MASSACHUSETTS

HOMEOWNER'S HANDBOOK

TO PREPARE FOR COASTAL HAZARDS

3RD EDITION, JULY 2020

Woods Hole Sea Grant

County of Barnstable Massachusetts

Acknowledgments

This handbook was developed as a cooperative project among the two Massachusetts Sea Grant programs, Woods Hole Sea Grant (WHSG) and MIT Sea Grant (MITSG), as well as Barnstable County, Massachusetts Emergency Management Agency (MEMA), Massachusetts Office of Coastal Zone Management (CZM), Federal Emergency Management Agency (FEMA), National Weather Service (NWS), and Massachusetts Department of Conservation and Recreation (DCR).

This project partnership aims to increase the resiliency of coastal communities to natural hazards by encouraging actions that reduce the risk to family and property. Preparing for coastal hazards by planning, performing home maintenance, and undertaking preventative retrofits enhances individual resilience and helps create a strong community.

We are editing this edition in the midst of the COVID-19 pandemic, which adds another level of considerations to emergency supply kits and planning, and we urge you to bear this in mind as you develop your plans. 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.

We are grateful to 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.

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PART 1

Introduction

Your home is one of your greatest financial investments. It 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 hand book can help you:

- ✓ Understand the historic risks of severe storms in our region and their impacts and consequences
- ✓ Develop emergency plans to protect yourself, your family and your home from the impacts of severe storms
- ✓ Strengthen your home's physical structure to withstand severe storms
- ✓ Ensure that you have the proper insurance to recover from the impacts of a severe storm.

This handbook will be updated on an as-needed basis as new information becomes available and feedback from the public is obtained. For local emergency planning information, contact your community's emergency management director (EMD). For a listing of EMDs, see *www.mass.gov/mema*.

Your home is one of your greatest financial investments. It is a place that shelters you, your family, and most of your possessions from the elements of nature.

COMMON MYTHS

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 belief in a number of 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 Hurricane Bob and Superstorm Sandy, so I am sufficiently prepared."

When another massive natural disaster occurs, the resulting damage could be much greater than the damage seen with Hurricanes Bob and Sandy. Bob, which was only a category 2 hurricane drove a surge of 10 to 15 feet into Buzzards Bay and caused over $680 million in damage in Massachusetts. 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 when it impacted 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. In all reality, we have been lucky in the past (see Part 2.1 for details on historic storms). Weather patterns are changing with climate change, making strong, damaging storms more likely in Massachusetts.

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, Hurricane Bob was responsible for six deaths and caused over $1.5 billion in damage, with most of that monetary loss occurring in Massachusetts (see Part 2.1 for details on storm damage).

MYTH 3 "My house isn't waterfront, 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 Part 2.2 for details on flooding).

MYTH 4 "We had a 100-year storm recently so we won't see another storm that big again for another 100 years."

The term 100-year storm can easily be misinterpreted to mean it only happens once every 100 years. However, the term actually refers to the probability of a storm of that intensity occurring. Statistically, it means each year there is a one percent (or 1-in-100) chance of that storm occurring. So while these events have a lower statistical likelihood of happening than your average storm, they can and do happen even within a few years of each other.

MYTH 5 "Even if I prepare for a storm, my home won't be stormproof."

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 Part 4 for details on ways of protecting your home).

MYTH 6 "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. 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 Part 5 for details on insurance).

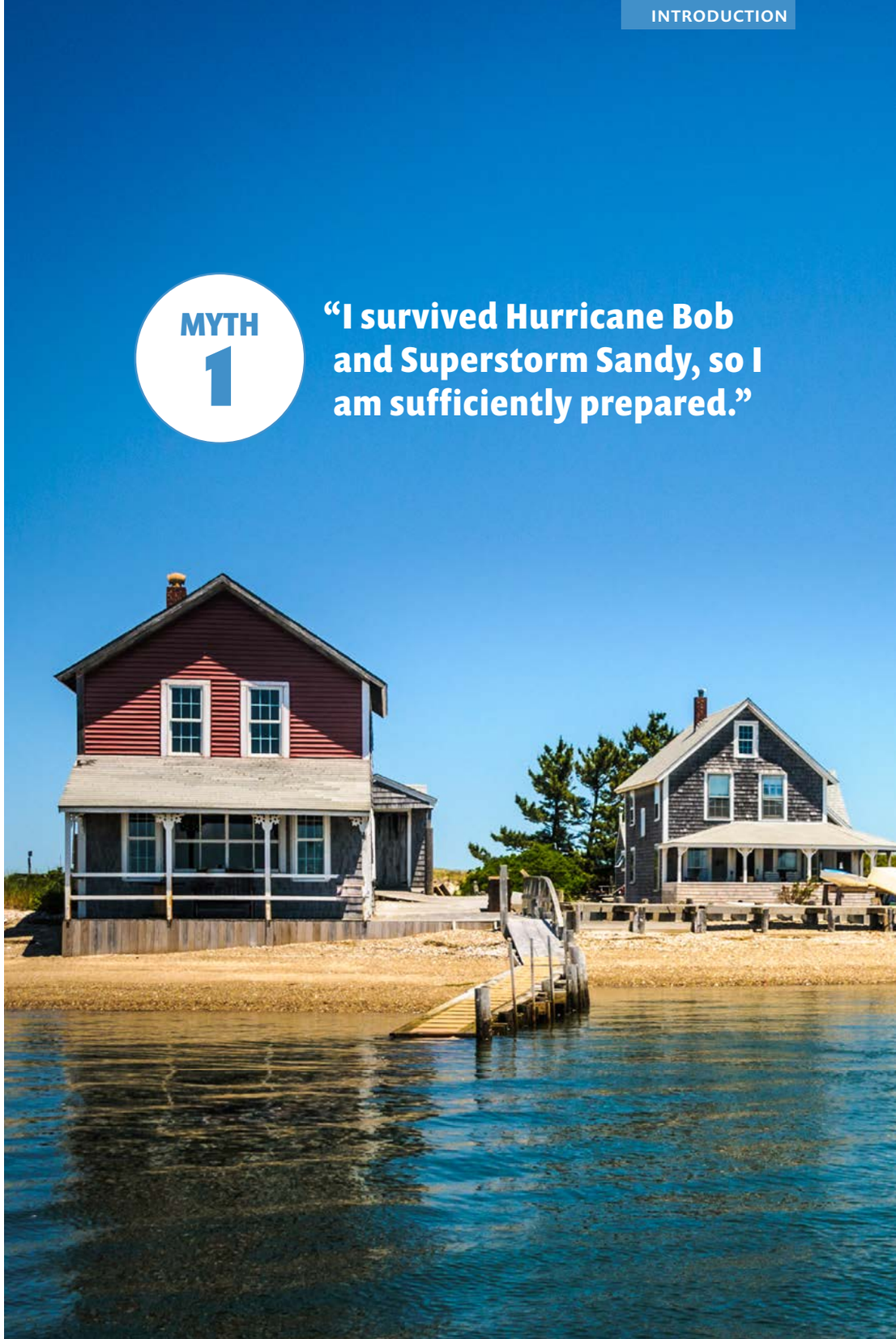
MYTH 7 "If a natural hazard event occurs, there is nothing I can do."

Fortunately, there are many small steps you can take to significantly reduce the risks 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 to your family's safety and determine whether your house survives and sustains minor or no damage. Thus, the information in this handbook covers two major parts for preparation: protecting yourself and your family (Part 3) and protecting your property (Part 4).

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

There are several relatively inexpensive ways to strengthen your house (see Part 4). 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.

MYTH 1 "I survived Hurricane Bob and Superstorm Sandy, so I am sufficiently prepared."



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.

Be aware that Massachusetts is vulnerable to potentially devastating natural hazards

Severe coastal storms, hurricanes and floods occur in our region (see Part 2). Preparing for larger hazard events will offer protection from the smaller, more frequent events.

Gather emergency supplies

You can gather emergency supplies in your house now to avoid the long lines and empty shelves you're likely to find at a store during an emergency (see Part 3).

Assemble an evacuation kit

If your evacuation plans include using a public shelter (or family/friends outside of the hazard area) for a coastal storm or flood, bring an evacuation kit along with any special diet foods or medications you require. The kit should be assembled and checked before hurricane season (see Part 3). Don't forget to plan for your pet and prepare a pet evacuation kit (see Part 3).

Create an evacuation plan

If you're ordered to evacuate, you should. Your evacuation plan should be to shelter in a building (e.g., friend/relative's house, shelter, hotel) that is not likely to sustain significant damage. See Part 3 for details on developing your family's evacuation plan.

Know your property and take appropriate action

Look at where your home is located. Consider potential for damage from flooding, downed trees, or wind damage to your home (see Part 4).

Know your house and take appropriate action

Does your home 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? Consider retrofits to improve your home's safety (see Part 4).

Strengthen your house

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 including installing clips to tie the roof to the walls and the walls to the foundation, elevating your home above predicted flood elevation, and protecting your windows, garage, and doors (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

If you perform the work to strengthen your home, 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 and belongings

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. Only flood insurance covers flood damage. Renters should purchase their own renter's insurance to cover their personal belongings. The Massachusetts Division of Insurance suggests that you create a home inventory of what you own and what it is worth.

Be aware that Massachusetts is vulnerable to potentially devastating natural hazards.

PART 2

Coastal Storm Hazards: An Overview for Homeowners

In Massachusetts, many different types of natural hazards can occur, including coastal storm flooding and erosion, 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 and by "nor'easters." Heavy winds, rain, large waves, and storm surge from both types of systems have potential for coastal damage. 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. Hurricanes are "warm core" low pressure systems, which means they are warmer at the center than at the periphery of the storm. They thrive on warm ocean 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 tropical systems 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

TABLE 2-1. SAFFIR-SIMPSON HURRICANE WIND SCALE

Source: Adapted from NOAA's National Weather Service website

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.

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 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.

HURRICANES POSE MULTIPLE THREATS

- high winds
- storm surge
- flooding associated with heavy rains
- potential to produce tornadoes

Winds

Wind intensity is used to define hurricane strength, according to five categories described in the Saffir-Simpson Hurricane Wind Scale.[2.1] 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. For example, wind gusts for a Category 3 storm can exceed the maximum sustained winds of a Category 5.

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.

Storm Surge

Storm surge (Figure 2-2) is a large (often 50 to 100 miles wide) dome of water, above the normal or predicted high tide level, being pushed toward the shore by the force of the winds moving around the storm. The worst storm surge usually occurs along the coast to the right of where the hurricane makes landfall (see Figure 2-3).

Storm surge typically accounts for 90 percent of storm-related deaths. The impact of the storm surge depends upon the timing

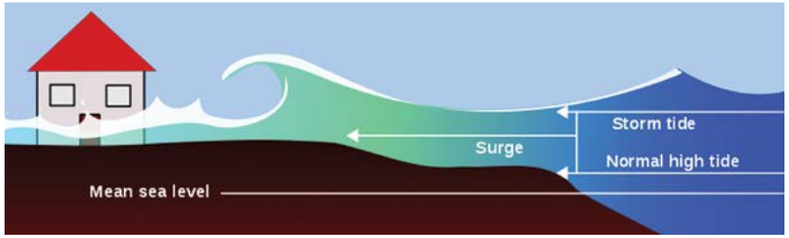


Figure 2-2. Storm surge depiction. Image Credit: NOAA/ The Comet Program.

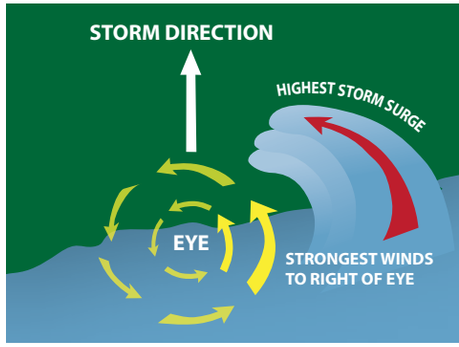
with respect to high tide. The highest storm surges usually occur in the upper parts of bays and inlets where the water becomes constricted and forced up. For example, a surge of 20 to 25 feet is possible at the upper part of Buzzards Bay along the Wareham and Bourne shoreline. Along the more open coast,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

Flooding

Rainfall totals of 10 inches or more are common when a tropical storm or hurricane moves across a coastal location, which 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, areas of higher ground, 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, dispelling a common misperception is that a hurricane or other tropical system will only impact Massachusetts's immediate coast. Records show that all areas of Massachusetts are vulnerable to potentially devastating impacts of tropical storm force winds, torrential rains and associated flooding, and therefore, inland residents do need to prepare as well.

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.).



NATURAL HAZARDS

Historic Hurricanes and Tropical Storms

Sept. 21, 1938

THE NEW ENGLAND HURRICANE OF 1938 AKA "LONG ISLAND EXPRESS"

- Category 3
- Landfall: Long Island and Connecticut
- Sustained winds in Massachusetts: 121 mph with gusts to 186 mph
- Storm surges: up to 12 feet
- Extensive damage and widespread power outages
- 8,900 buildings were destroyed and 15,000 damaged in New England
- Catastrophic damage to southern New England fishing fleet: over 6,000 vessels destroyed or severely damaged
- In southern New England, 564 people killed and 1,700 injured
- Total damages $306 million

Aug. 31, 1954

CAROL

- Category 3
- Landfall: eastern Long Island and eastern Connecticut
- Winds: 100 mph, gusting up to 135 mph
- In the region, destroyed 4,000 homes, 3,500 cars, and over 3,000 boats
- In New England, killed 65
- Total damages $460 million

Sept. 11, 1954

EDNA

- Category 2
- Landfall: Massachusetts
- Winds: 96 - 110 mph; gusts of 120 mph,
- Storm surges: 6 ft
- Heavy rainfall added 5 to 7 inches already saturated land causing extensive erosion
- Edna caused $40 million damage across the region

1930 | 1940 | 1950 | 1960 | 1970 | 1980 | 1990 | 2000 | 2010 | 2020

Sept. 15, 1944

GREAT ATLANTIC HURRICANE

- Category 2
- Landfall: Rhode Island
- Winds: 100 mph
- More than $5 million in damage on Cape Cod can be attributed to lost boats, as well as fallen trees and utility damage
- In New England, up to 11 inches of rain fell
- A total of 28 people killed
- Total damages $100 million

Aug. 19, 1991

BOB

- Category 2
- Landfall: Rhode Island
- Max sustained winds of 100 mph
- 10- to 15-foot storm surge in Buzzard's Bay
- A number of south-facing beaches on Nantucket and Martha's Vineyard lost 50 feet of beach to erosion
- Up to 7 inches of rain was reported to have fallen throughout New England
- Bob is blamed for 18 storm-related deaths
- $39 m in damages in Mass

Hurricanes and Tropical Storms and Climate Change

The U.S. has seen several stronger storms in recent years, such as Hurricanes Harvey and Maria in 2017 and Hurricane Dorian in 2018. There has also been a trend toward slower-moving tropical storms, which result in rain, wind, and storm surge persisting over multiple tidal cycles and causing more damage. By 2050, we can expect to see between 1.7 and 2.4 feet of sea level rise.[2-1] With sea level rise, storm surges will become more destructive. Sea level rise provides a higher base for storm surge to accumulate on top of, meaning that past storms may no longer be good proxies for future damage from storm surge. Finally, scientists believe that climate change is causing the tropics to expand, allowing more intense storms to reach further northward. In the future, the total number of tropical storms is generally projected to remain steady, or even decrease, but the most intense storms are generally projected to become more frequent, and the amount of rainfall associated with a given storm is also projected to increase.[2-3] Although Massachusetts has not historically been subjected to frequent high-intensity storms, that likelihood will increase with climate change.

2.1.2 Nor'easters—Extratropical Systems

While not as powerful in terms of wind speeds as hurricanes, nor'easters (also called northeasters) are more frequent in Massachusetts, usually occurring in the late fall, winter, and early spring. 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 strong temperature gradients that commonly occur just off the U.S. East Coast during winter.

Nor'easters:

- cover a larger area than hurricanes and are typically slow-moving
- usually affect a large portion of the coast
- can erode beaches and dunes and demolish buildings, boardwalks, and roads over several successive tides
- are most damaging when they stall off the coast
- typically produce winds ranging from 30 to 40 mph, with gusts that can exceed 74 mph (i.e., hurricane force)
- can generate storm surge heights of 3 to 5 feet above normal and destructive waves over 20 feet high, depending on the storm's duration and location relative to the shoreline
- can cause extensive flooding in both coastal and inland areas

Nor'easters and Climate Change

Because of climate change with its rising sea level and greater precipitation, nor'easters will become more destructive. As during tropical storms, destructive storm surge will have a higher base thanks to sea level rise. Precipitation in the winter is expected to become more episodic, with greater amounts of winter precipitation falling in more extreme events. The increase in average temperature will likely reduce the amount of precipitation falling as snow or ice and increase precipitation falling as rain.[2-4] 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.

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 occur near a coastal body of water such as the ocean, or inland water body, such as a stream, river or reservoir. Coastal flooding can result from:

- high tides (usually on either side of a new or full moon)
- storm surge
- heavy rainfall can exacerbate flooding or cause flooding in inland areas with poor drainage
- waves generated by storms located hundreds or thousands of miles from Massachusetts, or a combination of any of these mechanisms

It's important to take steps to determine your home's risk of flooding. One important step 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 designated floodplain. (See Parts 4 & 5 for ways to protect your home.)

Another important source of information on your property's flood risk is the Federal Emergency Management Agency's (FEMA) Flood Insurance Rate Maps (FIRMs). The FIRMs include flood zones designating the

NATURAL HAZARDS

Historic Nor'easters

February 1978

THE BLIZZARD OF '78

- 27" of snow in Boston. The storm stalled to the south of Cape Cod
- Hurricane force winds; 5-foot storm surge
- Waves caused serious erosion resulting in seawall breaks, washed-out roads, destroyed parking lots and damage to thousands of homes along the coast
- Caused 73 deaths, 4,324 injuries
- $500 million in damage
- The nor'easter of 1978 Set a 40-year record for water levels in Boston 15+ feet above MLLW

April 1, 1997

APRIL FOOL'S DAY STORM

- 24" of heavy, wet snow fell on Boston
- Public transportation was crippled, about 1,000 motorists spent the night stranded in their cars and 4,000 stayed in shelters

April 15-17, 2007

THE PATRIOT'S DAY STORM

- Tropical storm force winds lashed coastal areas with peak gusts ranging from 50-60 mph from Boston to the north shore, down to Cape Cod and Islands
- The combination of the long easterly fetch, the very low pressure at the storm center, and the high wind, caused significant coastal flooding and wave battery through several successive high tides
- Breached barrier beaches at both Pleasant Bay on outer Cape Cod and Katama Bay on Martha's Vineyard, creating new inlets for the bays

January 4, 2018

THE "BOMB CYCLONE"

- Winds gusted to hurricane-force at 76 miles per hour (122 km/h) on Nantucket Island
- At least 17.0 inches (430 mm) of snow fell on Boston In Boston, a freezing storm tide of 15.16 ft (4.62 m) was recorded during the blizzard which flooded areas of the financial district, including a subway station, setting a new historical record. Water levels in Boston broke a 40-year record by 2 inches (though about 4.5" was due to sea level rise)

1970 | 1980 | 1990 | 2000 | 2010 | 2020

October 31, 1991

THE HALLOWEEN STORM OR THE NO-NAME STORM OR THE PERFECT STORM

- 80-foot waves that destroyed over 100 homes and led to extensive coastal flooding throughout the area
- The storm became the subject of a best-selling book and popular film which told how the storm wrecked the shipping vessel Andrea Gail, and caused the death of the six crew members on board

March 2-5, 2018.

MARCH 2018 NOR'EASTER

- Wind gusts of 80-90 mph with a gust to 97 mph measured at Wellfleet
- Nearly half-million power outages primarily in southeastern and northeastern Massachusetts
- The structural damage from this major storm created vulnerabilities that led to even greater impacts at some locations when another nor'easter struck just days later on March 7 – 8

severity of the flood risk as well as the type of flooding experienced in the area. Floods maps can be viewed or downloaded from FEMA's Map Service Center (*www.msc.fema.gov*) and may also be available for viewing at your town or city hall building departments. While very helpful, these maps are intended to be used for regulatory and insurance purposes, not to demonstrate all possible flood risk. Even if you are not in a high-risk flood zone, you may still be at risk from flooding. According to FEMA, nearly 30 percent of flood insurance claims come from low-to-moderate risk areas. Furthermore, changes in precipitation, coastal erosion, and sea level can increase the risk of a FEMA-designated flood zone after a map is released because these maps are based on conditions at the time of study and do not include projected future changes.

Another source for flood-risk maps is the US Army Corps of Engineers (USACE), which has updated hurricane inundation maps for coastal communities in Massachusetts in response to Hurricane Sandy (*mass.gov/info-details/hurricane-evacuation-zones*). These maps are specific to the risk of flooding from hurricanes and correlate with hurricane evacuation planning maps discussed in more detail in Part 3.3.

Flooding and Climate Change

With climate change, flooding is expected to worsen with higher sea levels and more precipitation in large storm events.[2-5] This means that storm surges will become more destructive and rain and snow events can cause more inland and coastal flooding because our stormwater systems were not designed to manage the increased amount of rain.

2.3 HAZARD MITIGATION AND CLIMATE CHANGE ADAPTATION

With the changing climate and increasing threats from natural hazards, Massachusetts's coastal homes, buildings, roads, bridges, and other infrastructure are becoming increasingly vulnerable. 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 acknowledge we need to prepare for the projected changes attributed to climate change, as 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 (see Table 2-2), there are many

TABLE 2-2. SUMMARY OF OBSERVED AND DOCUMENTED CURRENT CLIMATE TRENDS IN MASSACHUSETTS

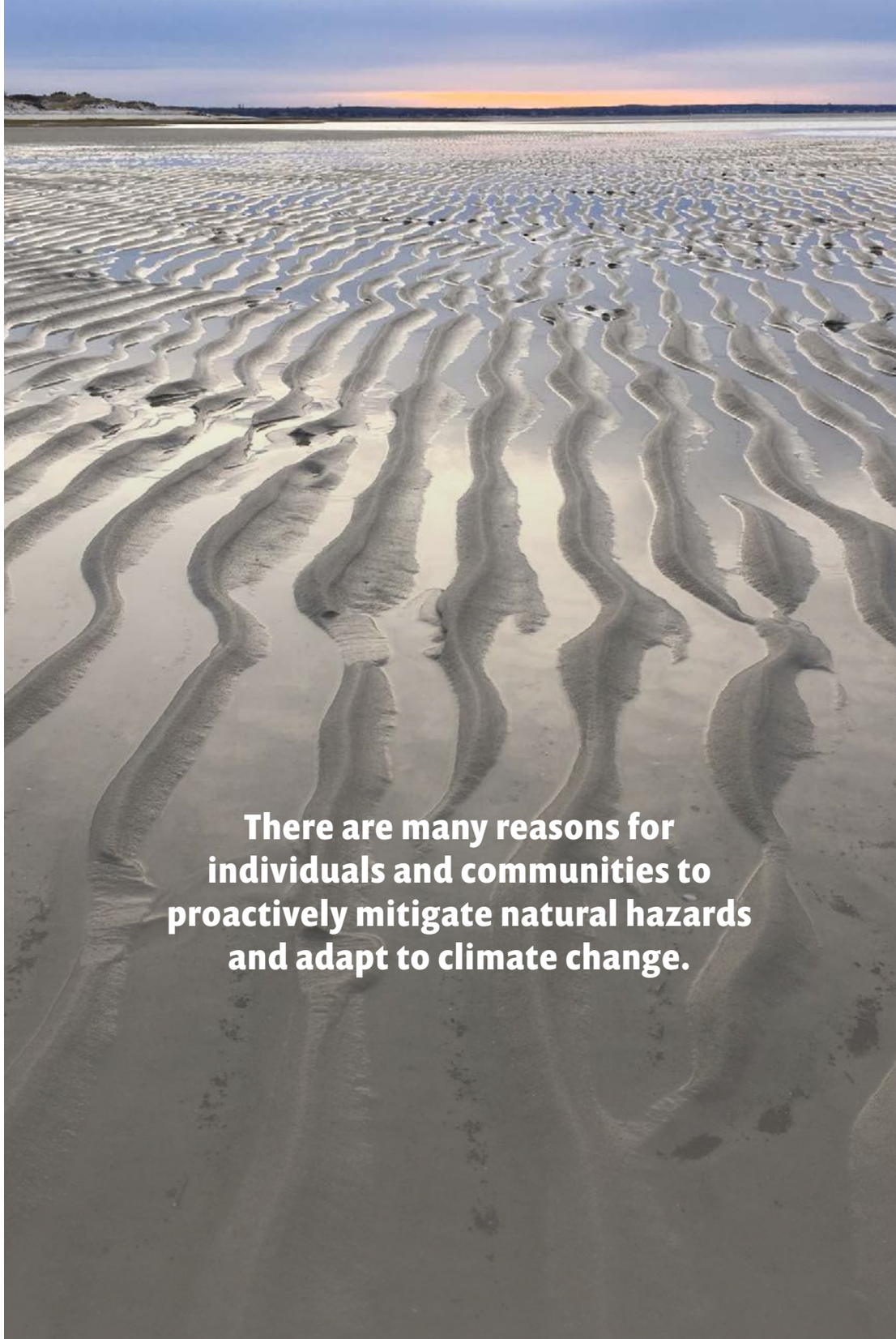
Source: From ResilientMA.org

Climate Change Variable	Current Trend in Massachusetts	What this Means
Air Temperature	Since 1970, air temperatures have risen an average of 0.5°F per decade. MA currently experiences an average of 4 days per year with temperatures over 90°F; by 2100, that number could be as high as a staggering 56 days.	Longer, hotter summers increasing drought potential and human health effects. Impacts on energy use, infrastructure, agriculture, and tourism. Increased risk of wildfires.
Precipitation	Precipitation is projected to increase 3-16% by 2100, with the bulk of that increase falling in heavy rain storms.	Increased risk of flooding because stormwater systems were not designed to handle that volume of water. Less snow in winter
Storminess	Warmer air currents over MA will hold more moisture than in the past, increasing the potential for damaging blizzards, nor'easters, and tropical storms.	Increased erosion and damage to roads, bridges, buildings, and natural resources. Interruption of business. Increased public safety risks.
Sea Level Rise	Sea level has risen about 1 foot since 1930, and is expected to rise between 4 and 10 feet by 2100.	Increased flooding. Loss of waterfront property and impacts to public access, including beaches.

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 and can reduce flood insurance premiums for individuals and community-wide.

What your community can do

Many communities are taking action through Multi-Hazard Management Planning, participation in the state's Municipal Vulnerability Preparedness Program, and joining the National Flood Insurance Program's Community Rating System. These programs help towns to plan ahead, providing a framework to improve coastal resiliency and funding or incentives to complete action items. These planning opportunities are ongoing, and citizen participation is encouraged: reach out to your town to find out what your town is doing and how you can get involved.



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). Appendix A contains a helpful list of emergency contact information.

Things to remember during an emergency:

- Stay alert, stay calm, and be informed (tuning in to local radio and television is important).
- Listen to your local radio and television stations carefully as there may be additional or modified directions and sheltering information based on the type of disaster and best available information at that time. "Local" means radio and television broadcasts specific to the area in which you live.
- In general, stay off the roads. Only drive if it is absolutely essential. The police may close many roads during an emergency, including entrances to highways. If you encounter a flooded roadway: turn around, don't drown!
- State and local emergency management agencies may issue a mandatory evacuation. All individuals are expected to remain calm and follow direction.
- Monitor official radio and television broadcasts for an updated list of shelters that may be open for a specific hazard event. If it is unsafe to shelter-in-place and you do not have an alternative, evacuate to a designated emergency shelter.
- Follow your family evacuation plan.

3.1 EMERGENCY NOTIFICATION AND INFORMATION SYSTEMS

When preparing for and responding to an emergency, it is important to understand the terms being used, i.e. the difference between a "watch" and a "warning." Please see the list of terms in the glossary for help understanding the levels of warnings associated with coastal hazards.

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 contact local public safety agencies to sign up for these local notification systems.

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*. Barnstable County Regional Emergency Planning Committee provides social media alerts for Cape Cod on Facebook (*www.facebook.com/bcrepc/*) and Twitter (*www.twitter.com/bcrepc*).

Wireless Emergency Alerts. The wireless industry, the FCC, and FEMA have developed 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 service is available on 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:

- **Media**. Local news media may provide up-to-date, real-time emergency information.
- **Towns/Counties**. Local (town/county) public information officers put out information through social media. Some counties may have online resources, for example the Barnstable County Regional Emergency Planning Committee website has up-to-date notification for shelters and situational awareness through the storm (*www.bcrepc.org*). Police and fire department personnel may use loudspeakers and make door-to-door contacts.
- **NOAA**. NOAA Weather Radios provide an excellent source of up-to-date, real-time emergency information, particularly severe weather alerts (*www.weather.gov/nwr*).
- **Mass211**. To reduce the number of non-emergency calls made to 9-1-1 during an emergency, the designated primary telephone information call center is 2-1-1. 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/mema* is updated to provide information during major emergencies and disasters and also includes a feed of their most recent Twitter posts.
- **Harbor Masters/U.S. Coast Guard**. Announcements from town harbor masters or an Urgent Marine Information Broadcast from the U.S. Coast Guard for maritime related emergencies.
- **TTY**. 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.

3.2 EMERGENCY SUPPLIES

During a hazard event, your access to basic supplies may be cut off or they may be unobtainable, so it is wise to have supplies for three to five days depending on the type and extent of the disaster event. The importance of these supplies has been demonstrated during several storms, most recently

the winter storms in March of 2018, which knocked out power for multiple days in many areas in Massachusetts.

Whether for use as you shelter at home, move to a safer location, or evacuate to a shelter, 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). See the list of supplies for each contingency in Table 3-1. Old food and water should be used or discarded and replaced with fresh supplies. Do not keep expired supplies. A great resource for preparedness kits, tools, and information is the federal government's Ready site (*ready.gov*).

It is wise to have supplies for three to five days depending on the type and extent of the disaster event.

TABLE 3-1. EMERGENCY SUPPLY LIST

Items	At-home	Evacuation	Shelter
NOAA weather radio w/AM FM; spare batteries	✓	✓	✓
Flashlight w/spare batteries and bulbs	✓	✓	✓
Medications clearly marked with your name, dosage, type of medication, and prescribing physician	✓	✓	✓
Water	✓	✓	✗
First-aid kit in waterproof box	✓	✓	✓
Pet supplies include items such as bowls, food, medications, bedding, waste disposal bags, pet carrier/cage, and extra leash/harness. Pets should have I.D. tags, as well as records of current, up-to-date license and vaccinations.	✓	✓	Be aware that some shelters will only allow service animals. Pet-friendly shelters will be noted when shelter locations are announced during an evacuation.
Three-day supply of non-perishable food and any special dietary food, e.g. diabetic, low salt, liquid diet	✓	✓	No need to bring food, but DO bring special dietary food, e.g. diabetic, low salt, liquid diet
Baby supplies (diapers, food, bottles, clothes, blankets, medication)	✓	✓	✓
Clothing and bedding - One complete change of clothing including footwear. Rain gear and sturdy shoes. Sleeping bag, air mattresses, blankets, and pillows	✓	✓	Portable baby bed, cots for elderly (cots might not be provided)
Personal care items: washcloth, small towel, soap, toothbrush, toothpaste, sanitary napkins, tampons, paper towels, toilet paper, towelettes, hand disinfectant, etc.	✓	✓	✓
Manual can opener	✓	✓	✗
Cell phone with a car charger	✓	✓	✓

Items	At-home	Evacuation	Shelter
Copies of important documents: name & address of doctors, lists of medications. Name & address of nearest relative not living in area, driver's license, social security card, proof of residence, insurance policies, wills, deeds, birth & marriage certificates, tax records, medical records, family pictures, etc.	✓	✓	✓
Grill (hibachi with charcoal, camp stove w fuel, BBQ w/ propane)	✓	✗	✗
Matches/lighter	✓	✗	✗
Disposable plates and utensils	✓	✗	✗
Tarp or sheeting, string/rope, duct tape	✓	✗	✗
Sunscreen and bug repellent	✓	✗	✗
Bleach	✓	✗	✗
Alternate power supplies (generators, inverters, power stations, and battery chargers). See Part 4 of this book for descriptions of alternative power sources.	✓	✗	✗
Games, toys, books, and other diversions	✓	✓	✓
Cash	✓	✓	✓

Your supply 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 your evacuation 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.

Note that if you plan to take shelter in your home (outside any evacuation zones), you may wish to have more than three to five 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.

3.3 EVACUATION PLANNING

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 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 flooding. See: *www.mass.gov/knowyourzone*. Residents should know which zone they live in, if any, so that they can evacuate if an order is given.

Another resource for evacuation planning is storm surge maps produced by the National Hurricane Center when a coastline is placed under a Hurricane or strong Tropical Storm Watch or Warning. These maps depict the plausible worst-case inundation that could occur from an imminent storm and are updated every six hours with changes in the National Weather Service forecast for that live storm. When available, they can be accessed through the National Weather Service webpage specific to each active storm. Because these maps are event-specific, they can be used in conjunction with the MEMA hurricane evacuation zones to help you determine if you feel safe remaining in your home even if no evacuation order has been issued. Remember, if there is an evacuation order, you should obey local authorities and relocate to a safer place.

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), which helps stream traffic off Cape Cod during a storm and provides for shelters for tourists who are unable to leave the Cape if the Bourne and Sagamore Bridges are closed as a result of adverse weather conditions (Figure 3-1).

When you put your evacuation plan together, here are some things to consider:

- 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.
- As part of your evacuation plan, determine how family members will communicate if they become separated. Each family member should have a list of phone numbers and email addresses of everyone in the family and phone numbers of a few contacts outside of the family and other appropriate contacts, such as family friends. 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.
- Parents should be familiar with the evacuation plans that are in place for their child's school, specifically, where the students will be held and for how long during each type of natural hazard.
- 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.

DISASTER PREPAREDNESS INFORMATION FOR PET OWNERS

Information is available at *www.mass.gov/info-details/emergency-preparedness-for-pets-and-animals*. To learn more about shelters and pets, visit the State of Massachusetts Animal Response Team's Disaster Animal Response Team webpage at *smartma.org/disaster-animal-response-teams-dart/*.

3.4 SECURING YOUR HOME AND PROPERTY 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.

Figure 3-1. The Cape Cod Canal effectively makes Cape Cod an island. The bridges over the canal provide the only escape by land from Cape Cod during an emergency. mage courtesy of Richard LaTour, MEMA.

- 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).
- See Part 4—Protecting Your Property for fundamental improvements to strengthen your home.

3.5 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. 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 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. If you evacuate, you should already have prepared your house and made plans for your pet.

If you have been told to evacuate by local authorities, you should do so. If you haven't been told to evacuate but are concerned about staying in your home, you can use the Know Your Zone maps and storm surge inundation maps discussed in Part 3.3, your own judgement, and your comfort level to decide whether to leave your home for any given storm.

When an emergency situation warrants evacuation to a shelter, information will be released through local radio and television stations, (*www.mass.gov/mema*) Mass211 (dial 2-1-1 on your phone), and other available means concerning which specific shelters are available for evacuation purposes and when public shelters will open. Remember that shelters may be opened selectively depending on the severity of the storm. Shelter planning in Massachusetts is a cohesive effort between local, county, state, federal, and volunteer partners. Some areas (ex. Barnstable County *www.bcrepc.org/sheltering/shelter-map/*) have region-specific information on sheltering. You can contact your local Emergency Management Director for information on where you can find your local and/or regional shelter.

- Listen to instructions issued by emergency management officials and evacuate with your evacuation kit before danger arrives.
- You may wish to shower/bathe and eat before evacuating as amenities might be limited.

- Register immediately upon entering the shelter.
- Obey shelter rules. NO alcoholic beverages are allowed in shelters.
- Keep the building safe and sanitary.
- 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 (see Table 3-1).
- 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.

3.6 SAFETY PROCEDURES FOR A FLOOD

A flood can be caused by storm surge or heavy rainfall in combination with a coastal storm or on its own. 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. Six inches of water can make you fall or cause your car to stall, and two feet of moving water can move your car. 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."

If you are in a flood or storm surge warning area or if flooding occurs, get to higher ground immediately. Get out of areas subject to flooding and avoid areas already flooded. If you are caught in your house, go to the second floor or the roof, if necessary. 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. 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]

Because flooding is so dangerous, it is important to heed evacuation orders. These are typically issued when a substantial storm surge is expected. With nor'easters, tropical storms, and hurricanes, there is normally enough time to evacuate before the storm. When flooding is caused by heavy rains, however, you may get less advanced notice. Regardless of cause of the flooding, these safety procedures should be followed if you find yourself in a flood.

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. Taking several basic steps right now to strengthen your house can reduce the risk of damage to your home and possibly reduce insurance premiums. The Coastal Property Checklist (Appendix B) provides some suggestions if you live along the immediate coast.

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. Every small improvement you invest in your home can lessen the amount of damage that could occur.
- **Your Location**. Buildings in proximity to water are much more likely to flood, even during minor storm events. 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**. While some older homes pre-date building codes, in general the building code determines the standards to which your house was built. Because building codes are continually revised, the code used depends on when your house was constructed. This handbook is not 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 (*mass.gov/massachusetts-state-building-code-780-cmr*). It is important to note, however, that building codes provide minimum requirements, not best practices (some of which are presented in this section).
- **How Your House Is Maintained**. Proper maintenance will extend the life of a house. It is important to keep moisture from intruding into the wood of the home and causing decay. Termites can also cause extensive damage and weaken a home.
- **How You Strengthen Your House**. Even if your house was not built with all available best practices, there are many small steps and some major ones that can be taken to retrofit or 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. Some of the measures you may consider doing or hiring a licensed professional to do include:

- **Increasing freeboard**. Elevating structures above the predicted flood elevation is one of the most effective things a homeowner can do to minimize flood risk. This can lift your home above where it would have been damaged, account for the uncertainty of flood elevation predictions, as well as qualify for substantial savings on flood insurance.
- **Strengthening the roof**. Measures include 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;
- **Undertaking non-elevation flood retrofit measures** (strengthening existing foundations and piers for flood forces, adding flood vents, elevating HVAC and mechanical equipment, etc.);
- **Strengthening the wall-to-foundation connections**; Increasing protection for windows, doors, and garage doors;
- **Using stronger connectors** than those required in the current building code and
- **Installing alternate sources of back-up electricity**.

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. Resources for more information include:

- 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 to ensure maximum safety from natural hazards.
- The Mitigation Directorate of FEMA is continuously researching hurricane resistant designs and building methods for the

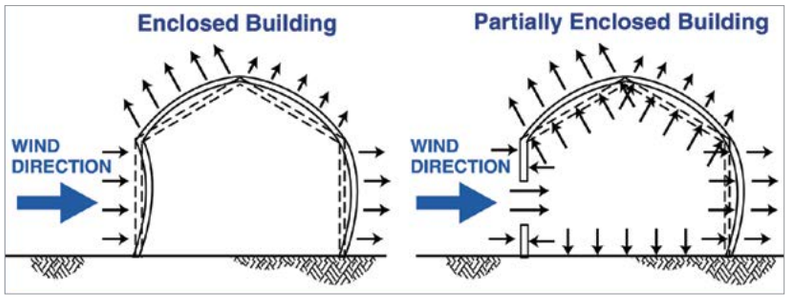
construction of residences and the performance of residences that have been subjected to hurricanes. All of the FEMA government publications are available for free and most can be downloaded from the FEMA website (*www.fema.gov*) and the agency's Safer, Stronger, Protected Homes and Communities page (*www.fema.gov/safer-stronger-protected-homes-communities*).[4-2] FEMA released two publications on retrofitting existing homes called Homeowners Guide to Retrofitting (for flooding) (FEMA P-312) and Wind Retrofit Guide for Residential Buildings (FEMA P-804), both of which are available at *www.fema.gov/library*.

4.1 CREATING THE WIND- AND RAIN-RESISTANT ENVELOPE

The envelope of a house consists of its roof, subfloor, exterior doors, windows and the exterior walls. It is very important to seal the envelope of your house from wind and rain. Storm-shattered windows are a common cause of breaking that envelope, allowing much greater wind and water damage: Besides the incoming hurricane-force wind and torrential rain in your living room, as well as shattered glass and debris from outside flying in. Even more importantly, it creates a problem with internal pressurization of your house (see Figure 4-1).

On a larger scale, 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.[4-3] Several FEMA hurricane mitigation assessment reports, prepared by engineers, indicate that breaching of the building envelope and subsequent internal pressurization leads to progressive structural failure for many houses.

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).



4.1.1 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. Thus, strengthening the roof is important: it should be considered for new construction and when a roof is replaced after its expected life.

In general, there are three ways that roofs and roof systems fail in high winds:

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

Sheathing

To prevent roof sheathing failure, there are exterior and interior methods to ensure the sheathing is adequately attached to the roof rafters or trusses:

- While replacing the roof covering, add nails (8d ring-shank nails are recommended) at a minimum spacing of six inches on center around the edge of the roof sheathing before re-applying the roof covering.
- From inside the attic, use 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

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

Gable end support

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 eight 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. In newer homes, this bracing should have been installed when the trusses were installed.

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 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.

Other roof improvements

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 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

PROTECTING YOUR PROPERTY

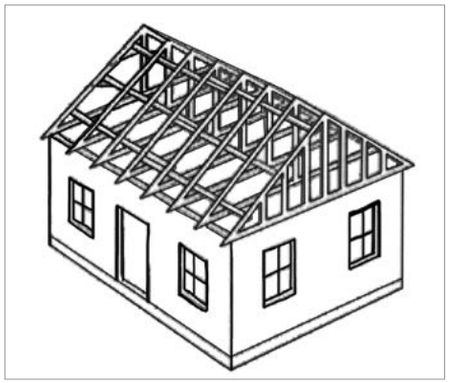


Figure 4-2. Trusses are built with a peak at the ridgeline of the house. The trusses at the end of the house form an A-shaped pattern know as a gable end. During a hurricane, the gable end is subject to great forces from the wind and could tip over, collapsing the other trusses in a domino fashion. Source: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

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.

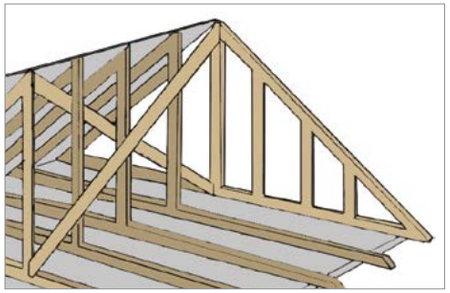
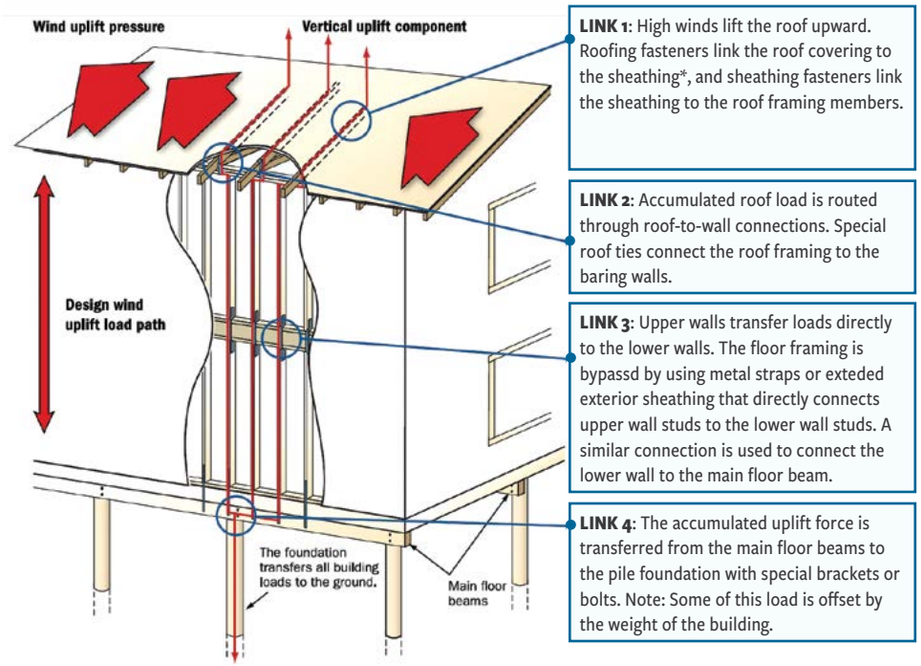


Figure 4-4. Diagonal braces form an X pattern from the top center of the gable end to the bottom center of the fourth truss and from the bottom center of the gable end to the top center of the fourth truss. The same screws as for lateral bracing are used. Source: FEMA's Against the Wind brochure 247.

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.



** Although not a structural connection, the attachment of the roof covering to the roof sheathing is an essential part of protecting the building envelope.*

Figure 4-6. Example of a continuous load path from roof to ground on a platform-and pile-construction building. Load paths will vary depending on construction type and design, however vertical 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.

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, Hawaii Sea Grant.

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 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*).[4-4] The site includes information on re-nailing roof decks, maintaining steep-sloped roofs, guidance for re-roofing, and choosing a roofing material.

Connecting the foundation to the roof: Continuous Load Path Connections

All houses have some continuous load path connection (see Figure 4-6), which ties your roof to your home's foundation and helps to keep the roof from blowing off during a severe wind event. Historically, the weakest part of this path has 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.

Some coastal areas now require much stronger connections, such as 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.

Strengthening the foundation to resist uplift will generally require the partial 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.

Lessons from Past Storms

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. Damages to buildings and other structures were produced by wind speeds that were lower than the International Code Council recommends using for design standards. The wind damage was 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.

In addition to unanticipated wind damage, flooding during Hurricane Sandy was more widespread than flood maps (Flood Insurance Rate Maps) created by FEMA had predicted. Fifty-three percent of the areas flooded by Hurricane Sandy in New York City had water levels that exceeded the mapped base flood elevation, or predicted height of flooding on the FEMA Flood Maps.

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. 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.[4-5]

Repairing storm-related roof damage

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 "waterproofing" to minimize further damage due to water intrusion. With limited resources, contractors triaged homes, 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.[4-6]

4.1.2 KEEP WATER OUT

Flood Prevention

Protecting your property from flooding can involve a variety of actions, from elevating 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.

FEMA's National Flood Insurance Program (NFIP) website (*www.floodsmart.gov*) provides detailed information on flooding and flood risks, including a flood damage tool that will help homeowners understand their flood risk (*agents.floodsmart.gov/getting-started/the-risk-of-not-being-insured#understand*).

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.

FEMA's Protecting Your Property from Flooding website (*www.fema.gov/media-library/assets/documents/13261*) is an excellent source of information about floods and protecting your property from flooding. Additional information is available in FEMA's Coastal Construction Manual (FEMA P-55), available for download at *www.fema.gov/library*.

Relocation

For homes that are repeatedly flooded, the best option may be to relocate the house and leave the flood-prone parcel as open space. This removes the structure from the hazardous location and creates more open space that will help to absorb and slow flood waters for neighboring structures. While relocation is the best solution to flooding, it is costly and can come with a series of additional challenges. See the Hazard Mitigation Grant Program section (Part 4.5) for more information.

Structural Elevation

The best way to reduce damage from floods for a structure that cannot be relocated is to elevate the structure above the predicted flood elevation for your site. Your local building department or contractor will know what the expected flood elevation is, per the MA building code. Remember that MA building standards require a higher elevation than just the base flood.

- **Follow the Building Code Requirements.** The building code requires that elevations meet certain minimums. If they are in coastal dunes or areas with high risk of waves, foundations must be designed by registered design professionals. Work with your local building department to ensure all minimum requirements are met.
- **Increase Freeboard.** The building code requires that new homes have a minimum elevation of a certain level above Base Flood Elevation (called freeboard). If you are building new or retrofitting an existing home, it is a good idea to elevate even higher than what is required by the building code to provide maximum protection from flood damage. Base Flood Elevation is based on historic flooding probabilities and does not take into account sea level rise, shoreline erosion, or changes in storms. Substantial insurance premium discounts are available for every foot of elevation above the base flood elevation up to four feet. (See Part 5.2)
- **Maximize the Flood Safety of Your Foundation.** Open foundations—piers, pilings, or columns—are the best way to prevent flood damage by eliminating the enclosed area below the first floor of the structure. If there is a risk of waves, having an open foundation is even more important. If a solid wall foundation makes the most sense for you and the flood zone you are in, consider increasing the number of flood vents in your foundation.
- **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. Be sure to elevate the equipment well above the base flood; some owners remove all equipment in the basement and re-install it on the next higher floor.

While elevating a structure is the best way to protect it from flooding, this often has negative aesthetic implications. Consider plantings or alternative designs created by registered design professionals to improve the aesthetic appearance of elevated homes, particularly in culturally-sensitive areas like historic districts.

For information on potential funding sources for home elevations, see Part 4.5, Hazard Mitigation Grant Program.

Wet Floodproofing

Wet floodproofing means modifying the uninhabited portions of the house, such as a crawlspace or basement, so that floodwaters can get in but won't cause significant damage. 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, not all of which may be permittable if your property is in or adjacent to certain coastal resource areas (e.g. dunes). Be sure to check with your insurance agent before retrofitting if part of your reasoning is to reduce annual insurance premiums. Wet floodproofing best practices:

- **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.

- **Install Flood Vents.** In crawlspaces with a floor at or above grade, flood vents can be installed to allow the free movement of water into and out of this space. For new construction, basements and below-grade crawlspaces are prohibited in flood zones, and flood vents are required in all above-grade but below-BFE enclosures. Flood vents allow for pressure to equalize on either side of the foundation wall, improving the structural stability of the foundation walls.
- **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. 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.
- **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 will be subject to regulation.
- **Abandon Your Below-BFE Basement or Crawlspace.** An experienced engineer can show you how to "give up" your basement by filling and capping the area, and installing flood openings. The cost of this can possibly reduce your flood insurance premiums dramatically, making the investment pay for itself over a few years. Equipment that is currently in the basement would have to be relocated to a higher floor.
- **Sewage Backflow Prevention.** 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.

Keep these points in mind when you wet floodproof:

- 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.
- 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 may not reduce your flood premiums, so the motivation for this activity should center on reducing the damage caused by flooding. Again, if you are seeking to reduce your annual insurance premiums, check with your agent before investing mitigation time and dollars. And remember, 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 may be 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 (not for wood frame structures). Concrete and masonry are easier to seal, more resistant to flood damage, and stronger

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than other conventional construction materials. It cannot be used to put residential structures in compliance with the National Flood Insurance Program or statewide building code. 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 the Massachusetts Flood Hazard Management Program at the Department of Conservation and Recreation and/or local Building Department for applicability. In addition, this flood protection method is not allowed for buildings located in protected resource areas or in coastal high hazard areas like V zones or coastal A zones (as designated on FEMA Flood Insurance Rate Maps). These Special Flood Hazard Areas are not only subject to inundation by the one percent annual chance flood event, but are also subject to additional hazards due to storm-induced velocity wave action. The best FEMA guidance on use of dry floodproofing is FEMA P-936 "Floodproofing for Non-Residential Buildings" found in the FEMA online library.

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. For new construction in the flood zone where dry floodproofing is to be used as a compliance tool, engineer certification is required.

Dry floodproofing encompasses a variety of measures:[4-7]

- 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;
- 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 three 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, who will perform the inspections, and how often/ when exercises to implement the human mitigation activities will be performed.
- 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. Remember that solving site-specific drainage issues cannot increase flooding on adjacent properties.

4.1.3 SECURE WINDOWS AND DOORS

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 nine pound 2" x 4" 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.

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. You should consult with a competent contractor specializing in supplying and installing these systems.

Roll-down Shutters

Roll-down shutters represent the window covering type that is easiest to deploy and offers the highest level of protection against wind-driven rain in addition to wind and debris (Figure 4-9). These are permanently attached to the building. These extruded aluminum shutters consist of a movable "curtain" of slats that is held in place by vertical tracks. When not deployed, the shutters store in a hood that is housed above the window or door being protected.

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. 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.

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.

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

Bahama (or Bermuda) and Colonial shutters offer a decorative approach to protecting windows against storm forces (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. 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 Missile 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 allow light to go through while 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, they require much more effort for the homeowner to deploy than the other types mentioned above.

Figure 4-11. Colonial shutters that are suitable for storm protection are typically made of aluminum or fiberglass. During a storm, the panels are closed and secured along the vertical center of the window. During good weather, the panels open along hinges on the side of the window and rest flat against the wall in a decorative manner.

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.

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, aesthetic impact on the home.

Impact-resistant stainless steel screen systems 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.

Flat impact polycarbonate units 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.

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 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.

Figure 4-13. Polyethylene basketweave fabric windscreen is deployed at edge of patio, enclosing the entire area. Image courtesy of Roll-a-way.

The polyethylene fabric types, which are basket weave systems, allow some light and visibility. 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 4-13). Because of the installation requirements of such systems, site-specific engineering is often required. Consultation with a contractor is recommended.

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 4-14). 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). Professional installation is highly recommended in order to ensure that proper attachment of the windows to the structure is achieved.

Figure 4-14. This 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.

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 4-15). 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.

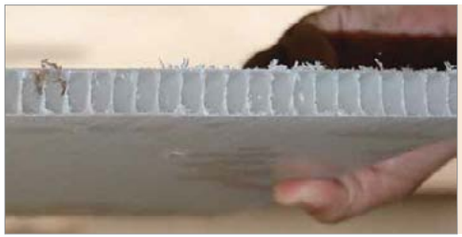


Figure 4-15. Plastic honeycomb panels have many times the strength of regular plywood and will not warp or rot. It is easy to cut and drill into, and, most importantly, it is light when compared to regular plywood. The major disadvantage is the lack of availability of this material in local hardware stores.

Plywood

Historically, plywood has been the most commonly used option for protecting window 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 4-16 and 4-17).

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.

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*.

Figures 4-16 and **4-17**. 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.

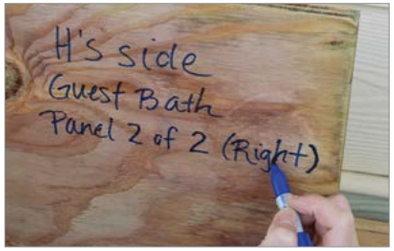


TABLE 4-1. PROS AND CONS OF VARIOUS TYPES OF WINDOW PROTECTION

Type of Protection	Pros	Cons	Approx. Cost for 3' x 4' Window Protection
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	$$$$
Impact Resistant Glass	Always in place hurricane and security protection. Blocks noise and harmful UV radiation. Reduces solar heat gain to keep house cool and energy efficient. Opens view planes. Pass large missile tests.	Costs to buy and replace existing windows and frames can be high. While house contents are protected, there is potential for outer layer to crack, requiring replacement.	$$$$
Accordion Shutters	Easily deployed; simple manual operation; good overall protection	Possible aesthetic issues	$$$
Colonial/Bahama Shutters	Easily deployed; good protection; provides shade	Blocks some light and view	$$$
Storm Panels	Strong; removable; Relatively inexpensiveper-manent shutter system; good protection for the costs	Manual deployment required; requires adequate space for storage when not in use	$$
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	$$
Plastic honeycomb	Strong system; lightweight; reasonable cost; won't warp or rot	Storage of panels; time to create and deploy. Availability	$$
Plywood	Materials readily available; easy to install on lower levels; inexpensive, 5/8" heavy but strong	1/2" not as strong as some other shutter systems; manual deployment is difficult on upper levels; must be properly stored	$

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. $: 10-100; $$: 100-250; $$$: 250-500; $$$$: > 500

A Note about Window Film

An after-market product composed of laminate, used to enhance glass breakage prevention, is commonly known as security window film (Figure 4-18). While laminates may provide more protection than unprotected windows, they are not a substitute for shutters, or even impact resistant glass, which is designed around specially strengthened frames and have undergone extensive testing to meet ASTM standards. For more information, visit the website of the International Window Film Association (*www.iwfa.com*).

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 is 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 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.

Fig 4-18. 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.

Figure 4-19. 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. Image courtesy of Florida Hurricane Depot.

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 4-19). 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 4-20). More information on the design of new garage doors or on how to retrofit existing ones can be obtained in *www.fema.gov/media-library-data/20130726-1707-25045-9020/chapter10.pdf*. 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 4-20. 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.

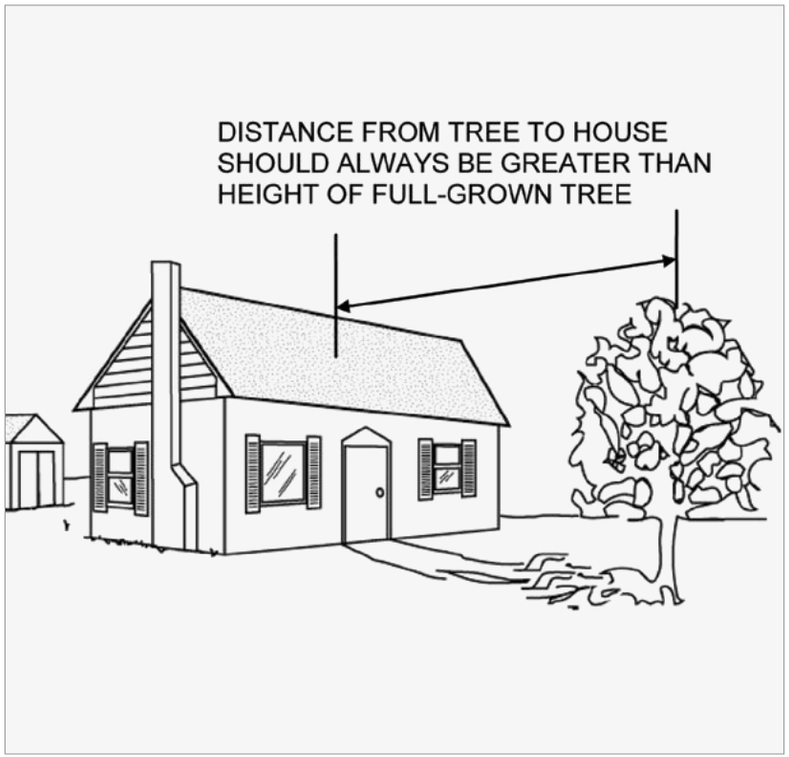


Figure 4-21. FEMA recommends that the distance between a tree and your house should always be greater than the height of the full-grown tree. This is to prevent trees from falling on the roof, either currently or in the future. Image courtesy of FEMA.

4.1.4 ASSESS POTENTIAL FOR DAMAGE FROM 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 4-21 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 or 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 CONSIDER 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.[4.9] 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 current. GFCIs 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.[4.10]

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.

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, not to mention the real possibility of electrical shock to the user.

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. The NEMA brochure can be downloaded free of charge at *nema.org*.

Figure 4-22. Downed or damaged power lines in a residential area can pose a serious danger to public safety. Image courtesy of CCCE/WHSG

Downed Power Lines: These can carry an electric current strong enough to cause serious injury or death (Figure 4-22). The following tips can keep you safe around downed lines: [4.11]

- 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. 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 4-23). 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. 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.[4.12] 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 hard-wired house power supply generator to ensure that it meets local electrical codes.

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 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.

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.

When 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.

Figure 4-23. 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.

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 cell phone needs charging or your cordless phone requires power, a power station could supply electricity so that calls could be made. 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 REPAIRING FLOODED HOMES AND BASEMENTS

Before the Flood: You can protect your property by improving the drainage around your home to direct water away from the foundation. Belongings stored in the basement that can be damaged by water should be elevated or removed, as they are likely to be damaged and will not be covered by insurance. 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 basement is flooding, a sump pump can remove much of the water. If the sump pump is overwhelmed, a water alarm can provide lead time before your belongings are damaged by floodwaters. Water alarms are inexpensive and similar to smoke alarms; they beep when exposed to water. Deploy any sandbags or other exterior protection measures such as temporary flood barriers if you have them.

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 flood-resistant wallboard panels sideways so they are only four feet high. If the next flood is less than four feet deep, you might only have to replace half the wall.

Mold & Mildew: Mold can cause serious health problems. You should limit your exposure to mold, typically with non-ventilating goggles, rubber gloves, and an N-95 (or greater) 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 and mold will not necessarily go away under these treatments.
- Hard surfaces should be scrubbed with detergent, bleach and water, and dry completely.
- Absorbent or porous materials, such as ceiling tiles and carpet, will 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. When selecting a contractor, it is necessary to perform proper due diligence and check qualifications to ensure that you will hire a qualified professional. It is up to you to select the companies and verify their records. Some tips when choosing a contractor:

- 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*) and Massachusetts Homeowner's Guide to Hiring a Home Improvement

PROTECTING YOUR PROPERTY

Contractor (*www.mass.gov/info-details/homeowners-guide-to-hiring-a-home-improvement-contractor*) can provide guidance on selecting a contractor. 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 and then left after receiving payment without completing the 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 FUNDING SOURCES

4.5.1 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 federal disaster declaration (*www.mass.gov/hazard-mitigation-assistance-grant-programs*). Individual homeowners and business owners may not apply directly to FEMA, but eligible local governments, special districts, or other government agencies may apply on their behalf. All eligible applicants must have a FEMA-approved Local Hazard Mitigation Plan which outlines property mitigation as a goal prior to applying for funding.

The following activities may be eligible for funding through the Hazard Mitigation Assistance program:

- **Property Acquisition and Structure Demolition**—the purchase of an at-risk structure and/or property and conversion to open space through the demolition of the structure. Typically, the local government purchases the property from a willing seller. Federally-funded relocation grants typically require the property to be placed under a deed-restriction for open space uses in perpetuity 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 an area subject to erosion and, typically, the acquisition of the underlying land. Relocation must conform to all applicable state and local regulations. The vacant land must be deed restricted in perpetuity to open space uses in order to restore and/or conserve the natural floodplain functions.
- **Structure Elevation**—physically raising an existing structure to an elevation at or above the predicted one percent chance event flood elevation (a.k.a. the Base Flood Elevation) or higher if required by FEMA or state building code. (See more information on elevation in Part 4.1.2.) All structure elevation projects must be designed in accordance with the state building code, including ASCE-24-14 and if they are federally funded, they must also comply with FEMA's Coastal Construction Manual. If funded by FEMA, an NFIP flood insurance policy must be maintained on the property in perpetuity.
- **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 typically mitigated in order to prevent damage include foundations, load-bearing walls, beams, columns, structural floors and roofs, and the connections between these elements.

FEMA's Hazard Mitigation Assistance Programs are not intended as a source of funding for repair, replacement or deferred maintenance activities, but are designed to assist property owners in implementing long-term, cost-effective improvements that will reduce, minimize or eliminate risk to people and property from the effects of natural hazards. To assist in establishing funding priorities, local hazard mitigation plans are utilized to identify the highest risks and the priorities for mitigation. In each annual cycle, FEMA outlines its priorities for funding; typically, those structures that have had the most past damages (especially from flooding) are prioritized over others.

4.5.2 HOUSING AND URBAN DEVELOPMENT 203(K) LOANS

The Department of Housing and Urban Development provides Section 203(k) loans, which allow homebuyers and homeowners to finance the cost of rehabilitation and purchase or refinance through a single mortgage.

PROTECTING YOUR PROPERTY

The 203(K) loans can be used for flood safety improvements. Eligible activities include:

- Structural elevation of the home above BFE
- Relocation of the home to a non-flood prone site
- Dry floodproofing (e.g., make structure water-tight)
- Relocating utilities and systems out of a basement or elevating the utilities
- Overhead sewers and/or backflow prevention
- Wet floodproofing (e.g., installing flood vents)
- Structural alterations and reconstruction
- Adding or replacing roofing, gutters and downspouts

More information on the 203(K) loans is available at *www.hud.gov/program_offices/housing/sfh/203k*.

For more information on using 203(K) loans for flood prevention, see *www.floods.org/koha?id=5229*.

4.5.2 USDA NRCS EMERGENCY WATERSHED PROTECTION BUYOUT PROGRAM

The Emergency Watershed Protection Program from the US Department of Agriculture's Natural Resource Conservation Service (USDA NRCS) can be used in special circumstances for buyouts of flood-prone properties. The program only applies in certain flood zones and the property must be located in an area that received an eligible federal disaster declaration. This program is not widely used or activated. For more information, visit *www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/ewpp/*.

Programs are designed to assist property owners in implementing improvements that will help with natural hazards.

PART 5

Protecting Your Property with Insurance

The proactive way to protect your property from natural hazards is to strengthen your house and address specific hazards such as wind or a flood. If there is still damage despite all your precautions, insurance can provide resources to aid recovery. Prepare for severe weather disasters by reviewing your policy. Special policies may be required for wind and flood insurance in addition to your homeowner's policy.

The Massachusetts Division of Insurance suggests that you create a home inventory 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 (including photos) 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

It is very important that consumers make time before a disaster strikes to be certain that insurance concerns have been addressed. Massachusetts's Division of Insurance suggests consumers consider the following 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.
- Keep in mind, after a disaster, 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 your home up to code. If you have a flood insurance policy with the NFIP and your home is substantially damaged by a flood, you might be able to get up to $30,000 to help with this "increased cost of compliance."
- 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 such as on a cloud-based server. It can be helpful to take photos of your property after a disaster to document your losses.
- Keep insurance policies, your household inventory and other important papers together in a safe and secure place. Copies of these documents can go in your evacuation kit.

Protect Your Home from Damage

Consumers can do a number of things to reduce the cost of their property and flood 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. See Part 4 of this document for ideas on property protection.

Communicate with Your Homeowners Insurance Agent

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

- Homeowners coverage is typically provided in terms of replacement cost or the cost to rebuild your house, but it may be "actual cash value" (ACV). ACV means you will only get the value including depreciation, not the cost to rebuild.
- Does the Homeowners 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 homeowner's policy. Many wind policies cover only hurricanes and not lesser events such as a tropical storm or a tropical depression. Some wind policies may also have a different deductible for a hurricane event.

- 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, about 75 percent of all Presidentially-declared disasters involve flooding[5-1].

To obtain insurance coverage from flood events, you need flood insurance. Standard homeowners' insurance policies do not provide protection against flooding. 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.

A separate flood insurance policy can be obtained from several private companies in Massachusetts, as well as from the National Flood Insurance Program (NFIP). NFIP coverage is available to all owners of insurable property (a building and/or its contents) in a community participating in the NFIP (most communities in MA). Renters may also obtain contents coverage through an NFIP policy. A policy with the NFIP can be secured through most local insurance agents.

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

Not sure about the high costs associated with flooding? Just 1" of water can cause $25,000 in damage.[5-2] 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.

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 that have 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, the NFIP reports that nearly 30 percent of flood insurance claims come from these areas.

In areas with the greatest risk of flooding, called Special Flood Hazard

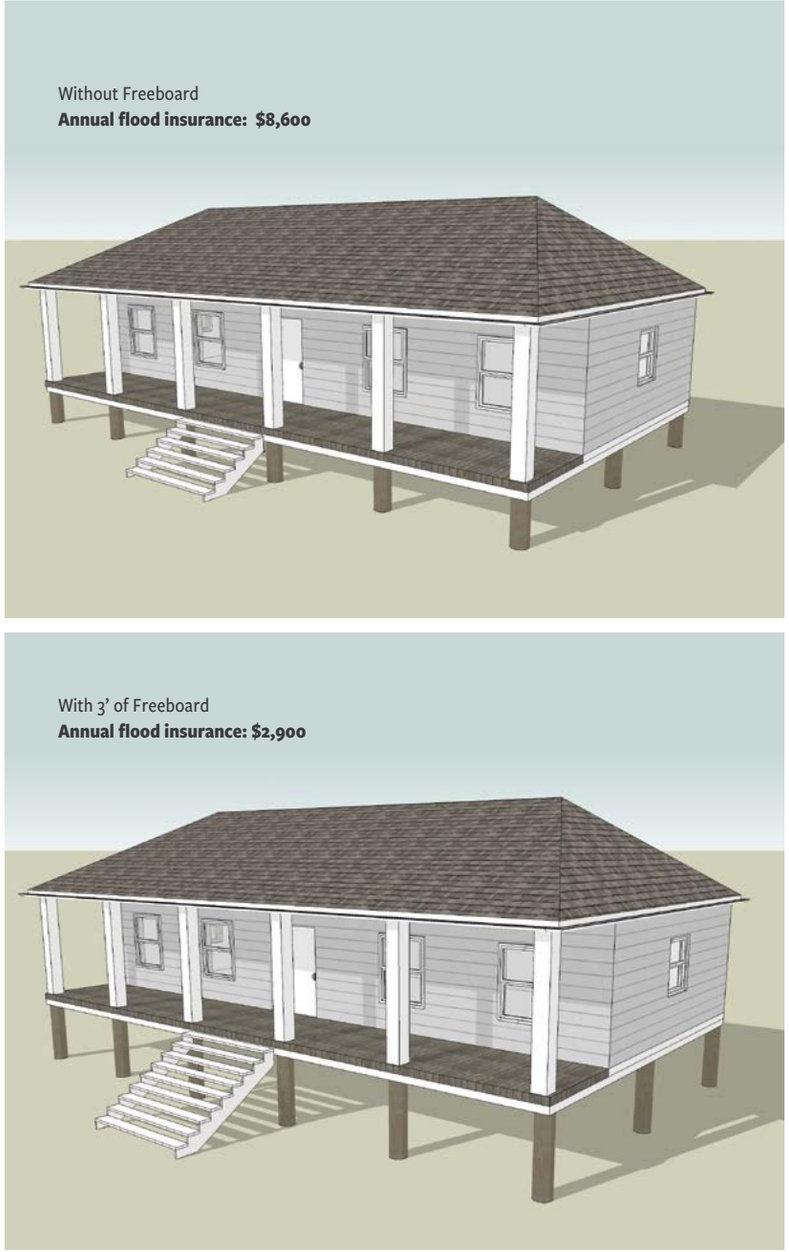


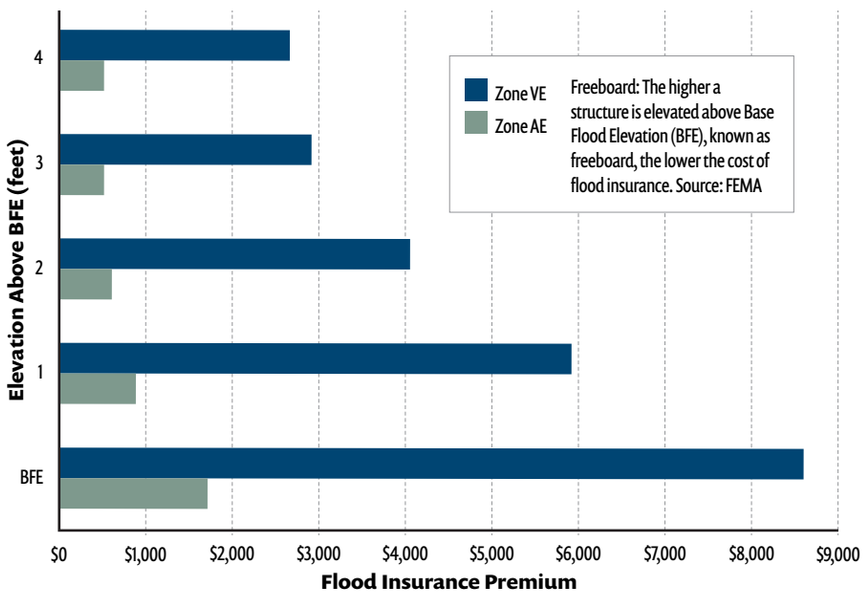
Figure 5-1. In this example, adding a small amount of height has very little effect on the look of a home, but results in a substantial flood insurance savings. Image modified from MassCZM, more information available at *www.mass.gov/service-details/using-freeboard-to-elevate-structures-above-predicted-foodwaters*.

Areas (SFHAs), a building has a 26 percent chance of being flooded during a 30-year mortgage. Homeowners, business owners, and renters inside or outside of any flood zone can all buy federal flood insurance as long as their community participates in the NFIP. For the one coastal Massachusetts community that is not in the NFIP, private flood insurance should be available. 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 relatively inexpensive flood insurance protection.

To lower flood insurance costs in high-risk areas, a property owner can pursue structural changes like elevation and additional freeboard (covered in Part 4) to make a home safer from flooding (see Figures 5-1 and 5-2). Other, non-structural options such as reduced coverage, higher deductibles, and using an Elevation Certificate to accurately rate flood risk will ensure the best price.

If your community participates in the Community Rating System (CRS),

FIGURE 5-2. CHANGES IN COST OF MAXIMUM RESIDENTIAL FLOOD INSURANCE COVERAGE WITH FREEBOARD (ELEVATION ABOVE BFE)



you may qualify for a flood insurance premium discount. Most participating communities in Massachusetts have earned a 5-15 percent discount for their residents and businesses. To find out if your town participates in the CRS, visit *crsresources.org/100-2/#crs-community-list*.

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.

The NFIP provides up to $250,000 in structural coverage and $100,000 in contents coverage for homes. Deductibles can vary. More 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 flood damage (more than 50 percent of the building's market value), NFIP policyholders in SFHAs may be eligible for up to $30,000 to help pay the costs to bring their home into compliance with state and local codes.

The National Flood Insurance Program has gone through significant changes since 2012. These changes have affected flood zones, premiums costs, and how additional fees are assessed. The NFIP will continue to evolve, changing the cost of flood insurance and many coverage details. Your insurance agent, local floodplain administrator, or the Flood Hazard Management Program at the Massachusetts Department of Conservation and Recreation are your best sources for current information on the NFIP.

5.2 WIND INSURANCE

In some coastal areas, it can be difficult to obtain homeowners insurance because of high exposure to wind and flood risk. If a property owner can get coverage, flood is almost always excluded and wind may be excluded as well. Some insurance companies will not cover properties that are likely to be affected by hurricanes, such as some properties on Cape Cod and the Islands. Some companies require high deductibles for wind damage. In order to bridge the availability gap in the private market for wind coverage, Massachusetts has created a FAIR plan, also known as an "insurer of last resort" for those properties unable to obtain insurance through the voluntary market. For more information on the FAIR plan, visit *www.mpiua.com*.

Appendix A Emergency Contact Information

MASS211 (DIRECTS CALLERS TO SERVICES DURING A CRISIS)
By phone dial: 2-1-1 (similar to 9-1-1) • *www.mass211.org/*

MASSACHUSETTS EMERGENCY MANAGEMENT AGENCY (MEMA)
www.mass.gov/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 • *www.facebook.com/massdotinfo*

MASSACHUSETTS EXECUTIVE OFFICE OF PUBLIC SAFETY AND SECURITY
617-727-7775 • *www.mass.gov/eopss*

NATIONAL WEATHER SERVICE BOSTON/NORTON FORECAST OFFICE:
508-622-3250 • *www.weather.gov/boston*

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
800-465-1212 (electricity), 800-233-5325 (gas) • *www.nationalgridus.com*
EVERSOURCE
800-592-2000 • *www.eversource.com*

Appendix B 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 makes some suggestions, but 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 for your flood elevation.
- ❑ Is the first floor of the dwelling located above the projected flood elevation for your area?
- ❑ 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 on anchoring home fuel tanks (search Anchoring home fuel tanks at *www.fema.gov*).
- ❑ 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.

- ❑ 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 one 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?
- ❑ What is the orientation of cross-bracing 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.
- ❑ 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?

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? Over-notching 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

- ❑ Do you know the estimated long-term erosion rates for your area? The Massachusetts Shoreline Change Project (*www.mass.gov/service-details/massachusetts-shoreline-change-project*) 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?
- ❑ 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

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2.5 Chapter 2: Our Changing Climate. Fourth National Climate Assessment 2018. Accessed June 2020 at *nca2018.globalchange.gov/chapter/2/*.

3.1 Turn Around Don't Drown. National Weather Service website. Accessed June 2020 at *www.weather.gov/safety/flood-turn-around-dont-drown*.

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4.3 Residential Coastal Construction Manual (FEMA P-55). Federal Emergency Management Agency, 2011. Accessed June 2020 at *fema.gov/residential-coastal-construction*.

4.4 Hurricane Ready. Insurance Institute for Business and Home Safety website. Accessed June 2020 at *www.disastersafety.org*.

4.5 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 June 2020 at *fema.gov*.

4.6 Roof Underlayment for Asphalt Shingle Roofs. Home Builders Guide to Coastal Construction, Technical Fact Sheet No. 7.2. Federal Emergency Management Agency in association with National Association of Home Builders Research Center, 2010. Accessed June 2020 at *www.fema.gov/media-library-data/20130726-1537-20490-6674/fema499_7_2rev.pdf*.

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4.9 Preventing Electrical Fires at Home. Massachusetts Department of Fire Services, April 2019. Accessed June 2020 at *www.mass.gov/files/documents/2020/04/07/Electrical%20Safety_2019.pdf*.
4.10 Ibid.
4.11 Downed Power Lines. Electrical Safety Foundation International, February 2015. Accessed June 2020 at *www.esfi.org/resource/downed-power-lines-261*.
4.12 Electrical Safety Precautions During Disasters. Consumer Product Safety Commission Electrical Safety Foundation International website. Copyright 2020. Accessed June 2020 at *www.esfi.org/home-disaster-safety*.
5.1 Flood Related Hazards. National Weather Service. Accessed June 2020 at *www.weather.gov/safety/flood-hazards*.
5.2 Flood Insurance: The Risk of Not Being Insured. *Floodsmart.gov*. Official website of the National Flood Insurance Program. Accessed June 2020 at *agents.floodsmart.gov/getting-started/the-risk-of-not-being-insured#understand*.

Acronyms

ASCE: American Society of Civil Engineers
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
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
WEA: Wireless Emergency Alerts
WHSG: Woods Hole Sea Grant

Glossary

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, continue preparing your home and review your plan for evacuation in case a hurricane warning is 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 has potential to 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.

Storm Surge Watch. The possibility of life-threatening inundation (or isolation) from rising water moving inland from the shoreline somewhere within the specified area, generally within 48 hours.

Storm Surge Warning. The danger of life-threatening inundation (or isolation) from rising water moving inland from the shoreline somewhere within the specified area, generally within 36 hours.

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. Severe thunderstorms are possible in and near the watch area. It does not mean that they will occur; it only means they are possible.

Severe Thunderstorm Warning. 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. Tornado, usually accompanied by severe thunderstorms, are possible in and near the watch area.

Tornado Warning. Tornado is imminent. When a Tornado Warning is issued, seek safe shelter immediately in a basement or interior room with no windows.

MASSACHUSETTS

HOMEOWNER'S HANDBOOK

TO PREPARE FOR

COASTAL HAZARDS

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Woods Hole Oceanographic Institution
Woods Hole, MA 02543
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