MASSACHUSETTS

HOMEOWNER'S HANDBOOK TO PREPARE FOR COASTAL HAZARDS

Second Edition
(December 2014)

Acknowledgments

This handbook was developed as a cooperative project among the Massachusetts Emergency Management Agency (MEMA), Massachusetts Office of Coastal Zone Management (CZM), Federal Emergency Management Agency (FEMA), Massachusetts Department of Conservation and Recreation (DCR), Barnstable County, and the two Massachusetts Sea Grant programs, MIT Sea Grant (MITSG) and Woods Hole Sea Grant (WHSG). A key priority of this project partnership is to increase the resiliency of coastal communities to natural hazards. One major component of strong communities is enhancing individual resilience and recognizing that adjustments to day-to-day living are necessary. This book is designed to promote individual resilience, thereby creating a fortified community.

We would like to thank the University of Hawaii Sea Grant for allowing us to model this handbook after the original Homeowner's Handbook authored by Dennis Hwang and Darren Okimoto. A special thanks to Wendy Carey and Delaware Sea Grant for providing the template used in preparation of the Massachusetts handbook, and to Tracie Sempier (Mississippi-Alabama Sea Grant) for sharing adaptation strategies.

This handbook would not have been possible without support and input from numerous individuals, including Robert Thompson (NWS - Taunton), Rich LaTour and Chris Besse (MEMA), Rebecca Haney and David Janik and Betsy Rickards (MassCZM), and Pam DiBona (MassBays), Richard Zingarelli and Eric Carlson (DCR - Floodplain Management), Ivy Frances (FEMA), Sean O'Brien and Phil Burt (Barnstable County - Regional Emergency Planning), Heather McElroy and Caroline Harper (Barnstable County - Cape Cod Commission), Bill Clark (Barnstable County - Cape Cod Cooperative Extension), Judith McDowell and Jeffrey Brodeur (Woods Hole Sea Grant), Steve Noon (Simpson Strongtie), Robert Scena (Control New England Inc.), and Andy Collins (Collins Construction). Design by Lianne Dunn Design & Illustration (www.LianneDunn.com).

Financial support for the handbook was generously provided by Woods Hole Sea Grant (NOAA Award NA10OAR4170083, publication no. 14-101), MIT Sea Grant (NOAA Award NA10OAR4170086, publication no. 14-20), and the Barnstable County Cape Cod Cooperative Extension.

This handbook was prepared by Greg Berman and Juliet Simpson in their roles as Sea Grant Extension Agents to further the outreach objectives of the two Massachusetts Sea Grant programs, National Oceanic and Atmospheric Administration, and U.S. Department of Commerce. The statements, findings, conclusions, and recommendations are those of the authors and do not necessarily reflect the views of the National Oceanic and Atmospheric Administration or the Department of Commerce.

It is our hope that the information contained within this handbook, which is in part a compilation from numerous publications associated with natural hazards and hazard mitigation, will be widely used and adopted by homeowners in Massachusetts and the region.

MASSACHUSETTS

HOMEOWNER'S HANDBOOK TO PREPARE FOR COASTAL HAZARDS

Second Edition
(December 2014)

Contents

Part 1 — Introduction **1**

1.1 Common Myths and Reasons to Prepare 2

1.2 Things You Can Do to Prepare 4

Part 2 — Natural Hazards: An Overview for Homeowners **7**

2.1 Coastal Storm Hazards 7

2.1.1 Hurricanes—Tropical Systems 7

2.1.2 Nor'easters—Extratropical Storms 14

2.2 Flood Hazards 16

Part 3 — Protecting Yourself and Your Family **19**

3.1 Emergency Supplies 19

3.2 Evacuation Kit 21

3.3 Evacuation Planning 22

3.4 Key Definitions 25

3.5 Emergency Notification Systems 26

3.6 Preparations Before a Hurricane or Coastal Storm 28

3.7 Evacuation Procedures for a Hurricane or Coastal Storm 29

3.8 Preparedness, Safety, and Evacuation Procedures for a Flood 30

3.10 Emergency Information and Contacts 30

Part 4 — Protecting Your Property **31**

4.1 Creating the Wind- and Rain-Resistant Envelope 33

4.1.1 Keep Your Roof On 34

4.1.2 Keep Water Out 41

4.1.3 Window and Door Coverings 45

4.1.4 Trees 55

4.2 Electrical and Power Issues 55

4.2.1 Alternate Power Sources 57

4.2.2 Generators 58

4.2.3 Power Stations 60

4.2.4 Inverters 60

4.2.5 Battery Chargers 60

4.3 Flooded Basements 60
4.4 Licensed Contractors 62
4.5 Hazard Mitigation Assistance Program 62

Part 5 — Protecting Your Property with Insurance 64
5.1 General Insurance Information 65
5.2 Flood Insurance 66

Part 6 — Climate Change and Potential Impacts on Natural Hazards 69
6.1 Climate Change 69
6.2 Regional Climate Trends 70
6.3 Potential Climate Change Impacts on Natural Hazards in Massachusetts 71
6.4 Hazard Mitigation and Climate Change Adaptation 73

Appendix A — Emergency Contact Information 75

Appendix B — Shelter Information 76

Appendix C — Construction at the Coast, Beach Management, and Coastal Property Checklist 78

Endnotes 85

Acronyms and Abbreviations 87

Useful Links and Resources 88

Part 1
Introduction

Your home, one of your greatest financial investments, is a place that shelters you, your family, and most of your possessions from the elements of nature. Yet natural hazards such as coastal storms, floods, high winds, and tornadoes can threaten the inhabitants and contents of your home. When a natural disaster occurs, the results can be devastating.

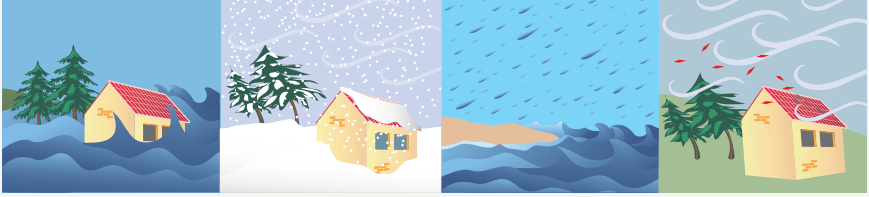
This handbook was created to help you prepare for natural hazards so that risks to family and property may be reduced. While it is never possible to eliminate all damage from a natural disaster, you as a homeowner can take action and implement many small and cost-effective steps that could significantly lower your risk. Mother Nature can be intense. Your family and home deserve the protection that only you can provide through preparation.

This handbook is divided into six parts. This introduction presents the purpose and layout of the handbook and includes a discussion of common myths that may have prevented you from taking action in the past. There is also a summary of the content of this handbook in the form of several things you can do to prepare. Part 2 provides basic information on coastal storms, flooding, and other hazards that will allow you to make an educated decision about the steps to take to protect your family and property. Part 3 discusses in detail how to protect yourself and your family. It includes recommendations for essential emergency supplies, evacuation kits, evacuation planning and procedures, and important information that emergency management agencies want you to know even before a warning is issued. Part 4 covers how you can protect your property from wind and water hazards. Part 5 presents general insurance information and resources to aid in recovery if storm damage occurs. Part 6 provides an overview of climate change in Massachusetts and how climate change may exacerbate impacts from coastal hazards in the future.

This handbook is available as a free downloadable file at the following websites:

- Woods Hole Sea Grant Program (www.whoi.edu/seagrant/) & MIT Sea Grant Program (http://seagrant.mit.edu/);
- Massachusetts Emergency Management Agency (http://www.mass.gov/eopss/agencies/mema/);
- Massachusetts StormSmart Coasts (http://www.mass.gov/czm/stormsmart).

This handbook will be updated on an as-needed basis as new information becomes available and feedback from the public is obtained. For general emergency information you can contact your state emergency management agency or one of its regional offices at the addresses and phone numbers provided (see Appendix A).



1.1 COMMON MYTHS AND REASONS TO PREPARE

You may be among the many homeowners in Massachusetts who have not fully prepared for a natural disaster because of complacency caused by several myths. The most common myths appear as quotes below and are discussed in order to remove some of the major barriers to taking action and to encourage people to prepare.

Myth 1: "I survived Hurricanes Bob, Irene and Sandy, so I am sufficiently prepared."

Many people have the impression that if they survived past hurricanes and nor'easters, they do not need to prepare any more than they did previously. Although previous storms resulted in widespread damage along the East Coast, their impacts to Massachusetts could have been much more severe. Had those storms tracked slightly differently, made landfall at different locations along the coastline, or been more powerful storms (when they reached Massachusetts), significantly greater effects would have been experienced in Massachusetts, including higher winds, more structural damage to buildings and severe flooding. Even the 1938 Hurricane made landfall too far west to be a worst case scenario for Buzzards Bay. In all reality, we have been lucky in the past (see Section 2.1 for details on historic storms).

Myth 2: "If a disaster occurs, it won't be that bad."

When a coastal storm or flood event occurs, the damage can be devastating. In 1991, Bob was responsible for six deaths and caused over $1.5 billion in damage, with most of that monetary loss occurring in Massachusetts (see Section 2.1 for details on storm damage).

Myth 3: "I don't live near the coast, so I am safe."

In fact, the vast majority of damage or destruction during recent tropical systems was caused by inland flooding associated with extreme rainfall (e.g., Irene in 2011). Additionally, hurricane force winds can extend over 100 miles from the center of the storm, which can cause widespread damage in all of Massachusetts, not just the coastal counties. Therefore, all homeowners should prepare—not just those who live along the coast (see Section 2.2 for details on flooding).

Myth 4: "Even if I prepare for a storm, my home could be damaged."

Even though someone may wear a seat belt, shoulder belt, and have an airbag, there is no guarantee that person won't be injured in a major auto accident. Yet most people recognize the importance of these safety devices in reducing risk, and use them. Likewise, the measures discussed in this handbook could significantly reduce risk, although there are no guarantees there will be no damage (see Section 2.1 for details on ways of protecting your home).

Myth 5: "If my home or property is damaged by a natural hazard event, government programs will provide assistance."

After major disasters, many homeowners find that the government is highly unlikely to repair their uninsured damaged houses or even provide adequate compensation for property damage. Government compensation evaluations are conducted after a disaster strikes and are based on the amount of damage that occurs on a county-wide basis. It is up to you to plan properly, strengthen your house, and have the appropriate financial protections in place such as insurance, if it is available. After a natural disaster occurs, the government may also be overwhelmed by the number of people in need and help may not arrive quickly (see Section 5 for details on insurance).

Myth 6: "My house survived Hurricanes Bob and Sandy, so I do not need to retrofit for hurricanes."

When another massive natural disaster occurs, the resulting damage could be much greater. Bob drove a surge of 10 to 15 feet into Buzzards Bay and caused over $680 million in damage in Massachusetts, however it was only a category 2 (out of 5 levels) hurricane. A fast moving category 3 hurricane could produce a surge of 20 to 25 feet into Buzzards Bay. While Sandy caused tremendous damage in many Mid-Atlantic states (and significant damage in Massachusetts), Sandy was only a Tropical Storm in Massachusetts — that is, coastal flood levels were less than 100-year levels, and wind speeds were well below coastal building code design-level wind speeds. Homeowners in coastal Massachusetts should consider retrofits that provide window protection and a continuous load-path connection, which will help protect homes against both hurricanes and nor'easters (see Section 4.1 for details on retrofits and additional simple measures).

Myth 7: "If a natural hazard event occurs, there is nothing I can do."

Fortunately, there are many small steps you can take to significantly reduce the risk of damage to life and property. While it is not possible to eliminate all risk or damage, taking steps to plan and prepare can make a major difference and determine whether your house survives and receives minor or no damage. Thus, the information in this handbook covers two major parts for preparation: (1) protecting yourself and your family (Section 3) and (2) protecting your property (Section 4).

Myth 8: "Strengthening my house is too expensive and not worth the effort."

There are several relatively inexpensive ways to strengthen your house:

- Hurricane clips or window coverings can range from a couple hundred dollars to a few thousand dollars. This alone offers significant protection.

- For minimal costs, the roof structure (trusses and rafters) for many houses can be strengthened with bracing.
- Strengthening your roof can be more expensive if done by itself. However, if it is done when you replace your roof at the end of its normal life, the incremental cost is reasonable.
- Foundation upgrades can be expensive, but considering your house is probably your major investment, it could be worth the immediate cost (and there may be federal assistance grants available to help with the cost). Savings on insurance can also offset the investment.

Strengthening your house can protect you from coastal storms and floods. Ultimately, strengthening your home should be considered a home improvement that adds value to your house and is worth the effort, even without external incentives. The time and money spent to prepare your house are a very small fraction of the resources that may be needed if you fail to minimize potential damage before a natural hazard strikes.

In addition, by strengthening your house you protect your neighbors as well as yourself. A house that falls apart during a storm will create debris that can damage adjacent properties. You also help the emergency efforts of the local, state, and federal governments by being able to assist other people instead of requiring help yourself.

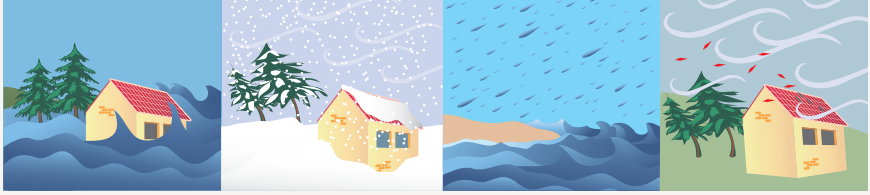
By preparing and strengthening your house, you are more likely to "weather the storm" and be better able to take care of family members, including the elderly, those with special needs, and pets. However, keep in mind that even if your fortified house may be capable of withstanding relatively small storms, you should still evacuate if the neighborhood you live in will become inaccessible due to deep floodwaters. Always follow evacuation instructions issued by your local and state emergency management officials.

1.2 THINGS YOU CAN DO TO PREPARE

There are some things you can do to prepare that will provide greater protection to your family and your property. They are summarized below with more detail provided later in this handbook.

Gather emergency supplies

You can gather emergency supplies in your house now. Check and restock each month so that the supplies are complete, not outdated or used. Avoid rushing to a store during an emergency to gather your supplies. There will likely be long lines and empty shelves — you will add to the crowd and confusion. The good news is many items you need are probably already in your home (see Part 3 of this book).



Compile an evacuation kit

If your evacuation plans include using a public shelter for a coastal storm or flood, you will need an evacuation kit that contains clothing, medications, personal hygiene products, and other items such as bedding for five to seven days. Water and food are provided at shelters, but if a special diet is required, you should bring these foods with you. Calling 211 from any land line phone will provide information on what specific shelters are available for evacuation purposes and when public shelters will open. The kit should be assembled and checked before hurricane season (see Part 3). If the kit will be used during evacuation for other hazards, three days of supplies may suffice. Don't forget to plan for your pet and prepare a pet evacuation kit (see Part 3 and Appendix B).

Create an evacuation plan for both a flood and a coastal storm

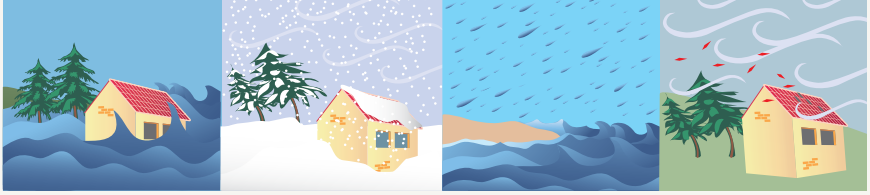
They are different. For a tropical storm or strong nor'easter, your plan may include sheltering in a structurally fortified house if it is outside the high-risk flood zone or any evacuation zone. If you can't use your house, use a suitable alternative structure (a friend's or relative's house) or a shelter that is officially open (listen to local radio and television or go to www.redcross.org and click on "find a shelter;" see Part 3). For a flood, evacuate to high ground outside the evacuation zone if you are instructed by emergency management officials to do so. Residents should know which zone they live in (see Part 3.3 of this book), so that they can evacuate if an order is given. In any event, do not drive through even shallow water—"turn around, don't drown." Discuss and practice drills of your evacuation plan with your family each year.

Know your property and take appropriate action

Look at where you are located. If the land has flooded in the past or is shown to be in (or adjacent to) a flood zone on Federal Emergency Management Agency (FEMA) flood maps, you should strongly consider flood insurance, as flood damage is typically not covered by homeowners insurance. If trees overhang your house, you should consider trimming or cutting branches that may damage your house in a storm. If your property is near a ridge, open land, or water, it may be especially susceptible to wind damage during a storm or hurricane (see Part 4).

Know your house and take appropriate action

When was your house built? Does it have connectors that tie the roof to the walls or the walls to the foundation? When will you need to replace the roof? Is the first floor above the predicted flood zone elevation? Look at your blueprints (possibly available at your town building department). They may be available from your home builder, your local building department, or your architect (see Part 4).



Strengthen your house

A recently built house should have hurricane clips to tie the roof to walls and should also have strong connectors from the walls to the foundation. If you have an old home, you can retrofit at a reasonable cost. All households should consider the many options now available to protect your windows, garage, and doors. You can also strengthen your roof when it is time to replace it, and elevate your home above the predicted flood elevation. The steps a homeowner can take will vary with each house, but for the majority of homeowners, there are a few steps that can make a significant difference (see Part 4).

Finance creatively

Consider efforts to strengthen your house as an important home-improvement project. Most projects are not that expensive. It is a great investment to strengthen your house and provide more protection to your family (see Part 4).

Seek the assistance of a qualified, licensed architect, structural engineer, or contractor

This handbook covers work that you may be able to do yourself. If you cannot do the work, seek qualified assistance through trusted references from friends and family, the Massachusetts Board of Registration of Professional Engineers, or contractors' associations. Even if you do the work yourself, it is always best to seek professional advice for initial guidance since every house is a little different (see Part 4). Remember to obtain all required local, county, and state permits and approvals before any work is initiated.

Don't gamble with your house

Obtain adequate insurance if you are in a flood-prone area (see Part 5). Remember that flood insurance coverage does not take effect until 30 days after purchase. Contact your insurance company or agent and verify that coverages are in place before a disaster strikes. Coverage may vary among insurance companies, so communicate with your insurance agent specifically about your policy and what is covered. Homeowner's and renter's insurance does not cover flood damage, only Flood Insurance covers this damage. Renters should remember that they should purchase their own renter's insurance to cover their personal belongings. The Massachusetts Division of Insurance suggests that you prepare for severe weather disasters by reviewing your coverage, understanding your deductibles, and by creating a home inventory. A proper home inventory will create a record of what you own and what it is worth.

Part 2
Coastal Storm Hazards: An Overview for Homeowners

In Massachusetts, many different types of natural hazards can occur, including coastal storms, flooding, tornadoes, severe thunderstorms, drought/extreme heat, wildfire, earthquakes, and even tsunamis. This handbook concentrates on the most likely and potentially devastating hazards in coastal Massachusetts with regard to loss of life and property damage: coastal storms and floods.

Preparing for larger hazard events will offer protection from the smaller, more frequent events. There is much more information available on these hazards than can be provided in this handbook. Included here is only basic information that may play a role in how you, as a homeowner, can prepare for these hazards.

2.1 COASTAL STORM HAZARDS

Residents near the coast in Massachusetts often will hear about erosion caused by hurricanes (part of the Tropical Cyclone spectrum in Table 2-1) and by "nor'easters." Heavy winds, rain, large waves, and storm surge from both types of systems have potential for coastal damage. While there are some significant differences between the two types of systems[2.1], tropical cyclones and nor'easters have several similarities. They are both low-pressure systems characterized by the upward movement of air, counterclockwise (in the Northern Hemisphere) rotating winds, high wind speeds, and flooding of coastal areas by heavy rainfall, storm surge, and waves. Though both storm systems produce similar effects, there are also significant differences. Hurricanes are "warm core" systems, which mean they thrive on warm temperatures, while nor'easters are "cold core" systems, thriving on strong temperature gradients. Hurricanes are most likely to threaten during late summer and early fall whereas nor'easters are more likely during late fall, winter, and early spring.

2.1.1 HURRICANES—TROPICAL SYSTEMS

Hurricanes and tropical storms have tracked over or have passed close to New England many times in the past. Recent examples of hurricanes or tropical storms directly affecting Massachusetts include Irene in August 2011 and Sandy in October 2012 (Figure 2-1). A hurricane is an intense tropical weather system with a well-defined circulation pattern and maximum sustained winds of 74 miles per hour (mph) or more. A tropical storm is also an organized weather system with well-defined circulation, but its maximum sustained winds are lower—between 39 and 73 mph. A tropical depression is a low-level circulation system of persistent clouds and thunderstorms with maximum

Table 2-1. 2012 Saffir-Simpson Hurricane Wind Scale[2.1]

Category	Sustained Wind Speed	Types of Damage Expected Due to Winds
Tropical Depression	≤ 38 mph	Clouds and thunderstorms with a defined circulation, **potential damage**.
Tropical Storm	39 – 73 mph	
1	74-95 mph	**Very dangerous winds will produce some damage:** Well-constructed frame homes could have damage to roof, shingles, vinyl siding, and gutters. Large branches of trees will snap and shallowly rooted trees may topple. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
2	96-110 mph	**Extremely dangerous winds will cause extensive damage:** Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.
3	111-129 mph	**Devastating damage will occur:** Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.
4	130-156 mph	**Catastrophic damage will occur:** Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
5	≥157 mph	**Catastrophic damage will occur:** A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

Source: Adapted from NOAA's National Weather Service website

Figure 2-1. NASA satellite image of Hurricane Sandy in October 2012. The bands of strong winds, rain, and storm surge spread from Florida to New England. Image courtesy of NASA.

sustained winds of 38 mph or less. While far less powerful than hurricanes, tropical storms and tropical depressions can cause substantial damage. As a hurricane weakens and dissipates, it may revert to a tropical storm and eventually a tropical depression. Although the wind becomes less of a threat, weakening tropical storms or even tropical depressions can dump excessive rainfall and sometimes contain embedded severe thunderstorms.

Hurricane strength is often given in categories using the Saffir-Simpson Hurricane Wind Scale,[2.2] which rates hurricanes from 1 to 5 based on the intensity of the sustained winds. Table 2-1 shows expected wind-related damage from the different hurricane categories. It is important to note that the Saffir-Simpson Scale only illustrates the "sustained winds" of a hurricane. Wind gusts can reach up to 135 mph for a Category 2 storm and 160 mph for a Category 3 storm.

Hurricanes may also produce tornadoes that add to their destructive power. During a hurricane, there is a triple threat of damage from high winds, storm surge, and flooding associated with heavy rains.

Storm surge (Figure 2-2) is a large (often 50 to 100 miles wide) dome of water, above the normal or predicted tide level, being pushed toward the shore by the force of the winds

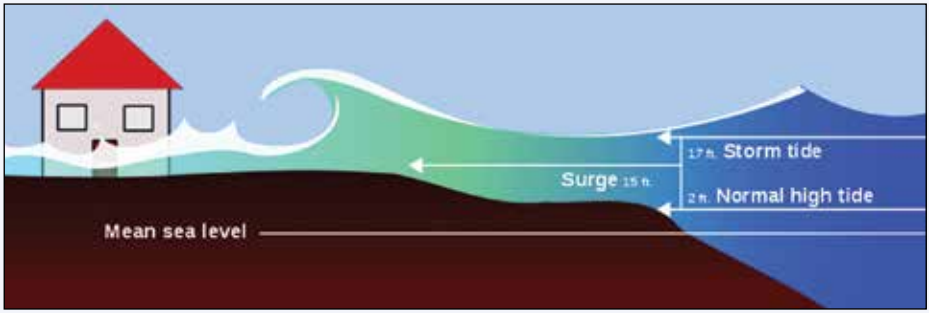


Figure 2-2. Storm surge depiction. Image Credit: NOAA/ The Comet Program.

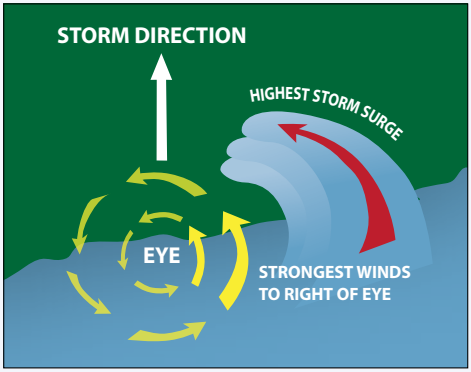


Fig 2-3. The strongest winds and storm surge in a hurricane are typically found on the right side of the storm because the propagation of the hurricane also contributes to its winds. The "right side of the storm" is defined with respect to the storm's motion (e.g. if the hurricane is moving to the north, the right side would be to the east of the storm, etc.).

moving cyclonically around the storm. The worst storm surge usually occurs along the coast to the right of where the hurricane makes landfall (Figure 2-3).

Storm surge typically accounts for 90 percent of storm-related deaths. The impact of the storm surge depends upon the timing with respect to high tide. The highest storm surges usually occur in the upper parts of bays and inlets where the water becomes constricted and forced up. For example, a surge of 20 to 25 feet is possible at the upper part of Buzzards Bay along the Wareham and Bourne shoreline. Along the more open coast, destructive waves can make up for any lower surge. Additional information is available at www.nhc.noaa.gov/surge.

Rainfall totals of 10 inches or more are common when a tropical storm or hurricane

Figure 2-4. The south side of Main Street, Woods Hole, MA during the 1938 Hurricane. Bureau of Commercial Fisheries building on left. Photo Credit: NOAA Photo Library, NOAA Central Library; C&GS Season's Report Thomas 1938-84.

Figure 2-5. Track and intensity of Hurricanes Carol and Edna. These two hurricanes occurred within two weeks of each other in 1954. (Adapted from www.nhc.noaa.gov/outreach/history/).

moves across a coastal location. Rainfall totals of this magnitude can result in destructive flash flooding near streams and rivers. Flooding also causes extensive property damage and agricultural losses. Torrential rains continue in upland areas long after the high winds of a hurricane diminish. A weakening tropical storm or even just a tropical depression can produce destructive, life-threatening flooding as was experienced with Irene in western and northern New England.

A common misperception is that a hurricane or other tropical system will only impact Massachusetts's immediate coast, and therefore, inland residents do not need to prepare. However, records show that all areas of Massachusetts are vulnerable to potentially devastating impacts of tropical storm force winds, torrential rains and associated flooding.

A review of the Massachusetts tropical system history clearly illustrates the need to prepare. Undoubtedly, the Massachusetts hurricane of the 20th century was the New England Hurricane of 1938 (aka "Long Island Express"). This storm made landfall over Long Island and Connecticut as a Category 3 hurricane (Figure 2-4). The winds were devastating; the Blue Hill Observatory in Milton, MA, measured sustained winds of 121 mph with gusts to 186 mph. Trees were blown down even at the Canadian border. Storm surges of up to 12 feet inundated portions of southeastern Massachusetts, with the most notable surges in Buzzards Bay and sections of Falmouth and New Bedford that were buried under 8 feet of water. Yet, this powerful hurricane would have brought even higher surges to Buzzards Bay if it made landfall just a little farther east. Western Massachusetts saw 3 to 6 inches of rain. Roofs, trees, and crops were extensively damaged and power outages were widespread, lasting for weeks in some areas. Overall, 8,900 buildings were destroyed (15,000 damaged) in New England, with 564 people killed and 1,700 injured in southern New England.

In 1954, not one but two very strong hurricanes hit New England, Carol (category 3) and Edna (high-end category 2) (Figure 2-5). Carol's strong winds caused devastation

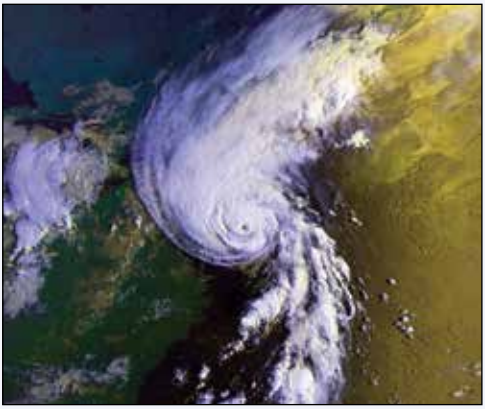


Figure 2-6. Hurricane Bob traveling northeast on August 19, 1991. While it made landfall in Rhode Island some of the strongest wind and storm surge effects occurred to the east of the storm in Massachusetts. Image Credit: NOAA Satellite image (NOAA-10).

from eastern Connecticut to Cape Cod. Making landfall just after high tide, Carol's storm surge caused massive flooding, with the Somerset and New Bedford areas receiving the worst of it in Massachusetts. New Bedford's storm surge was over 14 feet. Rainfall of 2 to 5 inches spread across the region, and peaked in north central Massachusetts at 6 inches. Ten days later, Hurricane Edna barreled up the East Coast, passing over Martha's Vineyard with peak gusts of 120 mph. Portions of eastern Massachusetts and nearly all of Cape Cod and the Islands lost power. The 6-foot storm surge coupled with a rising tide caused severe flooding on Martha's Vineyard, Nantucket, and Cape Cod, and many boats were lost in this region as well. Because Carol had so heavily eroded beaches just days before, these areas were more vulnerable to this second storm. Also, with the storm passing to the east, a heavy rainfall of 3 to 6 inches covered most of Massachusetts, with northeastern parts of the state receiving 7 inches. Still saturated from the rains of Carol, the area experienced extensive urban and stream flooding, with street washouts common, especially in northeast Massachusetts where rivers rose several feet above flood stage. Such storms are unpredictable, and "100-year" events (events that have a 1% chance of occurring in any given year) can happen in rapid succession. Less than a year after Carol and Edna, Connie and Diane dumped almost 25 inches of rain in parts of Massachusetts, causing unprecedented flooding, with 40 percent of downtown Worcester submerged.

Hurricane Bob barreled into Massachusetts in August of 1991 (Figure 2-6). Although this Category 2 hurricane was not among the worst in terms of wind speed or storm surge, the property damage totals alone secured a top-three spot for Hurricane Bob. The Category 3 storms from earlier in the century packed more of a punch, but the extensive coastal development in the second half of the 20th Century left many more homes and other structures in the path of Bob's fury. Overall, New England experienced $680 million in damage, $39 million in Massachusetts alone. Most of southeast Massachusetts faced hurricane-force winds, with coastal communities in these areas seeing sustained winds of 75 to 100 mph. Brewster and North Truro experienced gusts

Figure 2-7. Popponesset Barrier Beach, Mashpee, before (top) and after (bottom) Hurricane Sandy showing multiple breaches of the dune system as well as an overall lowering of dune elevation.

of 125 mph, with North Truro enduring sustained winds of 100 mph. Trees and utility poles were routinely damaged, and 60 percent of the residents of southeastern Massachusetts lost power. The storm surge in Buzzards Bay was 8 to 12 feet, ripping boats from their moorings, destroying homes and eroding large sections of coastline. Onset, Bourne, Mashpee, and Wareham saw the worst surge, 10 to 12 feet. Mattapoisett was also hit hard, with 29 of 37 homes destroyed on Cove Street and 32 of 35 homes destroyed on Angelica Point. Southern-facing shorelines experienced significant erosion, with some spots along Martha's Vineyard and Nantucket losing up to 50 feet of shoreline. (From www.nhc.noaa.gov/outreach/history/and www.mass.gov/eea/agencies/czm/publications/pages/worst-hurricanes.html.

Even a "near miss" or "glancing blow" from a powerful storm can cause significant flooding and erosion to the coastal portions of Massachusetts. In October of 2012 Hurricane Sandy made landfall over 200 miles south of Massachusetts (just barely qualifying as a category 1 with maximum sustained winds near 75 mph). However because of its tremendous size, it still created enough damage in Massachusetts for federally declared disaster funding made available to public agencies (not private property owners) in Barnstable, Bristol, Dukes, Nantucket, Plymouth, and Suffolk counties (Figure 2-7). While Hurricane Arthur (2014) did not directly hit Massachusetts, it did impact Nantucket, leaving flooding, erosion, and significant power outages on the island. Significant flooding of some streets in the Nantucket Harbor area was caused by a combination of heavy rain and high tide. The rain water could not drain into the harbor because of the high tide (only a few tenths of a foot below flood stage). Additional damage was created by boats breaking free from their moorings and washing up on the beach, or crashing into neighboring boats. Boat owners may want to inspect their boat, or even remove it from the water before the storm hits.

Figure 2-8. Wave damage from the of 1978 nor'easter along Peggotty Beach, Scituate, MA. Photo Credit: NOAA Photo Library.

2.1.2 NOR'EASTERS—EXTRATROPICAL STORMS

While not as powerful in terms of wind speeds as hurricanes, nor'easters (also called northeasters) occur more frequently in Massachusetts. Because they cover a larger area and are typically slow-moving storms, nor'easters usually affect a large portion of the coast and exert significant impacts on beaches, dunes, buildings, and roads over several successive tides. Nor'easters are most damaging when they stall off the coast.

Nor'easters are a year-round threat to Massachusetts but occur more frequently during the winter and early spring months. These intense storms move along the coast with winds blowing directly from the northeast, right off the Atlantic Ocean onto the shoreline. They develop from low pressure centers that derive their energy from the

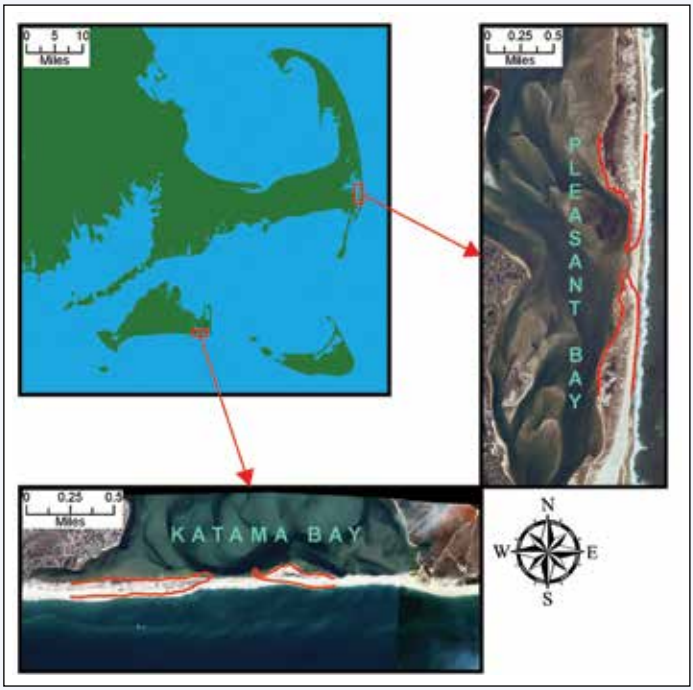


Figure 2-9. Locations of the barrier island breaches that occurred during the April 2007 storm. The US Army Corps of Engineers (USACE) collected the aerial photograph shortly before the storm and the red lines were extracted from elevation data collected after the storm breached the barrier beaches.

strong temperature gradients that commonly occur just off the United States east coast during winter.

Nor'easters typically produce winds ranging from 30 to 40 mph, with gusts that can exceed 74 mph (i.e., hurricane force). These strong winds can create destructive waves over 20 feet high, depending on the storm's duration and location relative to the shoreline. The size and strength of these waves can erode beaches and dunes and demolish buildings, boardwalks, and roads. Tidal flooding is also a serious hazard associated with nor'easters. Storm-tide heights of 3 to 5 feet above normal are especially damaging when they bracket several tidal cycles. The torrential rainfall from nor'easters can cause extensive flooding in both coastal and inland areas.

The nor'easter that struck in February of 1978 was described as "awesome" by then Massachusetts Governor Michael Dukakis (Figure 2-8). The storm stalled to the south of Cape Cod where it produced hurricane force winds, and a 5' storm surge. When added on top of the astronomical high tide (aka Spring Tide) this resulted in a water level of over 15' above MLLW in Boston, a record that still stands as of the printing of this handbook. Spring tides occur during the new and full moon phases when the gravitation pull of the moon and sun act in combination. The combination of strong northeast winds and long duration (typical to nor'easters) along with astronomically high tides allowed waves to cause serious erosion resulting in seawall breaks, washed-out roads, destroyed parking lots and thousands of homes along the coast. This storm caused 73 deaths (4,324 injuries) and over $500 million in damage. (From www.erh.noaa.gov/box/papers/blizzard78/mainblizzardof78.htm).

The Patriot's Day Storm of April 15-17, 2007 cut new inlets into breached barrier beaches at both Pleasant Bay and Katama Bay (Figure 2-9). Nor'easters have been responsible for all of the significant openings at these two barrier beach systems in recent times. While some breaches will close by themselves in a short amount of time (e.g., Hurricane Bob briefly opened Katama Bay in 1991), both of these 2007 breaches became new inlets for their respective bays. Nor'easters can represent the greatest coastal flooding threat to east and north facing bays (e.g., Pleasant Bay). This threat is exacerbated by the orientation of the inlets relative to the northeast direction of the storm waves, and due to the relatively slow rate of speed at which these systems move. The large storm driven waves increase water in a bay above normal tidal height, while the duration of these waves restrict the discharge of water on outgoing tidal cycles resulting in minimal low tides and higher high tides.

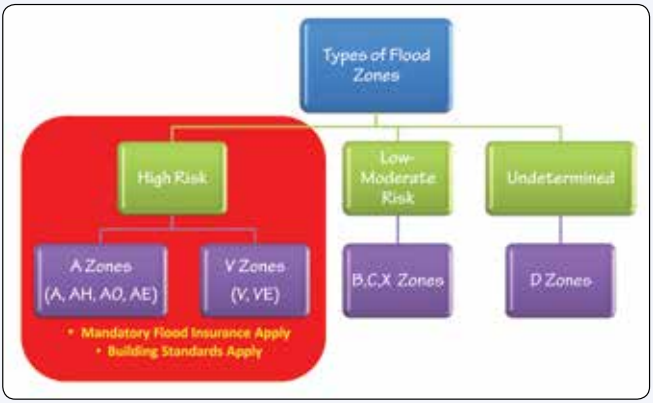


Figure 2-10. High Risk Flood Zones are in the Special Flood Hazard Area (subject to inundation by the 1 percent annual chance flood or 100-year flood). They consist of small waves and flooding (A zones) as well as high-velocity wave action (V zones) near the coast. In addition, there are areas of low-moderate risk (B, C, X zones) and areas where the risk is undetermined (D zones). Even in these zones, the homeowner should consider flood insurance if there are localized flooding or drainage conditions on their property as indicated by past weather or storm events. Image courtesy Hawaii Department of Land and Natural Resources.

2.2 FLOOD HAZARDS

Flooding is probably the most common natural hazard in coastal Massachusetts. Flooding can be caused not only by a hurricane, but also by a tropical storm, tropical depression, nor'easter, or any other weather system that produces heavy rain. Flooding can build up gradually over a period of days or suddenly in a few minutes (commonly known as a flash flood). Coastal flooding can result from high tides (usually on either side of a new or full moon), storm surge, waves generated by storms located hundreds or thousands of miles from Massachusetts, or a combination of any of these mechanisms.

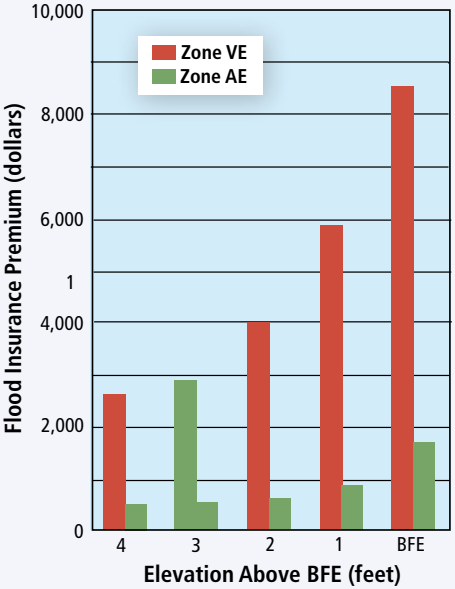
Flooding can be associated with living near a coastal body of water such as the ocean, or inland water body, such as a stream, river or reservoir. To determine whether you are in a high-risk flood area, look at the Federal Emergency Management Agency's (FEMA) Flood Insurance Rate Maps (FIRMs). These maps show what areas are susceptible to flooding and high velocity wave action (for those near coastal areas) from a one percent annual chance event (a.k.a. 100-year flood). Electronic copies of the maps can be downloaded from FEMA's Map Service Center (www.msc.fema.gov/portal). Copies of the maps may also be available for viewing at your town or city hall building departments.

Flood Zones are geographic areas that FEMA has defined according to varying levels of flood risk. They are depicted on a community's FIRM and each zone reflects the flood

risk severity or type of flooding in the area. Generally, these zones can be identified as one of three risk classifications (see Figure 2-10).

Even if you are not in a high-risk flood zone, you may nonetheless be at risk from flooding, as flood zone mapping is based on computer modeling to predict the extent of flooding. Although the best available science is used, floods do frequently extend beyond mapped flood zones. Some FIRMs in Massachusetts are over 20 years old; changing coastal conditions, such as coastal erosion and sea level rise, may mean that your property could be more at risk than the FIRM indicates. According to FEMA, nearly 20 percent of flood insurance claims come from low-to-moderate risk areas. Go to www.floodsmart.gov and type in your street address to determine a very general estimate of the flood risk for your property.

The US Army Corps of Engineers (USACE) has updated hurricane inundation maps for coastal communities in Massachusetts as part of an update to the New England Hurricane Evacuation Study. (http://www.mass.gov/eopss/agencies/mema/hurricane-inundation-maps.html). To be safe, people are always encouraged to prepare for the impacts of one category higher hurricane than the storm's official strength. These are different from Flood Insurance Rate Maps (FIRM) in that they show the worst case surge flooding as a result of the different categories of hurricanes. These correlate with evacuation planning maps mentioned in section 3.3. Another resource is the hurricane inundation maps produced by the National Hurricane Center when a coastline is placed under a Hurricane Watch or Warning. These hurricane inundation maps depict the plausible worst case inundation that could occur from a particular threatening storm. These maps are only produced, when a shoreline is sufficiently threatened by a hurricane to merit the issuance of a Hurricane Watch or Hurricane Warning.



Graph 2-11

Maximum coverage for a $250,000 residential building and $100,000 contents (adapted from FEMA Fact Sheet *Building Higher in Flood Zones: Freeboard—Reduce Your Risk, Reduce Your Premium* 06-19-14).

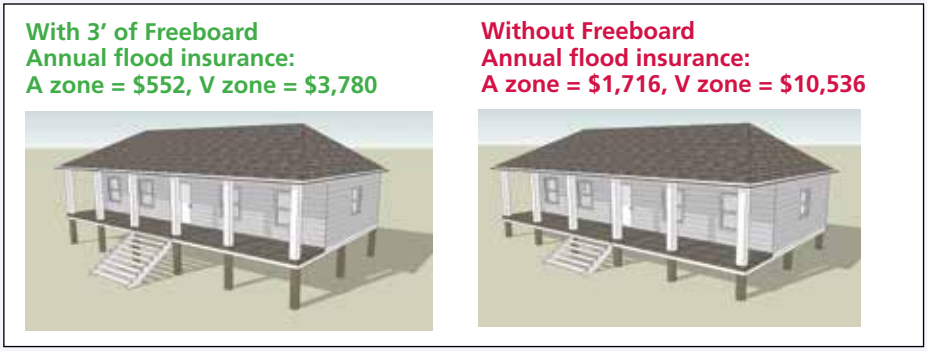


Figure 2-12. In this example, adding a small amount of height has very little effect on the look of a home, but results in a substantial flood insurance savings.[2,3] Image courtesy of MassCZM, more information available at at www.mass.gov/eea/docs/czm/stormsmart/ssc/ssc5-freeboard.pdf

A good way to determine the risk of flooding for your house is to observe and study your property, looking for potential nearby sources of flooding or blockages of surface flow. If your property is immediately adjacent to a road or drainage ditch there is the potential for water to accumulate in the ditch due to blocked culverts. If the crown of the nearby road is higher than your driveway or crawl space, this may be an indication that heavy rainfall runoff could accumulate on your property, regardless of whether you are in a mapped floodplain.

Even inland properties may be susceptible to flooding if there is poor localized drainage or if recent development has altered the ability of water to drain out of your area. If your property floods during small rain events, then the problem will be greater during a severe storm or hurricane. You can protect yourself by improving the local drainage, making your house resistant to floods, and purchasing flood insurance. You do not need to be in a high-risk flood zone to obtain flood insurance.

For those located within a flood zone, elevating a building's lowest floor above predicted flood elevations by a small additional height (known as "freeboard") has very little effect on the look of a home, yet it can lead to substantial reductions in damages caused by flooding as well as reductions in flood insurance cost (Graph 2-11 and figure 2-12). Consult with your local floodplain manager (www.fema.gov/floodplain-managers) to determine how much freeboard (if any) is needed for your property for flood insurance savings.

Even if you are not in a flood zone, you should consider purchasing flood insurance, especially as properties located outside of an official flood zone might also be at risk from flooding. The rates for properties outside mapped flood zones are very affordable and are invaluable if a flood event should occur.

Part 3
Protecting Yourself and Your Family

This part of the handbook covers the topic of protecting yourself and your family from coastal hazards. In particular, it is important that your household has a stock of emergency supplies, an evacuation kit, and evacuation plans for several types of hazards, including floods and coastal storms (hurricanes and/or nor'easters). Your response may differ depending on the nature of the threat. You should discuss and practice the evacuation plan with your family once a year or whenever there is a major lifestyle change (for example, when a member of the family goes to a new school or is working in a different location).

3.1 EMERGENCY SUPPLIES

A general rule of thumb when preparing for a hazard event is to plan to be self-sustaining for the first 72 hours (three days) after a hazard event. Due to a lack of access or availability, basic supplies may be unobtainable, so it might be wise to have supplies for three to five days depending on the type and extent of the disaster event. Therefore, a stock of emergency supplies will be helpful during a major event like a hurricane, tropical storm, or nor'easter, as well as for a minor event like a simple power outage. The importance of these supplies has been demonstrated during several recent storms—such as Hurricane Irene in 2011, Hurricane Sandy in 2012, the Halloween snowstorm in 2011, and the February 2013 blizzard. These storms knocked out power for multiple days in many areas in Massachusetts.

Your emergency supplies should be gathered as soon as possible and checked monthly to ensure that they are complete, unused, and fresh (mark and check expiration dates). Old food and water should be used or discarded and replaced with fresh supplies. Do not keep expired supplies. Your supplies should include at least the following:

- Portable radio, flashlight, and extra batteries (or flashlight and radio with hand-crank rechargeable batteries);
- NOAA weather radio;
- First-aid kit;
- List and supply of special medications (prescriptions and others);
- Three-day supply of nonperishable foods;

- Hibachi with charcoal, camping stove with fuel, or barbeque grill with propane. Do not use these items indoors or in an area with no ventilation. Follow all manufacturer instructions.
- Manual can opener;
- Matches or lighter;
- Disposable plates and kitchen utensils;
- Supply of water—A reasonable estimate is one gallon per person per day for drinking, cooking, and personal hygiene needs. It is important to have available good water containers for any water-interruption situations. Four- to six-gallon water containers are readily available in stores. Larger containers that sit in a bath tub and can be used to store up to 100 gallons of potable water are also available. Remember to store water for toilet use (in bathtubs, rubbish containers, washing machines, water heater, etc.);
- Pet supplies (food, water, bedding, carrier, leash, medications);
- Spare cash—automated teller machines require electricity to operate and may not be available or accessible for weeks.

Additional items you may want to add to your stock include:

- Sanitary supplies and/or a portable toilet;
- Waterproof plastic sheeting or tarp, string or rope, and duct tape;
- Cell phone with a car charger and a hardwired single line phone—cell phone networks may be overloaded during times of natural hazards. Cordless phones with a base station will not work without electricity. If you need to rely on cordless phones, get an alternate source of power. Otherwise, have an old-fashioned corded phone. Use your phone only in an emergency during a natural hazard event;
- Bedding and clothing for each person;
- Blankets and towels;
- Rain jackets and pants;
- Sunscreen and bug repellent;
- Baby supplies (diapers, food, medication);
- Toothbrush, toothpaste, soap, shampoo, cleanser, bleach, trash bags, towelettes, water-free hand disinfectant;

- Copies of important documents—driver's license, social security card, proof of residence, insurance policies, wills, deeds, birth and marriage certificates, tax records, medical records, family pictures, etc.;
- Alternate power supplies. During an emergency or power outage, alternative sources of power may be needed (among these are generators, inverters, power stations, and battery chargers). See Part 4 of this book for descriptions of alternative power sources that may supplement your emergency supplies.

Note that if you plan to take shelter in your home (outside the flood evacuation zone, well inland of the strongest winds of a hurricane, and in an exceptionally strong dwelling), you may wish to have more than five to seven days of supplies. There is always the possibility that a major storm or hurricane can disrupt the supply line of goods. If space is available and your house is protected, stocking up for a two-week period is prudent. Gather supplies over a period of time rather than rushing out during an emergency when shortages are likely.

3.2 EVACUATION KIT

The evacuation kit differs from your stock of emergency supplies because the kit is what you will take if you need to leave your house in an emergency. Your evacuation kit should be prepared as soon as possible and can be checked before the beginning of hurricane season, which runs June 1 to November 30. The components of the kit should be stored in one place, perhaps in a duffle bag or backpack, so that it is ready to go at a moment's notice. The kit is primarily for evacuation during a hurricane, although it could be used for other situations. It may include:

- One gallon potable water per day per person;
- Personal items and family needs, such as a two-week supply of daily prescription medications, a three-day supply of nonperishable food and any special dietary foods, manual can opener, infant formula and diapers, prescription eyewear and personal hygiene items such as waterless cleaner, toothbrush, toothpaste, and toilet paper;
- List of any required medications, special medical information, medical care directives, health insurance card, personal identification, and other important documents;
- First-aid kit;
- Flashlights, batteries, and spare bulbs;
- Portable radio with spare batteries;
- Change of clothes and towels;

- Pillows, blankets, and folding mattresses/air mattresses.

A general recommendation is that the evacuation kit should contain supplies for five to seven days. Should the supply chain be disrupted (because of damage to airports or warehouses, for example), you will be better off than others who do not have adequate supplies.

There is a fine line between bringing too many supplies that overload limited shelter space and not bringing enough. However, if you go to a shelter, keep in mind that there will be limited space, so bring only what is recommended unless you are instructed otherwise by your local emergency management agencies.

3.3 EVACUATION PLANNING

While many homeowners would likely access local shelters, many tourists may attempt to leave coastal areas if a serious storm is predicted. Some plans exist to facilitate the egress of a high volume of traffic in the event of a hurricane or other potential high hazards, particularly during peak tourist season. Traffic flow should factor into your evacuation planning, regardless of whether your community has a formal plan. An example is the Cape Cod Emergency Traffic Plan (CCETP). While it's not an evacuation plan, it can be used under any circumstance when public safety officials deem it necessary to facilitate the flow of traffic off of the Cape. Designed around Cape Cod and the potential issues which could exist with large traffic volumes during storms in mind, this plan can be broken down into six stages. The largest amount of activity in the plan occurs during the Execution Stage. This stage has two components. The Traffic Operations component establishes various traffic control points to help mainstream traffic off Cape Cod. The Sheltering Operations component establishes a shelter of last resort on the Joint Base Cape Cod, to shelter motorists who are unable to leave the Cape due to the closure of the Bourne and Sagamore Bridges as a result of adverse weather conditions (Figure 3-1). An interactive map of shelter information is available via the Barnstable County Regional Emergency Planning Committee (www.bcrepc.org). During

Figure 3-1. The opening of the Cape Cod Canal in 1914, and subsequent acquisition then widening by the U.S. Government in the 1920-30s, effectively made Cape Cod an island. The bridges over the canal provide the only escape by land from Cape Cod during an emergency. Image courtesy of Richard LaTour.

an activation of this plan, variable message boards will be on main roads with updates on the plan and advisories for motorists. Citizens can also tune to 99.9 FM, WQRC radio, for the latest updates on the activation of the CCETP. Visit Visit http://www.mass.gov/eopss/agencies/mema/for further information and maps from this plan.

In Massachusetts, it is important for families to plan for various natural hazard events, including floods and coastal storms. The MEMA initiative "Know your Zone" pertains to new evacuation planning maps which have been created for coastal communities. Based on hurricane modeling, these new maps outline areas which may be called on to evacuate in the event of a hurricane or major storm that will bring inland surge and flooding. See: http://www.mass.gov/eopss/agencies/mema/hurricane-evacuation-zones.html. Residents should know which zone they live in, if any, so that they can evacuate if an order is given. When you put your evacuation plan together, here are some things to consider:

- Stay alert, stay calm, and be informed (tuning in to local radio and television is important). Create an evacuation plan and review it with your family every year.
- Evacuation procedures for a hurricane or coastal storm may differ from those of an inland flooding event. You must plan for both. In a hurricane or strong coastal storm, you must protect yourself from strong winds, torrential rain, and coastal inundation. In a flood, you must protect yourself from rising water.
- Listen to your local radio and television stations carefully as there may be additional or modified directions based on the type of disaster and best available information at that time. Mother Nature is unpredictable, and a team of scientists and emergency responders will always be monitoring unusual conditions for public safety. "Local" means radio and television broadcasts specific to the area in which you live. Television is important but because a station may broadcast over a larger area—including multiple states—the information provided may be more applicable to one area than another.
- Your evacuation plan should consider yourself, the members of your family, those with special health needs for whom you take responsibility (like the disabled or elderly), and your pets. Practice evacuation procedures with your family through yearly drills.
- In an evacuation or emergency situation, it is expected that all able-bodied persons (men, women, and children) should be able to take care of themselves if they act calmly and with proper direction. This is why it is important to practice your plan regularly.

- Parents should confirm with their child's school the evacuation plans that are in place, specifically, where the students will be held and for how long during each type of natural hazard. You should not have to drive to school to pick up your children.
- As part of your evacuation plan, consider how family members will communicate if they become separated. Each family member should have a list of telephone and cellular phone numbers and email addresses of everyone in the family and phone numbers of a few contacts outside of the family. This list should be readily accessible and not require power to access (e.g., not stored on a cell phone or computer).
- If needed, develop a plan to help those who cannot help themselves, such as the disabled or those with limited mobility. If people with special health needs are with a care provider, confirm that the care provider has an evacuation plan. Otherwise, you, your relatives, your friends, or a specified designee can take responsibility for that person. Confirm that neighbors in this category will be taken care of.
- Develop a plan for your pets. Listen to local radio to determine if there are any pet-friendly shelter locations near you. Pets entering such shelters should be caged and owners must provide food, bowls, bedding, waste disposal bags, leash, and medication for their pets. If possible, take your pet with you to high ground outside of the evacuation zone. Detailed disaster preparedness information for pet owners is available at at www.mass.gov/eopss/agencies/mema/ready-massachusetts/pets-and-animals-in-emergencies.html
- If you are outside an inundation zone or flood zone and in a strong house that is located in a safe and appropriate location, you may be better able to store food and water and take care of your loved ones—including those with special health needs, the elderly, and your pets. This is why it is important to strengthen your home as much as possible. A strong house is built with connectors that tie the roof to the walls and the walls to the foundation (see Part 4). In addition, the house should have coverings for windows that protect against wind pressure and impacts.
- In general, stay off the roads. Only drive if it is absolutely essential. The police may close many roads during an emergency, so people can exit a highway, but not necessarily get on it.
- Monitor official radio and television broadcasts for an updated list of refuge areas or shelters that may be open for a specific hazard event. Do not count on all shelters to be open. Immediately following a large disaster, suitable shelter sites will be selected from a pre-designated list based on the type of hazard, areas of need, and estimated numbers of displaced people. Therefore, it is not possible to say in advance with

certainty which sites will actually operate as shelters. As soon as specific emergency shelter sites have been formally designated, this list will be announced through local media to the public. When shelters are open, the list will also be included on the American Red Cross website (www.redcross.org). If it is unsafe to shelter-in-place and you do not have an alternative, evacuate to a designated emergency shelter.

- Plan and prepare to be at your evacuation point for several hours or days. Plan for a minimum of 72 hours, but it would be wise to prepare to be self-sustaining for three to five days, depending on the type and extent of the disaster.
- Know the difference between a watch and a warning. Do not confuse the two (see Part 3.4 below). When each is triggered, there are different actions you and your family should take. Also note that state and local emergency management agencies may issue a mandatory evacuation.

3.4 KEY DEFINITIONS

Hurricane Watch. Sustained winds of 74 mph or higher are possible in the specified area of the watch, usually within 48 hours. During a watch, prepare your home and review your plan for evacuation in case a hurricane warning is issued. As discussed earlier, preliminary preparations should begin even before a watch has been issued.

Hurricane Warning. Sustained winds of 74 mph or higher are expected in the specified area of the warning, usually within 36 hours. Complete hurricane preparations and leave the threatened area if directed by officials.

Tropical Storm Watch. Winds of 39 to 73 mph or higher pose a possible threat, generally within 48 hours. These winds may be accompanied by storm surge, coastal flooding, and/or river flooding. During a watch, prepare your home and review your plan for evacuation in case a tropical storm warning is issued.

Tropical Storm Warning. Winds of 39 to 73 mph or higher associated with a tropical cyclone are expected in 36 hours or less. These winds may be accompanied by storm surge, coastal flooding, and/or river flooding.

Coastal Flooding. Minor Flooding—minimal or no property damage, but possibly some public threat or inconvenience. Moderate Flooding—some inundation of structures and roads near streams. Some evacuations of people and/or transfer of property to higher elevations are necessary. Damage to vulnerable property such as docks and ocean-facing decks is possible. Major Flooding—extensive inundation of structures and roads. Significant evacuations of people and/or transfer of property to higher elevations. Structural damage to at least some vulnerable homes or businesses is likely.

Coastal Flood Advisory. Minor coastal flooding is occurring or imminent. Listen to the NOAA weather radio station or local radio stations or check your local television station for information.

Coastal Flood Watch. Moderate to major coastal flooding is possible. Such flooding would potentially pose a serious risk to life and property. Be prepared to move to higher ground—listen to the NOAA weather radio station or local radio stations or check your local television station for information.

Coastal Flood Warning. Moderate to major coastal flooding is occurring or imminent. This flooding will pose a serious risk to life and property. Take necessary precautions at once. If advised to evacuate to higher ground, do so immediately.

Flash Flood or Flood Watch. Flash flooding or flooding is possible within the designated watch area. Be prepared to move to higher ground—listen to the NOAA weather radio station or local radio stations or check your local television station for information.

Flash Flood or Flood Warning. Flash flooding or flooding has been reported or is imminent. Take necessary precautions at once. If advised to evacuate to higher ground, do so immediately.

Severe Thunderstorm Watch and Warning. A Severe Thunderstorm Watch is issued when severe thunderstorms are possible in and near the watch area. It does not mean that they will occur; it only means they are possible. A Severe Thunderstorm Warning is issued when severe thunderstorms are occurring or imminent in the warning area. Severe thunderstorms are defined as having winds of 58 mph or higher and/or hail 1 inch in diameter or larger.

Tornado Watch and Warning. A Tornado Watch is issued when severe thunderstorms and tornadoes are possible in and near the watch area. It does not mean that they will occur; it only means they are possible. A Tornado Warning is issued when a tornado is imminent. When a Tornado Warning is issued, seek safe shelter immediately.

3.5 EMERGENCY NOTIFICATION SYSTEMS

If a situation or event becomes a potential threat to Massachusetts residents and visitors, the public will be alerted by one (or several) of the following methods, as appropriate:

Local Notification Systems. Many communities (and some counties) in Massachusetts operate local emergency notification ("reverse 911" type) systems that may require registration in order to get local notifications. Depending on the community and the system, these systems may provide alerts to landline phones, cell phones, or email addresses. These systems provide the most localized emergency information in a community and are

controlled by local officials. The public is encouraged to sign up for these local notification systems which can be done by contacting local public safety agencies.

Emergency Alert System. The Emergency Alert System (EAS) can be activated by the Governor, the Massachusetts Emergency Management Agency, the Massachusetts State Police, or the National Weather Service. The EAS can disseminate messages to TV and radio stations throughout the state with important emergency information.

Social Media (Facebook and Twitter). The Massachusetts Emergency Management Agency uses social media accounts on Facebook and Twitter to provide information during emergencies. This information can be viewed by the public on these platforms even by people who do not have accounts on these sites. The sites can be accessed at www.facebook.com/MassachusettsEMA and www.twitter.com/MassEMA.

Massachusetts Alerts! (Smartphone application). Massachusetts Alerts! (powered by ping4alerts!) is a new FREE mobile communications app for alerting the public in emergencies and disasters. Through geofencing technology, Massachusetts Alerts! enables MEMA to send highly targeted, instant multimedia messages to iPhone and Android devices to notify citizens to situations and events happening near them. The app also provides severe weather messages for the user's area with direct feeds from the National Weather Service. More information can be found at www.mass.gov/eopss/agencies/mema/massachusetts-alerts.html**Wireless Emergency Alerts.** The wireless industry, the FCC, and FEMA are developing the Wireless Emergency Alerts (WEA) system which will deliver messages directly to cell phones based on geographic location at no charge to the user. Currently the National Weather Service and MEMA send severe weather alerts. This is only for certain newer cell phones that are marked "Wireless Emergency Alerts Capable." More information can be found at www.fema.gov/wireless-emergency-alerts.

Other sources of information during an emergency:

- Local news media may provide up-to-date, real-time emergency information;
- Some counties may have online resources, for example the Barnstable County Regional Emergency Planning Committee has up-to-date notification for shelters and situational awareness through the storm www.bcrepc.org.
- NOAA All-Hazards Radios provide an excellent source of up-to-date, real-time emergency information, particularly severe weather alerts;
- Police and fire department personnel may use loudspeakers and make door-to-door contacts;
- **Mass 2-1-1.** 2-1-1 has been designated as the primary telephone information call center during times of emergency to reduce the number of non-emergency calls made to

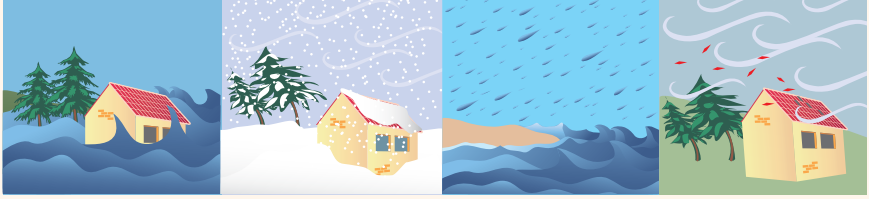
9-1-1. Callers can get updated disaster and shelter information, numerous post-disaster programs, and interpreter services. Available 24 hours per day with multilingual services. Information is also available on their website at www.mass211.org.

- **MEMA website.** The front page of the MEMA website www.mass.gov/eopss/agencies/mema/ is updated to provide information during major emergencies and disasters and also includes a feed of their most recent Twitter posts.
- Announcements from town harbor masters or an Urgent Marine Information Broadcast from the U.S. Coast Guard for maritime related emergencies
- A message on Teletypewriters (TTYs) if you have registered with a community Emergency Management Office to be notified over TTY in case of an emergency.

3.6 PREPARATIONS BEFORE A HURRICANE OR COASTAL STORM

The following precautions should be taken well before a hurricane or severe coastal storm arrives:

- Wedge sliding glass doors with a brace or broom handle to prevent them from being lifted from their tracks or being ripped loose by wind vibrations.
- Unplug all unnecessary appliances. Shut off gas valves.
- Turn refrigerators and freezers to their coldest setting.
- If you are going to evacuate, shut off electricity at its main switch and gas and water at their main valves.
- Package your valuables, such as jewelry, titles, deeds, insurance papers, licenses, stocks, bonds, inventory, etc., for safekeeping in waterproof containers. Take these with you if you are going to evacuate. However, valuables such as jewelry should not be taken to a shelter.
- Outside, turn down canvas awnings or roll them up and secure them with sturdy rope or twine.
- Check door locks to ensure doors will not blow open.
- Check outdoor items that may blow away or be torn loose; secure these items or move items such as potted plants inside.
- Store chemicals, fertilizers, or other toxic materials in a safe section or secure area of the premises.
- Secure propane tanks (both portable tanks for grills and larger tanks typically stored outside). They should not be stored near sources of heat (like your water heater or other appliances) or below the expected flood elevation.
- Fill the gas tank of your car and fill fuel cans for generators.
- Deploy window protections well in advance of the arrival of any winds. For those who



have already prepared plywood shutters, partial deployment could begin before there is any official hurricane or coastal storm warning. Closely monitor advisories and warnings to guide your deployment (see Part 4).

- Ensure that you have a sufficient amount of cash in hand to purchase goods and items if needed following the hurricane, as banks and ATM machines may be inaccessible because of a lack of electricity.

3.7 EVACUATION PROCEDURES FOR A HURRICANE OR COASTAL STORM

Your emergency supplies and evacuation kit should already be in place before there is a hurricane watch or warning. In your evacuation plan, you should already have decided if you will stay in your house, go to a shelter, or go elsewhere (e.g., a friend's or relative's house). You should stay in a place that is away from any flood or inundation zones and that is able to withstand strong winds and rain. If you evacuate, you should already have prepared your house and made plans for your pet. Shelter locations are not designated in advance but are determined based on the type and location of hazard event. If you plan to go to a shelter, listen to your local radio or television station for information about the closest open shelter location.

- As a general guideline, you should evacuate if you are located:
  - along low-lying coastal areas;
  - along low-lying areas subject to flooding (for example, near a stream or river);
  - in any Federal Flood Insurance Zone such as a high velocity wave zone (V zone) or flood zone (A zone), even if your house is built for wave action and flooding;
  - along ridge lines exposed to strong winds;
  - in certain wood-frame structures (e.g., single wall without a continuous load path design) or lightly constructed buildings.
- Go to a shelter only if it is open (find out by calling 211 from any land line phone). Listen to your local radio station or connect to (www.redcross.org) for a list of shelters that are open to the public. Local television stations may also provide this information. Shelter locations will be specific to the type of hazard and threat posed by the event.
- Listen to instructions issued by emergency management officials and evacuate with your evacuation kit before danger arrives. If you're evacuating to a designated shelter, follow the directions of personnel who are staffing the shelter. If there are no personnel, the shelter is either not open or you are at a part of the facility that is not being used as a shelter.
- When you get to an evacuation shelter, you will have limited space and there may be a bare floor. You should plan to provide your own bedding and other essentials such as personal hygiene items and medications. Your evacuation kit should contain all of these important items.
- Make the best of the situation and cooperate with the volunteers.

- Local emergency management officials and/or shelter staff will provide notification when it is safe to return home.

3.8 PREPAREDNESS, SAFETY, AND EVACUATION PROCEDURES FOR A FLOOD

Most flash floods are caused by slow-moving thunderstorms, thunderstorms that move repeatedly over the same area, or heavy rains from tropical storms and hurricanes. Each year, more deaths occur due to flooding than from any other thunderstorm-related hazard. The main reason is people underestimate the force and power of water. Many of the deaths occur in automobiles as they are swept downstream. Whether you are driving or walking, if you come to a flooded road, "turn around, don't drown." You will not know the depth of the water nor will you know the condition of the road under the water.[3.1]

If you are in a flood warning area or if flooding occurs, get to higher ground immediately. Get out of areas subject to flooding and avoid areas already flooded. Never attempt to cross swiftly flowing water or waters of unknown depth by foot or in an automobile. Do not attempt to cross flowing streams, even a small one, on foot. Road beds may be washed out under flood waters. Never drive through flooded roadways and do not attempt to cross water-covered bridges, dips, or low water crossings. Be especially cautious at night when it is harder to recognize flood dangers. [3.1]

The general rule if you are evacuating from a flood is to stay away from flood waters and head to higher ground. Stay away from moving water. Even 6 inches of water can make you fall or cause your car to stall. Two feet of moving water can move your car. If there is a flash flood and you are caught in your house, go to the second floor or the roof, if necessary.

3.9 EMERGENCY INFORMATION AND CONTACTS

For general emergency information, contact your local emergency management agency. A directory of local emergency managers can be found on the MEMA website (http://www.mass.gov/eopss/agencies/mema/). Many communities also have Citizen Corps programs such as Community Emergency Response Teams (CERTs) to promote volunteerism and assist in training and educating the citizens of Massachusetts on various emergency preparedness topics.

The best time to contact them is when there is no emergency; use them as a resource when you are planning and preparing your evacuation plan. Do not wait until an emergency when these agencies are responding to the emergency. Nevertheless, call them if you absolutely need help. However, by planning and preparing ahead, you can help yourself and the agencies.

Please see Appendix A for a list of emergency contact information and Appendix B for shelter information.

Part 4
Protecting Your Property

Protecting your property and protecting your family go hand in hand, since your house may be able to provide shelter from most weather conditions and perhaps even severe conditions. It's never too early to prepare, and you can take several basic steps right now to protect your family and your home from disaster. By strengthening your house, you can reduce the risk of damage to your home and possibly reduce insurance premiums. The amount of protection your house can provide from a natural hazard is limited by a number of factors that you should very carefully consider:

The Severity of the Hazard Event

Protecting your home against a nor'easter or a tropical storm is much easier than against a major event such as a Category 2 hurricane. For stronger storms, eliminating all damage is very difficult, so the main goal is to significantly lessen the amount of damage that could occur. Each and every small improvement you invest in your home can make a difference. The more small improvements you make to your home, the less likely there will be severe damage during minor events.

Your Location

Buildings in proximity to water are much more likely to flood, even during minor storm events. These flooding events can threaten you and your family, and evacuation should be considered even during minor events. In addition, if your home is close to an open beach, a large bay, or a large marshland area, the force of the wind can be much greater than if the house were surrounded in all directions by buildings, other homes, and/or trees.

How and When Your House Was Built

The current Massachusetts (8th Edition) Residential Code is comprised of the International Residential Code 2009 (IRC) and a separate package of Massachusetts amendments to the IRC. In no way is this handbook intended to alter the requirements of the state building code and all work should conform to the most recent version available on the Massachusetts Board of Building Regulations and Standard webpage (www.mass.gov/eopss/consumer-prot-and-bus-lic/license-type/csl/bbrs.html).

It is important to note, however, that building codes provide minimum requirements, not best practices (some of which are presented in this section). Some best practices for coastal areas include hurricane clips that tie the roof to the wall and other connectors that tie the wall to the foundation. This is known as a "continuous load path connection" (see Figure 4-1).

How Your House is Maintained

Maintenance of your house is important. Painting the exterior every five years protects the wood and prevents rot, which can weaken the structure. The effective lifespan of unpainted shingle siding depends on many factors (wood species, moisture, sunlight, etc.), however if properly maintained it can last for decades. Termites can also weaken a wood-framed house. If the wood in the house is rotten or has severe termite damage, it will be more difficult and more costly, or even impossible, to strengthen the home. In the coastal areas of Massachusetts, there are many places where houses are on crawl spaces and where standing water or high water tables are prevalent. It is important to keep moisture from intruding into the wood of the home and causing decay. Proper maintenance will extend the life of a house in more ways than one.

How You Strengthen Your House

Even if your house was not built with hurricane clips or does not follow continuous load path concepts, there are many small steps and some major ones that can be taken to retrofit or address how to strengthen your existing home.

The remainder of Part 4 concentrates on many of the options to consider when strengthening your home, whether you're designing a new home or planning a retrofit of an existing home, including:

- Elevating structures above the predicted flood elevation is one of the most important things a homeowner can do to minimize risk. Increasing freeboard (additional elevation above the minimum) can lift your home out of an area where it would have been damaged, as well as qualifying for substantial savings on flood insurance.
- Roof-to-wall connections (e.g., hurricane clips), improving the connection of the roof-sheathing to roof-framing members (rafters or trusses), and reinforcing gable ends with bracing;
- Wall-to-foundation connections;
- Stronger connectors than those required in the current building code;
- Flood retrofit measures (strengthening existing foundations and piers for flood forces, elevating HVAC and mechanical equipment, etc.);
- Protection for windows, doors, and garage doors; and
- Alternate sources of back-up electricity.

You may be able to perform the work for many of these measures. However, if the

work is beyond your capabilities, consider hiring a licensed structural engineer and/or architect to plan the strengthening and retrofitting program for your home and a licensed contractor to do the installation or construction. Even if you do this work yourself, it is best to contact one or more of these professionals first to obtain guidance and details specific to your house.

The complete topic of retrofitting existing homes has been tackled by numerous non-profit organizations and governmental agencies and the result of their hard work fills many reports and several excellent videos.

The following sources can give you more information:

- The Insurance Institute for Business and Home Safety (IBHS) website (www.disastersafety.org) includes numerous articles, reports, and videos that are extremely informative and explain preventative measures that reduce losses from all natural hazards, including hurricanes.[4.1] IBHS has a retrofit guide that is used in their FORTIFIED for Existing Homes Program.

- The Mitigation Directorate of FEMA is continuously researching hurricane-resistant designs and building methods for the construction of residences and the performance of residences that have been subjected to hurricanes. All of the government publications are available for free and most can be downloaded from the FEMA website (www.fema.gov) and the agency's *Safer, Stronger, Protected Homes and Communities* page (www.fema.gov/safer-stronger-protected-homes-communities).[4.2] FEMA released a publication on retrofitting existing homes called *Wind Retrofit Guide for Residential Buildings* (FEMA P-804), which is available at (www.fema.gov/library).

4.1 CREATING THE WIND- AND RAIN-RESISTANT ENVELOPE

It is very important to protect the envelope of your house from wind and rain. Windows can serve to protect that envelope, unless they shatter, which is almost certain to happen if they are unprotected. Taping your windows will not protect that envelope. A broken window during a hurricane can be devastating in several ways: Besides the incoming hurricane-force wind and torrential rain in your living room, there is shattered glass and debris from outside flying in. It can make walking in your own house hazardous. Even more importantly, there is the problem with internal pressurization of your house (see Figure 4-1).

A door or window breach can potentially double the uplift forces on your roof and can significantly increase the chances that your roof will lift off.[4.4] Several FEMA hurricane

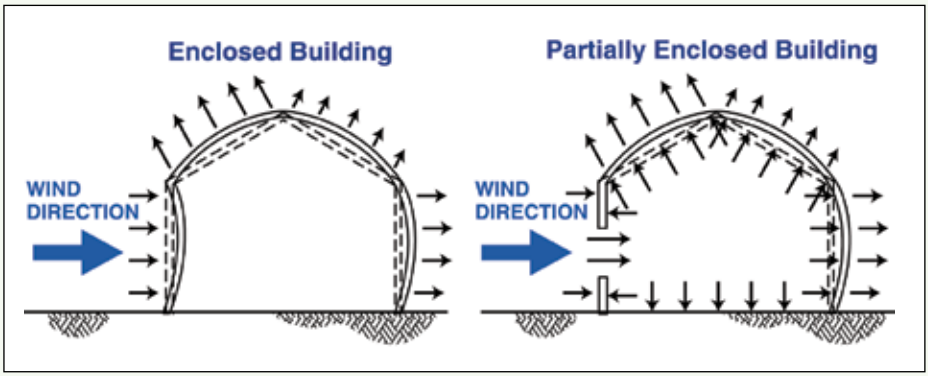


Figure 4-1. The diagram on the left shows a structure with the wind- and rain-resistant envelope intact. Pressure on the walls and roof comes from the outside only. In the diagram on the right, the structure's wind- and rain-resistant envelope has been breached due to a broken window. Now, pressure on the walls and roof comes from the outside and inside. The total amount of pressure on the roof and leeward wall increases significantly and can lead to the roof flying off and complete structural failure. Source: FEMA's *Residential Coastal Construction Manual* (2011)[4.3].

mitigation assessment reports indicate that breaching of the building envelope and subsequent internal pressurization leads to progressive structural failure for many houses.

4.1.1 KEEP YOUR ROOF ON

The wind from a hurricane attacks any weakness in the roof. Once a weakness is exposed, adjacent areas can be more easily damaged and peeled away. Thus, strengthening the roof is important: it should be considered for new construction and when a roof is replaced after its expected life.

Roof Framing/Truss Bracing

There are three ways generally that roofs and roof systems fail in high winds:

- Roof sheathing can be pulled off the roof framing by high-suction wind pressure.
- Roof framing can fail at the roof-to-wall connection.
- Gable end walls can collapse into the attic space or be pulled out from the exterior wall.

Failure of the roof sheathing can be prevented by ensuring the sheathing is adequately attached to the roof rafters or trusses. This can be done from the outside of the roof at the time the roof covering is replaced. Add nails (8d ring-shank nails are recommended) at

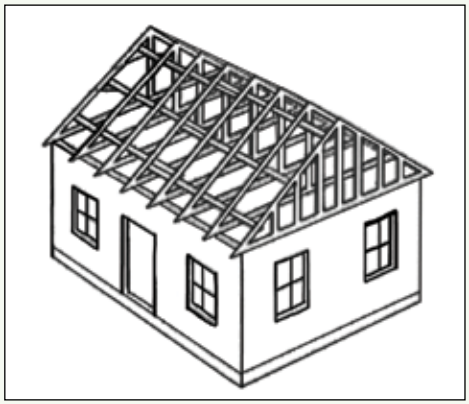


Figure 4-2. Trusses are built with a peak at the ridgeline of the house. The trusses at the end of the house form an A-shaped pattern know as a gable end. During a hurricane, the gable end is subject to great forces from the wind and could tip over, collapsing the other trusses in a domino fashion. Source: FEMA's *Against the Wind* brochure 247.

a minimum spacing of 6 inches on center around the edge of the roof sheathing before re-applying the roof covering. The sheathing may also be secured to the framing from inside the attic by using closed-cell expansive foam to form a bond between the edge of the roof rafter or truss chords and the underside of the roof sheathing.

Roof-to-wall connections can be accomplished on existing homes in several ways:

- Roof sheathing can be removed while replacing the roof covering, and a connector can be attached from the exterior wall to each rafter or truss. The roof sheathing is then re-installed, and the roof covering is replaced.
- The soffit on the outside overhang can be removed, a new 2"x4" board installed on the exterior siding parallel to the roof, a new connector attached to the rafter or truss, and then installed on the new board and the soffit re-installed.
- A section of drywall or interior wall and roof covering can be removed on the inside of the home, new connectors installed on the inside between the rafters or trusses,

Figure 4-3. In this application of lateral bracing, the 2"x4"s are 18 inches from the ridge and connect to horizontal members that attach the opposing trusses. Not all roofs will have the horizontal members. The 2"x4"s are connected with two #14 3-inch screws (A) and overlap over two trusses (A and B). The end is connected to the gable end with an angle or L bracket (C). Image courtesy of Dennis Hwang.

Figure 4-4. Diagonal braces form an X pattern from the top center of the gable end to the bottom center of the fourth truss and from the bottom center of the gable end to the top center of the fourth truss. The same screws as for lateral bracing are used. Source: FEMA's *Against the Wind* brochure 247.

and then crown molding or other architectural treatment installed to cover the new connectors.

It is possible to significantly strengthen your roof by providing lateral and diagonal bracing to the rafter or trusses. This is particularly important for houses with gable-end roofs. This bracing can be done simply with 2"x4" boards purchased at a hardware store. Figure 4-2 is from the FEMA brochure Against the Wind (FEMA 247), which can be downloaded at (www.fema.gov/library).

For lateral bracing, 2"x4" boards are attached to the trusses that run the length of the roof (Figure 4-3). The 2"x4" boards overlap over two trusses. Braces should be 18 inches from the ridge, in the center and at the base, about 8 to 10 feet apart. You or a professional can do this work, although this can be difficult with long pieces of lumber in small attics. This bracing should have been installed when the trusses were installed in newer homes.

Another important type of bracing for your gable end involves making diagonal braces (Figure 4-4). Diagonal braces provide additional support against collapse of the gable end caused by high winds pushing (or pulling) on the gable end. Gable ends are more

Figure 4-5. Spray polyurethane foam is used to add strength between the rafters and the plywood sheathing. This method can be used to strengthen existing roofs and may negate the need to replace older roofs. It can also be used where fasteners are missing or at the corners of hip style roofs or the ends of gable end roofs, which are especially susceptible to wind forces. See FEMA publication numbers P-499 and P-804. Image courtesy of FEMA.

susceptible to high-wind damage because they are usually installed between the exterior wall of the house and the roof rafter or truss. There is a joint in the wood framing at that point, making the connection of the gable ends a weak link in the load path.

Hip-style roofs do not need as much bracing, as they are aerodynamically superior and they have the bracing built into the design of the structure. While gable end roofs have a flat end that is A-shaped, hip-style roofs have all four sides of the roof sloping towards the center of the roof.

As a side note, there are small things you can do to strengthen the roof even if it is relatively new. For example, if you climb in your attic and see nails that are supposed to

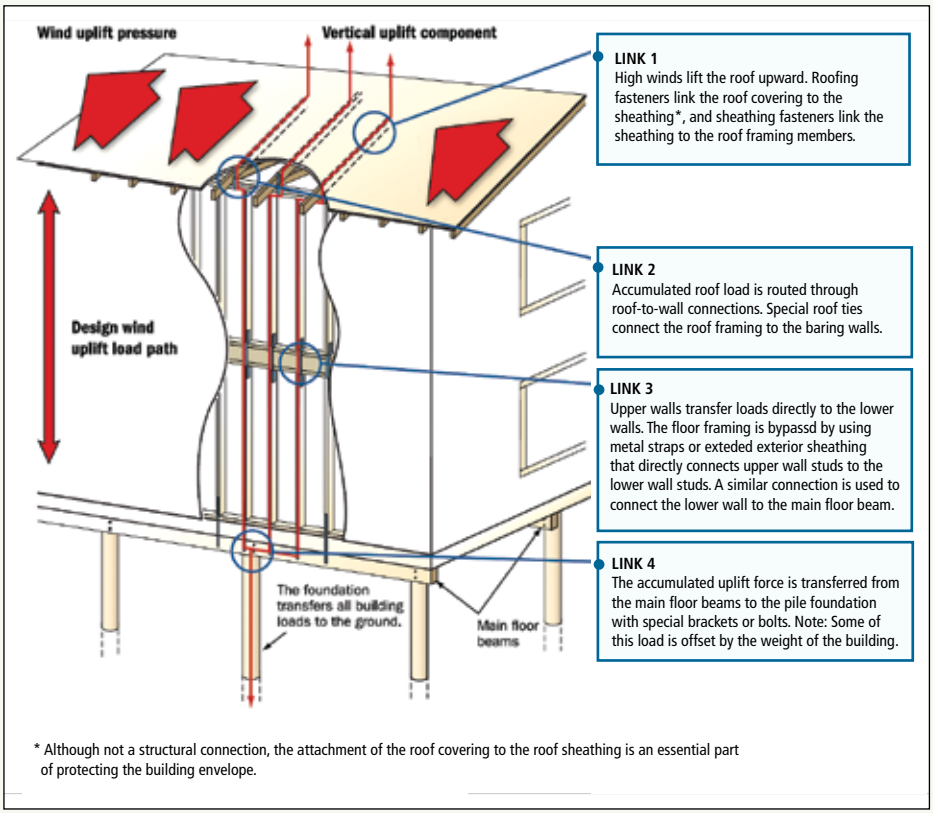


Figure 4-6. Example of a vertical load path from roof to ground on a platform-and pile-construction building. Load paths will vary depending on construction type and design, however continuous load path connection ties should be used at various locations along the load path. Image adapted from 2005 FEMA 499 Technical Fact Sheet No. 10, Page 1.

attach the plywood sheathing to the truss have missed the truss, then you have found what could be a structural weakness. The joint can be strengthened with a wood epoxy or spray polyurethane foam (Figure 4-5).

Another structural retrofit upgrade would be to install blocking between the roof rafters/ceiling/ floor joists for at least two bays in from the gable or end wall. This blocking creates a load path for the lateral wind force to be transferred to the horizontal floor or roof system, using the shear strength in the floor or roof to resist the applied wind load. This is now required in new construction with exposure C (e.g. near an open field or on the water with few other structures or trees to break up the wind).

FEMA provides guidance on these subjects in its *Homebuilders Guide to Coastal Construction* (FEMA 499) and *Wind Retrofit Guide for Residential Buildings* (FEMA P-804). An additional source of information regarding roofs and how to reduce risks from high winds can be found at the IBHS website (www.disastersafety.org).[4,5] The site includes information on re-nailing roof decks, maintaining steep-sloped roofs, guidance for re-roofing, and choosing a roofing material.

Continuous Load Path Connections

The continuous load path connection is analogous to a chain: both are only as strong as their weakest link. Historically, the weakest link has often been the roof-to-wall connection. Thus, the hurricane clip (typically between 30 cents to a dollar each) was created. Hurricane clips can be installed on each truss-rafter during new construction of houses, or during a retrofit. The concept of continuous load path connection is illustrated in Figure 4-6. This connection ties your roof to your home's foundation and helps to keep

Figure 4-7. This is an example of retrofitting an existing house originally built without hurricane clips. The popular H3 clip is used here; four nails attach the clip to the roof (truss-rafter) and four more nails attach to the wall or top plate below. For a retrofit, the clips are exposed on the outside of the house; therefore, both the clip and fasteners should be corrosion-resistant and painted to blend with the exterior of the house. With the correct clip and nails, you could perform the work or, if you prefer, hire a licensed contractor. Image courtesy of Dennis Hwang.

the roof from blowing off during a severe wind event.

Naturally, all houses have some connection from the roof to the foundation; otherwise, they would fall apart. However, in some coastal areas, much stronger connections are now required in the form of straps, anchors, and hurricane clips to protect against extreme winds from coastal storms. A properly selected hurricane clip is required for each rafter. In addition, the rafters at gable end eaves should be strapped down. Exterior beams supported by corner columns also require strap down. For houses with post and beam roof construction, fasteners should be installed for roof rafter to roof beams, top of post to horizontal ridge beam, and post to beam connections located at the exterior wall (see Figure 4-7).

You should seek a licensed structural engineer or architect to select the proper connectors and nails for your house. You can then do either all or part of this work yourself or hire a licensed contractor.

Building Beyond Code Requirements

Building beyond code requirements can minimize damage and result in a home that is more wind and flood resistant. For many homeowners, even minor damage of 15 percent or less can be an extreme hardship. After Hurricane Sandy (2012) devastated portions of New York and New Jersey, a FEMA Mitigation Assessment Team (MAT), conducted an assessment of both wind and flood building performance and determined the following:

As is frequently observed during FEMA MAT investigations, damages to buildings and other structures are routinely produced by less than design wind speeds (Hurricane Sandy was below a design wind event) due to the following: lack of understanding of basic wind-resistant design and construction practices; insufficient codes and standards at the time of construction; insufficient or lack of design guides and/or test methods at the time of construction; and improper or non-compliant building modifications or lack of maintenance by the property owners. Fifty three percent of the areas flooded by Hurricane Sandy in New York City had water levels that exceeded the mapped base flood elevation.

Overall, the damages observed by the MAT were consistent with typical flooding damage patterns, where damage to properly designed and constructed elevated homes is generally minor until such time as the waves reach above the elevated floor system, at which point the damage increases dramatically with increasing water level and wave height. Performance of residential building foundations with regard to coastal and near-coastal hazards depended primarily on the residence having adequate elevation,

proper construction, and proper foundation selection. If any of these criteria were not satisfied, performance suffered.[4.6]

Strengthening the foundation to resist uplift will generally require the removal of interior finishes. The installation of uplift connections should be planned by a licensed structural engineer and only after they have inspected the home to understand materials and methods used to construct the home and have calculated the wind uplift requirements.

It is preferable to do both the roof-to-wall connection and the wall-to-foundation connection. However, if the wall-to-foundation connection is too difficult or expensive because of the way your house was built, installing only the roof-to-wall connection is better than doing nothing. Remember, the weakest link for many homes is the roof-to-wall connection, and thus the hurricane clip will make that weakest link significantly stronger and improve the performance of the home during weaker wind events. Should Massachusetts experience a wind event of nearly 120 mph however, houses without a strong floor-to-foundation connection are still expected to fail.

Synthetic Roof Underlayment

Until the 21st century, most residential sloped roofs received a layer of asphalt-saturated felt building paper underneath the roofing material. Mimicking the attributes of house wraps, synthetic roof underlayments (Figure 4-8) are now available that serve the same function as a secondary weather barrier with better resistance to tearing, moisture, and ultraviolet rays than traditional roofing felt.

Recent natural disasters and subsequent rebuilding efforts have highlighted the versatility of synthetics as roof underlayments by providing a real-life test environment. After several hurricanes ravaged southern coastal areas of the United States, many people were forced out of their damaged homes. At the same time, large numbers of homes required quick roof repair and "drying in" to minimize further damage due to water intrusion. With limited resources, contractors triaged homes,

Figure 4-8. Synthetic underlayments are typically made from polypropylene, polyester, or fiberglass fabric, which weighs less than felt building paper, can be manufactured with anti-slip surfaces, and can withstand exposure to the elements for six months. Image courtesy of Carlisle Coatings & Waterproofing.

repairing the critical components and installing synthetic underlayments as temporary roofing. The underlayments performed better than FEMA's blue tarps and did not require removal and discarding when the new shingles were installed.[4.7]

4.1.2 KEEP WATER OUT

Flood Prevention

Protecting your property from flooding can involve a variety of actions, from elevation to inspecting and maintaining the building to installing protective devices. Most of these actions, especially those that affect the structure of your building or their utility systems, should be carried out by qualified maintenance staff or professional contractors licensed to work in your state. The most important information to know about your home when considering flood prevention techniques is the relationship between the base flood elevation (BFE), at the location of your house, shown on your community's Flood Insurance Rate Map (FIRM) and the elevation of your lowest floor (the one that would get wet, and likely damaged, if flooded).

FEMA's National Flood Insurance Program (NFIP) website (www.floodsmart.gov) provides detailed information on flooding and flood risks, including a flood risk profile tool that will rate the flood risk for a specific address: (www.floodsmart.gov/floodsmart/pages/flooding_flood_risks/defining_flood_risks.jsp).

The best way to reduce damage from floods for residential structures in a flood-prone area is elevation above the predicted flood elevation for your site on the FIRM. An excellent source of information about floods and protecting your property from flooding is found on FEMA's *Ready–Prepare, Plan, Stay Informed* website (www.ready.gov/floodawareness). Additional information is available in FEMA's *Coastal Construction Manual* (FEMA P-55), *Protecting Your Property from Flooding* (www.fema.gov/plan/prevent/howto/index.shtm#4), *Home Builder's Guide to Coastal Construction* (FEMA P-499), and *Homeowner's Guide to Retrofitting* (FEMA P-312).

Wet Floodproofing

For those homes not located in a special flood hazard area and if local regulations allow, you could consider the option of wet floodproofing your home. Wet floodproofing means modifying the uninhabited portions of the house, such as a crawlspace, so that floodwaters can get in but won't cause significant damage. It may be a practical solution for parts of the house that are not living space. Remember that wet floodproofing does nothing to alleviate the threat from fast-moving floodwaters (or waves), which are often a major cause of damage.

Wet floodproofing encompasses a variety of measures[4.8], not all of which may be permittable if your property is in or adjacent to certain coastal resource areas (e.g. dunes):

- **Use Flood-resistant Materials**. Materials have differing abilities to resist flood damage. Flood resistance classifications have been developed for flooring, wall and ceiling materials, and the adhesives used to install them. These classifications are published by FEMA and are listed in *FEMA Technical Bulletin 2: Flood Damage-Resistant Materials Requirements* (www.fema.gov/library). Examples that can be very attractive and flood resistant include clay tile, stone, or brick with waterproof mortar; solid vinyl flooring with chemical-set adhesives; stained concrete; terrazzo; decay-resistant or pressure-treated woods; and rigid, closed-cell foam insulation.

- **Create Flushable, Drainable Walls**. In wet floodproofing, floodwater should be able to flow into and drain out of walls and other cavities to prevent damage from water pressure and keep the wall cavity from trapping contaminants. After flooding, there should be a way to drain, clean and dry these spaces easily to remove silt and contaminants and prevent the growth of harmful fungi and bacteria. Consider removable wide baseboards or wainscoting.

- **Elevate Appliances and Utilities**. Items to elevate include your outside air conditioner compressor, inside furnace or air-conditioning unit, washer and dryer (choose front-loaders if on platform), water heater, freezer, and electrical outlets and switches. Also substitute cooktop and wall ovens for freestanding range or drop in units. An appliance can be elevated by placing it on a sturdy, flood-resistant platform or a strong shelf, which is securely attached to a structural support that can withstand flooding. If wood is used, it should be solid, pressure-treated lumber.

- **Install Barriers around Appliances**. Build a mini flood wall around appliances where shallow-depth flooding occurs often or set the washer and dryer on sturdy plastic sheeting or bags that can be raised during a flood threat.

- **Add a Storage Building above Flood Levels**. Relocate some appliances to a new building built high enough to be safe from flood damage. Keep enough space available in it to store valuable furnishings during a flood threat. Construction of the building may be subject to regulation.

Keep these points in mind when you wet floodproof:[4.9]

- Activities that involve work on the electrical system, gas, or air-conditioning compressor usually require the services of a licensed contractor. Check with your local permit official to find out about requirements in your area.

- Raising the electrical system above flood levels will protect it from water damage, but it won't make it safe to have service turned on while water is in the building.
- Even when a home is allowed to flood, sewage backflow prevention is important to prevent the serious health hazards and more expensive cleanup procedures associated with that type of contamination. A backflow valve should be installed.
- Since wet floodproofing does not keep the structure dry, cleanup still is very important. Even if you successfully stop sewage backup through your plumbing, there is a good chance water coming in from outside has some chemical and biological contaminants. Disinfection, cleansing, and thorough drying are essential to remove contamination and to prevent growth of hazardous molds and decay.
- Wet floodproofing activities will not reduce your flood premiums, so the motivation for this activity should center on reducing the damage caused by flooding. During a flood event, you may still be required to evacuate by local emergency management officials.

Dry Floodproofing

When elevation is not an option, another way to protect a structure and its contents from flood damage is to seal the building so that flood waters cannot enter. Dry floodproofing is primarily for slab on grade buildings with concrete or solid masonry walls. It cannot be used to put residential structures in compliance with the National Flood Insurance Program. **It can be used as a retrofit but not as a primary construction method**. It may have application in sturdy, structurally sound buildings in areas of shallow, low-velocity flooding. Check with your state floodplain coordinator and/**or** local **Building Department** for applicability. In addition, this flood protection method is not for buildings located in protected resource areas or in coastal high hazard areas like V zones or coastal A zones (as designated on FEMA FIRMs). These special flood hazard areas are not only subject to inundation by the 1 percent annual chance flood event, but are also subject to additional hazards due to storm-induced velocity wave action.

You should consult a design professional before undertaking a dry floodproofing project. Dry floodproofing is not effective when water velocities are high, when waves are present, or for rapidly rising water. Concrete and masonry are easier to seal, more resistant to flood damage, and stronger than other conventional construction materials.[4.8]

Dry floodproofing encompasses a variety of measures:[4.8]

- Applying a waterproof coating or membrane to the exterior walls of the building;
- Installing watertight shields over doors, windows, and other openings;

- Anchoring the building as necessary so that it can resist flotation;
- Installing backflow valves in sanitary and storm sewer lines;
- Raising HVAC and electrical system components above the flood level;
- Anchoring fuel tanks and other storage tanks to prevent flotation;
- Installing a sump pump and foundation drain system;
- Strengthening walls so that they can withstand the pressures of flood waters and the impacts of flood-borne debris;
- Building with materials that are flood-resistant, i.e. can withstand flood waters for at least 72 hours (examples: concrete, ceramic tile, pressure-treated lumber, steel, metal, brick, epoxy paint, foam, and closed-cell insulation); and
- Ensuring wells are properly constructed to avoid contamination from floodwaters.

Keep these points in mind when you dry floodproof:[4.8]

- There are several disadvantages to dry floodproofing. Flood insurance premiums are not reduced for dry floodproofed residential structures. Ongoing maintenance is required, adequate warning time is required to close any openings, and the home must not be occupied during a flood.
- The height of your dry floodproofing should not exceed 3 feet. The pressures exerted by deeper water can cause walls to buckle or collapse. Before you use dry floodproofing to protect against greater flood depths, have a structural engineer evaluate the strength of your walls.
- If your dry floodproofing measures require human intervention before flood waters arrive, such as placing shields over doors and windows, you should have an operations and maintenance plan that describes all the actions that must be taken and lists the people who are responsible. It should also include a schedule of periodic maintenance that states how often the dry floodproofing measures will be inspected and who will perform the inspections.
- The cost of individual dry floodproofing measures will vary with the size, condition, and use of your building; the dry floodproofing height; and the extent to which you use contractors and engineers.
- In many cases flooding on a property can be caused by poor drainage. If this is the case, it may be of great benefit to address the drainage issue with the professional advice of a licensed civil engineer.

4.1.3 WINDOW AND DOOR COVERINGS

Protection of your home's envelope from breaches during a windstorm is critically important, particularly to its vulnerable windows and doors.

If your home is located in a high-wind zone, it is important that window coverings not only withstand hurricane-force winds, but also withstand windborne-debris impacts. The usual standard for impact resistance is known as the "Large Missile Impact Test." Essentially, it determines whether a given covering can withstand the impact of a 9 pound 2"x4" board fired at 30+ mph.

Coverings should be tested and approved to meet industry standards for hurricane impact and should carry a label indicating such approval. Check with the manufacturer. Use only licensed contractors and reputable dealers selling products tested by reputable testing vendors.

The International Hurricane Protection Association (a trade association group comprising manufacturers, contractors, and other industry professionals) has several tips regarding selection of products, selection of installing contractors, and other useful information on its website (www.inthpa.com).[4.10] For further information regarding opening protection, visit the IBHS website (www.ibhs.org), in particular the Fortified for Existing Homes Program.

Several types of window and door opening protection systems are generically described below. Within each category, numerous reputable manufacturers provide different products, each with individual features, benefits, and costs. The prices shown are estimates for installed costs and represent local and nationwide averages as of May 2011. Pricing will vary between providers and change over time. You should consult with a competent contractor specializing in supplying and installing these systems.

Figure 4-9. Coastal home protected with roll-down shutters on all windows and doors. The shutter is held in place by vertical guide tracks and can be deployed manually or with an integrated electric motor. Image courtesy of QMI, Inc.

Figure 4-10. Accordion shutter (shown in the open position) installed over a large window of a coastal home. Shutter has been installed to allow deployment from inside the home. Image courtesy of Roll-a-way.

Figure 4-11. Bahama shutters made from durable extruded aluminum components add "islands" flair to a home and provide effective opening protection. Image courtesy of Roll-a-way.

Figure 4-12. These 0.050 gauge aluminum storm panels offer cost effective storm protection. In this example, panels slip into a track above the window and secure onto a bottom track using wing nuts. Image courtesy of Roll-a-way.

Roll-down Shutters

Roll-down shutters represent the window covering type that is easiest to deploy and offers the best overall protection features (Figure 4-9). These are permanently attached to the building. The shutter consists of a movable "curtain" of slats that is held in place

by vertical tracks. When not deployed, the shutter stores in a hood that is housed above the window or door being protected. Most of the components of roll-down shutters are made from extruded aluminum.

Because the roll-down shutter makes solid contact with the window sill, patio deck, or other structure at the bottom of the shutter and its farthest extent of travel, this shutter type demonstrates the highest level of protection against wind-driven rain in addition to wind and debris. Roll-down shutters can be deployed using a variety of operators—both manual and electric motor types. These can be installed directly over windows and doors, or in some cases, at a balcony's edge to form an enclosure.

Since roll-down shutters are easily deployed, they often are used on a regular (non-storm) basis for light control, insulation against heat and noise, or privacy and security. The variety of features and methods of operation leads to a wide range of costs for this shutter type. These shutters can be made for custom sizes and uses.

Accordion Shutters

One of the most commonly used shutter types in hurricane-prone regions is the accordion shutter (Figure 4-10). This is a permanently installed system with interconnected "blades" that operate between horizontal tracks. When not in use, the blades fold and are stored on either side of the door or window being protected. Accordion shutters are manually deployed and can be deployed from the inside of the home, if the opening is a single- or double-hung window or an in-swinging window or door.

Decorative/Protective Shutters

For homeowners who wish to add a decorative flair to the home's exterior while protecting windows against storm forces, Bahama (or Bermuda) shutters are available (Figure 4-11). These are most commonly made using extruded aluminum frames and louvers, although some composite materials have also been used in these types of shutters. Typically, these are finished using a durable exterior grade powder coating or automotive-grade polyurethane paint system. While these shutter types imitate the design of traditional wood shutters, it should be noted that no wood shutter of either type has been tested and approved as opening protection since wood will not pass the "Large Missle Test."

Storm Panels

Removable storm panel systems (Figure 4-12) are one of the most widely used and cost-effective systems available for opening protection. These consist of a series of panels, made from steel, aluminum, or impact-resistant polycarbonate. The clear plastic panels are an especially attractive option since they allow light to go through while

Figure 4-13. In-place stainless steel impact screen protects several windows of a coastal residence. This system requires no deployment and provides shade. Image courtesy of Roll-a-way.

Figure 4-14. Flat impact polycarbonate panels are installed directly over windows of a coastal home. This window covering provides excellent storm protection with minimal aesthetic impact. Image courtesy of Roll-a-way.

providing strong protection from flying debris. When not in use, panels are stackable for convenient storage. A wide variety of track options are possible. While these systems are relatively inexpensive (approximately $13 per square foot, depending on panel type and track options), they require much more effort for the homeowner to deploy than the other types mentioned above.

In-Place Systems

Requiring no advance deployment, impact-resistant systems that are permanently installed on a structure can be an attractive option for opening protection. Two types currently on the market are impact-resistant stainless steel screen units and installed flat impact polycarbonate. Both have little, if any, negative aesthetic impact on the home.

Impact-resistant stainless steel screen systems (Figure 4-13) consist of a heavy gauge stainless steel screen mesh that is secured in an extruded aluminum frame. The unit is installed over the window to be protected. These are available as operable units, which facilitates cleaning and emergency escape. Screen units also provide excellent solar shading characteristics. These systems cost approximately $25 to $50 per square foot.

Flat impact polycarbonate units (Figure 4-14) are available to protect most single and double window sizes and types found in residential homes. They are made from UV-stable optical quality grades of polycarbonate and provide excellent protection against all storm forces. Because these systems are not operable from the inside of the home, emergency escape from the home must be considered before installing this system.

Figure 4-15. Polyethylene basketweave fabric windscreen deploys directly over ground floor windows of a coastal home. Image courtesy of Roll-a-way.

Figure 4-16. Polyethylene basketweave fabric windscreen is deployed at edge of patio, enclosing the entire area. Image courtesy of Roll-a-way.

Typical systems cost approximately $25 to $35 per square foot.

Fabric Windscreen

In many cases, it may be difficult to protect your windows because they cover a large area or have an unusual configuration (for example, if they extend out past the wall). In this case, one option would be to use a hurricane screen, mesh, or fabric. Impact-resistant fabric panels (Figure 4-15) made from high tensile strength geosynthetic fibers such as polyethylene or reinforced PVC have become increasingly popular for use as window and door protection. These systems are attached on opposite sides of the window or door, usually to permanently installed panel mates or tracks with mounting studs. The panels include integrated grommets, which facilitate the deployment of the windscreens. These systems are relatively inexpensive, costing approximately $7 to $12 per square foot.

The polyethylene fabric types, which are basket weave systems, allow some light and visibility through the deployed screens. Some models incorporate emergency escape zippers. The PVC types are somewhat translucent, allowing light in the dwelling, but do not allow visibility through the screen.

Geosynthetic screens have also been extensively employed to enclose large, even irregularly shaped openings (Figure 4-16). Because of the installation requirements of such systems, site-specific engineering is often required. Consultation with a contractor is recommended.

Figure 4-17. This attractive window can be fitted with energy-efficient glass, impact-resistant glass, or both. The impact-resistant glass consists of a laminate or film sandwiched between two glass panes. The frames are reinforced and the hinges have extra fasteners to withstand high-wind events. Wind-generated debris may crack the glass, but the laminate will hold the windowpane together in the frame and prevent breaching of the wind- and rain-resistant envelope. After the storm, the glass will need to be replaced. Image courtesy of Dennis Hwang.

Impact-resistant Windows and Glazed Doors

In order to withstand both wind pressures and impact from wind borne debris, window and door manufacturers have developed products with both sturdier frames and laminated (impact-resistant) glazing (Figure 4-17). Such systems are available in a variety of styles, options, and costs.

While impact-resistant openings offer deployment-free protection, the glass can still be broken (but remains in the frame). Also, while these products are often available to the consumer through home improvement stores, professional installation is highly recommended in order to ensure that proper attachment of the windows to the structure is achieved.

Plastic Honeycomb Panels

A relatively recent and positive development in providing the consumer with more options for window protection is the introduction of plastic honeycomb panels made of polypropylene (see Figure 4-18). These panels are installed like plywood and have many of the good properties of regular plywood, with few of the disadvantages. The panels are white and translucent. The honeycomb panels also come in a clear plastic version that lets light through. This is an attractive option to other protective systems, which can significantly darken a house when they are in use. However, these panels are more expensive than the opaque version.

Plywood

Historically, plywood has been the most commonly used option for protecting window

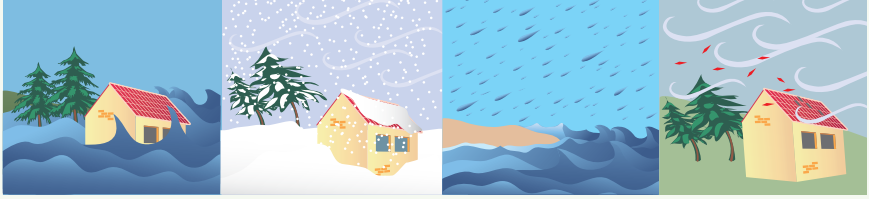


Figure 4-18. Plastic honeycomb panels have many times the strength of regular plywood and will not warp or rot. It is easy to cut and drill into, and, most importantly, it is light when compared to regular plywood. The major disadvantage is the lack of availability of this material in local hardware stores.

openings. This is undoubtedly due to its relatively low cost and ready availability. Plywood coverings offer protection for moderate level storms if properly installed (Figures 4-19 and 4-20).

The disadvantages of plywood are that it can rot or warp if stored in a wet or warm area. Also, plywood is relatively heavy. You will need two people to help prepare and install plywood window coverings. Because of its weight, it would be difficult or even dangerous to install plywood if a ladder is needed. Thus, plywood shutters may be appropriate for easily accessible windows on the first floor, or windows that can easily be reached by a terrace or patio on upper floors.

Although you can install plywood shutters yourself to save on cost, you should still seek the advice of a licensed architect or structural engineer before you start. Professionals can guide you on specific details for your windows.

A general recommendation is that you use at least 5/8-inch exterior-grade plywood for shutters. Thinner plywood is not as strong and did not perform as well during destructive Hurricane Andrew in Florida in 1992. While the International Residential Code (and other similar codes) allows some use of plywood as protection under very specific conditions, those allowances are restricted to areas where the design wind speed is 130 mph or less. For more information on hurricane shutter design using plywood, please refer to www.apawood.org.

Window Film

An after-market product, composed of laminate, used to enhance glass breakage prevention is commonly known as security window film (Figure 4-21). Such products are often touted as “hurricane film” or similar claims that cannot be substantiated by testing. Application of any of these window films to existing windows does NOT constitute adequate opening protection and should not be considered for use as opening

Figures 4-19 and 4-20. Not only is it necessary to install plywood opening covers correctly, it is also important to correctly label them and store them away from heat and humidity. Images courtesy of Dennis Hwang.

protection. For more information, visit the website of the International Window Film Association (www.iwfa.com).[4.11]

Table 4-1 lists the advantages and limitations of each type of covering discussed above. For most homes, a combination of different covering types is employed, based on the needs and budget of the homeowner.

Impact-resistant Garage and Entry Doors

One of the most important yet overlooked openings in a home that requires protection are its garage and entry doors. Most major suppliers of both types of doors offer products (with or without glazing options) that meet both wind- and impact-resistance requirements. Often, the replacement of a non-rated door with one of these newer types is cost-effective when compared to the cost of providing a covering for the older door.

As with impact-resistant glazed windows and doors, a

Fig 4-21. Laminated film comes in various thicknesses and strengths. Here the film is applied to an existing window before it is fastened to the frame with silicone structural sealant.

Table 4-1. Pros and Cons of Various Types of Window Protection

Type of Protection	Pros	Cons	Approx. Cost for 3' x 4' Window Protection (2014)
Roll-down Shutters	Easiest to deploy; Good overall protection, especially from wind-driven rain	Most expensive of permanent shutter systems; Motorized versions need manual backup for power outages or an emergency power source	$360 to $600
Accordion Shutters	Easily deployed; Simple manual operation; Good overall protection; Modest cost	Possible aesthetic issues	$300 to $360
Bahama Shutters	Easily deployed; Good protection; Provides shade	Blocks some light and view	$360 to $550
Storm Panels	Strong; Removable; Relatively inexpensive permanent shutter system; Good protection for the costs	Manual deployment required; Requires adequate space for storage when not in use	$144 to $168
Stainless Steel Impact Screens	Always in place; Provides shade	Some aesthetic impact; Emergency escape issues must be considered; Less effective for wind-driven rain	$375 to $750
Flat Impact Polycarbonate Units	Always in place; Minimal aesthetic impact	Emergency escape issues must be considered; Care must be taken in cleaning	$300 to $525
Fabric Windscreen (Direct Mount)	Inexpensive; Easy to handle and store	Manual deployment required; Greater shutter deflection than metal systems	$105 to $180
Impact Resistant Windows and Doors	Attractive and energy efficient; Provides security protection and storm resistance; Always in place; Many styles and options	Costs vary widely and can be high; Replaces existing windows or doors; Glass can still break requiring expensive replacement	Wide range in costs: $360 to $1,000 and higher
Plywood	Materials readily available; Easy to install on lower levels; Inexpensive	Not as strong as some other shutter systems; Manual deployment is difficult on upper levels; Must be properly stored; Doesn't provide impact-resistance for winds >130 mph	$25 to $35 for materials only
Laminates	Storm, security and UV protection; Energy efficient; Always on; Allows light in; Ideal for hard-to-reach windows	Other systems are stronger; Need to lock laminate to frame; Frame must be strong; Window may need replacement after storm	$180 to $204
Plastic honeycomb	Strong system; Lightweight; Reasonable cost; Won't warp or rot	Storage of panels; Time to create and deploy. While cost is reasonable, still most expensive of deployable systems; Materials difficult to obtain	$140 to $170

Note: Be certain that purchased products (other than plywood) have been tested and approved to meet industry standards for hurricane impact and that they carry a label indicating such approval.

qualified professional installer should be used to install an impact-resistant garage or entry door. Doors that swing out are more storm resistant than in-swing doors because the door is closing against the door jamb, which provides resistance to the door being pushed in by high winds.

The garage door is a significant weakness in the building envelope due to its large area and the stress it is subject to from wind pressure (Figure 4-22). Garage door options include:

- Replacement with a stronger door;
- Horizontal bracing;
- Vertical bracing;
- Or other type of a garage door bracing kit.

For many garage doors, vertical bracing is a popular and reasonably priced option (Figure 4-23). When a storm is imminent make sure to use the mechanical locks on the garage door, rather than relying only on the electric opener. Every little added connection helps strengthen the security of the building envelope.

Double entry doors should have slide bolts at the top header and bottom threshold of the inactive door, a deadbolt with at least 1 inch throw length between each door, and three hinges for each door. This requirement is similar to other guidelines for single entry doors, which call for at least three hinges and a bolt long enough that goes into the 2"x4" framing of the door. Whenever entry doors are fortified, at least two of them must be operable for access and exiting at any time.

Figure 4-22. Because of their width, double-wide garage doors are more susceptible to wind damage than single doors. The wind can force it out of the roller track, especially if the track is lightweight or some of the anchor bolts are not in place. This occurs because the door fails under excessive wind pressure. You should reinforce your garage door by installing horizontal and/or vertical bracing onto each panel, using wood or light gauge metal girds bolted to the door mullions. You may also need heavier hinges and stronger end and vertical supports for your door.[4.12] Image courtesy of Florida Hurricane Depot.

Figure 4-23. Vertical braces such as these can be deployed during high-wind events to strengthen the garage door. The braces are secured from the header over the garage door to the fasteners installed in the concrete floor. Deployment and breakdown are about 10 minutes each. The windows have been covered with a laminate film. Image courtesy of Dennis Hwang.

4.1.4 TREES

Cutting or trimming trees that overhang your house are additional measures that you can take to protect your property during a hurricane. Although trees provide a buffer to the full strength of the wind, there is a serious danger if there are large trees or limbs that are close enough to fall on the house. Few roofs are strong enough to withstand a falling 20 inch diameter, 40 foot tall pine tree.

Tree limbs or branches falling onto your house will cause considerable damage. Figure 4-24 illustrates the distance from the tree to the house to ensure that falling limbs do not affect the roof. If it is not possible to remove a tree, you can at least cut off all branches that hang over the roof of the house. Generally, you should hire a licensed tree trimmer to perform this work.

Trees with shallow roots may also be susceptible to falling over when the soil is saturated. Shallow roots cannot prevent a tree with leaves from falling over when the tree canopy is filled with blowing wind. This is a probable occurrence when the area is affected by severe rainfall (or snow/ice) along with heavy winds, which is usually the case with nor'easters and hurricanes.

4.2 ELECTRICAL AND POWER ISSUES

In case of an emergency, the power to your house should be turned off through the main breaker switch, circuit breaker panel, or fuse box. In addition, all homes should be equipped with ground fault circuit interrupters (GFCIs). GFCIs are inexpensive electrical devices that, if installed in household branch circuits, are designed to protect people from severe or fatal electric shocks. GFCIs could prevent over two-thirds of all electrocutions.[4.13] Because a GFCI detects ground faults, it can also prevent some electrical fires and reduce the severity of others by interrupting the flow of electric

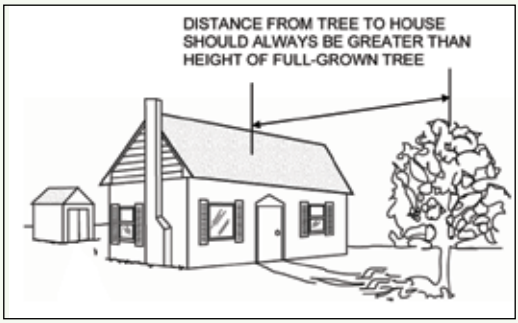


Figure 4-24. FEMA recommends that the distance between a tree and your house should always be greater than the height of the full-grown tree. This is to prevent trees from falling on the roof, either currently or in the future. Image courtesy of FEMA.

current. GCFIs are commonly found in kitchens, bathrooms, laundry rooms, or other places where water and electricity are close together. If you don't have them, consider having them installed by a licensed electrician.[4.13]

By following key safety precautions when dealing with electricity during and after storms and other disasters, you can help prevent death, injuries, and property damage. Take care when stepping into a flooded area and be aware that submerged outlets or electrical cords may energize the water, posing a potentially lethal trap.[4.13]

Flooded Areas: Do not use electrical appliances that have been wet. Water can damage the motors in electrical appliances such as furnaces, freezers, refrigerators, washing machines, and dryers.[4.14]

Wet Electrical Equipment: A qualified service repair dealer should recondition electrical equipment that has been wet. For more information, the National Electrical Manufacturers Association (NEMA) has produced a brochure, *Guidelines for Handling Water Damaged Electrical Equipment,* for use by suppliers, installers, inspectors, and users of electrical products to provide advice on the safe handling of electrical equipment that has been exposed to water. It outlines whether items will require complete replacement or can be reconditioned by a trained professional. Items covered include electrical distribution equipment, motor circuits, power equipment, transformers, wire, cable and flexible cords, wiring devices, GFCIs and surge protectors, lighting fixtures and ballasts, motors, and electronic products.[4.13] The NEMA brochure can be downloaded free of charge at nema.org.[4.14]

Downed Power Lines: These can carry an electric current strong enough to cause serious injury or death (Figure 4-25). The following tips can keep you safe around downed lines: [4.13]

- If you see a downed power line or wire of any kind, move away from the line and anything touching it. You may not be able to differentiate between a cable, telecommunications, or electric wire, so stay clear of all downed wires of any kind.

Figure 4-25. Downed or damaged power lines in a residential area can pose a serious danger to public safety. Image courtesy of U.S. EPA

Avoid contact with objects that could come in contact with downed wires such as metal fences, sheds, vehicles, and tree limbs and branches. The human body is a ready conductor of electricity.

- The proper way to move away from the line is to shuffle away with small steps, keeping your feet together and on the ground at all times. This will minimize the potential for a strong electric shock. Electricity wants to move from a high voltage zone to a low voltage zone—and it could do that through your body.
- If you see someone who is in direct or indirect contact with the downed line, do not touch the person. You could become the next victim. Call 911 instead.
- Do not attempt to use another object such as a broom or stick to move a downed power line or anything in contact with the line. Even nonconductive materials like wood or cloth, if slightly wet, can conduct electricity and then electrocute you.
- Be careful not to put your feet near water where a downed power line is located.
- If you are in your car and it is in contact with a downed line, stay in your car. Tell others to stay away from your vehicle.
- If you must leave your car because it's on fire, jump out of the vehicle with both feet together and avoid contact with the car and the ground at the same time. This way you avoid being the path of electricity from the car to the earth. Shuffle away from the car.
- Do not drive over downed lines or obscuring branches in the road. When branches fall they can break power lines and make it hard to see the power lines in the road.

4.2.1 ALTERNATE POWER SOURCES

Before discussing alternate power sources during an emergency, one general suggestion is to make your house as energy efficient as possible as you replace equipment and appliances in your house after they have outlived their normal life. For example, if your lights, television, or refrigerator need replacing, consider products with the EPA's Energy Star label (Figure 4-26). These products may cost slightly more, but over their

lifetime, the energy savings will far outweigh the small initial cost increase.

Energy efficient equipment will be especially useful during an emergency, when you may be on alternative forms of power with limited supply. For example, a regular 100-watt lamp running off an emergency power station (essentially built around a car battery) may run for two hours. That same emergency station can run a fuel-efficient 23-watt compact fluorescent light almost 8 to 9 hours with the same light output. As another example, a refrigerator with the Energy Star label can run on a fuel-efficient generator for 16 hours on one gallon of gas. Since most refrigerators do not need to run continuously, it may be possible to run the efficient refrigerator on one gallon of gas for one or two days.

4.2.2 GENERATORS

Some households may require uninterrupted power because of the critical needs of some family members. For example, the elderly, disabled, or sick may require a respirator, dialysis machine, or other medical equipment. Some medicine such as insulin, which is stored over a month, may need to be refrigerated. For many families, the most important major power requirement is to run a refrigerator or freezer. If your family cannot get by without the refrigerator or there are other critical power needs for medical or other purposes, then you may want to consider a portable generator.

Take special care with portable electric generators, which can provide a good source of power but can become deadly if improperly installed or operated.[4.13] Power from generators can back feed along power lines and electrocute anyone coming in contact with them, including electric utility line workers who are making repairs. A qualified, licensed electrician should install your generator to ensure that it meets local electrical codes. [4.14]

Other generator-related tips:

- Make sure your generator is properly grounded.
- Keep the generator dry.
- Plug appliances directly into the generator.
- Make sure extension cords used with generators are

Figure 4-26. Items with the Environmental Protection Agency's Energy Star Label use much less energy than standard models. Items include washing machines, dishwashers, refrigerators, freezers, air conditioning units, and light bulbs.

rated for the load, free of cuts and worn insulation, and have three-pronged plugs.

- Do not overload the generator.
- Use a ground fault circuit interrupter (GFCI) to help prevent electrocutions and electrical shock injuries. Portable GFCIs require no tools to install and are available at prices ranging from $12 to $30.

Most importantly, never run a generator indoors or in your garage because of the possibility of carbon monoxide gas accumulation, which cannot be detected by smell. Good ventilation is required. Operate your generator outside and away from open windows. Do not hook up a generator to your house power supply without a licensed electrician.[4.14]

In general, when running your refrigerator with a generator, keep the refrigerator and freezer at the coldest setting. Refrigerators may only need to run a few hours a day to preserve food. Using a refrigerator thermometer, you should aim to maintain 40°F in the refrigerator compartment and 0°F in the freezer. Open the refrigerator door as little as possible.

This handbook does not recommend any particular generator or brand. However, if you are considering a generator, look first at your power needs and then at cost, reliability, quietness, and fuel efficiency, among other factors. You may want to read consumer reviews of generators and consider some of the following factors:

Power needs. Size the generator so that it runs the equipment you need or want to run in an emergency. It will make a difference if you just run the refrigerator, versus the refrigerator, lights, and other equipment. Some equipment such as a refrigerator may require 500 watts to run but 1,500 watts to start up. Each piece of equipment is different. You can get general guidelines from the manufacturers in the form of charts and tables for equipment power needs. A more accurate estimate, however, is to call your manufacturer or buy an amp meter that measures running and startup wattage or amperage. You can also get good advice on sizing a generator from the dealer where you buy the unit.

Fuel efficiency. During an emergency there will be limited fuel supplies. The amount of power you need and the fuel efficiency of the generator will determine if you need one or two gallons per day instead of five or six.

Quietness. Generators are usually noisy, but some are quieter than others. If you need to run a generator, your family and neighbors will appreciate a quiet generator.

4.2.3 POWER STATIONS

Power stations are found in many hardware stores and may have a radio, flash light, air compressor, battery jump starter, AC outlet, and/or DC outlet built around a modified car battery. These units can come in handy during a power outage, since they can form part of your stock of emergency supplies and also provide limited emergency power. If your cordless phone does not work because the base of the unit has no power, a power station could supply electricity so that calls could be made (an alternative is to use a corded phone). It should be noted that after an emergency, there may be many reasons the phone does not work that are beyond your control, such as heavy traffic or loss of function with the phone system.

4.2.4 INVERTERS

Inverters take the 12-volt DC power from your car battery and convert it to 115-volt AC power that can run household appliances. This can be very important if you need to run power tools in an emergency and the power is out. The inverter will drain your car battery, so look for inverters that have a low battery shutdown feature to prevent total battery drain. You should not run an inverter with the car running unless the manufacturer provides specific instructions with safety guidelines. In addition, the car should not be run in a garage, but rather in a well-ventilated area if the manufacturer approves of such procedures.

4.2.5 BATTERY CHARGERS

Your car battery can be an important source of DC and AC power with an inverter. To keep the car battery charged, you should consider a battery charger as part of your emergency supplies. The charger only works when there is household power or backup power through a generator, but it can recharge your car battery if needed. New units are small and portable and provide a quick charge to a dead battery in only a few minutes and a total charge in a few hours.

4.3 FLOODED BASEMENTS

Be aware of your coverage: NFIP's flood insurance is designed to cover structural damage and things required to run the household (i.e. heating/AC systems), it does not cover any upgrades done to basements. Finished walls, floors and ceilings or personal belongings that get destroyed while in a basement typically won't be covered.

Before the Flood: Belongings stored in the basement that can be damaged by water should be elevated or removed. Belongings that can be damaged by mold should be

removed. Elevate or relocate the furnace and ductwork onto a platform or raise the base on legs above the flood plain. Mildew-resistant paint applied to interior basement walls can help reduce mold and some brands even provide 5 year guarantees that it will prevent the growth of mold and mildew on the painted surface. If your home is flooding from the basement up (e.g. sewer backup, rise in local groundwater, runoff issues), then a water alarm can provide lead time before your belongings are damaged by floodwaters. Water alarms are similar to smoke alarms; they beep when exposed to water (cost $10 - $20 at hardware stores).

After the Flood: Give your house plenty of time to dry. Many problems result from rebuilding after a flood before everything dries. If it takes a week for the visible signs of moisture to disappear, allow at least another week for the parts you cannot see to dry. Don't try to force a swollen door to close. Don't force wooden parts to fit. When completely dry, the wood may regain its original shape. If the electrical code allows, move the main breaker (or fuse box) and the electrical outlets and switches above the flood protection level for your home. If you need to replace a flooded furnace, water heater, or AC, install the new one on a higher floor. If your new air conditioner or heat pump will be outside, install it on a platform above the flood protection level. A water heater can be put anywhere near a hot water pipe. An updraft furnace located in a basement can be replaced with a downdraft furnace on a floor above the flood protection level. Install new wallboard panels sideways so they are only four feet high. If the next flood is less than four feet deep, you only have to replace half the wall.

Mold & Mildew: Mold can cause serious health problems. You should limit exposure to mold, typically with non-ventilating goggles, rubber gloves, and a ≥N-95 respirator appropriate for mold removal. If you are allergic or have a respiratory condition you should strongly consider completely avoiding exposure.

- Remove and discard anything that has been wet for more than 24-48 hours. Mold may be hidden in places such as the back side of dry wall, wallpaper, or paneling, the top side of ceiling tiles, the underside of carpets and pads, etc.
- Do not paint or caulk moldy surfaces, as it will likely peel.
- Hard surfaces should be scrubbed with detergent and water, and dry completely.
- Absorbent or porous materials, such as ceiling tiles and carpet, may have to be thrown away if they become moldy.
- If you are unsure about how to clean an item, or if the item is expensive or of sentimental value, you may wish to consult a specialist.

Visit www.epa.gov/mold/cleanupguidelines.html for further information.

4.4 LICENSED CONTRACTORS

Selecting a contractor to do your work is very important. This handbook does not recommend or endorse any particular company. When selecting a contractor, it is necessary to perform proper due diligence and check qualifications. It is up to you to select the companies and verify their records. It is a good idea to get a written estimate from at least three reputable contractors. Make sure the contractor is licensed, insured, and has not received complaints. You should always ask for a list of referrals. Get the agreement in writing with the final payment due on completion. The Home Builders Association of Massachusetts (www.hbama.com) can provide guidance on selecting a remodeler. You can also check the Better Business Bureau's Accredited Business Directory online at www.bbb.org/boston/accredited-business-guide.

Hiring a licensed contractor is very important. In many areas across the country that have been impacted by disasters, there are numerous examples of families who have lost savings and insurance funds as a wave of unlicensed contractors flooded the impacted area in search of work.

Before you have extensive work performed, you should also consider a consultation with a licensed architect or structural engineer, depending on the particular work that needs to be done. Even if you perform the work yourself, a licensed professional should be consulted for initial guidance, since every house is slightly different.

4.5 HAZARD MITIGATION ASSISTANCE PROGRAM

FEMA's Hazard Mitigation Assistance (HMA) program is intended to encourage investment in long-term mitigation measures to reduce vulnerability to natural hazards. Funding from this program is made available through the state after a disaster declaration (www.mass.gov/eopss/agencies/mema/hazard-mitigation/grants/hazard-mitigation-grant-program-hmgp.html). Among other things, the program can provide funds to states to assist homeowners in implementing mitigation measures to existing structures. Some of the project types (in both the pre- and post-disaster time frames) that have been approved by FEMA for use in assisting homeowners are:

- **Property Acquisition and Structure Demolition**—the acquisition of an existing at-risk structure and/or property and conversion to open space through the demolition of the structure. The property must be deed-restricted in perpetuity to open space uses to restore and/or conserve natural floodplain functions.
- **Property Acquisition and Structure Relocation**—the physical relocation of an existing structure to an area outside of a hazard-prone area or a regulatory erosion zone and, typically, the acquisition of the underlying land. Relocation must

conform to all applicable state and local regulations. The property must be deed-restricted in perpetuity to open space uses to restore and/or conserve the natural floodplain functions.

- **Structure Elevation**—physically raising an existing structure to an elevation at or above the Base Flood Elevation or higher if required by FEMA or State Building Code. Structure elevation may be achieved through a variety of methods, including elevating on continuous foundation walls; elevating on open foundations such as piles, piers, posts, or columns; and elevating on fill (as prescribed by State Building Code and allowed under the Wetlands Protection Act and local bylaws). Foundations must be designed to properly manage all loads and be appropriately connected to the floor structure above. Utilities must be properly elevated as well. FEMA encourages applicants and sub-applicants to design all structure elevation projects in accordance with the FEMA Coastal Construction Manual.
- **Structural Retrofitting of Existing Buildings**—modifications to the structural elements of a building to reduce or eliminate the risk of future damage and to protect inhabitants. The essential structural elements of a building to protect in order to prevent damage include foundations, load-bearing walls, beams, columns, structural floors and roofs, and the connections between these elements.

Funding under HMA programs is subject to the availability of appropriations and, for Hazard Mitigation Grant Program funds, to the amount of FEMA disaster recovery assistance specified under a presidential major disaster declaration. To assist in establishing funding priorities, local and state mitigation plans are utilized to identify the highest risks.

Part 5
Protecting Your Property with Insurance

There are several ways to protect your property from natural hazards. The proactive way is to strengthen your house to address specific hazards such as a flood. However, if there is still damage despite all your precautions, insurance can provide resources to aid recovery.

Unfortunately, many homeowners do not find out until it is too late that their insurance policies do not cover flooding. The National Flood Insurance Program (NFIP) offers a separate flood policy that protects for what most people is their single most important financial asset: their home. NFIP coverage is available to all owners of insurable property (a building and/or its contents) in a community participating in the NFIP. Renters may also obtain contents coverage through a NFIP policy.

An overview of the NFIP is on FEMA's FloodSmart website (www.floodsmart.gov/floodsmart/pages/about/nfip_overview.jsp). A list of participating Massachusetts communities can be found on the NFIP's Community Status Book site (www.fema.gov/national-flood-insurance-program/national-flood-insurance-program-community-status-book).

Not sure about the high costs associated with flooding? All it takes is a few inches of water to cause major damage to your home and its contents. FEMA's NFIP website (www.floodsmart.gov) includes an interactive tool that demonstrates the cost of flooding and shows you what a flood in your home could cost, inch by inch. What are your chances of experiencing a flood? The site also includes animated flood risk scenarios that demonstrate how various factors impact different neighborhoods, providing excellent illustrations of where flooding can occur and the damage flooding does to a home.

All areas are susceptible to flooding to varying degrees, and flood insurance is an important consideration for all Massachusetts residents. Homes and businesses in high-risk flood areas having mortgages from federally regulated or insured lenders are required to have flood insurance. While flood insurance is not federally required if you live in a moderate-to-low risk flood area, it is still available and strongly recommended. The NFIP reports that nearly 20 percent of flood insurance claims come from moderate-to-low risk areas.

No matter where you live, the Massachusetts Division of Insurance suggests that you prepare for severe weather disasters by reviewing your policy and creating a home inventory, which will create a record of what you own and what it is worth. A home inventory will help you estimate the value and replacement cost of your possessions in order to ensure that you have sufficient coverage under your homeowner's or renter's insurance policy. The inventory will create a detailed record of what you have in case disaster strikes and you need to provide your insurance company with a comprehensive list of what needs to be replaced.

5.1 GENERAL INSURANCE INFORMATION

Natural disaster planning is one of the most important duties a homeowner can perform. Protection of life is first and foremost before, during, and immediately following a disaster. It is very important that consumers take time out before a disaster strikes to be certain that insurance concerns have been addressed. Massachusetts's Division of Insurance provides the following suggestions that consumers should consider before they are faced with a disaster.

Pre-Disaster Activities

- Review your insurance policies to see if you have adequate coverage. If you're not sure you have enough coverage, talk to your agent or company. Contact local contractors in your area to get an idea about rebuilding costs.
- Also, keep in mind you may have to bring your home up to current building codes rather than just restoring it "the way it was." Ask your agent if your policy will pay for the additional expense of bringing it up to code.
- Inventory your personal property including model numbers, serial numbers, and purchase information.
- Back up your inventory by videotaping or photographing each room in your house and storing this visual record outside your home.
- Keep insurance policies, your household inventory and other important papers together in a safe and secure place. Consider sending copies of these documents to a trusted friend or family member living outside your area.
- In your disaster supply kit, include a disposable camera and a notebook and pens for use in documenting your losses.
- Include the phone numbers of your insurance agent, your insurance company's local claims office and home office in your list of emergency numbers.

Protect Your Home from Damage

Consumers can do a number of things to reduce the cost of their property insurance. Protecting property from possible damage before a disaster can have a major impact on insurers' willingness to continue insuring the property and can also impact future prices the consumer will have to pay in the event their home is met by a disaster. By performing some of the following duties, consumers can make major contributions toward reducing the amount of losses occurring to their home:

- Consider adding storm shutters to the windows and doors of your home.
- Glue or nail down any loose shingles.
- Make certain yard items are tied down or secured. Bicycles, grills, toys, unsecured benches, and any other items not tied down should be placed inside an enclosed building. These items become missiles during a storm.
- If you own a vehicle, do not park it under a tree if a storm is anticipated.

- Take precaution to remove any tree that has the potential of damaging your home during a storm.
- Elevating your home (as described previously) can also protect your home from damage.

Communicate with Your Insurance Agent

Check with your agent and policy declarations pages for information about what is covered:

- Coverage is typically provided in terms of replacement cost or the cost to rebuild your house.
- Does the policy have an inflation guard that increases each year as the cost to rebuild goes up? Construction costs have steadily increased and may increase even more so after a natural disaster.
- Additions or improvements to your house made since your initial policy purchase may not be covered, so it is important to have a periodic appraisal so that your coverage is adequate.
- Check with your insurance agent about possible discounts and incentives. Not all companies provide discounts for hurricane protective devices. These discounts over time can pay for the cost of certain retrofit upgrades.
- Understand your policy. Many policies cover only hurricanes and not lesser events such as a tropical storm or a tropical depression.
- Make sure you have coverage for (1) your main structure, (2) detached structures, (3) the contents in your house, and (4) expenses for loss of use (like hotel stays). Only the first item is required by mortgage lenders, so you may not have sufficient coverage for the remaining items.

5.2 FLOOD INSURANCE

Floods are the most common — and most costly — natural disaster. Across the nation, in the past several years, about 60 percent of all declared disasters involved flooding.

To obtain coverage from flood events, you need flood insurance. Standard homeowners' insurance policies do not provide protection against floods. It is a hard lesson that has been learned by some in Massachusetts in the past, and it is an unfortunate reality that many people don't find out until it's too late.

Just a few inches of water from a flood can cause tens of thousands of dollars in damage.

Flood insurance is the best way to protect yourself from devastating financial loss. More information on using additional freeboard to substantially reduce damage caused by flooding, as well as to reduce flood insurance premiums, was provided in Section 2.2.

In areas with the greatest risk of flooding, Special Flood Hazard Areas (SFHAs), a building has a 26 percent chance of being flooded during a 30-year mortgage. On average,

20 percent of all flood insurance claims paid by the NFIP are for property outside of SFHAs. Homeowners, business owners, and renters can all buy flood insurance as long as their community participates in the NFIP.

While some private companies offer flood insurance, most flood insurance in the U.S. is backed by the federal government under the NFIP. Flood insurance is available to homeowners, renters, condo owners/renters, and commercial owners/renters in participating communities through local insurance agents. Costs vary depending on how much insurance is purchased, what it covers, and the property's flood risk.

NFIP rates are set and do not differ from company to company or agent to agent. These rates depend on several factors, including the date and type of construction of your home and your area's level of risk. Residential property owners located in low-to-moderate risk areas should ask their insurance agents if they are eligible for the Preferred Risk Policy, which provides very inexpensive flood insurance protection.

If your community participates in the Community Rating System (CRS), you may qualify for an insurance premium discount—in some communities of up to 45 percent—if you live in a high-risk area and up to 10 percent in moderate-to-low risk areas. Note that these values are the maximum possible discount, most communities in Massachusetts receive much smaller discounts.

You should discuss insuring personal property with your agent, since contents coverage is optional. Typically, there's a 30-day waiting period from date of purchase before your policy goes into effect. That means now is the best time to buy flood insurance—don't wait until a storm is approaching.

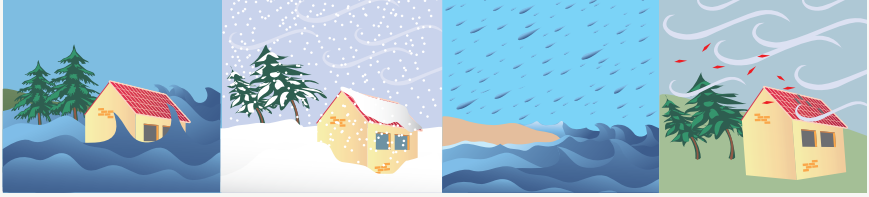
Information about flood insurance, including detailed information about what typically is and isn't covered, can be found at www.floodsmart.gov. FEMA's website also assesses the flood risk for any address and provides a list of insurance agents in the area that offer NFIP-backed insurance.

After substantial (>50% of market value) flood damage, NFIP policyholders in special flood hazard areas may be eligible for up to $30,000 to help pay the costs to bring their home into compliance with their community's floodplain ordinance.

The Stafford Act requires property in a SFHA to carry flood insurance after they have received Federal Disaster Assistance in order to be eligible for Federal Assistance that becomes available for a future flooding declared disaster.

Two main factors have made it difficult to estimate flood insurance, Updated Flood Insurance Rate Maps (FIRMs) and the Biggert-Waters Flood Insurance Reform Act of 2012 (BW-12). FIRMs are prepared for each flood-prone community through the NFIP. Efforts to make the maps more accurate have continued since the first flood maps were released, and you can expect local flood maps to continue to be updated in the future. If changes to the effective flood map indicate that a property is now in the floodplain, or that the potential depth of flooding is deeper this may make flood insurance more expensive. Check to see if there is a new effective FIRM or a preliminary FIRM that may affect your insurance rates. BW-12 was intended to raise rates to reflect true

flood risk, make the program more financially stable, and change how FIRM updates impact policyholders by removing subsidies and grandfathering. However, in March of 2014, Congress enacted the Homeowner Flood Insurance Affordability Act (HFIAA), which affects many of the reforms enacted by BW-12. In addition to capping annual rate increases, and reinstating grandfathering, the HFIAA repeals the property sales trigger that had previously required new homebuyers to pay a full-risk rate. Now homebuyers will in most cases receive the same status as the seller. The Massachusetts state legislature is considering a bill that would tie the level of required flood insurance to the outstanding mortgage balance instead of the full house replacement value. Your insurance agent will be your best source to tell you more about these and future changes that may affect the cost of flood insurance.



Part 6
Climate Change and Potential Impacts on Natural Hazards

Many scientists consider accelerated climate change to be the preeminent environmental issue of our time. Massachusetts faces multiple challenges from climate change that impact physical, ecological, economical, and cultural aspects of the entire state, especially coastal communities. Sea level has been rising in Massachusetts ever since the glaciers started melting thousands of years ago. Projected climate change effects in Massachusetts will likely include an increased rate of sea-level rise, warmer temperatures, and more extreme weather events (e.g., more droughts, more intense rainfall, and more intense storms and flooding). These changes are likely to magnify many of the coastal hazards we already face, and this is another good reason to be prepared with strategies and actions to increase the resilience of our homes and communities. This chapter provides an overview of climate change and regional climate trends and describes how these changes may exacerbate impacts of natural hazards.

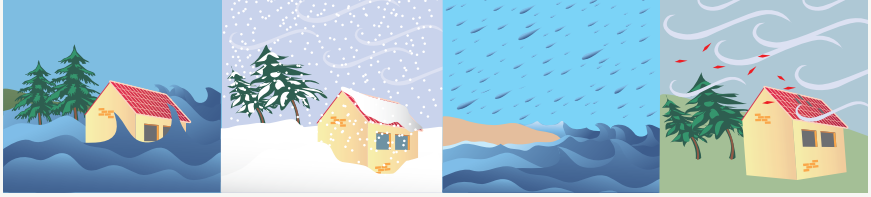
6.1 CLIMATE CHANGE

Climate is the description of average weather conditions over a long period of time, typically 30 years (EPA definition). Averages of rain and snow fall, temperature, humidity, wind speed, frost cover, and storm intensity are all factors that define the climate of any given region. A metaphor to help understand the time scales might be "Consider climate change to be what kind of clothes you've purchased to put in your closet, then weather would be that you decide to wear on any particular day".

Climate change refers to shifts in the long-term record of any of these climate factors (such as air temperature) sustained over a time period of several decades or longer.[6.1] Climate change is caused by a combination of natural influences and human activities.

While Earth's climate has experienced periods of natural changes over time frames of hundreds and thousands of years, the large and rapid changes underway today are unprecedented in human history. Climate change is affecting sea level, ocean chemistry, temperatures, length and timing of seasons, and the amount of annual rain and snowfall.[6.2] Many of these changes have negative consequences for people and the environment. Individuals and communities are working to reduce their risks from today's climate hazards and tomorrow's effects of climate change.

There have been numerous documented changes in global climate conditions over the past century. To date, the world has seen increases in annual average temperatures, increased rates of sea-level rise, and altered precipitation patterns, as well as other trends such as increases in extreme weather, changes in the onset of seasons, and rapid melting of glaciers. Current global climate change trends are expected to continue into the foreseeable future, and the rate of change for many of these trends is expected to increase.[6.3]



6.2 REGIONAL CLIMATE TRENDS

In general, the world is getting warmer, the oceans are getting warmer and more acidic, storms are getting more intense, and sea levels are rising at an accelerated rate. However, these are general trends and their impacts vary by region.

According to information recently synthesized by the U.S. Global Change Research Program, the northeast and Mid-Atlantic regions of the United States have historically experienced significant variability and extreme events related to weather and climate—floods, droughts, heat waves, and severe storms are characteristic throughout the geographic area.[6.3] In addition, major cities in the Northeast have experienced episodes of increased illness and deaths during heat waves.[6.3] Table 6-1 summarizes some documented climate trends.

U.S. climate scientists report that the annual average temperature in the Northeast region has increased by 2°F since 1970, with winter temperatures rising twice this much. Warming has resulted in many other climate-related changes including more frequent very hot days and longer growing seasons.[6.4] Precipitation has generally increased over the past 100 years. Precipitation extremes appear to be increasing, as indicated by an

Table 6-1. Summary of observed and documented current climate trends in the Northeast region.[6.6]

Climate Change Variable	Current Trend in the Northeast Region	What This Means
Air Temperature	Since 1900, the annual mean temperature has risen 1.5°F, with more rapid increases occurring over the past few decades (2°F since 1970).	Longer, hotter summers increasing drought potential and human health effects.
Ocean Water Temperature	Annual average temperatures in the waters off the southern New England coast have increased by 2.2°F since the 1970s.	Change in species composition and dynamics. Decline of some fish species while other southern species increase. Potential for more harmful algal blooms and invasive species.
Precipitation and Weather	Studies have found a 5 to 17 percent increase in regional precipitation during roughly the last 100 years.	More rainfall in more intense storms means increased risk of flooding. Less snow in winter.
Storminess	Hurricane intensity in the western North Atlantic Ocean has increased.	Increased erosion and damage to roads, bridges, buildings. Interruption of business.
Sea-Level Rise	Rates of local relative sea-level rise are variable across the Northeast region. Sea level in Massachussetts has risen 11 inches over the past 100 years.	Increased flooding. Loss of waterfront property and impacts to public access.

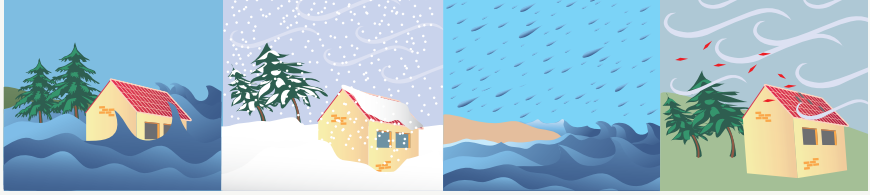


Table 6-2. Likelihood of occurrence for major climate change conditions in the Mid-Atlantic by 2100.[6.5]

Projected Change	Likelihood
Warming	Extremely likely (>95 percent chance of occurrence)
Higher sea levels	Extremely likely (>95 percent chance of occurrence)
Higher winter and spring precipitation	Very likely (>90 percent chance of occurrence)
Higher annual precipitation	Likely (>66 percent chance of occurrence)
Higher winter and spring streamflow	Likely (>66 percent chance of occurrence)
Greater hydrological extremes	Likely (>66 percent chance of occurrence)

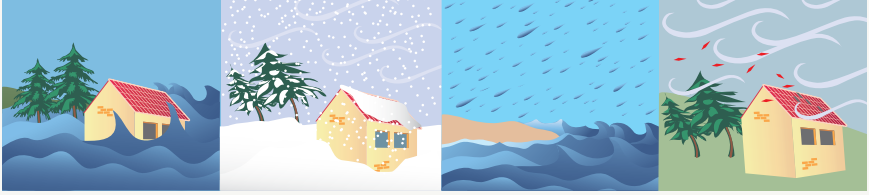
increase in heavy downpours.[6.4] Less winter precipitation is falling as snow and more as rain. For the region as a whole, the period between the first and last dates with snow on the ground has decreased by seven days over the past 50 years.[6.4] While it cannot be proven with certainty, the overwhelming majority of climate scientists have predicted that the rate of sea-level rise occurring today will likely become greater in the decades to come.[6.4]

Climate data and modeling scenarios that have been compiled and synthesized by a number of organizations can be used to project possible impacts of climate change. Table 6-2 includes a list of possible climate change impacts in the northeast region for the end of this century.

6.3 POTENTIAL CLIMATE CHANGE IMPACTS ON NATURAL HAZARDS IN MASSACHUSETTS

Massachusetts is vulnerable to climate change in several ways. We can expect to see warmer temperatures, more extreme weather events, increased rates of sea level rise, shorter winters and longer summers, and winters with less snowfall and more rainfall.[6.6] Bridges and roads will be more susceptible to damage because of more severe storms and heavy rainfall, resulting in possible impacts to evacuation routes. Sea-level rise and increased storminess may threaten public and private property at the coast, with increased risk of flooding and loss of waterfront land. Increased flooding could also affect inland areas, structures, and facilities.

Changing climate conditions such as temperature increases, altered precipitation patterns, and an increased rate of sea level rise are projected to exacerbate impacts of natural hazards in Massachusetts. Some climate change impacts such as precipitation and heat waves will occur quickly in response to increasing temperatures, and in fact



have already been measured (2014 National Climate Assessment). Others, such as sea-level rise, will continue on longer time scales from decades to hundreds of years. A general overview of potential impacts to coastal storms, floods, winter storms, drought, and other natural hazards is included below.

Coastal Storms

Coastal storms, which can lead to flooding, wind, and coastal erosion impacts, will be affected by climate change in several ways. Climate change may affect tropical system intensity, track, size, and/or rainfall. There is growing evidence that warming sea surfaces have resulted in the increased destructive potential of Atlantic tropical storms since 1970.[6.7] The increasing intensity of tropical storms is likely to continue in the coming century as ocean waters continue to warm. It has also been found that major storm tracks have been moving northward and this has been attributed to changing climate.[6.8]

It is important to note, however, that owing to difficulties in measuring tropical systems, separating the effects of human-influenced climate change from natural variability on hurricane activity is very difficult. At present, it remains uncertain whether past changes in hurricane activity have exceeded the trends and variability due to natural causes.[6.9]

Rainfall intensity of storms is likely to increase, causing more river and creek flooding.[6.9] Rising sea levels will intensify the negative effects of coastal storms, including erosion and flooding from the sea. The threat Massachusetts faces from flooding, erosion, and wind in future storms is greater than it is today or has been in the past.

Floods

With higher sea levels and more intense storms, the likelihood of major coastal and inland flooding is increasing. Coastal flooding will most directly increase due to sea-level rise and higher storm surge impacts. An acceleration in the rise in sea level will increase the extent of flood damage over time, with areas of lower elevation more susceptible to flooding. Inland flooding will increase due to the changing precipitation patterns (i.e., increased intensity of rainfall events) that are expected for the region. This type of flooding can also be directly affected by land-use decisions; as more land is developed and covered with impervious surfaces such as pavement, flooding increases as rainfall is less able to infiltrate through soils and into aquifers. During heavy rain events, not only will some roads be impassable due to flooding, but after waters recede, more roads and culverts may need repair. Additionally, the increase in precipitation levels will change stream flow and sediment movement, with the potential for scouring of bridge foundations.[6.10]

Winter Storms

Currently there are two climate change impacts that are likely to affect winter storms in Massachusetts. First, it is believed that precipitation in the winter will become more episodic, with greater amounts of winter precipitation falling in more extreme events.[6.11]

These extremes could exacerbate current winter storm patterns, making the overall effects of the storms worse. Additionally, the increase in average temperature will likely reduce the amount of precipitation falling as snow or ice—due to warmer temperatures, precipitation will more likely fall as rain.[6.12] When snow and ice are reduced and the increased episodic precipitation is rain, Massachusetts could see an increase in the occurrence of inland flooding during winter storm events.

Drought/Extreme Heat

Climate change is expected to increase the number and intensity of drought and extreme heat events. Drought can be caused by both reduced precipitation and increased heat that causes increases in evaporation. Current climate change predictions for the region indicate that precipitation may become more irregular, thus reducing the amount of precipitation that reaches the groundwater system. Additionally, higher temperatures in the region will cause increases in evaporation. These interactions will likely increase the number of short-term droughts—those that last one to three months—making them occur as frequently as once per year.[6.12]

The number of extreme heat days across the northeast is expected to increase. Boston typically experiences fewer than 10 days over 90°F each summer, but could have more than 60 by the end of the century. Similarly, days over 100°F are projected to increase from the current one per year to more than 20 per year.[6.14]

Sea-Level Rise

Rising sea levels will not only increase flood heights, but will also change flood patterns in Massachusetts, causing current 100-year (also known as a 1% chance in a given year) flood events to occur more frequently. Additionally, sea-level rise will cause coastal flooding to reach farther inland. Structures, including homes, roads, and utilities that have been built in low-lying areas can become difficult to access, suffer structural damage, or become unusable. These changes in flood heights and patterns associated with rising sea levels can be applied across many different natural hazard events—coastal storms, severe thunderstorms, and winter storms—that can cause flooding. Sea-level rise will also cause low-lying areas in Massachusetts to become inundated, meaning that they will eventually become permanently wet. Other risks associated with sea-level rise include higher water tables and saltwater intrusion into aquifers. Additional effects of sea-level rise combined with increased frequency and intensity of storms include increased coastal erosion, drowning of coastal wetlands, and decreased effectiveness of existing protective structures such as seawalls and revetments. Low-lying areas adjacent to these structures may be subject to increased flooding during storms. Guidance on sea level rise in Massachusetts is available at http://www.mass.gov/eea/docs/czm/stormsmart/slr-guidance-2013.pdf

6.4 HAZARD MITIGATION AND CLIMATE CHANGE ADAPTATION

With the climate changing and increasing threats from natural hazards, the development and infrastructure we have built in Massachusetts is becoming increasingly

vulnerable to many coastal hazards. Communicating risks related to climate change and increased rates of sea level rise can be challenging due to scientific uncertainties and long timeframes associated with impacts; the debate about the cause has also become politically polarized. Yet most everyone will acknowledge that there is no benefit in waiting to see if projected changes attributed to climate change will impact a specific region. Natural hazards are already taking a toll on individuals and communities.

Given the known natural hazard risks and the ever-increasing certainty of climate change impacts in Massachusetts, there are many reasons for individuals and communities to proactively mitigate natural hazards and adapt to climate change. Because significant time is required to motivate, develop the ability to adapt, and implement changes, acting now will allow for the time needed to achieve these long-term goals. Additionally, many strategies that address existing problems, such as short-term impacts of coastal storms, also provide benefits that help in preparing and planning for long-term effects of sea-level rise.

Appendix A
Emergency Contact Information

Mass 2-1-1 (directs callers to services during a crisis)
By phone dial: 211 (similar to 911)
http://www.mass211.org/

Massachusetts Emergency Management Agency (MEMA)
www.mass.gov/eopss/agencies/mema/
www.twitter.com/MassEMA
www.facebook.com/MassachusettsEMA

Massachusetts Department of Transportation (MassDOT)
877-623-6846
www.massdot.state.ma.us
www.twitter.com/MassDOT (Twitter feeds)

Massachusetts Executive Office of Public Safety and Security
617-727-7775 www.mass.gov/eopss

Boston, MA Forecast Office:
www.weather.gov/box/

American Red Cross
508-775-1540 Cape Cod and Islands
978-537-3339 Central MA
617-274-5200 Eastern MA
978-922-2224 Northeastern MA
www.redcross.org

Federal Emergency Management Agency (FEMA)
800-621-FEMA (3362)
www.fema.gov

Utilities Contacts
National Grid - electricity 1-800-465-1212, gas 1-800-233-5325
NSTAR - 1-800-592-2000

Appendix B
Shelter Information

When an emergency situation warrants shelter activation, information will be released through local radio and television stations, (www.mass.gov/eopss/agencies/mema/) Mass211 (calling 211 from any land line phone), and other available means concerning which specific shelters are available for evacuation purposes and when public shelters will open.

Shelter planning in Massachusetts is a cohesive effort between local, state, federal, and volunteer partners. Communities, if able and if the situation warrants, will open local shelters for their residents. Due to recent storm experiences, many communities have invested in their own cadres of shelter supplies and equipment for this purpose. You can contact your local Emergency Management Director for information on where you can find your local shelter. Depending on the severity of the storm, officials working with the American Red Cross, may open Regional Shelters in impacted areas. These facilities vary depending on the event and the geographical areas which are impacted. They exist to augment local shelter capabilities, and serve multiple communities. The locations of regional shelters may vary from storm to storm, as officials need to determine their need and where they can be best utilized based on the conditions of the event.

If you are advised to evacuate, try to keep family members together and don't forget your evacuation kit, including important papers. It is essential that you take your evacuation kit with you because food, cots, blankets, and other comfort items may not be immediately available. All Massachusetts communities have made every effort to provide sufficient shelter space for expected evacuees.

If you plan to seek a hotel or motel as your shelter in Massachusetts or neighboring state, make sure the hotel or motel is open and space is available. Motel rooms tend to fill up quickly when a hurricane is posing a threat to the New England region.

Prepare a plan for pets in case you must evacuate; many shelters will not take pets. Make sure you bring your animal's current license and vaccination record.

Remember that shelters may be opened selectively depending on the severity of the storm. Should an evacuation become necessary, please listen to your radio or television station or go to www.redcross.org, www.mass.gov/eopss/agencies/mema/ or call 211 for up-to-the-minute information on shelters open in your area.

WHAT TO BRING TO A SHELTER

Special dietary foods
Such as diabetic, low salt, liquid diet, and baby food and formula. Food and water are provided in shelters, but if a special diet is required, you should bring these foods with you.

Clothing and bedding
One complete change of clothing including footwear. Sleeping bag, blanket, and pillow (cots for elderly, as cots may not be provided). Rain gear and sturdy shoes.

Personal items
Washcloth, small towel, soap, toothbrush, toothpaste, sanitary napkins, tampons, paper towels, toilet paper, towelettes, etc.

Medications, first-aid supplies
Bring a three- to five-day supply of medications that is clearly marked with your name, dosage, type of medication, and prescribing physician. You must be able to take all medications by yourself. First-aid kit in a waterproof box.

Baby supplies
Clothes, diapers, formula, bottles, food, blankets, portable bed.

Important papers
Name and address of doctors. Name and address of nearest relative not living in area. Identification and valuable papers.

Miscellaneous
Games, cards, toys, battery powered radios, flashlights (no candles or lanterns), batteries, or other reasonable items you may need.

Service animals and pets
Be aware that some shelters will only allow service animals. Depending on the type of disaster, animal shelters may be set up when possible. Pet-friendly shelters will be noted when shelter locations are announced during an evacuation. Pets will be restricted to the pet section of the shelter, and residents will not be allowed to bring pets into general population areas.

Pets should have I.D. tags, as well as records of current, up-to-date license and vaccinations. A pet supply kit should include items such as bowls, food, medications, bedding, waste disposal bags, pet carrier/cage, and extra leash/harness.

Remember:

- NO alcoholic beverages or weapons are allowed;
- Take a bath and eat before you leave home;
- Register immediately upon entering the shelter;
- Obey shelter rules;
- Keep the building safe and sanitary.

Appendix C
Construction at the Coast, Beach Management, and Coastal Property Checklist

CONSTRUCTION AT THE COAST

If you're a coastal property owner, it's important to understand the dynamic processes that shape Massachusetts' shorelines as well as the potential risks and consequences of living at the coast. Most properties along the oceanfront, inland bays, marshes, and tidal rivers are vulnerable to coastal hazards such as storms, erosion, sea-level rise, and flooding. Property owners should be mindful of potential impacts and risks associated with living at the coast. Some basic considerations are included in this section.

Investigations conducted by the Federal Emergency Management Agency (FEMA) and other organizations after major coastal disasters have consistently shown that properly sited, well-designed, and well-constructed coastal residential buildings generally perform well. An excellent source of information for protecting your property at the coast is found in FEMA's *Coastal Construction Manual* (FEMA P-55) available on FEMA's website at fema.gov/library. Prepared by FEMA with assistance from other agencies, organizations, and professionals involved in coastal construction and regulation, this manual is intended to help designers and contractors identify and evaluate practices that will improve the quality of construction in coastal areas and reduce the economic losses associated with coastal disasters.

Additional coastal construction resources and publications are available via FEMA's website (www.fema.gov/residential-coastal-construction), including various National Flood Insurance Program Technical Bulletins, *Home Builder's Guide to Coastal Construction* (FEMA P-499), *Recommended Residential Construction for Coastal Areas: Building on Strong and Safe Foundations* (FEMA P-550), *Local Official's Guide for Coastal Construction* (FEMA P-762), *Wind Retrofit Guide for Residential Buildings* (FEMA P-804), and *Protecting Manufactured Homes from Floods and Other Hazards* (FEMA P-85).

BEACH MANAGEMENT IN MASSACHUSETTS

The science, management tools, and regulations pertaining to shore protection have generally progressed from building structures designed to protect buildings (seawalls and bulkheads) to practices that protect and enhance the natural beach (coastal buffer zones, dune protection, and beach nourishment).

Along the immediate coast, beach nourishment is one of the strategies used to minimize

storm damage to personal property and public infrastructure. Beach nourishment is the process of adding sand to an eroding beach to restore its width and elevation to specified, engineered dimensions. Large scale nourishment is commonly accomplished by pumping sand onto the beach from an offshore source using a dredge, although for smaller, parcel-scale, projects it may also be conducted by trucking sand onto the beach.

Beach nourishment does not prevent erosion or stop the movement of sand along a beach. It is actually a strategy that reestablishes the buffer of sand between the ocean and structures. To be effective over the long term, beach nourishment projects must be periodically maintained by adding more sand. Additional references for further reading are available at www.mass.gov/eea/docs/dep/water/resources/a-thru-m/bchbod.pdf and www.mass.gov/eea/docs/dep/water/resources/a-thru-m/bchtech.pdf

COASTAL LANDFORM MANAGEMENT

Coastal banks and dunes are an integral part of Massachusetts' beach system. They are vital to shoreline stability because they are protective features that also serve as reservoirs for sand. They are resilient natural barriers to the destructive forces of coastal storms and offer the least expensive and most efficient defense against flooding tides and waves.

Coastal storms can destroy even well-established dunes and vegetated banks. During storms, high-energy waves may wash against the base of the landform, eroding sand and undermining the seaward dune face. In extreme storms, the dune face may recede significantly and the feature itself may be destroyed. During storm events, sand is removed and redistributed along the beach—essentially the landforms act as a sand storage system and a buffer between waves and coastal property. Depending on the size of the feature and intensity of the storm, they can provide a barrier to storm surge and overwash, thereby reducing flooding on the landward side.

Coastal banks were deposited by glaciers thousands of years ago, and once eroded they will not naturally rebuild, although a new dune/beach system may build seaward of the eroded bank. Dune recovery after a storm depends on the severity of the storm and the initial condition of the dune. The front dunes can be severely eroded or completely flattened or overtopped during a storm. In the days and weeks after a storm, waves begin to push sand from nearshore bars back to shore to rebuild the beach. Eventually sufficient sand returns to the beach, and the dune begins to recover from storm damage as the wind blows sand up into the dune area. Natural dune rebuilding processes operate relatively slowly. Left solely to natural processes, dunes may take years or even decades to recover after a severe storm. Beach nourishment and dune building attempts to enhance and supplement these processes. In eroding areas where the natural retreat

of the beach system is prevented by structures, nourishment may be one of the only ways to extend the usable lifespan of that property. However, some methods of nourishment may actually be detrimental to the environment. One example is beach scraping, where sand is removed from a nearby intertidal area and pushed up onto the beach and dune. This method has the potential to deepen the water nearby the project site, allowing larger waves to reach the beach which can worsen the erosion.

A series of fact sheets (StormSmart Properties) have been developed by Massachusetts Office of Coastal Zone Management (CZM) to provide coastal property owners important information on a range of measures that can effectively reduce erosion and storm damage while minimizing impacts to shoreline systems. The fact sheets cover artificial dunes, dune nourishment, controlling runoff, planting vegetation, coir rolls, fiber blankets, sand fencing, and a variety of other shoreline stabilization techniques (www.mass.gov/eea/agencies/czm/program-areas/stormsmart-coasts/stormsmart-properties/).

Because dunes play such a direct role in providing storm and flood protection, it's important to remember that removal of dune material will increase flood risk. The NFIP prohibits all manmade alteration of sand dunes within VE and V zones unless an engineering analysis demonstrates that the activity will not result in an increased flood risk.

There are many ways for individuals and communities to help protect dunes in Massachusetts:

- Place signs on the dune to explain the importance of keeping off of the beach grass (and all vegetation).
- Restore damaged dunes, plant vegetation, and put up dune fencing to restrict traffic. Do not remove any material from the dune—all sand should remain on the dune and beach system.
- Use designated dune walkovers and access points to control pedestrian and vehicular traffic flow across dunes. All planted areas should be protected from vehicles, pedestrians, and pets.
- Allow beach grass and dune vegetation to grow naturally. Mowing destroys the grasses' ability to trap sand and may kill the plants.
- Maintain a clear, clean, and natural dune environment. Items such as Christmas trees, cut shrubs, and yard clippings will smother natural dune vegetation and may also become a fire hazard. This type of debris should not be placed on the dune or beach. Similarly, items such as cars, trucks, bikes, and boats should be kept off of the dune.

COASTAL PROPERTY CHECKLIST

If you live along the immediate coast, you are more vulnerable to the effects of coastal storms. High winds and waves may damage and destroy improperly constructed homes. Floating debris can crack foundation piles, causing collapse of the home or severe damage to windows and doors. Pressure from floodwaters on solid foundations can lead to collapse.

You can prevent or minimize damage by taking precautions during initial construction or by making modifications to an existing home. The following checklist is not all-inclusive and is not intended to replace local building code requirements or to serve as the only options for protecting your home from storm damage. For more information, contact your local building official or a building professional such as a coastal engineer, architect, or experienced contractor.

Flooding

- ❑ Do you know the projected flood elevation for your area? Ask your building department to see a flood map of your community.
- ❑ Do you know the estimated long-term erosion rates for your area? The Massachusetts Shoreline Change Project (www.mass.gov/eea/agencies/czm/program-areas/stormsmart-coasts/shoreline-change/) can provide information on shoreline trends, including erosion and accretion rates. Are any actions such as beach nourishment or other erosion control projects being implemented to mitigate long-term erosion?
- ❑ Is the first floor of the dwelling located above the projected flood elevation for your area?
- ❑ Is your home located in a V zone? Inclusion in a V zone indicates the potential for waves of three feet or greater in a storm event having a 1 percent chance of being equaled or exceeded in any given year. Retaining walls, bulkheads, or other soil management structures located underneath, connected to, or in close proximity to existing or proposed buildings may be prohibited within V zones.
- ❑ If your house is elevated on piles, do you have an open foundation, free of obstructions (i.e., if flood flow and waves can pass through the area relatively freely and not cause flood damage) that allows fast-moving waves and water to flow beneath the building?
- ❑ If storage areas or other enclosures are needed below projected flood elevations, they must be constructed with breakaway walls to allow water to flow through unobstructed. Is your enclosure breakaway?

- ❏ Are steps used for accessing the beach from the structure or the pedestrian dune crossover elevated or removed out of the reach of waves and floodwaters?
- ❏ Are the main electric panel, outlets, and switches located at least 12 inches above predicted floodwaters?
- ❏ Are the washer, dryer, furnace, and water heater elevated above predicted floodwaters?
- ❏ Are outside air-conditioning compressors and heat pumps elevated above predicted flood levels?
- ❏ Is the fuel tank securely anchored? It can tip over or float in a flood, causing fuel to spill or catch fire. Is it protected from impact, buoyancy, and scour? Cleaning a house inundated with oil-contaminated water can be difficult and expensive. FEMA has information (DVDs, YouTube, PDFs) on anchoring home fuel tanks (search Anchoring Home Fuel Tanks at www.fema.gov).
- ❏ What is the orientation of crossbracing on the pilings? Diagonal bracing will obstruct velocity floodwaters and waves and will often trap debris, therefore bracing is often placed parallel to the primary direction of flow. Check with your architect or engineer.
- ❏ Does the sewer have a backflow valve? Contact a licensed plumber to install the valve.
- ❏ Are there potential projectiles such as landscaping ties, cinder blocks, cement patio blocks, pile butts, or split rail fences located in the pathway of waves and flood waters? These objects can act like projectiles in a storm, cracking and damaging piles, windows, and possibly causing structural damage.

Wind

- ❏ Are windows and exposed glass surfaces protected by coverings?
  This is one of the best ways to protect your home against wind and flying debris.
- ❏ Is the roof fastened to the walls with galvanized metal hurricane clips? This will reduce the risk of losing your roof to high winds.
- ❏ Are the galvanized clips, straps, hangers, and joist-to-beam ties corrosion free? Corroded metal components can fail during extreme wind events. These should be replaced when corroded.

- ❑ Are the foundation piles notched less than 50 percent of the pile cross section? Overnotching can lead to failure of the piles.
- ❑ Are deck and lawn furniture, which are likely to become airborne debris, securely fastened or taken indoors?

Erosion

- ❑ Are your foundation piles deep enough to survive a coastal storm? How about back to back coastal storm events?
- ❑ Is your property protected by an artificially stabilized coastal bank or maintained beach and dune system?
- ❑ Is that project currently being maintained to its intended design? Is the bank or dune in front of your home well vegetated to reduce wind erosion? Is the dune of sufficient height and width to prevent overtopping by waves during a storm?
- ❑ Are there bare, low areas in the dune created by walking over the dune to access the beach? These areas are weak spots that will allow waves to flow over the dune and cause loss of the dune and subsequently allow waves and water into the house. Consider a zigzag pattern (if the dune is wide enough) so the water does not have a straight path towards your house. Stairways or seasonal walkways might also reduce erosion.
- ❑ Do not undertake any dune alteration activity unless a proper engineering analysis demonstrates that there will be no increase in flood risk. The NFIP prohibits man-made alteration of sand dunes within VE and V zones, which would increase potential flood damage.
- ❑ Is your home built on a concrete slab and located on the ocean or bay front? Concrete slabs can be undermined and destroyed during storms, causing the collapse of the structure. Crawl-space homes are also vulnerable to undermining. If feasible, elevate the structure on pilings to reduce future damages to the building.
- ❑ Does your home have a septic system located in a coastal high-hazard area (V zone)? Both buried and mound septic systems are frequently exposed, destroyed, or displaced during coastal storm events. Special design criteria must be used to protect septic systems in areas vulnerable to high-velocity flooding, wave action, erosion, and storm damage. (More information in 1999 Technical Fact Sheet FEMA P-348 available at www.fema.gov).

Structural

- ❏ Inspect strapping and connectors for corrosion and replace if necessary.
- ❏ Check roof for loose or missing shingles. Be certain gutters are clear of debris.
- ❏ Inspect condition of storm shutters or plywood used to protect windows and doors. Cover all large windows and doors (especially patio doors) with securely fastened, impact-resistant shutters with proper mounting fixtures.
- ❏ Make sure all doors and windows are caulked and/or weather stripped.
- ❏ Inspect sewer backflow valves.
- ❏ Inspect condition of elevated utilities and supporting platforms. Be sure utilities are securely anchored to the supporting frame.

Lot and Land Area

- ❏ Before a storm: Remove, secure, or store any objects that may be carried by waves or winds (e.g., deck furniture, landscaping, construction materials.)
- ❏ Before a storm: Raise or remove steps accessing the beach.
- ❏ As part of regular maintenance: Check condition of dune (width and elevation.)
- ❏ As part of regular maintenance: Inspect condition of beachgrass. Replant bare areas in the spring and fertilize as needed (and permitted.)
- ❏ As part of regular maintenance: Trim back dead or weak branches from trees.
- ❏ As part of regular maintenance: Inspect condition of beachgrass. If permitted by your local Conservation Commission, replant bare areas in the spring and fertilize as needed.

Endnotes

2.1 *Hurricane Vs. Nor'easter - Extension Bulletin.* Greg Berman and Kodi Nemunaitis-Monroe, Woods Hole Sea Grant Program and Barnstable County's Cape Cod Cooperative Extension. May 2012.

2.2 *The Saffir-Simpson Hurricane Wind Scale.* National Weather Service website. September 2014 at www.nhc.noaa.gov/aboutsshws.php.

2.3 *Freeboard.* Storm Smart Coasts-Massachusetts website. Accessed September 2014 at www.mass.gov/eea/agencies/czm/program-areas/stormsmart-coasts/stormsmart-communities/stormsmart-mitigate-freeboard.html

3.1 *Turn Around Don't Drown.* National Weather Service website. Accessed September 2014 at www.srh.weather.gov/tadd.

4.1 *Risks - Hurricanes.* Insurance Institute for Business and Home Safety website. Accessed September 2014 at www.disastersafety.

4.2 *Mitigation Directorate.* Federal Emergency Management Agency website. Accessed September 2014 at fema.gov.

4.3 *Residential Coastal Construction Manual* (FEMA P-55). Federal Emergency Management Agency, 2011. Accessed September 2014 at fema.gov/residential-coastal-construction.

4.4 *Is Your Home Protected from Hurricane Disaster? A Homeowner's Guide to Retrofit.* Insurance Institute for Business & Home Safety, 1998.

4.5 *Disaster Safety Videos.* Insurance Institute for Business and Home Safety website. Accessed September 2014 at disastersafety.org.

4.6 *Mitigation Assessment Team Report: Hurricane Sandy in New Jersey and New York—Building Performance Observations, Recommendations, and Technical Guidance* (FEMA P-942). Federal Emergency Management Agency, November 2013. Accessed September 2014 at fema.gov.

4.7 *Synthetic Roof Underlayment.* National Association of Homebuilders (NAHB) Research Center, ToolBase Services website. Copyright 2001. Accessed September 2014 at toolbase.org/Technology-Inventory/Roofs/synthetic-roof-underlayment.

4.8 *Homeowner's Guide to Retrofitting: Six Ways to Protect Your House from Flooding* (FEMA L-235--brochure and FEMA P-312--detailed manual). Federal Emergency Management Agency, December 2009. Accessed September 2014 at fema.gov.

4.9 *Protecting Your Property from Flooding.* FEMA website, June 2009. Accessed September 2014 at fema.gov.

4.10 *Hurricane Proofing Installation.* International Hurricane Protection Association website. Copyright 2009. Accessed September 2014 at inthpa.com.

4.11 Window Film Information Center. International Window Film Association website. Accessed September 2014 at www.iwfa.com.

4.12 *Bracing Garage Doors.* National Weather Service website. Accessed September 2014 at www.prh.noaa.gov/cphc/HAW/garage_doors.php

4.13 *Electrical Safety Precautions During Disasters.* Consumer Product Safety Commission Electrical Safety Foundation International website. Copyright 2010. Accessed September 2014 at publications.usa.gov/epublications/safety/precautions.htm.

4.14 *Guidelines for Handling Water Damaged Electrical Equipment.* National Electrical Manufacturers Association (NEMA) website. Copyright 2010. Accessed September 2014 at nema.org/stds/water-damaged.cfm.

6.1 *Glossary of Meteorology,* 2nd Edition. T. S. Glickman. American Society of Meteorology, Chicago, Illinois: University of Chicago Press, 2000.

6.2 *Global Climate Change Impacts in the United States.* U.S. Global Climate Change Research Program, 2009. Accessed September 2014 at globalchange.gov.

6.3 *Northeast Regional Highlights Fact Sheet.* From Global Climate Change Impacts in the United States report, 2009. Accessed September 2014 at globalchange.gov/publications/reports/scientific-assessments/us-impacts/regional-climate-change-impacts/northeast.

6.4 *Global Climate Projections.* Chapter 10 in Climate Change 2007: Working Group I: The Physical Science Basis by the Intergovernmental Panel on Climate Change (IPCC), 2007. Accessed September 2014 at ipcc.ch/publications_and_data/publications_and_data.shtml.

6.5 *Climate Change and Uncertainty in the Mid-Atlantic Region.* R. G. Najjar. Coastal Habitat Conservation in a Changing Climate: Strategies and Tools in the Mid-Atlantic Region. Wilmington, Del., 2012. Accessed September 2014 at collaborate.csc.noaa.gov/climateadaptation/Coastal%20Habitat%20Conservation/Workshop%20Presentations/Najjar_MidAtlanticCC_Jun21.pdf.

6.6 *Climate Change & Rhode Island's Coasts – Past, Present, and Future.* L. Heffner, R. Williams, V. Lee, P. Rubinoff, C. Lord. URI Coastal Resources Center/Rhode Island Sea Grant, 2012. Available online at nsgl.gso.uri.edu/riu/riut12001.pdf.

6.7 *A Statistical Deterministic Approach to Hurricane Risk Assessment.* 2006. Emanuel, K., Ravela, S., Vivant, E., and Risi, C. Bulletin of the American Meteorological Society. v 87, p. 299-314.

6.8 *A Consistent Poleward Shift of the Storm Tracks in Simulations of 21st Century Climate.* J. H. Yin. Geophysical Research Letters 32: L18701, DOI:10.1029/2005/GL023684, 2005. Accessed September 2014 at www.cgd.ucar.edu/~jyin/IPCC_paper_GRL_Jeff_Yin_final.pdf.

6.8 *Projections of Future Tropical Cyclone Activity.* I. Ginis. University of Rhode Island Climate Change Science Symposium, May 5, 2011.

6.10 *Potential Impacts of Climate Change on U.S. Transportation: Special Report 290.* 2008. National Research Council, Committee on Climate Change and U.S. Transportation. The National Academies Press, Washington D.C., 2008.

6.11 *Northeast Climate Impacts Assessment Report.* Climate Change in the U.S. Northeast, 2006. Accessed September 2014 at climatechoices.org/assets/documents/climatechoices/NECIA_climate_report_final.pdf.

6.12 *Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions.* Frumhoff, P.C., J.J. McCarthy, J.M. Melillo, S.C. Moser, and D.J. Wuebbles. 2007. Synthesis report of the Northeast Climate Impacts Assessment (NECIA). Cambridge, MA: Union of Concerned Scientists (UCS).

Acronyms and Abbreviations

ASCE: American Society of Civil Engineers

A zone: Areas within the 1% annual chance (base) flood limits and wave effects < 3'

BFE: Base Flood Elevation

CCETP: Cape Cod Emergency Traffic Plan

CERTs: Community Emergency Response Teams

CRS: Community Rating System

CZM: Massachusetts Office of Coastal Zone Management

DCR: Massachusetts Department of Conservation and Recreation

EAS: Emergency Alert System

EPA: Environmental Protection Agency

°F: Degrees Fahrenheit

FEMA: Federal Emergency Management Agency

FIRM: Flood Insurance Rate Map

GFCI: Ground Fault Circuit Interrupter

HMA: Hazard Mitigation Assistance

HMGP: Hazard Mitigation Grant Program

HVAC: Heating, Ventilation, and Air Conditioning

IBHS: Insurance Institute for Business and Home Safety

IRC: International Residential Code

MassDOT: Massachusetts Department of Transportation

MAT: Mitigation Assessment Team

MEMA: Massachusetts Emergency Management Agency

MITSG: MIT Sea Grant

MPH: Miles Per Hour

NASA: National Aeronautics and Space Administration

NEMA: National Electrical Manufacturers Association

NFIP: National Flood Insurance Program

NOAA: National Oceanic and Atmospheric Administration

NWS: National Weather Service

PVC: Polyvinyl chloride

SFHA: Special Flood Hazard Area

V zone: Zone subject to high velocity water including waves; (100-year flood limits and wave effects ≥ 3')

WEA: Wireless Emergency Alerts

WHSG: Woods Hole Sea Grant

Useful Links and Resources

This page includes links to websites where you can get more information on planning and preparing for a natural hazard.

American Red Cross: www.redcross.org

- Disaster Preparedness for Pets: www.redcross.org/prepare/disaster/pet-safety

Electrical Safety Foundation: www.esfi.org

Federal Alliance for Safe Homes: www.flash.org

Federal Emergency Management Agency (FEMA): www.fema.gov

- *Against the Wind: Protecting your Home from Hurricane and Wind Damage* (FEMA 247). Available at: www.fema.gov/library
- *Coastal Construction Manual: Principles and Practices of Planning, Siting, Designing, Constructing, and Maintaining Residential Buildings in Coastal Areas* (FEMA P-55) Available at: www.fema.gov/library
- *Home Builder's Guide to Coastal Construction.* Technical Fact Sheet Series, (FEMA P-499). Available at: www.fema.gov/library
- *Homeowner's Guide to Retrofitting: Six Ways to Protect Your Home From Flooding* (FEMA P-312). Available at: www.fema.gov/library
- *Local Officials Guide for Coastal Construction* (FEMA P-762). Available at: www.fema.gov/library
- National Flood Insurance Program (NFIP): www.floodsmart.gov
- NFIP Interactive Tool for Flood Costs: www.floodsmart.gov/floodsmart/pages/flooding_flood_risks/the_cost_of_flooding.jsp
- NFIP Interactive Tool for Flood Risk Profile: www.floodsmart.gov/floodsmart/pages/flooding_flood_risks/defining_flood_risks.jsp
- NFIP Technical Bulletins: www.floodsmart.gov
- Ready—Prepare, Plan, Stay Informed: www.ready.gov
- *Recommended Residential Construction for Coastal Areas: Building on Strong and Safe Foundations* (FEMA P-550). Available at: www.fema.gov/library
- Safer, Stronger, Protected Homes and Communities: www.fema.gov/safer-stronger-protected-homes-communities
- *Wind Retrofit Guide for Residential Buildings* (FEMA P-804). Available at: www.fema.gov/library

Insurance Institute for Business and Home Safety: www.ibhs.org

Mass 211: www.mass211.org

Massachusetts Department of Transportation (MassDOT): www.massdot.state.ma.us

Massachusetts Division of Insurance: www.mass.gov/ocabr/government/oca-agencies/doi-lp/mass-div-of-insurance

Massachusetts Emergency Management Agency (MEMA): www.mass.gov/eopss/agencies/mema

National Flood Insurance Program: www.floodsmart.gov

- Summary of Coverage: www.fema.gov/library/viewRecord.do?id=3011

NOAA: www.noaa.gov

Coastal Services Center: www.csc.noaa.gov

NOAA National Weather Service: www.weather.gov

Flood Safety: www.nws.noaa.gov/floodsafety

Boston, MA Forecast Office: www.erh.noaa.gov/er/box

National Hurricane Center: www.nhc.noaa.gov and www.nhc.noaa.gov/prepare

Severe Weather Safety: www.nws.noaa.gov/os/severeweather/resources/ttl6-10.pdf and www.nws.noaa.gov/om/severeweather/index.shtml

Weather Radio: www.weather.gov/nwr

NSTAR: www.nstar.com

National Grid: www.nationalgridus.com

U.S. Coast Guard: www.uscg.mil/news/stormcenter

Coastal Zone Management: www.mass.gov/czm

- StormSmart Coasts: www.mass.gov/czm/stormsmart

Woods Hole Sea Grant College Program: www.whoi.edu/seagrant

MIT Sea Grant College Program: www.seagrant.mit.edu

Notes

Hurricane Watch. Sustained winds of 74 mph or higher are possible in the specified area of the watch, usually within 48 hours. During a watch, prepare your home and review your plan for evacuation in case a hurricane warning is issued. As discussed earlier, preliminary preparations should begin even before a watch has been issued.

Hurricane Warning. Sustained winds of 74 mph or higher are expected in the specified area of the warning, usually within 36 hours. Complete hurricane preparations and leave the threatened area if directed by officials.

Tropical Storm Watch. Winds of 39 to 73 mph or higher pose a possible threat, generally within 48 hours. These winds may be accompanied by storm surge, coastal flooding, and/or river flooding. During a watch, prepare your home and review your plan for evacuation in case a tropical storm warning is issued.

Tropical Storm Warning. Winds of 39 to 73 mph or higher associated with a tropical cyclone are expected in 36 hours or less. These winds may be accompanied by storm surge, coastal flooding, and/or river flooding.

Coastal Flooding. Minor Flooding—minimal or no property damage, but possibly some public threat or inconvenience. Moderate Flooding—some inundation of structures and roads near streams. Some evacuations of people and/or transfer of property to higher elevations are necessary. Major Flooding—extensive inundation of structures and roads. Significant evacuations of people and/or transfer of property to higher elevations.

Coastal Flood Advisory. Minor coastal flooding is occurring or imminent. Listen to the NOAA weather radio station or local radio stations or check your local television station for information.

Coastal Flood Watch. Moderate to major coastal flooding is possible. Such flooding would potentially pose a serious risk to life and property. Be prepared to move to higher ground—listen to the NOAA weather radio station or local radio stations or check your local television station for information.

Coastal Flood Warning. Moderate to major coastal flooding is occurring or imminent. This flooding will pose a serious risk to life and property. Take necessary precautions at once. If advised to evacuate to higher ground, do so immediately.

Flash Flood or Flood Watch. Flash flooding or flooding is possible within the designated watch area. Be prepared to move to higher ground—listen to the NOAA weather radio station or local radio stations or check your local television station for information.

Flash Flood or Flood Warning. Flash flooding or flooding has been reported or is imminent. Take necessary precautions at once. If advised to evacuate to higher ground, do so immediately.

Severe Thunderstorm Watch and Warning. A Severe Thunderstorm Watch is issued when severe thunderstorms are possible in and near the watch area. It does not mean that they will occur; it only means they are possible. A Severe Thunderstorm Warning is issued when severe thunderstorms are occurring or imminent in the warning area. Severe thunderstorms are defined as having winds of 58 mph or higher and/or hail 1 inch in diameter or larger.

Tornado Watch and Warning. A Tornado Watch is issued when severe thunderstorms and tornadoes are possible in and near the watch area. It does not mean that they will occur; it only means they are possible. A Tornado Warning is issued when a tornado is imminent. When a Tornado Warning is issued, seek safe shelter immediately.

COASTAL STORMS

WINDS

BLIZZARDS

FLOODS