DRAFT

New York State Sea Level Rise Task Force

Report to the Legislature

Draft for Public Comment

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Acknowledgements

The New York State Sea Level Rise Task Force was created by an act of the New York State Legislature (Chapter 613 of the Laws of New York) in August 2007. New York State Department of Environmental Conservation (DEC) Commissioner Pete Grannis, Chair of the Task Force, assigned Special Counsel Robin Schlaff to establish and chair a steering committee. Kristin Marcell served as steering committee vice-chair.

The steering committee, comprised of state agency staff and representatives of non-governmental organizations (NGOs), spent an extraordinary amount of time researching, discussing and deliberating issues addressed in the report. Members of the steering committee coordinated the work of five work groups: Community Resilience, Ecosystems and Natural Resources, Infrastructure, Legal and Public Outreach. Each work group included representatives from academia, businesses, NGOs, environmental justice and community groups, and federal, state and local agencies. This report is the result of their efforts, and the Task Force gratefully acknowledges their contributions.

Projections of sea level rise affecting New York State were provided by the Columbia University Center for Climate Systems Research based on work undertaken for the New York City Panel on Climate Change.

Alan Belensz, Director of the DEC Office of Climate Change, provided a critical review of an early draft. Additional DEC staff contributors to writing, editing and production of this report include Audrey Their, Elaine Bloom, Bernadette LaManna and Ellen Bidell. Kim Farrow and Mary Kadlecek maintained the Sea Level Rise Task Force webpage. Mark Lowery provided editorial assistance and managed public outreach efforts.

The development of this report included a public review of the sea level rise projections, the Task Force process and an early draft of the report and recommendations. Throughout the process, participation of stakeholders and their thoughtful comments improved the quality of the report.

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Executive Summary

New York State's extensive ocean coastline has places that we know, that we remember and that have shaped us in some way. At more than 3,000 miles, the state's coastline includes many notable locations—Montauk Point, Coney Island, Robert Moses State Park, Battery Park and the Hudson River's shores from New York City to the federal dam at Troy. More than 60% of New Yorkers live in homes on or near these waterfront areas. Each shoreline area is unique and part of the essence of New York. But these places will change as sea level rises, and the differences will become more obvious as the sea continues to rise to unprecedented levels. A result of the world's changing climate, a rising sea will alter more than just the coastline. The entire state will feel the effects as residents and a significant amount of the landscape are impacted. These areas are diverse and interconnected and share New York's rich agriculture, commercial, economic and environmental history and resources.

The communities along New York State's coastline, including their structures, their residents, their environment and the surrounding natural resources, are products of decisions made over the course of many years. These decisions shaped decades of investment, development and conservation. While the extent of the impacts to coastal communities from a rising sea are not fully known, even the most conservative projections make clear that there will be dramatic changes in this century. Thus, how coastal communities and our state address this collective challenge is important to today's decision-makers. The responses needed to protect communities from the threat posed by sea level rise will take time, and now that the challenges are better understood, government is obligated to protect its citizens while there is time to do so effectively. New York must focus on the smart use of limited resources to address the impacts associated with sea level rise.

THE SEA LEVEL RISE TASK FORCE

In 2007, the New York State Legislature created the Sea Level Rise Task Force and charged it with preparing a report that addresses these issues, including recommendations for an action plan to protect coastal communities and natural resources from rising sea levels. The New York State Department of Environmental Conservation leads the Task Force, which has a diverse membership that includes representatives of state and local government agencies, non-governmental organizations and affected communities. The legislature directed the Task Force to "evaluate ways of protecting New York's remaining coastal ecosystems and natural habitats, and increasing coastal community resilience in the face of sea level rise, applying the best available science as to sea level rise and its anticipated impacts." The Task Force has studied and deliberated, with public participation, the complex issues involved with sea level rise in New York State. This report, including findings and recommendations, is the result of the considerable efforts of many dedicated individuals.

THE SEA IS RISING

Our climate is changing, causing the world's seas to rise. Since 1970, New York State has witnessed incrementally higher increases in average temperatures than the rest of the United States, an increase nearly twice the global average. These changes have resulted in warmer winters and hotter summers and other changes in the form of fewer, but heavier snows and heavier, more intense rainfall and storms. The warming produced by global climate change causes the sea level to rise because warmer water takes up more space and higher temperatures are melting ice sheets around the globe. New York Harbor has experienced an increase in sea level of more than 15 inches in the past 150 years, with harbor tide gauges showing a rise of between 4 and 6 inches since 1960.

The Task Force looked to the best available science to estimate potential sea level rise. Not all regions of the marine coast will be impacted in the same way, and this report focuses on estimates for two areas: the lower Hudson Valley and Long Island, and the mid-Hudson Valley and Capital Region. Sea level rise affecting the Lower Hudson Valley and Long Island is projected to be 2 to 5 inches by the 2020s and 12 to 23 inches by the end of this century. However, rapid melt of land-based ice could double these projections in the next few decades, with a potential rise of up to 55 inches by the end of the century. Sea level rise in the mid-Hudson Valley and Capital Region will be somewhat less but will follow similar trends. The combination of rising sea level, continuing climate change, and more development in high-risk areas have raised the level of New York's vulnerability to powerful coastal storms. Without meaningful action on a number of key fronts, this vulnerability will increase in area and magnitude over time.

EVERY NEW YORK TIDAL COASTAL COMMUNITY WILL BE AFFECTED BY SEA LEVEL RISE

Sea level rise will have dramatic implications for New York's coastal communities and their natural resources, affecting the entire ocean and estuarine coastline of the state. Every community along the Hudson River from the federal dam at Troy to New York Harbor and along Long Island Sound and the Atlantic coastline will be affected.

Sea level rise will continue to increase the risk to developed areas, future development and coastal habitats which are already highly vulnerable to powerful coastal storms. Many neighborhoods and their associated buildings, roads, and utilities will be directly affected, with the most vulnerable communities permanently inundated.

An area far broader than the immediate coastline will witness flooding and erosion associated with increasingly powerful storms. The impacts will be potentially more dramatic because of the hidden impacts on the utilities and infrastructure systems upon which our modern society relies: sewage, stormwater, fuel storage, energy generation, communication, solid waste, and transportation, including road, rail, airports, and ports. The emergency services that provide relief and support during storm

events and flooding will be more overwhelmed in areas where the intensity of impacts increases. Secondary impacts such as water-borne pollution associated with flooding of contaminated lands located throughout coastal communities may affect water quality and ecosystems. Public health will be further affected by vector-borne diseases and impacts to water supplies caused by changes in rainfall, heat and saltwater intrusion.

New York's natural resources and ecosystems will be greatly impacted by the human response to sea level rise. Natural systems such as wetlands currently provide critical benefits, including flood protection, to coastal communities on a large scale at almost no cost. These benefits would be prohibitively expensive to replicate with human-engineered solutions. Responses that harden the coastline, such as sea walls and bulkheads, prevent natural systems from migrating inland as water levels increase, leaving them to drown in place. Particularly in less urbanized areas, these choices may be more expensive and less effective over the long term than relocation or elevation of at-risk structures. In addition, such solutions will also limit public access to beaches.

THE TASK FORCE REPORT

The Task Force worked for more than two years to produce this report. The report examines the complexities of sea level rise and its implications for New York in the twenty-first century. It includes 9 findings and 14 specific recommendations for action.

The report's findings coalesce around the need for immediate action. Every day, New York's residents, governments and businesses make decisions that affect the future vulnerability of the state's coastline. The magnitude and scope of the challenge posed by sea level rise require that relevant and accurate information about climate risk, resilience and adaptation become part of these everyday decisions. The vulnerabilities of coastal communities must be inventoried and assessed, and this information shared with residents of at-risk communities. Appropriate responses must be formulated and implemented. Government policies and actions must be coordinated and prioritized to assist communities at greatest and most immediate risk in the most cost-effective ways and in ways that recognize the importance of our natural coastal resources and their role in New York's future. These efforts must be guided by accurate science, up-to-date mapping and effective planning tools.

We hope that the Task Force's work will spark action. The public and its governments must be invested in meeting the challenge of sea level rise. The challenge is real, and sea level rise will progress regardless of New York's response.

Introduction

The sea is rising, driven by changes in global climate, and New York State's low-lying marine and estuarine coastal areas–their people, businesses, infrastructure, and ecosystems–are at risk. More than 62% of New York's population lives in marine coastal counties, and these areas have tremendous economic value in terms of commerce and natural benefits such as habitat, water quality improvement, flood control, and storm protection. Sea level along New York's coast has been rising at the rate of almost one foot per century for at least 100 years, resulting in more severe storm impacts, shoreline erosion, and coastal flooding experienced by coastal communities today. The rate of rise is expected to increase with global warming, perhaps doubling over the next century.[1]

Infrastructure critical to both the state and national economies will be subjected to increased risk of coastal storm damage as sea level rises.

A powerful coastal storm occurring today poses great danger to the region, and this threat will intensify as sea level continues to rise. New York State must initiate action to safeguard its natural resources, human communities and economic assets. We must work to increase community resilience–the capacity to withstand or recover from loss or damage–while embracing a long-term commitment to understand evolving threats and adjust responses into the future.

The Sea Level Rise Task Force (Task Force) was established by statute in 2007.[2] It was charged with summarizing what is known about the impact of sea level rise and recommending actions that will both protect coastal ecosystems and help human coastal communities to increase resilience and adapt to rising sea levels. The Task Force was not charged with studying other climate-related impacts to our oceans, such as acidification, changes to ocean currents and other effects of warming ocean temperatures.

Rising seas threaten to permanently inundate valuable coastal habitats.

The New York State Department of Environmental Conservation leads the Task Force, whose workgroups include representatives from multiple state agencies and authorities, federal and local government, community and non-governmental organizations, businesses and academia.[3]

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[1] Tanski, Jay. *Long Island's Dynamic South Shore, A Primer on the Forces and Trends Shaping Our Coast*. NYS Sea Grant, 2007

[2] Chapter 613 of the Laws of New York, 2007.

[3] See Appendix A: Members of the Task Force and Workgroups.

The Task Force has sought public comment and engagement throughout the process of developing this report.[4]

Although the Task Force's effort is the only one focused primarily on sea level rise in New York State, it exists within a larger context of complementary initiatives that have examined climate change and coastal hazards.[5]

The wide variety of state, local government and private partners participating in current efforts to assess climate change risk are using the same projections of sea level rise and coastal hazards in developing policy for New York State. They also agree on the types of actions that should be taken to reduce long-term vulnerability in our coastal areas. This work will now help shape the efforts of the New York State Climate Action Council (CAC) as it drafts the state's Climate Action Plan.

Though scientific and policy unknowns remain, inaction is not a responsible option. New York State, working with other levels of government, needs to address the challenges presented by sea level rise, even as coastal communities and ecosystems are increasingly affected.

The following discussion outlines the basic hazards and challenges of sea level rise and presents the Task Force's recommendations for protecting the state's communities–both human-built and natural–in the face of these dangers.

Counties Impacted by Sea Level Rise

- Albany
- Bronx
- Columbia
- Dutchess
- Greene
- Kings (Brooklyn)
- Nassau
- New York (Manhattan)
- Orange
- Putnam
- Queens
- Rensselaer
- Richmond (Staten Island)
- Rockland
- Suffolk
- Ulster
- Westchester

[4] See Appendix B: Public Outreach Summary.

[5] New York City Panel on Climate Change's Climate Risk Information , New York City's Climate Change and Climate Adaptation Task Force, Metropolitan Transit Authority Adaptations to Climate Change, New York City Department of Environmental Protection's Climate Change Task Force, New York State Energy Research and Development Authority's Statewide Climate Impacts Assessment (ClimAID), the Nature Conservancy's Rising Waters and Coastal Resilience projects, and the Union of Concerned Scientists' Northeast Climate Impacts Assessment.

Key Terms[6]

Beach nourishment: the addition of sand, often dredged from offshore, to an eroding shoreline to enlarge or create a beach area, offering temporary shore protection and recreational opportunities

Coast: In this report, this term refers to New York State's marine coastline only, not to the Great Lakes or other inland coastlines.

Coastal hazards: impacts associated with sea level rise, storm surge, wind driven waves and erosion

Coastal Risk Management Zone: areas to be classified as currently at significant risk of coastal flooding due to storms and areas projected to be at high risk of flooding from projected sea level rise and strong storms

Ecosystem services: the benefits people obtain from ecosystems that communities would have to replace artificially if the natural systems were lost. These benefits include flood control, water quality improvement and storm protection.

Natural protective features: natural systems such as wetlands, dunes, barrier islands and aquatic vegetation that provide large-scale flood protection from wind-driven waves and storm surge as well as many other human and ecosystem benefits

Non-structural shoreline protection or non-structural measures: elevation and/or relocation of structures and their contents to limit flood damage or "accommodation" of floodwaters (taking no protective action as water rises)

Shore protection: a range of activities that focus on protecting land from inundation, erosion or storm-induced flooding through the construction of various structures or the addition of sediments to the shore

Soft shore protection, shoreline softening or soft engineering: a method of shore protection that prevents shore erosion through the use of natural materials similar to those already found in a given location, such as adding sand to an eroding beach or planting vegetation with roots that retain soils along the shore

Structural shoreline protection or structural measures: constructions such as jetties, bulkheads, dikes, rip rap and seawalls designed to lessen or eliminate the erosive effect of waves on property or infrastructure. Similar terms are *shoreline hardening* and *traditional shoreline stabilization*. The State of New York considers beach nourishment to be a soft structural measure.

[6] Adapted from Titus, et al., U.S. Global Climate Science Program Synthesis and Assessment Product 4.1 (2009) and the NYS Sea Level Rise Task Force

Sea Level Rise: Causes and Projections

Sea level rise is caused by a complex suite of factors. Climate change contributes to global sea level rise in two ways: 1) higher seawater temperatures cause the volume of seawater to increase, a phenomenon known as "thermal expansion" and 2) melting ice caps, glaciers and ice sheets increase the total amount of seawater.

In addition, the land surface is slowly sinking in coastal regions of New York State, with the exception of the Hudson Estuary north of Kingston. This movement is a result of geological forces and impacts of human activity and development. It affects local, or relative, rates of sea level rise. Effects of all types of sea level rise are compounded by potential increases in extreme precipitation and storms associated with climate change.

The interplay of these various factors and the gaps in our current knowledge make precise sea level predictions for any given geographic area difficult. However, all models agree that the outlook for our region is dramatic and will change the coast in fundamental ways. The New York City Panel on Climate Change and the draft New York State Climate Impacts Assessment (ClimAID) aggregated the projections for mean annual sea level rise shown in Table 1 below. The New York State Climate Action Council is using these projections in developing its Climate Action Plan, and the Task Force has chosen to use this range of projections as the foundation for its risk assessments and recommendations.

TABLE 1: Projected Sea Level Rise in New York[1]

Lower Hudson Valley & Long Island	**2020s**	**2050s**	**2080s**
Sea level rise[2]	2 to 5 in	7 to 12 in	12 to 23 in
Sea level rise with rapid ice melt scenario[3]	5 to 10 in	19 to 29 in	41 to 55 in
Mid-Hudson Valley & Capital Region	**2020s**	**2050s**	**2080s**
Sea level rise[2]	1 to 4 in	5 to 9 in	8 to 18 in
Sea level rise with rapid ice melt scenario[3]	4 to 9 in	17 to 26 in	37 to 50 in

[1] For more information see: http://www.nyc.gov/html/om/pdf/2009/NPCC_CRI.pdf

[2] Shown is the central range (middle 67%) of values from model-based probabilities (16 global climate models x 3 GHG emissions scenarios) rounded to the nearest inch.

[3] The rapid ice-melt scenario is based on acceleration of recent rates of ice melt in the Greenland and West Antarctic ice sheets and paleoclimate studies.

These projections are supported by empirical data documenting recent rates of sea level rise in New York State. For example, gauges at the New York City Battery indicate that sea level in the 2000s is 4 to 6 inches higher than in the early 1960s.[7] The New York City Panel on Climate Change found that as global temperatures have increased, the regional sea level has risen more rapidly in the past 100 to 150 years than over the last 1,000 years.[8]

Beyond models and measurements, New Yorkers have their own firsthand experience to confirm that the dangers of flooding and storm surges exacerbated by rising waters are real and immediate.

Five Category 3 hurricanes have made first landfall in New England since 1900. With the exception of one, all made landfall along Long Island's coastline.[9] In 1938, the Great New England Hurricane or "Long Island Express" struck Long Island communities with devastating results. Waves up to 50 feet high submerged low-lying areas, hundreds of homes were destroyed, and at least 50 lives were lost. The storm would have been considered a Category 3 using today's measurement scale for hurricane intensity. If the same hurricane were to hit now, with current levels of coastal development in New York and New England, the total insured loss to commercial and residential property associated with the storm surge flooding alone has been estimated at between $6 billion and $10.5 billion (2008 dollars).[10]

Only a small, sagging portion of the main building of the West Bay Beach Club in Quantuck, Suffolk County, remained after the 1938 "Long Island Express" hurricane.

Twenty-four years later, in 1962, a powerful Nor'easter known as the Ash Wednesday Storm struck the eastern third of the United States, generating ocean waves of 20 to 30 feet.[11] Surge at the Battery was more than 7.5 feet and more than 9 feet at Willets Point in Queens. East of Fire Island Inlet, two and a half days (five high tides) of high water carved through dunes and created a new inlet 1,200 feet wide at Westhampton Beach. Coney Island was entirely inundated.

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[7] Colle, B.A., K. Rojowsky, and F. Buonaiuto. 2010. New York City storm surges: Climatology and an analysis of the wind and cyclone evolution. *Journal of Applied Meteorology and Climatology 49*: 85-100. Pub ID# 3772.

[8] New York City Panel on Climate Change Climate Risk Information, http://www.nyc.gov/html/om/pdf/2009/NPCC_CRI.pdf

[9] *The 1938 Great New England Hurricane, Looking to the Past to Understand Today's Risk*, Patricia Grossi, et al, Risk Management Solutions, Inc., Newark, CA, 2008, p.17

[10] Ibid. p. 14

[11] NYS Coastal Erosion Task Force Report, 1994

At Seagate, waves overtopped and severely damaged timber bulkheads. In Jamaica Bay, low-lying areas were completely flooded. The Rockaways experienced severe erosion and lost eight homes. Estimates of damage on Staten Island, Brooklyn's South Shore, the Rockaways, Long Beach Island, Long Island, Fire Island, Westchester and the Peconic shoreline totaled more than $220 million in today's dollars (adjusted for inflation). [12]

More recently, a Nor'easter on December 11 and 12, 1992 caused a storm surge of nearly 7.75 feet at the Battery, propelled by wind gusts of 80 to 90 mph. Tunnels and subways in lower Manhattan flooded, as did portions of the Manhattan Eastside FDR drive, areas of Seagate, Broad Channel and many coastal towns on Long Island.

New York has always been vulnerable to tropical storms, hurricanes and—more commonly—Nor'easters. Without action to reduce community vulnerability, similar storms will in the future threaten many more lives, public infrastructure and private property in New York's coastal areas due to ever-increasing development and population growth. With elevated sea levels and associated higher storm surges, the geographic extent of vulnerable areas and damage will increase dramatically.

In addition to the devastating impacts of these acute events, gradually encroaching seawater will have chronic, incremental effects on coastal ecosystem structure and functions and on human uses of the coast.

Hazards of Sea Level Rise

Sea level rise, by itself and in combination with other coastal hazards, such as intense storms and the effects of climate change, will have many interacting consequences.

Rising Water Table

Higher groundwater levels may submerge infrastructure elements, interfering with their function and preventing access. Failed septic systems can create public health problems and harm ecosystems. Saline groundwater can corrode vulnerable infrastructure components. A higher water table also reduces the ability of the soil to absorb runoff, increasing the likelihood of flooding.

Saltwater Intrusion

As seawater rises, it encroaches upon estuarine, brackish and freshwater environments, increasing their salinity and permanently altering ecosystems. Saltwater intrusion also threatens aquifers and other freshwater sources of public drinking water.

[12] $31 million in 1963 dollars adjusted for inflation using Bureau of Labor Statistics CPI calculator (http://data.bls.gov/cgi-bin/cpicalc.pl.)

Inundation and Flooding

Permanent inundation refers to those areas that are completely underwater or are underwater for a portion of each day. *Frequently flooded* areas experience inundation regularly, in contrast to *episodically flooded* areas, which are at risk only from extreme weather events. Rising sea levels will expand the areas experiencing all types of inundation and flooding and push their boundaries further inland. Episodes of severe flooding will also become more frequent as the sea rises.[13]

Storm Surge

Storm surge is a dramatic elevation of the ocean surface that leads to rapid flooding. It is caused by the combined effects of ocean water pushed landward during a storm, low pressure at the sea surface, and high tides. With higher baseline sea levels, the effects of storm surge will be felt further inland. Increased storm intensity will compound coastal erosion and damage from storm surge.

Realistic projections of the effect of these phenomena in any given location over time are crucial in order to properly plan to reduce risk. Development, human populations and ecosystems will interact with sea level rise and related coastal hazards and with each other, according to local circumstances. The following discussion summarizes the major elements that will affect and be affected by sea level rise.

[13] Goddard Institute for Space Studies, Institute on Climate and Planets. 2004. *Climate Impacts in New York City: Sea Level Rise and Coastal Floods*. http://icp.giss.nasa.gov/research/ppa/2002/impacts/results.html

Findings

1. Sea level rise and coastal flooding from storm surge are already impacting and will increasingly affect New York's entire ocean and estuarine coastline from Montauk Point to the Battery and up the Hudson River to the federal dam at Troy. New York must act now to address the challenge of sea level rise.

2. The likelihood that powerful storms will hit New York State's coastline is very high, as is the associated threat to human life and coastal infrastructure. This vulnerability will increase in area and magnitude over time.

3. Natural shoreline features such as wetlands, aquatic vegetation, dunes and barrier beaches currently provide large-scale services such as flood protection, storm buffering, fisheries habitat, recreational facilities and water filtration at almost no cost. These services would be prohibitively expensive to replicate with human-built systems. New York is losing tidal marshes at a rapid pace and with them the natural infrastructure that protects the shore from floods, wave attack and erosion.

4. Sea level rise will cause all shoreline ecosystems to become more frequently inundated. Low-lying locations will become permanently submerged. Habitats and the species associated with them may migrate landward; this, however, will be impeded by the density of development on much of the state's shoreline and the widespread hardening of that shoreline.

5. Current investment and land use planning practices by both New York State and local governments are encouraging development in areas at high risk of coastal flooding and erosion.

6. Over the long term, cumulative environmental and economic costs associated with structural protection measures such as seawalls, dikes, and beach nourishment are expected to be several times more expensive and less effective than non-structural measures such as elevation of at-risk structures and planned relocation away from the coastal shoreline.

7. As water levels rise, shore protection structures along the state's coastline will limit public access to beaches as they eliminate the publicly accessible intertidal zone.

8. Existing maps of New York State's coast that identify communities, habitats and infrastructure at greatest risk of flooding and erosion are inaccurate, out of date, not detailed enough for planning and regulatory purposes and fail to incorporate historic and projected sea level rise.

9. There are low-cost, high-benefit actions that can be taken now to reduce vulnerability along New York State's coastline.

Recommendations

Adopt official projections of sea level rise and ensure continued and coordinated adaptation efforts.

Require state agencies responsible for the management and regulation of resources, infrastructure, and populations at risk from sea level rise to factor the current and anticipated impacts into all relevant aspects of decision making.

Classify areas where significant risk of coastal flooding due to storms has been identified and implement risk reduction measures in those areas.

Identify and classify areas of future impacts from ocean coastal flooding from projected sea level rise and storms to reduce risk in those areas.

Reduce vulnerability in coastal areas at risk from sea level rise and storms. Support increased reliance on non-structural measures and natural protective features to reduce impacts from coastal hazards.

Develop maps and other tools required to assist local decision-makers in preparing for and responding to sea level rise.

Amend New York State laws and change and adopt regulations and agency guidance documents to address sea level rise and prevent further loss of natural systems that reduce risk of coastal flooding.

Provide financial support, guidance and tools for community-based vulnerability assessments and ensure a high level of community representation and participation in official vulnerability assessments and post-storm recovery and redevelopment and adaptation planning processes.

Undertake a comprehensive assessment of the public health risks associated with sea level rise, coastal hazards and climate change including compromised indoor air quality, drinking water impacts, post-traumatic stress and other mental health problems, increases in disease vectors, impaired access to health care and loss of reliable access to food and medical supplies.

Raise public awareness of the adverse impacts of sea level rise and climate change and of the potential adaptive strategies.

Develop mechanisms to fund adaptation to sea level rise and climate change.

Fund research, monitoring and demonstration projects to improve understanding of key vulnerabilities of critical coastal ecosystems, infrastructure and communities from sea level rise.

Seek federal funding and technical assistance and changes to federal programs to make them consistent with or accommodating of state policies, programs and adaptation measures.

Ecosystems

Intact natural systems are essential to the health and functioning of the coast's ecological and human communities. They perform a wide variety of economically valuable functions[14] including water quality protection, water supply, commercial and recreational fish production, flood mitigation, recreation, carbon storage and storm buffering. They provide important habitat for plants and wildlife. Shoreline vistas, beaches and open spaces define coastal community character and quality of life for residents and visitors.

Although ecosystem change over time is a natural process, *accelerated* sea level rise and related coastal impacts caused by climate change will lead to fundamental changes in the nature of coastal habitat. Typical salt marsh vegetation could be lost when marshes are inundated. Deeper water or larger bays could lead to higher wave energy that could cause further erosion and marsh loss.

With inundation, nearshore habitats tend to "migrate" landward as shoreline ecosystems convert from one habitat type to another and the species present also shift. To the extent that human development inhibits these natural shifts in response to sea level rise, we risk losing many valuable coastal resources and ecological functions altogether.

A number of salt marshes on the south shore of Long Island and along the Long Island Sound have been lost through conversion to intertidal mudflats or submergence below the water surface.

[14] Costanza, R., et al. 2006. The Value of New Jersey's Ecosystem Services and Natural Capital. Report to New Jersey Department of Environmental Protection, Division of Science, Research, and Technology, Trenton, NJ. http://www.nj.gov/dep/dsr/naturalcap

Property damage caused by sea level rise and storm surges is likely to prompt greater public demand for shoreline stabilization and protective structures such as bulkheads, berms, seawalls, groins and jetties.

Such measures, however, prevent the shoreline and its associated species from moving landward. They also disrupt the sediment supply, hindering the formation and adaptation of many shoreline features, including the ability of beach, dune and barrier island systems to migrate landward. In addition, these structures will impair public access as water levels rise and will have other unintended consequences. For example, they can alter tidal and wave energy, causing damage to wetlands and parks and other waterfront amenities. While they offer short-term protection, traditional shoreline stabilization structures may not be the best choice to reduce the vulnerability of property and resources to coastal hazards.

Coastal Natural Resources Provide Significant Human Benefits

A two-year economic study commissioned by the New Jersey Department of Environmental Protection in 2004 established values for some "ecosystem services" provided by coastal wetlands, beaches and estuaries in New Jersey. Ecosystem services are the benefits people obtain from ecosystems, such as flood control, water quality improvement, carbon storage, and storm protection that communities would have to replace artificially if the natural systems were lost. The report estimated that the waste treatment services provided by coastal wetlands in New Jersey were valued at over $1 billion a year. It is important to note that this study focused solely on the economic value provided to humans and probably underestimates the absolute value of these unique natural resources.

Source: Costanza, R., et al. 2006. The Value of New Jersey's Ecosystem Services and Natural Capital. Report to New Jersey Department of Environmental Protection, Division of Science, Research, and Technology, Trenton, NJ. http://www.nj.gov/dep/dsr/naturalcap

The Task Force assessed seven major ecosystem types it deemed most threatened by sea level rise.

Wetland loss in coastal areas is a nationwide phenomenon,[15] and New York State is no exception. Tidal wetland acreage is dropping along the state's marine coast, and what remains is shifting from high marsh (periodically inundated) to low marsh (inundated daily at high tide).[16] In New York City's Jamaica Bay, vegetated tidal wetlands are undergoing rapid conversion to mudflats, experiencing a 40% loss since 1974.[17]

Coastal wetlands and marshes are an important form of natural infrastructure along the shore and are estimated to prevent approximately $23 billion in coastal storm damage each year on the northeast and Gulf coasts.

Tidal wetlands provide spawning grounds, nurseries, shelter, and food for finfish, shellfish, birds and other wildlife. They also improve surface water quality by filtering, storing, and detoxifying wastes.

Although there are many factors involved in tidal wetland loss, sea level rise will exacerbate the phenomenon. Loss of marsh islands, which are particularly vulnerable to sea level rise, has been identified in areas from Peconic Bay to the north shore of Long Island and from the south shore of Long Island to Jamaica Bay.

Besides serving as important fish and wildlife habitats, coastal wetlands are an important form of natural infrastructure and are estimated to prevent approximately $23 billion in coastal storm damage each year on the northeast and Gulf coasts.

Physical disruption and increased inundation caused by storms undermine the integrity of marsh structure and processes. Recent studies suggest that storms surges superimposed on higher sea levels will increase the frequency and extent of flooding in coastal regions and estuaries, thus increasing the risk of damage to vulnerable wetlands.[18,]

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[15] Stedman, S. and Dahl, T.E. 2008. *Status and trends of wetlands in the coastal watersheds of the Eastern United States 1998 to 2004*. National Oceanic and Atmospheric Administration, National Marine Fisheries Service and U.S. Department of the Interior, Fish and Wildlife Service.

[16] DEC data.

[17] Hartig, E.K., et al. 2002. Anthropogenic and climate-change impacts on salt marshes of Jamaica Bay, New York City. Wetlands 22: 71-89.

[18] Gornitz, V., S. Couch and E.K. Hartig. 2002. Impacts of sea level rise in the New York City metropolitan area. *Global and Planetary Change*, v. 32, p. 61-88 and Rosenzweig, C. 2009. Climate Risk Information: New York City Panel on climate change. http://www.nyc.gov/html/om/pdf/2009/NPCC_CRI.pdf

At the lower end of projected sea level rise rates, the slow deposition of water-borne sediment will enable some tidal wetlands to migrate into adjacent upland areas, mitigating their loss. Such migration will not be possible in areas where shoreline protective structures, development, or natural impediments (open water or steep slopes) prevent it, as is the case along much of New York State's heavily developed coastline. If the higher rates of projected sea level rise occur, migration will not be possible in most areas. New York State's tidal wetlands, especially marsh islands, will be lost to inundation.[19]

Where sediment supplies are limited, landward migration of low-energy systems such as beach dunes may be limited, changing the shoreline's configuration. Credit: Jay Tanski

Low- to Moderate-Energy Shorelines

Low- to moderate-energy shorelines are small, non-vegetated beaches and tidal flats along the margins of protected areas such as estuaries and barrier island lagoons. Their narrow, steep upper beaches and relatively flat low-tide areas[20] contain a mosaic of microenvironments.[21] This intertidal habitat supports resident species such as horseshoe crabs, killifish, crabs and shorebirds. Along with damage to these populations, loss of this type of shoreline may lead to changes which affect human uses of these areas, including access to the upland area, fishing and boating access, and residential use.

Beach erosion could lead to loss of recreational areas.

It is difficult to predict how low- to moderate-energy shorelines will respond to sea level rise. At the lower projections of sea level rise, they might migrate at sites where there is adequate sediment, a relatively low slope, and no obstructions. Higher rates of relative sea level rise or lack of adequate sediment supply would drive the shoreline inland faster and could have other effects that cannot yet be easily assessed. Sandy beaches may increase as marshes are lost.

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[19] Hartig, E.K., et al. 2002. Anthropogenic and climate-change impacts on salt marshes of Jamaica Bay, New York City. *Wetlands* 22: 71-89. and Fallon and Mushacke, 1996. (unpublished). Tidal Wetlands Trends in Shinnecock Bay, New York 1974 to 1995. New York State Department of Environmental Conservation. 36pp.

[20] Nordstrom, K.F. 1992. *Estuarine Beaches*. London: Elsevier Science Publishers.

[21] Bokuniewicz, H., et al. (eds.), 1993. *Estuarine Resources of the Fire Island National Seashore and Vicinity. Report NYSGI-T-93-001*. Stony Brook, NY: The New York Sea Grant Institute.

Significant changes in water depths or embayment size could accelerate erosion. Where sediment supplies are limited, landward migration of beach dune systems may be limited.

Submerged Aquatic Vegetation

Submerged aquatic vegetation (SAV) is a group of flowering plants that have adapted to living fully submerged in lagoons, bays, estuaries and coastal marine waters. This type of vegetation has a profound influence on coastal and estuarine environments. It regulates water flow, stabilizes sediments, serves as a food source for marine life, and replenishes dissolved oxygen in the surrounding waters. It provides critical habitat and nursery grounds for wading birds and waterfowl and for commercially, recreationally, and ecologically important fish and shellfish.

SAV beds are currently threatened by a host of factors.[22] In 1930, there were an estimated 200,000 acres of these beds in New York State. This area has decreased by almost 90 percent over time to 21,803 acres. According to the 2009 New York State Seagrass Task Force Report, most of this loss is associated with water pollution, fishing and boating.[23] But increasingly, sea level rise and climate-driven temperature change are becoming important stressors. The deeper waters caused by rising sea levels could limit light penetration. Shoreline protective structures will prevent the landward migration of existing beds. As sea levels rise, contaminants leaking from inundated septic systems or brownfield sites could cause further degradation, resulting in additional damage to SAV beds and limiting the available nursery habitat for economically important fish and shellfish.

Hardened shorelines, likely to increase as sea level rises, will prevent the landward migration of existing seagrass beds and decrease the availability of suitable nursery habitat for nearly every important finfish and shellfish in New York. Credit: Chris Pickerell

[22] Orth, R.J., et al. 2006. A global crisis for seagrass ecosystems. *Bioscience.* 56:987-996.

[23] *New York State Seagrass Task Force Report*, 2009. http://www.dec.ny.gov/docs/fish_marine_pdf/finalseagrassreport.pdf

Barrier Islands

Barrier islands are long, relatively narrow islands and spits running parallel to the coast, enclosing bays and lagoons.[24] Composed primarily of sand, barrier islands are constantly reshaped by wind, waves, and currents, especially during storms. They protect natural and human communities from ocean storms. Commercial and sport craft seek shelter behind these islands for safe passage between ports. Sheltered by barrier islands, salt marshes provide habitat critical to the spawning and early life stages of many fish species, supporting the multi-million dollar commercial and sport-fishing industries along our coasts. These islands support unique ecological communities, and many of the bays and estuaries enclosed by barrier islands on the north and south shores of Long Island are designated as Significant Coastal Fish and Wildlife Habitat Areas by the New York State Department of State.

Increased erosion of barrier islands could result in loss of important nesting, foraging and spawing sites. Credit: Jay Tanski

The processes controlling barrier islands are not completely understood, and there are significant local variations. For example, while all are highly dynamic and constantly changing, some have not migrated significantly during the last 750 to 1,300 years. The relationship between the rate of sea level rise and how the barrier islands will respond is not a simple one. Over the next 30 to 50 years, at projected low to moderate rates of sea level rise, the greatest impact to barrier islands will likely be from storms and disrupted sediment transport from human activity. Over time, barriers may not be able to maintain themselves if sea level rise outpaces the ability of the system to supply sediment. At the highest rates of sea level rise, overwash (the process by which storm surges flow across barrier islands, depositing sediment and raising their elevation) and breaching of new inlets would increase significantly, potentially changing the physical and environmental characteristics of the bays. The habitat affected by changes to barrier islands includes horseshoe crab egg-laying sites; shore bird foraging, nesting and resting sites; and fish spawning and nursery sites. Because the natural mechanisms that create barrier islands depend on the islands' ability to change in response to storms and sea level rise, efforts to stabilize coastal barrier islands are contrary to the very processes that sustain them.

[24] The term *barrier islands*, as used here, includes barrier spits and tombolos.

Coastal Bluffs

Sea level rise may increase bluff erosion. Credit: Jay Tanski

Bluffs are relict features of the shoreline, meaning they were formed by processes that no longer take place. As a result, coastal bluffs can remain stable or they can erode, moving landward as they do, but they will not increase. Bluff erosion supplies the materials that form other shoreline features: clay, fine silt, sand, gravel and boulders.

Rising sea levels combined with frequent, intense storms are likely to increase severe bluff erosion. In areas where bluff composition is chiefly fine-grained silt and clay unsuitable for beach building, sea level rise may increase the amount of this material deposited in offshore waters,[25] where it could smother colonies of blue mussel, ribbed mussel and American oyster. Closer to shore, large sediment deposits can damage fish spawning, feeding and nursery areas.

Where bluffs are composed primarily of sand and other coarse material, increased rates of erosion may change the present equilibrium between sediment supply and other processes that govern the formation and movement of shoreline features.

In addition to the impacts of eroded materials on aquatic and coastal habitat, increased bluff erosion presents a threat to homes built on or near bluffs and loss of habitat for species such as red fox and bank swallows. Increased bluff erosion may lead to an increased demand for shore stabilization. Stabilization of bluffs composed primarily of sands and cobbles, however, may cut off the supply of material to beaches, causing them to shrink or even disappear entirely over time.[26]

[25] Tanski, J.J. 1981. *Episodic bluff erosion on the north shore of Long Island, NY*. Master's Thesis. Marine Sciences Research Center, State University of New York at Stony Brook.

[26] Bokuniewicz, H. and Tanski, J. 1980. Managing localized erosion of coastal bluffs. *Proceedings of Coastal Zone '80.* American Society of Civil Engineers. Hollywood, Florida. pp. 1883-1898.

Marine Rocky Intertidal Areas

Rocky intertidal areas are dominated by bedrock, stones, or boulders, with little vegetation. They are generally high-energy habitats, exposed to continuous erosion by wind-driven waves or strong currents, and can be either natural formations or human-made structures such as stone jetties and rock revetments.

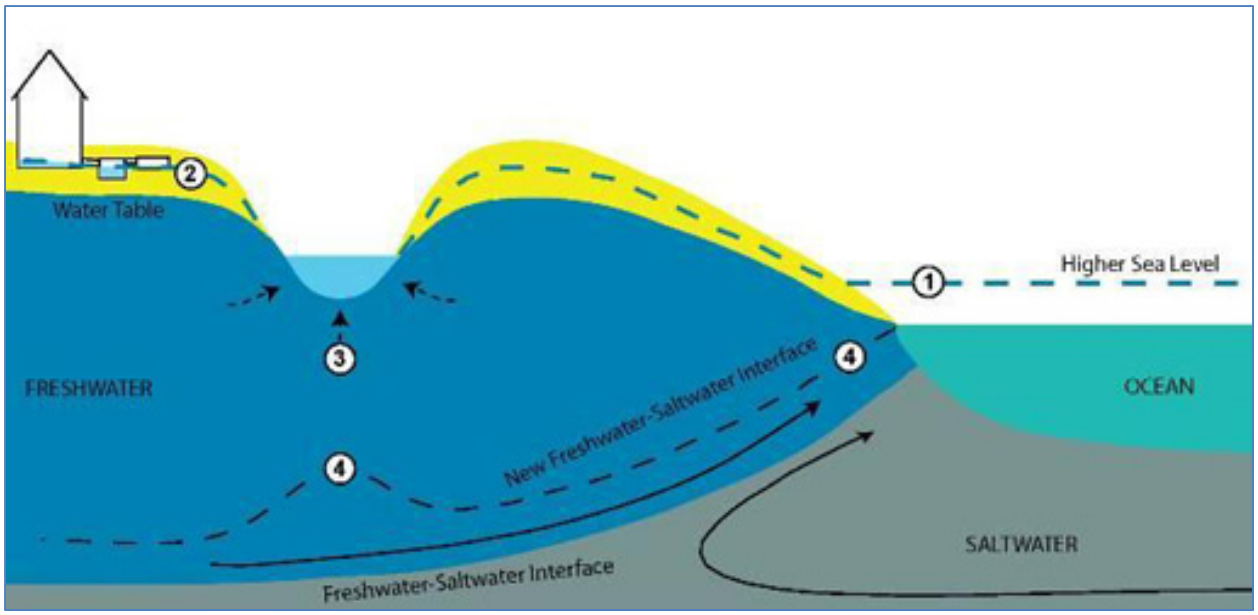
Natural rubble fields can expand only if the upland glacial soils within which they are buried are allowed to erode with advancing sea level. Credit: J. Meyerowitz, 2009

These zones have high biodiversity and high productivity, providing habitat, nursery grounds and food for marine and terrestrial organisms. Because of their exposed position and the fact that their resident species are dependent on a tidal cycle of alternating wet and dry periods, these areas are particularly vulnerable to sea level rise and other phenomena related to climate change. As the duration of tidal inundation increases, species will migrate landward. In areas that become completely inundated or where landward migration is obstructed, intertidal species will be lost.

Rocky intertidal habitat can be created or preserved through both natural (deposits of stone eroded in adjacent or updrift areas) and artificial means (building jetties and rock revetments). Jetties and rock revetments are often constructed on existing native habitat–frequently sandy beaches or bluffs–to protect shoreline property; this destroys the value associated with the original habitat.

Freshwater Resources

As sea level rises, so will the groundwater level, and this will have several different effects on freshwater ecosystems. First, a higher water table will mean a thinner unsaturated layer between the land surface and the water table and less time during which soils in low-lying areas experience dry conditions. This will substantially alter the habitat in these areas, increasing wetland or moisture-tolerant species, including disease-vectors and pests, at the expense of upland species that require drier conditions.



Freshwater is underlain by denser saltwater in the shallow (water table) aquifer system of Long Island. 1. Conceptualized position of higher sea level. 2. Corresponding position of higher water table. 3. Resulting increase in hydraulic gradient and flow to streams. 4. Associated decrease in the depth to freshwater-saltwater interface. As this interface moves higher drinking water supplies may be affected. Credit: Ben Gutierrez, USGS

Second, as sea level rises, the point at which freshwater and saltwater meet will shift further upstream in rivers and streams, and further inland and upward in coastal aquifers. Vegetation will likewise shift from freshwater to brackish or salt-tolerant species.

Anadromous fish (marine fish that spawn in freshwater) will be affected, as will other freshwater fish and fauna that currently use these areas for nesting, spawning and foraging. Freshwater habitat could migrate inland, though dams, bridges, shoreline development and other obstructions will impede such movement.

Ecosystems: Actions Needed to Adapt to Sea Level Rise

To maintain and expand the ecosystem services provided by New York's coastal systems, the state should pursue the following goals:

- Minimize future habitat loss
- Protect fresh drinking water resources
- Provide coastal natural resources with adequate space to adapt to sea level rise
- Restore the natural mechanisms, such as sediment movement in coastal waters, that drive adaptation processes, including landward migration of habitat

It is essential to start with a current and accurate accounting of shoreline conditions throughout New York State (Recommendation 6) that shows how shorelines may change with rising sea levels. Such an inventory should include the location of areas of potential inundation as well as locations of structural protection measures that could hinder the migration of natural systems responding to sea level rise.

The collected information must serve as the basis for coastal natural resource management strategies that are coordinated on federal, state and local levels. Such strategies should emphasize ecosystem-based management and ensure adequate funding to promote effective adaptation (Recommendations 2, 11, 12, 13).

As the first line of defense against extreme storms, features such as dunes, barrier islands and tidal wetlands take the brunt of waves and storm surge, reducing the impact on coastal communities and infrastructure. To preserve coastal ecosystem functions, natural features must be allowed to respond naturally or migrate inland as sea level rises.

New York State needs a regulatory framework that considers sea level rise in proposals for development in areas where the migration of dunes and other natural features may be restricted.

Current funding mechanisms and technical expertise have encouraged a structural approach to shore protection; this approach has several drawbacks. Structural measures such as seawalls, dikes, and beach-nourishment projects are expensive to build and maintain and they often interrupt sediment transport processes, result in biological impacts, and change erosion patterns. They create barriers that prevent natural systems such as tidal wetlands from migrating inland to adapt to sea level rise. Additionally, there is no assurance that they will be adequate protection from long-term sea level rise.

Conversely, non-structural solutions, such as elevation and strategic relocation, can reduce or eliminate the long-term threat of flooding at a much lower long-term cost and with fewer impacts to natural systems. In light of these factors, federal and state agencies are beginning to incorporate non-structural solutions into their long-term coastal protection planning and management.

Where shoreline stabilization is absolutely necessary to protect investment in essential public infrastructure, appropriate “soft engineering” or “living shoreline” techniques should be implemented, rather than structural shoreline protection measures. If properly designed and implemented, softer approaches, which integrate structural elements such as breakwaters and sills with natural elements such as marshes, beaches, and reefs, can potentially preserve some beneficial qualities of a natural shoreline and provide stabilization while minimizing negative effects.

New York State needs a regulatory framework that considers sea level rise in proposals for development and infrastructure in high-risk coastal areas where the migration of dunes and other natural features may be restricted (Recommendations 4, 5, 7). Such regulations should do the following:

- Restrict structural shoreline protective measures and development in priority areas for wetland, dune, and beach migration
- Prioritize and incentivize the use of non-structural shoreline protection measures to reduce risk
- Provide larger buffers or setbacks between natural protective features and new development
- Require local and regional planning efforts to begin to establish areas for migration of natural protective features

There is also a need for additional studies, including establishment of long-term monitoring systems, that will improve our vulnerability analyses for natural areas at greatest risk of flooding (Recommendation 12). These include the following:

- Monitor and evaluate the cause of tidal wetland loss and changes at a landscape scale
- Evaluate potential shifts in the upstream extent of the Hudson River salt front and inundation of underground drinking water supplies in Long Island
- Map projected range shifts of key coastal species
- Better understand how sea level rise, storms, erosion, and engineered shoreline modifications affect shoreline changes, water quality, wetlands, and aquatic habitat

Public Works and Infrastructure

Public and private infrastructure dominates large sections of New York's coastline. These include power plants, sewage and drinking water treatment plants and pump stations, landfills, waste transfer stations, major road and rail transportation arteries and a host of industrial facilities. Underneath the streets of New York City, elaborate systems of public utilities that enable the city to function are vulnerable to increased flooding. Densely populated communities and all of the housing, businesses, recreational resources and institutions that serve them and help shape their character line our marine coasts as well.

Sea level rise will threaten critical power generation and distribution facilities.

Nearly all of this infrastructure was constructed before sea level rise was recognized as a significant problem. Today, sea level rise is recognized as a phenomenon with potentially dramatic impacts on existing and new infrastructure. Decisions regarding coastal infrastructure are complex in process (Table 2). Decision-makers in both public and private sectors need to ensure that relevant planning decisions reflect this reality so that New York State's economy and communities are poised to thrive well into the future.

If we do not begin proactive adaptation planning, sea level rise and related coastal hazards will significantly exacerbate current flooding problems that much of New York State's coastal infrastructure already faces and create new problems as well. The impacts of inundation and flooding are complex. It is not only water that causes damage. Sea water contains salt, which corrodes equipment and undermines its strength. Floodwaters can release stored chemicals and petroleum, pick up contaminated soil and transport lead-based paint. Floodwaters can overwhelm combined storm and wastewater sewer systems and lead to release of untreated sewage. Many elements of existing infrastructure were not designed to withstand extended exposure to moisture. Much infrastructure will be susceptible to ongoing structural and mold problems, such as those that became long-term hindrances to recovery after Hurricane Katrina.

These infrastructure sectors influence and are dependent upon one another. Disruption in one often impedes the function of, or exacerbates the damage to, others. For example, solid waste removal systems depend heavily on transportation networks, and all sectors rely on transportation for access to sites that need repair after flooding.

Past experience has further illuminated the consequences of such interdependence. A Federal Communications Commission (FCC) independent panel noted in the aftermath of Hurricane Katrina that most public safety agencies plan only for one- or two-day power failures. Soon after the hurricane struck, fuel supplies for emergency generators became scarce, and natural gas supplies were disrupted.

Similarly, portable radio charging units and handheld satellite units became unusable when there was no power to charge their rechargeable batteries. [27]

If not addressed, these and other complex interactions will hinder both recovery from major weather events associated with sea level rise and adaptation to its chronic effects.

The Task Force examined several infrastructure sectors and the ways in which they may be compromised by sea level rise and related coastal hazards.

[27] Federal Communications Commission Independent Panel. March 6, 2006. Reviewing Impact of Hurricane Katrina on Communications Networks: Lessons Learned for Emergency Communications.

TABLE 2: Examples of Parties Responsible for Coastal Infrastructure Decisions

Examples of Infrastructure	Planning & Development	Potential financing & Incentives	Approval or Permits Often Required
Telecommunications cables	Private utility	Usually private funding only	Public Service Commission State or local transportation dept Federal Communications Commission Municipalities
Power plants	Private utility State Energy Plan NYSERDA (research assistance)	Usually private funding only	NYSDEC NYSDOS (Coastal Zone Mgt) Public Service Commission U.S. EPA Federal Energy Regulatory Commission Local planning commission
Residential development	Private developer or landowner Local waterfront or zoning plan	Empire State Development Corp. Local economic development corp. Federal flood insurance DEC and DOS via Brownfield Cleanup Program Environmental Facilities Corporation	NYSDEC NYSDOS (Coastal Zone Mgt) Army Corps of Engineers Local planning commissions County departments of health
Commercial development	Private developer or landowner Local waterfront or zoning plan	Empire State Development Corp. Local economic development corp. DEC and DOS via Brownfield Cleanup Program	NYSDEC NYSDOS (Coastal Zone Mgt) Army Corps of Engineers Local planning commission
Waste transfer stations	Municipality or private company Local solid waste mgt plan Local waterfront or zoning plan	Environmental Facilities Corporation	NYSDEC NYSDOS (Coastal Zone Mgt) Army Corps of Engineers Local sanitation dept Local planning commission
Shoreline protection structures	Private sector Municipal governments Army Corps of Engineers	Private funding Municipal governments Empire State Development Corp. Local economic development corporations	NYSDEC NYSDOS (Coastal Zone Mgt) Office of General Services (state land) Army Corps of Engineers U.S. Dept. of Interior (incl Fish & Wildlife Service) Local planning commission
State roads	NYSDOT	Governor Federal Dept. of Transportation (matching funds)	NYSDEC NYSDOS (Coastal Zone Mgt) Army Corps of Engineers U.S. EPA US Coast Guard (bridges) U.S. Dept. of the Interior
Wastewater sewer lines	Municipality Combined sewer overflow management plans	Environmental Facilities Corporation (Potential for private financing in future)	NYSDEC Local planning & zoning commissions County departments of health

Communications

Communication networks are vital to every aspect of daily life, but especially to police, fire and other emergency services. Many of today's communications networks (wireline, wireless, internet, voice-over internet protocol and cable) are interconnected and thus vulnerable to disruption**.** Flood-induced outages to one centralized facility or primary cable path can result in total loss of service over an entire area. "Cascade-effect" outages can affect facilities beyond the immediately damaged area. Frequent inundation of communication delivery systems will accelerate deterioration of cable sheathing, telephone poles, and other components, making outages more likely and longer lasting. Outages will increase as the areas affected by storm surges expand to places where infrastructure was not designed to withstand such events.

Energy

The risks to energy facilities parallel those facing communication infrastructure. Flooding of power plants can result in total loss of service for a given area. Frequent inundation of electric and gas transmission and distribution systems can accelerate their deterioration, causing more frequent and longer-lasting outages with extended repair times. Flooding and a higher water table can impede access for repair and maintenance of underground gas and electric lines and equipment. Above- and below-ground storage tanks containing bulk liquids along the coast could be damaged in storms or corroded by saltwater inundation. Leakage could contaminate ecosystems and drinking water and be costly to clean up.

Engineered shoreline protection structures have the potential to exacerbate erosion.

Shoreline Protective Structures

When water overtops bulkheads, seawalls and revetments—structures intended to protect the shoreline against seawater and erosion—buildings can be damaged or lost, especially if the presence of protective structures has encouraged development in high-risk areas. As sea level continues to rise, efforts to prevent overtopping may ultimately be futile.

Hurricane Katrina prompted the National Academy of Engineering and National Research Council to declare that: *"… because of the possibility of levee/floodwall overtopping—or more importantly...failure—the risks of inundation and flooding never can be fully eliminated by protective structures no matter how large or sturdy those structures may be."*[28]

[28]National Academy of Engineering and National Research Council: The New Orleans Hurricane Protection System, Assessing Pre-Katrina Vulnerability and Improving Mitigation and Preparedness, 2009.

Shoreline protective structures have limited life spans, lasting only a few decades, and attempts to maintain them in the face of sea level rise will be costly.[29] For example, the costs of beach nourishment alone are substantial.

According to a 2000 publication from the National Oceanic and Atmospheric Administration, "Coastal geologists put the 10-year cost of maintaining nourished beaches along the developed shorelines of New Jersey, North Carolina, South Carolina, and Florida, using 1996 costs and average frequency of renourishment, at $5.9 million per mile."[30, 31]

As these protective measures are eventually undermined or destroyed, the public investment will be lost. However, there will be some areas where shoreline protective structures may be necessary, such as New York City. In such cases, it may be appropriate to integrate soft engineering techniques and elevation of critical facilities into the design of shoreline protection projects.

Solid Waste

Flooding causes structural damage to solid waste facilities and the transportation infrastructure that allows movement of waste in and out of them. Post-storm repair work on solid waste facilities and transportation infrastructure, moreover, will conflict with the increased demand for debris removal that occurs after a storm, potentially overwhelming the system. Waste facilities inundated by water have significant potential to contaminate floodwaters with petroleum and other noxious substances, causing odors and pathways for disease and affecting nearby ecosystems, residents and businesses.

Sea level rise threatens marine transfer stations and other coastal waste management facilities. Such facilities are also potential sources of contamination if they are flooded during storms.

[29] *Social justice in coastal erosion management: The temporal and spatial dimensions*, J.A.G. Cooper, J. McKenna, Geoforum 39 (2008) 294-306.

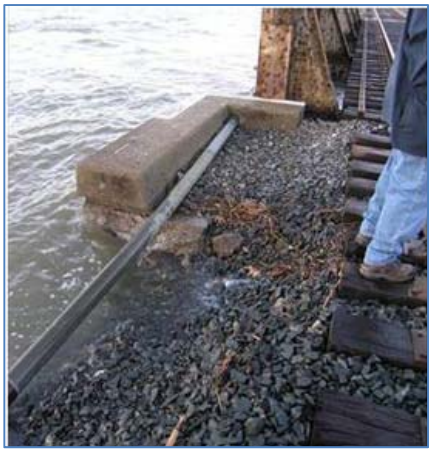
[30] Casey Hedrick, "State, Territory, and Commonwealth Beach Nourishment Programs," March 2000, NOAA, http://coastalmanagement.noaa.gov/resources/docs/finalbeach.pdf.

[31] This is $8.2 million in 2010 dollars when adjusted for inflation.

Transportation

Reliable, operational transportation networks are essential for maintaining normal business and residential life. The need for these systems is never more critical than during emergency response and evacuation. Loss of road, air, ship and rail transportation from flooding has widespread repercussions, compounded by prolonged repair times due to lack of service. Sections of commuter and freight railways along the Hudson are at special risk due to their location just feet from the river, as are coastal airports.

Regular or profound flooding could threaten rail movement throughout the Hudson Valley, including plans for high-speed rail development. Foundations for rail lines could be undermined by erosion, and signaling systems damaged by saltwater infiltration could lead to train accidents. Rising water tables will increase the risk of flooding and the need to pump standing water from underground or low-lying facilities such as the New York City subway system. They could also weaken the substrate or subgrade for other transportation infrastructure. Public roadways can become permanently obstructed or rendered impassable, requiring relocation of critical thoroughfares.



Railroads, highways and subways are all at risk from coastal flooding and salt water damage.

Of the major airports in the New York metropolitan area, both LaGuardia and JFK are at risk of flooding from powerful coastal storms and sea level rise. LaGuardia is at greatest risk. Even without sea level rise, a ten-foot storm surge, similar to that of Hurricane Donna in 1960, would begin to overtop its protective barriers. Water levels above 13 feet would cause significant flooding at the airport. However, such flooding is not expected to affect the airport's structures and equipment uniformly; a more detailed study is needed to evaluate which areas would be most vulnerable.

Sea level rise will also affect public commerce. The goods movement industry, especially in coastal states, relies heavily on waterborne transit. Sea level rise may affect ports, navigable waterways, and transportation infrastructure connections.

Drinking Water Supplies

Salt water intrusion threatens potable water supplies, especially on Long Island, where salt water intrusion into the sole source aquifer would compromise drinkable water for hundreds of people.

Sea level rise will push the Hudson River salt front upriver, threatening water supplies of several Hudson Valley communities and businesses, including this water intake at the IBM facility in Poughkeepsie, NY.

It also threatens the Hudson River, which is a primary water supply source for many communities and a potential emergency water supply source for New York City, having been used as such during three severe water shortages within the last 45 years. Saltwater intrusion could affect freshwater intakes at the Chelsea Pumping Station, Castle Point Medical Center, Poughkeepsie, Port Ewen, Highland/Town of Lloyd, Dutchess County Water Authority, and Rhinebeck. In addition, flooding and other sea level rise impacts pose many of the same risks to drinking water treatment facilities as those that threaten other infrastructure types: corrosion, erosion and deterioration.

Water treatment plants in the coastal zone are at risk from flooding and the associated corrosion caused by salt water infiltration. In addition to the treatment facilities themselves, the substrate for distribution pipes could be damaged by erosion and a rising groundwater table. Wells are also at risk from salt water corrosion and rising groundwater conditions. Costs of necessary repairs, placements and updates to New York State's water infrastructure over the next 20 years have been estimated at $38.7 billion, although estimates of the costs of modifications to respond to climate change specifically have not been developed. These costs will, however, be significant.[32]

Wastewater Management Systems

Wastewater treatment plants in the coastal zone are at risk from flooding and the associated corrosion caused by salt water infiltration. In addition to the treatment facilities themselves, the substrate for sewer pipes could be damaged by erosion and a rising groundwater table. Septic systems are also at risk from salt water corrosion and rising groundwater conditions.

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[32] NYS Department of Health, Drinking Water Infrastructure Needs of New York State, November 2008, http://www.nyhealth.gov/environmental/water/drinking/docs/infrastructure_needs.pdf

[33] NYSDEC, 2008. Wastewater Infrastructure Needs of New York State. 37pp.

Public Works and Infrastructure: Actions Needed to Adapt to Sea Level Rise

The first step in assessing the vulnerability of New York's infrastructure is to identify and map areas at greatest risk. The next step is begin to reduce risk in those areas (Recommendations 3, 4, 5). Alongside that effort, an inventory of the types and value of infrastructure, critical facilities (hospitals, police and fire departments, schools, emergency services, key transportation routes), and private and commercial property in high risk areas is required (Recommendation 6).

Policy changes needed to reduce vulnerability include limitations on the siting of new development or infrastructure (including transportation corridors) in high-risk areas (Recommendations 2, 5, 7). Also needed are changes to permit requirements for setbacks and design elevations and modifications to building codes for structural elements and corrosion-resistant equipment.

Construction of shoreline protection structures can encourage development in high-risk areas.

Non-structural solutions, such as elevation and relocation of structures, must play a major role in a statewide response especially in less urbanized areas where they may be less expensive and more effective at reducing long term vulnerability (Recommendation 5).

Long-term plans for maintenance, retrofits and upgrades should incorporate opportunities for adapting existing infrastructure to projected changes in flood risk through elevation, relocation, increased water-pumping capacity, or other measures. Emergency management planning must incorporate increased demand for emergency services and consider sea level rise impacts on evacuation routes. Use of state resources for repair or construction of shoreline protective measures–whether natural or engineered, temporary or long term–should be evaluated to ensure that they are the most cost-effective, long-term, site-specific approaches feasible. Plans for back-up measures for critical systems such as energy and drinking water should include impacts of sea level rise. Determinations of priority cleanup of hazardous waste sites and brownfields should consider the likelihood of increased flood risk. Some areas will have to explore alternative sources for drinking water should their primary sources be degraded.

Non-structural solutions, such as elevation and relocation of structures, must play a major role in a statewide response especially in less urbanized areas where they may be less expensive and more effective at reducing long term vulnerability (Recommendation 5). Such strategies include conserving natural systems such as barrier islands, tidal wetlands and dune systems that currently provide flood protection and community benefits at no cost. Low-impact development and green infrastructure can also help mitigate the effects of sea level rise, including flooding. Low-impact development also emphasizes conservation and use of on-site natural features to protect water quality. Green infrastructure refers to the use of natural or engineered systems that mimic natural processes. It includes rain gardens, rooftop catchment systems and green roofs, technologies and practices that allow treated wastewater and stormwater to infiltrate back into groundwater systems rather than piping it into the nearest waterbody, where it may exacerbate coastal flooding.

Due to their escalating capital and maintenance costs and the incentives they create for new development in high-risk areas structural protection measures and funding for them should be significantly reduced over time. In areas where structural protection is warranted, such as some areas of New York City, the state should develop guidance to enhance the ecosystem value of structural protection measures (Recommendation 8). At the same time, the state must coordinate with federal agencies like the Federal Emergency Management Agency (FEMA) and the U.S. Army Corps of Engineers (USACE) to reduce incentives for new development and redevelopment in high-risk areas (Recommendation 5, 14).

Communities

Without sound planning for adaptation, sea level rise and associated coastal hazards will wreak damage on both individual and community scales. Because of all the amenities that life near the shore offers, people have long been drawn to settle in the areas most vulnerable to storm damage. The number of people at risk from a Category 3 hurricane along New York State's coast, for example, has been estimated at nearly 2 million and, for a Category 4 hurricane, more than 3 million.[34] Residential structures in the 100-year floodplain of New York City and Nassau, Suffolk and Westchester counties have a total estimated value of over $125 billion. While this figure includes riverine as well as coastal flood plains, it reflects the scale of flood exposure in the region.[35]

While coastal development has burgeoned the many federal, state, and local decisions governing siting, design, construction and financing have not yet incorporated measures necessary to address the long-term effects of sea level rise and related coastal hazards. For example, Flood Insurance Rate Maps (FIRMS) issued by FEMA as part of the National Flood Insurance Program (NFIP) establish areas at current risk from 100-year and 500-year floods and dictate rates of flood insurance for structures within those areas. However, FEMA flood maps in coastal counties in New York State, with the exception of Nassau and Suffolk counties, use outdated flood studies from the 1980s. Although FIRMS are designed solely to serve as insurance rate maps, they are often used by state and local planners to approve or disapprove structures, decisions that have inherent long-term impacts. Because many FIRMS are outdated and do not include areas where risk of flooding will increase due to sea level rise, this practice dramatically underestimates the actual long-term cumulative impacts of individual development decisions in high-risk areas.

The current structure of many federal and state-funded actions and programs protect or subsidize high-risk coastal development by shifting the cost of flood protection and storm recovery from property owners and local governments to state and federal taxpayers. Examples of these subsidies include funding for structural shoreline protection (which includes artificial fill or 'beach nourishment'), insurance coverage through the National Flood Insurance Program, and federal and state post-disaster recovery funding and assistance that encourages replacing or rebuilding structures with a high level of risk exposure.[36] These policies distort market forces favoring coastal development.

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[34] New York State Office of Emergency Management. *New York State Standard Multi-Hazard Mitigation Plan*, Volume 1, Section 3, Table 3-29: Estimated Population Residing Within Hurricane Storm Surge Zones, p. 3-170. Report approved by FEMA 1/04/08. http://www.semo.state.ny.us/programs/planning/hazmitplan.cfm

[35] Ibid. Table 3-18: Estimating Potential Flood Loss by County, p. 3-146.

[36] Kenneth J. Bagstad, Kevin Stapleton, John R. D'Agostino, "Taxes, subsidies, and insurance as drivers of United States coastal development," *Ecological Economics*, V. 63, August 2007, p. 285-298

According to New York University's Institute for Policy Integrity:

> *As a result of the National Flood Insurance Program's (NFIP) below-market premium rates, building in floodplains appears more attractive to private developers ... In other words, the flood insurance program encourages private development at a rate that is inefficient and unsupported from a social perspective that more fully considers the ecological and financial risks.* [37]

Protecting development at high risk of coastal flooding thus far has come at great expense to the taxpayers of New York State. In the last five years alone, the state spent more than $22.6 million in projects to protect public infrastructure and commercial and residential property from erosion and flooding in coastal areas. Costs are expected to continue rising due to inflation and market forces. The predicted total cost for the construction of a planned Long Beach, Long Island project in Nassau County is estimated at over $100 million, with a projected state and local cost of roughly $30-35 million. The full implementation of the Fire Island Inlet to Montauk Point Storm Damage Reduction Project alternatives in Suffolk County has the potential to cost New York State and local governments upwards of $500 million over several decades.[38]

Current funding mechanisms and technical expertise have encouraged a structural approach to shore protection; however, this approach has several drawbacks. Structural measures such as seawalls, dikes, and beach nourishment projects are expensive to build and maintain.[39] Structural measures often interrupt sediment transport processes, incur biological impacts and change erosion patterns. Projects like these create barriers that prevent natural systems like tidal wetlands from migrating inland to adapt to sea level rise. Additionally, there is no assurance that they will provide adequate protection from long-term sea level rise.

Large-scale engineered fortifications, may not be the best way to protect large cities and densely populated urban areas such as New York City from coastal storm impacts and inundation. The devastation following Hurricane Katrina resulted in an examination of structural protection measures, leading to findings that have broad national implications.

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[37] Holladay, S. and Schwartz, J. *Flooding the Market: The distributional costs of the NFIP*. Institute for Policy Integrity at the New York University School of Law. Policy Brief No. 7, April 2010

[38] NYS DEC, Division of Water, Coastal Management Bureau

[39] Casey Hedrick, "State, Territory, and Commonwealth Beach Nourishment Programs," March 2000, NOAA, http://coastalmanagement.noaa.gov/resources/docs/finalbeach.pdf

Among the significant findings of the National Academy of Engineering and the National Research Council:

> *…the risks of inundation and flooding never can be fully eliminated by protective structures no matter how large or sturdy those structures may be.*[40]

The Council found that continued implementation of primarily structural defenses sends an unreliable message to the public—that they are safe: "Hard structures, like levees, more often than not give coastal residents a false sense of security."

Non-structural solutions can reduce or eliminate the long-term threat of flooding at a much lower long-term cost with fewer impacts to natural systems. These alternatives rely on planning strategies such as land acquisition, buffer zones, conservation of natural flood protection systems, building elevation, building codes and other local regulations.[41, 42]

The most notable research specifically evaluating the efficacy and efficiency of non-structural approaches to risk reduction, such as land-use planning in coastal areas, has been conducted at Texas A&M University under Dr. Samuel D. Brody. Research in multiple local communities examined the relationship between specific mitigation techniques and insured flood losses and demonstrated that none of the structural approaches significantly reduced insured residential property damage. In contrast, almost half of the non-structural strategies were found to be significantly related to reduced losses from floods reported to the National Flood Insurance Program. Having a flood policy within a local comprehensive or development management plan was found to have the strongest statistical correlation with damage reduction. Protected areas and setbacks from flood-prone areas were also significantly associated with reduced flood loss.[43]

In light of these factors, federal and state agencies are beginning to incorporate non-structural solutions into their long-term coastal protection planning and management.

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[40] *The New Orleans Hurricane Protection System: Assessing Pre-Katrina Vulnerability and Improving Mitigation and Preparedness*, National Academy of Engineering and National Research Council, National Academies Press, 2009.

[41] Jacob, John S.; Showalter, Stephanie. August 2007. *The Resilient Coast: Policy Frameworks for Adapting the Built Environment to Climate Change and Growth in Coastal Areas of the U.S. Gulf of Mexico*. Sea Grant - Texas.

[42] It is important to note that non-structural approaches do not include 'soft structural' techniques such as beach nourishment due to their strict engineered approach according to the Shoreowner's Protection Act (Environmental Conservation Law, Article 34) and corresponding regulations (6 NYCRR Part 505).

[43] Blackburn, Jack; Phil Bedient. "Learning the Lessons of Hurricane Ike - A Synopsis of Ongoing SSPEED Center Research Funded by the Houston Endowment." May 2010

Risk in coastal areas is also increasing due to decisions that favor coastal development at the local level. Local governments are at the front lines of decision-making about regulation, taxation, zoning and development decisions in New York State's 315 coastal cities, towns and villages. Because New York is a 'home rule' state, local governments have the power to control land use as long as their decisions are consistent with a local comprehensive plan or other well-considered plan. They decide how close landowners can build to the water, enforce building codes and permit development projects. In most communities, these decisions are made in isolation. Communication between localities is minimal and regional-scale impacts of development on natural systems are often not considered. In addition, many local leaders have little knowledge of the risks posed by sea level rise and therefore continue to permit new development in high-risk coastal areas.

To better understand why high-risk coastal development is so often permitted and even encouraged at the local level, an understanding of how local governments function and support themselves is key.

Local governments typically have limited financial resources and staffing available to develop and implement climate-change adaptation or other hazard-related strategies. Local political pressures generally favor economic growth. New residential development is the primary means to raise revenue for these governments through assessment of real property taxes. Commercial development translates to investment dollars, creation of jobs and local economic stimulus. Coastal locations have premium real estate values making them highly desirable to buyers and the local governments that receive tax revenue. This situation presents a serious obstacle to dealing with climate change impacts locally.

Finally, the perception of risk is greatly skewed by human memory. Several decades have passed since a major storm has devastated New York State and investors, decision-makers and buyers have been lulled into underestimating the actual risk over the lifetime of the development and the cost to recover.

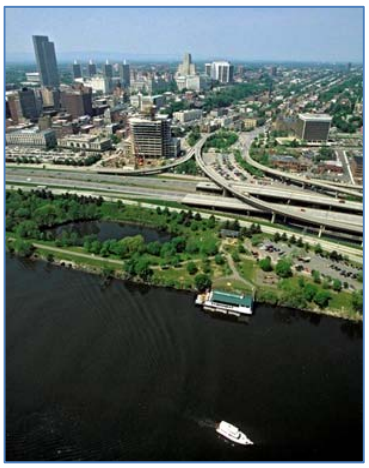
The cumulative effect of the above factors is that the potential consequences of a large storm event continue to increase. Indeed, the resilience of communities such as Long Beach, Long Island and the North Shore of Staten Island is increasingly being tested as their protective natural systems and critical infrastructure are under threat or in decay.

Community resilience to threats related to sea level rise involves more than physically protecting property, buildings, or structures from potential impacts. The concept encompasses a range of intangible considerations that are critical to a particular community's capacity to withstand and recover from loss or damage.

The various considerations for community resilience, recovery, and adaptation fall into four broad categories.

Public Health

Storm surges and other flooding events can cause injury and death. They can also generate a host of more persistent environmental health hazards, including bacterial, fungal and chemical contamination of drinking water sources, sewage and solid waste system disruption, hazardous materials releases, and increased or displaced populations of insects, rodents and other disease vectors.



City of Albany waterfront. Waterfront amenities will be increasingly vulnerable to flooding.

Current land-use planning and permitting processes and public health policies rarely address the public health implications of development in areas at high risk for flooding.[44] During and after floods, the imperative to restore the status quo as quickly as possible can interfere with efforts to identify and address less obvious problems, such as newly contaminated soil or housing.[45] Recovery can be further hampered by gaps in understanding risk factors and treatments for post-flood disease outbreaks.

Loss of Shelter

Long Beach lost many homes and other structures to the 1938 "Long Island Express." The potential for catastrophic losses among south shore communities has increased with rising seas and development in high-risk areas.

Besides physical injury, the most significant risk from flooding is long-term or permanent loss of shelter. Weakened structures, damaged electrical or plumbing systems, mold, and contamination can render buildings uninhabitable. Housing degradation can result from both acute events such as storm surges and the more gradual effects of sea level rise, including erosion and salt water inundation.

Without realistic risk assessments for structures in high-risk and chronically affected areas temporary shelters become strained, leading to permanent relocation of a significant percentage of a community's population.

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[44] Levi, J., et al. 2009. Health problems heat up: Climate change and the public's health. *Trust For America's Health*. See also Morello, L. 2009. Adaptation: public health often moves behind the climate curve study. *ClimateWire: The Politics and Business of Climate Change*, Retrieved from http://www.eenews.net/climatewire/2009/10/27/

[45] Gautam, K.P. and van der Hoek, E.E. 2003. *Literature Study on Environmental Impact of Floods*. Delft Cluster and the Netherlands Centre for River Research.

Disrupted Livelihoods and Loss of Economic Vitality

The full economic impact of storm surges and inundation goes beyond direct damage and losses. Though less well studied, indirect losses from the disruption of the local economy–key industries, employers, commercial centers, or tourist attractions– can have devastating consequences for a community. These losses are harder to measure than those stemming directly from physical damage. Determining the cost of repairing a ruptured power line is straightforward. It is a greater challenge to determine the losses to businesses or industries forced to close because of a power failure or interrupted transportation network. The effects can be long lasting, entailing economic consequences from which a community may never recover.

There are few, if any, mechanisms in place to measure such indirect losses, and those that are available (such as business interruption and unemployment insurance) are often not applicable to the small businesses that form the economic backbone of many communities. Small businesses account for approximately 75% of all new jobs in the United States, but they are also the most vulnerable to a disaster.[46] Understanding the vulnerability of interdependent networks of small businesses and other hubs of local economic activity is critical to strengthening community resilience in the face of sea level rise. Current guidance on conducting such assessments, however, is lacking.

Quality of Life and Community Cohesion

Flood and storm damage can lead to transient or permanent loss of services and amenities–hospitals; clinics; community, senior and day care centers; schools; and recreational open space. In many cases, communities, especially low-income communities, have invested considerable time and energy to secure these amenities, and their full value may not be reflected in typical vulnerability assessments. Such losses degrade the quality of life for shoreline communities.

Other, more subtle losses that affect a community's ability to recover from flooding may have pronounced long-term consequences. Community cohesion and identity are important indicators of overall community resilience. A community that has overlapping social networks, organizations that work together, and community members who are involved in decision-making has a greater ability to plan for and cope with natural or human-made disasters. The sense of community cohesion and identity can be seriously undermined when treasured commercial streets, landmarks, historic sites, heirlooms, tourist attractions or traditions are lost or altered. Losses of this kind cannot be gauged by simple monetary replacement costs.

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[46] Lam, N.; Pace, K.; Campanella, R.; LeSage, J.; and Arenas, H. 2009. *Business Return in New Orleans: Decision Making Amid Post-Katrina Uncertainty*. PLoS ONE, Vol. 4, Issue 8. pp. 1-10.

Climate Justice

Climate justice is a relatively new area of research and analysis that focuses on the ethical dimensions of climate change.[1] The term also describes a social and political movement that demands that government policies and actions aimed at mitigating and adapting to climate change address human rights and environmental justice.

Without proactive policies, climate change could be particularly damaging to the people least able to respond to it. [2,3] In addition, if climate justice is not considered, government and private sector actions to mitigate and adapt to shifting climate could create uneven financial burdens as well as social and cultural disruptions.

Because low-income communities of color could be disproportionately affected,[4] their participation is critical to adaptation and community resilience planning efforts. Local residents have on-the-ground and historical knowledge of local land uses and hazards that is vital to adaptation planning and developing effective response strategies to sea level rise impacts. Engaging members of the community in the planning process gives them a sense of ownership of the final outcome. Participating in the process builds awareness and promotes action to limit risks.

Two New York City-based environmental justice organizations, UPROSE (Sunset Park, Brooklyn) and WE ACT (Harlem, Manhattan), have led the effort to include local communities in federal, state, and local government community resilience planning. Their work is centered on ensuring that environmental justice communities are economically viable and have access to public health and safety protections, municipal services, and prompt and appropriate emergency response.

1. Estrada-Oyuela, Raul A. 2002. *Equity and Climate Change. In Ethics, Equity and International Negotiations on Climate Change*, edited by P. R. Luiz and M. Mohan. Cheltenham, UK: Edward Elgar.

2. Patz, Jonathan. 2005. "Impacts of Regional Climate Change on Human Health." *Nature* 384:310-317

3. Morello-Frosch, R.; Pastor, M.; Sadd, J.; Shonkoff, S.B. 2009. *The Climate Gap: Inequalities in How Climate Change Hurts Americans & How to Close the Gap*.

4. Ibid.; Medina-Ramón, M.; Zanobetti, A.; Cavanagh, D.; Schwartz, J. 2006. "*Extreme temperatures and mortality: assessing effect modification by personal characteristics and specific cause of death in a multi-city case-only analysis*." *Environ Health Perspect*, 114(9), 1331-1336.

Communities: Actions Needed to Adapt to Sea Level Rise

New York State is at a crossroad. Our fundamental choices for responding to the increased risks to our communities from sea level rise and resultant flooding include the following:

- Maintaining the status quo by letting communities respond to events as they occur, with state assistance in emergencies
- Promoting structural protective measures for most of the state's shorelines
- Designing new structures and retrofitting old structures to allow floodwaters inside, but ensure that there is minimal damage to a building's structure and contents[47]
- Reducing risk by elevating and relocating structures over the course of time
- Prioritizing the conservation of natural systems like tidal wetlands, dunes, and barrier islands to allow them to continue to provide large-scale flood protection services and other community benefits derived from these natural systems

Ideally the state will support development of local or regional plans that emphasize long-term reduction or elimination of risk, take into account the cumulative environmental impacts or benefits of decisions, and include the most cost-effective mix of the above solutions tailored to the specific needs of communities and geographic areas.

Building the resilience of downstate communities to sea level rise and storm surge will require improving community-level planning and decision-making in a number of critical areas, including land use, public health, and emergency response and post-storm recovery. To effectively confront these threats, it will be necessary to build local capacity to conduct and sustain a range of planning, awareness-raising, and implementation activities by providing technical assistance and guidance, clear legal and regulatory frameworks, and financial resources.

Regional planning is critical to ensure sound decision-making to reduce risk along the coast. Uncoordinated, *ad hoc* responses to coastal adaptation will likely result in escalating costs for chronic damages due to sea level rise and high costs for post-storm recovery. Varying levels of protection among communities due to differences in local resources will leave some communities at risk of casualties and significant loss of property. A failure to address regional ecosystems holistically will lead to burgeoning environmental impairments and social problems and the loss of critical natural systems and the services they provide.

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[47] One example of such a strategy is to design underground parking with structural components that could withstand inundation. When floodwaters are forecast, vehicles could be temporarily moved to another location, and floodwaters could be allowed to flow through the structure.

Local planning for sea level rise must identify vulnerable development, critical facilities, infrastructure and natural resource assets at the site level and evaluate strategies to reduce risk over time. The state should provide grants, guidance, risk maps and other tools and technical assistance to empower local decision-makers to analyze their communities' circumstances through vulnerability assessments that will lead them to develop appropriate strategies for reducing vulnerability (Recommendations 2, 3, 4, 6, and 11). A database of feasible adaptation responses for communities and habitats should be created that allows each community to compare alternate strategies for achieving mutual, desired goals and select the strategy most appropriate for its own situation (Recommendation 8).

Guidance on these assessments must acknowledge the role of independent, community-based assessments conducted by local organizations. These assessments can produce more detailed information on the specific risks and vulnerabilities that threaten selected neighborhoods, community amenities, or vulnerable populations within a community (Recommendation 8).

Well-designed and inclusive multi-stakeholder planning processes can raise awareness, build capacity, generate community-specific knowledge, and strengthen community cohesion and identity (Recommendations 8, 10).

Particular effort and funding should be dedicated to ensuring that lower-income communities and communities of color are adequately involved in planning efforts. The members of such communities often have less time and resources to devote to participation, and without adequate representation, their needs may be overlooked.

Guidance should address evaluating and updating emergency management strategies and plans. In particular, there is a critical need for more focused and sustained engagement by public health professionals (Recommendation 9). Better data and analysis are needed to help communities assess their vulnerability to immediate mortality risks, risks of infectious and vector-borne diseases, health-related costs of flooding and mental health issues, and the need for early warning systems.[48]

Communities need guidance to develop and implement local regulations and zoning laws that will reduce new development in high-risk areas and manage risks to existing infrastructure, property and people. Developing appropriate plans for recovery and redevelopment (Recommendation 5) following powerful storms can provide communities with an opportunity to be proactive, decrease their vulnerability and identify areas that can provide restoration and migration opportunities for natural resources.

In some cases, state regulation is needed to mandate risk-reduction strategies where local governments lack the resources or authority to pass or enforce local regulation to reduce risk or conserve natural flood protection systems (Recommendations 5, 7).

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[48] Ahern, M., et al. 2005. Global Health Impacts of Floods: Epidemiologic Evidence, Epidemiologic Reviews, Johns Hopkins Bloomberg School of Public Health.

Governments can make development in coastal areas less attractive by requiring development projects to internalize the risks of sea level rise and storms in coastal development planning and decision-making. For example, governments could require that infrastructure siting, design, and construction explicitly evaluate the potential impacts of storm surge and sea level rise. Real estate titles or other consumer-oriented information sources could disclose projected risks to the buyer. Flood insurance programs and state building codes could strengthen siting and building standards in coastal areas (Recommendation 7). Such actions could have a dramatic influence on coastal decision-making, reducing loss of life and property and the costs to recover from extreme weather events. All state policies and programs should be carefully reviewed to determine whether they encourage at-risk development and to suggest appropriate modifications (Recommendation 2).

Federal, state and local agencies will need to coordinate to comprehensively address vulnerabilities in high-risk coastal areas (Recommendation 13). Effective interagency coordination on climate change would have an enormous benefit to regional and local governments dealing with a dizzying array of uncoordinated agency funding and regulatory programs. Consolidation of policy and regulatory priorities, funding programs, and technical assistance across agencies will conserve both state and local resources and potentially save tax dollars.

Adaptation Champions

Community-based organizations in New York State can provide strong and sustained local leadership on climate change adaptation. The following are examples of "adaptation champions" from the three main regions of the state affected by sea level rise. Their sustained efforts have stimulated local interest in adaptation, increased buy-in for climate change adaptation projects, and attracted external resources.

The Hudson Valley

To help people think about the local impacts of climate change–and how the Hudson Valley might prepare for them—the Rising Waters project brought together private and public stakeholders in the fields of transportation, health care, utilities, emergency preparedness, planning and environmental advocacy. The project developed contrasting scenarios to explore the future consequences of climate change adaptation decisions. Participants reached consensus on key findings and recommendations for adaptation, which were released in a May 2009 report. Several stakeholders are now engaged in developing a climate change speakers bureau in the Hudson Valley, promoting a sustainable shoreline initiative and conducting marsh restoration. Rising Waters was spearheaded by The Nature Conservancy's eastern New York chapter and partners such as DEC's Hudson River Estuary Program and National Estuarine Research Reserve, Cornell University, the Cary Institute of Ecosystem Studies, and Sustainable Hudson Valley.

New York City

Parts of Sunset Park, a waterfront community in Brooklyn, are less than 10 feet above sea level, and flooding during major storms is a critical local concern. UPROSE (United Puerto Rican Organization of Sunset Park), a grassroots environmental justice organization, is developing a community-specific climate change adaptation plan that can be tailored and replicated by other vulnerable communities. The initiative is part of PlaNYC, New York City's comprehensive sustainability plan to reduce the city's greenhouse gas emissions by 30% and adapt to climate change. UPROSE educates residents about the science of climate change and simple changes they can make in their daily lives to reduce their carbon footprint. UPROSE works with constituencies to identify resources that can help them implement adaptation strategies and build Sunset Park's resiliency.

Long Beach, Nassau County

The neighborhood of North Park is taking steps to ensure that the city of Long Beach on Long Island takes seriously the existing and potential effects of sea level rise and other coastal hazards. For decades, residents have endured severe flooding. The area's inadequate and aging shoreline infrastructure and its proximity to Reynolds Channel makes North Park particularly vulnerable to impacts from sea level rise, storm surge, and tidal influences. At high tide, even relatively mild storms have been known to create knee-deep water in some streets, at times forcing children to wade to their school buses or stranding seniors in their homes. Citizen activists and the Long Beach Latino Civic Association have drawn attention to these impacts through repeated testimony before local authorities and consistent participation in municipal and state-level planning processes.

Meeting the Challenge

Despite data gaps, we now possess sufficient information, consensus, and growing political will to support responsible actions to deal with sea level rise. New York State must now decide what these actions will be.

Coastal communities are already experiencing damage from sea level rise and other coastal hazards and, even today, are at great risk from the impacts of a powerful storm. If a Category 3 hurricane similar to the "Long Island Express" of 1938 hit our coast now, there would be severe and long-term economic, ecological and public health consequences.

Holding back the rising sea on a large scale is not practical or even possible. The actions recommended in this report are to guide communities—people, with their accompanying infrastructure—out of harm's way and to allow coastal ecosystems to migrate landward as well so that they may continue to provide natural protection against flooding and other coastal hazards.

There is a tremendous need for new and updated information to make decisions. High-resolution elevation maps are needed coastwide to outline areas at greatest vulnerability to coastal hazards. Storm-surge models should be run with sea level rise projections. FEMA flood studies must be updated to reflect current conditions. Shoreline inventories should be completed for infrastructure, critical facilities and existing structural shoreline defense measures. Tidal wetland and coastal erosion hazard area maps, required by law to be updated on a regular basis, haven't been updated in decades. The implications of sea level rise for emergency management systems must be fully vetted. We also must continue to monitor coastal processes and improve our understanding of how they will be affected by sea level rise.

Enacting cost-effective adaptation policies in advance of rising seas and ecological shifts is the most responsible management path.[49, 50] However, efforts to fill data gaps should occur at the same time we are acting to preserve and protect coastal communities and ecosystems. The best available data must be brought to bear at every stage through an adaptive management approach. Such an approach can reduce uncertainty in long-term decisions over time by monitoring and evaluating the results of research and policy actions and changing the course of action as needed.

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[49] The uncertainty, or precautionary, principle of ecosystem management suggests that in the absence of all the answers, we should not wait for the answers, but should take action to protect the ecosystem using the best available science while we improve our understanding.

[50] Rio Declaration on Environment, Principle 15. The United Nations Conference on Environment and Development Rio de Janeiro, June 1992.

Widespread structural approaches to manage vulnerability to sea level rise and coastal hazards have long been the norm, but they are expensive, short-term responses that do not recognize the natural and beneficial functions nor the mitigating capacities of the landscape and, in fact, typically disrupt or undermine these benefits. Further, the cumulative impacts of many of these structures can compromise entire ecosystems leading to greater damage. By appearing to reduce vulnerability, they promote development in hazardous areas.

The recommendations contained in this report strongly favor and support non-structural strategies as the first line of protection to be fully considered and applied in almost all circumstances. Responses must be flexible to account for unique local circumstances and may require multi-faceted approaches.

We can be certain that communities will continue to be exposed to natural hazards. Land development is what can and should be managed to lower vulnerability.

> *The preponderance of opinion in both the academic and practitioner communities is that keeping people out of harm's way through the "soft mitigation" practice of planning, particularly land use planning, is far preferable to investments in either hard protective structures or investments in community reconstruction after the fact, necessary though these last two occasionally may be.*[51]

Sea level rise will affect almost every aspect of coastal life–physical, social, economic, and ecological. The response to it must be similarly comprehensive. It must begin with the state's explicit adoption of sea level rise projections and incorporation of adaptation strategies into all relevant regulatory, funding and programming decisions.

A high priority is identifying and mapping the regions at greatest immediate and future risk from sea level rise. This will raise awareness in communities about the risk so that they can act to reduce the vulnerability of high-risk areas. With state assistance local and regional scale planning must be done to identify the most appropriate strategies for each area of the coastline. Those involved in shaping decisions at every level will need to strike a balance among the many competing claims on scarce shoreline resources and ensure that long-term risks are factored into daily choices.

[51] Jacob, John S., Showalter, Stephanie. August 2007. The Resilient Coast: Policy Frameworks for Adapting the Built Environment to Climate Change and Growth in Coastal Areas of the U.S. Gulf of Mexico. Sea Grant - Texas.

STORM-SURGE BARRIERS *("floodgates" or "barrages") are artificial obstructions at the mouth of a tidal watercourse with adjustable gates that are closed during large ocean-dominated flood events or surges and reopened after the floodwaters recede. The feasibility and sustainability of storm-surge barriers in New York and their long-term financial, social and ecological impacts must be assessed. The question of who pays and who gets the benefits–and who does not–is a potent social justice issue. While barriers may be a viable option for interim periods (decades), they may actually increase long-term catastrophic risks if prolonged sea level rise in combination with storm surges eventually render them ineffective. It is important to note that barriers cannot be used alone. They must be coupled with extensive systems of levees and pump facilities requiring large amounts of space and costly maintenance. Planning, financing, operation and maintenance will require multi-state agreements. If considered at all, they must be part of a broader comprehensive and sustainable coastal management strategy that includes a long-term exit strategy from high-risk areas.*

Eastern Scheldt storm-surge barrier, Netherlands. Credit: Raimond Spekking/ Wikimedia Commons/CC-NY-SA-3.0 & GFDL

Community-based organizations and independent assessments that originate at the community level are important to understand the socioeconomic factors, language barriers, social divisions and local traditions that affect vulnerability to, and ability to recover from, damage from sea level rise and related coastal hazards. Community-based organizations are key to effectively communicating with residents, for whom sea level rise and climate change effects may seem abstract or remote. They can mobilize public opinion in ways that a top-down, regulatory approach cannot.

Any sea level rise adaptation strategy, including the recommendations in this report, represent only one stage in a planning process that must be continuously reviewed and revised to incorporate new data, new experience and the changing needs of communities and natural ecosystems. The Task Force is committed to seeing that the insight gained through its work continues to inform future efforts.

Recommendations of the Sea Level Rise Task Force

In 2007, the New York State Legislature created the Sea Level Rise Task Force and charged it with preparing a report and recommendations for an action plan to protect coastal communities and natural resources from rising sea levels. The New York State Department of Environmental Conservation leads the Task Force, which has a diverse membership that includes representatives of state and local government agencies, non-governmental organizations, and affected communities. The legislature directed the Task Force to "evaluate ways of protecting New York's remaining coastal ecosystems and natural habitats and increasing coastal community resilience in the face of sea level rise applying the best available science on issues associated with sea level rise and its anticipated impacts." The Task Force has studied and deliberated, with public participation, the complex issues involved with sea level rise in New York State. This report, including findings and recommendations, is the result of the considerable efforts of many dedicated individuals.

Please note: The following have not incorporated the recommendations from the New York City Climate Change Adaptation Task Force report. Some revisions may be made for consistency with this effort.

1. Adopt official projections of sea level rise.

What: Formally adopt the projections of the Sea Level Rise Task Force for relative sea level rise in all marine coastal areas of the state, including the Hudson River to the Federal Dam at Troy, for use by all state agencies and authorities. These projections should serve as recommended standards for other government, non-government and private interests. Projections should be developed with the best available science, extend for at least 100 years into the future, and be reviewed and updated on a regular basis.

How/Who: An executive order should require the state to adopt projections of sea level rise and call for their update on a regular basis. The proposed New York State Climate Science Institute, or other such state scientific body, led by the State Department of Environmental Conservation and State Department of State, and with the cooperation of other relevant state agencies and local governments, should develop guidance for incorporation of projections into relevant policies and regulations. Local governments should also consider adoption of these projections for planning purposes.

When: Full implementation within 2 years.

2. Require state agencies responsible for the management and regulation of resources and infrastructure subject to sea level rise and management of at-risk populations affected by sea level rise to factor the current and anticipated impacts of sea level rise into all relevant aspects of decision making.

What: Sea level rise poses a significant risk to the citizens, infrastructure, economy and natural resources of the state. Official state projections of sea level rise, and associated impacts of sea level rise, should be factored into all relevant aspects of state agency decision making including long-term planning, programming, permitting, regulating and funding decisions, and the state should seek and provide technical guidance consistent with anticipated changes. Agencies should consider storm and sea level rise impacts over the lifespan of proposed projects or actions and the time horizon of any associated impacts to the proposed projects or actions in all state operational, permitting and/or funding decisions. Relevant agencies should regularly update, modify, and refine guidance documents and plans based on the most current information on sea level rise.

How/Who: An executive order should provide direction to all relevant state agencies to factor current and anticipated impacts of sea level rise into all relevant aspects of decision making. Implementation involves changes to regulation and agency guidance. Relevant agencies include, but are not limited to, DOS, DEC, Office of Emergency Management (OEM), Environmental Facilities Corporation (EFC), Energy Research and Development Authority (NYSERDA), Office of Parks, Recreation, and Historic Preservation (OPRHP), Department of Health (DOH), Office of General Services (OGS), Office of Housing and Community Renewal (OHCR), Empire State Development (ESD), Department of Transportation (DOT), Metropolitan Transit Authority (MTA), Port Authority of New York and New Jersey (PANYNJ), New York Power Authority (NYPA), Long Island Power Authority (LIPA) and the Public Service Commission (PSC).

When: Full implementation within 2-5 years.

3. Classify areas where significant risk of coastal flooding due to storms has been identified in order to implement risk reduction measures in those areas.

What: Define immediately the most vulnerable coastal areas and revise standards for development and redevelopment to reduce risk in these areas. Areas at high-risk of coastal flooding have already been identified by the Federal Emergency Management Agency (FEMA). The state should define a new "*coastal risk management zone*," comprised of, and consistent with, zones designated by FEMA to include coastal high hazard areas (V, V 1-30, or VE zones) and any areas defined by FEMA as "Areas of Moderate Wave Action" (i.e., areas within the A zone and subject to wave action of 1.5 to 3 feet) as areas currently most vulnerable to coastal hazards. These zones should provide the basis for additional review under state regulatory authority and guidance such as additional focus or analysis under State Environmental Quality Review Act review to reduce vulnerability in coastal areas as outlined in the following recommendations.

How/Who: A statute or an executive order should define the coastal risk management zone. DEC and DOS should provide guidance for agency implementation in cooperation with other federal, state and local agencies.

When: Full implementation within 2-5 years.

4. Identify and classify areas of future impacts from ocean coastal flooding from projected sea level rise and storms in order to reduce risk in those areas.

What: Develop maps that extend the area of the *coastal risk management zone,* acknowledging differential levels of risk*,* to include areas potentially vulnerable to projected changes in sea level and high-intensity storm events based on projections of sea level rise adopted by the state including the following:

- areas at greatest risk from sea level rise
- areas at risk from storm surge with current sea levels
- areas at risk from storm surge with sea level rise

These maps should be used by permitting authorities, regulators and planners to manage the risk of coastal flooding from sea level rise. Methodology and criteria should also be developed and promulgated to map areas that may be sites of dune, barrier beach and/or wetland migration in response to sea level rise with disclosure of sources of uncertainty. Digital base maps from the National Flood Insurance Program could be utilized as a basis for maps of projected flood plain inundation. All maps should be updated regularly as new projections for sea level rise are adopted by the state. The most recently updated maps should serve as official maps.

How/Who: This recommendation should be implemented in a two-step process.

1) DEC and DOS should develop maps for planning purposes in cooperation with federal and state agencies, coastal counties and local governments. These maps should reflect projected sea level rise and changes in coastal flooding through 2100. Maps of high-risk areas and the methodology for classification of risk should be made available to local governments and to the public via openly accessible online web tools.

2) Official state maps should be developed to identify the *coastal risk management zone* and depict coastal areas that are at increased risk for flooding. These maps should acknowledge differential levels of risk. This *coastal risk management zone* should provide the basis for additional review under state regulatory authority and guidance such as additional focus or analysis under State Environmental Quality Review Act review to reduce vulnerability in coastal areas as outlined in the following recommendations and for coastal and local planning as outlined in the following recommendations.

When: Planning maps based on the best available current science should be produced as soon as possible for counties for which high-resolution elevation data are available and for other counties upon data availability. Priority for data acquisition should be given to counties of greatest vulnerability. Official maps should be developed upon adoption of projections of sea level rise and strong storms and identification of areas of dune, barrier island and/or wetland migration. Full implementation within 5-10 years.

5. Reduce vulnerability in coastal areas at risk from sea level rise and storms (*coastal risk management zone*) and support increased reliance on non-structural measures and natural protective features to reduce impacts from coastal hazards.

What: Where appropriate, the preference for new development and re-development in the *coastal risk management zone* should be for projects or actions consistent with policies and programs that emphasize reliance on natural protective features and non-structural measures such as elevation and relocation to minimize negative effects of coastal storms, erosion and sea level rise.
Support should be provided to regional and/or local planning efforts to reduce risk from sea level rise and coastal hazards, to projects or actions identified in plans to conserve natural protective features and to secure opportunities for habitat migration in response to sea level rise, and to implement site-appropriate structural and non-structural measures to reduce risk of coastal hazards.

Policies and programs resulting from such planning efforts should be consistent with the federally approved New York State Coastal Management Program Policies, pursuant to the Coastal Zone

Management Act and other state policies and programs (e.g., Environmental Conservation Law Articles 25 and 34) and should accomplish the following:

Part I: Coastal Resilience Plans

a) Public investment, programs and policies should be directed toward the development and implementation of long-term regional scale *coastal resilience plans*. These plans should identify areas for the use of non-structural measures to reduce vulnerability in the coastal risk management zone wherever use of such measures is feasible, identify areas where structural protection is justified to protect significant public investment, water dependent uses and/or critical infrastructure, and identify opportunities to further reduce vulnerability through non-structural measures in the recovery and restoration process following high-intensity coastal storms.

b) *Coastal resilience plans* should meet the following criteria:

i) Use of New York State accepted sea level rise and storm surge projections

ii) Inclusion of vulnerability assessments that takes into account developmental, economic, environmental quality and socio-cultural functions and that use topographic and other relevant data necessary to support effective land use planning

iii) Identification of zones, areas or sites that are appropriate to elevate, relocate, protect, and/or "accommodate" (do nothing as water rises) infrastructure and/or coastal development in high-risk coastal areas located either wholly or in part in the *coastal risk management zone*

iv) Identification of long-term policies or measures to reduce vulnerability, to be implemented following high-intensity storm events including, but not limited to, the following:

- Landscape scale planning measures:
    - Assessments of future impacts of sea level rise and coastal hazards in land use planning and redevelopment decisions
    - Projections of future land use patterns
    - Restriction of new development and redevelopment in high-risk areas, including the pathways of former breaches or washovers on barrier islands
    - Plans for infrastructure risk mitigation and relocation, if warranted
    - Identification and reduction of long-term risks to public health
    - Preservation and protection of natural processes and protective features, including processes that shape and form natural protective features
- Site-based measures:
    - Rebuilding with construction techniques that reduce risk, utilize relocation and elevation, where appropriate, and minimize the negative effects of chronic flooding and high-intensity storm events
    - Development of measures to reduce risk to legal, non-conforming uses

- Criteria to evaluate habitability of structures
- Acquisition or donation of substantially damaged or repetitive loss properties from willing owners
- Environmental restoration opportunities

- Evaluation of actions:
  - Evaluation of short-term recovery actions to ensure they do not inhibit long-term adaptation
  - Identification of implementation costs, benefits, and sources of funding and resources to implement actions
  - Consistency with local hazard mitigation plans
  - Adoption of necessary local laws to make a plan enforceable by local government
  - Other long-term recovery issues identified by the community

v. Transparency of planning processes and incorporation of citizen participation

vi. Designation of locations that will require continued funding for structural protection measures because relocation, elevation or employment of non-structural measures is not feasible for facilities or infrastructure of critical public necessity and/or water dependent uses

vii. Plan approval by DOS and DEC

c) Criteria for approval of *coastal resilience plans* should be developed in coordination with local governments

d) Support, including guidance and funding, should be directed to, and increased for, regional, county and/or local planning offices in coastal areas to develop coastal resilience plans through existing planning support programs such as hazard mitigation plans and local waterfront revitalization plans, the Climate Smart Communities program, and small grants programs such as the Hudson River Estuary grants program

e) Communities located wholly or in part in the coastal risk management zone should be encouraged to implement county/regional or local *coastal resilience plans* as part of revisions or modifications to their comprehensive plans, hazard mitigation plans and/or local waterfront revitalization plans and to achieve consistency with the state's *coastal risk management zone* policies.

Part II: Funding for measures to reduce risk

a) In jurisdictions with approved *coastal resilience plans*, projects or actions seeking state funding should be consistent with such plans.

b) Projects or actions seeking state funding in jurisdictions within the coastal risk management zone that do not have approved *coastal resilience plans* should meet the following conditions:

i. The existing standards and policies of the applicable Local Waterfront Revitalization Program (LWRP) or state Coastal Management Program (CMP), as appropriate, are maintained and the project or action is consistent with local hazard mitigation plans. Where a LWRP, CRP or hazard mitigation plan is not finalized or has not been developed or adopted, care should be taken so that projects or actions do not compromise local ability to develop and implement such a plan.

ii. Proposed projects or actions should account for potential impacts due to projected sea level rise, using state-accepted projections during the functional lifetime of the proposed project, including impacts to shore protection measures, upland uses and adjacent areas and for potential vulnerabilities following the useful lifespan of the project.

iii. Projects or actions should not compromise existing public access to the water as sea level rises. Where public access is constrained by the design of a project, replacement access, including links to adjacent publicly accessible areas, should be provided. Projects or actions should be designed to increase public access wherever possible as consistent with the WRP or LWRP.

iv. Applicant's plans must include estimates for the construction and maintenance costs for the functional lifetime of the proposed project or action.

v. A project or action commenced after the effective date of this policy should not serve as the sole basis for the justification of a structural shore protection project.

vi. If the proposed project or action is a structural protection project it should be subject to the following additional conditions:

1. The applicant should demonstrate that protection appropriate to, and compatible with, both the character and purpose of the activity or development cannot be achieved through one or a combination of non-structural measures

2. Redundant, non-structural measures should be provided, to the extent feasible, so that in the event of failure of the structural protective measures life and safety are not imperiled and essential services are maintained or quickly restorable

3. The proposed project or action should not result in an unavoidable barrier to migration of an existing tidal wetland habitat, submerged aquatic vegetation, dune or barrier island system and should not cause adverse impacts to adjacent properties or ecological systems. If the project or action does result in an unavoidable barrier, the proponent of the project or action should have the burden to demonstrate that the creation of such barrier or causation of adverse impacts is unavoidable because reasonable alternatives do not exist and that the benefits of the proposed project or action outweigh its adverse impacts.

The proponent should further demonstrate that the proposed project or action should minimize the effect of such barrier or adverse impacts, and should provide for mitigation to offset all unavoidable effects.

4. All maintenance costs will be the responsibility of the applicant, and the mechanism for funding and implementing long term maintenance needs must be specified.

c) An open and transparent review process for proposals for projects or actions should be developed.

i. Such review should be conducted with minimal procedural and administrative delay, and where feasible, be combined or consolidated with other review requirements to avoid unnecessary duplication of review.

ii. For de minimis projects and actions such review process should be streamlined and should take into consideration staffing and other constraints while insuring adequate and timely review.

d). All projects or actions are subject to approval by DEC and DOS.

How/Who: An executive order or legislation should provide direction to DEC, DOS, ESDC, DOT, OGS, OEM, and other agencies as appropriate. DOS should work with other agencies to ensure that policies of this recommendation are consistent with New York State coastal policies.

When: Full implementation within 10-15 years.

6. Develop maps and other tools to assist decision makers in preparing for, and responding to, sea level rise.

What: Ensure that decision makers have access to current and accurate planning data in the following categories:

a) Basic mapping data:

i. *High-resolution elevation data:* Land-elevation data are critical to mapping the projected impacts of sea level rise, related storm surge and flooding. The best available technology should be used to gather these data.

ii. *Coastal erosion hazard areas (CEHA):* Remapping is necessary for effective management of New York State's coastal erosion hazard areas to minimize investment in areas subject to coastal storm damage, erosion and sea level rise impacts. The original maps should be replaced with digital maps using geographic information systems (GIS) and current imagery with accurate coastal erosion hazard areas delineated.

Subsequent periodic review and update of CEHA maps will be needed in order to maintain accurate identification of erosion hazard areas and the use of this information to reduce the loss of property, investment, and lives.

iii. *Tidal and freshwater wetland boundaries:* The state should maintain complete up-to-date maps of tidal and freshwater wetlands. The existing tidal wetlands maps are nearly 40 years old and should be updated to include all existing tidal wetland areas. Guidance and criteria to map areas of tidal wetland migration should be developed. The Tidal Wetland Act should be modified to include consideration of the effects of sea level rise on tidal wetlands over time and tidal wetlands should be re-inventoried to include migration areas.

iv. *Detailed shoreline inventories:* The state should map the location and status of critical habitats, natural (barrier islands, wetlands, etc) as well as human-made shoreline protective features, infrastructure and critical facilities at risk.

v. *FEMA floodplain maps:* Accuracy and electronic access to these maps should be improved for local governments and the public to allow them to identify areas within the *coastal risk management zone* more readily.

vi. Socio-economic and environmental data on relevant non-climate stressors should be made available for incorporation into vulnerability assessments.

b) The state should adopt, support, and promote the use by the public and private sector of a publicly accessible source of decision-support tools and information for planning (maps and data) based on the existing Nature Conservancy model (www.coastalresilience.org), or similar models, including maps of areas of future inundation from sea level rise and high intensity storms, changes in shoreline position, and areas of potential habitat migration including wetlands, dunes, and barrier islands.

How/Who: New York State agencies (e.g., DOS, DEC, Office of Cyber Security (OSC), DOT, OEM) with an interest in and/or responsibility for data collection and dissemination should form a working group to identify and implement funding strategies at the state and federal agency levels to ensure that information collection and dissemination are coordinated with federal agencies, New York City and other local governments, and that information is updated on a regular basis.

When: A working group should determine funding strategies within one year. Priority for high-resolution elevation data acquisition should be given to unmapped counties of greatest vulnerability. Full implementation within 10-15 years.

7. Amend NYS laws, change and adopt regulations and agency guidance documents to address sea level rise and prevent further loss of natural systems that reduce risk of coastal flooding in the coastal risk management zone.

What:

SEQRA—State Environmental Quality Review Act (SEQRA, ECL Article 8) and corresponding regulations (6 NYCRR Part 617)

Proposed statutory/regulatory changes:

a) Add a definition of the phrase *coastal risk management zone* to 6 NYCRR 617.2;

b) Strengthen the environmental impact review process for certain actions if they are undertaken in a *coastal risk management zone*. Specifically,
   i. add a new sub-paragraph 12 in section 6 NYCRR 617.4(b) to read as follows: "any Unlisted Action occurring wholly or partially within the *coastal risk management zone*"
   ii. Or in the alternative, amend the criteria for determining significance in 6 NYCRR § 617.7(c) to incorporate potential significant adverse impacts related to sea level rise into the determination process.

c) Add a section to the short and long environmental assessment forms, requiring an evaluation of impacts from or to the proposed project based on the risk of sea level rise and coastal hazards (i.e., rising groundwater, coastal flooding, saltwater intrusion or other impacts) and other related effects of sea level rise.

d) Develop guidance for environmental review to require that decisions in the *coastal risk management zone* consider potential coastal flooding and other effects of climate change for the expected "lifetime" of the project, structure, or facility.

New York State Uniform Fire Prevention and Building Code Act *(New York State Executive Law Article 18)*

Proposed statutory/regulatory changes:

a) Evaluate and revise existing building standards to address sea level rise and wind- and water-related impacts associated with coastal storms and coastal flooding. These revisions should become mandatory within the *coastal risk management zone* over time, using an incremental implementation approach.

b) Restrict the use of systems, materials or practices within the *coastal risk management zone* that may pose a significant risk of water pollution when flooded if alternatives exist to these systems, materials or practices.

Proposed changes in guidance or programming:

Provide guidance for local application of revised standards in areas designated for elevation, relocation, protection or accommodation.

Real Property Law
(Article 14, sections (460 - 467)

Proposed statutory/regulatory changes:

a) Add a new article 15 to the Real Property Law that provides for notification and informed purchasing decisions of owners, buyers and tenants in the *coastal risk management zone*. Specifically,

i. require that the maps created by the state to identify the *coastal risk management zone* be filed in the office of each of the county clerks of the State of New York, or at the New York City Department of Finance in the case of New York, Kings, Queens, Richmond and Bronx counties and with other municipal agencies responsible for the maintenance of property records or tax maps, and that the maps are made accessible to the public both online and in the same manner as other property records and tax maps;

ii. require that until these new maps are prepared and publicized, the most recent FEMA flood-insurance rate maps be filed in the offices and agencies listed in the preceding paragraph and made accessible in the same manner, along with a description of how the FEMA maps will serve to identify the *coastal risk management zone* until maps depicting projected vulnerability from sea level rise can be developed;

iii. require that all real estate brokers and lending institutions involved in real property transactions affecting property wholly or partially situated within the *coastal risk management zone* include language in any contract with an owner, buyer, or tenant that identifies the subject property as being located in the *coastal risk management zone*. Prior to the preparation and filing of the state's maps depicting the *coastal risk management zone* these requirements should apply to any property identified as wholly or partially situated within a “coastal high hazard area” (V, V 1-30, or VE zone) and those areas identified by the FEMA as "Areas of Moderate Wave Action."

b) Amend the NYS Property Disclosure Statement in section 462 (2) of the Real Property Law by including the following language:

"10. Is any or all of the property located in a FEMA designated coastal high hazard area, area of moderate wave action, or floodplain? YES NO UNKN NA (IF YES, EXPLAIN BELOW)"

Coastal Erosion Hazard Areas Act (CEHA)

(Environmental Conservation Law Article 34) and corresponding regulations (6 NYCRR Part 505)

Note: There currently are no specific penalties provided for violations of ECL Article 34, which defines and regulates those areas of the state's coastline most prone to erosion hazards. DEC therefore relies on the general civil penalty provisions of ECL §71-4003, which allows a maximum fine of only $500, plus $500 per day of continuing violation; this penalty has not been a sufficient deterrent to continuing violations.

Proposed statutory/regulatory changes:

a) Amend ECL Article 71 by adding a new Title 34 that provides for appropriate penalties on the order of $10,000 to $25,000 per violation of ECL Article 34 as well as injunctive relief to allow DEC to compel removal of unauthorized structures and/or restoration of unauthorized excavation within coastal erosion hazard areas.

b) Incorporation of areas within coastal barrier breaches and washovers and their associated sandy shoals into the regulated natural protective features as provided in Article 34 of the state's Environmental Conservation Law, where excavation and permanent development are prohibited.

c) Strengthen the act to increase effectiveness of delegated local implementation of CEHA through consideration of the following:

   i. New York State indemnification of properly-administered local CEHA programs against takings claims (e.g. Pine Barrens §57-0123.6 and the Hudson Valley Greenway Compact §44-0119.7) to reduce the influence of potential litigation costs, including potential takings claims, on local program decision making

   ii. DEC authority to reverse or veto local actions or decisions that are inconsistent with the purposes and policies of Article 34

   iii. Review and, as necessary, revision of the definition of "coastal erosion hazard area" or "erosion hazard area" in ECL §34-0103 and the corresponding provisions in ECL Article 34 to properly account for sea level rise

Waterfront Revitalization of Coastal Areas and Inland Waterways
(New York State Executive Law Article 42)

Proposed statutory/regulatory changes:

a) Following adoption of new legislation addressing sea level rise policy, DOS should add "adaptation to sea level rise" as an additional policy consideration in Executive Law Article 42 §912.

b) DOS should review and amend as appropriate state and regional Coastal Management Program policies, using the new sea level rise legislation to enforce the policy change, to ensure that discretionary actions that would create new development and and/or expand existing development are consistent with the new state standards and guidelines developed for the *coastal risk management zone* as proposed in recommendations 2, 3, 4, and 5. Regulations for state agency consistency should be reviewed and modified to ensure state agency adherence to coastal policies.

Proposed changes in guidance or programming:

a) DOS should ensure that policies developed at the regional and local levels to protect natural resources and development at risk from sea level rise are consistent with the purpose and intent of state Coastal Management Program policies.

b) DOS should provide guidance and criteria for municipal development of *coastal resilience plans,* in partnership with DEC.

c) The Significant Coastal Fish and Wildlife Habitat Program should consider sea level rise in updates to impact assessments and narratives.

Local planning and zoning laws
(Village Law §7-722(2) (a); Town Law §272-a (2) (a); General City Law §28-a (3) (a))

Proposed statutory/regulatory changes:

a) These laws should be amended to require consideration of sea level rise impacts in comprehensive plans for coastal communities that are wholly or in part included in the coastal risk management zone.

b) Communities should be encouraged to include buffer areas and/or other land use based coastal protection strategies in their zoning of waterfront areas in comprehensive plans and/or local waterfront revitalization plans to reduce risk to natural resources and ensure that all planning related to new construction and/or infrastructure is consistent with the new state standards and

guidelines developed for the coastal risk management zone as proposed in recommendations 2, 3, 4, and 5.

c) Following the development of appropriate guidance and funding mechanisms for local implementation, encourage communities wholly or in part located in the *coastal risk management zone* to meet designated criteria for implementation of *coastal resilience plans,* including post-storm recovery and redevelopment planning that recognizes the long-term risks of high-intensity storm events, as part of revisions or modifications to their comprehensive plans and/or local waterfront revitalization plans (see revisions to Article 42 above).

Solid and Hazardous Waste Law
(ECL Article 27)

Proposed statutory/regulatory changes:

a) DEC regulations should be amended to consider the impacts of coastal hazards over the lifetime of the project in the siting and design of solid waste facilities that are located within, or rely upon infrastructure located within, the *coastal risk management zone*.

b) Include considerations of sea level rise and its impact on groundwater levels and erosion in determinations of threat significance under the NYS Inactive Hazardous Waste Disposal Site Program, determinations of eligibility under the brownfield programs, and remedial decisions under these and the state's other cleanup programs (e.g., oil spills and cleanup measures undertaken as part of the implementation of the Environmental Quality Bond Act).

Proposed changes in guidance or programming:

a) Revise technical manuals, training and guidance documents to reflect changes in regulations.

b) Assess performance of hazard mitigation projects and identify opportunities to remediate design shortcomings due to past lack of consideration of the effects of sea level rise on long-term resuspension of contaminants.

Tidal Wetlands Act

(ECL Article 25 and corresponding regulations 6 NYCRR Part 661)

Proposed statutory/regulatory changes:

a) Amend ECL §25-0102 by adding the italicized phrase: *"It is declared to be the public policy of the state to preserve and protect tidal wetlands and to prevent their despoliation and destruction, giving due consideration to the occurrence of sea level rise that will result in wetlands loss and migration, and to the reasonable economic and social development of the state."*

b) Amend ECL §25-0103 by adding definitions of sea level rise and *coastal risk management zone* and include adopted projections of sea level rise.

c) Develop criteria to inventory and map tidal wetland migration areas resulting from sea level rise and incorporate such criteria into the mapping protocols for tidal wetlands. Update this inventory every 10 years.

d) Revise the Tidal Wetlands Act to define and include tidal wetland migration areas.

e) DEC should amend the implementing regulations at Part 661 to correspond to the principles articulated above.

f) DEC should revise and narrow the criteria for variances in section 661.11 similar to the criteria set forth in 505.13.

Proposed changes in guidance or programming:

a) DEC should establish guidance for permitting to ensure that decisions on tidal wetland permits take into account the expected "lifetime" of the project, structure or facility.

b) DEC should provide guidance and complete state consistency review using coastal policies or, if necessary, make regulatory changes to ensure that the approval of stabilization structures (e.g., bulkheads, seawalls) will not eventually result in the elimination of foreshore areas and the public trust embedded in those areas due to restriction of landward movement of high-water lines.

Freshwater Wetlands Act
(ECL Article 24 and corresponding regulations 6 NYCRR Part 663)

Proposed statutory/regulatory changes:

> DEC should revise Part 664 by designating those smaller wetlands that are in close proximity to the tidally influenced coastline of the state as having "unusual local importance."

Shore Protection Authorization Laws
(Unconsolidated Laws Chapter 7 - Projects to Prevent Shore Erosion (§§1531 et seq.))

Proposed statutory/regulatory changes:

After the development of appropriate guidance and funding mechanisms, implement the following:

> Require that any municipality that enters into a cost-share shore protection contract with New York State under this law meet the criteria for implementation of a coastal resilience plan in conformance with the criteria developed by DEC and DOS (see discussion of Executive Law Article 42, above).

Long Island South Shore Estuary Reserve Act
(Article 46)

Proposed statutory/regulatory change:

> Amend the act to require the South Shore Estuary Reserve Council to consider regional implementation of sea level rise adaptation following the guidance developed by DOS and DEC (see discussion of Executive Law Article 42, above), and to develop regional policies, consistent with the state Coastal Management Program policies and the intentions of this Task Force, to guide adaptation by communities along the Long Island south shore.

How/Who: An executive order should direct agencies to amend or develop regulation and guidance as appropriate. The New York State Legislature should amend or enact new laws where necessary.

When: Full implementation of all regulatory recommendations within 10-15 years.

8. Provide financial support, guidance and tools for community-based vulnerability assessments and ensure a high level of community representation and participation in official vulnerability assessments and post-storm recovery and redevelopment and adaptation planning processes.

What: Support the development of community-based efforts and strengthen and expand existing state and local programs to develop vulnerability assessments, *coastal resilience plans* and adaptation plans based on current and projected risks from coastal hazards such as sea level rise and storm surge and ensure that community members are actively included in all planning processes. The state should create financial and technical support programs for community-based organizations so that they can work in partnership with state and municipal entities to develop and implement planning processes. Programs should include the following:

a) Guidance on the incorporation of the most current scientific information and data on increasing risks associated with coastal hazards such as sea level rise, and relevant stressors such as demographic changes, economic downturns and poverty

b) Guidance on the process for developing vulnerability assessments, implementing *coastal resilience plans,* and incorporating them into broader climate change adaptation planning processes

c) Guidance to help communities identify and assess risks to local community assets including centers of economic activity, high-profile community amenities and landmarks, and other potential effects that could undermine community cohesion, identity or character

d) Mechanisms such as grant programs, technical assistance programs, legal training, and capacity building to encourage and support vulnerability assessments, implementing *coastal resilience plans* and post-planning implementation activities available to both government planners and community representatives

e) Guidance for local decision makers and community members on how to assess vulnerabilities and risks associated with the public health impacts of sea level rise and storm surge

f) Development and dissemination of guidance and training on climate adaptation, use of adaptation decision- support tools and model laws through the state's Climate Smart Communities and Local Waterfront Revitalization programs, including the benefits of intermunicipal and/or regional partnerships to achieve adaptation goals

g) Development and dissemination of guidance on structural and non-structural shoreline management techniques, shoreline erosion-control methods, and green infrastructure as tools to manage flood and erosion hazards and to maximize ecosystem benefit

How/Who: DEC, DOS and other relevant state agencies should partner with the private and philanthropic sector, community leaders, and community-based organizations.

When: Full implementation within 2-5 years.

9. Undertake a comprehensive assessment of the public health risks associated with sea level rise, coastal hazards and climate change including compromised indoor air quality, effects on drinking water, post-traumatic stress and other mental health problems, increases in disease vectors, impaired access to health care, and loss of reliable access to food and medical supplies.

What: Require the public health sector to lead an assessment of and preparation for significant short-, medium- and long-term public health risks from hazards associated with sea level rise in New York State. The information in the assessment should be used to inform the implementation of all the recommendations of the Task Force, in particular, in the creation of maps and guidance to support development of *coastal resilience plans* (recommendation 5, 6, 8) and to inform state agency incorporation of the current and anticipated impacts of sea level rise into all relevant aspects of decision making.

How/Who: The Department of Health should be tasked to coordinate with other state agencies and stakeholders to complete this critical assessment. DOH should coordinate with appropriate agencies and stakeholders.

When: Full implementation within 2-5 years.

10. Raise public awareness of the adverse impacts of sea level rise and climate change and the potential strategies to adapt.

What: Relevant New York State agencies should develop a coordinated message and programming in a variety of venues for a wide range of audiences to build an aware, informed and engaged public and ensure that state and local decision makers and community leaders are aware of the vulnerabilities associated with sea level rise in coastal areas. Support sustained efforts by local leaders such as community-based organizations, elected officials and educational institutions to engage with the public through a variety of methods and ensure effective community-focused efforts.
Potential specific actions:

a) Provide sustained support and model tools for outreach efforts that incorporate opinion leaders from all sectors of the community, are tailored for specific audiences and include a particular focus on vulnerable populations

b) Develop guidelines and protocols for making use of community-based and non-English media and other communication mechanisms

c) Channel resources to community-based organizations to enable them to engage in sustained awareness-raising and community education activities around climate adaptation issues

d) Support the establishment of community-based mechanisms to facilitate the flow of information from individuals and neighborhoods experiencing impacts to planners and responders, as well as from the science and response community to local decision makers

How/Who: DEC and DOS should lead this effort, partnering with New York Sea Grant, OEM, local governments, universities, NGOs and community-based organizations.

When: Full implementation within 2-5 years.

11. Develop mechanisms to fund adaptation to sea level rise and climate change.

What: Conduct an assessment of viable funding mechanisms for the development of tools and research to support the development and implementation of *coastal resilience plans*, coastal area mapping, restoration of natural protective features and critical habitats, green infrastructure and the acquisition of lands in vulnerable areas. Significant financial resources are needed to meet the planning and adaptation needs at the state and local levels.

How/Who: Develop an agency working group to recommend and prioritize specific funding actions for the Governor and Legislature. Potential approaches include the following**:**

a) Use revenues generated by real property and real estate transfer taxes for new construction with a sales price of $1 million or more in the coastal risk management zone. A similar strategy has been implemented in New Jersey.

b) Utilize FEMA post-disaster mitigation funds to carry out adaptation measures identified in approved Coastal Resilience Plans.

c) Create a new “coastal users’ tax” for hotels, motels, guest lodging and vacation rental properties in the coastal risk management zone. A similar strategy has been implemented in Florida.

d) Use publicly owned properties acquired through real estate tax delinquency as relocation sites for exchange with willing flood vulnerable owners. A similar strategy has been employed successfully in the Town of Brookhaven.

e) Earmark penalties from enforcement of the Shoreowner's Protection Act.

f) Pass an environmental bond act.

g) Increase or add permit fees for new construction in the *coastal risk management zone*.

h) Consider modifications to the evaluation criteria of the State Open Space Plan, Comprehensive Outdoor Recreation Program and the Coastal and Estuarine Land Conservation Program to include acquisition of coastal natural protective features.

i) Apply savings from the phase-out of state funding for unsustainable shore protection measures to implementation of nonstructural disaster-resilient methods.

j) Prioritize resilient adaptation strategies in state, county, and local hazard mitigation plans when allocating state post-disaster mitigation funds.

k) Explore and promote tax incentives for donations of conservation easements on vulnerable properties, to encourage private preservation at low or no cost to public acquisition programs, such as state income tax credits, uniform bargain sale policies for public acquisition programs and guidelines for local tax assessors on property tax abatement for eased properties.

l) Leverage state resources through partnerships with land trusts, philanthropic and federal granting communities.

m) Allocate monies from state enforcement actions such as Environmental Benefit Projects and Programs.

When: Implementation within two years.

12. Fund research, monitoring, and demonstration projects to improve understanding of key vulnerabilities to critical coastal ecosystems, infrastructure, and communities from sea level rise.

What: State agencies should coordinate funding priorities for future research initiatives including the following:

a) Improve information, definition and explanation of the areas at greatest risk of flooding due to sea level rise and the impacts of high-intensity storms

   i. Track trends in water levels and land subsidence that contribute to relative sea level rise through a long-term monitoring network of tidal gages in the tidal Hudson River Estuary, Long Island Sound, and along the Atlantic coast

   ii. Improve understanding of the effects of climate change on high-intensity storm events.

   iii. Complete fine-scale modeling in coastal New York State, including the Hudson River Estuary, to determine which shoreline areas are at greatest risk from sea level rise and storm surge and how the salt front, a critical factor for drinking water supplies and aquatic life in the Hudson River, will be affected by sea level rise

   iv. Help communities monitor the location and scale of chronic effects of moderate to low-intensity coastal-inundation events

b) Track tidal wetland trends at a landscape scale and understand the key factors contributing to their loss

   i. Expand existing monitoring of trends in tidal wetland health to all tidal wetlands in the marine district and the Hudson River (to the Federal Dam at Troy) and add other critical habitats affected by sea level rise including pocket marshes, islands, fringe marshes and marshes with varying tidal periods

   ii. Unify tidal wetland monitoring and assessment programs in the marine district and the tidal Hudson River (to the Federal Dam at Troy)

   iii. Model the likely migration pathways of tidal wetlands and other coastal habitats in response to sea level rise. Develop methodology and criteria to map areas that may be sites of tidal wetland migration in response to sea level rise

   iv. Clarify the role of sea level rise in ongoing tidal wetlands loss and assess the relative effects of other factors contributing to marsh loss such as eutrophication and conversion of tidal habitats (i.e., high marsh to low marsh; vegetated to unvegetated)

   v. Determine how productivity of marshes changes with sea level rise

c) Improve understanding of natural processes affecting land forms in coastal areas, including how sea level rise affects shoreline change

   i. Develop coastal and estuarine sediment budgets, quantifying sources, sinks and pathways of sediment transport and effects of fine sediment on wetlands and coarser sediment on beaches, bluffs, barrier islands and other coastal habitats

   ii. Assess ecosystem services in natural and engineered shorelines and identify best practices for enhancing ecosystem services in engineered shorelines

   iii. Evaluate reinstituting or expanding the Atlantic Coast of New York beach monitoring program with a focus on providing useful information for incorporation into local government and infrastructure planning for coastal resilience

   iv. Collect reliable high-resolution shoreline-change data for estuarine shorelines and initiate continuing monitoring program to assess present and future conditions

   v. Assess and quantify the physical and geological factors controlling movement of shorelines, including barrier islands and estuarine shoreline, and develop projections of future shoreline migration and change

   vi. Develop guidelines and design criteria for the use of innovative erosion control measures that incorporate natural and structural elements and focus on community resilience and natural resource conservation

   vii. Develop accurate high-resolution data to quantify the interaction among bluff erosion, beach width, and sediment supply and shore protection structures

   viii. Examine legal issues surrounding ownership of emergent lands following strong storms

d) Improve understanding of how hazards associated with sea level rise affect water quality and aquatic habitats

   i. Track basic water quality parameters, such as temperature, salinity, pH and dissolved oxygen, to gain better understanding of habitat health factors

   ii. Identify sentinel species for sea level rise impacts and their likely migration pathways if their existing habitats are diminished (e.g., horseshoe crabs)

   iii. Determine factors that will facilitate the migration of submerged aquatic vegetation inland and identify areas for future migrations

   iv. Assess the impact of changes in quantity and quality of groundwater on submerged aquatic vegetation health

v. Map depth to groundwater in coastal areas to understand where high water tables are located

e) Monitor coastline conditions, ocean temperatures, wetland area, real-property losses due to flooding and erosion, and climate-related public health impacts to track trends related to climate change and hazards associated with sea level rise

f) Policies that limit the beneficial use of dredged materials for habitat restoration should be reassessed to ensure they do not unnecessarily hinder wetland restoration along the coastline

How/Who: DEC and DOS should coordinate with relevant agencies and scientific bodies to develop and implement research priorities in concert with federal, state and private research agencies and organizations.

When: Full implementation within 10-20 years.

13. Ensure continued and coordinated adaptation to sea level rise.

What: Create a permanent mechanism to ensure the following:

a) Interagency coordination

b) Review of projections of sea level rise and anticipated impacts on a regular basis following the IPCC schedule (roughly every 5 years)

c) Development of priorities for federal, state, and local research, and policy and regulatory initiatives to respond to sea level rise

d) Management of progress in policy implementation, including the recommendations of the Sea Level Rise Task Force

Individual state agencies or interagency teams should be responsible for developing priorities based on their respective expertise, and these agencies should work to implement agreed upon priorities and incorporate findings related to sea level rise into all state planning processes. The DEC Office of Climate Change and the DOS Coastal Program should coordinate the mechanism and include adequate involvement from non-governmental stakeholders.

How/Who: An executive order should direct the DEC Office of Climate Change, in coordination with DOS, to coordinate development of this effort with appropriate state agencies (see Recommendation #2).

When: Full implementation within 2 years.

14. Seek federal funding and technical assistance and changes to federal programs to make them consistent with or accommodating of state policies, programs and adaptation measures.

What: Identify opportunities to leverage federal programs and resources to reduce coastal vulnerability. Review federal programs for compatibility with the recommendations of the Sea Level Rise Task Force and seek modifications or assistance at the federal level to improve coordination of adaptation strategies at all levels of government. The following actions would provide opportunities for improvement:

a) Encourage federal agencies to adopt regional sea level rise projections and to include sea level rise in all relevant decision making

b) Examine how current federal policies (e.g., FEMA planning, mitigation and disaster recovery funding; Army Corps of Engineers (ACOE) storm-damage-reduction projects), rules and regulations can be modified to reduce the number of new structures and encourage relocation of existing structures in high-risk coastal floodplains

c) Evaluate whether changes to the current federal and state cost-share formula for the coastal storm damage risk reduction program (i.e., Shore Protection Program) could be used as a practical and effective disincentive to discourage new development and re-development in the coastal risk management zone

d) Evaluate whether current methodologies used in completing benefit/cost analyses for coastal protection projects account for sea level rise and do not unfairly favor structural alternatives over non-structural alternatives

e) Evaluate whether current rules, regulations and funding policies disadvantage communities that have taken positive steps to limit new development and re-development within high-risk coastal floodplains in applying for federal grants or other monies

f) Examine the practicality of revising the current policies to support actions that allow a transition to non-structural measures i.e., acquisition, relocation, elevation, and the strategic reconfiguration of infrastructure networks

g) Develop tools and mechanisms to more thoroughly and fairly evaluate benefit/cost effects to natural resource communities

h) Seek modifications to the National Flood Insurance Program so that rates better reflect actual risk exposure, including sea level rise, such as the following:

   i. Delineate a coastal zone that recognizes risks from storm surge and erosion due to sea level rise

ii. Ensure that flood insurance rates reflect full risk exposure and include risks of sea level rise, particularly in repetitive-loss areas

iii. Create federal incentives for the relocation of existing development out of floodplains and disincentives for siting new structures in floodplains

iv. Consider adoption of the "No Adverse Impact" standards developed by the Association of State Floodplain Managers

v. Strengthen incentives in FEMA's Community Rating System for the implementation of resilient land use management strategies

vi. Create a program to track gain and loss of structures in high-risk areas

vii. Evaluate a flood insurance surcharge that can be used to fund adaptation planning and implementation

i) Coordinate state agency communication on climate change, sea level rise and adaptation measures with federal agencies to deliver consistent messages, and formulate outreach programs to deliver the messages to the public.

j) Facilitate communication among federal and state science programs and state and local users of data collection and analysis products to ensure understanding of user needs and interests; and support adaptation through outreach and workshops

How/Who: The DOS and DEC should convene a working group of agencies to investigate and recommend changes in federal laws, regulations and practices.

When: Working group convened within 1 year. Recommendations finalized in 2-5 years.

Appendix A: Members of the Task Force and Workgroups

Members, Sea Level Rise Task Force

Ex-Officio Members

- Alexander "Pete" Grannis, Commissioner, NYS Department of Environmental Conservation, Chair
- Secretary of State Ruth Noemí Colón represented by Fred Anders, Chief, Natural Resources Management
- Director of the former State Emergency Management Office (now State Office of Emergency Management) John Gibb
- Superintendent of the Department of Insurance James Wrynn, represented by Ivan Lafayette, Deputy Insurance Superintendent for Community Affairs
- Commissioner of the Department of Health Richard F. Daines, M.D., represented by Richard Svenson, Director of the Division of Environmental Health Protection
- Acting Commissioner of the Department of Transportation Stanley Gee, represented by Lisa Weiss, Route 9A Urban Design Director

Appointed Members

- Adam Freed, Deputy Director of the New York City Office of Long-Term Planning and Sustainability, appointed by the mayor of New York City
- Carrie Meek Gallagher, Suffolk County Commissioner of Environment and Energy, appointed by the Suffolk County Executive
- Michael Gerrard, Andrew Sabin Professor of Professional Practice and Director, Center for Climate Change Law at Columbia Law School, appointed by the Speaker of the Assembly
- Dr. Gerceida Jones, Professor of Astronomy, New York University, appointed by the Temporary President of the Senate
- Dr. Jack Mattice, Director, New York Sea Grant (retired), appointed by the Temporary President of the Senate
- Jerry Mulligan, Westchester County Commissioner of the Department of Planning, appointed by the Westchester County Executive
- Sarah Newkirk, Coastal Program Director of The Nature Conservancy, appointed by the Speaker of the Assembly
- Brad Tito, Deputy Director of Environmental Coordination, Office of the Nassau County Executive, appointed by the Nassau County Executive
- James Staudenraus, Vice President of Operations, George Henry Ltd., appointed by the Assembly Minority Leader
- John Walters, III, Chief of Department, Port Washington Fire Department, appointed by the Senate Minority Leader

Sea Level Rise Task Force Members

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Fred Anders, Chief, Natural Resources Management, Department of State (representing Ruth Noemí Colón, Acting Secretary of State)

John Gibb, Director, State Office of Emergency Management

Fred Nuffer, Public Assistance Liaison, Mitigation Programs, State Office of Emergency Management (representing John Gibb. Director, State Office of Emergency Management)

Ivan Lafayette, Deputy Insurance Superintendent for Community Affairs, Department of Insurance (representing James Wrynn, Superintendent, Department of Insurance)

Richard Svenson, Director of the Division of Environmental Health Protection, Department of Health (representing Richard F. Daines, M.D., Commissioner, Department of Health)

Lisa Weiss, Route 9A Urban Design Director (representing Stanley Gee, Acting Commissioner, Department of Transportation)

Adam Freed, Deputy Director, New York City Mayor's Office of Long-Term Planning and Sustainability

Carrie Meek Gallagher, Commissioner of Environment and Energy, Suffolk County

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Appendix B: Public Outreach Summary

The Public Outreach Work Group adopted and implemented an outreach plan with the goal of supporting the SLRTF's decision-making process. The plan included six objectives:

Objective 1. Incorporate stakeholders into impact-sector deliberations.

Objective 2. Provide public access to information on the SLRTF's activities and informational documents.

Objective 3. Provide opportunities for public participation in SLRTF meetings.

Objective 4. Provide opportunities for public input on specific issues.

Objective 5. Provide opportunities for public review of draft recommendations.

Objective 6. Provide opportunities for public review of draft final report.

Objective 1 - Incorporate stakeholders into impact-sector deliberations.

Agencies participating in the SLRTF assigned appropriate staff to the legal and sector impact work groups. These staff, in turn, actively recruited experts and stakeholders from academia, businesses, other agencies and non-governmental organizations. Inclusion of a broad spectrum of individuals, including community representatives, in the work groups provided opportunities for early input by interested parties.

Objective 2 - Provide public access to information on the SLRTF's activities and informational documents.

To facilitate public participation in the development of recommendations, staff of DEC's Office of Climate Change created and maintained an SLRTF website at www.dec.ny.gov/energy/45202.html. This website included instructions for enrolling in the SLRTF listserve and provided an e-mail address (slrtf@gw.dec.state.ny.us) to which unsolicited comments and questions could be directed. The Public Outreach Work Group assembled a list of potentially interested organizations and distributed direct notice of the opportunity to enroll in the e-mail listserve and watch the website for information on the SLRTF's activities and opportunities to participate. Announcements of all public and Task Force meetings were distributed to the listserve, and announcements and summaries of all public and Task Force meetings were posted on the website.

Objective 3 - Provide opportunities for public participation in SLRTF meetings.

The SLRTF held six meetings at the Public Service Commission offices at 90 Church Street, New York City, and held one videoconference among members. All SLRTF meetings were open for observation by the public, and opportunities for observer comment were provided at each meeting.

Objective 4 - Provide opportunities for public input on specific issues.

The SLRTF and its work groups invited several leading researchers to provide input on climate science and projections of sea level rise, held a focus group for municipal officials from communities along the Hudson estuary to discuss findings and policy recommendations, and met with policy leaders from a variety of disciplines to discuss potential state responses to sea level rise.

Objective 5 - Provide opportunities for public to comment on approach and suggest issues to be addressed in SLRTF recommendations.

The Task Force held a series of five public meetings in late January 2009 to describe the approach it was using to generate its recommendations, to hear public comment on that approach and to allow the public to suggest issues to be addressed by the recommendations. Meetings were held in New York City, Poughkeepsie, Nassau County and Suffolk County. Public notice of the meetings included a DEC news release, which generated several newspaper articles describing the Task Force and its objectives and announcing the meetings. Approximately 150 individuals attended the five meetings.

Objective 6 - Provide opportunities for public review of draft final report.

The Steering Committee produced a draft final report incorporating recommendations for future action as recommended by the work groups and approved by the SLRTF. The draft final report was released for public review and comment in fall 2010. Release of the draft report was accomplished through the website, listserve and news release and included notice of opportunities to comment. Written public comment was accepted during a 30-day public comment period following release of the draft report. The Task Force conducted a public information and comment videoconference and webinar during the public comment period. Videoconference locations included DEC offices in Albany, Westchester, New York City and Suffolk County. The webinar was also accessible via Internet connection.

Appendix C: Organizational Framework

Chapter 613 of the Laws of New York, 2007 established the New York State Sea Level Rise Task Force (SLRTF) and charged it with the creation of a report to the Legislature. The statute identified six *ex-officio* Task Force members and ten members to be appointed by various elected officials. The statute directed that the Task Force would be chaired by the commissioner of Department of Environmental Conservation.

Chapter 613 initially required the SLRTF to deliver its final report to the governor, the temporary president of the senate and the speaker of the assembly by December 31, 2009. The statute was subsequently amended to extend the due date to January 1, 2011. The report must include an assessment of the anticipated impacts of sea level rise; recommendations to provide more protective standards for coastal development, wetlands protection, shoreline armoring and post-storm recovery; recommendations of measures to protect and connect habitats to facilitate range shifts, protect and restore critical habitats and ecosystem services, identify and monitor climate change effects on natural biota, and integrate climate change adaptation strategies into state environmental plans; and recommendations on regulatory and/or statutory changes to respond to sea level rise.

The geographic scope of the SLRTF's recommendations included the coastlines of the counties of Suffolk, Nassau and Westchester, New York City, and the shoreline of the main stem of the Hudson River to the Federal Dam at Troy.

Commissioner of Environmental Conservation Alexander Grannis appointed Special Counsel Robin Schlaff to organize and chair a steering committee and Special Projects Coordinator Kristin Marcell as executive assistant and vice chair of the steering committee. Both Ms. Schlaff and Ms. Marcell worked with staff of the Office of Climate Change to identify representatives of several state and local agencies to serve on a steering committee. Individuals from academia and non-governmental organizations were added to the steering committee as the process developed. Members of the steering committee were responsible for the work products that ultimately resulted in the SLRTF report. Ms. Schlaff served as the liaison of the Steering Committee to the SLRTF and was responsible for bringing matters that required action to the SLRTF.

The SLRTF steering committee organized five work groups necessary to complete its charge:

- Ecosystems and Natural Habitats
- Infrastructure
- Community Resilience
- Legal
- Public Outreach

Ms. Schlaff appointed chairs or co-chairs of each work group. Chairs recruited individuals with appropriate expertise to serve as work group members and incorporated specific stakeholders as integral members of the work groups. Group chairs coordinated the efforts of work group members and ensured that required products were delivered in a timely fashion.

Work group chairs communicated regularly to share information and relevant research and to inform each other of potential overlapping issues.

Each sector work group produced a sector report for incorporation into the larger SLRTF report. Sector reports summarized existing information on likely sea level rise effects to the sector, described the current regulatory environment as it relates to the sector, identified ongoing programs as they relate to sea level rise impacts to the sector, and provided recommendations for filling gaps in necessary information for impact assessment, regulatory changes and management actions.

The legal work group served as a resource to address legal questions as they arose during the work of the other work groups and developed recommendations for specific statutory and regulatory changes to implement sector work group recommendations.

The public outreach work group developed and implemented a stakeholder involvement plan to support the SLRTF's decision-making process.

It was recognized that the involved agencies and other organizations have numerous ongoing research, monitoring, planning and management efforts that the report and recommendations should consider. To facilitate identification of such programs, staff surveyed other agencies, academic institutions and organizations to develop an understanding of relevant past and ongoing work. The sector work groups drew on this work to identify opportunities for integration of programs and needs for supplemental work. The final report represents a synthesis of relevant past and ongoing research and monitoring activities pertinent to the responsibilities of the SLRTF and a review of applicable current federal, state and local laws and regulations.

Time and resources allocated for generation of the SLRTF report did not allow for development of a comprehensive vulnerability assessment and site-specific, risk-reduction strategies. Emphasis was placed on describing the potential risk of coastal inundation along New York's shorelines and the likely affected sectors, identifying research and monitoring needs, suggesting adaptation strategies, and developing a roadmap for future work.

Appendix D: Summary of State Sea Level Rise (SLR) Policy Development – Mid-Atlantic and Northeast

State	Authority	Climate and/ or SLR Action Plan	SLR Projections; Derivation	Notes
NY	Executive Order, 2007 [Est. Sea Level Rise Task Force]	SLR Task Force report due January, 2011	Yes; regional projections based on IPCC models, as adopted by the New York City Panel on Climate Change (NPCC). For more information: http://www.nyc.gov/html/om/pdf/2009/NPCC_CRI.pdf	Report will include recommendations to specifically address SLR impacts, vulnerabilities and recommendations for adaptation. For more information: http://www.dec.ny.gov/energy/45202.html
MD	Executive Order (2007)[Est. Maryland Commission on Climate Change]	*Maryland Climate Action Plan*, 2008	Yes; regional projections based on IPCC models.	Comprehensive climate plan with SLR subcomponent, "*Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change, Phase 1: Sea-level rise and coastal storms*," that includes an assessment of impacts, vulnerabilities and recommendations for adaptation. For more information: http://www.mde.state.md.us/assets/document/Air/ClimateChange/Chapter5.pdf
VA	Executive Order (2007) [Est. Governor's Commission on Climate Change]	Governor's Commission on Climate Change, Final Report*, A Climate Change Action Plan*, 2008	Yes; largely used Chesapeake Bay Program Scientific and Technical Advisory Committee (STAC) report, "*Climate Change and the Chesapeake Bay: State-of-the- Science Review and Recommendations*."	The Action Plan focuses primarily on energy and emissions reduction with less discussion of SLR. For more information: http://www.chesapeake.org/stac/Pubs/climchangereport.pdf and http://www.deq.state.va.us/export/sites/default/info/documents/climate/CCC_Final_Report-Final_12152008.pdf
NJ	NJ DEP's Coastal Management Office (NJ CMO)	NJCMO policy to work with pilot communities on SLR	While NJ has not officially adopted SLR projections, NJ CMO is using 0.5, 1.0, and 1.5 m increase by 2100 in their current coastal hazards work with pilot communities.	The NJ CMO's SLR projections are consistent with DE's Coastal Program and the rates under consideration by the Mid-Atlantic Regional Council on the Ocean (MARCO). For more information: http://www.state.nj.us/dep/cmp/czm_hazards.html

DE	DE Coastal Management Program (DCMP)	Statewide SLR adaptation plan (in process); Sea Level Rise Initiative	Yes; Regional projections based on IPCC projections. DE will assess vulnerabilities using 0.5, 1.0 and 1.5 m scenarios by 2100.	Adaptation plan will specifically address SLR impacts, vulnerabilities and adaptation strategies; results may be incorporated into a larger climate change plan if one is developed. For more information: http://www.swc.dnrec.delaware.gov/coastal/Pages/SeaLevelRiseAdaptation.aspx
CT	Section 7 of Public Act No. 08-98 (2008)[*An Act Concerning Connecticut Global Warming Solutions*]	Connecticut Climate Change Action Plan, 2005; Governor's Steering Committee on Climate Change Impacts report, *The Impacts of Climate Change on Connecticut Agriculture, Infrastructure, Natural Resources and Public Health*, 2010	Yes; Relies on a combination of the New York Panel on Climate Change (NPCC) and the Northeast Climate Impacts Assessment (NECIA) projections. For more information: http://www.nyc.gov/html/om/pdf/2009/NPCC_CRI.pdf and http://www.northeastclimateimpacts.org/	Additional report on adaptation strategies for vulnerabilities identified in the Impacts report are due December 2010. For more information: http://ctclimatechange.com/index.php/ct-happenings/gsc-adaptation-subcommittee/
RI	R.I. Coastal Resources Mgmt Pgm Section 145 (2009); R.I. General Laws § 23-84 (2010)	State Coastal Policy on SLR; The Climate Risk Reduction Act of 2010 calls for a new Climate Change Commission that will evaluate SLR	Yes; coastal policy based on projections of 3 to 5' of SLR by 2100 based on regional adjustments of IPCC estimates and data on historical shorelines in RI. Long term SLR will be periodically reassessed to incorporate new scientific information.	State policy in effect using adopted projections of SLR and directly affecting planning and management in coastal zones. New Climate Change Commission will address SLR as it studies the impacts of climate change to RI and develops recommendations to respond. For more information: http://www.crmc.ri.gov/climatechange.html
MA	Chapter 298 (2008) [*An Act Establishing the Global Warming Solutions Act*]	State coastal hazards policies; Final Report of the Coastal Hazards Commission, 2007	No state projections of SLR have been developed to date.	The Global Warming Solutions Act of 2008 mandated a climate change adaptation strategies report be developed by the state Secretariat of Energy & Environment and submitted to the governor and legislature. A report by the Coastal Hazards Commission addresses SLR mapping, data needs, planning, and management. The MA Office of Coastal Zone management has a "Storm Smart Coasts" program through which regional coordinators provide technical assistance to municipalities. It includes guidance on SLR. For more information: http://www.mass.gov/czm/stormsmart/index.htm

NH	Executive Order, 2007 [Est. Climate Change Policy Task Force]	*New Hampshire Climate Action Plan*, 2009.	No state projections of SLR have been developed to date; report references IPCC where SLR is mentioned.	Focus on broad actions, not SLR; reference to improved land use; coastal program - special project to examine adaptation planning.
ME	38 M.R.S.A §480, Ch. 355 (2006)	Coastal setback that accounts for 2' of SLR in the next 100 years.	No state projections of SLR have been developed to date.	A project may not be permitted if, within 100 years, it is likely to be severely damaged by erosion to the property after allowing for a 2' rise in sea level over 100 years. Beach nourishment and dune restoration projects are excluded from this requirement. For more information: http://www.maine.gov/dep/blwq/topic/dunes/index.htm