

CITY OF WORCESTER



Municipal Vulnerability Preparedness Plan: Findings & Recommendations

June 2019



Table of Contents

Acknowledgments.....	3
Executive Summary – Municipal Vulnerability Preparedness Planning.....	4
Worcester Community Resilience Building Workshop - Summary of Findings & Recommendations	5
1. Overview	5
2. Community Resilience Building Workshop Overview.....	8
2.1 Climate Change-Related Natural Hazards.....	9
2.2 Community Vulnerabilities by Hazards.....	14
2.3 Community Vulnerabilities by Feature (Infrastructural, Societal, Environmental)	24
2.4 Summary of Community Strengths and Assets.....	29
3. Recommendations to Improve Resilience	30
3.1 Prioritized Recommendations.....	30
3.2 Other Potential Actions of Lower Priority.....	34
3.3 Findings from the Public Listening Session	35
4.1 Project Team and Workshop Participants	36
4.2 Citations and References	39

Appendix A: Presentation from the Community Resilience Building Workshop (1/25/2019)

Appendix B: Worcester Flooding and Critical Assets Map

Appendix C: Final risk matrix resulting from the CRB workshop

Appendix D: Presentation from the Listening Session (6/13/2019)

Acknowledgments

Special thanks to:

- Massachusetts Executive Office of Energy and Environmental Affairs for providing the City with grant funding to implement the Community Resiliency Building (CRB) process.
- Core Group members and workshop participants for investing their time, focus, and passion into the workshop and moving the identified priorities forward.



Worcester City Manager, Edward M. Augustus Jr., welcomes attendees on the morning of the Municipal Vulnerability Preparedness Community Resiliency Building Workshop organized by the City of Worcester's Division of Energy and Asset Management (EAM).

Executive Summary – Municipal Vulnerability Preparedness Planning

The **City of Worcester** is taking proactive measures to preserve the natural environment and protect its community members from the impact of climate change-related hazards. Using the planning grant funding made available through the Massachusetts Executive Office of Energy and Environmental Affairs' (EEA) Municipal Vulnerability Preparedness (MVP) program, the City aims to build on the work recently completed through their Hazard Mitigation Plan (HMP).

This Report summarizes the City's MVP resiliency planning efforts. The City collaborated with community stakeholders through a Community Resilience Building (CRB) workshop (held on January 25, 2019) to identify climate change-related natural hazards that impact Worcester, discussed the community strengths and vulnerabilities to those hazards, and developed priority actions to address climate change issues.

For Worcester, community stakeholders identified the three (3) focal climate-change hazards, or the natural weather-related events that are influenced or exacerbated by changing climate trends, which are ***flooding from extreme precipitation (heavy rain)***, ***ice and snowstorms coupled with extreme cold***, and ***extreme heat coupled with drought***. The CRB Workshop participants identified community features that could be source of vulnerability from the perspective of those three climate-change hazards:

Infrastructural	Societal	Environmental
Transportation	Community Populations	Water Features
Utility Infrastructure	Social Services	Surface Features
Buildings/Structures		Soil/Air Quality

Together, the CRB workshop participants identified a list of priority actions to focus the City's resiliency planning efforts including investing in stormwater infrastructure improvements, engaging community members to prepare for climate change, and protecting open green space and water resources.

The City presented the findings from the CRB workshop to the general public at-large during a listening session meeting on June 13, 2019 at Worcester City Hall.

Worcester Community Resilience Building Workshop - Summary of Findings & Recommendations

1. Overview

In recent years, the effects of climate change that **City of Worcester** has been experiencing have become more apparent. Climate change manifests itself in a number of extreme, and often conflicting, weather events.

As New England now has more intense precipitation events, the City was twice designated America's 2nd Snowiest U.S. City (population 100,000 or more) during the winters of 2012-2013 (109" of snow) and 2014-2015 (120" of snow)¹. Over the last ten years climate change has also led to more extreme and prolonged heat waves during the summer months. In 2016, the City was in Stage III drought, yet, in the fall of that same year, an intense rain event caused severe flash flooding, exposing the City's stormwater system vulnerabilities.



In October, 2016, the City was in the midst of a severe drought (stage III), while also being affected by one of the most severe and damaging rain events in its history.

As climate change intensifies weather events, it is becoming ever so important for the City to plan and prepare for the hazards caused by such extreme weather events.

Municipal Vulnerability Preparedness Program

The Municipal Vulnerability Preparedness (MVP) program is a new grant and designation program for cities and towns. Launched in 2017, the MVP program builds on Governor Baker's Executive Order 569 ('Establishing an Integrated Climate Change Strategy for the Commonwealth'), as well as other administration-led state and local partnerships, to support Massachusetts municipalities to plan and implement key climate change resiliency adaptations. Funding for MVP Planning grants is first used to

¹ www.goldensnowglobe.com

complete vulnerability assessments and to develop action-oriented resiliency plans, which help communities to do the following:

- Define extreme weather, natural and climate related hazards in their communities
- Understand how their community may be impacted by climate change with a Massachusetts specific climate change clearinghouse with the latest science and data (<http://www.resilientma.org>)
- Identify existing and future community vulnerabilities and strengths related to: a) infrastructure b) environment and c) society
- Develop and prioritize actions for the community
- Identify opportunities to take action to reduce risk and build resilience.

Once the resiliency plan is completed and approved by the state, MVP Action grants can be applied for to implement key actions identified through the planning process.

In 2018, Worcester received a \$100,000 Municipal Vulnerability Preparedness (MVP) Planning grant to assist it with implementation of the Community Resilience Building (CRB) planning process², as well as conducting several risk and vulnerability assessments, and developing educational and outreach materials for Worcester residents related to climate change and flooding.

Additionally, the City is undertaking a number of other planning efforts, which could help inform best approaches for addressing the projected climate change impacts. Some of these efforts include the City's 5-year Hazard Mitigation Plan³, the soon to be completed 50-year Integrated Water Resource Management Plan, the forthcoming Master Plan, the Open Space & Recreation Plan, and the recently launched Green Worcester Strategic Plan. The proposed recommendations from the CRB planning process should be integrated into these and similar planning initiatives as well as relevant implementation projects.

Community Resilience Building (CRB) Workshop Planning Process

The CRB preparation process was carried out over several months and culminated in an intensive, one-day CRB Workshop with community stakeholders on January 25, 2019 at Worcester City Hall.

The City's Division of Energy and Asset Management organized the workshop in collaboration with a Core Group that was established at the commencement of the CRB planning process. The Core Group was composed of several City departments representing public works, schools, planning, environment, and emergency services.

The City selected Kleinfelder as the state-certified MVP consultant to provide technical assistance on this project. The Core Group, with help and guidance from Kleinfelder, met prior to the workshop and selected goals, identified potential hazards, and set the expectations for the CRB Workshop.

Approximately 50 community members participated in the collaborative workshop, including Core Group members, City department staff, City committee representatives, residents, and constituents

² The CBR framework was developed and tested by The Nature Conservancy. www.communityresiliencebuilding.com

³ Adopted by the City Council on February 26, 2019

from non-profit organizations, utility companies, local businesses, and academic institutions. Workshop participants were assigned to six diversified teams for completing various tasks during the workshop.

The workshop raised awareness, facilitated dialogue and experience-sharing, and generated ideas and momentum for building a more resilient Worcester.

The workshop's objectives were as follows:

- Define the top climate-related hazards impacting the City;
- Identify areas particularly vulnerable to those hazards related to the City's social, environmental, and infrastructure frameworks;
- Identify potential challenges in addressing those issues;
- Document community strengths to assist addressing hazards; and
- Provide recommendations to improve resilience by leveraging those community strengths as assets and reducing vulnerabilities.

This report provides a summary of the concerns, ideas, and priorities shared by these participants during Worcester's CRB Workshop.

Table group discussions and presentations



2. Community Resilience Building Workshop Overview

On January 25, 2019, the City held a one-day Community Resilience Building Workshop.

The City of Worcester is subject to the effects of natural weather-related events that are influenced or exacerbated by changing climate trends, or what are commonly known as climate change hazards.

At the beginning of the CRB Workshop, following introductions and opening words, Kleinfelder presented six recognized climate change hazards relevant to Worcester:

1. Heavy rainfall
2. Ice/snow storms
3. Wind
4. Brush Fires
5. Extreme Heat, and
6. Drought

Kleinfelder presented historical climate data and the best-available climate change projections related to the frequency, magnitude, and impact of these climate hazards. **The full presentation is attached as Appendix A.** The presented information was based on City-wide and regional climate change projections from the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, FEMA flood maps, and local knowledge from City staff.

The presentation included a map (**Worcester Flooding and Critical Assets Map - Appendix B**) that overlaid climate change hazards related to flooding⁴ with the City's critical assets.⁵ The same map was used for the small group break-out sessions throughout the day.

Following the climate change hazard presentation, stakeholders participated in a full-group discussion about how each hazard had impacted Worcester in the past and offered climate-related concerns about the future. Anecdotal stories were shared surrounding the extreme rainfall and snow events.

Afterward, participants worked in six small groups to identify infrastructural (e.g. pump stations), societal (e.g. public health), and environmental (e.g. water quality) features of the community that may be impacted by the identified climate change hazards. Infrastructural features are the built aspects that support the City's functionality. Societal features are those that reflect the conditions and population demographics of the Worcester community. Environmental features are the natural aspects of the City and the current condition of those elements. Features were defined by their location, their ownership, and whether the participants considered the feature a vulnerability and/or a strength from the standpoint of resiliency for the Worcester community.

The six groups shared their findings with the entire group, and in the second part of the workshop, worked on identifying potential actions to improve community resilience to extreme weather events.

⁴ Information used to develop the flooding map was based on Worcester's Customer Service Request System (CSRS) data for reported flooding events between 2006 and 2016.

⁵ Derived from Worcester's 2018 Draft Hazard Mitigation Plan and the accompanying critical assets GIS layer.

2.1 Climate Change-Related Natural Hazards

During a meeting prior to the CRB Workshop, the Core Group identified two top hazards: heavy rain (flooding) and ice/snow storms.⁶ The Core Group initially suggested combining multiple hazards with a close association and a high probability of occurring at the same time.

At the beginning of the CRB Workshop, the full stakeholder participant group was asked to identify a third, and possibly fourth climate change hazard, in addition to the two already cited. Following a group discussion, the workshop attendees reached a consensus to add extreme cold to the previously identified ice/snow storms hazard and selected a third primary climate change hazard as the combination of extreme heat and drought.

At the conclusion of the climate change hazards discussion, workshop participants identified the following three climate change hazards (not ranked) as those having the greatest direct impact on Worcester in the recent past, and/or anticipated to be of greater concern in the future:

→ **Flooding from extreme precipitation (heavy rain)**



→ **Ice/snowstorms coupled with extreme cold**



→ **Extreme heat coupled with drought**



⁶ According to the www.goldensnowglobe.com, Worcester has been in the top 10 snowiest U.S. Cities 5 times in the last decade:

2017-2018 – 96.1” (6th)

2016-2017 – 78.3” (5th)

2014-2015 – 119.7” (2nd)

2012 – 2013 – 108.9” (2nd)

2010 – 2011 – 92.6” (7th)

Hazard - Flooding From Extreme Precipitation (heavy rain)



The impacts of flooding events are well-documented throughout the City and the occurrence of heavy rainfall events is projected to increase in the future. The City is frequently impacted under current conditions by extreme precipitation resulting in flooding in several low-lying areas as well as areas with finite stormwater drainage capacity. These areas include the Green Island, Southgate Street, and Pelham Street areas, to name a few.

The Green Island neighborhood area, which experiences frequent and extreme cases of flooding, is a prime reflection of the challenges faced by the City during periods of heavy rainfall. Participants commented on the area as a low-lying part of Worcester’s hilly landscape with a mainly impervious surface characteristic and combined sewer – the factors that lead to increased stormwater surface runoff and local area flooding.

Future projections indicate that infrastructure systems will become further stressed under these extreme weather events. This hazard impacts public transportation, can result in significant property loss, and can create public health and safety issues.



A flooded underpass on Cambridge Street during an extreme rainfall event in Worcester in July of 2018.
Photo credit: Matthew Healey from The Boston Globe

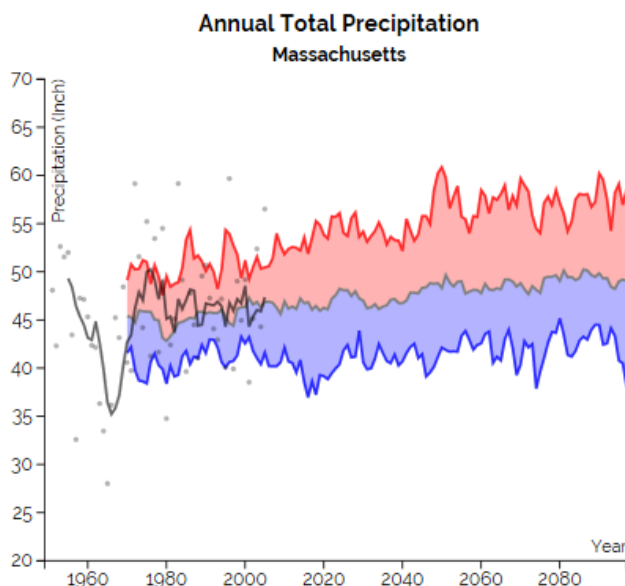


Figure 1: Projected Annual Total Precipitation in Massachusetts 1960-2100

Source: www.resilientMA.org

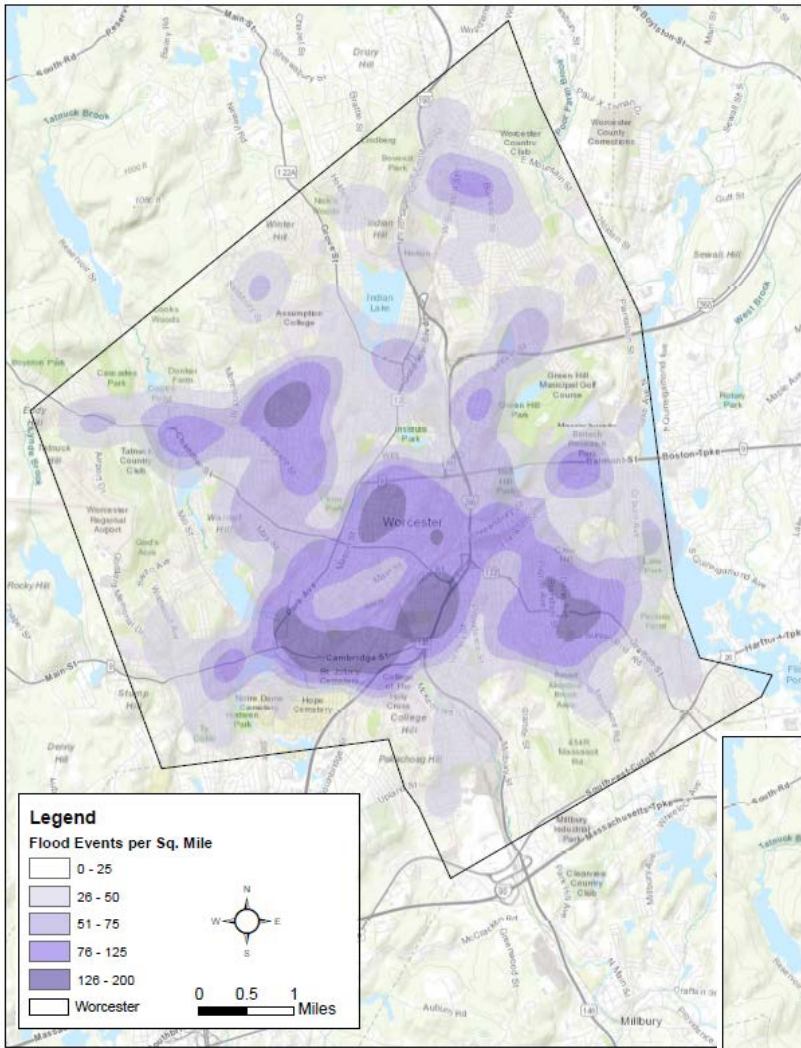
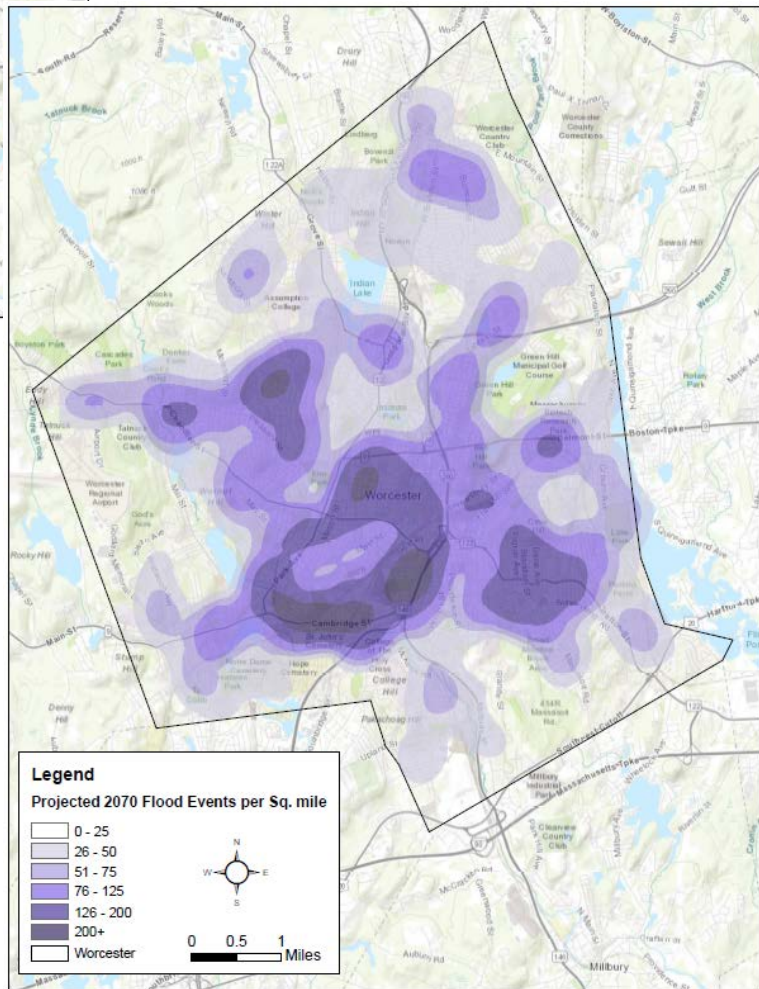


Figure 2: Depiction of current flooding due to finite stormwater drainage capacity, and 2070 flooding projections.

Source: City of Worcester data and www.resilientma.org



Hazard - Ice/Snowstorms and Extreme Cold



During the heavy snowfall events, ice storms and extreme cold of the winter months, the City's energy infrastructure is subjected to increased stresses, such as gas line breaks (due to frost heaves acting on buried pipes) and electrical lines damage (due to strong winds and heavy weight of ice). Workshop participants believed that these impacts are exacerbated by the steep roadway slopes and local microclimates that develop as a result of the varying topography across the entire city. This hazard also has a detrimental societal effect due to its impact on roadways, public transportation, and above ground utilities. Participants discussed how low income and vulnerable populations, who rely disproportionately more on public services, were more severely impacted by heavy snow and ice storms.



A snowstorm in 2015 in Columbus Park neighborhood of Worcester.

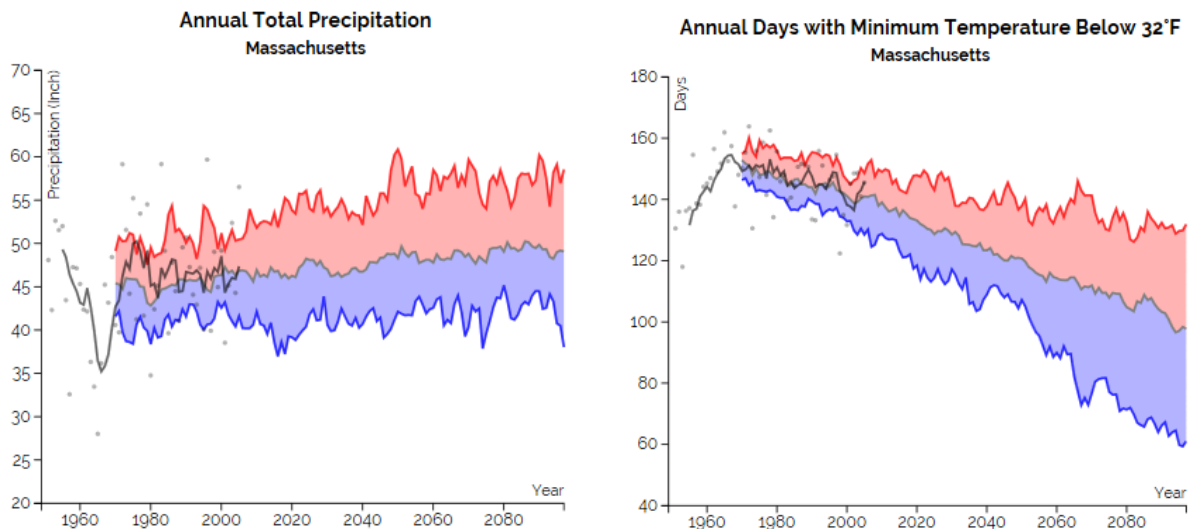


Figure 3: Worcester is susceptible to large snow and ice storm events due to:

- Annual precipitation volume in winter is projected to increase 30% due to climate change.
- Annual days below freezing is projected to decrease over the next 80 years due to climate change.
- Projected rising temperatures will cause more winter precipitation to fall as rain or freezing rain instead of snow.
- Therefore, there will be higher chance of ice and freezing rain storms

Source: www.resilientma.org



Hazard - Extreme heat/Drought

While this has not historically been a frequent hazard for the City, it was identified as a hazard of concern because climate projections indicate that temperature-related extreme events (degree and duration) will become more frequent and intense in the future. This hazard has an impact on community facilities and residents, especially vulnerable populations such as economically disadvantaged or elderly populations, who are at higher risk for heat-related illness and may not have access to air conditioning.

This is also a concern for future droughts such as the one the City experienced in 2016, causing a temporary shortage of available drinking water supply and resulting in the purchase of additional water from the Massachusetts Water Resources Authority (MWRA), costing the city over \$3 million.

Responding to these climate change hazards produces an added strain on the City’s existing resources.

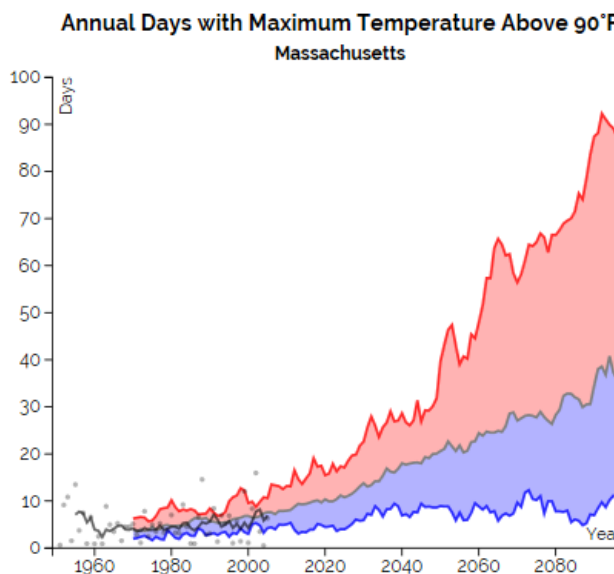


Figure 4: Projected Annual Days with Max Temperature Above 90 F Total Precipitation in Massachusetts 1960-2100

Source: www.resilientma.org



Low water levels at Pine Hill and Quinapoxet Reservoirs, some of the sources for Worcester’s drinking water, during Stage III drought in 2016

2.2 Community Vulnerabilities by Hazards

The CRB Workshop continued with a discussion about the City's vulnerabilities to the identified hazards. Past and present extreme weather events exposed aspects of the City that are vulnerable to the impacts of climate change hazards. These vulnerabilities include the City's built and natural environment as well as the populations that live and work within the Worcester community. Kleinfelder presented the following at-risk aspects of the City based on the findings of the City's draft Hazard Mitigation Plan and anecdotal data provided by City staff:

- Infrastructural aspects such as the transportation network, utility systems, and municipal buildings
- Societal aspects such as sensitive populations and access to municipal services
- Environmental aspects such as the natural water systems, urban open space and forestry, air quality, and subsurface soil conditions

The list below summarizes the vulnerable features of the Worcester community as identified by participants during the CRB Workshop small group sessions.

For the purpose of this report, vulnerability is defined as the exposure to one of the three selected climate change-related hazards and the sensitivity or adaptive capacity of the community feature. These features are organized into three categories: the infrastructure (built facilities and assets), the society (people and services), and the environment (water systems, trees, and open space).





Features most vulnerable to flooding from extreme precipitation hazard

During the CRB Workshop, participants voiced their concerns that the three identified hazards will likely impact Worcester with increasingly more damaging and disruptive extreme weather events. Some of the challenges faced when combating climate change and these climate-related hazards are presented below as discussed in detail during the workshop's small group sessions.

The impacts of flooding events are well-documented throughout the City. The Green Island area in the southern portion of the city experiences frequent and extreme cases of flooding, and serves as a prime example of the challenges faced by the City during periods of heavy rainfall. The Green Island area is low-lying and is mostly located within the 100-year floodplain. It acts as a drainage outlet (into Blackstone River, behind Walmart on Route 146) for its watershed, which comprises a large portion of the City's area. The neighborhood has a lot of impervious surfaces and is surrounded by a large combined sewer area, where sanitary and stormwater sewer flows are combined during heavy rain events and often discharged into the Blackstone River. During intense and/or prolonged rains, water levels in the river begin to rise. When that happens, the stormwater cannot enter the river channel, in turn backing up into the streets, resulting in Green Island street flooding and, at times, property damage.

Future projections indicate that infrastructure systems will become further stressed under these extreme weather events. To prepare themselves accordingly, the City is developing the Worcester Integrated Plan with the intent of optimizing their capacity to improve the water resource-related services and infrastructure, including stormwater, drinking water, and wastewater.



A public event where educators set up kayak rides to teach people about the Blackstone canal, currently piped underneath downtown Worcester.



Mill Brook conduit extension under Worcester downtown.



Figure 5-A: Approximate delineation of the Green Island neighborhood (between Quinsigamond Avenue, Millbury Street, and Kelley Square)

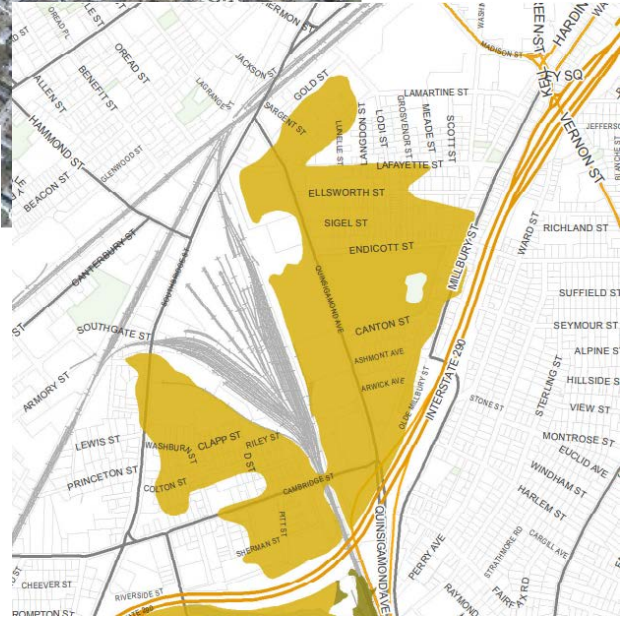


Figure 1-B: 100-year flood zone (i.e. 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage) in the Green Island area depicted in orange color – based on the historic data to predict flooding events, and not accounting for climate change impacts.

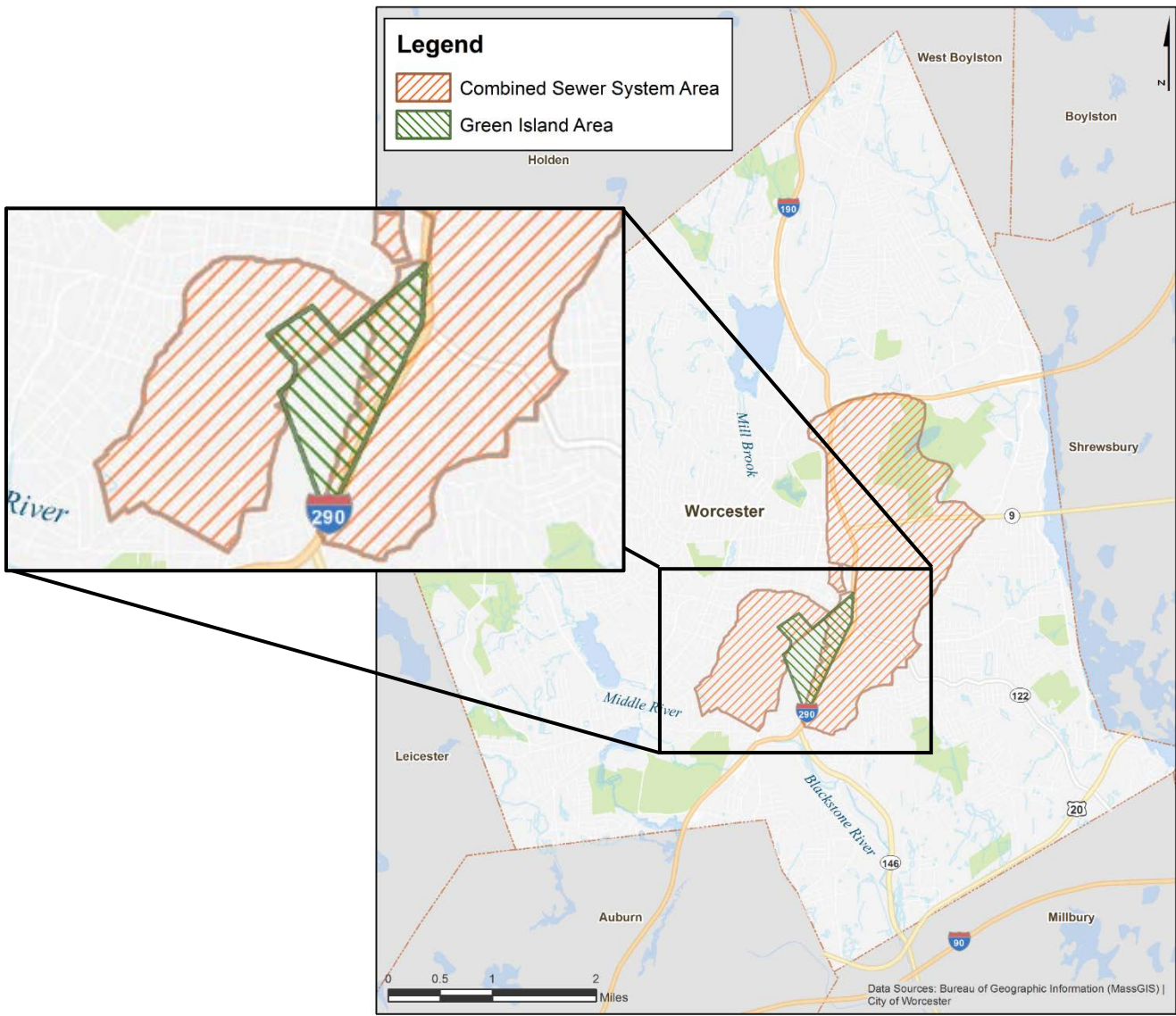


Figure 6: City's combined sewer system area, where sanitary sewerage and storm water runoff are combined during heavy and/or prolonged rain events, is particularly susceptible to surface flooding.

Infrastructural Vulnerabilities:



- Transportation:

- Worcester Regional Transit Authority (WRTA) Depot
- railroad tracks and railroad bridges
- highways and roadways throughout City
- sloped roadways along Belmont Street
- low bridges along Cambridge Street
- Quinsigamond Avenue
- Southbridge Street
- Hammond Street
- Millbury Street along the Blackstone River
- Southwest Cutoff (MA-20) under the Grafton Street overpass
- Major Taylor Boulevard near the DCU Center



Concerns: Obstructed emergency access/evacuation routes, negative economic impacts on commuters and local businesses.

- Utilities:

- stormwater infrastructure
- wastewater/combined sewer infrastructure
- electric power lines
- communication infrastructure throughout the City

Concerns: clogged catch basins, undersized culverts, inadequate conveyance capacity, poor surface water quality, disrupted emergency communications, power outages and service interruptions.

- Buildings:

- DCU Center
- medical facilities throughout City
- emergency response services/shelters
- old and aging housing stock
- old and aging schools

Concerns: obstructed access to emergency shelter, negative impact on economic business opportunities, obstructed access to/from medical services, residential and commercial property damage.

- Other Assets:

- upland retaining walls
- dams

Concerns: the lack of adequate structural condition information; potential of failure and resulting property damage.



Societal Vulnerabilities:

- **Populations:**
 - large non-English speaking demographic
 - large homeless population
 - elderly community
 - widely distributed neighborhoods of variable density
 - wide disparity in education levels
 - large environmental justice community

Concerns: inadequate modes of emergency communication and alerts, limited access to municipal services, low homeownership rates, limited access to recreational areas, transient and immigrant population with lack of local knowledge on resources and service providers.

- **Social Services:**
 - public transportation
 - emergency services
 - community centers
 - health care services
 - housing services

Concerns: perception of inadequate capacity for sheltering vulnerable populations by some members of the public, inequitable access to social services, lack of inclusivity, lacking inter-departmental knowledge sharing and collaboration within city government.



Environmental Vulnerabilities:

- **Water Features:**
 - waterways
 - wetlands
 - lakes and ponds
 - aquatic life

Concerns: combating invasive species, degrading water quality, trash accumulation in public spaces, and the lack of enforcement on other pollution prevention measures.

- **Surface Features:**
 - hill topography and tree canopy throughout City

Concerns: managing surface runoff and foliage build-up in stormwater infrastructure.

- **Soils:**
 - brownfield/hazardous waste sites throughout the City.

Concerns: managing risk for groundwater contamination and pollution of waterways from industrial sites.



Features most vulnerable to ice/snowstorms and extreme cold hazard

Worcester’s transportation infrastructure and energy facilities are impacted by heavy snow and ice storms during the winter months. The workshop participants expressed concern about the resilience of aboveground utilities – in the street’s right of way and especially in the homes’ backyards, some of which have electrical utility lines, proving access for repair vehicle difficult at times.

Intense winds that occur during these extreme ice/snow events can result in fallen trees or branches damaging electric power and communication lines and creating hazardous conditions along roadways. The City has focused on collaboration between the City’s Urban Forestry division, utility companies, and the City’s emergency management systems, but there are competing City- wide issues that also place stress on the City’s available funding and resources.



Worcester’s MBTA commuter line stop (at Union Station) during a snowstorm.

The City’s vulnerable populations are also impacted by the ice/snow events and the extreme cold. Participants voiced concern about the homeless population and elderly residents during these extreme cold situations. The vulnerabilities are exacerbated by the City’s aging housing stock, which is typically less energy efficient and exhibits structural deterioration, thus more susceptible to damage from the ice/snow and extreme cold climate change hazard.



Infrastructural Vulnerabilities:

- Transportation:
 - old bridges (Southgate Street)
 - highway and roadway potholes throughout City
 - sloped roadways along Belmont Street
 - low bridges along Cambridge Street

Concerns: Obstructed emergency access/evacuation, inefficient pavement management/deicing, negative economic impacts on commuters and local businesses.

- Utilities:
 - drinking water infrastructure
 - natural gas pipes
 - electric power lines
 - communication infrastructure throughout the City



Concerns: managing frozen water pipes, disrupted emergency communications, power outages and service interruptions.

- Buildings:
 - Worcester Technical High School
 - emergency response services/shelters
 - old and aging housing stock
 - old and aging schools

Concerns: obstructed access to emergency shelters, negative impact on economic business opportunities, obstructed access to/from medical services, residential property damage.



Societal Vulnerabilities:

- Populations:
 - large non-English speaking demographic
 - large homeless population
 - elderly community
 - wide disparity in education levels
 - large environmental justice community

Concerns: inadequate modes of emergency communication and alerts, limited access to municipal services, low homeownership rates, transient population with lack of local knowledge on resources and service providers.

- Social Services:
 - public transportation
 - emergency services
 - community centers
 - health care services
 - housing services

Concerns: perception of inadequate capacity for sheltering vulnerable populations by some members of the public, inequitable access to social services, lack of inclusivity, lacking inter-departmental knowledge sharing and collaboration within city government.



Environmental Vulnerabilities:

- Surface Features:
 - hill topography
 - tree canopy throughout City

Concerns: managing roadway and sidewalk surface icing conditions, power outages due to downed trees.



Features most vulnerable to extreme heat and drought hazard

In 2016, the City experienced a drought causing a temporary shortage in the available drinking water supply in their reservoir system. To prevent the disruption in water service to the end users, the City purchased water from the Massachusetts Water Resource Authority, pulling water from an existing interconnection with the MWRA's systems at a cost of three million dollars (\$3M). This unanticipated cost limits the City's capacity to respond to other issues during times of emergency.

The workshop participants discussed concerns about the impact of increased heat/drought-related events on the City's open space and recreational waterways. Participants suggested that water scarcity and temperature increases can result in a growth in the invasive species populations. This can contribute to the degradation of water quality. The participants also discussed how the City's ongoing effort to protect vulnerable populations from the heat/drought hazard which will become further stressed in the future climate change projection scenarios.



A small group facilitator leads discussion at a small table during the MVP workshop.



Infrastructural Vulnerabilities:

- Transportation: highways and roadways throughout City.
Concerns: managing the heat island effect.

- Utilities:
 - drinking water reservoirs,
 - electric power lines and communication infrastructure throughout the City.*Concerns:* managing drinking water reservoir quantity and quality, disrupted emergency communications, power outages (brownouts) and service interruptions.

- Buildings:
 - emergency response services/shelters,
 - old and aging housing stock,
 - old and aging schools.*Concerns:* managing thermal regulating components of buildings, lack of air conditioning in shelter locations (high schools' gymnasiums) inadequate energy efficiency of buildings, lack of alternative neighborhood energy options.



Societal Vulnerabilities:

- Populations:
 - large non-English speaking demographic
 - large homeless population
 - elderly community
 - wide disparity in education levels
 - large environmental justice community.

Concerns: inadequate modes of emergency communication and alerts, overstressed municipal services, limited access to recreational areas, transient population with lack of local knowledge on resources and service providers.

- Social Services:
 - public transportation
 - emergency services
 - community centers
 - health care services

Concerns: perception of inadequate capacity for sheltering vulnerable populations by some members of the public, overstressed healthcare providers, inequitable access to social services, lack of inclusivity, lacking inter-departmental knowledge sharing and collaboration within city government.



Environmental Vulnerabilities:

- Water Features:
 - waterways
 - reservoirs
 - wetlands
 - lakes and ponds
 - aquatic life

Concerns: combatting invasive species, degrading water quality, limited access to recreational water sources.

- Surface Features:
 - hill topography
 - tree canopy throughout City

Concerns: lack of tree shade/tree cover.

- Air Quality:
 - urban forestry
 - residential brush fires

Concerns: managing air quality degradation due to brush fires.

2.3 Community Vulnerabilities by Feature (Infrastructural, Societal, Environmental)

3 flood-prone infrastructure items:

Community Resilience Building Risk Matrix www.CommunityResilienceBuilding.org

Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)

Priority Time

II-M-L Short Long Ongoing

Features	Location	Ownership	V or S	Hazard	Actions	Priority	Time
Infrastructural							
1. Hospitals & community health centers - need for backup power	Various	D	S	(tornado)	Use as example of BID (B) best practice - ACCESS TIME to address	H	0
2. Hwy Access	West - Street	L/S	S/V	all	2.0. Hwy - roadways emergency route - community ID plan to communicate, public company to	H	3/10
3. Water - sewer (esp. CSO - K to 4 Channing Ave, Amherst)	Various	V	V	group wind	relatively this project has been done - 100% water, fire, flood, etc. - 100% water, fire, flood, etc.	M	L/O
4. Electric / gas distribution lines - old	Various	V/S	V	group flood	4.1. 100% electric - water and sewer - (see above) - 100% electric - water and sewer - (see above)	M	L/O
5. Stormwater / drainage system	Various	L/S	V	all	5.7. Alternative approach of stormwater - decision on how to manage water - clean, green, etc.	H	3/10
6. Fire hydrants, etc. - infrastructure	Various	L/S	V	all	6.1. Fire hydrants - decision on how to manage water - clean, green, etc.	H	3/10
7. Stormwater	Various	L/S	V	all	7.1. Stormwater - decision on how to manage water - clean, green, etc.	H	3/10
8. Public safety - emergency services	Various	L/S	V	all	8.1. Public safety - decision on how to manage water - clean, green, etc.	H	3/10
9. Old housing stock - need for energy, health, etc.	Various	R/L	S	all	9.1. Old housing stock - decision on how to manage water - clean, green, etc.	H	3/10
10. Schools - need for energy, health, etc.	Various	R/L	S	all	10.1. Schools - decision on how to manage water - clean, green, etc.	H	3/10
11. Universities - need for energy, health, etc.	Various	R/L	S	all	11.1. Universities - decision on how to manage water - clean, green, etc.	H	3/10
Societal							
1. Community centers - need for energy, health, etc.	Various	R/L	S/V	all	1.1. Community centers - decision on how to manage water - clean, green, etc.	H	3/10
2. Fire safety - need for energy, health, etc.	Various	R/L	S/V	all	2.1. Fire safety - decision on how to manage water - clean, green, etc.	H	3/10
3. Emergency - need for energy, health, etc.	Various	R/L	S/V	all	3.1. Emergency - decision on how to manage water - clean, green, etc.	H	3/10
4. Hazardous materials - need for energy, health, etc.	Various	R/L	S/V	all	4.1. Hazardous materials - decision on how to manage water - clean, green, etc.	H	3/10
5. Public knowledge / awareness - need for energy, health, etc.	Various	R/L	S/V	all	5.1. Public knowledge / awareness - decision on how to manage water - clean, green, etc.	H	3/10
6. Public safety - need for energy, health, etc.	Various	R/L	S/V	all	6.1. Public safety - decision on how to manage water - clean, green, etc.	H	3/10
7. Public - need for energy, health, etc.	Various	R/L	S/V	all	7.1. Public - decision on how to manage water - clean, green, etc.	H	3/10
8. Public - need for energy, health, etc.	Various	R/L	S/V	all	8.1. Public - decision on how to manage water - clean, green, etc.	H	3/10
Environmental							
1. Blue space - need for energy, health, etc.	Various	R/L	S/V	all	1.1. Blue space - decision on how to manage water - clean, green, etc.	H	3/10
2. Water - need for energy, health, etc.	Various	R/L	S/V	all	2.1. Water - decision on how to manage water - clean, green, etc.	H	3/10
3. Urban - need for energy, health, etc.	Various	R/L	S/V	all	3.1. Urban - decision on how to manage water - clean, green, etc.	H	3/10
4. Planning - need for energy, health, etc.	Various	R/L	S/V	all	4.1. Planning - decision on how to manage water - clean, green, etc.	H	3/10
5. A - need for energy, health, etc.	Various	R/L	S/V	all	5.1. A - decision on how to manage water - clean, green, etc.	H	3/10
6. Biophilic - need for energy, health, etc.	Various	R/L	S/V	all	6.1. Biophilic - decision on how to manage water - clean, green, etc.	H	3/10
7. Planning - need for energy, health, etc.	Various	R/L	S/V	all	7.1. Planning - decision on how to manage water - clean, green, etc.	H	3/10
8. Blackstone River - need for energy, health, etc.	Various	R/L	S/V	all	8.1. Blackstone River - decision on how to manage water - clean, green, etc.	H	3/10

An example of a completed matrix of features, hazards, and action items for one (of six) small group during the workshop.

Infrastructural Vulnerabilities

Energy Infrastructure

The workshop participants expressed concern about energy systems reliability decreasing due to the impacts of climate changes and changing patterns in energy use. Energy consumption will play a role in the level of stress placed on the energy infrastructure systems during these future climate change scenarios. Climate change will likely increase the number of days that buildings will require cooling and decrease the number of days that buildings require heating. The energy systems will experience an increased frequency of stressed periods, especially during the peak demand hours of the summer and winter months. Additionally, increased frequency and intensity of winter storm events will exacerbate the risk of failure for aboveground infrastructure including electrical transmission lines, and particularly those in close proximity to trees.

Workshop participants identified another concern in the lack of alternative energy power supply options or backup generators at critical City-owned facilities that may also be used as emergency shelters. The loss of electrical power could prevent these critical facilities from providing vital social services and public health support to vulnerable populations and the Worcester community as a whole.

The City has a mix of aboveground and underground energy infrastructure. Participants expressed that both types were vulnerable to climate change. Underground energy infrastructure is vulnerable to flooding while aboveground assets are vulnerable to ice and fallen trees from strong winds.

Transportation Infrastructure

Workshop participants identified concerning vulnerabilities in the transportation system with a specific focus on a few key locations most vulnerable to identified climate hazards. The reliability of WRTA bus services is vulnerable to flooding and participants were concerned about the potential impacts on life-safety and the local economy. Flooding and snowstorms are likely to increase roadway accidents, disrupt emergency response, and accelerate roadway degradation. The participants mentioned concern in the continuity of commuter rail service because of the residents who rely on the regional transportation system to commute to and from work in Boston and other areas. It was also noted that many of the roadway routes are exposed to flooding and this would impact the commutes of the Worcester community. Participants also reported that some roadway drainage systems are not adequately sized or designed for future extreme rainfall events.

Communication System

The lack of redundancy in the emergency communication system was a concern voiced by many workshop participants. Current emergency communication protocol requires citizens whose primary numbers are cell phones to “opt-in,” which limits the reach or effectiveness of the City’s messaging in an emergency. (Citizens with land-lines can be notified using a reverse 911 feature within the notification system). Additional avenues of communication require coordination between various emergency responders, multiple City departments, city organizations and groups, and the applicable state and federal agencies.

Environmental Vulnerabilities

Water Quality

The water quality of surface water features, such as rivers, streams, and ponds, was identified by workshop participants as a concern for the community due to Worcester's industrial past. The groups discussed groundwater contamination issues from current and former factory sites. The participants believe that the water bodies adjacent to these industrial sites were particularly vulnerable during extreme precipitation events. They discussed how increased groundwater flow due to precipitation may transport contaminants from the soils and into the waterways. Participants then mentioned how some residents may lack adequate education about how their actions impact water quality. Participants also expressed concerns about sewer contamination from the combined sewer overflows in the wastewater collection system during heavy rainfall events.

Trees and Vegetation

Many cities like Worcester do not have enough vegetation to combat the urban heat island. Lack of urban tree canopy is a special concern in those areas that have high impervious surfaces and are in environmental justice areas where residents may not otherwise have access to shade and cooling.

Participants expressed concerns related to the risk of non-native species thriving in the warmer future conditions of Worcester.

Proper tree management was also a concern for workshop participants. Existing trees in poor health are a greater risk to nearby energy infrastructure and the general safety of the community because impaired root systems or branches are more susceptible to uprooting or breaking during a storm event.



High amount of impervious surfaces and low tree canopy in the City's business districts.

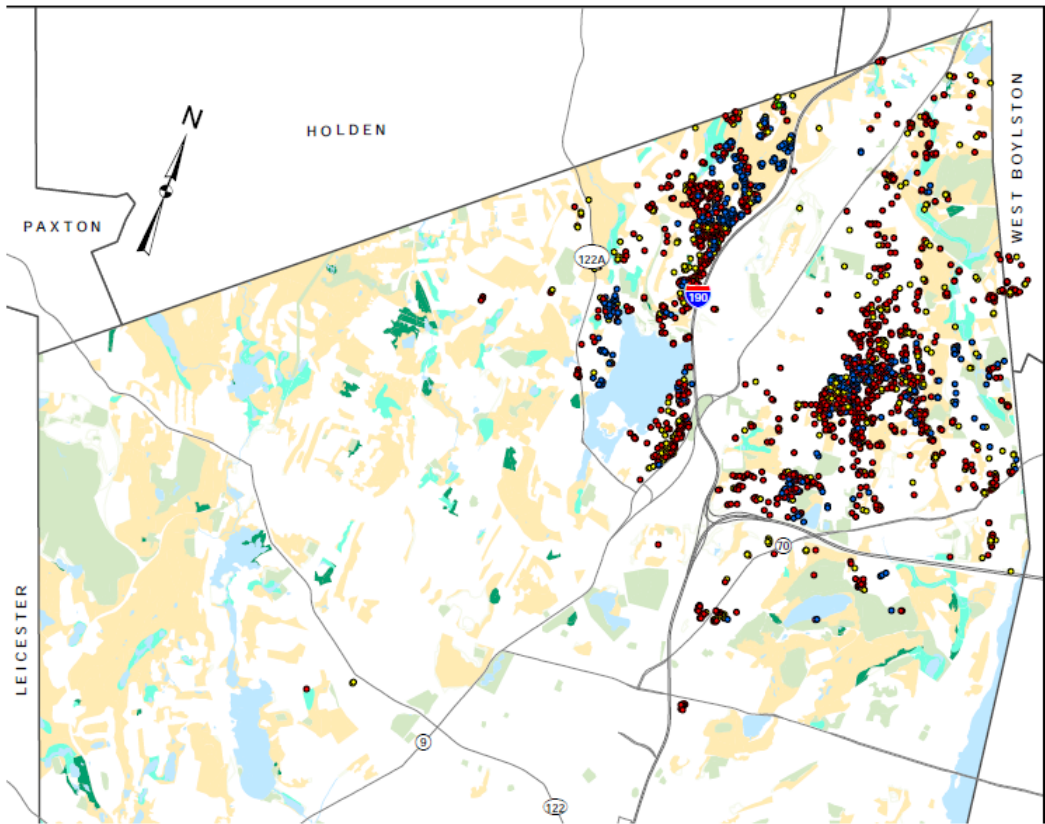


Figure 7: Infected trees by Asian Longhorned Beetle. The infected trees have been removed and consequently replanted with 30,000 new trees, by City of Worcester, Worcester Tree Initiative, and volunteers.

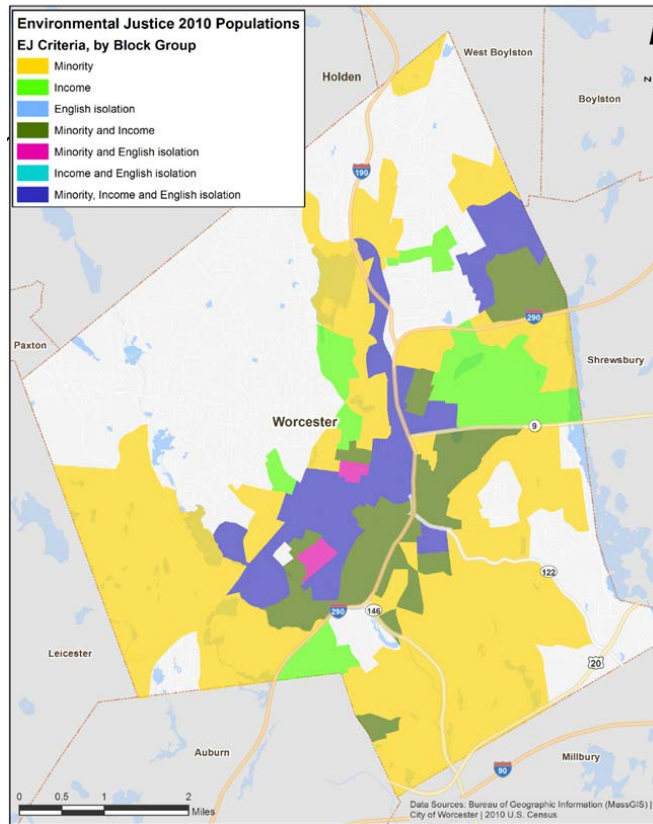
Source: Worcester Open Space & Recreation Plan, 2013. Figure 6a.

Societal Vulnerabilities

Vulnerable Populations

Workshop participants discussed their concern for the vulnerable populations in Worcester. According to the census data and emphasized during the workshop, the City has a large and growing population of residents living at or below the poverty line and residents who are foreign-born. These demographic groups disproportionately depend on municipal and social services, such as bus transit, affordable housing, translation of emergency messages and notifications into their native languages, and access to medical services. Increasing climate hazards may disrupt these services. Vulnerable populations also face heightened health risks from exposure to climate hazards (such as extreme heat or cold), disruptions to utility services, and the burden of increased heating and cooling cost.

Environmental Justice Populations Map



Municipal Facilities

Worcester's municipal buildings were identified by participants during the workshop as being vulnerable to several climate hazards. For example, some buildings' poor resiliency to the extreme heat related to the lack of proper air conditioning systems. Their poor resiliency to the extreme cold related to having inadequate heating systems. Certain environmental justice populations are particularly reliant on schools to be the primary form of childcare during work hours. Participants agreed that the impacts of school closures due to inadequate building systems are felt financially even more so by these populations. Participants also voiced a concern about the adequacy of certain school buildings if they are used as emergency shelters (e.g. lack of air conditioning in most schools preventing them from being used as shelters during heat waves).

2.4 Summary of Community Strengths and Assets

When planning for resiliency in the face of extreme weather events, the strengths of a community provide a strong foundation for gathering support and implementing change. The following list captures the wide range of strengths and assets identified by workshop participants to contribute to improved community resiliency:



- The City is interested in and committed to building resiliency, as demonstrated by the participation of a broad swath of stakeholders in the workshop. This stakeholder community can provide support to on-going efforts and maintain the momentum for implementation of next steps.
- The City has collaborative residents, well-informed municipal staff, and numerous available public facilities that can be leveraged in an emergency to facilitate emergency response as well as resiliency building measures.
- The City has a team of dedicated staff focused on implementing emergency response protocols and improving resiliency throughout the City.
- The City has numerous recreational open spaces and waterways throughout the City that can be enhanced to contribute to resiliency.
- The City already has a comprehensive transportation and roadway network that can be improved upon to further contribute to resiliency and facilitate emergency response.
- The City has an extensive and robust water supply reservoir system that can be enhanced to mitigate the impacts of drought-related events.
- The City's current efforts towards urban forestry management and wetlands conservation can be leveraged to facilitate enhanced resilient solutions to mitigate the City's natural hazards.

3. Recommendations to Improve Resilience

In the second part of the workshop, Kleinfelder presented examples of community resilience actions potentially relevant to Worcester (**Appendix A**). Participants then worked in small groups to generate lists of potential actions to reduce Worcester’s vulnerabilities and reinforce its strengths. Participants were asked to consider whether the actions address multiple hazards, whether there were intermediate steps, whether proposed actions strengthened existing initiatives, and then to factor in cost. Next, the small groups prioritized actions and differentiated them as short-term, long-term, or ongoing. As a final step of the CRB Workshop small group sessions, each group was asked to identify their top three recommendations to improve Worcester’s resilience to the identified climate hazards.

3.1 Prioritized Recommendations

The following list of prioritized recommendations was generated from the workshop participant discussions and is intended to provide guidance on the City’s follow-up actions and next steps. This list was presented to attendees at the Listening Session held on June 13, 2019 at Worcester City Hall.

Priority Actions for Infrastructure Resiliency

Action A: Invest in Improved Management and Maintenance of the City’s Stormwater System

- Conduct **system wide hydrologic/hydraulic drainage evaluation and modeling** to ensure projects effectiveness, and make project prioritization.
- Develop **comprehensive flood mitigation solutions** for the City’s recurring flooding problems.
- Proceed with in-depth **analysis of the most at-risk areas to flooding** under future climate scenarios identified in the workshop preliminary analysis (see Appendix B).
- Consider **design options for the underground Blackstone canal** to address the recurring flooding in the Green Island area as it is located in a vulnerable floodplain and is home to many low-income residents.

Action B: Investigate a stormwater enterprise fund/stormwater utility fee to support enhanced stormwater management initiatives

- Establish a credit to **incentivize green infrastructure**, porous pavement.

Action C: Prioritize green infrastructure projects to mitigate urban heat island and reduce flooding

- Implement in areas adjacent to public right-of-way for dual benefits.

Action D: Develop a public outreach and education initiative

- Continue to educate residents on ways to **mitigate the occurrence of frozen pipes** related to extreme cold.
- Continue to promote **water conservation** amongst residents during droughts for in-home use and for landscaping.
- Promote **adopt a catch basin** program.

Action E: Implement adaptation/resiliency strategies to harden critical city-owned buildings

- Identify community schools within neighborhoods to test **micro-pilot programs** and techniques.
- Proceed with an **assessment of Worcester public schools** to address their heating and energy performance and become more resilient to extreme heat and cold. In the process, the buildings will be more efficient and sustainable (work on insulation problems and heat leaks).
- Identify the best location in City-owned buildings for **emergency shelters/resiliency hubs** with generators or other onsite power for emergency resources.
- Create a **resilient building scoring system** to prioritize building improvements and inform capital planning.

Action F: Advocate and assist in creating a resilient transportation network

- Advocate that **WRTA and MBTA create and implement reliable contingency plans** for commuters during extreme events.
- Identify **bus routes at risk of flooding** and develop a contingency plan for emergency route plan.
- Design and install **bus shelters** at popular bus stops where riders would be **vulnerable** to extreme heat or extreme cold exposure.

Action G: Assess the vulnerability of drinking water supply to future drought conditions

- Study impacts of increased development and increased incidence of **summer droughts** on existing water supply.
- Develop a public **education** program on the **protection of potable water**, “what we drink.”



Priority Actions for Societal Resiliency

Action A: Initiate an education program/campaign about climate change

- Use **effective communication strategies**, including the City's website and social media, for public information related to **preparedness**.
- Develop a program for education on **awareness of climate change** impact and possible preparedness measures; e.g. talk to your neighbors and help others.

Action B: Improve the City's emergency planning to incorporate climate change

- Determine if designated **shelters** are adequate and not vulnerable to current and future flooding.
- Identify strategies in partnership with kids for **engaging families with limited English** proficiency.
- Reach out to people through **emergency messaging** (opt-in vs all-in) focusing on identified neighborhoods with most **at risk populations**.
- Implement a **flashing light warning system** for snow emergencies.
- **Expand social media use** to communicate before/during/ after weather-related emergencies.
- Create a **resiliency network** to reach isolated populations.
- Create a **sheltering plan** (including heating/cooling) **and communication** plan to inform residents of an emergency and knowing what resources are available and where to go during an emergency, especially for most vulnerable populations.
- Create or confirm an **emergency plan for assisted living and affordable housing residents** (e.g. public health department and first responders).

Action C: Empower renters and property owners to prepare for climate change

- Develop education that is specific to **renters and property owners** to ensure everyone can prepare.
- Create a registration for **landlord license** and checklist to improve resiliency and protect renters.

Priority Actions for Environmental Resiliency

Action A: Protect open space and water resources

- Develop a detailed study to **assess the possible impact of climate change on the City's natural resources**.
- Study options for implementing **regulatory controls or policy changes addressing climate change** (ex: legal mechanisms to promote green infrastructure, and protect open space areas).
- Continue to **protect water resources** from contamination from industrial properties by providing **education** on best practices.
- Provide education on **upland fertilizer usage** at higher elevations that seeps down to lower neighborhoods and waterways as more frequent extreme precipitations will add stress to the water system and will increase the risk for contamination.
- Require **green infrastructure** as part of all new development to reduce urban heat during extreme heat event and also increase stormwater retention/ filtering on site.

Action B: Improve waste collection practices

- Educate the community about special measures; “what to do” for **waste collection** during flooding/heat.
- Implement a City-wide **food composting** program.

Action C: Improve the tree canopy

- Continue to support the **Right Tree, Right Place** program.
- Create and adopt a **tree replacement policy**, including addressing tree pruning and maintenance.



3.2 Other Potential Actions of Lower Priority

The following list captures other potential actions identified by workshop participants in small group discussions, ranked as of lower priority.

Infrastructure

- Continue to develop a prioritization for the **sewer separation program**.
- Investigate **Cambridge Street low overpass** combined with drainage improvements.
- Continue to **evaluate dams** for assessment/elimination/redundancy.
- Coordinate with National Grid to improve **energy resiliency** by promoting and supporting a **microgrid**.
- Develop an inventory of **retaining walls** and perform a condition assessment.
- Develop a comprehensive “**complete streets**” inventory to identify projects for grant funding.
- Add **splash pads** to community parks.
- Assess the vulnerability of the **Senior Center**.
- Establish a **betterment tax** for properties along **flooding** route.

Societal

- Provide a training program for municipal staff with a **community advisory board** to increase **access and knowledge of city/local/regional resources available to residents**, especially those new to the city and immigrants, including through marketing/outreach material and website content to reduce language barriers and improve access to informational services.
- Expand and improve **WRTA service** to provide community greater community resilience and equity.
- Lobby the State to improve how the **building code incorporates resiliency**.
- Provide **high water and fast water training and equipment** for emergency responders, including fire/police.
- Provide **multiple language translations** for all public outreach materials.
- Provide **multidisciplinary training** for non-profits, religious organizations, etc.

Environmental

- Determine if it is feasible to purchase **repetitive loss properties** for stormwater retention/storage.
- Develop a **wetlands migration and improvement plan**.
- Investigate if **zoning ordinances** could accommodate development based on **microclimates**.
- Study the **daylighting of Beaver Brook**.
- Evaluate whether **wind power** is feasible at tops of hills to increase the City's energy resiliency.
- Create an **open space management plan** (if one does not exist).
- Cap **brownfield sites** to prevent infiltration and possibly allow for full redevelopment in a resilient way.

3.3 Findings from the Public Listening Session

The City held a Public Listening Session on June 13, 2019 at Worcester City Hall. The presentation and subsequent dialogue with participants were led and facilitated by City staff members:

- Luba Zhaurova (from the City's Energy and Asset Management Division), and
- Stefanie Covino (from the City's Planning and Regulatory Services Division).

Members of the public in attendance to the listening session were engaged by the presentation. The public appeared supportive of the MVP planning process and generally agreed with climate change-related issues presented.

The public provided certain suggestions and recommendations to the City including:

- Ensuring that multilingual strategies for public outreach are implemented and vulnerable populations have access to the critical climate change related information they need.
- Providing maps showing the geographic location of specific vulnerabilities and indicating any hotspots or neighborhoods that impact the types of vulnerabilities experienced.
- Improving interdepartmental communication and understanding between City divisions.
- Focusing on the "Right Tree Right Place" initiative to ensure that trees are not interfering with utility power lines and solar power installations.

4.1 Project Team and Workshop Participants

Project Team

City of Worcester, Energy and Asset Management Division:

- John Odell (Director, Worcester Energy and Asset Management)
- Luba Zhaurova (Sustainability Project Manager, Worcester Energy and Asset Management)

Kleinfelder Team:

- Nathalie Beauvais (Facilitator, Project Manager, MVP Certified Provider)
- Jonnas Jacques (Facilitator, Assistant Project Manager)
- Indrani Ghosh (Facilitator, MVP Certified Provider)
- Robin Seidel (Facilitator, MVP Certified Provider)
- John Rahill (Facilitator)
- Darrin Punchard (Punchard Consulting, Facilitator)

Core Group:

- Luba Zhaurova (Worcester Energy and Asset Management)
- John Odell (Worcester Energy and Asset Management)
- Meghan Gomes (Worcester Emergency Communications & Management)
- Michael Shanley (Worcester Emergency Communications & Management)
- James Brooks (Worcester Housing Development)
- Stefanie Covino (Worcester Planning & Regulatory Services)
- Michelle Smith (Worcester Planning & Regulatory Services)
- James Bedard (Worcester Public Schools)
- Matthew Labovites (Worcester Public Works & Parks – Operations)

Workshop Participants and Affiliation

<u>Participant Name</u>	<u>Affiliation (Role)</u>
Robert Antonelli	Parks Division Assistant Commissioner, DPW&P City of Worcester
Bruce Augusti	MEMA
Steven Bandarra	Sustainability Coordinator Worcester State University
James Bedard	Director of Environmental Management & Capital ProjeWorcester Public Schools
James Brooks	Director City of Worcester, EOED - Housing Development Division
Susan Buchan	Director of Energy Projects E4TheFuture
John Cannon	Director of Facilities Operations Holy Cross
Michael Carroll	Director of Sustainability Worcester Academy
Deborah Cary	Executive Director Mass Audubon
Matilde Castiel	Commissioner of Health & Social Services Department City of Worcester
Peter Coffin	Blackstone River Coalition
Dante Comparetto	Member of the Worcester School Committee; MPA student (Scribe)
Stefanie Covino	Conservation Planner, City of Worcester, EOED - Planning & Regulatory Services Division (Facilitator)
Jill C. Dagilis	Executive Director of Worcester Community Action Council
Kevin Dandrade	Vice President TEC, Inc.
Jeuji Diamondstone	Community organizer and writer
Kristin Divris	Water Utility Resilience Program MassDEP
Martin Dyer	City of Worcester Fire Department
Mike Freeman	Assistant Director of Transportation Worcester Public Schools
Jonathan Gervais	Environmental Manager City of Worcester, DPW&P
Karin Valentine Goins	WalkBike Worcester
Meghan Gomes	Preparedness Coordinator City of Worcester, Emergency Communications & Management
Isabel Gonzalez-Webster	Director Worcester Interfaith
Andrea Gossage	Community & Customer Manager, MA Jurisdiction National Grid
Mary Beth Harrity	Tatnuck Brook Watershed Association
Etel Haxhijaj	Massachusetts Community Organizer and Worcester Resident, Mothers Out Front
Carolyn Howe	Friends of Patch Reservoir
Jenny Isler	Director of Sustainability at Clark University
Lorraine Laurie	Green Island Neighborhood Group
Andrew Loew	Project Manager CMRPC
Sean M. Lovely	City of Worcester, Police Department
Samuel Martin	Worcester Youth Center
Paul P. Mathise	Director of Sustainability Worcester Polytechnic Institute
Timothy J. McGourthy	Executive Director of Worcester Research Bureau

Participant Name	Affiliation (Role)
Ed McKeon	Coes Zone Task Force
Gaylen Moore	Worcester Resident Mothers Out Front
John Odell	Director City of Worcester, Energy and Asset Management Division
Peter Peloquin	Planning Assistant CMRPC
Rob Pezella	Director of School Safety Worcester Public Schools
Stephen Rolle	Assistant Chief Development Officer – Division of PlannCity of Worcester
Joe Sancoucy	Department of Inspectional Services
Jacob Sanders	Intergovernmental and Municipal Initiatives City of Worcester, Office of the City Manager
Errica Saunders	350 Central Mass
Michael E. Shanley	Acting Director of Emergency Communications & Management
Michelle Smith	Chief Planner City of Worcester, EOED - Planning & Regulatory Services Division
Vincent Sullivan-Jacques	Director of Volunteer Outreach and Community Engage Assumption College
Liz Tomaszewski	Associate Director of Sustainability Worcester Polytechnic Institute
Jeanette Tozer	Senior Project Manager EOED - Special Projects
Joe Wanat	City of Worcester Zoning Board Member (Vice-Chair)/Engineer at VHB
Ari Winograd	Planning and Operations Coordinator, City of Worcester, Division of Public Health/Central MA Regional Public Health Alliance

4.2 Citations and References

Citation

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