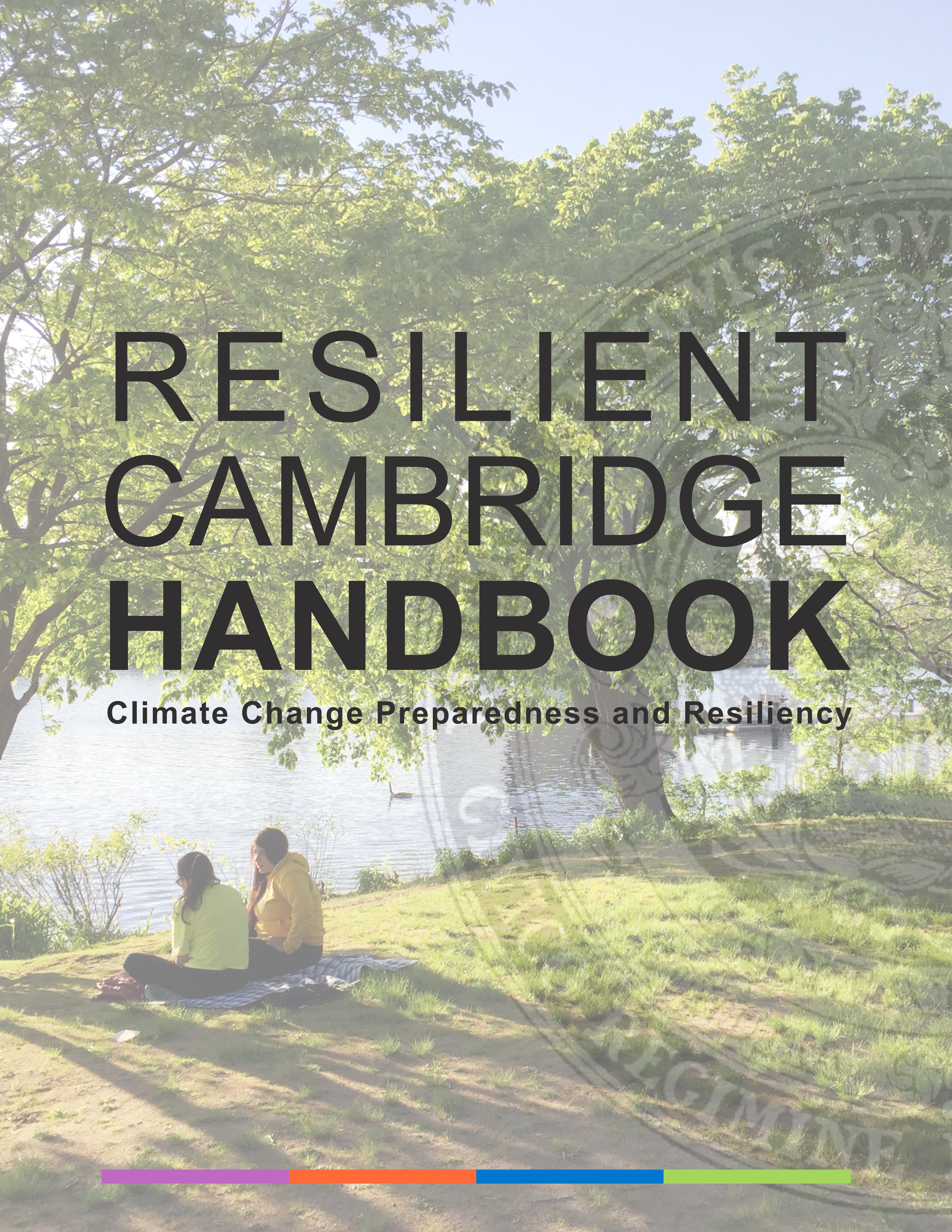

RESILIENT CAMBRIDGE **HANDBOOK**

Climate Change Preparedness and Resiliency

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To view more on Cambridge's climate resiliency efforts, visit:

www.cambridgema.gov/ResilientCambridge

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Introduction

WHAT IS THE RESILIENT CAMBRIDGE HANDBOOK?

The Resilient Cambridge Handbook is a companion document to the City of Cambridge Climate Change Preparedness and Resiliency (CCPR) **Resilient Cambridge Plan**. It describes a range of resiliency strategies using a consistent, easy-to-read format. The Handbook is a practical guide for different stakeholders within Cambridge. The City expects that the collective implementation of the recommended strategies will reap greater benefits. The resilience strategies are organized into the following four (4) categories matching Resilient Cambridge's transformative ideas:

A

Closer Neighborhoods providing for increased social and economic resilience.

B

Better Buildings protecting against projected climate change impacts and/or designing for a speedy return to normal operation.

C

Stronger Infrastructure ensuring continued service and/or a swift recovery from climate shocks and stresses.

D

Greener City integrating the built environment with green infrastructure, the urban forest, and natural areas to support a resilient ecosystem.

HOW CAN THE HANDBOOK BE USED?

The Handbook is organized by the previously mentioned four categories: **Closer Neighborhoods**, **Better Buildings**, **Stronger Infrastructure**, and **Greener City**. Each category includes several strategies. The format of each strategy is consistent so that the reader can directly compare its effectiveness across the four broad categories. Each strategy includes a toolbox of specific actions to achieve preparedness and resiliency.

The strategies and actions can also be regrouped under different themes. For example, the strategies may be sorted by the risk addressed, such as flooding or extreme heat, or they may be sorted by the jurisdiction such as City, State, or Federal. The strategies are actionable measures that can be adopted in the short- to medium-term. They also present a set of ideas and guiding principles to inform the Cambridge community's understanding of climate change vulnerability and resiliency as a basis for long-term planning.

The City has researched best practices and the most relevant to Cambridge are documented in the Handbook for each of the four strategies. Each section also provides a narrative to support how the strategies were developed taking into account the following key considerations:

Impact

Level of impact that implementation of the proposed strategy will have on mitigating the risks on critical infrastructure assets, services, and vulnerable population groups.

Cost

Preliminary cost assessment for implementing the strategy using best and readily available knowledge on order-of-magnitude cost or, if available, cost per unit. This preliminary assessment is not based on a cost-benefit analysis, but cost only.

Equity

Preliminary assessment of whether implementing the strategy benefits preparedness and resilience to all members of the community irrespective of income, age, level of education or English language proficiency. It indicates a strategy's effectiveness to provide equal protection and meaningful involvement of all people and community groups with respect to climate change.

Wellness

How the strategy helps to build healthy and safe community environments. It addresses projected public health impacts due to climate change, if proposed action will improve livelihoods, provide for job opportunities, preserve business continuity, or promote an enhanced quality of life in the neighborhood.

Feasibility

Preliminary assessment of the technical, regulatory, and political feasibility of the strategy.

Co-Benefits

The City of Cambridge does not consider mitigation and adaptation as mutually exclusive, and instead views these as a two-pronged approach to manage the short- and long-term disturbances of climate change. This consideration assesses to what extent a strategy also contributes to mitigating climate change by reducing greenhouse gas (GHG) emissions.

HOW TO READ THE TEMPLATES FOR EACH STRATEGY

The Handbook provides guidance on how the proposed strategies and actions can be implemented. The format of each strategy is consistent so that the reader can directly compare its effectiveness across the four broad categories. The following instructions explain how to read the template provided per specific strategy and related actions:

The Strategy

The top of the page lists the name of the strategy and describes its main intent.

Toolbox / Actions

The Toolbox lists specific actions to achieve the strategy. Its purpose is to be as specific as possible, leading toward achieving an implementable strategy. The toolbox actions may be concurrent or, in some cases, mutually exclusive.

Relevance to Cambridge

This section identifies why the strategy is relevant to Cambridge.

Actions Already Being Taken

There are many actions already being taken by the City's stakeholders and partners. The City wishes to avoid duplication, or confusion with existing policies, regulations, and programs or initiatives that address climate change-related risk(s).

Applicability

This section provides preliminary information that would contribute toward developing a complete implementation plan for that strategy. As a first step, the following key components have been identified:

- **Proponent** identifies a possible “champion” who could lead the implementation and provide possible financing. These two are not necessarily the same. Options include City, Government (other than City), Institutions/Not-for-Profit Organizations, Private Corporations, Private Residents, and Partnerships.
- **Jurisdiction** defines who implements and monitors the enactment of the strategy. Options include the City as the owner, regulation or policy at the municipal level (under the jurisdiction of the City); the State as an owner, or regulation and policy at the State level; and Federal (mainly for strategies beyond the State level and at the federal government level).
- **Scale** identifies the scope of the intervention, which can range from a single parcel to the neighborhood scale, citywide scale, or regional scale. Options include Parcel, Neighborhood, Citywide, and Regional.
- **Related Strategies** lists the strategies that share similar action(s) in the Toolbox.

NEXT STEPS

The Resilient Cambridge Handbook is a living document that may be updated considering broader climate change risks (e.g., ice storms or drought), quantification of cost and funding opportunities, new technologies, and user feedback.

Closer Neighborhoods

Strategies for Closer Neighborhoods range from public health approaches focusing on outreach and education to protection of community resources, assuring their continuity of operations under "new normal" conditions due to repeated flooding, storm surge, and heat waves. Some strategies are focused on how best to enhance neighborhood services — e.g., cooling centers and networks supporting populations at risk. Other strategies are focused on strengthening communication and neighborhood bonds. Finally, some strategies propose a more comprehensive approach to strengthen current emergency plans and social networks.

These are the strategies that will help make Closer Neighborhoods:

1. Provide Neighborhood Resilience Hubs

Establish a neighborhood resilience hub to foster community networks on a daily basis and increase preparedness and resilience among residents and businesses through education, training, planning, and implementation of resilience and sustainability measures.

2. Enhance Resilient Public Amenities

Provide resilient public amenities that would be attractive enough to be used during short periods of heat emergencies.

3. Create Support Systems For Populations At Risk

Establish a program to pre-identify and support individuals who are more at risk due to health conditions, substance use, homelessness or social isolation, and develop community support and emergency response systems to ensure their safety and well-being.

4. Strengthen Emergency Communications Systems

Develop neighborhood-scale communication systems, which are redundant to normal communications systems, to provide back-up during telephone, cellular, cable and internet service outages.

5. Support Business and Organizational Preparedness

Increase business and organizational continuity planning and preparedness.

6. Protect Community Resource Buildings

Adopt Resilient Cambridge Better Buildings recommendations for preparedness to extreme events.

7. Enhance Emergency Response Plans

Strengthen existing emergency response plans to include the potential impacts of climate change, including strategies to enable sheltering in place and evacuation when appropriate.

8. Provide For Healthcare Continuity and Access

Work locally with key healthcare service providers and with the regional health and medical coalition to ensure capacity, continuity, and access to medical services.

9. Encourage Stronger Social Network

Develop a neighborhood resiliency social network in partnership with community leaders and organizations.

10. Continue Climate Education

Develop climate education programs aimed at educating all residents on climate change preparedness and mitigation.

11. Support Renter Preparedness

Develop programs to protect renters during climate-related events.

BEST PRACTICES

The City collected best practices and model strategies for community resiliency and preparedness from research conducted over the summer of 2016 by the JSI Research & Training Institute, Inc. (JSI). Peer-reviewed studies, guidance from agencies including the Centers for Disease Control's Building Resilience Against Climate Effects (BRACE) framework, as well as reports from other communities were reviewed. Additional best practices have been added as the City is experiencing warmer temperatures. The review of those best practices focuses primarily on the health impacts from extreme heat and flooding. Descriptions of the following best practices and models are provided in the following section:

- Heat-health action plan
- Emergency medical services support
- Preparedness and climate resiliency education
- Safe and pleasant shelters
- Accessible medical services

Heat-Health Action Plan

Heat vulnerability for communities and individuals is an under-appreciated risk. High heat leads to an increase in mortality across age groups. Causes vary from no access to air conditioning (AC), lack of awareness of heat warnings, and vulnerable individuals staying home in hot weather. For example, the death toll for the 1995 Chicago heat wave consisted mostly of victims who were senior and low-income residents who could not afford air conditioning and did not open their windows due to concerns about safety. An epidemiological analysis of the Chicago heat wave showed that Black residents suffered a higher rate of heat-related health emergencies and fatalities than white residents. The Latinx population had an unusually low fatality rate due to the heat. One explanation given is that many Black communities lived in isolated areas of Chicago in sub-standard housing, while Latinx residents lived in areas with higher population density and more social cohesion[1].

The implementation of a Heat-Health Action Plan (HHAP), with a focus on educating medical providers and developing recommendations for patient care, is suggested as effective at preventing excess mortality[2]. U.S. EPA advises that healthcare workers should educate patients on heat-health risks, work with their patients to develop prevention tactics, and educate their patients on when to seek help during a heat wave[3].

Emergency Medical Services Support

Best practices include preparing for higher demands

1 Case Study: Deadly Chicago Heat Wave of 1995 - AdaptNY, https://www.adaptny.org/2016/07/21/case-study-deadly-chicago-heat-wave-of-1995

2 Heudorf, U.; Schade, M. Heat waves and mortality in Frankfurt Am Main, Germany, 2003-2013: What effect do heat-health action plans and the heat warning system have? Zeitschrift fur Gerontologie und Geriatrie 2014, 47, 475-482.

3 Excessive Heat Events Guidebook EPA 430-B-16-001 | June 2006 Updated Appendix A | March 2016. https://www.epa.gov/sites/production/files/2016-03/documents/eheguide_final.pdf

on Emergency Medical Services (EMS) and the healthcare system. It is reported that EMS call volume and ambulance transport increase dramatically with rising temperatures. In many states, city public health services are now planning for projected heat waves.

Preparedness and Climate Resiliency Education

The City of Portland, Oregon, has organized an ambitious and popular disaster preparedness and climate resiliency education program called Planning for Resilience and Emergency Preparedness (PREP) (Figure A.1). Courses offered include Your Resilient Neighborhood, focusing on citizen stormwater and heat management strategies; and Should I Stay or Should I Go, examining real-time disaster survival, management and recovery scenarios. PREP is designed to encourage heads of households, institutional leaders, and business owners to develop contingency plans to address specific disaster threats.

Safe and Pleasant Shelters

Citizens often resist going to shelters during climate-related emergencies. This was evidenced in California where mandated evacuations were often ignored during wildfires in 2016. To address this resistance, one opportunity is to provide safe and pleasant places for sheltering. For example, there are some attractive City libraries that could be made available as temporary shelters, so people are more amenable to temporarily leaving their homes.

Accessible Medical Services

The experience with Superstorm Sandy in New York City showed that the needs of people on kidney dialysis were often unknown to neighbors, and those residents were not helped when dialysis centers were closed. There is a need to identify medical services that are typically delivered outside of hospitals — e.g., methadone treatment, chemotherapy, medical oxygen — that need to be prepared and resilient[4].

Effective Communication

Effective communication is a key element for a resilient community, as described in the following examples:

Figure A.1. City of Portland, Oregon, offers an educational program called Planning for Resilience and Emergency Preparedness (PREP). (Source: http://www.preporegon.org)

4 https://www.cdc.gov/Pcd/issues/2020/19_0430.htm

Community Resiliency Centers, Berkeley, California

Building upon a series of successful block parties promoting climate preparedness, Berkeley, California, in partnership with key stakeholders, established a network of Community Resiliency Centers where City staff work with local institutional leaders to identify populations at risk. These teams carry out resiliency research, education, and programming and pre-position emergency equipment and supplies in anticipation of disaster events.

Evacuteer Program, New Orleans, Louisiana

The City of New Orleans partnered with Evacuteer, a local non-profit that recruits, trains, and manages evacuation volunteers who assist New Orleans' emergency response services (Figure A.2). This helps in getting vulnerable individuals and families to safety in the event of a major climate-related disaster. This partnership between the non-profit and the City was tested during Hurricane Gustav in 2008 and is credited with helping move more than 18,000 vulnerable New Orleanians out of harm's way.

PREPHub model by the MIT Urban Risk Lab, Cambridge, Massachusetts

Personal electronic devices also could remain in operation with access to off-grid charging stations (Figure A.3). These could be installed in public spaces to provide post-emergency services to citizens. An example in Cambridge is the PREPHub model developed by the MIT Urban Risk Lab, a disaster readiness structure where a pedaled generator enables people to recharge batteries and cellphones. An embedded webcam will let people take "selfies" and send those snapshots to relatives and social services as evidence they are safe; and an announcement system can alert people to dangers or direct them to a shelter[5].

Figure A.2. City of New Orleans Evacuteer Program. (Source: http://www.evacuteer.org/, New Orleans)

Figure A.3. PREPHub model in Cambridge, MA. (Source: MIT Urban Risk Lab)

5 http://prephub.org/

RELEVANCE TO CAMBRIDGE

Table A.1 provides a summary of how the best practices inform the development of specific strategies for Closer Neighborhoods.

Table A.1 List of Strategies and Related Best Practices

Strategy	Title	Related Best Practice	Description
A1	**Provide Neighborhood Resilience Hubs**	Network of Community Resiliency Centers, Berkeley, California	A network of Community Resiliency Centers where City staff work with local institutional leaders to identify populations at risk and carry out resiliency research, education, and programming. Hubs store emergency equipment and supplies in anticipation of likely disasters.
A2	**Enhance Resilient Public Amenities**	Goal Zero with AT&T, New York City, New York	Street Charge modules equipped with three 15-watt monocrystalline solar panels charge their internal batteries using energy from the sun. Commuters on the go can walk up to a Street Charge station, plug in their phones, tablets or other small electronics and charge them just like they would at home.
A3	**Create Support Systems For Populations At Risk**	Planning for Resilience and Emergency Preparedness (PREP), City of Portland, Oregon	An ambitious and popular disaster preparedness and climate resiliency education program offering courses on stormwater and heat management strategies, real-time disaster survival, and management and recovery scenarios.
A4	**Strengthen Emergency Communication Systems**	PREPHub model by the MIT Urban Risk Lab, Cambridge, Massachusetts	Small structures can be installed in public spaces where a pedaled generator allows people to recharge batteries or cellphones to provide post-emergency communications to citizens during disasters. An embedded webcam lets people take "selfies" and send those snapshots to relatives and social services as evidence they are safe.

Table A.1 List of Strategies and Related Best Practices (continued)			
Strategy	**Title**	**Related Best Practice**	**Description**
A5	**Support Business and Organizational Preparedness**	Business Continuity Plan, Ready.gov	When business is disrupted, it can cost money. Lost revenues plus extra expenses imply reduced profits. Insurance does not cover all costs and cannot replace customers that defect to the competition. A business continuity plan to continue business is essential.
A6	**Protect Community Resource Buildings**	Refer to Table B.2 in section B: Better Buildings	Refer to best practices for strategies B1, B2, B3 and B4 for implementing flooding and heat resiliency for existing and new development to ensure operational continuity during extreme events.
A7	**Enhance Emergency Response Plans**	Evacuteer Program, New Orleans, Louisiana	A partnership between municipal government and a local non-profit that recruits, trains, and manages evacuation volunteers who assist the City's emergency response services.
A8	**Provide For Healthcare Continuity and Access**	Guidance from the Centers for Disease Control's Building Resilience Against Climate Effects (BRACE) framework	The City's Human Services and Cambridge Health Alliance to develop guidance with key stakeholders and adapt it for the City's healthcare providers and populations.
A9	**Encourage Stronger Social Network**	As informed by strategies above	Use the City's existing initiatives to enhance measures for addressing climate change.
A10	**Continue Climate Education**	Climate Forward Ambassador Program, Somerville, Massachusetts	The Somerville Office of Sustainability and Environment's (OSE) Climate Forward Ambassador program was designed to educate a diverse group of Somerville residents about climate change. The goal is to increase the Somerville community's capacity to engage in climate action.

Table A.1 List of Strategies and Related Best Practices (continued)			
Strategy	**Title**	**Related Best Practice**	**Description**
A11	**Support Renter Preparedness**	Community Resilience Toolkit, HUD	The U.S. Department of Housing and Urban Development (HUD) Resilience Toolkit (Toolkit) was designed to assist communities in enhancing their resilience to climate-related natural hazards and risks.

KEY CONSIDERATIONS

Impact:

- Resilience hubs' effectiveness can be measured by the number of individuals that these proposed hubs will be able to serve annually and by the number of Cambridge-based public agencies, non-profit organizations, housing developers and management, and business organizations that have prepared and regularly updated their own disaster preparedness, management, and recovery plans in coordination with the Local Emergency Planning Committee's (LEPC) new hubs.
- Resilient public amenities would lower the probable mortality risk associated with extreme heat and the demand on EMS and healthcare system (EMS call volume and ambulance transports increase dramatically with temperature increase). The City estimates an additional one to two transports per month in Cambridge per 1-degree increase[6]. This could improve conditions and access for athletes, bikers, and commuters.
- The City will work with utility providers to set up an emergency plan and to secure the distribution of the telecommunications system. This will have an important safety impact during emergencies, assuring communication between populations in need and first responders. In the recovery phase, a resilient telecommunication network is critical to assure business continuity. Providing personal-device charging stations completely off-grid is also an important safety measure.
- Disaster preparedness and climate resiliency planning means that an increasing number of Cambridge-based public agencies, non-profit organizations, housing developers and management, and business organizations have prepared and are regularly updating their own disaster preparedness, management, and recovery plans.
- A disaster simulation exercise will help prepare Cambridge-based public agencies, non-profit organizations, housing developers and management, and business organizations. The bi/tri-annual disaster simulation training exercise should be organized by local, State, and federal disaster management agencies.
- Business continuity will be measured by calculated cost of lost productivity per extreme event.

6 The numbers were calculated based on a study published by Li, T., R.M. Horton, D.A. Bader, G. Huang, Q. Sun, and P.L. Kinney, 2015: Heat-related mortality projections for cardiovascular and respiratory disease under the changing climate in Beijing, China. Sci. Rep., 5, 11441, doi:10.1038/srep11441;

Cost:

- The hubs can be located in buildings owned by the City or managed by LEPC partners. The LEPC will engage volunteers in the education and training activities to keep costs at a minimum.
- The cost of resilient public amenities would be minimal if using existing facilities that already have air-conditioning. There might be an economic benefit to extending hours at shopping malls and movie theaters during heat waves. At the same time, operational costs should be considered. Cost could be a factor in implementing new public amenities, such as misters and water trailers.
- Cost for creating a risk management plan for businesses and securing telecommunication assets is assumed to be marginal if integrated with operational and capital-improvement costs. The public emergency hubs are likely to be more expensive as this is a specific cost to its proponent or the entity who will install it.

Equity:

- The Resilience Hubs are expected to serve as a resource for residents at risk. Indicators of sensitivity may include an individual's age, whether they are living in poverty, whether they have a disability or chronic illness, and whether they have secure housing.
- Resiliency hubs need to be places that are not associated with a person's circumstances and do not give off a negative connotation. For example, the use of the word "shelter" adds to a possible stigma. The resiliency hubs also must be able to accommodate pets, as people reluctant to leave pets are often part of populations at risk.
- Resiliency strategies will have a positive impact on improving access to services for neighborhoods with high percentages of residents who experience housing insecurity, difficulty in paying monthly housing payments, and homelessness. The focus will be on providing support to the populations most at risk.
- Emergency phones and emergency charging stations in public areas need to be readily available to provide access to all.
- An effective emergency response is more likely to benefit populations at risk that are more likely to rely on the City's services (e.g., those without access to transportation, individuals lacking a social safety net).

Wellness:

- Access to water and air-conditioning could decrease morbidity and death, resulting in fewer hospitalization and emergency services during heat waves.
- Ensuring ease of operations of first responders and community services to populations at risk during extreme events and climate change stress is a key component of a comprehensive public health plan.

Feasible:

- Building owners could be incentivized to offer their spaces as resilience hubs, which could be used during extreme weather events. Contracts and agreements should be negotiated well in advance.
- Movie nights, extended hours at shopping malls, or community events at cooling and warming centers can help entice people to these spaces during extreme weather events.

Co-Benefits:

- The hubs will integrate and coordinate community preparation for events associated with climate change into the existing emergency planning activities of the LEPC. The hubs could partner with the Cambridge Mayor’s Summer Youth Employment Program to provide opportunities for youth to work with city agencies (e.g., Public Health, CDD) to develop and pilot educational outreach programming.

- The City could collaborate with the Teen Media Services program to develop public-service announcements to spread the reach of climate change messaging and promote cooling centers.
- Strategies could align with the U.S. Mayors Climate Protection Agreement, Heat Plan, and Emergency Response plans.
- Solar panels should be used to power the backup system and energy should be stored for later use in emergency resilience hubs. This will consequently reduce some greenhouse gas impact for the City.

A1

Provide Neighborhood Resilience Hubs

Government agencies should work with neighborhood organizations to establish resilience hubs to foster community networks that operate on a regular basis, and increase preparedness and resilience among residents and businesses through education, training, planning, and implementation of resilience and sustainability measures.

TOOLBOX ACTIONS

1.1 Establish support hubs where local community leaders can obtain resources and meet with Emergency Management and Public Health Preparedness officials. These should be paired with services provided on a regular basis, such as centers providing health services or centers providing English classes to non-English speakers.

1.2 Coordinate the structure and engagement opportunities with existing LEPC. For example, form a climate change subcommittee with expanded membership that fully integrates preparation for climate change events.

1.3 Increase disaster behavioral response resources to ensure capacity exists for counseling and facilitation of public meetings.

Why is it Relevant to Cambridge?

Some residents in Cambridge are at a higher risk due to the increased probability, larger extent, and greater depths of flooding throughout the City. Most of Cambridge will experience Urban Heat Island effect due to limited vegetation and urbanization patterns.

Cambridge is fortunate to have a rich network of civic-minded organizations engaged with first responders through LEPC to support the City in disaster preparedness, management, and recovery activities.

Stewards of implementation could include Cambridge Public Health Department, Cambridge Community Development Department, Cambridge High Schools, multi-service centers, libraries, community health centers, literacy programs, other community resources, and the Cambridge Community Response Network. Identified stewards should develop protocols and procedures to address the full range of possible climate-related disasters they are likely to confront soon. The resilience hub should be established in the near future and be used on a regular basis to create a habit for its use.

Actions Already Being Taken

- The City has been informing residents and leaders of local institutions about the general climate-related risks they may face through the Climate Change Vulnerability Assessment.

- The City has been hiring consultants to conduct interviews and inspect buildings to assess vulnerability and risk.
- The Cambridge Public Health Department interacts with residents in populations at risk through their everyday programming, partnership with community service providers, and citywide events (e.g., Public Health Preparedness and Community Resilience Program, Healthy Homes Program, Pathways Program for new immigrant families, literacy program, Men's Health program and Men of Color Health Initiative, Injury and Violence Prevention Program, door-knocking campaigns, Substance Abuse Prevention Program, Supplemental Nutrition Assistance Program promotion, Hoops 'N' Health event, school health program, membership in the Cambridge Community Response Network, and seasonal flu clinics.)
- Cambridge has an existing structure for Emergency Management and Public Health Emergency Preparedness that engages in "disaster preparedness, management, and recovery activities." The primary mechanism for organizational engagement is through the LEPC. Many larger businesses who participate in the LEPC have Continuity of Operations Plans (COOP) that apply to all hazard preparedness, including power outages, winter storms, flooding, and hurricanes.
- The City funded two sites (Margaret Fuller House and the Cambridge Library) in the Port neighborhood to assess their resiliency and initiate plans for climate-related resident resiliency support.

QUESTION:
In your opinion, what steps could the City of Cambridge take to better support you and your neighbors in the event of a future climate-related disaster?

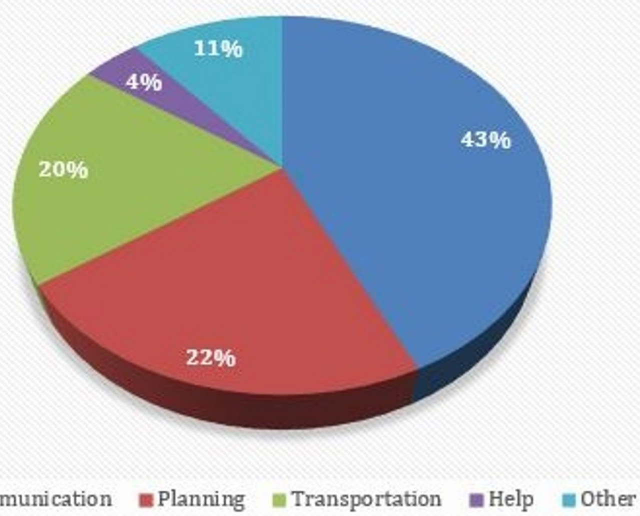

Figure A.4. Graph from interviews section in Appendix C: "Local Perceptions of Disaster Preparedness in the Alewife District of Cambridge, MA," January 23, 2017. Report by the MS in Urban Planning Program and Urban Harbors Institute, University of Massachusetts Boston.

A1 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**Cambridge Public Health Department, Cambridge Community Development Department, Cambridge Health Alliance, multi-service centers, libraries, community health centers, literacy programs, other community resources, Cambridge Community Response Network**
Jurisdiction Who monitors the implementation?	☑ **City** ☐ **State** ☐ **Regional**
Type of Implementation How is the strategy categorized for the implementation type?	☑ **Pilot/Project/Study** ☐ **Policy/Regulations** ☑ **Program**
Scale What is the scale of the intervention?	☐ **Parcel** ☑ **Neighborhood** ☐ **Citywide** ☐ **Regional**
Related Strategies	**A4: Strengthen Emergency Communications Systems** **A9: Encourage Stronger Social Network** **A10: Continue Climate Education**

A 2

Enhance Resilient Public Amenities

The City should work with private companies to provide for resilient public amenities at major squares such as Harvard, Central, Porter, and Kendall.

TOOLBOX ACTIONS

2.1 Install water trailer program in partnership with Cambridge Water Department. Move the trailer around during heat waves to locations with populations at risk, such as youth, seasonal workers, seniors, or those experiencing homelessness.

2.2 Introduce "emergency kiosks" at the major squares: Porter, Harvard, Central, and Kendall. Emergency kiosks are modeled after the PREPHub by MIT Urban Risk Lab and include charging stations, emergency call buttons, water, lighting, and other amenities.

2.3 Initiate a City program to host indoor, air-conditioned events during heat waves, or provide subsidized vouchers to the movies and other cooling venues.

2.4 Expand the Cambridge "warming center" for the homeless population to also include "cooling center" hours.

2.5 Prepare public transportation stops for climate change impacts. Adaptation might include shade structures for all bus stops and warming lamps. At train stops, adaptation might include an emergency heat strategy.

Why is it Relevant to Cambridge?

The number of days over 90 degrees Fahrenheit is projected to nearly triple by 2030, from an average of 11 days a year presently to about 31 days (about one month) a year. This means there will be more heat waves (three days in a row over 90 degrees) and that longer heat waves will occur.

Urban areas like Cambridge will see heat vulnerability exacerbated because of the “urban heat island effect,” which is caused by the dense buildings and pavement that absorb heat.

Presently, hot days pose limited risks to human health because days over 90 degrees do not occur often, and long heat waves are unusual. People with chronic respiratory and heart problems are more vulnerable to the effects of heat. As heat waves occur more frequently, we will enter temperature ranges on the hottest days that are dangerous to public health. Heat waves contribute to a rapid deterioration of air quality and increased physiological stress, so the effects on the health of at-risk residents are likely to get worse each day a heat wave persists.

Actions Already Being Taken

- The City is providing extended pool hours during heat waves.
- Citywide Senior Center is a cooling center that could be further extended to be a resilience hub.
- Mass care/shelter operations in Cambridge have typically included the Fire Department, Cambridge Public Health Department, Region 4AB Medical Reserve Corps and American Red Cross, which open the shelters, staff them, track inventory and entry, provide medical triage and referral, and arrange for food provision and sanitation management.

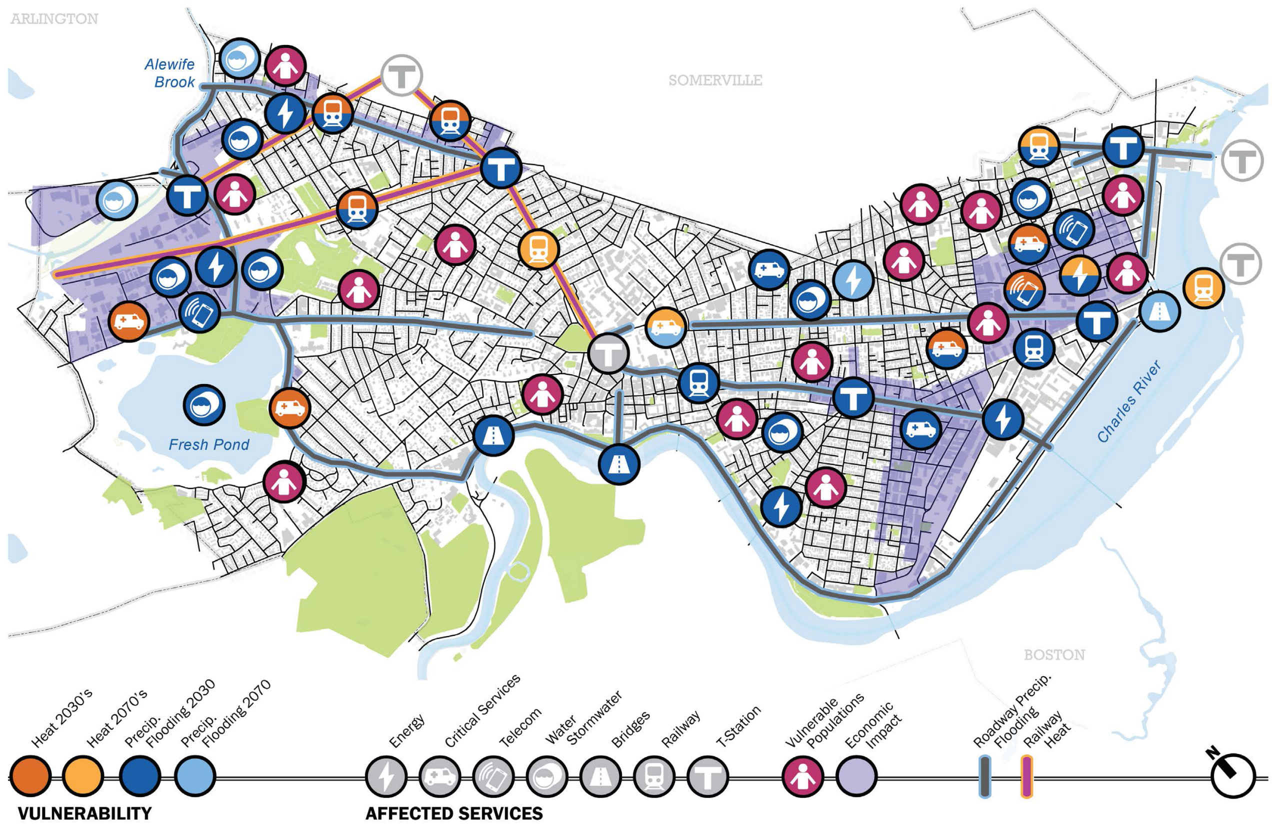

Figure A.5. Key physical and social vulnerabilities to projected climate change impacts. (Source: Kleinfelder, April 2017).

A2 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**Cambridge Water Department, MBTA, Cambridge Community Development Department, Parks and Recreation, Department of Human Service Programs/ Continuum of Care**
Jurisdiction Who monitors the implementation?	☑ **City** ☐ **State** ☐ **Regional**
Type of Implementation How is the strategy categorized for the implementation type?	☑ **Pilot/Project/Study** ☐ **Policy/Regulations** ☐ **Program**
Scale What is the scale of the intervention?	☐ **Parcel** ☐ **Neighborhood** ☑ **Citywide** ☐ **Regional**
Related Strategies	**A3: Create Support Systems For Populations At Risk** **A4: Strengthen Emergency Communications Systems** **A6: Protect Community Resource Buildings** **A7: Enhance Emergency Response Plans**

A 3 Create Support Systems for Populations At Risk

The City could develop a program to pre-identify and support individuals who are more vulnerable due to health conditions, addiction, homelessness, or social isolation, and develop community support and emergency response systems to ensure their safety and well-being.

TOOLBOX ACTIONS

3.1 Identify and reach out to populations at risk — including homeless population and people with addiction or mental health issues — and their leaders to validate/select preparedness, communications, and resiliency-building strategies that work for their communities. Ensure that high-risk employee groups (e.g., construction, day laborers) are included when considering populations at risk.

3.2 Educate populations at risk, employers, healthcare providers, and in-home caregivers of medically vulnerable populations on heat and flooding risk and recognizing danger signs. For example, consider implementing action plans, such as a Heat-Health Action Plan (HHAP), with a focus on educating medical providers and developing recommendations for patient care.

3.3 Schedule home visits/assessments for vulnerable residents (e.g., older adults) during heat emergencies or after flooding events.

3.4 Develop a database of facilities and locations with concentrations of at-risk individuals to assist with response prioritization.

Why is it Relevant to Cambridge?

Cambridge is home to large numbers of people who may be most at risk for impacts from climate-driven emergencies. For example, the City knows that people who are older, in financial stress, or have limited English are up to four times more likely to experience negative physical or mental health impacts from flooding disasters[7]. Indicators of sensitivity may include an individual's age, whether they are living in poverty, whether they have a disability or chronic illness, and whether they have secure housing. Identifying these populations at risk and anticipating their risks and needs due to climate-driven disasters can have a significant positive impact.

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7 Lowe D, Ebi KL, Forsberg B. Factors Increasing Vulnerability to Health Effects before, during and after Floods. International Journal of Environmental Research and Public Health. 2013;10(12):7015-7067. doi:10.3390/ijerph10127015.

Actions Already Being Taken

- The Cambridge Public Health Department (CPHD) provides resiliency services for homeless persons, including those with substance-use disorders.
- The Department of Human Service Programs operates a Multi-Service Center that in turn provides direct services, planning, and coordination for people who are living on the street and in emergency shelters.
- Emergency personnel are trained in services for substance users.
- The Continuum of Care is a network of service providers who already share pertinent information regarding this at-risk population.

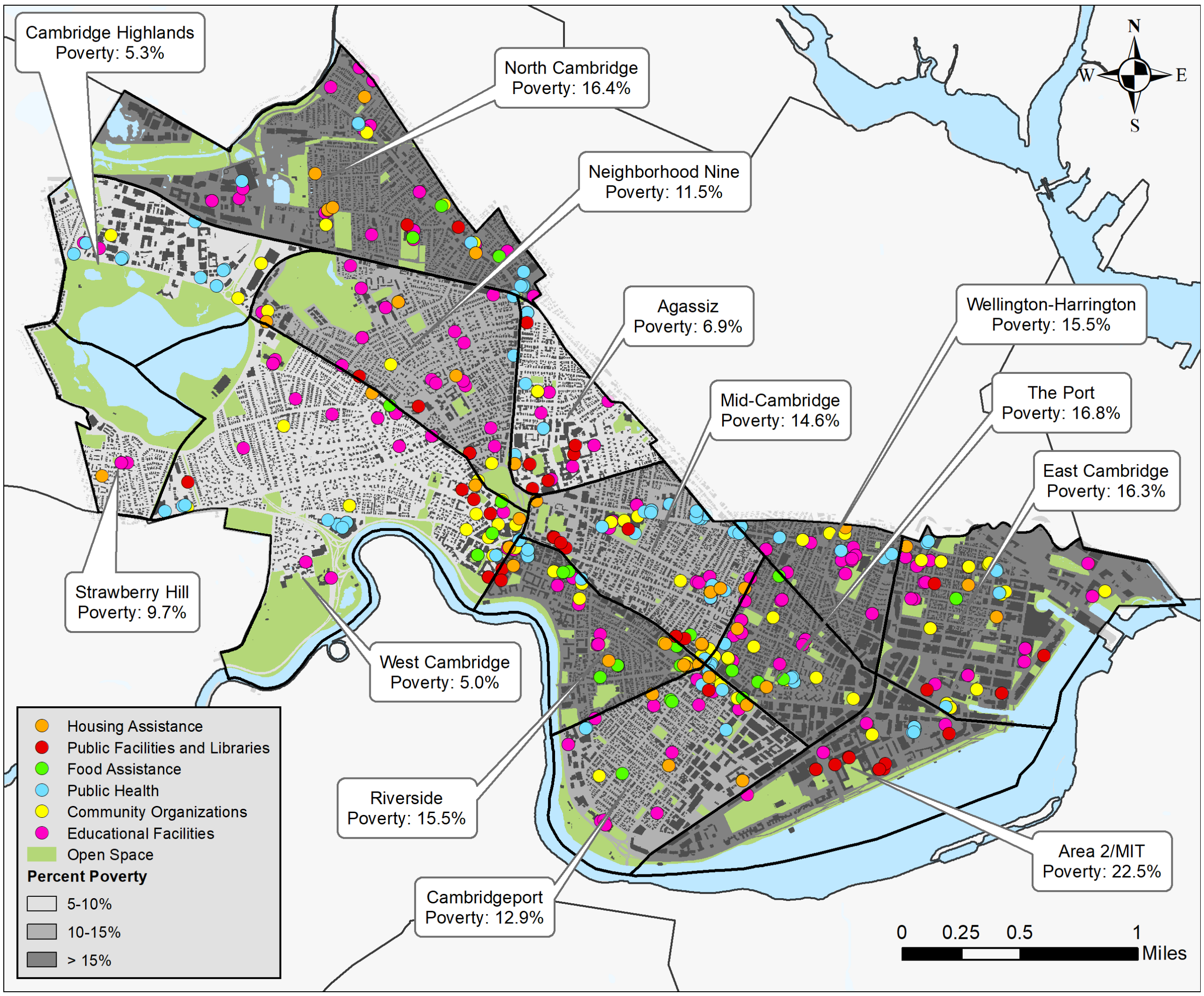

Figure A.6. The citywide map shows that MIT/Area 2, The Port, East Cambridge, Riverside, Wellington-Harrington, and North Cambridge have the highest percentages of residents who are below the poverty line. These neighborhoods have several public housing projects, community-based organizations, and public health facilities, which positively support these residents.

A3 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**Department of Human Service Programs, Continuum of Care, Cambridge And Somerville Programs for Addiction Recovery (CASPAR), Cambridge Health Alliance/ Cambridge Public Health Department**
Jurisdiction Who monitors the implementation?	☑ **City** ☐ **State** ☐ **Regional**
Type of Implementation How is the strategy categorized for the implementation type?	☐ **Pilot/Project/Study** ☐ **Policy/Regulations** ☑ **Program**
Scale What is the scale of the intervention?	☐ **Parcel** ☑ **Neighborhood** ☐ **Citywide** ☐ **Regional**
Related Strategies	**A1: Provide Neighborhood Resilience Hubs** **A7: Enhance Emergency Response Plans** **A8: Provide For Healthcare Continuity and Access** **A9: Encourage Stronger Social Network**

A4 Strengthen Emergency Communication Systems

The City should develop a neighborhood-scale communication system that serves as a backup for normal communication systems when there are telephone, cellular, or internet service outages.

TOOLBOX ACTIONS

4.1 Update and strengthen the City of Cambridge's existing Heat Emergency Guide, potentially incorporating health surveillance data into early activation triggers.

4.2 Partner with leaders respected by at-risk populations via community resource organizations, such as faith communities and schools or other organizations that focus on high-risk individuals. This partnership could build opportunities to meet community information needs for preparedness and engagement in emergency notifications.

4.3 Introduce a new neighborhood check-in system involving block captains. A "phone tree" could use WhatsApp, or a similar platform, which is friendly to international users and relies on WiFi rather than cellular data to avoid monetary charges. A survey could be issued to determine whether a resident would like to enroll in the phone tree and if they have a "language-need" request; if the latter applies, they would be partnered with someone of their same first language.

4.4 Introduce a "buddy system" for senior residents and residents living alone. Police and case manager check-ins for populations at risk, including the homeless, could be encouraged. Meet-ups could be facilitated to introduce the "buddies" to one another; this also helps address everyday social isolation. The resident can elect to be part of a "buddy circle" if it is more preferable to them than one-on-one interactions.

4.5 Track and expand the City-led emergency notification text service.

4.6 Include training and resources to assess symptoms of those in distress and arrange for transport and care.

Why is it Relevant to Cambridge?

Telecommunication networks are instrumental for information exchange and serve as crisis communication networks during disasters. Local government and first responders were alerted to the criticality of wireless phone and data networks for disaster recovery during Hurricane Sandy in New York

City, when emergency services provision depended on the relay of information to responders for health, public safety, and support of populations at risk.

As part of the CCVA, the most at-risk infrastructure component identified was the telecommunication data hub in the Quadrangle (the area north of Fresh Pond Reservation between the Shopping Center and Cambridge Highlands, which is bounded by Concord Avenue to the south and the railroad tracks to the north). Protecting all infrastructure components is a safety priority and, in the recovery phase, key for business continuity. The priority for short- to medium-term actions is to protect the telecommunications system from flooding by elevating it, and to create an emergency communication system that can provide backup if the normal communications system fails during outages of telephone, cellular, or internet services.

Actions Already Being Taken

- As part of CCVA, the City engages telecommunication companies to join a Technical Advisory Group to learn about climate change and advise the City on how to best provide for resilient infrastructure.
- The City is installing Soofa benches in public spaces. A Soofa bench (developed by Changing Environments, an MIT Media Lab spin-off) is a solar-powered bench that can charge up to two electronic devices at a time. They are currently installed in Danehy Park and around Fresh Pond in the Alewife neighborhood.

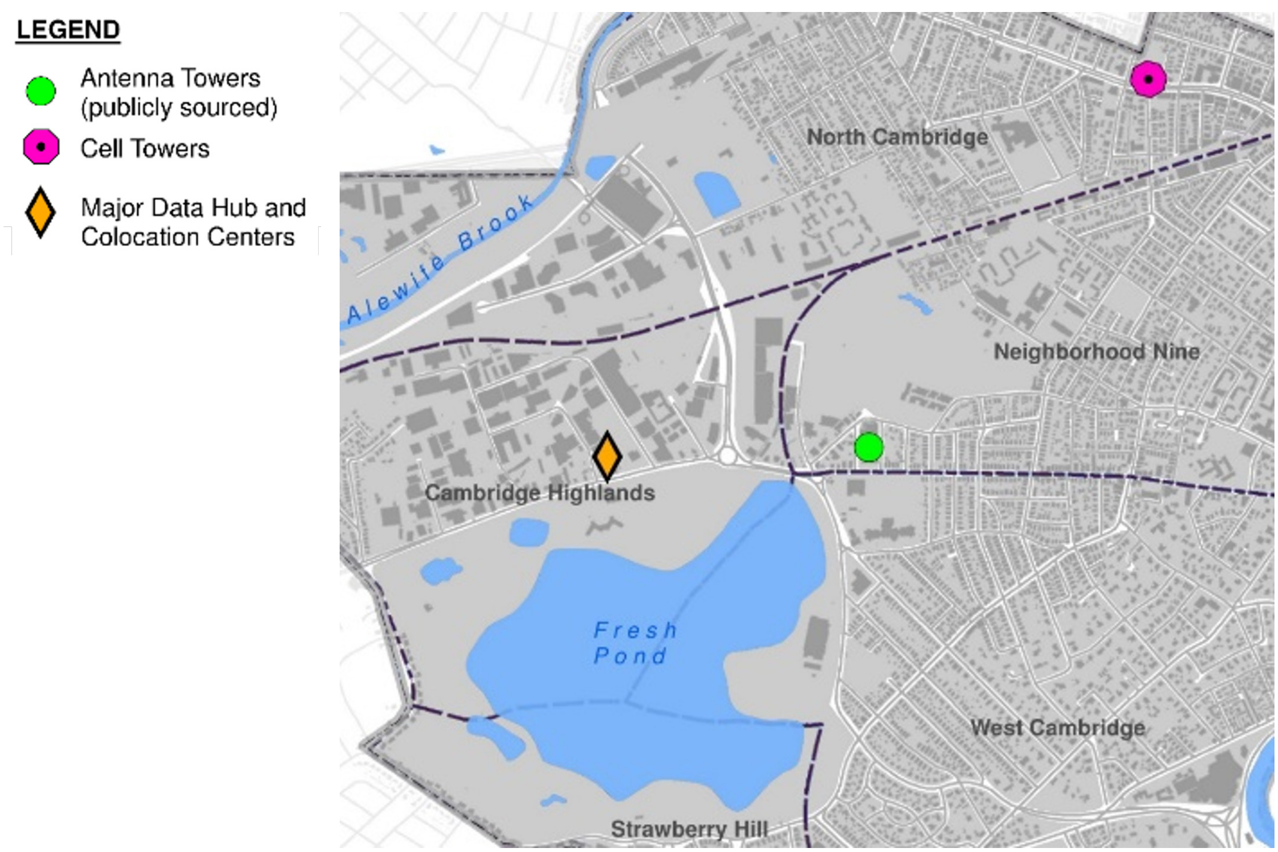

Figure A.7. CCVA Part 1, Telecommunication Infrastructure in Alewife. (Source: Kleinfelder, November 2015)

A4 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**Cambridge Water Department, MBTA, Cambridge Community Development Department, Parks and Recreation, Department of Human Service Programs/ Continuum of Care**
Jurisdiction Who monitors the implementation?	☑ **City** ☐ **State** ☐ **Regional**
Type of Implementation How is the strategy categorized for the implementation type?	☐ **Pilot/Project/Study** ☐ **Policy/Regulations** ☑ **Program**
Scale What is the scale of the intervention?	☐ **Parcel** ☐ **Neighborhood** ☑ **Citywide** ☐ **Regional**
Related Strategies	**A2: Enhance Resilient Public Amenities** **C2: Encourage the Resiliency of the Electrical Distribution System** **C8: Support a Resilient Telecommunication Network**

A
5

Support Business and Organizational Preparedness

The City should help businesses with business and organizational continuity planning and preparedness, including support services such as daycare.

TOOLBOX ACTIONS

5.1 Help companies, institutions, and business associations prepare and regularly update a disaster preparedness, management, and recovery plan.

5.2 Provide a forum for companies, institutions, and business associations to participate in a bi/tri-annual disaster simulation training exercise organized by local, state, and federal disaster management agencies.

5.3 Facilitate contingency plans for all City employees to adjust to extreme events and "new normal." This will help ensure business continuity and avoid loss of employment due to climate change stresses.

5.4 Ensure resilient infrastructure supports business continuity including resilient transportation systems for accessibility (refer to C3).

Why is it Relevant to Cambridge?

One of the CCVA key findings was that roughly $16.1 million per day and as much as 25% of U.S. annual GDP could be affected by extreme precipitation or extended heat waves[8]. This is based on the highest estimated impact that as many as 30,000 jobs or nearly one-quarter of the City's 2012-level employment could be disrupted. Preserving business continuity in the City is critical for neighborhoods and the City.

Another key aspect critical for continuity of business operations is continuity in providing support services, such as daycare, to allow workers from at-risk populations to maintain their employment with minimal disruption.

The Community Development Department with the Metropolitan Area Planning Council developed small-business continuity guidelines that document measures and available resources for preparedness during extreme events[9].

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8 CCVA economic analysis http://www.cambridgema.gov/cdd/projects/climate/~/media/8A81573575EB440BA0DBE9421B6AB1B1.ashx

9 www.cambridgema.gov/CDD/econdev/resourcesforbusinesses/smallbusiness/emergencypreparednessforbusinesses

Actions Already Being Taken

- The City has developed Small- and Large-Business Toolkits to help companies prepare for and recover from extreme weather events.
- The City offers post-flood inspection services, which include best practices on how to sanitize, and which food and goods to discard/keep (source: Cambridge Inspectional Services Department).
- The City's post-flood inspection services offer continuity of operations for laboratories after a flood (source: Cambridge Inspectional Services Department).

Figure A.8. The City of Cambridge's business toolkits for extreme weather events. (Source: City of Cambridge Resiliency Toolkits, funded by an MVP Grant, 2019)

A5 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**Small businesses, large businesses, Community Development Department**
Jurisdiction Who monitors the implementation?	☑ **City** ☐ **State** ☐ **Regional**
Type of Implementation How is the strategy categorized for the implementation type?	☑ **Pilot/Project/Study** ☑ **Policy/Regulations** ☐ **Program**
Scale What is the scale of the intervention?	☑ **Parcel** ☐ **Neighborhood** ☐ **Citywide** ☐ **Regional**
Related Strategies	**A1: Provide Neighborhood Resilience Hubs** **B1: Regulate Flood Protection For New Buildings** **B2: Regulate Heat Protection For New Buildings** **B3: Encourage Flood Protection For Existing Buildings** **B4: Encourage Heat Protection For Existing Buildings**

A6 Protect Community Resource Buildings

The City should increase resilience of critical community facilities to climate shocks, prioritizing those with high vulnerabilities identified in the Cambridge CCVA.

TOOLBOX ACTIONS

6.1 Build/protect critical community facilities to the 2070 10-year-flood elevation from precipitation or sea level rise (SLR)/storm surge, whichever is higher. (Refer to strategies B1 and B3 outlining the toolbox/actions for protection.)

6.2 Design community facilities to recover to the 2070 100-year-flood elevation from precipitation or SLR/storm surge, whichever is higher. (Refer to strategies B1 and B3 outlining the toolbox/ actions for recovery.)

6.3 Provide for new and existing critical community facilities to be resilient to future heat risks identified for the neighborhood. (Refer to strategies B2 and B4 outlining the toolbox/action for heat resiliency.)

6.4 Maintain continuity of operations during extreme events and under "new normal," with a focus on making sure all employees have contingency plans both at work and at home. (Refer to A5.)

6.5 Maintain a resilient transportation and transit infrastructure to ensure mobility and evacuation routes during and after climate shocks and stresses. (Refer to C3.)

Why is it Relevant to Cambridge?

Buildings that house community resources most at risk to extreme weather events should consider adopting Better Buildings recommendations for preparedness to extreme events. Some resources are considered critical to the entire community. A list of those critical resource facilities is included in the Resilient Cambridge Better Buildings Technical Report.

Actions Already Being Taken

- The City offers post-flood inspectional services (source: Cambridge Inspectional Services Department).
- The Department of Public Works' municipal facilities improvement plan is addressing CCVA findings.

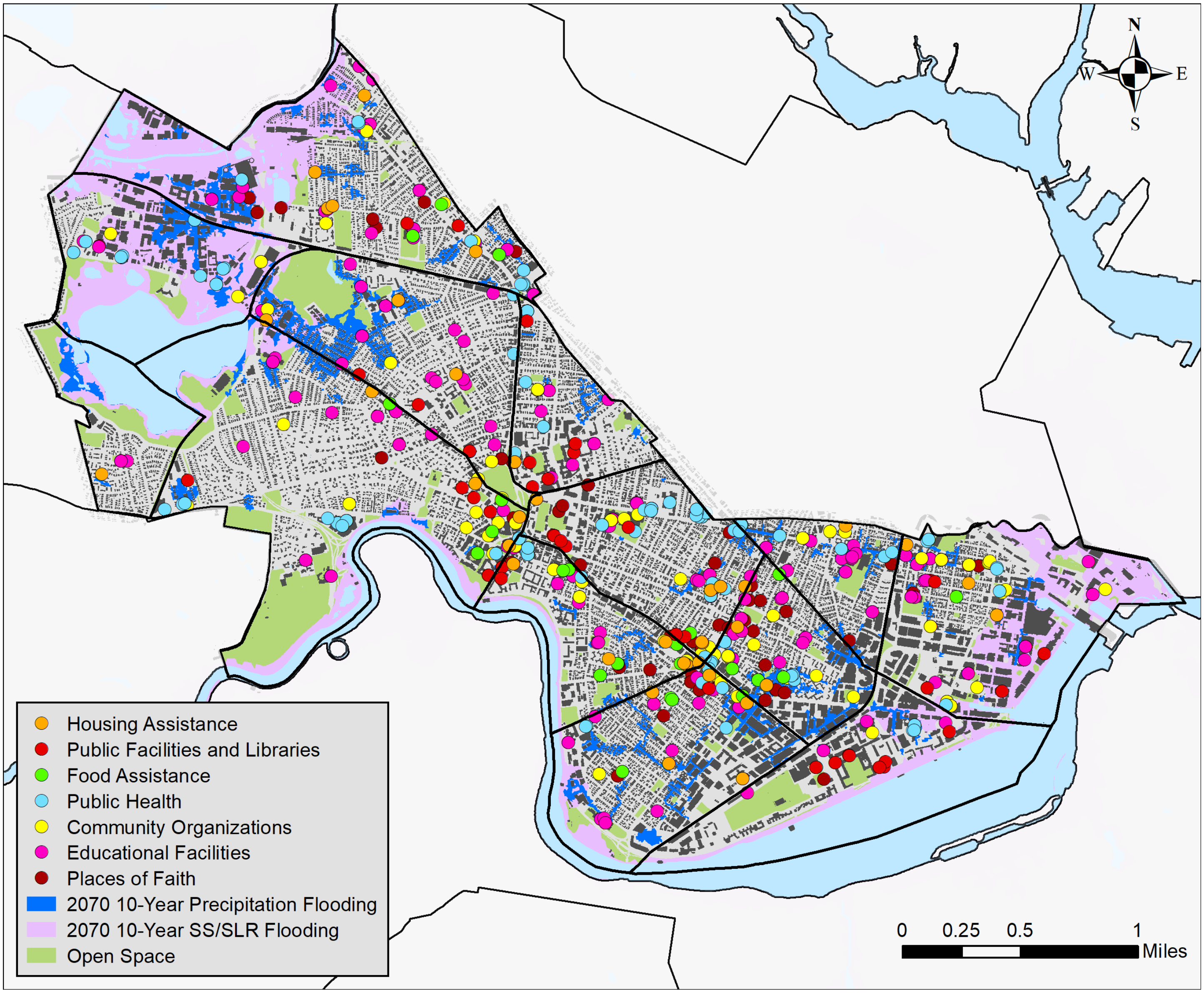


Figure A.9. Community resources at risk for 10% probability (10-year) 2070 flooding from both precipitation and sea level rise/ storm surge (SLR/SS) flooding.

A6 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**Affordable housing, public facilities, food supplies and assistance, public health facilities, community-based organizations, educational facilities, places of faith**
Jurisdiction Who monitors the implementation?	☑ **City** ☐ **State** ☐ **Regional**
Type of Implementation How is the strategy categorized for the implementation type?	☑ **Pilot/Project/Study** ☑ **Policy/Regulations** ☐ **Program**
Scale What is the scale of the intervention?	☑ **Parcel** ☐ **Neighborhood** ☐ **Citywide** ☐ **Regional**
Related Strategies	**A5: Support Business and Organizational Preparedness** **B1: Regulate Flood Protection For New Buildings** **B2: Regulate Heat Protection For New Buildings** **B3: Encourage Flood Protection For Existing Buildings** **B4: Encourage Heat Protection For Existing Buildings** **B5: Support Building Management For Flood and Heat Protection** **C3: Enhance the Resiliency of the Transportation System**

A7 Enhance Emergency Response Plans

Strengthen existing City emergency response plans to include the potential impacts of climate change, including strategies to enable sheltering in place and evacuation, when appropriate

TOOLBOX ACTIONS

7.1 Update and strengthen the City of Cambridge's existing Heat Emergency Response Guide to potentially include:

- Health surveillance data into activation triggers
- Automatic notification of partners triggered by heat index
- An increase in outreach to homeless individuals

7.2 Plan to address enhanced aggravation of health conditions specific to heat waves and flooding.

7.3 Provide public guidance on reducing risks from home-prepared food, including proper sanitizing techniques, guidance on spoilage, and common-sense information on when to discard food and other perishables.

7.4 Advise on damage to perishable goods, proper handling, and appropriate mold remediation practices.

7.5 Inspect establishments permitted to serve and sell food after flooding or loss of power.

7.6 Assess and advise on general hygiene, habitability, trash and rodent control, as well as hazardous building and utility conditions. If inspections find live electricity that could pose a hazard, request utility companies repair and restore service.

7.7 Provide a list of qualified contractors to remove water damage and restore laboratories to full operational status.

Why is it Relevant to Cambridge?

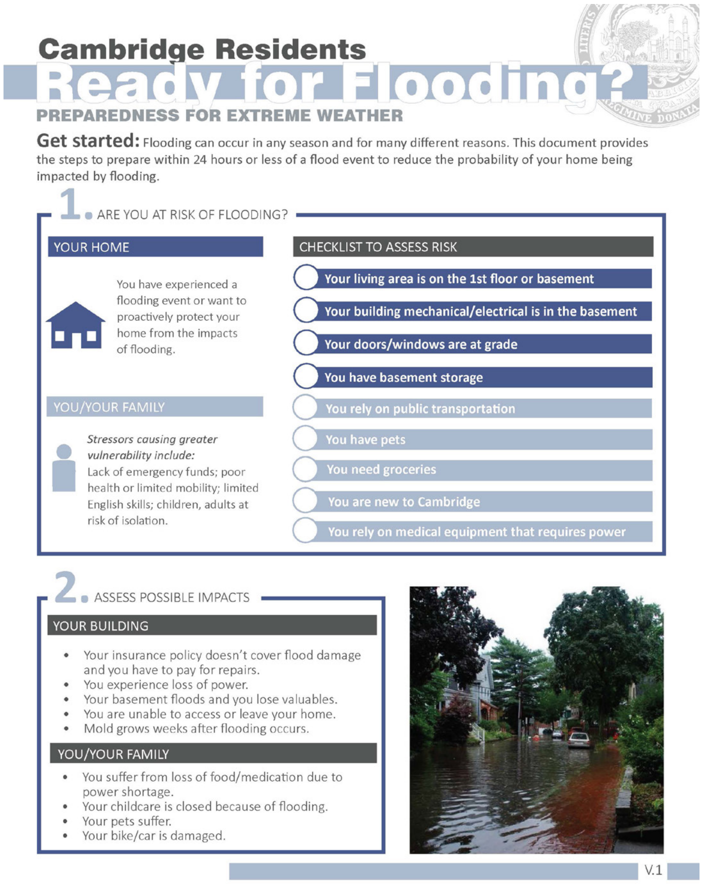
While Cambridge has already developed plans to respond to emergencies impacting the City, climate change will result in different and expanded challenges than the City has previously planned for, including increased regional flooding and extreme heat events.

Incorporating concerns regarding climate change into these existing plans will help ensure the City is ready for future emergencies and disasters.

Assuring continuity of services and access to these key services during extreme events and "new normal" is a key component for the City's overall resiliency.

Actions Already Being Taken

- The City has strong, regionally coordinated emergency preparedness plans, leadership, and staffing. It has projected vulnerabilities through the Cambridge CCVA.



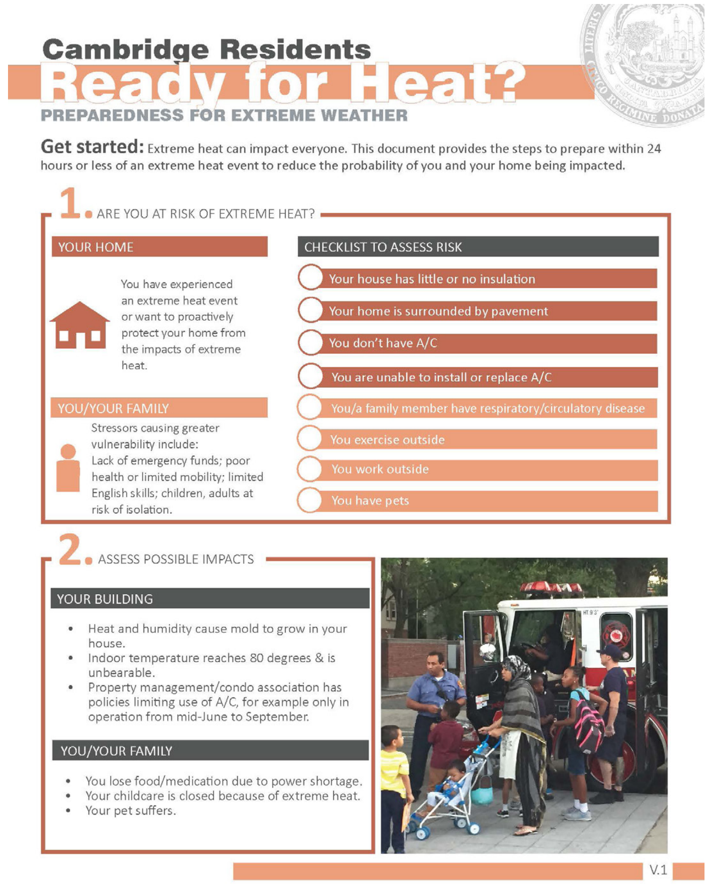


Figure A.10. The City of Cambridge's resident toolkits for extreme weather events. (Source: City of Cambridge Resiliency Toolkits, funded by an MVP Grant, 2019)

A7 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**Emergency Response Services, Department of Human Service Programs, Public Health Department**
Jurisdiction Who monitors the implementation?	☑ **City** ☐ **State** ☐ **Regional**
Type of Implementation How is the strategy categorized for the implementation type?	☐ **Pilot/Project/Study** ☑ **Policy/Regulations** ☑ **Program**
Scale What is the scale of the intervention?	☐ **Parcel** ☐ **Neighborhood** ☑ **Citywide** ☐ **Regional**
Related Strategies	**A2: Enhance Resilient Public Amenities** **A4: Strengthen Emergency Communication Systems**

A 8 Provide For Healthcare Continuity and Access

The City should work locally with key healthcare service providers and with the regional health and medical coalition to ensure capacity, continuity, and access to medical services.

TOOLBOX ACTIONS

8.1 Increase resident awareness and enrollment in the Cambridge Code Red emergency notification system.

8.2 Increase knowledge of the healthcare workforce and allied professionals who conduct home visits, or are home care staff, to help identify vulnerabilities and educate patients on risks. Heat-Health Action Plans should focus on educating providers and developing recommendations for patient care. Healthcare workers should educate patients on health risks, work with their patients to develop prevention tactics, and educate their patients on when to seek help during a heat emergency.

8.3 Work with healthcare service providers (specifically for seniors and individuals with disabilities) to establish closer relationships (such as Community Health Worker programs) and agree to share information on current patients in the event they may be impacted by an emergency (storm, flooding, heat). Support development of contingency plans by families if primary caretaker cannot get to individual at the time of the emergency event.

8.4 Work with pharmacies to ensure continuity of services and integrate them into the emergency response structure. Identify early triggers for emergency medication access to go into effect and a corresponding alert to residents.

8.5 Work with healthcare partners, including long-term care facilities and the MA Region 4AB Health and Medical Coordinating Coalition, to strengthen emergency response and evacuation plans and ensure continuity of operations during a widespread, regional event with staffing shortages.

8.6 Ensure agreements are in place between key organizations and providers, transportation services, etc. Identify means of healthcare and allied community resources to secure financial coverage for emergency response.

Why is it Relevant to Cambridge?

Like other cities in the Northeast, Cambridge is vulnerable to adverse health impacts of heat and flooding. Heat has been the largest single weather-related cause of death in the U.S. since NOAA began reporting data for heat in 1988. In addition, heat impacts on health are the most well understood, measurable, and yet preventable impacts of climate change. Healthcare workers should educate patients on heat-health risks and mold risks, work with their patients to develop prevention tactics, and educate their patients on when to seek help during a heat emergency and after flood damage.

It is also important to ensure that residents have continued access to medical care and that the services are comprehensive, including behavioral health and substance use, and can adequately manage higher demands and accessibility. Also critical is continuity in services for needed medications and medical supplies. Interruptions in medication and medical technologies can exacerbate underlying conditions and increase the risk of morbidity and mortality.

Actions Already Being Taken

- Healthcare and multi-stakeholder public health collaborations
- Heat Plan
- Emergency response planning

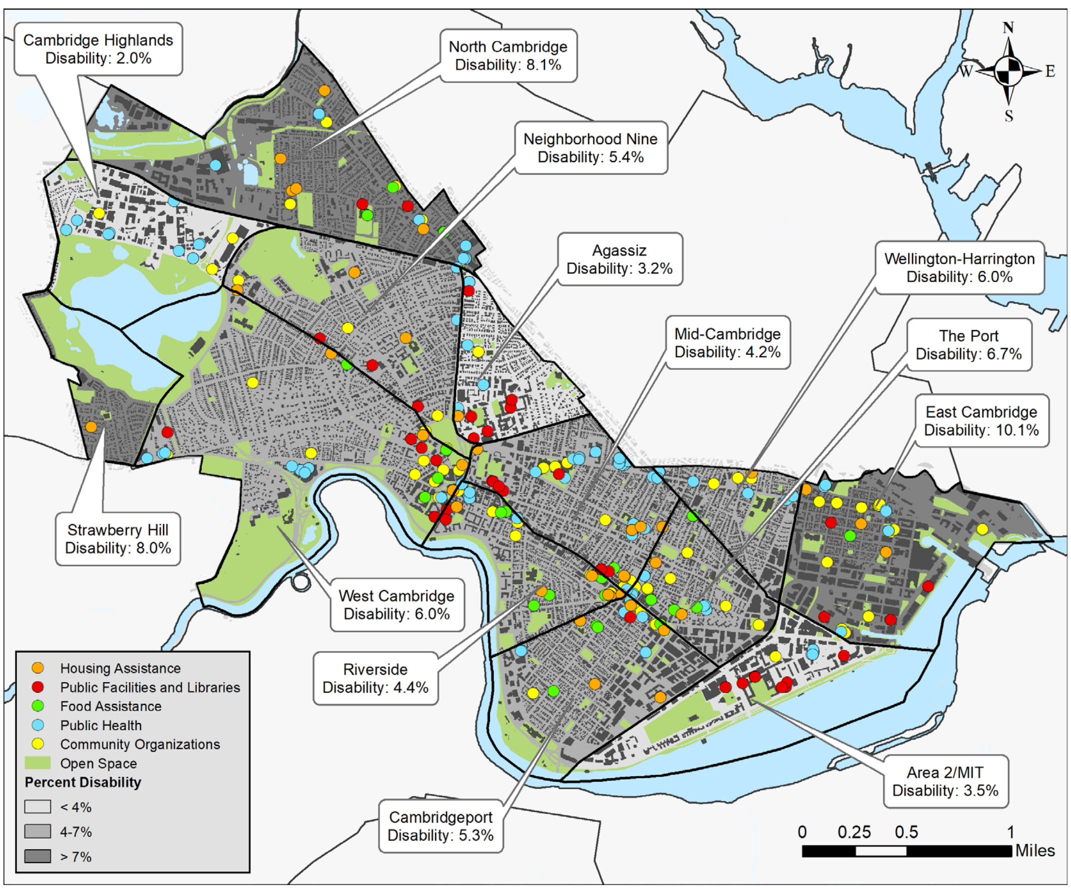


Figure A.11. East Cambridge, The Port, North Cambridge, and Strawberry Hill have the highest percentage of residents who identify as having a disability. Although individuals with a disability often do not report, making accurate representation difficult.

A8 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**Hospitals, pharmacies, Cambridge Health Department**
Jurisdiction Who monitors the implementation?	☑ **City** ☐ **State** ☐ **Regional**
Type of Implementation How is the strategy categorized for the implementation type?	☑ **Pilot/Project/Study** ☐ **Policy/Regulations** ☑ **Program**
Scale What is the scale of the intervention?	☐ **Parcel** ☑ **Neighborhood** ☐ **Citywide** ☐ **Regional**
Related Strategies	**A1: Provide Neighborhood Resilience Hubs**

A 9

Encourage Stronger Social Network

The City should develop a neighborhood resiliency social network in partnership with community leaders and organizations.

TOOLBOX ACTIONS

9.1 Identify and reach out to populations at risk directly and through informal community leaders, the faith community, and community service providers to validate/select preparedness, communications and resiliency-building strategies and systems that work for their communities. Ensure that homeless, students, and high-risk employee groups are included when considering populations at risk.

9.2 Design asset-based climate change engagement campaigns that:

- Address concerns among at-risk populations at (e.g., safety, comfortable heating and cooling, health disparities, job security).
- Build upon strengths and capacity of neighborhood residents, workers, students, workplaces, and community-based organization (e.g., social, faith-based, educational, advocacy).

9.3 Compile resource listings and design culturally and linguistically appropriate educational and outreach materials with tailored messages. Disseminate resources locally via neighbors, peers, and other trusted channels of communication to increase family, school, workplace, and neighborhood mutual support for advocacy and preparedness.

9.4 Engage in activities that build social connections between neighborhood residents, help foster neighborhood cohesion and resilience, and elevate community voices to advance community-driven climate solutions. Block parties and volunteer projects that address climate change are suitable activities.

Why is it Relevant to Cambridge?

Collaboration with leaders of at-risk populations to build social cohesion and resiliency is among the top of the near-term priorities voiced by Cambridge stakeholders who are engaged in public health and climate change preparedness efforts. Indicators of sensitivity may include an individual's age, whether they are living in poverty, whether they have a disability or chronic illness, and whether they have secure housing. Extreme heat is a risk factor for students engaged in demanding sports at area public and private schools, such as Tobin and Fayerweather. It also presents an occupational hazard for construction workers, day laborers, and others who work outside or in uncooled environments. These populations, and those who create policies and supervise them — from employers to school coaches — need to be engaged. Increasing awareness and resiliency through culturally appropriate community-led peer outreach, coupled with mutual support and voluntary efforts that address climate-related risk factors, can be effective in preparing and strengthening both individuals and neighborhoods. Equity-focused climate change frameworks further emphasize fostering the decision-making power of those most impacted.

"The opportunity for increasing community resilience is in the very process of developing a plan when those who are most vulnerable are at the heart of society's efforts to build a resilient future." (Source: Community-Driven Climate Resilience Planning.)

As informed by best practices and the stakeholder engagement process for the project, it is critical for members of the community to become aware of, and connected to, climate-related community systems and programs.

Actions Already Being Taken

- The Cambridge Community Response Network (CCRN) has been created to help build a more resilient City by developing a strong community in which neighbors feel connected to and responsible for each other.[10]
- Recognizing the power of grassroots and locally based connections, the Cambridge Peace Commission organizes a Meet Your Neighbor Day cosponsored by the Citizen's Committee on Civic Unity for a Cambridge-specific approach to building connections and community.[11]
- The Cambridge Climate Protection Action Committee, Community Engagement Teams, Cambridge Health Alliance Volunteer Health Advisors, literacy ambassadors, "Food-for-Free," the Cambridge Men's League, area aging agencies, and school, workplace, and faith community networks and activities can be expanded upon.

10 www.cambridgema.gov/Departments/peacecommission/CCRN

11 www.cambridgema.gov/Departments/peacecommission/meetyourneighborday

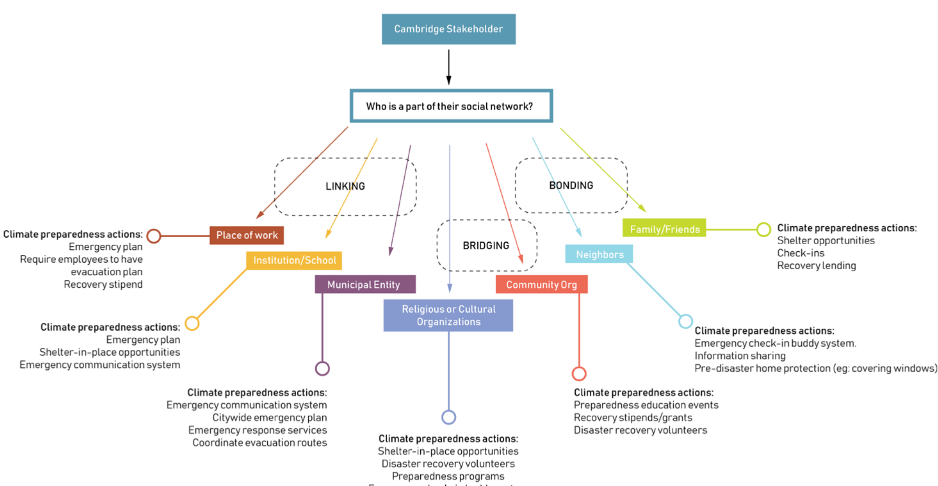


Figure A.12. This diagram illustrates how the City can build upon existing partnerships with organizations to develop a neighborhood resiliency network.

A9 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**Cambridge Public Health Department, Community Development Department, Cambridge Arts Center**
Jurisdiction Who monitors the implementation?	☑ **City** ☐ **State** ☐ **Regional**
Type of Implementation How is the strategy categorized for the implementation type?	☑ **Pilot/Project/Study** ☐ **Policy/Regulations** ☑ **Program**
Scale What is the scale of the intervention?	☐ **Parcel** ☑ **Neighborhood** ☐ **Citywide** ☐ **Regional**
Related Strategies	**A1: Provide Neighborhood Resilience Hubs** **A2: Enhance Resilient Public Amenities** **A3: Create Support Systems for Populations At Risk** **A4: Strengthen Emergency Communication Systems** **A5: Support Business and Organizational Preparedness** **A6: Protect Community Resource Buildings** **A7: Enhance Emergency Response Plans** **A8: Provide For Healthcare Continuity and Access**

A 10 Continue Climate Education

The City should develop climate education programs aimed at educating all residents on climate change preparedness and mitigation.

TOOLBOX ACTIONS

10.1 Host educational climate preparedness workshops at the public library branches and with community resource organizations (align with Toolkit audiences: renter, small business owner, etc.)

10.2 Initiate a Campaign for climate awareness. The City could distribute MVP toolkits to all residents describing resources available (FloodViewer, Toolkit, Programs, etc.), and how to prepare for climate events such as heat and flood (evaluating your risk, recommended prevention steps, checking in on others, symptoms of excessive heat exposure, etc.).

10.3 Host a climate-related community meals dinner series where a community leader presents information in a simple, understandable way.

10.4 Reach out to neighborhoods with high percentages of minority communities.

10.5 Develop equity and accessibility guidelines for climate information that will be included in the educational information on climate change preparedness.

Why is it Relevant to Cambridge?

Public facilities such as libraries provide educational materials and skills courses. Other public facilities, such as the Cambridge Multi-Service Center, help residents navigate complex bureaucratic processes. Adult education and tutoring centers help individuals obtain their GED or complete job training. These facilities could use their existing platforms to provide climate materials, resources, and education to residents with low educational attainment. It should be the aim of public agencies and facilities to provide these resources for all reading levels.

Wellington-Harrington and the Port do not have libraries or other public facilities supporting education, so residents would need to receive climate education through other means or in other neighborhoods. However, these two neighborhoods have several schools; the City could investigate partnering with these institutions to provide evening climate education classes for adults. Another option is to send climate information home with youths or provide workshops tailored to parent-student learning about climate risks.

Information about climate risks and hazards is complex and overwhelming; therefore, distributed information should be written in an easy-to-understand way and in a voice that empowers rather than paralyzes residents. In addition, it is important that this information is disseminated in a variety of mediums — not all residents have access to WiFi or unlimited data, or have permanent home addresses.

Actions Already Being Taken

- Climate fact sheets as well as low-literacy outreach resources have been created (including a locally tailored model video and workshop guide for the Port).
- The Cambridge Climate Access program was created

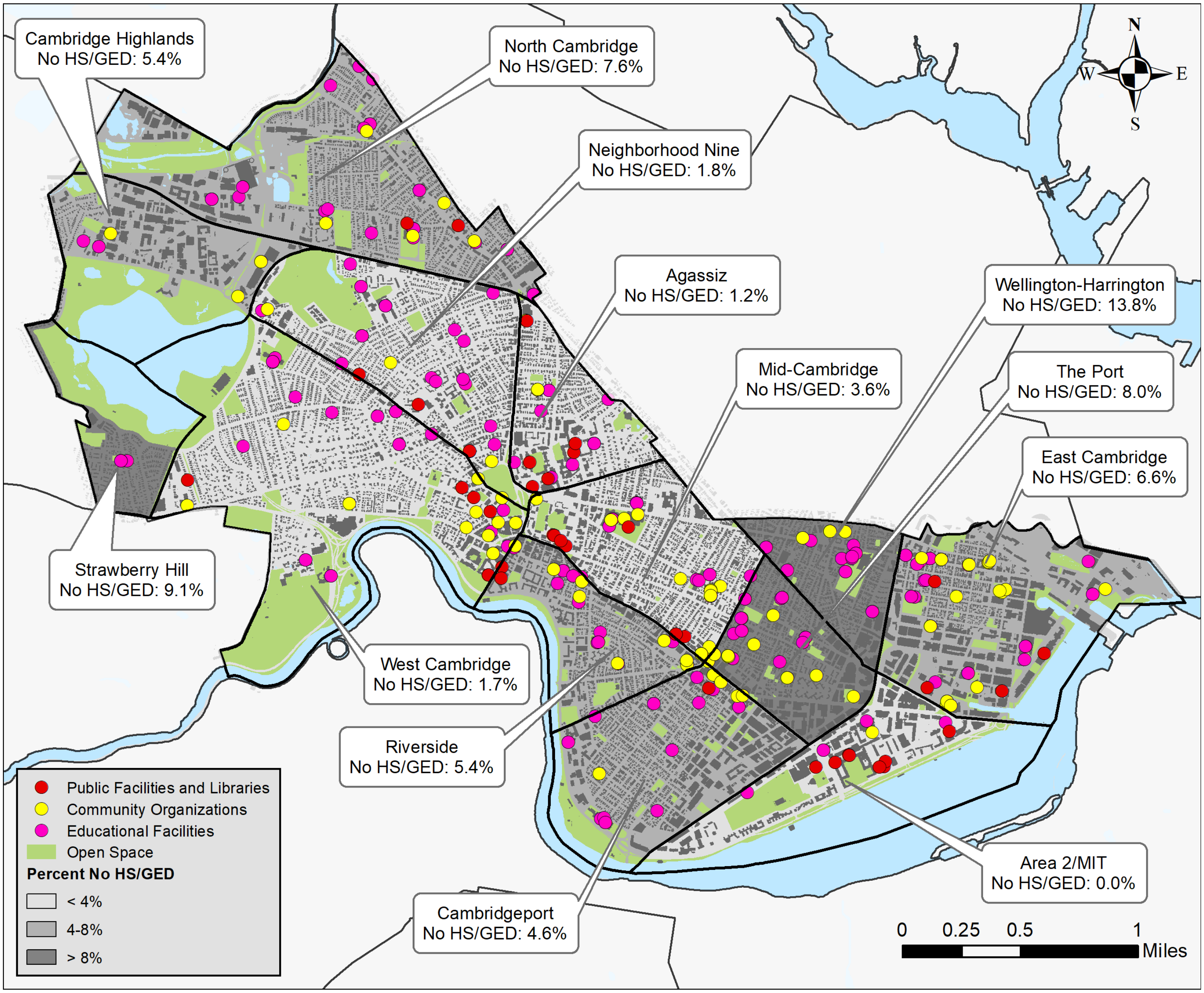


Figure A.13. There is a higher percentage of those with limited education in Wellington-Harrington, The Port, and Strawberry Hill, where there is also a higher percentage of individuals living below the poverty line.

A10 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	Cambridge Public Library branches, Department of Human Service Programs, Community Engagement Team, Cambridge Community Resilience Networks, immigrant and faith leaders, CHA's Health Improvement Team, literacy ambassadors, food pantries/Food-for-Free
Jurisdiction Who monitors the implementation?	☑ City ☐ State ☐ Regional
Type of Implementation How is the strategy categorized for the implementation type?	☑ Pilot/Project/Study ☐ Policy/Regulations ☑ Program
Scale What is the scale of the intervention?	☐ Parcel ☐ Neighborhood ☑ Citywide ☐ Regional
Related Strategies	A2: Enhance Resilient Public Amenities A6: Protect Community Resource Buildings A8: Provide For Healthcare Continuity and Access A9: Encourage Stronger Social Network

A 11

Support Renter Preparedness

Develop programs for the protection of renters during climate-related events.

TOOLBOX ACTIONS

11.1 Establish a disaster emergency housing relief fund for affordable housing developers and property managers.

11.2 Establish a climate-emergency rental assistance program for tenants who cannot pay rent due to the consequences of a climate-related event (could include job loss, damage to property, injury).

11.3 Pass a policy that streamlines eviction moratoriums during a disaster or during a disaster recovery period.

11.4 Coordinate with housing courts to convey intent to protect tenants during climate events from notices-to-quit from landlords.

Why is it Relevant to Cambridge?

Housing tenure contributes to an individual's vulnerability. Renters have limited legal control over how they prepare and adapt their rental unit for increasing climate impacts. Additionally, it is assumed that renters could be more vulnerable to displacement in the event that their unit would be damaged by an extreme weather event. Due to increasing housing pressures and the high-level of density in Cambridge (Cambridge is the 10th densest city in the United States), many residents are "rent-burdened," which means a high percentage of their income goes toward housing costs. In Cambridge, "63.8% of occupied units are rented and 36.2% are owner-occupied (including owner-occupied condominiums). Approximately 14.8% of the entire housing stock is subsidized in some form," according to American Community Survey. The average cost to rent a one-bedroom unit is $2,525, according to Zillow (2019), ranking in the top five most expensive places to live in the United States. "According to the National Low Income Housing Coalition a renter must earn $44 per hour in order to afford a two-bedroom apartment, more than three times the current Massachusetts minimum wage ($12/hr. as of 1/1/2019)" (Cambridge Community Foundation).

Actions Already Being Taken

- During the COVID 2020 crisis, the Mayor granted an emergency housing relief fund; local political leaders and activists advocated for statewide moratoriums on evictions and housing assistance.
- Some landlords and owners willingly accepted rent reductions or delays in payments. Mortgage lenders provided easements on lending schedules.

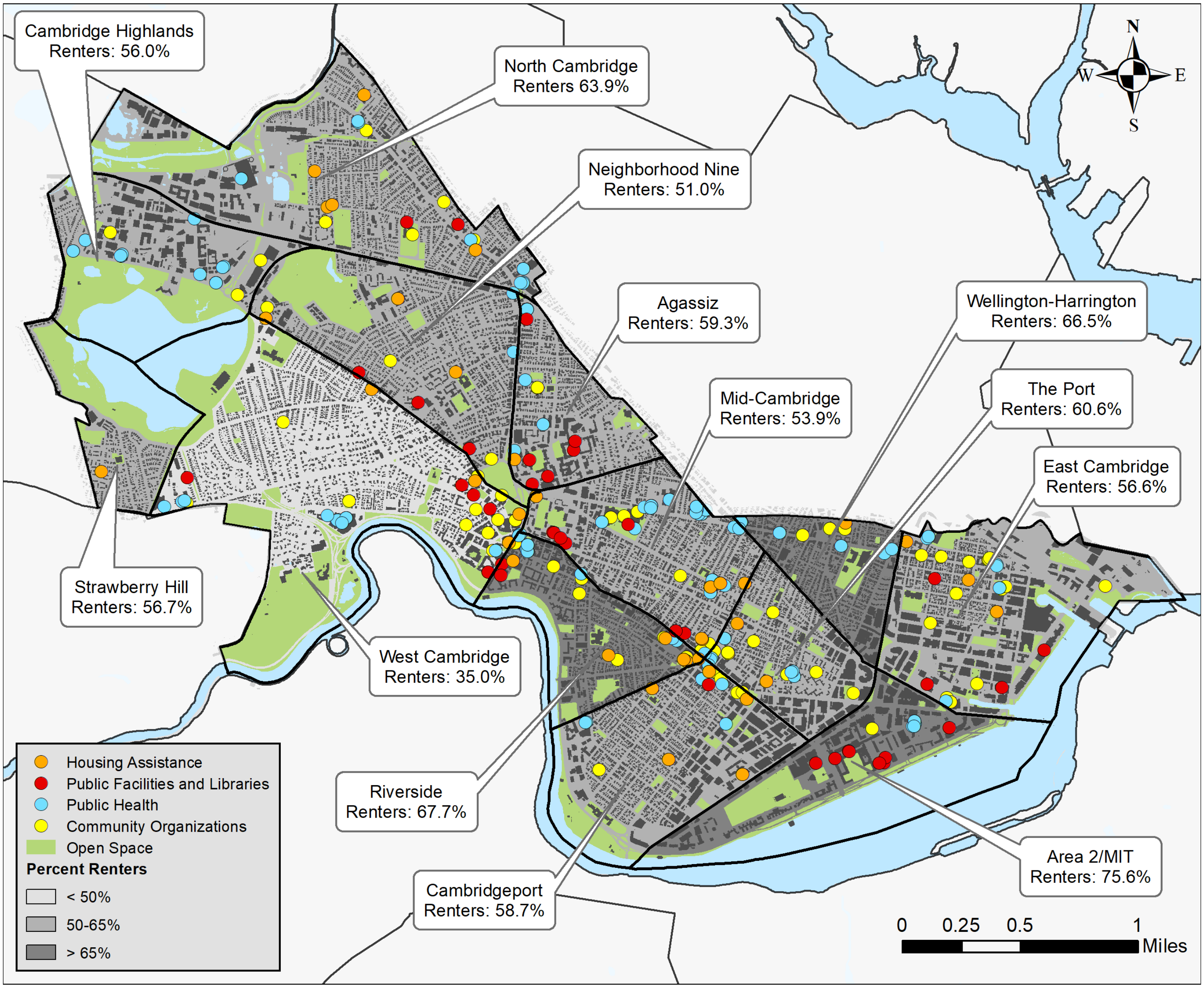


Figure A.14. The highest percentages of renters in Cambridge are in MIT/Area 2, Riverside, and Wellington-Harrington. The Port and North Cambridge also have relatively high percentages: 60-63%.

A11 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**Cambridge Public Library branches, City Department of Human Service programs, Community Engagement Team, Cambridge Community Resilience Networks, immigrant and faith leaders, CHA's Health Improvement Team, literacy ambassadors, food pantries/Food-for-Free**
Jurisdiction Who monitors the implementation?	☑ **City** ☐ **State** ☐ **Regional**
Type of Implementation How is the strategy categorized for the implementation type?	☐ **Pilot/Project/Study** ☑ **Policy/Regulations** ☑ **Program**
Scale What is the scale of the intervention?	☐ **Parcel** ☐ **Neighborhood** ☑ **Citywide** ☐ **Regional**
Related Strategies	**A2: Enhance Resilient Public Amenities** **A6: Protect Community Resource Buildings** **A8: Provide For Healthcare Continuity and Access** **A9: Encourage Stronger Social Network** **B5: Support Building Management For Flood and Heat Protection**

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Better Buildings

The overall benefit of the strategies for better buildings is to achieve resilient buildings and a resilient neighborhood that is protected from climate change impacts and designed for a speedy return to normal. Strategies for flood and heat resiliency have been developed separately for new and existing buildings because different approaches and means are needed for each.

These are the proposed strategies to make Better Buildings:

1. Regulate Flood Protection For New Buildings

Establish regulations and design guidelines for new buildings and redevelopments to be resilient to future flood risks identified for the neighborhood.

2. Regulate Heat Protection For New Buildings

Establish regulations and design guidelines for new buildings and redevelopments to be resilient to future heat risks identified for the neighborhood.

3. Encourage Flood Protection For Existing Buildings

Establish a program to support the retrofitting of existing buildings and redevelopments to be resilient to future flood risks.

4. Encourage Heat Protection For Existing Buildings

Establish a program to support the retrofitting of existing buildings and redevelopments to be resilient to future heat risks.

5. Support Building Management For Flood and Heat Protection

Develop a program to enable building residents and occupants to effectively manage and operate resilient buildings.

6. Promote Site Green Infrastructure

Implement green infrastructure (GI) at the parcel level to improve water management and reduce the heat-island effect.

7. Establish Adapted Zoning Policies and Regulations

Revise zoning to factor in climate change risks, such as flooding and extreme heat, and adjust building requirements to consider new constraints such as revised flood elevation.

8. Study Adapted Planning For Resilient Urban Blocks

Identify potential blocks and study the effectiveness of special incentives zones.

9. Encourage Resiliency of Building Scale Energy

Install solar PV panels to increase renewable energy production and renovate century-old buildings to increase energy efficiency.

10. Develop Flood Protection and Operations Planning for Historic and Critical Facilities

Maintain integrity of critical and historic structures or relocate, when possible, historic structures and critical facilities out of the predicted floodplain.

BEST PRACTICES

As cities are experiencing the impacts of climate change and working to recover after a disaster, there are many best practices from around the United States and internationally. The following best practices serve as examples in building design, programming, and changes in regulations and standards to integrate climate change projections. They have been selected for their applicability in the context of the City of Cambridge.

Flood Protection for New and Existing Buildings

American Copper Buildings, New York City, New York

The American Copper Buildings are two residential buildings with a total of 760 apartments along the East River in New York City (Figure B.1). The buildings were designed for flood resilience. The lobby walls were constructed of stone to prevent flood damage, and there is a stormwater detention pit under the basement floor. The mechanical systems are on the second floor, and there are five natural gas emergency generators on the 48th floor.

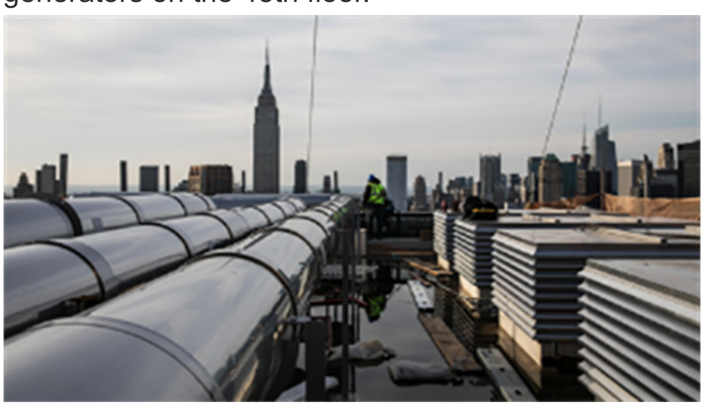

Figure B.1. American Copper Building, NYC (Source: New York Times, Curbed NY)

HafenCity, Hamburg, Germany

HafenCity, Hamburg, built a series of mixed-use buildings fully elevated from the street level for flood protection and improved neighborhood resilience (Figure B.2). Buildings facing the lower street are more prone to flooding and have flood control measures such as flood gates (Figure B.3). Garages and common lobby spaces are good examples of areas that can be designed and operated to recover from flood events.

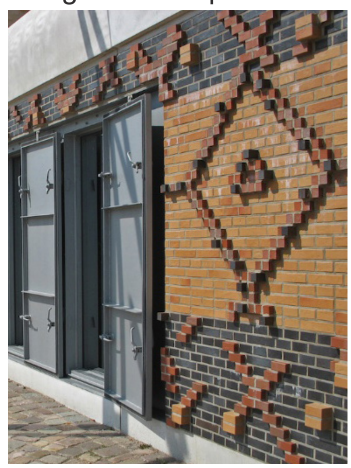

Figure B.2. Flood protection shutters. (Source: HafenCity, Hamburg)

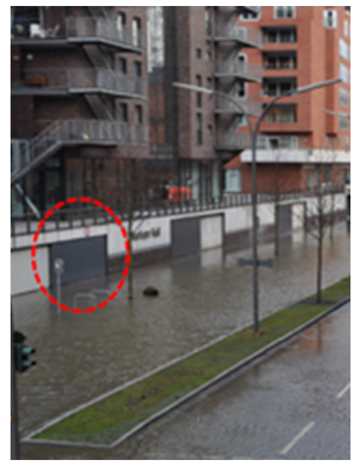

Figure B.3. Flood protection gates to achieve a flood protection level. (Source: HafenCity, Hamburg)

Finch Cambridge, Cambridge, Massachusetts

In the Alewife neighborhood, Finch Cambridge by nonprofit Homeowners Rehab, Inc., was developed on a repurposed site to address the need for low-income housing in the City. The project received funding from the City of Cambridge, the MassHousing, the Massachusetts Department of Housing and Community Development (DHCD), and

TD Bank[12].The new building, located across the street from Fresh Pond Reservation Park, features 98 affordable units, community room, rooftop terrace, and front and rear recreational areas. While unplanned initially, the effort to build and operate more sustainably led to the building meeting Passive House level performance (indoor temperatures that stay within 55-85 degrees for four days passively). Additional resilient design features include: all units built above the 2070 design flood elevation, and mechanical equipment located on the roof.

Figure B.4. Cornell Tech's 26-story residential tower, NYC (Source: Cornell University)

Heat Protection for New and Existing Buildings

Cornell Tech's Residential Tower, Roosevelt Island, New York

Cornell Tech's 26-story residential tower is the first high-rise building to meet the Passive House standard, which prioritizes building design principles that meet thermal resilience goals (Figure B.4). The tower is projected to use 60 to 80 percent less energy than other similarly sized buildings by using LEED[13], Net Zero and Passive House principles[14], such as a tighter building envelope, and well-insulated exterior window and wall systems. This helps maintain habitable interior temperatures during power failure from extreme heat events, which allows people to shelter-in-place.

New York City Cool Roofs Program, New York City, New York

New York City's CoolRoofs™ Program was launched in 2009 (Figure B.5). The initiative is a partnership between the NYC Department of Small Business Services, the Mayor's Office of Sustainability, the Mayor's Office of Recovery and Resiliency, and Sustainable South Bronx, a division of The HOPE

Figure B.5. Buildings commissioner cools a roof in Long Island City (Source: NYC CoolRoofs)

12 https://huntnewsnu.com/55378/city-pulse/new-housing-development-will-provide-affordable-homes-in-cambridge/

13 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)

14 https://be-exchange.org/wp-content/uploads/2017/11/Passive_House_Briefing-5-1.pdf

Program[15]. Through the program, building owners have applied approximately 6 million square feet of cool, reflective coating on more than 600 building roofs. The program offers cool roof installations at no cost or low cost to select buildings (e.g., community centers, schools, hospitals, cultural buildings) with priority given to non-profit organizations and affordable housing. Building owners are provided discounted rates for the coating, as well as labor, technical assistance, and materials (e.g., paintbrushes, rollers, gloves). Private building owners who share the electricity cost savings are also eligible. The program reduces the Urban Heat Island (UHI) effect, reduces greenhouse gas (GHG) emissions and provides a 10- to 30-percent savings on cooling costs.

The City of Toronto's Eco-Roof Incentive Program, Environment and Energy Division, Toronto, Canada

The City of Toronto launched its Eco-Roof Incentive Program in 2009 to encourage the adoption of green roofs and cool roofs on new and existing buildings (Figure B.6). As part of this incentive program, green-roof projects receive a grant of $100 per square meter, while cool-roof projects receive a grant of $2 to $5 per square meter. This program complements the Toronto Green Roof Bylaw (adopted by the Toronto City Council in May 2009), which requires the construction of green roofs on new residential, commercial and institutional buildings with a minimum floor area of 20,000 square feet. The Bylaw is supported by a green roof screening tool to determine applicability to the developer. As a result of the Program and the Bylaw, there are over 2.5 million square feet of green roofs installed on approximately 500 roofs across the City.

Figure B.6. Green roof system. (Source: Toronto, Canada; Green Roof at Ryerson University)

Building Maintenance Plans for Resiliency

Building maintenance plans are preventive measures that reduce damage and failure of systems during events. For example, protection of structural elements and electrical systems will require special procedures before and during flood events. After the event, swift removal of waterborne materials is essential. Methods include pumping standing water, hosing down flood deposits or debris, and removing wet or damaged materials before they develop mold. Establishing positive drainage away from the building with a slope greater than 2 percent and high-pressure water supply connections can assist in hosing down debris to catch basins after an event, before deposits harden and require more mechanical means of removal. The ability to maintain power to critical systems is also important. Components such as energy management systems can localize and reduce energy consumption, as well as communicate to the grid when needed. In

15 https://www1.nyc.gov/nycbusiness/article/nyc-coolroofs https://www.fema.gov/media-library-data/1436288616344-93e90f72a5e-4ba75bac2c5bb0c92d251/ASCE24-14_Highlights_Jan2015_revise2.pdf

addition, installing backup power systems or the ability to quickly connect to emergency power systems is essential. New York State and Austin, Texas, provide good models for smart building management to reduce the stresses brought by climate change.

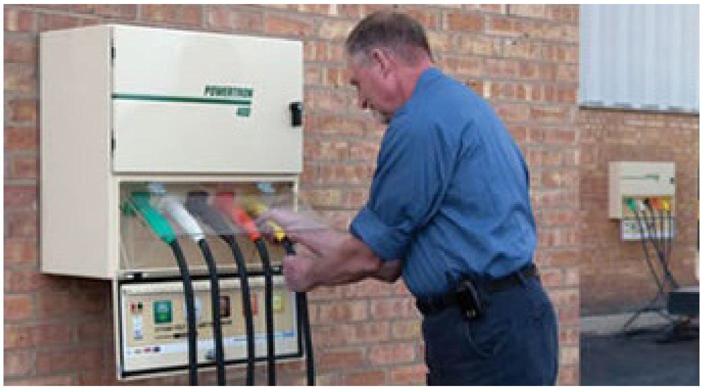

Figure B.7. Emergency generator. (Source: Powertron Solutions)

New York State Generator Connections

New York State requires disaster preparedness plans for nursing homes and assisted living facilities. Plans require emergency generators or access to temporary emergency generators through a contract with a supplier (Figure B.7). In addition, the plans require retrofitting these buildings with pre-connections for temporary generators during outages.

Austin Energy Smart Thermostats, Austin, Texas

Austin Energy, a municipal utility in Austin, Texas, has a goal to achieve 900 megawatts (MW) in savings through increased energy efficiency and demand-side management, and a renewable energy goal of 55 percent by 2025, including 200 MW in local solar.

As part of this energy management goal, Austin Energy provides the Power Partner℠ Thermostats rebate program. The program first provided free thermostats to customers and then subsidized the program via a rebate to purchase the smart thermostat. Austin Energy pays thermostat vendors a one-time fee to enter the program and an annual fee (per thermostat) to manage the demand-response events. There are several demand-response vendors and over 10 models of thermostats provided by different manufacturers available through the Smart Thermostat Program.

The Smart Thermostat (Figure B.8) allows the utility company to adjust temperatures during peak demand and send messages, pricing signals, and critical usage information to customers. The ability to reduce peak electricity usage through smart thermostats reduces the stress on the electrical distribution system and the possibility of outages.

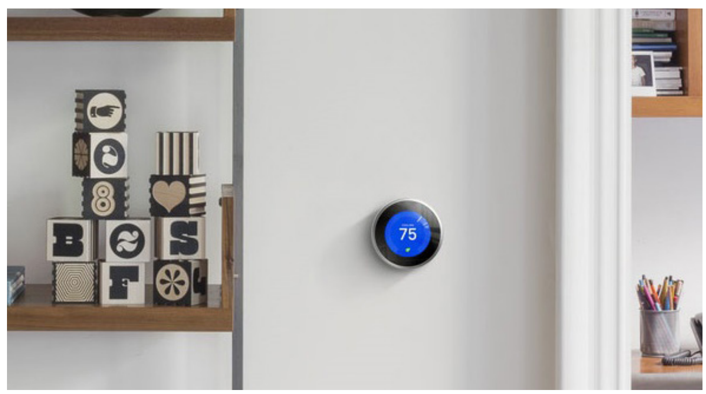

Figure B.8. Smart Thermostat. (Source: Austin Energy)

Building Standards and Regulations

Climate change requires predicting future impacts for communities to be prepared. Building standards and regulations have been established based on past events and historic storms. The building and construction industry, including professional associations, municipalities, and government regulatory agencies, are in the process of revising standards and regulations to factor in climate change projections. Best practices for new standards and regulations have been documented for their applicability to the City of Cambridge and the Commonwealth of Massachusetts. Possible regulatory approaches include the following:

Flood Resistant Design and Construction (24-14)[16]

The ASCE/SEI 24-14, published by the American Society of Civil Engineers (ASCE), is a referenced standard in the International Codes® (I-Codes®) (Figure B.9). It states the minimum requirements and expected performance for the siting, design and construction of buildings and structures in flood hazard areas that are subject to building code requirements. Buildings and structures designed according to ASCE 24 are better able to resist flood loads and flood damage.

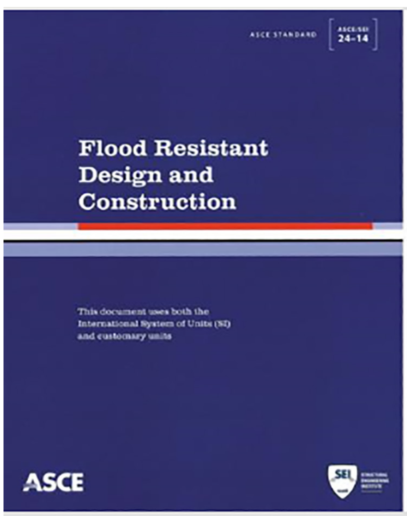

Figure B.9. Flood Resistant Design and Construction (24-14) reference standard. (Source: American Society of Civil Engineers)

Types of buildings and structures include commercial, residential, industrial, educational, healthcare, critical facilities, and other occupancy types. Federal Emergency Management Agency (FEMA) deems ASCE 24 to meet or exceed the minimum National Flood Insurance Program (NFIP) requirements for buildings and structures. ASCE 24 includes additional specificity, some additional requirements, and some limitations that are not in NFIP regulations[17].

New Orleans Municipal Code, New Orleans, Louisiana

Section 78-80 of the New Orleans' Municipal Code requires a Certificate of Elevation for building permit applications to ensure accuracy in compliance with regulations. Specifically, all building permits issued for new construction or substantial improvement must be printed with the lowest floor elevation (including basement), referenced with respect to the mean sea level[18]. The process of raising structures has been streamlined to avoid the need for plan review for structural renovation permits, which may be obtained by licensed survey or shoring companies where the entire structure is proposed to be raised[19].

New York City Building Code: Flood Resistant Construction

The New York City Building Code references the American Society of Civil Engineers, ASCE 24, but also has specific requirements that apply to post-

16 https://www.fema.gov/media-library-data/1436288616344-93e90f72a5e4ba75bac2c5bb0c92d251/ASCE24-14_Highlights_Jan2015_revise2.pdf

17 https://www.fema.gov/media-library/assets/documents/14983

18 Mean sea level (MSL) (often shortened to sea level) is an average level of the surface of one or more of Earth's oceans from which heights such as elevations may be measured. MSL is a type of vertical datum – a standardized geodetic reference point.

19 New Orleans, Louisiana - Code of Ordinances, Chapter 78 – Floods Article II. – Flood Damage Prevention, Division 4 – Flood Hazard Reduction. https://library.municode.com/la/new_orleans/codes/code_of_ordinances

Flood Insurance Rate Map (FIRM) construction and substantial improvements located within A Zones as defined by FEMA. References to ASCE 24 include using freeboard requirements by category of buildings. According to the ASCE 24 guidelines, residential dwellings and most other buildings are required to have a 1-foot freeboard above the FIRM Base Flood Elevation (BFE)[20]. Some essential facilities, such as hospitals, fire and police stations, and emergency shelters, are required to have 2 to 3 feet of freeboard above the BFE. Other design guidelines are specific to design for hydrostatic pressure of below-grade structures, design of foundation structures, mechanical, heating, ventilation, and air conditioning elements, and use of flood damage-resistant materials. There is also design consideration for utilities and service equipment to prevent water intrusion. Additional provisions apply to relief vents and fresh-air intakes serving building traps that shall be carried above-grade and shall terminate in a screened outlet. Applications involving utility or mechanical work shall include a separate certification by the applicant that will conform to ASCE 24.

In New York, some retroactive provisions require improvements to be made regardless of whether building permits are being considered. For example, existing nursing homes or similar occupancy types in flood zones would require installing connections for temporary external generators, to be in place by 2030 to ensure backup power for at-risk populations. At the same time, new hospital buildings will be required to meet construction code standards for flood-resistant construction[21].

Regulatory and Zoning Measures

EPA Recommendations for Climate Change

The EPA (Environmental Protection Agency) published a report recommending the adoption of flexible zoning, which could include dynamic zoning or a floating zone. Dynamic zoning allows a community to pass regulations that fit its current conditions but will change based on some empirical future conditions[22]. Two key ideas that could inform Resilient Cambridge follow:

- Adopt elements of dynamic zoning or building flexibility into codes to cope with changing conditions. With dynamic zoning, the zoning code includes "triggers" that, when activated, change the code requirements automatically. The nature of dynamic zoning might be particularly helpful for climate-change-related impacts. One legal expert notes that, "gradual and adaptive regulations can minimize harm and takings in terms of compensation requirements," while giving property owners some certainty about how they can expect to use their property once certain thresholds are passed. It should be noted that this is an innovative approach to zoning that has yet to be tested in "real life" conditions.
- Install Green Infrastructure at parcel level. Green infrastructure (GI) and low-impact development (LID) rainwater management strategies improve the environmental conditions by mimicking a site's natural hydrology. They limit the amount of impervious cover on a site, and infiltrate, filter, store,

20 Base Flood Elevation is the computed elevation to which floodwater is anticipated to rise during the base flood, which is referred to as the 100-year flood, or a flood that has a 1 percent annual chance of exceedance in any given year.

21 As recommended in http://www.nyc.gov/html/sirr/downloads/pdf/final_report/Ch_8_Healthcare_FINAL_singles.pdf

22 https://www.epa.gov/smartgrowth/smart-growth-fixes-climate-adaptation-and-resilience

evaporate, or detain rainwater runoff at or close to its source. GI also contributes to the reduction of UHI impacts by lowering temperatures.

Boston's Coastal Flood Resilience Design Guidelines

The Coastal Flood Resilience Design Guidelines document is a resource to help Boston property owners and developers make informed, forward-looking decisions about flood protection for existing buildings and new construction (Figure B.10). This effort directly builds on Climate Ready Boston's initiatives on coastal flood resilience, which recommends a zoning overlay district and resilience design guidelines to advance building adaptation and protection from future flood risk — specifically, the 1 percent annual chance flood risk in the year 2070 with 40 inches of sea level rise. The role of the design guidelines is to raise awareness of future coastal flooding risks for residents and businesses, to describe and illustrate a range of strategies to reduce flood damage and disruption, and to provide consistent standards for official review for projects within the proposed Zoning Overlay District.

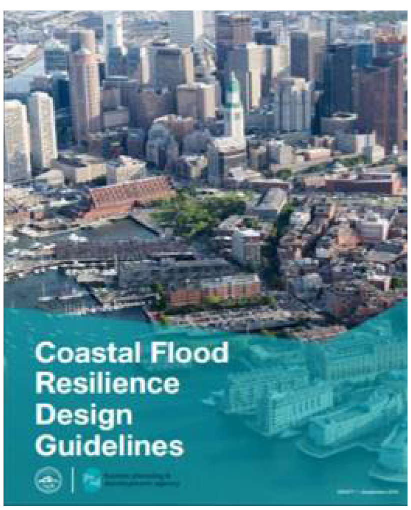

Figure B.10. Coastal Flood Resilience Design Guidelines

Adapted Planning Efforts

Teachers Village, Newark, New Jersey

There are examples of neighborhoods that organize and join efforts to meet higher standards to be more sustainable and resilient. Teachers Village is a sustainable neighborhood development project that includes new construction and retrofits incorporating green infrastructure and energy conservation into a mixed-use neighborhood (Figure B.11). The project will be certified as LEED Neighborhood Development, an example of an accreditation that employs improved performance of buildings, which is monitored over time, maximizes open space, and prioritizes pedestrian connectivity to transit, jobs, and amenities within the neighborhood or block. The model program provides a precedent for concerted implementation of resiliency and sustainability measures at the block and neighborhood scales[23].

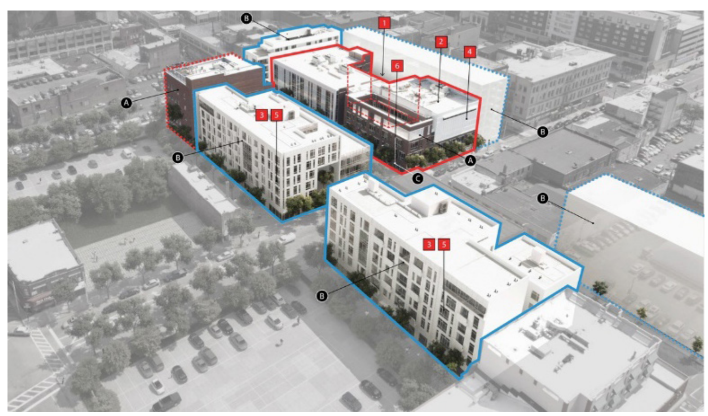

Figure B.11. Teachers village demonstrating concentrated implementation of sustainable strategies. Source: us green building council

23 https://www.usgbc.org/projects/teachers-village

Building Scale Energy

The Cambridge Multi-Family Energy Pilot

The City of Cambridge and Eversource together launched a multifamily energy pilot program to help apartment and condominium buildings save energy. The program offers whole-building energy assessments, free solar assessments, and free retrofit advisory services. In the first year, 1,300 households participated in the program[24]. One nine-unit market-rate building owned by an off-site property owner in the Port is involved in the program, but no buildings in the resilient blocks identified as part of The Port Preparedness Plan[25] have enrolled in the program at the time of publication of this document[26].

Historic Building Guidance

Boston Resilient, Historic Buildings Design Guide

Resilience to climate change risks is fundamental to the City of Boston's preservation goals. To maintain the rich historic fabric of the City, historic buildings must be able to withstand sea level rise, increasing storm events, and precipitation. Not only do these events threaten the structure and materials of historic buildings, they also threaten the safety of the occupants of historic buildings[27].

Additional National Examples

The Connecticut State Historic Preservation Office (SHPO) developed a statewide resiliency planning guide to assist local and state planners and to engage a wider audience in preservation planning needs for historic resources in an era of climate change. The report summarizes the SHPO's efforts to integrate historic preservation issues into resiliency planning in Connecticut.[28]

The Augustine Resilient Heritage Report, sponsored in part through a small matching grant by the Florida Department of State, Division of Historical Resources, focuses on creating a document that identifies methods for prioritizing archaeological sites threatened by rising seas; outlines the economic impacts of previous and future flooding events; and recommends potential solutions, such as mitigation strategies and policy revisions[29].

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24 http://cambridgeenergyalliance.org/current-efficiency-promotions

25 https://www.cambridgema.gov/-/media/Files/CDD/Climate/CCPR/ccprtheportplan/ccprtheportfinalpages52819processed.pdf

26 http://www.bostonplans.org/getattachment/d1114318-1b95-487c-bc36-682f8594e8b2

27 https://www.boston.gov/sites/default/files/embed/file/2018-10/resilient_historic_design_guide_updated.pdf

28 https://portal.ct.gov/-/media/DECD/Hurricane_Sandy_Relief/Website-Stuff/ResiliencyPlanningStatewideGuide_Reduced.pdf

29 https://www.placeeconomics.com/wp-content/uploads/2020/11/St.-Augustine-Resilient-Heritage-Report-Sep2020.pdf

RELEVANCE TO CAMBRIDGE

Table B.1 provides a summary of how the best practices inform the development of specific strategies for Better Buildings.

Table B.1 List of Strategies and Related Best Practices

Strategy	Title	Related Best Practice	Description
B1	**Regulate Flood Protection For New Buildings**	American Copper Buildings, New York City, New York	The residential buildings in a flood-prone area in New York City adopted a series of resiliency measures, including lobby walls in stone, to prevent flood damage, stormwater detention pit under the basement floor, mechanical systems elevated to the second floor and five natural gas emergency generators on the 48th floor. This series of measures could be applicable to new development in Cambridge.
B2	**Regulate Heat Protection For New Buildings**	Cornell Tech's 26-Story Residential Tower, Roosevelt Island, New York	The residential tower meets the Passive House standard, which prioritizes building design principles that meet thermal resilience goals. Adopted measures include a tighter building envelope, and well-insulated exterior window and wall systems. The building can also maintain habitable interior temperatures during power failure from extreme heat events, which allows people to shelter-in-place while using 60 to 80% less energy than similar buildings. These measures can also contribute to Cambridge Net zero goals.
B3	**Encourage Flood Protection For Existing Buildings**	HafenCity, Hamburg, Germany	A group of mixed-use buildings implemented flood measures, such as flood gates for buildings facing the lower street, garages and common lobby spaces designed and operated to recover from flood events. The ensemble of measures not only protects specific buildings but the entire neighborhood in alignment with Cambridge's goals for Better Buildings.

Table B.1 List of Strategies and Related Best Practices (continued)			
Strategy	**Title**	**Related Best Practice**	**Description**
B4	**Encourage Heat Protection For Existing Buildings**	New York City Cool Roofs Program, New York City, New York	The CoolRoofs™ program offers cool roof installations at no cost or low cost to select buildings (e.g., community centers, schools, hospitals, cultural buildings) with priority given to non-profits and affordable housing.
B5	**Support Building Management For Flood and Heat Protection**	New York State Generator Connections	New York State requires disaster preparedness plans for nursing homes and assisted living facilities. The plans require these facilities to have emergency generators or access to temporary emergency generators through a contract with a supplier.
		Austin Energy Smart Thermostats, Austin, Texas	The Austin Energy provides the Power Partner[SM] Thermostats rebate program, in which they first provided free thermostats to customers to purchase the smart thermostat. It allows for managing demand-response events during peak demand and sends messages, pricing signals, and critical usage information to customers.
B6	**Promote Site Green Infrastructure**	Green Factor, Somerville, Massachusetts	The City of Somerville implemented a green factor, which is a landscape requirement ratio of the weighted value of various landscape elements to a total lot area as part of the City's zoning code. The City of Cambridge is currently assessing means for developing a similar factor to mitigate UHI impacts and for achieving a greener City by engaging landowners and residents.

Table B.1 List of Strategies and Related Best Practices (continued)			
Strategy	**Title**	**Related Best Practice**	**Description**
B7	**Establish Adapted Zoning Policies and Regulations**	Flood Resistant Design and Construction (24-14)[30]	Published by the American Society of Civil Engineers (ASCE), the guidelines state the minimum requirements and expected performance for the siting, design and construction of buildings and structures in flood-hazard areas that are subject to building code requirements. ASCE 24 includes additional specificity, some additional requirements, and some limitations that are not in NFIP regulations[31].
		New Orleans Municipal Code, New Orleans, Louisiana	Section 78-80 of the New Orleans Municipal Code requires that a Certificate of Elevation for all building permits issued for new construction or substantial improvement must be printed with the required mean sea level elevation of the lowest floor (including basement).
		Coastal Flood Resilience Design Guidelines	The Coastal Flood Resilience Design Guidelines document is a resource to help Boston property owners and developers make informed, forward-looking decisions about flood protection for existing buildings and new construction.
		EPA Recommendations for Climate Change	Adopt dynamic zoning to cope with changing conditions. The zoning code could include "triggers" that, when activated by a special event, change the code requirements automatically.

30 https://www.fema.gov/media-library-data/1436288616344-93e90f72a5e4ba75bac2c5bb0c92d251/ASCE24-14_Highlights_Jan2015_revise2.pdf

31 https://www.fema.gov/media-library/assets/documents/14983

Table B.1 List of Strategies and Related Best Practices (continued)			
Stategy	Title	Related Best Practice	Description
B8	**Study Adapted Planning For Resilient Urban Blocks**	Teachers Village, Newark, New Jersey	Teachers Village is a sustainable neighborhood development project including new construction and retrofits that incorporate green infrastructure and energy conservation into a mixed-use neighborhood. Proposed strategies would be applicable in Cambridge.
B9	**Encourage Resiliency of Building Scale Energy**	The Cambridge Multi-Family Energy Pilot, Cambridge, Massachusetts	The City of Cambridge and Eversource launched a multifamily energy pilot program to help apartment and condominium buildings save energy. The program offers whole-building energy assessments, free solar assessments, and free retrofit advisory services.
B10	**Develop Flood Protection and Operations Planning For Historic and Critical Facilities**	Boston Resilient, Historic Buildings Design Guide	To maintain Boston's vibrant historic character, the City developed guidance on how to protect its historic properties from climate change risks. Cambridge has several historic buildings that are at risk of flooding or could be damaged by extreme heat and humidity.

KEY CONSIDERATIONS

Impact

- Resilient buildings implementing strategies would provide for better protection from flooding for the 2070 10-year storm (10% storm probability) and reduce cost for repair and recovery after the projected 2070 100-year event (1% probability).
- Dislocation of businesses or residents will be minimized, as well as economic impacts resulting from loss of housing or business activity.
- Lost revenue and tax generation will be minimized.
- Adapted zoning requirements including revised/ higher design flood elevations will ease communication with developers and enhance implementation.
- If implementation is maximized and results have a significant impact, it will improve conditions for neighborhoods and citywide.
- Designing for extreme conditions for building systems will have a major impact on passive survivability, adaptation to extreme temperatures over time, and reduction of energy and indoor temperatures.

Cost

- Cost for new construction can range from marginal to high, according to projected flood elevation.

- Preliminary information for range in cost of repairs are documented in the Resilient Cambridge Cost Analysis Appendix.
- For the various GI strategies, cost depends on the type of system (thickness, vegetation, and use). Costs for green roofs in the United States are estimated to average between $15 to $20 per square foot. These costs include all aspects of green roof development, from the waterproofing membrane to soil substrate creation to planting (Source: Low Impact Development Center, Inc.). But homeowners who choose to incorporate green roof systems, for example, will find that they quickly pay for themselves due to the resulting reduction in heating and cooling costs. The roofs provide a natural "coat" that improves the building's energy balance.

Equitable

- Creating better buildings could mean that property values will not decrease due to future climate conditions.
- Lower energy bills could be a result of improving buildings for resilience to extreme heat.
- Improvement of existing buildings for at-risk populations to survive during heat events will require financing beyond a home or building owner's pocket.
- Financial incentives for strategies or access to grants should be supported to assure equitable implementation.

Wellness

- Improving building resiliency to flooding could prevent mold and displacement of vulnerable populations.
- Reduced damage, increased maintenance and clean emergency power reduces waste, and improves indoor and outdoor air quality.

Feasible

- Recommended strategies and actions have been tested in other communities and use national standards.
- Raising buildings of more than 4 feet may negatively impact the public realm and be poorly received by stakeholders. Envision Cambridge developed urban design alternatives to maintain the quality of the public realm.
- Raising buildings might not be economically viable if zoning and height requirements are not adjusted to allow for limited use of areas below Design Flood Elevations. The City is considering zoning options with the Climate Resilience Zoning Task Force.
- Emergency and maintenance plans and installing smart thermostats are feasible to new and existing buildings, however, integrating backup power sources into existing buildings could be difficult due to cost and space issues.

Co-Benefits

- The strategies for better buildings will help support the City's water quality improvement efforts.
- The strategies for resiliency to heat and sustainable building will help the City meet other goals such as Net Zero Energy.
- PV and battery storage systems are clean emergency power systems that will also provide renewable energy when the grid is connected.
- GI implemented at parcel level would enhance the effects of the Cambridge Envision goals of "Sustainability & Resilience" and "Community Health & Wellbeing."
- Emergency and maintenance plans are operational measures and controls, and backup power are physical measures that integrate solutions that cover building, parcel, and infrastructure systems.

B1 Regulate Flood Protection For New Buildings

Implement the City's design guidelines in new buildings and redevelopments to be resilient to future flood risks.

TOOLBOX ACTIONS

1.1 Build/protect to the 2070 10-year flood elevation from precipitation or sea level rise/storm surge — whichever is higher. "Build to" is to design habitable spaces and critical systems above the 2070 10% flood elevation. "Protect" habitable uses and critical systems is to provide dry flood-proofing up to the 2070 10% flood elevation. Design to "build" above or "protect" from future flooding, which could occur during the expected lifespan of the building.

1.2 Recover from the 2070 100-year flood elevation from precipitation or sea level rise/ storm surge — whichever is higher. The intent is to allow flooding of non-habitable areas and install materials that can be easily cleaned or repaired after a 2070 1% event. The intent is for buildings to "recover" faster from flooding following more extreme events by installing materials that can be easily cleaned or repaired.

1.3 Elevate or protect vulnerable utilities, such as fuel storage, furnaces, and electrical panels above 2070 100-year flood elevation.

1.4 Avoid using finished basements as living space if at risk of flooding.

Why is it Relevant to Cambridge?

The City of Cambridge has created a web-based GIS application and associated database called FloodViewer, where property owners can assess projected flood elevations — with climate change projections — at a parcel level. This application is publicly available to inform residents about the risk and vulnerability of specific buildings and facilities. New development in the City should be informed by predicted climate change and flooding risk in 2070, which will help contribute toward making the neighborhood more resilient. The development and use of Cambridge-specific flood risk maps — instead of having to rely on FEMA flood maps — is critical for resiliency.

FEMA assesses flood risk and develops maps used for the NFIP. FEMA flooding maps are based on historic information and do not factor in climate change and

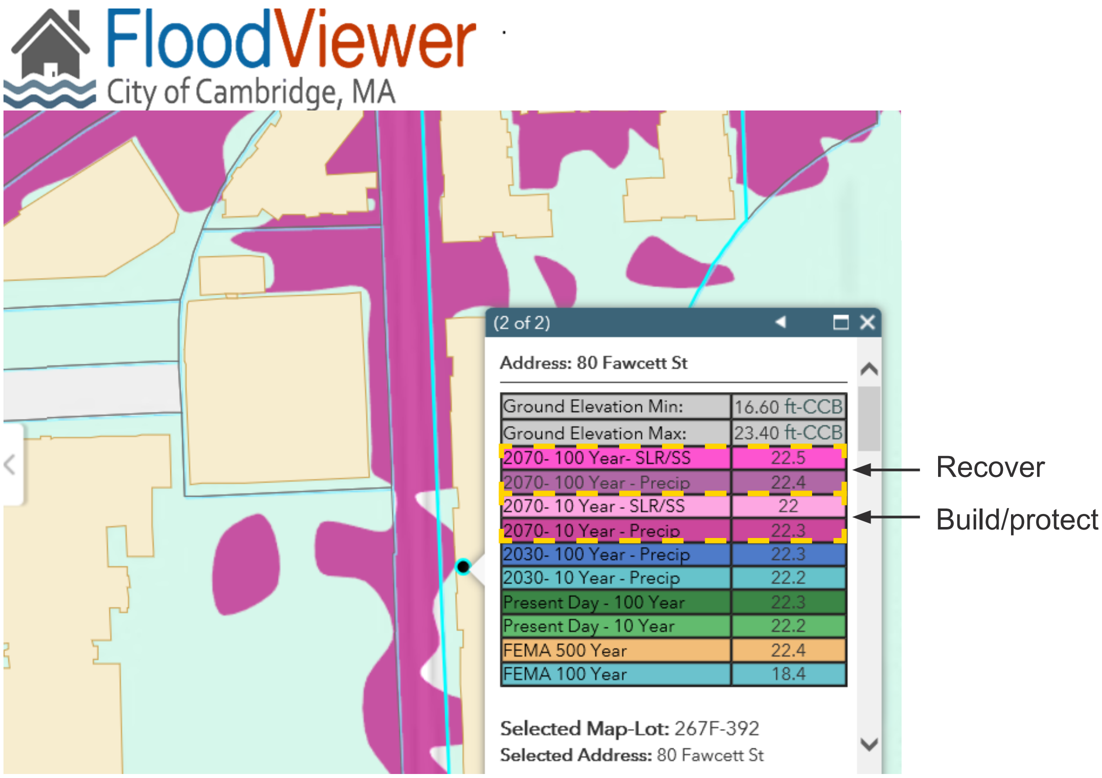


Figure B.12. FloodViewer 2.1 documents possible flood elevations for 10-year and 100-year storms[36] per parcel.

increased risk[32]. FEMA uses historic statistical data for river flow, storm tides, hydrologic/hydraulic analyses and rainfall and topographic surveys[33]. The FEMA flood risk maps for Cambridge were analyzed using the area documented as a high-risk Special Flood Hazard Area (SFHA), which is area that will be inundated by a flood event having a 1% chance of being unequaled or exceeded in any given year. Property owners who have a federally backed mortgage are required to purchase flood insurance if within the bounds of the SFHA[34]. Statistically, during the lifetime of a typical 30-year mortgage, structures that are located within the SFHA have a 26% chance of suffering flood damage during the loan payoff process[35].

Figure B.12 demonstrates how parcel and flood elevation data from the FloodViewer can inform design recommendations. Before future climate change conditions were acknowledged, buildings were built to the FEMA 100-year elevation shown as 18.4 feet-Cambridge City Base (CCB) in Figure B.13. However, it is acknowledged that FEMA uses historical reference

32 https://www.fema.gov/national-flood-insurance-program-flood-hazard-mapping

33 https://www.fema.gov/national-flood-insurance-program-flood-hazard-mapping

34 https://www.cambridgema.gov/Services/femafloodmaps

35 https://www.fema.gov/faq-details/Flood-Zones/

36 10-year SLR/SS and 10-year precipitation imply a coastal storm and a precipitation storm, respectively, that have a 10% annual chance of occurring. The 100-year SLR/SS and 100-year precipitation imply a coastal storm and a precipitation storm, respectively, that have a 1% annual chance of occurring.

data that does not factor future climate conditions. Adjusting building guidelines to the projected 10-year storm means that for the site in Figure B.12, 4 additional feet of flood protection measures would be needed to protect to 22.3 feet-CCB.

Tools or action items to fulfill "build to" and "protect" are providing for:

- Dry flood-proofing
- Wet flood-proofing
- Elevation of critical systems
- Elevation of structure
- Resilient elevators
- Water alarms
- Backwater valves

Actions Already Being Taken

- Since the publication of the Draft Resilient Cambridge Handbook and the FloodViewer, the City has been coordinating with developers to adapt the projected flood elevation for 2070 in their new construction.
- The City is already requiring backflow preventers.
- The City is informing residents and business owners by publishing tools such as the "Flooding: Is Your Property Protected?" brochure and the MVP (Municipal Vulnerability Preparedness) Preparedness Toolkits.

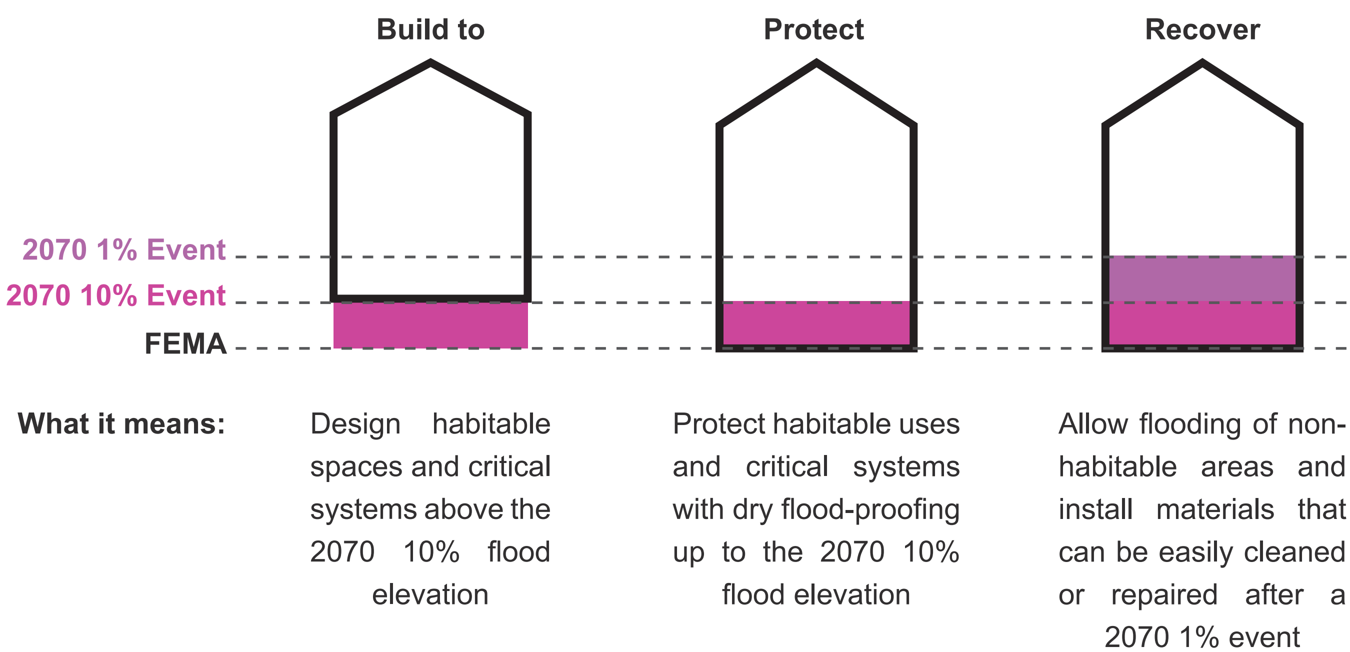


Figure B.13. Build/Protect To and Recover From definitions applied to buildings from the Better Buildings Technical Report.

B1 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**City, property owners**
Jurisdiction Who monitors the implementation?	☑ **City** ☐ **State** ☐ **Regional**
Type of Implementation How is the strategy categorized for the implementation type?	☑ **Pilot/Project/Study** ☑ **Policy/Regulations** ☐ **Program**
Scale What is the scale of the intervention?	☑ **Parcel** ☐ **Neighborhood** ☐ **Citywide** ☐ **Regional**
Related Strategies	**A5: Support Business and Organizational Preparedness** **A6: Protect Community Resource Buildings** **B7: Establish Adapted Zoning Policies and Regulations** **D3: Reduce Impervious Area**

B2 Regulate Heat Protection For New Buildings

Implement the City's design guidelines for new buildings and redevelopments to be resilient to future heat risks.

TOOLBOX ACTIONS

2.1 Design buildings with passive strategies including building orientation, high-performance insulation and windows, shading, and natural ventilation, and cool or green roofs.

2.2 Design buildings with a high-performance building envelope (e.g., R-value of 20 minimum wall insulation, R-value of 40 minimum roof insulation, and U-factor of 0.3 maximum glazing) and limit air leakage (less than or equal to 3 air changes per hour (ACH) at 50 pascals).

2.3 Design buildings to meet the Passive House Institute U.S. Certification.

2.4 Utilize mixed-mode ventilation systems, which include passive cooling, and install ceiling fans where applicable.

2.5 Install 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).

2.6 Maintain mature trees on private and public property. To help shade buildings, plant new trees, where possible, and install trellises and other site features with vegetation.

Why is it Relevant to Cambridge?

Cambridge weather could feel like Northern Virginia by midcentury and South Carolina by the end of the century, assuming business-as-usual operations. Average temperatures in the area would increase and annual days over 90 degrees would increase significantly (several months over 90 degrees compared with less than two weeks per year, in present day).

More robust building envelopes will help prevent buildings from falling victim to drastic changes in weather. With a stronger thermal barrier, buildings will be able to maintain comfortable living conditions more easily without increased energy input. Currently, residential buildings have a minimum R-value requirement of R-13 for wall construction (R-12.5 for commercial buildings). For roofing, residential buildings must have a minimum R-value of R-38 and commercial, R-26[37]. The City recommends all buildings be built with at least R-20 walls and R-40 roofing[38]. In general, exterior continuous insulation (minimum 1-inch thick) that is well installed and taped at all seams is a best practice for creating a more robust envelope.

As for window glazing, buildings are currently built with U-values of U-0.35 to U-0.45. The City recommends new buildings meet Energy Star qualifications and U-factors of, at most, U-0.30.

In addition to improving building envelopes, SRI should be considered in building construction. The SRI is a measure of a surface's ability to stay cool in the sun by reflecting solar radiation and emitting thermal radiation. High reflectivity from cool, blue roofs or green roofs will help reduce the UHI effect. In general, buildings should be designed to meet the Passive House Institute U.S. Certification. Both programs are widely accepted leaders in sustainability and are a good step toward building resilient and efficient buildings.

As additional building heat protection, the City recommends proper maintenance of mature trees on public and private property, planting more trees to provide shade to buildings, and advocating for vegetative shading. Improved building shading will help reduce the cooling load on the building. Additional benefits to increased tree coverage are trees' ability to reduce heat-island effects, improve air quality, and increase evapotranspiration, which is the process of water evaporating into the atmosphere from the soil and other surfaces and by transpiration from plants.

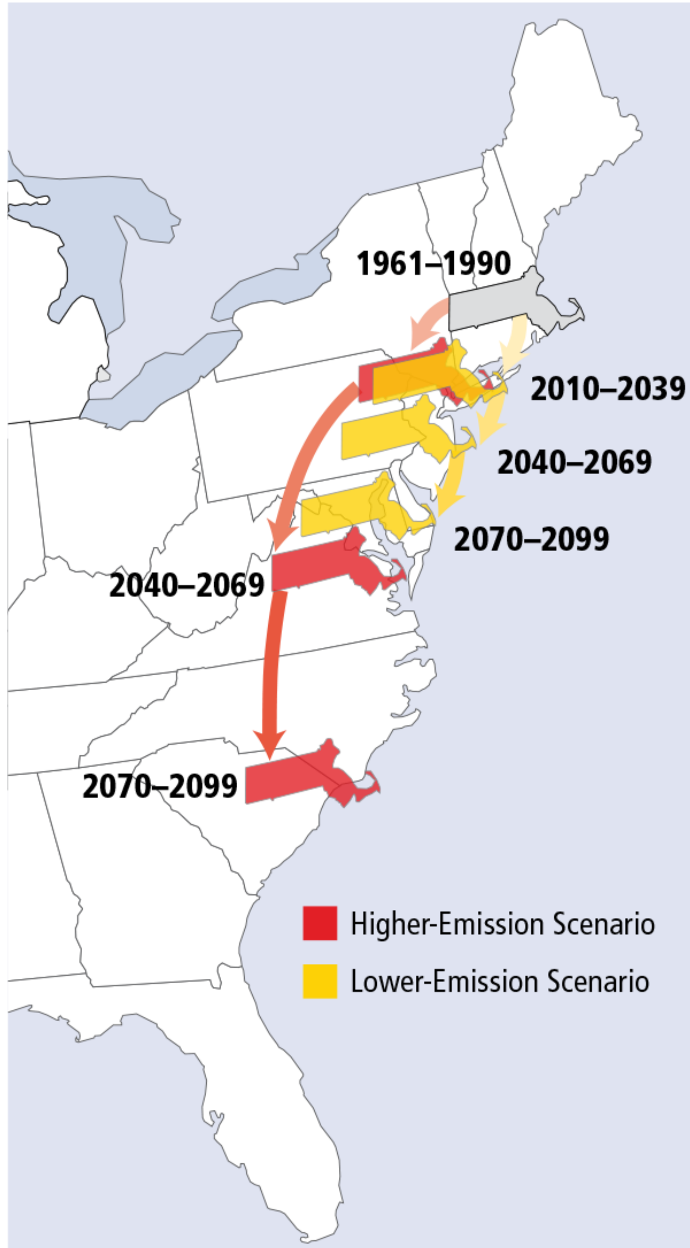


Figure B.14. Projected climate "migrations" for Massachusetts illustrate that average temperatures could be compared to South Carolina by 2070. (Source: Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions. Synthesis report of the Northeast Climate Impacts Assessment (NECIA). Cambridge, MA: Union of Concerned Scientists (UCS)).

37 IECC 2015

38 LEED V4

Actions Already Being Taken

- The City is already integrating guidelines and recommendations for new development to encourage implementing passive strategies, high-performance building envelopes, mixed-mode ventilation with passive cooling, reflective rooftops, and improved tree and vegetation coverage for building shading. These guidelines are in the context of aiming for official certifications such as Passive House or LEED.
- Public building capital costs are incorporating the revitalization of public buildings aligned with the proposed requirements in this Handbook.
- The Massachusetts Energy Stretch Code was adopted in 2009 for higher energy standards.
- The strategy and recommended actions are supporting other energy-related initiatives (e.g., LEED requirements, Energy Star).
- The City works in collaboration with the State and utilities programs encouraging solar energy and other renewable energy options, including the extension of storage capacity.

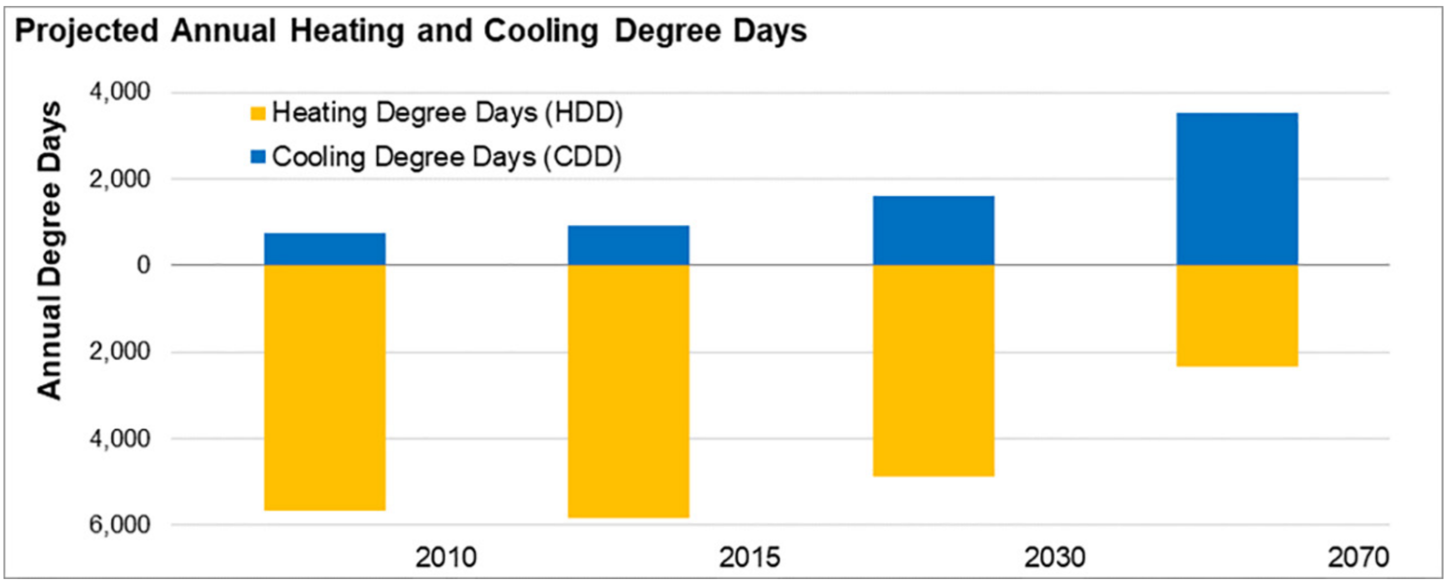


Figure B.15. Calculations based on Boston, MA, historical and future annual HDD and CDD normals. (Source: Petri, Y. and Caldeira, K. Impacts of global warming on residential heating and cooling degree-days in the United States, 2015. BuroHappold analysis for The Port Preparedness Plan, Appendix 2.)

B2 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**City, property owners**
Jurisdiction Who monitors the implementation?	☑ **City** ☐ **State** ☐ **Regional**
Type of Implementation How is the strategy categorized for the implementation type?	☑ **Pilot/Project/Study** ☑ **Policy/Regulations** ☐ **Program**
Scale What is the scale of the intervention?	☑ **Parcel** ☐ **Neighborhood** ☐ **Citywide** ☐ **Regional**
Related Strategies	**A2: Enhance Resilient Public Amenities** **A5: Support Business and Organizational Preparedness** **B4: Encourage Heat Protection For Existing Buildings** **B5: Support Building Management For Flood and Heat Protection**

B 3

Encourage Flood Protection For Existing Buildings

Implement the City's design guidelines for existing buildings to be resilient to future flood risks.

TOOLBOX ACTIONS

3.1 Retrofit/protect to the 2070 10-year flood elevation from precipitation or sea level rise/storm surge — whichever is higher as determined by the City's FloodViewer.

3.2 Retrofit to recover to the 2070 100-year flood elevation from precipitation or sea level rise/storm surge — whichever is higher as determined by the City's FloodViewer.

3.3 Elevate or protect vulnerable utilities, such as fuel storage, furnaces, and electrical panels, above the 2070 10-year flood elevation as determined by the City's FloodViewer.

3.4 Use flood resilient construction materials below the 2070 10-year flood elevation as determined by the City's FloodViewer.

3.5 Relocate living spaces out of basements if at risk of flooding on the FloodViewer.

Why is it Relevant to Cambridge?

The City of Cambridge has created a web-based GIS application and associated database called FloodViewer, where one can assess projected flood elevations — with climate change projections — at a parcel level. The web application is publicly available to inform residents about the risk and vulnerability of specific buildings and facilities. New buildings should meet standards informed by predicted climate change and flooding risk to the City in 2070.

Actions Already Being Taken

- The City is also working with developers and property owners to implement guidelines and recommendations for flooding mitigation strategies to protect facilities.
- The City is informing residents and business owners by publishing tools such as the "Flooding: Is Your Property Protected?" brochure and the MVP Preparedness Toolkits.

Figure B.16. FloodViewer 2.1 documenting possible flood elevations per parcel.

B3 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**City, property owners**
Jurisdiction Who monitors the implementation?	☑ **City** ☐ **State** ☐ **Regional**
Type of Implementation How is the strategy categorized for the implementation type?	☑ **Pilot/Project/Study** ☐ **Policy/Regulations** ☑ **Program**
Scale What is the scale of the intervention?	☑ **Parcel** ☐ **Neighborhood** ☐ **Citywide** ☐ **Regional**
Related Strategies	**A5: Support Business and Organizational Preparedness** **A6: Protect Community Resource Buildings** **D3: Reduce Impervious Area** **D4: Seek Green Infrastructure Opportunities**

B4 Encourage Heat Protection For Existing Buildings

Implement the City's design guidelines for existing buildings to be resilient to future heat risks.

TOOLBOX ACTIONS

4.1 Maximize opportunities for natural ventilation and upgrading building mechanical systems, and install ceiling fans (where applicable) for improved passive survivability.

4.2 Install backup solar energy and storage power systems, and separate circuits for critical building loads including air-conditioning.

4.3 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), non-roof surfaces with a minimum solar reflectance of 0.33, or install cool or green roofs (structural capacity dependent).

4.4 Replace windows with low-emittance (low-e) glass windows with a U-value maximum of 0.03.

4.5 Encourage temperature control set-points to mitigate higher temperatures during the summertime.

4.6 Encourage LEED certification for existing buildings.

Why is it Relevant to Cambridge?

Building weatherization offers proven measures that will save energy and lower energy costs. It also helps existing homes adapt to days of extreme heat and cold. Examples include re-insulation and air sealing of building envelopes to meet current code requirements, replacing windows with low-e windows and maximum U-values of U-0.03, and exterior shading and reflective roofing materials. Considering projected climate stresses in the future, upgrading buildings for Heating Ventilation and Air Conditioning (HVAC) systems will improve ventilation and save energy from trying to adapt to fluctuating temperatures. Additionally, thermostats and temperature control set-points should be increased within the American Society of Heating, Refrigerating and Air-Conditioning Engineers' (ASHRAE) comfort temperature range of 67 to 82 degrees, to reduce energy consumption and cooling loads during the summer.

Existing homes and businesses will be more resilient to climate change stresses when they have access to alternative energy sources, such as solar and storage, or natural gas backup generators, in tandem with circuits dedicated to critical equipment. This will reduce possible energy-supply disruption due to increased demand or shortage caused by extreme events.

For additional building heat protection, the City recommends proper maintenance of mature trees on public and private property, planting more trees to provide shade to buildings, and advocating for vegetative shading. Improved building shading will help reduce the cooling load on the building. Additional benefits to increased tree coverage are the trees' ability to reduce heat-island effects and improve air quality.

By implementing the suggested measures, Cambridge buildings will increase their passive survivability, allowing buildings to maintain a comfortable environment in case of emergency or lack of power.

Actions Already Being Taken

- The City is already testing the implementation of guidelines and recommendations established for homeowners, such as promoting and incentivizing weatherization, improved building envelopes and shading, rooftop reflectivity and low-e windows with improved U-values; and encouraging HVAC system replacement and improved ventilation systems and strategies, along with improved space temperature control and set-points, and backup solar energy and storage power systems.
- The City's capital improvements are including the revitalization of public buildings in alignment with proposed requirements in this Handbook.

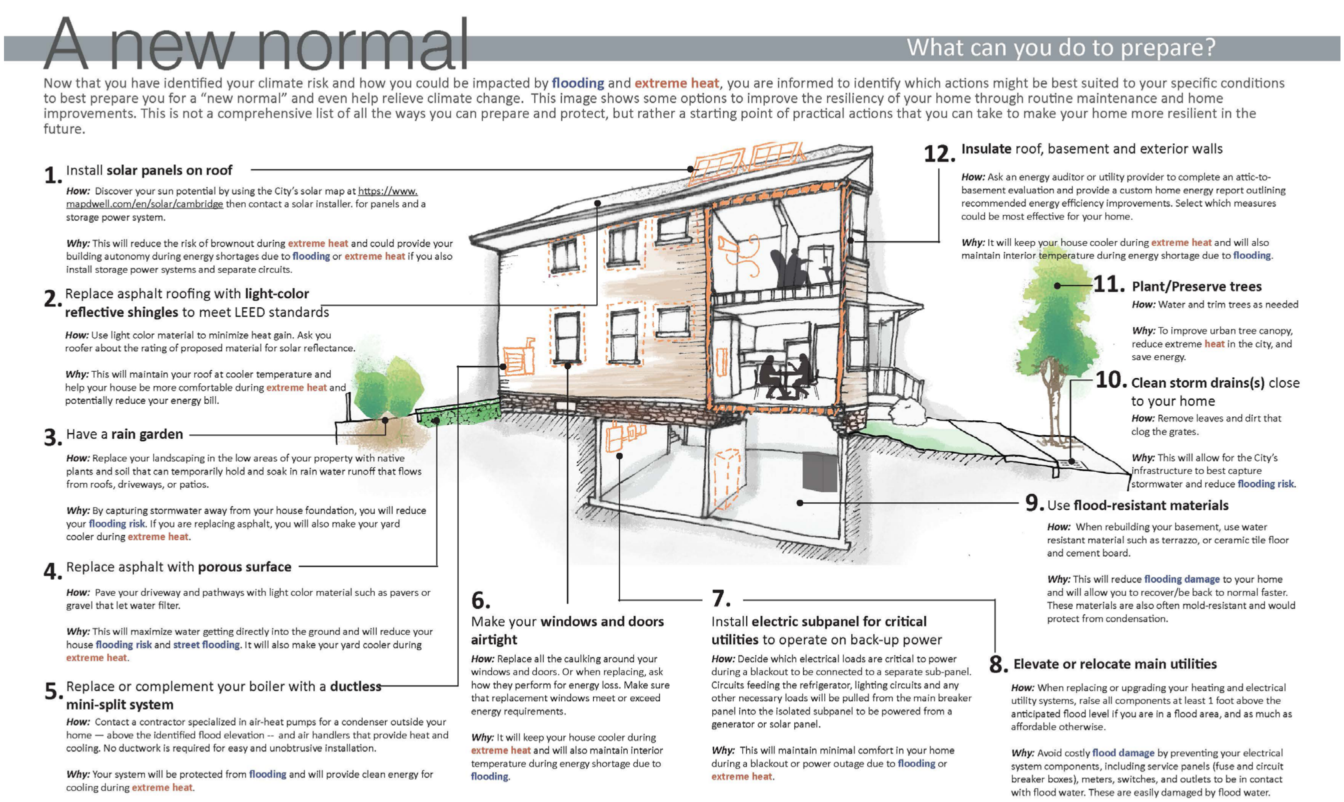


Figure B.17. A snapshot from the City of Cambridge's resident toolkit for extreme weather events. (Source: City of Cambridge Resiliency Toolkits, funded by an MVP Grant, 2019)

B4 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**City, property owners**
Jurisdiction Who monitors the implementation?	☑ **City** ☐ **State** ☐ **Regional**
Type of Implementation How is the strategy categorized for the implementation type?	☑ **Pilot/Project/Study** ☐ **Policy/Regulations** ☑ **Program**
Scale What is the scale of the intervention?	☑ **Parcel** ☐ **Neighborhood** ☐ **Citywide** ☐ **Regional**
Related Strategies	**A2: Enhance Resilient Public Amenities** **A5: Support Business and Organizational Preparedness** **B2: Regulate Heat Protection For New Buildings** **B5: Support Building Management For Flood and Heat Protection** **D1: Provide For a Resilient Urban Forest**

B5 Support Building Management For Flood and Heat Protection

Integrate resiliency actions into building management and operations planning and projects.

TOOLBOX ACTIONS

5.1 Require that commercial and multi-family residential buildings over 10 units have a maintenance plan and emergency plan for maintaining, at a minimum, basic services during and after flood and heat events.

5.2 Require that new buildings include building management systems/smart thermostats and energy management systems.

5.3 Ensure all new buildings are "generator ready" and there are transfer switches and quick-connect outlets for existing buildings.

5.4 Consider distributed energy systems (on-site generation) that allow autonomy in new buildings during outages.

5.5 Increase tree and vegetative cover and maintain existing green spaces to help buffer heat and flooding.

Why is it Relevant to Cambridge?

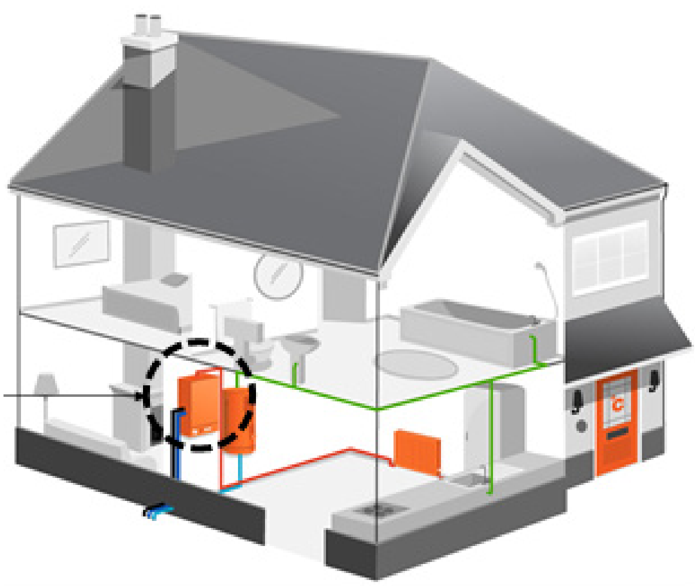
Some neighborhoods will inevitably experience regular or episodic flooding, leaving portions of buildings subject to damage. With increasing temperatures similar to current-day Virginia along with increasing heat days, infrastructure and buildings will potentially be left without power. This will require active management techniques before, during, and after events to ensure public safety and reduce damage. Professionally managed buildings can use technology and institute procedures to reduce damage and continue operations. Examples include deploying temporary flood barriers, removing vehicles from flood-prone areas, elevating or shutting off systems in flood zones, managing power to prevent outages, and powering critical systems during outages. Even Cambridge's small-scale buildings can adopt resiliency efforts, such as installing backup generators or solar thermal or photovoltaic (PV) systems, installing smart thermostats, and devising emergency plans.

Building maintenance plans are preventative measures that will reduce damage and failure of systems during events. After the event, swift removal of waterborne materials is essential, such as pumping standing water, hosing down flood deposits or debris, and removing wet or damaged materials before they develop mold.

The ability to maintain power to critical systems is also important. Components such as building management systems and energy management systems can localize or reduce energy consumption, as well as communicate to the grid when needed. In addition, installing backup power systems or having the ability to quickly connect to emergency power systems is essential.

Garages and lobbies are a good example of areas that can recover from flooding events with proper management. Protection of structural elements and electrical systems will require special procedures before and during flood events. In some cases, building entrances and lobbies subject to flooding can quickly recover with small efforts by management. For example, elevators can be designed to withstand flooding by removing all equipment to upper levels and waterproof controls within the flood zone.

For additional heat protection for buildings, the City recommends maintaining mature trees on public and private property, planting more trees to provide shade to buildings, and advocating for vegetative shading. Improved building shading will help reduce the cooling load on the building. Additional benefits to increased tree coverage are trees' ability to reduce heat-island effects, improve air quality, and increase evapotranspiration.



Actions Already Being Taken

- The Cambridge Multi-Family Energy Pilot, the City of Cambridge and Eversource partnered to launch a multifamily energy pilot program to help apartment and condominium buildings save energy. The program offers whole-building energy assessments, free solar assessments, and free retrofit advisory services. In the first year, 1,300 households participated in the program.
- The Department of Public Works has developed and maintains a comprehensive tree inventory of public street and park trees and continues to oversee tree plantings throughout the City. Residents may request trees in front of their property for a fee.
- The City of Cambridge developed a comprehensive Urban Forest Master Plan. The Plan provides an overview of current and future threats to the urban forest specific to climate change and how threats will affect existing trees and the choice of species for future plantings.

Figure B.18. A micro-CHP system for residential and small commercial buildings reduces electricity need during normal operation, and provides backup heat and power for critical loads. (Source: U.S. EPA Combined Heat and Power Partnership)

B5 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**City, property owners**
Jurisdiction Who monitors the implementation?	☑ **City** ☐ **State** ☐ **Regional**
Type of Implementation How is the strategy categorized for the implementation type?	☑ **Pilot/Project/Study** ☑ **Policy/Regulations** ☐ **Program**
Scale What is the scale of the intervention?	☑ **Parcel** ☐ **Neighborhood** ☐ **Citywide** ☐ **Regional**
Related Strategies	**A5: Support Business and Organizational Preparedness** **D1: Provide For a Resilient Urban Forest**

B6 Promote Site Green Infrastructure

Implement Green Infrastructure (GI) at the parcel level to improve water management and reduce the heat-island effect.

TOOLBOX ACTIONS

6.1 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 include:

- Using porous (pervious) pavement for driveways and parking stalls.
- Installing bioretention basins, such as rain gardens, tree boxes, infiltration planters.
- Installing green roofs.
- Harvesting rainwater using blue roofs, rain barrels, etc.

6.2 Preserve and Increase tree and vegetative coverage; plant roots absorb water and foliage protects against heat. Revegetate when possible.

Why is it Relevant to Cambridge?

Impervious surfaces, which are defined as constructed surfaces including buildings, roads, parking lots, brick, asphalt, and concrete, are a significant contributor to surface run-off, thereby impacting stormwater management. As an example, close to 50% of the urban land in the Alewife Neighborhood, excluding the Fresh Pond Reservation, is impervious. GI can supplement the gray infrastructure already in place in Cambridge to increase stormwater storage capacity.

GI is also proven to be effective in reducing the UHI effect. Urban areas such as Cambridge will see heat vulnerability exacerbated.

The number of days over 90 degrees is projected to nearly triple by 2030. Such temperature increases are dangerous to public health. GI can reduce the levels of excess energy through absorption and the evaporation of water, and can thus be used to reduce the outdoor temperature in urban areas.

Actions Already Being Taken

- The City requires buildings of at least 25,000 square feet of gross floor area to meet the requirements of the most current applicable LEED building rating system, which includes site GI requirements (Source: The Green Building Requirements, Article 22, "Sustainable Design and Development," of the Zoning Ordinance).
- The City has implemented a "25:2" compensatory stormwater requirement storage for redevelopment

activities, and is required to reduce phosphorus loadings to surface waters as part of MS4 compliance and permitting (e.g., 65% total phosphorous reductions required by Charles River total maximum daily load (TMDL) and 60% reduction target for Mystic River alternative TMDL). These requirements are both drivers that have resulted in increased adoption of green infrastructure. The City currently reviews all redevelopment activities — as well as City projects on municipally owned parcels and public ROW — for opportunities to leverage green infrastructure to achieve compensatory storage, flood mitigation, and water quality outcomes.

- The City is giving Floor Area Exemptions for Functional Green Roof Area (Zoning Ordinance Article 22, Subsection 22.30).
- The City developed an Urban Forest Masterplan to understand the existing tree canopy and heat vulnerability. This document identifies areas for improvement and makes recommendations for smart planting and targets to reduce UHI. The City, in coordination with the Climate Resilience Zoning Task Force (CRZTF), is studying the adoption of a cooling guide to enhance planting trees, landscape, lighter-colored materials and structural shading for implementation at the parcel level.

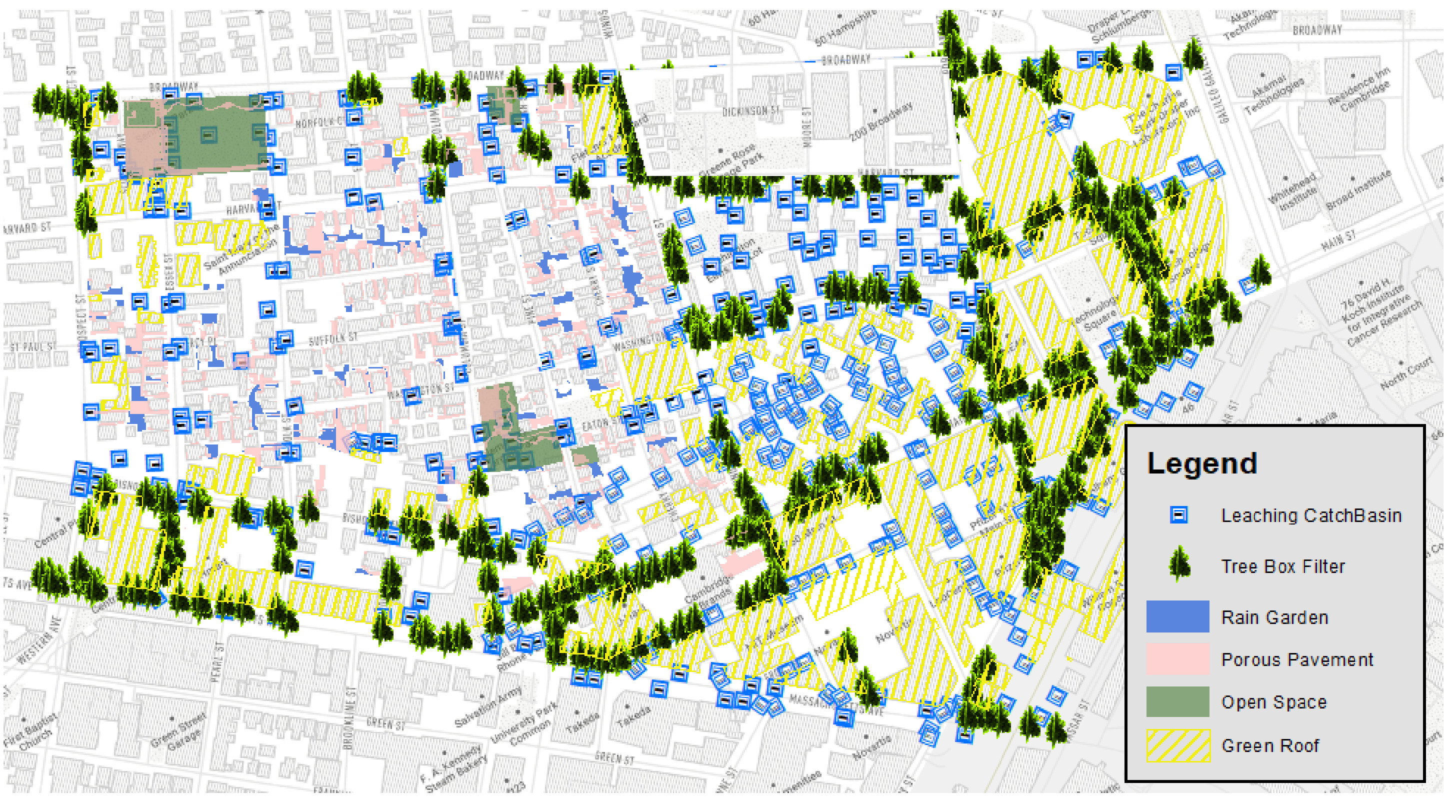


Figure B.19. Types of green infrastructure considered for the Port (outside the resilient blocks), showing their maximum implementation potential. (Source: Appendix 1: Gray and Green Infrastructure Analyses for the Port for the Port Preparedness Plan, 2019)

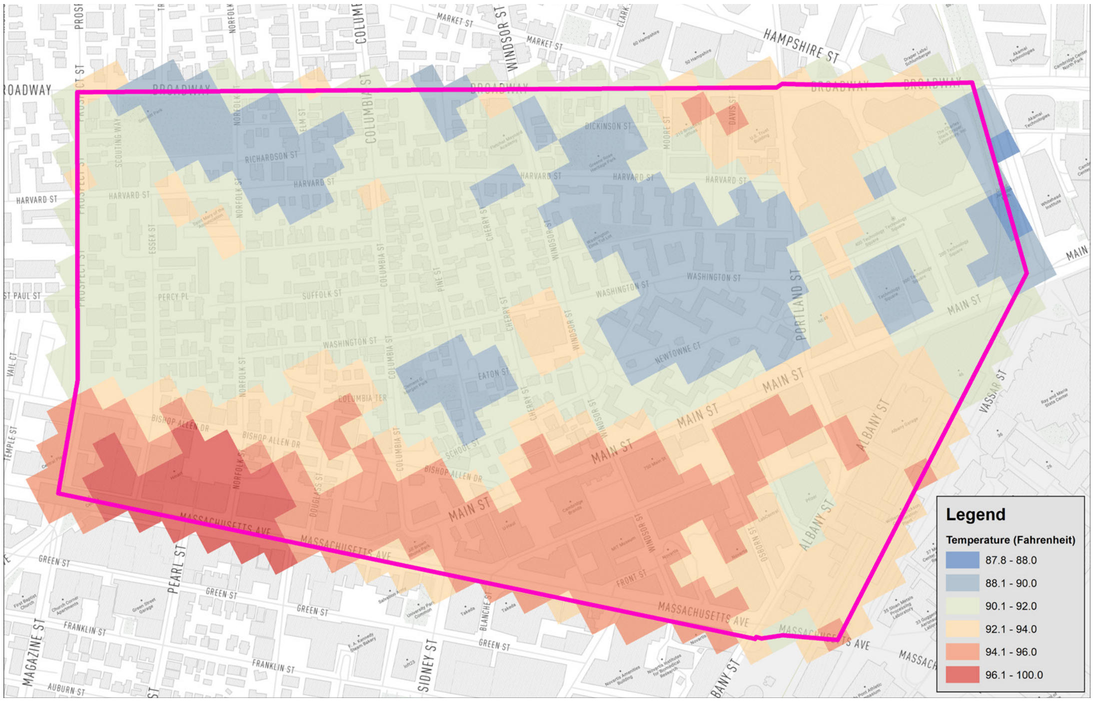


Figure B.20. *Ambient temperature on a 90-degree day in the Port under existing conditions. (Source: CCPR: The Port Preparedness Plan, Appendix 1)*

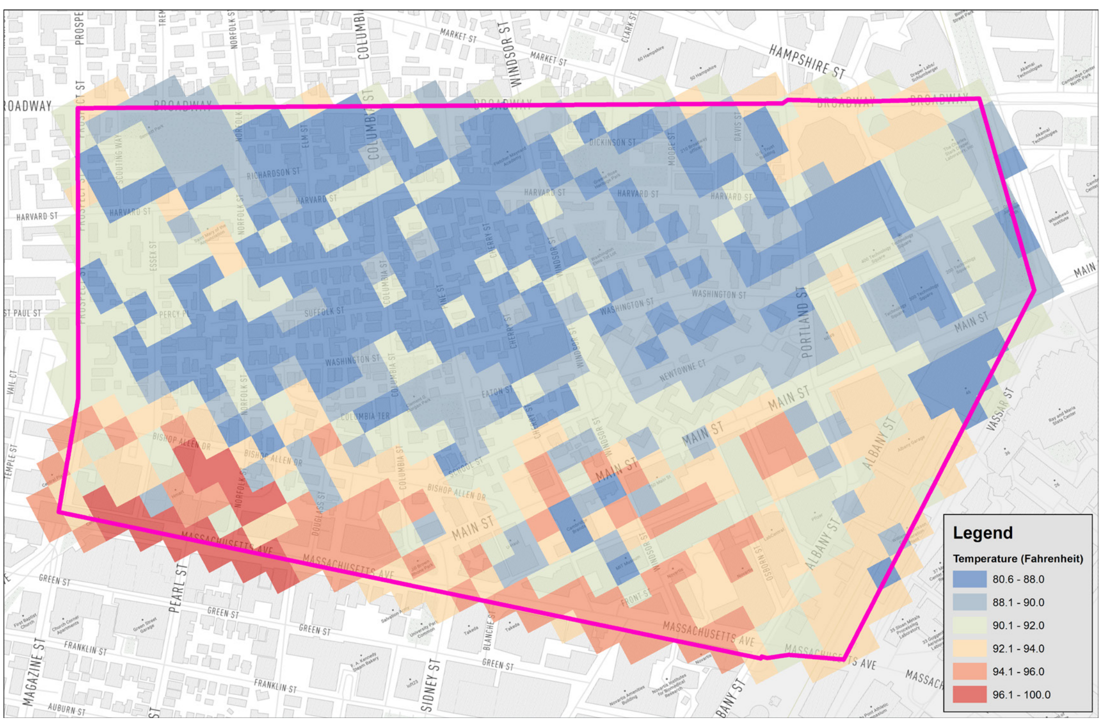


Figure B.21. Ambient temperature on a 90-degree day in the Port with improvements from green infrastructure and white roofs. (Source: CCPR: The Port Preparedness Plan, Appendix 1)

B6 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**City, property owners**
Jurisdiction Who monitors the implementation?	☑ **City** ☐ **State** ☐ **Regional**
Type of Implementation How is the strategy categorized for the implementation type?	☐ **Pilot/Project/Study** ☑ **Policy/Regulations** ☐ **Program**
Scale What is the scale of the intervention?	☑ **Parcel** ☐ **Neighborhood** ☐ **Citywide** ☐ **Regional**
Related Strategies	**D1: Provide For a Resilient Urban Forest** **D2: Enhance Outdoor Thermal Comfort** **D4: Seek Green Infrastructure Opportunities**

B7 Establish Adapted Zoning Policies and Regulations

Revise zoning to factor in climate change risks such as flooding and extreme heat. Advocate for updated building requirements and guidelines that address climate change, such as revised flood elevations and enhanced energy performance.

TOOLBOX ACTIONS

7.1 Amend Cambridge Flood Protection Overlay Districts (Section 20.70 of Zoning Ordinance) to include projected 2070 10-year (10% probability) events.

7.2 Update City of Cambridge Zoning (Article 5.0) dimensional standards to include building height exceptions to factor in flood elevation requirements.

7.3 Adopt, in the zoning code, a model "resiliency district" that describes the characteristics a prepared community would like to see in new developments.

7.4 Advocate for the Massachusetts building code 780 CMR to modify the definition of base flood elevation to anticipate 2070 flood elevation.

7.5 Create tools and resources to enforce the energy code, especially for commercial buildings; advocate for State policies that encourage on-site renewables and zoning barriers, such as the ability to serve residents in multiple buildings and ground-mounted solar.

7.6 Encourage insurance companies to provide discounts for basic resiliency improvements.

7.7 Identify funding sources for homeowners to incentivize utility improvements.

7.8 Promote and incentivize programs that encourage weatherization, upgrading building envelope, and shading buildings for improved passive survivability.

7.9 Create incentives for stormwater catchment overlay districts to encourage and support implementation of GI in strategic locations where they will have the most impact.

Why is it Relevant to Cambridge?

The detailed analyses of flooding risks for Cambridge, performed as part of the Climate Change Vulnerability Assessment, demonstrate that risk is not the same within the City. Some areas, such as Alewife and the Port, have a greater probability of experiencing severe flooding with climate change. As shown by the City's

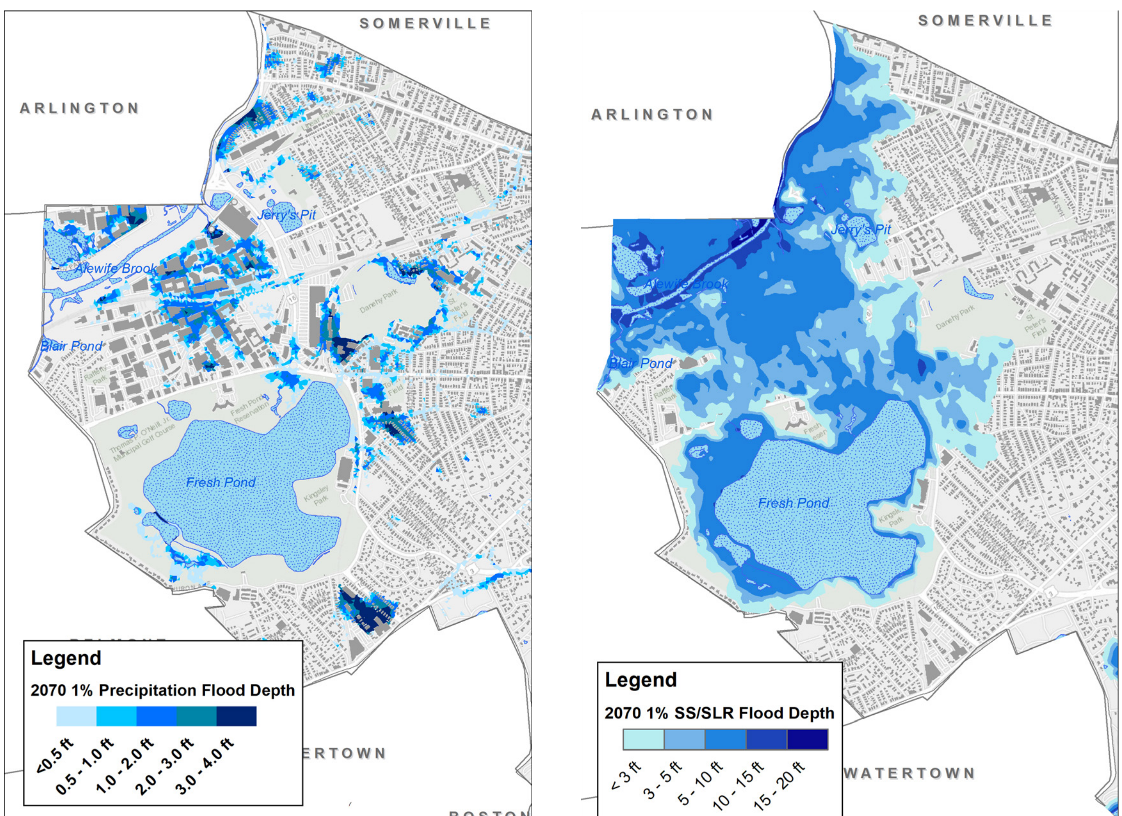
FloodViewer, requirements can be targeted to most at-risk areas, on a parcel-by-parcel basis, to adapt to projected flood elevations. The advantage of expanding the definition of the flood risk to include projected flood levels to 2070 is to provide a concerted, long-term, urban design approach to develop an enjoyable public realm while protecting buildings from flooding.

The City will advocate for updating State and model building codes to support climate readiness.

While the energy code proposes more strict requirements, there are gaps between what is required and what is built, due to inadequate enforcement tools. To complement the energy code, tools and resources should be created to enforce the code, especially for commercial buildings.

Actions Already Being Taken

- The City is coordinating with developers for new construction to adapt to projected flood elevation for 2070.
- The City is coordinating with the Metro Mayors' Coalition.
- The City Manager has appointed a Climate Resilience Zoning Task Force comprising a variety of community stakeholders and perspectives to identify areas of the existing zoning ordinances that could be updated to plan for future climate conditions.



2070 1% Precipitation Event **2070 1% SLR/SS**

Figure B.22. Depth of flooding above ground for a 1% precipitation event and a 1% sea level rise/storm surge event in 2070. (Source: Kleinfelder for CCVA Part 1 Revision, 02-2017 & CCVA Part 2)

B7 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**City, State**
Jurisdiction Who monitors the implementation?	☐ City ☑ State ☐ Regional
Type of Implementation How is the strategy categorized for the implementation type?	☐ Pilot/Project/Study ☑ Policy/Regulations ☐ Program
Scale What is the scale of the intervention?	☐ Parcel ☐ Neighborhood ☑ Citywide ☐ Regional
Related Strategies	A5: Support Business and Organizational Preparedness A9: Encourage Stronger Social Network B1: Regulate Flood Protection For New Buildings B2: Regulate Heat Protection For New Buildings B3: Encourage Flood Protection For Existing Buildings B4: Encourage Heat Protection For Existing Buildings B5: Support Building Management For Flood and Heat Protection B8: Study Adapted Planning For Resilient Urban Blocks

B8 Study Adapted Planning For Resilient Urban Blocks

Neighborhoods should maximize benefits through targeted implementation of resiliency strategies at the urban block scale.

TOOLBOX ACTIONS

8.1 Identify potential blocks and study the effectiveness of special incentive zones.

8.2 Convene resilient block task force groups under the guidance of the City to focus on developing an implementation plan.

8.3 Create partnerships to cross boundaries of private and public land to create connected green solutions to stormwater flooding and UHI reduction.

8.4 Implement improved roofs, such as cool roofs, solar PV, blue roofs, and green roofs, on every building.

8.5 Increase tree canopy in both the private and public realm.

8.6 Use green infrastructure and light-colored surfaces on the ground between buildings.

Why is it Relevant to Cambridge?

The urban block presents an opportunity for innovative projects in the neighborhood to demonstrate how maximum resiliency efforts for buildings, drainage and energy systems, and ecosystems can reduce flooding and UHI effect, and increase energy resiliency in one defined area. The idea for change pushes resiliency strategies to the maximum implementation possible to explore how efforts in strategic locations could benefit the resiliency of the neighborhood.

An urban block is the smallest area in an urban neighborhood that is surrounded by streets. It is usually divided into any number of smaller lots in private and/or public ownership but sometimes only one building or a park constitutes an entire block. An urban block supports neighbors with abutting properties and supports shared interests and investments in the surrounding community.

If each property within a resilient urban block is built to its maximum potential with respect to climate change, then residents of the block receive greater benefits in terms of resiliency improvements. These benefits could spread citywide if the resilient urban block is combined with other properties.

Table B.2 Maximum Projected Benefits For The Implementation Of Strategies For The Residential Block[39]		
Maximum Benefit		Co-benefits
Heat	Up to 2 degree reduction in ambient air temperature	Neighborhood beautification
Flooding	Peak flow reduced by 41% in the residential block	Stormwater quality improvement
Energy	3,070-3,780 MMBtu in energy savings if 85% of the buildings in the block are improved (in terms of total area), equivalent to the electricity usage from approximately 145 households	Mitigates approximately 200 metric tons CO_2e in GHG emissions, equivalent to the annual GHG emissions of 10 existing triple-deckers

Table B.3 Maximum Projected Benefits For The Implementation Of Strategies For The Mixed-Use Block[39]		
Maximum Benefit		Co-benefits
Heat	Up to 6 degrees reduction in ambient air temperature	Neighborhood beautification
Flooding	Peak flow reduced by 22% in the mixed use-block	Stormwater quality improvement
Energy	11,320-14,430 MMBtu in energy savings if 88% of the buildings in the block (in terms of total area), equivalent to the electricity usage from approximately 545 households	Mitigates approximately700 metric tons CO_2e in GHG emissions, equivalent to the annual GHG emissions of 35 existing triple-deckers

Actions Already Being Taken

- The Port Morgan Stormwater Tank project is considering opportunistic the implementation of gray and green infrastructure in public right-of-way and private properties to the maximum extent possible.

39 The Port Preparedness Plan, 2019 https://www.cambridgema.gov/-/media/Files/CDD/Climate/CCPR/ccprtheportplan/ccprtheportfinalpages52819processed.pdf

B8 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**City, property owners**
Jurisdiction Who monitors the implementation?	☑ **City** ☐ **State** ☐ **Regional**
Type of Implementation How is the strategy categorized for the implementation type?	☑ **Pilot/Project/Study** ☐ **Policy/Regulations** ☑ **Program**
Scale What is the scale of the intervention?	☐ **Parcel** ☑ **Neighborhood** ☐ **Citywide** ☐ **Regional**
Related Strategies	**B1: Regulate Flood Protection For New Buildings** **B2: Regulate Heat Protection For New Buildings** **B3: Encourage Flood Protection For Existing Buildings** **B4: Encourage Heat Protection For Existing Buildings** **B9: Encourage Resiliency of Building Scale Energy**

B9 Encourage Resiliency of Building Scale Energy

Enhance energy resilience to provide energy autonomy during extreme events.

TOOLBOX ACTIONS

9.1 Upgrade building envelopes to maintain indoor temperature and reduce energy consumption.

9.2 Add solar PV systems to building roofs, which can be connected to battery backup for redundancy during a power outage.

9.3 Install a backup generator to ensure that emergency power is available.

Why is it Relevant to Cambridge?

Power outages during periods of extreme heat create additional economic and public health issues, as the systems that maintain safe thermal conditions and critical life support functions may not function, and indoor environmental conditions may progress from uncomfortable to unsafe. This risk is not limited to extreme heat — lack of power during wintry weather conditions are equally dangerous. Extended power outages that last multiple days increase this risk, as indoor temperatures may quickly rise or plummet in buildings that were not designed for high thermal performance.

During a summer power outage, temperatures within a single-family wood-frame house — a similar construction type to Cambridge's double/triple-deckers — would exceed 90 degrees within three days. During a winter power outage, temperatures within that same building could drop below 50 degrees within 24 hours.

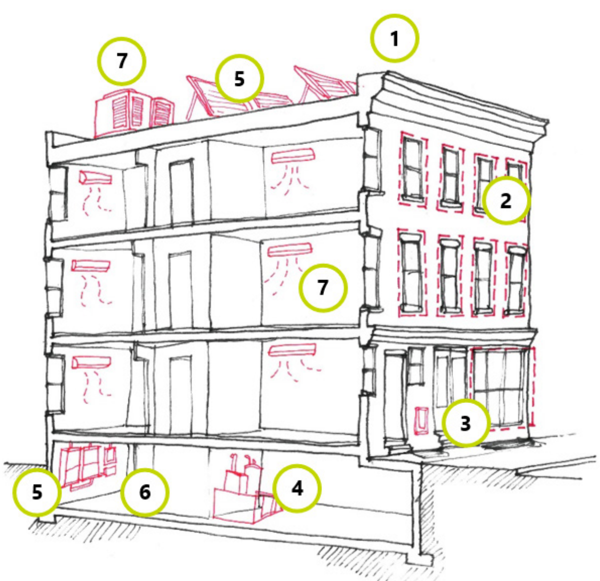
As the risks of climate change become more well defined, there has been a growing interest in strategies to keep building occupants safe and provide some measure of functionality during prolonged outages.

Actions Already Being Taken

- The Cambridge Energy Alliance launched the Multi-Family Energy Pilot in 2017 to help multifamily condominiums and apartment buildings implement solar energy and energy efficiency upgrades. This pilot provides residents with a Retrofit Advisor to facilitate energy and solar assessments, identify qualified contractors, and determine the most appropriate financing options for their project. Since the Pilot was launched, more than 1,300 households have participated.
- Mass Save is a statewide gas and electric utility-run program that offers services and incentives for a wide range of energy upgrades. This includes energy-efficiency rebates and incentives for

building owners and tenants, which cover heating and cooling system upgrades, building envelope improvements (e.g., insulation, air sealing), and new construction and major renovations. Mass Save also administers the HEET Loan program, which provides qualified property owners and condominium owners with a zero-interest loan of up to $25,000 for certain energy efficiency improvements, including heat pump installations.

- The Massachusetts Clean Energy Center (MassCEC) is a state economic development agency dedicated to accelerating the growth of clean energy in Massachusetts. MassCEC offers rebates, vouchers, and loans for the installation of renewable clean energy technologies in residential buildings, and provides rebates and technical assistance for businesses interested in increasing their clean energy output. MassCEC also works with emerging industries within the clean energy sector, including energy storage and microgrids. In early 2018, MassCEC announced $1.05 million in funding for 14 microgrid feasibility studies as part of its Community Microgrids Program.
- The Solar Massachusetts Renewable Target (SMART) program, created by the Massachusetts Department of Energy Resources (MassDOER), is a long-term incentive program to support solar energy projects. The program offers tariff-based incentives paid by the electricity utility company directly to the solar energy system owners, who may be third-party operators. MassDOER also incentivizes the installation of technologies such as air source heat pumps (ASHPs) by providing Alternative Energy Certificates (AECs), which accrue based on output and can be sold through the Alternative Energy Portfolio Standard (APS) market. MassDOER and MassCEC have also jointly launched the Mass Solar Loan Program for residents interested in directly owning solar energy systems. This program provides low-interest, fixed-rate loans to both homeowners and small participants in community shared solar associations.



1. Paint or replace roofing with a reflective and/or light-colored coating
2. Install additional insulation and replace windows
3. Install exterior hookups for temporary backup heat and power
4. Elevate or flood-proof mechanical and electrical equipment
5. Install cogeneration or solar and energy storage system to provide backup power
6. Install sub-panel(s) to isolate critical loads for backup power
7. Install VRF system for cooling; heating where possible

Figure B.23. A commercial office retrofit prototype sketch. (Source: The Port Preparedness Plan Appendix 2)

B9 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**City, property owners**
Jurisdiction Who monitors the implementation?	☑ **City** ☐ **State** ☐ **Regional**
Type of Implementation How is the strategy categorized for the implementation type?	☐ **Pilot/Project/Study** ☐ **Policy/Regulations** ☑ **Program**
Scale What is the scale of the intervention?	☑ **Parcel** ☐ **Neighborhood** ☐ **Citywide** ☐ **Regional**
Related Strategies	**B1: Regulate Flood Protection For New Buildings** **B2: Regulate Heat Protection For New Buildings** **B3: Encourage Flood Protection For Existing Buildings** **B4: Encourage Heat Protection For Existing Buildings** **B8: Study Adapted Planning For Resilient Urban Blocks**

B 10 Develop Flood Protection and Operations Planning For Historic and Critical Facilities

Neighborhoods should maximize benefits through targeted implementation of resiliency strategies at the urban block scale.

TOOLBOX ACTIONS

10.1 Develop design guidelines for preparing historic buildings and critical facilities for climate change.

10.2 Build/retrofit critical facilities to the 2070 100-year (1% probability) event.

10.3 Develop flood operations plans for the City's critical facilities.

Why is it Relevant to Cambridge?

Climate change threatens infrastructure, critical services, public health, and the City's economic well-being. To 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.

Many buildings in Cambridge have a role in shaping the identity of both the neighborhoods and the City. Most of the historically designated buildings in Cambridge are small residential buildings.

Resilience to climate change risks is fundamental to the City of Cambridge's preservation goals. To maintain the rich historic fabric of the City, historic buildings should be enhanced or be protected as best possible from flooding caused by either extreme precipitation, sea level rise and storm surge, as well as extreme heat likely to trigger increased humidity. These events threaten the structure and materials of historic buildings. They also threaten the role that historic buildings and sites play in creating a sense of community and fostering social resilience .

Working with the Cambridge Historic Commission, the City could perform full risk and vulnerability assessments on historic structures. The City, in partnership with the Cambridge Historical Commission, could consider applying for funding through the Massachusetts State Historical Commission to develop climate resiliency design guidelines for historic buildings and districts. This approach could lead to developing and adopting design guidelines that recommend specific treatments for historic buildings and historic districts in response to climate change. Design guidelines would include recommendations for climate-resilient actions related to flooding, stormwater management, passive heating and cooling. Adopting design guidelines specific to climate-resilient actions provides the City and property owners with standards for how to approach changes to properties and historic districts, and alleviates a piecemeal and time-consuming review process that would otherwise occur.

There is also an opportunity in the development of guidelines to further research the role that historic buildings and sites play in creating a sense of community and fostering social resilience, and the importance of preserving this heritage. This is also true of intangible cultural heritage, which includes oral traditions, performing arts, social practices, rituals, festive events, knowledge, and practices concerning nature and the universe or the knowledge and skills to produce traditional crafts. The challenge is to make Cambridge more resilient without changing its sense of place and this is likely to be better addressed through a district-wide approach.

Actions Already Being Taken

- Renovations and new buildings in Cambridge are being required to build/protect to the 10-year storm event.

B10 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**City**
Jurisdiction Who monitors the implementation?	☑ **City** ☐ **State** ☐ **Regional**
Type of Implementation How is the strategy categorized for the implementation type?	☑ **Pilot/Project/Study** ☑ **Policy/Regulations** ☑ **Program**
Scale What is the scale of the intervention?	☑ **Parcel** ☐ **Neighborhood** ☐ **Citywide** ☐ **Regional**
Related Strategies	**B1: Regulate Flood Protection For New Buildings** **B2: Regulate Heat Protection For New Buildings** **B3: Encourage Flood Protection For Existing Buildings** **B4: Encourage Heat Protection For Existing Buildings** **B6: Promote Site Green Infrastructure**

Stronger Infrastructure

Strategies for Stronger infrastructure range from parcel- to regional-scale solutions for protection of critical infrastructure and mitigation of the negative impacts from both sea level rise/storm surge flooding and precipitation flooding.

These are the strategies that will help make Stronger Infrastructure:

1. Protect Fresh Pond Reservoir

Protect Fresh Pond Reservoir, the terminal reservoir for the City's drinking water supply, from future flooding impacts.

2. Encourage the Resiliency of the Electrical Distribution System

Engage with Eversource and the Massachusetts Public Utilities Commission to increase the resiliency of the electricity distribution system, particularly the Alewife substation.

3. Enhance the Resiliency of the Transportation System

Engage the MBTA and MassDOT to increase the resiliency of major transportation and transit infrastructure to ensure mobility and access to evacuation routes. Complete street grid by adding new local roads for better connectivity to the Alewife train station. Implementing complete street design for main mobility corridors could mitigate Urban Heat Island (UHI) and contribute to resilient stormwater management strategies.

4. Continue the Combined Sewer Separation

Continue combined sewer separation citywide to reduce adverse public-health impacts during flood events and to protect water quality.

5. Upgrade Stormwater Storage

Evaluate the collective benefits of adopting updated stormwater storage requirements at the parcel scale to mitigate flooding at the sub-neighborhood scale.

6. Support Sustainable Energy Infrastructure

Establish a Community Energy Pilot project. Encourage parking photovoltaic (PV) Canopies. Undertake a Microgrid Feasibility Study.

7. Implement Green Infrastructure For Stormwater Management

Implement Green Infrastructure (GI) to mitigate flooding during smaller or short-duration rainfall events, and contribute to water quality improvement. GI will also help improve urban tree canopy and mitigate effects of UHI.

8. Support a Resilient Telecommunication Network

Building and upgrading telecommunication facilities to the City's resilient building guidelines would be a key component in developing and providing a resilient network. Research a systems design platform that allows data to bypass traditional fiber optic lines and connect data centers to end users through a dedicated wireless network.

BEST PRACTICES

Many U.S. cities already experiencing the impacts of climate change are strengthening their built infrastructure to be resilient. These models provide a library of possible strategies that can inform the City's approach toward preparedness and resilience. Best practices documented in this section address flood control, innovative street design, an enhanced approach to energy production and distribution, and integrating clean energy.

Resilient Stormwater Infrastructure

Figure C.1. Portland Green Roof. (Source: Portland Environmental Services, Portland, Oregon)

EcoRoof Incentives, Portland, Oregon

The City of Portland, Oregon, offers incentives for EcoRoofs, more commonly known as green roofs (Figure C.1). Buildings with 60% or more green roof coverage can have higher development rights or Floor Area Ratio (FAR). The formula is for an additional 3 square feet of development for any additional square foot of green roof — above the 60% threshold[40]. The City of Austin, Texas, adopted a similar program by adopting a Green Roof Density Bonus, which can give a density bonus of up to 8 square feet for every square foot of green roof installed.

Save the Rain, Onondaga County, New York

Onondaga Lake was once the most polluted lake in North America. As part of the efforts to clean up the lake, the “Save the Rain” program aims to reduce combined sewer overflow (CSO) discharges by using a combination of gray and green infrastructure solutions. The program was able to reduce 95% of combined sewer overflow from a limited addition of gray infrastructure and an extensive use of green infrastructure, including rain barrels, tree pits, bioretention filter-strips, underground filtration systems, and porous pavements. The GI provided co-benefits by beautifying neighborhoods, adding open green space, and reducing localized flooding and basement backups.

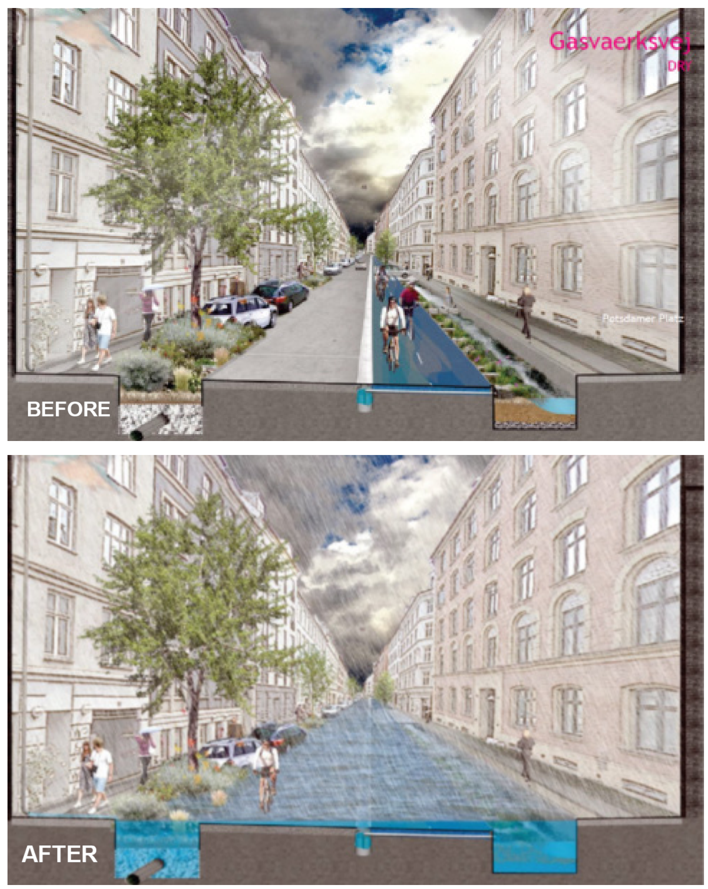


Figure C.2. Integrated green and gray infrastructures to maximize the public realm for flood resiliency. (Source: City of Copenhagen)

40 https://www.portlandoregon.gov/bes/article/127469

Innovative Street Design

Canal Streets, Copenhagen, Denmark

Some streets in Copenhagen, Denmark, are designed as “canal streets.” Canal streets use lowered street profiles (Figure C.2) that form a flood pathway or corridor, directing stormwater away from public spaces. Abutting open spaces and bio-retention basins aligned with streets also contribute to storing some excess stormwater if the corridors overflow due to a heavy rainfall event.

Figure C.3. Raised street and sidewalk in Sunset Harbour, Miami, Florida. (Source: The Miami Herald)

Raised Streets, Miami, Florida

Miami, Florida, is making efforts to elevate streets (Figure C.3) to protect the community from rapidly increasing sea-level rise (SLR)/storm surge (SS) impacts. This approach protects the roadways and requires redesigning building access to adjust to the higher street elevations.

Figure C.4. Solar panels on the rooftop of a building in Brooklyn, New York. (Source: Reuters)

Enhanced Energy Systems

Off-the-Grid Solar Array, New York City, New York

New York City provides residents with 3.5 kilowatt-hour (kW) of power through an off-the-grid solar array with battery storage (Figure C.4). The array is elevated and uses air-tight construction. It was able to generate electricity for small uses, such as mobile-device charging, after Hurricane Sandy in 2012 while the surrounding areas lost power.

Microgrids

Microgrids are small-scale distribution systems that link multiple distributed energy resources (DERs) into a network that can generate, store and control its own power. Microgrids can operate in tandem with the main power grid during normal conditions, but they also can disconnect and function as independent “islands” if the main grid fails.

Microgrids founding program, State of Connecticut

In July 2012, then-Connecticut Governor Dannel Malloy passed legislation demanding an improvement to the State's emergency preparedness and response efforts. In turn, Connecticut became the nation's first state to develop a program that funds the development of microgrids at critical facilities. Critical facilities eligible for the program are: hospital, police station, fire station, water treatment plant, sewage treatment plant, public shelter, correctional facility, municipal center, telecommunications equipment, gas station, pharmacy, and grocery store. The Town of Fairfield was among the first recipients of a grant award because of the new legislation[41] (Figure C.5).

The City constructed a 310-350 kW hybrid microgrid that serves three critical facilities (Police Headquarters, Fire Headquarters, and Operation Hope) that span over 2.5 acres. The project included the following elements: up-sizing a 50-kW natural gas-fired generator to a 60-kW generator by computer adjustment; replacing the diesel-fired emergency generator at the Police Headquarters with a natural-gas generator installed above the 100-year floodplain; and interconnecting all three buildings for electric service. The City installed a 20-kW PV system on Operation Hope's roof; a 27-kW PV generator was placed on the Fire Headquarters' roof; and a state-of-the-art controls system was installed at the Police Headquarters to ensure that the correct amount of electricity is delivered to each facility as needed, with green power having preference.

Figure C.5. Fairfield Town and Connecticut State officials at the unveiling of the municipal microgrid system on October 29, 2015. (Source: Fairfield Daily Voice)

41 http://se-enable.com/wp-content/uploads/MG_Fairfield-Case-Study_Digital.pdf

Parkville Microgrid, Hartford, Connecticut

The Parkville Microgrid project arose from the City's interest in a resilient power solution to serve critical community facilities that could act as a refuge for residents during emergencies or harsh weather. The final system was designed to serve 100% of electricity requirements for Parkville Elementary School, Dwight Branch Library, Parkville Senior Center, and Charter Oak Health Center (during non-emergency operation). In the event of electrical grid outage, the system will provide 640 kW of emergency power to these locations in addition to a local fuel station and grocery store. The Parkville microgrid uses natural gas-powered fuel cells, which, although not considered a renewable source of energy, produces fewer emissions than gas-fired electricity generation. The microgrid was funded through a public-private partnership between the City of Hartford, microgrid operator Constellation, and fuel cell provider Bloom Energy. Additionally, numerous state grants and incentives, including Renewable Energy Credits, were used.

Hardened Electrical System, Arverne, New York

Efforts in Arverne, New York, are making the electrical distribution system more resilient (Figure C.6) in response to damages sustained during Hurricane Sandy. Electrical lines are hardened by burying them underground to prevent damage from extreme weather. Additionally, transformers have been elevated and made waterproof. All mechanical systems are required to be on the upper floors to prevent damage in case of flooding.

Figure C.6. Arverne, New York. (Source: Arverne by the Sea, NY. September, 2014 ULI)

Cogeneration Plant, New York University, New York

Cogeneration (cogen) uses a heat engine or power station to simultaneously generate electricity and useful heat (Figure C.7). Like microgrids, cogen plants can operate as independent "islands" in the event of a grid failure.

During and after Hurricane Sandy in 2012, when Con Edison's electrical grid shut down in Manhattan below midtown, New York University (NYU) benefited from its cogen plant, which was built in 2011. The plant at NYU produces electricity, hot water, heat, and chilled water. Once the plant's controls sensed that power was not flowing from the grid, the plant automatically isolated itself and began operating independently[42]. The 22 buildings connected to NYU's cogen plant for electricity continued to have power, heat, and hot water, and reconnected to the grid once Con Edison was able to restore power.

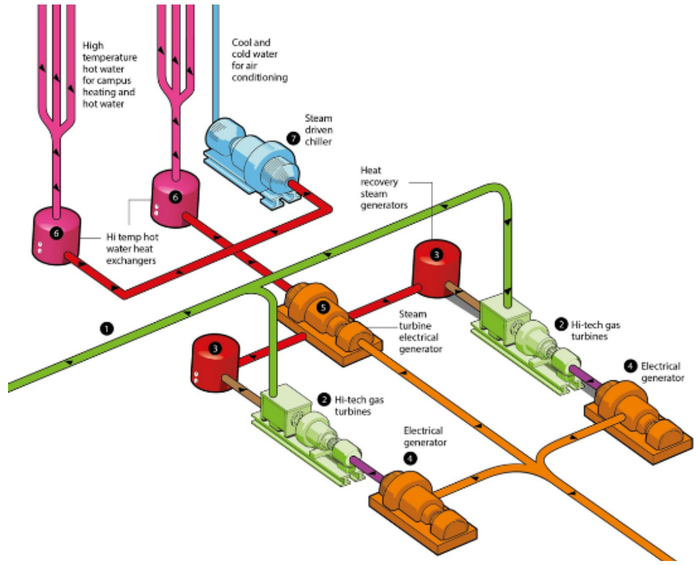


Figure C.7. Gas-fired cogeneration plant. (Source: New York University)

Smart Power, Salem, Oregon

The City of Salem, Oregon, provides backup power for the regional grid via a 5-MW (megawatt) lithium-ion battery capable of storing 1.25 MWh (megawatt hours) of energy. The center is designed to test how to better integrate renewable energy, such as solar and wind power, into the electrical grid. It utilizes stored renewable energy during peak energy loads and helps stabilize the grid during power outages. The Smart Power Center has demonstrated the ability to access power from third-party generators to create a microgrid that can serve about 500 business and residential customers in southeast Salem.

42 https://www.edf.org/blog/2013/10/29/two-technologies-literally-shone-during-sandys-darkest-hours

RELEVANCE TO CAMBRIDGE

Table C.1 provides a summary of how the best practices inform the development of specific strategies for Stronger Infrastructure.

Table C.1 List of Strategies and Related Best Practices

Strategy	Title	Related Best Practice	Description
C1	**Protect Fresh Pond Reservoir**	The Big U, New York City, New York	The Big U provides resilient infrastructure strategies by combining amenities for recreational uses along berms, as well as protecting from flooding. It combines public realm enhancement with resilience measures in an approach compatible with Cambridge strategies.
C2	**Encourage the Resiliency of the Electrical Distribution System**	Hardened Electrical System, Averne, New York	Arverne, New York, is making its electrical distribution system more resilient in response to damage from Hurricane Sandy. A series of measures have been evaluated. For example, transformers must be elevated and made waterproof, and mechanical systems must be on upper floors above projected flood elevations.
		Smart Power, Salem, Oregon	Smart Power integrates renewable energy, such as solar and wind power, into the electrical grid so that it can be used during peak energy loads and help stabilize the grid during power outages.
C3	**Enhance the Resiliency of the Transportation System**	Raised Streets, Miami, Florida	The raised streets are protected from flooding and help maintain accessibility. This approach, however, requires redesigning access to buildings to adjust to the higher street elevations.
		Canal Streets, Copenhagen, Denmark	The Canal Streets form a flood pathway corridor, directing stormwater away from public circulation. The abutting open spaces and bio-retention basins also help store some excess stormwater if the corridors overflow due to heavy rainfall events. The maximization of the street stormwater capacity might provide strategies for Cambridge's underground space that is crammed with competing utilities.

Table C.1 List of Strategies and Related Best Practices (continued)			
Strategy	**Title**	**Related Best Practice**	**Description**
C4	**Continue the Combined Sewer Separation**	City of Cambridge Combined Sewer Separation	The City of Cambridge is working to separate combined sewers citywide. This has helped reduce the amount of negative impacts to public health and water quality during flood events.
C5	**Upgrade Stormwater Storage**	EcoRoof Incentives, Portland, Oregon	The EcoRoof (green roof) incentives allow for the implementation of stormwater storage at the parcel-scale, which benefits the neighborhood.
C6	**Support Sustainable Energy Infrastructure**	Off-the-Grid Solar Array, New York City, New York	The City provided power to residents through an off-the-grid solar array with 3.5 kW of power and battery storage.
		Cogen Plant, New York University, New York	During and after Hurricane Sandy in 2012, when Con Edison's electrical grid shut down, New York University (NYU) benefited from its cogen plant. The plant operated independently of the grid and was able to power 22 buildings with electricity, heat, and hot water. The plant reconnected to the grid once Con Edison was able to restore its power. This could be a viable approach for Cambridge's large institutional stakeholders.
		Parkville Microgrid (Hartford, CT)	The Parkville Microgrid project provides for a resilient power solution to serve critical community facilities that could act as a refuge for residents during emergencies or harsh weather.
		Microgrids founding program, State of Connecticut	Connecticut became the nation's first state to develop a program that funds the development of microgrids at three critical facilities (Police Headquarters, Fire Headquarters, and Operation Hope). The approach is aligned with Massachusetts' goals for energy resiliency and the City of Cambridge Net Zero goal.

Table C.1 List of Strategies and Related Best Practices (continued)			
Strategy	**Title**	**Related Best Practice**	**Description**
C7	**Implement Green Infrastructure (GI) Opportunities For Stormwater Management**	Philadelphia Water Department, City of Philadelphia	Green City, Clean Waters is a program created by Philadelphia Water to meet the City of Philadelphia's Clean Water Act obligations by reducing stormwater pollution and overflows in the combined sewer systems. The program uses green stormwater infrastructure (GSI) systems in public rights-of-way, and public and private properties. The City of Cambridge is considering similar opportunities of implementing GI in capital projects as well as finding opportunities to implement GI on private properties.
C8	**Support a Resilient Telecommunication Network**	San Juan, Puerto Rico	AeroNet, based in San Juan and one of Puerto Rico's largest internet service providers, lost most of its above- and below-ground fiber optic lines during Hurricane Maria. As part of the rebuilding effort, the company is relying on both fiber optic and microwave data delivery systems to keep its customers online when weather conditions deteriorate.

KEY CONSIDERATIONS

Impact:

- Proposed strategies will enhance protection for the Fresh Pond Reservoir for the 2070 100-year sea-level rise/ storm surge storm event[43].
- Creating distributive, multi-modal transportation networks will make system failure less widespread, but additional measures will need to be adopted for assuring continuity of operations (e.g., preventing railroad tracks from buckling under extreme heat or preventing roadway exposure to flooding). Protecting utilities and designing flood barriers will have the most significant impacts on transportation and transit infrastructure.
- Combined sewer separation projects have been proven effective in improving stormwater water quality and reducing street flooding.
- Localized, distributed generation, such as solar, solar and (battery) storage, Combined Heat and Power (CHP), and microgrids will increase resilience, specifically during heat events. These systems could generate electricity (and cooling) during emergencies, while also reducing the impact on the grid.

Cost:

- The cost for hardening overhead lines and sectioning the distribution systems is likely prohibitive. Cost may be mitigated by using a targeted approach for areas most at-risk. Elevating or protecting substations from flooding would have the most widespread, cost-effective benefit for the community. Smart Grid technology is in the initial stages of development, and there is minimal data regarding relative cost.
- The cost of creating distributed, multi-modal transportation networks will be substantial and disruptive to the community during construction.
- The cost of separating combined sewer systems is substantial because it requires extensive construction activities. However, many sewer networks in Cambridge are over 150 years old and will need to be replaced regardless of other requirements.
- The cost for solar has decreased significantly over the past 10 years (currently less than $4 per watt with incentives), however, the cost of solar plus storage systems are currently high, due to the cost of battery systems (roughly $30,000 for a typical single-family home). The cost of CHP systems is typically high but can vary depending on the type of system, installation, air controls and gas line (roughly $1,500 to $5,000 per kW). All the recommended systems could be funded by third parties.

Equity:

- Protecting the Fresh Pond Reservoir helps preserve water-quality standards for Cambridge's drinking water supply.
- Modifying the planning horizon used in the Cambridge Department of Public Works' "25:2" post-construction stormwater standard for new development helps reduce stormwater runoff. The standard is a recommendation that on-site stormwater management strategies are designed so that the 25-year post-construction peak runoff is lower than the 2-year pre-construction peak

43 Design for the berm at Fresh Pond is based on the MassDot BH-FRM model to be updated with the 2020 MassDOT MC-FRM model. Updated information will allow to confirm if the berm at Fresh Pond is still providing protection up to the 2070 1% flood elevation according to MC-FRM.

runoff, replacing stochastic methods (based on data from past storm events) with 2070 design storm rainfall estimates. This strategy encourages new development and major retrofit projects to significantly reduce on-site stormwater runoff and contribute toward the City's overall flood mitigation efforts.

- CHP facilities are typically located in areas with more affordable land. Distributed energy may have an impact on energy prices. Specifically, the customers that do not benefit from the renewable energy may be impacted by higher electricity costs due to stranded power assets.

Wellness:

- A resilient electrical system will provide uninterrupted cooling and, in return, mitigate negative health impacts caused by extreme heat.
- During significant rainfall events, combined sewer overflows can occur and discharge untreated sewage to the Charles River or Alewife Brook. As flooding intensifies, so does the negative public-health impact. This strategy is effective in mitigating adverse health impacts from discharging raw sewage into surface water bodies.
- Focusing on clean renewable energy will reduce air pollution and help the City during extreme heat events when air quality is an issue.

Feasible:

- The berm and the flood wall around Fresh Pond are interventions to protect the Fresh Pond Reservoir from future sea level rise/storm surge impacts.
- The cost of creating distributive, multi-modal transportation networks will be challenging due to high cost, disruption to the community, and permitting challenges.
- Solar PV installations on rooftops are achievable, although there are interconnection issues during outages. Siting and financing CHP and microgrids are typically difficult to achieve. In addition, microgrids with multiple owners create additional implementation issues.

Co-Benefits:

- Protecting the Fresh Pond Reservoir from future climate change impacts is aligned with Envision Cambridge, as it would effectively make the City more resilient. It also preserves the water quality of the City, which is a primary public-health benefit to the community.
- Hardening overhead lines, elevating electrical substations and transformers, and sectioning the distribution system will mitigate impacts of extreme events from climate change. In addition, implementing Smart Grid Technology will help mitigate greenhouse gas emissions (GHG), as it allows for the integration of renewable energy systems that produce less GHG emissions.
- Improving the resiliency of major transportation and transit infrastructure is aligned with Envision Cambridge's proposed measures for continuity of services for daily needs.
- The creation of a distributive, multi-modal transportation system will mitigate the GHG impact.

C1 Protect Fresh Pond Reservoir

Through built infrastructure projects, the City should protect Fresh Pond Reservoir, the terminal reservoir for the City's drinking water supply, from future flooding impacts.

TOOLBOX ACTIONS

1.1 Evaluate building a vegetated berm at the Design Flood Elevation (DFE) for the 2070 100-year (1% probability) event along the Fresh Pond Golf Course.

1.2 Evaluate building a flood wall at the Design Flood Elevation (DFE) for the 2070 100-year (1% probability) event along the perimeter of Fresh Pond.

Why is it Relevant to Cambridge?

Fresh Pond is an "Outstanding Resource Water" because it is part of the drinking water supply system for the City of Cambridge. Discharges to Fresh Pond are therefore regulated by water-quality standards. By 2070, during precipitation events of two-year recurrence (a storm that can be expected to occur once every two years based on past frequency, but has a 60 to 70% chance of occurring in any given year), significant untreated discharges into the Pond from surrounding areas could occur. Surrounding areas include railway and areas zoned for industrial uses, which may contain hazardous materials. Similarly, untreated discharges could also occur under more intense storm surge scenarios, where coastal-driven flooding could result in polluted floodwaters and saltwater entering the Pond.

Actions Already Being Taken

- The southernmost hummock in Fresh Pond Community Gardens was raised to 2070 projected 100-year (1%) SLR/SS flood elevation as reported in the FloodViewer.
- All proposed hummock in the Fresh Pond Reservations will be designed at or above the 2070 projected 100-year (1%) SLR/SS flood elevation as reported in the FloodViewer.
- As informed by CCVA's projection, the first floor of the Water Treatment Plant is at 24 feet-Cambridge City Base (CCB), which is above the 2070 projected 100-year (1%) SLR/SS flood elevation. This assumption will need to be confirmed when updated projections are available.

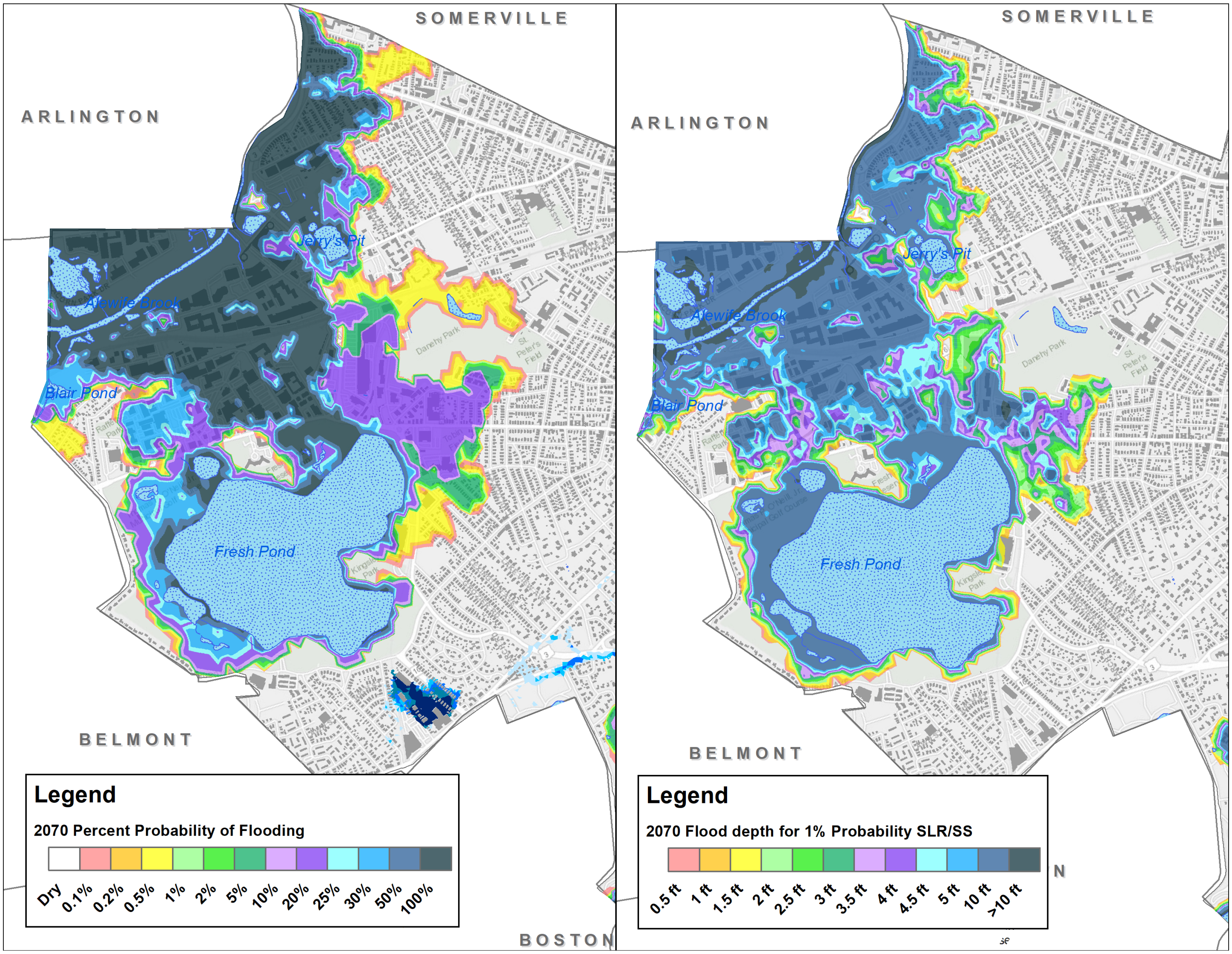


Figure C.8. Sea level rise/storm surge probability of flooding (%, left) and depth of flooding (ft, right) in year 2070 for the Fresh Pond area in Cambridge. (Source: CCVA-Part 2)

C1 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**City**
Jurisdiction Who monitors the implementation?	☑ **City** ☐ **State** ☐ **Federal**
Type of Implementation How is the strategy categorized for the implementation type?	☑ **Pilot/Project/Study** ☐ **Policy/Regulations** ☐ **Program**
Scale What is the scale of the intervention?	☐ **Parcel** ☑ **Neighborhood** ☐ **Citywide** ☐ **Regional**
Related Strategies	**C7: Implement Green Infrastructure (GI) Opportunities for Stormwater Management**

C2 Encourage the Resiliency of the Electrical Distribution System

The City will engage utility providers and the Massachusetts Public Utilities Commission to increase the resiliency of the electricity distribution system.

TOOLBOX ACTIONS

2.1 Evaluate hardening overhead lines.

2.2 Analyze sectioning and increasing redundancies in the utility distribution system.

2.3 Evaluate elevating and protecting Cambridge substations.

2.4 Evaluate the implementation of "Smart Grid" technology.

2.5 Advocate for State to develop a program that funds the development of microgrids at critical facilities.

Why is it Relevant to Cambridge?

A resilient electrical distribution system is important for the welfare of a city. As an example, the North Cambridge substation powers all of North Cambridge, exposing this area to power outages. Strain on Cambridge's electrical grid will continue to increase if resiliency measures are not taken, as increased energy demands from extreme heat will impact peak energy loads. Power outages will disproportionately affect populations that are most at risk. For example, seniors who do not have access to air-conditioning due to a power outage are more likely to experience negative health impacts. Additionally, power outages have an economic impact as they put the community at risk from economic loss due to disruption of business.

Actions Already Being Taken

- Coordination with Eversource Electric, the main electricity provider in Cambridge, ensures that power needs are met. Eversource is also engaged in stakeholder discussions so that future climate risks are appropriately communicated, and potential solutions are determined collaboratively.
- Eversource is making significant investments in the local electric grid to harden and make it resilient to extreme storms.
- Creating transmission redundancy at Prospect Substation strengthens the reliability of the system within the City (e.g., at the Veolia-Kendall Cogeneration Station).

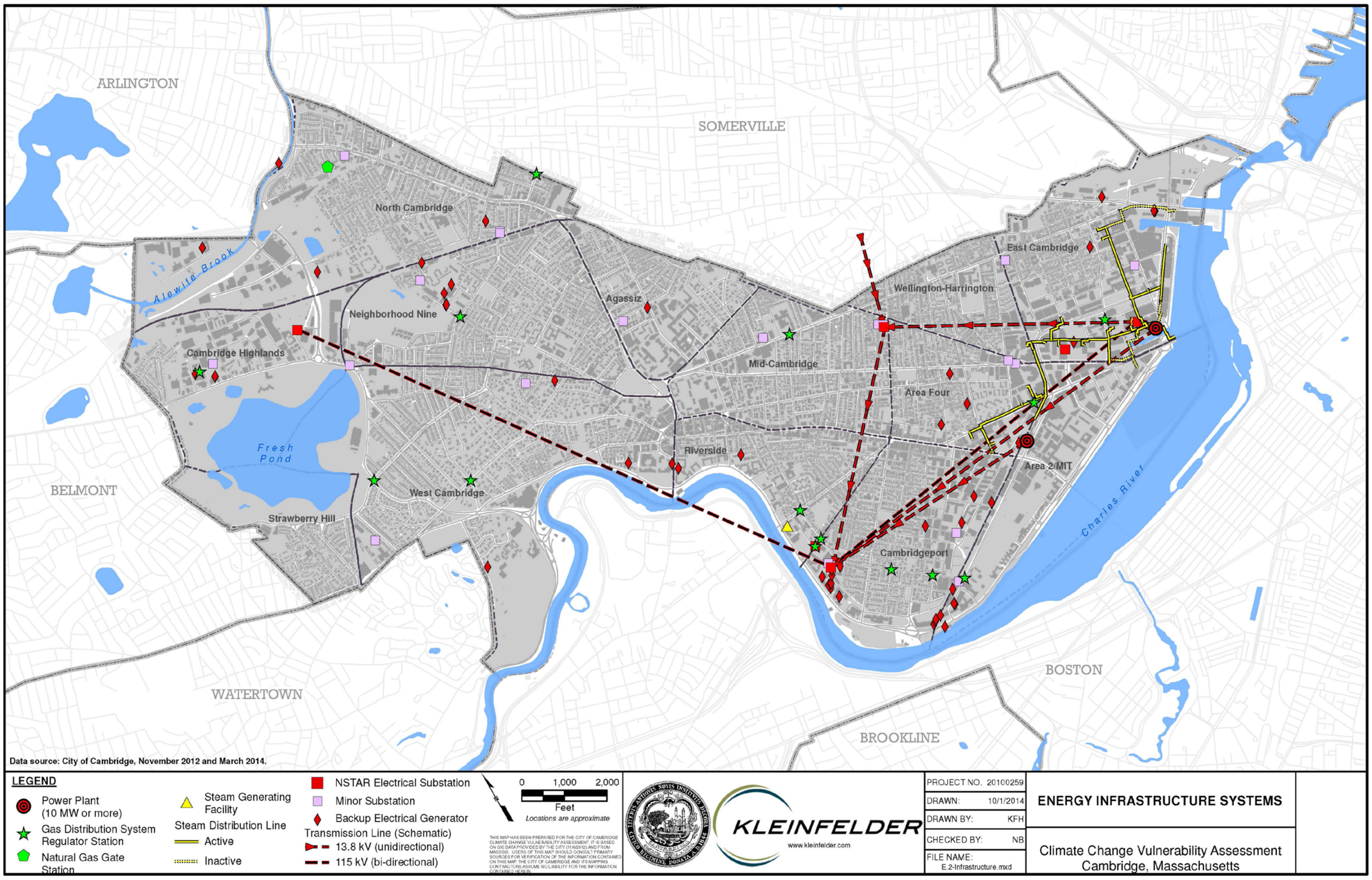


Figure C.9. A map of the energy infrastructure systems in Cambridge. (Source: CCVA)

C2 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**City, Massachusetts Public Utilities Commission, utility providers**
Jurisdiction Who monitors the implementation?	☑ **City** ☐ **State** ☐ **Federal**
Type of Implementation How is the strategy categorized for the implementation type?	☑ **Pilot/Project/Study** ☐ **Policy/Regulations** ☐ **Program**
Scale What is the scale of the intervention?	☐ **Parcel** ☐ **Neighborhood** ☑ **Citywide** ☐ **Regional**
Related Strategies	**A4: Strengthen Emergency Communication Systems** **A5: Support Business and Organizational Preparedness** **B9: Encourage Resiliency of Building Scale Energy** **B10: Develop Flood Protection and Operations Planning For Historic and Critical Facilities**

C3 Enhance the Resiliency of the Transportation System

Engage the MBTA and MassDOT to increase the resiliency of major transportation and transit infrastructure to ensure mobility and access to evacuation routes.

TOOLBOX ACTIONS

3.1 Protect utilities serving the MBTA, such as energy, telecommunications, and water.

3.2 Plan for alternative evacuation routes.

3.3 Evaluate a distributive, multi-modal transportation network by completing the street grid and making better connections and redundancies to the MBTA subway.

3.4 Evaluate the installation of flood barriers around the MBTA station.

3.5 Provide detour routes around flooded roadways.

Why is it Relevant to Cambridge?

The subway lines take 10,000 riders to six Cambridge stations each day, and 33 Cambridge public bus routes carry 85,000 passengers every week. Approximately 25% of residents who do not own cars rely on public transit as their primary means of transportation. Impacts to any part of the subway have the potential to affect the entire system, as there is little redundancy within the subway lines. Transit systems in Cambridge were not designed or adapted to cope with significant exposure to flooding. Pumping stations are likely inadequate, and there are few, if any, barriers to limit the penetration of flood waters into sensitive areas. Additionally, equipment may not be sufficiently raised off the ground. The rail used in MBTA subway lines is conditioned to operate optimally at around 80 degrees; the risk of the rail buckling increases as heat rises beyond that temperature. Additionally, many roadways and intersections are at risk from flooding in the 10-year, 24-hour rainfall event. Roadway flooding has the cascading impact of restricting law enforcement and public safety from serving citizens of Cambridge.

Actions Already Being Taken

- By reducing speed, trains can safely cross over lightly buckled track sections when the ambient temperature is above 90 degrees.
- Single track trains are still in operation when a section of rail is shut down due to flooding or heat.
- Shuttle buses are provided when a section of rail is shut down due to flooding or heat.
- Both MassDOT and MBTA are in the process of identifying their most vulnerable transportation and transit assets/infrastructure, as well as developing their resiliency plans.
- MassDOT is completing its final design for

installation of removable flood walls at three locations. MassDOT is also completing the construction of tide gates at vulnerable outfalls, and assessing the conditions of stormwater outfalls and tide gates to understand their vulnerability to SLR/SS by 2030.

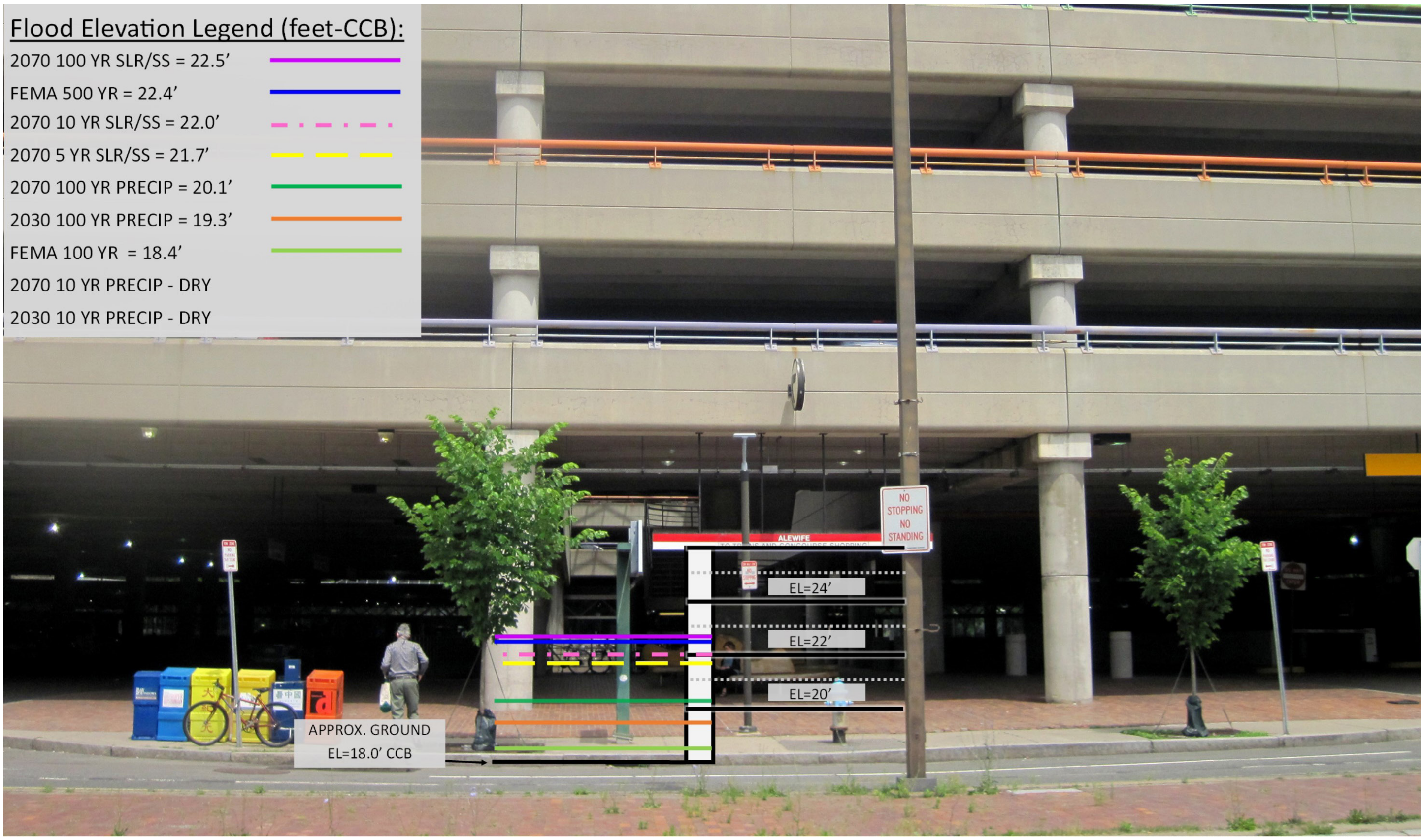


Figure C.10. Alewife Garage flood elevations. (Source: Kleinfelder)

C3 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**City, MBTA, MassDOT**
Jurisdiction Who monitors the implementation?	☑ **City** ☐ **State** ☐ **Federal**
Type of Implementation How is the strategy categorized for the implementation type?	☑ **Pilot/Project/Study** ☐ **Policy/Regulations** ☑ **Program**
Scale What is the scale of the intervention?	☐ **Parcel** ☐ **Neighborhood** ☑ **Citywide** ☐ **Regional**
Related Strategies	**B3: Encourage Flood Protection For Existing Buildings** **B10: Develop Flood Protection and Operations Planning For Historic and Critical Facilities**

C4 Continue the Combined Sewer Separation

Continue combined sewer separation in the City to reduce adverse public-health impacts during flood events and to protect water quality.

TOOLBOX ACTIONS

4.1 Continue the City's sewer separation program and evaluate implementation of sewer separation program in remaining combined sewer catchment area CAM001.

4.2 Evaluate implementation of sewer separation program in remaining combined sewer catchment area CAM002.

4.3 Evaluate implementation of sewer separation program in remaining combined sewer catchment area CAM401A/B.

Why is it Relevant to Cambridge?

The City of Cambridge still has approximately 41 miles of combined sewer. The City has 9 CSOs. The City's sewer separation projects and stormwater management efforts have addressed localized flooding problems and stormwater quality issues for existing conditions. However, the City's collection system may be subject to vulnerability considering a predicted increase in heavy precipitation events and flooding from SLR/SS.

The stormwater outfalls associated with pipes greater than 18 inches in diameter are considered critical. The City is continuing separation efforts to improve water quality in Cambridge, reduce or eliminate combined sewer overflows and sanitary sewer backups, reduce flooding, and prevent adverse public-health impacts.

Actions Already Being Taken

- Separation of the combined sewer system began in the 1930s. Separated systems are designed and constructed to convey only stormwater to the rivers and only sanitary waste to a treatment plant. Sewer separation continues today and the City's collection system currently includes approximately 113 miles of separated sanitary sewer mains, 99 miles of separated stormwater mains, and 40 miles of combined sewer mains. About 55% of the collection system owned and maintained by Cambridge has been separated.
- The City of Cambridge develops and maintains 5- and 10-year capital infrastructure program objectives for municipal storm sewer infrastructure.
- The City performs remedial reconstruction of storm sewer and drainage infrastructure, a cleaning program for combined sewer overflows, and televised reviews to check on physical condition of structures.

Figure C.11. Combined sewer separation in Cambridge. (Source: Kleinfelder)

C4 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**City**
Jurisdiction Who monitors the implementation?	☑ **City** ☐ **State** ☐ **Federal**
Type of Implementation How is the strategy categorized for the implementation type?	☐ **Pilot/Project/Study** ☐ **Policy/Regulations** ☑ **Program**
Scale What is the scale of the intervention?	☐ **Parcel** ☑ **Neighborhood** ☐ **Citywide** ☐ **Regional**
Related Strategies	**C8: Support a Resilient Telecommunication Network**

C
5

Upgrade Stormwater Storage

Evaluate green and gray infrastructure strategies (for upcoming and potential projects) and regulatory strategies for addition of stormwater storage to mitigate flooding at sub-neighborhood scale.

TOOLBOX ACTIONS

5.1 Implement large stormwater storage projects (like PL6 and Morgan tanks in the Port).

5.2 Conduct a pilot study of GI in public rights-of-way (PROW) and private property in the Port neighborhood.

5.3 Study retrofit options for City parks to increase tree canopy and manage stormwater runoff.

5.4 Maintain an Inflow & Infiltration (I&I) removal database of projects and opportunities to identify and prioritize where green and gray infrastructure strategies can best mitigate flooding and maximize cobenefits.

5.5 Evaluate retrofit opportunities for City parcels, parking lots, and within PROW where green and gray infrastructure strategies overlap objectives/requirements with MS4 permitting.

5.6 Evaluate updating the criterion for "25:2" compensatory stormwater storage requirement to use either 2030 or 2070 design storms for new development.

5.7 Evaluate the combination of gray and green infrastructure to meet stormwater requirements for all new development.

Why is it Relevant to Cambridge?

The City of Cambridge is at risk for inland flooding for both the 2030 and 2070 10-year storm scenarios. There are many negative health impacts associated with inland flooding, especially in areas where sewer systems are still combined. It is important to implement stormwater storage strategies in the City of Cambridge; a stricter stormwater storage policy could be effective for new development.

The City is evaluating options for connecting leaching catch basins with tree box filters. Leaching catch basins with sumps can capture the stormwater runoff from the roadway, filter out road salt, and redirect the collected stormwater to the tree boxes. The tree boxes can have engineered soil and crushed stones as filter media to promote groundwater infiltration. In addition the connection from the leaching catch basin to the tree box filter captures runoff from a much larger area, provides water to trees, further infiltrates stormwater into the ground, and improves the water quality of the runoff.

Actions Already Being Taken

- The City has an inflow and infiltration (I&) removal database and program.
- Stormwater storage is incorporated at City parks and other public open spaces.
- The City has pilot leaching catch basins.
- The City is conducting modeling/co-benefits analysis of GI for residential streets.

Figure C.12. Subsurface infiltration system to help manage stormwater runoff at Longfellow Park. (Source: City of Cambridge)

C5 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**City, property owners**
Jurisdiction Who monitors the implementation?	☑ **City** ☐ **State** ☐ **Federal**
Type of Implementation How is the strategy categorized for the implementation type?	☑ **Pilot/Project/Study** ☑ **Policy/Regulations** ☐ **Program**
Scale What is the scale of the intervention?	☑ **Parcel** ☑ **Neighborhood** ☑ **Citywide** ☐ **Regional**
Related Strategies	**C7: Implement Green Infrastructure for Stormwater Management** **D4: Seek Green Infrastructure Opportunities** **D5: Expand and Improve Open Spaces**

C 6

Support Sustainable Energy Infrastructure

The City should support the implementation of microgrids and community energy systems to increase efficiency and the amount of energy supplied by renewable sources, reducing pollution and costs.

TOOLBOX ACTIONS

6.1 Evaluate updating requirements to include on-site solar PV and storage systems at critical facilities and residential developments.

6.2 Investigate opportunities for small- to medium-sized CHP systems and district ground source heating and cooling systems.

6.3 Evaluate building microgrids consisting of generation and storage, and evaluate a smart, controlled network.

6.4 Enable community energy systems for individual households and businesses to invest in and benefit from.

Why is it Relevant to Cambridge?

Most of Cambridge's electricity is generated outside the City and is constrained due to transmission capacity issues and lack of redundancy. The power plants located in or near the City use fossil fuels, including imported oil and gas. The grid and the fuel supply chain will become more vulnerable due to more flood, storm, and heat events, as well as increases in average temperature.

These vulnerabilities, and the potential to generate approximately 91 gigawatt hours (GWh) per year of electricity (or 5.3 percent of the City's annual electricity use) through rooftop solar PV plus storage and CHP, provide more justification for increasing resiliency and reliability while decreasing GHG emissions in Cambridge.

Actions Already Being Taken

- Cambridge Green Building Requirements (CD Article 22) and the MA Stretch Code have already adopted higher standards.
- The City has been coordinating with Eversource Electric to ensure power needs are met during extreme events focusing on the population most at risk.

Figure C.13. Solar panels on a pitched roof.

C6 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**City, utility providers, property owners**
Jurisdiction Who monitors the implementation?	☐ **City** ☑ **State** ☐ **Federal**
Type of Implementation How is the strategy categorized for the implementation type?	☑ **Pilot/Project/Study** ☑ **Policy/Regulations** ☑ **Program**
Scale What is the scale of the intervention?	☑ **Parcel** ☐ **Neighborhood** ☐ **Citywide** ☐ **Regional**
Related Strategies	**A4: Strengthen Emergency Communications Systems** **A5: Support Business and Organizational Preparedness** **B9: Encourage Resiliency of Building Scale Energy**

C 7 Implement Green Infrastructure For Stormwater Management

Implement Green Infrastructure (GI) to mitigate flooding during smaller or short-duration rainfall events, and contribute to water quality improvement. GI will also help improve urban tree canopy and mitigate the effects of UHI.

TOOLBOX ACTIONS

7.1 Evaluate potential for installation of depressed planters (curbside bioretention, median bioswales) in medium-density residential parcels in conjunction with street improvement projects, or pilot Cool Corridors concept.

7.2 Initiate a program to identify and retrofit catch basins (within the highest GI flood mitigation and co-benefit opportunity areas) and replace these with leaching catch basins, where feasible.

7.3 Study retrofit options for City parks to increase tree canopy, while also managing stormwater runoff.

7.4 Implement GI in PROW and private property in The Port neighborhood.

Why is it Relevant to Cambridge?

Flood mitigation via the implementation of GI strategies provides an opportunity to achieve multiple co-benefits via integrated planning and design focusing on stormwater quality. There is a potential for flood mitigation strategies to address additional positive outcomes, including water quality improvement. By providing additional storage space for stormwater runoff, GI strategies may be advantageous for water quality treatment purposes. GI strategies, such as vegetated systems with filter media, can be effective in removing surface pollutants and excess nutrients. Where conditions allow, filtering practices — such as rain gardens, bioswales/bioretention, and subsurface infiltration systems — can be effective in reducing pollutants typically conveyed during the “first flush,” or early stages of storm events.

When designing for flood mitigation purposes, systems are often sized to maximize storage space (to the extent feasible) for volumes larger than typical water quality sizing. For example, in the case of a subsurface infiltration or detention system sited below a ball field, the space allocated for flood storage may far exceed the Water Quality Volume (WQV) of a system designed for other purposes. While the primary purpose of the system may be for flood mitigation, the system would also capture the runoff associated with smaller, more frequent storm events, thus resulting in water quality benefits. GI installed in new construction should achieve the City's "25:2" requirement.

In addition to flooding, GI provides additional benefits such as expansion of tree canopy, improving quality of urban green spaces, mitigation of UHI effects, and enhancing urban livability.

Actions Already Being Taken

- GI has been incorporated in public spaces and ROW. This includes streetscape improvements to Western Avenue, Fresh Pond Reservation resiliency work, curbside bumpouts and bioretention best management practices (BMPs) in Alewife, leaching catch basins citywide, and ongoing projects in Inman Square and Huron Ave, among others.
- A pilot study has been conducted for the implementation of GI in the Port neighborhood.
- The City prioritized GI for private property stormwater BMPs meeting water quality and "25:2" requirement.
- The City prioritized GI for new parks and park retrofits.

Figure C.14. Rain garden in Alewife neighborhood. (Source: Kleinfelder)

C7 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**City, property owners**
Jurisdiction Who monitors the implementation?	☑ **City** ☐ **State** ☐ **Federal**
Type of Implementation How is the strategy categorized for the implementation type?	☑ **Pilot/Project/Study** ☐ **Policy/Regulations** ☑ **Program**
Scale What is the scale of the intervention?	☑ **Parcel** ☑ **Neighborhood** ☑ **Citywide** ☐ **Regional**
Related Strategies	**B6: Promote Site Green Infrastructure** **B8: Study Adapted Planning For Resilient Urban Blocks** **C5: Upgrade Stormwater Storage** **D4: Seek Green Infrastructure Opportunities**

C 8

Support a Resilient Telecommunication Network

Build and upgrade telecommunication facilities and technology to the City's resilient building guidelines to provide a resilient network.

TOOLBOX ACTIONS

8.1 Build and upgrade telecommunication facilities in the City and within the regional system to the City's resilient building guidelines. This would be a key component in providing for a resilient network.

8.2 Research system platforms that enhance the climate resiliency of the telecommunication network in the City and the region.

Why is it Relevant to Cambridge?

In our daily life, we count on infrastructure to be efficient, affordable, and reliable. Our jobs, homes, and services depend on energy, water, transportation networks, and telecommunication to be functioning 24/7. New design standards must incorporate future climate projections, and new projects must adopt progressive standards to alleviate the need to rebuild soon. The goal is for daily life to remain uninterrupted during climate-related events.

Figure C.15. Hurricane Maria aftermath in Puerto Rico. (Credit: Getty Images)

The resiliency of the telecommunication network requires a regional resiliency strategy. As a first step to boost the resiliency of our telecommunication systems and ensure service continuity, the City could coordinate with telecommunication providers to identify solutions for developing a more climate-resilient communication network. For example, recent research has focused on opportunities for a system that allows data to bypass traditional fiber optic lines — most of which are strung along utility poles or buried underground — and connect data centers to end users through a dedicated wireless system[44]. It provides for a resilient channel that is "always" active and runs on backup power. Options like this one could be further researched and tested in pilot projects to provide for the weatherization of the telecommunication network.

44 https://climateresilientinternet.reportablenews.com/pr/cri-launches-world-s-first-climate-resilient-internet-certified-to-withstand-extreme-weather

C8 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	City, telecommunication providers
Jurisdiction Who monitors the implementation?	☐ City ☑ State ☐ Federal
Type of Implementation How is the strategy categorized for the implementation type?	☑ Pilot/Project/Study ☐ Policy/Regulations ☑ Program
Scale What is the scale of the intervention?	☐ Parcel ☐ Neighborhood ☐ Citywide ☑ Regional
Related Strategies	A4: Strengthen Emergency Communication Systems A9: Encourage Stronger Social Network B10: Develop Flood Protection and Operations Planning For Historic and Critical Facilities C2: Encourage the Resiliency of the Electrical Distribution System

Greener City

Strategies for resilient ecosystems are closely aligned with each other and focus on mitigating the Urban Heat Island (UHI) effect to protect populations at risk from the negative health impacts of extreme heat, and to improve water quality and reduce flooding impacts from smaller storm events.

These are the proposed strategies for a Greener City:

1. Provide For a Resilient Urban Forest

Reduce the UHI effect by increasing the urban forest canopy, developing a comprehensive urban forest management plan, and continuing urban forest maintenance efforts.

2. Enhance Outdoor Thermal Comfort

Enhance thermal comfort outdoors along bike and pedestrian routes and MBTA bus stops.

3. Reduce Impervious Area

Reduce impervious area of upstream parcels to limit flooding at downstream parcels, and adopt measures to increase the quality of the vegetated areas citywide.

4. Seek Green Infrastructure Opportunities

Implement Green Infrastructure (GI) to mitigate UHI. GI will also improve water quality and reduce flooding impacts from smaller rainfall events.

5. Expand and Improve Open Spaces

Develop a City Open Space Plan integrating retrofit projects that increase tree canopy and projects that create new parks to provide cool, equitable outdoor areas for public enjoyment.

BEST PRACTICES

Cambridge is working to create a Greener City that supports resiliency and enhances the quality of life of its residents by cooling the environment on hot days, reducing stormwater pollution, and expanding the vegetated landscape. The strategies to achieve a Greener City are based on best practices from other cities and regions. These best practices provide examples of how conventional infrastructure projects can be enhanced to integrate the natural and social environments, as well as promote educational programs.

Infrastructure Projects

Park Designed for Stormwater Storage, Pittsburgh, Pennsylvania

The City of Pittsburgh, Pennsylvania, obtains 90% of its drinking water from the City's three rivers. The rivers also receive combined (sanitary and storm) sewer outfalls, as well as treated water discharged from the wastewater treatment plant. To preserve the water quality of the rivers, the City of Pittsburgh has included elements of GI in every major park improvement in the past 15 years. As part of the "The Vision Plan for

Figure D.1. Open space planning in Pittsburgh. (Source: Rivers in Synergy, Pittsburgh, PA)

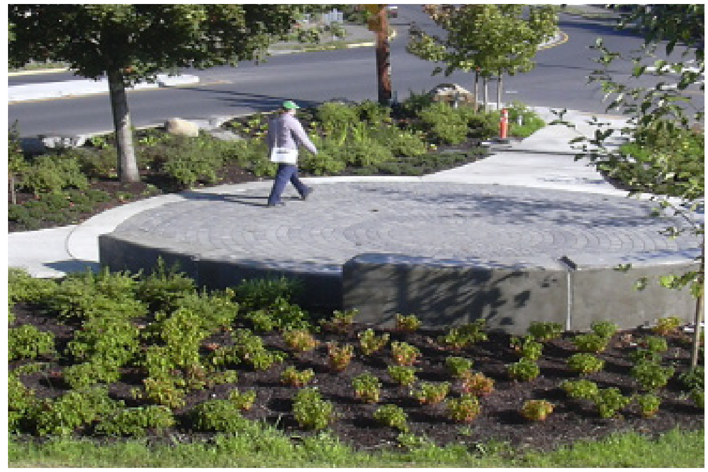


Figure D.2. Portland Green Street. (Source: Environmental Services, City of Portland)

Pittsburgh's Riverfronts[45]," parks and other vegetation are placed alongside the rivers in the Ohio River Basin (Figure D.1). This natural landscape allows stormwater to be retained, cleansed, and infiltrated before it reaches the river.

Green Streets Program, Portland, Oregon

A street that uses vegetated facilities to manage stormwater runoff at its source is referred to as a Green Street[46] (Figure D.2). Green Streets may include street trees, vegetation along sidewalks, swales, and rain gardens. In 2007, the Portland, Oregon, City Council approved a policy to promote and incorporate the use of Green Street elements in public and private development. Under this policy, all development funded by the City of Portland must incorporate Green Street facilities, or 1% of their construction cost will go to a Green Street Fund. The City also assists in developing incentives and encouraging the private sector to implement Green Street projects through planning, design, and funding. The policy has a public outreach component to educate residents on the benefits of Green Streets. Lastly, Portland must conduct ongoing monitoring of Green Street facility effectiveness.

Building projects

Living Walls, various cities

Many cities have begun to implement green walls to preserve air quality and help mitigate the UHI effect.

Figure D.3 shows an example of a green wall on a high-rise building in the center of Concepción, Chile. This building has a vertical green wall constructed from locally sourced wood that shields the structure from the sun to the north, east, and west, and acts as a "double green skin" that insulates the interior. The

45 https://riverlifepgh.org/wp-content/uploads/2016/10/Vision-Plan-For-Pittsburghs-Riverfronts-Web-version.pdf

46 https://www.portlandoregon.gov/bes/45386

Figure D.3. Green wall on a building in Concepción, Chile, (left) and a green wall on a small business building on Shin-Koenji street in Tokyo, Japan (right). (Sources: inhabitat.com/consorcio-headquarters-by/; tokyogreenspace.wordpress.com/)

structure's south wall features a high-performance façade constructed from locally sourced corrugated metal that helps insulate the interior and render it highly energy efficient.

The third element is a cantilevered roof that provides shade to the structure's top floor balcony. Figure D.3 shows an example of a lush second floor garden on Shin-Koenji shopping street in Tokyo. Tokyo Metropolitan Government's 10-year project for Green Tokyo has aimed to create a total of 400 hectares of green space by greening rooftops, wall surfaces, railroad areas, parking lots and all other possible urban spaces.

Chicago Green Roof Improvement Fund, Chicago, Illinois

The Chicago Green Roof Improvement Fund provides[47] a 50% grant match for the cost of placing a green roof on an existing building located in the Central Loop District (Figure D.4); the grant provides a maximum of

Figure D.4. Chicago Green Roof. (Photo credit: Conservation Design Forum)

$100,000 per project. The Green Roof Grant Program awards $5,000 grants for green roof projects on residential and small commercial projects. In addition, the City of Chicago currently requires all new, near-flat roofs meet the U.S. EPA Energy Star cool roof standards as part of the Chicago Energy Conservation Code. A cool roof uses special materials to reflect the sun's heat instead of warming the building below.

The City of Chicago's Cool Roofs Grant Program provides up to $6,000 per project to help residents and small business owners install roofs that meet or exceed the cool roof standards.

Educational Programs

Green Schools Program, Boston, Massachusetts

New rain gardens, bioswales and other GI are being designed to capture and filter stormwater runoff, while also serving as an educational tool for teachers and

47 https://www.chicago.gov/city/en/depts/dcd/supp_info/chicago_green_roofs.html

students of five Boston Public Schools. Construction and plantings are complete at the Irving School in Roslindale (Figure D.5), and construction has begun at the Hernandez School in Roxbury. These projects are a collaboration between Boston Water and Sewer Commission (BWSC), Boston Public Schools (BPS), the Charles River Watershed Association (CRWA), Horsley Witten Group, Offshoots, and Kristin Metz. The new green school yards are educational, interactive, and offer some greenery to the urban landscape, and also serve as model schools for surrounding districts.

Figure D.5. Tree planters and a bioretention basin are installed in a parking lot of Irving School in Roslindale, Boston. (Source: Boston Water and Sewer Commission (BWSC) and Greenovate City of Boston)

Green Infrastructure Education, Philadelphia, Pennsylvania

West Philadelphia residents, middle schoolers and University of Pennsylvania students launched a citizen study of the Mill Creek portion of their watershed, prompting neighbors to install flower boxes, rain barrels, green roofs and walls, street trees, and rain gardens. The study included incorporating green stormwater infrastructure into a new public school and establishing outdoor classrooms where students learn about natural features, the built environment, and how human behaviors shape the quality of urban life. The study also encouraged municipal officials to “daylight” portions of a creek that was enclosed within a culvert. The creek was restored to its natural state to improve stormwater management and create a new public amenity.

Save the Rain, Onondaga County, New York

Onondaga Lake was once the most polluted lake in North America. As part of the efforts to clean up the lake, the “Save the Rain” program aims to reduce combined sewer overflow (CSO) discharges by using a combination of gray infrastructure and GI solutions. The program was able to reduce 95% of combined sewer overflow from a limited addition of gray infrastructure and an extensive use of GI — including rain barrels, tree pits, bioretention filter-strips, underground filtration systems, and porous pavements. The GI provided co-benefits by beautifying neighborhoods, adding open green space, improving water quality and reducing localized flooding and basement backups.

RELEVANCE TO CAMBRIDGE

Table D.1 provides a summary of how the best practices inform the development of specific strategies for Greener Cities.

Table D.1 List of Strategies and Related Best Practices			
Strategy	**Title**	**Related Best Practice**	**Description**
D1	**Provide For a Resilient Urban Forest**	Urban Forest Master Plan, Cambridge, Massachusetts	The Urban Forest Master Plan (UFMP) will guide the development of the urban forest in the future, and will include a strategic plan to evaluate, maintain, and expand the urban forest canopy, while helping the City be more resilient to climate change, reducing the UHI effect, mitigating stormwater runoff, reducing nutrient runoff, and contributing to community well-being.
D2	**Enhance Outdoor Thermal Comfort**	Green Streets Program, Portland, Oregon	Under this policy, all development funded by the City of Portland must incorporate green street facilities, or 1% of their construction cost will go to a Green Street Fund. Similarly, Cambridge can continue to promote and incorporate the use of green street elements in public and private development.
		Heat Management Assessment, Louisville, Georgia	Focusing on UHI, the Georgia Institute of Technology worked with the Louisville Metro Office of Sustainability in Kentucky in 2016 to develop a heat management assessment.
D3	**Reduce Impervious Area**	Chicago Green Roof Improvement Fund, Chicago, Illinois	The Chicago Green Roof Improvement Fund provides a 50% grant match for the cost of placing a green roof on an existing building. Cambridge could develop a similar funding program.

Table D.1 List of Strategies and Related Best Practices (continued)			
Strategy	Title	Related Best Practice	Description
D4	**Seek Green Infrastructure Opportunities**	Park Designed for Stormwater Storage, Pittsburgh, Pennsylvania	The City of Pittsburgh has included elements of GI in every major park improvement in the past 15 years. This natural landscape allows stormwater to be retained, cleansed, and infiltrated before it reaches the river.
		Green Infrastructure Education, Philadelphia, Pennsylvania	West Philadelphia residents, middle schoolers and University of Pennsylvania students launched a citizen study of the Mill Creek portion of their watershed, which prompted neighbors to install flower boxes, rain barrels, green roofs and walls, street trees, and rain gardens. Key waterways like Alewife Brook could benefit from a similar initiative.
		"Save the Rain," Onondaga County, New York	Onondaga Lake was once the most polluted lake in North America. As part of the efforts to clean up the lake, the “Save the Rain” program aims to reduce combined sewer overflow (CSO) discharges by using a combination of gray infrastructure and GI solutions.
		Green Infrastructure Plan, Hoboken, New Jersey	The U.S. Department of Housing and Urban Development funded the “Hoboken Green Infrastructure Strategic Plan” as part of New Jersey’s Regional Plan for Sustainable Development. The strategic plan evaluated neighborhood-wide strategies to adopt gray, green, and blue infrastructure. The Stormwater Analysis included in the Resilient Cambridge Plan provides a preliminary analysis for further developing an integrated approach to implement GI infrastructure opportunistically.

Table D.1 List of Strategies and Related Best Practices (continued)			
Strategy	Title	Related Best Practice	Description
D5	**Expand and Improve Open Spaces**	Framework for an Equitable Future, New York, New York	New York City released the Framework for an Equitable Future, which included the Community Parks Initiative, a multi-faceted program to invest in under-resourced public parks in the City's densely populated and growing neighborhoods with higher-than-average concentrations of poverty. The City of Cambridge is developing an Open Space Plan that will provide information on implementing a similar framework.

KEY CONSIDERATIONS

Impact:

- Increasing the urban forest canopy has proven effective in reducing the UHI effect.
- Planting street trees, applying a water-based seal coat to pavement to achieve lower surface temperatures, and sprinkling water on pavement have each been shown to reduce the UHI effect. To enhance outdoor thermal comfort, strategies will need to be applied at the parcel scale, including buildings' strategies like green roofs or applying a white coating to roofs. Preliminary analyses show that white roofs provide a greater benefit in reducing UHI compared to green roofs.
- Providing access to drinking water at waiting areas, like bus stops, and increasing access to waterplay areas/pools provide effective short-term cooling options for residents.
- Reducing upstream impervious surface has flood-reduction benefits for downstream parcels. A 25% to 50% reduction in impervious surface would have a significant impact in reducing flooding for the 2030 10-year (10% probability) storm. Gray infrastructure (i.e., detention tanks) would be necessary for further storage capacity beyond the projected 10-year storm.
- The primary benefit of implementing GI over gray infrastructure is that this strategy mitigates the UHI effect in addition to flooding and has other co-benefits such as improved water and air quality.

Cost:

- Planting street trees, implementing green roofs, and installing vertical planters have a relatively low capital cost, but operations and maintenance costs need to be considered. The City may be able to provide incentives in the future for existing property owners to implement green roofs as part of retrofits. Also, many residents are willing to fund tree plantings for their aesthetics and increased property value.
- The cost of reducing impervious surfaces is relatively low but some measures will trigger higher operation costs

Equity:

- The proposed measures have an impact for capital cost and operation cost; they will effect affordability.
- GI is an effective way of improving the City's stormwater infrastructure and greening neighborhoods with at-risk populations that traditionally have less open space and vegetation.

Wellness:

- Enhancing outdoor thermal comfort is effective in alleviating negative health impacts due to extreme heat.
- Strategies that help reduce the UHI effect would bring down ambient temperature and provide access to an enhanced vegetated public realm.

Feasible:

- Enhancing outdoor thermal comfort is a feasible strategy. Cambridge has already taken steps to enhance thermal comfort.
- Solutions that do not reduce existing parking are likely to be most feasible.
- Implementing GI, particularly on the parcel scale, means stricter regulations on new and existing development. This will need community support.

Co-Benefits:

- Increasing urban forest canopy and shaded buildings would help the City decrease energy demands, which is aligned with its Net Zero goals.
- Adding street trees improves the aesthetics of the neighborhoods and quality of life of residents, which is aligned with Envision Cambridge.
- Increasing the urban forest canopy would absorb greenhouse gas emissions. While the reduction might be marginal in absolute numbers, it can contribute to the merits of a healthy urban ecosystem for a resilient City.

D1 Provide For a Resilient Urban Forest

Reduce the UHI effect and improve water quality by increasing the urban forest canopy, developing a comprehensive urban forest management plan, and continuing urban forest maintenance efforts.

TOOLBOX ACTIONS

1.1 Increase trees along streets, in parking lots, and areas with a high percentage of impervious area, and incentivize private property owners to preserve existing trees and plant new trees.

1.2 Adopt a comprehensive urban forest management plan, implement actions, and continue urban forest maintenance as recommended in the Cambridge Urban Forest Master Plan.

1.3 Enhance the Tree Protection Ordinance.

1.4 Promote existing tree planting programs and expand community outreach and engagement.

Why is it Relevant to Cambridge?

The number of days over 90 degrees is projected to nearly triple by 2030, from present conditions of approximately 11 days a year to around 31 days a year. The challenge for Cambridge, which is densely populated and developed, will be to balance urbanization with the health of the City's vegetation. The density of development makes the implementation of new planting challenging due to a lack of available land area. Large areas of impervious surfaces exacerbate UHI impacts and flooding. Loss of mature trees and the impact of human activity contributes to tree canopy loss. A 1 degree temperature increase can add 1.5% to 2% to peak electricity demand for air-conditioning[48]. Unmanaged increases in energy demand could cause power outages and have negative public health and economic impacts for Cambridge residents.

Actions Already Being Taken

- The Department of Public Works has developed and maintains a comprehensive tree inventory of public street and park trees and continues to oversee tree plantings throughout the City.
- The DPW has a goal of planting 1,000 trees annually in existing and new tree wells.
- The City of Cambridge developed a comprehensive Urban Forest Master Plan. The Plan provides an overview of current and future threats to the urban

48 https://www.epa.gov/heatislands/heat-island-impacts

forest specific to climate change and how threats will affect existing trees and the choice of species for future plantings.

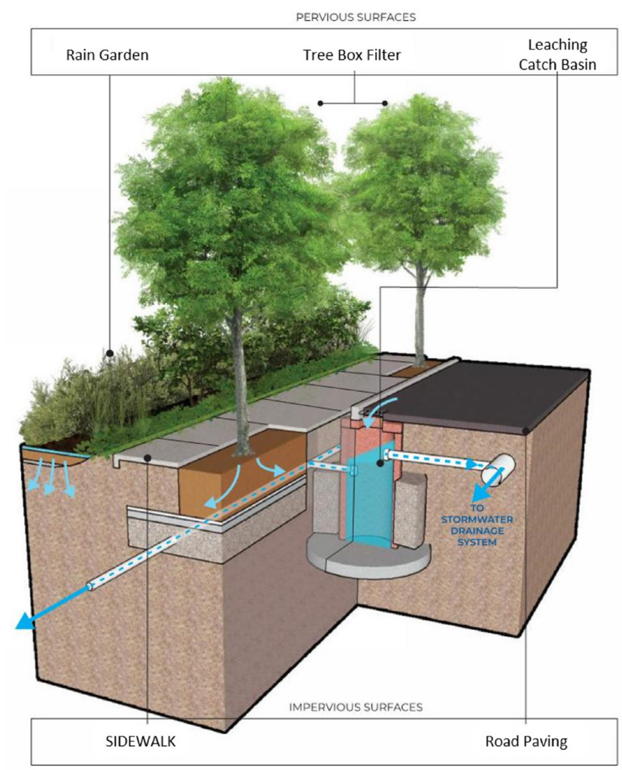
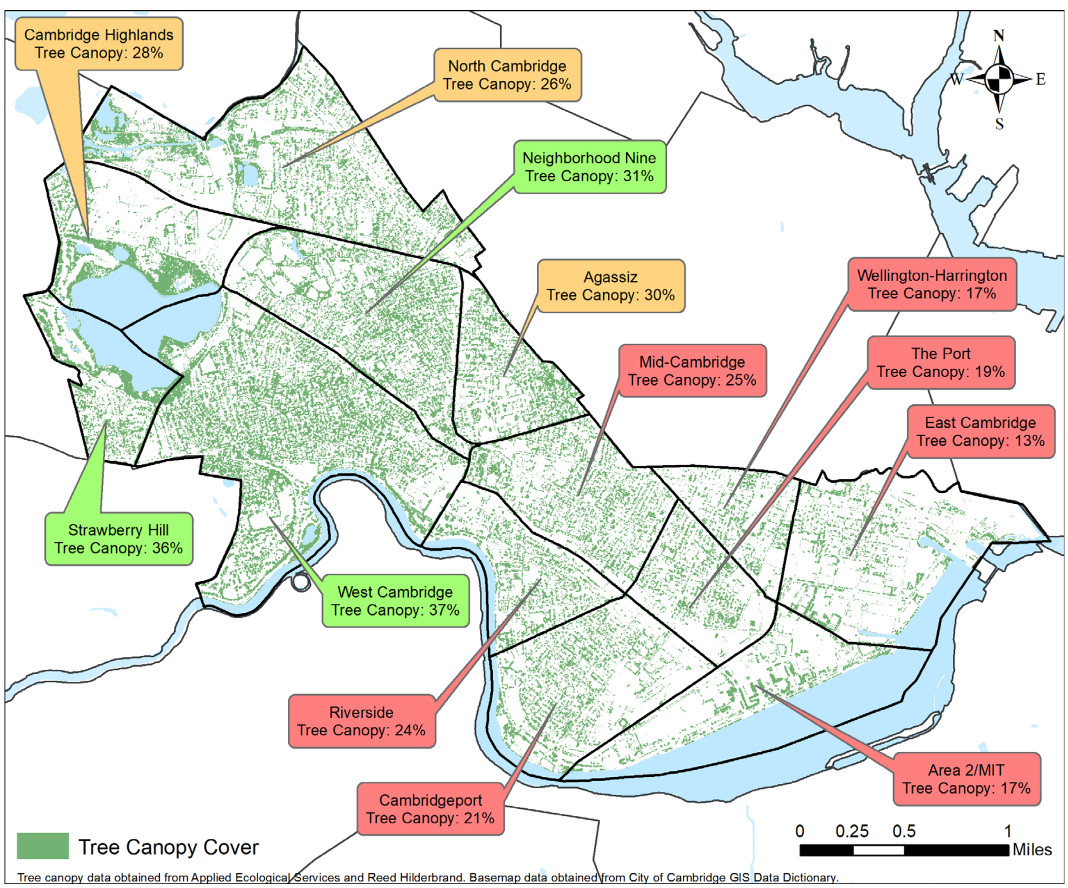


Figure D.6. Conceptual approach for connecting tree box filter are leaching catch basins. (Source: Kleinfelder, 2018)

Figure D.7. Existing citywide tree canopy. (Source: Resilient Cambridge Plan Greener City Report, 2020)



D1 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**City, property owners**
Jurisdiction Who monitors the implementation?	☑ **City** ☐ **State** ☐ **Federal**
Type of Implementation How is the strategy categorized for the implementation type?	☐ **Pilot/Project/Study** ☑ **Policy/Regulations** ☑ **Program**
Scale What is the scale of the intervention?	☑ **Parcel** ☐ **Neighborhood** ☐ **Citywide** ☐ **Regional**
Related Strategies	**D2: Enhance Outdoor Thermal Comfort** **D4: Seek Green Infrastructure Opportunities**

D2 Enhance Outdoor Thermal Comfort

Improve thermal comfort outdoors along bike and pedestrian routes and MBTA bus stops.

TOOLBOX ACTIONS

2.1 Target street trees and PROW (public-rights-of-way) planting, particularly along heavy pedestrian traffic corridors.

2.2 Add additional permanent or flexible shaded structures at outdoor bus waiting areas.

2.3 Conduct a feasibility analysis to better understand opportunities for replacing existing pervious pavement or vegetated areas if possible, and consider high Solar Reflectance Index (SRI) paving where pervious, vegetated areas are not possible.

2.4 Set clear guidelines to be integrated into zoning for greening of private parcels; this should encourage improvements that also benefit the public realm.

Why is it Relevant to Cambridge?

Many Cambridge residents are exposed to heat through transit use. The pedestrian network in Cambridge is extensive. All Cambridge streets have sidewalks and street lighting. Cambridge has built a reputation as one of the best cities for bicycling in the U.S. There are 46 miles of bike routes that almost completely mirror the City’s 48 miles of major roads. The City even established a bike-share program that provides 27 bike-sharing stations in the City.

Users of bike routes and pedestrian walkways are directly exposed to heat. The approximately 85,000 weekday riders using the bus system in Cambridge may need to wait outdoors at some points, exposing them to potential heat impacts.

The primary goal of Cambridge's cooling guide is to contribute to UHI reduction and thermal comfort in the face of increasing temperatures. The cooling guide presents a menu of strategies that property owners and developers can chose from to meet a target "cool score." Scores are based on the relative temperature reduction provided by each strategy and are given extra credit for cooling the public realm. Actions are complemented by the maximization of tree planting and GI in the PROW.

Actions Already Being Taken

- MBTA provides online GPS tracking of buses that may be downloaded as an app on a smartphone to minimize outdoor wait times.
- The City formed the Climate Resilience Zoning Task Force (CRZTF) to evaluate the efficacy of the cooling guide and other Climate Change Zoning initiatives.
- The Department of Public Works has developed and maintains a comprehensive tree inventory of public street and park trees and continues to prioritize tree plantings throughout the City.
- The City provides free access to public pools and waterplay areas in many locations in Cambridge.

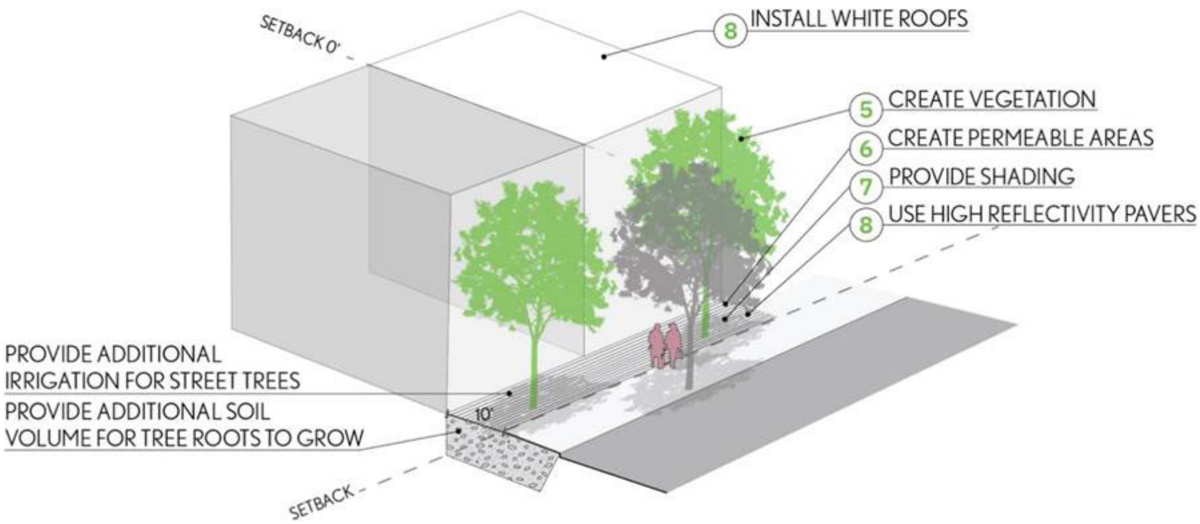


Figure D.8. The goal of the Cambridge cooling guide is to contribute to UHI reduction and thermal comfort in the face of increasing temperature. (Source: Cool Factor analysis. CRZTF, 2020.)

D2 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**City, MBTA, property owners**
Jurisdiction Who monitors the implementation?	☑ **City** ☐ **State** ☐ **Federal**
Type of Implementation How is the strategy categorized for the implementation type?	☑ **Pilot/Project/Study** ☑ **Policy/Regulations** ☑ **Program**
Scale What is the scale of the intervention?	☐ **Parcel** ☐ **Neighborhood** ☑ **Citywide** ☐ **Regional**
Related Strategies	**B6: Promote Site Green Infrastructure** **B8: Study Adapted Planning For Resilient Urban Blocks** **C7: Implement Green Infrastructure For Stormwater Management** **D1: Provide For a Resilient Urban Forest** **D4: Seek Green Infrastructure Opportunities**

D3 Reduce Impervious Area

Reduce impervious area of upstream parcels to limit flooding at downstream parcels. Adopt measures to increase the quality of the vegetated areas citywide.

TOOLBOX ACTIONS

3.1 Evaluate revegetating paved areas and parking lots.

3.2 Evaluate reducing parking lot sizes using porous paving or increasing shaded areas (trees or shading structure).

3.3 Evaluate installing green roofs on new buildings and existing buildings.

3.4 Proceed with a comprehensive analysis of the vegetated area citywide to complement the normalized difference vegetation index (NDVI) analysis developed for CCPR.

3.5 Reduce impervious surfaces on City-owned properties.

Why is it Relevant to Cambridge?

The impervious surface coverage in the Mystic River and Charles River watersheds is a significant contributor to surface runoff, thereby impacting stormwater management. Maximizing upstream stormwater storage alleviates downstream flooding. Cambridge has capacity for reducing impervious surfaces for stormwater storage, particularly on parcels that will be redeveloped. There are impervious lots that could be revegetated, and several commercial buildings that could implement green roofs.

Actions Already Being Taken

- As part of its stormwater policy, the City requires any new development site to reduce its post-development 25-year peak flow to lower than the pre-development two-year peak flow.
- Zoning ordinance Article 22 incentivizes the implementation of green roofs by not counting them against a building's Gross Floor Area.
- Zoning ordinance Article 19 requires a special permit from the Planning Board for any structure that is constructed, expanded, etc., or for dumping, filling, excavation, etc., within the floodplain.
- The City has designed and commissioned several GI projects, such as porous pavement, rain gardens, bioretention basins — particularly as part of the Huron A, B, Concord Avenue and Western Avenue sewer separation projects.
- The City designed and built a 3.4-acre wetland — New England's largest constructed stormwater wetland — to meet stormwater storage requirements as part of the Alewife combined sewer separation project. This wetland area stores, attenuates and

treats the separated stormwater before discharging to the Little River.

- The City is working with the Climate Resilience Zoning Task Force to enhance the greening of the City and reduce impervious areas in accordance with updated zoning requirements and design guidelines.

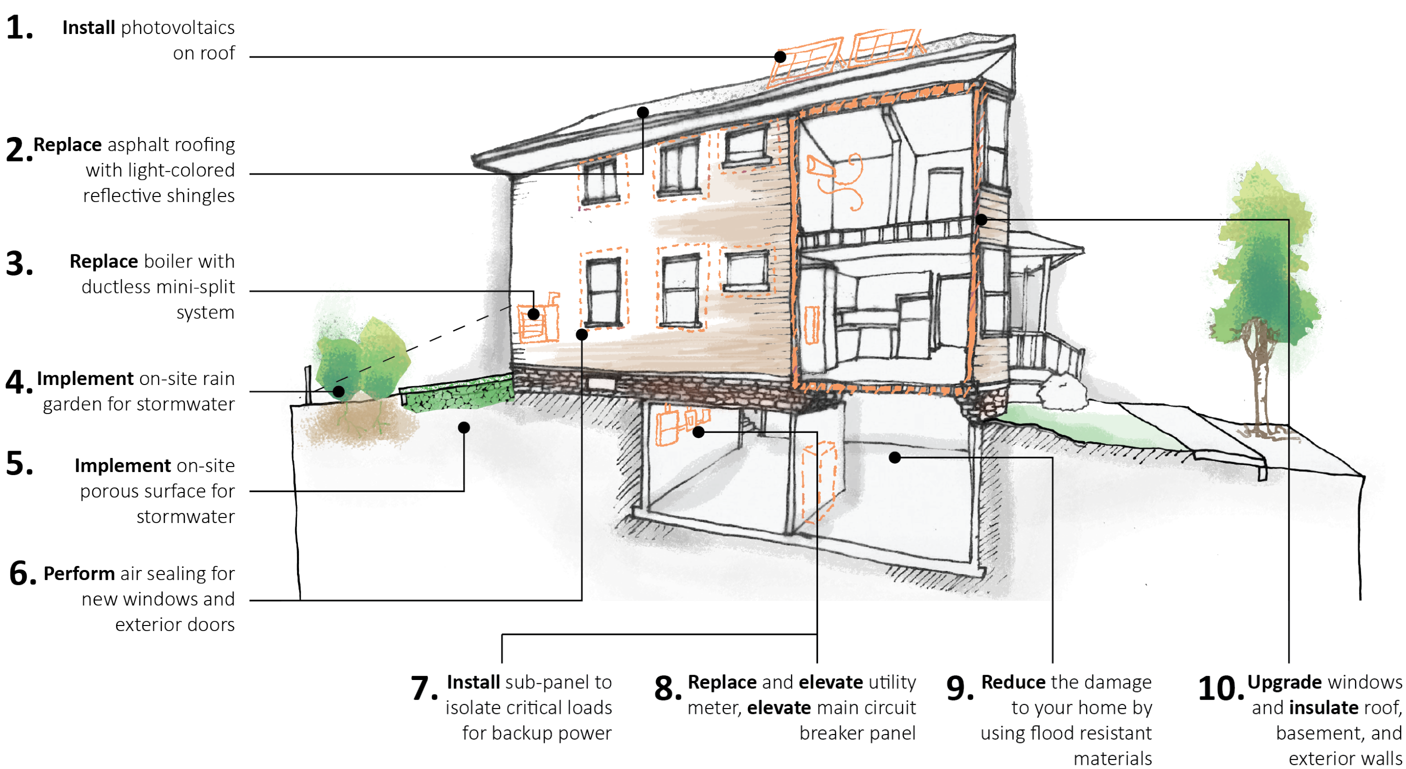


Figure D.9. This Residential Toolkit illustrates actionable steps a homeowner can take to reduce impervious area on a property. (Source: City of Cambridge)

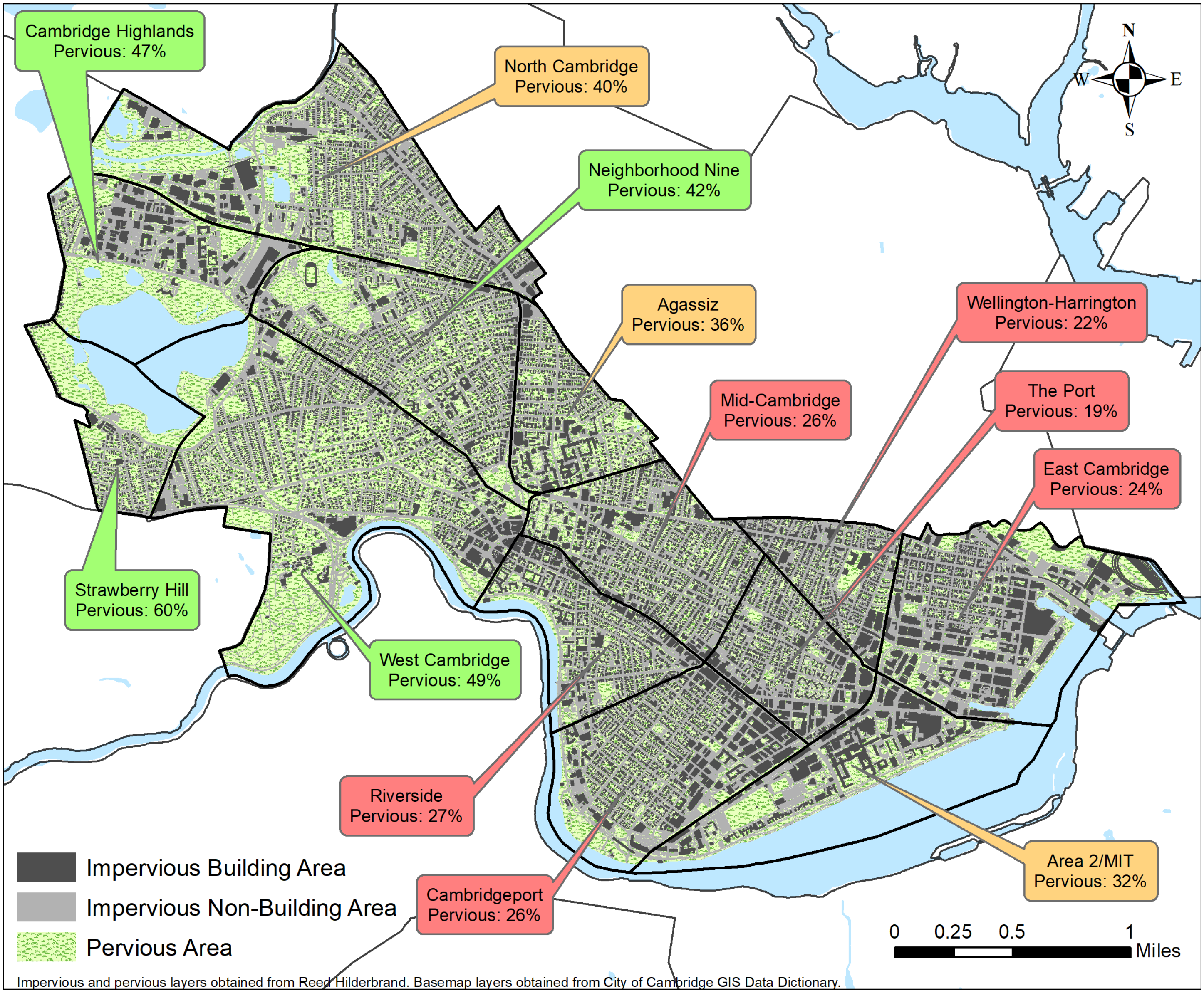


Figure D.10. This map shows citywide impervious and pervious surfaces.

D3 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**City, property owners**
Jurisdiction Who monitors the implementation?	☑ **City** ☐ **State** ☐ **Federal**
Type of Implementation How is the strategy categorized for the implementation type?	☑ **Pilot/ Project/ Study** ☐ **Policy/Regulations** ☑ **Program**
Scale What is the scale of the intervention?	☑ **Parcel** ☐ **Neighborhood** ☐ **Citywide** ☐ **Regional**
Related Strategies	**B6: Promote Site Green Infrastructure** **B8: Study Adapted Planning For Resilient Urban Blocks** **D1: Provide For a Resilient Urban Forest** **D4: Seek Green Infrastructure Opportunities**

D4 Seek Green Infrastructure Opportunities

Implement GI to mitigate UHI. GI will also improve water quality and reduce flooding impacts from smaller rainfall events.

TOOLBOX ACTIONS

4.1 Evaluate installation of raised planters in medium-density residential parcels in conjunction with street improvement projects.

4.2 Evaluate the potential to include bioretention basins in retrofitting medium-density residential parcels and in new high-density residential parcels, new light industrial development, public open space, and PROW.

4.3 Evaluate using porous pavement and permeable pavers for residential driveways, new streets, and parking lots of commercial parcels. Evaluate installation of green roofs in retrofitting existing commercial buildings, new light industrial buildings, and new high-density residential development.

4.4 Develop an education program for residents and public schools on local GI opportunities that benefit the local UHI.

4.5 Integrate green and gray infrastructure recommendations into the identification, planning, and design for future projects (e.g., priority infiltration and inflow removal projects, sewer separation projects, Chapter 90 roadway projects, pilot Cool Corridor concepts, private site development review, municipal stormwater retrofits).

Why is it Relevant to Cambridge?

The City encourages all new development to follow the "25:2" stormwater policy. This policy may become more stringent as flooding increases. GI allows for an increase in flood storage and improved water quality in the City's water bodies. GI can supplement the gray infrastructure already in place in Cambridge to increase storage capacity. GI is also proven to be effective in reducing the UHI effect. Cambridge and other urban areas will see heat vulnerability exacerbated. The number of days over 90 degrees is projected to nearly triple by 2030. Such temperature increases are dangerous to public health.

Actions Already Being Taken

- Porous pavement and infiltrating catch basins have been installed in some streets in Cambridge.
- As part of its stormwater policy, the City requires

that new developments store the difference in volume between the two-year, 24-hour storm event pre-development runoff and post-development 25-year, 24-hour storm event runoff.

- The City is evaluating the maximization of GI for implementation into current street reconstruction projects.

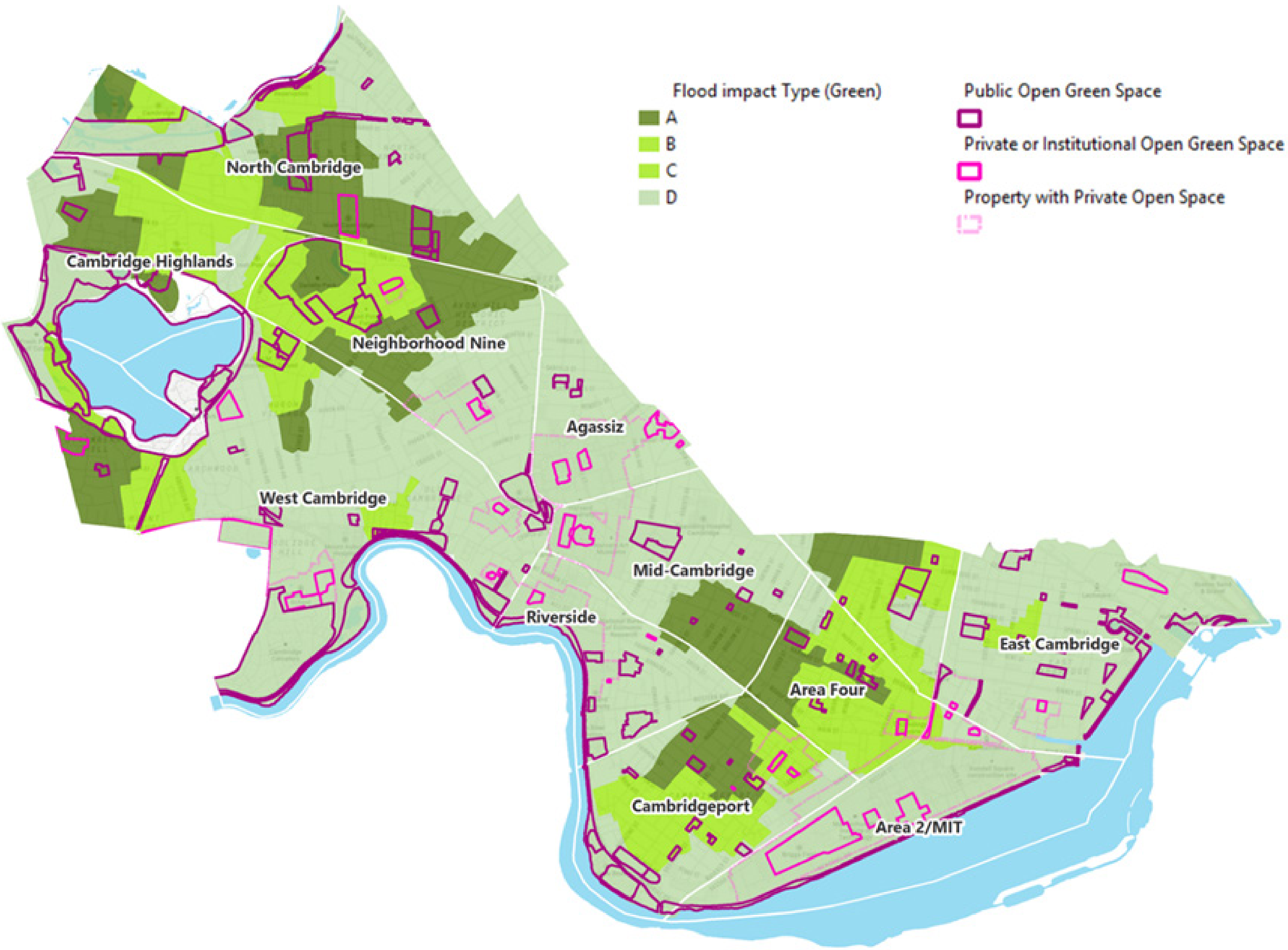


Figure D.11. Citywide open space opportunities for GI implementation.

Figure D.12. Green infrastructure is installed along the bike path on Western Avenue in Cambridge. (Source: Kleinfelder)

D4 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**City, property owners**
Jurisdiction Who monitors the implementation?	☑ **City** ☐ **State** ☐ **Federal**
Type of Implementation How is the strategy categorized for the implementation type?	☑ **Pilot/ Project/ Study** ☐ **Policy/Regulations** ☑ **Program**
Scale What is the scale of the intervention?	☐ **Parcel** ☑ **Neighborhood** ☐ **Citywide** ☐ **Regional**
Related Strategies	**B6: Promote Site Green Infrastructure** **B8: Study Adapted Planning For Resilient Urban Blocks** **C7: Implement Green Infrastructure For Stormwater Management** **D1: Provide For a Resilient Urban Forest**

D
5

Expand and Improve Open Spaces

Develop a City Open Space Plan integrating retrofit projects that increase tree canopy and projects that create new parks to provide cool, equitable outdoor areas for public enjoyment.

TOOLBOX ACTIONS

5.1 Develop a City Open Space Plan integrating retrofit projects to increase tree canopy and new parks to provide cool, outdoor areas for public enjoyment.

5.2 Enhance contiguous planted areas along the PROW, such as cool streets.

5.3 Study options for new or improved parks or publicly accessible open spaces.

5.4 Consider zoning change for a green roof ordinance or program to incentivize the creation of new green roofs that are ideally publicly accessible, or at least accessible to residents or workers.

5.5 Partner with large property owners and institutions to improve green open spaces and promote use by the public.

5.6 Advocate for facilities that provide cooling activities throughout the City, such as public pools, waterplays, and other water features.

Why is it Relevant to Cambridge?

The natural, vegetative environment contributes to a better quality of life and a healthier built environment for Cambridge residents. It also helps reduce temperatures and mitigate flood impacts. There is an urgent need to preserve and grow the natural, vegetative environment in Cambridge. While these strategies will help mitigate climate impacts, natural vegetation is also vulnerable to increasing temperatures, changes in natural germination cycles, and increased likelihood of drought and unstable growing conditions. Increased flooding threatens to damage planted areas through erosion and, in some cases, brackish inundation.

The City aims to address existing and projected climate impacts by increasing the amount of vegetation and access to open spaces citywide. These actions will also enhance the quality of life for Cambridge residents.

Actions Already Being Taken

- The City is currently updating its existing Open Space Plan, which outlines the shared community goals of the open space system, including increasing the amount of open space area and improving and maintaining the quality of existing and new open spaces.

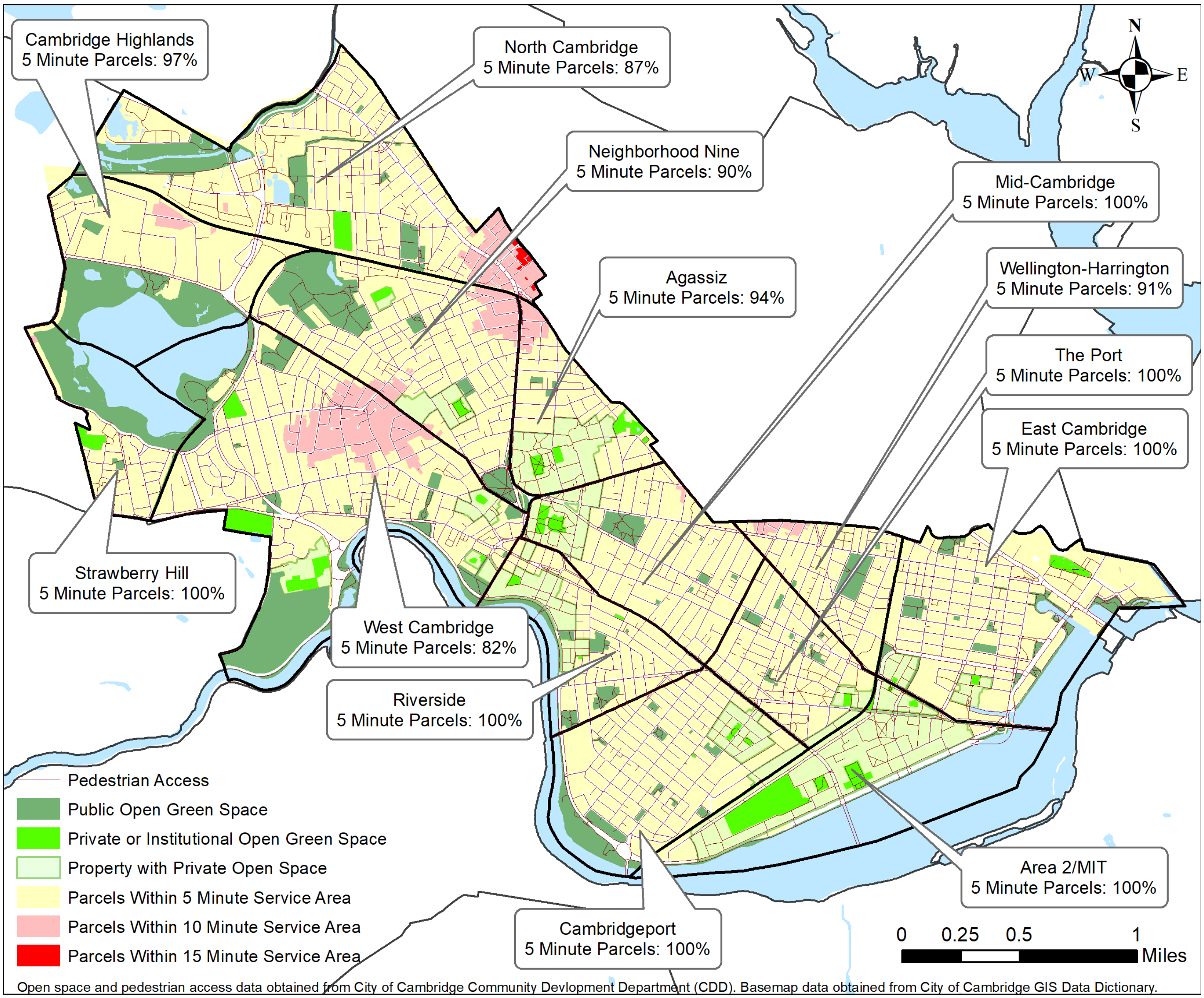


Figure D.13. This map shows the open spaces and service areas citywide.

D5 APPLICABILITY (WHO & HOW)

Implementation Proponent Who will steward implementation and who could provide possible financing for implementation or mobilization?	**City**
Jurisdiction Who monitors the implementation?	☑ **City** ☐ **State** ☐ **Federal**
Type of Implementation How is the strategy categorized for the implementation type?	☑ **Pilot/Project/Study** ☑ **Policy/Regulations** ☑ **Program**
Scale What is the scale of the intervention?	☐ **Parcel** ☑ **Neighborhood** ☐ **Citywide** ☐ **Regional**
Related Strategies	**A2: Enhance Resilient Public Amenities** **D1: Provide For a Resilient Urban Forest** **D2: Enhance Outdoor Thermal Comfort**

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