City of New Haven

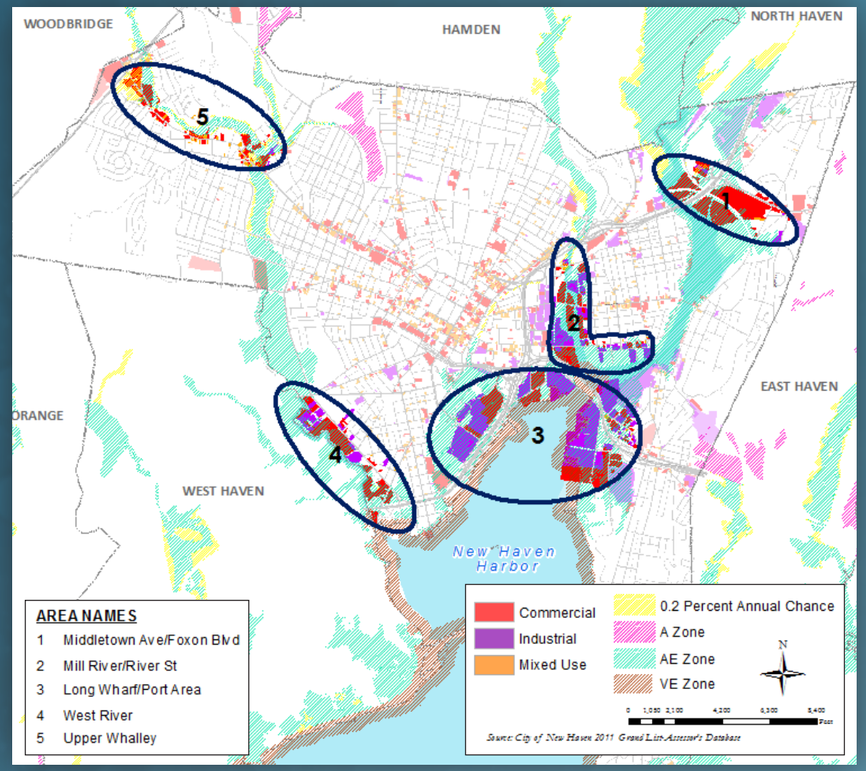
Commercial Industrial Toolbox

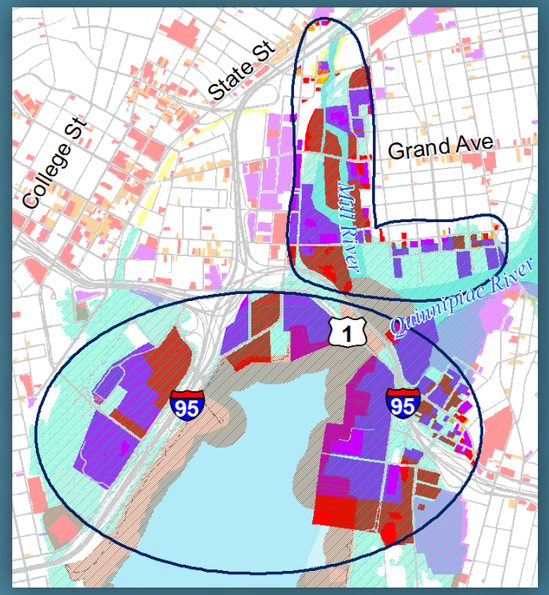
Project Objectives

- To promote resilient construction and renovation techniques applicable to commercial and industrial properties within flood-prone areas.
- To implement some of the goals of the New Haven Hazard Mitigation Plan, which focuses on strategies that can serve to reduce or prevent damages from future flood and storm surge events, restore economic losses as quickly as possible, and raise public awareness about flood-related risks.
- To protect life and property, and minimize, if not entirely prevent, temporary loss of business operations due to flooding.
- To develop techniques or strategies that can be replicated throughout the state.

Overview of Vulnerable Commercial and Industrial Properties

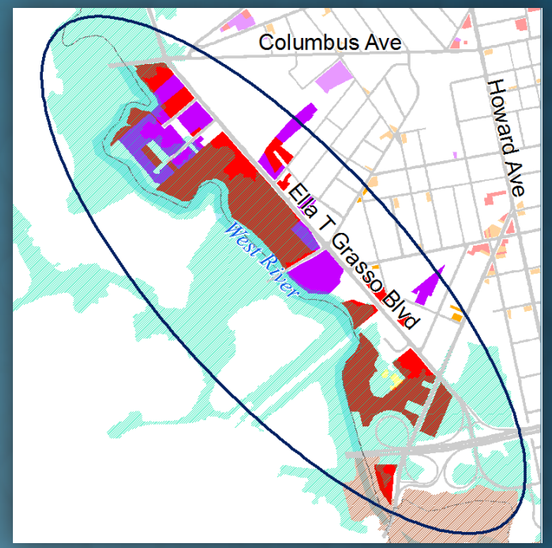
- There are approximately 2,875 commercial buildings within New Haven = nearly $6 billion of building value.[1]
- Commercial and industrial uses account for > 29% of existing land use in the city,[2] and are predominantly found within 5 areas that are particularly vulnerable to riverine and coastal flooding, as shown here.
- The total potential economic loss from a 100-year riverine flood and a 100-year coastal flood event are projected to be nearly $32.9 million[3] and $176.6 million respectively, for commercial and industrial businesses.[4]
- The National Flood Insurance Program (NFIP) is a voluntary program, administered by the Federal Emergency Management Agency (FEMA), through which property owners in participating communities can purchase Federal flood insurance as a protection against flood losses.
- The NFIP offers commercial policyholders coverage for < $500,000 each for building property and contents of the business; property outside of a building and business interruption losses are not covered.[5]
- Incorporating flood damage mitigation strategies into commercial and industrial sites can minimize financial losses and help offset the limited coverage provided by the NFIP.





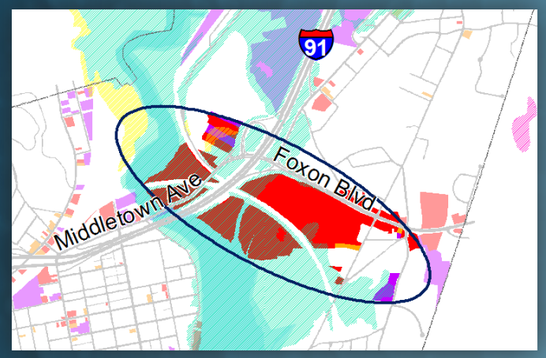
Areas 2: Mill River/River Street and Area 3: Long Wharf/Port Area

- Situated around New Haven Harbor
- Prone to both riverine and coastal flooding
- Lie within floodplains associated with the Mill and Quinnipiac Rivers, as well as coastal hazard areas associated with Long Island Sound



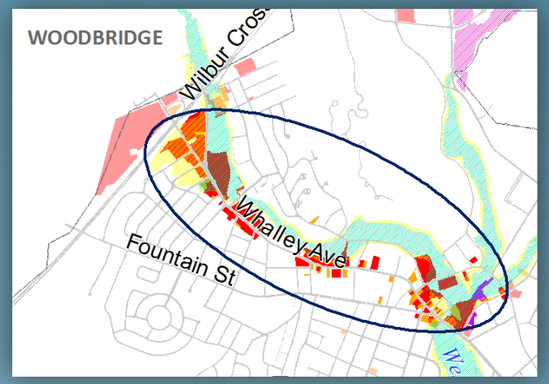
Area 4: West River

- Southwest corner of the city, concentrated along Ella T. Grasso Boulevard
- Lies within floodplains associated with the West River
- The southern portion of the district, closer to New Haven Harbor, is located within a velocity hazard area and is prone to coastal flooding and storm surges.
- In recent years, the area's susceptibility to flooding has been reduced due to the installation of self-regulating tide gates, as well as recent tidal marsh and channel restoration projects.



Area 1: Middletown Avenue/ Foxon Boulevard

- Northeast corner of the city
- Lies within floodplains associated with the Quinnipiac River
- Prone to flooding due to its low-lying and flat topography and the size of the Quinnipiac River watershed that lies up-river, well beyond City limits



Area 5: Upper Whalley

- Northwestern New Haven, situated along the West River
- Characterized by a mix of commercial and residential uses
- Located within floodplains associated with the West River

[1] City of New Haven, *Draft Natural Hazard Mitigation Plan Update,* October 2016
[2] Ibid.
[3] Total includes municipal losses as well.
[4] City of New Haven, *Draft Natural Hazard Mitigation Plan Update,* October 2016
[5] FEMA, *National Flood Insurance Program, Summary of Coverage for Commercial Property.* August 2013.

Applicable State and City Codes:

The Connecticut State Building Code (CSBC), adopted October 2016, is based on the 2012 International Building Code (IBC) from the International Code Council. Per Section 1612.4, design and construction of buildings and structures located in flood hazard areas must be in accordance with the American Society of Civil Engineers (ASCE) *Minimum Design Loads for Buildings and Other Structures* (ASCE 7) and *Flood Resistant Design and Construction* (ASCE 24). ASCE 7 describes how buildings in flood hazard areas can be designed to resist flood loads. ASCE 24 prescribes a number of strategies to enhance structural resiliency in flood hazard areas – these measures meet or exceed the minimum NFIP requirements. Thus, several of the mitigation strategies listed above are mandated or restricted by the building code. For instance, dry floodproofing measures are not permitted for non-residential buildings in several flood hazard sub-areas (such as Coastal Zone A or Zone V).

In addition to the CSBC, the City of New Haven adopted the Floodplain Damage Prevention Ordinance in 2013 to reflect newly updated FEMA Flood Insurance Rate Maps (FIRMs). This ordinance established the Floodplain Development Permit, which is required for any development within the floodplain. In addition, specific mitigation measures may be subject to additional regulations and permits. For instance, installation of green infrastructure could be dictated by Section 60 (Stormwater Management Plans) of the City's Zoning Ordinance and Chapter 26 (Stormwater Discharges) of the City's Code of Ordinances.

Resources for Property Owners:

Following is a list of potential techniques or strategies that New Haven commercial and industrial property owners should consider to reduce risk to natural hazards. This list represents a Commercial-Industrial Toolbox that can help property owners:

a. Prepare for natural hazards or weather-related disasters;

b. Prevent damage or protect property from damaging floods; and,

c. Recover from damaging storms and severe flood events.

Costs indicated for the techniques or tools do not include installation since that work is dependent on many variables including the type of foundation, size of building, number of floors, site elevation in floodplain, and nature of existing electrical, mechanical and plumbing systems.

1. Raising Awareness:

Encourage building owners and operators to evaluate exposure and risk to extreme flooding events and to take action to mitigate those risks.

Methods of Raising Awareness

- Access available FIRMs and other resources to identify a site's vulnerability to flooding at FEMA website - www.fema.gov - or from the City of New Haven (Main library and City Plan and Building Departments located at City Hall).
- Identify potential mitigation tools or techniques and conduct a benefit-cost analysis (BCA) to evaluate cost-effectiveness of on-site flood protection measures.

Benefits

- Enables owners to better understand and prepare for the flood risks associated with their properties.
- Quantifies the net benefits of considered measures to prevent or mitigate those risks.

Challenges

- Requires experience, or may require training to identify a site's vulnerabilities and to conduct a BCA.

Approximate Costs

- The costs incurred by property owners to retain professional services to perform the BCA vary considerably depending on the size and nature of the business and its facilities.

2. Green Infrastructure:

Green Infrastructure: Using designed landscapes to collect and store stormwater runoff on a site and to filter potential contaminants suspended in stormwater runoff.

Types of Green Infrastructure

- Bioretention ponds, bioswales and rain gardens
- Green roofs
- Pervious pavements
- Rainwater harvesting
- Tree planting

Benefits

- Uses natural processes to reduce and slow stormwater runoff.
- Restores groundwater recharge and reduces flooding levels in streams and rivers.
- Filters stormwater pollutants and prevents such pollutants from reaching waterways.

Challenges

- Green roofs require rooftop waterproofing and structural reinforcement.
- Designed landscapes may be overwhelmed by heavy flooding events; therefore, they should be used in conjunction with other mitigation strategies.

Approximate Costs

- Bioretention ponds, bioswales and rain gardens: $5 - $45/square foot (sq. ft.)
- Green roofs: $10 - $20/sq. ft.
- Pervious pavements: $3- $10/sq. ft. depending on material (pervious asphalt, pervious concrete or precast concrete unit pavers)
- Rainwater harvesting: $2,500 to $5,500 depending on tank material (galvanized steel, polyethylene or fiberglass) and tank size.
- Tree planting: $175 - $400 per tree.

**Costs depend on site, soil, types and sizes of plants, slope of roof, needed structural reinforcement, needed rooftop reinforcements, capacity, how water will be delivered to rainwater harvesting tank (gravity flow, hose, etc.), and planned use for collected water, among other variables.

City of New Haven is installing 200 bioswales throughout the city. Photo of Edgewood School Bioswale

Sources: A Better City: Challenge for Sustainability, "Building Resilience Toolkit," accessed April 2017: http://challengeforsustainability.org/resiliency-toolkit/; U.S. Environmental Protection Agency, "Green Infrastructure", accessed April 2017: www.epa.gov/green-infrastructure; National Oceanic Atmospheric Administration, *Green Infrastructure Options to Reduce Flooding: Definitions, Tips, and Considerations*, 2015; CT NEMO Program, *Rain Gardens: A Design Guide for Connecticut & New England Homeowners, accessed April 2017*: http://nemo.uconn.edu/raingardens/calculator.htm. General Services Administration, *The Benefits and Challenges of Green Roofs on Public and Commercial Buildings*, May 2011. Center for Land Use Education and Research at the University of Connecticut, *Permeable Pavements for Stormwater Control*. September, 2011. Rainwater harvesting tank vendors: www.rainharvestingsupplies.com; www.rainharvest.com; www.plastic-mart.com, accessed May 2017.

3. Wet Floodproofing:

Modifying a building to withstand some exposure to floodwaters using flood openings and/or flood damage-resistant materials, while minimizing damage to the structure and its contents.

Types of Wet Floodproofing

- Install flood openings like flood vents in the walls to allow water to pass through and to equalize the hydrostatic pressure from the floodwaters.
- Use water-resistant materials that do not need to be replaced if flooded.

Benefits

- Reduces the risk of flood damage to a building and its contents, even with minor mitigation.
- Greatly reduces loads on walls and floors due to equalized hydrostatic pressure.
- The cost of relocating or storing contents, except basement contents, may be eligible for flood insurance coverage, after a flood warning is issued.

Challenges

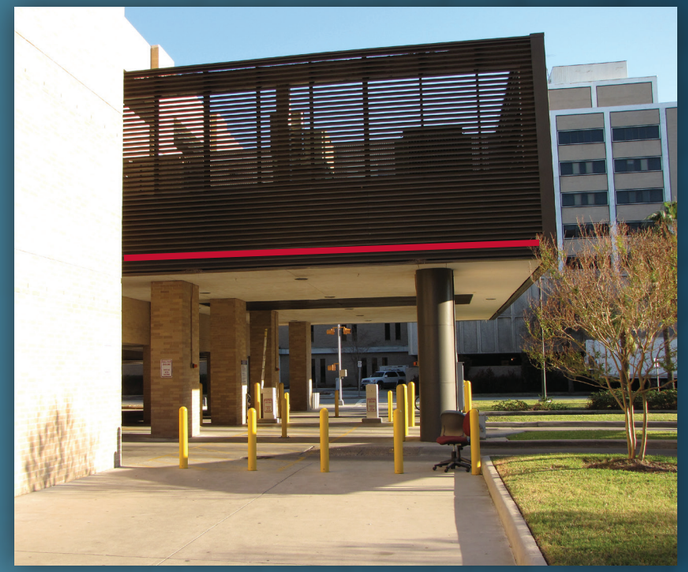
- Does not satisfy the NFIP requirement for bringing substantially damaged or improved structures into compliance.
- Does not protect the buildings located in V Zones against wave action or high-velocity flood flows, and is not permitted by FEMA in V Zones (Coastal High Hazard Areas) for new construction or substantial reconstruction of structures.
- Usually requires a pre-flood warning and ample time to prepare the building and contents for flooding.
- Requires human intervention to safely access and move contents from the flood prone area.
- Results in a structure that is wet on the inside and possibly contaminated by flood-borne contaminants and other materials borne by floodwaters and may require extensive cleanup.
- Prohibits the building from being occupied during a flood and may make the structure uninhabitable for some period after flooding.
- May require additional costs to bring the structure up to compliance with current building codes.

Approximate Costs

- Flood vents: $30 - $400 each.
- Flood damage-resistant materials: costs vary greatly , depending on the size and nature of the system or building, among other variables.

4. Elevation:

Raising the existing structure or critical building components (such as mechanical or electrical equipment) above the base flood elevation (BFE).



Types of Elevation

- Elevate a structure on fill or on piles, piers, or columns.
- Elevate critical building components such as mechanical and electrical equipment on platforms or frames.

Benefits

- Protects a building or building components from flooding by raising it above the BFE.

Challenges

- May require extensive site modification, structural reinforcements, and/or structural support.
- May be cost-prohibitive for existing buildings and/or buildings with sub-grade basements.
- The space below the building cannot be occupied except for use as parking, storage or building access.
- If the space below the building is enclosed, it should be wet floodproofed as well.
- Access to building and/or building components should be considered and addressed, including requirements of the Connecticut Building Code and Americans with Disabilities Act (ADA).
- Fill is not permitted by FEMA in V Zones (Coastal High Hazard Areas).

Approximate Costs

- Costs for elevating a structure are variable.
- Raising electric components (panel, meter, outlets, switching and wiring) in a 1,000-sq. ft. structure: $1,500 - $2,000.

Sources: FEMA, *Protecting Building Utility Systems from Flood Damage: Principles and Practices for the Design and Construction of Flood Resistant Building Utility Systems.* FEMA P-348, Edition 2, February 2017; FEMA, *Floodproofing Non-Residential Buildings*. FEMA P-936, July 2013; FEMA, *Coastal Construction Manual*. FEMA P-55, Volume II, August 2011; FEMA, *Flood Damage-Resistant Materials Requirements,* Technical Bulletin 2, August 2008. FEMA, *Wet Flood Proofing Requirements*, Technical Bulletin 7-93, December 1993. Flood vent vendors: http://floodsolutions.com; https://www.floodinsurancefloodvents.com accessed: May 2017. Dodge Date & Analytics, *Smart Vent Cost Analysis*, 2012: www.construction.com/CEPartVer/2012/Smart_Vent_Cost_Analysis.pdf. FEMA, *Build with Flood-Damage Resistant Materials: Protecting Your Property from Flooding*, April 2011.

Sources: A Better City: Challenge for Sustainability, "Building Resilience Toolkit," accessed April 2017: http://challengeforsustainability.org/resiliency-toolkit/; Department of City Planning, City of New York, *Urban Waterfront Adaptive Strategies*, June 2013; FEMA, *Protecting Building Utility Systems From Flood Damage: Principles and Practices for the Design and Construction of Flood Resistant Building Utility Systems.* FEMA P-348, Edition 2, February 2017. FEMA, *Raise Electrical System Components: Protecting Your Property from Flooding*, April 2011.

5. Dry Floodproofing:

Employing flood-resistant barriers or impermeable elements at openings of building to bar floodwater entry and to resist flood loads.

Types of Dry Floodproofing

- Install impermeable membranes and sealants applied to exterior wall faces.
- Make critical core components and areas flood-resistant if dry floodproofing the entire building footprint is not needed or is not possible.
- Install backflow valves on sewage pipes to prevent sewage from backing up into a building.
- Install structurally reinforced, portable watertight barriers (i.e., flood doors or shields) in front of (not attached to) building openings (doors, windows, garages) just prior to flood events.
- Install polished concrete flooring that is impermeable and will not need replacement after flooding.
- Where practical, permanently close any openings in the building's exterior either with brick, concrete block or glass block.

Benefits

- Reduces the flood risk to the structure and damage to contents.
- Less costly than other measures such as floodwalls or levees.
- Retains the structure in its present environment and may avoid significant changes in appearance.
- May be used to bring existing structures into compliance with the community's floodplain management regulations and codes.
- Can be used to protect against more frequent flooding from lesser storm events, even if it is not practical or cost-effective to floodproof to the BFE.

Challenges

- Does not protect the building against wave action or high-velocity flood flows and is therefore not permitted by FEMA in V Zones (Coastal High Hazard Areas), and is not permitted by the Connecticut State Building Code in Coastal A Zones.
- Usually requires human intervention and adequate warning time for installation of protective measures.
- May provide no protection if measures fail or are exceeded during large or long-duration floods.
- May result in more damage than flooding if design loads are exceeded, walls collapse, floors buckle, or the structure floats.
- Seepage through barriers or walls should be expected, particularly when piping, conduits, and other elements penetrate the barriers or walls.

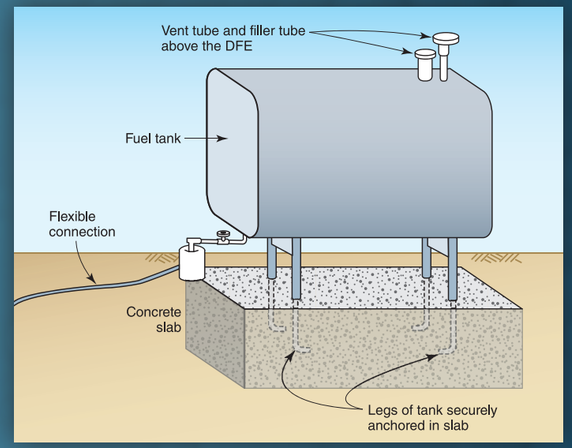
Approximate Costs

- Backflow valve: $600 to $1,400 depending on valve type and size.
- Aluminum flood shield: $90 - $300/ft.
- Polished concrete: $2 - $7/sq. ft.
- Glass block: $400 - $1,100 per window.

Sources: FEMA, *Protecting Building Utility Systems from Flood Damage: Principles and Practices for the Design and Construction of Flood Resistant Building Utility Systems*. FEMA P-348, Edition 2, February 2017; FEMA, *Floodproofing Non-Residential Buildings*. FEMA P-936, July 2013; FEMA, *Coastal Construction Manual*. FEMA P-55, Volume II, August 2011. FEMA, *Install Sewer Backflow Valves*, April 2011. San Antonio River Authority, *Holistic Watershed Master Plan: Wilson, Karnes and Goliad Counties, Volume I – Flooding Issues*. May 2015. Flood shield vendor: www.tmhardware.com/Door-Flood-Barrier-Shield.html, accessed: May 2017. Concrete floor vendors: www.glossyfloors.com/cost-of-polished-concrete-per-square-foot/, www.concretenetwork.com/concrete/polishing/comparison-chart.html, accessed May 2017. Modernize Home Empowerment, "Glass Block Windows" https://modernize.com/windows/types/glass-block-windows.html, accessed May 2017.

6. Secure Tanks:

Exterior tanks containing fuel crucial for building operations or other materials used in manufacturing or production are especially vulnerable to floodwaters and can break away during flood events and release hazardous materials into the environment. These methods help to secure the tanks.



Methods to Secure Tanks

- Install concrete base or anchors buried in the ground that have sufficient weight to resist flood waters; secure tanks to anchors with metal straps
- Mount tanks on wheels to enable relocation to higher ground prior to flood events
- Locate tanks in dry, flood-proofed enclosures.

Benefits

- Prevents flotation during flooding flood events, thereby minimizing damage and contamination.

Challenges

- In V Zones (Coastal High Hazard Areas), aboveground storage tanks are not permitted under elevated buildings or attached to buildings below the lowest floor.
- In coastal areas, anchors should be made of corrosion-resistant materials to avoid salt spray damage.

Approximate Costs

- Anchoring a 1,000-gallon fuel tank to a concrete base: $300 - $500.

Sources: FEMA, Protecting Building Utility Systems from Flood Damage: Principles and Practices for the Design and Construction of Flood Resistant Building Utility Systems. FEMA P-348, Edition 2, February 2017; FEMA, Anchor Fuel Tanks: Protecting Your Property from Flooding. April 2011.

7. System Backup:

Alternative energy systems to enable a building's power networks to continue to operate during emergencies.

Methods of System Backups

- Install combined heat and power (CHP) generators such as reciprocating engines, steam turbines, microturbines, fuel cells, combustion turbines.
- Install batteries for emergency applications.
- Install a microgrid for local power users.

Benefits

- Maintains power in isolation, even when overall power grid is off-line; thereby preventing service interruptions.
- Provides reduction in energy costs and emissions.
- CHP generators are highly efficient and offer greater reliability than conventional diesel generators.

Challenges

- Should be installed in conjunction with floodproofing techniques (such as elevating the generators above the BFE).
- Requires periodic testing to ensure serviceability.
- Batteries have finite supply of power which may run out during extended flooding events.
- High-capacity batteries can be large.
- Microgrids may not be the most environmentally-friendly option, depending on fuel source and require new electrical infrastructure.

Approximate Costs

- Reciprocating engine: $1,400 - $2,900/kilowatt (kW).
- Steam turbine: $650 - $1,150/kW.
- Microturbine: $2,500 - $4,300/kW.
- Fuel cell: $4,600 - $23,000/kW.
- Combustion turbine: $1,250 - $3,300/kW.
- Batteries: $255 - 300/kW.
- Microgrid: $1M - $2.5M.

Sources: FEMA, *Floodproofing Non-Residential Buildings*. FEMA P-936, July 2013; U.S. Environmental Protection Agency (EPA) Combined Heat and Power Partnership, "CHP Benefits," accessed April 2017: https://www.epa.gov/chp/chp-benefits; EPA Combined Heat and Power Partnership, *Catalog of CHP Technologies*, March 2015 https://www.epa.gov/chp/catalog-chp-technologies, accessed April 2017. National Renewable Energy Laboratory, *Economic Analysis Case Studies of Battery Energy Storage with SAM*, 2016 http://www.nrel.gov/docs/fy16osti/64987.pdf; KEMA Inc, *Microgrids – Benefits, Models, Barriers and Suggested Policy Initiatives for the Commonwealth of Massachusetts*, 2014 http://files.masscec.com/research/Microgrid.pdf.

8. Internal Drainage System:

To collect and discharge floodwaters from a basin within a building into the sewer system.

Methods of Internal Drainage Systems

- Install basins and sump pumps in areas where floodwater could accumulate.

Benefits

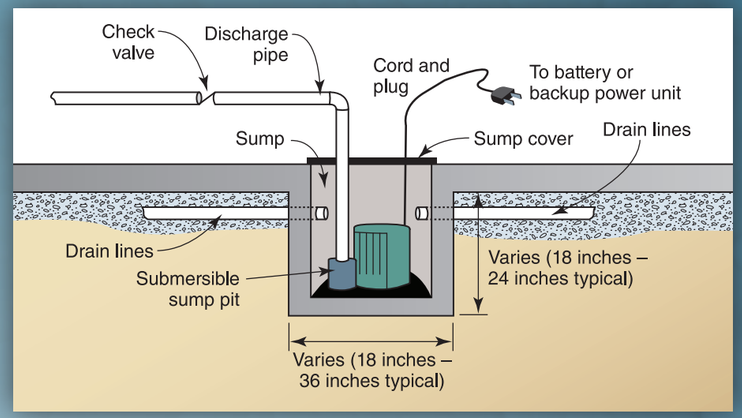
- Provides drainage for increased water leakage due to flooding events.

Challenges

- Should be combined with other dry floodproofing and system backup measures, so as to protect the electrical system supplying the sump pump.
- Heavy flooding can overwhelm pumping capacity.
- Per 412.5 of the 2012 International Plumbing Code portion of the 2016 Connecticut State Building Code, floor drains shall not be connected to the storm sewer system.
- Requires care when pumping out basements to avoid foundation wall collapse.
- Requires periodic testing and routine maintenance to ensure running properly.
- NFIP requires sump pump installation when dry floodproofing is used as a retrofit technique.

Approximate Costs

- Sump pump: $200 - $3,500



Sources: FEMA, *Floodproofing Non-Residential Buildings*. FEMA P-936, July 2013; Sump pump vendor: www.grainger.com, accessed May 2017; Dodge Date & Analytics, *Smart Vent Cost Analysis*, 2012: www.construction.com/CE/articles/2012/Smart_Vent_Cost_Analysis.pdf.

Modern Manufacturing Facility

"Dry Floodproofing" such as polished concrete flooring with impermeable sealant could be installed to resist damage from floodwaters and make clean-up easier.

"System Backup" such as providing backup electrical and communications systems in ceilings to take over if conduits in floor slabs are flooded can help keep businesses in operation immediately after flood events.

"Dry Floodproofing" such as impermeable sealants can be applied to exterior walls.

Facility in the Fair Haven section of the city near the Mill River

"Internal Drainage Systems" should be installed in basement storage areas

The "Elevation" of critical infrastructure above flood elevations, will ensure that building systems and operations can be quickly restored after a flood event.

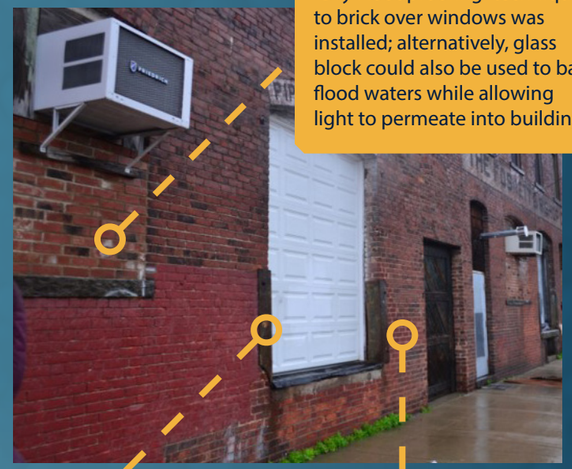
Historic Manufacturing or Warehouse Facility

"Internal Drainage Systems" could be installed in basement storage areas

Fair Haven Furniture: 72 Blatchley Avenue

"Wet Floodproofing," such as louvered vents, could be installed in openings leading to basement or crawl space to improve the building's ability to withstand hydrostatic pressure caused by floodwaters.

"Dry Floodproofing" technique to brick over windows was installed; alternatively, glass block could also be used to bar flood waters while allowing light to permeate into building.



"Dry Floodproofing" such as impermeable sealants can be applied to exterior walls.

"Dry Floodproofing" such as portable flood resistant barriers could be installed at ground-level doors and other openings to bar floodwater entry.

Small Commercial or Retail Facility

Popeye's: 317 Kimberly Avenue

"Dry Floodproofing" such as portable flood resistant barriers could be installed at depressed truck loading areas to bar floodwater entry.

The "Elevation" of this new restaurant and its critical infrastructure were constructed above flood elevations, while maintaining ADA access from parking areas.

"Dry Floodproofing" such as impermeable sealants can be applied to exterior walls.

"Secure Tanks" to buried concrete bases or other anchors to resist floodwaters and avoid spillage of hazardous materials into the environment.

Modern Showroom and Warehouse/Distribution Facility

"Green Infrastructure" such as bioswales, pervious pavements, rain gardens and tree plantings can help reduce stormwater runoff and reduce potential for flooding from lesser storm events.

Bender: 335 East Street

"Internal Drainage Systems" could be installed in basement storage areas.

"Dry Floodproofing" such as impermeable sealants can be applied to exterior walls.

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This brochure was prepared by the City of New Haven.

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www.circa.uconn.edu