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15 May 2020

Appendix to Sustainable Concord: Climate Action and Resilience Plan

Town Center Resilience Assessment and Recommendations

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1. Study Introduction

Concord is susceptible to the impacts of climate change, namely increases in heat, rainfall, and storms, and damage caused by riverine and stormwater flooding. While the Town of Concord has excelled at taking action to prevent the emission of greenhouse gases that cause climate change, the Town still has more to do to prepare for the changes that already exist. Concord's town centers can be made more resilient to the current and upcoming impacts of climate change through planning efforts which will allow businesses and residents to continue enjoying their town amidst changing conditions and challenges.

In collaboration with the framework provided by the Sustainable Concord planning process, our consulting team, Kim Lundgren Associates and One Architecture & Urbanism, is working to develop resilience design recommendations for two of Concord's town centers: the Main Street-Milldam center and the West Concord center. Our team has recognized the importance of stakeholder engagement, and we have made it a priority to include the voices of Concordians within the planning process. This document will summarize the findings of our planning research (i.e. identified vulnerabilities and best practices) and our takeaways from two community engagement opportunities, as well as preliminary recommendations for Concord's town centers via urban design, architecture, and policy solutions.

2. Climate Projections and Impacts[1]

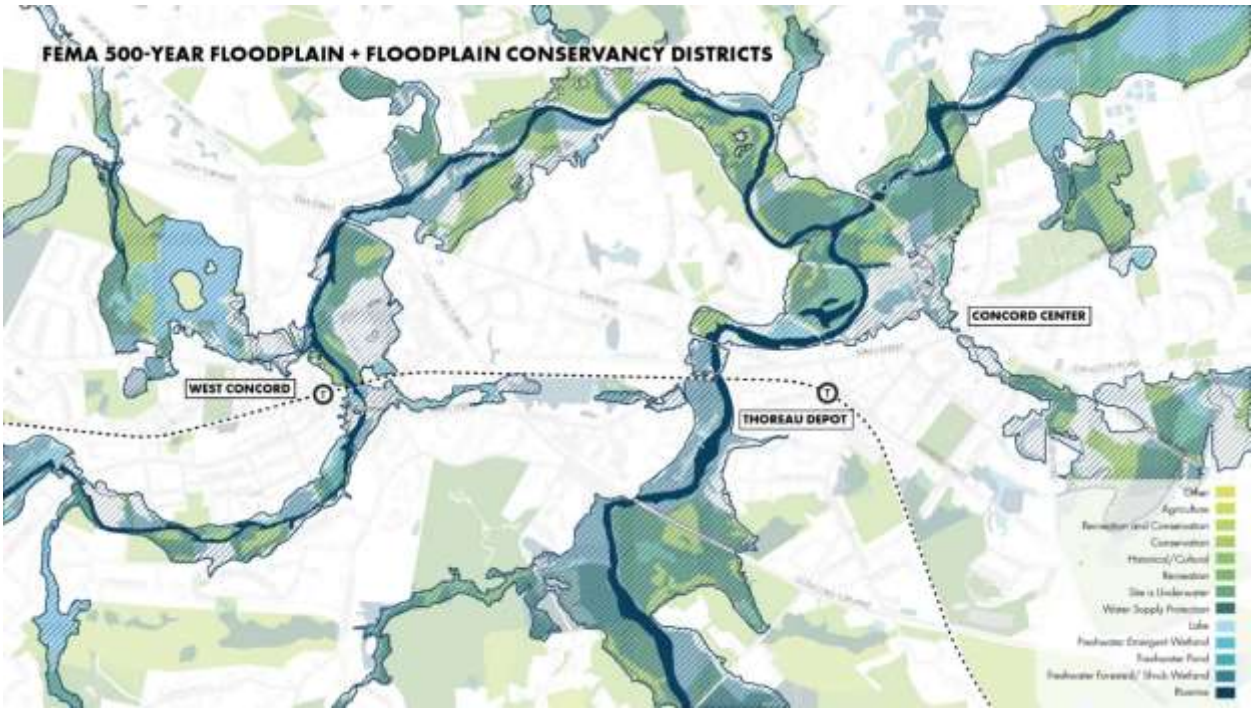
Our preliminary recommendations for Concord's town centers are based off both the scientific evidence and climate change projections from past studies and state resources as well as feedback and ideas gathered from communicating with stakeholders and residents. As a result of the changing climate, the Town of Concord is expected to be impacted by more intense and frequent storms and a noticeable increase in average temperature.
For example, severe storms that now occur every decade are predicted to become an annual event by 2050, thus putting a strain on Concord's infrastructure. The Sudbury-Assabet-Concord river system, which already has historic patterns of flooding, will have moderate increases to its flooding volume by 2055 and even larger increases by 2085. Additionally, while the severity and frequency of storms are expected to rise with climate change, the Town of Concord will also need to adapt its current water needs and sources. A changing climate will increase the frequency of droughts, thus impacting the need for a clean water supply.[2]

[1] Additional maps from the vulnerability analysis process is attached in the supplemental materials. These maps and findings were presented and discussed with a stakeholder group from various Town agencies in December 2019.
[2] The reports studied are: Climate Change Resilience Plan Vulnerability Assessment & Response Strategies, 2017, MAPC "The relationship between precipitation and flooding is complex. Flash floods and urban flooding may be caused directly by heavy downpours, but river flooding also depends on factors such as the amount of impervious surface cover, soil type, and soil saturation" ... "One rule of thumb that the City of Cambridge is using until more precise information is

Average ambient temperature is expected to increase in the upcoming years. The average annual temperature, which has historically hovered around 46-50° Fahrenheit, is expected to increase by 3-4° by 2035 and 6-9° in the decades leading up to 2100. Rising temperatures will impact human health and comfort; even small increases from average temperatures are associated with increased rates of illness and death, as well as exacerbating chronic conditions like cardiovascular disease and diabetes. Rising temperatures also affect human comfort and have negative impacts on Concord's ecology.[3] Data in the tables below is from the ResilientMA.org resource - The Massachusetts Climate Change Clearinghouse (resilient MA).[4]

While the challenges of climate change are intimidating, measures can be taken today to adapt Concord's neighborhoods from various extreme weather effects, including increased flooding and stormwater runoff. These measures will protect the town from weather-related events like flooding while offering long-term solutions for more persistent problems like water quality and supply and increased urban temperatures.

Focus Areas



available predicts that 100-year floods will occur at the current 500-year flood level." magic 2017. Riverine flooding is a result of multiple circumstances, currently there are no models available with volume and flooding projections. The Commonwealth of MA is planning on addressing the data gap with a statewide study.

[3] An urban heat island study performed by the MAPC in 2016 showed surface temperature of paved surface at the Concord Town centers can reach 140° Fahrenheit.

[4] Tables from ResilientMA are featured in the glossary section of this document

For our study, we chose to focus on two areas: The Concord Center (encompassing Main Street) and West Concord. The Concord Center is home to a majority of Concord's businesses and is one of the town's established historical districts. Properties in the Concord Center, especially those in close proximity to the river and Milldam, contain old and dense properties, are located on a floodplain, and have a history of extreme weather and flooding. Similarly to Main Street, West Concord consists of several businesses and is economically vulnerable to shocks in weather and climate. Together, both focus areas make up Concord's businesses districts and are thus the economic hubs of the town. Ensuring the protection of these historical and vibrant areas from climate change and extreme weather are key to protecting the livelihoods and character of Concord and its residents.

3. Summary of Community Survey and Workshop Findings

Survey

The team developed a survey to gather information from businesses and property owners in the town centers on current climate impacts and vulnerabilities and potential actions. The survey was mailed to businesses and available online through the Town's website. The survey received fifteen unique responses (by February 26th 2020). Roughly two-thirds of survey respondents were business owners while the remaining sample consisted of school representatives and residents.

Survey respondents described three priority areas for action: (1) an improved stormwater management system, (2) energy use and supply concerns and (3) an emergency community preparedness and education plan. Survey respondents from both Main Street and West Concord mentioned the impact of flooding on their businesses and property; several respondents had experienced multiple basement floods, particularly those situated on Main Street and West Concord. They expressed concern over the longevity of existing infrastructure under a rapidly changing climate, particularly stormwater drainage, snow removal services, and energy sources and availability. Survey results reflect the detrimental effect of weather events Concord's businesses and schools and underscore the opportunity for comprehensive resiliency planning and emergency preparedness.

Concord Center - Main Street and Milldam

One businessowner located on Main Street experienced basement flooding seven times in the last six years due to overflowing on Milldam, resulting in property damage and the business temporarily closing for eight days. Due to flooding, several businesses which responded to our survey mentioned a loss of assets, including inventory and physical space. Currently, many businesses on Main Street and Milldam rely on pump systems and dehumidifiers to protect their property.

Respondents expressed concern over the impacts of severe weather on Concord's economy. Under extreme weather conditions, business worsens due to a lack of access caused by runoff on pedestrian crosswalks, overflowing streets, and sidewalks inadequately serviced in snow conditions.

West Concord
Out of 4 business located in West Concord -two expressed similar concerns regarding prolonged rain and flooding. Both of the businesses surveyed experienced asset damage and decreased sales during periods of extreme weather.

Other Locations
While the focus of our survey was on stakeholders in Concord's business districts, issues related to other areas of Concord continued to come up. Like Main Street and West Concord, other areas of the town have been susceptible to flooding, affecting the local habitat and tree cover, and disrupting schools, businesses, and homeowners.

Open House
The team held an "office hour" style meeting where Concord residents could discuss any ideas or concerns with us directly. The office hours were held in a public space from 2-6pm during one weekday in February and was publicly advertised to relevant stakeholders within our areas of focus (Main Street-Milldam and West Concord). We received three visitors representing businesses and schools. During this office hour meeting, we responded to questions and comments and educated visitors about the potential role of resiliency planning in Concord.

Overall, the comments and concerns we heard from Concord residents and stakeholders aligned with the results of our survey. One small business and property owner in West Concord emphasized the impact of spring flooding on the basements in his neighborhood, especially in businesses on the north side of Commonwealth Avenue. The business owner stressed the importance of investing in sumps and in corresponding backup generators to support the infrastructure in a power outage, which were common in the 1970s and 80s. According to this stakeholder, the implementation of permeable pavers and shade-tolerant plants would work well for his property. This business owner also suggested investment in stormwater drains on West Concord streets; as of now, a single drain is responsible for all buildings on Commonwealth Avenue and Beharrel Street. This is not sufficient, as six to eight inches of rain are a common occurrence in the spring and summer.

Best Practices + Recommendations

In the meeting we presented boards with best practices for flooding and urban heat for the property typologies we identified in the assessment process:

- Historic structures
- 20th-21st Century construction

- Streets and surface parking
- Open Space

Based on our findings from the community survey and the information discussed in the office hours meeting, we suggest the following preliminary resilience planning mechanisms. These will be further unpacked in the next section:

Historic Properties

Concord's historic properties are especially vulnerable to excessive heat and flooding. As seen in similar preservation projects across the Northeast, particularly a case study completed in Newport, Rhode Island (History Above Water), a large array of potential solutions exist which will help make Concord's valuable historic assets more resilient. The existing properties at West Concord, as documented from our conversations with stakeholders, use similar techniques to protect from subsurface streams flooding – they wet proof their basements. This approach focuses on insolation of the basement and installation of pumps. Waterproofing of basements will prevent water from entering porous building materials, such as concrete. We recommend that property owners and residents in especially flood-prone areas elevate or fill their building's lowest levels; in addition, we recommend that they relocate important systems and assets above ground level in preparation for increased flooding. We also encourage strategies already employed by survey respondents, such as installing pump systems and dehumidifiers.[5] The option of elevating the ground floor and basement will need to be further studied, it will be more feasible for standalone structures and not buildings that are part of a continuous street façade.

In addition to basement protection and waterproofing, historic properties may require an insulation and system overhaul to improve the energy efficiency and longevity of HVAC, stormwater, roofing, and exterior structures. If investments in these systems precedes extreme weather conditions, Concord's residents will have less to pay in operating fees and repair costs.

20/1th Century Development and Contemporary Development

Similarly, to the solutions provided for historic properties, we recommend elevation of building levels below ground level, if not the elevation of entire building structures and the streetscape. If elevation is not possible for existing development, we strongly suggest that all future development is built above ground level with the entrance above the Design Flood Elevation of FEMA 500 year floodplain or more conservative model available.[6] For more contemporary development which can support the necessary weight, we encourage the implementation of green and blue roofs (vegetation planted over a waterproofing membrane on top of a structure) to allow for drainage and irrigation systems whilst preventing stormwater runoff. And considering stormwater retention areas and green infrastructure as part of large parking lot areas. For future development, we recommend that the Town of Concord implements careful land use planning and zoning laws to

[5] More details on Flood resistant construction can be found in the Boston Coastal Flood Resilience Design Guidelines by the BPDA and on the FEMA website.

[6] FEMA definition for Design flood Elevation (DFE) https://www.fema.gov/media-library-data/20130726-1828-25045-8178/fema_quick_ref_guide_flood_areas_022713_508.pdf

ensure that all new development (including housing, offices, and parking) takes place in only safe areas, outside of flood zones.

Surface Parking and Streets
Concord's streets have been routinely mentioned in our survey results; respondents stressed the importance of well-maintained streets and accessibility access to stores by customers. Currently, Concord's streets flood and fill with snow often, prohibiting customers from accessing the various stores and services available in the business districts. Thankfully, a number of solutions exist to improve stormwater drainage and runoff collection.

We recommend that the Town of Concord explores bioswales and rain gardens, which can act as small, attractive vegetated spaces while simultaneously channeling stormwater runoff, removing debris and pollution, and incorporating runoff into existing water systems. Bioswales are commonly seen along streets or around parking lots. Rain gardens, which share a similar appearance to bioswales, are affective mechanisms for absorbing stormwater on pedestrian walkways and on roofs. Like bioswales, rain gardens can be incorporated into the town's water system and can clear runoff pollution through the natural use of water-wise plants and soil.

Street trees were mentioned and discussed by the stakeholders during the office hours meeting. Due to aging, condition, high wind, and fear of impact of utility infrastructure many street trees were removed. Implementing layered green infrastructure along streets can reduce surface and ambient heat along the Town center streets – this can also be a place making opportunity to increase visitation to Town centers. Thinking about replanting some historic species in locations might reinforce the historic character. As one of the visitors mentioned "Elm street was name after rows of trees that are no longer in place".

Green Space
Concord's green spaces, especially regarding the preservation of natural resources such as trees, were commonly mentioned in the survey results. We recommend the preservation of tree canopy and increased urban vegetation. Similarly, to the policies mentioned in our Surface Parking and Streets recommendations, the Town of Concord can implement bioswales and rain gardens in open spaces to channel stormwater runoff while preserving the aesthetic of the natural environment.

Concord can also protect existing natural resources, like streams, rivers, and wetlands through a process known as restoration. Bodies of water and wetlands are often covered up, built atop of, or degraded through the process of urbanization. By reversing the effects of man-made infrastructure on these natural resources, Concord will be less prone to disasters such as flooding. For example, through a process known as daylighting, Concord can restore its streams and rivers to their open-air original state, thus creating a natural pathway for runoff. By increasing the availability of trees, parks, green spaces, and natural infrastructure, Concord can benefit from protection from extreme heat and sun while improving air and water quality.

4. Resilience Best Practices
Recommendations and Resources by Typology

Historic Structures

Concord's historic properties are especially vulnerable to excessive heat and flooding due to aging structures and outdated building technology. By investing in resilience projects now, Concord can guarantee the long-term protection of its historical past and identity, whether through the protection of individual buildings or entire historical districts, such as the Main Street business district. Implementing resilience in existing structures might require alterations to the exterior; these changes will need to be in line with their historic integrity. We suggest that property owners and managers invest in projects that protect their assets from extreme weather conditions to preserve historic structures. The trade off between longevity, preservation, and resilience to the Historic character can be balanced by sensible design. The vulnerabilities identified are subsurface flooding, riverine flooding, flooding from extreme precipitation, and increase in heat.
We recommend that historic building owners take the following precautions:

1. Floodproofing basements and installing pump systems and dehumidifiers
2. Relocating important systems and assets above ground level
3. Renewing HVAC, stormwater, roofing, and exterior structures (insulation)
4. Elevating entrances above the Design Flood Elevation (DFE)[7] mark, removing uses from basement floors, or filling a building's lowest levels.

Resources:

FEMA Guidelines

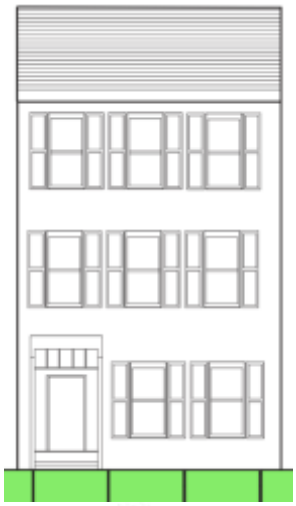
The Federal Emergency Management Agency (FEMA) provides design guidelines and recommendations for a range of structure types, including giving special consideration to recognized historic buildings. Under their guidance, historic structures located within floodplains do not have to meet typical management requirements as long as the historic structure designation is maintained. Still, both our team and FEMA recommends investing in mitigation measures that are permissible for designated historic structures in order to preserve vulnerable structures from environmental changes. Mitigation also offers economic benefits for property owners; waterproofing and retrofitting may reduce flood insurance costs. FEMA's report on historic structure solutions contains several case studies and can be found at this link: https://www.fema.gov/media-library-data/20130726-1628-20490-7857/tb_p_467_2_historic_structures_05_08_web.pdf.

Boston Planning and Development Agency Resilient guidelines (Resource)

The Boston Planning and Development Agency (BDPA) has created in-depth design guidelines for buildings located within flood-prone areas, some of which are applicable to Concord's context. Our

[7] The elevation of the highest flood (generally the BFE including freeboard) that a retrofitting method is designed to protect against. Also referred to as Flood Protection Elevation – from the FEMA Glossary

recommendations align well with BPDA's. For historic buildings, specifically those that cannot be completely retrofitted due to preservation requirements, both our team and BPDA recommends protecting (and moving) critical systems, waterproofing and improving insulation, elevating the lowest interior floor, and upgrading HVAC and other systems. BPDA's how-to report on floodproofing historical buildings can be found at this link: https://www.boston.gov/sites/default/files/imce-uploads/2018-10/resilient_historic_design_guide_updated.pdf

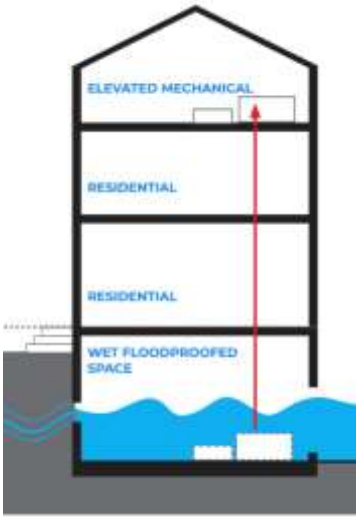


Subgrade + Ground Floor Flooding

Concord's properties—new and old—have histories of subgrade flooding, especially those located on Main Street or in West Concord. There are two main types of floodproofing which may help: dry and wet.

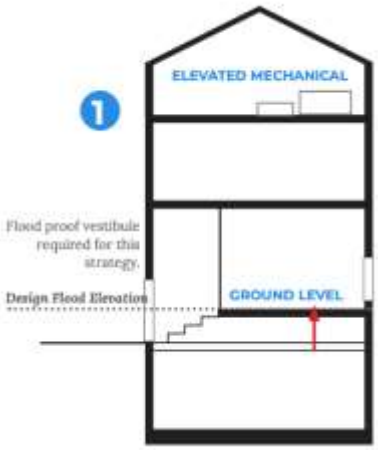
In dry floodproofing, the building structure is made watertight below the design flood elevation (DFE), as designated by FEMA, to prevent floodwater from entering. This is done by sealing walls with waterproof coatings or membranes, installing impermeable membranes or temporary flood barriers, and placing watertight shields over windows and doors.

Dry floodproofing with temporary flood barriers (Source: BPDA)



In wet floodproofing, water is allowed to move in prepared enclosed parts of a building's lower area, and is then allowed to leave the structure when water recedes. In wet floodproofing, water inside the building can reach the same level as water outside, thus equalizing pressure and preventing structural damage. In order to wet floodproof, all spaces (e.g. basements) below DFE should be retrofitted with materials that can be made wet, sustain minimal structural damage, and can easily be dried or restored. Since water may enter the lower levels, all valuable assets and systems should be relocated to higher levels and heavy objects should be mounted to walls or the floor. Property owners are encouraged to invest in sump pumps and dehumidifiers to facilitate the drying out of water-filled spaces.

Wet floodproofing (Source: BPDA)



In addition to floodproofing, historic structures should consider elevating their entrance. This can be done in three ways: (1) elevating only the lowest level, (2) elevating the lowest level and the entry, and (3) elevating the entire structure. In all cases, the entrance level should not be lower than the DFE. Elevation of all structures, and historic structures, can be difficult and expensive. And changes of entrance grade elevation can impact accessibility of commercial properties.[8] Elevation is encouraged for newer developments (see below section on 20th and 21st century construction), but may be plausible for property owners who were already considering a major interior renovation of their historic building. To preserve historic structure designation, property owners should choose elevation methods that have minimum visual impacts on the building's front façade to prevent making any large aesthetic changes. If elevation is not possible, levels below the DFE can be filled instead. For specifics high risk buildings, owners can explore the installation of a modular/ deployable systems.[9] *Elevation of ground level only with floodproof vestibule (Source: BPDA)*

Energy + Insulation

Damage caused to a building's nonstructural systems, such as heating and air conditioning systems, can dramatically affect a facility's ability to function. Thus, property mitigation techniques involve both protecting and futureproofing all vital systems. Valuable mechanical and electrical systems should be brought above the DFE in case of flooding.

In addition to protecting existing systems, property owners are encouraged to consider investing in newer technologies to improve energy efficiency. This is especially important in a changing climate where it is predicted that average temperatures will increase and put further strain on energy systems. Historical buildings can utilize operable windows, shutters, and skylights to allow for natural ventilation and light, thus reducing energy consumption. While it may not be wise to install a completely new HVAC system, property owners can upgrade existing mechanical systems (e.g. reusing radiator system with new boilers, improving insulation). Property owners can

[8] The Historic District in Newport RI, explored various options for flood protection www.cnu.org/what-we-do/build-great-places/keeping-history-above-water

[9] There are multiple options and flood barrier technologies in the market such as Aquafence and NOAQ Boxwall

reduce any existing air leaks in their properties, which commonly arise from attics and crawl spaces, windows and hatches, chimneys, or around doors. It may also be wise to invest in an energy audit which will evaluate the current energy use of a building and identify any deficiencies in a building's system or insulation.

Common areas where air escapes (Source image: National Park Service)

Policies for Historic Character

Under Concord's current historic building guidelines, several types of alterations require review by the Concord Historic Districts Commission (HDC). In particular, all of the following must first be discussed and approved by the HDC: changes to grade and elevation, changes visible from public street, changes in material or design of exterior elements, and changes to any landscaping structures or features. A full list of HDC's guidelines can be found here: https://concordma.gov/DocumentCenter/View/5806/Historic-Districts-Design-Guidelines---Amended-August-2015.

A Georgian doorway fitted with unobtrusive slots to hold a temporary flood barrier (Source: National Park Service)

A waterproof coating applied to the lower external walls of a cottage (Source: National Park Service)

While our most conservative recommendations should not create any noticeable aesthetic changes if done carefully, it may be worthwhile for the Town to consider making amendments to existing preservation criteria. Notably, historic properties could better utilize natural infrastructure (e.g. tree coverage, bioswales and rain gardens) to mitigate damage caused by extreme weather and reduce

energy resources, most of which require review and approval from the HDC. Under these requirements, property owners hoping to elevate their buildings to reduce flood damage must first week approval, as do owners who want to dry waterproof their structures with newer materials. Strict policies constraining owners of historic buildings from trying to make their buildings more futureproof should be discouraged.

We project that the challenge to the guidelines will arise once property owners are required to alter basements, especially in the town centers where business use these spaces for storage. It will potentially require a solution for storage space on or off site. We believe that by retrofitting and adapting Concord's historic buildings, Concord can ensure its future as both a historic landmark town and as an economic hub. The Envision Concord master plan recognizes this, stating that one of its priority items (gathered from a public engagement process) is to "Protect the historic, natural, and agricultural character of the town, including sustainable development practices" (p. 138). Envision Concord also mentions the possibility of growing the historic downtown area. Although the plan does not recommend "the build-out of significant numbers of the existing buildings" (p. 146) due to historic preservation guidelines, it is worthwhile to explore the option that when feasible, property owners in the downtown area consider adding additional square feet to their property by adding supplementary floors to make up for square feet either lost or filled in for flood protection. These additional spaces can be constructed towards the back of the property, thus mitigating aesthetic differences from the street.

Concord has the opportunity to be a leader in sustainable historic preservation. One precedent, Newport, Rhode Island, recently voted to adopt new design guidelines for historic properties. Newport historic property owners, if located in a coastal FEMA flood zone, may apply for permission to elevate their properties above flood lines. Property owners are strongly encouraged to incorporate materials and design elements consistent with the building's historic character. While a seemingly small step in the direction of resilience planning, giving property owners this opportunity signals that Newport prioritizes the safety of its residences and the upkeep of historic properties, many of which are central to Newport's identity but are especially vulnerable to changing climates. We believe that Concord can successfully follow similar policies to encourage the protection of historic properties while maintaining their existing character.

Repairs after severe flooding in on a historic district in Ellicott City, MD (Source Image: Baltimore Sun)[10]

The historic area of Ellicott City, Maryland suffered a devastating flooding in the recent years. The Main St area is in the convergence of numerous streams in the valley of the Patapsco River.[11] In a report from 2018 the USACE outlines non-structural actions property owners can take to prevent damage from future flooding – these actions are similar to the outlined above: elevation, dry and wet proofing, etc.[12]

The Maryland Flood Mitigation Guide is a great resource for historic adaptation and mitigation strategies.[13] The approach to mitigation is twofold from the neighborhood and district scale strategies to the property level solutions. The large-scale solutions propose strategies for stormwater management, infrastructure improvements, and transportation improvement. At the building level the report outlines tradeoffs of the various adaptation strategies: elevation, wet floodproofing, dry floodproofing, flood damage resistant material, and perimeter barriers. Matrix to review property specific strategies from the guide are located at the end of this document.

[10] *Ellicott City, MD is an example of a riverine city impacted by extreme storms and riverine flooding. https://www.citylab.com/environment/2019/05/ellicott-city-flood-control-historic-downtown-memorial-day/589054/*
[11] *https://www.preservationmaryland.org/wp-content/uploads/2020/03/Resilient-America-Ellicott-City-Case-Study-Mar2020-FINAL.pdf*
[12] *Idib.*
[13] *https://mht.maryland.gov/documents/PDF/plan/floodpaper/2018-06-30_MD%20Flood%20Mitigation%20Guide.pdf*

Sensitive elevation of historic building. Whitehaven, Wicomico County. (Source: Maryland Flood Mitigation Guide)

20th – 21st Century Construction

Newer development shares the same strategies as those given for historic properties. Depending on the age of "newer" development, property owners and managers may need to invest in renewed systems (e.g. HVAC) to reduce future operating costs in a situation when extreme weather is a more common occurrence. However, buildings constructed in the 20th and 21st century generally have a plethora of more available options for increasing resilience. For example, newer buildings, unlike historic structures, have more flexibility when it comes to making amendments. More modern construction is generally constructed with stronger surfaces, thus enabling the placement of newer, environmentally friendly technologies such as green roofs. We recommend that building owners take the following precautions for their newer developments:

1. Floodproofing basements and installing pump systems and dehumidifiers
2. Elevating buildings above the Design Flood Elevation (DFE) mark or filling a building's lowest levels
3. Relocating important systems and assets above ground level
4. Implementing green and/or blue roofs
5. Implementing stormwater retention areas and/or green infrastructure in parking lots or gardens (e.g. bioswales, rain gardens)
6. For future development, constructing buildings above ground level or elevating entire buildings and the streetscape
7. Enforcing land use planning and zoning laws to ensure that all new development takes place in safe areas, outside of flood zones

Resources:

In short, FEMA guidelines for newer developments are very similar to those recommended for historic properties (above). However, since newer construction usually has structures more conducive to weight-bearing, it is possible, and encouraged by FEMA, for newer and future construction to incorporate newer technologies and make larger retrofitted changes, such as overhauls to energy systems or the incorporations of sustainability co-benefits through green or blue roofs or solar panel installation. For future construction, they strongly advice for all buildings to be elevated above DFE.

Subgrade + Ground Floor Flooding

Recommendations for subgrade and ground floor flooding precautions have significant overlap with those made for historical properties. Specifically, we recommend dry and wet floodproofing existing and future structures and considering elevation for existing structures. We encourage all building owners to invest in infrastructure, such as sump pumps and dehumidifiers, to facilitate the drying out of low levels in case of flooding or extreme weather. This coupled with moving important systems and assets to higher floors should mitigate a large proportion of economic burden associated with flooding damage. For future construction, we strongly suggest that all buildings in flood-prone areas have the lowest level, entryway designed above DFE with sensibility to accessibility and urban design.

Since newer and future construction does not have to apply with strict historical preservation guidelines, building owners have more flexibility over what mitigation strategies they can employ. Notably, property owners have the ability to utilize their landscape to create natural solutions for flood prevention. Such natural solutions, also called green stormwater infrastructure, can be implemented in a building's yard, or in the case of larger businesses, in parking lots. Bioswales and rain gardens are two similar types of green stormwater infrastructure which utilize vegetated features (an aesthetic bonus to property owners) to collect, treat, evapotranspire, or temporarily store stormwater runoff. Both bioswales and rain gardens have had great success in several urban and suburban projects around the United States; they are commonly placed on sidewalks, in parking lots, or other areas prone to flooding or stormwater runoff.

Cross-section of a bioswale on a neighborhood sidewalk (Source: City of Bothell)

To prevent the development of future buildings and residences in flood-prone areas, we recommend that as flood modelling evolves and once there is a more updated Riverview floodplain available the Town of Concord revisit its Floodplain Conservancy District to ensure that all new development takes place in areas outside of flood zones. The process of reevaluating land and assigning it for public or private used will also be discussed in the later Open Space section.

Energy + Insulation

In addition to the recommendations made for historical properties (e.g. utilizing windows and shutters for natural ventilation, finding and sealing air leaks, and upgrading existing mechanical systems), owners of more modern properties can consider investing in larger-scale energy and insulation projects. For example, building owners can invest in solar panels which will create a supplemental energy source, especially helpful in times when Town-wide energy systems are working at full capacity. For simpler cases, property owners can invest in emergency equipment, such as generators, which can be mounted and enclosed on rooftops.

Building owners also have more flexibility when it comes to insulation. Enhanced building envelopes can be constructed in a building's exterior to improve wall, roof, and floor insulation, thus decreasing a building's amount of energy loss. Such investments are likely to be beneficial in the long-run; the Environmental Protection Agency (EPA) estimates that, on average, homeowners can save 15% on heating and cooling costs (or roughly 11% of total energy costs) by improving insulation in their homes. Like we suggested for historic properties, we advise that all property owners consider doing a professional energy audit to understand any weaknesses or easy fixes in their building's existing insulation system.

Green / Blue Roofs

Property owners that have buildings with weight-bearing flat roofs can invest in green and blue roofs which will assist in stormwater management. Green roofs[14] are roofs designed to handle vegetation and soil. In essence, green roofs can function similarly to bioswales or rain gardens; they can capture and filter rain and stormwater while providing an aesthetically-pleasing outdoor amenity for residents that have access to their roofs. In addition to stormwater benefits, green roofs can reduce air pollution and decrease the urban heat island effect by providing shade and reducing overall roof surface temperature, thus decreasing a building's greenhouse gas emissions.

US Department of Transportation Headquarters' green roof (Source: EPA)

Similar to green roofs, blue roofs offer similar environmental benefits, with more of a focus on stormwater retention. Blue roofs are specifically designed to store rain water and slowly release it. In a future where extreme events like storms are more common, blue roofs can help manage higher stormwater loads by reducing the amount of water handled by downspouts or weak and aging infrastructure. Typically, modular trays are placed on a building's roof containing porous

[14] https://www.epa.gov/soakuptherain/soak-rain-green-roofs

materials, such as rocks or gravel, thus slowing the rate of water drainage. A building can have both blue and green roofs, permitting that the building has the appropriate roof space and can bear the weight.

Blue roof with modular gravel bins on a rooftop in Brooklyn (Source: Flickr)

Streets and Surface Parking

Over the past several years, Concord's streets have experienced high levels rainfall and snow. It is important to mitigate the effects of extreme weather on Concord's streets in order for residents to have safe commutes and to ensure that local businesses can stay open and receive customers. According to our research, many businesses along Main Street and Milldam, or in West Concord, have experienced worsened economic activity as a result of poor street maintenance or flooding. To protect the safety and economic vitality of Concord's residents, we recommend the following steps for the Town of Concord:

1. Implementing bioswales, rain gardens, or other water-retaining, permeable solutions
2. Elevating streetscapes above DFE mark if possible
3. Increased snow removal services in periods of high snowfall
4. Protecting street trees and electrical infrastructure

Bioswales, Permeable Soils + Water Retention

As previously mentioned in this guide, bioswales and other forms of water retention and filtration systems are good examples that the Town of Concord can implement throughout its streets, sidewalks[15], crosswalks, and parking lots.[16] In addition to the methods previously discussed, Concord can improve the permeability of pavements (through the use of pervious concrete, porous asphalt, or interlocking pavers) to reduce flooding and icing in a relatively cost-effective and space-saving way.

[15] Green Streets Active Practice Guide, Tucson, Arizona is a good example of Green infrastructure integration http://nrcsolutions.org/wp-content/uploads/2017/05/NRC_CaseStudies_Tucson_AZ.pdf

[16] Green Parking lots http://nrcsolutions.org/solution-4/

Bioswales and planters as part of the Portland Green Street Program (Source: City of Portland)

The addition of green infrastructure solutions to public streets also offers the possibility of placemaking, the creation of public spaces that promote the local community's health, happiness, and sociability. Additionally, green infrastructure solutions are both attractive but also create other benefits, such as reducing the urban heat island effect and decreasing greenhouse gas emissions.

Street Trees + Power Lines

While trees can act as a green infrastructure solution by absorbing stormwater runoff and pollutants, they can also become damaged in periods of extreme weather. Damaged trees may also fall into buildings or power lines, creating a dangerous and hazardous situation. The Town of Concord can install lightning protection systems to help direct storm-related electricity away from trees and into the ground, thus preventing tall trees from taking the brunt of a lightning storm. Additionally, we encourage investing in tree inspection and maintenance. This process involves a professional checking the tree for signs of damage or disease, pruning dead or infected limbs and branches, creating additional physical support systems for weaker trees, and providing trees with nutrition through fertilizing and mulching. Certain trees may also be better suited for Concord's future climate; a brief list of trees resistant to flooding can be found in the Open Space section.

By protecting both buildings and trees, Concord can reduce the chance that power lines and energy sources get damaged in the case of a storm or extreme flooding. As we enter a period of changing weather, we are expected to be even more dependent on our energy and electrical systems, relying on them to keep us cool and dry. After hitting the Northeast with winds at 80 miles per hour, Hurricane Sandy effectively shut down power for 6 million homes. Currently, 80% of the Northeast's power lines are above ground where they are susceptible to falling trees, snow, and ice. The most effective solution at protecting Concord's energy grid is to bury power lines underground, but we realize that this process is difficult and very expensive. Instead, we

recommend that the Town invest in insulation and protective methods for aboveground infrastructure, such as replacing wooden poles with metal or concrete poles and using structural supports to keep poles upright.

Open Space

In addition to offering serenity and encouraging public gatherings and physical activity, open spaces can be used to preserve natural resource and landscapes, such as trees, animals, or bodies of water. It is common for rivers and wetlands to be covered up, built atop of, or degraded through the process of urbanization. By reversing the effects of unnecessary man-made infrastructures on these natural resources, Concord will be less prone to disasters such as flooding or extreme stormwater runoff, in addition to lowering heat levels, protecting native species, and improving water quality. We recommend the following steps to the Town of Concord to protect the town's natural resources and species while creating mechanisms to prevent against extreme weather:

1. Daylighting rivers and streams, restoring floodplains, and repairing culverts.
2. Preserving the existing tree canopy and planting more urban vegetation
3. Preserving open space through land acquisition

Preserving Resources

We recommend that Concord preserve its natural resources by restoring rivers and streams and by planting more trees to grow the tree canopy. The process in which rivers and other bodies of water are opened up is called "daylighting." In daylighting[17], obstructions (usually man-made, such as concrete or pavement) covering the flow of water are removed. The restored body of water can then store and redirect stormwater, thus reducing peak flow and preventing runoff.

Concord can also grow the existing tree canopy and support local species and habitats by planting more trees. Trees offer shade, encourage placemaking, lower pollution, and absorb excess rainwater. As previously mentioned, some trees may be susceptible to uprooting or damage in the case of extreme weather. Thus, we recommend that Concord considers planting trees that are more resistant to flooding, including the following species: river birch, weeping willow, red maple, and California sycamore.

Policies for Preserving Open Space

The Town of Concord have already done many efforts to can implement various policies in order to preserve open space and purchase wetlands and land in the floodplain. By preserving ecologically vulnerable open spaces, such as wetlands, Concord can ensure that the land remains undeveloped, or if it has previously been developed, Concord can ensure that the land is properly

[17] A good example of daylighting from the Santa Fe River restoration in New Mexico http://nrcsolutions.org/daylighting-rivers/

restored. The preservation of open space often comes in the form of easements or public land acquisition. In the case in which sections of the property are in the Floodplain Conservancy area a property owner donate their land parcels to a conservation easement while maintaining ownership of the property. Though the landowner will still be able to live on their land, the land will be forever protected and will be unable to be developed.

In the case of public land acquisition, municipalities identify vulnerable or undeveloped land parcels and then acquire the property by purchasing it from willing sellers, transferring donated land to public ownership, or by utilizing dedicated funds for land preservation. Land acquisition strategies may be difficult to implement in areas with high land value (such as scenic or highly-accessible areas) or in places where development pressure is high. This strategy, when applied in the right context, has had great success in several areas of the United States (such as Colorado) and has proven a reliable way to protect valuable habitats while lessening the impacts of flooding on a community.

Lastly, we encourage the town to increase programming in open spaces. Programming can include summer concerts, barbecues and potlucks, farmers markets, or educational opportunities. By increasing programming efforts, Concord can raise awareness of the benefits of open space and native resources, thus encouraging stewardship and protection of natural areas.

Glossary: Concepts and Infrastructure

Adaptation: the adaptation of life to a changing climate, including vulnerability reduction and planning for sea-level encroachment
Bioswales: vegetated channels that provide stormwater treatment and retention while allowing water to move from one place to another
Daylighting: the process of restoring originally open-air watercourses which has at one point been diverted below ground. Allows for a natural reduction to runoff while creating habitats for local species
Ecological Restoration: the process of assisting the recovering the recovery of an ecosystem that has been degraded, damaged, or destroyed
Green Infrastructure: projects designed and built in urban areas. Typically, urban areas are more degraded and, as such, green infrastructure projects require a more engineered solution, such as bioswales, permeable pavement, or a green roof
Natural Infrastructure: projects that incorporate existing or restored natural landscapes, such as floodplains, wetlands, and forests. Typically, natural infrastructure projects involve a strategically-managed landscape, such as a forest or wetland, to provide a set of desired benefits, such as carbon sequestering, flood control, or water filtration
Permeable Pavement: pavement that infiltrates, treats, and/or stores rainwater where it falls. Usually made of concrete or porous asphalt
Rain Gardens: shallow, vegetated basins that collect and absorb runoff from rooftops, sidewalks, and streets
Sump Pump: a pump used to remove water in water-collecting low spaces; often used in the basements of homes
Urban Tree Canopy: purposefully-planted that reduce and slow stormwater by intercepting precipitation on leaves and branches while improving air quality and providing shade
Wetland Restoration: the manipulation of a former of degraded wetland to its natural functions, allowing for the absorption of floodwater

Projected temperature and heat data from ResilientMA[18]:

Climate Indicator		Observed Value 1971-2000 Average	Mid-Century Projected Change in 2050s	End of Century Projected Change in 2090s
Maximum Temperature	Summer	78.9 °F	Increase by 2.6 - 6.7 °F	Increase by 3.6 - 12.5 °F

[18] Projected changes in temperature variables by the middle and end of century based on climate models and the medium and high pathways of future greenhouse gas emissions.

	Fall	60.6 °F	Increase by 3.4 - 6.8 °F	Increase by 3.8 - 11.9 °F
Minimum Temperature	Winter	17.1 °F	Increase by 3.3 - 8.0 °F	Increase by 4.6 - 11.4 °F
	Fall	39.4 °F	Increase by 3.5 - 6.5 °F	Increase by 4.0 - 11.4 °F
Days with Maximum Temperature > 90°F	Summer	4 days	Increase by 6 - 22 days	Increase by 9 - 52 days
Days with Minimum Temperature < 32°F	Winter	82 days	Decrease by 4 - 12 days	Decrease by 6 - 25 days
	Spring	37 days	Decrease by 6 - 15 days	Decrease by 9 - 20 days
	Fall	27 days	Decrease by 8 - 13 days	Decrease by 8 - 20 days

Projected Changes in Precipitation from ResilientMA[19]:

		Observed Value	Mid-Century	End of Century
Climate Indicator		1971-2000 Average	Projected Change in 2050s	Projected Change in 2090s
Days with Precipitation > 1"	Annual	7 days	Increase by 10-42% 8-10 more days per year	Increase by 15-55% 8-11 more days per year
	Winter	2 days	Increase by 10-69% 2-3 more days per year	Increase by 25-109% 2-3 more days per year
	Spring	2 days	Increase by 2-46% 2 more days per year	Increase by 11-82% 2-3 more days per year
Total Precipitation	Annual	47 inches	Increase by 2-13% Increase of 1 - 6 inches	Increase by 3-16% Increase of 1.2 - 7.3 inches
	Winter	11.2 inches	Increase by 1-21% Increase of 0.1 - 2.4 inches	Increase by 4-35% Increase of 0.4 - 3.9 inches
Consecutive Dry Days	Summer	12 days	Variable (-1 - +2 days)	Variable (-1 - +3 days)

[19] Projected changes in precipitation variables by the middle and end of century based on climate models and the medium and high pathways of future greenhouse gas emissions

Climate Indicator		Observed Value 1971-2000 Average	Mid-Century Projected Change in 2050s	End of Century Projected Change in 2090s
	Fall	12 days	Increase by 0 - 3 days	Increase by 0 - 3 days