way to reduce losses is to acquire hazard-prone properties, both land and structures, demolish or relocate structures, and restrict all future development on the land.
- Setbacks – Setbacks can protect structures from hazards by keeping the structures away from a property's most vulnerable areas.
- Building Codes – Building codes that regulate design, construction, and landscaping of new structures can improve the ability of structures in hazard-prone areas to withstand hazard events.
- Retrofitting – Existing structures can be protected from hazards through retrofitting.
- Infrastructure Protection – Infrastructure protection entails fortification against the impacts of climate change.
- Shore Protection Structures – Shore protection structures protect existing development allowing it to stay in place. They often damage or destroy other valuable coastal resources and create a false sense of security; nevertheless in some cases, for the purposes of protecting existing development, there may be no other acceptable or practical options.

## Shoreline Management

- Regulation and Removal of Shore Protection Structures – To protect the natural shoreline and the benefits it provides, regulations can be used to limit shoreline hardening as well as promote alternative forms of protection.



- Rolling Easements – Rolling easements are shoreline easements designed to promote the natural migration of shorelines. Typically, rolling easements prohibit shore protection structures which interfere with natural shoreline processes and movement, but allow other types of development and activities. As the sea rises, the easement moves or “rolls” landward, wetland migration occurs, and public access to the shore is preserved.
- Living Shorelines – Living shorelines can be effective alternatives to shore protection structures in efforts to restore, protect, and enhance the natural shoreline and its environment. Living shorelines use stabilization techniques that rely on vegetative plantings, organic materials, and sand fill or a hybrid approach combining vegetative plantings with low rock sills or living breakwaters to keep sediment in place or reduce wave energy.
- Beach Nourishment – Beach nourishment is the process of placing sand on an eroding beach, typically making it higher and wider, to provide a buffer against wave action and flooding.
- Dune Management – Dunes may be restored or created in conjunction with a beach nourishment project or may be managed as part of a separate effort.
- Sediment Management – Dredging and placing sediment, building shore protection structures and other structures that trap or divert sediment.

### Coastal Ecosystem Management

- Ecological Buffer Zones – Ecological buffers are similar to setbacks (and may be included within setbacks) but are typically designed to protect the natural environment by providing a transition zone between a resource and human activities.
- Open Space Preservation and Conservation – Open space preservation and conservation can be accomplished through the management of lands dedicated as open space through a number of the measures previously discussed, such as zoning, redevelopment restrictions, acquisition, easements, setbacks, and buffers.
- Ecosystem Protection and Maintenance – In the context of coastal adaptation, ecosystem protection largely involves the protection of tidal wetlands and other ecosystems. The facilitation of wetland migration is an important aspect of this.
- Ecosystem Restoration, Creation, and Enhancement – Similar to the above, ecosystem restoration and creation can replace tidal wetlands that are lost to sea level rise.



## Water Resource Management and Protection

- Stormwater Management – Drainage systems may be ill-equipped to handle the amount of stormwater runoff that will accompany the more intense rainfall events expected in the future, and those in low-lying areas will be further challenged by losses in elevation attributed to rising sea levels.
- Water Supply Management – Climate change will negatively affect both water quantity and quality, and coastal populations will continue to grow, so water supply managers must be prepared to respond to associated challenges to water supply.

Elements of *protection, retreat, and accommodation* are found in several of these categories and sub-categories of adaptation. For example, Growth and Development Management actions can be used to manage retreat or accommodation, whereas Shoreline Management may include methods of protection as well as removing protection. NOAA notes that these adaptation measures are organized into categories that describe their primary purpose, but in many cases, they serve multiple purposes and could fit into multiple categories (e.g., acquisition could fit under Growth and Development Management, Coastal and Marine Ecosystem Management, and Shoreline Management in addition to Loss Reduction).

## Options for Coastal Resilience

The City of Ocean City has organized its preferred adaptation strategies into three categories that are appropriate for the geography, population, and infrastructure. The three categories and their sub- categories are listed in Table 2.

**Table 2**

### Coastal Resilience Adaptation Options

Adaptation Categories	Possible Sub-categories
Management of coastal real estate and structures	Building codes (freeboard, V zone standards in A zones)
	Acquisition of damaged properties
	Zoning overlays
	Zoning amendments
	Coastal realignments through any of the above
Shoreline protection and management of	Hard shoreline protection



coastal and near-shore lands	Living shorelines
	Buffers for flood protection
	Land conservation for tidal marsh migration
Roadway alterations	Elevation of roadways
	Re-evaluation of emergency routes

Ocean City’s neighborhoods are diverse and it is likely that each will be faced with a combination of vulnerabilities to sea level rise and the increased incidence and severity of coastal storms. A combination of adaptation measures may therefore be necessary in each neighborhood in order to reduce risks and maximize resilience. Similarly, neighborhood scale resilience planning will likely be important. When this planning occurs, neighborhoods will be urged to evaluate individual adaptation measures and determine how comprehensive solutions can be developed and implemented for building coastal resilience.

Project Opportunities:

- Flood risk is increasing for coastal populations and supporting infrastructure.
- Improved land use, wise use of floodplains, responsible evacuation planning, and strategic retreat are important and cost-effective actions.
- Communities should adopt combinations of solutions, including nonstructural, structural, natural and nature-based, and programmatic measures to manage risk, where avoidance is not possible.
- Communities must identify their acceptable level of residual risk to plan for long-term, comprehensive, and resilient risk management.
- Many opportunities exist to improve risk management, including enhancing collaboration, building new partnerships, and strengthening pre-storm planning.
- Addressing coastal risk requires collaboration among local, regional, State and Federal entities, NGOs, academia,
- Resilience can be encouraged through the use of a CSR framework and commitments to advance sea level and climate change science, storm surge modeling and related themes.



## Coastal Protection Strategies

As Sandy illustrated, the forces of nature can be significant, sometimes overwhelming even well-designed coastal defenses. Given this reality, the City's plan for coastal protection focuses not on retreat – a strategy that may make sense in only very limited circumstances, but is neither possible nor desirable on a larger scale – and instead focuses on the following strategies:

### Increase coastal edge elevations

Sea level rise threatens to inundate some neighborhoods with daily or weekly tidal flooding by the 2050s. To address this risk, the City will increase the height of vulnerable coastal edges with bulkheads, beach nourishment and other measures over time. This adaptive strategy allows for ongoing monitoring of sea level rise and investment as and where needs arise.

### ***Beach Nourishment***

Beaches are an important recreational and economic resource for the city. They are also a critical part of the City's coastal defense network. Regular wave action and the natural sediment transport process (the ongoing movement of sand following the dominant wave direction) continue to erode beaches over time, however. Storms only accelerate this process. A regular program of beach nourishment – that is, adding large quantities of sand to widen and elevate beaches on a regular cycle, as well as after significant storm events – is critical to ensuring that city beaches continue to serve their vital coastal protection role.

### ***Armor Stone (Revetments)***

Hardening exposed shorelines with armor stone (various kinds of massive rocks, including granite), or revetments can protect against erosion caused by storms and rising sea levels. Revetments, also known as rip-rap can also be used to raise edge elevations. Experience has demonstrated that revetments require minimal maintenance. In addition, the shallow slopes of revetments can provide near-shore habitat for marine organisms and vegetation.

### Bulkheads

Historically, bulkheads (or structures, usually made of stone or concrete, at the water's edge) have been installed to hold shorelines in place. They are also used to protect exposed shorelines from erosion. Raising bulkheads in targeted locations citywide would mitigate the effects of rising sea levels in low-lying areas shown to be prone to future tidal flooding.



### ***Tide Gates/Drainage Devices***

Tide gates, valves, which seal a pipe end but still allow water to drain, and other backflow-prevention devices are used to ensure that water does not flow backwards through drainage infrastructure. These commonly used devices, although not universally applicable, can be used to improve the performance of the city's drainage network and reduce flood risk, though they must be evaluated on a site-specific basis so as not to impede the ability of upland areas to drain stormwater.

### **Minimize upland wave zones**

Storm waves, which are projected to increase in size and strength over time, threaten to cause neighborhood damage, erosion, and the loss of beach sand in vulnerable areas. To address this risk, the City will work to provide significant attenuation of waves – that is, to knock down waves, or diminish their velocity – both off and onshore, before they reach neighborhoods. This approach will reduce potential damage to structures, reduce erosive forces on the shoreline, and protect infrastructure. Moreover, this approach should also influence the delineation of high-risk V and Coastal A Zones on FEMA's future FIRMs, especially if measures are built where possible, to the 100-year flood elevation with an additional allowance for future sea level rise. This, in turn, potentially could reduce the costs of flood insurance and mitigation within protected areas.

### ***Dunes***

Dunes – reinforced sand mounds typically located along the back edge of a beach – help break waves and keep floodwaters from inundating neighborhoods. Dunes can be “sacrificial,” designed to allow sand to wash away as storm waters recede. Generally, they require maintenance and sand replenishment from time to time, especially after storms. Dunes work well when planted (because plant roots help hold the sand in place) and reinforced (with a structural inner core of rock or geotextiles, on which the sand sits). In some locations, they work even better when there is enough land to allow for both primary and secondary dunes (a double-dune system), which also provide redundant coastal protection.

### ***Wetlands, Reefs, and Living Shorelines***

Wetlands – swamps, marshes, and bogs – are areas that are inundated or saturated by surface or groundwater sufficiently frequently to support vegetation that thrives in wet soil conditions. Reefs are an offshore feature typically below sea level. Living shorelines are coastal edges that incorporate a combination of reefs, breakwaters, maritime or coastal forests, and tidal wetlands to reduce wave action and erosion. These natural features are known to offer significant ecosystem and water quality benefits, and also to aid in the retention of stormwater, sediment, nitrogen, and other nutrients. What is less



well-understood is their ability to reduce waves during storms, although anecdotal evidence indicates that they can perform this function. Analytical research has shown that, when placed appropriately, wetlands, oyster reefs, and living shorelines, possess effective wave-attenuation properties. Those properties may be improved even further by altering the depth at which these features are placed or modestly increasing the inclusion of hardened elements such as rock.

### ***Groins***

These installations of rocks or timber, perpendicular to the shoreline, are often referred to as jetties. They can help retain sand from beach nourishment projects on-site and also serve to break waves and absorb wave energy. Though groins must be carefully evaluated because they have the potential to disrupt natural sediment transport processes, with careful planning, they can serve a vital function in protecting oceanfront communities.

### **Protect against storm surge**

To address the risk of storm flooding, the City will work to keep water from storm surge out of vulnerable neighborhoods and away from critical infrastructure. To do this, the City will use flood protection structures, such as floodwalls, levees, and local storm surge barriers built, where possible, to the 100-year flood elevation with an additional allowance for future sea level rise. Generally, the City will seek measures that minimize damage if overtopped.

### **Improve coastal design and governance**

To ensure the successful implementation of the strategies outlined above, the City will make improvements to the design and governance of coastal areas. Specifically, the City will study how natural areas and open space can be used to protect adjacent neighborhoods and maintain neighborhood quality of life, and will work to manage its own waterfront assets more effectively, while also developing partnerships to improve permitting and study innovative coastal protections.

### **Possible Adaptation Strategies**

Risks and vulnerabilities have been characterized, potential adaptation actions have been identified, and policy measures have been explored. It is recognized that one of the earliest impacts of rising sea levels in Ocean City is decreased stormwater drainage as higher tides push into underground pipe conveyances and outfalls. Backup of stormwater systems during high tides has been identified as a source of increased flooding within the local community during major rainfall events. During very high tides, some stormwater systems had been observed to flow backwards on days without



rainfall, potentially resulting in the conveyance of saltwater onto roads, yards, and low-lying structures.

Increased occurrence of such tidal flooding events, sometimes called “sunny day or nuisance flooding,” has been identified as a primary concern from sea level rise. There is also recognition that rising seas can result in the replacement of upland ecosystems with intertidal marsh and estuarine mudflat systems, while also increasing saltwater contamination risks for drinking water wells and underground aquifers.

The following “Focus Areas” have been identified as the basis for framing and evaluating the community’s sea level rise adaptation options.

### **Municipal Infrastructure**

Since Ocean City is a barrier island, much of the City’s infrastructure and private property is vulnerable to flooding. Sea level rise can be expected to exacerbate these vulnerabilities over time. Identifying these vulnerabilities, evaluating the relative costs and benefits of infrastructure improvement options, and recommending specific adaptation actions for municipal implementation are key goals for sea level rise planning.

### **Access and Connectivity**

Recent reconstruction of the Longport Bridge and Route 52 have markedly improved access capabilities to/from the City, and the 34<sup>th</sup> Street Bridge is under construction. Due to the elevation of the reconstructed Route 52 causeway, this linkage to the mainland is the most important during times of coastal storms and associated flooding.

Getting to Route 52 from some areas of the City is not possible during major storm events due to the low elevation of certain municipal streets. Sea level rise can be expected to increase the frequency and severity of these storm-related flood events over the next several decades. This conditions necessitating evaluation of emergency access is identified as a key goal of the planning effort. A companion report titled “Community Resilience Plan – 9<sup>th</sup> Street Gateway and Central Business District” includes a detailed evaluation of conditions contributing to flooding and provides solutions to improve access during major storm events.

### **Coastal Dynamics**

Barrier islands like Ocean City are the visible portion of a much larger and highly dynamic coastal sediment system. Coastal erosion problems on Ocean City can be expected to worsen with sea level rise, and therefore will need to be managed through a variety of management interventions. Possible approaches include beach



renourishment, dune restoration, living shorelines, coastal armoring, and relocation of vulnerable infrastructure.

### Management and Stewardship

Preservation of Ocean City's rich history and proactive management promoting future sustainability are core values of the community. Careful planning, coordination with allies agencies, and adaptation to unanticipated changes will enable Ocean City to maintain its heritage as "America's Greatest Family Resort" for future generations.

### Stormwater Retrofits

Several areas in Ocean City have low-lying stormwater drainage systems that become inundated and can even flow backwards during exceptionally high tides. This backflow causes saltwater flooding of streets and yards, while also increasing flood risks during rainfall events.

If no action is taken, sea level rise can only be expected to worsen these conditions in the future. The City has already installed backflow preventers on stormwater pipe outfalls that drain the most vulnerable areas. Continuation of such stormwater retrofits therefore appears to be a highly cost-effective adaptation strategy.

### Beach Renourishment

In 1991, after years of eroding beaches and local efforts to renourish the beachfront using back-bay dredging, the Federal Government, through the Army Corps of Engineers, and the State of New Jersey began a 50-year beach renourishment program on the beaches from the northernmost groin to 36<sup>th</sup> Street. The beach renourishment program was extended south to Corson's Inlet in 2016. A priority for future beach renourishment projects and negotiation of a new authorization should be maintenance of flood protection under a condition of accelerating sea-level rise. Additionally, the City should continue to investigate the possibility of augmenting their sand dune system to help protect the island from storm surge during coastal storm events.

### Community Rating System

The Community Rating System or CRS is a part of the National Flood Insurance Program (NFIP) that provides reductions to flood insurance premiums in participating communities. Insurance premium reductions are based upon a community's level in the CRS Program. The reductions take into account the community floodplain management programs, including public information activities. In order to increase the Flood Insurance discount levels the community must continue to promote the necessity that



citizens of Ocean City purchase flood insurance and to continue to implement CRS programs and report status to the NFIP each year.

Ocean City entered the National Flood Insurance Program in 1970 and has been recertified each year since 1991. The entire island has been determined to be in the Special Flood Hazard Area for the 100-year storm as determined in 1984 by the National Flood Insurance Program (NFIP) with an A-zone Base Flood Elevation (BFE) of either 9' or 10' NGVD and a V-zone BFE of 11-14' on the beach. All properties are required to be newly constructed or substantially repaired in accordance with NFIP rules in effect since 1970 and updated from time to time. The Construction Official is responsible for compliance with the NFIP rules.

The City of Ocean City recently underwent a review for FEMA's Community Rating System (CRS). A federal incentive program designed to incentivize flood resiliency, CRS rewards communities for adopting floodplain management ordinances, adhering to minimum standards for new construction and educating citizens about their flood risk. Due to the extensive public investments, outreach, and regulation that the City has pursued over recent years, the City improved its CRS rating to a score of five. This rating translated into a 25 percent discount in flood insurance for each resident in the Special Flood Hazard Area. The Floodplain Management has made it a goal to gain a CRS Class 3 from the current level of CRS Class 5, and continue to be the highest rated community in the state.

### **Integrated Coastal Zone Management**

Integrated Coastal Zone Management (ICZM) is a process of governance and consists of the legal and institutional framework necessary to ensure that development and management plans for coastal zones are integrated with environmental (including social) goals and are made with the participation of those affected. The purpose of ICZM is to maximize the benefits provided by the coastal zone and to minimize the conflicts and harmful effects of activities upon each other, on resources and on the environment. The City should evaluate opportunities to incorporate elements of this management tool developed by the World Bank into their continuing planning programs.

### **Green Infrastructure**

In the context of coastal resilience, green infrastructure is defined as the integration of natural systems and processes, or engineered systems that mimic natural systems and processes, into investments in resilient infrastructure. Green infrastructure takes advantage of the services and natural defenses provided by land and water systems



such as wetlands, natural areas, vegetated sand dunes, and forests, while contributing to the health and quality of America's communities.

Damage from flooding in inland areas, and from storm surge and flooding in coastal environments, is significantly reduced when natural wetland, riparian, and floodplain areas and the ecosystem services they provide are protected. A particularly effective use of green infrastructure to reduce damage from natural disasters is to conserve environmentally sensitive areas through strategies such as acquisition of land or easements, natural resource protection ordinances, and other regulatory controls and incentives.

Potential benefits to Ocean City's economy associated with green infrastructure include, but are not limited to the following:

- Creation of job and business opportunities
- Increased tourism, retail sales, and other economic activity
- Increased property values
- Reduced energy, health care, and gray infrastructure costs

While many of the above benefits do not directly relate to post-disaster recovery, they can contribute to increased community resilience and, in doing so, reduce vulnerability to natural disasters.

According to a recent study by the Natural Capital Project and the Nature Conservancy, 16 percent of the U.S. coastline, inhabited by 1.3 million people and representing \$300 billion in residential property value, is located in high-hazard areas.<sup>5</sup> Sixty-seven percent of these areas are protected by natural green infrastructure (intact reefs, sand dunes, marshes, and other coastal vegetation), and the number of people and total property value exposed to hazards would double if this habitat were lost. These findings underscore the effectiveness of preserving and restoring natural habitat areas, as well as mimicking the services provided by such areas through "nature-based" approaches (e.g., artificial oyster reefs and living shorelines), to increase resilience to natural disasters.

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<sup>5</sup> Arkema, Katie K., Greg Guannel, Gregory Vertutes, Spencer A. Wood, Anne Guerry, Mary Ruckelshaus, Peter Kareiva, Martin Lacayo, and Jessica M. Silver. 2013. *Coastal Habitats Shield People and Property from Sea-Level Rise and Storms*. The Natural Capital Project, Stanford University and The Nature Conservancy. Published in *Nature Climate Change* 3, pp. 913–918. Available at <http://www.nature.com/nclimate/journal/v3/n10/full/nclimate1944.html>.

Ocean City will continue to explore new and innovative ways to increase coastal resilience. Integrated approaches to planning for future disasters combine green and gray infrastructure strategies such as those used in Louisiana's *Coastal Protection Master Plan*<sup>6</sup> which proposes a combination of restoration, nonstructural, and targeted structural measures to provide increased flood protection.



### Building More Resilient Homes

It is not feasible for building owners to raise their attached multi-story structures to comply with the Federal Emergency Management Administration ("FEMA") and National Flood Insurance Program ("NFIP") regulations and requirements. Therefore, the City is working with FEMA, the N.J. Department of Environmental Protection ("NJDEP") and the N.J. Department of Community Affairs ("NJDCA") to reconcile the city's zoning code with state and federal regulations to allow for "wet floodproofing" and "dry flood proofing" of ground level floors located below the Base Flood Elevation ("BFE"). Of particular concern, is the utilization of space on the street level of buildings in the flood hazard area.

State and federal regulations prohibit/discourage residential and mixed-use buildings from having usable space on the ground floor if that level is located below the BFE. It is feared that these requirements would have an adverse impact on commerce in the central business district and community character. If implemented, existing state and federal regulations would discourage urban design which facilitates "eyes on the street" which in turn would adversely impact public safety and security. In addition, state and

<sup>6</sup> Louisiana, State of. 2012. *Louisiana's Comprehensive Master Plan for A Sustainable Coast*. Coastal Protection Master Plan available at <http://coastal.la.gov/a-common-vision/2012-coastal-master-plan>.



federal regulations prohibit/discourage elevator mechanicals from being located anywhere below the BFE. Therefore in some areas the lowest level an elevator may be located in is the second floor. This in turn necessitates the construction of elaborate and excessive handicapped ramps to comply with the Americans with Disabilities Act (“ADA”). The City is using a NJDCA Post Sandy Planning Assistance Grant to update its design standards.

### **Watershed Master Plan**

In order to satisfy the prerequisite for advancing to CRS Class 4, this FMP evaluates the future conditions, including the impacts of a median projected sea level rise (based on the National Oceanic and Atmospheric Administration’s (NOAA’s) “intermediate-high” projection for the year 2100) on the local drainage system during multiple rainfall events, including the 100-year rainfall event.

The City must have adopted regulatory standards that require onsite management of runoff from all storms up to and including the 25-year event that receive credit under SMR in Section 452.a. The adopted regulatory standards must manage future peak flows so that they do not increase over present values. “All storms” includes at a minimum the 10-year storm in addition to the 25-year event. Management of a 2-year storm is also recommended. For “major development” Section 25-1700.32.12 of the Ocean City Code requires hydrologic and hydraulic analysis of the 2-, 10- and 100-year storm events.

Local observations and scientific evidence have confirmed that rising seas are already affecting communities in the United States. Diverse impacts that include loss of road access during high-tides, increased flood damage to low-lying buildings, and documented shifts in coastal ecosystems necessitate new kinds of planning and resource mobilization.

Sea level rise in and of itself – even without the impact of coastal storms – is a growing risk that already affects certain low-lying neighborhoods. These include areas where homes and other structures in some cases are lower in elevation than adjacent roadway infrastructure, exacerbating flooding. These areas today experience flooding at the highest range of the regular tidal cycle. As sea levels continue to rise, these neighborhoods will flood more frequently, while other low-lying neighborhoods that do not flood regularly with the tides will start to do so.



To meet this challenge, private citizens, businesses, non-governmental organizations, and governments at the local, state, and federal level are engaging in innovative partnerships that mark critical initial steps toward long-term sea-level rise adaptation.

There is wide agreement among scientists that the increased sea-level rise observed over the past century is a consequence of rising ocean temperatures and glacial melting associated with anthropogenic global warming. For this reason, scientists are concerned that sea-levels have the potential to rise at a much faster pace over the 21<sup>st</sup> century due to the high likelihood of accelerated climate change.

A recent report by NOAA – “Global SLR Supporting the US National Climate Assessment” – provides scenarios to help assessment experts and their stakeholders analyze the vulnerabilities and impacts associated with possible, uncertain futures. Scenario planning offers an opportunity to initiate actions now that may reduce future impacts and vulnerabilities.

In recent decades, the NOAA report indicates that the dominant contributors to global sea level rise have been ocean warming (i.e. thermal expansion) and ice sheet loss. The scenarios in the NOAA report are based on four estimates of global SLR by 2100 that reflect different degrees of ocean warming and ice sheet loss. The report stresses that none of these scenarios should be used in isolation, and experts and coastal managers should factor in locally and regionally specific information on climatic, physical, ecological, and biological processes and on the culture and economy of coastal communities. The report notes that their approach is consistent with US Army Corps of Engineers (USACE) guidance for coastal decision makers, and draws on several commonly used methodologies as the basis for developing scenarios.

**Table 3**  
**Global SLR Scenarios**

<b><u>Scenario</u></b>	<b><u>SLR by 2100 (M)*</u></b>	<b><u>SLR by 2100 (FT)*</u></b>
<i>Highest</i>	2.0	6.6
<b>Intermediate-High</b>	<b>1.2</b>	<b>3.9</b>
<i>Intermediate-Low</i>	0.5	1.6
<i>Lowest</i>	0.2	0.7

\* Using mean sea level in 1992 as a starting point.



The data in Table 3 suggests that global sea levels in the year 2100 will almost certainly be at least eight inches higher than present, but could potentially rise by up to 6.6 feet.

The CRS requires Ocean City to evaluate the future conditions, including the impacts of a median projected sea level rise (based on the National Oceanic and Atmospheric Administration's (NOAA's) "intermediate-high" projection for the year 2100) on the local drainage system during multiple rainfall events, including the 100-year rainfall event. The Intermediate-High Scenario is based on an average of the high end of semi-empirical, global SLR projections. Semi-empirical projections utilize statistical relationships between observed global sea level change, including recent ice sheet loss, and air temperature. The Intermediate-High Scenario allows experts and decision makers to assess risk from limited ice sheet loss.

### SLR and Coastal Flooding

It is certain that higher mean sea levels increase the frequency, magnitude, and duration of flooding associated with a given storm, which often have disproportionately high impacts in most coastal regions. Extreme weather events will continue to be the primary driver of the highest water levels. However, a consensus has not yet been reached on how the frequency and magnitude of storms may change in coastal regions of the US.

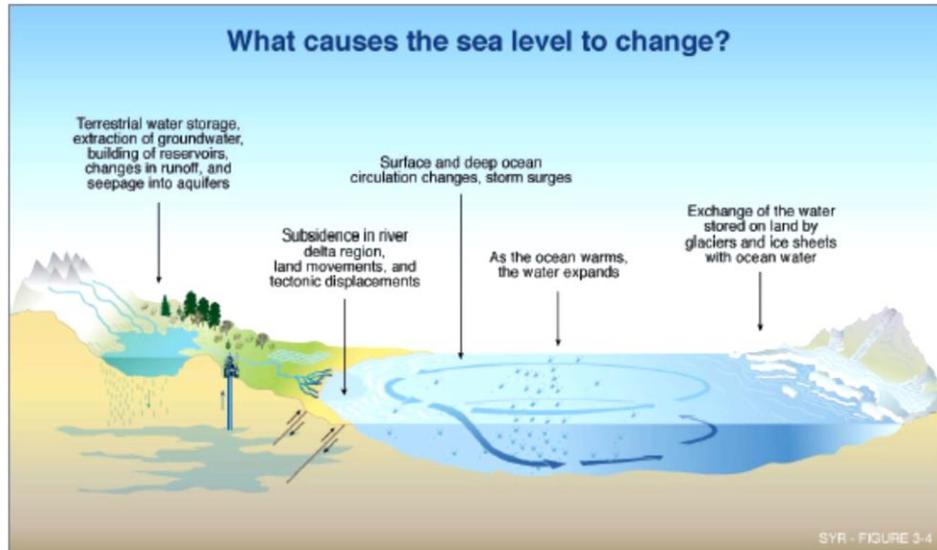
The greatest coastal damage generally occurs when high waves and storm surge occur during high tide. In many locations along the US coast, small increases in sea level over the past few decades already have increased the height of storm surge and wind-waves. Thus, considering the impact of different weather events combined with scenarios of SLR is crucial in developing hazard profiles for emergency planning and vulnerability, impact, and adaptation assessments. Given the range of uncertainty in future global SLR, using exploratory scenarios in coastal planning offers an opportunity to initiate actions now that may reduce future impacts and vulnerabilities.

### Historical Sea Level Trends

Global SLR is the result of the change in the volume of water in the oceans due primarily to changes in ocean temperature, melting and increased discharge of land-based ice (i.e. glaciers, ice caps, and ice sheets in Greenland and Antarctica), and changes in runoff (e.g. dam construction or groundwater withdrawal).

Figure 3

Causes of Sea Level Change



Regional Patterns in the US Atlantic

RSL has been rising along the entire US Atlantic coast. Regarding the SLR scenarios, the NOAA report states, "We have very high confidence (>9 in 10 chance) that global mean sea level will rise at least 0.2 meters (8 inches) and no more than 2.0 meters (6.6 feet) by 2100."<sup>7</sup>

Vertical Land Movement (VLM)

Regional and local sea level scenarios should account for vertical land movement. Glacial rebound in North America is largest around Hudson Bay, where the former ice sheet was both centered and thickest. Meanwhile, land is subsiding further south at and beyond the edges of the former ice sheet, in response to the rebound to the north. GIA is changing coastal land elevations at rates of mm-per-year. As a result, it is necessary to consider GIA in the analysis of sea level observations and trends.

The contribution of GIA to net changes in RSL varies for much of the US coastline and its island territories, with modeled rates ranging from +0.5 to +2.0 mm/yr. for much of the mainland. Portions of the Northeast and Northwest mainland coasts have modeled rates at the upper end of this range.

At some locations along the coastline, VLM may be exacerbated by factors other than GIA. Other factors of VLM include, but are not limited to: plate tectonics; natural

<sup>7</sup> Global SLR Supporting the US National Climate Assessment, November 2012, page 10.



compaction of thick layers of loose, unconsolidated sediments; sediment compaction due to excessive withdrawal of groundwater, oil, or gas; and subsidence due to oxidation of organic soil. Sun et al. (1998) indicate that land subsidence due to groundwater withdrawal in southern New Jersey has increased from 2 cm to 3 cm over the past 40 years.<sup>8</sup>

### Extremes of Weather and Climate

Coastal managers are most immediately concerned with the effect that global, regional, and RSL changes have on coastal flooding. In addition to changes in mean sea level, consideration of future extremes is vitally important for planning and design of coastal infrastructure (Zhang et al. 2000). SLR can amplify factors that currently contribute to coastal flooding: high tides, storm surge, high waves, and high runoff from rivers and creeks (Cayan et al. 2008).

All of these factors change during extreme weather and climate events and often have disproportionately high impacts in most coastal regions. Although a consensus has not yet been reached on how the frequency and magnitude of storms may change in coastal regions of the US, it is certain that higher mean sea levels increase the frequency, magnitude, and duration of coastal flooding associated with a given storm. Thus, considering the impact of different weather events combined with scenarios of sea level change is crucial in developing hazard profiles for emergency planning and vulnerability, impact, and adaptation assessments.

### Dynamic Changes in Ocean Circulation

Regional and local sea level change scenarios also should reflect dynamic changes in ocean circulation, ice sheet losses, and mass redistributions associated with ice sheet losses, though this information is very limited at present.

Climate models have forecast the slowing of the overturning circulation in the Atlantic from warming seawater in the north Atlantic, introduction of fresh water from GIS, and other sources. These factors could slow the boundary currents along the US east coast and raise sea levels in the northeast (Yin et al. 2009, Yin et al. 2010).

### Other stressors related to Coastal Vulnerability

Coastal land use and landforms affect inundation patterns on the coast. In addition to the aforementioned factors, a number of local coastal processes determine the

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<sup>8</sup> Sun. H., Grandstaff. D., R. Shagam., Land subsidence due to groundwater withdrawal: potential damage of subsidence and sea level rise in southern New Jersey, USA, *Environmental Geology*, Vol.37, 1999, PP.290-296.



configuration of coastal landforms (e.g. beach profiles, sea cliffs, barrier islands, marshes, atolls, etc.; see CCSP 2009). Although specific locations where these factors dominate coastal processes are difficult to integrate into scenarios of environmental change the NOAA report indicates that they should at least be considered in determining vulnerability and impacts. These factors vary substantially among US coastal areas and include, but are not limited to:

- Sediment supply to the coast and associated transport along the coast
- Elevation and range of tides
- Wave height, period, and slope of the shoreline
- Sediment accumulation rates - physical and biogeochemical
- Presence or absence and configuration of barriers, whether human-made or natural, to coastal flooding and to constraints on shoreline change
- Permafrost decline - a unique driver of coastal elevation change in northern Alaska that controls, in some locales, the retreat of coastal bluffs.

The four scenarios of global mean SLR provide a set of plausible trajectories of global mean SLR for use in assessing vulnerability, impacts, and adaptation strategies. Locally and regionally specific information on climatic, physical, ecological, and biological processes and on the culture and economy should be factored into all assessments. It is noted that potential influences of global phenomena, such as SLR, can influence those conditions creating unanticipated impacts at the local scale, especially over longer time horizons. Thus, coastal vulnerability, impact, and adaptation assessments require an understanding of the long-term, global and regional drivers of environmental change.

### **Impact of Sea Level Rise on Local Drainage System**

The CRS requires Ocean City to evaluate the future conditions, including the impacts of a median projected sea level rise (based on the National Oceanic and Atmospheric Administration's (NOAA's) "intermediate-high" projection for the year 2100) on the local drainage system during multiple rainfall events, including the 100-year rainfall event.

The impacts of a more rapid pace of global sea-level rise which may affect developed low-lying coastal areas fall in four main categories: intensified flooding and submergence; increased erosion of shorelines; greater intrusion of saline waters into estuaries and coastal aquifers; and drainage problems.



With higher sea level, more urban centers and residential areas are likely to be affected by storm surges, resulting in episodic or permanent inundation. An accelerated sea-level rise combined with the low rate of sediment supply is likely to trigger erosion on shorelines that are presently stable or to enhance erosion on shorelines that are already retreating.

Based on a 1984 drainage study which evaluated the impacts of the 10-year storm, the City replaces drainage facilities on all new road projects up to the 10-year storm which complies with the NJDOT standard for roads. During the 10-year storm, one-third of the island is under water. During the 50-year storm 75% of the island is under water; and during the 100-year storm the entire barrier island is inundated.

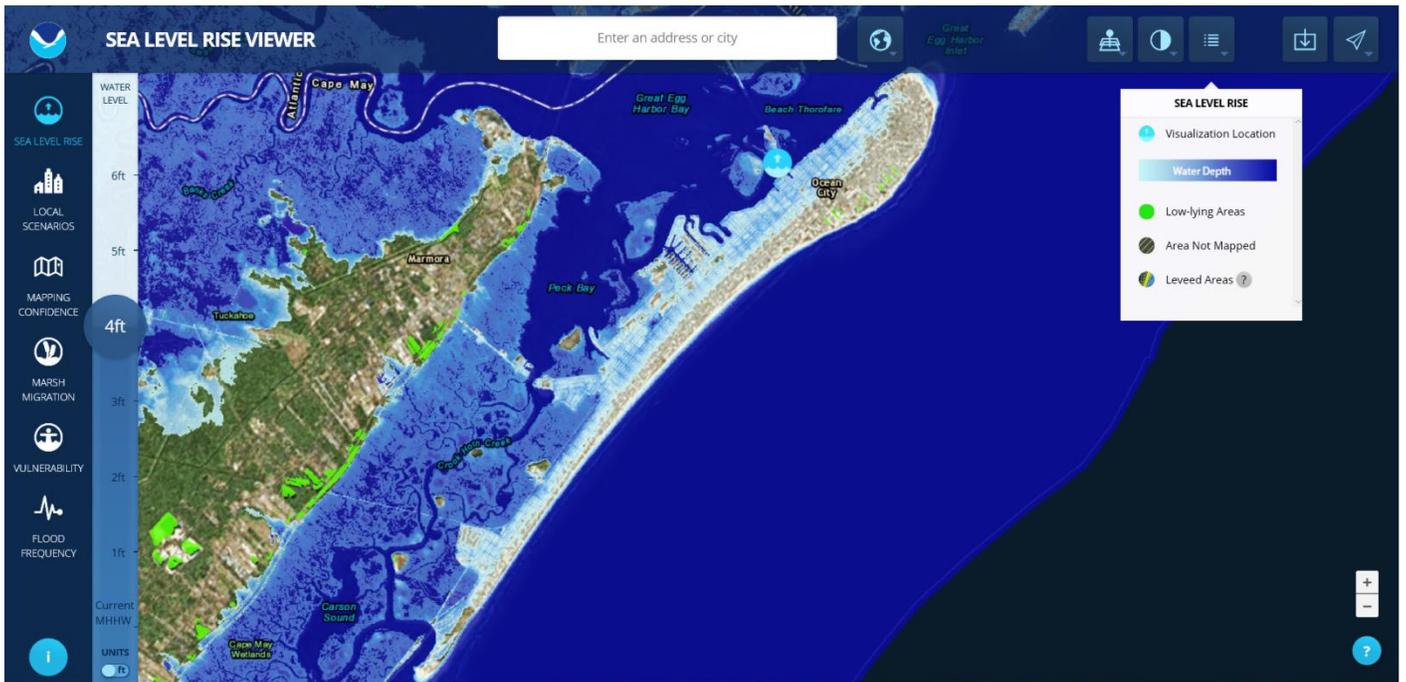
The following two images from NOAA's Sea Level Rise Viewer illustrate the scale of potential flooding, not the exact location, and do not account for erosion, subsidence, or future construction. Water levels are two feet above Mean Higher High Water (MHHW) (excludes wind driven tides) in the Figure 4 and four feet above MHHW in Figure 5. The data, maps, and information provided should be used only as a screening-level tool for management decisions.

Areas that are hydrologically connected to the ocean are shown in shades of blue (darker blue = greater depth). Low-lying areas, displayed in green, are hydrologically "unconnected" areas that may also flood. They are determined solely by how well the elevation data captures the area's drainage characteristics.

Figure 4  
Sea Level Rise (2 Feet)



Figure 5  
Sea Level Rise (4 Feet)





## Coastal Hazard Mitigation and Sea Level Planning

Climate change and sea level rise are important issues to Ocean City wherein the City has recognized climate change as a phenomenon requiring long-term governmental monitoring and management. Accordingly, City Departments, Boards and Commissions will consider impacts of these conditions on planning, management, procurement and budgetary decisions, and regulations relating to the objective of reducing greenhouse gas emissions, and mitigating negative effects that are projected to evolve from climate change.

Stormwater Management: The City of Ocean City, in partnership with the Ocean City Intermediate School and Duffield Associates, obtained a 2010 Sustainable Jersey Small Grant to rejuvenate the Douglas Kimble Memorial Court Yard by installing a rain garden system to enhance the uses of this area and alleviate the constant water build up. The completed rain garden has created proper drainage while providing a place to for students and community members to learn the many benefits to eco-friendly gardening practices, and act as a model for water quality and control for Ocean City and other barrier island communities.

In 2014, the City constructed a bioswale at the corner of North Street and West Avenue. The project objective is for the bioswales to improve flooding, filter water that enters local waters via the stormwater system, and reduce labor costs associated with stormwater system maintenance. The bioswale is also intended to improve the pedestrian experience by adding green space, and improve air quality by using low-maintenance native plantings. Funding for this *green streets* project was obtained by the Ocean City Environmental Commission from a New Jersey American Water Company grant.

Ocean City will continue to explore potential benefits that green infrastructure will have on reducing flooding and stormwater run-off.

Demonstration Dune Project: The City of Ocean City has maintained an active program for planting dune grass to improve the resilience of its dunes. In addition to Public Works, a variety of community groups including the Ocean City Environmental Commission participates in the spring and fall dune grass planting events.



A mature dune system however, includes a wide variety of plants, each of which has a unique purpose for the ecosystem. For example, some plants trap wind-blown sand while others establish a strong foundation for the dune.

The Ocean City Environmental Commission constructed a demonstration dune project between 11<sup>th</sup> and 12<sup>th</sup> Streets on the boardwalk. This project was funded by a grant from the Association of New Jersey Environmental Commissions.

This project is not intended to replace current dune-planting activities. The City and other volunteer organizations will continue the established dune grass planting at locations in need. The goal of this project is to systemically demonstrate the value of a planned dune-planting program and help the city improve their dune planting efforts. Based on the results of this project, additional planting activities may be incorporated into other dune locations.

Emergency Notification: The City of Ocean City will apply to the State of New Jersey for Hazard Mitigation Grant Program funding to purchase programmable, solar-powered, mobile message boards which can be quickly deployed during emergencies and community events to warn motorists of impending hazards or provide residents with information and instructions. This is in addition to the relatively robust emergency notification system the City already employs, including Reverse 911, Facebook and Twitter updates.

Public Information: The City of Ocean City will apply to the State of New Jersey for Hazard Mitigation Grant funding to engage in a public information and awareness campaign to advise residents of natural and man-made hazards and recommend that citizens put together preparedness plans. While the City's social media program is relatively robust, this expanded public information campaign would augment the CRS/PPI and could be rolled-out in less than one year.

### **Energy Resilience at Critical Facilities**

Ocean City continues to take steps to protect itself against natural disasters in the years since Superstorm Sandy. The island's natural gas mains have been successfully converted from a low-pressure system to a high-pressure system. The upgrade by South Jersey Gas is designed to protect residents against severe weather impacts, such as those experienced during Sandy.

The work in Ocean City was a part of the Storm Hardening and Reliability Program (SHARP), in which South Jersey Gas replaced 92 miles of distribution mains along the barrier islands of Atlantic and Cape May counties.



In conjunction with PSEG's "Energy Strong" program and the availability of funding, the City of Ocean City will designate critical community facilities to deliver uninterrupted electrical service during disaster events, black-outs and brown-outs. Critical community facilities include the police headquarters, fire headquarters and fire stations, the Cape May County sewage treatment plant, stormwater pump stations, City Hall, the DPW Central Garage, shelters, grocery stores and fuel stations, and residential buildings with large at-risk populations like seniors and the disabled.

### Natural Coastal Protection

Natural coastal protection is the protection of coastal lands and populations from erosion, inundation and storm impacts by natural systems. The Nature Conservancy's Natural Coastal Protection project is a collaborative work to review the growing body of evidence as to how, and under what conditions natural ecosystems can and should be worked into strategies for coastal protection.

"The use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change. This includes the sustainable management, conservation and restoration of specific ecosystems that provide key services."<sup>9</sup>

The best solutions to the challenges facing coastal communities may depend less on current development and modern infrastructure, and more on rethinking the value of existing or restored natural resources. The Nature Conservancy's "Natural Solutions Toolkit" explores nature-based solutions by:

- Developing hybrid approaches that link natural and built defense structures
- Managing freshwater resources in innovative ways to benefit nature, economy, and society
- Accounting for multiple ocean benefits provided by various ecosystems
- Reducing water treatment costs while protecting biodiversity, storing carbon, and improving human health and well-being
- Using water markets to incentivize water conservation and reallocate saved water back to freshwater and estuary ecosystems

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<sup>9</sup> Convention on Biological Diversity's ad hoc Technical Expert Group on Biodiversity and Climate Change (AHTEG).



Natural ecosystems may help to counter the impacts associated with sea level rise, warming waters and changes in storm patterns already affecting coastal areas: binding sediments, reducing waves and growing upwards as sea levels rise, thereby protecting coastal lands and populations from erosion, inundation and storm impacts.

This capacity of natural ecosystem to provide protection is important in many locations: where nature provides other critical services, for food or recreation; where engineered defenses are too costly; or where adjacent lands are of low value and considered not worth extensive investment. The ability of ecosystems to perform these functions is highly variable, however, and so it is vital that we understand when and where ecosystems can help to protect coastlines. Such natural coastal protection depends on the local conditions and the structure of the ecosystems themselves.

Coastlines are among the most dynamic environments on earth. They are constantly shaped by waves, winds, tides and storms. Natural ecosystems thrive amidst this change, and indeed have developed the capacity to shape that change. Mangroves and salt marshes capture the moving sediments and help to reduce waves. Offshore coral reefs act as breakwaters, and further create the rock and sand to build islands and beaches.

Evidence demonstrates that salt marshes have value for coastal hazard mitigation and climate change adaptation. Because the magnitude of this value is not fully understood, coastal decision-makers should employ natural systems to maximize the benefits and ecosystem services provided by salt marshes and exercise caution when making decisions that erode these services.



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<http://www.conservationgateway.org/ConservationPractices/Marine/crr/library/Pages/default.aspx#overviews>
4. **Ocean City Plans:**
  - Master Plan
  - All-Hazards Mitigation Plan
  - Floodplain Management Plan
  - Evacuation Plan
  - Emergency Response Plan
  - Open Space and Recreation Plan
  - Stormwater Management Plan
  - Flood Insurance Study
5. NJ Resiliency Network web site - <http://www.njresiliency.com/>
6. NOAA Sea Level Rise Viewer <https://coast.noaa.gov/slr/#>



## Appendix A - Flood Hazard Mitigation Initiatives

### DEP Office of Flood Hazard Risk Reduction Measures

Following Superstorm Sandy, the State created the Office of Flood Hazard Risk Reduction Measures within the Department of Environmental Protection to coordinate and implement flood hazard risk reduction projects arising in connection with Sandy recovery. Initiatives include the Easement Acquisition Program to facilitate the construction of comprehensive dune systems and engineered beaches to protect coastal communities; the Flood Hazard Risk Reduction and Resiliency Grant Program that provides funding for municipalities to implement project to reduce storm surge or flood risk; the HUD-selected Rebuild by Design projects for the Hudson River and Meadowlands areas, and HUD's National Disaster Resilience Competition.

### Beach and Dune Projects

The New Jersey Department of Environmental Protection (NJ DEP) and the U.S. Army Corps of Engineers (Army Corps) are working together to advance beach and dune construction projects that will reduce risk to life, property and infrastructure by rebuilding 44 miles of New Jersey coastline and providing the State with the most comprehensive and continuous coastal protection system it has ever had. To secure outstanding easements required by the Army Corps, Governor Christie took aggressive action by signing an Executive Order that authorizes the State to secure easements, not provided voluntarily, through eminent domain. The Executive Order also created the Office of Flood Hazard Risk Reduction Measures to coordinate that effort.

### Acquisition of Properties in Repetitive Flood Loss Areas

Using federal disaster relief resources, NJ DEP began implementing a \$300 million buyout program to acquire properties from willing sellers in repetitive loss areas. Approximately 1,000 homes impacted by Sandy will be targeted by the buyout program, in addition to another 300 repetitively flood-damaged homes located in the Passaic River Basin. Properties acquired by the State will eventually be razed and maintained as open space, thus reducing the risk of future flood waters, while keeping people and property out of harm's way.

### Building More Resilient Homes

The New Jersey Department of Community Affairs created housing programs designed to incorporate resilience and mitigation measures into reconstruction efforts. Two programs in particular, the RREM program and the HMGP Elevation Program provide grants to help homeowners elevate their homes to provide better flood protection and more affordable flood insurance premiums.



## Development of New Local Projects to Support Community Resilience

The New Jersey Office of Emergency Management (OEM) has allocated \$50 million to create the HMGP Local Projects program, which will enable county and local governments across all 21 counties to pursue regional and local resiliency projects. These funds can be used to advance drainage, flood control, energy resiliency and other hazard mitigation projects.

## Energy Resilience at Critical Facilities throughout the State

A multi-agency team from the State has been collaborating with the U.S. Department of Energy (DOE) and the DOE's National Renewable Energy Laboratory (NREL) to comprehensively study the energy needs of critical facilities throughout the State, and to identify creative and cost-effective alternative energy solutions. In coordination with the Board of Public Utilities, NREL conducted a state-wide survey of public buildings and leveraged existing data and resources maintained by the State to inform a locally-tailored analysis of energy resilience and efficiency for local communities. To realize energy resilience projects, the State announced \$25 million in HMGP Energy Allocations to municipalities, counties, and other critical facilities that can be used to support a variety of alternative energy solutions — including microgrids, solar power with battery back-up, and natural gas-powered emergency generators — technologies that will allow critical facilities to operate even if the power grid fails.

## Energy Resilience Bank

The New Jersey Board of Public Utilities (BPU) and the New Jersey Economic Development Authority (NJEDA) are working together to create and develop the New Jersey Energy Resilience Bank (ERB), the first public infrastructure bank in the nation to focus on energy resilience. Having received approval for the ERB from the U.S. Department of Housing and Urban Development (HUD), the ERB initially will be capitalized with \$200 million in federal Community Development Block Grant – Disaster Recovery funds. Although programmatic details are still being developed and finalized by BPU and NJEDA, with assistance from the State's Department of Environmental Protection (DEP), the ERB will combine innovative financing along with technical assistance to facilitate the development or retrofit of distributed energy resources technologies -- such as combined heat and power, fuel cells, microgrids and solar with battery storage -- at the State's critical facilities, which include water and wastewater treatment plants, hospitals and long-term care facilities and shelters. Incorporating these technologies will make these facilities, and the communities they serve, more resilient to future severe weather events.

## NJ Transit Grid

NJ Transit teamed with DOE and Sandia National Laboratories to design "NJ TransitGrid," a first-of-its-kind transportation microgrid capable of providing highly reliable power to transit operations in densely populated areas of New Jersey. NJ TransitGrid would enable NJ Transit to sustain transit operations in



the event of a larger electrical grid failure, allowing for continued service and movement of commuters across the most traveled portion of rail lines in the nation, including critical evacuation routes.

### Liquid Fuel Resilience

New Jersey is taking action to address emergency liquid fuel challenges highlighted during Superstorm Sandy by building resilience in fuel supply and distribution. The State is making \$7 million in HMGP funds available to support the purchase of generators or permanent connection points for mobile generators for approximately 250 fuel stations located along key thoroughfares throughout the State. In addition, NJ OEM is acquiring a strategic cache of emergency generators that can be deployed during a major power outage to critical assets such as shelters, hospitals, public safety facilities, and retail fuel stations. The New Jersey Office of Homeland Security and Preparedness has also partnered with the U.S. Department of Homeland Security to explore opportunities to increase the resiliency of the State's petroleum storage and distribution and supply systems.

### HMGP Energy Allocation & Lifeline/Life Safety Program

These companion programs, funded through FEMA Hazard Mitigation Grant Program monies, each provided grants to local governments statewide to support energy resilience needs, including at critical lifeline and life safety facilities.

## [Appendix B - Community Resilience Economic Decision Guide for Buildings and Infrastructure Systems](#)

This Economic Guide provides a standard economic methodology for evaluating investment decisions aimed to improve the ability of communities to adapt to, withstand, and quickly recover from disruptive events. The Economic Guide is designed for use in conjunction with the NIST Community Resilience Planning Guide for Buildings and Infrastructure Systems, which provides a methodology for communities to develop long-term plans by engaging stakeholders, establishing performance goals for buildings and infrastructure systems, and developing an implementation strategy, by providing a mechanism to prioritize and determine the efficiency of resilience actions. The methodology described in this report frames the economic decision process by identifying and comparing the relevant present and future streams of costs and benefits – the latter realized through cost savings and damage loss avoidance – associated with new capital investment into resilience to those future streams generated by the status-quo. Topics related to non-market values and uncertainty are also explored. This report provides context for increasing resilience capacity through focusing on those investments that target key social goals and



objectives, and providing selection criteria that ensure reduction of risks as well as increases in resilience. Furthermore, the methodological approach aims to enable the built environment to be utilized more efficiently in terms of loss reduction during recovery and to enable faster and more efficient recovery in the face of future disasters.

<http://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1197.pdf>

### [Appendix C - New Jersey Climate Adaptation Alliance](#)

The New Jersey Climate Adaptation Alliance was formed in response to a diverse group of stakeholders who came together on November 29, 2011 at Rutgers University to participate in the conference "Preparing NJ for Climate Change: A Workshop for Decision-Makers."

A changing climate and rising sea levels will have a devastating impact on New Jersey's economy, the health of our residents, the State's natural resources, and the extensive infrastructure system that delivers transportation services, energy and clean water to millions of New Jerseyans. The Alliance will focus on climate change preparedness in key impacted sectors (public health; watersheds, rivers and coastal communities; built infrastructure; agriculture; and natural resources) through:

- Conducting outreach and education of the general public and targeted sectorial leaders;
- Developing recommendations for state and local actions through collaboration with policymakers at the state, federal and local levels;
- Undertaking demonstration and pilot projects in partnership with the private sector, local governments, non-governmental organizations, and others;
- Identifying science, research and data needs; and
- Developing capacity for implementation of preparedness measures and documentation of best practices.

### [Needs of Coastal Communities](#)

Rutgers staff engaged coastal professionals and decision makers to better understand their needs with regard to climate data and science to inform decision making. In general, Rutgers staff heard a need for clear and consistent and science-based standards



and/or guidance to inform local coastal resilience planning. The outcomes of the STAP effort can be informative in addressing some of those needs, including:

- Coastal decision makers and practitioners agreed that, since Superstorm Sandy, there has been widespread increased awareness of flooding and coastal hazards and a greater recognition of the contribution of sea-level rise to those hazards. Among coastal municipalities, there is greater support for regulatory measures to inform and support coastal community planning and recognition of a need for a more holistic approach to resilience guided by a statewide vision for planning and implementation in New Jersey.
- Coastal municipalities pointed to inconsistent and sometimes conflicting guidance from multiple State and Federal agencies on standards and regulatory practices that are meant to be implemented at the local level. More specifically, the municipal practitioners indicated a need for clear and consistent guidance on sea-level rise projections between and within State agencies. In addition to having climate data that are consistent, local officials indicated a need to integrate sea-level rise projections with local knowledge about historic floods to better inform decision making.
- Coastal municipalities need technical assistance to, among other things, apply climate data and science to efforts to plan for resilience. They also indicate a need for additional training on disaster response and preparedness.
- Coastal practitioners also expressed concern that, with a post-Sandy emphasis on home elevations, residents who have elevated their homes will avoid evacuation feeling secure in their homes not realizing that roadways, infrastructure and critical facilities remain exposed and non-resilient.

Rutgers staff will continue to work with communities, coastal planners, and decision makers, and intend to further develop and deploy guidance for using the methods outlined in the two reports.

Both full reports can be found at <http://njadapt.rutgers.edu/>. Questions regarding the reports can be directed to Dr. Marjorie Kaplan at [kaplan@envsci.rutgers.edu](mailto:kaplan@envsci.rutgers.edu) or Jeanne Herb at [jherb@ejb.rutgers.edu](mailto:jherb@ejb.rutgers.edu).