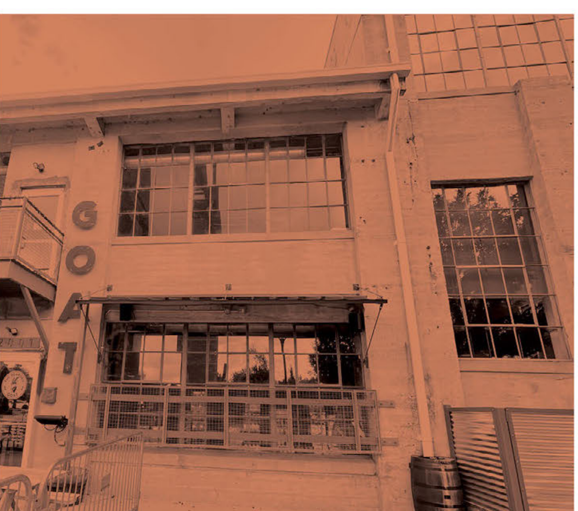
HISTORIC RESILIENCE PRIMER

Resilient Adaptation Strategies for North Carolina's Historic Properties

NC DEPARTMENT OF
NATURAL AND CULTURAL RESOURCES



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Tar River flooding in Princeville, N.C., c. 1899.
Courtesy of Edgecombe County Memorial Library and Digital N.C. Collection.

SECTION I

INTRODUCTION & BACKGROUND

INTRODUCTION

WHAT IS A HISTORIC RESILIENCE PRIMER?

Improving the resilience of North Carolina's historic resources requires a multifaceted approach aligning historic preservation planning processes with multi-jurisdictional regulatory priorities and the logistical realities of property ownership. This *Historic Resilience Primer* was developed as a guide to supplement the *Resilience Design Standards: Model Standards for North Carolina's Historic Properties* and *A Handbook for Historic Resilience Community Planning*. The goal of the *Historic Resilience Primer* is to help planners, historic preservation commissions, and property owners navigate the complexities of integrating historic preservation and hazard mitigation priorities. The primer includes contextual information on the impacts of natural hazards in North Carolina, state and federal hazard mitigation resources, and detailed and concrete examples of historically appropriate resilience adaptations. The purpose of this guide is to help answer questions ranging from "how do I know what my flood risk is?"to "what options do I have to help improve my historic property's resilience to severe storms?" to "what is dry floodproofing and how does it work?"

While much of the information outlined in this primer is applicable to non-historic resources, the focus is on resilience adaptations for historic properties, which requires a delicate balance between hazard mitigation requirements and the additional regulations associated with historic designation. This means that while certain resilience adaptations may be effective and appropriate for properties without historic designations, they may need to be modified or substituted to ensure appropriateness for historic properties.

HISTORIC RESILIENCE COMMUNITY PLANNING

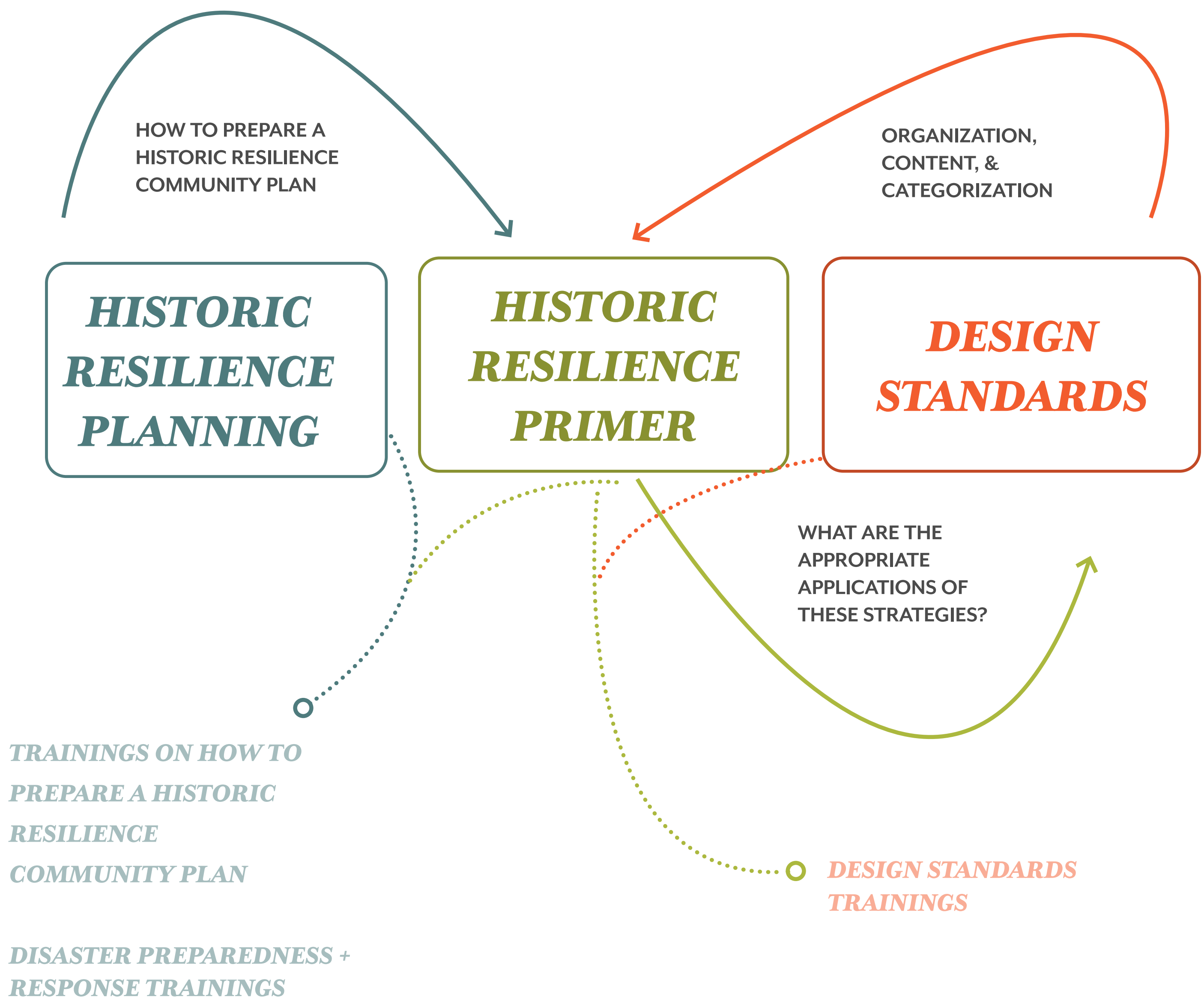
- IDENTIFY VULNERABLE HISTORIC RESOURCES
- REVIEW POLICY AND REGULATORY FRAMEWORK IMPACTING HISTORIC RESILIENCE
- ENGAGE COMMUNITY STAKEHOLDERS AND SEEK INPUT ON COMMUNITY VALUE OF DIFFERENT HISTORIC RESOURCES
- PRIORITIZE VULNERABLE HISTORIC RESOURCES FOR PROTECTION
- DEVELOP AND IMPLEMENT COMMUNITY STRATEGY FOR ENHANCING HISTORIC RESILIENCE

HISTORIC RESILIENCE PRIMER

- OVERVIEW OF HAZARD RISKS & IMPACTS
- HAZARD MITIGATION & HISTORIC PRESERVATION BEST PRACTICES
- STRATEGIES FOR HISTORICALLY APPROPRIATE RESILIENCE ADAPTATIONS
- EXAMPLES OF HISTORICALLY RESILIENT RESPONSES

HISTORIC RESILIENCE DESIGN STANDARDS

- GUIDELINES FOR RESILIENT HISTORIC ADAPTATIONS
- COMPLIANCE & REGULATION



WHO IS THE RESILIENCE PRIMER FOR?

This guide is for anyone interested in resilience-focused adaptation strategies for historic properties, most specifically to help mitigate the impacts of natural hazards like hurricanes, severe storms, and flooding. As a supplement to the *Resilience Design Standards: Model Standards for North Carolina's Historic Properties* (hereinafter the *Standards*), much of the content included in the *Historic Resilience Primer* (hereinafter the *Primer*), expands on the resilience strategies and retrofits outlined in the *Standards*, providing details about how and why those retrofits work and how to use them in a historically appropriate way. The goal of the *Primer* is to be understandable and useful to a range of audiences—from historic property owners interested in incorporating resilience strategies into their next renovation, to municipal planners and historic district commissions looking to learn more about hazard mitigation best practices and historically appropriate resilience adaptations. The *Standards* provide a regulatory framework for historic preservation commissions to assess the appropriateness of specific structural interventions for properties with local historic designations or that are listed on the National Register of Historic Places.

The *Primer* expands this framework so that it is useful information for older properties and neighborhoods—regardless of historic designations—where preserving historic integrity remains a priority.

The *Primer* aims to find common ground between historic preservation and hazard mitigation professionals—two worlds that are sometimes at odds despite common goals. The following chapters provide contextual information to help build understanding about natural hazards in North Carolina and how to mitigate their impacts in historically appropriate ways. For local historic preservation commissions reviewing proposed resilience adaptations for historic properties,the *Primer* offers explanations of hazard mitigation best practices, hazard vulnerability, and floodplain regulations that can help streamline the decision-making processes and show how mitigation requirements can complement historic preservation goals. For emergency managers coordinating post-disaster recovery efforts or designers working to proactively improve a historic property's resilience, the *Primer* highlights critical alignments to expedite recovery and protect historic character.

WHY DOES HISTORIC RESILIENCE MATTER?

Historic preservation in North Carolina offers numerous social and economic benefits to both local communities and the state as a whole. Taking steps to protect historic buildings, sites, and landscapes ensures that these assets and their benefits will exist for generations to come. Resilience planning for historic buildings, sites, and landscapes promotes the following:

CULTURAL HERITAGE AND IDENTITY

Historic preservation helps to safeguard and celebrate North Carolina's rich cultural heritage. By preserving historic buildings, neighborhoods, and landmarks, communities maintain a sense of identity and connection to their past.

TOURISM AND ECONOMIC DEVELOPMENT

Historic preservation attracts tourists, boosting local economies. Many travelers are drawn to North Carolina's historic sites, districts, and landmarks, which serve as significant attractions. Tourists spend money on accommodations, dining, shopping, and other services, supporting local businesses and creating employment opportunities.

JOB CREATION AND REVITALIZATION

Historic preservation projects generate jobs and stimulate economic growth. Preservation initiatives require skilled labor in construction, renovation, restoration, and maintenance. Revitalizing historic districts often leads to increased property values, encourages small business development, and attracts new investments.

ENVIRONMENTAL SUSTAINABILITY

Preserving historic buildings and neighborhoods promotes environmental sustainability. Instead of demolishing structures and constructing new ones, adaptive reuse and restoration of historic properties reduce waste, energy consumption, and the need for new materials.

EDUCATION AND CULTURAL TOURISM

Historic preservation provides educational opportunities for residents and visitors alike. This promotes a deeper understanding of North Carolina's heritage, which can be shared across generations.

SENSE OF PLACE AND QUALITY OF LIFE

Historic preservation contributes to a community's sense of place and enhances the overall quality of life. These elements create aesthetically pleasing environments that enrich residents' daily lives, fostering a sense of belonging and attachment to their communities.

ECONOMIC MULTIPLIER EFFECT

Historic preservation initiatives have a multiplier effect on the local economy. As money is spent on preservation projects, it circulates through various sectors, creating a ripple effect. This spending stimulates other businesses, generates additional revenue, and supports a wide range of industries beyond the preservation sector itself.

Historic resources play a vital role in building more resilient communities in the state. Given the social and economic benefits of historic preservation in North Carolina, focusing on the long-term resilience of historic places and integrating historic preservation considerations into resilience planning efforts is crucial. This publication, *Historic Resilience Primer,* provides a roadmap for integrating historic preservation and resilience planning and gives those responsible for these special locations the contextual background, best practices, and adaptation strategies they need to protect historic buildings, landscapes, and sites.

NORTH CAROLINA HISTORY & HAZARDS

PRE-COLONIAL HISTORY

The history of our state's built environment long predates our contemporary understanding of "historic architecture." With archaeological evidence pointing to early indigenous groups inhabiting the area now known as North Carolina as early as 12,000 years ago, it's clear that this landscape has shaped and been shaped by its people for millennia.

PALEOINDIAN PERIOD (12,000–9,500 YEARS BEFORE PRESENT)

Some of North Carolina's earliest known inhabitants were hunter-gatherer descendants of the first groups to cross the land bridge from Siberia to North America at the end of the last ice age (Claggett, 1996). With cooler, rainier conditions, different plant communities, and a range of now-extinct megafauna, North Carolina's landscape looked dramatically different. Not much is known about settlements during this period, but groups were likely seasonally mobile.

ARCHAIC PERIOD (9,500–4,000 BEFORE PRESENT)

During this period, the climate was slowly becoming more similar to the present day. As plant and animal food sources became more seasonally stable, indigenous settlement patterns shifted from transient to more permanent, leaving a number of known sites across the state.

WOODLAND PERIOD (4,000–400 YEARS BEFORE PRESENT)

With climate and plant communities that were similar to present conditions, this period is widely considered North Carolina's last "native" landscape prior to colonization. During this period agricultural practices expanded, hunting technologies developed, and larger and more permanent settlements were constructed with wood, thatch-roofed structures.

PALEOINDIAN

12,000(+)–9,500 YEARS BEFORE PRESENT

ARCHAIC

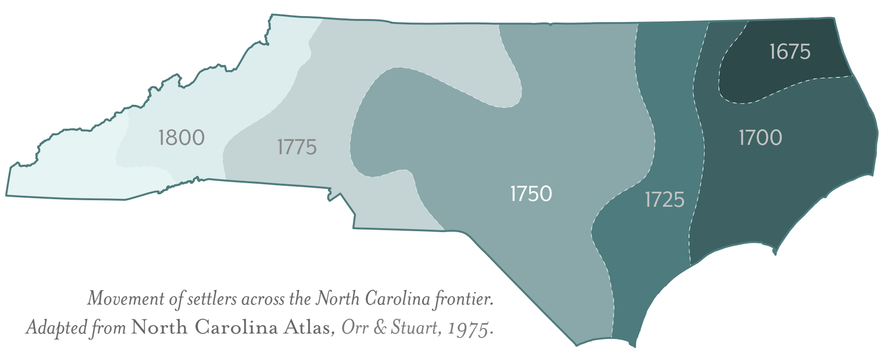
9,500–4,000 YEARS BEFORE PRESENT

MISSISSIPPIAN PERIOD (700–250 YEARS BEFORE PRESENT)

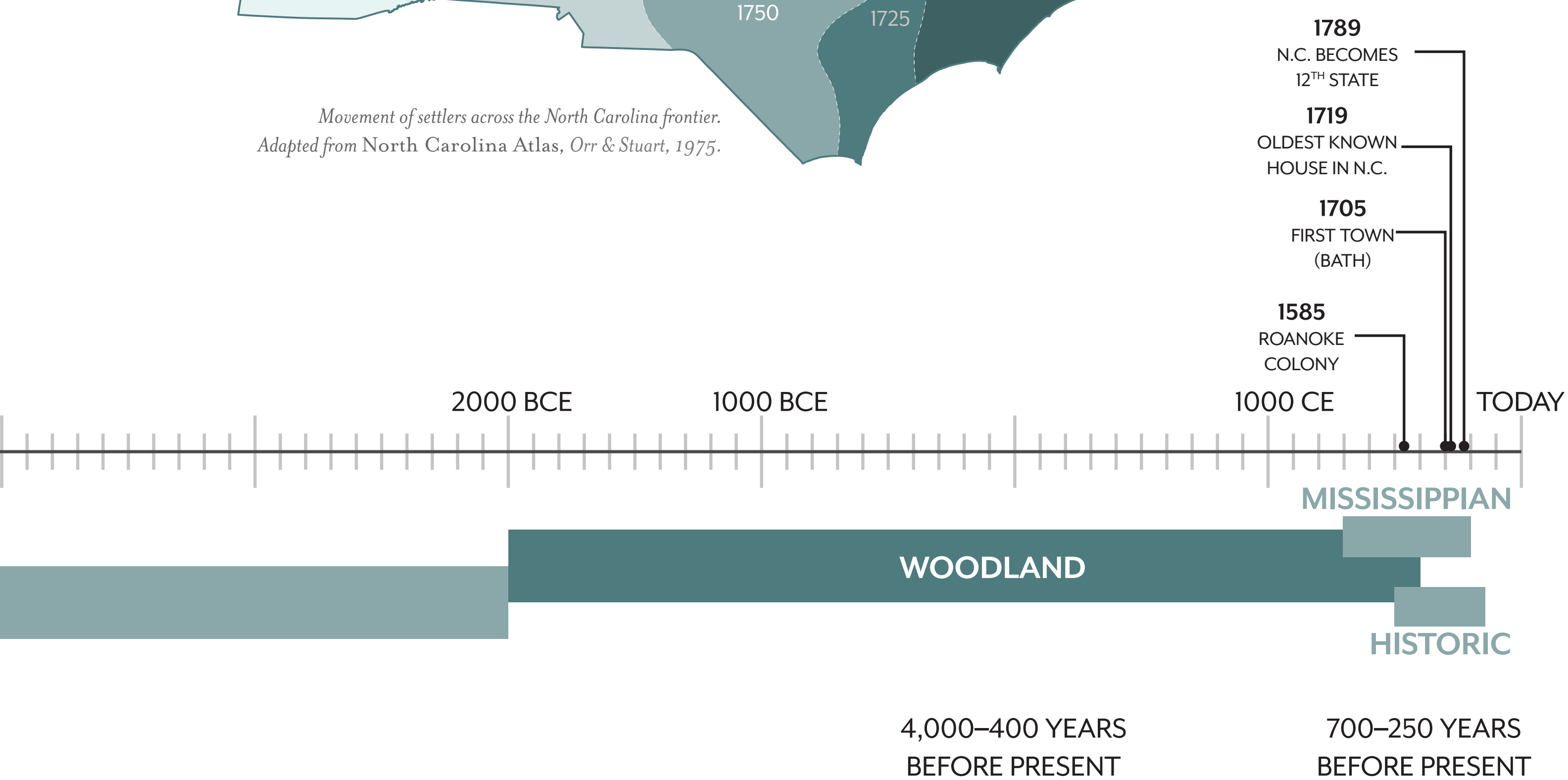
Unlike the groups of earlier periods, Mississippian groups likely migrated to the area. Settlement patterns are similar to those of the Woodland period, but appear to be primarily located in the southern and western regions of the state.

HISTORIC PERIOD (1540–1850)

This period begins with initial European contact and marks the start of rapid cultural transformations stemming from exchanges with the indigenous groups of Eastern North Carolina. Although early records of American Indian tribes are likely incomplete, the tribes known to be stewarding the North Carolina landscape when early explorers arrived included the Chowanoke, Croatoan, Hatteras, Moratoc, Secotan, Weapemeoc, Machapunga, Pamlico, Coree, Neusiok, Tuscarora, Meherrin, Cherokee, Cape Fear, Catawba, Shakori, Sissipahaw, Sugeree, Waccamaw, Waxhaw, Woccon, Cheraw, Eno, Keyauwee, Occaneechi, Saponi, and Tutelo. These people are the ancestors of the eight American Indian tribes currently recognized by and residing in the State of North Carolina, which include the Eastern Band of Cherokee Indians, Coharie, Lumbee, Haliwa-Saponi, Sappony, Meherrin, Occaneechi Band of the Saponi Nation, and the Waccamaw-Siouan people.



Movement of settlers across the North Carolina frontier. Adapted from North Carolina Atlas, *Orr & Stuart, 1975.*



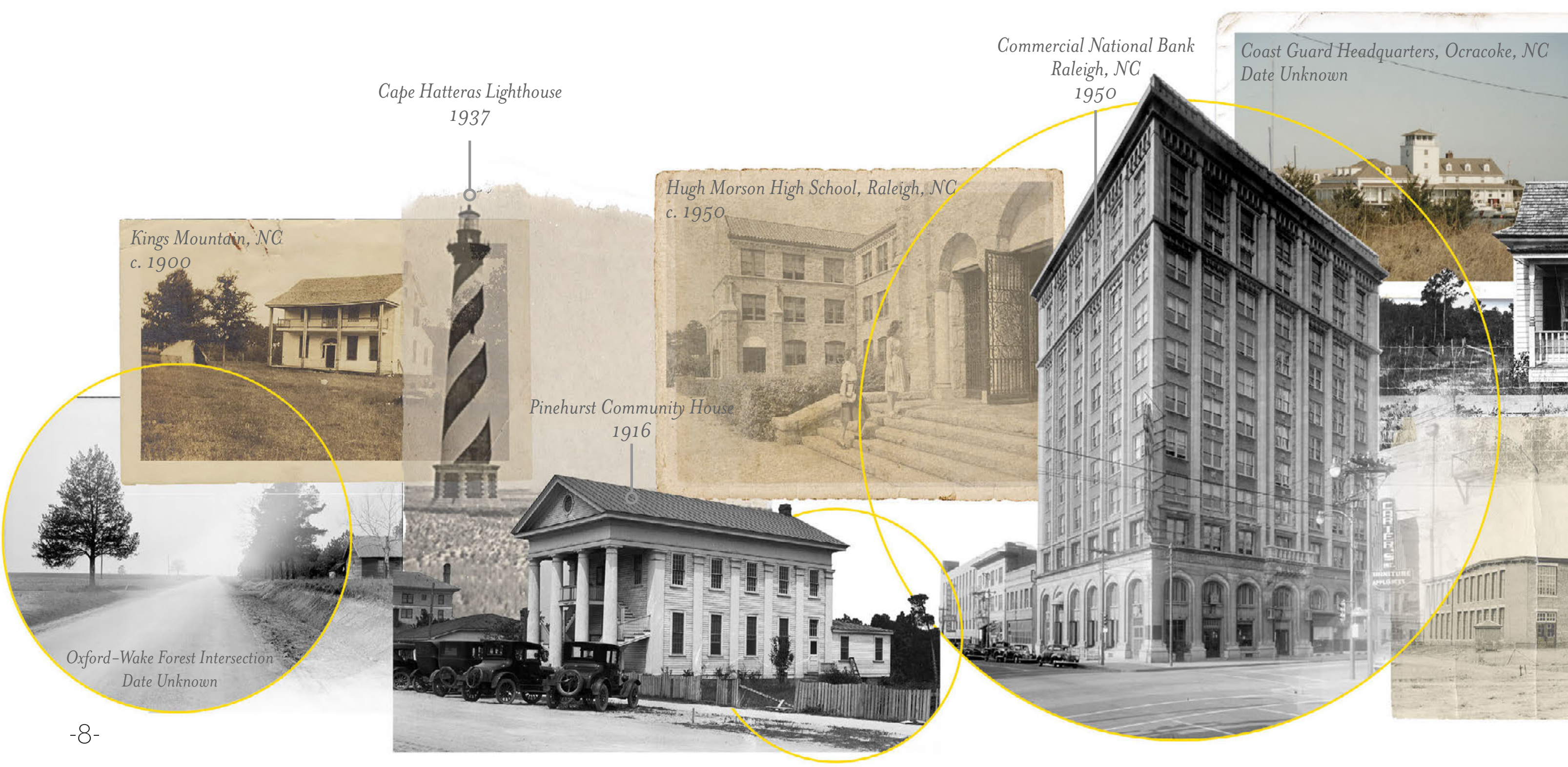
HISTORIC PRESERVATION IN NORTH CAROLINA

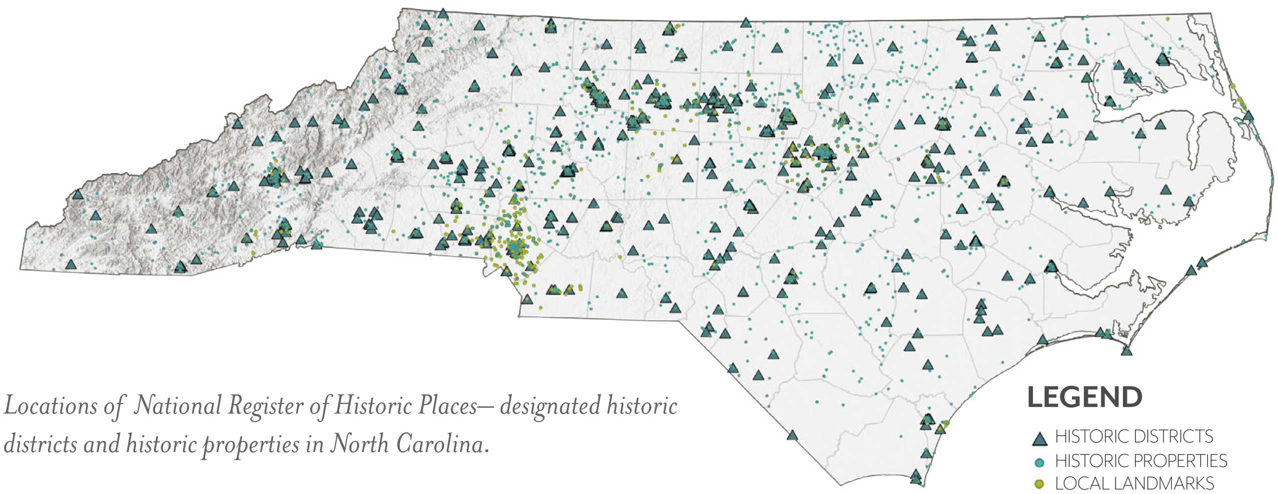
Although the period following the early European settlement of North Carolina represents just a blip in the arc of the state's history, the architectural legacy of European-influenced buildings has endured as the most visible example of our past. A range of architectural influences shaped the built environment of colonial North Carolina. Traditional English building styles were introduced by British immigrants, while German and Scotch-Irish influences were introduced as the descendants of earlier settlers migrated to the area from further north. Between the late seventeenth and early nineteenth centuries, North Carolina's frontier expanded westward to the Appalachian Mountains, spreading European architectural styles across the state.

The National Historic Preservation Act (NHPA) was passed in 1966, establishing the National Register of Historic Places. The NHPA documented a clearly defined process for historic preservation in the United States and established state historic preservation offices to oversee preservation activities, execute surveys, and maintain state records of historic properties ("National Historic Preservation Act," 2022). Today, the North Carolina State Historic Preservation Office (NCHPO) continues to lead preservation efforts across the state through:

- Maintaining a statewide survey of historic buildings, districts, and landscapes
- Nominating eligible properties to the National Register of Historic Places
- Conducting environmental reviews
- Providing technical assistance to homeowners of historic properties
- Providing grant assistance for historic preservation projects
- Assisting local historic preservation commissions
- Facilitating historic preservation education

In 1971, a law was passed in North Carolina enabling local governments across the state to create local historic districts and establish local historic district commissions, supplementing

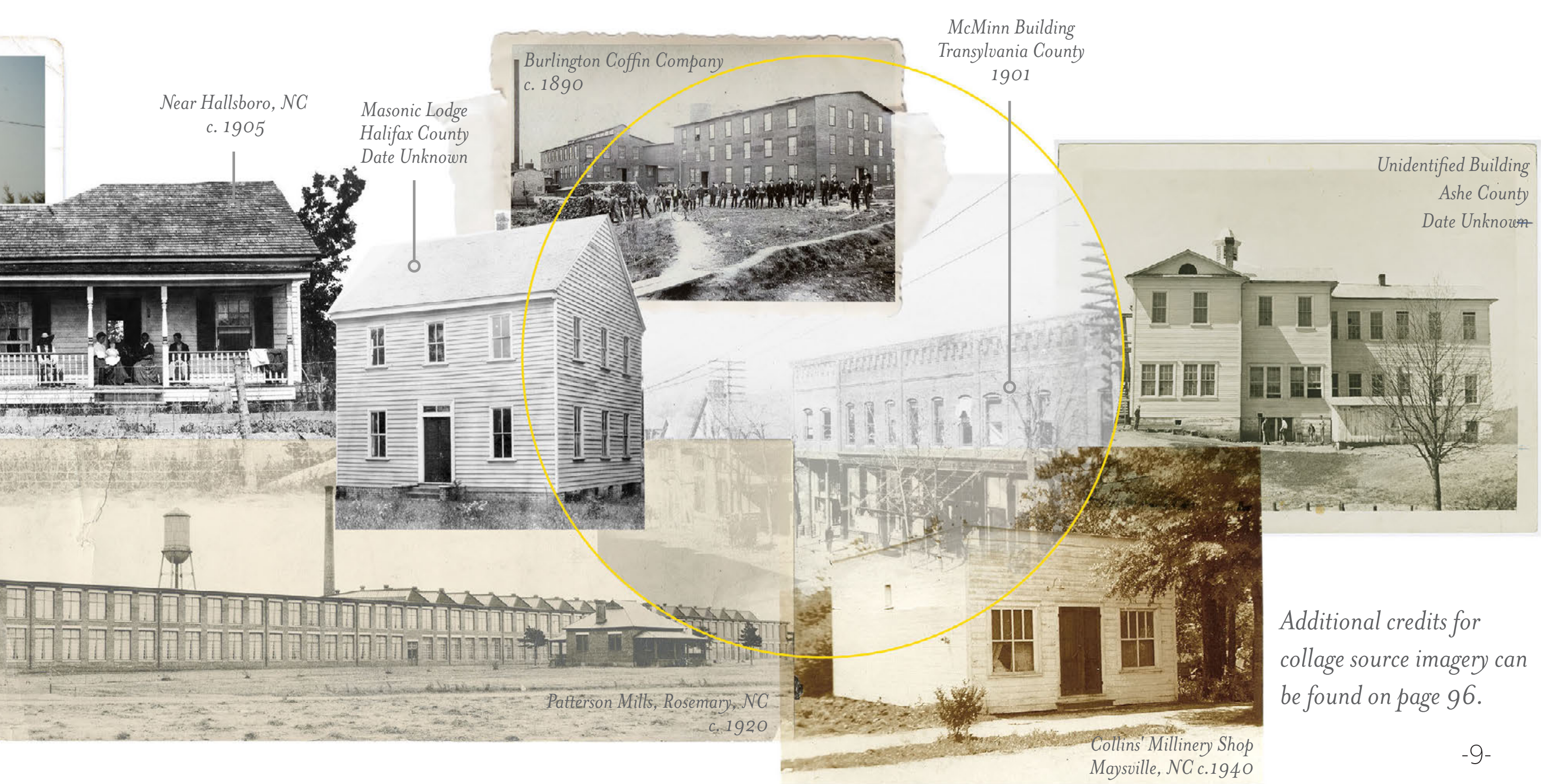




Locations of National Register of Historic Places— designated historic districts and historic properties in North Carolina.

and strengthening the NCHPO's mission to protect and enhance properties significant to the state's history (State Historic Preservation Office & Preservation North Carolina, 1994). These efforts have led to approximately 2,900 listings of historic structures, sites, and districts across North Carolina, ensuring the longevity the state's of historic places and their stories. Preservation seeks not to prevent physical change, but to moderate it and to reduce the sense of dislocation it can produce. Historic landmarks and districts provide a tangible link with the past, with the people and events that have made significant contributions to our history and thus have helped shape our present.

Historic preservation represents a relatively small public expenditure, but many cities and towns have found it to be a useful tool for stabilizing property values and stimulating new investment in older residential neighborhoods and commercial areas, increasing tourism and commercial activity, and attracting people to formerly declining rural areas.

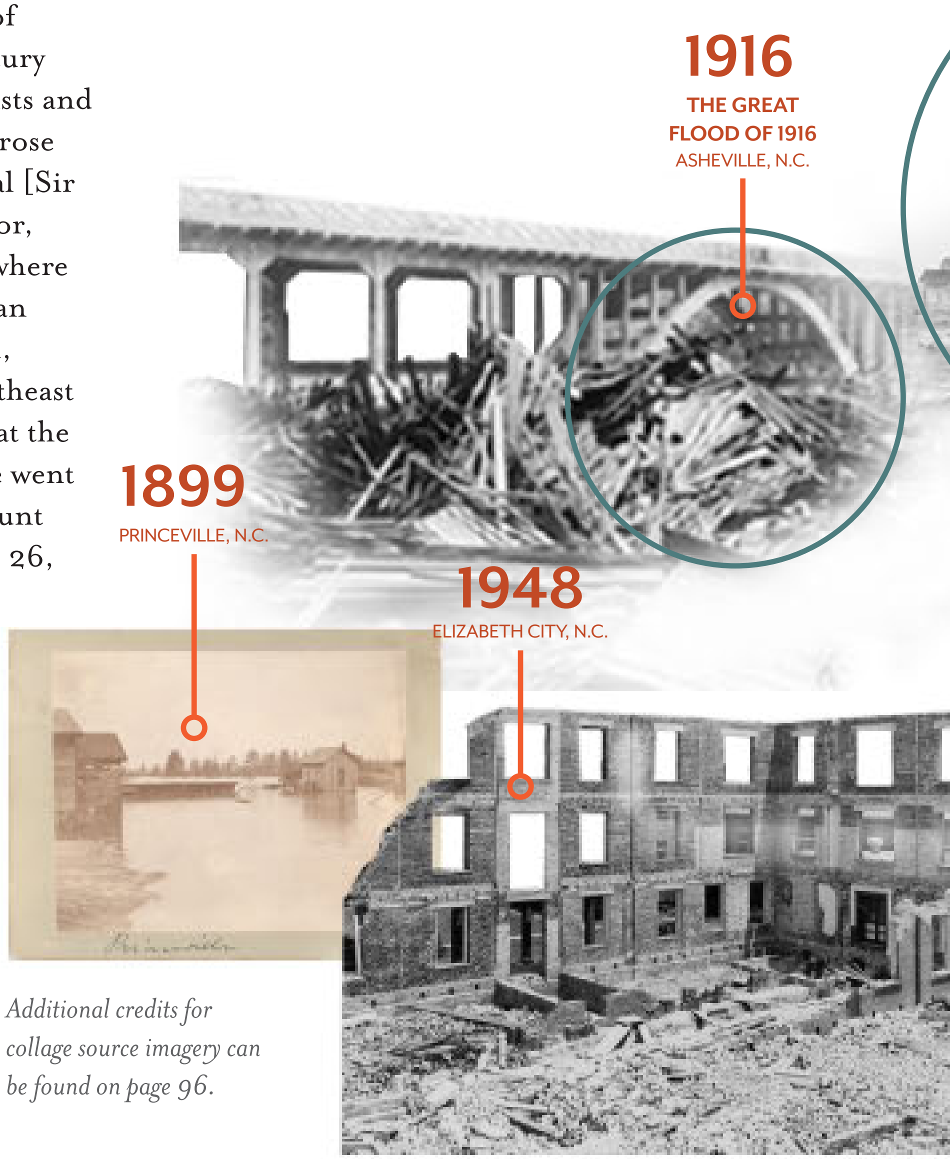


Additional credits for collage source imagery can be found on page 96.

HISTORY OF HAZARDS

In general, North Carolina's temperate climate produces moderate weather patterns and relatively comfortable year-round conditions, but the seasonal threat of severe weather has long been a part of life for North Carolinians. From severe thunderstorms and occasional tornadoes in spring, to the summer and fall Atlantic hurricane season, to our infrequent but severe winter storms, planning for and adapting to natural hazards is a part of the state's history and future. While day-to-day seasonal weather patterns can lead to severe and damaging storms across the state at any time of the year, hurricanes and nor'easters have always presented the most significant risks. Records of storms affecting North Carolina in the first two centuries after colonization are incomplete, but accounts of hurricanes dating back to the sixteenth century begin to paint a picture of what early colonists and explorers were confronted with: "[T]here arose such a tempest at northeast that our Admiral [Sir Francis Drake], then riding out of the harbor, was forced to cut his cables and put to sea, where he lay beating off and on six days…" (from an account of an expedition to Roanoke Island, August 31, 1587) and "the wind blew at northeast and direct into the harbor so great a gale that the sea broke extremely on the bar, and the tide went out forcibly at the entrance." (from an account of an expedition to Roanoke Island, August 26, 1591) (Hudgins, 2000).

A number of severe storms have gained such notoriety due to their extensive damage that they've become permanent fixtures in North Carolina's collective memory, serving as benchmarks for comparison with contemporary storms. "The Great Flood" of 1916, the "Okeechobee Hurricane" (1928), Hurricane Hazel (1954), the "Ash Wednesday Storm" (1962), Hurricane Hugo (1989), Hurricane Fran (1996), Hurricane Floyd (1999), and more recently Hurricanes Matthew (2016) and Florence (2018), represent some of the most severe and most devastating storms affecting North Carolina.



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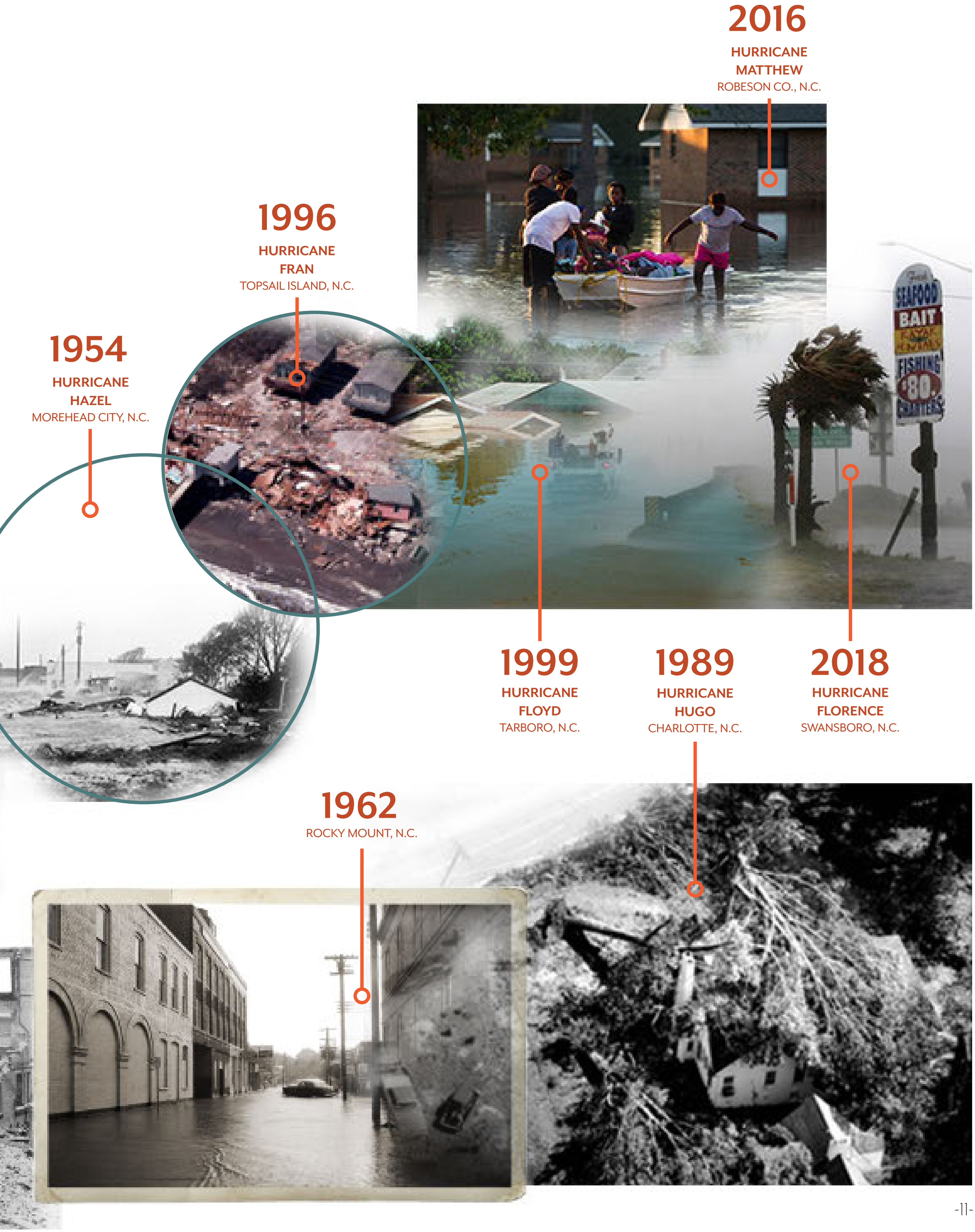

1954
HURRICANE
HAZEL
MOREHEAD CITY, N.C.
1962
ROCKY MOUNT, N.C.
1989
HURRICANE
HUGO
CHARLOTTE, N.C.
1996
HURRICANE
FRAN
TOPSAIL ISLAND, N.C.
1999
HURRICANE
FLOYD
TARBORO, N.C.
2016
HURRICANE
MATTHEW
ROBESON CO., N.C.
2018
HURRICANE
FLORENCE
SWANSBORO, N.C.
SEAFOOD
BAIT
FISHING
CHARTERS

MAPPING HAZARD RISKS

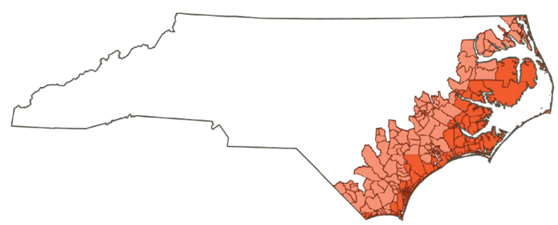
Severe storms and hurricanes may be among North Carolina's most ubiquitous natural hazards, but there are other threats possible. The state's Hazard Mitigation Plan, last updated in 2018, identifies the natural, technological, human-made, and public health hazards that could potentially affect the state and their likelihood of occurrence. The natural hazards identified in this plan include flooding, hurricanes and coastal hazards, severe winter weather, excessive heat, earthquakes, wildfires, dam failures, drought, tornadoes, and thunderstorms. The plan also covers geological hazards, such as landslides, as well as infectious diseases. To better frame the resources and recommendations included in this primer and identify the most critical topics covered by the *Standards*, we asked, "Which hazards are the most geographically widespread and the most damaging?"

This series of maps highlights the risk levels and projected impacts for each of the hazards across the state using data available through the National Risk Index (NRI) dataset of the Federal Emergency Management Agency (FEMA). This dataset was designed to help visualize natural hazard risk metrics based on expected annual losses, social vulnerability, and community resilience ratings. Layering various economic and social factors on top of data about where and how often different natural hazards are likely to occur helps paint a more complete picture of a community's vulnerability and resilience. The question is not just whether a community will experience a severe weather event, but if it has the capacity and resources to bounce back from it.

Using NRI data for each of the natural hazards identified in the State of North Carolina Hazard Mitigation Plan, these maps illustrate the areas of the state in which these hazards are most likely to occur, as well as the expected annual monetary value of associated property damages. While some of the hazards, like heat waves and drought, are geographically widespread, these types of hazards aren't likely to cause much damage to historic properties. Other hazards, like landslides and earthquakes, impact a relatively limited geographic area but typically result in extensive damage and costly repairs. Unsurprisingly, the most geographically widespread hazards with the highest potential for property damage are hurricanes and flooding.

HURRICANE

EXPECTED ANNUAL LOSS: **$296,945,679**

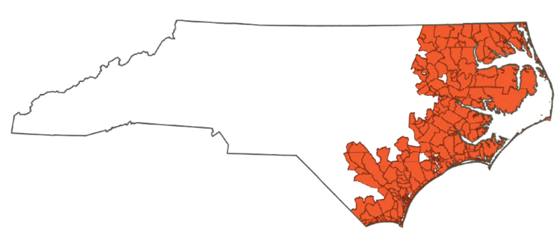


RIVERINE FLOODING

EXPECTED ANNUAL LOSS: **$58,549,711**

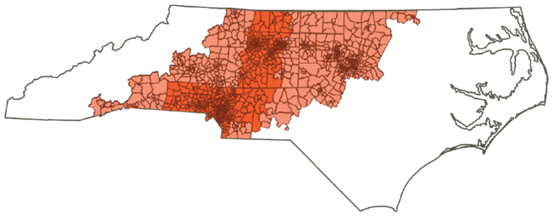
COASTAL FLOODING

EXPECTED ANNUAL LOSS: **$3,715,162**



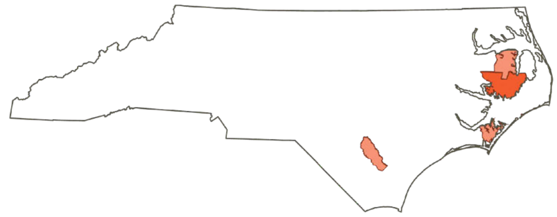
ICE STORM

EXPECTED ANNUAL LOSS: **$21,965,293**



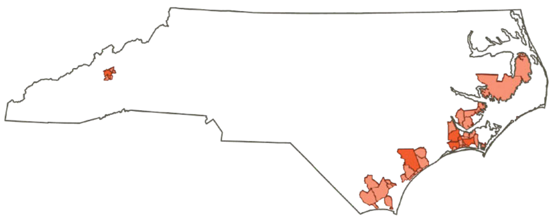
TORNADO

EXPECTED ANNUAL LOSS: **$84,308,439**



WILDFIRE

EXPECTED ANNUAL LOSS: **$12,419,282**

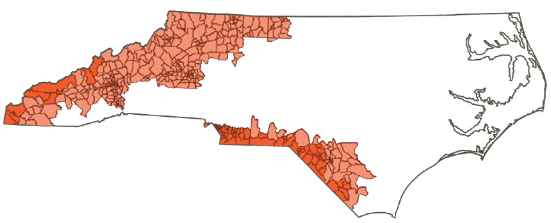


WINTER WEATHER

EXPECTED ANNUAL LOSS: **$1,667,155**

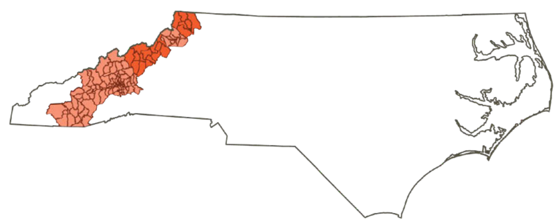
STRONG WIND

EXPECTED ANNUAL LOSS: **$8,273,348**



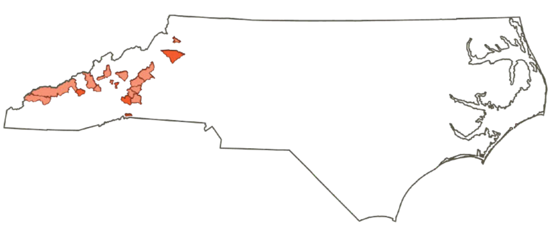
COLD WAVE

EXPECTED ANNUAL LOSS: **$9,869**



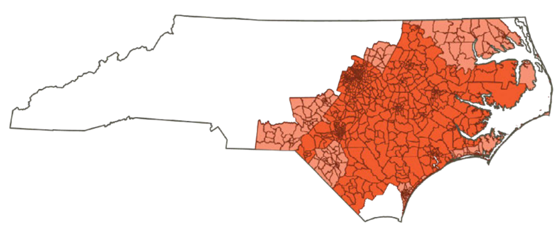
LANDSLIDE

EXPECTED ANNUAL LOSS: **$2,594,553**



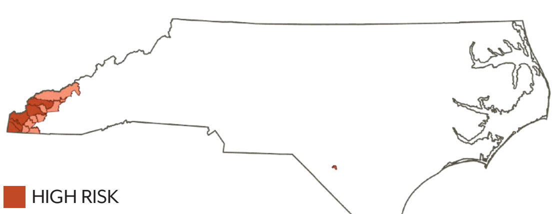
HEAT WAVE

EXPECTED ANNUAL LOSS: **$159**



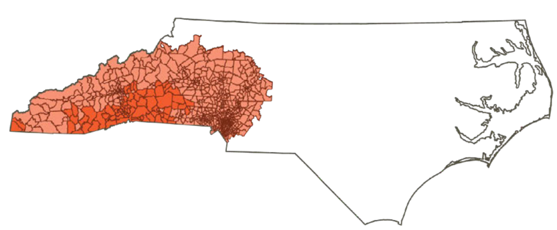
EARTHQUAKE

EXPECTED ANNUAL LOSS: **$15,380,233**



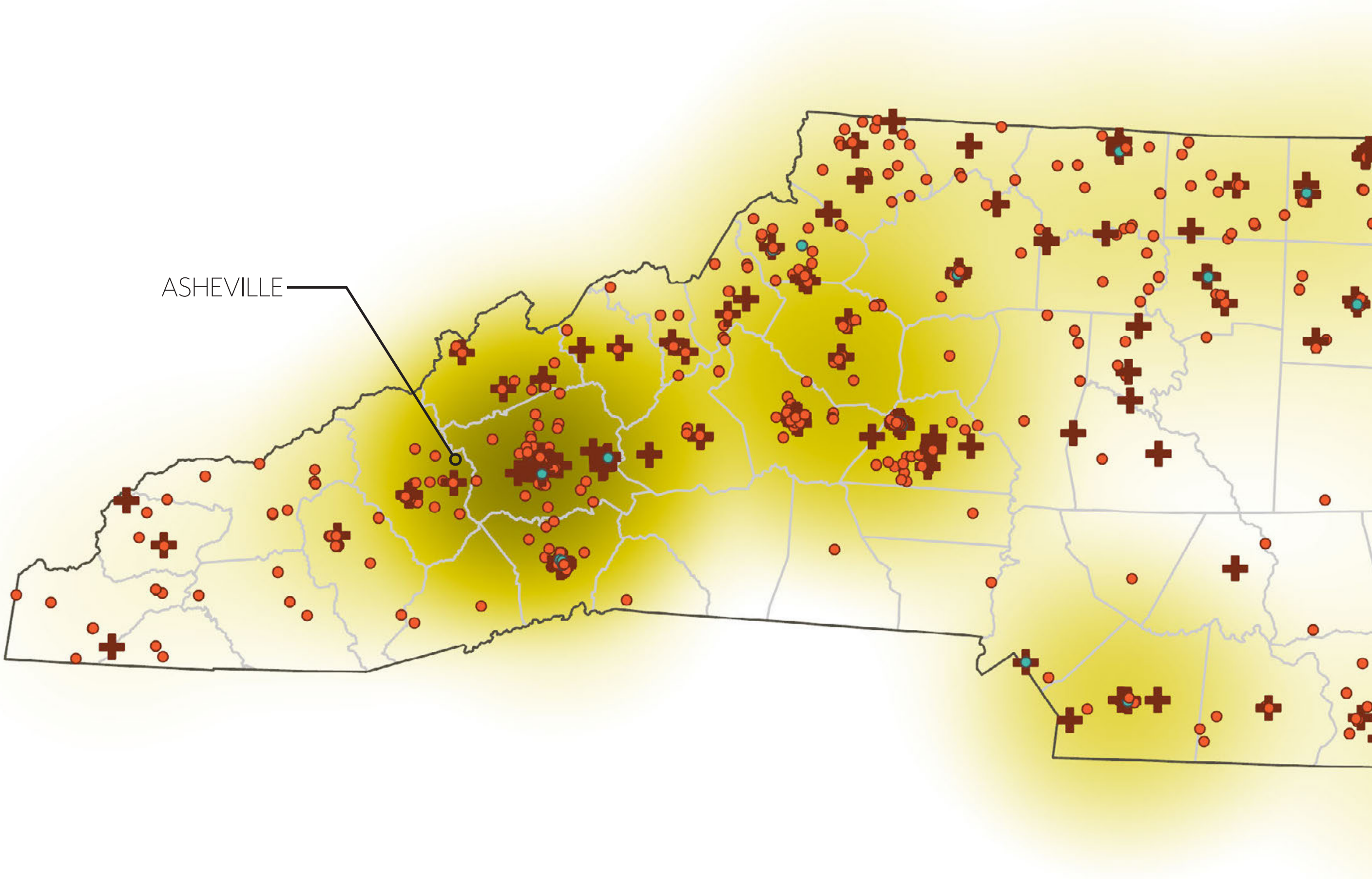
DROUGHT

EXPECTED ANNUAL LOSS: **$0**



HIGH RISK

MODERATE RISK



HIGHEST RISK HAZARDS: WATER & WIND

The impacts expected from hurricanes and flooding are most often associated with damage from wind and damage from water, so the content in this primer and the *Standards* has a strong focus on increasing resilience and minimizing impacts from those sources. Water and wind damage is also expected with many of the other possible hazards across North Carolina including "strong wind," "tornadoes," and in some cases "severe winter weather" and "ice storms," so the resilience recommendations included in these documents are applicable to a range of different weather events across the entire state.

Hurricane Hazel damage, Carolina Beach, N.C., 1954. Courtesy of N.C. State Archives.

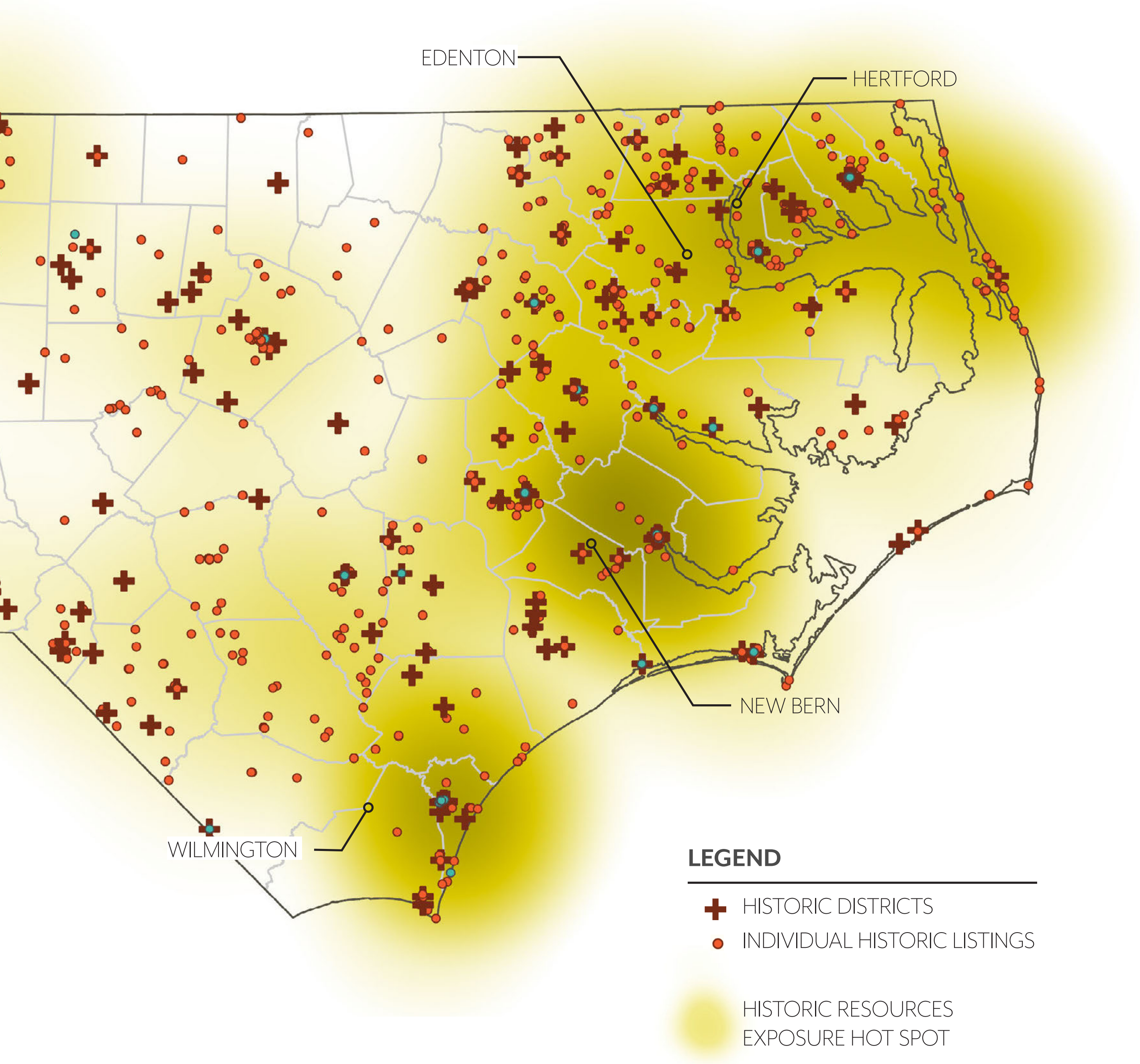
HISTORIC PROPERTIES AT RISK

NATIONAL REGISTER

NR HISTORIC LISTINGS: 302
NR HISTORIC DISTRICTS: 79

LOCAL DESIGNATION

LOCAL LANDMARKS: 74
LOCAL HISTORIC DISTRICTS: 20



WATER & WIND

FAMILIAR THREATS

Water and wind are familiar threats for North Carolinians. Between 1996 and 2017, North Carolina experienced flooding in every county, resulting in 72 deaths and $1,663,464,754 in property and crop damages (North Carolina Department of Public Safety, 2018). The low elevation and flat topography of the eastern counties leave those areas susceptible to both riverine and coastal flooding, as well as strong storm surges during heavy storms. Riverine flooding in the Piedmont has long been exacerbated by a rapidly urbanizing landscape, and the steep topography of Western North Carolina amplifies the impacts of heavy rain and can lead to high-velocity, violent flooding. Damaging winds are possible across the state. While hurricanes are the most notorious cause of wind damage, dangerous winds can also result from infrequent tornadoes, summer afternoon thunderstorms, and even colliding atmospheric pressure systems on a pleasant sunny day.

FLOODING

While recent storm events like Hurricane Matthew (2016), Hurricane Florence (2018), and Tropical Storm Fred (2021) highlight the widespread impacts and heightened flood vulnerability of North Carolina communities from the coast to the mountains, the state's relationship with severe storms and flooding extends farther back in documented history. In July 1916, the combined rainfall of two tropical storms in Western North Carolina resulted in the French Broad and Catawba Rivers cresting 17 and 23 feet above flood levels, respectively. The impacts were widespread, with at least 80 lives lost and an estimated $22 million in damages, equaling roughly $600 million in 2022 dollars. Twelve years later, the eastern part of the state was hit by the 1928 Okeechobee Hurricane. The storm dropped between 4 and 9 inches of rain on the region, which was still recovering from heavy rains earlier in the season. The combined impacts led to record crests on the Cape Fear, Tar, Neuse, and Lumber rivers, which remain some of the highest levels experienced by the region. Robeson County suffered an estimated $1 million in crop loss, which happened again the following year due to additional flooding. The crop losses of 1928 and 1929 led to the passage of a federal farm relief program for the

Washed-out railroad trestle over the Catawba River. Photo from "The Floods of July 1916: How the Southern Railway Organization Met an Emergency," D.H. Ramsey Library, Special Collections, University of North Carolina at Asheville.

Flooding in downtown Asheville during the Great Catawba River Flood of 1916. Courtesy of the Durwood Barbour Collection of N.C. Postcards (P077), North Carolina Collection Photographic Archives, Wilson Library, UNC-Chapel Hill.

Two unidentified adults on a car surrounded by floodwater. Unknown location, N.C., 1964. Courtesy of Braswell Memorial Library, Rocky Mount, N.C., and Digital N.C. Collection.

Flooding in Fayetteville, N.C., during the Homestead Hurricane of 1945. Courtesy of the Fayetteville Observer *and The Bill Belch Collection.*

Southeast United States in 1930. Western North Carolina again experienced flooding throughout the Pigeon River basin in August 1940 due to a slow-moving tropical storm. Rainfall measured anywhere from 8 to 21 inches in the region over the course of five days. The subsequent flooding claimed 26 lives and caused an estimated $20 million in damages at the time. Only five years later, the Piedmont region suffered its worst flooding event on record during the Homestead Hurricane of 1945. Like the earlier examples, the storm arrived after heavy rainfall had already saturated area soils, limiting storage capacity throughout the Neuse, Cape Fear, Lumber, and PeeDee river basins. At several points along the Cape Fear River, for example, several historic water levels were recorded, including 33.2 feet in Lillington, 43.2 feet in Elizabethtown, and 68.9 feet in Fayetteville (National Weather Service, n.d.).

Flooding caused by Hurricane Arthur on the Outer Banks of North Carolina, July 4, 2014, photographed from a Coast Guard MH-60 Jayhawk helicopter from Air Station Elizabeth City. Courtesy of U.S. Coast Guard, Petty Officer 3rd Class David Weydert.

TYPES OF FLOODING

Flooding is a broad term that covers high-water conditions from a range of sources with a range of impacts. It's important to understand the different types of flooding because they can cause different types of structural damage and may require special considerations when deciding on resilience adaptations.

RIVERINE FLOODING

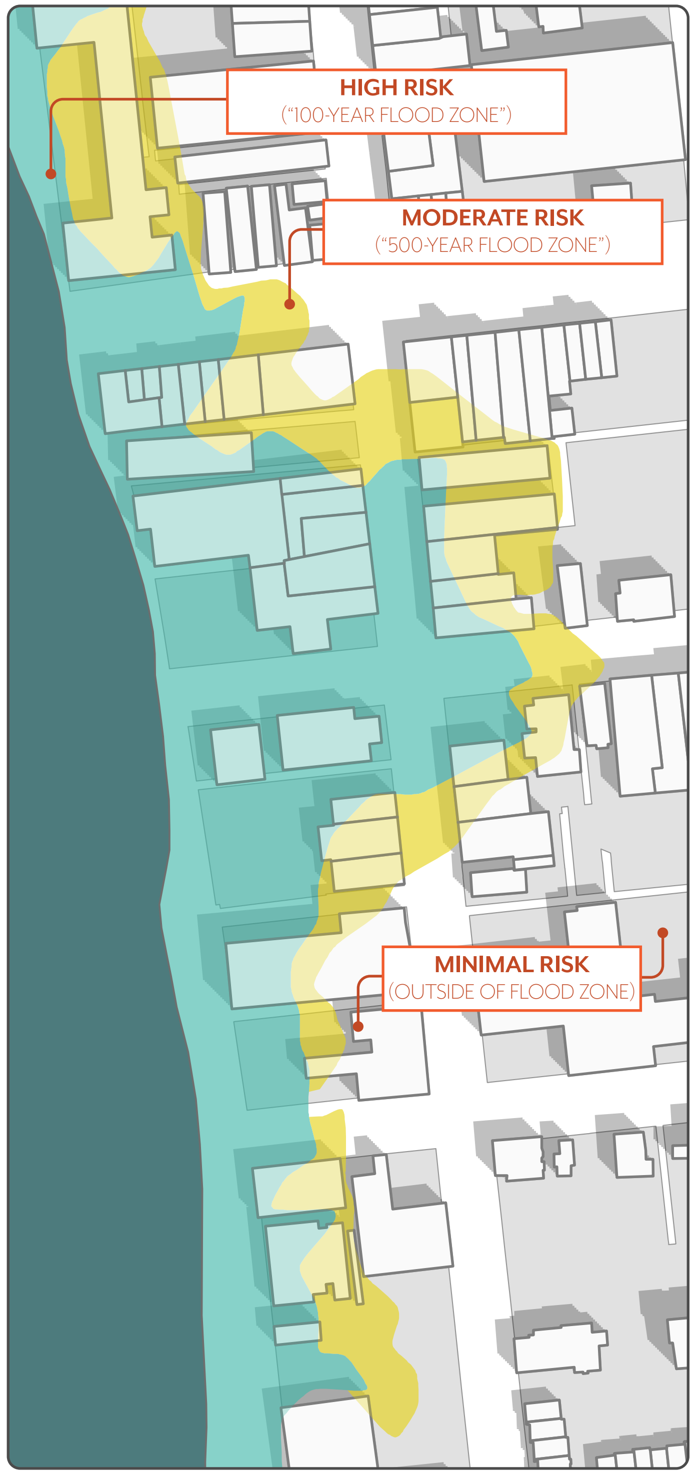
FEMA defines riverine flooding as occurring when streams and rivers exceed the capacity of their natural or constructed channels to accommodate water flow, and water overflows the banks, spilling out into adjacent low-lying, dry land (FEMA, 2020b). Depending on the surrounding topography, riverine floodwaters can flow very slowly, as is frequently the case in the Coastal Plain, or move with very high velocity in places with steeper slopes like Western North Carolina. In the eastern part of the state, flooding may not begin for days after a storm event, but the water may also take days to subside. In the mountains, rivers can start flooding within minutes or hours of a storm event, but typically the water levels drop to near-normal shortly after the storm.

COASTAL FLOODING

Coastal flooding is when water inundates or covers normally dry coastal land as a result of high or rising tides or storm surges (FEMA, 2020b). A storm surge is a temporary rise in local sea level due to a low-pressure storm system offshore. Higher water levels combined with high wind leads to large waves battering the shore, with the potential to cause extensive structural damage as well as flooding (U.S. Climate Resilience Toolkit, 2020).

UNDERSTANDING FLOOD ZONES & FLOOD RISK

Flood risk is a basic measure of the likelihood of flooding for a particular location. It is determined by a complex relationship of factors including proximity to a water body, the local history of flooding, and hydraulic models that predict how and where water might move across the landscape after different storm intensities. This information is presented in simplified form on flood maps developed by FEMA. There are a number of different names and labels used for the different flood zones, but in general, these maps break down flood risks into three main categories (FEMA, 2020a):



HIGH RISK

These areas are also called Special Flood Hazard Areas (SFHAs) and are commonly referred to as "100-year flood zones." This means that in any given year, these areas have a 1 percent chance of flooding, which translates to a 26 percent chance of flooding over the course of a 30-year mortgage. As the highest risk zone, these areas face stricter regulations relating to development and flood insurance and experience more frequent and severe flooding than other areas. On flood maps, these areas are labeled as "A" zones in inland or riverine areas and "V" zones in coastal areas.

MODERATE RISK

These areas are commonly referred to as "500-year flood zones," meaning that in any given year there is a 0.2 percent chance of flooding. Although there are usually fewer regulations associated with moderate risk areas, flooding should be considered an inevitable eventuality. On flood maps, these areas are labeled either as "B" zones or "X (shaded)" zones.

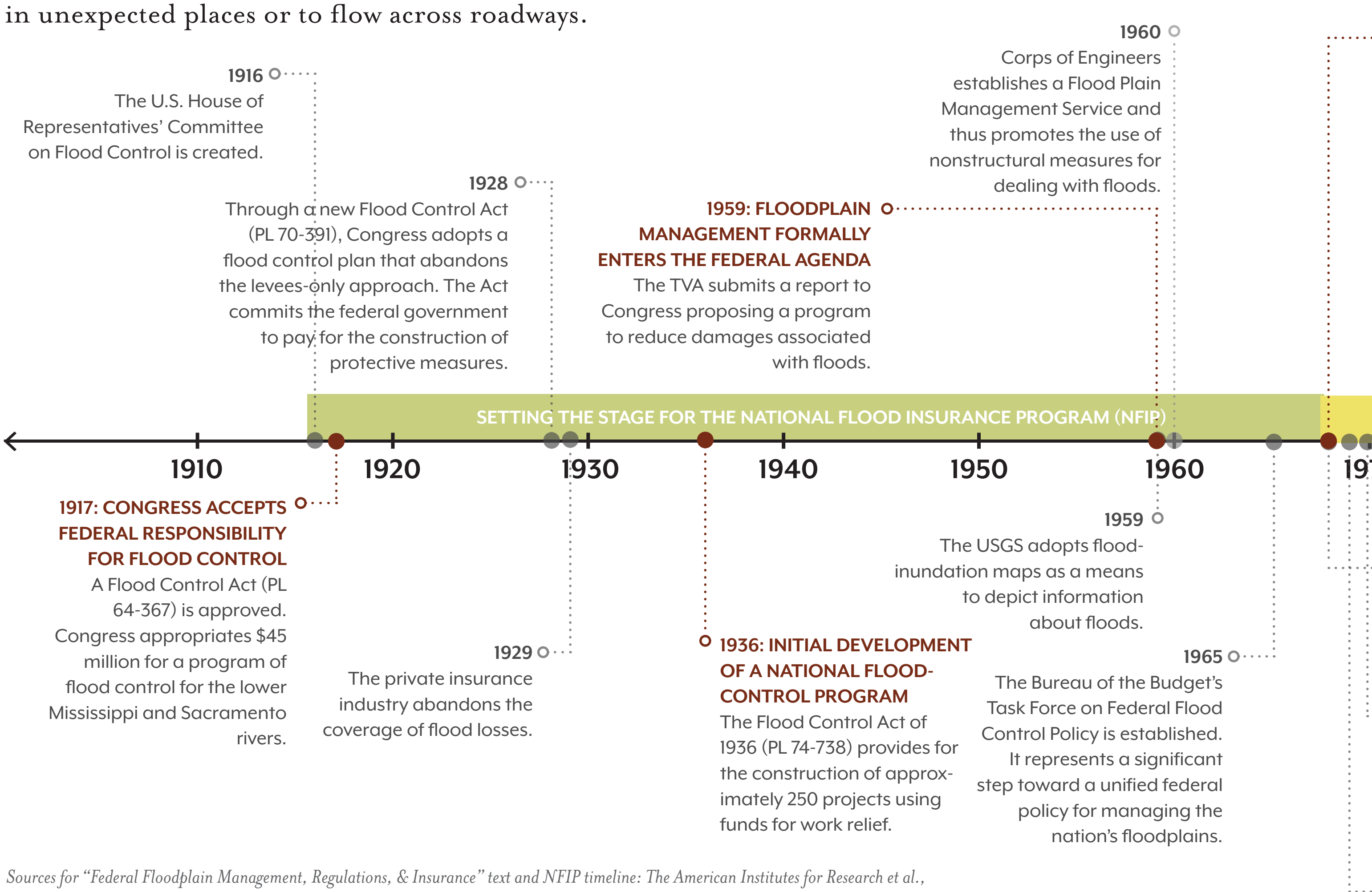
MINIMAL RISK

These areas are considered to be outside of the flood zone, and while flood impacts are unlikely here, the risks are never 0 percent. Many of North Carolina's recent severe hurricanes have far exceeded the boundaries of high- and moderate-risk zones and caused extensive damage in places that have never been flooded before. On flood maps, low-risk areas are labeled as "C" zones or "X (unshaded)" zones.

FEMA FLOOD MAPS

FEMA flood maps for every county in the U.S. are scheduled to be reviewed, and if necessary, updated every five years. While these maps are widely considered the most comprehensive and authoritative source for information about flood risk, they may not always reflect current conditions, especially in rapidly developing areas. Additionally, FEMA flood maps are based on computational models, meaning they predict where flooding is likely to occur, but they can not predict exactly where it is going to occur. Many factors can increase or decrease flood likelihood, and if conditions have changed since the last review period, the flood maps may not accurately represent the flood reality. FEMA flood maps also don't include flooding related to sudden, intense rainfall events that cause water to rapidly collect in unexpected places or to flow across roadways.

The primary resource where residents can determine their flood risk level is through FEMA's Flood Map Service Center. Here, a property address can be entered into the service interface, which will return a Flood Insurance Rate Map (FIRM) depicting the flood risk level of the property and the surrounding area. If residents are interested in learning about how risks and flooding events have changed over time, they can also visit the Historical Flood Risk and Costs site, as well as NOAA's Storm Events Database. North Carolina also manages the Flood Risk Information System (FRIS) database, which allows residents to search for their property by address or explore an interactive map to view flood zones across the state.



Sources for "Federal Floodplain Management, Regulations, & Insurance" text and NFIP timeline: The American Institutes for Research et al., 2005; FEMA, n.d.; American Flood Coalition, 2021.

FEDERAL FLOODPLAIN MANAGEMENT, REGULATIONS, & INSURANCE

The federal government has created and enforced policies to influence and regulate behavior in floodplains since the early twentieth century. Key events set the stage for federal floodplain-related action. In 1913, a flood in the Ohio River Valley killed 415 people and caused about $200 million in property loss. This flood spurred public interest in flood control. In 1917, a Flood Control Act represented the first time Congress accepted federal flood control responsibility. By 1929, the private insurance industry stopped their practice of covering flood losses. Movement toward a national flood-control program gained traction with the Flood Control Act of 1936. Federal floodplain management legislation passed in the late 1950s through the mid-1960s.

With the National Flood Insurance Act of 1968, a new era of floodplain regulation began. The National Flood Insurance Program (NFIP) began its operations in 1969. Initially, participation in the program was voluntary. In 1972, NFIP lowered its subsidized rates for flood insurance to encourage increased participation. The following year, homeowners in high-risk flood zones were required to purchase flood insurance. NFIP has continued to evolve as reforms have been enacted. These reforms include eliminating incentives to rebuild on properties that repeatedly flood (2004), implementing rate changes (2012), and placing limits on flood insurance rate increases (2014). Beginning in 2021, the Risk Rating 2.0 system helps users calculate premiums with more precision.

1968: NFIP LAUNCHES
The National Flood Insurance Act of 1968 launches the NFIP with two primary goals: reducing future flood damage and protecting property owners.

1968
The USGS begins to outline approximate floodplain boundaries on topographic maps.

1969
NFIP begins its operations.

1972
The NFIP's subsidized rates for flood insurance are lowered by 37.5 percent to encourage increased participation in the program.

1973: FLOOD INSURANCE REQUIRED FOR HOMEOWNERS IN HIGH-RISK FLOOD ZONES
The Flood Insurance Protection Act of 1973 also increased the amounts of flood insurance available to property owners.

1979: FEMA ESTABLISHED
Executive Order 12127 officially establishes the Federal Emergency Management Agency (FEMA). NFIP is now managed by FEMA.

1994
The National Flood Insurance Reform Act of 1994 strengthened the NFIP with a number of reforms.

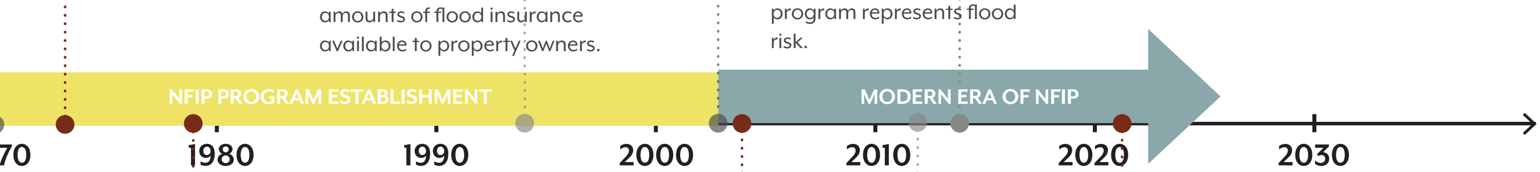
2003
The NFIP digitizes its flood mapping process, modernizing how the program represents flood risk.

2004: CRITICAL REFORMS TO NFIP ENACTED
The Flood Insurance Reform Act of 2004 eliminates incentives to rebuild on properties that repeatedly flood.

2012
The Biggert-Waters Flood Insurance Reform Act of 2012 authorizes the national mapping program and implements rate changes to increase the NFIP's fiscal soundness.

2014
The Homeowner Flood Insurance Affordability Act of 2014 restores grandfathering and places limits on flood insurance rate increases, ushering in a new customer-centric era at the NFIP.

2021: RISK RATING 2.0 UNVEILED BY FEMA
Risk Rating 2.0 now allows FEMA to calculate premiums based on the value of each home/property and its individual flood risk rather than only the flood zone.

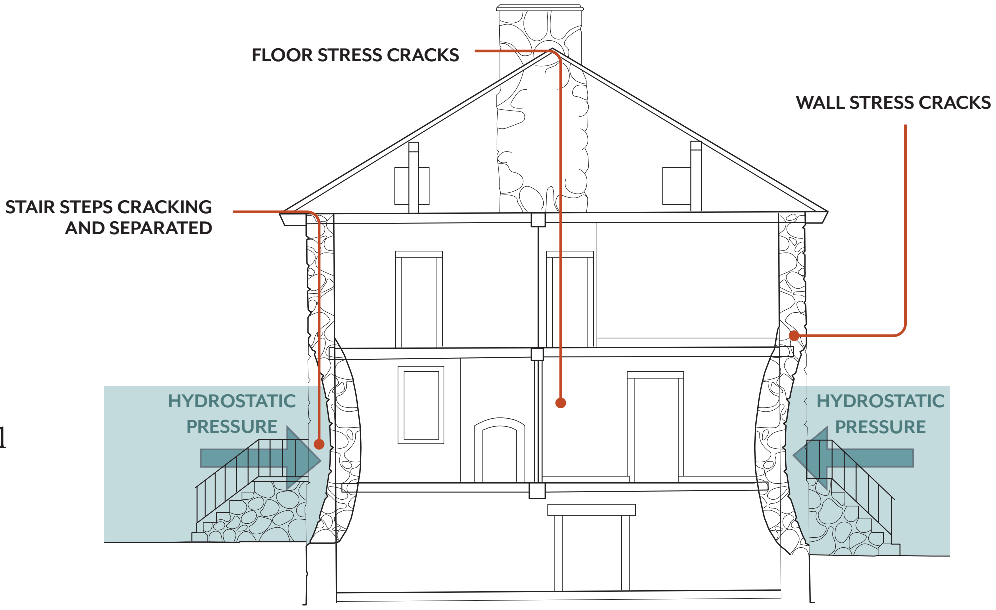


FLOODING IMPACTS

Damage from flooding can vary widely in type and severity. These impacts primarily depend on the depth of water in and around a building, the duration of a flood, and how swiftly the water is flowing. Certain building materials may be more susceptible to water damage, which can also be influenced by water chemistry (salinity or contaminants). Unsurprisingly, deeper water and longer flood durations lead to more extensive damage. Rot and general deterioration from prolonged inundation are the most common types of flood-related damage and often affect wood foundation pilings, structural beams, wood floors, mechanical systems and utilities, walls, cabinetry, furniture, and appliances. Additionally, deep or fast-moving water can exert the following forces with the potential to cause structural damage:

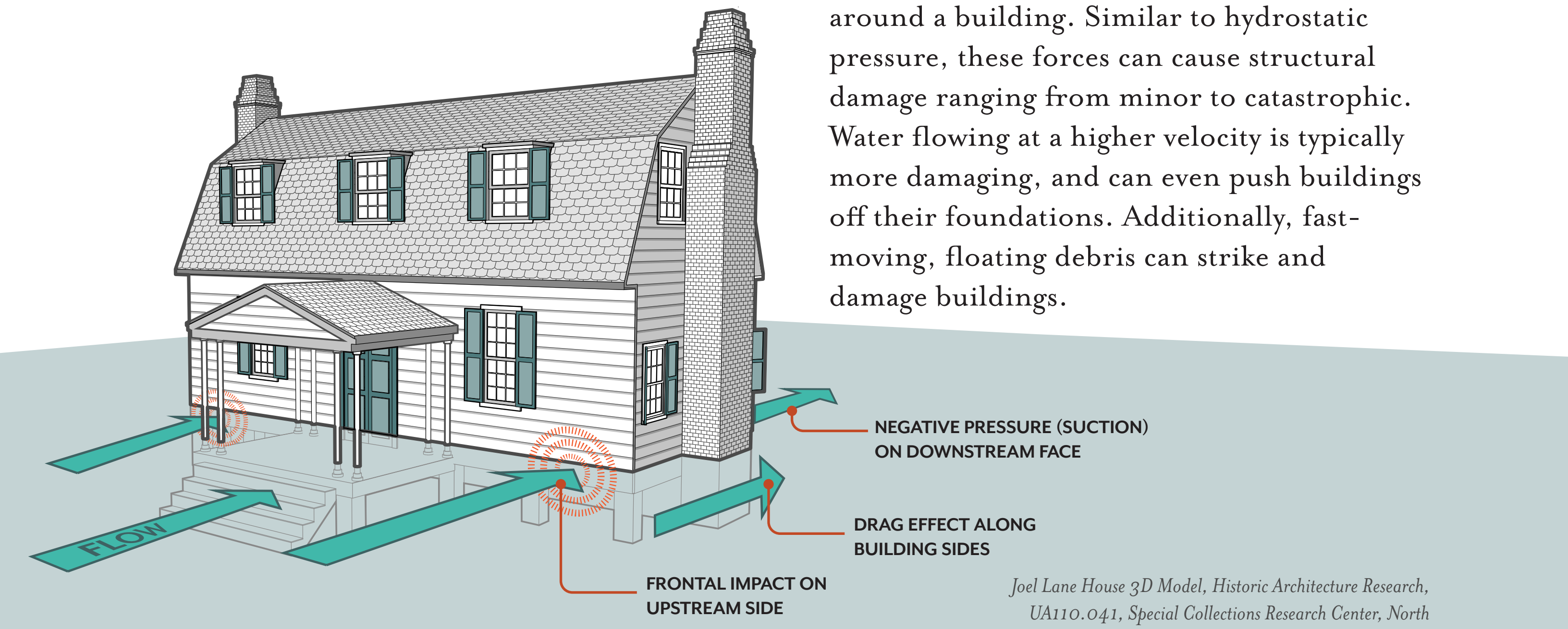
HYDROSTATIC PRESSURE

The strong inward pressure of water surrounding a building can damage the foundation and weaken its structural integrity, even when the water isn't flowing. This may result in immediate and obvious damage like total or partial collapse. Sometimes this type of structural damage isn't immediately visible, so a professional damage assessment is important.



HYDRODYNAMIC FORCES

These are the forces created by water flowing around a building. Similar to hydrostatic pressure, these forces can cause structural damage ranging from minor to catastrophic. Water flowing at a higher velocity is typically more damaging, and can even push buildings off their foundations. Additionally, fast-moving, floating debris can strike and damage buildings.



Joel Lane House 3D Model, Historic Architecture Research, UA110.041, Special Collections Research Center, North Carolina State University Libraries, Raleigh, North Carolina.

RESILIENT BY DESIGN

As evidenced by the myriad historic buildings that have survived generations of floods, the building materials used in historic structures are often naturally more resistant to rot and water damage than many modern building materials (Finley, 2022). Historic structures often integrate dense, old-growth wood products from insect- and rot-resistant tree species native to North Carolina like black locust, cedar, cypress, and hemlock, which outperform modern lumber products (Finley, 2022). Additionally interior plaster coatings common in historic properties are nonporous, fire-resistant, and often contain lime, which has antiseptic qualities reducing the growth of mold (MacDonald, 1989). After a flood, cosmetic damage to wood floors and baseboards is likely, and depending on the water depth, damage to furniture, mechanical systems, and utilities can be extensive. Structural elements like foundations and framing can survive intact if measures are taken to expedite drying. A common practice in disaster recovery is to remove all waterlogged material as quickly as possible, and this might include removing drywall, flooring, and exterior finishes (National Trust for Historic Preservation, n.d.). For contemporary buildings, this practice can be critical in preventing or slowing rot and mold formation, and it can be done with seamless results, but it doesn't always benefit historic buildings, and in some cases can permanently alter their historic character. It's still imperative to release any trapped water, increase ventilation, and facilitate thorough drying, but the same results can often be achieved with less invasive methods, such as temporarily removing baseboards to increase airflow within a structure. The National Park Service's "Guidelines on Flood Adaptation for Rehabilitating Historic Buildings" recommends preserving historic building materials when possible and replacing naturally flood-resistant materials in-kind when necessary. Flood-impacted materials will need to be assessed on a case-by-case basis, but when appropriate, air drying is the safest option.

MINIMIZING FLOOD DAMAGE

After a historic structure has been flooded, it is important to dry out the building, assess the damages, repair and restore where necessary, and plan for future floodproofing in a timely manner. Be sure to prioritize health and safety during this process, making sure that all electrical and gas services are completely turned off. Be aware that floodwaters often contain sewage and other contaminants that present serious health hazards, and wear protection and disinfect as needed. Lastly, be sure to document flood damage through photographs, videos, and written notes prior to cleaning up for insurance claims (Wilds & North Carolina State Historic Preservation Office, n.d.).

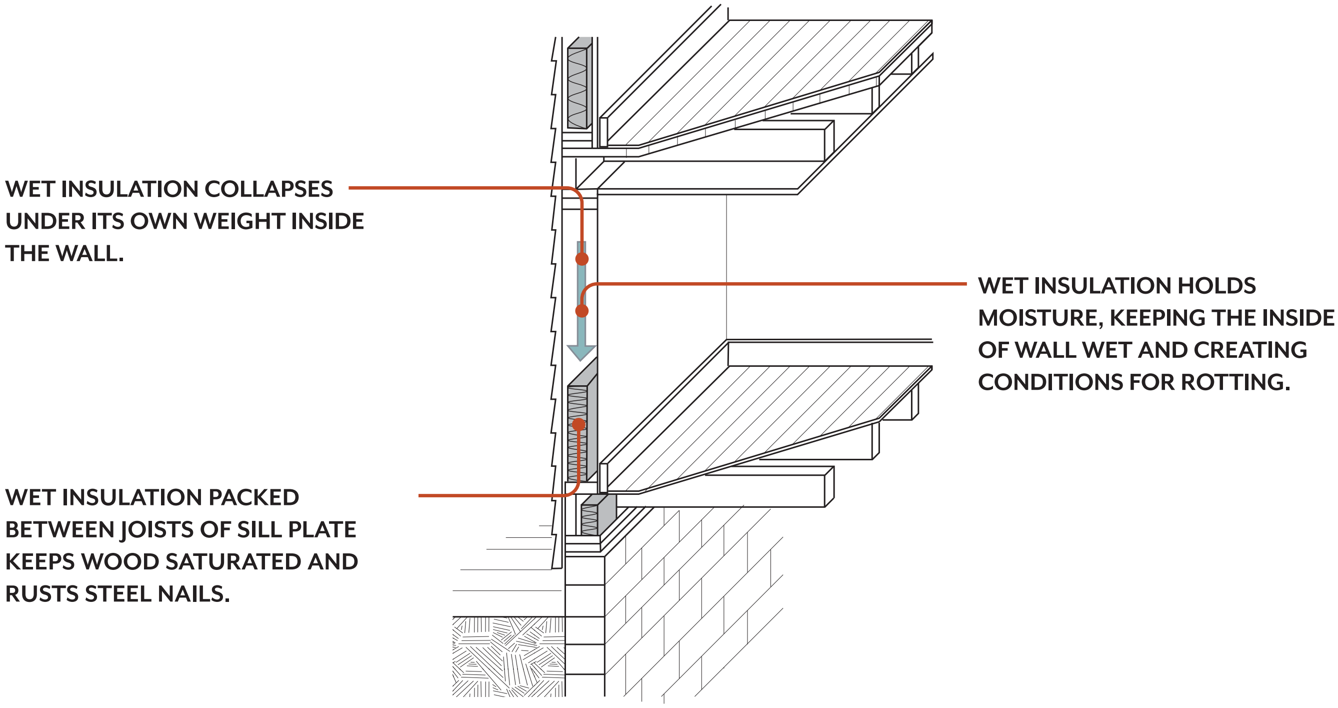
During and after a flood there are three primary ways that floodwaters can affect a building:

- Materials swell, warp, or rot, and equipment shorts or malfunctions.
- Mud, silt, and unknown contaminants are left on surfaces, causing health hazards.
- Dampness promotes the growth of mildew and mold (FEMA, 2010).

To minimize damage after a flood it is imperative to release any trapped water within a structure and prevent additional water entering through any damage in the roof or windows. Additionally, it is important to remove any remaining mud, dirt, and debris as soon as possible. It is safer and easier to remove mud while it is still wet (National Trust for Historic Preservation, n.d.). Once flood-damaged contents and debris have been cleared, it is important to drain any remaining water from walls and ceilings through the least invasive methods possible. Drying efforts should begin in the attic and work down through the building. How you drain walls and ceilings greatly depends on the materials they are made of and any insulation that might be present. Generally, wallboard, which acts like a sponge absorbing water and contaminants, should be replaced if it was submerged in floodwaters (FEMA, 2010). If it was soaked by clean rainwater, it can be dried with fresh, moving air. Plaster walls and ceilings are more resilient than wallboard and should not have to be replaced as long as the plaster does not separate from the supporting wood lath. Small, loose plaster areas can be reattached using plaster washers (Wilds & North Carolina State Historic Preservation Office, n.d.). Plaster does take a very long time to dry, and it may be necessary to shore plaster ceilings using temporary 2 x 4 "T"-shaped braces with plywood pressed against the ceiling. Additionally, drilling small vent/drain holes and temporarily removing baseboards can help to increase airflow within a plaster wall assembly (FEMA, 2010). It is also very important to remove any wet insulation from wall and ceiling cavities to speed drying and prevent molding, rotting, and collapse due to the increased weight. There are three types of insulation commonly used in walls and ceilings: foam board, fiberglass, and cellulose. Closed-cell foam-board insulation is nonabsorbent and can be reused after wall cavities are dry and all surfaces have been cleaned of mud, silt, and other contaminants. Fiberglass batts should be discarded if muddy and removed to air dry if soaked only with clean rainwater. Cellulose insulation will hold water for a very long time and if wet, it should be removed and replaced. If there is standing water in your basement and you drain it too quickly, the pressure outside of the walls will be greater than the pressure inside the walls, which may lead to cracking and collapse. Therefore, it is recommended to gradually pump water out of a basement by pumping down 2–3 feet per day (FEMA, 2010). After the water has been drained, inspect the interior for slab cracks or heaving, wall cracks or buckling, and loss of mortar. On the exterior, check for eroded soils around the foundation that could allow new water to drain into the basement and fill in soil that has eroded to create positive drainage away from the structure.

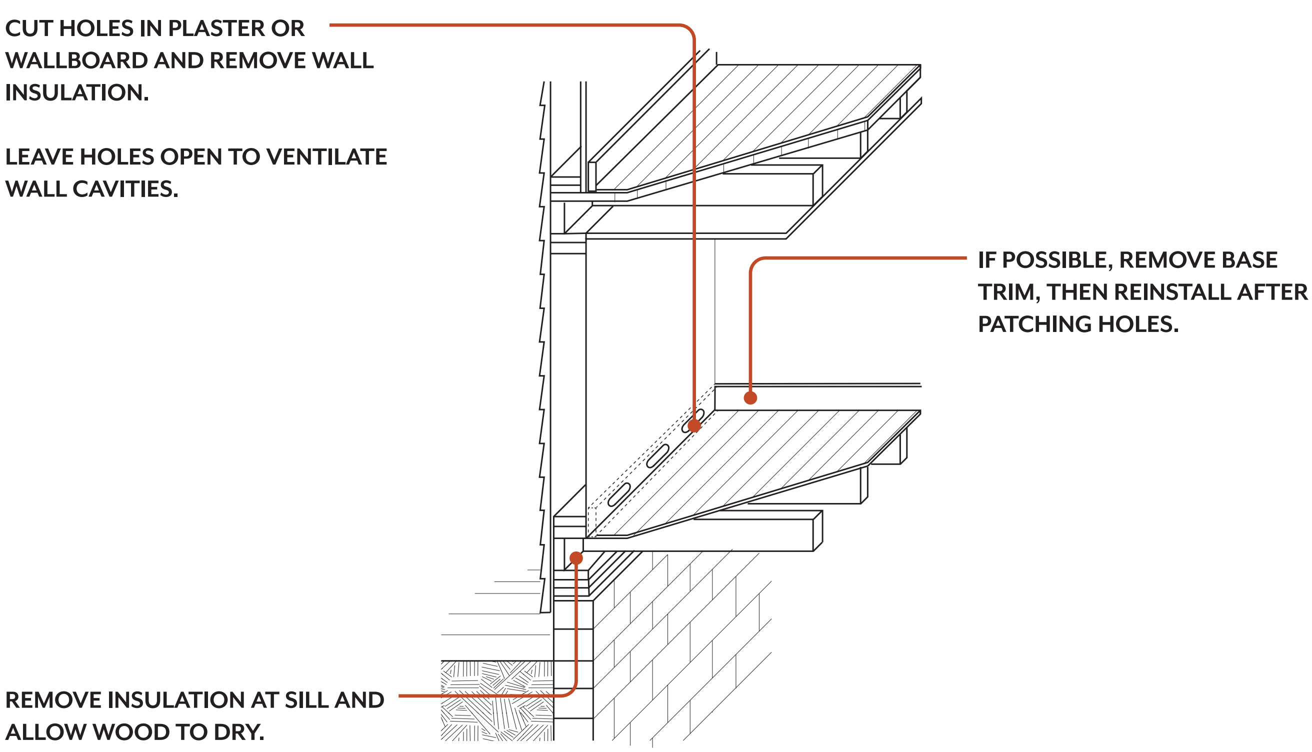
Once the trapped water has been removed, it is essential to increase ventilation and facilitate thorough drying by reducing any humidity in the structure. This is often a time-consuming process, and for historic materials, non-heat methods for reducing humidity are preferred as rapid drying methods using heat-forced air can cause irreparable harm to significant building features (Wilds & North Carolina State Historic Preservation Office, n.d.). Noninvasive strategies include: opening all windows and doors, opening closet and cabinet doors, removing all carpet and furniture to dry outside of the house, using mechanical fans to pull exhaust to the exterior, drilling small vent holes in wall cavities, and temporarily removing the baseboards. Since floorboards may begin to warp as they dry, weights or shoring on top of wood floors may lessen severe warping and buckling (Wilds & North Carolina State Historic Preservation Office, n.d.).

Illustration (opposite page) adapted from National Trust for Historic Preservation (n.d.). Treatment of Flood-Damaged Older and Historic Buildings, Fig. 3 (p. 5).



WATER SATURATION

IN WOOD-FRAMED WALLS AND FLOORS



SUGGESTED TREATMENT

FOR VENTILATING WOOD-FRAMED WALLS AND FLOORS

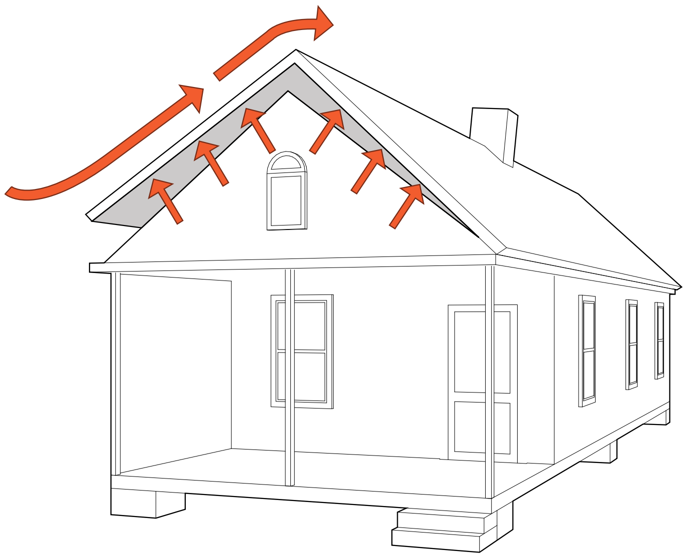
WIND DAMAGE

Tornado damage in Tarboro, N.C., 1927. Courtesy of Edgecombe Memorial Library, Rocky Mount, N.C., and Digital N.C. Collection.

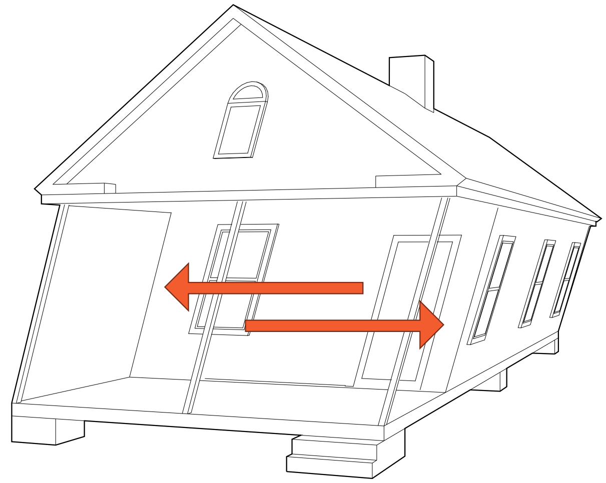
Like flooding, damaging wind can originate from a number of different weather events, with severe thunderstorms, tornadoes, and hurricanes being the primary sources. However, unlike flooding, vulnerability to damaging wind is less predictable. Although some areas of the state are more prone to the weather events that bring strong winds, wind damage can happen anywhere, making prevention and preparation measures particularly important. Guidance from the National Weather Service states that isolated damage is possible when wind speeds are sustained at around 40–50 mph, and widespread damage is likely with winds exceeding 50–60 mph (NOAA National Severe Storms Laboratory, n.d.).

Wind damage to structures can occur as a result of several different forces that often happen in tandem. Roof damage commonly occurs as a result of “uplift,” a combination of positive interior pressure pushing a roof up from underneath and negative exterior pressure creating suction that lifts the roof. “Shear” or “racking” is caused by horizontal winds that deform rectangular building elements into out-of-square parallelograms. “Sliding” is when horizontal winds create shearing forces that slide a structure off its foundation, while “overturning” is when in a structure lifts and rotates off its foundation. In addition, storm-force winds can pick up debris as well as topple trees and other vegetation. Debris damage to a structure or windows can allow water to infiltrate and can cause extensive damage to both the interior and exterior of structures (Miller et al., 2020) (Cushman, 2007).

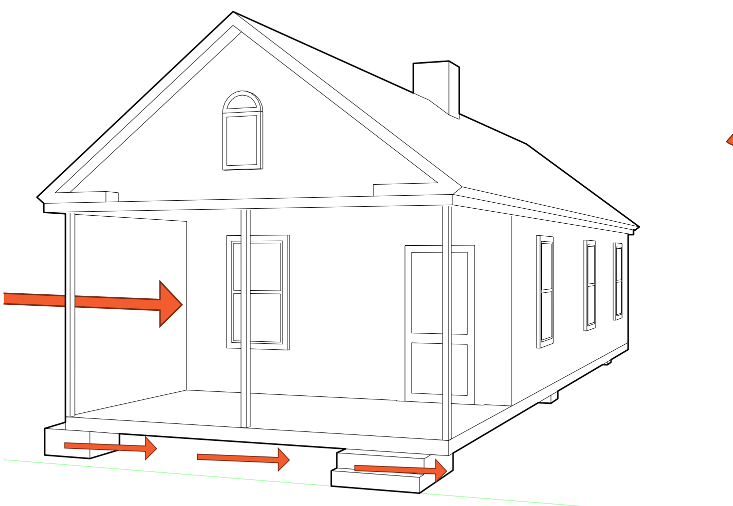
Strong wind from Hurricane Dorian in September 2019 caused shearing along the foundation of the George Dixon House in Portsmouth Village. Courtesy of Jeff West, Superintendent of Cape Lookout National Seashore.



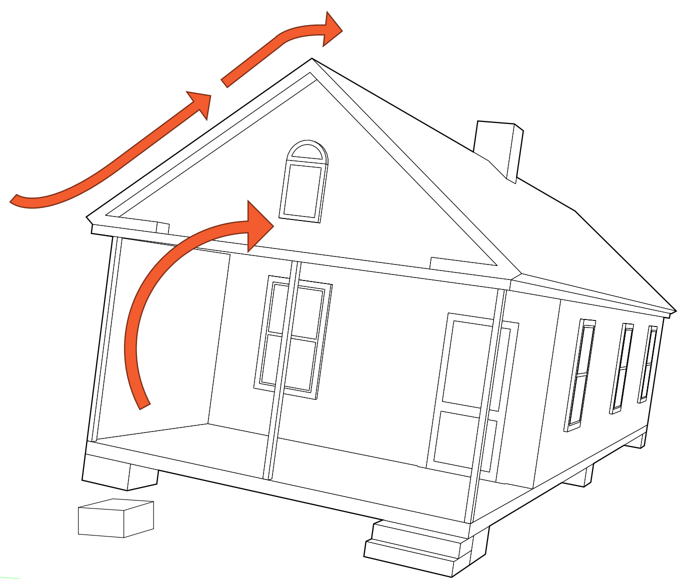
UPLIFT
Wind forces simultaneously push roof upward from below and lift roof upward from above.



RACKING (SHEAR)
Horizontal wind pressures cause shearing along the foundation.



SLIDING
Horizontal wind pressure causes the house to slide off its foundation.

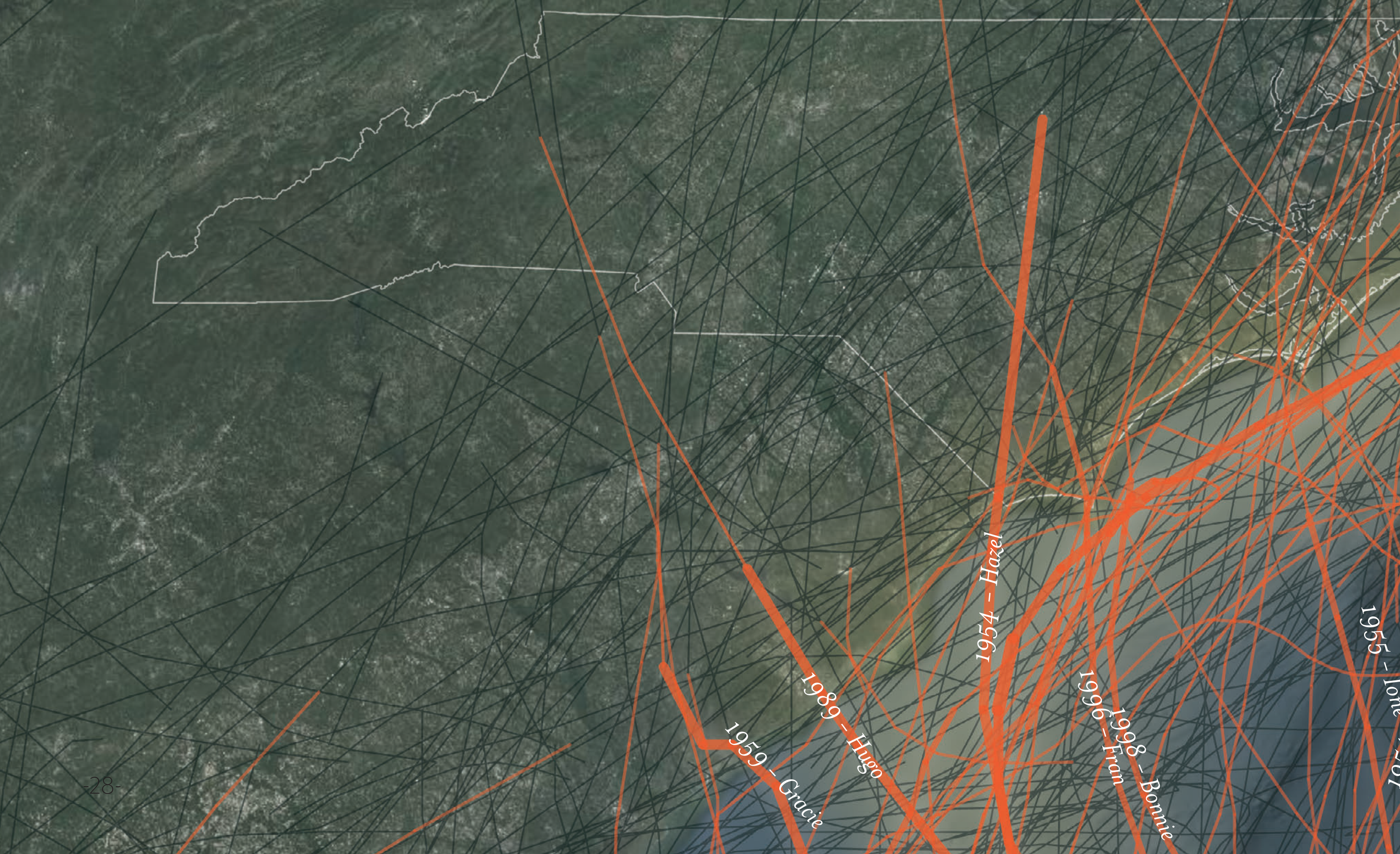


OVERTURNING
Winds cause building to rotate off the foundation.

HURRICANES

With their combined forces of water and wind, hurricanes are often the most destructive and memorable storm events impacting North Carolina. Some of the state's most notorious hurricanes–like Hazel, Hugo, Fran, Floyd, and in recent years Matthew and Florence–have achieved widespread name recognition and serve as benchmarks with which the severity of other storms is compared. For communities impacted by hurricanes like these, the stories and legacy of survival, recovery, and resilience become an important part of local identity.

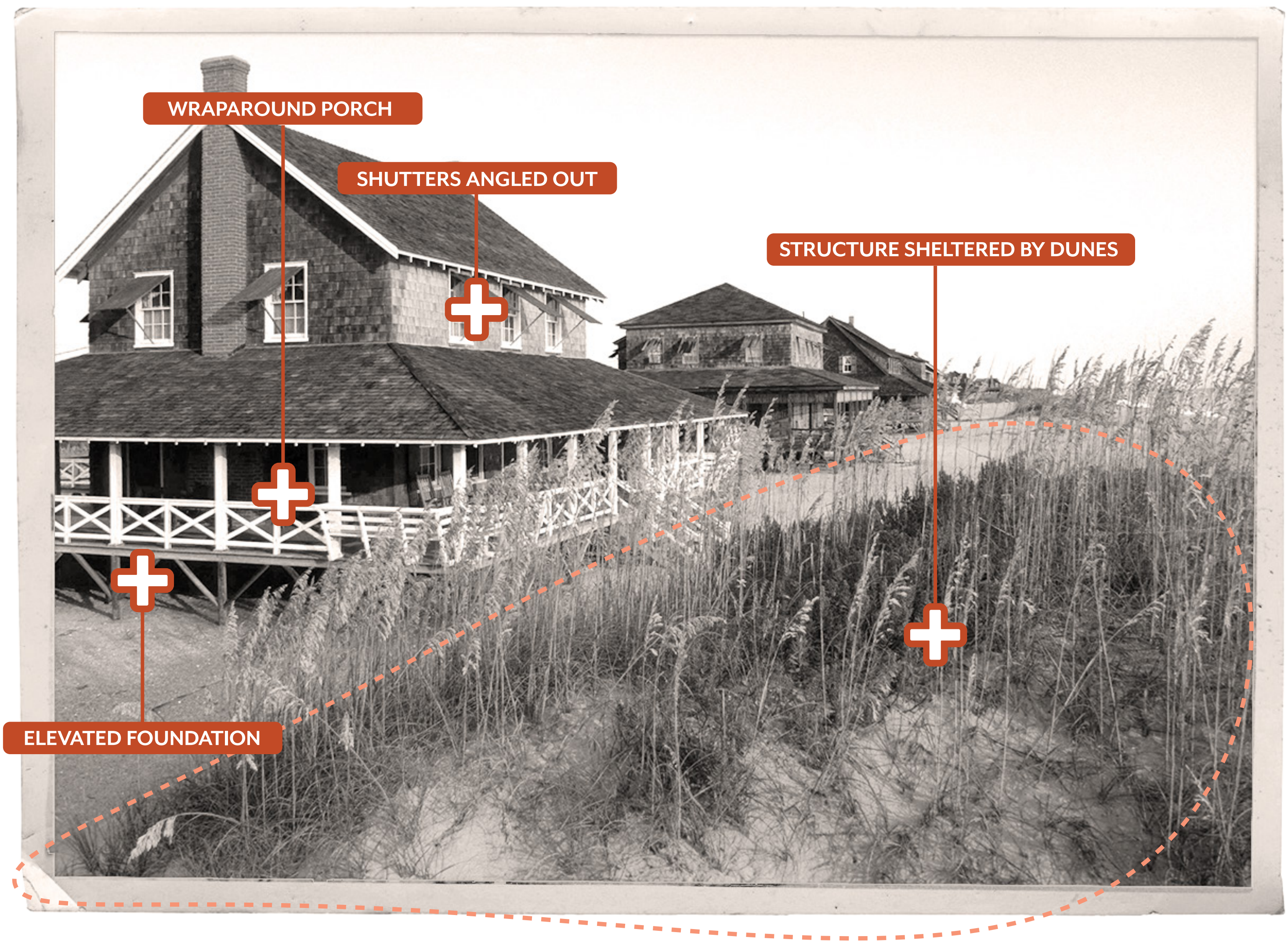
Hurricanes are a type of tropical cyclone, an organized storm system with a well-defined center forming over tropical water (National Weather Service: Mobile/Pensacola, n.d.). As the system strengthens, a classification system based on maximum sustained wind speed is used to categorize the storm. Before becoming a hurricane, a tropical cyclone with maximum sustained wind speeds of 38 mph or less is classified as a tropical depression. With wind speeds between 39–74 mph, the system is classified as a tropical storm, and once sustained wind speeds reach 74 mph, it is upgraded to a hurricane. Hurricane strength is measured using the Saffir-Simpson Scale, which ranks storms from 1 to 5 based on maximum sustained wind speed. The Saffir-Simpson Scale also estimates the type and extent of property damage expected for each of the five categories. Hurricanes classified as 3 or higher are considered major hurricanes, however, the Saffir-Simpson Scale doesn't account for other potentially catastrophic hazards like storm surge, flooding from rainfall, and tornadoes, so hurricanes of lower classifications can also cause extreme damages, as seen with recent hurricanes Matthew (2016) and Florence (2018), both of which made landfall in the Carolinas as Category 1 storms.



Hurricane Hazel damage, 1954. Courtesy of Cape Fear Museum of History and Science.

A HISTORY OF RESILIENCE

VERNACULAR EXAMPLES OF RESILIENCE ADAPTATIONS



View from dunes, Nags Head Beach Cottage Row, Nags Head, N.C., 1988. Photographer: Tim Buchman. Courtesy of Preservation North Carolina.

Historic properties are inherently resilient—they remain an important part of our cultural fabric because they've stood the test of time, shaped by and adapting to changing social, economic, and physical landscapes. The vernacular design elements of historic North Carolina buildings—from materials and construction details to site selection and orientation—tell the stories of early North Carolinians, their values, and how they adapted their building styles to this state's unique landscapes and climates. These vernacular elements reflect a marriage of practicality and aesthetics: the availability and abundance of local materials informed what the structures were built with and the construction methods used, while cultural values and trends influenced the stylistic choices.

Downtown Wilmington, 1931. Courtesy of the North Carolina Aerial Photograph Photo Collection, State Archives; Raleigh, NC.

Historic architectural and vernacular elements also tell stories of resilience. From early examples of "zoning," to where a building is located and how it is oriented on a lot, to architectural form and details, historic buildings reveal how earlier generations responded to the range of climate and weather patterns across the state, and reduced the risks of the natural hazards that are a reality in North Carolina.

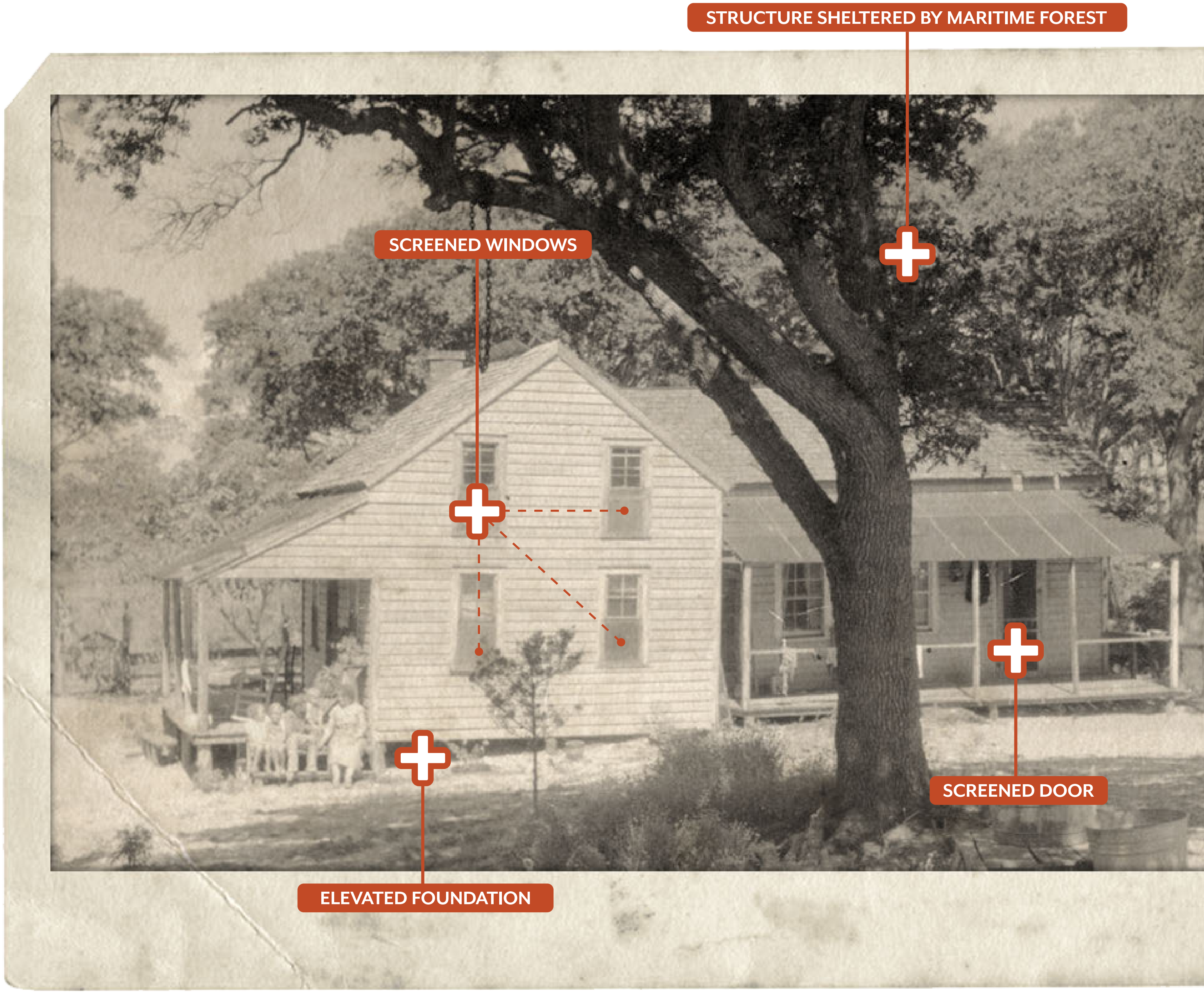
SITE SELECTION AND ORIENTATION

Building placement on a suitable site was one of the most important factors for longevity and resilience. Depending on the region, local context, and intended building use, site selection would balance and prioritize different conditions and landscape characteristics. In the Appalachian region of Western North Carolina, sites for farmhouses were typically chosen if they had south-facing slopes for passive solar heating in winter, proximity to a spring for drinking water and refrigeration, protection from west and northwest winter winds, accessibility to a road, and gentle slopes with minimal excavation required. Tillable fertile land, which usually occurs within a floodplain, was also important for farming and homesteading. Homesites had to balance floodplain proximity with long-term safety, so homes were located just enough uphill to reduce flood risks without limiting the buildable area because of steep and rocky slopes.

In an urban setting, settlement patterns and the clustering of distinct land uses reveal community values and how social, economic, and safety needs were balanced. In Wilmington, this story is told through the local historic districts. As the state's chief port, Wilmington's infrastructure and businesses that centered around the import and export of goods were necessarily located along the Cape Fear River. While the river was critical to Wilmington's economic success and growth, the risk of flooding was constant. In contrast to the commercial areas along the riverfront, the residential areas and cultural districts developed on higher, less flood-prone ground.

BUILDING DESIGN

Historically, buildings were designed in response to their use, site, and climate, with everything



A Salter Path home, c. 1935–40. Courtesy of the Charles A. Farrell Photo Collection, State Archives of North Carolina.

from the floor plan to the details to the materials intended to maximize comfort and safety for long-term resilience. In Nags Head, vacation homes in the Beach Cottage Row Historic District were built beginning in the mid-1800s with elevated foundations to minimize flood risks and prevent damage from high tides. Screened doors provide summertime ventilation, and battens allow the cottages to be secured in the off-season and during severe weather. When angled outward, window shutters provide shade, but they can be closed down to provide additional protection during storms. Wraparound covered porches extend the living spaces and allow cottage residents to enjoy the ocean breeze while providing shade during the hottest hours of the day. Additionally, the steep-pitched porch roofs balance the scale of the windswept two-story cottages with the height of the maritime vegetation and beach dunes, encouraging storm winds to blow up and over the structures. In contrast to these beachfront vacation homes, year-round residents of Nags Head and other coastal areas typically lived further inland in more sheltered areas along the sound or protected by maritime forests. Alternatively, in a similar climate a few hundred miles to the south and over a hundred years

“THESE SMALL HOUSES AT SALTER PATH, NORTH CAROLINA, HAVE SURVIVED HURRICANES FAR MORE SEVERE THAN SANDY. FISHERMEN WHOSE FAMILIES HAD LIVED ON THE BOGUE BANKS FOR GENERATIONS BUILT THESE HOUSES.

THEY UNDERSTOOD SEVERE WEATHER ON THE OCEANFRONT, SO THEY BUILT THEIR HOUSES IN A VALLEY BEHIND THE OCEANFRONT SAND DUNES. THE LIVE OAKS SHELTERING THE HOUSES HAVE BEEN THERE FOR OVER 100 YEARS. SO HAVE THE HOUSES. **THEY WERE BUILT WITH NATURE IN MIND.”**

—Frank Harmon, *Native Places*, 2018, p. 42

earlier, the Charleston “single house” evolved with a very different form and set of architectural details in the growing port city located at the mouth of the Ashley and Cooper Rivers. The Charleston single house is a long, narrow structure whose primary living space is often elevated in flood-prone areas with storage and cellars below. The houses are typically narrow in order to fit on thin, deep urban lots, and located so as to maximize space for a small garden. Usually, they are only one (single) room wide to ensure that each room receives daylight on 2–3 sides and ample cross ventilation through tall operable windows. Additionally, high ceilings allow light to penetrate deeply into the floor plan and cause the cooler air to collect on the floor, creating a comfortable living space even on hot, humid summer days. A one- or two-story porch typically lines the long elevation along the south or west to mitigate the hot summer sun, create an exterior living space that overlooks the garden, and establish a threshold between the public realm of the street and the private interior of the house.

RESILIENT & HISTORIC FUTURE

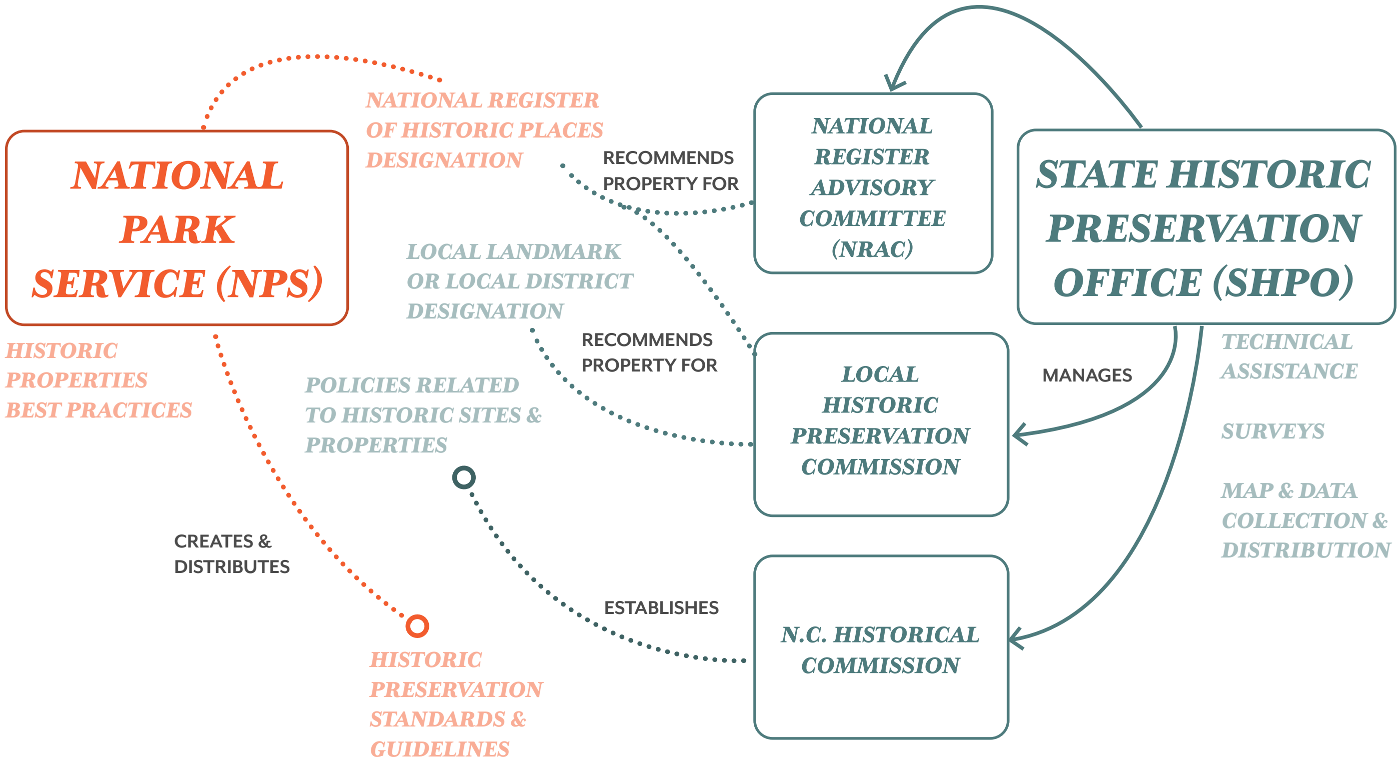
THE URGENT NATURE OF HISTORIC RESILIENCE PLANNING

Resilience adaptation is imperative for historic properties because it ensures that these special buildings, sites, and landscapes persist through an uncertain environmental future. Historic preservation in North Carolina provides social and economic benefits by preserving cultural heritage, attracting tourists, creating jobs, revitalizing communities, promoting environmental sustainability, offering educational opportunities, enhancing quality of life, and stimulating economic growth through multiplier effects. The preservation of these sites nurtures shared and communal values through a sense of collective memory; of civic identity; of shared history; of embodied knowledge; and of connection to our ancestors—all of which shape the larger American landscape. Those who are responsible for historic buildings, landscapes, and sites must be proactive to ensure that future generations can continue to reap these benefits.

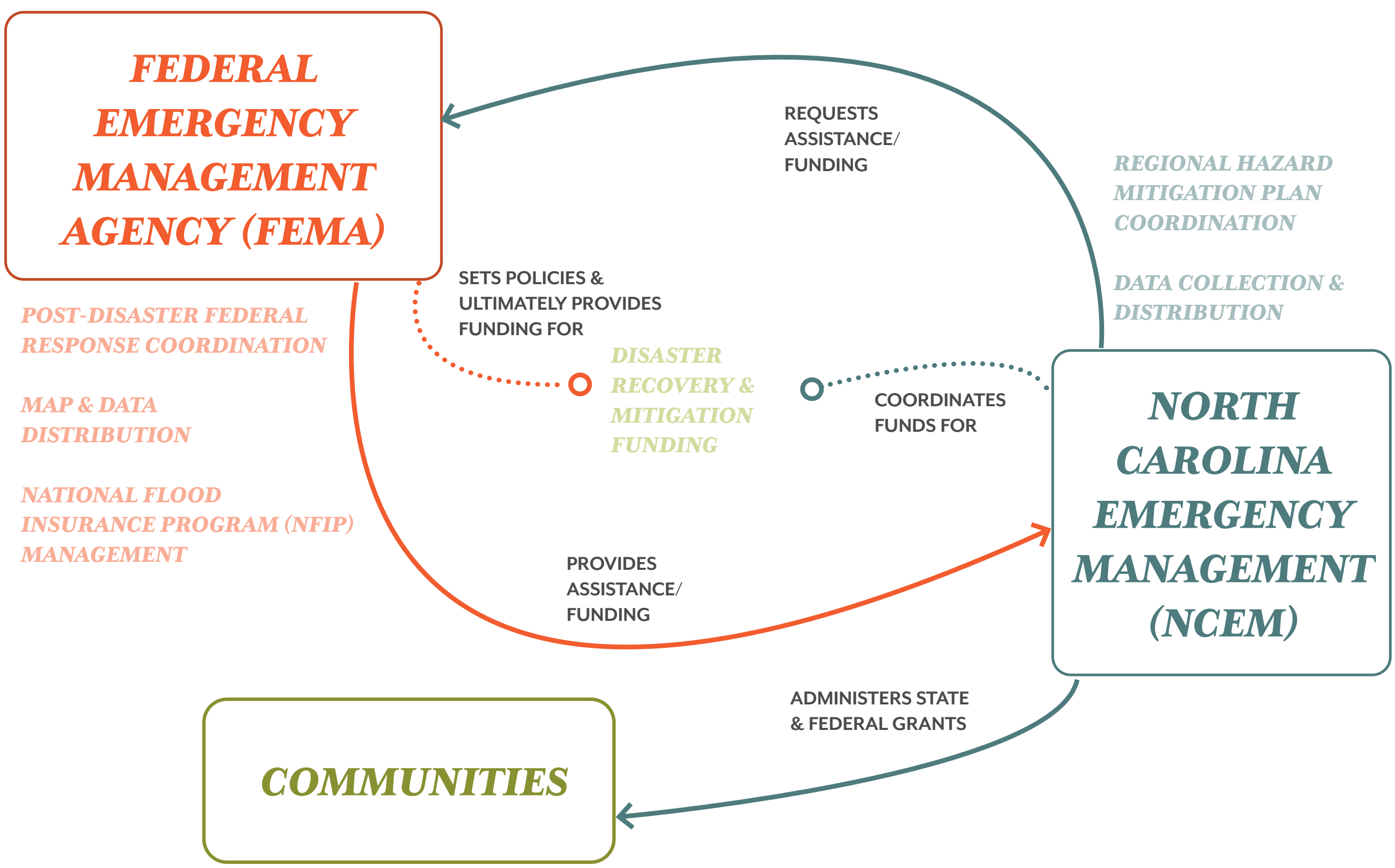
The current and future impacts of climate change lend a sense of urgency to planning for historic resilience. Among the climate-change impacts for North Carolina are more extreme heat and rainfall events. As storms become more frequent and severe, it is more critical than ever to establish maintenance protocols and integrate adaptation best practices into historic preservation.

Historic preservation and emergency management organizational networks often operate independently. However, disaster recovery activities require these entities to interact. These organizational networks have many shared goals and priorities in the face of these conditions. Cross-organizational collaboration would improve the integration of preservation priorities with hazard mitigation priorities.

The following chapter presents best practices and strategies for how resilience planning can be integrated into historic preservation.



The relationship of state and federal historic preservation entities, policies, and guidelines.



The relationship of state and federal emergency management entities, activities, and data.

After Hurricane Matthew, this Ocracoke cottage was elevated by an additional 3'9" on new brick piers. A wide skirtboard on the porch helps minimize the perceived increase in height. Courtesy of the State Historic Preservation Office, North Carolina Department of Natural and Cultural Resources.

SECTION II

HISTORIC RESILIENCE ADAPTATIONS

INTRODUCTION

UNDERSTANDING RESILIENCE ADAPTATIONS

The following chapters provide an overview of how to implement the resilience adaptations included in the *Standards* in a historically appropriate way. The content is intended to supplement the *Standards* with illustrated guidance that explains the core principles of the hazard mitigation approaches that are suitable for historic buildings. The topics are organized by theme in the following chapters: “Disaster Preparedness Best Practices;” “Sites, Landscapes, and the Public Realm;” and “Building Elements and Systems.” With the primary goal of developing a common understanding of mitigation and preservation strategies, this section provides an overview of how certain resilience adaptations work, when they’re effective and appropriate, and how to ensure compatibility with historic preservation priorities.

A residence in the Beaufort Historic District. Courtesy of Ramsay Leimenstoll, Architect.


LOW HEDGE LANDSCAPE SCREENING
BRICK PIERS
RECESSED PIERCED BRICK PANELS
ELEVATED FOUNDATION

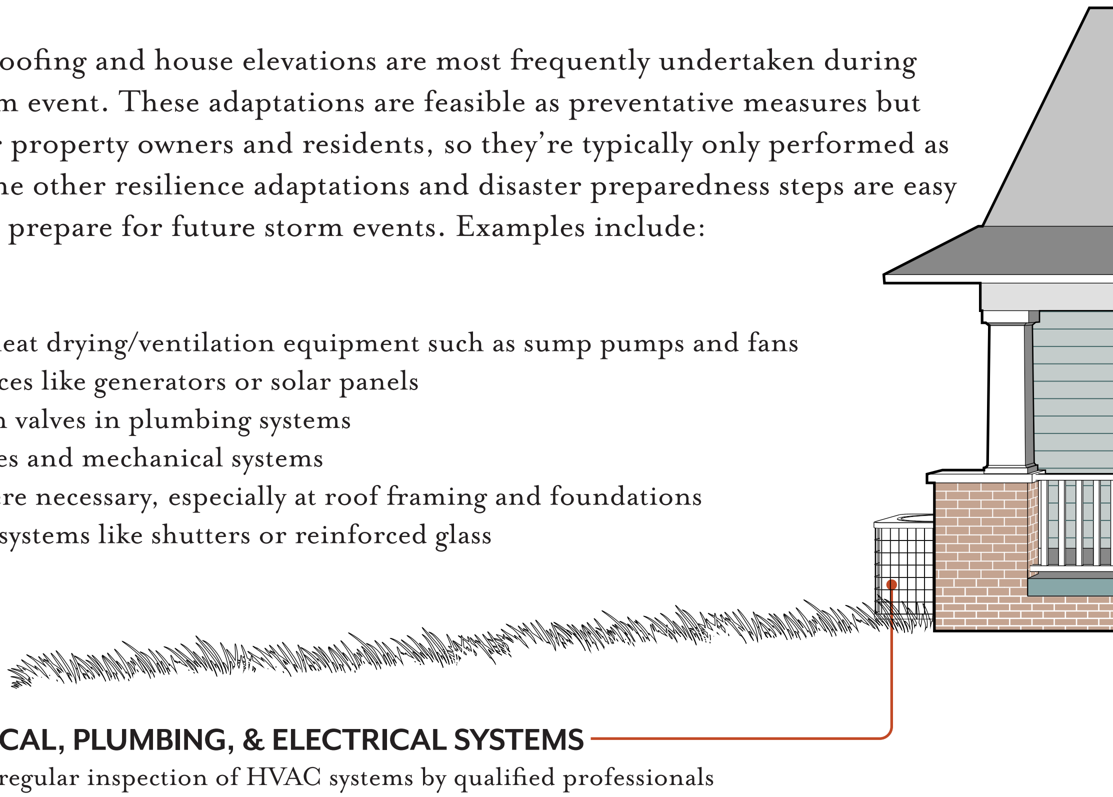
DISASTER PREPAREDNESS BEST PRACTICES

ROUTINE MAINTENANCE & DISASTER PREPAREDNESS

In some cases, permanent retrofits may be necessary to adequately protect historic properties from water and wind damage, but many times damage can be avoided altogether with proactive maintenance and preparation. Routinely inspecting historic buildings and making necessary repairs is a cost-effective way to increase resilience and is an important part of historic property ownership, regardless of hazard risk. As always with historic properties, it is important to preserve historic building materials when possible and to replace naturally flood-resistant materials in-kind when necessary.

Major renovations like floodproofing and house elevations are most frequently undertaken during the recovery from a major storm event. These adaptations are feasible as preventative measures but can be costly and disruptive for property owners and residents, so they're typically only performed as needed. In contrast, many of the other resilience adaptations and disaster preparedness steps are easy to implement as a way to better prepare for future storm events. Examples include:

- Acquiring cleanup and non-heat drying/ventilation equipment such as sump pumps and fans
- Acquiring backup power sources like generators or solar panels
- Installing backflow prevention valves in plumbing systems
- Elevating or protecting utilities and mechanical systems
- Reinforcing the structure where necessary, especially at roof framing and foundations
- Installing window protection systems like shutters or reinforced glass



MECHANICAL, PLUMBING, & ELECTRICAL SYSTEMS

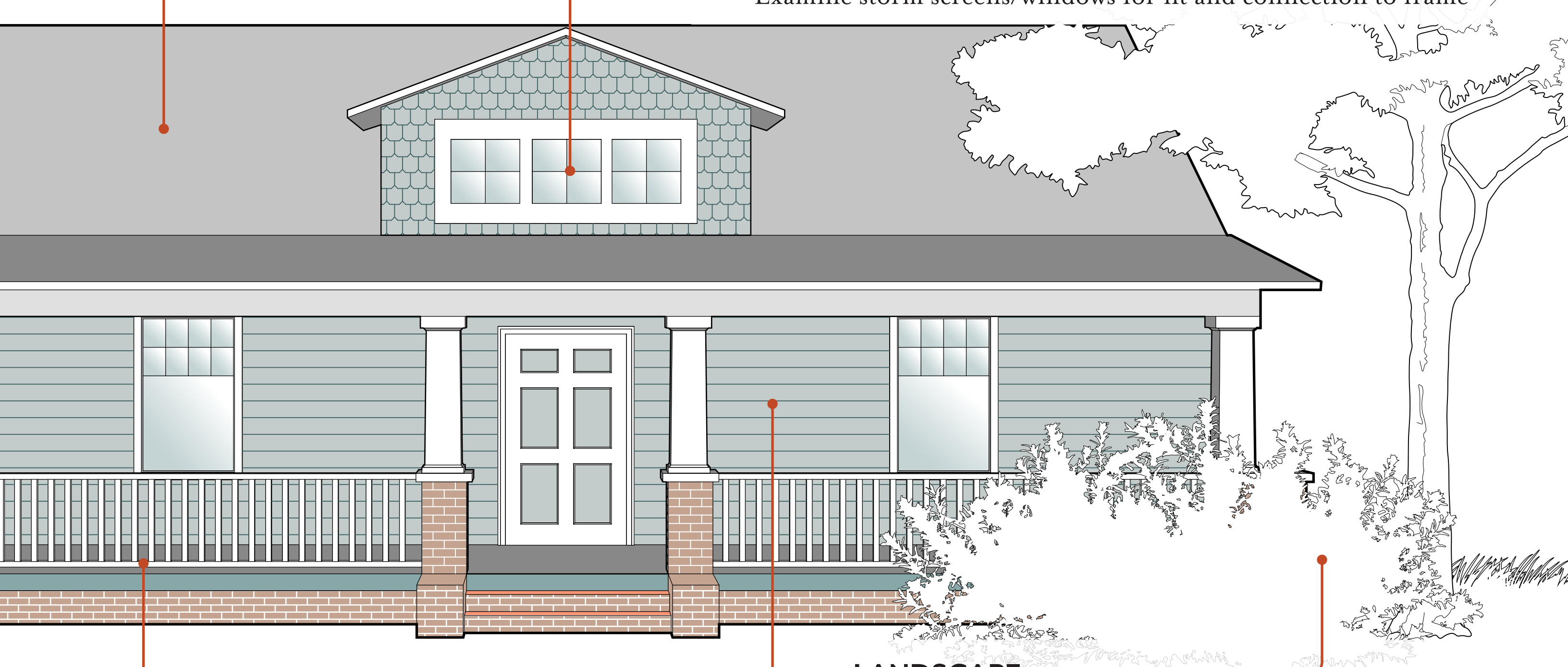
- Ensure regular inspection of HVAC systems by qualified professionals
- Ensure all utilities and mechanical systems are above base flood elevations
- Inspect ductwork for holes or loose connections
- Check plumbing and plumbing fixtures for leaks or corrosion
- Inspect water heater for leaks, routinely drain for sediment build-up
- Clean sump pump regularly and check for discharge
- Test fire and smoke detection systems for proper operation

ROOFS & CHIMNEYS

- Inspect and refasten ridge cap
- Inspect roof for deterioration or rust
- Replace cracked or missing shingles or slate tiles
- Inspect chimney stability, flashing, and cap
- Inspect and clean gutters, look for debris, corrosion, holes, and faulty connections
- Check downspouts for clogs, leaks, and discharge distance, and make sure they direct water appropriately
- Reinforce roof framing to better handle strong winds
- Inspect attic vents to make sure they are unobstructed and adequate for the space and climate

DOORS & WINDOWS

- Inspect windows for water seepage, flaking paint, and decayed wood
- Inspect doorjambs, moldings, and operational hardware
- Caulk around door and window frames
- Replace damaged window frames, sashes, and cords
- Replace cracked glass panes and deteriorated putty
- Ensure operable shutters are functional
- Examine storm screens/windows for fit and connection to frame



PORCH & FOUNDATION

- Check structural connections from roof rafters to columns to foundation
- Check base of columns for rot
- Replace damaged or missing balusters
- Patch cracks and spalling in foundation to prevent moisture penetration
- Install splash guard at downspouts
- Check for standing water near foundation
- Inspect crawl space for moisture and ensure proper ventilation
- Inspect foundation for structural integrity and reinforce where necessary

LANDSCAPE

- Inspect areas prone to erosion
- Remove vegetation growing on structure
- Prune foundation shrubs for airflow
- Prune overhanging tree limbs
- Grade landscape to direct water away from structure
- Ensure functioning outdoor drainage features

SIDING

- Refasten loose siding and trim
- Replace damaged siding
- Inspect for decay, moisture damage, and insects
- Inspect flaking, blistering, peeling, and weathering paint to find moisture source

SITES, LANDSCAPES, & *the* PUBLIC REALM

INTRODUCTION

Historic structures often reflect vernacular architectural knowledge and wisdom of the time, and in many cases that extends to a building's relationship to the site and landscape in which it is situated. From the large oaks providing shade around a home to the historic coastal houses built behind the protection of dunes and live oaks, the remnants of these design strategies are so ubiquitous that we often don't notice them (Harmon, 2018). Because the relationship between buildings and their surrounding landscape is integral to the historic nature of a site, storm damage to yard and landscape elements can negatively impact the overall historic character of properties, even if the structure itself isn't damaged. Common examples of storm damage include erosion and fallen or damaged trees. The most effective strategies for reducing or preventing damage to landscape features typically involve regular, proactive maintenance like inspecting and pruning large trees, monitoring areas prone to erosion, and maintaining space between landscape plantings and buildings to allow for airflow that keeps building materials dry.

Landscapes can also be designed to provide added protection from natural hazards. This strategy, which utilizes natural ecological systems and landform grading, is commonly called "green infrastructure" or "nature-based solutions." For historic properties, green infrastructure approaches have the advantage of not requiring changes to actual structures, and in many cases the visual impact of green infrastructure provides a benefit (e.g., landscape plantings) compared to traditional "gray" approaches to infrastructure (e.g., catch basins, culverts, etc.). The appropriateness and effectiveness of green infrastructure and other landscape-based solutions are dependent on a number of contextual factors, so consulting experienced, licensed professionals is critical to ensuring that resilience goals are met.

At a site scale, landscape approaches to resilience typically fall into two main categories: 1) stormwater management strategies to reduce the frequency and severity of flood impacts; and 2) general maintenance and upkeep of landscape features to reduce the likelihood of damage to the landscape itself or to nearby buildings. These approaches are most successful when multiple strategies are used together, often in conjunction with a suite of other site and building adaptations.

STORMWATER MANAGEMENT STRATEGIES

The main goals of stormwater management are to direct water away from buildings or sensitive infrastructure; slow down and reduce the volume of runoff during and after a storm by increasing infiltration; temporarily collect and store some stormwater; or some combination of all these. Stormwater management strategies are particularly effective at dealing with smaller rainfall events, so they can be great options for properties that experience minor flooding on a somewhat regular basis. While site-level stormwater management is not always able to provide benefits during larger, more severe rain events, the cumulative effect of well-designed stormwater management systems has the potential to reduce flood impacts at the neighborhood scale and in downstream communities.

REDIRECTING WATER

The most straightforward way to manage stormwater is by controlling where it flows. This is achieved by manipulating a site's landforms to direct water away from buildings. Regrading may be necessary if water flows toward or collects around building foundations, and in some cases it can also be used as a method for elevating homes. On sites where runoff flows across the ground in a wide, shallow layer (referred to as sheet flow), berms can help slow down and redirect water and may be appropriate for reducing stormwater runoff between neighboring properties. A well-designed grading plan can also help minimize the visual impact of elevated homes and maintain an appropriate sense of scale.

INFILTRATION

Replacing impervious surfaces like asphalt or concrete driveways, brick walkways, and patio areas with permeable surface options increases infiltration and reduces the volume of water flowing off the site. Many permeable paving products are available in styles that are compatible with historic homes and gardens and fit in with the distinctive character of historic districts. Oftentimes, a property's original paving materials or historically appropriate paving materials like brick or stone can be installed in a way that improves infiltration by replacing the traditionally fine-grained subsurface material (like sand or fine grit) with a coarse aggregate that allows water to percolate through it. Highly compacted soil and gravel also acts like an impervious surface, so taking measures to improve aeration and reduce future compaction can also help improve infiltration.

STORMWATER COLLECTION & STORAGE

Another option for reducing a site's stormwater runoff is to collect and temporarily store it. Rain gardens or engineered bioretention basins are the best-known examples of this type of strategy– during storms they collect water, then allow it to slowly infiltrate into the ground. Bioswales are often used in conjunction with rain gardens and provide many of the same benefits while providing a dedicated route for moving water to the rain garden. Dry wells are an alternative to this system that function in a similar way. While rain gardens double as highly visible decorative garden areas, dry wells are largely invisible underground systems that work by storing captured rainwater underground and allowing it to slowly infiltrate directly into the subsurface soil layer. Cisterns offer another way to store water but provide the additional benefit of allowing collected water to be recycled for nonpotable reuse like landscape irrigation and flushing toilets.

RETAINING WALLS

Retaining walls hold steeply sloping soils in place and are often used to manage vertical grade changes by terracing the landscape. Retaining walls alter the way stormwater moves through a site and when strategically located can solve excessive runoff and erosion issues. Retaining walls can also be utilized to help soften the visual impact of an elevated structure on the landscape. Prior to adding retaining walls to a site, it is important to consider how they will affect the historic character and relationship of the structures to the surrounding land (NPDES, 2021a).

CISTERNS

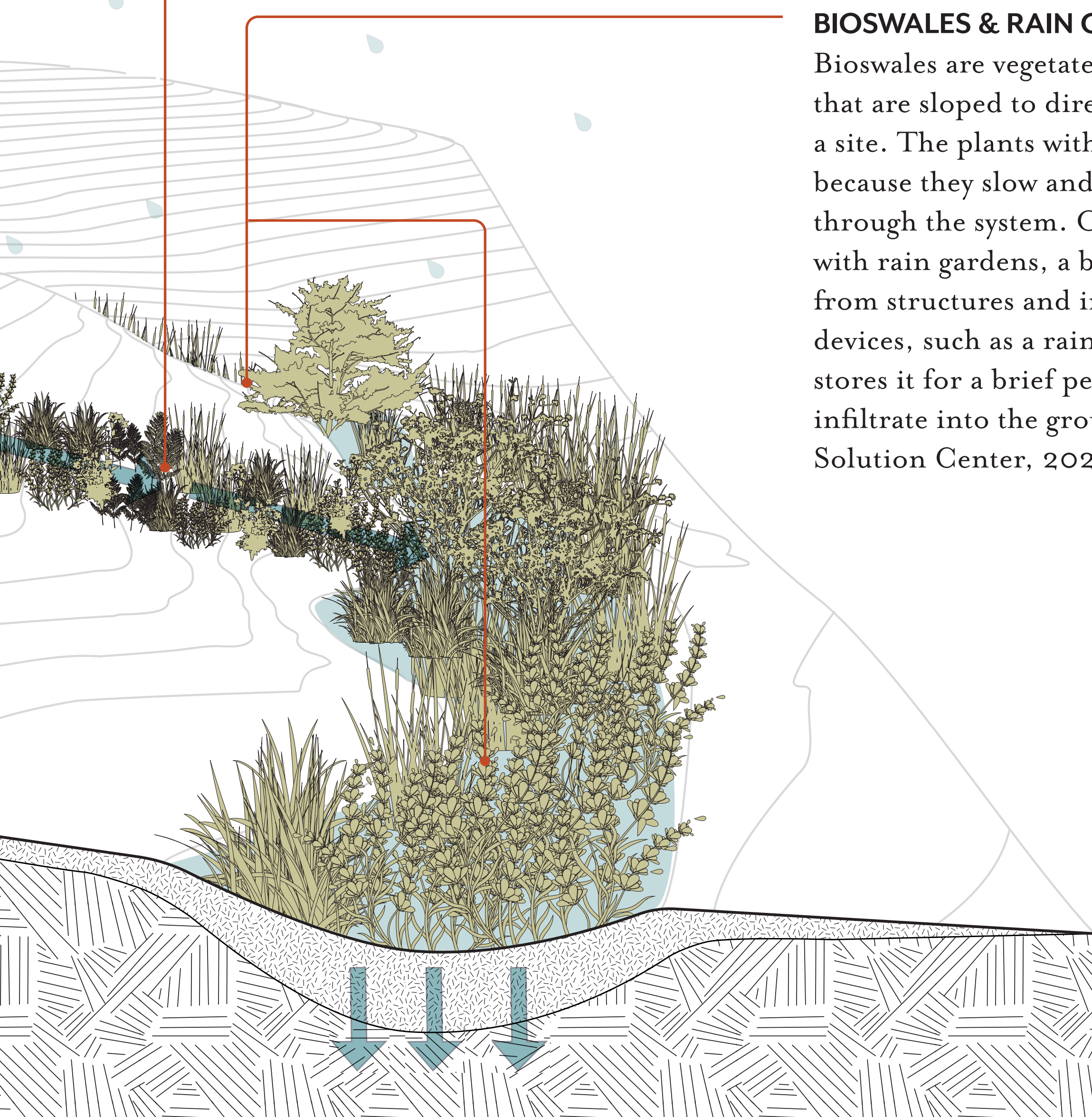
Cisterns have been used for centuries in different forms as a way to collect and hold the rainwater that falls on a house or site. A cistern can be a great way to capture and store water for later use (Young & Sharpe, 2016).

GRADING

If needed, regrading the site so that the land slopes away from buildings will help divert water from structures and move it off-site. Regrading is best when incorporated with other methods of handling stormwater on-site (Building America Solution Center, 2020).

BIOSWALES & RAIN GARDENS

Bioswales are vegetated swales in the landscape that are sloped to direct and drain water across a site. The plants within a bioswale are essential because they slow and filter the water as it moves through the system. Often used in conjunction with rain gardens, a bioswale conveys water away from structures and into downstream treatment devices, such as a rain garden. The rain garden stores it for a brief period, allowing it to slowly infiltrate into the ground (Building America Solution Center, 2020).



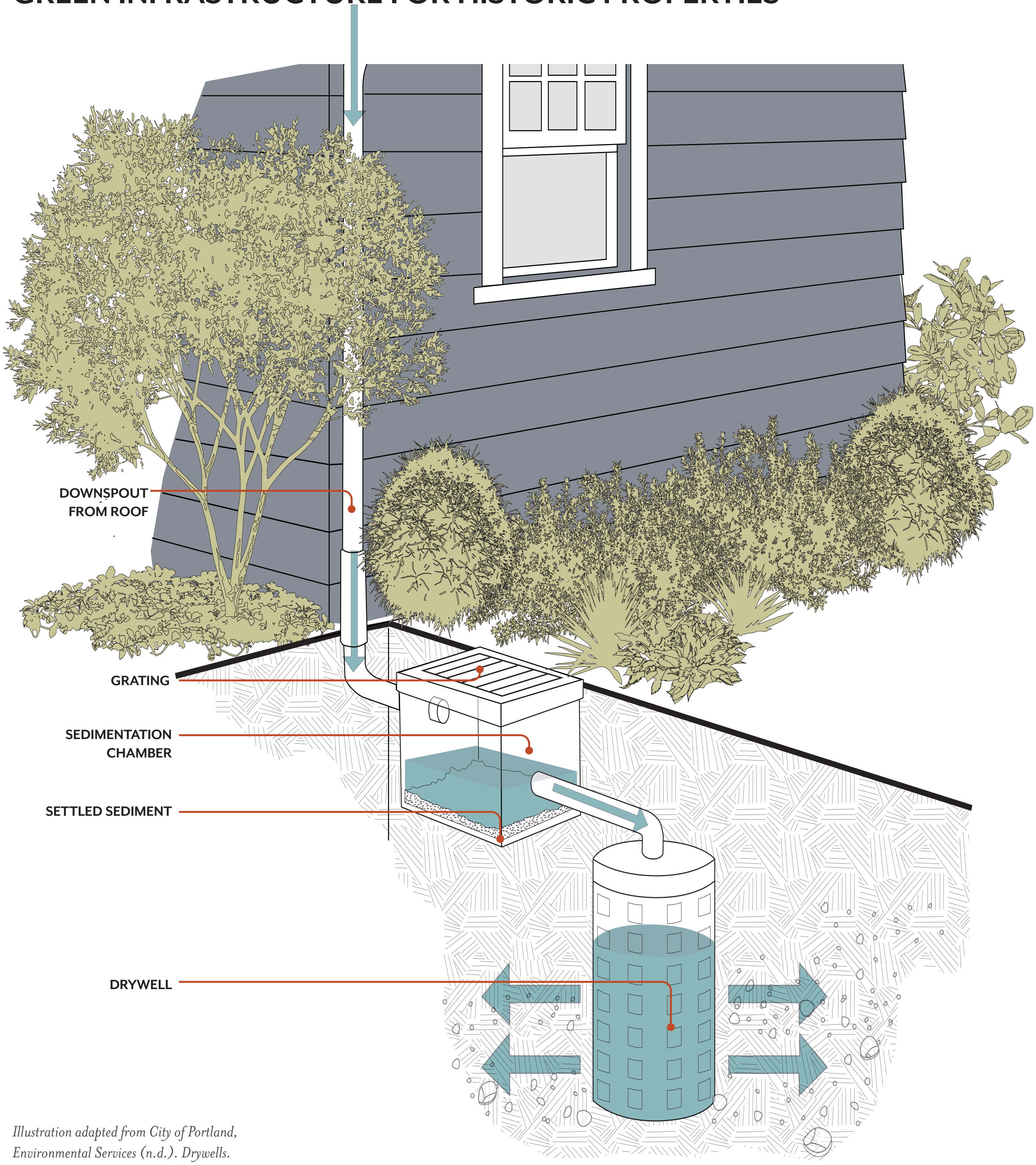


Illustration adapted from City of Portland, Environmental Services (n.d.). Drywells.

DRY WELLS

Also called stormwater drainage wells, dry wells aid in the subsurface infiltration of water. They are covered, drilled holes in the ground that are more deep than wide. As stormwater is captured and moved into the well, it is allowed to slowly infiltrate into the groundwater. This strategy is best in areas with good drainage already, and it is not suitable for clay soils (U.S. EPA, 2023a).

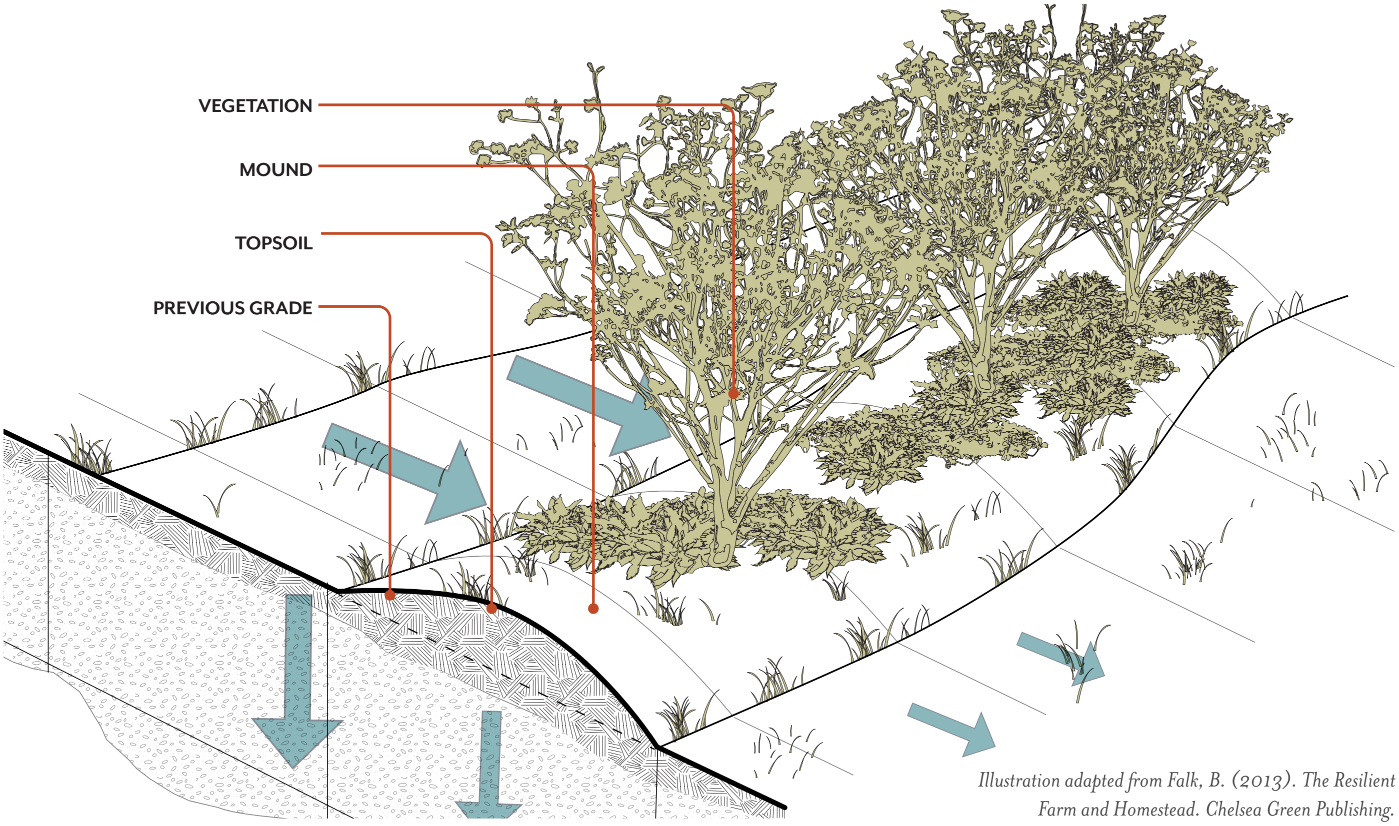


Illustration adapted from Falk, B. (2013). The Resilient Farm and Homestead. Chelsea Green Publishing.

BERMS

Berms can be shaped into myriad sizes and forms and constructed with many different materials, such as stone aggregate or soil planted with turfgrass. Berms are used to slow and filter sediments from stormwater sheet flows. They are best suited for areas with relatively shallow slopes (NPDES, 2021b).

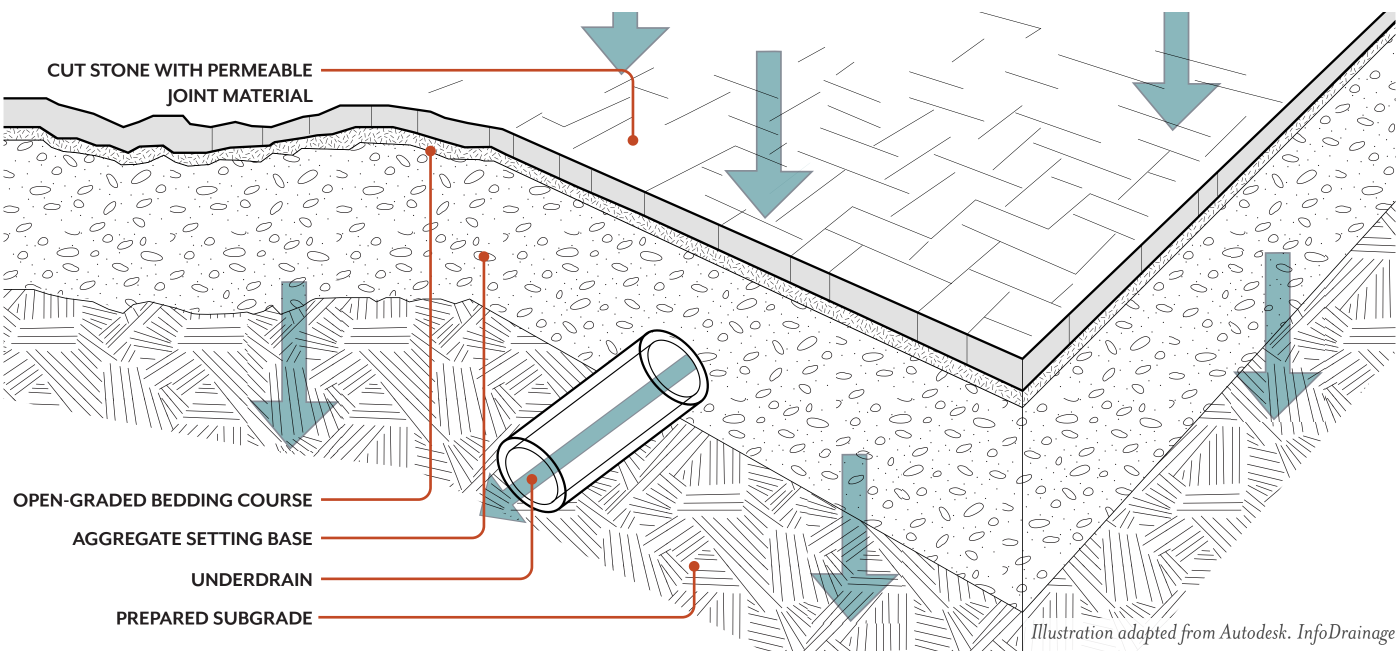


Illustration adapted from Autodesk. InfoDrainage Help Documentation on Porous Paving.

REPLACE HARDSCAPE WITH PERMEABLE PAVING

Removing hardscaped surfaces and replacing them with porous or permeable surfaces is an effective method of reducing stormwater flow across an area. These techniques reduce sheet flow and allow water to settle and infiltrate in place (U.S. EPA, 2023b).

MAINTENANCE STRATEGIES FOR THE LANDSCAPE

Regular maintenance and upkeep of the landscape is critical to the long-term resilience of any property, especially historic properties. Proactive maintenance regimens help ensure that large vegetation is healthy and unlikely to fall or drop damaging debris during wind or snow storms. This is particularly important for sites with trees located close to structures. Having regular assessments and care done by a certified arborist is an important investment that can prolong the life of heritage trees and ensure safety for buildings and their occupants (University of Florida/Institute of Food and Agricultural Sciences, 2018).

Other maintenance and preventative measures include:

- While conducting regular yard maintenance, avoid harming tree roots and trunks with lawn mowers and weed trimmers as damage wounds can make trees more prone to disease and storm damage (FEMA, 2021b).

- Keep shrubs and other foundation plantings pruned to increase air circulation around the base of buildings. This can help prevent rot from developing on siding, allow crawl spaces to dry out more quickly after a minor flood, and possibly improve access to a foundation for the installation of temporary flood-protection measures.

- If permeable pavers are used, they must be regularly vacuum-cleaned to remove sediment buildup that can clog the area and reduce the water-infiltration rate. This typically happens twice a year, but additional service may be needed following significant flooding (NPDES, 2021c).

LARGE-SCALE INFRASTRUCTURE & DISTRICT-LEVEL INTERVENTIONS

Landscape approaches that enhance resilience are often easy to implement on individual sites and can be effective at minimizing impacts from nuisance flooding. However, in areas facing more frequent or more severe flooding, site-scale stormwater management strategies can fall short. When entire neighborhoods, historic districts, or towns are at high risk, larger-scale infrastructure interventions such as levees or perimeter floodwalls may be needed to adequately mitigate risks. Larger nature-based projects like stream and wetland restoration, dune restoration, and living breakwaters are also becoming more widely implemented as a growing body of evidence indicates that these systems are cost-effective. These strategies can significantly reduce flood risk and can provide myriad other long-term public benefits and ecosystem services (U.S. EPA, 2017) (FEMA, 2021a). Because these types of projects require large investments, and often rely on cooperation between multiple local, state, and federal agencies, they typically start with a detailed study addressing the feasibility and effectiveness of multiple alternatives.

Commissioning a study focused on resilience adaptations for a historic district can present a suite of options that can be undertaken by individual property owners or executed in a coordinated effort across the entire district. An example of this type of study is the Biltmore Village Emergency Flood Response Plan (Asheville, N.C.), completed by the U.S. Army Corps of Engineers in 2009 following the devastating flooding from hurricanes Frances and Ivan in September 2004. This report provided detailed recommendations for strategies that included temporary floodproofing best practices for the entire district and permanent retrofit recommendations for certain buildings (U.S. Army Corps of Engineers: Nashville District, 2009).

NOAA researcher records elevation data from a Living Shoreline demonstration site within the North Carolina National Estuarine Research Reserve in Beaufort, N.C. Courtesy of NOAA, 2013 Annual Report.

BUILDING ELEMENTS & SYSTEMS

INTRODUCTION

Building elements encompass a wide range of architectural features like windows, doors, porches, chimneys, roofs, and foundations. In historic buildings, the materials, details, and relationships between these different elements help define their architectural character. From modest bungalows to grander Federal styles, the relationships between architectural elements such as the number of bays, window heights, the number of stories, and roof pitches that are style- and character-defining features that speak to the time and place of a building. While the brick masonry of Federal homes may have been appropriate and available for the inland settlements of Edenton and New Bern, the "story-and-a-jump" homes of Ocracoke Village tell the history of resourceful settlers who constructed buildings out of scrubby maritime vegetation and boards collected from shipwrecks. It's important to protect all of these character-defining architectural elements from flood- and wind-related damage to maintain their overall historic integrity. Many of these exterior elements also act as the first line of defense in protecting a structure from typical weather conditions including sun, wind, and rain exposure. Damaged or poorly maintained exterior building elements, such as broken windows, damaged roofs, improperly flashed chimneys, and leaky siding seams, can attract water infiltration, posing a risk to the larger historic structure.

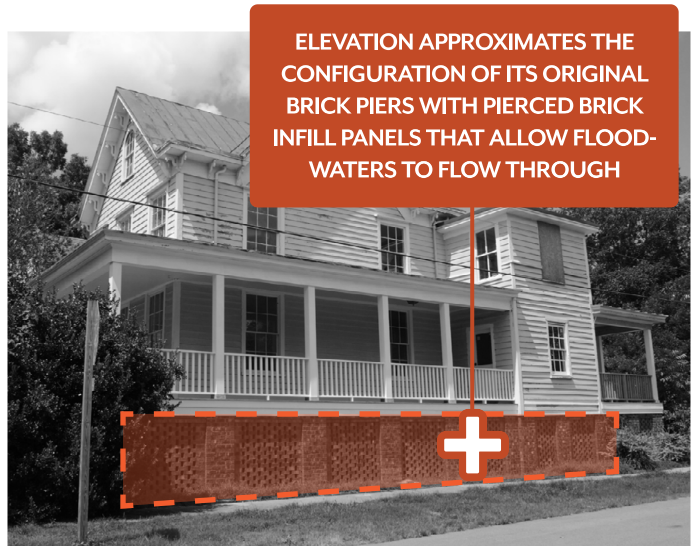
Building systems include the utility infrastructure (wiring, plumbing, ductwork, etc.), the mechanical equipment, and the fixture components that work together to create a habitable, comfortable building. Properly maintained building systems help promote climate control through temperature and humidity regulation as well as ensure proper ventilation. Resilience adaptations for building systems increase the resilience of entire buildings.

HISTORICALLY APPROPRIATE RESILIENCE ADAPTATIONS

Because of the unpredictability, growing frequency, and compounding effects of severe weather, adopting resilience measures should be considered to proactively protect building elements and systems from storm-related damage. Overall, resilience adaptations for building elements and systems fall into two categories: temporary and permanent. Temporary measures—like sandbags, plywood sheets, and flood gates—can be deployed during a storm to protect building systems and removed after the danger has passed. Permanent measures—like elevation and floodproofing—are adaptations that change the materials or structure of a historic building, protecting it long-term. Often, implementing temporary and permanent measures in tandem can be the best option for protecting building elements and systems from wind and water hazards.

With both temporary and permanent adaptations, it is critical to consider historic character and choose materials and scales that are appropriate to a structure's architectural style. The details of important buildings across the state reflect economic and political histories. The significance of proportions, materials, and architectural details to historic character requires that they be protected from damage in a climate-uncertain future and preserved when deciding on form-altering resilience adaptations.

The attachment of temporary measures like plywood sheets should not damage the frames of doors and windows. If damage does occur, it should be repaired in a historically appropriate manner. When applying permanent adaptations to a building's systems, it is key to ensure that the historic character-defining relationships between the overall building and each element—porches, balconies, chimneys, landscape, etc.—are maintained as best as possible. Maintaining the historic proportions will help minimize the overall appearance of the adaptation changes. In addition, when permanent changes must be made, it is important to reuse existing materials if possible. When new materials must be incorporated, make an effort to use materials that are as similar as possible to the existing materials to create consistency across the structure and maintain historic integrity.



The new foundation of this New Bern house raises its first-floor level 5' above grade. Courtesy of the State Historic Preservation Office, North Carolina Department of Natural and Cultural Resources.

Portsmouth Village Historic District. Courtesy of Jeff West, Superintendent of Cape Lookout National Seashore.

FLOOD HAZARD IMPACTS

In North Carolina, flooding causes some of the most severe and widespread hazard impacts, both spatially and temporally (National Weather Service, n.d.-a) (National Weather Service, n.d.-b). Across the state, flood mitigation strategies must respond to a wide range of flood types, each with unique impacts. Riverine flooding often occurs outside of the locus of a storm and may peak hours, or even days, after a storm has ended. Flash floods occur with little warning, resulting in damage to vulnerable structures. High-velocity coastal flooding frequently occurs during severe storms, but nuisance coastal flooding is also a regular result of tidal fluctuations. In Western North Carolina, fast-moving floodwaters traveling down steep slopes may have enough force to push entire homes off their foundations, carry large debris loads, and cause landslides. The impacts of flooding can worsen over time as stagnant water, and the hydrostatic pressure it exerts, builds against structures, or as mold blooms on saturated surfaces damaged by floodwaters (FEMA, 2001; FEMA, 2008a).

With a changing climate increasing the uncertainty of future conditions, it is imperative that we move toward adapting to and planning for future risks. North Carolina is likely to see changes in the frequency and intensity of storms, with more severe storms becoming more common (EPA, 2016). These more intense storms carry a greater risk for flooding and, therefore, a greater risk of damage resulting from floodwater (EPA, 2016).

FLOODING & HISTORIC STRUCTURES

As flood waters receded post—Hurricane Dorian, pressure from the flood water trapped inside the Methodist Church on Portsmouth Island buckled sections of the flooring as the water sought to escape. After the interior was cleaned and dried out, the floors were repaired and trap doors were installed in the floor to provide a path for future flood waters to drain out. Courtesy of Jeff West, Cape Lookout National Seashore.

Historic properties face unique challenges in an unknown climate future. Once-resilient structures, built in vernacular traditions that responded to the weather events and climate of their time, are now facing intensifying storms, sea level rise, and increased development in adjacent areas (Eggleston, et al., 2021, 2-5). These modern realities have left historic properties more vulnerable than ever to worsening flooding impacts. New adaptations are required to ensure that valued historic properties remain resilient now and in the future.

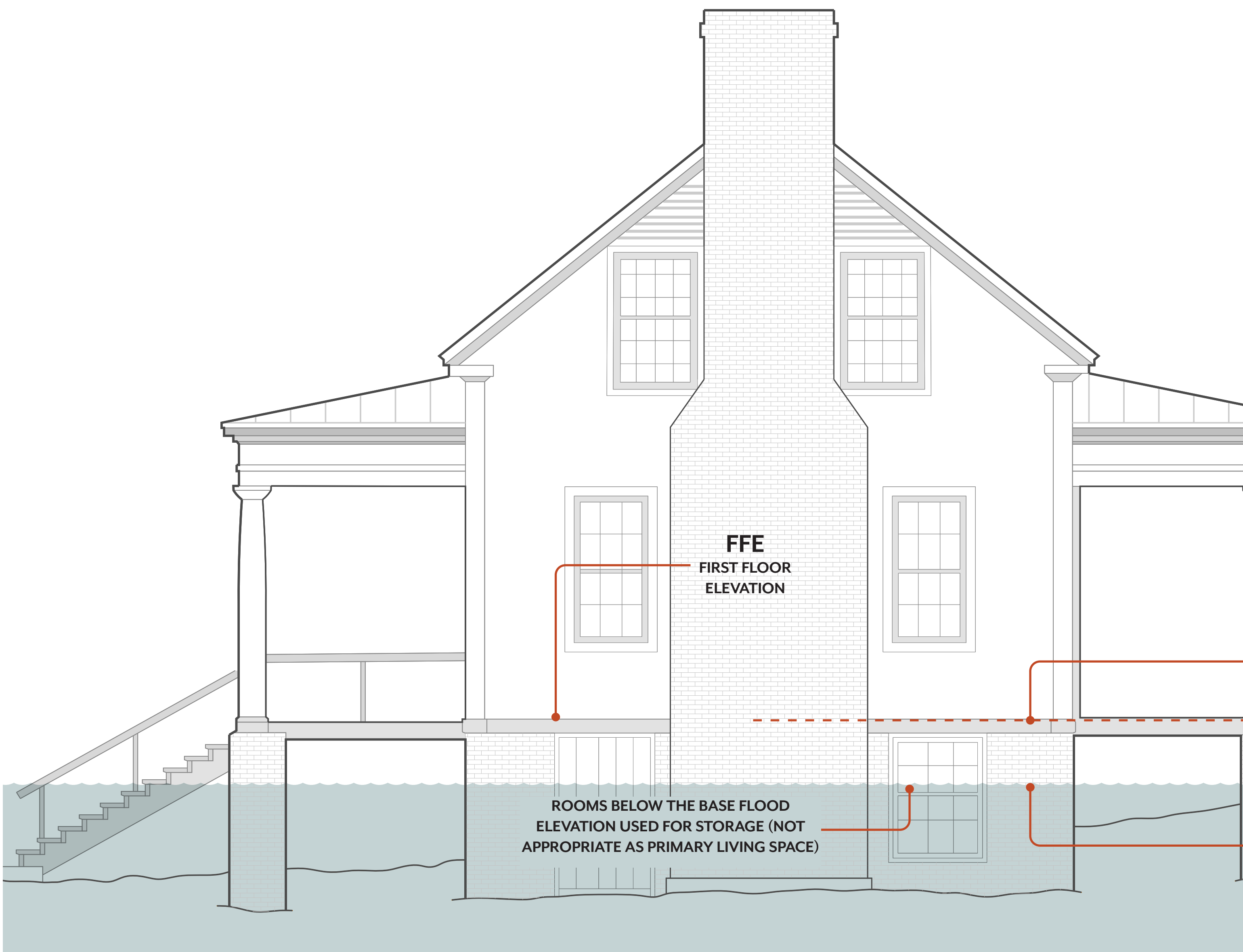
In their *Guidelines on Flood Adaptation for Rehabilitating Historic Buildings*, the Department of the Interior and the National Park Service define resilience as "the capacity of a historic property to withstand and recover from a flooding event" (Eggleston et al., 2021, 2). The resilience adaptations discussed in this chapter are those that increase the ability of historic structures, as a whole, to withstand damage and recover from flooding events. These include floodproofing, which prepares and protects lower levels of historic structures that come in contact with floodwaters, and elevation, which raises a historic structure out of its established flood risk level. These risk levels have been defined by FEMA and are discussed in the subsequent section.

In the event that historic structures do flood, it is critical to facilitate drying in a manner that preserves the original materials in place when possible. Because traditional building materials such as brick, tight-grained wood, and lime-based plaster are inherently resilient, they should be allowed to slowly dry out in place, which will require extended drying-out periods. While increased ventilation and the use of fans can significantly accelerate the process, the use of heat to rapidly dry out a space can damage historic materials and finishes. Materials contaminated by floodwaters and associated contaminants should be carefully cleaned of residue and sanitized to destroy any pathogens prior to beginning any repair work. More information about reducing damages and cleaning up after a flood can be found on pages 23–24.

GUIDING REGULATIONS & REQUIREMENTS FOR ELEVATIONS

The adaptation of residential structures in Special Flood Hazard Areas (SFHAs) to prevent flooding is largely guided by local floodplain, zoning, and building codes, as well as local regulations and ordinances. These guiding rules dictate the activities allowed in and construction standards for a floodplain, which are applicable to both new builds and repairs of existing structures. Local rules are derived from guidance administered by FEMA, through the National Flood Insurance Program (NFIP), and the U.S. Army Corps of Engineers (USACE); however, local regulations may be more stringent than the federal guidelines, which represent the minimum NFIP requirements governing construction in a SFHA. Property owners should seek out local floodplain managers or building code officials to find the specific requirements in place in their area (Conrad et al., 2012).

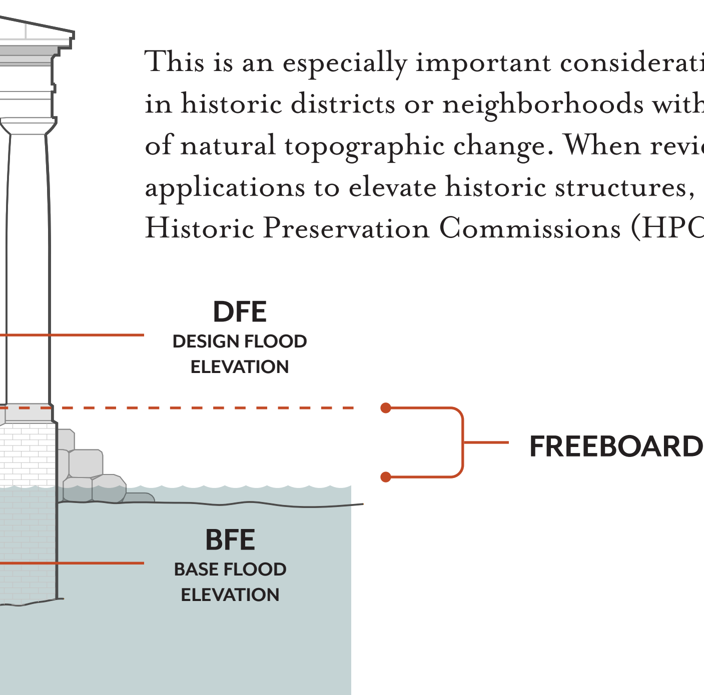
One important local regulation is the design flood elevation (DFE). The DFE is the elevation to which the lowest floor of a structure should be raised to avoid damage from a base flood (described in the previous section). The DFE is calculated as the base flood elevation (BFE;



elevation to which floodwaters rise during a 100-year flood) plus any freeboard height designated by the local community. The flood protection elevation (FPE) or flood protection level (FPL) is either the DFE or the BFE plus 1 foot, whichever is higher (Conrad et al., 2012). Importantly, properties built before the National Flood Insurance Program was established may qualify for variances, adjusting the elevation to which they must be raised (FEMA, 2008b; FEMA, 2014). Property owners should consult with local or state preservation specialists, in addition to local floodplain managers or building code officials, to determine if these variances are applicable. A property owner should obtain an Elevation Certificates if they are considering elevating a building.

When elevating a home, it's important to note that local topography and proximity to water bodies can have a significant impact on the total height to which a building must be raised, even when the BFE remains consistent. For example, a building in a low-lying area near the source of flooding may need to be elevated several feet to comply with the local DFE requirements, while a building located uphill may only need to be elevated a few inches to comply with the requirements.

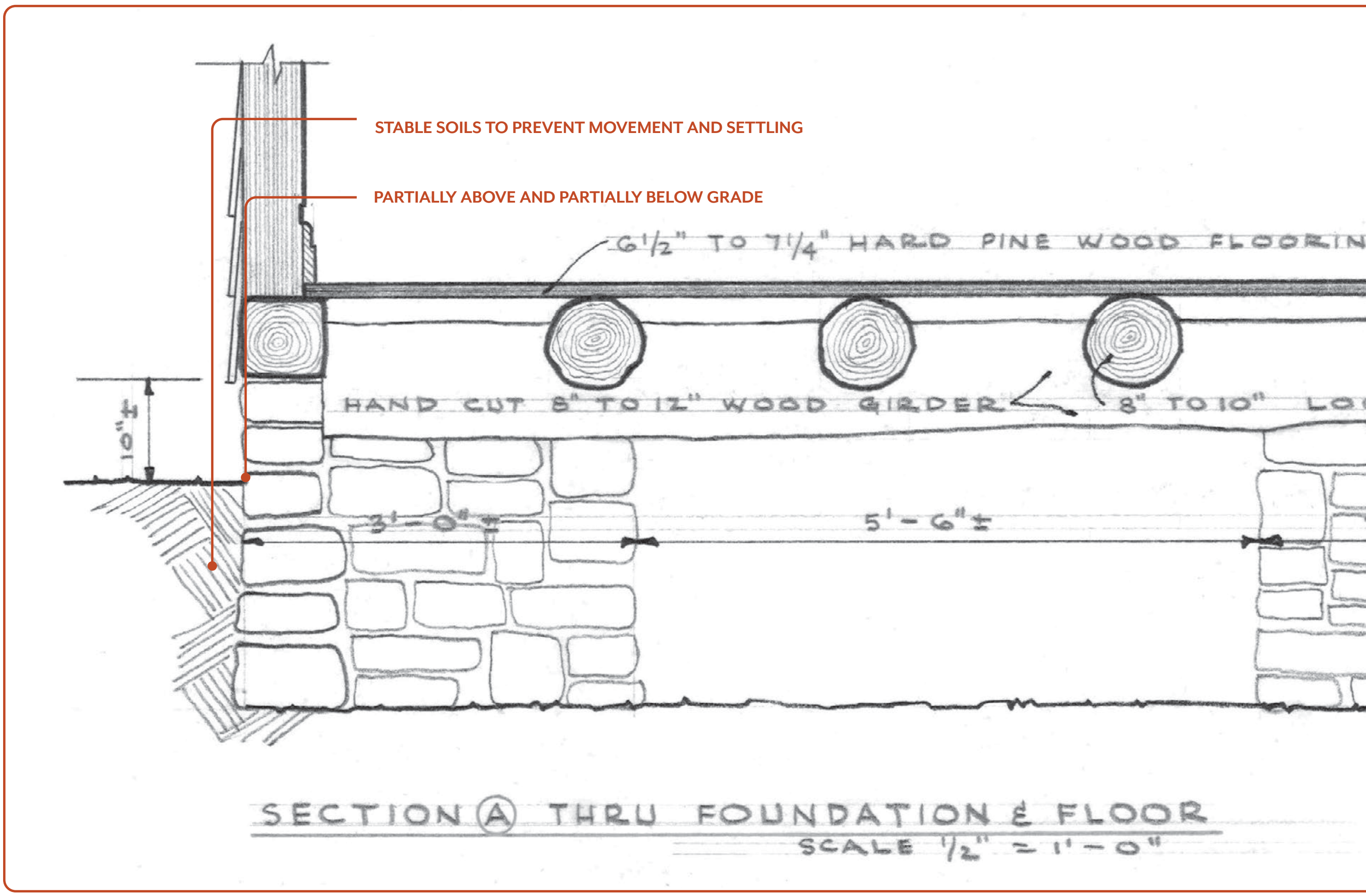
This is an especially important consideration in historic districts or neighborhoods with a lot of natural topographic change. When reviewing applications to elevate historic structures, local Historic Preservation Commissions (HPCs) may encounter elevation projects with substantial differences in the total elevation proposed, and an understanding of how local topography influences local elevation regulations may help reduce friction during the review process.
Elevation and floodproofing measures are often reactively implemented in response to flood damage during the flood recovery process, although in some cases they are proactively pursued. These strategies are typically reactive for a number of reasons including cost, disruption to occupants during construction or renovation, and overall project complexity. Although not ideal, the post-flood recovery period is frequently seen as a convenient time for historic property owners to consider elevation or floodproofing measures due to the availability of funding through FEMA recovery grants. Since significant repairs may already be needed, elevations or floodproofing retrofits are less likely to impact a building's occupants when scheduled after a disrupting event. Although the availability of external funds can help initiate an elevation or floodproofing project, the extended timeline that often accompanies federal recovery grants can have negative impacts on historic properties. Without immediate action, flood-damaged historic properties may continue to deteriorate if cleanup and repair efforts are postponed until grants are in-hand, resulting in more complex and expensive repairs than originally anticipated. Some of the best outcomes related to the integrity of historic properties can be realized from self-funded post-flood recovery projects or proactive resilience adaptations.

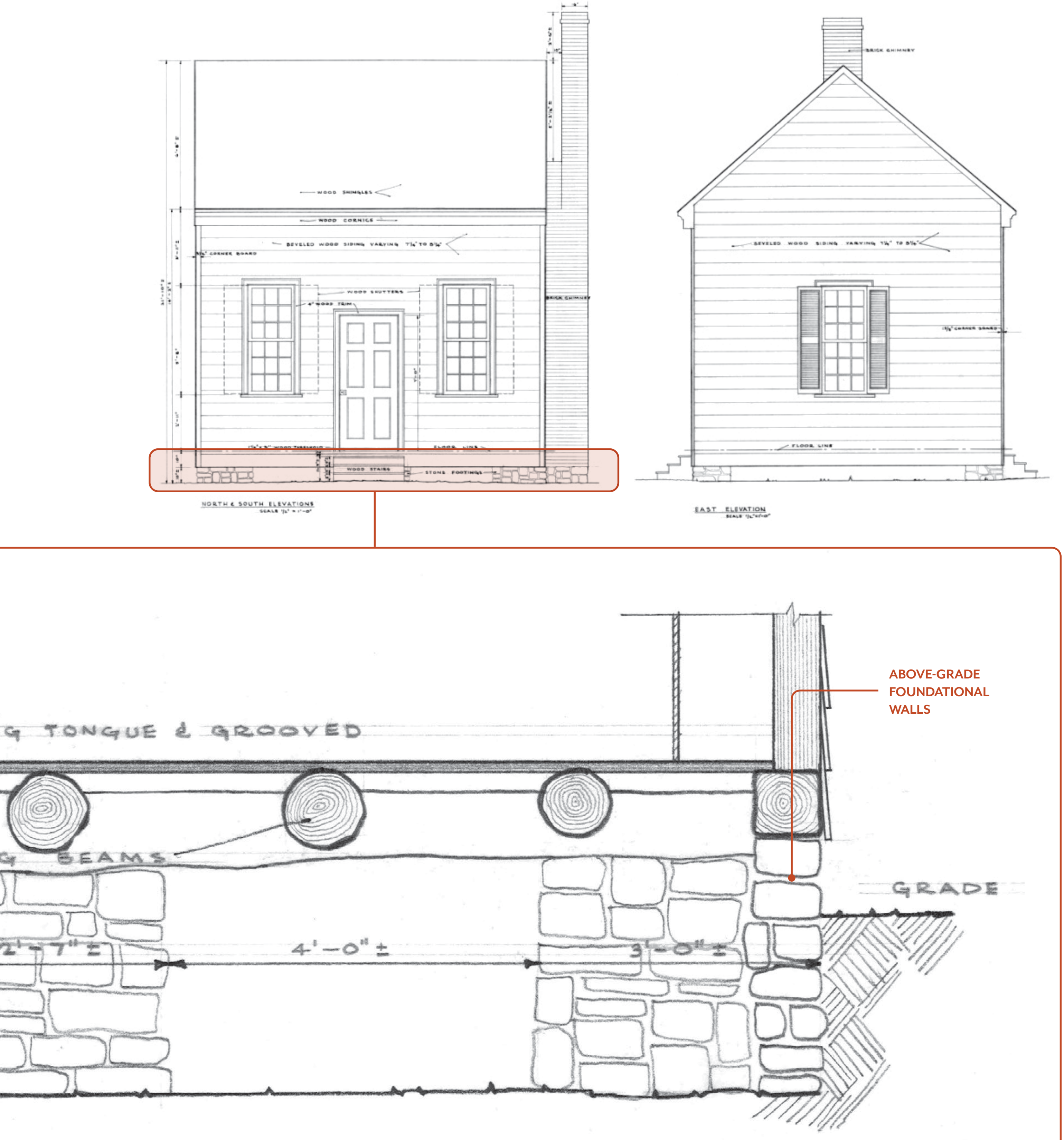


FOUNDATIONS

Foundations ground historic structures to their site and serve as their structural base by distributing the weight of the structure into the ground. Ideally, foundations and footings reach down to stable soils to prevent movement and settling that could result in cracks, wall settling, or structural failure in extreme cases. Foundations also resist horizontal forces caused by hydrostatic water pressure and lateral wind loads. Most foundations are partially above and partially below grade. Above-grade foundational walls and piers are important character-defining elements of a historic property due to their materials, height, mass, and form. Visible exterior foundation walls are typically defined by the proportion and scale of bays and/or the location of openings used for vents, windows, or doors. Open pier foundations are typically defined by the height, width, and pattern of pier locations. As the visible and formal connection to a site, other important contextual variables include its topography, slope, landscaping, orientation, and relationship to adjacent properties.

Foundations are essential to a building's structural integrity and to a historic property's resilience. Below, different adaptation strategies for floodproofing and elevating structures are discussed as a means to increase the resiliency of foundations and to raise the lowest levels of historic structures to resist floodwaters. In the *Standards*, standard H, "Adapting Historic Foundations for Resilience," explains the guidelines to follow when making resiliency choices for historic foundations.





Cameron-Nash Law Office (Hillsborough, Orange County, North Carolina). Clockwise from top left: north and south elevations, east elevation, and foundation section. The building was constructed in the early nineteenth century, either for Cameron or Nash. The office is listed on the National Register of Historic Places. Image Credit: Cameron-Nash Law Office (Hillsborough, N.C.), Historic Architecture Research, UA110.041, Special Collections Research Center, NC State University Libraries, Raleigh, NC.

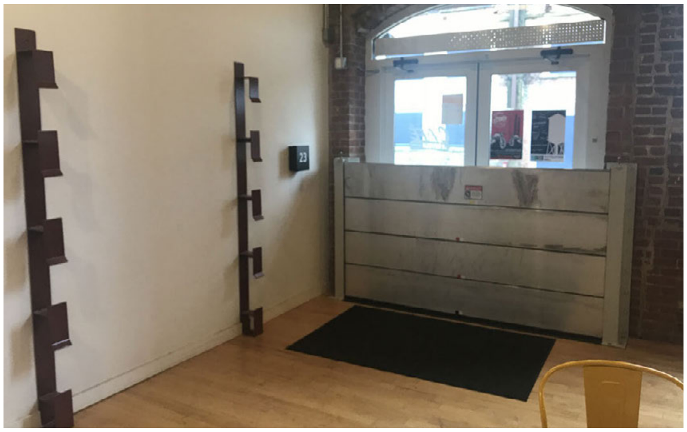
FLOODPROOFING

Floodproofing is a resilience strategy that does not radically alter the existing form of a structure while still improving its resistance to flood impacts like contamination from water seepage and buckling from hydrostatic forces. The two methods of floodproofing—wet and dry—are described in greater detail below:

DRY FLOODPROOFING

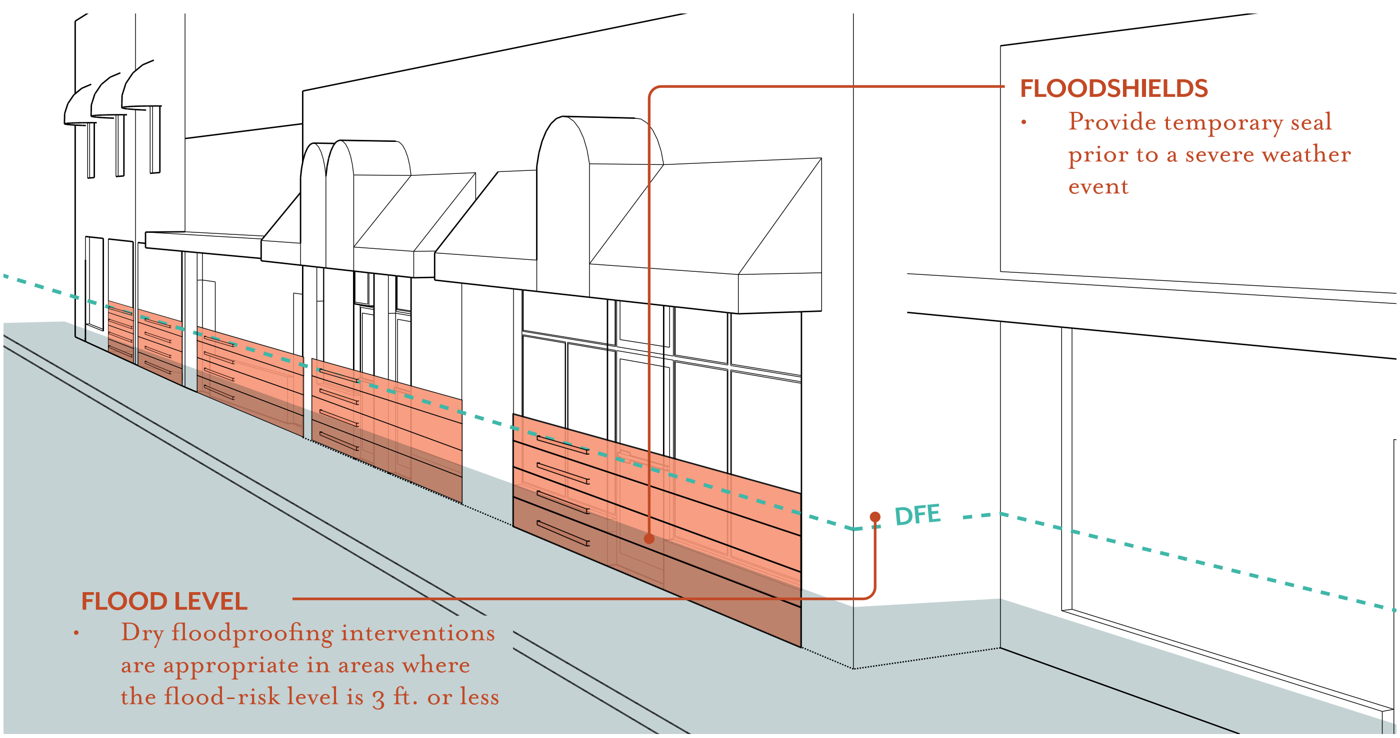
Dry floodproofing is an adaptation meant to keep water out of all or part of a structure during flooding.

- ***Effective*** in areas where flooding is infrequent, low velocity, short in duration, and the established flood risk level is 3 feet or less. If the flood level is greater and the design loads for hydrostatic forces are exceeded, then the foundation's walls might collapse, floors may buckle, and the structure may even float, potentially resulting in more damage than if the building were allowed to flood.
- ***Appropriate*** only for structures with load-bearing masonry walls or foundations that can withstand hydrostatic pressure, buoyant forces, and debris carried by floodwaters.
- ***Requires*** consultation with a structural engineer to determine if reinforcement or anchoring is necessary.
- ***Requires*** door, window, and vent openings that are partially or entirely below the flood-risk level to be permanently sealed or adapted so that they can be temporarily sealed prior to a severe weather event with floodshields.
- ***Concerns*** include the potential damage that waterproof coatings can cause to existing historic foundations.
- ***Concerns*** include trapping moisture against foundations with the installation of waterproof membranes and the phenomenon of rising damp—where capillary action moves groundwater high up into exterior walls.
- ***Concerns*** include unintended moisture seepage, therefore all utilities, mechanical units, and ductwork should be installed above the established flood-risk level.
- ***Best practice*** is to install a sump pump and/or drain to manage water infiltration and to use backflow prevention devices to manage reverse flow drainage in plumbing lines.
- ***Best practice*** is to combine it with an infiltration drainage system around the perimeter of the building to take water away from the foundation.
- Generally, it is ***not an appropriate adaptation*** for residential or wood-frame historic buildings, for substantially damaged structures, or for structures in the floodplain. Consult with local regulations to see if dry floodproofing is allowable.



Flood logs at Revolution Mill in Greensboro, N.C., were deployed during Hurricane Florence. They held up to the rising water, which rose to 3 ft. on one side of the building. Once the danger passed, Revolution Mill stored the flood logs on custom racks, ready for quick deployment in the next storm. Courtesy of Eddie Belk, Belk Architecture.

Above, grates were installed at Revolution Mill in Greensboro, N.C., to prevent flood debris from breaking windows during a flood event. Courtesy of Ramsay Leimenstoll, Architect.



FLOODPROOFING, *continued.*

WET FLOODPROOFING

Wet floodproofing is an adaptation that allows floodwaters to move through a structure and drain as the water recedes.

- ***Effective*** where flood events are infrequent, flooding lasts less than 24 hours, and the area to be flooded is unfinished and/or constructed of flood-resistant materials.
- ***Appropriate*** only where the installation of water-resistant materials will not damage the existing historic fabric.
- ***Appropriate*** only for non-primary living spaces (crawl space, basement, storage, garage, etc.).
- ***Requires*** consultation with a structural engineer to determine if reinforcement or anchoring is necessary.
- ***Requires*** flood vents or openings that allow water to enter, move through, and exit spaces below the established flood-risk level. Additionally, there ***must*** be openings for the free flow of water between any connecting enclosed spaces below the established flood-risk level to minimize hydrostatic pressure.
- ***Requires*** all utilities, mechanical units, and ductwork to be installed above the established flood risk level.
- ***Best practices*** include installing a sump pump and/or drain to manage water removal and the use of backflow prevention devices to manage reverse flow drainage in plumbing lines.
- ***Requires*** all materials below established flood-risk level to be water resistant (avoid drywall, blown-in or fiberglass insulation, carpeting, non-pressure-treated wood, etc.).
- ***Best practices*** are to combine with a perimeter drain system to take water away from the building.
- ***Generally,*** it's not recommended for wood-frame or veneer structures where floodwaters reach above the masonry foundation or where floodwaters would damage intact interior historic finishes and materials.

CONTROLLING HYDROSTATIC PRESSURE

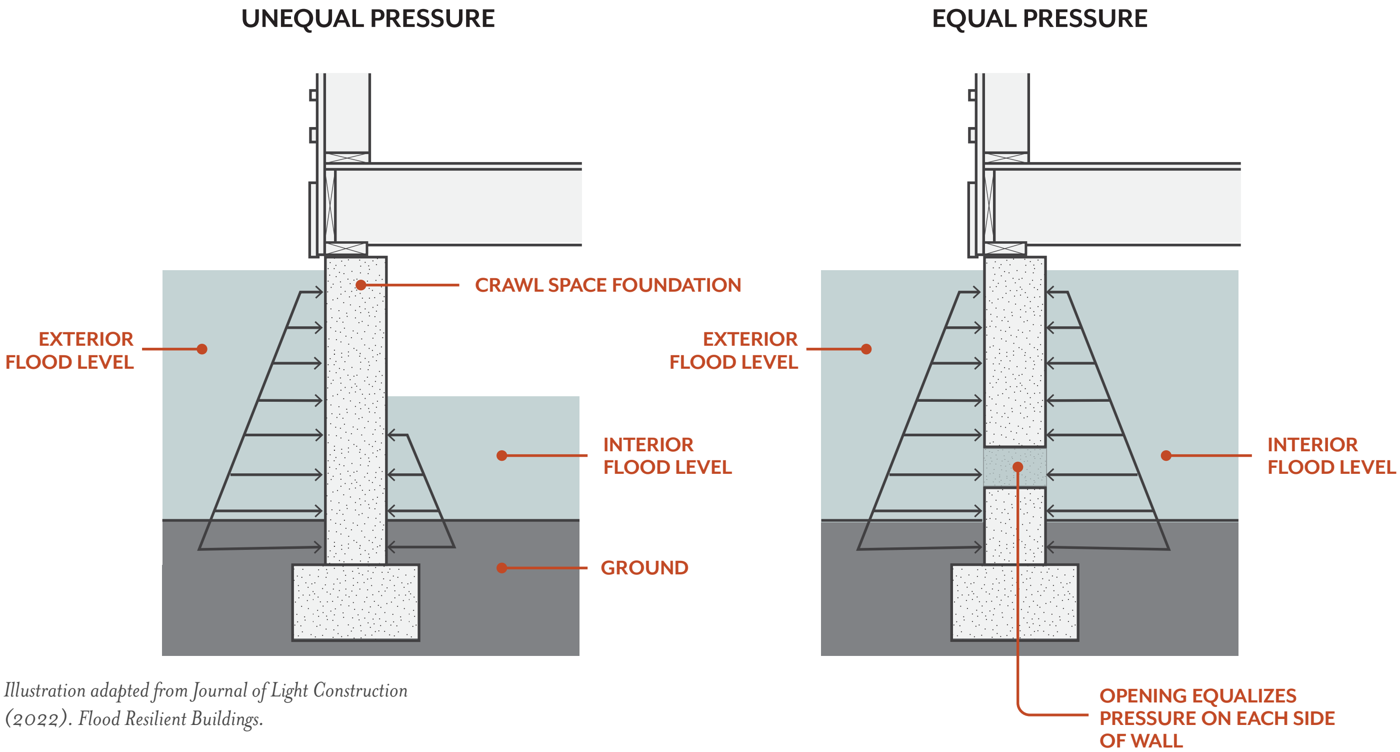


Illustration adapted from Journal of Light Construction (2022). Flood Resilient Buildings.

WET FLOODPROOFING APPLICATION

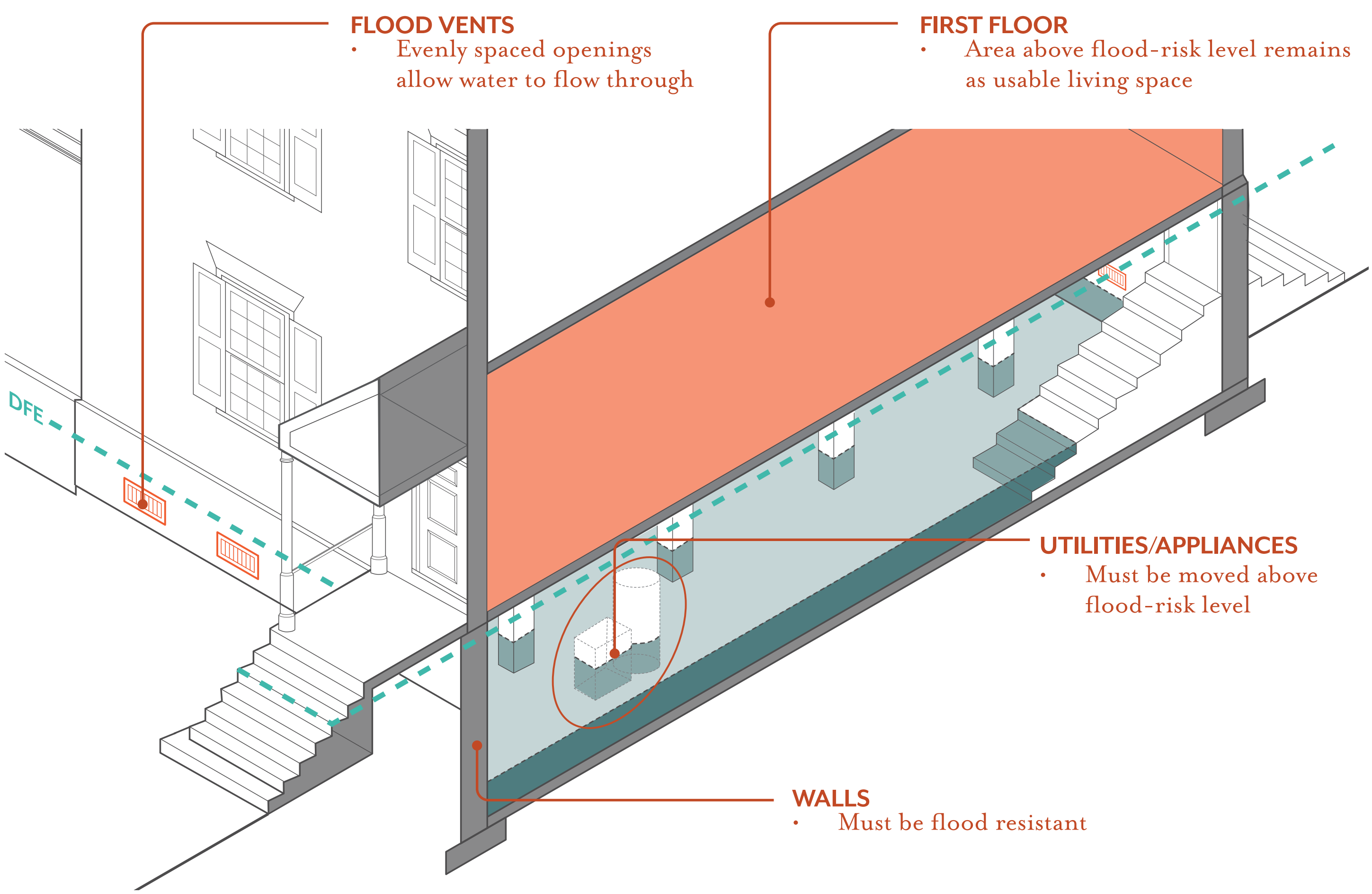


Illustration adapted from Boston Planning & Development Agency et al. (2019). Coastal Flood Resilience Design Guidelines (p. 45).

ELEVATION

Elevating buildings above the established flood-risk level is one of the most effective resiliency strategies, but it can come with impacts to historic character and higher costs compared to other strategies. There is no universal approach to elevations due to locally defined regulations and design constraints unique to each structure. Historic designations require that impacts on adjoining properties and streetscape characteristics are also considered. Elevating historic buildings requires consultation with design and building professionals as well as preservation specialists to ensure that the integrity of a historic structure is not compromised. Due to these challenges, FEMA offers a variance for buildings listed on the National Register of Historic Places to minimize a change in elevation to only the height required to avoid flood hazards. If elevating a historic structure is being considered, remember:

- Elevation is especially difficult for large load-bearing masonry buildings, buildings with shared party walls, and buildings with slab-on-grade foundations.
- Elevation works best for wood-frame buildings with crawl spaces and pier or post foundations.
- Elevation of porches, chimneys, additions, and exterior stairs to align with the updated finished floor level must also be addressed.

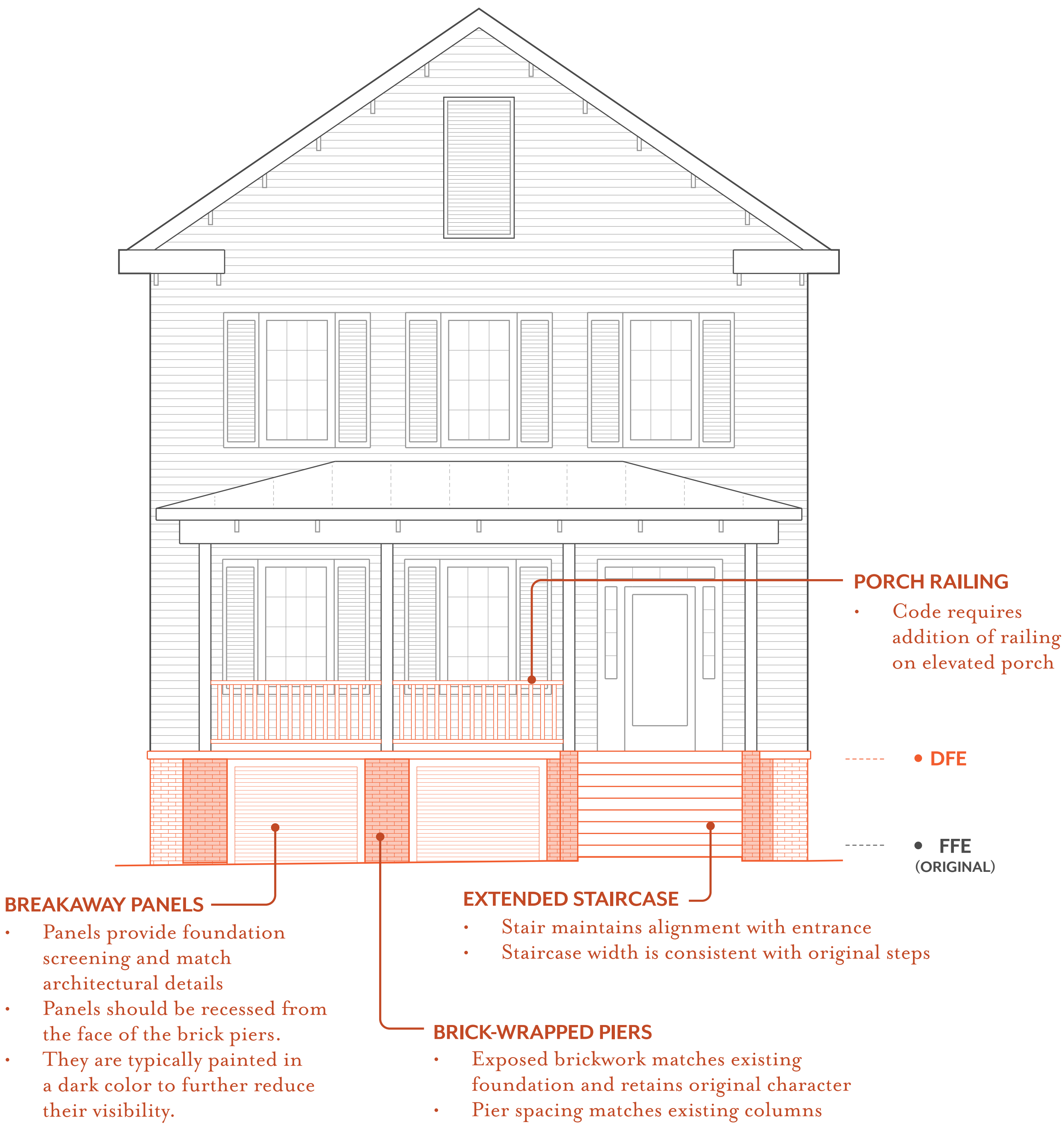
Building elevations can be accomplished with a variety of techniques and foundation improvements, and factors like site topography, anticipated flood height, total elevation increase, and historic compatibility influence the appropriateness of various methods. Common elevation methods include elevating on piers, constructing new foundation walls, elevating with fill, and nonstructural elevations.

A new brick foundation with pierced brick panels was constructed to elevate this New Bern house and its front porch approximately 5 ft. above grade. Courtesy of the State Historic Preservation Office, North Carolina Department of Natural and Cultural Resources.

The extended porch steps in the small front yard now end just short of the sidewalk. Courtesy of the State Historic Preservation Office, North Carolina Department of Natural and Cultural Resources.

ELEVATING ON PIERS

After a house has been elevated, piers or piles are installed to support the structure. The foundation typically remains open to allow floodwater to freely flow beneath the structure, but screening elements like decorative lattice or stylistically appropriate breakaway panels (which are nonsupporting enclosures intended to collapse under lateral loads without causing collapse, displacement, or structural damage to the elevated building or foundation) can be installed when necessary to minimize the visual impacts of the elevation without restricting water movement. When appropriate, open foundations on piers may allow for increased elevation height and can withstand higher-velocity flood conditions such as those in coastal areas.



ELEVATING ON NEW FOUNDATION WALLS

After a house has been elevated, the existing foundation is either extended or a new foundation is built in its place. These foundations are fully enclosed with a material matching the original foundation, and the enclosed space functions as a crawl space. Perimeter foundation walls are susceptible to damage from hydrostatic forces during flood events, so vents that allow floodwaters to freely move in and out through the foundation are required. These should match existing flood vents, or if they weren't present prior to elevation, style cues can be taken from similar structures of the same time period.

PORCH RAILING

- Code requires addition of railing on elevated porch

EXTENDED STAIRCASE

- Stair maintains alignment with entrance
- Staircase width is consistent with original steps

BRICK-VENEER FOUNDATION

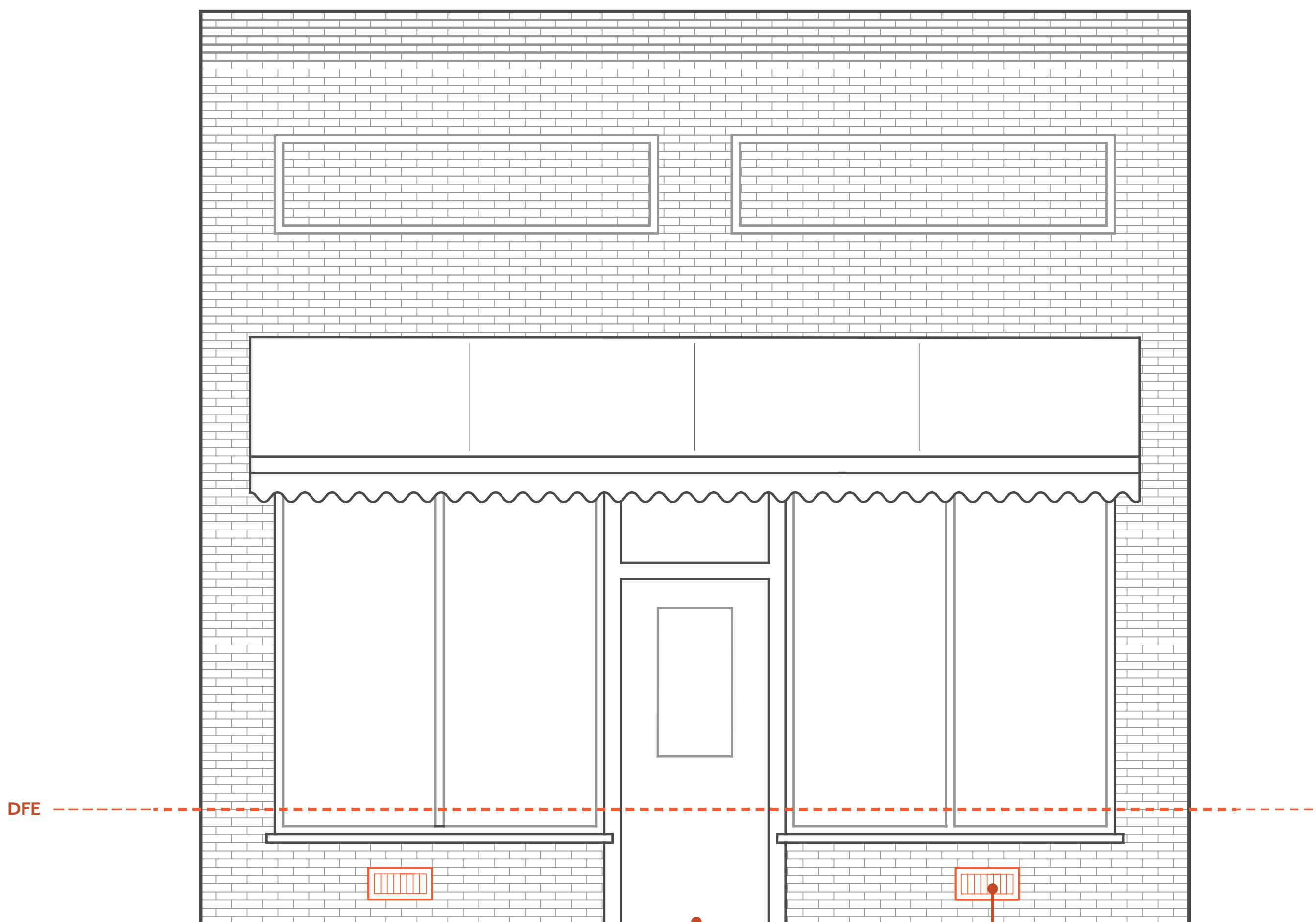
- Brick veneer on concrete block foundation maintains compatibility with other historic building materials

FLOOD VENTS

- Evenly spaced openings allow water to flow through
- Increases ventilation and speeds drying time after flood

NONSTRUCTURAL ELEVATION

With this type of elevation, no alterations are made to the foundation or structural elements of the building. Instead, the desired elevation is achieved on the inside of the building. In some cases, this means “abandoning” the lowest floor of a building, converting it to uses compatible with wet floodproofing techniques (like storage), and relocating all livable areas to upper floors. For single-story buildings with high ceilings, this involves constructing a new first floor elevated to the DFE directly above the original first floor. To access the elevated building interior, people walk through the original entryway at street level into a wet-floodproofed vestibule, then ascend a small set of stairs or a ramp to access the area elevated above flood levels.

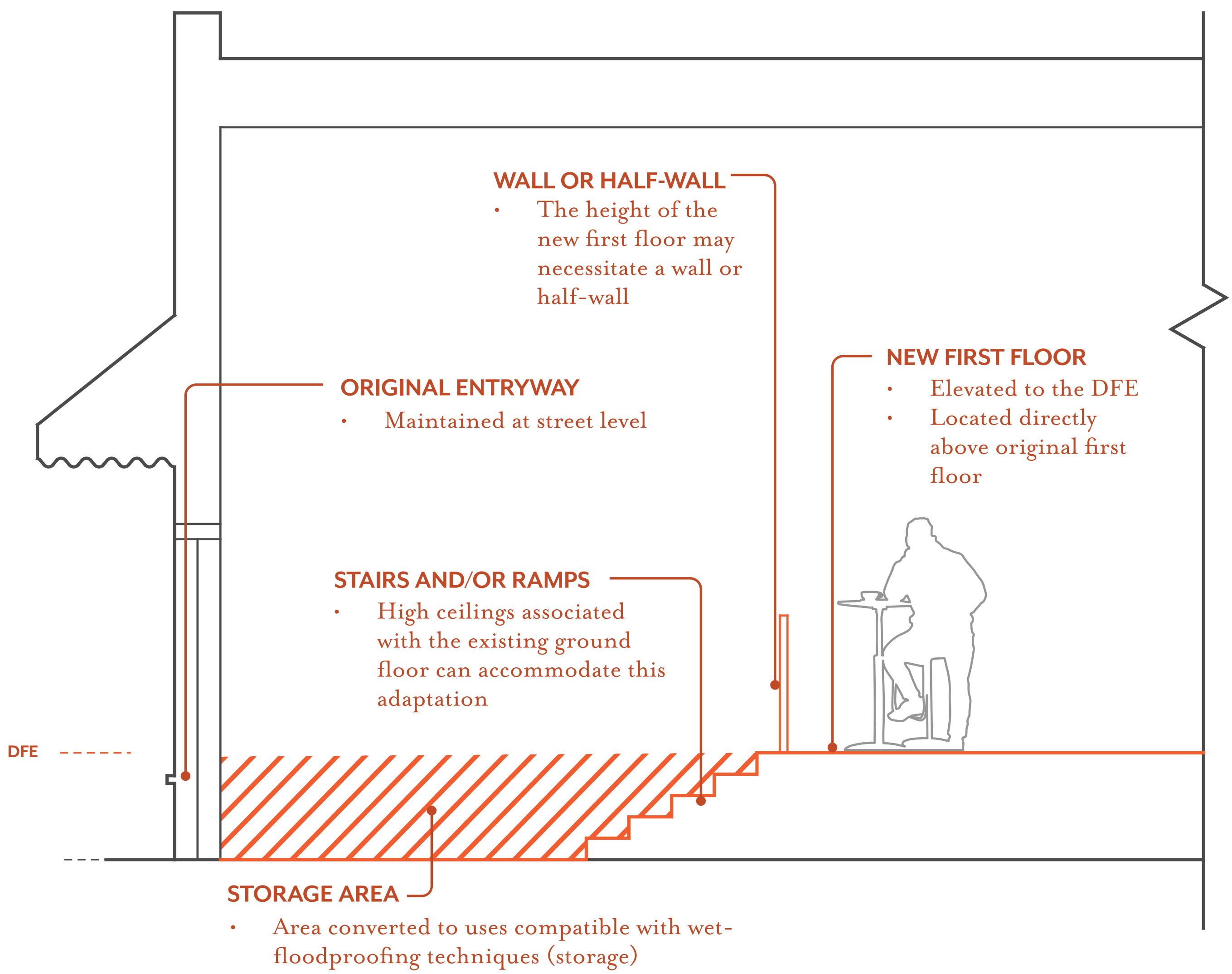


AT-GRADE CONNECTION REMAINS

- This strategy allows for an at-grade connection between the sidewalk and the building, preserving the building’s exterior character
- Strategies associated with nonstructural elevation should match the character of the existing facades

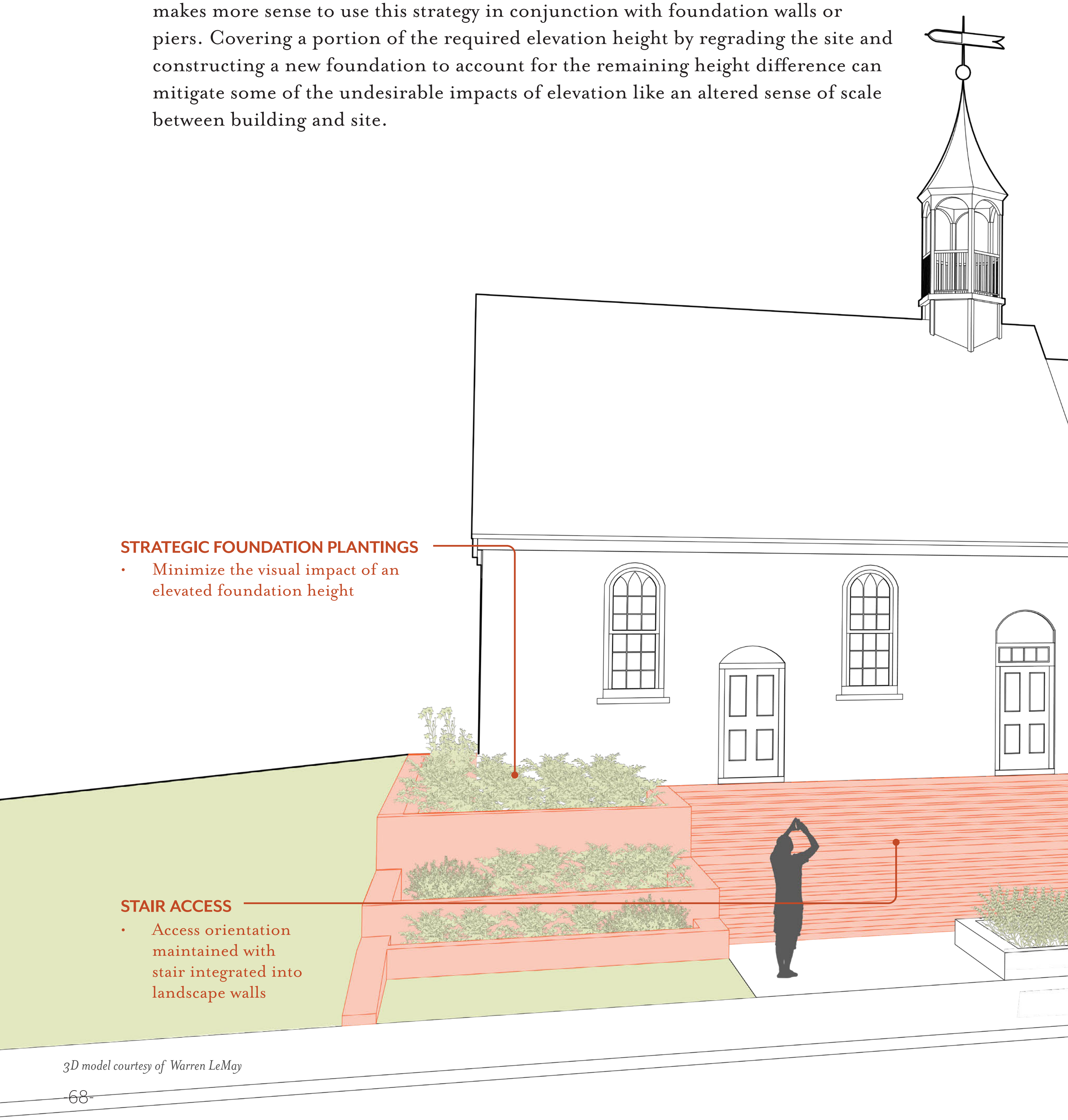
FLOOD VENTS

- Evenly spaced openings allow water to flow through
- Increases ventilation and speeds drying time after flood


WALL OR HALF-WALL
• The height of the new first floor may necessitate a wall or half-wall
ORIGINAL ENTRYWAY
• Maintained at street level
NEW FIRST FLOOR
• Elevated to the DFE
• Located directly above original first floor
STAIRS AND/OR RAMPS
• High ceilings associated with the existing ground floor can accommodate this adaptation
DFE
STORAGE AREA
• Area converted to uses compatible with wet-floodproofing techniques (storage)

ELEVATING WITH FILL

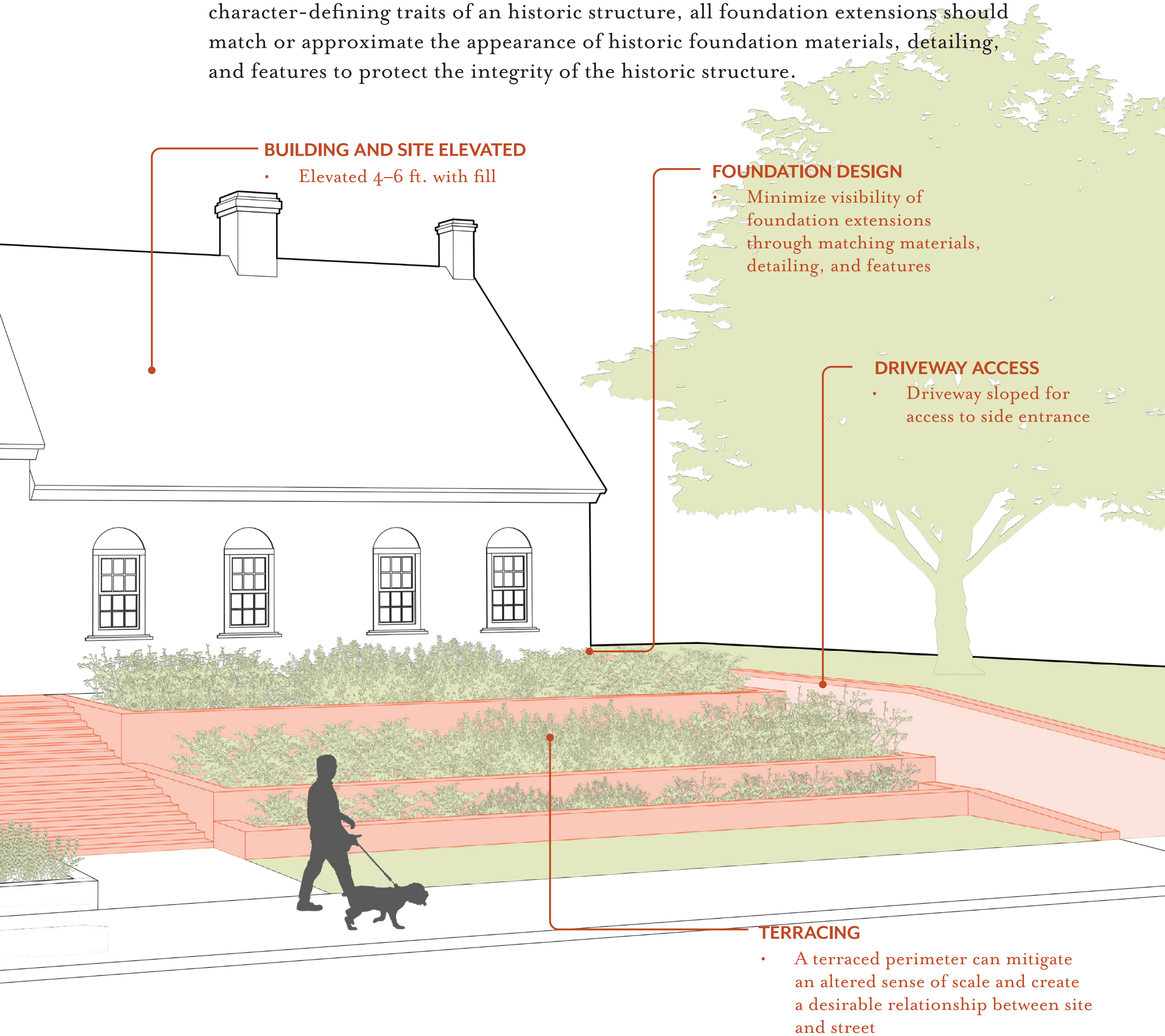
After a house has been elevated, the site beneath the structure and the area surrounding it are regraded by adding fill to raise the elevation of the land—essentially building a small hill underneath the newly elevated structure. For some properties, elevating with fill can be the sole elevation method, but for others it makes more sense to use this strategy in conjunction with foundation walls or piers. Covering a portion of the required elevation height by regrading the site and constructing a new foundation to account for the remaining height difference can mitigate some of the undesirable impacts of elevation like an altered sense of scale between building and site.



3D model courtesy of Warren LeMay

MAINTAINING HISTORIC CHARACTER

Overall, it is crucial to maintain the character-defining form, features, and proportions when elevating a historic structure. This may be achieved through site elements and/or foundation design. Site modifications that can minimize the visual impact of an elevated foundation height include strategic foundation plantings, screening with fencing or low retaining walls, adding fill beneath and around a structure to create a slope, terracing, or berms. Foundation design can also minimize the visibility of foundation extensions. For example, the use of salvaged brick or stone as well as overlapping the last courses of the foundation with exterior siding and trim or skirtboards can conceal the changes. To minimize the impacts on character-defining traits of an historic structure, all foundation extensions should match or approximate the appearance of historic foundation materials, detailing, and features to protect the integrity of the historic structure.

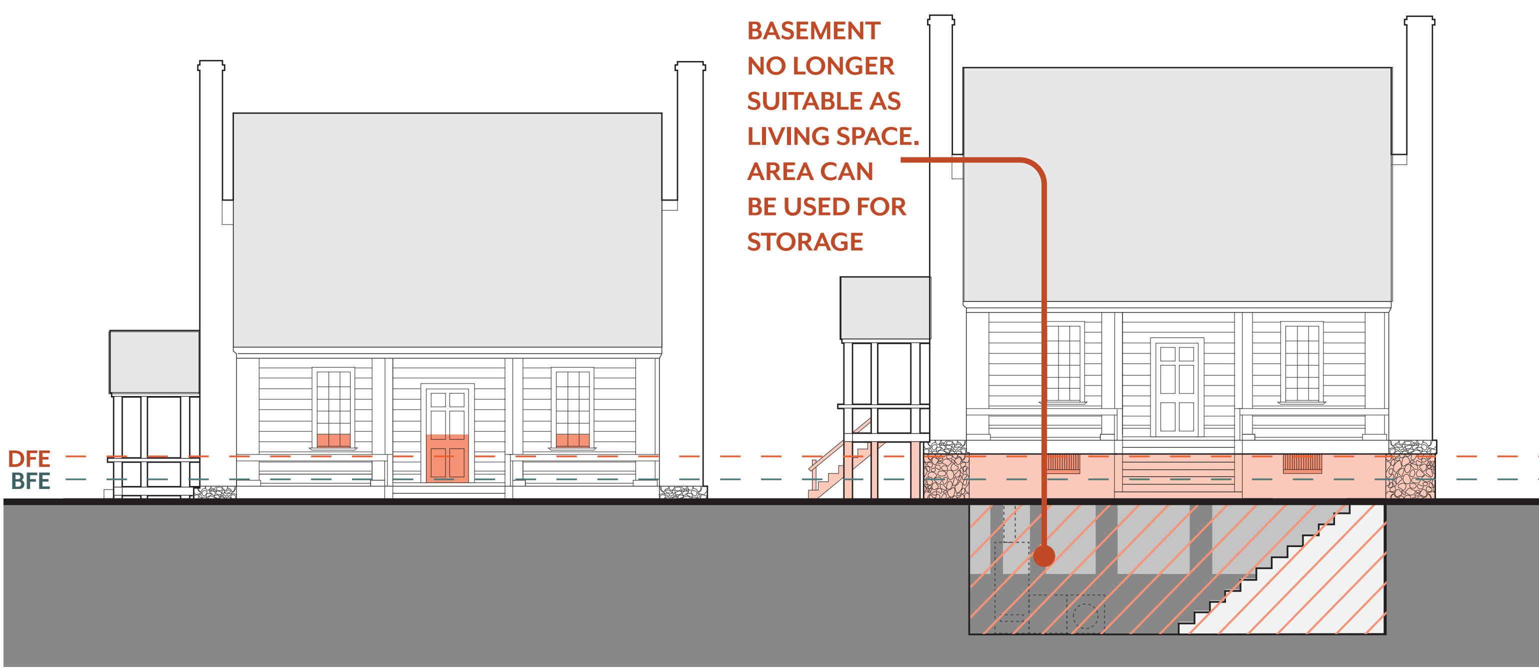


SUMMARY OF ELEVATION OPTIONS

Floodproofing and elevation are both adaptation strategies meant to increase the resiliency of foundations and to raise the lowest levels of historic structures to resist floodwaters. They each come with tradeoffs and are appropriate for historic structures with certain characteristics.

Floodproofing does not radically alter the existing form of a historic structure; rather, treatments or materials are used in areas beneath base flood levels to allow the structure to withstand different flood impacts. Dry floodproofing uses waterproof treatments like liners and sealants to prevent water from entering structures during flood events. While it is generally not considered an appropriate adaptation for historic structures, it could be implemented on structures with adequately strong masonry foundations. Wet floodproofing allows floodwaters to move through a structure and drain as the water recedes. Features like foundation vents and waterproof materials, in keeping with the historic character of the structure, protect against damage from hydrostatic pressure and water contaminants.

Elevation does change the form of a historic structure by raising it above the established flood



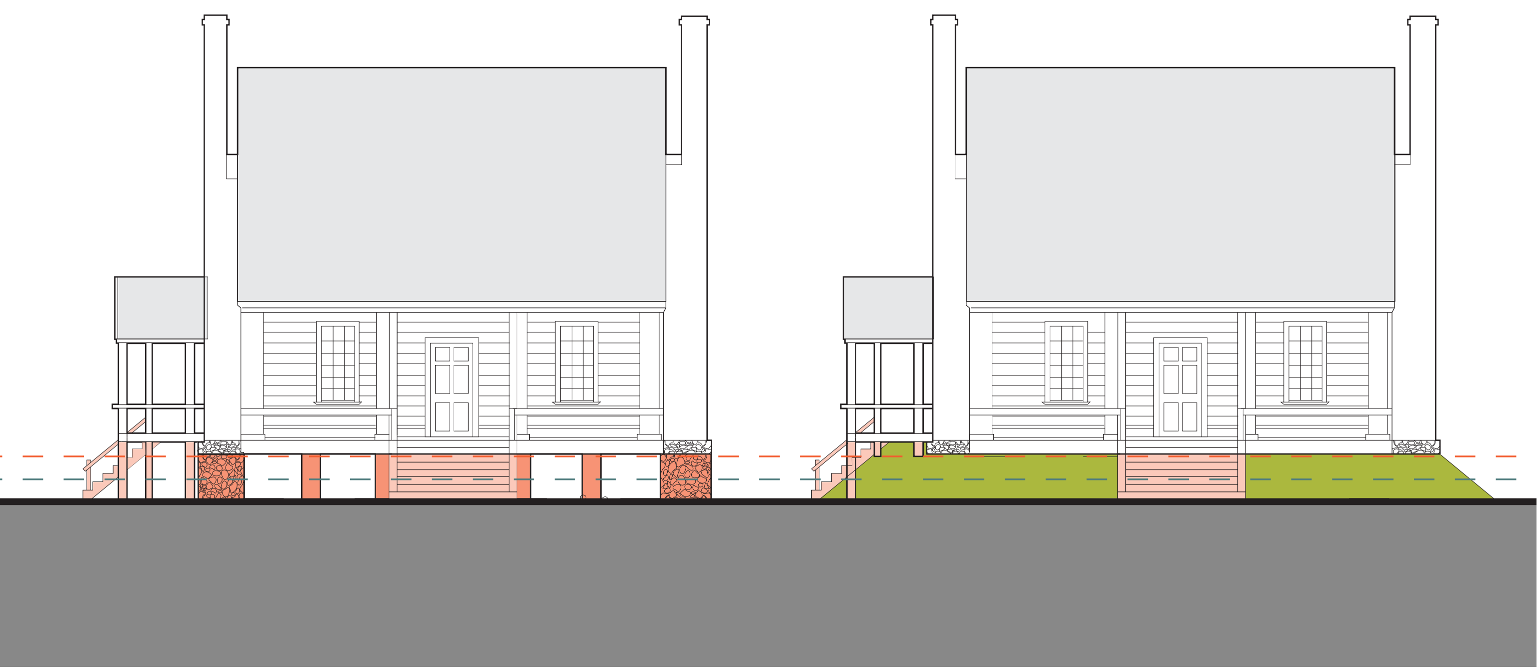
DRY FLOODPROOFING
(WINDOW & DOOR BARRIERS)

MOST EFFECTIVE FOR AREAS WHERE FLOODING IS INFREQUENT AND WHERE THE ESTABLISHED FLOOD RISK LEVEL IS 3 FT. OR LESS.

WET FLOODPROOFING
(REQUIRES MOVING UTILITIES)

MOST APPROPRIATE WHERE FLOOD EVENTS LAST LESS THAN 24 HOURS AND WHERE THE FLOODED AREA IS CONSTRUCTED OF FLOOD-RESISTANT MATERIALS risk level, but it can be accomplished sensitively to maintain the character-defining traits of a building. Elevation strategies include creating or expanding an enclosed crawl space, raising a building on piers, using fill to change the topography of a site, or abandoning uses on the first floor of a structure. In each elevation strategy, it is important to retain the building's historic form, features, and overall proportions.

Regardless of the adaptation strategy chosen, be sure to consult with building and preservation professionals to ensure the structural and character-defining integrity of your historic structure.



ELEVATION WITH STILTS / SUPPORTS

WORKS BEST FOR FRAME BUILDINGS WITH CRAWL SPACES AND PIER OR POST FOUNDATIONS

ELEVATION WITH FILL

APPROPRIATE ONLY WHEN METHOD WILL NOT INCREASE FLOOD HAZARD IMPACTS TO ADJACENT PROPERTIES

PORCHES & STAIRS

Architecturally, porches, porticos, and stoops provide a threshold from the public realm of the street or site to the private realm of the building. Functionally, porches and stoops extend the interior spaces of the building, offering spaces to sit and entertain as well as allow access to the building. Front porches and steps often present a formal appearance to the street and contain ornate details that typically reduce the scale of a building's elevation to the scale of a person, while rear porches and steps are more informal and utilitarian (Historic Preservation Office, n.d.). Historically, porches in the South were typically oriented to shield the building interior from solar gain to the south, west, or east and to open it up to cooling summer breezes from the southwest, as well as to provide shelter from rain, snow, and other weather events. Common components of porches include stairs, railing, decking, structure, side walls or screening walls, and supporting columns or posts.

As prominent, exterior features on historic buildings, porches and stairs are often more exposed than other building systems and, thus, more vulnerable to severe weather conditions and impacts. Close attention to and regular maintenance of these structures and materials are the first line of defense to ensure they hold up to extreme weather conditions. This regular maintenance includes material-protecting treatments like paint or penetrating sealer, routine replacement of rotten boards and damaged or missing fasteners, and regular inspection of structural connections from the roof rafters to columns to foundation. In coastal areas where extreme wind and high-velocity wave action is possible, structural reinforcement may be required to ensure that porches and stairs stay connected to the building.

When a historic building is elevated, porches and stairs must be elevated with the structure to maintain alignment with the new building's first floor elevation (FFE). Proportional relationship between stairs, porches, and the rest of the building should also be maintained when possible. When elevating porches and stairs, it is important to be cognizant of and compliant with building code requirements. These changes and requirements will be largely site specific and could include the addition of new handrails or guardrails. Property owners should work with a design professional to help navigate these compliance requirements, especially in the context of a historic structure. Notably, elevation of a public structure that requires subsequent changes to porches and stairs is a good opportunity to address concerns around ADA and handicap accessibility with the addition of a ramp, elevator, or other method.

The increased height of an elevated building will also require the addition of new stairs to those existing. In these cases, there are opportunities to utilize different methods to minimize the visual impact of the elevation. Some common options include the addition of landings, changing materials, or reorientation to break up a long run of stairs. When dealing with a small site or other spatial constraints, the orientation and location of stairs may need to be altered to best fit the site and building. If the building is situated close to the property line it may be impossible to maintain the existing stair orientation. In those cases, the best decision may be to change the orientation of the stairs or the main building entrance to best accommodate access.

In addition to changing the stairways and porches themselves, landscape strategies can be employed to help hide or soften the appearance

The Duncan House, Beaufort, N.C. Courtesy of Ramsay Leimenstoll, Architect.

BUILDING CODE REQUIREMENTS

- Property owners should work with a design professional to help navigate these compliance requirements, especially in the context of a historic structure

PORCH PIERS

- Constructed from historically appropriate material

VISUAL RELATIONSHIP

- Proportional relationship between stairs, porches, and the rest of the building is maintained

of elevation and additional stairs. In the *Standards*, see standard C, "Adapting Historic Sites and Landscapes for Resilience," for appropriate landscape strategies that can be applied to a site to minimize the visual impact of changes to stairs and porches. Standard I, "Adapting Historic Porches, Entrances, and Stairs for Resilience," explains the guidelines to follow when making resiliency choices for a historic structure's porches, entrances, and stairs.

The operable wooden shutters on the Bellamy Mansion (in foreground) and its slave quarters (in background) in Wilmington are routinely closed and secured in anticipation of hurricanes to protect the windows and interior from storm damage. Courtesy of Bellamy Mansion Museum.

DOORS & WINDOWS

Windows and doors are critical, character-defining features in historic structures due to their visual prominence on exterior elevations. Window, doors, and other apertures are defined by their size, shape, location, materials ,and craftsmanship. Windows and doors serve as both interior and exterior features that heavily influence one's experience of scale and rhythm and often account for a considerable portion of architectural detail on a building's elevation. Traditionally, these elements were designed to protect building inhabitants and their contents from the weather while offering views, light, ventilation, and access. Windows and doors, especially on primary elevations, should be repaired rather than replaced when possible to preserve their defining details.

As operable exterior building elements, windows and doors experience quite a lot of wear and require regular maintenance that includes replacement of broken panes, repair of sash cords, removal and reapplication of caulking, glazing putty, and weather stripping, and scraping and painting. If wood is damaged or rotted, it is best to repair on-site when possible. Since these elements are susceptible to damage from wind, air- or waterborne debris, and hydrostatic pressure during storm events, resilience adaptations for windows and doors focus on strengthening or supplementing existing barriers to provide protection from damaging forces. With advances in manufacturing technologies and the development of novel materials, a suite of modern retrofits are now widely available that are easy to install and sensitive to historic character.

In the *Standards*, standard J, "Adapting Historic Windows and Doors for Resilience," explains the guidelines to follow when making resiliency choices for a historic structure's windows and doors.

SHUTTERS

- Historically, many windows included operable shutters that provided solar shade as well as protection during storm events. Modern shutters are frequently solely decorative, but if shutters are operable, properly sized, stylistically appropriate, and fitted with appropriate locking hardware, they remain a great way to protect windows.
- Impact-resistant acrylic panels can be installed on the back of shutters to improve their performance. These can't be seen when the shutters are open but provide additional protection when the shutters are closed over a window.

STORM WINDOWS

- Storm windows are a tool to preserve historic windows and their character-defining traits while increasing their energy efficiency and protecting the windows. These metal- or wooden-framed glass or acrylic sheets can be installed on the exterior or interior of a historic window frame, where they add another layer of protection from daily temperature variations, drafts, and sound. Exterior storm windows also provide protection from severe wind, rain, and debris. Interior storm windows can be paired with operable shutters for an additional level of defense against severe storms.

GLASS TREATMENTS

- Impact-resistant laminated glass is a good option for replacing windowpanes that are susceptible to air- or waterborne debris strikes and is visually indistinguishable from traditional glass panes.
- Wind-resistant film can be applied to existing windows to protect them from airborne debris damage.

DOORS

- Long-throw slide bolts are effective at reinforcing double-leaf doors to prevent accidental openings during strong winds.

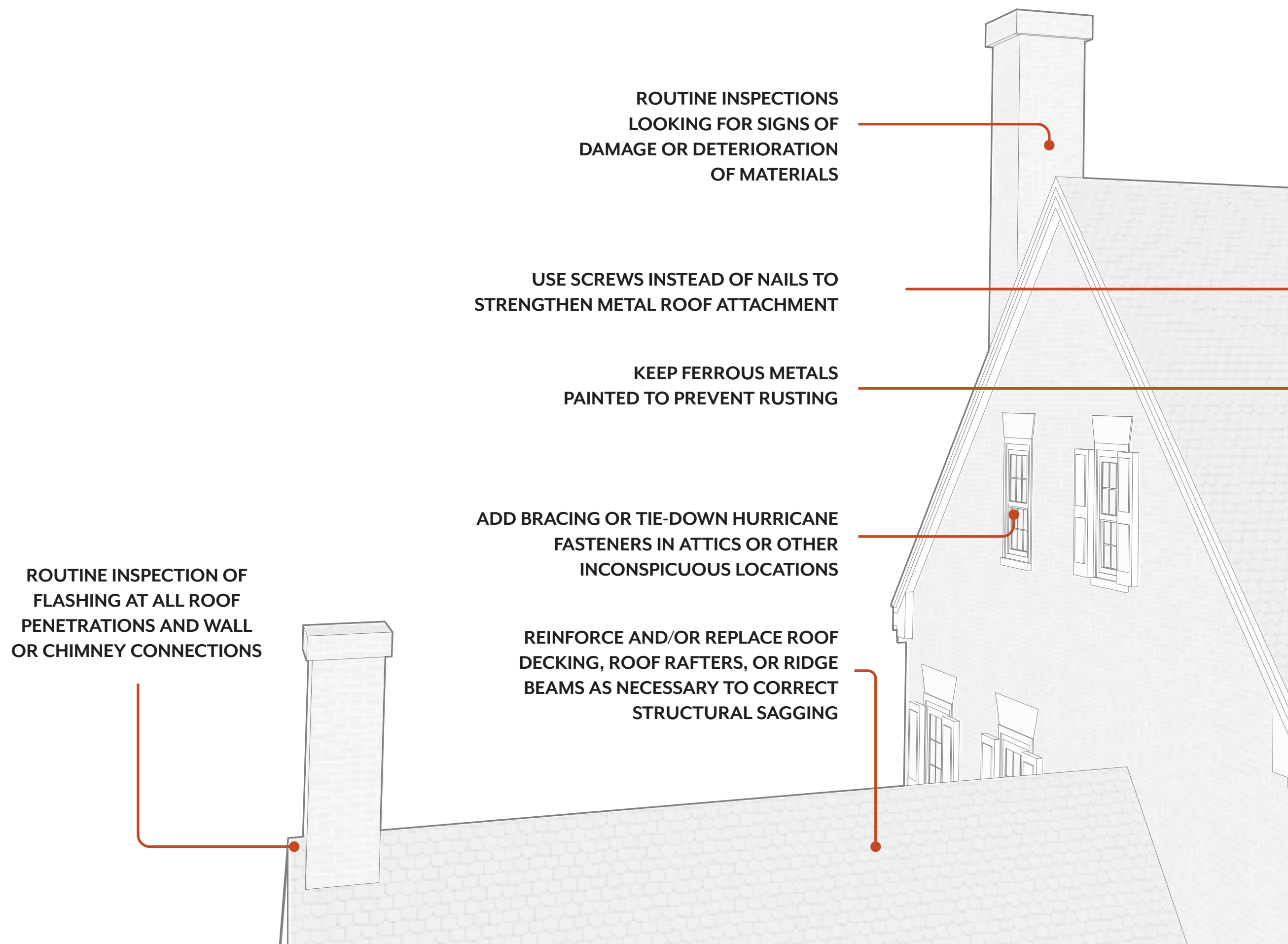
TEMPORARY PROTECTIVE MEASURES

- Removable resilience measures including plywood, fabric, and acrylic panels can be used alone or in conjunction with permanent retrofits.

ROOFS & CHIMNEYS

Roofs are an integral structural and architectural building element and the "first line of defense" from rainfall, wind, and solar radiation. Architecturally, roofs greatly contribute to the character-defining traits of a building through their overall shape, size, and pitch, as well as through features and details including parapets, cornices, chimney flues, overhang proportions, brackets, soffits, and eaves, and roofing material. Gutters and downspouts are also important utilitarian elements tasked with channeling water from the roof to the ground or stormwater system. Their proper location, sizing, and maintenance is essential for drainage and to prevent damage to the roof, walls, and foundations. It is important to locate gutter downspouts to minimize interference with building elevations while also ensuring that they channel water away from the building and its foundations. Roofs resist downward forces including heavy rain, hail, and debris (either falling from nearby trees or windborne) as well as the damaging upward forces commonly known as uplift. Uplift threats often come from high winds caused by severe storms, and in North Carolina we experience this type of force largely during hurricanes. Uplift forces can rip the shingles off a roof or, in extreme circumstances, cause its structural destruction. As with all other building systems, regular maintenance is the first step in ensuring that a roof will survive future extreme weather events. For example, adding elastomeric coatings will help protect standing seam roofs from corrosion. Regularly inspecting all aspects of a roof and its supporting structure will ensure that all elements, such as dormers and gutters, are securely attached and flashed properly.

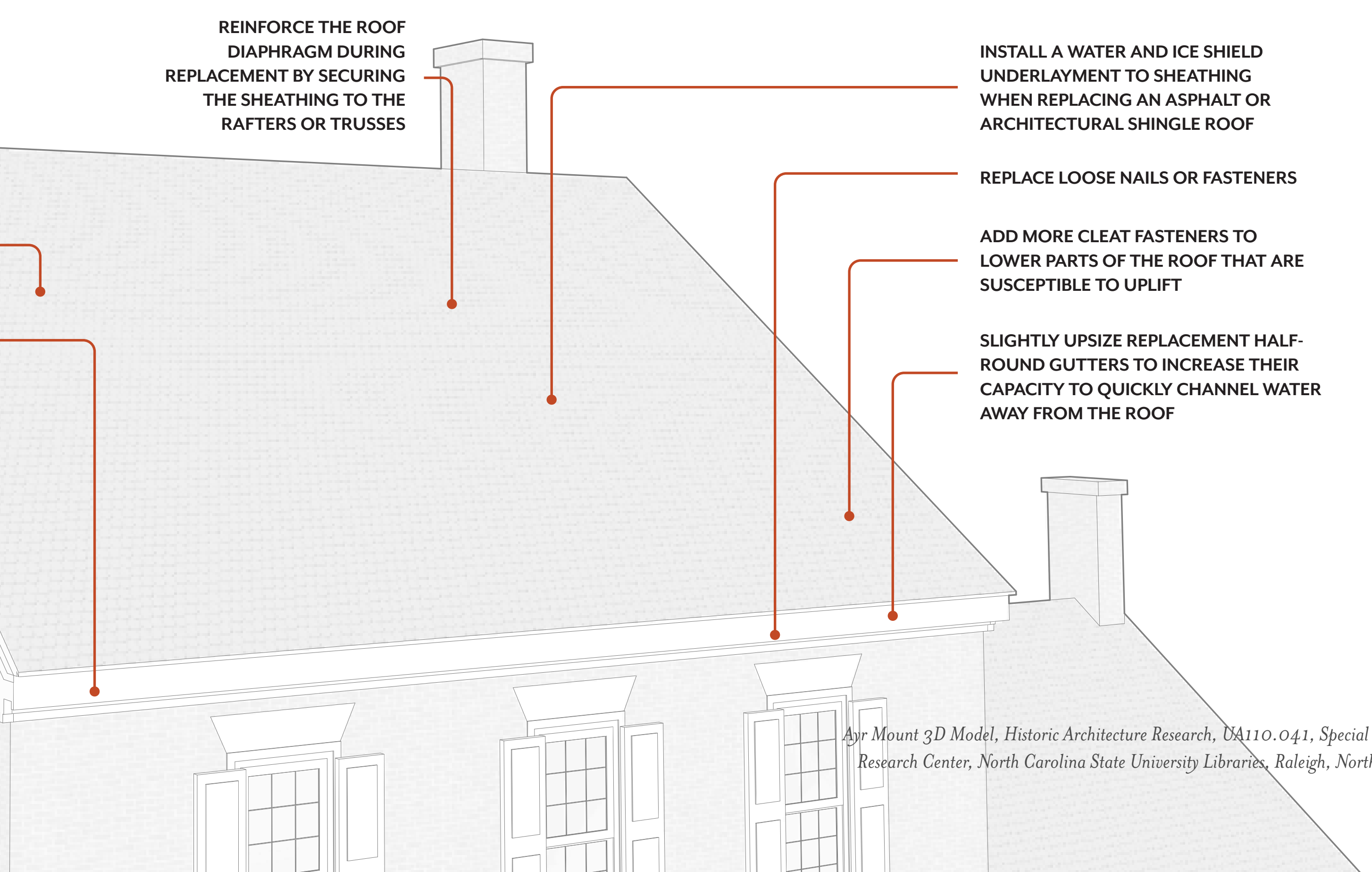
Chimneys, like roofs, are an important character-defining feature. Before central heating and air-conditioning systems, buildings



were often heated with a fireplace or stove vented through a chimney. A chimney, usually built with masonry materials of brick or stone, can be located along an exterior wall with the primary role of venting coal or wood smoke or along an interior wall with the role of venting and retaining heat to radiate back to the interior of the building. Chimneys or metal flues were also historically used to vent kitchen cookstoves. Often the interior of historic buildings is organized around the chimney, fireplace, and hearth—the "heart" of primary living spaces.

Chimneys can be especially vulnerable to deterioration over time as mortar is slowly lost and the connection to the rest of the structure (especially wood-framed walls and roofs) becomes vulnerable to differential movement and structural separation, which allows for the infiltration of water. Chimneys are also susceptible to the high-wind forces that come with hurricanes. In severe weather, chimneys can suffer minor damage or collapse completely from hurricane-force winds. As chimneys age, they may need mortar repointing or structural reinforcing to withstand hurricanes, flooding, and severe wind. Securely cap chimneys to prevent water intrusion.

As with other building systems, it is important to maintain the relationship of the chimney to the historic building as a whole when utilizing resilience measures. If a structure is elevated, the chimney should be elevated, too, and a new foundation should be built for it. In this case, take care to ensure that the new foundation uses the same materials, configuration, and proportions in order to reflect the appearance of the original chimney. The same efforts should be made for a chimney that has collapsed and must be rebuilt. In the *Standards*, standard K, "Adapting Historic Roofs and Chimneys for Resilience," explains the guidelines to follow when making resiliency choices for a historic structure's roof and chimney.



Ayr Mount 3D Model, Historic Architecture Research, UA110.041, Special Collections Research Center, North Carolina State University Libraries, Raleigh, North Carolina.

UTILITIES

Utilities are not necessarily considered character-defining traits of a historic structure, but they are integral to a building's habitability and comfort. However, utilities are often installed in some of the most vulnerable areas in and around a structure. Mechanical equipment, such as conditioning units, are often located at the exterior of a building where they can be damaged by heavy rain, flooding, and debris impacts from high-velocity floodwaters or extreme winds. Other mechanical equipment, such as water heaters and ductwork, and utilities are often located in basements and crawl spaces, which are incredibly susceptible to flood damage.

When building utilities are damaged or destroyed in a home, they can be costly to repair and may hinder the overall recovery process of the building, extending its recovery time and, in some cases, leading to more damage post-storms. For example, the loss of electricity, air-conditioning, and dehumidification can lead to rapid mold growth in structures that were inundated with floodwaters, while the contamination of sanitary sewers can pollute drinking water and increases the potential for waste to back up in a building's plumbing fixtures. Damaged building systems and utilities can also pose a great threat in storm events, such as exposed electrical wiring in floodwaters. With these hazards in mind, proactive measures, like moving utilities to more protected locations, can be one of the best methods to protect them from damage. For utilities that are situated outside the building, elevating them in inconspicuous locations, like at the rear of the building, or surrounding them with watertight enclosures will provide more protection. For vulnerable utilities and equipment located below the BFE, it is a good idea to consider moving them to higher levels in the structure to get them out of harm's way.

As with many other resiliency changes that are made to a structure, it is highly recommended to get an expert opinion on the best methods to use. Taking steps to protect the utility systems of a structure will help ensure that, if and when storm damage occurs, the utilities can continue to function and can help expedite the recovery process. In the *Standards*, standard L, "Adapting Utilities and Systems for Resilience," explains the guidelines to follow when making resiliency choices for a historic structure's utilities.

VISUAL AND PROTECTIVE ENCLOSURE FOR MECHANICAL EQUIPMENT

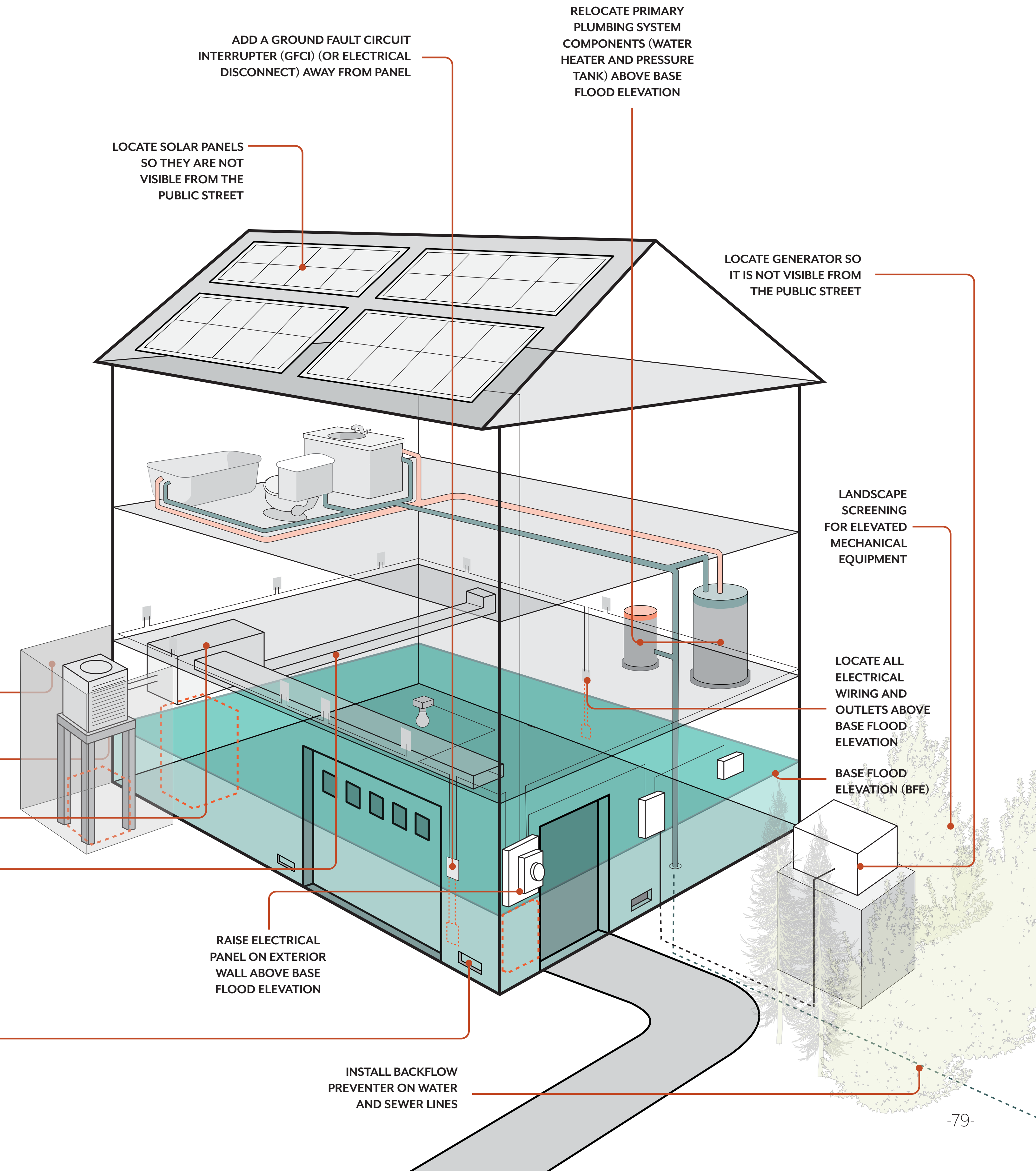
PLACE EXTERIOR HVAC UNIT ON ELEVATED PLATFORM OR HIGHER GRADE

ELEVATE THE INTERIOR HVAC UNIT

RAISE DUCTWORK ABOVE BASE FLOOD ELEVATION

INCREASE VENTILATION FOR QUICKER DRYING AFTER FLOODING WITH VENTS (AND/OR FANS)

Illustration (opposite page) adapted from FEMA P-348, Edition 2 (2017). Protecting Building Utility Systems from Flood Damage. Mitigation Measures for Residential Buildings: Principles and Practices for the Design and Construction of Flood Resistant Building Utility Systems.

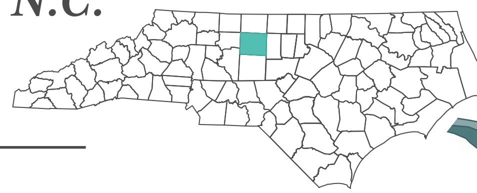

ADD A GROUND FAULT CIRCUIT INTERRUPTER (GFCI) (OR ELECTRICAL DISCONNECT) AWAY FROM PANEL
RELOCATE PRIMARY PLUMBING SYSTEM COMPONENTS (WATER HEATER AND PRESSURE TANK) ABOVE BASE FLOOD ELEVATION
LOCATE SOLAR PANELS SO THEY ARE NOT VISIBLE FROM THE PUBLIC STREET
LOCATE GENERATOR SO IT IS NOT VISIBLE FROM THE PUBLIC STREET
LANDSCAPE SCREENING FOR ELEVATED MECHANICAL EQUIPMENT
LOCATE ALL ELECTRICAL WIRING AND OUTLETS ABOVE BASE FLOOD ELEVATION
BASE FLOOD ELEVATION (BFE)
RAISE ELECTRICAL PANEL ON EXTERIOR WALL ABOVE BASE FLOOD ELEVATION
INSTALL BACKFLOW PREVENTER ON WATER AND SEWER LINES

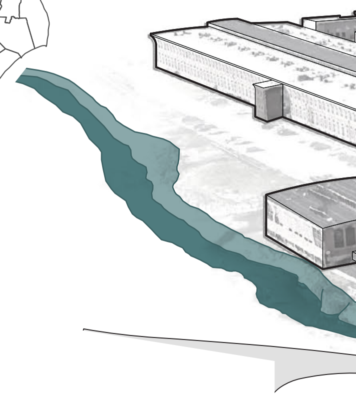
Restoration of Buffalo Creek on the Revolution Mill campus in Greensboro involved removing debris from the creek, terracing the banks, and installing large rocks to slow the stream flow at key points—all of which will help mitigate future flooding. Courtesy of Eddie Belk, Belk Architecture.

SECTION III
CASE STUDIES

ADAPTIVE REUSE: GREENSBORO, N.C.

REVOLUTION MILL





AT A GLANCE

LOCATION: Greensboro, N.C.

NATIONAL REGISTER LISTING: 1984

YEAR(S) BUILT: 1898–1915

REHABILITATION DATES: 2003–2023

BUILDING TYPE: Textile mill

PROJECT BUDGET: $100,000,000+

DESIGN AND CONSTRUCTION TEAM: Belk Architecture; CT Wilson Construction; Weaver Cooke; Piedmont Conservation Council, Inc.

ARCHITECTURAL SIGNIFICANCE: This facility exemplifies the distinctive characteristics of standard textile mill construction of the late nineteenth and early twentieth centuries and is one of the best examples in Greensboro.

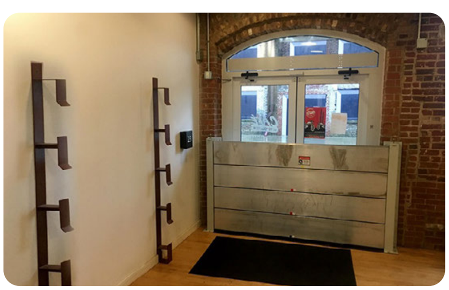
HISTORY

Revolution Cotton Mills has stood on the banks of North Buffalo Creek in Greensboro, N.C., for over a century. The mill was founded by Moses and Ceasar Cone, with construction beginning in 1898, initial mill operations starting in 1900, and construction work on the main building complex wrapping up in 1915. By 1930, the mill was one of the largest flannel producers worldwide, continuing to produce flannel until its closure in 1982. When the complex was listed on the National Register of Historic Places in 1984, it was noted as the best example of early twentieth century mill design in Greensboro.

Adaptive reuse of the property started in the late 1980s with office and event spaces, and major redevelopment of the complex began in 2012. Today, the former mill is a lively mixed-use complex with commercial shops, residential apartments, offices, and event spaces. The comprehensive redesign of around 600,000 square feet was brought to life by G. Edwin Belk and Architects as well as the CT Wilson Construction Company with a budget of over $100,000,000.

RESILIENCE ADAPTATIONS

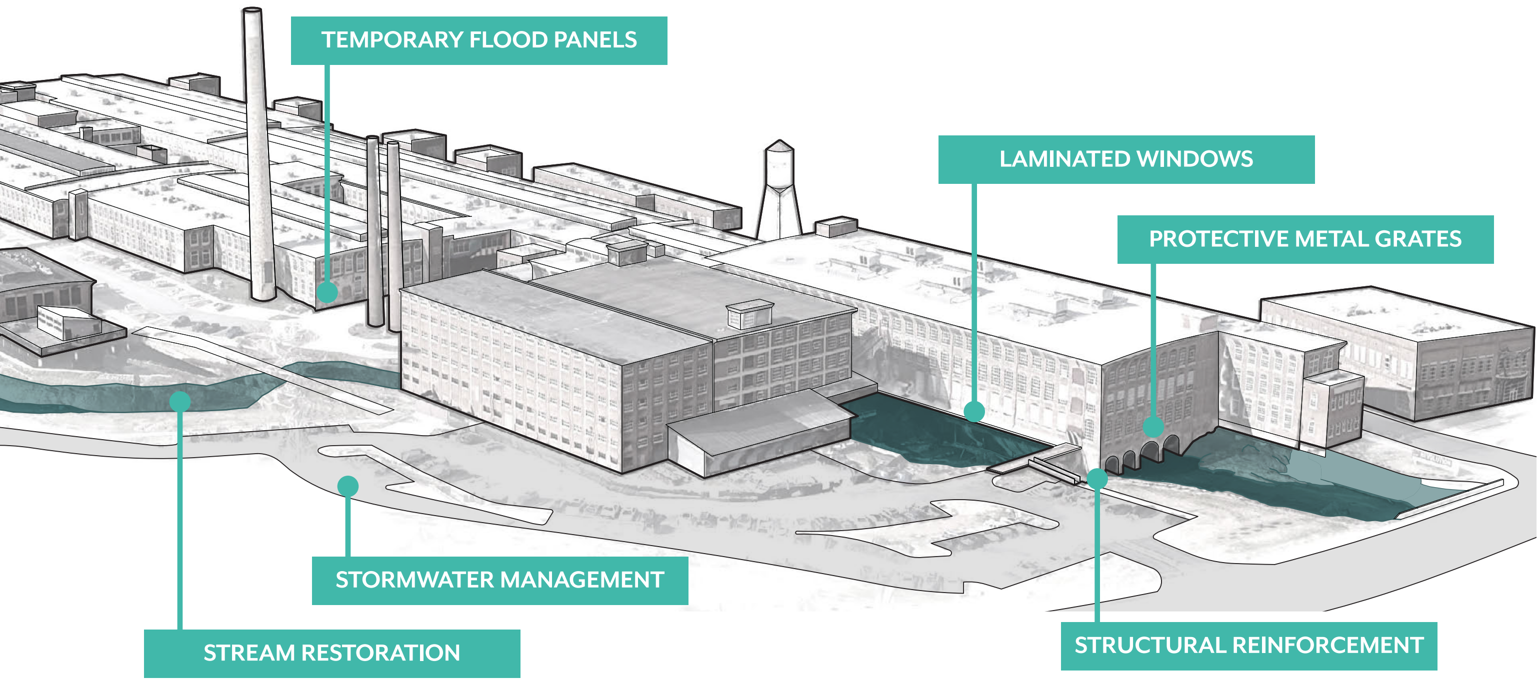
A major consideration during the rehabilitation was reducing flood impacts from North Buffalo Creek. As was typical for late nineteenth century and early twentieth century mills, the creek was chosen as a site for Revolution Cotton Mills so it could be a power source for mill operations. North Buffalo Creek runs beneath two of the mill buildings, and nearly the entire site lies within a high flood-risk area (1 percent chance of flooding in any given year), known as the 100-year floodplain. Revolution Cotton Mills has a history of significant flood impacts from Buffalo Creek, so a suite of resilience adaptations were adopted during the redevelopment process:



Courtesy of Belk Architecture.

TEMPORARY FLOOD PANELS

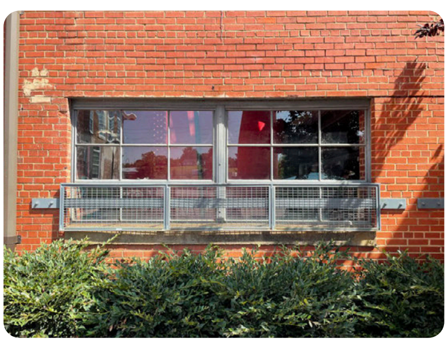
Flood panels were installed along all the entrances into the building where flooding occurs. The panels are stored on permanently installed racks near each door and can be quickly deployed to seal doorways from floodwaters. Upstream sensors alert building management to dangerous water levels and provide a 45-minute window to install the flood panels.



Courtesy of Ramsay Leimenstoll, Architect.

STRUCTURAL REINFORCEMENT

The foundation of the buildings spanning the river were also reinforced with steel and concrete to ensure resistance to the hydrostatic pressures and high-velocity flow of floodwaters.



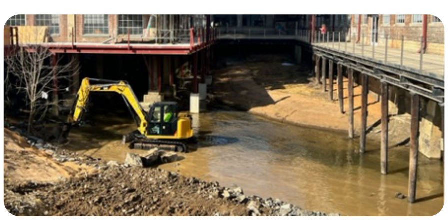
Courtesy of Ramsay Leimenstoll, Architect.

LAMINATED WINDOWS

North Buffalo Creek's base flood elevation exceeds the first-floor height by 3 ft. To protect the building interior from debris during flooding, the lowest band of glass windows were replaced with stronger laminated glass.

PROTECTIVE METAL GRATES

To further increase debris-impact resistance, protective metal grates were added to windows and glass doors that are prone to high floodwaters.



Courtesy of Nick Piornack, Revolution Mill.

STREAM RESTORATION

Within the project site, North Buffalo Creek restoration work includes deepening and widening the creek to increase the floodplain's water storage capacity, stabilizing the banks, and replacing invasive species with native plants. This nature-based solution complements the building retrofits and improves the overall resilience of the site.

Courtesy of Ramsay Leimenstoll, Architect.

STORMWATER MANAGEMENT

A network of drainage enhancements such as cisterns and trench drains helps manage stormwater during smaller rain events and reduces the frequency of nuisance flooding and standing water.

OCRACOKE HISTORIC DISTRICT

AT A GLANCE

LOCATION: Hyde County, N.C.

COMMUNITY TYPE: Maritime

SIZE OF COMMUNITY: 200 acres

NATIONAL REGISTER LISTING: 1990

PERIOD OF HISTORICAL SIGNIFICANCE: 1823–1959

NUMBER OF HISTORIC BUILDINGS: 232

ARCHITECTURAL STYLES REPRESENTED IN THE HISTORIC DISTRICT: Story-and-a-jump, bungalow, I-House, pyramidal cottage, foursquare

HAZARDS FACED BY DISTRICT: Flooding, storm surges

HISTORY

Ocracoke is a sixteen-mile-long island, ranging from one-half mile wide to two miles wide at the village near its southern extremity, located between Hatteras and Portsmouth islands on the North Carolina Outer Banks. It is thirty-four miles across Pamlico Sound from the Hyde County mainland and is part of Hyde County. It is also the only major island with a permanent population that has not been connected to the mainland by a bridge. Ocracoke Village is on the sound side of the island. The village is primarily residential, with a small commercial center on Silver Lake, a Coast Guard Station at the harbor mouth, and an 1823 cone-shaped white lighthouse south of the harbor.

Ocracoke Historic District (OHD) was added to the National Register of Historic Places in 1990 with a period of historical significance (PHS) of 1823–1959 as a maritime community significant to the exploration and settlement of coastal North Carolina and the United States.

CLIMATE-RESILIENT VERNACULAR DESIGN

With a location on the Pamlico Sound side of Ocracoke Island in North Carolina's coastal Outer Banks, Ocracoke Village is one of the best places to find historic examples of climate-resilient vernacular design. Because the area has dealt with strong winds and flooding from storms since its settlement, houses in the historic district are more often sited within the dense, scrub vegetation of the inland maritime forest, rather than on exposed coastlines. Many houses were also built with cisterns to catch rainwater in an area where freshwater is scarce. While houses were often elevated on piers, they could also feature trap doors in the floor, allowing water into a structure during floods so that it would not be lifted off of its foundation (National Register of Historic Places, 1990).

RECOGNIZING CLIMATE IMPACTS ON HISTORIC BUILDINGS

The integrity threshold for historical significance was lowered during the application process of the OHD in recognition of the climatic pressures faced by historic buildings in the area, the majority of which had been modified to adapt to severe weather conditions. This represents an early example of historic standards responding to and accommodating the reality of climate impacts.

Nearly all of the historic buildings have been modified to adapt to severe weather conditions and in response to the effects of constant exposure to wind, moisture, and insects. Typical alterations include such generally reversible changes as screening porches, enclosing porches, applying wooden shingles or synthetic siding over the original horizontal weatherboards, raising the original foundations and replacing chimneys. A traditional story-and-a-jump house will typically have replacement siding, porch alterations, and a rear addition but is still considered contributing if it retains its traditional form and setting (National Register of Historic Places, 1990).

Courtesy of the State Historic Preservation Office, North Carolina Department of Natural and Cultural Resources.

SIMON AND SARAH GARRISH HOUSE

This story-and-a-jump house was built in 1888. Changes to its original form include a replacement chimney, two front dormers, a rear addition, aluminum siding, and a replacement porch railing. The homestead is still considered a historic property because the site retains an early storage building, a round domed cistern, and characteristic Ocracoke landscaping (National Register of Historic Places, 1990).

Aerial view of the harbor and buildings surrounding Silver Lake on Ocracoke Island in North Carolina. Courtesy of Adobe Stock/Kyle.

HISTORIC RESILIENCE PLANNING: ASHEVILLE, N.C.

BILTMORE VILLAGE

AT A GLANCE

LOCATION: Buncombe County, N.C.

SIZE OF COMMUNITY: 20 acres

NUMBER OF HISTORIC BUILDINGS: 11

NATIONAL REGISTER LISTING: 1979

PERIOD OF HISTORICAL SIGNIFICANCE: 1892–1930

BUILDING TYPES: Commercial, residence, religious

ARCHITECTURAL STYLES REPRESENTED: Half-timber manorial, Queen Anne, pebbledash, Georgian

HAZARDS FACED BY DISTRICT: Flooding

HISTORY

Biltmore Village was developed by George W. Vanderbilt in the late 1800s as a community for the workers at his nearby estate. It is a locally designated Historic District in the City of Asheville, and nearly all of the village is listed on the National Register of Historic Places. Biltmore Village is located along the Swannanoa River about a mile and a half upstream from its confluence with the French Broad. These rivers were economic engines of the city and region in the early twentieth century, providing access and resources to mills, tanneries, and other factory-based industries. While the rivers provide economic resources, they also bring hazards. There have been several notable floods in the last century, including the Great Catawba River Flood of 1916. The French Broad River crested 21 feet above its usual height, causing a flood that killed 80 people and caused over $1,000,000 in damages (upwards of $27,000,000 today). In 2004, tropical storms Frances and Ivan dropped record amounts of rain on Asheville, resulting in a flood that killed 11 people and caused $7,000,000 in damages. During the 2004 floods, Biltmore Village flooded up to 4 feet. In response, Biltmore Village has implemented new strategies to combat flooding hazards and preserve the historic character of the area.

IMPLEMENTING A FLOOD RESPONSE PLAN

In response to these events, the Army Corps of Engineers, in collaboration with the City of Asheville, North Carolina Department of Natural and Cultural Resources, and the State Historic Preservation Office, released the Biltmore Village Emergency Flood Response Plan in March 2009. The document stands as a prime example of coordination between local, state, and federal agencies to preserve the historic character of a community while also ensuring its resilience in an uncertain climate future. Strategies outlined in this plan include a range of temporary protective measures, maintenance recommendations, structural retrofits, and district-wide adaptations. Implementation of these recommendations has been achieved building-by-building.

SUMP PUMPS & DRAINS INSTALLED

In the Market Gardeners Cottage on the Biltmore Estate, basement renovations including a sump pump, central drain, and foundation vents have improved the ability to remove water from the historic structure in case of flood.

HISTORICALLY SENSITIVE ELEVATIONS

After the 2004 floods, the Biltmore Shoe Store, originally constructed in 1900 by architect Richard Sharp Smith, was elevated in a way that maintained the unique character of the one-and-a-half story, half-timbered pebbledash cottage.

TEMPORARY RESILIENCE MEASURES

Sandbags are one of the most common and easily deployed temporary flood-protection measures. They are typically stacked over a plastic sheet in single rows up to three rows high or in pyramid configurations for inexpensive temporary protection against higher floodwaters in Biltmore Village.

ELEVATING NEW BUILDS

A new structure in Biltmore Village reflect the pebbledash and half-timbering that is unique to the area and are able to incorporate first-floor water storage through parking affordances.

UPDATES TO BASEMENTS

Some basement areas in this commercial block that abuts the public right-of-way in Biltmore Village were filled in, and some wooden floors were replaced with concrete to protect them from future flood damage.

Sump pump photo courtesy of The Biltmore Company, Asheville, North Carolina. Additional photographs courtesy of the State Historic Preservation Office, North Carolina Department of Natural and Cultural Resources.

GLOSSARY

Below, you'll find definitions and helpful links for terms that appear in the Historic Resilience Project's publications. The Federal Emergency Management Agency (FEMA) has an extensive glossary of related terms.

100-Year Floodplain (1 Percent Annual Chance Floodplain): An area with a 1 percent chance of flooding in any given year. This does not mean that an area will *only* flood once every 100 years. For more on the probability of flooding, recurrence intervals, and the possibility of a 100-year flood occurring in successive years, see the U.S. Geological Survey, "The 100-Year Flood."

500-Year Floodplain (0.2 Percent Annual Chance Floodplain): An area with a 0.2 percent chance of flooding in any given year. This does not mean that an area will *only* flood once every 500 years. For the probability of a 500-year flood occurring twice in a lifetime, see the U.S. Geological Survey, "The 100-Year Flood."

Base Flood Elevation (BFE): The height of flooding in a 100-year flood, as determined by FEMA. The BFE and other information appears on Flood Insurance Rate Maps (FIRMs) that can be accessed at the FEMA Flood Map Service Center.

Certificate of Appropriateness (COA): An official approval issued by a local preservation commission that is required for altering the exterior of a property that is a designated local historic landmark or in a historic district. In limited circumstances, a COA may be required for altering the interior of a local landmark. Decisions for COAs are based on adopted design standards and evidence presented to the preservation commission through a quasi-judicial process. See Chapter 160D, Section 947 of the North Carolina General Statutes.

Climate Change: Long-term shifts in local, regional, and global weather patterns with a wide range of associated effects—including higher temperatures, rising sea levels, and more intense storms and droughts. See NASA, "What Is Climate Change?"

Coastal Area Management Act (CAMA): CAMA is a North Carolina law that protects the state's coastal areas by regulating activities and development that affect them. Administered by the Coastal Resources Commission with assistance from the North Carolina Department of Environmental Quality, CAMA applies to properties in twenty North Carolina counties along the coast. See Chapter 113A, Article 7 of the North Carolina General Statutes. For more on CAMA rules and resources, see Division of Coastal Management.

Coastal Flooding: Coastal flooding occurs when normally dry land near the coast is inundated or covered by water as a result of high or rising tides that coincide with storm surges. See the FEMA National Risk Index.

Community Rating System (CRS): This voluntary incentive program encourages communities to make efforts to enhance their floodplain management practices beyond the minimum requirements of the National Flood Insurance Program (NFIP). See FEMA, Floodplain Management Community Rating System.

Design Flood Elevation (DFE): Used for retrofitting purposes, the DFE is the highest elevation of floodwater plus a community's additional freeboard or safety measurement. It is also known as the Flood Protection Elevation.

Dry Floodproofing: A combination of measures, generally used to protect nonresidential buildings, that keeps water out of all or part of a structure during flooding. See FEMA, *Floodproofing Non-Residential Buildings*.

Engineered Structural Soil: A manufactured soil that nourishes and protects plants and trees, especially in urban environments, with a blend of porous materials, such as gravel, sand, clay, and compost. It provides structural support, increased drainage, and ample room for root growth. See CityGreen, What Is Structural Soil?

Established Flood Risk: The National Park Service (NPS) defines this term as the "property-specific height of anticipated floodwater," and it is based on information about a site and its flooding history. The NPS uses this term in lieu of other federal, state, and local regulatory language to avoid confusion about flood risks. For more, see *The Secretary of the Interior's Standards for Rehabilitation & Guidelines on Flood Adaptation for Rehabilitating Historic Buildings*.

Floodplain: An area of land that is susceptible to inundation by floodwaters from rivers, streams, or other sources. Communities in a regulatory floodplain, or flood-hazard area, must regulate building development, construction, and repair to participate in the NFIP.

Floodplain Management Ordinance: To participate in the NFIP, a community must adopt a Floodplain Management Ordinance, consisting of regulations to ensure that flood hazards are considered in all official actions relating to land management and use.

Floodway: The portion of the regulatory floodplain that must be kept free of development so that flood elevations will not increase beyond a set limit—a maximum of one foot, according to NFIP guidelines. The floodway usually consists of the channel of a river or other watercourse and the land alongside it. Also known as a regulatory floodway.

Freeboard: The height that is added to the Base Flood Elevation as a safety measure (it's usually one to three feet above the BFE). It determines the lowest level of a structure that must be elevated or floodproofed to meet state or community floodplain management regulations.

Green Infrastructure: Unlike gray infrastructure, such as sewer systems, green infrastructure filters and absorbs stormwater at its source. The Federal Water Pollution Control Act defines it as the "range of measures that use plant or soil systems, permeable pavement or other permeable surfaces or substrates, stormwater harvest and reuse, or landscaping to store, infiltrate, or evapotranspirate stormwater and reduce flows to sewer systems or to surface waters." See the EPA's "What Is Green Infrastructure?"

Hazard Mitigation: The process of taking action to reduce or eliminate the potential loss of life and property in future disasters. FEMA has more information about hazard-mitigation measures and funding opportunities at Hazard Mitigation Assistance Grants.

High-Risk Flood Zone: Also known as Special Flood Hazard Areas (SFHAs), these zones are in the 100-year floodplain and experience frequent and severe flooding. Since they have a 26 percent chance of flooding over the course of a thirty-year mortgage, they face stricter development and flood-insurance regulations. On flood maps, high-risk zones are labeled "A" in inland or riverine areas and "V" in coastal areas.

High-Tide Flooding: High-tide flooding occurs when a local sea level temporarily exceeds the threshold height for flooding. It is caused by extremely high tides, not storm surge or riverine flooding. See the U.S. Climate Resilience Toolkit.

Historic Character: The distinctive features and visual elements that add architectural and historic interest to structures, streets, and sites. See the National Park Service, *Architectural Character: Identifying the Visual Aspects of Historic Buildings as an Aid to Preserving Their Character*.

Historic Easements and Protective Covenants: These legal documents provide long-term protection to a historic property, preventing demolition and modifications that could alter its historic character. The restrictions run in perpetuity and are transferred with the property's deed. See Preservation North Carolina.

Hydrodynamic Forces: The forces created by flowing water as it presses against the front of a structure, drags along its sides, and pulls on the back. Very fast-moving water can sometimes push a building off its foundation or carry debris that can strike and damage it. For information about hydrodynamic and hydrostatic forces, see FEMA, *Engineering Principles and Practices for Retrofitting Flood-Prone Residential Structures*.

Hydrostatic Forces/Hydrostatic Load: The lateral and vertical forces of standing or slow-moving water that exert intense pressure on walls and floors. Hydrostatic forces can cause significant structural damage.

Moderate-Risk Zone: These areas are commonly referred to as the 500-year flood zone, meaning that in any given year they have a 0.2 percent chance of flooding. Although there are usually fewer regulations associated with moderate-risk areas, flooding should be considered an inevitable eventuality. On flood maps, these areas are labeled either as "B" zones or "X (shaded)" zones.

National Flood Insurance Program (NFIP): Managed by FEMA, the NFIP provides federally backed flood insurance to residents, business owners, and communities. The rates are determined by FIRMs that delineate areas with high, moderate, or low risks of flooding. FEMA has more information at Flood Insurance.

Nuisance Flooding: Temporary but recurring shallow flooding that does not pose an immediate threat to public safety or cause major property damage but does disrupt daily activities, strain infrastructure, and lead to minor property damage. Nuisance flooding may occur along the coast, where it is also known as high-tide flooding, or in other low-lying areas. See more at the National Park Service, "Coastal Geohazards—Nuisance Flooding."

Resilience: The National Academies of Sciences, Engineering, and Medicine define resilience in a 2012 report as "the ability to prepare and plan for, absorb, recover from and more successfully adapt to adverse events." See the full report, *Disaster Resilience: A National Imperative*.

Riverine Flooding: A flood that occurs when a stream or river overflows its banks and spills into adjacent areas. See the FEMA National Risk Index.

Special Flood Hazard Area (SFHA): A designation on FEMA flood maps for a high-risk area where 100-year floods can be expected. The SFHA zones on a Flood Hazard Boundary Map (FHBM) or a FIRM are A, AO, A1-A30, AE, A99, AH, AR, AR/A, AR/AE, AR/AH, AR/AO, AR/A1-A30, V1-V30, VE, or V. The NFIP's flood management regulations must be enforced in these areas, and flood insurance is mandatory.

Storm Surge: An abnormal, usually sudden rise in sea level that results from atmospheric pressure changes associated with hurricanes, cyclones, and severe storms.

Stream Restoration: A complex process that improves the function of a damaged or degraded stream channel and returns it to a more natural condition with a dynamic, self-sustaining ecosystem. For information on North Carolina's stream-restoration efforts, see the North Carolina Department of Transportation Stream Mitigation Program.

Wet Floodproofing: Protective measures that allow floodwaters to enter and flow through parts of a building so that the internal and external hydrostatic forces are minimized and equalized. Wet floodproofing is usually limited to parking, storage, or special-access areas rather than living spaces.

Zone AE: FEMA uses zones on its flood-insurance maps to convey the levels of risk in different geographic areas. Zone AE is considered a high-risk area in the 100-year floodplain. The "AE" label is now used on FIRMs instead of "A1-A30."

Zone AH: Zone AH has a 1 percent annual chance of shallow flooding, ranging in depth from one to three feet. These areas have a 26 percent chance of flooding over the life of a thirty-year mortgage.

Zone AO: Zone AO is a river or stream flood-hazard area or an area with a 1 percent or greater chance of shallow flooding each year, usually in the form of sheet flow, ranging in depth from one to three feet. These areas have a 26 percent chance of flooding over the life of a thirty-year mortgage.

Zone V: Zone V is a coastal area with a 1 percent or greater chance of flooding each year. The NFIP requires that buildings in this zone are anchored to resist wind and water forces, elevated above the BFE, and protected from waves, hurricane-force winds, and erosion. FEMA requires a V-Zone Certificate for all structures built or substantially modified in this zone. The North Carolina Floodplain Mapping Program has documents, certificates, and other resources.

RESOURCES

For more information, explore these helpful links for topics that appear in the Historic Resilience Project's publications.

Historic Resilience

RESOURCE	DESCRIPTION/PURPOSE
National Park Service's ***Guidelines on Flood Adaptation for Rehabilitating Historic Buildings*** **(PDF)**	A document with technical preservation guidance for historic properties at risk of flooding.
NCHPO Disaster Preparedness and Response	A webpage with information and links for property owners on disaster preparedness and response.
Disaster Mitigation for Historic Structures: Protection Strategies **(PDF)**	A manual by 1000 Friends of Florida for integrating historic preservation and disaster preparedness.
Resilient Rehab: A Guide for Historic Buildings in Miami-Dade County **(PDF)**	Guidance from Miami-Dade County on how to protect historic resources from natural hazards.

Local Examples

RESOURCE	DESCRIPTION/PURPOSE
Edenton Historic District Design Standards **(PDF)**	Design standards for Edenton's historic districts, including a "Disaster Preparedness and Prevention" chapter.
Charleston's ***"Design Guidelines for Elevating Historic Buildings"*** **(PDF)**	Design guidelines focusing on these key aspects of elevation projects for historic buildings: streetscape/context, site design, foundation design, and architecture/preservation.
Baltimore's ***Fells Point Flood Mitigation Guidelines*** **(PDF)**	Guidelines for property owners and tenants to minimize the impact of flooding on historic rowhouse properties.
FEMA's ***Homeowner's Guide to Retrofitting: Six Ways to Protect Your Home from Flooding*** **(PDF)**	A guide to protecting your home from flooding.

Mapping and Data

RESOURCE	DESCRIPTION/PURPOSE
HPOWEB 2.0	A mapping tool and database from NCHPO of historic resources throughout North Carolina.
African American Heritage & Culture of North Carolina	A digital asset map of cultural sites and natural resources developed by the N.C. African American Heritage Commission and the Conservation Trust for North Carolina.
FIMAN (Flood Inundation Mapping and Alert Network)	A real-time digital tool that provides rain and stage gage data, flood inundation maps, flooding alerts, and other information.
NC FRIS (North Carolina Flood Risk Information System)	Digitally accessible flood maps, reports, risk assessments, and more.
NC Floodplain Mapping Program (flood.NC.gov)	Extensive information, maps, and resources on flooding in North Carolina.
Sea Level Rise and National Register Listings	A mapping tool and database from NCHPO that enables users to overlay historic resources and flood-hazard areas.
FEMA Glossary	FEMA's official glossary of emergency-management terms.

Planning Resources

RESOURCE	DESCRIPTION/PURPOSE
State of North Carolina's *Hazard Mitigation Plan* (PDF)	A federally mandated plan identifying potential hazards in North Carolina and actions that could reduce the loss of life and property.
FEMA's *Integrating Historic Property and Cultural Resource Considerations into Hazard Mitigation Planning* (PDF)	A planning guide for the protection of historic resources from natural hazards.
***Plan Integration for Resilience Scorecard™ Guidebook: Spatially Evaluating Networks of Plans to Reduce Hazard Vulnerability, Version 2.0* (PDF)**	A guide to evaluating the consistency of adopted community plans and the extent to which they potentially strengthen or weaken community resilience.
PlanNC Guidebook: A Practitioner's Guide to Preparing Streamlined Community Plans	A School of Government handbook that describes a seven-step process for efficiently preparing community plans.

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Historic Buildings and Vintage Photographs Collage (pages 8–9)

Photograph of an unidentified building, Ashe County (date unknown) courtesy of North Carolina Digital Heritage Center; Chapel Hill, NC. Contributed by Ashe County Public Library; West Jefferson, NC.

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History of Hazards in North Carolina Collage (pages 10–11)

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Photograph of Hurricane Hazel Impacts, Morehead City, NC (1954) accessed from the National Weather Service, courtesy of Associated Press, East Carolina RENCI.

Photograph of Hurricane Florence Impacts in Swansboro, NC (2018): CBS News, Associated Press.

Photograph of Hurricane Matthew Impacts in Robeson County, NC (2016): The News and Observer.

Photograph of Hurricane Floyd Impacts in Tarboro, NC (1999): WTOP News, Associated Press.

Photograph of Hurricane Hugo Impacts in Charlotte, NC (1989): The Charlotte Observer.

Photograph of Hurricane Fran Impacts on Topsail Island, NC (1996): The News and Observer.







BOAT TOURS
Community Square & Docks
OCRACOKE
WORKING WATERMEN'S
EXHIBIT