Better Buildings Technical Report

RESILIENT CAMBRIDGE

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Produced by Kleinfelder, in collaboration with Cadmus for the City of Cambridge

Better Buildings

1. Introduction

Change means our neighborhoods, homes, and buildings can withstand extreme weather

Buildings are opportunities for property owners and residents to improve individual and citywide resiliency to climate-related hazards such as flooding and extreme heat. Mitigating these risks to buildings includes designing or retrofitting to **protect people**, **minimize operational interruptions**, and **prevent damage to physical property**.

The City of Cambridge (the City) is already experiencing impacts from climate change by having more frequent extreme precipitation and periods of extreme heat. Buildings in the City will need to adapt to continue providing safe shelter and a productive environment for residents and workers, while maintaining or improving public health. This report provides the context for better and more resilient building recommendations citywide as part of Resilient Cambridge.

Approximately 6% of the buildings in Cambridge are at risk of flooding from extreme precipitation during a 10% annual storm by 2070, 6% are at risk of flooding from a 10% annual storm surge/sea level rise event by 2070[1], and all buildings are at risk of extreme heat.

To respond to future flooding caused by climate change, the City is documenting what would be achieved by providing recommendations to build/protect to the 2070 10% annual storm flood elevation from precipitation or sea level rise/storm surge, whichever is higher, and recover from the 2070 1% annual storm flood elevation from precipitation or sea level rise/storm surge, whichever is higher. The City is addressing extreme heat by documenting the implications of a gradual shift from a focus on heating to cooling and maintaining livable temperatures during brownouts and blackouts.

The purpose of Resilient Cambridge is to provide recommendations for **policies, projects,** and **programs,** which guide development of new buildings designed for future climate conditions and facilitate retrofitting existing buildings to be more resilient.

[1] MC-FRM Version. 11, Spring 2021

2. Building Typology

Existing buildings in Cambridge are continuously being upgraded and renovated, and these renovations provide the opportunity to improve resiliency in the greater building stock. New development can be designed and built to be resilient, though it will not significantly improve the resiliency of the greater building stock as new buildings have contributed only 1.25% to the building stock in the previous decade.[2] The buildings in Cambridge have a broad range of characteristics; however, most buildings in Cambridge are wood framed and were built between 1850-1950.

Typologies were created/determined by evaluating the existing building stock, which were then used in the analysis to determine the most at-risk building uses. By grouping the buildings by typology, common characteristics of building uses were collected to inform the development of a broad range of strategies to guide new buildings and address existing buildings' vulnerabilities. There are many land uses, which were categorized and parsed through to determine the typologies. In addition to use, common characteristics such as construction type were used to further define the categories based on the commonalities among most of the buildings. There will always be outliers and unique conditions, but the goal is to provide applicable recommendations and strategies for the most typical buildings.

Defining a building typology allows for distinguishing common characteristics of buildings by use (i.e., residential or commercial), form (i.e., single family or high rise), and size (i.e., number of units or square feet) to form assumptions about the efficacy of proposed strategies. The typical building typologies were synthesized from the following sources:

- 2019 Assessor's Data by Use
- 2019 Assessor's Data by Building Style
- CDD Principal Use – 2019
- CDD Land Use
- Cambridge Zoning Districts
- CCPR The Port Energy Appendix

A *Unified Cambridge Building Typology* was identified and assigned to each building in the City by using similarities across the data sets. The typologies are:

- Residential lower density (1-3 units); for example, a two-family, triple-decker, single-family house or townhouse
- Residential medium density (4-25 units); for example, mid-size apartment buildings, industrial buildings renovated as condos etc.
- Residential higher density (26+ units); for example, high-rise towers
- Small Commercial (less than 25,000 square feet)
- Large Commercial (more than 25,000 square feet)
- Mixed Use (Res/Comm/Ind)
- Education (K-12)
- Higher Education (Universities)
- Research and Development (R&D)
- Industrial
- Government Operations
- Utility
- Transportation
- Healthcare/Assisted Living (Health)
- Charitable/Religious

[2] City of Cambridge Assessors Database, 2019.

Figure 1 demonstrates the differences between the number of buildings per typology versus the square footage within the City's portfolio. The figure illustrates that *Small* and *Medium Residential* represent about 83% of the total number of buildings, but only 23% of the total square footage. *Large Residential* is 2% of the buildings and approximately 12% of the total square footage, *Higher Education* is approximately 4% of the buildings and 23% of the square footage, and *R&D* and *Large Commercial* is about 2% combined of the total buildings but 23% of the total square footage. The implications are that recommendations addressing these building typologies will impact fewer landowners with a greater impact on square feet within the City.

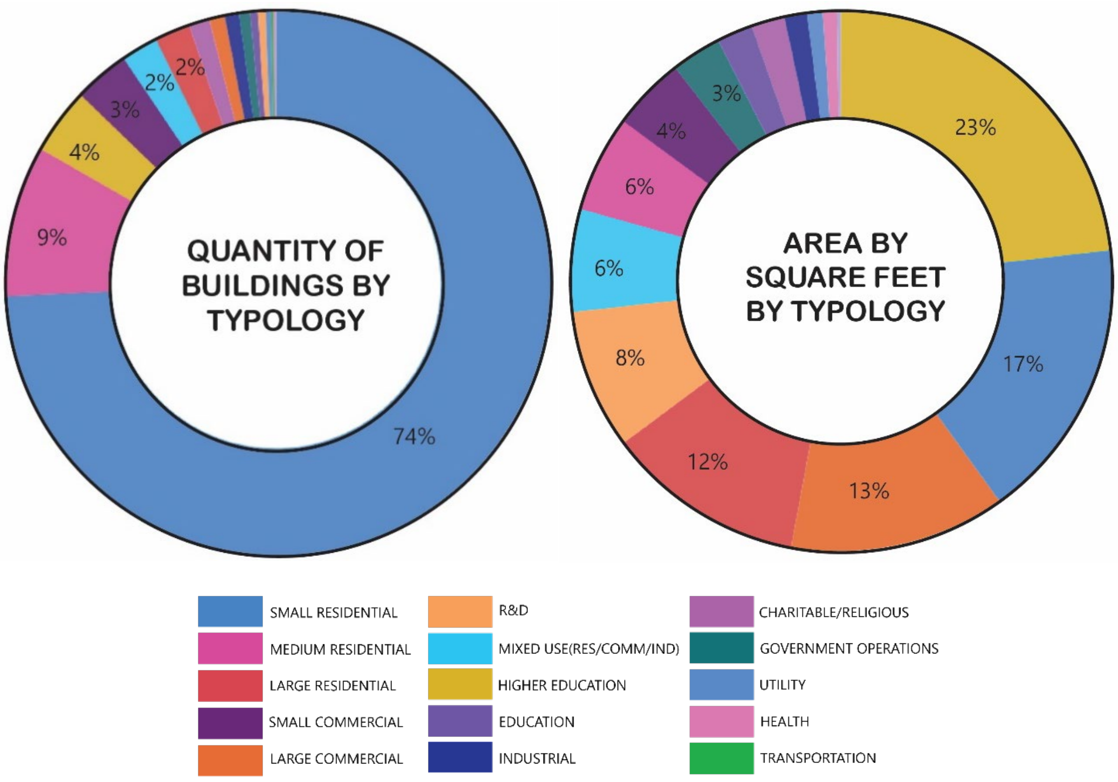


Figure 1 - Cambridge Unified Building Typology 2019 Existing Conditions for 14,305 Buildings.

<u>Special Uses</u>

The City recognizes that there are special uses that cross the boundaries of the typologies previously listed and will require unique interventions. Special uses studied are:

Critical Facilities - Climate change threatens infrastructure, critical services, public health, and the City's economic well-being. To effectively aid in recovery following an extreme weather event, critical facilities will play a vital role. Critical facilities include hospitals, fire stations, energy facilities, pump stations, transit stations and telecommunications facilities, which include the City's Emergency Communications Center, the AT&T switch facility, and the data hub/co-location center in the Alewife area, which is a distribution and switching station according to the Climate Change Vulnerability Assessment (CCVA 2015). Additionally, municipal buildings function as critical facilities due to their role in recovery during and after extreme weather events. Adding to the facilities identified in CCVA, the City considers the following facilities critical to citywide resiliency:

Key Critical Facilities Assets Analyzed in CCVA and Added to Resilient Cambridge:

*added facilities are marked by **

Police Stations

- Police Headquarters – 125 Sixth Street, Cambridge, MA

Fire Stations

- Fire Headquarters – 491 Broadway
- Fire Company 2 – 378 Mass Avenue
- Fire Company 3 – 175 Cambridge Street
- Fire Company 4 – 2029 Mass Avenue
- Fire Company 5 - 1384 Cambridge Street
- Fire Company 6 – 176 River Street
- Fire Company 8 – 113 Garden Street
- Fire Company 9 – 167 Lexington Avenue

Emergency Shelters

- Kennedy/Longfellow School - 158 Spring Street
- Peabody School - 70 Rindge Avenue
- Tobin School - 197 Vassal Lane
- Graham & Parks School - 44 Linnaean Street
- Cambridge Rindge and Latin - 459 Broadway
- Morse School - 40 Granite Street
- 136 Bishop Allen Drive
- 402 Massachusetts Avenue

Hospitals

- Cambridge Hospital - 1493 Cambridge Street
- Spaulding Outpatient Center Cambridge and Youville Assisted Living - 1575 Cambridge Street
- Mount Auburn Hospital - 330 Mt. Auburn Street

Health Centers

- Cambridge Family Health - Inman Square, 237 Hampshire Street
- Cambridge Family Health North - Porter Square, 2067 Massachusetts Avenue
- North Cambridge Health Center - 266 B Rindge Avenue
- Senior Health Center - 806 Massachusetts Avenue
- Windsor Street Health Center/Public Health - 119 Windsor Street
- Teen Health Center at Cambridge Rindge and Latin - 459 Broadway
- East Cambridge Health Center - 163 Gore Street

Municipal Offices

- Public Health Dept. - 119 Windsor Street
- Cambridge City Hall - 795 Massachusetts Avenue*

DPW Facilities

- DPW Frazier Administrative Bldg.*
- DPW Ryan Garage*
- The Shop - Electrical Department*

Emergency Communications Center

- 125 Sixth Street*

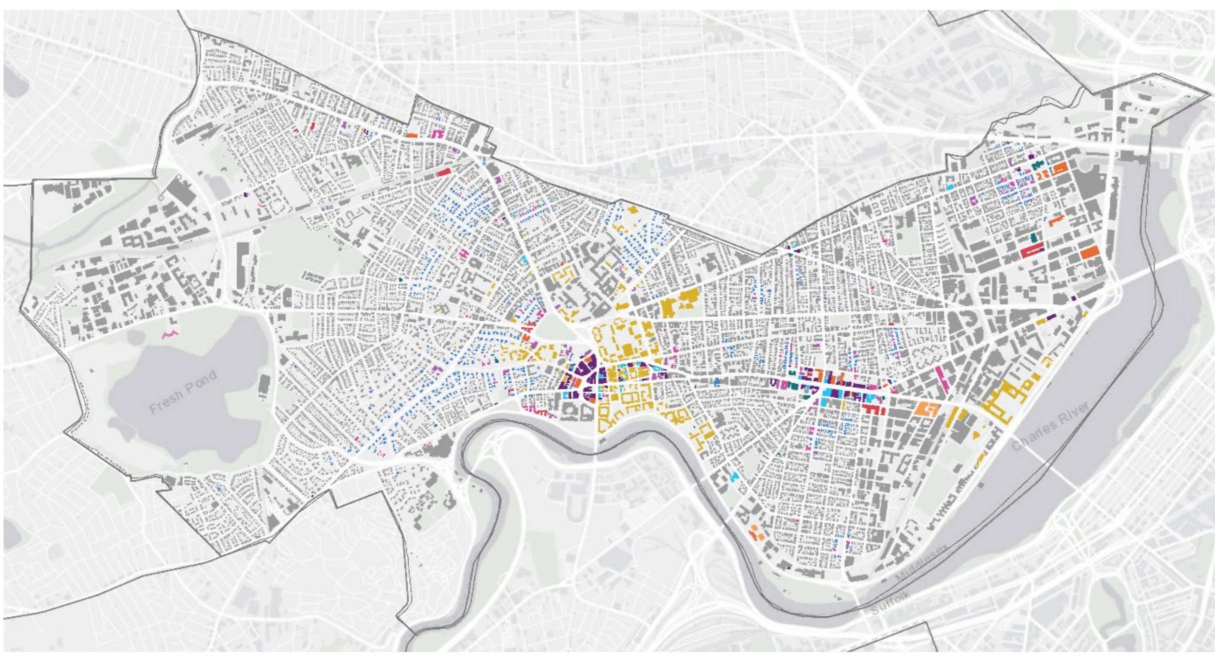
Water Infrastructure

- Fresh Pond Reservoir*
- Walter J. Sullivan Water Purification Facility*

Historic Buildings - Many buildings in Cambridge have a role in shaping the identity of both the neighborhoods and the City. The City's distinct building vernacular dates to colonial times and is mixed with contemporary architectural icons.

The National Register of Historic Places dataset[3] is used to determine impacted historic buildings in the City. In the dataset, 1,485 buildings have been recognized as historically designated, which means a building or property must be at least 50 years old, must retain a high degree of integrity, and must have some level of historic significance. Buildings within this dataset are governed by federal historic preservation laws and regulations. Buildings designated by the Cambridge City Council as Historical Landmarks and Easements are governed by local laws and regulations. This is important to note because modifications for resiliency to a historic building needs appropriate governing approval.

Most of the historically designated buildings in Cambridge are Small Residential or Higher Education.



3 https://www.cambridgema.gov/GIS/gisdatadictionary/Historical/HISTORICAL_NationalRegisterHistoricPlaces

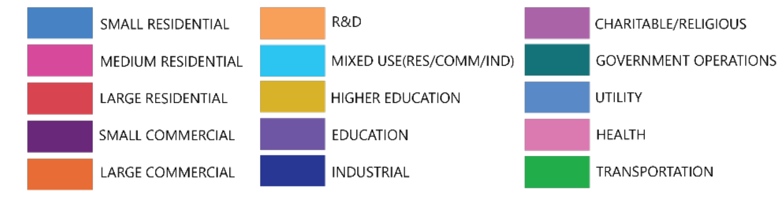


Figure 2 – Buildings in Cambridge designated as historic per the National Register of Historic Places, Feb 2020

3. Buildings and Flooding Risk

From a regulatory perspective, the building code currently defers to FEMA (Federal Emergency Management Agency) Flood Insurance Rate Maps (FIRMs) for indicating if buildings are in the floodplain. If a building is located in the 1% Annual Flood Hazard Area on the FIRM, the building code requires new and significantly renovated buildings to be built above or protected to the Base Flood Elevation (BFE), plus a safety factor known as freeboard, which is provided in ASCE 24-14[4]. FEMA flood maps are based on historic events and data depicting current conditions. The FEMA requirement is considered the "baseline" in this report. Acknowledging that the past is no longer the best predictor of flood risk (and therefore to determine the elevation or level of protection that a building being built today should be to protect it throughout its anticipated life), the City developed the CCVA climate scenarios[5] for extreme precipitation and sea level and rise storm surge (SLR/SS) that redefine future flood risk in the City considering climate change.

Baseline (FEMA)

Buildings located within the 1% Annual Flood Hazard Area or Zone AE are considered most at risk of flooding by the National Flood Insurance Program (NFIP). FEMA uses historic river discharge, storm tides, hydrologic/hydraulic analyses and rainfall and topographic surveys.[6] The FEMA FIRMs for Cambridge were most recently updated in 2010. Property owners who have federally backed mortgage are required to purchase flood insurance if located within the bounds of the Special Flood Hazard Area (SFHA).[7] Statistically, during the lifetime of a typical 30-year mortgage, structures that are located within SFHA have 26% chance of experiencing flood damage during that 30-year period.[8]

Cambridge Climate Change Scenarios

Best available data and modeling were used to document the probability of buildings likely to be impacted from the 2070 10% and 1% annual storm events. This is aligned with the City's current recommendations to ***build/protect to the 2070 10% annual flood elevation*** from precipitation or sea level rise/storm surge, whichever is higher and ***recover from the 2070 1% annual flood elevation*** from precipitation or sea level rise/storm surge, whichever is higher. The year 2070 is used based on the

[4] https://www.fema.gov/sites/default/files/2020-07/asce24-14_highlights_jan2015.pdf
[5] https://www.cambridgema.gov/-/media/Files/CDD/Climate/vulnerabilityassessment/finalreport_ccvapart2_mar2017_final2_web.pdf
[6] https://www.fema.gov/national-flood-insurance-program-flood-hazard-mapping
[7] https://www.cambridgema.gov/Services/femafloodmaps
[8] https://www.fema.gov/pdf/floodplain/nfip_sg_unit_3.pdf

assumption that a typical building built today would last about 50 years and/or that most buildings around today would be replaced or significantly renovated in the next 50 years.

Precipitation Flooding - Precipitation flooding shown in the City's FloodViewer v2.1[9] is simulated using the City's hydrologic/hydraulic model (updated in May 2019) that models the impacts of overland riverine and piped infrastructure flooding and reports the extents of flooding and flood elevations at different locations in the City under different scenarios. The City's FloodViewer 2.1 visualizes modeling results for the 10% annual storm (also known as the 10 Year 24-hour design storm) and the 1% annual storm (also known as the 100 Year 24-hour design storm) for present, 2030 and 2070. The FloodViewer identifies ***parcels*** at risk of flooding during the design storm scenarios and takes into consideration the construction of infrastructure projects already under final design and/or construction. However, the model does not consider proposed improvements to infrastructure, such as those recommended in Resilient Cambridge. The FloodViewer does not identify the flooding of individual buildings and only identifies parcels that intersect with the flood data layer.

The analysis for this technical report used the City's hydraulic/hydrologic model results to identify ***buildings*** at risk when projected flooding intersects the building footprint as shown in Figure 3, rather than the parcel as identified in the FloodViewer.

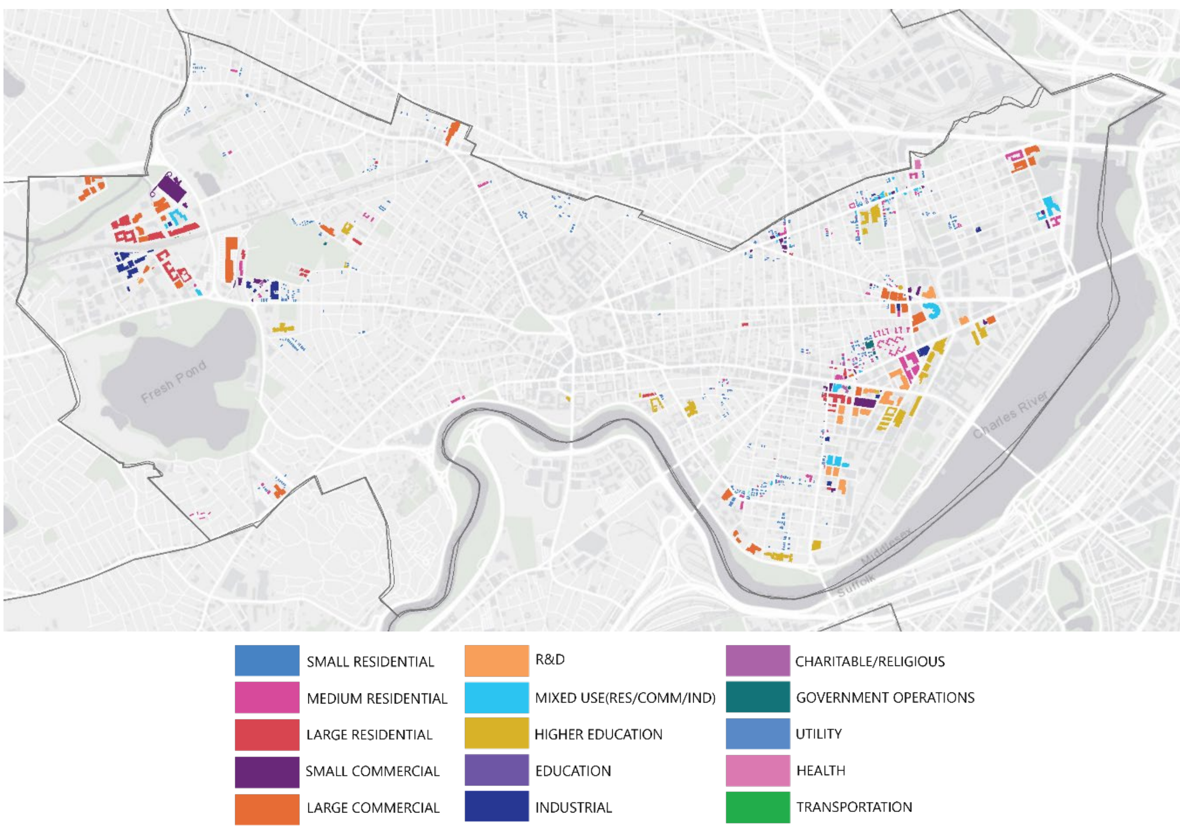


Figure 3 – The color-shaded buildings are at risk during a 2070 10% annual precipitation event.

[9] Property owners should refer to the most recent version of the Cambridge FloodViewer to determine if they are at risk of flooding: https://www.cambridgema.gov/Services/FloodMap

The building typologies most at risk of precipitation flooding are the Small or Medium Residential typology. 793 buildings are at risk of flooding during a 2070 10% annual storm and, of those, more than half are residential buildings as shown in Figure 4 below.

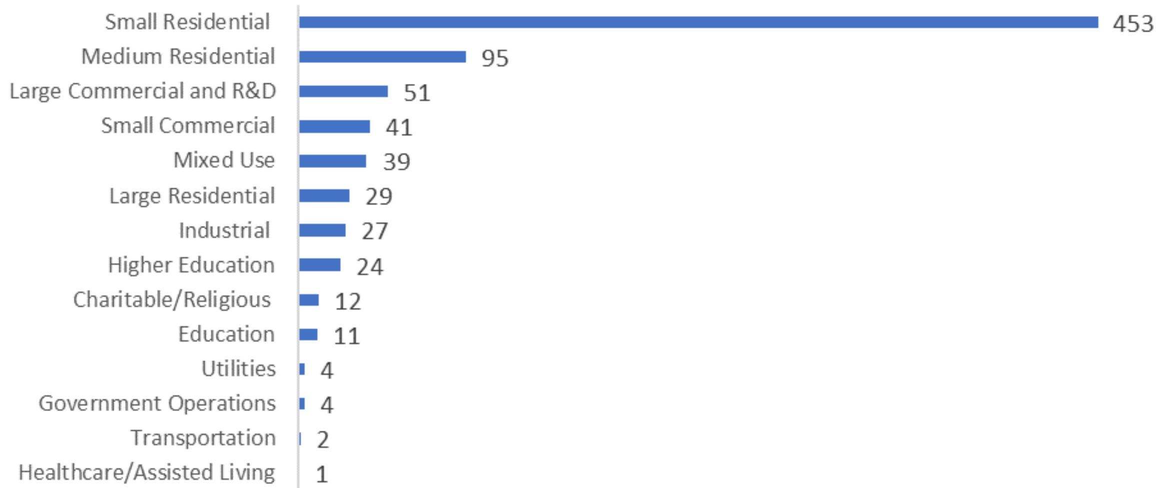


Figure 4. Buildings at risk of flooding from a 2070 10% annual precipitation event by typology.

Approximately 6% of the buildings dedicated to Large Commercial and R&D are at risk of flooding from the 2070 10% annual storm. However, this 6% represents 41% of the impacted square footage of building area subject to flooding. Higher Education buildings represent 8% of the square footage at risk and have organized management that could work with the City to mitigate or minimize the impacts of flooding. This indicates that working with a few property owners and universities could address almost half of the square footage at risk of flooding. Approximately 40 Small Business buildings are at risk of flooding from the 2070 10 % annual storm and do not represent a large square footage of built area. But it should be considered that these might have limited means for implementing resiliency measures and might benefit from similar approaches to small and medium residential buildings.

Of the 1,485 historic buildings in the National Register dataset, 29 are at risk of flooding from a 2070 10% annual storm. Most of the historic buildings are wood framed structures at further risk of secondary exposure to infestation or mold caused by extreme heat and humidity. These will require special evaluation to assess feasible resiliency measures preserving the historical integrity of the building.

The historic buildings at risk during a 2070 10% annual precipitation event are:

1. 18 Grant St
2. 89 Banks St
3. 72-74 Hampshire St
4. 134 Massachusetts Ave
5. 254 Massachusetts Ave
6. 23 Sidney St
7. 380 Massachusetts Ave
8. 884 Main St
9. 96-152 Green St
10. 408 Massachusetts Ave
11. 907 Main St
12. 877 Main St
13. 424-464 Massachusetts Ave
14. 6 Brookline St
15. 401 Massachusetts Ave
16. 11 Brookline St
17. 1 Shady Hill Sq
18. 69-71 Cherry St
19. 270 Washington St
20. 55 Pine St
21. 288-290 Washington St
22. 296 Washington St
23. 261 Washington St
24. 289 Washington St
25. 297-299 Washington St
26. 21 Thorndike St
27. 863 Main St
28. 608-616 Main St
29. 413-457 Massachusetts Ave

Results are also available for the 2070 1% annual precipitation event. There are approximately 3,400 buildings impacted in the 1% annual precipitation event, as shown below in Figure 5:

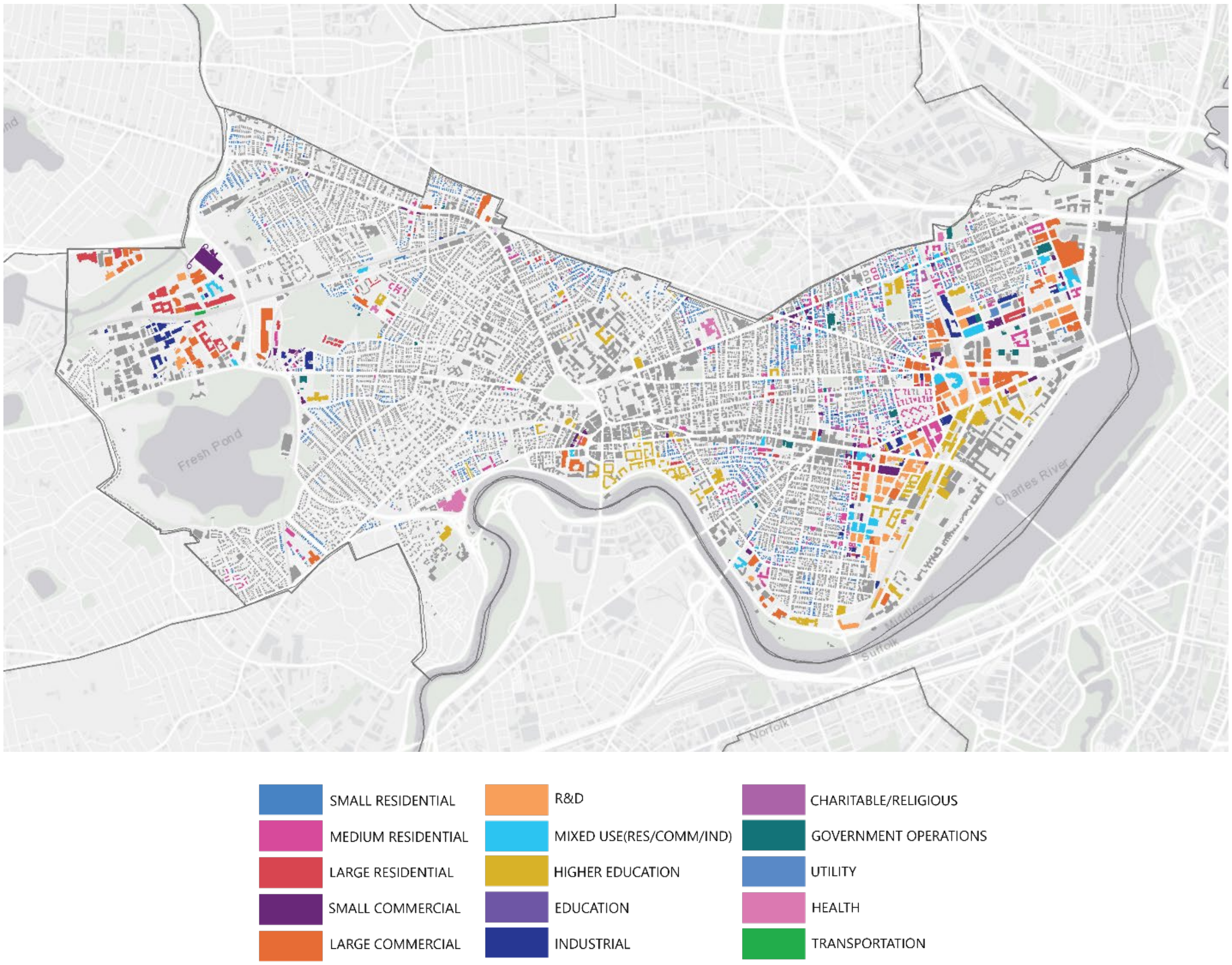


Figure 5 – The color-shaded buildings are at risk during a 2070 1% annual precipitation event.

<u>*Sea Level Rise / Storm Surge*</u> <u>(SLR/SS) -</u> The Massachusetts Coast Flood Risk Model (MC-FRM) was developed by the Woods Hole Group for the Massachusetts Department of Transportation (MassDOT) to assess assets at risk of coastal flooding. The MC-FRM produces storm surge /sea level rise data for the 2070 probability of exceedance scenario, which serves as guidance of the build/protect to elevation used by the City. The MC-FRM Version 11 data (available as of February 2021) has been adopted by the State and is currently the best available data to determine extents and probabilities of sea level rise/storm surge flooding in Cambridge.

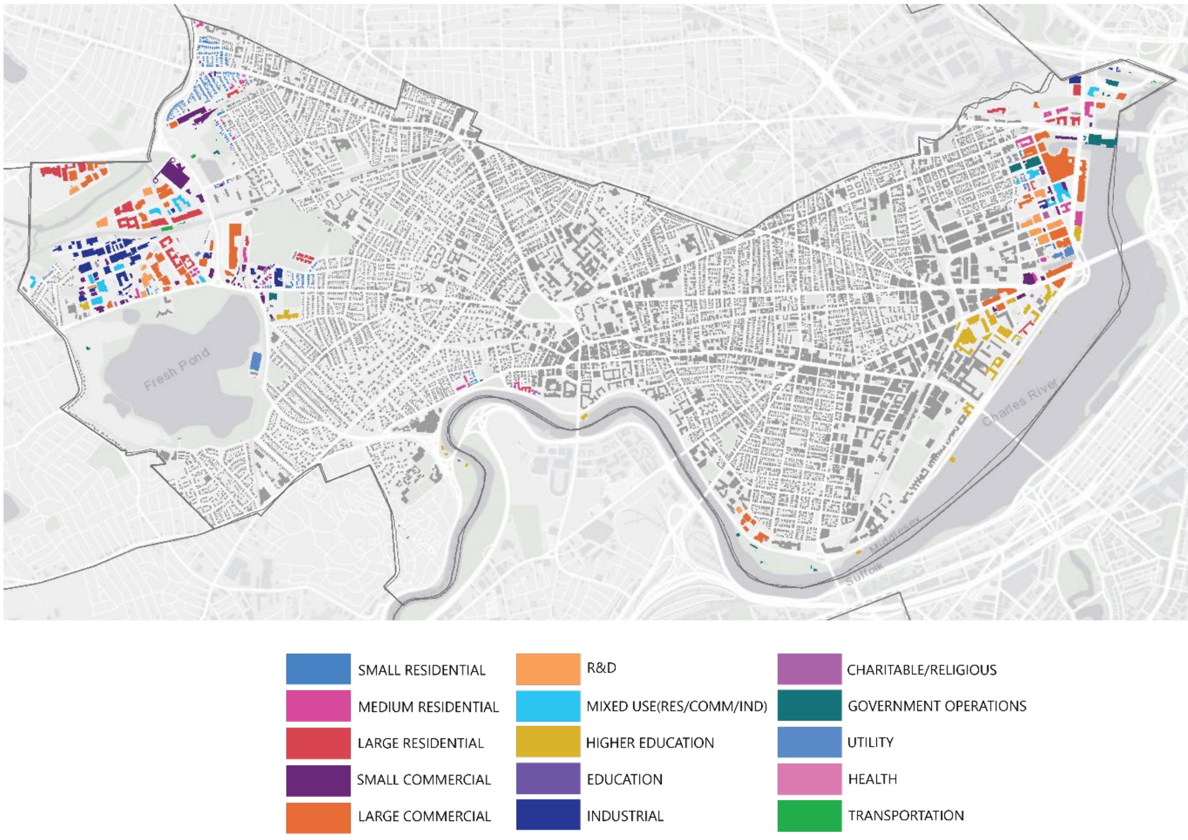


Figure 6– The color-shaded buildings highlight the buildings at risk during a 2070 10% annual SLR/SS event (MCFRM V11 Feb 2021).

As identified in Figure 6, there are 812 buildings at risk of flooding for the 10%annual SLR/SS event. Small residential building typology has the greatest exposure. Large Commercial and R&D buildings in Kendall Square and Alewife areas are among those at risk as shown in Figure 6 below.

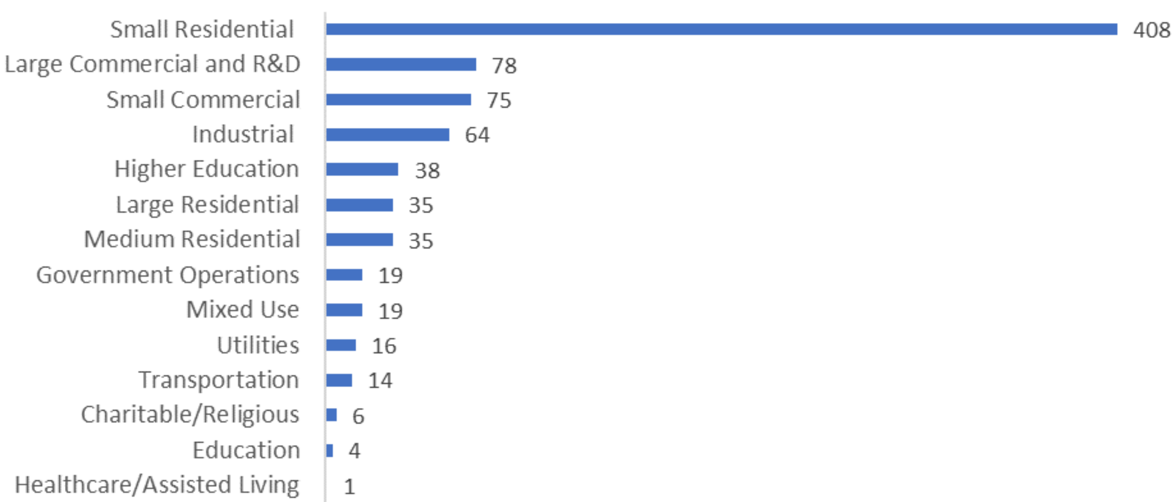


Figure 7. Buildings at risk of 2070 10% annual SLR/SS flooding by typology.

The City also projects that approximately 3,700 buildings are at risk from a 1% annual SLR/SS event, Figure 8 below shows the flood extent of a 1% annual SLR/SS event. There is an increase from 38 to 210 Higher Education buildings impacted along the Charles River.

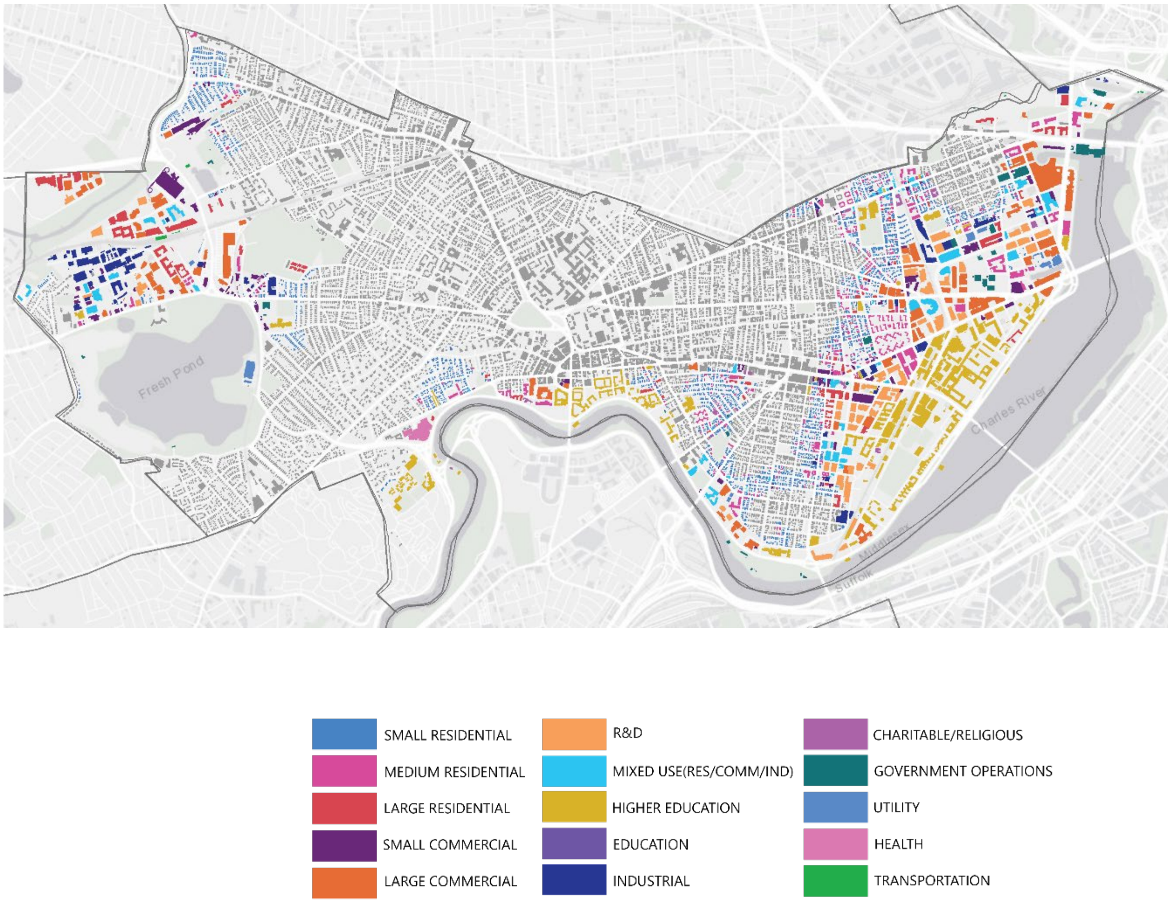


Figure 8– The color-shaded buildings highlight the buildings at risk during a 2070 1% SLR/SS event (MCFRM V11 Feb 2021).

Key findings:

Currently, only 287 buildings in the City are within the FEMA 1% Special Flood Hazard Area. New buildings in the 1% Special Flood Hazard Area are required to be built so that the top of the lowest occupiable floor of a building is at or above the base flood elevation as identified on the FEMA FIRM plus freeboard as identified in ASCE 24-14.[10] FEMA does not factor climate change in flood projections and consequently is underestimating flooding risk in Cambridge. The City's modeling projects that approximately 5,000 buildings are at risk of flooding during a 2070 1% annual precipitation ***or*** SLR/SS event, though the number of buildings at risk could be higher should the events occur concurrently.

Among the 5,000 buildings, there are approximately 3,500 buildings at risk of precipitation flooding and 3,750 buildings at risk of SLR/SS flooding for the 2070 1% annual events. This includes 17 critical facilities for which the City recommends building or protecting to the 2070 1% annual flood elevation from precipitation or SLR/SS, whichever is higher, to provide greater protection of critical facilities and services which are dependent on during and after extreme weather events.

The critical facilities at risk are:

- Public Health Dept/Windsor Street Health Center
- Police Headquarters/Emergency Communications Center
- Kennedy/Longfellow School
- Tobin School
- The Shop - Electrical Department/Fresh Pond Reservoir/Walter J. Sullivan Water Purification Facility
- Mount Auburn Hospital
- Fire Company 2
- Fire Company 4
- Fire Company 5
- Fire Company 8
- Morse School
- Emergency Shelter
- DPW Frazier Administrative Building
- East Cambridge Health Center
- Cambridge Family Health North - Porter Square
- Cambridge Family Health - Inman Square
- Senior Health Center

Figure 9 illustrates that shifting from using the FEMA 1% annual flood map historic baseline to projected 2070 1% annual flood risk triples the number of buildings at risk. According to FEMA, about 2% of Cambridge buildings require flood protection. This could shift to as much as 27% per the 2070 1% annual storm projected by the City. Approximately 5,000 buildings in Cambridge at risk of either a 1% annual precipitation or SLR/SS event.

[10] https://www.fema.gov/sites/default/files/2020-08/fema_489__hurricane_ivan_bpat_.pdf

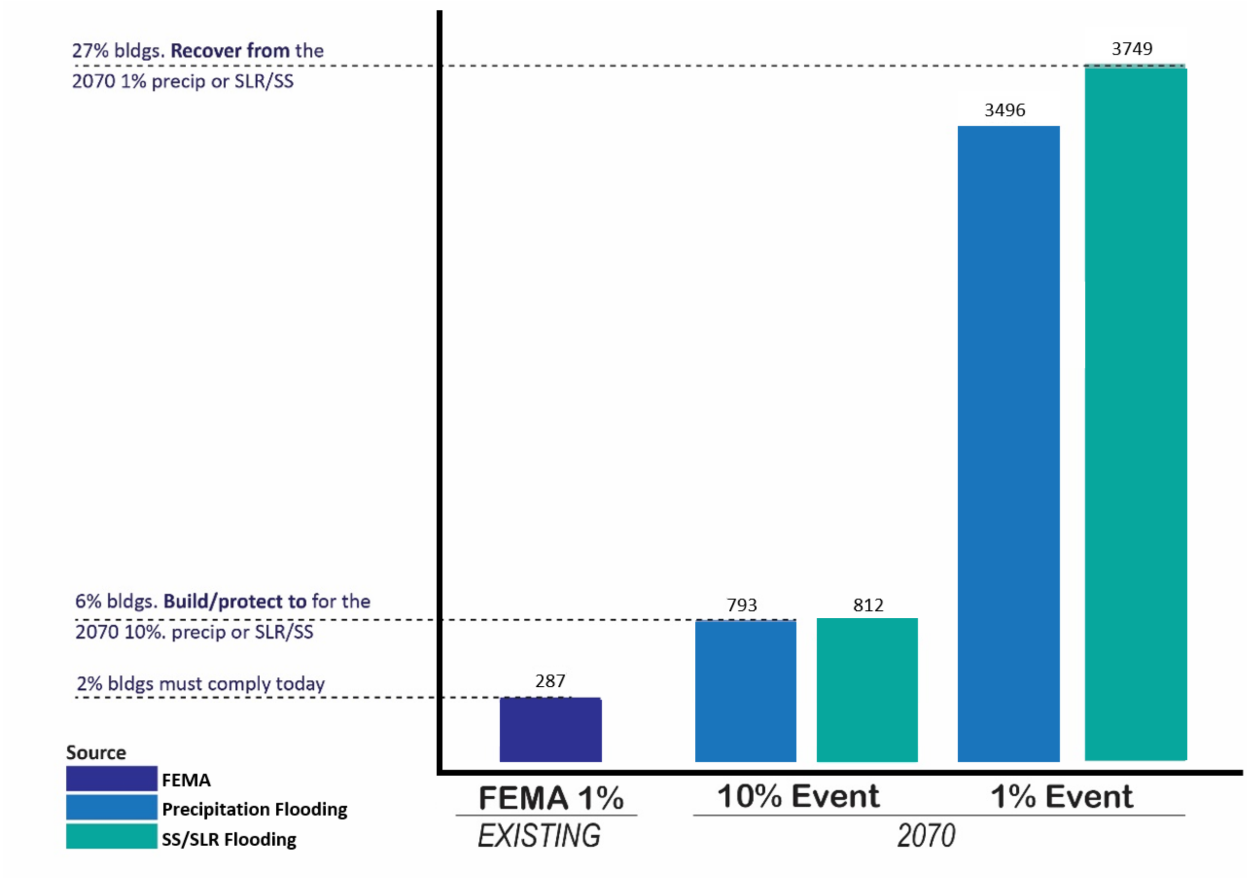


Figure 9- Buildings at risk of flooding in Cambridge.

At the time of writing this report, citywide flood elevations were not available for the MC-FRM SLR/SS data. When flood elevations become available, the City of Cambridge FloodViewer will be updated to provide information of both extent and maximum flood elevations from SLR/SS events.

<u>Relationship between areas at risk of flooding and race and ethnicity</u>

In the United States, people of color have historically been left out of planning practices and discriminatory housing, education, and economic policies have hindered their ability to maintain secure housing, accumulate wealth, and seek equal opportunities. The four neighborhoods with the largest percentage of people of color in Cambridge are MIT/Area 2, North Cambridge, Cambridge Highlands, and The Port. These are also four of the neighborhoods with the most significant flood risk and thus the most buildings potentially impacted by flood damage. Two of the most at-risk neighborhoods, The Port and North Cambridge, are home to large public housing facilities and there are many renters in these neighborhoods as well. Many of the residents of MIT/Area 2 are students who either rent or reside in dormitories. Renters have less autonomy to prepare their units for the impacts of flooding.

- MIT/Area 2 – 76% renter-occupied
- North Cambridge – 64% renter-occupied
- The Port – 61% renter-occupied

A citywide analysis in the Closer Neighborhoods Technical Report identified The Port and MIT/Area 2 as two of four neighborhoods having the highest percentages of residents who are below the poverty line citywide (21%-27%). Given that The Port and MIT/Area 2 have a confluence of impacts, including flooding, housing insecurity (i.e. non-owner occupied units suggesting residents with limited control over housing), and around a quarter of the population live in poverty, these neighborhoods should be priorities in terms of implementation of climate change preparedness strategies, including resilient building strategies. These neighborhoods also have the highest percentages of people of color. Given these overlaps, it is important that climate action helps empower people of color, particularly those who are renters and fall under the poverty line.

Resilient Cambridge recommends strategies that would increase the resiliency of environmental justice communities and support renters in maintaining housing in the face of a disaster event.

4. Buildings and Heat Risk

Resiliency to extreme heat has a critical role in Resilient Cambridge; maintaining a livable indoor air temperature and maintaining healthy buildings is a public health necessity. From a public health perspective, heat has been the largest single weather-related cause of death in the U.S. since the National Oceanic and Atmospheric Administration (NOAA) began reporting data in 1988. Fortunately, heat impacts on health are the most well understood, measurable, and potentially preventable impacts of climate change.[11] By 2030, annual days over 90 degrees Fahrenheit (°F) in Cambridge may triple. By 2070, Cambridge may experience over 2 months over 90°F compared with less than two weeks in 2015 as shown in Figure 10.

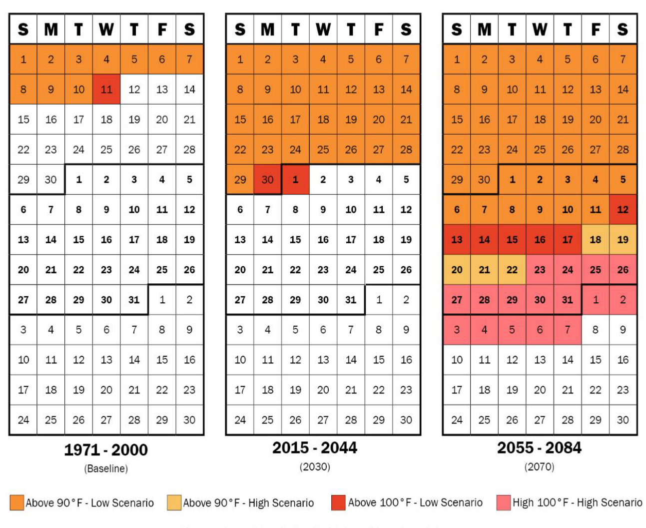


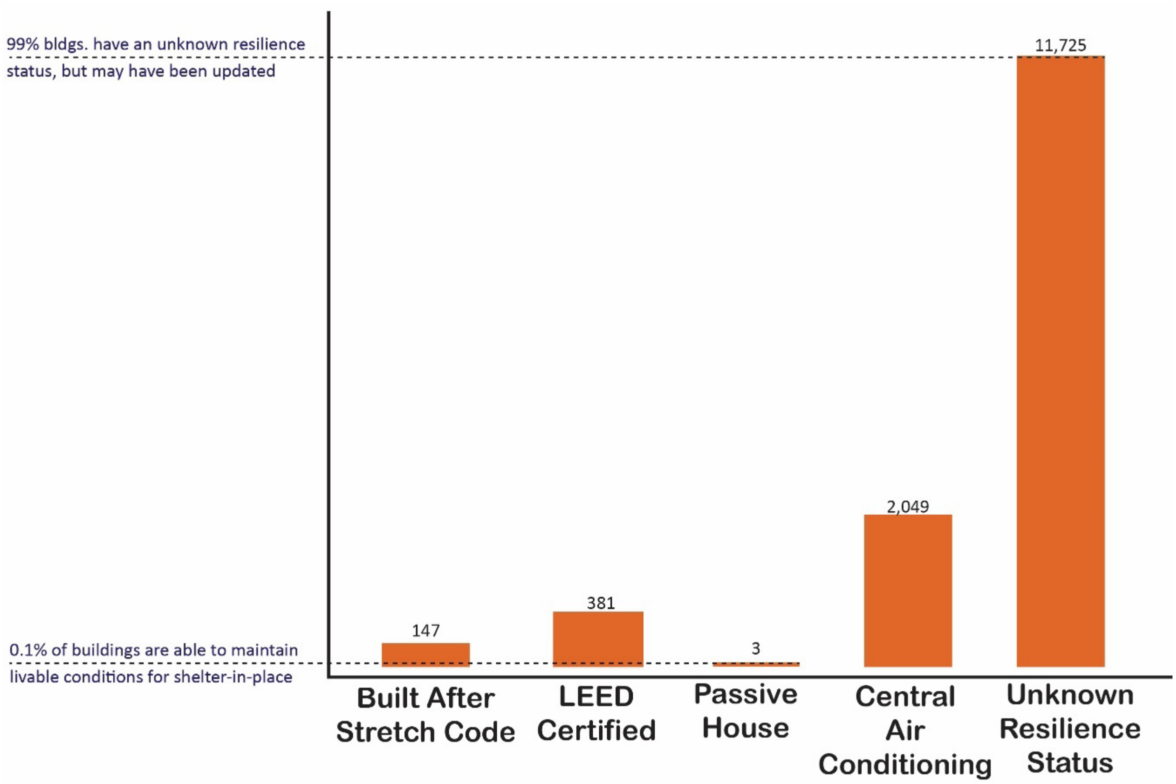
Figure 10- Number of days above 90 degrees Fahrenheit (°F) as reported in CCVA 2015.

[11] https://www.cambridgema.gov/-/media/Files/CDD/Climate/vulnerabilityassessment/ccvareportpart1/vulnerabilityandriskassessmentstechnicalreports/ccvavulnerabilityandriskassessmentexecutivesummarynovember20151.pdf

The City has a relatively high proportion of older housing stock that is not well-adapted to hot weather due to minimal insulation and limited central air conditioning (A/C). As reported in the City's 2019 assessor's data, an estimated 14% of all buildings in Cambridge have central A/C. Currently, the State requires landlords to maintain a livable temperature between 68°F and 78°F between September 15th and June 15th (i.e., heating season). There is not a similar requirement for cooling.[12] There are states, such as Arizona, which designate A/C as an essential need, and it is a tenant right that landlords must provide.[13]

In 2009, an appendix to the "base" building energy code in Massachusetts, called the "Stretch Code," was implemented. The Stretch Code emphasizes energy performance and is designed to result in buildings that are more energy efficient than those built to the "base" energy code.[14] In Cambridge, 82% of the buildings were built before the adoption of the Stretch Code, and variability within the code's adoption and application means the relatively new requirement is a poor indicator of resilience. It is expected that the building portfolio will be gradually upgraded through this requirement. A baseline of the existing building stock is shown in Figure 11.

The best program to serve as an exemplary metric for resilience to extreme heat for buildings is the Passive House certification. Passive House refers to the high standards of the certification to minimize energy consumption and maintain comfort through a high-performance envelope and reduction of dependence on mechanical systems. One single-family residential building and two multifamily residential buildings are currently Passive House certified in Cambridge.



12 https://www.mass.gov/guidance/guidance-on-heating-season-and-min-temps
13 https://arizonalegalcenter.org/arizona-tenant-rights-with-air-conditioning/
14 https://www.mass.gov/info-details/building-energy-code

Figure 11. Extreme heat baseline.

In the future, buildings in the region are expected to require more days of using mechanical cooling than heating. As the climate changes and more extreme weather events occur, it is presumed that the need for maintaining comfortable indoor temperatures will become increasingly important for resilience. By 2030, building cooling loads could double compared to present and by 2070 cooling loads could be twice that of heating loads as shown in Figure 12. Buildings in the area are increasingly installing central air conditioning systems or opting to use window air conditioners to provide cooling. As average temperatures continue to rise, more air conditioner use will be needed citywide and the electricity consumed will also increase.

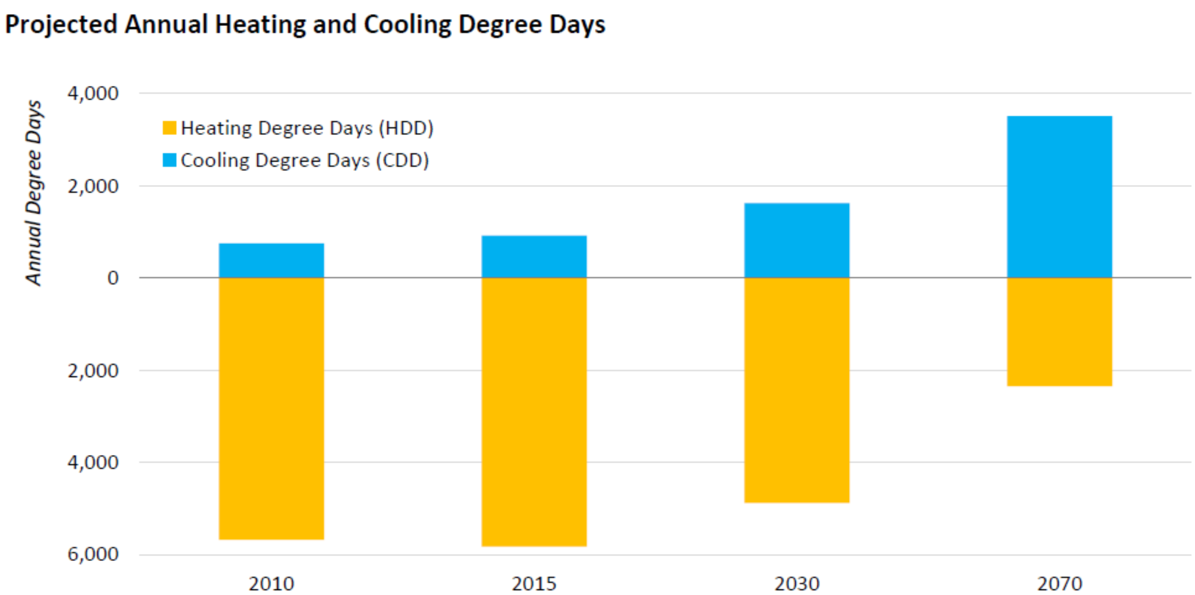


Figure 12. - Historic and projected annual heating and cooling degree days[15]

Power outages during periods of extreme heat create additional economic and public health issues. The systems that maintain safe thermal conditions and critical life support functions may not work, and indoor environmental conditions may progress from uncomfortable to unsafe. Extended power outages that last multiple days increase risk, as indoor temperatures may quickly rise, or plummet, in buildings that were not designed for high thermal performance.[16] Previous studies have shown that during a summer power outage, temperatures within a single-family wood-frame house could exceed 90°F within three days.[17]

[15] Petri, Y. and Caldeira, K. Impacts of global warming on residential heating and cooling degree-days in the United States, 2015. BuroHappold analysis.

[16] https://www.cambridgema.gov/-/media/Files/CDD/Climate/CCPR/ccprtheportplan/theportccprappendix2energyresilience05222019final_processed.pdf

[17] Urban Green Council, New York Chapter of the U.S. Green Building Council, "Baby Its Cold Inside," February 2014. https://www.urbangreencouncil.org/babyitscoldinside

5. Resilient Building Strategies for Flooding

The City's recommended approach for resilient buildings shown in Figure 13 to protect against flooding is to:

- Build/protect to the 2070 10% flood elevation from precipitation or sea level rise/storm surge, whichever is higher.
- Recover from the 2070 1% flood elevation from precipitation or sea level rise/storm surge, whichever is higher.

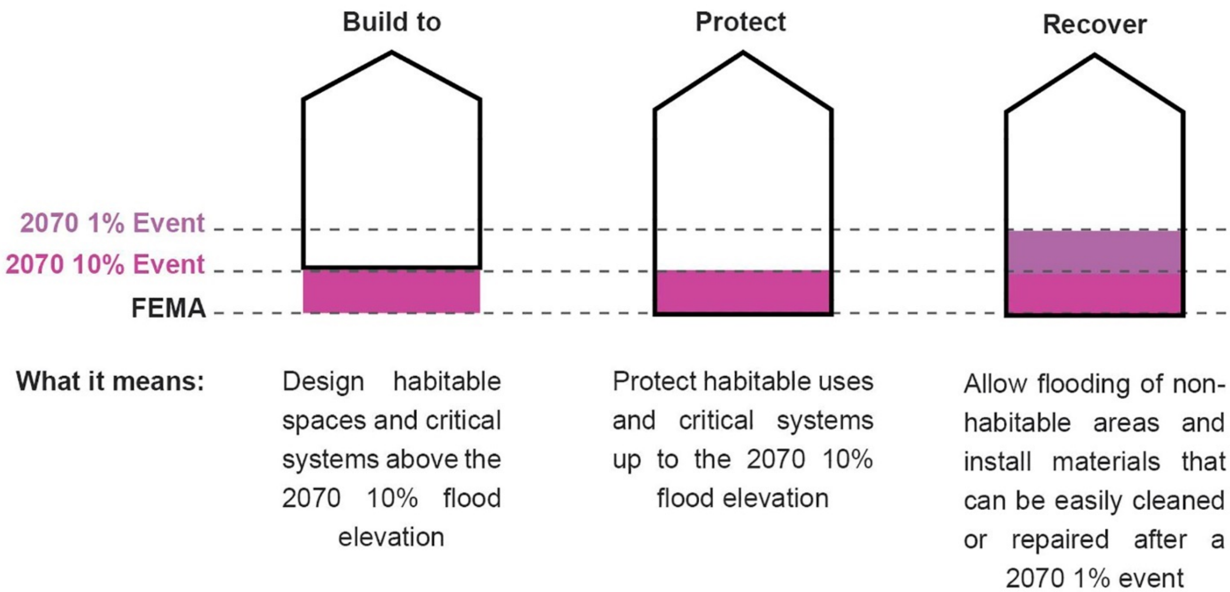


Figure 13 – Build/Protect To and Recover From definitions illustrated. Note: The City's FloodViewer provides flood elevations for each parcel in the City for each of the 1% and the 10% annual storm events.

Building typology and its related characteristics play a large and complex role in determining the best strategies for resilience. Characteristics include the type of structure, exterior material, finished basement below grade occupiable space, utility location, and first floor elevation, which are all important in assessing a building's vulnerability. Guidance on building resilience in the floodplain is provided in the American Society of Civil Engineers (ASCE) 24-14 Flood Resistant Design and Construction.

Resiliency strategies need to consider:

- ***Structure:*** There are three types of physical forces related to flooding that can affect the physical structure of a building: hydrostatic pressure, hydrodynamic loads, and impact loads.

  Hydrostatic pressure is the pressure that is created when water levels on each side of a wall are unequal. When depth of flooding exceeds 2-3 feet, FEMA suggests structural capacity of a one- to two-story light-framed building may be at risk for dry floodproofed buildings.[18] A dry floodproofed building is made watertight below the level that needs flood protection to prevent water from entering.

Lateral pressure from water is 62.4 pounds/foot for fresh water and 64.0 pounds/foot for saltwater[18], which when applied against a vertical surface, such as a wall, can cause failure depending on the type and thickness of a structure, anchor bolt spacing, and area of the vertical surface. If a building is leaky or a door is left open to equalize water pressure, structural failure is reduced.

Hydrodynamic loads occur when water is flowing around or against a building. Hydrodynamic forces often occur from coastal wave action and high velocity riverine flooding. This type of pressure can cause foundation and structural shift.

Impact loads are caused when floating debris in the floodwater makes contact with a building.[19]

- ***Utilities:*** The location of utilities can play a vital role in the vulnerability of a building. Most critical heating and cooling systems equipment are in the basement and must be replaced if exposed to flooding. Electrical infrastructure of a building is typically at risk when flooding exceeds 15 inches above the finished floor.
- ***Below grade occupiable space:*** Finished basements become a life-safety issue when the living space can be flooded. To prevent water from coming in, building envelope and openings can be waterproof.
- ***Building envelope and openings***: When flood-resistant materials are combined with a sound structure, buildings can recover quickly from flooding. Flood resistant material is considered any material that can withstand prolonged contact with flooding, survive wetting and drying, and be cleanable to remove harmful pollutants.[20] Flood resistant exterior material includes concrete block, cast-in-place cement, cast stone, or face and glazed brick. Dry floodproofing a structure is making it water-tight by sealing walls with waterproof coatings, waterproof membranes, or masonry/concrete. Openings, such as doors and windows, need to be blocked temporarily to prevent water from entering a dry floodproofed structure. Low basement windows can be protected by window well walls designed to the design flood elevation. Windows and doors may be blocked with deployable barriers or operable barriers, which seal when water pressure is applied.
- ***Roof:*** The roof plays an important role in the relationship between the building and the neighborhood/City for stormwater quality and control. Roofs across the City make up a considerable amount of surface area. Rooftop green infrastructure (GI) includes:
    - Green roofs - Intensive green roofs can help improve stormwater quality. Green roofs are low soil volume plantings and intensive green roofs include mature herbaceous and woody plants. Green roofs can also provide energy resiliency benefits due to the extra level of insulation provided, reduce extreme heat, and has urban heat island effect (UHI) benefits.

[18] https://www.fema.gov/sites/default/files/2020-07/fema_p-936_floodproofing_non-residential_buiildings_110618pdf.pdf

[19] https://www.fema.gov/sites/default/files/2020-08/fema259_complete_rev.pdf

[20] https://www.fema.gov/sites/default/files/2020-07/fema_tb_2_rev1.pdf, page 6

- Blue roofs – Can retain water during peaks rain events. Blue roofs are being used throughout Cambridge to reduce and delay stormwater runoff. When combined with a cool roof, there can be additional UHI benefits.

- **Site:** See the Greener City Technical Report for more information.

Historic Buildings: A building is considered historic by the MA State Building Code if listed on the National Register of Historic Places or designated as historic under a state or local historic preservation program that is approved by the U.S. Department of Interior.[21] The Massachusetts State Building Code states that proposed repairs, alterations, and changes in occupancy that constitute substantial improvement to existing buildings must comply with the standards for building in the 1% FEMA flood zone. Ultimately, adapting historic buildings should not alter the character of the neighborhood and options for resiliency may be unique to each building. Compatible strategies have been identified but will need to be assessed on a case-by-case analysis.

Critical Buildings: Protecting and maintaining access to and from critical system elements (transformers, transfer switches, fuel tanks, pumps, etc.) is paramount in extreme weather response and recovery. The City's recommended approach for critical building resiliency is to build/protect to the 2070 1% flood elevation. Building or protecting to a higher elevation adds a factor of safety to compensate for unknown factors that could contribute to flood depth. FEMA calls this factor of safety "freeboard," which is typically 1-3 additional feet (depending on building criticality) added to the base flood elevation.

The Resilient Cambridge Handbook provides strategies for addressing the technical considerations for Better Buildings.

The CCPR Alewife Handbook issued November 2017 documents a set of strategies for adapting buildings for climate change. The Port Preparedness Plan issued in May 2019 added more strategies and the toolbox is now updated in Resilient Cambridge further informed by best methods and practices.

Table 1 – Better Buildings Strategies

Strategy	Title	Actions	Toolbox
B1	Regulate Flood Protection for New Buildings	1. Build/protect to the 2070 10 percent annual flood elevation from precipitation or sea level rise/storm surge, whichever is higher 2. Recover to the 2070 1 percent annual flood elevation from precipitation or sea level rise/storm surge, whichever is higher 3. Establish requirements for all vulnerable utilities to be located above the determined flood elevation 4. Require the American Society of Civil Engineers (ASCE) 24-14 Flood Resistant Design and Construction below 2070 1 percent annual flood elevation 5. Locate electrical shut-off to building above grade level, not in basement	• Backwater valves • Dry floodproofing • Wet floodproofing • Elevation of critical systems • Elevation of Structure • Resilient Elevators • Water Alarms

[21] https://up.codes/viewer/massachusetts/iebc-2009/chapter/11/historic-buildings#1101

B3	Encourage Flood Protection for Existing Buildings	1. Retrofit/protect to the 2070 10 percent annual flood elevation from precipitation or sea level rise/storm surge, whichever is higher 2. Retrofit to recover to the 2070 1 percent annual flood elevation from precipitation or sea level rise/storm surge, whichever is higher 3. Elevate or protect vulnerable utilities such as fuel storage, furnaces, and electrical panels above 2070 10%annual flood elevation 4. Use flood-resilient construction materials below the 2070 10%annual flood elevation 5. Relocate electrical panels and main shutoff at or above grade level, not in basement, if substantial renovation being considered	• Backwater valves • Dry floodproofing • Wet floodproofing • Deployable flood barriers • Elevation of critical systems • Fill basement/cellar • Elevate the structure • Water Alarms • Secure Critical Systems/Equipment • Elevation of ground floor above DFE, if possible
B5	Support Building Management for Flood and Heat Protection	1. Require all commercial and multi-family residential buildings over 10 units to have a maintenance plan and emergency plan for maintaining, at a minimum, basic service for flood and heat events 2. Require new buildings to include building management systems/smart thermostats and energy management systems 3. Ensure all new buildings are “generator ready” and there are transfer switches and quick-connect outlets for existing buildings 4. Encourage distributed energy systems (on-site generation) that allow autonomy in new buildings during outages 5. Encourage increased tree and vegetative cover and maintenance throughout the City to help buffer heat and flooding	• Continuity of Operations Plan • Community Rooms • Generators
B6	Encourage Site Green Infrastructure	1. Implement on-site store/retain/delay strategies for stormwater. Refer to LEED* “Sustainable Sites” and “Water Efficiency” sections for guidelines and implementation. Possible approaches or technologies: • Use porous (pervious) pavement for driveways and parking stalls • Install bioretention basins: rain gardens, infiltration planters • Install green roofs • Harvest rainwater 2. Preserve and Increase tree and vegetative coverage – plant roots absorb water; foliage protects against heat. Revegetate when	• Blue roof • Pervious pavement • Rain barrels • Green roof • Rain gardens • Trees

		possible. (*LEED refers to the Leadership in Energy and Environmental Design Green Building Rating System as developed and revised by the United States Green Building Council (USGBC)) **See the Stronger Infrastructure and Greener City technical reports for more detail on city-wide strategy on GI.*	
B9 (NEW)	Encourage Resiliency of Building Scale Energy	1. Install solar PV panels to increase renewable energy production 2. Renovate existing/"older" pre stretch-code buildings to increase energy efficiency	• Solar Panels • Microgrids • Back-up batteries • Generators • Insulation
B10 (NEW)	Develop Flood Protection and Operations Planning for Historic and Critical Facilities	1. Maintain integrity of critical and historic structures 2. When possible, relocate critical facilities out of the predicted floodplain.	• Dry floodproofing • Relocation • Operations Plans • Generators • Deployable flood barriers

Factoring in technical considerations, it is assumed that different strategies are applicable or effective to either or both ***build/protect to*** and ***recover from*** according to building typologies. Table 2 summarizes possible actions for the most common building typologies. More detail about strategies for the most common typologies can be found in Appendix B1 Cost Estimate for Building Resiliency.

Table 2 – Applicable Strategies

	Retrofit Strategies	Building Typologies					Retrofit Applicability	
		Small Res.	Medium Res.	Large Res.	Small Com.	R&D/ Large Com.	Build/ Protect To	Recover From
Flooding	B3: Backwater valves							
	B3: Deployable flood barriers							
	B3: Dry floodproofing							
	B3: Elevation of critical systems							
	B3: Elevation of structure							
	B3: Fill basement/cellar							
	B6: Green infrastructure							
	B6: Impervious Surface Replacement							
	B3: Relocation/demolition							
	B3: Resilient elevators							
	B3: Secure critical systems/infrastructure							
	B3: Water alarms							
	B3: Wet floodproofing							

6. Resilient Building Strategies for Extreme Heat

Sustained exposure to extreme heat affects the health and safety of building occupants and damages critical equipment. Increased humidity may impact a building's envelope and structure. A high proportion of older buildings in the City may not be adapted to hot weather due to insufficient insulation and lack of adequate indoor air circulation or air conditioning. Buildings can also exacerbate the urban heat island effect (UHI) by making the air warmer in the City due to many heat-absorbing surfaces, such as dark roofs. UHI spots can warm up faster—sometimes 10 degrees greater— and retain heat longer than more natural land cover. In the evening, the greater temperature increase is more noticeable.

Figure 14 illustrates how extreme heat can impact a building's indoor condition and outdoor environment, contributing to UHI.

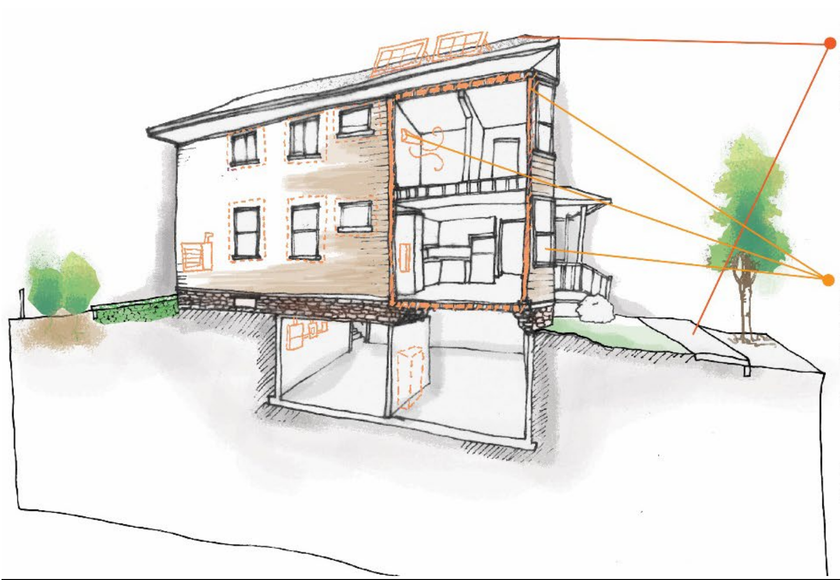


Figure 14 – Urban Heat Island and extreme heat contributors.

Building components used as indicators for resiliency to extreme heat are:

- ***Vapor Barriers*** – Best practice maintains that vapor barriers be placed on the warm side of the wall. As Cambridge moves from a climate requiring more days of cooling than heating, existing conditions where vapor barriers are on the interior side of the wall will allow for condensation to form. Condensation that cannot adequately dry may cause mold and degradation of wood-framed structures.

- ***Envelope*** – Creating a tight building envelope provides the most resilience during an extreme heat event by maintaining indoor comfort for longer when mechanical cooling and heating are not available. The building envelope is comprised of the walls, roof, and floor. Ideally, the tighter the envelope, as in minimizing air leakage and infiltration, the longer your building will maintain the desired indoor temperature and require less energy to do so.

- ***Air-Conditioning*** – Buildings that have mixed-mode ventilation systems, which include passive cooling, air source heat pumps, and ceiling fans allow for redundancy of cooling methods and minimize energy consumption.
- ***Windows*** – Windows allow passive cooling and more control of temperature during shoulder season weather. Glass is a good conductor of heat, specifically from direct light, often allowing too much heat to come into buildings, thereby heating up the interior. Window shades, shade structures, solar films, and triples glazed windows can divert and minimize direct sunlight from heating up an interior space.
- ***Roof:*** Traditional roofs in New England are asphalt shingles on pitched roofs and PVC, TPO, or EPDM on flat roofs. The color of the roof varies, and it is becoming increasingly popular to use lighter materials. White roofs or cool roofs reduce the building's contribution to UHI and can reduce energy load on the building by decreasing air-conditioning needs[22].

  For the Climate Change Vulnerability Assessment (CCVA)[23] published in 2015, the City developed a model for reporting urban temperature[24]. It has been developed to allow testing the projected impact of implementation of resiliency strategies including changes in tree canopy, pervious surface and implementation of cool roofs. As defined by the US department of Energy, a cool roof is one that has been designed to reflect more sunlight and absorb less heat than a standard roof. Although green roofs do not reflect sunlight like white roofs, they absorb less heat and for the purpose of this report, cool roofs include green roofs.

The Resilient Cambridge Handbook provides strategies for addressing the technical considerations for Better Buildings.

Table 3 – Better Buildings Strategies

Strategy	Title	Actions	Toolbox
B2	Regulate Heat Protection for New Buildings	1. Design buildings with passive strategies including building orientation, high performance insulation and windows, shading and natural ventilation, and white or green roofs 2. Require all new buildings to be designed with a high-performance building envelope (e.g., R-20 minimum wall insulation and R-40 minimum roof insulation, U-0.3 maximum glazing) and limit air leakage (less than or equal to 3 ACH at 50 pascals) 3. Design buildings to meet the Passive House Institute U.S. Certification, aiming to design for	• Building Envelope • Cool Roof • Green Roof • Operable Windows • Solar Shading • Heat Pumps

[22] https://www.energy.gov/energysaver/design/energy-efficient-home-design/cool-roofs

[23] http://envision.cambridgema.gov/wp-content/uploads/2016/08/Cambridge_November2015_FINAL-web.pdf

[24] The methodology for developing the model is explained in a technical memo available at https://www.cambridgema.gov/-/media/Files/CDD/Climate/vulnerabilityassessment/ccvareportpart1/climateprojectionsandscenariodevelopment/appendixdurbanheatislandprotocolnovember20151.pdf

		the projected Climate Zone 3, or to meet the LEED Pilot Credit for Resiliency 4. Require buildings to have mixed-mode ventilation systems, which include passive cooling, and install ceiling fans where applicable. Require reflective rooftops with a minimum solar reflectance index (SRI) of 82 (for rooftop slopes less than 10 degrees) and 39 (for rooftops over 10 degrees), non-roof surfaces with a minimum solar reflectance of 0.33, or install green roofs (structural capacity dependent) and green infrastructure. 5. Maintain mature trees in private and public property. Plant new trees where possible to shade southern- and eastern-exposed building facades. Advocate for trellises and other site features with vegetative grown shading buildings.	
B4	Encourage Heat Protection for Existing Buildings	1. Maximize opportunities for natural ventilation and upgrading building mechanical systems and install ceiling fans (where applicable) for improved passive survivability 2. Install backup solar energy and power storage systems and separate circuits for critical building loads including AC in "selected cool zone" 3. Retrofit rooftops with a minimum Solar Reflectance Index (SRI) of 82 (for rooftop slopes less than 10 degrees) and 39 (for rooftops over 10 degrees). This can be achieved by installing cool or green roofs (structural capacity dependent). 4. Replace windows with low-e glass windows with a U-value maximum of U-0.03 5. Encourage temperature control setpoints to maintain higher temperatures during the summertime 6. Encourage LEED certification for existing buildings	• Improved insulation • Cool roof • Solar Shading • Heat pumps • Operable windows • Ceiling fans • Triple glazed windows
B5	Support Building Management for Flood and Heat Protection	1. Require all commercial and multi-family residential buildings over 10 units to have a maintenance plan and emergency plan for maintaining, at a minimum, basic service for flood and heat events 2. Require new buildings to include building management systems/smart thermostats and energy management systems	• Continuity of Operations Plan • Community Rooms • Generators

		3. Ensure all new buildings are "generator ready" and there are transfer switches and quick-connect outlets for existing buildings 4. Encourage distributed energy systems (on-site generation) that allow autonomy in new buildings during outages 5. Encourage increased tree and vegetative cover and maintenance throughout the City to help buffer heat and flooding	
B6	Encourage Site Green Infrastructure	1. Implement on-site store/retain/delay strategies for stormwater. Refer to LEED* "Sustainable Sites" and "Water Efficiency" sections for guidelines and implementation. Possible approaches or technologies: • Use porous (pervious) pavement for driveways and parking stalls • Install bioretention basins: rain gardens, tree boxes, infiltration planters • Install green roofs • Harvest rainwater 2. Preserve and increase tree and vegetative coverage – plant roots absorb water; foliage protects against heat. Revegetate when possible (*LEED refers to the Leadership in Energy and Environmental Design Green Building Rating System as developed and revised by the United States Green Building Council (USGBC))	• Blue roof • Pervious pavement • Rain barrels • Green roof • Rain gardens • Trees
B9 (NEW)	Encourage Resiliency of Building Scale Energy	1. Install solar PV panels to increase renewable energy production 2. Renovate existing/"older" pre stretch-code buildings to increase energy efficiency	• Solar Panels • Microgrids • Back-up batteries • Generators • Insulation

Proposed strategies may be effective in improving UHI and/or extreme heat. Table 4 summarizes possible actions.

Table 4 – Applicable Heat Strategies by Typology

	Retrofit Strategies	Building Typologies					Resiliency Improvement	
		Small Res.	Medium Res.	Large Res.	Small Com.	R&D/ Large Com.	Urban Heat Island	Extreme heat
Extreme Heat	B4: Building envelope							
	B4: Cool roofs							
	B8: Energy storage							
	B6: Green roofs							
	B4: Operable windows/Shading structures							
	B4: Heat pumps							

Cool Factor:
The City Manager has appointed a Climate Resilience Zoning Task Force representing a variety of community stakeholders and perspectives to work through resiliency elements[25]. One of the key ideas emerging from the Task Force is for the development of a Cool Factor that focuses on a crediting approach to development regulations, encouraging strategies to reduce extreme heat as shown in Figure 15. Ideally, building owners will use the Cool Factor Score Sheet to help determine contribution to UHI. All SRI and SR requirements are based on LEED V4.1 standard for the Urban Heat Island Reduction Credit. The proposed Score Sheet assumes that "cool roofs" will become a prerequisite of the Cool Factor with SRI requirement of 82 for low slope ≤ 2:12 and 39 for steep slope > 2:12. There may be co-benefits of the Cool Factor, which include stormwater flood retention and improved water quality.

[25] The City Manager has appointed a Climate Resilience Zoning Task Force representing a variety of community stakeholders and perspectives to work through resiliency elements raised during the Envision process and through the Douglas Brown, et al., with the input of the appropriate City agencies and departments. This task force is being created to build upon the City's 2017 Climate Change Vulnerability Assessment (CCVA) and ongoing Climate Change Preparedness and Resilience (CCPR) planning efforts and to advise on development standards that can be incorporated into the Zoning Ordinance that would result in new development that is more resilient to climate change risks. https://www.cambridgema.gov/CDD/Projects/Zoning/climateresiliencezoning

City of Cambridge	Cool Factor Score Sheet	2/25/2021
Project Address: Sample	Special Permit Number: PB-XXX	Total Lot Area (SF): 40000
Project Description: Sample run to demonstrate how the form works.		☑ Yes Pass

		Outside 20' of PROW	Value Factor		Within 20' of PROW	Value Factor
Green Roofs & Facades	**C1** Green Façade	100	0.10	+	100	0.20
	C2 Living Wall	100	0.30	+	100	0.60
For definitions, see reference document.	**C3** Green Roof	100	0.30	+	100	0.60
	C4 Short Intensive Green Roof	100	0.50	+	100	1.00
	C5 Intensive Green Roof	100	0.60	+	100	1.20

Figure 15 – Draft example of Cool Factor Score Sheet. February 2021.

7. Case Studies for Possible Implementation

By gathering data on the common characteristics of the selected typologies, assumptions can be made about the impacts of flooding and heat on buildings to develop the most applicable solutions. Refer to Appendix B1 Cost Estimate for Building Resiliency for more detailed cost information.

Small Residential

Strategies that could be implemented toward a resilient small residential building.

Protect to
Strategies: elevate critical systems, backflow preventors, dry floodproofing, water sensor alarms. (Cost estimate: $15,141)

Recover From
Strategies: fill basement, elevate critical systems, backflow preventers. (Cost estimate: $15,370)

Extreme Heat
Strategies: mini-split heat pump system, enhance envelope (upgrade windows), cool roof. (Cost estimate: $27,650)

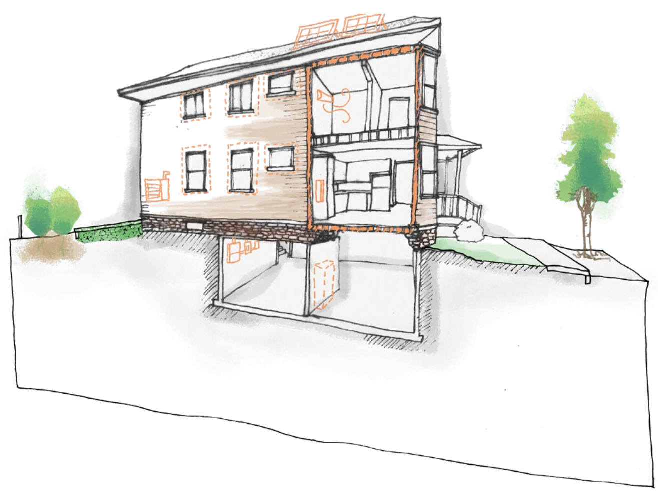


Figure 15 – Typical Small Residential Building.

Medium Residential

Multi-Family Resilience Hubs

Resilient community rooms are an increasingly popular strategy developers use to improve resiliency and reduce vulnerability of building occupants. Converting a common room in a multi-family building into a resilience hub allows residents to access cooling/heating in an extreme weather event.

Figure 16 – Typical Medium Residential Building

Heat pumps are included here as a measure for providing heating/cooling to a limited space or, in the case of a 1-3 unit residential, to the full building. Ductless heat pumps, in particular, offer a flexible way to provide heating and cooling to a single zone or a whole building without the need to install a central system. For purposes of this analysis, one single-zone ductless heat pump is assumed to be installed in a common room of a multi-family or commercial building to serve as a resiliency hub during an extreme heat event or a prolonged summer outage to allow occupants access to a cool space. This ductless heat pump is estimated at approximately $4,500 to $6,000. For use during prolonged outages, battery storage in conjunction with a solar PV system may be able to support this system for a more prolonged outage during the summer, though fossil fuel backup generation may be necessary for prolonged winter outages.

City Block/Neighborhood Scale Implementation for Flooding

Areas for district-wide stormwater infrastructure improvement:

To gain a better understanding of where district scale improvements would impact the most buildings, Table 5 provides an analysis of neighborhoods and the number of buildings impacted. Nearly 40% of impacted buildings by the 2070 10%annual precipitation event are located within **Wellington-Harrington** and **Cambridgeport** neighborhoods. The City is already undertaking major stormwater infrastructure improvements in The Port that have addressed district-wide impact. This area remains impacted but at a lesser degree.

Neighborhoods such as Area 2/MIT, Mid-Cambridge, and Strawberry Hill contain a small percentage of impacted buildings; intervention in these areas may be targeted on a case-by-case basis working with institutions and property owners.

Regional consideration for SLR/SS

Nearly 2/3 of impacted buildings in the 2070 10 percent annual SLR/SS event are located within the North Cambridge neighborhood, followed by Cambridge Highlands. It might be most effective to consider a regional approach to SLR/SS by enhancing resiliency at the Amelia Earhart Dam and the Charles River Dam.

Table 5 – Neighborhoods Most Impacted by Flooding

Neighborhood	2070 10 PERCENT ANNUAL PRECIPITATION FLOOD EVENT	NEIGHBORHOOD	2070 10 PERCENT ANNUAL SLR/SS FLOOD EVENT
	# of buildings impacted		# of buildings impacted
AGASSIZ	29	Agassiz	0
AREA 2/MIT	8	Area 2/MIT	42
CAMBRIDGE HIGHLANDS	25	Cambridge Highlands	134
CAMBRIDGEPORT	159	Cambridgeport	11
EAST CAMBRIDGE	52	East Cambridge	114
MID-CAMBRIDGE	11	Mid-Cambridge	0
NEIGHBORHOOD NINE	81	Neighborhood Nine	91
NORTH CAMBRIDGE	78	North Cambridge	376
RIVERSIDE	36	Riverside	1
STRAWBERRY HILL	4	Strawberry Hill	0
THE PORT	119	The Port	0
WELLINGTON-HARRINGTON	147	Wellington-Harrington	0
WEST CAMBRIDGE	44	West Cambridge	43
TOTAL	**793**	TOTAL	**812**

City Block/Neighborhood Scale Implementation for Heat

As studied in The Port Preparedness Plan, the Super Resilient Urban Block was identified as a strategy in achieving results that are greater if individual efforts are aggregated or if the efforts are combined. In the following map shown in Figure 16, when the “transition areas” identified by Envision Cambridge are intersected with “hot spots”, if becomes clear that the transitions areas would benefit most from a Super Resilient Block approach.

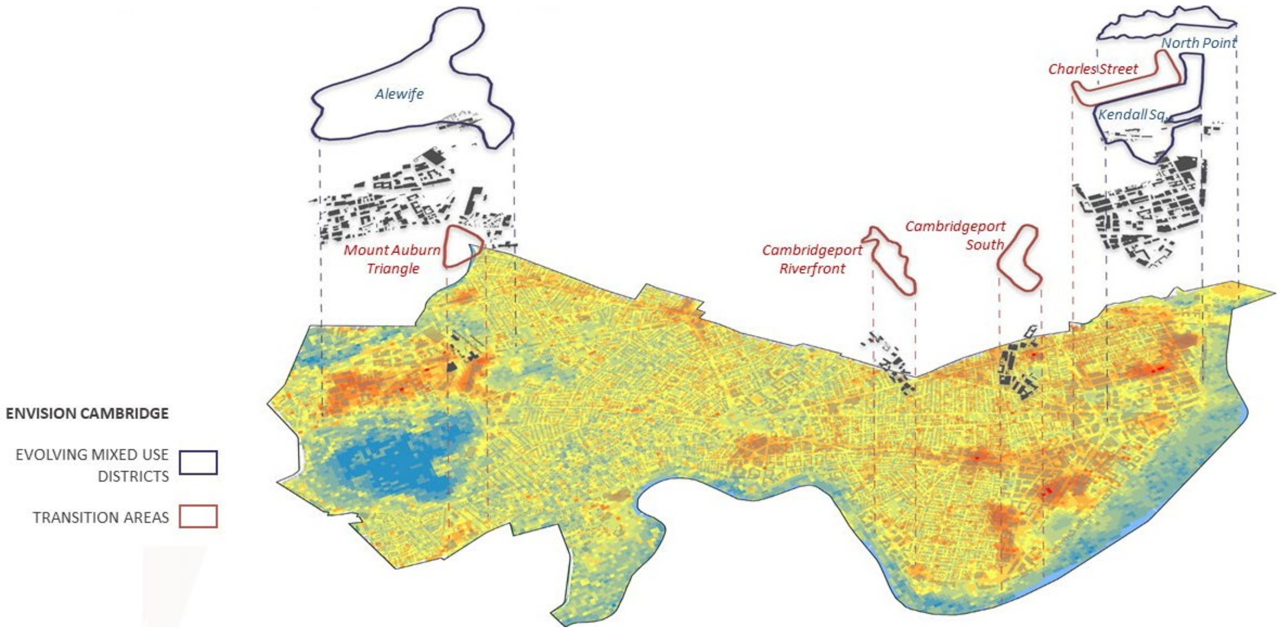


Figure 16– Transition areas identified in Envision Cambridge compared against hot spots on a 90-degree day.

There could be an ambient air temperature reduction by as much as 6 degrees if all proposed strategies were implemented to the Maximum Extent Practical (MEP). Figure 17 identifies strategies that could be implemented at a typical mixed-use block to make it “super resilient”. These strategies also align with the Cool Factor recommendations.

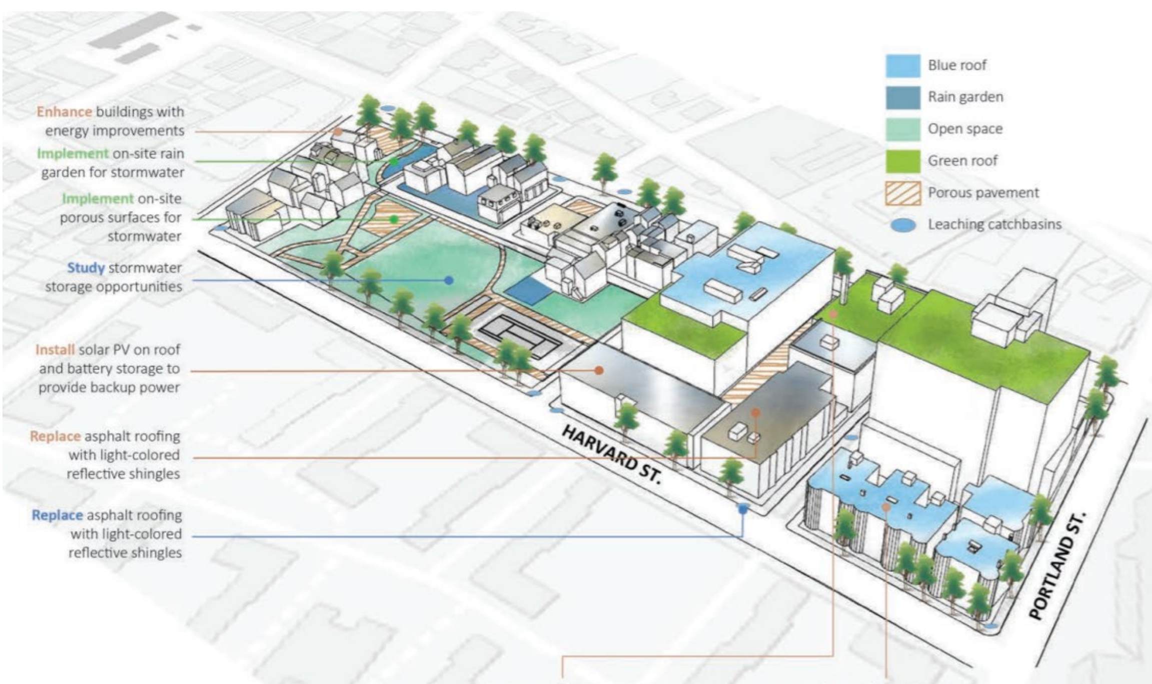


Figure 17 – Super Resilient Urban Block from The Port Neighborhood Preparedness Plan

8. Key Findings and Recommended Early Actions

The overall benefit of the strategies for better buildings is to develop a resilient neighborhood that is protected from climate change impacts and designed for a rapid return to normal. To speed up the rate at which buildings are designed or retrofitted for future climate conditions, **policies, projects,** and **programs** will need to be developed to improve the resiliency of the buildings in Cambridge. The City will also continue **advocating** for resiliency strategies that are most effective at the regional scale.

Policies

- *Update/Revise Special Projects Guidelines* – The City could formalize recommendations for implementing strategies for flood protection and heat resiliency through zoning and recommended guidelines for new buildings and buildings undergoing significant renovation. Part of the assessment on how to integrate new regulations would require a granular analysis to understand the trade-offs between cost-benefit estimates at the building scale versus the neighborhood scale, as well as new buildings versus retrofits. Additional analysis is needed to understand the potential impacts of new policies and regulations on equity, housing affordability, and gentrification. The City could explore the feasibility and implications of a requirement during summer months (i.e., cooling season) for landlords to maintain a livable temperature like the State requirement for maintaining livable temperatures during the winter/heating season.
- *New buildings* are an opportunity for inherent resiliency features to be incorporated into new structures. Strategy B7– Establish Adapted Zoning, Policies, and Regulations – should provide the regulatory mechanisms to ensure building resilience going forward.
- *Retrofitting existing buildings:* The City could study/determine possible "triggers" for requiring that new buildings and retrofitted buildings meet the new resiliency standards for flooding and heat preparedness. In Cambridge, it could be expected that all buildings in the City will undergo a renovation significant enough to require a permit by 2050. The City could consider which level of renovation should trigger the implementation of resiliency strategies and to which degree of compliance. The permits may range from Level 1 through Level 3 Alterations. According to the Massachusetts State Building Code[26]:
  - Level 1 alterations include the removal and replacement or the covering of existing materials, elements, equipment, or fixtures using new materials, elements, equipment, or fixtures that serve the same purpose.
  - Level 2 alterations include the reconfiguration of space, the addition or elimination of any door or window, the reconfiguration or extension of any system, or the installation of any additional equipment.
  - Level 3 alterations apply where the work area exceeds 50 percent of the aggregate area of the building and where required by a change of occupancy classification.

  Currently, renovations considered Level 3 alterations are required to build to the FEMA 1% Special Hazard Area elevation.

Projects

- *Resilient Critical Facilities:* The City could consider integrating recommendations in its capital projects for upgrading critical facilities within the next 10 years to meet resiliency requirements to build/protect to for the 2070 1%annual event**.** A first step would be identifying which facilities should be prioritized and a timeframe for implementation.

[26] https://www.mass.gov/handbook/ninth-edition-of-the-ma-state-building-code-780

- *Neighborhood/district scale infrastructure projects:* Focusing on precipitation flooding and UHI, the City's stormwater infrastructure projects, implementation of the Urban Forest Master Plan, parks upgrade and road reconstructions all present opportunities for the City to implement a significant district level improvement. The priority for stormwater infrastructure would be to study options for stormwater improvement projects in the Wellington-Harrington and Cambridgeport neighborhoods, such as Green Street in Cambridgeport and Ahern Field in Wellington/Harrington. A priority for UHI solutions would be to target areas in South Cambridgeport, Alewife, and Kendall Square.

<u>Programs</u>

- The City could develop a *program for resiliency upgrades* for existing buildings, targeting small and medium residential and small commercial properties. A first step would be to review model programs such as FloodHelp NY and Chicago's Flood Damage Assistance as well as programs to improve buildings for extreme heat . The City would assess the feasibility of developing a similar program in Cambridge. An example of a targeted program could be to incentivize or subsidize green roofs or GI on small and medium residential properties in The Port, Wellington-Harrington, and Cambridgeport neighborhoods to reduce stormwater runoff. The programs should focus on these areas that have greater racial diversity and economic challenges: MIT/Area 2, North Cambridge, Cambridge Highlands, and The Port.
- *Partnerships for Resiliency with Institutions and large property owners:* The City could work with institutions and large commercial/R&D property managers individually or as a group using existing platforms, such as the Cambridge Compact. In this case, the City would provide expertise on the best approaches for resiliency and a platform for discussion on resiliency.
- *Point-of-Sale/Rental Policy* – Analysis reveals that many of Cambridge's permits are for relatively low-cost work, meaning that most buildings will not retrofit for resiliency as quickly as needed. Requiring notification at a point-of-sale or in a rental agreement would notify property residents of risk if the property has not been retrofitted for resiliency.

<u>Special Consideration for Resilient Historic Structures</u>

- Working with the Cambridge Historical Commission, the City could assess which structures are most are risk and perform full risk and vulnerability assessments on historic structures.
- Another option is for the City to apply for funding through the Massachusetts State Historical Commission to update the National Register survey/inventory with added funding to develop historic buildings and districts design guidelines.

<u>Advocacy and Regional Coordination</u>

- *The City should continue advocating for regional solutions* focusing on enhanced resiliency for the Amelia Earhart Dam and the Charles River Dam for addressing flooding risk from SLR/SS. The City has been working with the Resilient Mystic Collaborative and the Metro Mayors Climate Preparedness Task Force and key state agencies, including the Massachusetts Department of Conservation and Recreation, on analyses of possible impacts of SLR/SS of the dams being overtopped or flanked and possible strategies for increasing resiliency.
- *Advocate to update State Regulations to include climate change consideration*: The 10th edition of the MA State Building Code and Stretch Code has proposed amendments to look at forward-looking

climate projects, which will require stricter building standards for a greater number of buildings, rather than past editions, which only used historic data.[27]

[27] https://www.clf.org/wp-content/uploads/2019/03/CLF_ClimateCodeReport_2019.pdf