

## Action Plan 18. Planning For a Shifting Shoreline and Coastal Storms

### Problem<sup>103</sup>

For millennia, the Buzzards Bay coastline has been subject to the rise in sea level and storms that have continued to erode and shift materials that change the shape, elevation, and position of the shoreline. These actions shift the locations of barrier beaches and alter wetland areas, resulting in the loss of habitat for certain species, and the migration of other habitats like salt marshes. Structures built in these hazard prone areas can not only impede natural processes, but when destroyed in storms represent hazards to public health and the environment, and result in a financial burden to government. The frequency and intensity of these processes will likely increase in the coming decade due to climate change. Some state and federal programs are creating moral hazards by promoting development in high risk areas.

In 2002, Massachusetts Coastal Zone Management updated its program plan with goals to prevent, eliminate or significantly reduce threats to loss of life, destruction of property and degradation of environmental resources resulting from improper development, allow natural physical coastal processes to continue unabated, limit, public expenditures in coastal high hazard areas, and prioritize public expenditures for acquisition and relocation of structures out of hazardous coastal areas. Unfortunately, current state, federal, and local laws, regulations, and policies are far from achieving these goals.

### Goals

**Goal 18.1. Protect public health and safety from problems associated with coastal hazards including rising sea level, shifting shorelines, and damage from storms and storm surge.**

**Goal 18.2. Reduce the public financial burden caused by the destruction of or damage to coastal property.**

**Goal 18.3. Plan for shifting shorelines and the inland migration of buffering wetlands and shifting sand formations, and the species that utilize these habitats.**

### Objectives

Objective 18.1. To incorporate sea level rise, increased frequency and intensity of coastal flooding, and shore-

line change phenomena into all relevant planning and management programs.

Objective 18.2. To develop a comprehensive strategy for handling existing structures in areas that will be affected by future shoreline changes and other coastal hazards.

Objective 18.3. To adopt regulatory and non-regulatory measures for guiding growth and development in areas that will be influenced by coastal flooding and new shorelines.

Objective 18.4. To restructure the flood and hazard insurance programs in threatened areas to decrease the financial burden on the public.

Objective 18.5. To adopt emergency response plans to reflect additional needs and constraints caused by reduced access and increased flooding potential of developed coastlines.

### Solutions

This action plan requires changes in regulations, policies, and actions by all levels of government. Public spending for infrastructure in high risk areas should be avoided, and government should not create incentives for private construction in high risk zones. The latter problem will require changes in and rethinking of flood insurance programs, and actions the federal government should require in the aftermath of disaster relief aid. Municipalities will need to conduct evaluations of new risks caused by rising sea levels. They should adopt hazard mitigation plans, and participate in the FEMA community rating systems. RPAs and CZM should assist in these efforts. They also need to lead by example by not building new public structures in high risk areas.

### Costs and Financing

Much of the expenses associated with this action plan relate to conducting risk assessments and planning. These efforts might cost hundreds of thousands of dollars per community and require dedication of staff time. Those measures requiring regulatory or policy changes have nominal costs.

### Measuring Success

Because of the rarity of catastrophic storms, and slowness of sea level rise, tracking programmatic actions, like completion of hazard mitigation plans, will be the measures of success.

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<sup>103</sup> This action plan was revised and re-written from the original 1991. The first four objectives were in the 1991 CCMP, but have had some minor changes in text. [Goals 1 and 2 were in the 1991 CCMP, but have had some changes in text, including concepts relating to coastal hazards. Goal 3 was changed from planning for loss to planning for inland migration of wetlands.

## Background

### Development Pressures and Adaptation

With the tremendous increase of development on the coast and storm damage prone areas in recent decades, human activities to control natural coastal processes have included the filling of tidelands, and the "hardening" of shorelines through the construction of groins, revetments, bulkheads and other structures. Through direct and indirect effects, there have been wetland losses and impairments, such as restrictions to tidal flow. Hardened shorelines also prevent natural shoreline processes, like coastal sand transport, which in turn may exacerbate coastal erosion rates. These structures also prevent the natural inland migration of salt marshes.

The increasing propensity of private construction in vulnerable coastal areas, particularly residential development, followed by improved public infrastructure of roads, utilities, and bridges, has caused concerns about the economic and ecological costs of this development. The economic losses due to storm-related damage to the coastal zone has increased, not because of increased storm frequency or intensity, but because of increased development along the coast.<sup>104</sup> In dense urban centers along the coast, the economic value of that public and private property and infrastructure is so great that public and private action will result in the continued protection and elevation of existing filled tidelands as has occurred for past several centuries<sup>105</sup>. In less densely developed coastal areas, particularly residential areas, there is a debate about whether the public (taxpayer) should bear the costs of protecting and rebuilding private property in these vulnerable areas, and whether government should limit new development in these areas.

The focus of this management plan is to implement strategies to reduce the severity of impacts of future storms and sea level rise on the coast and on existing and future coastal development. This approach is called adaptation. Mitigation measures are required to address global climate changes, but these measures are best addressed at the national and international levels of governments, not in this action plan.

### Geologic Cycles and Greenhouse Gases

Shorelines have shifted significantly over geologic time. In the 15,000 years since the Laurentian ice sheet began retreating across North America, shorelines eve-

<sup>104</sup> Pielke et al., 2008. Normalized Hurricane Damage in the United States: 1900-2005. [http://sciencepolicy.colorado.edu/admin/publication\\_files/resource-2476-2008.02.pdf](http://sciencepolicy.colorado.edu/admin/publication_files/resource-2476-2008.02.pdf)

<sup>105</sup> Despite a 2.5 ft rise in sea level, between 1700 and 1950, the cities of Boston and New York increased appreciably both in size and elevation as millions of cubic yards of fill were placed on uplands, tidelands, and wetlands.

### **Global Climate Change and Sea Level Rise**

During the past 750,000 years the earth has repeatedly cycled between ice ages lasting 70,000 to 100,000 years, and brief warm periods lasting between 10,000 to 30,000 years. We are currently living in one of these warm interglacial periods. Since the peak of the last ice age 18,000 years ago, when Buzzards Bay was covered with a mile thick sheet of ice, sea level has risen roughly 400 feet. During the last interglacial period, the earth's climate was warmer than today, all of Greenland's ice sheet melted, and sea level was roughly 15-20 feet higher than today.

While sea level rose an average of 4 feet per century for thousands of years after the peak of the last ice age, during the past 3,000 years, relative sea level rise around Buzzards Bay has been less than 1 foot per century. Due to emissions of greenhouse gases from human activity, the rate of sea level rise may increase to 1.5 feet for the 21st century. Increased ocean temperatures may also cause coastal storms to become more severe and more frequent. Changes in global temperature will also alter weather and precipitation patterns in both subtle, and not so subtle ways.

This action plan is not about climate change or greenhouse gas emissions. Anthropogenic inputs of greenhouse gases will add to an existing trend of rising sea level, and other climate change patterns. However important it is to address these human impacts to world climate, this is an international and global scale problem that is beyond the scope of this watershed management plan. Moreover, as noted in the 2007 IPCC report for managers, "anthropogenic warming and sea level rise would continue for centuries due to the timescales associated with climate processes and feedbacks, even if greenhouse gas concentrations were to be stabilized." Thus, for the indefinite future, whether or not greenhouse gas emissions are controlled, coastal managers and planners need to promote long term policies to address the expected continued rise of sea level rise over the next centuries, and society must plan and adapt for future storm damage impacts to minimize the financial and ecological impacts of coastal development.

rywhere began withdrawing inland as sea level rose in response to melting glaciers and expansion of warming seawater. As recently as 6,000 years ago, most of Buzzards Bay was a dry-land valley, and the southeastern Massachusetts land mass extended seaward 100 miles encompassing Elizabeth Islands, Marthas Vineyard, Nantucket, and portions of Georges Bank. As recent as 3,000 years ago the northern extent of the Buzzards Bay shore traversed from Mattapoisett Neck to North Falmouth. All during these millennia, the sandy shores along southern New England continually shifted inland due to erosion in response to major hurricanes and winter storms and rising sea levels.

The rate of these changes and sea level rise varied greatly since the last ice age, but the current rate of sea level rise has slowed and become more constant during

the past 3,000 years, increasingly at roughly 10 inches per century. However, scientists project that the rate of sea level rise and shoreline change will increase appreciably in the next few centuries because of elevated concentrations of greenhouse gases from human activity. The resulting warming is expected to increase the rate of sea level by both raising ocean water temperature (thermal expansion), and by melting glaciers and ice caps in Antarctica and Greenland.

Since colonial times, the two principal ways of measuring coastal changes has been through shoreline mapping and more recently, through the collection of tidal elevation data.

A casual examination of old nautical charts shows that some tidal rocky areas, headlands, and tiny islands in Buzzards Bay have disappeared. A more thorough analysis of charts and aerial photographs by Massachusetts Coastal Zone Management has shown that shoreline migration in some parts of Buzzards Bay have averaged more 10 feet a century. However, in most of Buzzards Bay, shorelines have been static due to the protected nature of most of Buzzards Bay shores, and in a few areas, because of the presence of bedrock (see Figure 93).

Tidal data collected around the world document that during the past century global sea level has been rising at an average rate of approximately 0.3 ft per century, consistent with the past few millennia. Actual rates depend on whether a portion of a continent is subsiding or lifting. In Buzzards Bay, like most of Atlantic seaboard,

relative sea level has been rising at a slightly higher rate, approximately 0.8 ft per century during the same period, due to the slow subsidence of the earth's crust along the east coast (NOAA, 2007, see Figure 92). Recent models have suggested that sea-level rise during the 21st century could range anywhere from 4 inches to 2.5 feet, with a median consensus estimate of 1.5 feet (IPCC, 2007; see also Monk, 2002; Titus, 2000, Titus and Richman, 2000). An additional 0.5 foot increase could result from additional glacial melting predicted by some models.

Atmospheric monitoring and analysis of glacier ice cores show unequivocally that greenhouse gases have increased dramatically in the atmosphere during the past 100 years. There is wide consensus that these increases will further elevate worldwide ocean and atmospheric mean temperature in the coming decades and centuries. A warmer planet will further raise sea level by expanding ocean water and melting glaciers and polar ice sheets. These changes will not only result in increased coastal inundation, but a warmer climate could result in more severe storms, which in turn accelerates ongoing changes to the coastline.

The greenhouse gases of greatest concern are carbon dioxide, largely derived from the combustion of fossil fuels, and methane, largely increasing because of increased farm animal production, increased areas of rice production, and deforestation of tropical forests. While methane is in much lower concentrations in the atmosphere than carbon dioxide, it has 16 times the heat trapping effect of carbon dioxide, so its release into the at-

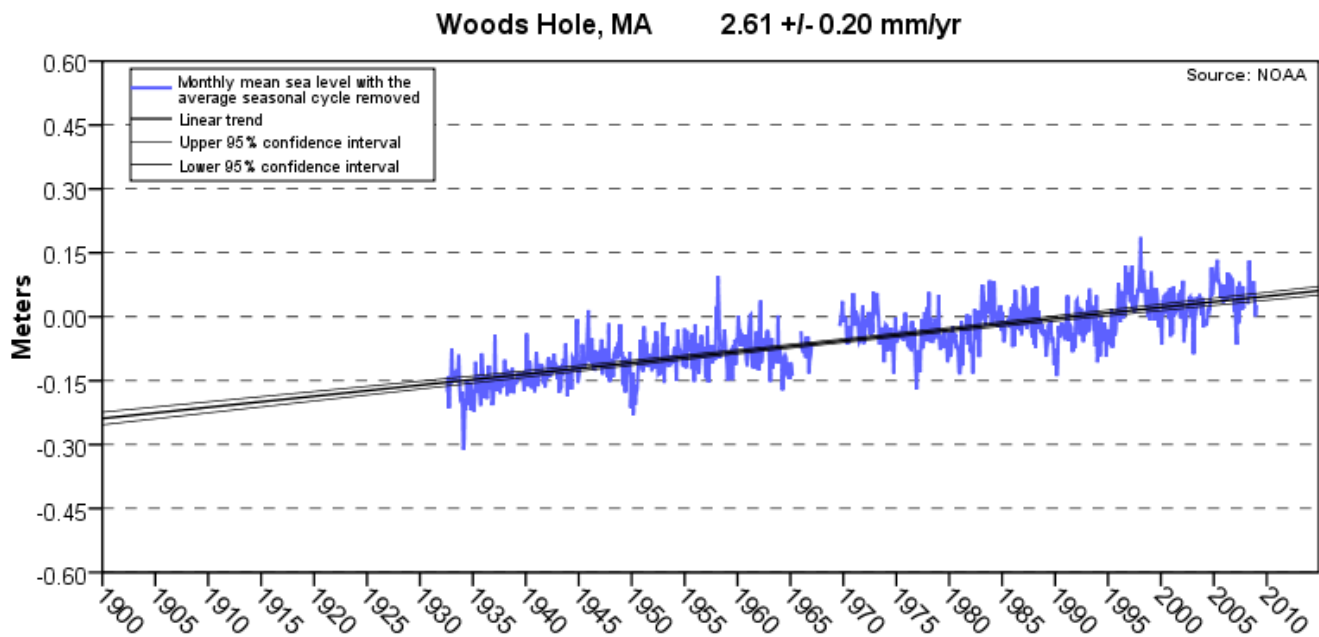


Figure 92. Mean Sea Level Trend at NOAA tidal station 8447930 Woods Hole, Massachusetts.

The mean sea level trend is 2.61 millimeters/year (0.86 feet/century) with a standard error of 0.10 mm/yr based on monthly mean sea level data from 1932 to 2006. Figure generated at <http://tidesandcurrents.noaa.gov/> on 17 April 2009. IPCC (2007a) consensus estimate predicts a 1.4 foot increase during the 21st century. An additional 1 ft increase could occur during the same period because of glacial melting.

mosphere is also of concern.

Climate change is receiving significant scientific and public attention in national and international forums, and scientific models to predict future conditions have improved. Some previous predictions of sea level rise during the 21st century were unrealistically high (IPCC 2001), and consensus estimates now predict a 60% increase over the current rate. To most individuals, the rise in sea level will seem gradual and imperceptible during their lifetime. Furthermore, even if governments immediately curtailed greenhouse gases, climate change patterns and sea level rise will continue for centuries (IPCC, 2007).

While these facts may generate complacency in some (and alarm in others), policy makers, regulators and lawmakers must recognize that irrespective of potential future conditions, coastal storms and erosion will continue to shape the shores of Buzzards Bay and affect residents. These individuals must establish a course of action to plan for both the effects of coastal storms, and the effects of sea level rise, and to regulate coastal development in a way to minimize costs to property owners, municipalities, and the environment.

For the 1991 Buzzards Bay CCMP, the Buzzards Bay NEP funded two studies about the potential impacts of rising sea levels (Giese, 1987 and IEP, 1989). These studies evaluated the potential loss of upland area due to sea-level rise in the 11 communities directly abutting the bay. Loss of "upland" included both potential shoreline loss and conversion of dry land to wetlands from rising groundwater. The study evaluated three rates of sea level rise: 0.45, 1.3, and 2.1 ft per century (the middle rate is close to the current 2007 IPCC consensus best esti-



Figure 93. Aerial photograph of Sippewissett Marsh showing salt marsh peat offshore, remnants from a period, hundreds of years ago, of lower sea level and a more westward barrier beach.

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Results showed that under this scenario, several municipalities bordering Buzzards Bay would experience significant losses in area of their coastal uplands by rising waters. Effects from these losses would include increased occurrences of floods at higher elevations, loss and erosion of wetland resource areas, elevated groundwater levels, and potential saltwater intrusion into groundwater near shore. Although some changes, like elevation of groundwater levels will appear as a gradual

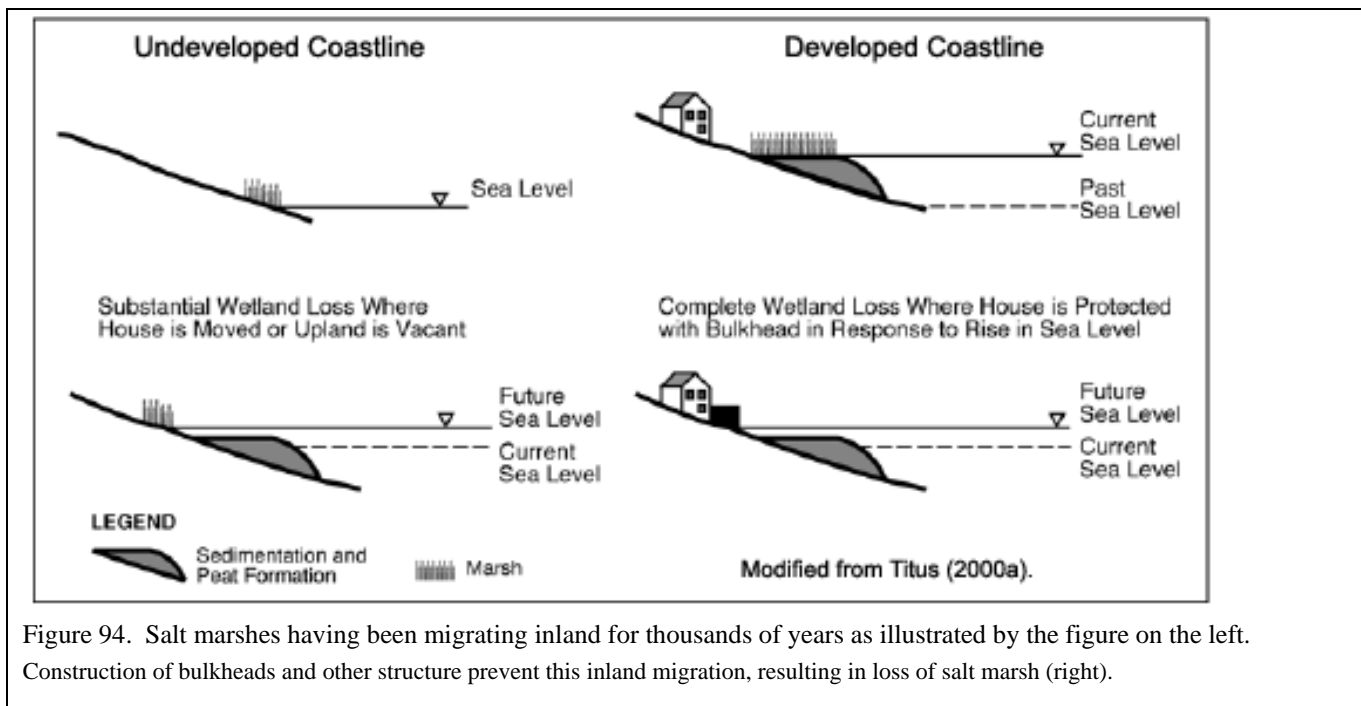


Figure 94. Salt marshes having been migrating inland for thousands of years as illustrated by the figure on the left. Construction of bulkheads and other structure prevent this inland migration, resulting in loss of salt marsh (right).

and continuous change, most sea level rise shoreline change effects would be manifested as dramatic shoreline changes caused by major coastal storms, followed by gradual redistribution and migration of coastal sediments during more quiescent periods.

Managers must also address the inland migration of wetlands, particularly salt marshes, which is an important collateral environmental impact of sea level rise. Sediment cores coastal bays and estuaries show a natural inland migration of nearshore freshwater cedar swamps converting to salt water systems, first as salt marshes, then salt ponds. Barrier beaches migrate inland. Some areas of coast lose sediment, and sediments may build up elsewhere. Construction of bulkheads, sea walls, and revetments interrupt this inland migration and consequently the frontward eroding edges of salt marshes are often not replaced on their backside (Figure 94). Preserving the ability of salt marshes to migrate, and the restoration of tidal restricted salt marshes altered in the past remain priority actions for the Buzzards Bay NEP.

Figure 94 clearly illustrates this phenomenon in the aerial photograph of Great Sippewisset marsh. This photograph shows the extent of the existing salt marsh, as well old salt marsh peat offshore showing the extent of salt marsh centuries ago when the barrier beach was more than 100 feet shoreward. This salt marsh peat is now habitat for juvenile lobsters and other invertebrates. The photograph also shows a railroad track and bed constructed in the 19th century. This railroad track isolated areas to the east from tidal exchange. While some culverts were installed under the track to permit tidal exchange, over the years many culverts collapsed or filled in. The net result of this construction was the conversion of salt marsh to freshwater wetlands at many sites, and prevention of the natural inland migration of the salt marsh in response to sea level rise.

**Storm Damage and Storm Frequency**

Hurricane frequency is cyclic over a 30 year period (Figure 95). Because most coastal development in the U.S. occurred during the relatively quiescent period between 1970 and 2000, If a hurricane equivalent to the Hurricane of 1938 (estimated to be a Category 3 hurricane with a tidal surge of 14 feet in portions of Buzzards Bay) were to strike Buzzards Bay today, property damage would be far more extensive. This is because in the 1930s, most of the population lived in cities like New Bedford (which actually had a higher population than today), with a smaller portion of the population in the

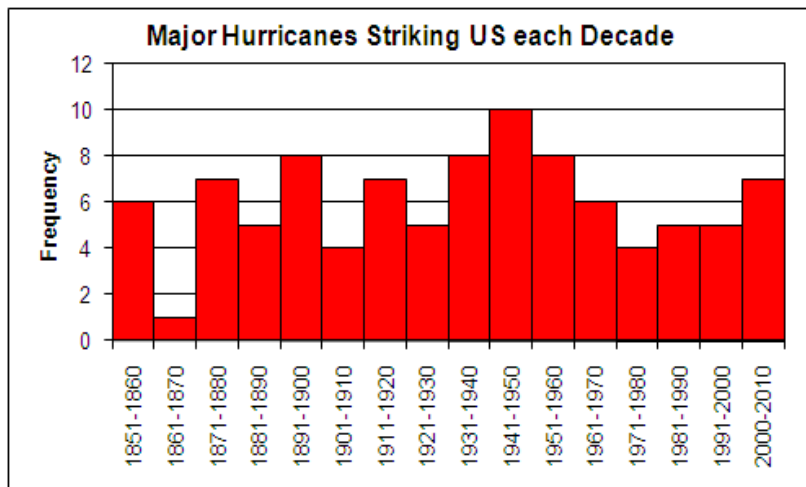


Figure 95. Frequency of major hurricanes (greater or equal to category 3) striking U.S. during the past 150 years.

The frequency of severe hurricanes striking seem to be cyclic, but future trends are less certain. Data from [Blake et al. 2005](#), modified to include 2005 (severe year) and 2006 (hurricane free year) and 2007 and 2008 data. See also: <http://www.nhc.noaa.gov/pastdec.shtml>.

100-year flood zone. Surrounding communities were more rural, and the structures built closest to shore were often summer cottages, built to be expendable in the face of coastal storms. With improved roads and infrastructure, and with establishment government subsidized flood insurance programs that de facto promoted residential growth near shore, and development within the flood zone of Buzzards Bay increased dramatically. Even in the face of relatively minor storms, Buzzards Bay communities have seen tens of millions of dollars in claims under the National Flood Insurance program since 1978 (Table 41).

The effects of another direct hit of a category 3 hurricane in Buzzards Bay will be immediate and dramatic than the gradual effects of sea level rise. Figure 96 shows current "SLOSH" models for coastal flooding developed by the U.S. Army Corps of engineers for the Town of Marion. This is one of the Buzzards Bay communities with extensive areas within the flood zone. The Buzzards Bay NEP has estimated the assessed value of structures within this flood zone to total xxx million dollars.

**Management Solutions and Opportunities**

From a planning point of view, shoreline dynamics occur broadly within three hydrologic regions: flood-prone areas, surface-water areas, and groundwater areas. Issues to be considered include loss of uplands, increased flooding impacts, loss of wetlands, accelerated shoreline changes, saltwater intrusion, and elevated groundwater levels. For currently developed areas, two basic management strategies are available: retreat from the rising water or attempt to protect threatened areas, with varying

Table 41. National Flood insurance losses in the Buzzards Bay watershed since 1978 and policy values  
 Data from FEMA as of 02/28/2009. From: <http://bsa.nfipstat.com/reports/1040.htm#25> as of April 21, 2009.

LOSS STATISTICS MASSACHUSETTS since 1978 AS OF 02/28/2009						NFIP Policy Statistics for Massachusetts as of January 31, 2009.				
COMMUNITY NAME	TOTAL LOSSES	paid losses	unpaid losses	TOTAL PAYMENTS	dollars per paid claim	Policies In-force	total insurance coverage	Annual Premiums Paid	Hazard Mitigation Plan	CRS partic.
ACUSHNET	1	1	0	\$14,622	\$14,622	11	\$2,863,800	\$7,992	no	-
BOURNE	459	377	82	\$5,435,069	\$14,417	1143	\$240,108,100	\$1,677,292	yes	no
CARVER	9	6	3	\$24,692	\$4,115	5	\$1,400,000	\$1,711	no	-
DARTMOUTH	122	76	46	\$778,988	\$10,250	516	\$113,612,000	\$539,568	no	-
FAIRHAVEN	395	314	81	\$3,273,025	\$10,424	725	\$140,240,500	\$908,250	no	-
FALMOUTH	619	472	147	\$9,091,549	\$19,262	2092	\$502,122,200	\$2,783,527	no	-
GOSNOLD	1	1	0	\$2,215	\$2,215	7	\$2,055,700	\$7,895	no	-
MARION	174	131	43	\$2,877,321	\$21,964	408	\$103,432,000	\$615,097	no	-
MATTAPOISETT	468	380	88	\$6,754,052	\$17,774	692	\$156,627,700	\$968,386	no	-
MIDDLEBOROUGH	16	11	5	\$81,802	\$7,437	28	\$6,582,300	\$31,349	no	-
NEW BEDFORD	51	27	24	\$635,184	\$23,525	224	\$65,282,400	\$325,253	yes	no
PLYMOUTH	348	254	94	\$4,127,976	\$16,252	445	\$100,790,800	\$429,518	yes	no
ROCHESTER	0	0	0	\$0	\$0	1	\$350,000	\$388	no	-
WAREHAM	835	721	114	\$11,500,072	\$15,950	1803	\$323,510,900	\$2,051,640	no	-
WESTPORT	107	78	29	\$1,112,631	\$14,265	293	\$71,013,400	\$316,012	no	-

combinations of both. For undeveloped areas, avoidance is another possibility. However, political, legal, and economic considerations will probably override the scientific issue. Although we know that changes are occurring now and cannot be reversed, the issues of property rights and equity will probably dominate how the problem is managed. The challenge is to incorporate existing scientific information, even with its uncertainties, into a rational and equitable management scheme.

An example of this can be found in the 1991 Buzzards Bay CCMP. The Buzzards Bay NEP recommended that rising nearshore groundwater levels could be addressed through DEP regulations requiring a five-foot separation to groundwater for septic system leaching fields (instead of the current 4 foot separation required). DEP addressed this issue indirectly by tackling another issue simultaneously. In their 1996 regulations they required a five-foot separation in very fast perking soils (as might be found near coastal beaches). The strategy was imperfect, for while this regulatory change addressed groundwater separation in most coastal areas, it did not capture all near shore areas, and this recommendation has been revised in this updated action plan.

For three decades the Massachusetts Coastal Zone Management Office (CZM) has tried to tackle broader sea level rise and coastal erosion issues across Massachusetts. Besides the various guidance documents, policies, and regulations that were developed by CZM staff, the agency, with funding from NOAA, began conducting a GIS analysis of historic maps and aerial photographs. This effort culminated in two important shoreline change reports that identified the most erosion prone coastal areas of Massachusetts (Thieler et al., 2001; O'Connell et

al., 2002). The reports helped towns and regulatory agencies formulate policies and regulations that recognized the threats to infrastructure and the environment posed in these dynamic areas. In 2002, MCZM updated its program policies to address sea level rise issues in their review of projects. For example, in Coastal Hazard Policy #1, the program plan notes, "sea level rise should be factored into the design life, elevation, and location of buildings and other structures within the coastal floodplain," and "non-structural alternative approaches to coastal hazards reduction are preferred over structural alternatives."<sup>106</sup>

Massachusetts joined the National Flood Insurance Program (NFIP) in 1978, the first year of the program. Today, more than 95% of Massachusetts' 351 communities participate in the NFIP program. In 1986, Massachusetts also was one of the first states to receive FEMA approval for its State Hazard Mitigation Plan. In 2007, the State Hazard Mitigation Team, comprised of staff from the Massachusetts Emergency Management Agency and Department of Conservation and Recreation, together with other state and federal agencies, prepared the most recent State Hazard Mitigation Plan. This document was organized differently than past plans, addressed a number of additional laws and requirements, and for the first time attempted to include priorities contained in local plans.

The 2007 state plan recognized the importance of local government in defining patterns of development and redevelopment and placed an increased emphasis on the creation of local mitigation plans, with the state pro-

<sup>106</sup> Last accessed 1/14/10 at: [http://www.mass.gov/czm/plan/czm\\_management\\_plan.htm](http://www.mass.gov/czm/plan/czm_management_plan.htm).

viding funding to regional planning agencies to achieve those goals. At the time of the writing of this report, only 25% of the communities in Massachusetts had a local Hazard Mitigation Plan.

While the state was updating its 2007 State Hazard mitigation Plan a parallel effort was underway to evaluate coastal hazards in Massachusetts. This effort began in February 2006, when the governor created the Massachusetts Coastal Hazards Commission. The charge to the Commission was to review existing coastal hazards practices and policies, identify data and information gaps, and draft recommendations for administrative, regulatory, and statutory changes. In May 2007, the Commission has released its final report. The report contained 29 specific recommendations, most of which were directed to state and federal agencies, and most of these recommendations revolved around improving databases, resources, and local and regional plans to better respond to disasters.

Both these reports touched on the importance of local hazard mitigation planning and better understanding the role of local government. Touched upon in both these state documents is the fact that the development and approval of the local plans creates increased opportunities of funding and technical assistance to local government. One of the more important of these opportunities is the eligibility for hazard mitigation grants. Equally important is that municipalities become eligible to participate in the Community Rating System (CRS). The CRS program provides two key local benefits. The first of these is that it reduced flood insurance policy rates for homeowners in the flood zone. Second it results in a higher rate of municipal reimbursements in the event of natural disasters. The key disadvantages from the town's point of view is that the town must first dedicate resources to help develop the local Hazard Mitigation Plan. Second, the town must dedicate staff to comply with annual reporting requirements and activities to meet annual CRS certification.

While municipalities may participate in the CRS to reduce threats to human life and property, and for additional political or financial benefits that participation convey, from an environmental policy perspective, many activities that achieve high CRS scores will also reduce environmental impacts from new development, or reduce environmental impacts resulting from natural disasters<sup>107</sup> (see Table 42). For this reason, local participation in the CRS is a high priority in this action plan.

In 2008, in an effort to better increase public awareness and local government action to plan for sea level rise and future storm and coastal erosion impacts, CZM launched the StormSmart Coasts initiative. The

<sup>107</sup> According to FEMA CRS guidance documents, participation will help "reduce the risk of erosion damage, and protect natural and beneficial floodplain functions." FEMA 2006. CRS Coordinators manual. 130 pp.

Table 42. Select Community Rating System Activities that may benefit the environment.

Listed by CRS program category number; from FEMA, 2006.

410 (Additional Flood Data) Develop new flood elevations, floodway delineations, wave heights, or other regulatory flood hazard data for an area that was not mapped in detail by the flood insurance study; or have the flood insurance study's hydrology or allowable floodway surcharge based on a higher state or local standard.

420 (Open Space Preservation) encourages communities to keep hazardous areas open and undeveloped;

420 Open Space Preservation: extra credit is provided for open space areas that are preserved in their natural state, have been restored to a condition approximating their pre-development natural state, or have been designated as worthy of preservation for their natural benefits, such as being designated in a Habitat Conservation Plan.

430 (Higher Regulatory Standards) Require freeboard; require soil tests or engineered foundations; require compensatory storage; zone the floodplain for minimum lot sizes of 1 acre or larger; regulate to protect sand dunes; or have regulations tailored to protect critical facilities or areas subject to special flood hazards (e.g., alluvial fans, ice jams, or subsidence).

430 Higher Regulatory Standards: regulations that protect natural areas during development or that protect water quality are credited.

450 (Stormwater Management) Regulate new development throughout the watershed to ensure that post-development runoff is no worse than predevelopment runoff.

450 Stormwater Management: erosion and sediment control and water quality requirements for projects that affect stormwater runoff are credited.

520 (Acquisition and Relocation) Acquire and/or relocate flood prone buildings so that they are out of the floodplain.

540 (Drainage System Maintenance) Conduct periodic inspections of all channels and retention basins and perform maintenance as needed.

effort consisted of a mix of outreach materials, an information exchange StormsmartCoasts website, and workshops directed toward planners and local government officials. As such it became a logical extension of the state's efforts to place more emphasis on local government actions to manage development. The website was established to provide an accessible collection ideas, strategies, and case studies to help communities improve efforts to manage coastal floodplains and support local efforts to improve the management of coastal floodplains in Massachusetts.

## Major Issues

Even though the magnitude and timing of future storms and shoreline changes is not known, the fact that shorelines erode and migrate is incontrovertible. More

importantly, future hurricanes are certain to cause more economic damage in the future, not because storms will be more intense, but because there is so much additional development, infrastructure, and residences built in coastal storm damage prone areas than in past decades. Pielke et al.(2008) found that between 1900 and 2005, increases in economic damage caused by hurricanes was the result of patterns of development, not increased storm frequency or intensity. Many have argued that the National Flood Insurance Program is creating a so-called moral hazard<sup>108</sup> by undercharging for actual risks and even funding those who failed to pay for government flood insurance. In 2010, to help minimize ever growing rate of federal flood reimbursements, the US Congress even attempted to pass legislation to eliminate reimbursements for vacation and second homes<sup>109</sup>.

In 2002, Massachusetts Coastal Zone Management updated its program plan with goals to "1) prevent, eliminate or significantly reduce threats to loss of life, destruction of property and degradation of environmental resources resulting from improper development, human occupation and other activities in the coastal zone; 2) allow natural physical coastal processes to continue unabated, to the extent feasible, while allowing appropriately sited coastal development and economic growth; 3) limit, prohibit or condition public expenditures in coastal high hazard areas in order to ensure that increased exposure to coastal hazards is not promoted; and 4) prioritize public expenditures for acquisition and relocation of structures out of hazardous coastal areas." Currently, state, federal, and local policies, laws, and regulations do not meet these goals.

Despite the harsh reality of increased development in storm prone areas, most regulations at all levels of government currently assume a static sea level, static shorelines, static nearshore groundwater elevations, or inadequate estimates of coastal inundation. Therefore flood prone areas could expand along the coast as sea level rises

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<sup>108</sup> A moral hazard, a term defined by the insurance industry more than a century ago, occurs when an individual, who is insulated from a risk, behaves differently than if they were fully exposed to that risk.

<sup>109</sup> In the proposed legislation, the bill authors wrote, "The Congress finds that—...(10) phasing out flood insurance premium subsidies currently extended to vacation homes, second homes, and commercial properties would result in significant average annual savings to the national flood insurance program. And In addition, we are concerned by provisions that delay the phase out of subsidies and the phase in of risk-based rates. There is an inherent moral hazard when any premium rates are subsidized, and we believe these reforms are urgently needed. Charging less than full-risk rates by the NFIP maintains a system of financial incentives backed by the federal government for individuals to live and build in high-risk flood zones."

## Management Approaches

This action plan requires changes in regulations, policies, and activities at all levels of government, especially public spending for infrastructure in high risk areas, and public spending and program polices that promote development in high risk areas by creating moral hazards. The latter problem will require changes in and rethinking of flood insurance programs, and actions the federal government should require in the aftermath of disaster relief aid.

With respect to regulations, DEP should amend its wetlands regulations for the resource area "Land Subject to Coastal Storm Flowage" (100 year floodplain) to include performance standards to create a seawall exclusion area 1 vertical foot above the upper salt marsh boundaries. This would allow for salt marsh migration for at least the next 50 years. Such regulatory change could be accomplished in less than a year if desired.\

CZM should prepare and post online a Coastal Hazards Characterization Atlas for Buzzards Bay to assist area planning boards, conservation commissions and other relevant local boards to create plans and regulations to better plan develop in coastal areas prone to storm damage and shifting shorelines. They completed such an atlas in 2005 for Massachusetts South Shore communities. Municipalities need such reports to help justify changes in zoning and general bylaws, and to develop and update local land use plans.

Similarly, CZM and USGS could develop a Risk and Vulnerability Assessment Map for each coastal municipality using a standardize methodology and recent LIDAR data. This map series should include scenarios of sea level rise and storm surge. The LIDAR is already planned for acquisition by the federal Government for 2011, and much of the GIS could be conducted in house in 2011. The BBNEP is already planning a watershed inundation map account for 1-3 foot sea level rise scenarios and expansion of the Flood Zone. for work for a Buzzards Bay Community in 2012.

The Federal Emergency Management Agency should update and maintain Flood Insurance Rate Maps for Buzzards Bay based on the best available LIDAR data. Firms for Bristol County in 2009 did not appear to incorporate the latest Firm data.

MassGIS, with support from CZM, should continue to expand its online GIS portals (such as Olive) to make available and distribute coastal hazards information.

EPA should also evaluate the distribution of coastal hazards and emergency management information to coastal municipalities to ensure that the public is kept informed with up to date and accurate hazard information and actions government officials are requesting the public to take. FEMA already publishes information on the number of claims filed and paid in each municipality, but maps of claim locations or recurring damage to pub-

lic structures would help justify local measures to manage growth in hazard prone areas.

EEA should revise and promote policies, regulations, and take actions to promote sand nourishment as the preferred alternative for eroding and shifting shorelines. Most federal and local dredging projects still have the largest fraction of dredged materials disposed at sea. This action would also compliment CZM's policies on the beneficial use of dredge materials.

EEA should help fund a standardized Benefit-Cost Analysis model that fully compares the capital, societal, and natural resource benefits and costs of proposed shoreline protection projects and appropriate alternatives. The hidden extra costs of government (and taxpayers) to provide services to development in hazard-prone areas is not fully appreciated and needs to be explained.

After catastrophic storms, the Department of Fish and Game and the Department of Conservation and Recreation should acquire storm prone properties from willing sellers in fee or through conservation restrictions and easements. This is accomplished by revising current criteria in agency policy (or state regulations) to promote coastal land acquisition, and utilizing federal incentive grant programs. FEMA has a program in place, but state agencies and municipalities must apply. Implementation strategy: participate in applicable federal programs

The Massachusetts Emergency Management Agency, the Department of Conservation and Recreation, and the Office of Coastal Zone Management, along with other appropriate planning agencies, should continue to encourage coastal communities to develop, update, and implement coastal hazard mitigation plans. Few Massachusetts communities, and none in Buzzards Bay have these in place.. EEA can provide technical assistance, and possibly the legislature could help by funding. Could be accomplished by law as a requirement for communities

Municipal Planning Boards will adopt and implement strict development/redevelopment standards within FEMA A and V flood hazard zones and other areas subject to coastal flooding, erosion, and relative sea level rise.: For example, the Marion subdivision regulations prevent new subdivisions in the flood zone. Broader zoning measures will require town meeting approval. Possible supporting legislation may be needed at Town Meeting.

Through municipal; zoning and local wetland by-laws, Buzzards Bay municipalities should establish coastal construction setbacks and regulate construction activities more stringently for areas predicted to be subject to sea-level rise, erosion, or flooding. In particular, these regulations should prohibit the construction of seawalls, revetments, and groins to allow wetland and natural sediment migration processes. Priorities should be set focusing first on the velocity zone and faster erod-

ing coasts. Responsible agent(s): Municipal boards and town meeting

Municipalities should acquire storm prone properties through Community Preservation Act funding. Estimated costs: potentially millions existing local CPA funds, Implementation strategy: purchase in fee or conservation restrictions. Schedule: gradual; depending on willing buyers. Hazard prone properties tend to be very expensive waterfront properties, so local interest and capacity may be low.

The Board of Building Regulations and Standards should update the State Building Code requirements for coastal construction to include freeboard requirements and other measures, and also encourage collaboration between Building Inspectors and Conservation Commissions Municipalities are not allowed to create local building codes. These policies and requirements must be set at the state level. Already committed to (freeboard). Implementation strategy: issue draft regulations for comment then finalize

Municipalities should prepare and distribute outreach materials encouraging the voluntary adoption of freeboard for new and major reconstruction. Explanation: Property owners may incorporate freeboard if they recognize the savings in insurance costs. Responsible agent(s): Municipal Building Departments. Implementation strategy: brochure handed out at permit window, information on website.

Measuring success: production of outreach materials; increased construction employing freeboard.

All municipalities should adopt and keep up to date their hazard mitigation plan, and participate in Community Rating System. CRS not only benefits communities by focusing their planning efforts, and minimizing public storm-related expenses, but also can result in low insurance premiums for residents. Responsible agent(s): Municipal Hazard mitigation coordinator; some assistance from RPAs and MCZM. Estimated costs: costs of plan development, cost of staff (part-time of existing position?) to track and implement CRS activities.

Implementation strategy: RPAs and CZM assist the towns to first adopt a hazard mitigation plan.

Measuring success: adoption of new regulations.

CZM should help implement a program of regional sand management through adoption of state policies, regulations, and activities that promote nourishment as the preferred alternative for coastal hazard protection and requiring beneficial uses of dredged materials, with limited waiver ability from the requirement. Municipalities should consider beneficial uses of dredge materials, even beyond their political boundaries. Responsible agent(s): MCZM with cooperation from Develop a process using existing or newly enacted policies and/or regulations, which (1) improves coordination between the USACE, state agencies, and municipalities, (2) iden-

tifies cost-share funds, and (3) achieves permit requirements in a timely manner, so as to ensure that all dredged material suitable for beach nourishment will be placed on adjacent or nearby eroding public beaches.

CZM and DEP should develop a guidance document or revise the Wetland Protection Act regulations to incorporate best management practices or performance standards for Land subject to coastal storm flowage. The state's WPA regulation have long lacked clear performance standards for LSCSF.

CZM should conduct a regional sand management study that identifies (1) critically eroding public beaches where access is open to the public, (2) areas most vulnerable to coastal hazards, and (3) potential regional nourishment methodology and costs. CZM will need to update and finalize existing draft document entitled Assessing Potential Environmental Impacts of Offshore Sand and Gravel Mining for the Purposes of Beach Nourishment to include contemporary state of knowledge regarding the potential short and long-term physical and biological impacts associated with offshore sediment removal

## Financial Solutions

Much of the expenses associated with this action plan relate to conducting risk assessments and planning. These efforts might cost hundreds of thousands of dollars per community and require dedication of staff time. The actual cost changing, implementing, and conforming to any regulations are probably negligible. Specific projects like the CZM Coastal Hazards Characterization Atlas for Buzzards Bay might cost \$10,000 or more to produce. The costs of updating CZM and GIS GIS portals because both systems are already well established and the agencies can use of existing website management staff.

Potential funding sources for planning and assessment include NOAA Coastal Zone Enhancement (Section 309) Grants, and various FEMA grant programs.

## Monitoring Progress

Because of the rarity of catastrophic storms, many of the benefits of this action plan might not be assessed for decades. Therefore to evaluate this action plan, programmatic actions must be tracked. Such tracking might

include town completion of hazard mitigation plans, measuring success: adoption of new laws or regulations, participation in FEMA's CRS program, and acquisition of sensitive properties.

## References

- Blake, Eric S., Rappaport, Edward N., Landsea, Christopher W., and Jerry G. Jarrell. 2005. Deadliest, Costliest, and Most Intense United States Tropical Cyclones from 1851 to 2004 (NOAA Technical Memorandum NWS TPC-4). Miami, Florida: National Weather Service, National Hurricane Center, Tropical Prediction Center. Updated August 2005. available at: [www.aoml.noaa.gov/hrd/Landsea/dcmifinal2.pdf](http://www.aoml.noaa.gov/hrd/Landsea/dcmifinal2.pdf)
- IPCC (Intergovernmental Panel on Climate Change). 2001. Climate Change 2001: The Scientific Basis
- IPCC (Intergovernmental Panel on Climate Change). 2007. Climate Change 2007: Synthesis Report Summary for Policymakers.
- Kriesel, W. P. and C. Landry. 2004. "Participation in the National Flood Insurance Program: An Empirical Analysis for Coastal Properties". *Journal of Risk and Insurance*, Vol. 71, No. 3, pp. 405-420, September 2004.
- MEMA and DCR. 2007. Commonwealth of Massachusetts State Hazard Mitigation Plan 2007. 182 pp.
- Munk, W. 2002. Twentieth century sea level: An enigma. *Proc Natl Acad Sci U S A*. 2002. 99: 6550-6555.
- O'Connell, J.F., E.R. Thieler, and C. Schupp. 2002. New Shoreline Change Data and Analysis for the Massachusetts Shore with Emphasis on Cape Cod and the Islands: Mid-1800s to 1994. *Environment Cape Cod*, Vol. 5, No. 1, pp. 1-14, 2002 WHOI-R-02-007
- Pielke R. A. Jr., J. Gratz, C. W. Landsea, D. Collins, M. A. Saunders, and R. Musulin. 2008. Normalized Hurricane Damage in the United States: 1900-2005. *Natural Hazards Rev.* 9: 29-42.
- Thieler, E.R., J.F. O'Connell, and C.A. Schupp. The Massachusetts Shoreline Change Project: 1800s to 1994. U.S. Geological Survey Report, 39 pp., \$6.00, 2001 WHOI-T-01-001
- Titus, J. G. and C. Richman. 2000. Maps of Lands Vulnerable to Sea Level Rise: Modeled Elevations along the U.S. Atlantic and Gulf Coasts. *Climate Research*, 18:205-228.
- Titus, J. G. 2000. Does the U.S. Government Realize that the Sea is Rising? How to Restructure Federal Programs so that Wetland and Beaches Survive. *Golden Gate University Law Review*, 30:717-778.

## 1991 Shoreline Action Plan and Outcomes

### Goals

1. Protect public health and safety from problems associated with higher waters and shifting shorelines.
2. Reduce the public financial burden caused by the destruction of or damage to coastal property.
3. Plan for the loss of buffering wetlands and shifting sand formations.

### Objectives

1. To incorporate sea-level rise and shoreline change phenomena into all relevant planning and management programs
2. To develop a comprehensive strategy for handling existing structures in areas predicted to be affected by future shoreline changes.
3. To adopt regulatory and non-regulatory measures for guiding growth and development in areas that will be influenced by new shorelines.
4. To restructure the flood and hazard insurance programs in threatened areas so that the financial burden on the general public is decreased.

### Recommendations and Outcomes

1. DEP will amend its wetlands regulations and adopt performance standards for the resource area "Land Subject to Coastal Storm Flowage" (100 year floodplain).

Outcome: Deemed partially complete through adoption of the Rivers Protection Act.

2. CZM will provide technical assistance to Buzzards Bay area planning boards, conservation commissions and other relevant local committees, commissions and boards in mapping coastal areas that are, or will be, affected by erosion and/or sea level rise

Outcome: Deemed complete through completion of shoreline change maps, Geise study, and other publications and outreach materials.

3. CZM will provide technical assistance to Buzzards Bay communities in developing by-laws, regulations, guidelines, and policies for building in flood zones mapped by the Federal Emergency Management Agency.

Outcome: Deemed complete through adoption of post Hurricane Bob policies completion of shoreline change maps, Geise study, and other publications and outreach materials.

4. Buzzards Bay communities should pass bylaws increasing the required setback for septic systems from groundwater, water bodies, and vegetated wetlands for areas subject to sea-level rise, erosion, or flooding.

Outcome: Local regulations largely not adopted, by state Title 5 regulations and River Protection act helped partially achieve this recommendation.

5. Buzzards Bay communities should establish coastal construction setbacks and regulate construction activities more stringently for areas predicted to be subject to sea-level rise, erosion, or flooding.

Outcome: Some communities (like Falmouth) adopted firmer no build set backs from some wetlands, but most towns did not adopt setbacks. Some Title 5 changes helped partially meet this recommendation.

6. Buzzards Bay communities should establish higher flood elevations that exceed the minimum elevations mapped by the Federal Emergency Management Agency.

Outcome: Recommendation cannot be implemented by town; rejected as written.

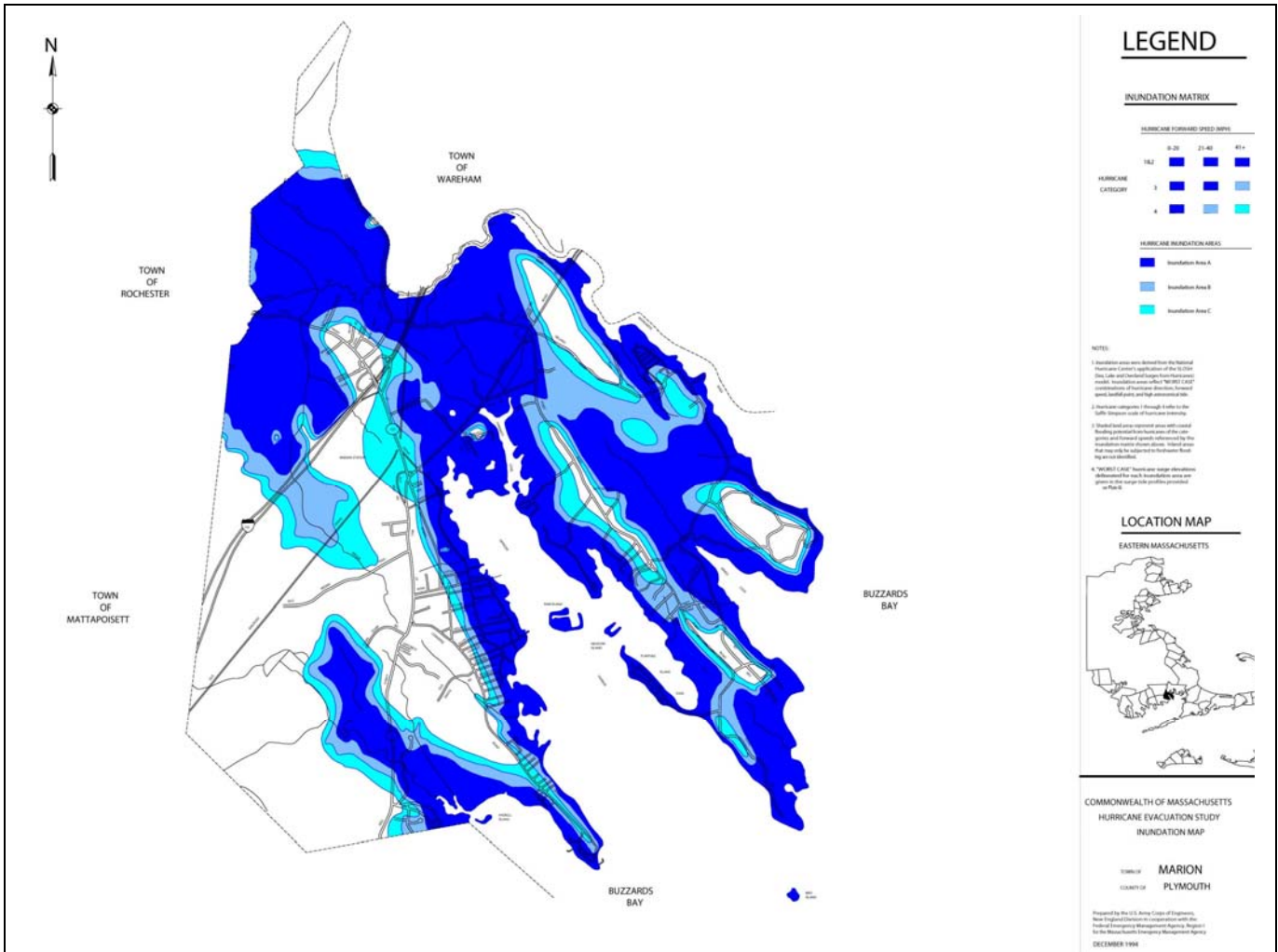


Figure 96. SLOSH model map of Marion, MA produced the U.S. Army Corps of Engineers.

## MA 2007 Coastal Hazard Plan Recommendations

The following recommendations were included in the 2007 Coastal Hazard Plan for Massachusetts. They are being reviewed for consistency with this action plan and possibly incorporated by reference into this action plan.

**Recommendation #3** Develop an RVAM for each coastal community using a standardized GIS methodology.

*Lead Agency: Massachusetts Emergency Management Agency (MEMA), DCR, regional planning agencies, and municipalities*

*Funding Requirement: yes*

*Potential Funding Source: FEMA Hazard Mitigation Grant, state funds, and municipal funds*

*Next Steps: form task force of stakeholders to develop the standardized GIS methodology*

*Project Duration: 5 years*

**Recommendation #4** Map and model climate change and sea-level rise data related to coastal hazards in Massachusetts.

*Lead Agency: USGS*

*Funding Requirement: yes*

*Potential Funding Source: federal funds and state funds*

*Next Steps: acquire funds, assess status of current data, and develop plan to collect new data*

*Project Duration: 5 years*

**Recommendation #5:** Develop a process to capture coastal conditions immediately after major storm events.

*Lead Agency: CZM and MEMA*

*Funding Requirement: no*

*Next Steps: form task force to identify opportunities, make arrangements with appropriate agencies, and train the Storm Team*

*Project Duration: 6 months*

**Recommendation #6:** Model potential storm damage based on historical event data to educate decision makers and the public to the magnitude of risk in the coastal zone.

*Lead Agency: MEMA, DCR, and CZM for wind modeling; FEMA, USACE, and NOAA for inundation modeling*

*Funding Requirement: yes*

*Potential Funding Source: federal funds and state funds*

*Next Steps: acquire funds and run scenarios using appropriate models*

*Project Duration: 2-4 years*

**Recommendation #8:** Evaluate the distribution of coastal hazards and emergency management information to coastal communities before and during major storm events.

*Lead Agency: MEMA, CZM, and municipalities*

*Funding Requirement: yes*

*Potential Funding Source: state funds*

*Next Steps: acquire funds and develop survey to be distributed to residents*

*and visitors of high-risk coastal areas*

*Project Duration: 1 year*

**Recommendation #9 (Priority):** Establish a storm-resilient communities program to provide case studies

for effective coastal smart growth planning and implementation.

*Lead Agency: Massachusetts Executive Office of Energy and Environmental*

*Affairs (EEA)*

*Funding Requirement: yes*

*Potential Funding Source: state funds*

*Next Steps: acquire funds and define the model storm-resilient community*

*Project Duration: 2-4 years*

**Recommendation #10:** Finalize guidance document for state and local agencies on the implementation of Executive Orders 149 and 181 relative to publicly funded infrastructure projects, and develop guidance for the remaining sections of Executive Order 149.

*Lead Agency: CZM and DEP*

*Funding Requirement: no*

*Next Steps: update and finalize draft guidance document*

*Project Duration: 1 year*

**Recommendation #18:** Develop informal local coordination processes or modify bylaws to provide for the coordination of permitting and approval by local departments.

*Lead Agency: chief elected municipal officials*

*Funding Requirement: no*

*Next Steps: assemble municipal agents to discuss opportunities for*

*coordination*

*Project Duration: 6-12 months*

**Recommendation #21:** Identify existing culverts and tide gates associated with transportation crossings of coastal wetlands that are priorities for replacement due to flood hazards or environmental resource concerns, and address flooding, wetlands hydrology, and maintenance in the early stages of the design and implementation of new or replacement transportation projects that cross coastal wetlands and waterways.

*Lead Agency: Massachusetts Executive Office of Transportation (EOT), CZM, DEP, and USACE*

*Funding Requirement: yes*

*Potential Funding Source: state funds*

*Next Steps: form working group to develop strategy*

*Project Duration: 1 year*

**Recommendation #25** Identify and map potential offshore and inland sources of suitable nourishment sediment.

*Lead Agency: USGS*

*Funding Requirement: yes*

*Potential Funding Source: federal funds*

*Next Steps: map existing data*

*Project Duration: 5 years*

**Recommendation #27:** Establish a Technical Advisory Committee, consisting of a broad range of qualified professionals, to evaluate and develop construction and monitoring guidance, and recommend appropriate approval conditions for those protection approaches determined to be new and innovative.

*Lead Agency: EEA*

*Funding Requirement: no*

*Next Steps: identify members and hold first planning meeting*

*Project Duration: ongoing*

Recommendation #28: Build upon an ongoing study by WHOI Sea Grant and the Cape Cod Cooperative Extension to quantify the inherent values of Cape Cod coastal beaches for storm damage protection, recreation, and wildlife habitat to develop similar values for all Massachusetts beaches.

*Lead Agency: Woods Hole Oceanographic Institution (WHOI) Sea Grant and Cape Cod Cooperative Extension*

*Funding Requirement: yes*

*Potential Funding Source: WHOI funds and Cape Cod and Islands License Plate*

*Campaign funds*

*Next Steps: acquire funds and release request for response*

*Project Duration: 1-2 years*

Recommendation #29: Develop a standardized benefit-cost analysis model using an approach adapted from that used by the USACE to justify projects that fully compares the capital, societal, and natural resource benefits and costs of proposed shoreline protection projects and appropriate alternatives.

*Lead Agency: EEA and academic or research institute*

*Funding Requirement: yes*

*Potential Funding Source: private grants*

*Next Steps: identify lead researcher and acquire funding*

*Project Duration: 2 years*