# RESILIENCE DESIGN STANDARDS

*Model Standards for North Carolina's Historic Properties*

NC DEPARTMENT OF
NATURAL AND CULTURAL RESOURCES

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*for* ***Resilience***

# INTRODUCTION

***Resiliency is a critical aspect of the long-term preservation of North Carolina's historic built environment and sites. Historic properties cannot be frozen in time. In fact, ensuring their future requires that they be continuously maintained and adapted to meet twenty-first-century realities—including the impact of climate change, rising sea levels, and the increasing threats of severe weather events.***


***Figure 1:*** *Sequentially, Hurricanes Florence and Dorian severely damaged properties in Portsmouth Village on Cape Lookout National Seashore. The National Park Service has since completed repairs to the Lifesaving Station and multiple other historic structures.*

HURRICANES, TORNADOES, HIGH-VELOCITY winds, storm surges, and flooding events have always impacted North Carolina, but in recent years there has been a marked intensification of severe weather events that have taken their toll across our state, including on its historic resources. Hurricanes Florence and Michael alone affected historic properties in 61 of our state's 100 counties, exposing historic properties and communities in every region of the state to days of rain, high wind, tornadoes, widespread flooding, and extended utility outages. As a result, the compelling need for guidance and design standards that address resiliency and mitigation measures for the state's historic resources led to the development of this document.

Local historic preservation commissions across North Carolina, local landmarks under the purview of these commissions, and the owners of properties in local historic districts are intended as the principal users of these resilience design standards. They are intended as a supplement to the local design standards where resilience is a concern and they are differentiated by the R (for resilience) that precedes each resilience standard. They will also be of value to any property owners of historic buildings interested in enhancing their resilience. The standards are crafted to apply across a variety of settings, communities, and historic districts, but as is the case with any model regulations, they should be tailored to the particular community and aligned with the local design standards. Keep in mind that not all agencies use the same terminology


***Figure 2:** Damaged by high water from Hurricane Matthew, the Will Willis Fish House & Store and dock (which provides public access to the Ocracoke Harbor) were repaired and elevated 2 feet—just in time to survive Hurricane Dorian intact.*

and/or the same definitions for shared terms. For example, in keeping with National Park Service (NPS) terminology, these design standards use the term *established flood risk level* to describe the property-specific height of anticipated flood water.

Nearly all the illustrations in this document come from local historic districts, National Register of Historic Places properties, and Preservation Tax Credit projects in North Carolina. Many of the examples of resilience adaptations come from historic district properties in New Bern, Ocracoke, and Asheville as well as from the Revolution Mill campus in Greensboro, all of which are located in communities that are facing flooding and other severe weather challenges. The examples are not intended as templates to be copied directly but, rather, as concepts that might be adapted successfully for other historic properties.

For local landmarks and properties in local historic districts, any permanent resiliency adaptations that are publicly visible—such as the installation of flood vents or shutters, the elevation of a property, and changes to the topography of the site or setting—require a Certificate of Appropriateness (COA) from the local preservation commission. Likewise, permanent changes made to a historic building or site in response to storm damage—such as repair, reconstruction, or replacement of porches, roofs,



***Figures 3 and 4:*** *The Cape Hatteras Lighthouse, Principal Keeper's Quarters, and Double Keeper's Quarters were moved inland in 1999 to save them from the encroaching sea. The distance between and the orientation of the three structures are maintained at the new location to preserve the significant spatial characteristics and relationships of the historic complex.*

walls, windows, foundations, chimneys, steps, and other architectural features and details—also require a COA. Although no COA is required for temporary measures implemented immediately before or after a severe weather event, care must be taken to minimize any damage to a property's character-defining features during their installation or removal.

Some resiliency adaptations discussed in this document involve interior reinforcement and other interior alterations. While such interior changes may not require a COA, they are included in this document to provide a more comprehensive description of resiliency adaptations. Also, some exterior adaptations will fall within the Minor Works category (versus Major Works) and can be approved by local preservation commission staff without review by the full commission. However, what is categorized under Minor Works varies from commission to commission, so it is important to check with commission staff early in the planning process. Beyond the applicable local preservation design standards, it is also essential to review all other local regulations and floodplain ordinances that apply to disaster preparedness and prevention.

Not all adaptation treatments are appropriate for all historic properties, and the treatments selected should always minimize changes to a building's historic character. Implementing responsible, appropriate


***Figure 5:*** *Vernacular cottages along the N.C. coast like this Ocracoke house seen in 2016 after Hurricane Matthew are flooding with greater frequency during severe weather events. This house was elevated in 2017 and successfully weathered Hurricane Ian.*

resiliency adaptations to ensure the future of historic resources can be accomplished in a variety of ways that retain the integrity of a historic property's significance. The following four steps outline a process for developing and implementing a plan to (1) prevent or reduce the risk of damage to or destruction of a historic property caused by water and wind during severe weather events and (2) ensure the continued preservation of the historic building and site.

STEP #1: **Document the property and evaluate its current capacity to survive flooding and other severe weather events and identify the building's potential vulnerabilities.** Beyond the property's visible features and materials, note locations of potential or known buried materials on the site. Record the historic property and its character-defining features to guide any future repairs and store a copy of the documentation at a secure site.

STEP #2: **Review and understand the compliance requirements of the local floodplain ordinance and related local regulations.** Consider how the local community plans to adapt to the risk of severe weather events and any special exemptions or variances for historic properties impacted by these risks. For example, the Federal Emergency Management Agency (FEMA) regulations allow for a variance for buildings listed on the National Register of Historic Places to minimize a change in elevation height to only that height necessary to avoid flood hazards. The National Flood Insurance Program (NFIP), administered by FEMA, includes a provision providing relief for historic buildings from certain floodplain requirements and offering alternative compliance in situations when prescriptive flood code compliance would be in conflict with the Secretary of the Interior's Standards for Rehabilitation.

STEP #3: **Identify and assess feasible and affordable resilience adaptation treatment options for the historic property to determine how they will address the risks of flooding/other severe weather, taking into consideration the time it will take for any adaptation to reduce the risks.** Often a combination of resilience strategies tailored to the specific property is needed.

STEP #4: **Select an adaptive resilience approach that minimizes the impact on the historic character and appearance of the individual historic property and/ or the larger historic district.**

While historic design standards are the focus of this document, they are merely one strand in the overall web of development regulations. Land use zoning and land subdivision ordinances may limit the activities, building elements, and infrastructure options that may be undertaken. Stormwater regulations, flood damage–prevention ordinances, and other environmental regulations will limit where development may go and how it impacts the natural environment. Building codes and safety regulations will set certain minimum requirements for building safety and access. Moreover, private interests may limit what is possible—for example, restrictive covenants and easements may set legal limits on activities and types of development. These and other regulations

FIG. 6

FIG. 7

FIG. 8

FIG. 9

FIG. 10

*Clockwise from top left—**Figures 6 and 7:** In 2018, Hurricane Florence caused $100 million in residential and commercial damages in New Bern. To help prepare for future weather disasters, the city has since approved a long-term, multi-phased resilience and hazard mitigation plan. **Figure 8:** Hurricanes have flooded the Canton downtown historic district multiple times. The town received a FEMA grant in 2022 to repair flood damage to the Town of Canton Museum building and wet floodproof its basement to make it more resistant to future floods. **Figure 9:** When a tornado damaged the 5-V tin roof on the 1842 Salsbury Schoolhouse, a new rib-panel metal roof was installed within a few days to preserve the building. **Figure 10:** Sequentially, Hurricanes Florence and Dorian severely damaged properties in Portsmouth Village on Cape Lookout National Seashore. Some properties like the Frank Gaskill House could not be salvaged.*

apply to any development, including development seeking to address the resilience of historic and cultural resources. These design standards seek to draw a balance between historic and architectural integrity and necessary resilience measures. Keep in mind that other regulations may apply.

Developed in tandem with these design standards, the Resilience Primer offers additional information and guidance for North Carolina property owners and local historic preservation commissions. The primer provides an overview of the intensifying impact of climate change and severe weather events across North Carolina and includes more in-depth information on the technical aspects of resilience adaptations as well as information on other regulations and agencies engaged in floodplain management. A glossary and links to additional resources are also included.

# A Disaster Preparedness and Prevention *for* Resilience

# OVERVIEW

***Thoughtfully preparing for and preventing water and wind damage from severe weather events is less stressful and typically more affordable than dealing with the consequences following a disaster. Proactively addressing resiliency challenges in ways that minimize the visual impact on the historic character and appearance of historic properties will ensure their preservation for future generations. Reducing the threat of damage to historic properties caused by hurricanes, high-velocity winds, rising sea levels, flash floods, and nuisance flooding may require a combination of permanent and temporary treatments to the historic buildings and sites.***

FIG. A1

***Figure A1:*** *Because this chimney is not capped, it was temporarily covered with waterproof material to prevent water intrusion.*

FIG. A2

***Figure A2:*** *A French drain installed at the Joel Lane House in Raleigh funnels stormwater away from the perimeter of the building foundation and front porch.*

THE INITIAL LINE of defense in protecting historic buildings from wind and water damage during severe weather events is ongoing maintenance and routine repair of their exterior envelopes to keep them weathertight. Resiliency modifications to historic buildings often focus on protecting the doors, windows, and foundation openings with the use of operable shutters, foundation flood vents, and temporary flood gates as well as relocating utilities above the established flood risk level. For properties below the established flood risk level, elevating, dry floodproofing, or wet floodproofing may prove to be the most appropriate adaptation strategies. For others, relocation or even demolition may be the final outcome.

Wind and water from severe weather events can cause significant structural damage to historic buildings, especially if they are structurally deficient. So, it is best to consult with preservation architects, engineers, building code officials, and building professionals to determine if structural reinforcement is warranted. While structural retrofitting can be challenging, attics and crawl spaces often provide access and opportunity to reinforce a building's structural system and roof framing from the interior with bracing, straps, ties, and fasteners. For wood-frame structures, it is important to ensure


*Clockwise from top left—**Figure A3:** Wave attenuators were installed in the Cape Fear River at Brunswick Town /Fort Anderson State Historic Site to stop naturally occurring erosion and absorb wave energy from international shipping while allowing for the eroded shoreline to be rebuilt with sedimentation. **Figure A4:** To provide long-term stability against flash flooding, soil nail walls beneath the stacked rock veneer were installed on the abutment slopes of the Bunker Hill Covered Bridge in Catawba County. **Figure A5:** This parking area on the Revolution Mill campus in Greensboro falls below the established flood risk level. Electronic flood monitors in nearby Buffalo Creek track high water flow so tenants can be promptly notified if vehicles need to be moved to higher ground in anticipation of flooding. **Figure A6:** A column beneath the Main Mill House provides a visual gauge of the creek's water level on the Revolution Mill campus in Greensboro. **Figure A7:** A gravel bed fills the narrow side yard between these two houses in the Beaufort Historic District to ensure that storm water will drain rapidly instead of collecting along foundation walls.*

***Figure A8:*** *The lower-level parking deck of this Biltmore Village infill building also functions as a holding area for flood water.*

that any retrofit of a structure will reinforce rather than stress the existing structural system. Many traditional building materials—including brick, stone, mortar, lime-based plaster, ceramic tile, and tight-grained wood—are inherently resilient but must be promptly and properly dried out after a flooding event. In locations below the established flood risk level, it may be appropriate to replace non-resilient materials with proven damage-resistant materials that approximate the original in appearance and design and won't cause damage to the historic fabric.

Examples of traditional site modifications that can help protect a historic building from flooding include the gentle re-grading of a site so that it slopes away from the building foundation; creating berms or constructing retaining walls to redirect surface runoff water; and improving stormwater management through the installation of dry wells, cisterns, or infiltration trenches that take stormwater runoff away from the building perimeter. Such modifications should be monitored and maintained, as they will lose effectiveness if they are clogged over time with sedimentation from runoff. Keep in mind that any site mitigation will change how water moves through and around a property, so any alterations must be made with an understanding of the potential impact on neighboring properties.


***Figure A9:*** *An aerial view of the attenuators installed in the Cape Fear River at Brunswick Town /Fort Anderson State Historic Site to stop naturally occurring erosion and absorb wave energy from international shipping while allowing for the eroded shoreline to be rebuilt with sedimentation.*

If permanent resilience modifications that require major ground disturbance are planned, the N.C. Office of State Archaeology can advise on whether the work warrants monitoring and/or a pre-disturbance survey by an archaeological firm to assess the potential significance of buried materials and the anticipated impact of the proposed modifications.

For local landmarks and properties in local historic districts, any permanent resiliency adaptations that are publicly visible—such as the installation of flood vents or shutters, elevation of the property, and changes to the topography of the site or setting—require a Certificate of Appropriateness (COA). Likewise, permanent changes made to a historic building or site in response to storm damage—such as repair, reconstruction, or replacement of porches, roofs, walls, windows, foundations, chimneys, steps, and other architectural features and details—also require a COA. Although no COA is required for temporary measures implemented immediately before or after a severe weather event, care must be taken to minimize any damage to a property's character-defining features during their installation or removal. Beyond the applicable local preservation design standards, it is also critical to review other local regulations and floodplain ordinances that apply to disaster preparedness and prevention.

# *A* RESILIENCE STANDARDS FOR DISASTER PREPAREDNESS AND PREVENTION

*Use these design standards in conjunction with applicable local preservation design standards and the Secretary of the Interior's Standards for Rehabilitation.*

**R A.1** When planning resiliency adaptations to a historic building or site, identify, retain, and preserve the historic materials, features, and spaces of the building, site, and setting that are important in defining the historic character of the property. Assess their existing capacity for resilience as well as their vulnerability to severe weather events.

**R A.2** Protect and maintain historic architectural and site features and materials to minimize damage from severe weather events. Repair them as necessary following best preservation practices and applicable design standards. It is not appropriate to remove a significant historic feature or material rather than repair it.

**R A.3** If historic features and materials are damaged or deteriorated beyond repair, replace the damaged portion in-kind to match the original. If the original material is not inherently resilient to flood damage and is located below the established flood risk level, substitute a proven damage-resistant material that approximates the original in design and appearance and will not damage the historic material.

**R A.4** Utilize historic and non-historic building and site features—such as gutters and downspouts, window shutters, storm windows, foundation flood vents, infiltration trenches, dry wells, cisterns, rain gardens, and site topography—that can mitigate and/or minimize damage from severe weather events.

**R A.5** If structural interventions to a historic building or site are warranted, consult building professionals—such as structural engineers, architects, local code officials, and contractors—to ensure that any intervention is appropriately calculated and that the building or site is structurally capable of withstanding the intervention as well as any displaced wind or water loads.

**R A.6** Install or implement temporary and permanent protective measures in ways that do not destroy or damage character-defining materials, features, and spaces of a historic property. If interventions include major ground disturbances that may impact buried remains, consult with professional archaeologists to assess the need for monitoring the site work or conducting a pre-disturbance survey.

**R A.7** Implement resiliency adaptations in ways that minimize their visual impact on the historic character and appearance of a historic building and site and, where applicable, larger historic district.

# B Temporary Protective Measures *for* Resilience

# OVERVIEW

***This section addresses temporary protective measures, which are non-permanent modifications that are made in anticipation of severe weather or flooding events and removed afterward. Measures to temporarily protect damaged historic properties in the immediate aftermath of flooding, wind-driven rain, and high-velocity winds are also discussed in this section. Typically, temporary measures are relatively inexpensive modifications and do not require a Certificate of Appropriateness (COA) or historic preservation commission staff review unless their installation involves permanent changes to the exterior of a historic property. However, there may be other local regulations that apply to such installations or that define the timeframe for their removal. Because most temporary measures require someone to be on-site to install or deploy them quickly when storms are looming, they are not ideal for historic properties in areas where rapid flooding occurs frequently.***

SANDBAGS, BUILDING WRAPS, temporary dams, and floodgates are all temporary flood protection measures that are effective for short-term, shallow flooding events. Stacked in doorways and lower-level window openings, sandbags are the most common temporary protective measure associated with short-term flooding. They are readily available and simple to install and remove. A variety of similar reusable products in various shapes and sizes filled with sand or synthetic pellets are also available and serve the same purpose for repeated use. Extending downspouts to take runoff water farther away from a building's foundation is another temporary protective measure that can minimize water infiltration during heavy rains. Flood wrapping systems attach to a building's lower perimeter to provide a temporary waterproof barrier for buildings structurally stable enough to withstand the hydrostatic pressure of flood water. Temporary dams and free-standing flood barriers can encircle a building and protect it from flood forces but are consequently more complex to install and deploy. Floodgates are removable flood barriers that block flood water penetration through door and window openings. They require permanently attached stanchions or other watertight

FIG. B1

**Figure B1:** *At Revolution Mill in Greensboro, temporary floodgate slats are stored on brackets close to the entry doors for quick access in anticipation of flooding.*

FIG. B2

**Figure B2:** *Steel tracks flanking the doorway opening were permanently attached by drilling through mortar joints in the brick. The slats are slid into the tracks to seal the entrance and protect the interior from flood damage.*

FIG. B3

***Figure B3:*** *On this Morehead City residence, high tensile–strength hurricane fabric panels, held in place with metal clips, offer temporary protection to door and window openings from high-velocity winds and flying debris.*

fastening systems that accommodate their insertion on masonry buildings. Floodgates should be stored in readily accessible locations to ensure that they can be quickly installed when needed. While they can be installed on the exterior or interior of an opening, installing them during severe weather on the exterior can be challenging.

Plywood, acrylic, and high–tensile strength hurricane fabric panels all offer temporary protection for windows and doorways from high-velocity winds and airborne debris. Custom-cut hurricane fabric panels are lightweight, easy to store, and allow light to filter through them, as do acrylic panels. Alternatively, 5/8-inch plywood panels can be cut on-site to securely fit within any opening. The repeated and rapid installation of temporary panels on a historic building requires hardware connections—such as non-corrosive hurricane clips and screws or countersunk bolts with receiving cups that are permanently attached to the building. Care should be taken to limit the quantity and location of such hardware fasteners to minimize their visibility. Sealants used for recessed joints to minimize water penetration and deterioration of surrounding historic material should also be applied cautiously. If the exterior envelope of a historic building is damaged by strong winds, falling trees, and floating or airborne debris, heavy-duty tarps can provide temporary protection until permanent repairs can


FIG. B4

FIG. B5

FIG. B6


FIG. B7

*Clockwise from top left—**Figure B4:** Multiple tarps protect the roof and chimney of this Tarboro house damaged by a fallen tree during Hurricane Irene until repairs can be made. **Figure B5:** Lower portions of the exterior siding on this house in New Bern were temporarily removed to allow the wall cavities, interior wainscot, and finishes to dry out from flooding. **Figure B6:** This metal flood gate can be quickly installed within steel tracks attached to the gate opening to this Charleston, S.C. property when flooding is anticipated. **Figure B7:** Sandbags stacked over a plastic sheet create inexpensive temporary flood protection for this shop doorway in Biltmore Village.*

be made. Keep in mind that major repairs can often take six months or longer.

Because any temporary flood protection system can fail, allowing water to seep into a building, it should be backed up by sump pumps and emergency generators located above the established flood risk level. In situations where power fails, even a hand pump, bucket, and mop are helpful to have on-site. When temporary flood protection measures fail, it is essential that all resulting debris and sediment are quickly removed and the building is allowed to dry out thoroughly after the flood waters recede. Open windows and doors (especially when there


*Clockwise from top left—**Figure B8:** Plywood panels provide temporary protection for window openings and exterior wall areas of this New Bern house damaged by Hurricane Florence. **Figure B9:** Wooden elements retained in place after being inundated with over 30-inches of floodwaters at Williams Hall on the Carolina Industrial School campus were slowly dried out and treated with a borate preservative to deter future mold growth and insect damage. **Figure B10:** The damaged gable roof of the Tileston School in Wilmington was temporarily protected by the installation of a synthetic rubber roofing membrane. **Figure B11:** Corrugated drainpipe extensions were used to temporarily carry rainwater further away from the foundation of this Edgecombe County house. **Figure B12:** Low heat and a dehumidification system were utilized to dry out the Masonic Building in Wilmington after flooding.*

is no power), forced air systems utilizing fans and low heat, dehumidifiers, and temporary air systems can all expedite the drying-out process. Historic materials contaminated by flood waters can often be dried, cleaned, disinfected, repaired if necessary, and retained in place. Wooden elements exposed to flood water or moisture should also be treated with a borate-based preservative to deter future mold, fungal growth, or insect damage.

Should severe weather or flooding expose buried archaeological remains on a historic site, the N.C. Office of State Archaeology can advise property owners on best mitigation practices.

# B RESILIENCE STANDARDS FOR TEMPORARY PROTECTIVE MEASURES

*Use these design standards in conjunction with applicable local preservation design standards and the Secretary of the Interior's Standards for Rehabilitation.*

**R B.1** When planning temporary protective resiliency adaptations to a historic building or site, identify, retain, and preserve the historic materials, features, and spaces of the building, site, and setting that are important in defining the historic character of the property and site. Assess their existing capacity for resilience as well as their known vulnerabilities.

**R B.2** Select temporary barriers or systems that (1) will protect the historic building and site from the anticipated type of flooding or wind damage and (2) can be deployed with the available warning times, labor, and equipment.

**R B.3** Assess the ability of a historic building's masonry walls and any temporary flood barriers or wrapping systems covering masonry openings to withstand the forces of flooding. Consult with a structural engineer to determine whether the existing walls will require reinforcing to withstand such forces.

**R B.4** Install free-standing temporary flood barriers or dams with adequate clearance from any historic structure wall to ensure that the forces of water against the barrier are not transferred to the building.

**R B.5** For openings in existing solid masonry perimeter walls, install removable flood gates or barriers that are braced or strong enough to withstand the forces of flooding.

**R B.6** Attach temporary removable barriers, floodgates, and protective window panels with fasteners or stanchions in ways that do not damage or alter a property's historic materials and character, and do so in locations that minimize their visibility.

**R B.7** In anticipation of severe weather or hurricanes, install temporary pre-cut plywood, high–tensile strength hurricane fabric, or acrylic panels to protect historic windows. Size temporary panels to fit within the window openings. Install panels with non-corrosive hurricane clips or other fasteners that minimize damage to historic woodwork or masonry during installation and allow for quick installation and removal of panels as needed.

**R B.8** In anticipation of severe weather and flooding, install temporary door shields, wraps, or gates in doorway entrances. Secure those in place with non-corrosive stanchions or tracks that minimize damage to adjacent historic woodwork or masonry and that also allow for quick installation and removal.

**R B.9** Promptly remove moisture, sediment, and debris from storm-damaged historic buildings that suffer water intrusion. Clean and disinfect all affected surfaces promptly and treat wooden elements with a borate-based preservative to deter future mold, fungal growth, or insect damage. In addition to natural ventilation through operable windows and doors, where feasible, enhance the elimination of moisture from the building interior using forced-air systems with low heat and fans and/or temporary ventilation and dehumidification systems.

**R B.10** Protect storm-damaged roofs, chimneys, and exterior walls of a historic building with heavy-duty tarps or protective wraps until repairs can be made. Ensure that they do not impede moisture evaporation from the building's interior.

**R B.11** Where storm-damaged windows or doors are removed for repair or replacement, install pre-cut panels of $^5/_8$-inch plywood or acrylic sized to fit all openings to temporarily protect a historic building's interior from damage. Install panels with minimal damage to surrounding historic woodwork or masonry.

# C Adapting Historic Sites and Landscapes *for* Resilience

# OVERVIEW

***Maintaining the relationship of a building to its site and setting is key to preserving a property's historic character. Fortunately, many flood, wind-driven rain, and high-velocity wind mitigation options involve on-site or off-site changes that do not alter the features, materials, or spaces of a historic building or site. However, such resiliency adaptations must be planned and executed to mitigate any negative impact on the historic property's integrity; significant landscape features; and cultural, religious, or archaeological resources. Further, proposed changes to the way water moves through a property may also impact neighboring properties—both upstream and downstream—and may also trigger compliance with other local ordinances.***

KEEPING STORMWATER AND flooding away from a historic building can sometimes be achieved through relatively small-scale adaptations such as gently re-grading the site so that water is diverted away from the building and its foundation, adding soil fill to the crawl space so its grade is raised higher than the grade outside its perimeter, and employing infiltration trenches and other underground drainage systems to rapidly move water away from the building. Cisterns, dry wells, sump pumps, swales, berms, and retaining walls can all increase the ability to control or contain stormwater on-site. Also, pruning foundation plantings to maximize airflow and evaporation can speed post-flood or -storm drainage and well-spaced vegetation and hedgerows can act as windbreaks to control wind and soil erosion.

FIG. C1

**Figure C1:** *To minimize the visual impact when this New Bern house was elevated 5 feet above grade, fill was used to raise the front yard grade within a low retaining wall and a low hedge was added along the side elevation.*

Mature trees close to historic properties should be monitored and pruned or removed if necessary, as they can cause substantial damage to buildings and cemeteries during severe weather events. Diseased trees are particularly at risk from the power of high-velocity winds, warranting their preventative removal. Archaeological sites, cemeteries, and other significant site features are vulnerable to disturbance and damage from severe weather events, and it is important to protect them in place. However, in locations where flooding and severe weather events are ongoing, relocation according to best preservation practices may be the most appropriate resiliency strategy. Also, if resilience modifications that require major ground disturbance are planned, the N.C. Office of State Archaeology can advise on whether the work warrants monitoring and/or a pre-disturbance survey by an archaeological firm to assess the potential significance of buried materials and the anticipated impact of the proposed modifications.

Reducing or removing hardscape surfaces and improving on-site water retention at a historic property will lower the amount of runoff and

FIG. C2

FIG. C3

FIG. C4

*Clockwise from left—**Figure C2:** 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. **Figure C3:** A pedestrian bridge spans Buffalo Creek to connect parking areas that are above the established flood risk level to the buildings at Revolution Mill. **Figure C4:** A large, grassy median with a brick walkway creates a permeable area that subdivides a paved parking lot in Biltmore Village.*


***Figure C5:*** *Two bands of brick pavers flank a planting strip to create a permeable driveway surface in Beaufort's historic district.*

mitigate stormwater on the property. Crushed oyster shells, brick pavers, pea gravel, or natural stone driveways allow for water infiltration, as do traditional ribbon driveways with narrow brick or concrete runner bands separated by a planting strip. However, gravel driveways, depending on the size and shape of the crushed stone, can become so compacted by vehicular traffic over time that they become impermeable surfaces.

MAINTAINING THE RELATIONSHIP OF A BUILDING TO ITS SITE AND SETTING IS KEY TO PRESERVING A PROPERTY'S HISTORIC CHARACTER.

Fortunately, there are a variety of eco-friendly contemporary permeable pavement materials and modular pavers available for walkways, driveways, and parking areas that can replace traditional asphalt and concrete hardscapes. Some modular systems are designed with recesses to contain fine gravel or grass. Installing at least 4 inches of well-draining gravel or structural soil—a mixture of gravel and soil that




***Figure C6**: Concrete paver modules have been installed to create a permeable parking surface for accessing this dock in Beaufort. The openings in the modules can be filled with gravel or plantings.*

***Figure C7** (top): Monumental stones in this Tarboro graveyard were damaged by trees felled by Hurricane Irene. **Figure C8** (bottom): These monumental stones have been carefully repaired and reset.*

provides a root-penetrable, high-strength pavement base—provides a permeable, high–compressive strength surface that reduces stormwater runoff. However, without ongoing maintenance, silt from run-off and soil erosion can clog below-grade gravel beds and drain lines. Adjacent bioswales can help filter out silt and debris. Some large permeable parking drainage systems incorporate underground water collection systems that require maintenance from a street sweeper or vac truck to remove sediment and debris that can clog them.

At the larger scale of historic landscapes and historic districts, resiliency adaptations include maintaining or installing off-site floodwalls and levees and improving or replacing existing stormwater management systems to reduce surface floods and reverse-flow flooding. Gutter filtration systems can be incorporated as well to keep debris and silt from blocking stormwater drains. For properties and districts with adjacent natural water management systems such as living shorelines, beaches, dunes, rivers, creeks, and wetlands, it is critical to maintain, restore, and improve these systems as needed to ensure their continued effectiveness.

## *C* RESILIENCE STANDARDS FOR ADAPTING HISTORIC SITES AND LANDSCAPES

*Use these design standards in conjunction with applicable local preservation design standards and the Secretary of the Interior's Standards for Rehabilitation.*

**R C.1** When planning resiliency adaptations to a historic site, identify, retain, and preserve site and landscape features, materials, and spaces that are important in defining the historic character of the site and setting, including the topographic and spatial relationship to historic buildings. Assess their existing capacity for resilience as well as their known vulnerabilities.

**R C.2** Implement resiliency adaptations to a historic site and setting in ways that minimize the visual impact on the historic character and appearance of the property and, where applicable, the historic district.

**R C.3** Utilize historic and non-historic site features—such as infiltration trenches, dry wells, cisterns, rain gardens, swales, and other rain-collection systems—to contain stormwater on-site if the visual impact on the historic character of the site is minimal.

**R C.4** Protect and maintain the site, setting, and landscape features of a historic property to ensure that surface water flows away from historic buildings and to prevent damage or erosion of foundations and landscapes.

**R C.5** Protect historic buildings from damage caused by falling trees or branches by pruning trees close to buildings as needed to minimize the potential damage and by removing them if they are diseased or pose an imminent danger to the historic property.

**R C.6** Protect and avoid disturbance to cemeteries, buried archaeological remains, religious or cultural features, and other significant site features to reduce the risk of damage or destruction from severe weather events. If significant site features cannot be preserved in place, follow local design standards and best preservation practices for their relocation.

**R C.7** If resiliency site adaptations require major ground disturbance that may disturb buried archaeological remains, monitor the site work and/or have an archaeological firm conduct a pre-disturbance survey to assess the potential significance of buried materials that may be impacted.

**R C.8** For large-scale adaptations, restore and/or improve on-site or adjacent natural water control systems, including wetlands, rivers, living shorelines, beaches, and dunes.

**R C.9** Construct site features such as berms, retaining walls, levees, flood walls, or embankments that are compatible with the historic property on property adjacent to but outside the site or historic district to increase flood protection for the site or district.

**R C.10** Limit the size of new walkways, driveways, and parking areas on a historic site to retain as much permeable landscape as possible and utilize permeable paving or paver systems to minimize their impact on surface flooding during heavy rains. Where needed, increase soil permeability below pavers with structural soil.

**R C.11** It is not appropriate to divert runoff stormwater from heavy rains onto neighboring properties.

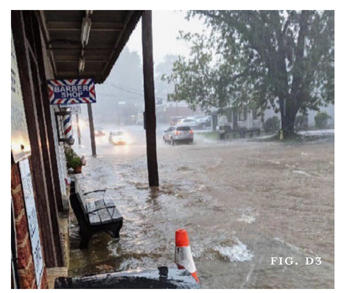
# D *Adapting Public Rights-of-Way* *for* Resilience

# OVERVIEW

***Features of public parks, squares, streets, and sidewalks that may contribute to their historic character include sculptures, art installations, street furniture, retaining walls, structures, vegetation, and streetlights. It is important to ensure that such features in a public right-of-way are inspected and properly maintained or repaired so they are storm resistant. Likewise, street trees require inspection, appropriate pruning, and replacement when identified as a safety hazard due to disease or storm-damage. Overhead power lines are particularly susceptible to damage from falling trees and airborne debris. Although significantly more expensive to install than overhead power lines, buried power lines provide protection from power outages triggered by severe weather events.***

THE EXISTING STORMWATER management and filtration systems in many historic districts are often undersized for today's storm sewer demands, resulting in nuisance flooding when there are heavy rains or storms. This issue is particularly problematic for downtown commercial areas where grade-level storefronts abut public rights-of-way and, consequently, repeated flooding events impact both the commercial properties and the streetscape proper.








*Clockwise from left—**Figure D1:** Water retention structures with planters are being installed between the sidewalk and curb at several intersections within the Beaufort Historic District to collect future flood waters. **Figure D2:** From Hurricane Frances in 2004 to Hurricane Florence in 2018, the public rights-of-way in Biltmore Village have flooded multiple times. **Figure D3:** Multiple flooding events in downtown Mt. Pleasant, including a 9-inch deluge from Hurricane Florence, left investors fearful of future flooding and hesitant to rehabilitate historic properties. A recent downtown stormwater study identified deficiencies to be corrected within the state-maintained public right-of-way that will protect the adjoining buildings. **Figure D4:** A large street tree in the public right-of-way uprooted by Hurricane Isabel caused substantial damage to this Wilson house. **Figure D5:** Permeable gravel parking bays edged by contoured concrete curbing surround the perimeter of the two floodplain parks in Greensboro's Fisher Park Historic District.*


***Figure D6:*** *In New Bern, the public right-of-way served as the temporary repository for flood-damaged building materials and debris following Hurricane Florence.*

The resurfacing of older streets has often eliminated the original crown to the street and also resulted in new paving layers covering the street gutter along the curb. These changes to the paved street surface thwart the intended funneling of water off the street into the lower gutter band to reach the storm sewer drain. Re-grading streets and modifying sidewalks to slope toward storm sewer drains via the street gutter band will better control and direct the flow of water runoff.

THE EXISTING STORMWATER MANAGEMENT AND FILTRATION SYSTEMS IN MANY HISTORIC DISTRICTS ARE OFTEN UNDERSIZED FOR TODAY'S STORM SEWER DEMANDS RESULTING IN NUISANCE FLOODING WHEN THERE ARE HEAVY RAINS OR STORMS.

Controlling and directing the path of water in public rights-of-way requires a thorough and holistic understanding of the impact such changes will have on nearby properties—both upstream and downstream. Qualified engineers and landscape architects can offer the expertise needed to assess proposed drainage mitigation strategies. Beyond the massive task of improving or replacing undersized stormwater management systems, the addition of


***Figure D7:*** *Raised planting beds line the public right-of-way and elevate the grade from the sidewalk to the property line of this infill building in Biltmore Village.*

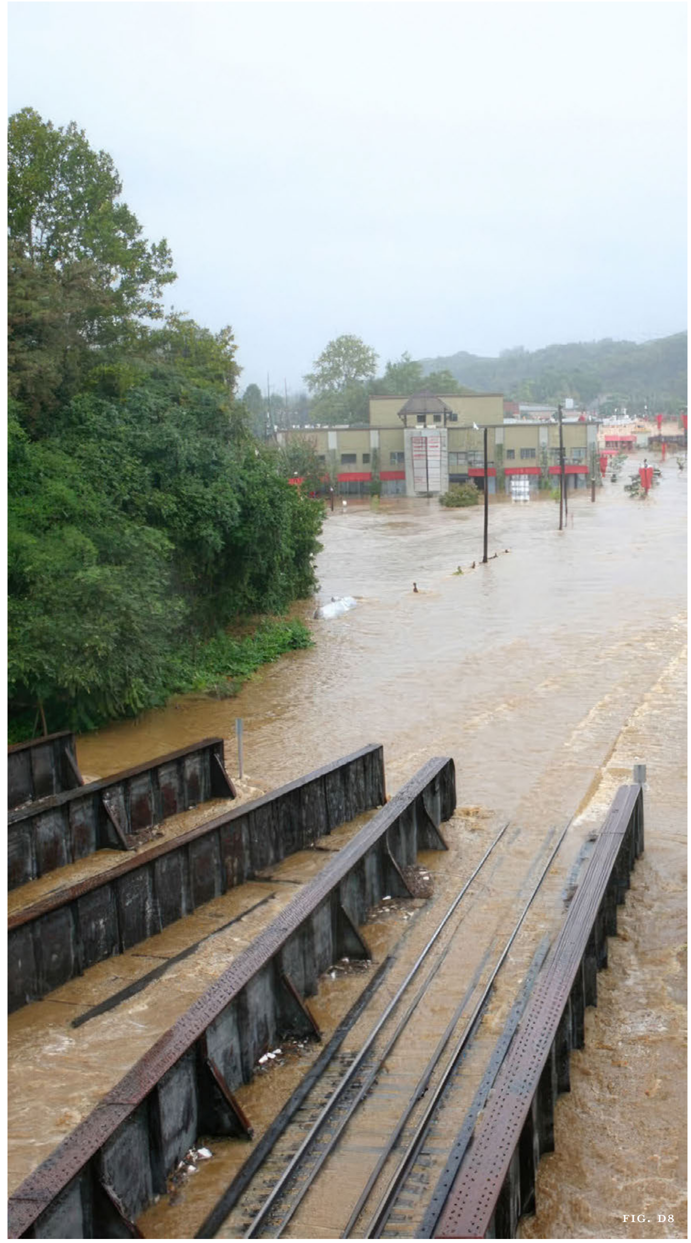



***Figure D8:*** *From Hurricane Frances in 2004 to Hurricane Florence in 2018, the public rights-of-way in Biltmore Village have flooded multiple times. The railroad tracks as well as streets leading to Biltmore Village were flooded in 2004 by Frances.*

backflow-prevention devices and filtration systems can prevent clogging and facilitate the flow of stormwater below grade. Reducing the amount of hardscape surface in public rights-of-way can help mitigate the quantity of surface stormwater runoff. Creating planting strips between street curbs and sidewalks and using porous or permeable paving surfaces for sidewalks, pathways, and parking areas are examples of ways to green public rights-of-way and increase their resilience. The introduction of structural soil—a mixture of gravel and soil that provides a root-penetrable, high-strength pavement base beneath permeable paving and in turf areas where urban trees are planted—provides a permeable, high–compressive strength surface that reduces stormwater runoff and enhances plant root growth in these areas.

FIG. D9

*__Figure D9:__ Temporary floodgate panels were installed to protect this commercial storefront that abuts the public right-of-way from flooding.*


FIG. D10

*__Figure D10:__ Sand-filled fabric tubes can help prevent loose mulch, plant matter, and debris from flowing into nearby storm sewer drains during heavy rains.*

Water collection features and water containment and holding systems incorporated into public rights-of-way are additional ways to mitigate and divert stormwater flow. However, keep in mind that no matter how efficient stormwater systems are, they will be overwhelmed during severe flooding events.

Beyond flooding issues, high-velocity winds during severe weather events can wreak havoc on mature street trees, overhead powerlines, and streetlights, causing damage to both public rights-of-way as well as adjoining private property. Both airborne and floating debris can create dangerous conditions on streets and sidewalks during storms and often contribute to hazardous conditions during post-disaster clean-up.

# *D* RESILIENCE STANDARDS FOR ADAPTING PUBLIC RIGHTS-OF-WAY

*Use these design standards in conjunction with applicable local preservation design standards and the Secretary of the Interior's Standards for Rehabilitation.*

**R D.1** When planning resiliency adaptations to public rights-of-way, identify, retain, and preserve features, materials, and spaces that are important in defining the historic character of a public right-of-way. Assess their existing capacity for resilience as well as their known vulnerabilities.

**R D.2** Select adaptive resilience treatments in a public right-of-way that minimize the impact on the historic character and visual appearance of the streetscape and/or the historic district.

**R D.3** Protect and maintain public rights-of-way and adjacent historic properties by providing proper drainage and ensuring that stormwater runoff does not flow toward adjacent historic buildings and landscapes.

**R D.4** When repaving streets, ensure that the intended slope from the crown of the street to the gutter band leading to stormwater drains is maintained to facilitate proper drainage of stormwater runoff within public rights-of-way.

**R D.5** Improve existing stormwater management and filtration systems or design new systems including backflow-prevention devices, for public rights-of-way to reduce surface floods and reverse-flow flooding so that water does not flow back through the system to flood through flood drains.

**R D.6** Protect and maintain streets, sidewalks, curbs, gutters, sculptures, fountains, street furniture, streetlights, street signs, and other historic constructed features in public rights-of-way through regular inspections and routine maintenance. Repair flood- or storm-damaged features using accepted preservation methods.

**R D.7** Protect and maintain street trees, planting strips, and other natural landscape features in public rights-of-way through regular inspections and appropriate maintenance including proper trimming and pruning. Replace all diseased, storm-damaged, or dead street trees that present a safety hazard with healthy trees of similar species or appearance.

**R D.8** Protect and maintain public rights-of-way and prevent storm debris from clogging storm sewers by promptly removing storm debris from streets, curbs, and sidewalks.

**R D.9** Utilize permeable surfaces or pavers for new walkways and parking areas in public rights-of-way to reduce their impact on surface flooding during heavy rains or severe weather events.

# E

## *Dry Floodproofing* *for* ***Resilience***

## OVERVIEW

***Dry floodproofing is a resiliency adaptation intended to keep water out of a building or specific parts of a building during flooding. To accomplish this, all exterior portions of the building foundation must be treated to provide a watertight seal below the established flood risk level. All interior spaces below the established flood risk level must be sealed as well, and all door, window, and vent openings that are partially or entirely below the established flood risk level must be permanently sealed or adapted so they can be temporarily sealed prior to a severe weather event.***

DRY FLOODPROOFING IS most effective for areas where flooding is infrequent and where the established flood risk level is 3 feet or less. It is only an option for historic buildings with load-bearing masonry walls or foundations that can withstand the hydrostatic pressure of flood waters, buoyant forces, and the impact of debris borne by the flood waters. Evaluating the strength of masonry to withstand such forces requires the expertise of a structural engineer to determine if structural reinforcement and the anchoring of a building to its foundation are necessary to prevent movement or collapse from flood pressures. For buildings that implement dry floodproofing, evacuation during severe weather is still necessary in case a structure proves unable to withstand calculated loads or flooding exceeds the anticipated flood risk level causing walls to collapse and/or the flooring to buckle.

Maintaining a masonry foundation in good repair is essential to dry floodproofing, as is the temporary or permanent blocking of any openings that extend below the established flood risk level to prevent water infiltration. The application of a waterproof membrane or coating to a masonry foundation in less-visible locations below the established flood risk level may be warranted, but it should be approached with caution as it may accelerate the deterioration of the foundation by trapping moisture within the foundation and significantly increasing the wicking

FIG. E1


FIG. E2

***Figures E1, E2:*** *Floodgates protect 20 doorways at Revolution Mill in Greensboro, including the entrances to the Main Mill House, where freestanding floor-mounted brackets have been installed to store the floodgate slats within the entry vestibule for easy access.*

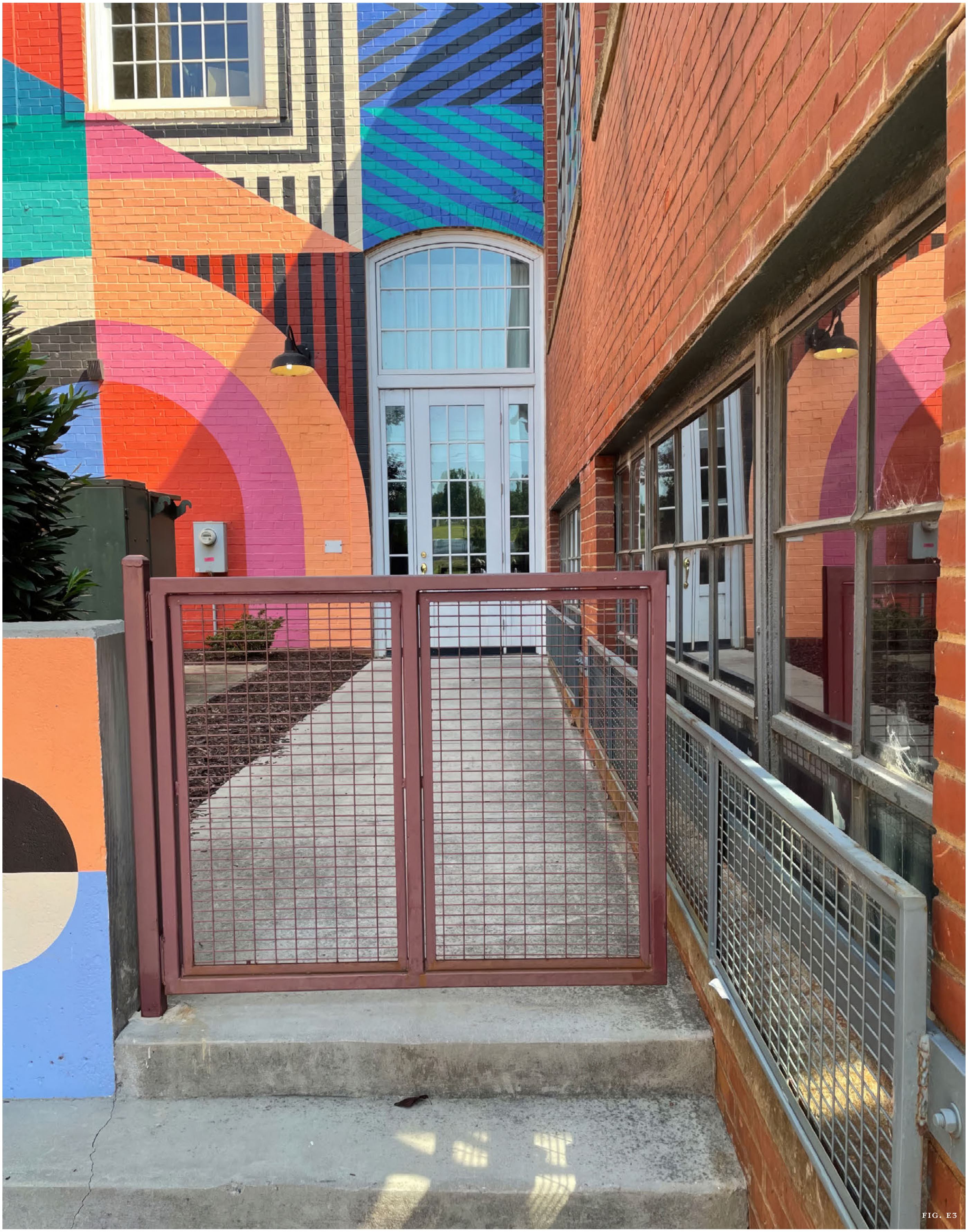


FIG. E3

***Figure E3:*** *Metal gates and grilles protect entrance walkways and window areas that fall below the established flood risk level from waterborne debris on the Revolution Mill campus. The use of impact-resistant laminated glass in the lower window sashes further protects the building interiors from water intrusion.*

FIG. E4

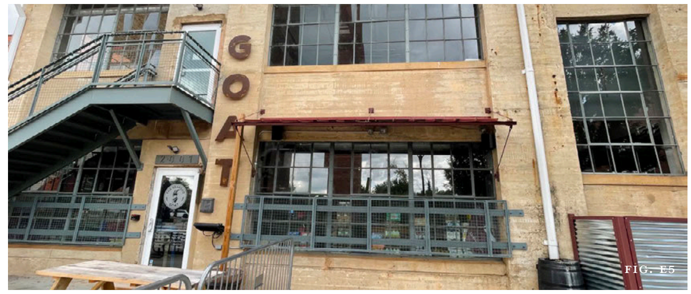




FIG. E5

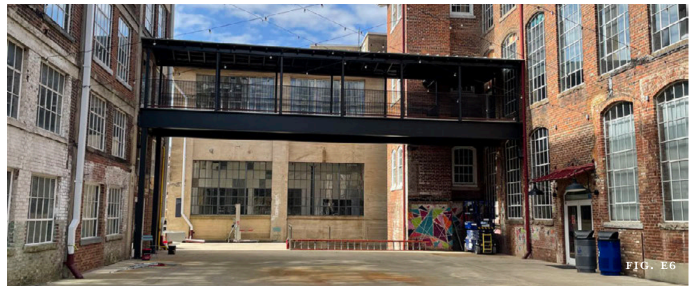


FIG. E6

FIG. E7

*Clockwise from top left—**Figure E4:** At Revolution Mill in Greensboro, river rock was added to the grade beneath the Carpenter's Shop to slow erosion from flood waters, and metal mesh panels were suspended just below the first floor to protect suspended plumbing lines and ductwork from waterborne debris. **Figure E5:** Metal grilles and laminated glass panes protect storefront windows below the established flood risk level from floating debris during flooding, and an exterior stair provides access above the flood risk level to the second floor of this commercial space at Revolution Mill. **Figure E6:** A new elevated pedestrian bridge at Revolution Mill now provides safe egress between the second floors of the Main Mill House and the 1250 Building during flooding events, such as in Figure E7. **Figure E7:** A flooding event at Revolution Mill.*

of groundwater much higher up within the exterior walls—a phenomenon called rising damp—causing unintended deterioration of the structure. If a waterproof coating is needed, select one that is compatible with and will not damage any historic masonry. Also, keep in mind that any applied coating or membrane will require ongoing inspection and maintenance to ensure that it remains waterproof. Given the limited dry floodproofing application options, the damage such coatings may cause to existing historic foundations, the necessary alterations to a building's exterior, and the associated costs and maintenance, dry floodproofing coatings or membranes are generally not appropriate resilience adaptations for historic buildings.

Because some moisture will inevitably find its way into a building that is dry floodproofed, it is important to raise utilities, mechanical units, and ductwork above the established flood risk level and prepare the basement or crawl space to drain any seepage by installing a sump pump with a back-up power source and backflow-prevention devices. The addition of an infiltration drainage system around the building's perimeter, which will take water away from the foundation and prevent reverse-flow drainage, is also recommended.

# E RESILIENCE STANDARDS FOR DRY FLOODPROOFING

*Use these design standards in conjunction with applicable local preservation design standards and the Secretary of the Interior's Standards for Rehabilitation.*

**R E.1** In planning dry floodproofing adaptations to historic buildings, identify, retain, and preserve exterior features that are important in defining the historic character of the building, including its form, historic materials, and functional and decorative features.

**R E.2** Inspect, protect, and maintain historic exterior walls and foundations of buildings to ensure that they are intact. Repair or replace in kind damaged or deteriorated features as necessary following best preservation practices and applicable design standards. It is not appropriate to remove a significant historic feature or material rather than repair it.

**R E.3** Consult with a structural engineer to determine whether the foundation of a historic building can withstand the hydrostatic pressure of flood waters, buoyant forces, and the impact of flood-borne debris. Develop a plan to reinforce the foundation and anchor the structure to the foundation as necessary to prevent collapse or movement of the building due to flood forces.

**R E.4** Implement dry floodproofing methods only on masonry buildings or frame buildings with masonry foundations when the established flood risk level falls below the height of the foundation.

**R E.5** Apply a membrane or waterproof coating to the foundation of a historic building below the established flood risk level that is compatible with and does not damage the historic masonry or trap moisture within the foundation. Monitor the coating or membrane to ensure that it remains impermeable and recoat or replace it as needed to maintain its effectiveness.

**R E.6** Where needed for adequate ventilation, install foundation vents that can be closed and sealed in advance of anticipated flooding.

**R E.7** Install temporary flood shields on any character-defining window and door openings of buildings that extend into the established flood risk level. For openings in less visible locations, install temporary flood shields or compatible masonry infill panels recessed within the opening so the opening profile is still visible.

**R E.8** Install a drainage system around a historic building's foundation perimeter to effectively move water away from the building after flooding or heavy rains. Monitor and maintain the drainage system to ensure that it does not get blocked or clogged over time and hold moisture near the foundation.

**R E.9** For existing or replacement foundations on historic buildings, install backflow-prevention devices and sump pumps with a backup power source per the Resiliency Standards for Utilities and Systems to manage reverse flow drainage in plumbing lines and seeping and drainage within a building's basement or enclosed foundation.

# F Wet Floodproofing *for* Resilience

# OVERVIEW

***Wet floodproofing is a resiliency strategy that allows flood waters to move through openings in the crawl space, basement, or lower interior spaces of a historic building and then drain out as the flood waters recede. This strategy is most appropriate in situations where flood events are infrequent and of short duration (less than 24 hours) and where the area that will be flooded is an unfinished space or one constructed of flood-resistant materials. Because of the difficulty of removing water within wall cavities, wet floodproofing is not recommended for wood-frame or veneer structures if anticipated flood waters would reach above the masonry foundation. Wet floodproofing is also not a recommended adaptation if flood waters would damage intact historic interior finishes and materials.***

FIG. F1

**Figure F1:** *Wet floodproofing at the Edenton Cotton Mill was achieved by converting the lower level of the mill to parking for residents.*

ALTHOUGH FLOOD WATERS within a building will equalize the hydrostatic pressure of the flood waters on-site, the foundation and historic structure of the building must be strong enough to withstand these pressures without collapse. A structural engineer can evaluate a building to determine if additional reinforcement or structural anchoring is needed.

To control the flow of flood water through a building's crawl space, basement, or building space below the established flood risk level, bi-directional flood vents must be installed that allow water to enter, move through, and exit the space. Also, there must be openings that allow for the free flow of water between any connecting enclosed interior spaces. Flood vents relieve hydrostatic pressure to reduce the risk of flood damage. The number and location of required flood vents are calculated based on the square footage of the building and the height of the established flood risk level. If existing foundation vents are character-defining features of a building, it is important to retain them in highly visible locations and to install additional flood vents that (1) are compatible with the historic foundation vents in design and placement or (2) are painted out to reduce their visibility. In addition to the installation




***Figure F2** (inset, below left): An Ocracoke cottage before Hurricane Matthew. **Figure F3:** After Hurricane Matthew, this Ocracoke cottage was elevated an additional 3'-9" on new brick piers. A wide skirtboard on the porch helps minimize the perceived increase in height. **Figure F4** (inset, above right): Wooden louvered panels installed between the piers allow flood waters to flow through the cottage's open crawl space.*

of flood vents for wet floodproofing in historic buildings, it is important to design a system to drain any water that collects within the space. Sump pumps with a backup power source, backflow valves, and perimeter drains are all effective in removing collected water and carrying it away from a building. Also, all utilities and mechanical systems must be permanently elevated above the established flood risk level or protected with a waterproof enclosure. The installation of a ground fault circuit interrupter (GFCI) will help protect a building's electrical system from flood damage.

Because traditional building materials such as brick, tight-grained wood, and lime-based plaster are inherently resilient, they should be allowed to dry out






*Clockwise in left column—**Figures F5, F6, and F7:** Bunn's Barbecue in Windsor adopted a wet floodproofing strategy for its small, one-story building. Post-flooding, the owners rely on the supportive community to help stack tables and chairs, squeegee the floors to eliminate the mud and muck, and hose down and sanitize the building before drying it out and reopening.*

***Figure F8:** Some basement areas in this commercial block that abut 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. **Figure F9:** Fortunately, the resilient ceramic tiles on this corner building have survived multiple floods intact.*

slowly in place, which will likely require an extended drying-out period post-flooding. Increased natural ventilation through operable windows and doors, forced-air ventilation, low heat, and the use of fans can significantly accelerate the process. Using high heat to rapidly dry out a space can damage historic materials and finishes, so its use is not appropriate.

As flood waters and the associated mud and silt can carry a variety of contaminants, all surfaces exposed to flood waters must be carefully cleaned of residue and sanitized to destroy any pathogens prior to beginning any repair work on historic buildings. In addition, the application of a borate-based preservative to exposed wood surfaces is recommended to prevent future deterioration due to fungal or insect infestations. In retrofitting interior spaces with seriously damaged or non-historic finishes, it is appropriate to install compatible water-resistant and impervious substitute materials in a manner that will not result in damage to existing historic fabric and finishes.

FIG. F10

FIG. F11

***Figures F10 and F11:*** *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.*

# *F* RESILIENCE STANDARDS FOR WET FLOODPROOFING

*Use these design standards in conjunction with applicable local preservation design standards and the Secretary of the Interior's Standards for Rehabilitation.*

**R F.1** In planning wet floodproofing adaptations to a historic building, identify, retain, and preserve exterior features that are important in defining the historic character of the building, including its form, historic materials, and functional and decorative features.

**R F.2** Inspect, protect, and maintain historic exterior walls and foundations of buildings to ensure that they are intact. Repair or replace in kind damaged or deteriorated features as necessary following best preservation practices and applicable design standards. It is not appropriate to remove a significant historic feature or material rather than repair it.

**R F.3** Implement wet floodproofing methods in locations where the materials and finishes are flood-resistant, the impacted space is unoccupied or can be vacated, and any furnishings can be removed for the time necessary to clean and dry the space out following a flood event.

**R F.4** In locations on a historic building below the established flood risk level, replace deteriorated or damaged historic materials or features with flood-damage-resistant substitute materials if they will not impact the historic character of the building or damage remaining historic materials.

**R F.5** Consult with a structural engineer to determine whether the foundation of a historic building can withstand the hydrostatic pressure of flood waters, buoyant forces, and the impact of flood-borne debris. Develop a plan to reinforce the foundation and anchor the structure to the foundation as necessary to prevent collapse or movement of the building due to flood forces. Where needed to relieve hydrostatic pressure caused by flood waters, install flood vents that are compatible in design and placement with existing foundation vents.

**R F.6** Design a system to drain the historic building safely and efficiently as flood waters recede on the site. Install backflow-prevention devices and sump pumps with backup power per the Resilience Standards for Utilities and Systems to manage reverse-flow drainage in plumbing lines and seeping and drainage within the foundation.

**R F.7** Retain existing foundation vents in highly visible locations, if feasible.

**R F.8** Relocate all utilities and mechanical units in a historic building above the established flood risk level or protect them in a watertight enclosure. Protect the building's electrical system by installing a ground fault circuit interrupter (GFCI).

**R F.9** Post-flooding, thoroughly clean and sanitize all surfaces in a historic building that have been exposed to flood waters using the gentlest possible means to remove flood-borne bacteria, mold, and surface grime. Coat wood surfaces with a borate-based preservative to prevent deterioration caused by fungal or insect infestation.

**R F.10** Prior to repairing any flood damage to the interior of a historic building, use temporary or permanent ventilation systems, dehumidifiers, low heat, and fans as needed to thoroughly dry all spaces and materials that were impacted by flood waters.

# G Elevating Buildings *for* Resilience

# OVERVIEW

***Elevating historic buildings a nominal amount to raise them above the established flood risk level without significantly impacting their historic character is generally possible; however, it can be a challenging and expensive resiliency strategy. Because each building and site presents a different combination of design and construction challenges, and because floodplain regulations vary by locality, there is no universal approach that can be applied across the board. A successful strategy depends on numerous factors, including building size, form, massing, style, materials, foundation type, porches, and setting. Elevating a historic building also requires consideration of the impact the change will have on adjoining properties and, where applicable, on a district streetscape.***

AS FEMA FLOODPLAIN maps are developed at the macro-scale and cover large areas, it is recommended that property owners obtain an Elevation Certificate (EC) for their properties. An EC is prepared by a licensed surveyor and includes a survey delineating a property's elevation above mean sea level and a listing of the building's location, flood zone, and lowest point of elevation. The EC confirms at the micro-scale a property's or building's elevation in relation to the base flood elevation and helps verify the established flood risk level more accurately for the property. An EC is an important step in determining the amount of height increase required to help mitigate flood risk. Consulting with building professionals—including structural engineers, architects, contractors, and local code officials—to determine the viability of elevating a building and the structural repair and reinforcement that would be

FIG. G1

FIG. G2

***Figure G1:*** *This Ocracoke house was subject to flooding and needed to be raised 3'-9" to meet the established flood risk level.* ***Figure G2:*** *In 2017, taller piers were constructed to elevate the building, and fill sand was added to fill a depression beneath the house and ensure that the grade in the crawl space was slightly higher than the surrounding site. Horizontal cedar board sheathing was installed between the new brick piers and two additional rows of cedar shingles were added to the base of the house to minimize the perceived pier height. No water entered the house during the 2019 hurricanes.*


***Figure G3:*** *To elevate all three Shelter Neck UU Camp (formerly, Carolina Industrial School) buildings in Pender County at least 6 feet, a combination of strategies has been proposed to mitigate the increased elevation while maintaining the buildings' historic integrity: increase the height of the foundation walls, install retaining walls 10–15 feet away from each building's footprint, add fill that slopes from the foundations to the retaining walls, and screen the foundation walls with vegetation.*

required is an essential step in planning a change in elevation. Likewise, it is important to consult with preservation professionals to ensure that a change in elevation will not compromise the character and integrity of a historic building to the point that it loses its National Register of Historic Places status or its status as a contributing building in a listed National Register Historic District. Also, keep in mind that while the established flood risk level is determined locally (and is subject to change as flood plains shift or expand), FEMA regulations allow for variances for buildings listed on the National Register of Historic Places to minimize a change in elevation height to only that height necessary to avoid flood hazards.

Large load-bearing masonry buildings, buildings with shared party walls, and buildings with slab-on-grade foundations are especially challenging candidates for elevation due to how they have been constructed. This resilience method works best for frame buildings with crawl spaces and pier or post foundations. However, the elevation of frame buildings should only be considered if the established flood risk level is higher than the existing foundation or piers. The process involves lifting a building above its historic foundation or piers onto temporary cribbing or steel beam supports while the height of the existing foundation or piers is extended or the entire foundation is replaced to achieve the desired change in elevation. The elevation of character-




*Clockwise from top left—**Figure G4:** Following hurricane floods in 2004, the Biltmore Market Gardener's Cottage in Asheville was elevated approximately 2 feet. Substantial plantings in the front yard visually screen the increased height of the foundation. **Figure G5:** This Biltmore Village infill project reflects the district's architectural character and addresses wet floodproofing principles by elevating the first floor above the established flood risk level. A raised sidewalk above the vented foundation wall helps visually minimize the increased height. **Figure G6:** Although elevated approximately 5 feet above grade, the consistency of the raised foundation height and setback of these adjacent New Bern houses still maintain the character of the historic district streetscape.*

defining porches, chimneys, additions, and exterior stairs to align with the change in finished floor level must also be addressed thoughtfully.

Determining how much a building can be elevated is contingent on many factors including the topography and size of the site; setback from the street; and building configuration and its exterior detailing, including existing porches, chimneys, foundation, foundation vents, and exterior stairs. Retaining a building's character-defining form, features, and overall proportion, whether vertical or horizontal in orientation, are all important considerations. Given these parameters, elevating a historic building high enough to provide a raised basement space or parking area beneath it is rarely an appropriate solution.

Creative use of existing or new site features and strategic changes to site topography can help mitigate a perceived change in building height. For example, adding fill beneath the building and around the building's perimeter before sloping the grade away from the building, the introduction of terracing or berms, and the selective placement of foundation plantings are all site modifications that can screen and minimize the visual impact of the new foundation height. In addition to these strategies, the installation of low retaining walls or fences can create




***Figure G7:*** *The foundation of this 2018 infill house in the Beaufort historic district elevates the first floor above the established flood risk level. Plantings visually screen the foundation height.* ***Figure G8:*** *The landscaping in front of this elevated Biltmore Village shop visually screens the raised foundation.* ***Figure G9:*** *When this New Bern house was moved, it was elevated above the established flood risk level. A low retaining wall with fencing set between brick piers minimizes the perceived height of the foundation along the side yard.*

a strong horizontal line that visually ties the building to the ground.

The design, detailing, and structural reinforcement of a modified or new foundation or piers are critical to the successful elevation of a historic building. See the "Adapting Historic Foundations for Resilience" section on page 35 for information and details on the appropriate modification or replacement of historic foundations and piers.

# *G* RESILIENCE STANDARDS FOR ELEVATING HISTORIC BUILDINGS

*Use these design standards in conjunction with applicable local preservation design standards and the Secretary of the Interior's Standards for Rehabilitation.*

**R G.1** When elevating a historic building to protect it from flooding, identify, retain, and preserve materials and features of the building that are important in defining its historic character, including its exterior walls. Utilize or replicate historic foundation treatments and materials.

**R G.2** Elevate a frame building only if the established flood risk level extends above the height of the building's masonry foundation.

**R G.3** Consult with a structural engineer or architect and local building code official to determine if a historic building is structurally stable enough to elevate and what structural repair and reinforcement is necessary. If additional reinforcement is needed, locate it within the walls, crawl space, or other inconspicuous locations.

**R G.4** Employ a historic building's and site's existing features and attributes—including the size, topography, and configuration of the building site as well as the existing building foundation, building height, porches, terraces, and exterior stairs—to minimize the visual impact of an increased elevation on the historic character of the building.

**R G.5** Ensure that a change in a historic building's elevation maintains both the visual relationship between the building and significant site features—such as mature trees, walls, and fences—as well as the building's relationship to adjoining properties and, where applicable, to the district streetscape.

**R G.6** Where feasible without significantly impacting adjacent properties or the streetscape, minimize the visual impact of the relationship between a change in elevation and to the adjacent grade through techniques such as increasing the height of the grade and/or adding terracing, foundation plantings, low fencing, or a retaining wall.

**R G.7** Ensure that a change in building elevation does not alter the character-defining form, proportion, and features of the primary building facade.

**R G.8** Elevate porches and additions that contribute to a property's historic character to maintain their relationship to the main building.

**R G.9** Ensure that an elevated building design meets applicable resilience design standards for foundations, chimneys, porches, and exterior stairs.

**R G.10** It is not appropriate to elevate a historic building that incorporates a raised basement rather than wet floodproof the basement level.

**R G.11** It is not appropriate to elevate a historic building to accommodate parking beneath it.

# H Adapting Historic Foundations for Resilience
## OVERVIEW

***In modifying or replacing a historic building's foundation or piers to prevent flood damage, it is critical to preserve the overall historic character and appearance of the building. To this end, consideration should be given to the size, configuration, topography, and landscaping of the site; the height, mass, proportion, form, orientation, and construction type of the building; and existing setback, adjacent properties, and local building code regulations.***


FIG. H1

***Figure H1:*** *Original, recessed windows in the foundation of the Biltmore Gardener's Cottage were retained when the foundation was raised, and they continue to provide daylight, as well as ventilation when opened, to the basement space.*

IT IS ESSENTIAL to consult with a structural engineer or architect as well as a local code official to determine whether a historic building is structurally stable enough to be elevated and whether its existing foundation is capable of being extended or if a new foundation is necessary. In addition to supporting a building, a modified or new foundation must also be capable of resisting lateral forces from the increased height, storm surges, and wind loads. Resisting these forces in an adapted or new foundation may require structural reinforcement. Any foundation reinforcement with non-historic materials, such as concrete blocks or cast-in-place concrete, should be installed so that it is not visible on the building's exterior. Because foundation treatments must be building-specific, it is best to provide contractors with specifications as well as elevations and plan drawings that clearly communicate any proposed foundation work.

The type of replacement foundation selected should factor in the anticipated type of flooding. For example, fast-moving flood waters will do less damage to structurally supported open pier foundations than to closed foundations. Likewise, foundations with piers connected by break-away masonry curtainwalls will remain more structurally stable during fast-moving floodwater events than solid masonry foundations. The installation of operable flood vents in solid masonry foundations will allow for the flow of flood waters into and out of any crawl spaces and provide protection


***Figure H2:*** *The new foundation of this New Bern house raises its first-floor level 5 feet above grade and approximates the configuration of its original brick piers with pierced brick infill panels that will allow future flood waters to flow through.*


***Figure H3:*** *This mid-twentieth-century Ocracoke house was raised approximately 2 feet with fill sand, and a new concrete-block foundation with decorative block vents was constructed. A low block retaining wall defines a planting bed around the foundation and helps to minimize the change in height, as does the addition of 2 lower bands of siding that wrap the upper portion of the new foundation.*

from fast-moving flood waters. Calculating the number, size, and location of flood vents is best done in consultation with building professionals. On primary elevations, select flood vents that approximate the appearance of existing foundation vents or screens and recess them within the foundation wall to minimize their visibility. For pier foundations, the installation of traditional curtain panels of pierced brick, wooden louvers, or lattice recessed between the piers allows for ventilation and the passage of flood waters. Painting wooden panels in a darker color will further minimize their visibility.

Where an existing foundation or piers can be adapted or replaced in kind, it is important to approximate the appearance of the historic foundation in masonry color, size, texture, and bond pattern; mortar joint width, color, and profile; pier placement, width, and spacing; and other visual features and details—including foundation vents—especially on the principal elevation and other highly visible locations. Using salvaged brick or stone can also minimize the visibility of the foundation extension. If a non-traditional material such as cast-in-place concrete is necessary for structural reinforcement or stability of a foundation of a historic building, face the material with a veneer of the original foundation material so

IN MODIFYING OR REPLACING A HISTORIC BUILDING'S FOUNDATION OR PIERS TO PREVENT FLOOD DAMAGE, IT IS CRITICAL TO PRESERVE THE OVERALL HISTORIC CHARACTER AND APPEARANCE OF THE BUILDING.

FIG. H4

*__Figure H4:__ A new brick foundation with pierced brick panels was constructed to elevate this New Bern house and its front porch approximately five feet above grade.*

FIG. H5

*__Figure H5:__ The extended porch steps in the small front yard now end just short of the sidewalk.*

that any non-historic materials are not visible from the exterior.

The perceived height of a building's new or adapted foundation can be mitigated in several creative ways, such as by overlapping the bottom courses of exterior siding and trim or porch skirt boards to conceal the last few courses of the foundation; adding fill both within the crawl space and the foundation perimeter; and selectively adding foundation plantings, fencing, or low retaining walls to further screen the foundation.

THE TYPE OF REPLACEMENT FOUNDATION SELECTED SHOULD FACTOR IN THE ANTICIPATED TYPE OF FLOODING.

Because the finished floor level of a slab-on-grade building basically aligns with the surrounding site grade, its elevation requires abandoning the slab and installing a new structural support system. Maintaining the original relationship of the building to the site will likely require regrading and adding substantial fill beneath and around the foundation to more closely approximate that character-defining relationship.

FIG. H6

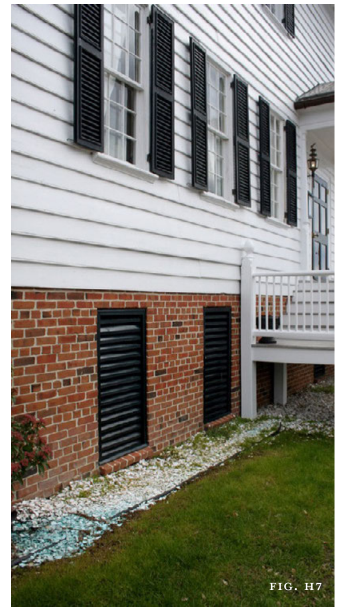


FIG. H7

FIG. H8

FIG. H9

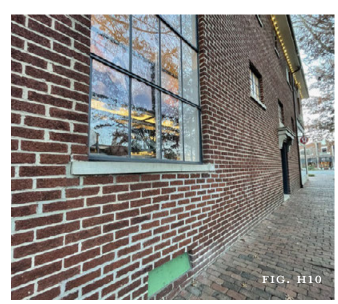


FIG. H10

*Clockwise from left—**Figure H6:** A low hedge and recessed pierced brick panels minimize the visual impact of the raised brick pier foundation for this porch in the Beaufort Historic District. **Figure H7:** When the Barker House in Edenton was elevated following Hurricane Isabel, flood vents were incorporated into the brick foundation. **Figure H8:** New brick piers with recessed brick infill panels were used when the ca.1857 Octagon House in Hyde County was elevated approximately 2 feet to reduce water damage and improve ventilation. **Figure H9:** Original, pierced brickwork vents in the foundation provide ventilation for the crawl space beneath the first floor of the Edenton Cotton Mill building. **Figure H10:** When the basement of this commercial building in Biltmore Village was filled, the foundation vent opening was retained but sealed closed to prevent moisture infiltration.*

# *H* RESILIENCE STANDARDS FOR HISTORIC FOUNDATIONS

*Use these design standards in conjunction with applicable local preservation design standards and the Secretary of the Interior's Standards for Rehabilitation.*

**R H.1** When planning resiliency adaptations to a historic building, identify, retain, and preserve or replace in kind historic foundation materials and features that are important in defining the historic character of the building, including foundations and foundation vents that will be impacted by elevating the building.

**R H.2** Inspect, protect, and maintain historic foundation materials and features to minimize damage from flooding and severe weather. If damaged or deteriorated, repair them as necessary following best preservation practices and applicable design standards. It is not appropriate to remove a significant foundation material or feature on a historic building rather than repair it.

**R H.3** When increasing the height of a historic foundation or masonry piers, consult with a structural engineer, architect, and/or local building code official to determine if additional structural reinforcement is needed. Locate additional reinforcement within the walls, crawl space, or other inconspicuous locations.

**R H.4** When elevating a historic building, design new masonry foundations and modify historic building's foundations to accommodate additional height so as to be visually compatible with the historic character of the building and the original foundation in terms of the masonry color, size, and bond pattern as well as the mortar joint color, width, and profile. Align the exterior face of the foundation with the exterior plane of the building sill.

**R H.5** Design raised foundations for mid-twentieth-century buildings constructed with slab-on-grade to be compatible with brick or concrete foundations typical of that era.

**R H.6** Design new piers to be compatible in placement, width, and spacing with the character of the historic building. Align the face of the piers with the exterior plane of the building framing so that exterior siding and skirtboards overlap them.

**R H.7** Re-grade the area beneath a historic building's new foundation or piers as necessary to retain the relationship between the building and its site and to ensure that the grade around the foundation slopes away from the building to provide proper drainage.

**R H.8** Install recessed panels between piers constructed of traditional materials such as brick or wood. Pierced brick panels and wooden louvered and lattice panels all allow for the free flow of water. Paint wooden louvers or lattice panels in dark colors to reduce their visibility.

**R H.9** On primary elevations, locate and design new flood vents to look similar in appearance and placement to historic foundation vents. If needed, use modern flood vents on secondary elevations and in areas obscured by features such as porches.

**R G.10** Where appropriate, minimize the visibility of increased foundation or pier height on a historic building by using salvaged masonry materials on the primary elevation, extending siding or skirtboards below the top of foundation walls or piers, adding fill to raise the grade, and using screening with foundation plantings, fencing, or low retaining walls.

# I

## *Adapting Historic Porches, Entrances & Stairs* *for* ***Resilience***

# OVERVIEW

***Porches, porticos, stoops, other exterior entrances, and front steps are typically prominent features of historic buildings. Given their exposure, they often receive the brunt of severe weather and high winds and require ongoing maintenance and repair. Like roofs and foundations, in areas prone to hurricanes and flooding, these features may also need additional reinforcement to resist such forces intact. Particular attention should be paid to reinforcing a historic building's structural connections, from the roof and rafters to the columns or post to the foundation or piers. Hurricane connectors and other types of reinforcement and bracing should be thoughtfully located to minimize their visibility on the building's exterior.***

PANELS OF HURRICANE fabric like those used for windows and doors may be warranted to provide temporary protection of porches from airborne storm debris, and the permanent installation of fasteners for temporary panels should follow the same guidelines as those used for windows and doors.

When a historic building is elevated, character-defining porches and other entranceways must be elevated as well to maintain both their alignment with the building's finished floor height and their relationship to the building's façade and foundation. The elevation of these features should follow the resiliency design standards used for elevating buildings and foundations. The replacement or extension of any existing porch pier foundation should be coordinated with the adaptation of the main foundation and requires the same assessment of structural stability necessary for reinforcement.

Elevating the floor of a porch or other building entranceway so that it is more than 30 inches above grade requires the addition of a railing (where there is none) to meet building code requirements and enhance safety. New handrails and balusters should be compatible in material and detail with the architectural character of the building.

FIG. I1

FIG. I2

***Figure I1:*** *In Burgaw, when this house was elevated 30 inches, the wraparound porch was elevated on new brick piers.* ***Figure I2:*** *The original porch columns and railings were retained, and the steps were extended to accommodate the increased porch height.*

FIG. 13

***Figure 13:** If the Shelter Neck chapel is elevated an additional 6 feet, a mechanical lift will access the front porch from the raised site area above the proposed retaining wall. A ramp will be installed to provide access from the existing site grade to the raised area above the retaining wall, eliminating the need for a ramp that would have been longer than 100 feet and longer than the area of the chapel itself.*

Simple versions of traditional porch elements that complement rather than compete with existing historic trim work are most appropriate. If the height of existing balustrades must be increased due to the new elevation, consider the addition of a simple guardrail that does not compete with the existing balustrades.

Accommodating the increased height of a porch or other entrance floor above grade will also require the extension of existing steps or the addition of new stairs. Given their visibility, adding steps to front porches or to an entranceway on the primary façade can draw attention to the extended height of the porch foundation. Retaining the original stair



***Figure 14:*** *View of the Duncan House in Beaufort prior to being elevated.* ***Figure 15:*** *The Duncan House was elevated on a new brick foundation and porch piers — without significantly impacting its historic character or the character of the district streetscape. The foundation vents between the porch piers were painted a dark color to make them visually unobtrusive and the porch steps incorporate traditional cutouts in the risers, allowing water to drain off and enhancing ventilation beneath them.*

GIVEN THEIR EXPOSURE, PORCHES, PORTICOS, OTHER EXTERIOR ENTRANCES, AND FRONT STEPS OFTEN RECEIVE THE BRUNT OF SEVERE WEATHER AND HIGH WINDS AND REQUIRE ONGOING MAINTENANCE AND REPAIR.

location, width, and detailing is usually the most understated and appropriate strategy for achieving a unified appearance. However, for significantly longer runs, creating a landing or a change in stair materials, design, or orientation can visually break the length of the stair and can also accommodate site restraints. Where site restraints are challenging, relocation and/or reorientation of the stairs may be necessary. As is true of all foundations that are elevated, the perceived height of elevated porches and entrances can be mitigated by the selective addition of fill to increase the site grade, the


FIG. I6

FIG. I7

FIG. I8


FIG. I10

FIG. I9

*Clockwise from upper left—**Figure I6:** The change in width of the lower porch steps and the placement of newel posts on the third step reduces the visual impact of the increased height of the elevated porch on this house in Washington. **Figure I7:** When this New Bern building is elevated an additional 27 inches, it will be moved back 4 feet so that the new brick porch steps will not extend past the property line along the street elevation. A brick planter the height of the original foundation will extend along the property line in front of the elevated foundation. **Figure I8:** When this Ocracoke house and porch were elevated 3'-9", the existing porch posts were replaced with wooden posts. **Figure I9:** The new porch floor of the Ocracoke house rests on the brick piers that previously supported the bungalow-style posts. Traditional wooden railings and steps were added to accommodate the added height of the porch above grade. **Figure I10:** A simply detailed ramp provides handicapped access to the raised shop entrance in Biltmore Village.*

addition of foundation plantings, and the addition of low retaining walls or fencing that visually screen the height.

The challenge of providing handicapped access to elevated porches and entrances may be addressed by the addition of a ramp, mechanical lift, or elevator following appropriate design standards.

# *I* RESILIENCE STANDARDS FOR HISTORIC PORCHES, ENTRANCES AND STAIRS

*Use these design standards in conjunction with applicable local preservation design standards and the Secretary of the Interior's Standards for Rehabilitation.*

**R I.1** When planning resiliency adaptations to a historic building, identify, retain, and preserve porches, stoops, porticos, and other entrances that are important in defining the historic character of the building, including their form, historic materials, and functional and decorative features such as stairs, columns, posts, railings, trim work, stairs, and foundations.

**R I.2** Inspect, protect, and maintain historic porches, porticos, and other entrances to ensure that they are intact and that all material joints are properly flashed or sealed and all decorative and functional features are securely attached to the structure to minimize damage from severe storms and high winds. If damaged or deteriorated, repair as needed following best preservation practices and applicable design standards. It is not appropriate to remove a significant feature or material rather than repair it or replace it in kind.

**R I.3** Reinforce the resistance of a historic building's porch or other entrances to severe weather events by installing hurricane connectors and additional bracing in inconspicuous locations to securely anchor them to the structure of the main building and foundation. Connect individual structural elements of a porch or entranceway—including beams, plates, posts, columns, and rafters—to each other to increase their stability and anchor any posts or columns securely to flooring.

**R I.4** If a historic building is elevated and an existing porch or entranceway is structurally capable of being elevated, ensure that it retains its original alignment with the building's finished floor level when elevated. Follow all applicable resilience design standards for foundations and elevated buildings.

**R I.5** If a change in elevation requires the addition of a porch railing or an extension of an existing railing with guardrails, design a simple railing or extension to be compatible with and deferential to the historic character of a porch or entranceway.

**R I.6** When extending or constructing new stairs for an elevated porch or entranceway, maintain the location and approximate width of the original stairs and reuse historic stair elements and railings, if feasible. Design new newels to match existing newel posts in design and dimension where possible or design simple newels that are compatible with the original newels and railings in scale, material, and details.

**R I.7** If a new stair to an elevated porch or entranceway will result in a significantly longer run of steps, create a landing or a change in materials, design, or orientation to visually break the length of the stair and/or to accommodate the stairs within the setback of a shallow lot.

**R I.8** If replacing a historic building's masonry steps, match the original stair in design, scale, size, shape, material, and texture.

**R I.9** Follow local design standards for accessibility if a change in porch or entranceway elevation requires the installation of a ramp, mechanical lift, or elevator to accommodate handicapped accessibility to the historic building.

# J Adapting Historic Windows and Doors *for* Resilience

## OVERVIEW

***Windows and doors are two of the most distinctive character-defining architectural components of historic building exteriors. While traditionally constructed and detailed to be resilient in terms of shedding water and preventing air infiltration, they are vulnerable to damage from powerful storms and flooding. Keeping windows and doors well maintained, weather-stripped, and caulked contributes to a building's resiliency and sustainability by ensuring that weathertight seals prevent water and air infiltration around window and door openings and, in turn, protect the building's interior from damage.***

TRADITIONALLY, OPERABLE LOUVERED or paneled shutters were used to provide hurricane protection for historic windows. They remain an effective defense today so long as they are in good condition and can be securely fastened in the closed position. If appropriate for the architectural style of a house, the introduction of operable shutters protects historic windows while increasing their resiliency to weather events. When shutters are closed, they should fill the window opening, with each leaf covering the full height and half the width of the window. Traditional shutters are constructed of wood, but in some situations, the use of period-appropriate operable shutters constructed of a proven damage-resistant substitute material (such as synthetic wood) that meets design standards for substitute materials and matches the configuration, color, and texture of traditional wood shutters may be an appropriate substitution.

Installing impact-resistant acrylic panels to the reverse face of operable shutters adds additional protection that is visible only when the shutters are closed in anticipation of a storm. Using stainless steel screws with neoprene washer spacers to attach the acrylic panels to the shutters protects the shutters from moisture damage.

The installation of storm windows and doors adds a layer of protection and increases energy efficiency. Storm windows can also be paired with operable shutters to provide a double defense for historic windows. The selection of narrow-profile storm windows finished in colors that are compatible with the window sash or exterior trim color of a historic building minimizes the appearance of storm windows, as does the alignment of operable storm window dividers with the meeting rail of the existing double-hung window sashes.

WINDOWS AND DOORS ARE TWO OF THE MOST DISTINCTIVE CHARACTER-DEFINING ARCHITECTURAL COMPONENTS OF HISTORIC BUILDING EXTERIORS.

FIG. J1

FIG. J2

***Figure J1** (above): The established flood risk level from Buffalo Creek runs 3 feet above the first floor of the Main Mill Building at Revolution Mill in Greensboro.* ***Figure J2** (inset): To protect the building interior from floating debris during flooding, the lowest band of window lights in the original windows was replaced with laminated glass and protective metal grilles were installed in front of them.*

FIG. J3

FIG. J4

FIG. J5

FIG. J6

FIG. J7

***Figure J3:*** *The operable wooden shutters on the Bellamy Mansion (foreground) and its slave quarters (background) in Wilmington are routinely closed and secured in anticipation of hurricanes to protect the windows and interior from storm damage.* ***Figure J4:*** *To properly secure window openings without damaging trimwork when damaged sashes are removed to make repairs, install a plywood panel over the opening and clamp 2x4s (inside and outside) with carriage bolts.* ***Figure J5:*** *Slide bolts at the top and bottom and a security bar across the width of the double doors in this Louisburg house reinforce them and offer extra protection of the interior during severe weather events.* ***Figure J6:*** *Attaching these operable shutters with longer hinges allows them to close over storm windows in this Martin County House, providing dual protection from severe weather.* ***Figure J7:*** *Shutters fabricated of synthetic wood with traditional details and hardware like those used on the Edmond Hoskins Store in Edenton are an appropriate resilience adaptation for historic windows in storm-prone areas.*

The introduction of impact-resistant laminated glass for new windows or the replacement of damaged glazing in existing windows in a historic building offers significant protection from severe storms and airborne or waterborne debris that could shatter glass in windows, storefronts, and entry locations that are vulnerable to flooding. Wind-resistant films that do not alter the appearance of glass also offer protection from shattered glass caused by airborne debris.

In addition to permanently installed operable shutters or storm windows, detachable, temporary protection systems with plywood, fabric, or acrylic panels to protect historic windows and doors are available and effective alternatives. See the "Temporary Protective Measures for Resilience" section for additional information on temporary window-and-door protection systems. It is important to minimize damage to historic materials and surfaces when installing or removing temporary panels and hurricane shields. The careful installation of permanent non-corrosive metal hurricane clips, fasteners, or countersunk bolts with cup connectors can facilitate the rapid installation and removal of temporary panels without additional damage to historic materials.

# *J* RESILIENCE STANDARDS FOR WINDOWS AND DOORS

*Use these design standards in conjunction with applicable local preservation design standards and the Secretary of the Interior's Standards for Rehabilitation.*

**R J.1** When planning resiliency adaptations to a historic building, identify, retain, and preserve doors and windows that are important in defining the historic character of the building, including their functional and decorative features such as shutters and hardware.

**R J.2** Inspect, protect, and maintain doors, windows, shutters, and hardware to ensure that they are in working order and that all openings can be secured and/or protected during severe weather or hurricanes. Ensure that associated tiebacks, fasteners, bolts, and locks are anchored into frames or walls. If damaged or deteriorated, repair windows and doors, and their features, as necessary following best preservation practices and applicable design standards. It is not appropriate to remove a significant historic feature or material rather than repair it.

**R J.3** Install interior long-throw, slide bolts to the tops and bottoms of double-leaf doors to increase their resistance to airborne debris and high winds.

**R J.4** If shutters are appropriate for the architectural style of a historic building,or if existing shutters are not operable, install traditionally detailed, operable wood or approved synthetic-wood shutters sized to fit all window openings to protect historic windows from airborne debris and water infiltration.

**R J.5** Install acrylic panels to the reverse face of operable wood shutters to provide additional protection to windows from severe weather events when the shutters are secured in the closed position.

**R J.6** Introduce narrow-profile exterior storm windows that do not obscure or damage a historic building's existing sashes and frames to protect existing windows from water and wind infiltration. Select storm windows with a painted or factory-finish color compatible with the building's sash or exterior trim color. Align operable storm window dividers for double-hung windows with the meeting rail of existing sashes.

**R J.7** Install clear wind-resistant films that do not alter the appearance of existing window glass to provide protection from shattered glass due to high winds and airborne debris.

**R J.8** Select impact-resistant laminated glass for new windows or replacement glazing in existing windows to offer significant protection from severe storms and waterborne debris that could shatter glass.

**R J.9** In anticipation of severe weather or hurricanes, install temporary pre-cut plywood, high–tensile strength fabric, or acrylic panels to protect historic windows. Size temporary panels to fit within all window openings. Install panels with hurricane clips or other hardware fasteners that minimize damage to historic woodwork or masonry during installation and allow for quick installation and removal.

**R J.10** In anticipation of severe weather and flooding, install temporary door shields, wraps, or gates to doorway entrances. Secure them in place with non-corrosive stanchions or other fasteners that minimize damage to adjacent historic woodwork or masonry and that also allow for quick installation and removal.

**R J.11** Installation of permanent storm panels; track systems; or roll-up, sliding, or accordion-style shutters on historic residential properties is not appropriate.

# K Adapting Historic Roofs and Chimneys for Resilience

## OVERVIEW

***A well-maintained roof is a historic building's first line of defense in shedding rainwater, but roofs are susceptible to the threat of heavy winds that can cause serious structural damage through uplift as well as the loss of shingles, slates, tiles, or metal panels. Any decorative and functional elements that attach to or penetrate a roof plane—such as dormers, chimneys, skylights, cupolas, cornices, gutters, and downspouts—must be securely attached to withstand strong winds and, through intact flashing, keep their connections to the roof weathertight.***



***Figures K1 and K2:*** *In Elizabeth City, Hurricane Isabel seriously damaged the built-up roof of this historic commercial building, resulting in substantial interior damage as well (above). It has since been fully rehabilitated (below).*

ROUTINE INSPECTION OF roofs for signs of damage to or deterioration of roofing materials, replacement of loose nails or fasteners, and in-kind replacement of deteriorated surfaces are all essential in keeping historic roofs resilient. While slate, clay tile, and standing seam metal roofs are all extremely durable traditional roofing materials, severe weather events can take a toll on them. It is important to promptly secure any loose units and replace missing or damaged sections in kind. Likewise, it is equally important that standing seam and other ferrous metal roofs are kept painted to prevent them from rusting. Elastomeric coatings can further increase the resilience of standing seam roofs by protecting them from deterioration due to corrosion. Increasing the number of cleat fasteners on the lower portion of a roof plane and securing areas prone to lifting, like gable and eave edges, with screws instead of nails will strengthen the resistance of metal roofs to uplift from strong winds.

Concerns about the capability of a historic roof to withstand hurricane-strength winds may warrant consultation with a structural engineer to identify ways to reinforce the roof structure to resist uplift and strengthen the integrity of the roof structure by adding bracing or tie-down hurricane fasteners in attics or other inconspicuous locations. If roofing is being replaced, reinforcing the roof by securing sheathing to rafters or trusses can increase its resiliency, as will the installation of a water-and-ice-

***Figure K3:*** *The east chimney of the 1835 William T. Smith House collapsed due to the impact of Hurricane Florence.*
***Figure K4*** *(inset, bottom right)****:*** *A new chimney was constructed to match the original based on documentary photographs.*
***Figure K5*** *(inset, top left)****:*** *View of William T. Smith House after chimney repairs were completed in 2022.*

shield underlayment to sheathing when replacing an asphalt or architectural shingle roof. In addition, slightly upsizing replacement half-round gutters will increase their capacity to channel water away from the roof more quickly.

Masonry chimneys are distinctive features of many historic buildings that are at high risk of damage or collapse when exposed to hurricane-strength winds and tornadoes. Moisture penetration from heavy rains can also cause a chimney to deteriorate over time due to the related loss of mortar and spalling of brick. Metal chimney caps that prevent moisture entry through the flue must be securely anchored down using stainless steel cables and weights to resist high winds during severe weather events.

FIG. K6

FIG. K7

FIG. K8

FIG. K9

FIG. K10

FIG. K11

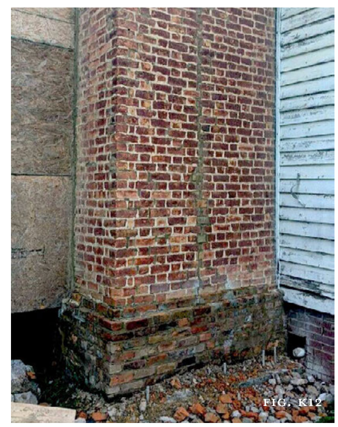


FIG. K12

***Figures K6 and K7:*** *Proposed repair of significant hurricane damage to East Arcadia Gym in Bladen County would include rebuilding the gable end wall, substantial repair of the exposed roof structure and sheathing, installation of new asphalt shingles, and interior repairs.* ***Figure K8:*** *Dormers on the roof of the N.C. Department of Natural and Cultural Resources Western Office suffered wind-driven rain damage from Hurricane Irma in 2017 requiring thorough drying out of the wood and repair to make them weathertight again.* ***Figure K9:*** *Hurricane Florence uplifted portions of the 1860 standing seam metal roof on the Bellamy Mansion.* ***Figure K10:*** *Once the standing seam metal roof on the Bellamy Mansion was repaired, an elastomeric coating was applied to the historic roof to extend its life.* ***Figure K11:*** *When this Ocracoke cottage was elevated, its chimney was also elevated and placed on a new brick base that matches the original chimney's shape and brick bond pattern.* ***Figure K12:*** *To secure the damaged west chimney of the 1835 William T. Smith House and keep it from collapsing, helical jacks were installed and the chimney base was repointed.*

When historic buildings are elevated, chimneys must also be elevated proportionally to retain their relationship to the building's interior and exterior. If a historic chimney is intact and structurally capable of being raised along with a building, accommodate the change in elevation with a new chimney foundation that is consistent with the shape and dimensions of the historic chimney and that matches the original masonry work in materials and appearance. If a chimney has collapsed or is not structurally stable enough to repair in place or to elevate, replace it with a new chimney that matches the size, configuration, materials, and appearance of the original chimney. Select masonry units that match the dimensions, shape, color, and texture of the original brick or stone and duplicate the original mortar joints in color, width, texture, and profile.

# *K* RESILIENCE STANDARDS FOR HISTORIC ROOFS AND CHIMNEYS

*Use these design standards in conjunction with applicable local preservation design standards and the Secretary of the Interior's Standards for Rehabilitation.*

**R K.1** When planning resiliency adaptations to a historic building, identify, retain, and preserve roofs and chimneys that are important in defining the historic character of the building, including their form, historic materials, and functional and decorative features such as gutters, downspouts, dormers, chimney caps, skylights, monitors, and cupolas.

**R K.2** Inspect, protect, and maintain historic roof forms, materials, fasteners, and features to ensure that they are intact and that all openings and roof penetrations are properly flashed and sealed and that all decorative and functional features are securely attached to the structure to minimize damage from severe storms and high winds. If damaged or deteriorated, repair roofs and their features following best preservation practices and applicable design standards.

**R K.3** Inspect historic chimneys for signs of damage or deterioration, including cracked or spalled bricks, missing mortar, loose fasteners, and detached flashing. Maintain and repair historic chimneys to minimize potential damage from severe weather events following best preservation practices and applicable design standards. It is not appropriate to remove a significant feature or material rather than repair it.

**R K.4** Assess with a structural engineer the structural capacity of a historic roof to withstand a severe storm and, if needed, add bracing and hurricane connectors in the attic or in other inconspicuous locations to reinforce the resistance of the existing roof to major storms.

**R K.5** If replacing deteriorated historic roofing, increase the structural stability of the roof by securing roof sheathing to the rafters or trusses and installing additional fasteners and hurricane connectors while the roof structure is exposed.

**R K.6** If replacing a standing seam or another metal roof in-kind, increase the number of cleats/fasteners installed in areas vulnerable to uplift to increase the roof's resistance to wind. Use screws instead of nails to securely install roofing panels along the gable end and rake of the roof. If feasible, incorporate a drip edge to prevent future deterioration beneath the roof edge.

**R K.7** If replacing an asphalt shingle or architectural shingle roof, install an ice-and-water-shield underlayment to exposed sheathing as an added barrier against water intrusion.

**R K.8** If a historic building is elevated and an existing chimney is structurally capable of being elevated with the building, ensure that the new elevated base matches the existing chimney base in design and size.

**R K.9** If a historic building is elevated and an existing chimney is not intact or structurally capable of being elevated with the building, construct a new chimney with an elevated base that matches the original in design, shape, and size.

**R K.10** For elevated chimney bases or new chimneys, match the bond pattern, dimensions, color, and texture of the original brick or stone. Duplicate the original mortar joints in color, width, texture, and profile.

**R K.11** It is not appropriate to install metal flashing on a historic building's chimneys, roof parapets, or visible elevations if it would compromise the distinctive features or historic character of the building.

# L Adapting Utilities and Systems for Resilience

## OVERVIEW

***Hurricanes, tornadoes, flood waters, and other severe weather events can wreak expensive havoc on the mechanical, electrical, and plumbing systems that service historic buildings. Beyond the initial damage that those events may cause, the subsequent failure of utilities and systems significantly impacts the post-disaster recovery process, when electricity, clean water, and mechanical ventilation are all essential. If flood waters or wind-driven rains have breached a building's exterior and its mechanical systems cannot function to circulate and remove moisture from the air, mold can form on interior surfaces within 24 to 48 hours. Likewise, a clean water supply and electrical power are needed to safely clean and decontaminate interiors to eliminate re-occupancy health concerns.***

ELEVATED WATER LEVELS can also inundate a building's sanitary sewer systems, especially those combined with storm sewer systems, and back up waste into buildings through drains and toilets. However, installing backflow-prevention devices in waste and sewer lines will prevent rising water from flowing back into the building.

Utilities and mechanical systems are typically installed at the first floor of a building, at grade on the building's exterior, in basements, or in crawl spaces—all locations that make them especially vulnerable to damage from flood waters. In areas at risk of flooding, elevating utilities and mechanical equipment above the established flood risk level is advisable and can be accomplished in a variety of ways. Raising electrical panels higher on the exterior wall of a building is often a relatively simple, low-cost preventive step with little visual impact on the historic character of the building. Adding an electrical disconnect, a Ground Fault Circuit Interrupter (GFCI), in an easily accessible location separate from a building's utility panel and well above the flood risk level provides additional protection, as does keeping a backup generator on-site in case of power outages.

HURRICANES, TORNADOES, FLOOD WATERS, AND OTHER SEVERE WEATHER EVENTS CAN WREAK EXPENSIVE HAVOC ON THE MECHANICAL, ELECTRICAL, AND PLUMBING SYSTEMS THAT SERVICE BUILDINGS.

A building's exterior mechanical units can often be elevated on platforms or raised bases above the flood risk level with minimal visual impact if they are located on a secondary or rear elevation. They can be visually screened by landscaping or fencing that still allows for service access and adequate ventilation. Because elevated exterior units will remain subject to severe weather, it is important to ensure that they are adequately supported and secured against high-velocity winds and that their connections are all weatherproofed. In cases where elevating exterior mechanical units is problematic or cost-prohibitive,

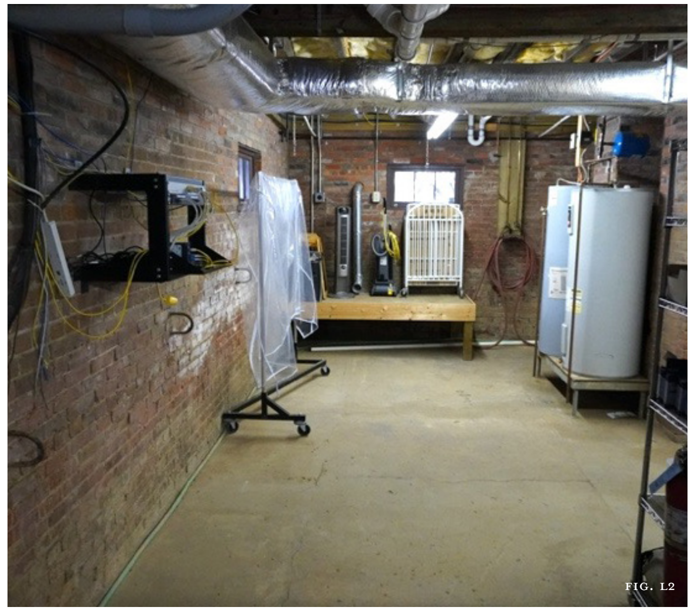



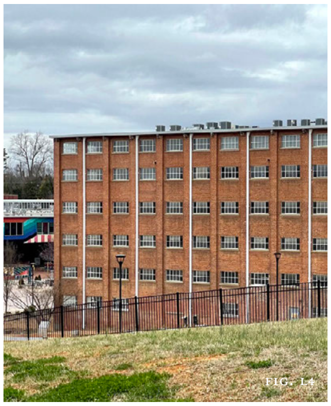


***Figure L1:*** *A ductless mini-split system mounted on a sturdy platform above the established flood risk level of this property on the sound in Atlantic increases its resilience to flooding.* ***Figure L2:*** *Mechanical ductwork, plumbing lines, and electrical lines were all moved higher when the Biltmore Market Gardener's Cottage was elevated. Water heaters and stored items were also raised at least a foot above the basement floor to prevent potential water damage.* ***Figure L3:*** *Sealed foundation vents, a sump pump, a dehumidifier, and a central drain reservoir all work to eliminate moisture in this basement.*

constructing a waterproof enclosure to maintain the exterior units in place is a logical alternative.

Where there is enough height, utilities and mechanical systems located within basements can simply be elevated above the established flood risk level.

Relocating units in crawl spaces or basement locations to higher utilitarian interior spaces, the attic, or even the roof may offer more protection from flood waters. It is also important to elevate or modify the ductwork configuration in crawl spaces or basements to prevent flood damage. Some seepage and moisture collection in a basement or crawl space location is to be expected during heavy rains or








*Clockwise from top left—**Figure L4:** HVAC units and solar panels installed far above established flood risk level on the roof of the Main Mill House are only minimally visible from distant elevated points of the Revolution Mill campus in Greensboro. **Figure L5:** A bank of electrical meters and panels screened from public view off the rear elevation of a property in the Beaufort Historic District were installed above the established flood risk level but are still accessible for servicing. **Figure L6:** New HVAC units for this elevated Ocracoke cottage were discreetly located on a raised platform aligning with the finished floor level on the side rear corner of the house. **Figure L7:** At St. Thomas Episcopal Church in Windsor, the mechanical unit was elevated on a secondary elevation and visually screened from view by lattice fencing. **Figure L8:** HVAC units and the electrical system are elevated above the established flood risk level on the side rear elevation of this commercial building in Biltmore Village.*

flooding, warranting the installation of a sump pump with a backup power source in the lowest level of a building to pump excess water away from the foundation.

Keep in mind that the lifecycle of mechanical systems is shorter than that of historic buildings. Therefore, depending on the age and condition of the unit, consider replacing an older mechanical system with a new system that can be installed above the established flood risk level. Ductless mini-split systems are one current replacement choice for smaller interiors that minimizes the need for ductwork.

# *L* RESILIENCE STANDARDS FOR UTILITIES & SYSTEMS

*Use these design standards in conjunction with applicable local preservation design standards and the Secretary of the Interior's Standards for Rehabilitation.*

**R L.1** Relocate a historic building's interior and exterior utility and mechanical equipment and related components—including electrical outlets and panels, water heaters, compressors, ductwork, generators, air handlers, elevator equipment, and telecommunication systems—above the established flood risk level or protect them in place with a watertight enclosure to prevent flood damage. Ensure that any penetrations for HVAC connections through exterior walls are tight and well-sealed to prevent moisture intrusion.

**R L.2** Ensure that relocated utilities, mechanical equipment, and fuel storage tanks are provided the space and ventilation necessary to function properly, are accessible for service and inspection, and are securely anchored in place to resist strong winds and flood waters.

**R L.3** Locate a building's elevated utility and mechanical equipment and components on rear or secondary elevations on a platform or base compatible with the building's historic character. Screen exterior mechanical units from view with fencing, low walls, latticework, or landscaping to minimize their visibility.

**R L.4** Install an electrical disconnect (GFCI) to protect the electrical system of a historic building in an easily accessible location well above the established flood risk area separate from the utility panel.

**R L.5** Install backflow-prevention devices in water and sewer lines to prevent pollution or contamination from reverse-flow water from heavy rains and flood waters.

**R L.6** Install a sump pump powered by a backup power source at the lowest level of the structure to reduce seepage and drainage from heavy rains and flood waters.

# M Adapting Commercial and Industrial Buildings for Resilience

# OVERVIEW

***The preceding resiliency standards are applicable to historic buildings regardless of use. However, due to their location and building type, historic commercial, industrial, and institutional buildings can present additional challenges in terms of resilience that are worth noting and may require additional flexibility.***

FIG. M1


FIG. M2

***Figure M1:*** *The massive masonry buildings at Rocky Mount Mills sited along the Falls of the Tar River were dry floodproofed when the historic complex was adapted for mixed use.* ***Figure M2:*** *Landscaped drainage beds buffer and separate fenced-in patio areas from the sloping Haw River site on the Granite Mill mixed-use campus.*

COURTHOUSES, SCHOOLS, CHURCHES, and storefronts are frequently located in downtown historic districts that rely on outdated or undersized infrastructures, making nuisance flooding a relatively common occurrence. Likewise, the siting of historic mills and factories beside rivers and creeks makes flash floods an ongoing concern. Historic commercial and institutional buildings are often two or more stories high and constructed with load-bearing masonry walls and heavy timbers. Elevating such heavy structures is unrealistic, leaving wet or dry floodproofing as the best adaptation for resiliency.

Historic mills and educational complexes with extensive campuses—whether in continued use or adapted for new uses—must accommodate vehicular circulation and large parking areas as well as pedestrian access between buildings, including handicapped accessibility. These historic properties require more complicated adaptation strategies to increase their resilience to severe weather and flooding than are typically needed for residential properties in historic districts. They often need to employ more extensive hardscape features, such as retaining walls and railings along site walkways between buildings, that are not appropriate for downtown commercial buildings that front public rights-of-way and have little opportunity for site modifications to front entrances.

For historic storefronts that no longer retain their original bulkheads (area below display windows), the introduction of a visually compatible waterproof

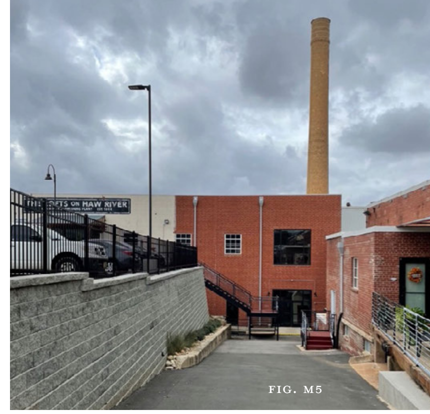





***Figure M3:*** *Rain barrels connected to downspouts on the secondary elevation of the Revolution Mill apartment building collect and contain rainwater that is subsequently used for site landscaping projects.* ***Figure M4:*** *A floodproof enclosure houses utility infrastructure units on the Granite Mill campus to protect them in case of flooding from the adjacent Haw River.* ***Figure M5:*** *Concrete-block retaining walls separate level parking areas above the established flood risk level from vehicular access to lower levels of the Granite Mill campus.*



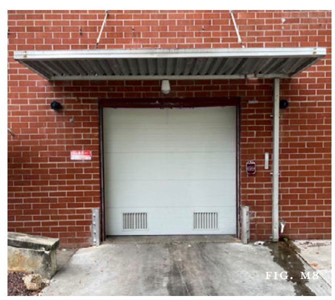



***Figure M6:*** *This Biltmore Village infill project incorporates wet floodproofing principles, with a wet basement parking area and lobby space on the lower level and retail spaces on the second floor above the established flood risk level.* ***Figure M7:*** *Given its proximity to the French Broad River and its relatively low site, the historic Madison County Courthouse's location in downtown Marshall is vulnerable to flash flooding.* ***Figure M8:*** *Metal stanchions installed to hold temporary floodgates flank this utilitarian roll-up door to a brewery's storage area on a rear elevation at Rocky Mount Mills.*

coating or water-resistant facing—such as ceramic tile, brick, or concrete panels—may be an appropriate resiliency adaptation for preventing moisture infiltration during short-term flooding events. Alternatively, the use of flood gates and flood panels as discussed in the preceding section on temporary protective measures may be a better choice.

For sites where damage from waterborne or airborne projectiles is anticipated during flooding or severe weather events, the introduction of laminated glass and metal grilles mounted in front of windows below the established flood risk level will help protect damage to the interior from shattered glass.

# *M* RESILIENCE STANDARDS FOR COMMERCIAL AND INDUSTRIAL BUILDINGS

*Use these design standards in conjunction with applicable local preservation design standards and the Secretary of the Interior's Standards for Rehabilitation.*

**R M.1** When planning resiliency adaptations to historic commercial and industrial buildings and sites, identify, retain, and preserve features that are important in defining the historic character of the property, including their form, materials, spaces, and site features following all applicable preceding resiliency design standards.

**R M.2** Utilize historic and non-historic site features—such as infiltration trenches, dry wells, cisterns, rain gardens, bioswales, and retaining walls—to control the flow of stormwater on-site if the visual impact on the historic character of the property is minimal.

**R M.3** Install water-resistant exterior or interior materials and coatings if a building's historic materials are damaged or deteriorated beyond repair. Replacement materials and coatings should visually approximate the scale, pattern, and texture of the original materials and coatings.

**R M.4** Install permanent flood barriers, panels, and walls on secondary or tertiary building elevations only if the loss or alteration of historic building materials can be minimized.

**R M.5** Install temporary flood panels on primary elevations if the installation does not result in a loss of historic building material and if stanchions or fasteners are relatively inconspicuous when panels are not in place. For masonry buildings, install fasteners of stainless steel or other corrosion-resistant metal through mortar joints to prevent damage to bricks.

**R M.6** House infrastructure and HVAC units above the established flood risk level or within watertight enclosures in locations that minimize their visual impact on the historic character of a site.

**R M.7** Construct parking areas and walkways on-site in locations that are above the established flood risk area. Where feasible, use permeable paving materials to minimize the resulting surface runoff.

**R M.8** For large historic sites and campuses, provide handicapped-accessible walkways and ramps above the established flood risk level that are compatible in material and detail with the character of the historic property.

**R M.9** For large commercial and industrial properties located close to rivers or other bodies of water, install stream monitors or other alarm systems to track rising water levels and alert occupants.

# 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.

# GLOSSARY

**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.

# GLOSSARY

**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.

# GLOSSARY

**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. |

# RESOURCES

## *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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