Resiliency Design Guidelines - Compiled | CHARM

CHARM

In September 2016, Governor Baker signed ***Executive Order 569:*** **Establishing an Integrated Climate Change Strategy for the Commonwealth**. Complementing the Global Warming Solutions Act, which is aimed at greenhouse gas emission reductions that cause climate change, EO 569 directs public agencies to provide leadership and protect public safety by reducing emissions from operations, planning and preparing for impending climate change, and enhancing the resilience of government facilities and other assets.

Since then, state agencies and authorities, as well as cities and towns, have begun taking steps to prepare for the impacts of climate change by assessing vulnerability and adopting strategies to increase the adaptive capacity and resiliency of building facilities and other infrastructure.
In 2018, the Department of Housing and Community Development's Bureau of Housing Design and Construction (DHCD/BHDC) initiated the Climate Hazard Adaptation and Resilience Masterplan (CHARM) project to:

- assess the state-funded public housing portfolio's risk and vulnerability to climate change impacts,
- provide a detailed climate change resilience opportunity assessment of selected pilot housing developments, and
- develop design guidelines for DHCD facilities to implement capital projects that incorporate climate adaptation and resilience best practices.

CHARM provided a unique opportunity for DHCD to assess climate risk to its portfolio and residents, develop resilience guidelines, and advance a strategic plan for implementation.

RAPID RISK AND VULNERABILITY ASSESSMENT

The Rapid Risk and Vulnerability Assessment (RRVA) tool was developed as part of the DHCD Climate Hazard Adaptation and Resilience Masterplan (CHARM) project Resilience Toolkit. The RRVA is intended as an informational and planning tool when used by Local Housing Authority (LHA) staff, and as a planning tool and reference to applicable resilience guidance when used by the BHDC Architects and Engineering Service Unit (AESU) and the Regional Capital Assistance Teams (RCATs) to develop scopes of work for LHA capital projects.

Upon completion of the interactive spreadsheet version of the RRVA tool, the user is directed to a series of project-specific resilience strategies for consideration in the design of the project or for addition to the project as initially planned. In the tool, those strategies are linked to DHCD Design Guideline sections by Construction Specification Institute (CSI) number. The climate resilience design considerations for each of those linked sections, as well as additional climate resilience resources by section, are included in this document for easy reference. The scope of work for projects may include a copy of the completed RRVA for reference or the Design Consultant may request a copy.

RISK AND VULNERABILITY ASSESSMENT

A full Risk and Vulnerability Assessment (RVA) was developed for 1,347 developments based on a the latest climate hazard data produced by the state through a spreadsheet assessment tool that identified which developments are most at risk for climate change impacts from extreme weather events such as drought, precipitation flooding, sea level rise and increased storm surge, and extreme temperatures.

The risk and vulnerability assessment ranked developments based on:

- **Criticality** parameters that include a development's size and density, type of housing occupants per DHCD categories, ability to provide for sheltering in place, environmental impact, interdependencies with other community resources, and if a development had experienced evacuations in the past.
- **Exposure** parameters that indicate the development's susceptibility to selected climate-related events including primary climate hazards (flooding due to sea level rise and storm surge, flooding due to extreme precipitation, and extreme heat) and related climate hazards (severe winter storms, extreme wind, landslide, drought, wildfire). Exposure is based on information from historic climate events as well as projected climate-related impacts as made more extreme by climate change and projected for 2030 and 2070. Developments that score higher in exposure are the ones that reported having experienced climate-related impacts and/or that are at risk to future climate-related impacts by 2030; and
- **Adaptive capacity** parameters that characterize the development's ability to adapt and/or sustain itself and its residents during an extreme event. Developments with significant on-site infrastructure (e.g. generator, wastewater treatment, etc.) have a higher adaptive capacity score. A higher score means that residents may be able to maintain livable conditions in at least a portion of the development during hazardous weather or power outages without evacuating the site.

The developments and building components most at risk have been identified and will be tagged in the DHCD Capital Planning System (CPS), so that the information is readily available to housing authorities as they select and scope the projects in their capital plans.

Therefore, engineers and architects working with these design guidelines should be informed by the housing authority and AESU or RCAT whether the subject property requires particular focus on climate adaptation and resiliency measures. The Design Consultant should also take the initiative to bring up issues and questions related to resilience if they seem pertinent in the design process.

CLIMATE CHANGE IMPACTS

DHCD has summarized best available resilient design guidance for these four categories:

Precipitation Protection: The risk of flooding is increasing as the impacts of climate change lead to more frequent and intense rainfall events. Flooding is often occurring beyond designated flood zones adjacent to water bodies, because of site design and aging, or undersized storm sewer infrastructure unable to carry stormwater during extreme rainfall events.

Sea Level Rise & Storm Surge is also exposing some housing authority developments to increased, coastal flooding and other impacts which will continue to worsen through time. Adapting to sea level rise and storm surge is often similar to adapting to the flooding risk from extreme precipitation, but in some locations may require more expansive interventions to mitigate risk.

Extreme Heat: As the climate warms, the number of days with extreme high temperatures and increased risk from high heat index (the combination of temperature and humidity) will grow drastically. Some parts of the state will experience this trend more acutely, and locations already experiencing the effects of urban heat island will be more impacted. Measures for reducing extreme heat impacts at a site and building are recommended in the relevant sections of this guide**.**

Emergency Preparedness: To help ensure staff and resident safety during extreme events, and to shelter in place during power outages and extreme weather events, when and where possible, these items recommend strategies for preparing housing authority developments. These recommendations will be used in tandem with new operational emergency preparedness planning guidance from DHCD.

TABLE OF CONTENTS

RESILIENCE DESIGN GUIDELINES

Below is a compilation of the major points in the Resiliency Design Guidelines which occur in the individual sections of the Design and Construction Guidelines and Standards (DCGS). Additional points are located in specific sections of the DCGS, so it is recommended that for specific project requirements Resiliency Design Guidelines be reviewed in the DCGS sections.

04 20 00 UNIT MASONRY

CLIMATE RESILIENCE DESIGN CONSIDERATIONS

Many of the existing brick and masonry buildings in the public housing portfolio have limited cavity space for supplemental insulation. Repairing or improving the thermal performance of masonry at all properties should always be done with attention to managing moisture and permeability as well as thermal performance.

Properties exposed to flooding and increased wind-driven rain associated with climate change should particularly review the guidance throughout this section related to moisture protection. The consultant should consider the most durable and cost-effective method for addressing water infiltration and thermal performance in a masonry veneer building envelope, as well as the structural soundness of properties subject to the hydrostatic pressure of floodwater.

CLIMATE RESILIENCE RESOURCES

Project teams can learn more about strategies to manage masonry where there are thermal and/or moisture concerns from these resources among others:

- EPA's guide "Moisture Control Guidance for Building Design, Construction and Maintenance" details considerations for installing and preparing masonry surfaces for coating applications, which may be important where moisture is a concern: https://www.epa.gov/sites/production/files/2014-08/documents/moisture-control.pdf
- FEMA's "Engineering Principals and Practices for Retrofitting Flood-Prone Residential Structures" contains guidance and graphics related to dry floodproofing masonry walls in section 5D. It is available here: https://www.fema.gov/sites/default/files/2020-08/fema259_complete_rev.pdf

06 10 00 ROUGH CARPENTRY & 06 20 00 FINISH CARPENTRY

CLIMATE RESILIENCE DESIGN CONSIDERATIONS

Flood damage resistant materials should be used for walls, floors, framing and other parts of the building that are subject to flooding by fresh or sea water. Wood building materials are considered flood damage resistant if they can withstand direct contact with water for at least 72 hours without being significantly damaged.

Pressure-treated and/or decay-resistant lumber, pressure-treated and marine grade plywood should meet these requirements for flood damage resistance, and should not absorb contaminants or promote mold and mildew.

Hardware fastened to these water-resistant building materials should be stainless or galvanized steel.

For flood prone properties, if wood is not required to match the existing materials that will adjoin the repaired structure, or as part of the architectural expression of the building, the wood-composite structural plastic products described in 06 50 00 Structural Plastics and Composites may be more appropriate than flood damage resistant lumber. These products are more resistant to moisture absorption and rot than treated lumber.

Flood damage resistant materials should be continuous from the lowest point in the building up to the Design Flood Elevation (DFE).

The design of the entire assembly should take into consideration flood hazards and mitigate mold and mildew growth.

CLIMATE RESILIENCE RESOURCES

Project teams can learn more about best practices for choosing wood materials where water is a concern from these resources among others:

- FEMA's Homebuilder's Guide to Coastal Construction includes a set of accessible fact sheets which include graphics and resilience strategies for choosing materials and resilient fasteners: https://www.fema.gov/sites/default/files/2020-08/fema499_2010_edition.pdf
- EPA's guide "Moisture Control Guidance for Building Design, Construction and Maintenance" includes some guidance on choosing appropriate wood materials for areas where moisture is a concern. It also includes photos to help diagnose moisture related problems. It is available here: https://www.epa.gov/sites/production/files/2014-08/documents/moisture-control.pdf
- For guidance on cleaning wood assemblies after a flood the guide Creating A Healthy Home, A Field Guide for Clean-Up of Flooded Homes may be useful. It is available here: https://www.huduser.gov/portal/Publications/pdf/FloodCleanupGuide_NCHH.pdf

07 07 00 SOLAR PHOTOVOLTAIC SYSTEMS

CLIMATE RESILIENCE DESIGN CONSIDERATIONS

Solar photovoltaic (PV) systems with battery backup have the potential to provide residents with much needed resiliency in the face of natural disasters and associated power outages. By providing power when the electric grid goes down, these systems can allow residents the option to shelter in place and reduce or eliminate the need for emergency generators fueled by diesel or other fossil fuels. While batteries for this purpose may increase the cost to install a solar photovoltaic system, the cost of batteries is declining and is expected to continue to decline, just as solar technology has done in recent decades. Space for future battery installation should be considered in the system design.

To accommodate future battery storage, locate any central solar photovoltaic inverters in a location with additional room for a battery system (at least 10' x 10') or near an exterior wall for a battery to be located outside. Specify an islandable inverter. An islandable inverter will also allow a solar photovoltaic system to operate during a power outage, provided there is adequate sunshine. An islandable inverter should be equipped with one or more 120v electrical receptacles to allow device charging or refrigeration during the day. Ensure that all solar photovoltaic equipment, conduit, inverters, panels, subpanels, meters, and switches are located above the design flood elevation (DFE), if known.

When choosing locations for solar PV systems, consider solar PV canopy installations above unshaded parking lots or paved areas. These installations can lower surface temperatures of paved area and add to the solar PV output at a development.

CLIMATE RESILIENCE RESOURCES

Project teams can learn more about best practices for solar photovoltaic systems from this resources and others:

- The Clean Energy Group provides technical and design guidance for solar photovoltaic and battery storage systems, as well as technical assistance funding for feasibility studies to affordable and low-income housing partners: https://www.cleanegroup.org/ceg-projects/solar-storage-optimization/
- The National Renewable Energy Laboratory's REopt Lite tool is a user-friendly, web-based, free solar photovoltaic and battery storage system feasibility assessment tool: https://reopt.nrel.gov/tool
- The National Renewable Energy Laboratory's PVWatts is a web-based, free preliminary solar feasibility assessment tool: https://pvwatts.nrel.gov/

07 10 00 WATERPROOFING AND DAMPPROOFING

CLIMATE RESILIENCE DESIGN CONSIDERATIONS

Waterproofing is a climate resilience best practice for protecting the building structure and equipment from flooding associated with extreme precipitation, sea level rise and extreme tidal conditions. It is particularly critical for elevator systems and to keep electrical, heating, cooling, and domestic hot water systems from flooding. It can have the added benefit of reducing pest infestation, such as from termites that is likely to become worse over time as the climate zone in Massachusetts becomes warmer and more humid.

Waterproofing may only be of value for a limited time in buildings that already experience frequent and severe flooding. Few of the original plans for housing authority buildings have information about the elevation of each building in a development that could be compared to the future flood elevation projections that are or will soon be available for most Massachusetts communities (2030, 2050, 2070). For some buildings, the costs of relocating electrical and mechanical equipment from basements to upper floors, diverting coastal or stormwater flood waters away from a building with piped stormwater infrastructure or external permanent or temporary barriers, or pumping water out of below-grade spaces with sump pumps should be compared to the efficacy of a major waterproofing project.

Waterproofing should be continuous from the lowest point in the building up to the Design Flood Elevation (DFE).

Materials: Foundation and Wall Dampproofing and Waterproofing

There is a distinct difference between dampproofing and waterproofing. Dampproofing is intended to keep out soil moisture, while waterproofing is intended to keep out both moisture and water. Waterproofing is intended to create a barrier that large quantities of water, under pressure (such as standing water), cannot penetrate. Dampproofing is intended to prevent the penetration of small quantities of water not under pressure. As waterproofing is a more rigorous and usually a more expensive treatment than dampproofing, waterproofing should only be used when dampproofing will not provide sufficient protection. In general, the designer should avoid construction below the water table.

Materials: Air and Vapor Barriers

For midrise residential buildings, the Massachusetts Energy Code requires a continuous air barrier assembly at opaque exterior walls or soffits, including joints and junctions to abutting constructions to control air movement through the wall. The air barrier also serves as a liquid-water drainage plane flashed to discharge water or condensation to the exterior.

Modified bituminous sheet is the recommended product. Consider a 40-mil thick, peel and stick membranes. Care must be taken in selecting compatible accessory transition strips to adjacent spray applied materials. Compatibility of material issues may require the use of a primer prior to attachment.

CLIMATE RESILIENCE RESOURCES

Project teams can learn more about best practices for moisture control from this resources and others:

- EPA's guide "Moisture Control Guidance for Building Design, Construction and Maintenance" has strategies for using appropriate paint types and photos of example challenging conditions: https://www.epa.gov/sites/production/files/2014-08/documents/moisture-control.pdf
- FEMA's publication "Reducing Flood Risk to Residential Buildings That Cannot Be Elevated" (FEMA P-1037) has strategies and graphics explaining how to reduce water intrusion as well as some of the details to consider when doing so. https://www.fema.gov/sites/default/files/2020-07/fema_P1037_reducing_flood_risk_residential_buildings_cannot_be_elevated_2015.pdf
- FEMA's "Flood Damage-Resistant Materials Requirements" (FEMA Technical Bulletin 2) should be used for materials selection in waterproofed spaces: https://www.fema.gov/sites/default/files/2020-07/fema_tb_2_rev1.pdf

07 20 00 BUILDING INSULATION AND MOISTURE PROTECTION

CLIMATE RESILIENCE DESIGN CONSIDERATIONS

Well insulated, airtight buildings with appropriate vapor control keep heat inside in winter and can be cooled more efficiently in summer. This section on insulation and moisture protection is applicable to both "normal" weather variability as well as the more extreme thermal conditions, extreme precipitation, and flooding that may be exacerbated by climate change.

The need for moisture protection associated with upgrading building insulation is an issue that requires attention both to internally trapped moisture from vapor drive and condensation.

Goal

The designer's goal should be to design an effective, low-cost, durable, non-toxic building envelope which contributes minimal greenhouse gas to the environment and contributes to climate resilience. The insulation and moisture control materials should be selected to work effectively with the other components of the envelope.

Water Barrier

Bulk water barriers are required for all new construction, additions, and siding replacements. The most effective wall assemblies have a primary water barrier (the exterior cladding: brick, clapboards, shingles, etc.) and a secondary, vapor-open, bulk water barrier (house wrap with all joints taped, peel-and-stick membrane, liquid-applied air and water barrier or other product). Some sort of spacer or vented rainscreen should be applied exterior to the secondary water barrier to facilitate drainage of any water that penetrates past the exterior cladding.

Water barriers placed to the exterior of the insulation should be vapor open so that moisture is not trapped in the assembly. Water barriers may also perform as air barriers if properly detailed.

Vapor Retarder

Vapor retarders are often included in wall and roof assemblies to inhibit moisture diffusion into envelope cavities where it may condense and damage the assembly. Moisture tends to diffuse from areas of higher humidity (typically the interior, heated space) to areas of lower humidity (typically cold outside air). The wall or roof assembly needs to be designed to avoid moisture getting into the cavities, cooling down below its dew point, and condensing in the cavity. Placing materials with low perm ratings on the heated side of the assembly is an effective way to block moisture diffusion, if there is no insulation exterior of the sheathing. With exterior continuous insulation of at least R-7.5, no vapor retarder should be placed on the interior, heated side of the assembly.

Kraft faced insulation which adjusts its permeability with temperature conditions may be the best choice at wall cavities.

High permeability materials should be used on the cold side of the envelope assembly to permit moisture that does get into the assembly to diffuse to the exterior, allowing the assembly to dry out. Assemblies should be analyzed to ensure that the materials used will not trap water. The Building Science Corporation website lists permeability of many common building materials. (https://www.buildingscience.com/documents/information-sheets/building-materials-property-table)

Penetrations or gaps in the moisture barrier are a serious matter, especially if the moisture barrier is also the air barrier, care must be taken to seal all openings, electric boxes, seams, tears, etc.

Air Barrier

Air barriers are required for all new construction, additions, and siding replacements. Air barriers may be formed of rigid materials or flexible membranes that are securely fastened and sealed to resist air infiltration. All seams and penetrations must be sealed and all transitions from wall planes to foundations, floors, ceilings or roof planes, as well as doors and windows, must be fully detailed for a continuous barrier covering the entire building.

An air barrier may be placed anywhere within the wall or roof assembly. It can be a taped “house wrap” or “peel-and-stick” membrane placed outside the sheathing, air-tight sheathing with taped joints, air-tight drywall construction, spray foam insulation, or some combination of these products. Continuity is important as a small opening can allow a large volume of air to move through it. The air may carry moisture which will condense within the wall or roof assembly, causing mold or rot to form, or it may just leak unconditioned air into the building or conditioned air out of the building. Special attention should be paid to transitions from walls to roofs and at other building elements which may tend to interrupt the barrier.

The air barrier may also function as a water barrier or moisture retarder. It is important that the membrane’s physical properties and position in the assembly are consistent with the functions (intentional or not) that it will perform. A well installed building wrap can function both as a water barrier and an air barrier, thus serving two of the four building envelope functions. Building wraps are often placed outside the insulation where they perform as a secondary water barrier behind the siding. They are designed to be vapor permeable to allow moisture to migrate from the wall assembly to the outside.

In high-rise construction, the vapor, water, and air barrier in one product. These products are designed to be vapor retarders. In the Massachusetts climate they should only be used where insulation is applied exterior to the membrane. The membrane also acts as a secondary water barrier. The insulation to the exterior is generally a foam that will perform when wet from water leaking past the siding. It may also have to be dense enough to provide support for the siding.

Batts may get wet during flooding and are easily replaced, or can be dried out after opening up the cavity and ensuring adequate dehumidification. Any cavity insulation that becomes wet during flooding should be tested both for mold and for moisture content before re-installing or sealing the cavity.

Foam boards may get wet during flooding and then dried out after opening up the cavity and ensuring adequate dehumidification. Any cavities that become wet during flooding should be tested both for mold and for moisture content before re-installing insulation or sealing the cavity.

Loose fill, especially cellulose, cannot be allowed to get wet during flooding. Any cavities with loose fill that become wet during flooding should be cleared of all insulation and tested both for mold and for moisture content before installing new insulation and sealing the cavity.
Spray foam may get wet during flooding and then dried out after opening up the cavity and ensuring adequate dehumidification. Any cavities that become wet during flooding should be tested both for mold and for moisture content before re-sealing the cavity.

CLIMATE RESILIENCE RESOURCES

Project teams can learn more about best practices for moisture control from this resources and others:

- FEMA's "Flood Damage-Resistant Materials Requirements" (FEMA Technical Bulletin 2) should be used for materials selection in waterproofed spaces: https://www.fema.gov/sites/default/files/2020-07/fema_tb_2_rev1.pdf

07 30 00 ASPHALT ROOF SHINGLES

CLIMATE RESILIENCE DESIGN CONSIDERATIONS

Massachusetts may experience increased amounts of precipitation and more extreme heat and storms in the coming years as a result of climate change.

Insufficient roof drainage and insulation can lead to ice dams during the winter, which cause water leakage, rot, and mold growth. Improving roof insulation at the eaves of sloped roofs will reduce the freeze-thaw cycling of ice and snow on the roof that leads to ice dams.

Consider adding a secondary water barrier when a roof is being rebuilt. NRCA and the International Code Council recommend the use of a secondary water barrier for all low-slope roof systems. A self-adhering polymer-modified bitumen underlayment provides a weatherproofing layer beneath primary roof coverings, and asphalt-saturated felts are water-shedding.

With asphalt-saturated felt alone, standing water can work its way under the felt in severe weather or in vulnerable areas of the roof and water can seep through fastener holes or other defects; self-adhering underlayment contains a compound that seals around fasteners.

A roof replacement offers an ideal time to evaluate the orientation of the roof for future installation of solar photovoltaic (PV) or solar thermal domestic hot water heating systems. A solar PV system can be an importance climate resilience measure during power outages when coupled with a battery system and/or an islandable inverter. Even if a solar and battery installation is not cost effective at present, the roof replacement project should be designed for "solar readiness" at a future date. Making a roof replacement "Solar ready" can be done by making intentional design choices so that solar could be installed without having to change the roof structure, without having to open walls for conduit or electric cable, or without having to create an additional location for electric components, batteries, storage tanks, or other necessary components of the system. To make an asphalt roof "solar ready", the work scope should address:

1) Identifying the roof surfaces that have the best solar exposure;
2) Ensuring that these surfaces are structurally designed to accommodate the weight, wind, and snow loads that the solar system might impose;
3) Relocating or consolidating rooftop equipment or plumbing vents from the roof surfaces with best exposure;
4) Identifying space within the building that is readily available for the installation of controls and ancillary components, such as electric invertors and hot water storage tanks; and
5) Installing an internal chase or other means for connecting the future rooftop solar system to the building's mechanical or electrical systems and spaces identified for auxiliary solar equipment per 4) above.

Consider specifying high solar reflectance index (SRI) ENERGY STAR light colored shingles to reduce the heat island effect outside the building and heat transmission into the building to reduce the impact of extreme heat and chronic temperature increases. Avoid dark brown and black shingles because they tend to build up and retain heat, and also have a shorter lifespan.

CLIMATE RESILIENCE RESOURCES

Project teams can learn more about best practices for protecting roofs by consulting these and other resources:

- The report "Climate Resilience Strategies for Buildings in New York State" includes information on materials to use when retrofitting asphalt roofs. It also includes guidance on reducing heat absorption and preparing roofs for significant rain. It is available here: here: https://ap.buffalo.edu/content/dam/ap/PDFs/NYSERDA/Climate-Resilience-Strategies-for-Buildings.pdf
- High solar reflectance index ENERGY STAR roofing products can be found here: https://www.energystar.gov/productfinder/product/certified-roof-products/

07 40 00 SIDING

CLIMATE RESILIENCE DESIGN CONSIDERATIONS

Moisture resistive materials may be useful where flooding is a concern. For coastal or areas where flooding is a concern, recommended materials include: Vinyl siding, fiber cement siding, brick or masonry, or heartwood of naturally durable species.

Resilient buildings in areas that experience frequent wind driven rain should include a pressure neutral rainscreen when installing fiber cement board, brick, masonry, or wood siding. Maintain an air gap between the siding and wall by installing suitable clips or vertical furring strips between the insulation, air and vapor retarder and siding material. The cavity facilitates drainage of water from the space between the vapor retarder and backside of the siding and it facilitates drying of the siding and vapor retarder.

Typical vinyl siding products inherently provide air cavities behind the siding that facilitate drainage, so vertical furring strips are not needed.

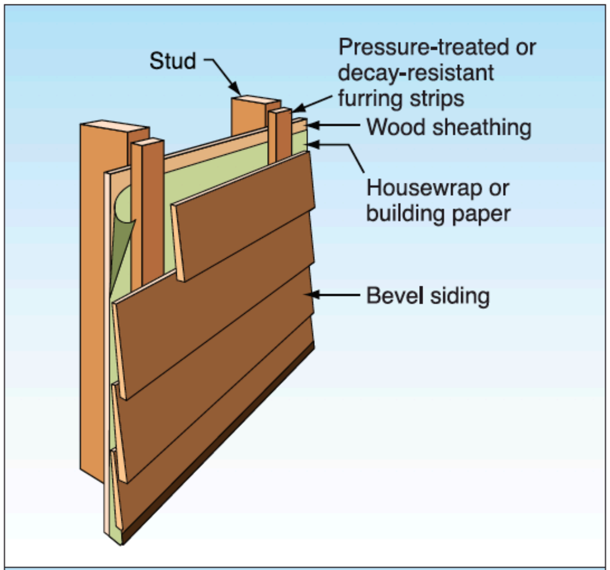

Figure 9. Pressure-equalized rain screen system.

U of Buffalo, *Climate Resilience Strategies for Buildings, p. 120 and*
FEMA 499 5.3 p.5 of 8

Flood damage resistant materials should be continuous from the lowest point in the building up to the Design Flood Elevation (DFE), if known.

Rain-screen type installation of wood and cement siding is recommended by certain manufacturers to prevent moisture from penetrating into the exterior sheathing and wall cavity due to air pressure and capillary action.

Materials

There are several manufacturers of fiber cement shingles and clapboard. Third party pre-finishing with solid stain is available along with a 15-year warranty from the paint applicator.

This product is best suited for areas requiring impact resistance, durability and climate resilience. The clapboard siding product may not be a cost-effective choice where these are not the primary concerns; consider alternatives such as the panelized fiber cement products or alternative bevel siding materials.

CLIMATE RESILIENCE RESOURCES

Project teams can learn more about best practices for protecting buildings from water intrusion using siding by consulting these and other resources:

- The report “Climate Resilience Strategies for Buildings in New York State” addresses strategies for adapting buildings in order to make them more resilient and is available here: https://ap.buffalo.edu/content/dam/ap/PDFs/NYSERDA/Climate-Resilience-Strategies-for-Buildings.pdf
- FEMA’s “Home Builders Guide to Coastal Construction” has a number of strategies and graphics that may be useful in planning siding updates. It is available here: https://www.fema.gov/sites/default/files/2020-08/fema499_2010_edition.pdf

07 45 00 GUTTERS AND DOWNSPOUTS

CLIMATE RESILIENCE DESIGN CONSIDERATIONS

See the Design Guideline section for recommendations. Not a singular comprehensive statement for the compilation.

CLIMATE RESILIENCE RESOURCES

Project teams can learn more about best practices for managing and maintaining gutters and downspouts (including the use of rain barrels) using these sources and others:

- The roof drainage and green infrastructure sections of the publication "Climate Resilience Strategies for Buildings in New York State" address stormwater management and gutter considerations as well as green infrastructure. This document also has links to other resources. https://ap.buffalo.edu/content/dam/ap/PDFs/NYSERDA/Climate-Resilience-Strategies-for-Buildings.pdf

07 50 00 MEMBRANE ROOFING

CLIMATE RESILIENCE DESIGN CONSIDERATIONS

Massachusetts is expected to experience more days of extreme heat state-wide in the coming decades. Standard built up asphalt, rubber, black EPDM, or other dark roofs can reach temperatures of 150°F or more in the summer sun. A light-colored "cool roof" under the same conditions could stay more than 50°F cooler.

A cool roof can benefit a building and its occupants by:

- Reducing energy bills by decreasing air conditioning needs
- Improving indoor comfort for spaces that are not air conditioned, such as garages or covered patios
- Decreasing roof temperature, which may extend roof service life. Beyond the building itself, cool roofs can also benefit the environment, especially when many buildings in a community have them. Cool roofs can:
    - Reduce local air temperatures (sometimes referred to as the urban heat island effect);
    - Lower peak electricity demand, which can help prevent power outages; and
    - Reduce power plant emissions, including carbon dioxide, sulfur dioxide, nitrous oxides, and mercury, by reducing cooling energy use in buildings.

Roofing products should either be specified with an SRI at or above 65, or additional coatings should be added to other roofing materials to increase roof SRI to 65 or higher and provide a "cool roof".

A roof replacement offers an ideal time to evaluate the orientation of the roof for future installation of solar photovoltaic (PV) or solar thermal domestic hot water heating systems. A solar PV system can be an importance climate resilience measure during power outages when coupled with a battery system and/or an islandable inverter. Even if a solar and battery installation is not cost effective at present, the roof replacement project should be designed for "solar readiness" at a future date.

Making a roof replacement "Solar ready" can be done by making intentional design choices so that solar could be installed without having to change the roof structure, without having to open walls for conduit or electric cable, or without having to create an additional location for electric components, batteries, storage tanks, or other necessary components of the system. To make a membrane roof "solar ready", the work scope should address:

1) Identifying the roof surfaces that have the best solar exposure;
2) Ensuring that these surfaces are structurally designed to accommodate the weight, wind, and snow loads that the solar system might impose;
3) Relocating or consolidating rooftop equipment or plumbing vents from the roof surfaces with best exposure;
4) Identifying space within the building that is readily available for the installation of controls and ancillary components, such as electric inverters and hot water storage tanks; and
5) Installing an internal chase or other means for connecting the future rooftop solar system to the building's mechanical or electrical systems and spaces identified for auxiliary solar equipment per 4) above.

Design

Unlike black EPDM rubber roofing, TPO or white EPDM roofing comes in white or light colors and can reduce energy consumption, abate urban heat and help to slow the reaction of smog forming pollutants. The light color provides a high level of solar reflectance for urban settings and reduces the amount of energy required to maintain comfort in an air-conditioned building by reducing heat flow through the building envelope.

TPO or white EPDM membranes carry an Energy Star listings in certain applications with reflectivity ratings in the high 80 percent range where Energy Star specifications require 65 percent minimum. A benefit of using TPO roofing is that it is available in sheets up to 12 feet wide.

Use TPO or white EPDM membrane in minimum 60 mils thickness, complying with ASTM 4434, Type 1. Thicker TPO or white EPDM membranes are available (70 and 80 mils) and can be used in certain circumstances.

Execution

Before work proceeds, a pre-installation meeting must be held with representatives from the manufacturer, architect, roofing contractor, general contractor, LHA, and DHCD.

Install TPO roofing according to manufacturer's installation requirements for warranty specified.

Flat roofs with single-ply membranes must have a minimum pitch of 1/8 inch per foot for positive drainage. Single-ply membranes should not be installed on roofs with a pitch of over 2 in 12. Use parapets if possible and run roofing up wall in lieu of gravel stops.

White EPDM roofing can be installed fully-adhered, mechanically-fastened or loose laid. Fully-adhered white EPDM using water or solvent based adhesives to adhere the rubber to the substrate is preferred. Mechanically-fastened EPDM roofing should be avoided. A ballast of light-colored round river rock or concrete pavers is used to hold the materials in place and in roof locations susceptible to high winds. For re-roofing projects ballast can be washed and reused.

Specify products with welded seams.

Technical Standards

Roof Coating Manufacturers Association https://www.roofcoatings.org/
Cool Roof Rating Council https://coolroofs.org/resources/home-building-owners

CLIMATE RESILIENCE RESOURCES

Project teams can learn more about best practices for protecting roofs by consulting these and other resources:

- High solar reflectance index ENERGY STAR roofing products can be found here: https://www.energystar.gov/productfinder/product/certified-roof-products/

07 62 00 SHEET METAL TRIM & FLASHING

CLIMATE RESILIENCE DESIGN CONSIDERATIONS

Enhanced flashing techniques are recommended in areas that frequently experience high winds and driving rain. Water penetration at deck ledgers, eaves, or building intersections can cause wood dry rot and corrosion of connectors leading to deck collapse, water intrusion, or other structure failure.

In coastal areas it is important to lap flashing and moisture barriers correctly, and to use sealed tapes and products. At roof to wall intersections, use flashing with longer vertical edges. Tape the top step of flashing with a 4-inch or wider self-adhering roof tape, and lap the house wrap or building paper over the flashing and tape that as well.

CLIMATE RESILIENCE RESOURCES

Project teams can learn more about protecting structures from moisture using flashing in this resource and others:

- FEMA’s Homebuilder’s Guide to Coastal Construction includes discussion on flashing: https://www.fema.gov/media-library-data/20130726-1538-20490-2983/fema499web_2.pdf
- EPA’s Moisture Control for Building Design, Construction, and Maintenance contains several useful flashing details: https://www.epa.gov/sites/production/files/2014-08/documents/moisture-control.pdf

07 90 00 SEALANTS

CLIMATE RESILIENCE DESIGN CONSIDERATIONS

The decision to use sealants to waterproof a wall should include a **consideration of the structural soundness of the building**, including the walls and floor slab, and the building’s ability to resist flood and flood-related loads. The structural systems should be evaluated when any type of dry floodproofing is under consideration. When the determination has been made that the building and foundation system can withstand the expected flood-related forces, selecting a sealant system is relatively straightforward.

Dry Floodproofing

Dry floodproofing can be a **relatively inexpensive** mitigation measure. Waterproof membranes and sealants may be useful for preventing water from entering the structure through walls. Masonry and masonry veneer walls can be made watertight using sealants. For dry floodproofing, electrometric "urethane" sealant and bentonite grout may be used.

Applying Sealants to Above-Ground and Below-Ground Walls

Creating a waterproof barrier in a section of wall to make it impermeable may require the use of sealants which are applied directly to the exterior surface of the building to seal exterior walls and floors. Sealants typically fall into two categories:

- Positive-side sealant. Applied to the wall exterior where the sealant acts as a barrier between floodwaters and the wall.
- Negative-side sealant. Applied to the interior of a wall or floor where the water pushes against the sealant after it has passed through the wall or slab

Above-ground walls can be sealed using either category of sealant while below-ground walls and floor slabs almost always require negative-side sealants.

- Positive-side sealants also include wrap-style adhered membranes and spray-applied sealants, both of which can be applied to the exterior wall or foundation at or below the ground.
- Products such as elastomeric waterproofing material and self-adhering membrane sheets have been successfully used to prevent water intrusion for more than 24 hours.
- Temporary positive-side sealants called "flood wraps" can be attached to the wall above-grade during flooding. Negative-side sealants that are applied to a concrete slab or wall must be bonded directly to the slab or wall to prevent the sealant from pulling away from the surface.
- Negative-side sealants on slabs must be formulated and installed to withstand floor-related wear and must be applied across expansion joints common in concrete floor systems.

CLIMATE RESILIENCE RESOURCES

Project teams can learn more about best practices for protecting buildings from water intrusion using sealants by consulting these and other resources:

- The City of Boston Coastal Flood Resilience Guidelines includes graphics and images of sealants used to mitigate water intrusion and is available here: http://www.bostonplans.org/getattachment/d1114318-1b95-487c-bc36-682f8594e8b2
- The Southeast Region Research Initiative has tested various dry-floodproofed wall assemblies and their report, while technical and extensive, is available here: https://static1.squarespace.com/static/54500d67e4b0fe2b86e37264/t/549343a1e4b0d5186e34f6e6/1418937249160/SERRI+Report+80024-01_Floodproof+Construction+%28Sept+2011%29.pdf
- FEMA P-936 includes a discussion of sealant types and application images. This document is primarily focused on non-residential buildings and is available here: https://www.fema.gov/sites/default/files/2020-07/fema_p-936_floodproofing_non-residential_buiildings_110618pdf.pdf

08 10 00 DOORS AND FRAMES

CLIMATE RESILIENCE DESIGN CONSIDERATIONS

Doors provide daily and emergency ingress and egress, air circulation, and visual access to the outdoors and street life for building residents. Shading devices and screens can be integrated into the design of doors to help reduce temperature related climate impacts, including overheating during heat waves. Electrically controlled door openers need an automatic manual override during power outages.

Wood doors and frames should be avoided in locations subject to flooding and wind-driven rain. In these guidelines, fiberglass, vinyl and metal doors and frames are preferred for reasons of overall cost-effectiveness and durability, and the consideration of resilience reinforces this preference. All doors filled with foam or wood cores should be evaluated after exposure to salt or fresh water flooding, to determine whether the interior materials were saturated and could provide an environment for mildew and mold growth.

If flooding is a concern, exterior doors can be fitted with removable shields, or replaced with flood doors to protect from low-level flooding. Integrated waterproof flood doors or flood gates may be installed at entryways and if paired with sump pumps connected to a backup power source, may prevent interior flooding, pending that the rest of the structure is flood tight. Consult an engineer to see if this is a viable strategy.

Frequent inspection of temporary barriers is often necessary, and yearly training and practice is recommended so that staff can practice installation and make any repairs necessary.

Materials

Select products with low/no VOC and formaldehyde emissions or content.
Select FSC certified wood or reclaimed wood, or composite doors outside of flood areas or areas with wind-driven rain.

CLIMATE RESILIENCE RESOURCES

Project teams can learn more about best practices using this source and others:

- FEMA P-259, Retrofitting Flood-Prone Residential Structures, Section 5D on dry floodproofing is available here: https://www.fema.gov/media-library-data/20130726-1506-20490-2593/fema259_complete_rev.pdf

08 40 00 ENTRANCES and STOREFRONTS

CLIMATE RESILIENCE DESIGN CONSIDERATIONS

Entrances and storefronts provide daily and emergency ingress and egress, air circulation, and visual access to the outdoors and street life for building residents. Shading devices, operable windows and screens can be integrated into the design of entrances and storefronts to help reduce temperature-related climate impacts, including overheating during heat waves. Designers should consider frits or other solar gain mitigation.

Techniques for South, West, and East facing storefront and entrance glazing to minimize overheating. Electrically controlled door openers need an automatic manual override during power outages or include emergency power backup

Should existing or planned storefront windows extend below the Design Flood Elevation (DFE), flood damage resistant materials should be used below the DFE in place of storefront windows.

Temporary flood barriers may be installed at entrances and deployed in advance of an anticipated flood events. Some types of temporary flood barriers may be integrated into the structure. Temporary barriers can be quickly deployed, generally in less than 24 hours depending on operational availability and size of deployment. However, a flood must be anticipated with sufficient warning time and buildings must be evacuated prior to installing barriers which prevent egress. Consult an engineer to see if this is a viable strategy as flood barriers may put stresses on the building structure and may be in conflict with the building code.
Integrated, waterproof, flood doors or flood gates may be installed at entryways and if paired with sump pumps connected to backup power sources, may prevent interior flooding, providing that the rest of the structure is flood tight. Consult an engineer to see if this is a viable strategy. For further information consult FEMA P-259 Chapter 5D. Note however the cost might be prohibitive.

Frequent inspection of temporary barriers is often necessary, and yearly training and practice is recommended so that staff can practice installation and make any repairs necessary.

CLIMATE RESILIENCE RESOURCES

Project teams can learn more about best practices for protecting entrances and storefronts using this resource and others:

- FEMA's Engineering Principles and Practices for Retrofitting Flood-Prone Residential Structures; https://www.fema.gov/sites/default/files/2020-08/fema259_complete_rev.pdf

08 50 00 WINDOWS

CLIMATE RESILIENCE DESIGN CONSIDERATIONS

Windows play an important role in minimizing the negative effects of climate hazards like extreme heat and flooding, by providing daylighting, improved thermal performance, enabling emergency egress, and providing building occupant comfort. Increased reliance on daylighting reduces dependence on electrical systems that can fail during heat waves and other climate hazard events. Shading devices can be integrated into window design to help reduce temperature-related climate impacts, including overheating during heat waves.

Windows have traditionally been specified with the same style and performance profile for an entire development. However, it is also possible and may be cost effective for the designer to customize the performance of the windows depending on which way the face of the building is oriented to the sun and wind, and what neighboring structures are adjacent. North facing windows should allow for more solar gain and lower thermal transfer outwards, to take advantage of sunshine for heating and to keep heat in in the winter. South facing windows should prevent solar gain and lower thermal transfer inwards to reduce the need for cooling in the summer. Existing windows can be retrofitted by adding a window coating to reduce solar gain and thermal loss. When replacing or retrofitting existing windows, consult a window expert to help select the appropriate windows or retrofit strategies.

Taking advantage of natural ventilation can reduce energy consumption. Windows can play an important role in cooling a building, especially during power outages. Ensure that all windows are operable. Consider installing additional windows in walls perpendicular to the prevailing wind direction for additional cooling. In units without A/C, windows can be opened at night to flush hot air from the building.

Shading windows reduces the amount of solar heat gain in the interior of the building, thereby **reducing cooling loads** during the summer months and leading to lower indoor temperatures during power outages when the cooling system is not operational. Consider adding overhangs to south-facing windows or awnings to east- or west-facing windows or add interior window shading treatments, although these will be less effective compared with outdoor shading.

CLIMATE RESILIENCE RESOURCES

Project teams can learn more about best practices for using windows to mitigate heat loss and to limit solar heat gain using these resources among others:

- Enterprise's "Strategies for Multifamily Building Resilience" in chapter eleven provides a number of accessible strategies and example images of how window shades, both external and internal, can be used to limit solar heat gain during the summer season: http://www.cplusga.com/wp-content/uploads/2016/06/enterprise-manual.pdf
- The Boston Planning and Development agency also offers strategies and graphics for managing and upgrading windows. These are based on local building types and the graphics are easy to understand. This resource is available here: http://www.bostonplans.org/getattachment/d1114318-1b95-487c-bc36-682f8594e8b2

08 70 00 HARDWARE

CLIMATE RESILIENCE DESIGN CONSIDERATIONS

Ocean salts and humidity common in many coastal areas and areas subject to flooding further accelerates the corrosion rate of untreated steel and other metals commonly used in connectors, fasteners, hardware, and other building materials. Consider alternative hardware if corrosion is likely at a development.

Near the coast, sheltered or covered areas do not benefit from occasional rinsing from rain and therefore accumulate more salt, resulting in higher corrosion rates.

To avoid corrosion of hardware, use stainless-steel hardware. Stainless steel hardware is acceptable in virtually all locations A hot-dipped galvanized alternative may not be appropriate in every location.

CLIMATE RESILIENCE RESOURCES

Project teams can learn more about selecting resilient hardware using this resource and others:

- FEMA's Homebuilder's Guide to Coastal Construction section 1.7 includes discussion and guidance on hardware selection: https://www.fema.gov/media-library-data/20130726-1538-20490-2983/fema499web_2.pdf

09 20 00 GYPSUM

CLIMATE RESILIENCE DESIGN CONSIDERATIONS

In areas where flooding is a concern, follow wet floodproofing techniques for interior wall construction. Construct walls with a horizontal gap between the lower and upper wallboard to prevent wicking of moisture. Use non-paper-faced gypsum below the wallboard and paint it with latex based paint. Use ridged, closed cell insulation in the lower section of the wall in place of batt or cellulose. Exterior cavity wall construction can also use closed cell ridged foam insulation and non-paper-faced gypsum.

Figure 9. Recommended wet floodproofing techniques for interior wall construction. The following flood damage-resistant materials and methods will prevent wicking and limit flood damage:

1) construct walls with horizontal gaps in wallboard;

2) use non-paper-faced gypsum wallboard below gap, painted with latex paint;

3) use rigid, closed-cell insulation in lower portion of walls;

4) use water-resistant flooring with waterproof adhesive; and

5) use pressure treated wood framing

(SOURCE: LSU AGCENTER AND COASTAL CONTRACTOR MAGAZINE).

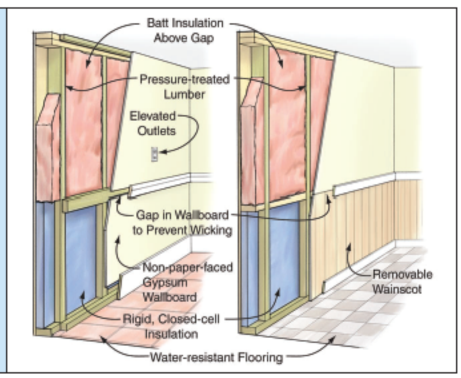

Image: FEMA 499, 1.6 p 6 of 8

CLIMATE RESILIENCE RESOURCES

Project teams can learn more about best practices for managing moisture in gypsum walls where moisture is a concern using this resource among others:

- FEMA's "Home Builders Guide to Coastal Construction, section 1.6," has a number of strategies and graphics that may be useful in planning updates to walls exposed to moisture. It is available here: https://www.fema.gov/sites/default/files/2020-08/fema499_2010_edition.pdf

09 30 00 TILE

CLIMATE RESILIENCE DESIGN CONSIDERATIONS

Non-slip flooring assists in safely evacuating through corridors, entries, and common areas during or after a flooding event, and waterproof flooring can be dried and remain in place after a flood. Install slip resistant waterproof flooring such as **textured tile** in common areas to both resist flood water damage and to help prevent injury during egress in the event floors become wet. Non-slip flooring can also be installed in units with tenants aging in place, to help prevent slips and falls.

CLIMATE RESILIENCE RESOURCES

Project teams can learn more about resilient flooring strategies using these resource and others:

- The Boston Planning and Development Agency discusses resilient flooring options in their "Coastal Flood Resilience Design Guidelines": http://www.bostonplans.org/getattachment/d1114318-1b95-487c-bc36-682f8594e8b2
- FEMA's Home Builder's Guide to Coastal Construction includes a set of accessible fact sheets which include graphics and resilience strategies: https://www.fema.gov/sites/default/files/2020-08/fema499_2010_edition.pdf

09 64 00 WOOD FLOORING

CLIMATE RESILIENCE DESIGN CONSIDERATIONS

Where flooding is a concern, consider removal of existing flooring and/or installation of an alternative such as ceramic, vinyl plank, or other water-resistant tile.

CLIMATE RESILIENCE RESOURCES

Project teams can learn more about best practices for installing and selecting materials for climate resilient flooring using this resource and others:

- FEMA's "Home Builder's Guide to Coastal Construction" includes a set of accessible fact sheets which include graphics and resilience strategies: https://www.fema.gov/sites/default/files/2020-08/fema499_2010_edition.pdf

09 65 00 RESILIENT FLOORING

CLIMATE RESILIENCE DESIGN CONSIDERATIONS

Materials should be able to withstand submersion for up to 72 hours if the floor is below the design flood elevation. Consider flooring types and material combinations when selecting materials for areas where flooding is a concern.

The following materials are not appropriate where flooding is a concern: Sheet-type floor coverings (e.g., linoleum, vinyl) or wall coverings (e.g., wallpaper) that restrict drying of the materials they cover. For further information consult FEMA 499, 1.7.
Consider the combination of materials when planning flood resistant floors such as tile. Using a wood subfloor however would trap moisture in the subfloor assembly, possibly leading to mold or rot.

Building materials installed in flood-prone spaces—including framing, wallboard, flooring, and ceiling paneling—should be able to withstand water exposure without major damage, promoting mold or mildew, or absorbing contaminants. Building materials under the design flood elevation (DFE) should be able to withstand contact with flood waters for up to 72 hours without requiring more than cosmetic repairs.

FEMA’s Technical Bulletin 2, Flood Damage-Resistant Materials may be of use when selecting products, as products listed as class 4 and class 5 may be appropriate for inclusion.

CLIMATE RESILIENCE RESOURCES

Project teams can learn more about best practices for installing and selecting materials for climate resilient flooring using this resource and others:

- FEMA’s Homebuilder’s Guide to Coastal Construction (P-499) includes a set of accessible fact sheets which include graphics and resilience strategies: https://www.fema.gov/sites/default/files/2020-08/fema499_2010_edition.pdf
- The Boston Planning and Development Agency discusses resilient flooring options in their “Coastal Flood Resilience Design Guidelines”: http://www.bostonplans.org/getattachment/d1114318-1b95-487c-bc36-682f8594e8b2
- FEMA’s Technical Bulletin 2, Flood Damage-Resistant Materials Requirements discusses appropriate materials for use in flood prone areas: https://www.co.kent.de.us/media/11852/FEMA%20-%20TB2.pdf

09 68 00 CARPET

CLIMATE RESILIENCE DESIGN CONSIDERATIONS

Avoid the use of carpet in areas where flooding is a concern such as basements and below grade spaces.

09 90 00 PAINTING

CLIMATE RESILIENCE DESIGN CONSIDERATIONS

If flooding is a concern, consider the types of materials to be painted and which type of paint is most appropriate. Epoxy or oil-based paints are acceptable wall finishes when applied to a concrete structural wall. However, when the same paint is applied to a wood wall, it is no longer considered acceptable since low-permeability paint can inhibit drying of the wood wall. Paints resistant to mold growth may be most appropriate for areas with high humidity such as bathrooms, kitchens, and basements. Painting metal surfaces with a rust-inhibiting coating may help mitigate rusting in flood prone areas.

CLIMATE RESILIENCE RESOURCES

Project teams can learn more about appropriate paint types as well as other strategies to deal with painted surfaces from this resource among others:

- EPA’s guide “Moisture Control Guidance for Building Design, Construction and Maintenance” has strategies for using appropriate paint types and photos of example challenging conditions: https://www.epa.gov/sites/production/files/2014-08/documents/moisture-control.pdf

14 20 00 ELEVATORS

Climate Resilience Design Considerations

Where flooding is a concern, raise elevator components that can be elevated out of sump pits and above the design flood elevation (DFE), and take steps to mitigate flooding in elevator pits by waterproofing the interior of the pit and installing sump pumps tied to a backup power source. Priority steps may include:

- Install elevators with motors and controllers above the Design Flood Elevation (DFE)
- Reinforce the shaft below the Design Flood Elevation
- Install a sump pump in the elevator pit if one is not already present
- Dry floodproof pit components that cannot be elevated
- Install flood alarms in the elevator pit
- Set controls to prevent the cab from lowering into floodwater

Elevator shafts that extend below the Design Flood Elevation (DFE) should be designed and built to resist the hydrostatic pressure of floodwater.
Elevate or keep electronic elevator controls above DFE in the machine room and Install a flood alarm to alert the operator when the pit is flooded.

Advanced elevator controls:

- Set elevator controls to prevent cabs from being lowered to a flood-prone lower floor during a power outage or flood. Install one or more float switches in the elevator pit with controls to prevent the elevator cab from descending into a flooded pit. Designate fire recall floors above the DFE.
- During power outages advanced elevator controls should automatically shut down all but one elevator at a flood-safe floor. The remaining functioning elevator may run on backup power.
- Install one or more float switches in the elevator pit with controls to prevent the elevator cab from descending into a flooded pit. Designate fire recall floors above the DFE.

Backup power – Sizing of elevator motors is an important consideration when considering backup power.

Holeless hydraulic elevators are preferred where flooding is a concern as the plungers are located high off the ground and out of the reach of floodwater.

Check the elevator pit for water infiltration and accumulation. If it occurs determine cause and correct if possible. Possible solutions include adding a crystalline coating on the walls of the pit or adding sump pumps. If pumps are the solution, a dual pump system is preferred. If the elevator is hydraulic, include a separator for hydraulic fluid with sump pump installation.

Investigate the shaft and design giving consideration to existing building fireproofing and shaft wall construction. Debris from fire proofing can become problematic with new solid-state controls and microprocessors.

On new hydraulic elevators or when doing an upgrade of an existing older type hydraulic elevator which has been determined not to have cylinder protection, always specify: new PVC lined cylinders, environmentally safe replacement hydraulic oils, and provide additional corrosion protection such as cathodic protection. (Replacement of cylinder adds approximately 6 weeks to the downtime of the elevator)

Wheel Chair Lifts

Evaluate the alternatives and options i.e. Limited Use Limited Access (LULA) thoroughly; typically lifts do not don't get used much and other solutions are more effective.

Exterior stair lifts should be avoided.

CLIMATE RESILIENCE RESOURCES

Project teams can learn more about elevator updates and system suggestions where flooding is a concern using this resource and others:

- Enterprise Community Partners provides graphics and explanations of resilient elevator systems in chapter 4 of their guide: Ready to Respond Strategies for Multifamily Building Resilience: https://toolkit.climate.gov/reports/ready-respond-strategies-multifamily-building-resilience
- The Boston Planning and Development Agency has included strategies for developing resilient elevators in their Coastal Flood Resilience Design Guidelines document: http://www.bostonplans.org/getattachment/d1114318-1b95-487c-bc36-682f8594e8b2

21 00 00 FIRE SUPPRESSION-SPRINKLER

CLIMATE RESILIENCE DESIGN CONSIDERATIONS

Fire-suppression pumps may be connected to backup power to ensure continued service during power outages. This may be especially important if the residents are expected to shelter in place during power outages. Consider installing a permanent exterior electrical connection so that temporary generators can be connected to emergency circuits if no permanent backup generator is located on site. Generator maintenance will be important to ensure quick and reliable backup power to fire suppression and other systems.

CLIMATE RESILIENCE RESOURCES

Project teams can find further information on maintaining backup power to critical systems using this resource and others:

- Enterprise Community Partners provides graphics and explanations of backup power options in chapter 13 of their guide: Ready to Respond Strategies for Multifamily Building Resilience: https://toolkit.climate.gov/reports/ready-respond-strategies-multifamily-building-resilience

22 00 00 PLUMBING

CLIMATE RESILIENCE DESIGN CONSIDERATIONS

Where flooding is a concern, raise domestic hot water heaters above the Design Flood Elevation (DFE). Install backwater valves to prevent storm and sanitary sewer backups during coastal storm surge, sea level rise, or precipitation-related flooding events. Whole-building backwater valves should be equipped with an alarm that alerts building management when activated, so that residents can be informed not to use plumbing fixtures in their units. Collapsible potable water containers can be filled and distributed during periods when backwater valves are engaged in order to provide drinking water. Smaller backwater valves may also be installed on the waste line leaving individual fixtures such as sinks, toilets, showers, and bathtubs, and are recommended on the lowest fixtures in flood-prone locations.

Elevate domestic hot water heaters above the Design Flood Elevation (DFE). Elevating equipment can involve moving equipment on to a pedestal or platform to bring it above flood elevation. Relocation can include moving equipment to a floor above flood level, and may be limited by the space available. If elevation and/or relocation is not possible, protect the equipment using floodwalls or other methods.

In order to reduce or prevent flooding from sewer overflows, backwater valves should be installed in areas at risk of flooding due to storm surge, sea level rise, or stormwater/rainfall events. If it is feasible and integrated into the emergency management plan, notify residents and distribute potable water in storage containers while the backwater valve is engaged. This step could help residents minimize tap use and reduce the possibility of causing an internal backup while the valve is closed. Backwater valves should also be provided for all waste lines that are subject to sewer back-up, e.g. underground sewer lines with fixtures below grade that have in the past been subjected to sewer back-ups.

CLIMATE RESILIENCE RESOURCES

Project teams can find further information on elevating water heaters and installing backflow valves from sources like this and from others:

- Enterprise Community Partners has created an accessible guide to backwater valves in chapter 5 and to elevating systems in chapter 8 of their guide: Ready to Respond Strategies for Multifamily Building Resilience: https://toolkit.climate.gov/reports/ready-respond-strategies-multifamily-building-resilience

23 00 00 HEATING VENTILATION & AIR CONDITIONING

CLIMATE RESILIENCE DESIGN CONSIDERATIONS

When central HVAC equipment is replaced, it should be located or moved from locations where flooding is a risk to prevent water from damaging components. Equipment can be elevated, relocated or as a last option protected in place. Elevation can involve moving equipment on to a pedestal or platform to bring it above flood elevation. Relocation can include moving equipment to a floor above flood level, and may be limited by the space available. Protecting equipment in place is the option of last resort and it may involve elevating equipment as much as possible and combining that with a low floodwall.

Consider reducing or eliminating central systems, particularly those at risk of flooding in basements or on first floors. This enables heating and cooling systems to be distributed and located in residential units and above the base flood elevation. Distributed systems provide heating and cooling using smaller equipment located inside each residential unit. Smaller equipment serving individual units is often more energy efficient than larger equipment serving the whole building. Options include warm-air furnaces, PTAC units, or air-source variable refrigerant flow (VRF) or ducted or ductless mini-split heat pump units.

Consider quick connects for temporary backup generator, boiler, or chiller connection. Quick connects are connection points on the exterior of the building for hooking up temporary backup heating, cooling, or electrical equipment.

Consider adding shading around exterior HVAC systems to conserve energy during summer.

The first choice of fuel is electricity with natural gas as second choice. Strategic electrification is a policy priority of the Baker administration as well as the Mass Save® 3-Year Plan, and is important to the DHCD's goals of reducing greenhouse gas (GHG) emissions and making public housing more resilient to climate hazards of flooding and extreme heat.

Cooling load calculations (applicable to special needs housing) should reflect residential occupancy, not commercial standards, and account for shading of windows.

ERV systems are practical when the exhaust air is available and in quantities that justify the initial investment. These systems pre-heat or pre-cool the outside air thru an air-to-air heat exchanger.

CLIMATE RESILIENCE RESOURCES

Project teams can learn more about protecting HVAC systems from water and extreme heat using resources such as these:

- The City of Boston's "Coastal Flood Resilience Design Guidelines" has strategies to protect systems from flooding and to shade mechanical equipment http://www.bostonplans.org/getattachment/d1114318-1b95-487c-bc36-682f8594e8b2
- Enterprise Community Partners has created an accessible guide to distributed and elevated HVAC systems: Ready to Respond Strategies for Multifamily Building Resilience: https://toolkit.climate.gov/reports/ready-respond-strategies-multifamily-building-resilience

23 80 00 AIR SOURCE HEAT PUMP

CLIMATE RESILIENCE DESIGN CONSIDERATIONS

Reducing or eliminating central heating systems and baseboard electric resistance heating equipment, which are often located in basements or near the floor at first floors locations and at risk of flooding, enables heating and cooling systems to be located in residential units and above the base flood elevation. As climate change causes more extreme heat days, the need for air conditioning will increase. Distributed systems like Air Source Heat Pumps (ASHPs) provide heating and cooling, eliminating the need for window air conditioning. In flood prone areas, external components of ASHPs should be located on platforms anchored to concrete footings above the Design Flood Elevation (DFE).

26 00 00 ELECTRICAL

CLIMATE RESILIENCE DESIGN CONSIDERATIONS

Raise electrical equipment, conduit, panels, and wiring above the Design Flood Elevation (DFE), and seal penetrations through buildings in order to prevent water intrusion. Update emergency lighting to LEDs for efficiency and add wayfinding maps and reflective strips to help residents during power outages and emergency conditions. Consider the backup power needs of residents, especially if they are expected to shelter in place during power outages. Size backup generators to the critical loads identified. For any backup generators, plan for regular generator maintenance and operator training. Consider installing a permanent exterior electrical connection so that temporary generators can be connected to emergency circuits if no permanent backup generator is located on site.

All buildings in a development which are susceptible to flooding may not themselves be vulnerable. Improvements should be considered on a building-by-building basis.

Generators

Provide a generator only where required by the building code or as directed by DHCD and/or the LHA.

Consider the need for backup power if residents are expected to shelter in place during power outages. Local codes may require a backup generator to power certain systems during an outage. In addition to those systems, consider adding backup power to circuits running the items listed below, especially if residents are expected to shelter in place.

- Emergency outlets to charge cell phones and computers
- Electronic igniters for gas- or oil-fired heating systems
- Fans and pumps for heating systems
- Water-booster pumps to deliver potable water to upper floors in taller buildings
- Sump pumps
- Telecom systems
- Cable modems and wireless routers
- Alarms and security equipment
- A central washer and dryer
- Refrigeration
- Key fob egress systems

Generator Maintenance

Develop a maintenance plan that periodically runs the generator, and consume or replace liquid fuel according to a schedule so that it is not low or stale when it is needed. Train staff in equipment maintenance and operation. A maintenance log system can be useful to keep system maintenance current and well documented.

Design

Raise electrical equipment, conduit, panels, and wiring, above the Design Flood Elevation (DFE) and seal penetrations through outside walls, especially where the service runs underground. Electrical equipment below the DFE that is not rated for wet installation should be encased in a non-corroding conduit or enclosure if code allows. Encasing will also make replacement easier should equipment be damaged in a flood. Conduits should be installed vertically so that they drain after a flood. For specific guidance consult FEMA P-259 5W.8 Electrical Systems.

Exterior Lighting

Entries are of particular concern for safety during routine access and emergency situations. Entry safety lighting should be maintained in good condition.

All exit signs must be illuminated. To improve energy efficiency, swap out existing non-LED exit signs with low wattage LED signs. In addition to code-required exit signs, add wayfinding maps and reflective strips on the edge of stairs and ramps to enable safe egress from the building.

CLIMATE RESILIENCE RESOURCES

Project teams can learn more about the requirements and benefits of generator backup and protecting wiring and systems through resources like these and others:

- Enterprise shares best practices for maintaining backup power in chapter 13 of their Multifamily Building Resilience Guide: https://toolkit.climate.gov/reports/ready-respond-strategies-multifamily-building-resilience
- FEMA guidance for designing and installing electrical systems may be found in FEMA P-259, “Engineering Principles and Practices for Retrofitting Flood-Prone Residential Structures”: https://www.fema.gov/sites/default/files/2020-08/fema259_complete_rev.pdf

28 00 00 ELECTRONIC SAFETY AND SECURITY

CLIMATE RESILIENCE DESIGN CONSIDERATIONS

Raise electrical equipment, conduit, panels, and wiring above the Design Flood Elevation (DFE), and seal penetrations through buildings in order to prevent water intrusion.

Raise electrical equipment, conduit, panels, and wiring above the Design Flood Elevation (DFE) and seal penetrations through outside walls, especially where the service runs underground. Equipment located below the DFE that is not rated for wet installation should be encased in a non-corroding conduit if code allows. Encasing equipment in a waterproof enclosure or a waterproof conduit will also make replacement easier should it be damaged in a flood. Conduits should be installed vertically so that they drain after a flood.

For specific guidance consult FEMA P-259 5W.8 Electrical Systems.

CLIMATE RESILIENCE RESOURCES

Project teams can learn more about protecting wiring and systems through resources like this and others:

- FEMA provides a number of electrical system retrofit strategies in section 5W.8 of their “Engineering Principals and Practices For Retrofitting Flood-Prone Residential Structures”: https://www.fema.gov/sites/default/files/2020-08/fema259_complete_rev.pdf

32 30 00 SITE IMPROVEMENTS

Climate Resilience Design Considerations

Site improvements play an important role in a resilient community. Spray parks can be used to keep cool, emergency site lighting helps wayfinding during an emergency, and retaining walls can be used to manage flood and landslide risk.
Temporary flood barriers may be installed at entrances and deployed in advance of anticipated flood events. Permanent flood barriers can help mitigate unexpected flooding events and can be attractively integrated into the area landscape.

Site equipment and furniture not permanently affixed to a base should be tied down in areas prone to high wind or flooding, to avoid damage to buildings or risk to people during extreme events.

Flood Control Structures and Walls

- Permanent barriers can include floodwalls and berms. These are built on solid foundations and are engineered to support hydrostatic pressure from a flood, or the stresses of a landslide. These are especially useful in protecting against unanticipated events, events which develop rapidly, or at properties where staffing resources may be limited during an emergency event or a short notice period. The width of berms may mean they are impractical at certain sites or in urban developments.
- Permanent barriers can be integrated with the area landscape design to provide seating and other recreational uses as well as erosion control, and can be attractive additions to the landscape.
- Flood waters will also keep in any water that gets behind the wall. Consider the need for pumps or an outlet for water that is retained.
- The addition of permanent barriers may also affect local drainage, possibly causing water problems for nearby buildings.
- Consider ingress and egress for residents and emergency personnel. Steps, ladders, or ramps may be necessary additions when floodwalls or berms are added.
- FEMA P-312 Chapter 8.0 *Barriers* may be a useful resource when considering the addition of a permanent barrier.

Full Perimeter Moveable Barriers

Temporary flood barriers may be installed at entrances and deployed in advance of an anticipated flood events. Some types of temporary flood barriers may be integrated into the structure. Temporary barriers can be quickly deployed, generally in less than 24 hours depending operational availability and size of deployment. However, a flood must be anticipated with sufficient warning time, and buildings must be evacuated prior to installing barriers which prevent egress. Consult an engineer to see if this is a viable strategy as flood barriers may put stresses on the building structure and may be in conflict with the building code. Consider a sewer line check valve to prevent backflow through sewer lines when planning for flood mitigation barriers.

Temporary/deployable flood barrier types include panelized systems, moveable walls, sandbags and other systems such as “sand-less sandbags” filled with expandable media. These systems will need to be stored on-site and may require considerable storage space. Some systems may require periodic maintenance and inspection, as well as continued recurring training for deployment. Panelized systems are temporary flood panels which are fitted to permanently installed slots to form flood resistant walls. Moveable flood walls are available at various heights and can be used to protect a perimeter or a portion of a perimeter. They can be collapsed and stored/stacked in between uses. Sandbags and sandbag alternatives are inexpensive and can be effective, but can be hard to transport. Portable stairways may useful where sandbags are planned for use to allow for ingress and egress. (Note: Water-inflated tube systems are also available on the market, but often have to be filled from fire hydrants with fire department supervision. Fresh water filled tube systems will also become buoyant in salt water floods, so water-inflated tube systems are not recommended.)

The ANSI/FM 2510 approval standard for flood mitigation equipment may be of use when selecting barriers. The National Flood Barrier Testing and Certification Program maintains a list of flood barrier products and the product standards that they meet.

Door Opening and Window Well Coverings

Integrated waterproof flood doors or flood gates may be installed at entryways and if paired with sump pumps connected to a backup power source , may prevent interior flooding, pending that the rest of the structure is flood tight. Consult an engineer to see if this is a viable strategy.

Window well coverings: Low window openings at or below ground level should have a wall constructed around the opening to above the flood protection elevation. An alternative is permanently sealing the window opening if it is not required for safety egress.

For further information FEMA P-259 Chapter 5D may be a useful resource

Design

Retaining walls must be designed to withstand earth load and hydrostatic pressure to insure a long-lasting installation. Depending on the installation, they may be either of flexible (unit assemblies requiring no frost footings) or rigid (monolithic structures carried to frost depth) construction. Design for retaining walls over six feet in height must be stamped by a Massachusetts registered Structural Engineer.

Pathway lighting helps reduce the risk of trips and falls on exterior pathways. Entries are of particular concern for safety during routine access and emergency situations

CLIMATE RESILIENCE RESOURCES

Project teams can learn more about strategies to incorporate flood control structures from resources such as these:

- FEMA P-312 Sections 7 *Floodproofing* and 8 *Barriers* may be a useful resource when considering the addition of a barrier. It is available here: https://www.fema.gov/media-library-data/1404148604102-f210b5e43aba0fb393443fe7ae9cd953/FEMA_P-312.pdf
- For further information on door opening coverings FEMA P-259 Chapter 5D may be a useful resource. It is available here: https://www.fema.gov/media-library-data/20130726-1506-20490-2593/fema259_complete_rev.pdf

32 90 00 LANDSCAPING

CLIMATE RESILIENCE DESIGN CONSIDERATIONS

When planning landscaping, consider the potential flood mitigation and cost savings opportunities that Low Impact Development (LID), or green infrastructure, may present. LID techniques, such as implementation of bioswales or rain gardens (for stormwater management) also have co-benefits including area beautification and localized temperature moderation.

Design

Including Low Impact Development (LID)/green infrastructure in landscape planning can reduce vulnerability to climate change by managing stormwater and contributing to localized temperature benefits. Green infrastructure can also provide aesthetic benefits and be a source of pride for neighborhoods, playing a role in both community and climate resiliency. These landscaping measures can often be simple in nature and design. For example, trench bioswales can be designed and built to retain runoff from roof downspouts or roadways. Consider using this NOAA tool to assess the costs and benefits of including green infrastructure. Green infrastructure may have economic benefits to the local community, and, in some cases, is a more cost-effective option than replacing hard infrastructure. For more information on potential cost savings, this report from the American Society of Landscape Architects is available.

Where possible retain existing trees. Analyze individual trees for shape fullness and proximity to buildings as well as the presence of damaged, undesirable or dead wood in order to determine the necessity for pruning.

CLIMATE RESILIENCE RESOURCES

Project teams can learn more about the costs, savings and benefits of green infrastructure through resources such as these. Also included is a green infrastructure maintenance guide that gives residents agency in maintenance while providing for oversight.

- NOAA provides tools to evaluate the benefits and costs of green infrastructure in their Guide to Assessing Green Infrastructure Costs and Benefits for Flood Reduction: https://coast.noaa.gov/data/digitalcoast/pdf/gi-cost-benefit.pdf
- The American Society of Landscape Architects have included easy- to-read guidance on how green infrastructure can reduce infrastructure costs, help mitigate flooding, and improve public health outcomes in their report: Banking on Green: A Look at How Green Infrastructure Can Save Municipalities Money and Provide Economic Benefits Community-wide: https://www.asla.org/uploadedFiles/CMS/Government_Affairs/Federal_Government_Affairs/Banking%20on%20Green%20HighRes.pdf
- Portland, Oregon shares lessons learned about maintaining green infrastructure in their carefully edited, informative, and brief guide: Green Street Stewards Maintenance Guide: https://www.portlandoregon.gov/bes/article/319879

33 00 00 SITE UTILITIES

CLIMATE RESILIENCE DESIGN CONSIDERATIONS

Flooding can put low lying site utilities at significant risk, and residents will be impacted if building systems are offline due to flooding or power outages. Protecting site utilities will help protect buildings both during flooding and will help speed recovery and building re-occupancy after a flooding event. Consult FEMA P-348: Protecting Building Utilities From Flood Damage when making site utilities updates for further guidance.

Design

When updating sewer lines to a building, consider including backwater valves. Backwater valves are installed where the wastewater pipe exits the building, so sewage only flows outward. Valves have a hinged flapper that remains open to allow outward flow, but seals tightly if there is backpressure. Install individual backwater valves on the lowest fixtures in the building, or whole-building backwater valves for storm sewer and sewer lines. For further guidance on backwater valves consult FEMA 259 section 5D.10.

CLIMATE RESILIENCE RESOURCES

Project teams can learn more about backwater valves and sealing septic systems through resources such as these and others:

- FEMA provides info on types of backwater valves and when conditions call for their installation in section 5D.10 of their guide: FEMA P-259 Engineering Principals and Practices For Retrofitting Flood-Prone Residential Structures: https://www.fema.gov/sites/default/files/2020-08/fema259_complete_rev.pdf
- FEMA P-348: Protecting Building Utilities From Flood Damage: https://www.fema.gov/sites/default/files/2020-07/fema_p-348_protecting_building_utility_systems_from_flood_damage_2017.pdf
- Enterprise provides access to graphics and the value of backwater valves in chapter 5 of their guide: Ready to Respond Strategies for Multifamily Building Resilience: https://toolkit.climate.gov/reports/ready-respond-strategies-multifamily-building-resilience

33 36 00 SEPTIC SYSTEMS

CLIMATE RESILIENCE DESIGN CONSIDERATIONS

When refurbishing or relocating septic tanks it may be appropriate to seal septic tanks to prevent groundwater infiltration if the water table rises. Leach fields may not be appropriate in flood prone areas. In cases where backflow may be possible based on elevations and potential flooding, consider including backwater valves.

Backwater valves are installed where the wastewater pipe exits the building, so sewage only flows outward. Valves have a hinged flapper that remains open to allow outward flow, but seals tightly if there is backpressure. There are advantages and disadvantages to interior and exterior installations of backwater valves. Consider these and coordinate with the LHA when determining whether the location of backwater valves. Buildings that do not have readily accessible basements should use exterior backwater valve assembly installations in conjunction with downstream clean-outs. Exterior backwater valves shall be the removable and re-insertion type used with a riser sleeve pipe, and be located between the exterior cleanout and the building structure. Include the periodic maintenance requirements for backwater valves in the Study/Investigation Report. For interior-located backwater valves, i.e. in basements, the backwater valves should be located in easily-accessible areas for simplified maintenance. If valves are already present, determine whether they are fully functional. For further guidance on backwater valves consult FEMA 259 section 5D.10. Also consider sealing septic tanks in areas where flooding is a concern to prevent contamination per FEMA 259 5W.12.

CLIMATE RESILIENCE RESOURCES

Project teams can learn more about backwater valves and sealing septic systems through resources such as these and others:

- FEMA provides info on types of backwater valves and when conditions call for their installation in section 5D.10 of their guide: FEMA P-259 Engineering Principals and Practices For Retrofitting Flood-Prone Residential Structures: https://www.fema.gov/sites/default/files/2020-08/fema259_complete_rev.pdf
- Enterprise Community Partners provides access to graphics and the value of backwater valves in chapter 5 of their guide: Ready to Respond Strategies for Multifamily Building Resilience: https://toolkit.climate.gov/reports/ready-respond-strategies-multifamily-building-resilience