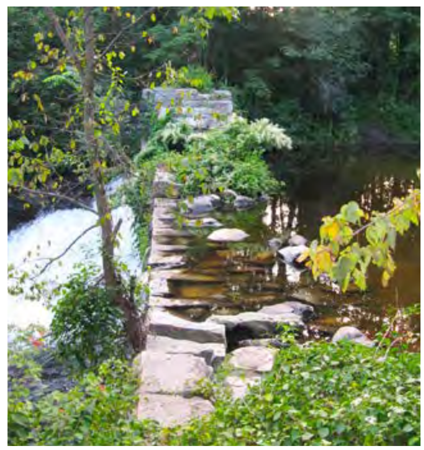
City of Northampton



Community Resilience Building Workshop

Summary of Findings
May, 2018

City of Northampton

Community Resilience Building Workshop
Summary of Findings

I. Overview

Cities and towns across Massachusetts are feeling the effects of climate change. Annual temperatures have been getting warmer since the 1970s, and high-intensity storms are becoming more frequent. With a wider variability in weather extremes, risks such as flooding, electrical grid failures, droughts, changes in ecosystems, tick and mosquito-borne diseases, and heat-related illnesses are some of the many concerns that climate change is predicted to bring.

In response, forward-thinking cities such as Northampton have begun focusing on how to adapt to climate change, and strategies that will help their infrastructure, neighborhoods, and ecosystems become more resilient. Through proactive and collaborative planning, Northampton is aiming to reduce climate risk, but also to adapt in ways that continue to make Northampton an increasingly vibrant and thriving community. This type of leadership offers a model for other municipalities in Massachusetts and New England to follow.

Through proactive and collaborative planning, Northampton is aiming to reduce climate risk, but also to adapt in ways that continue to make Northampton an increasingly **vibrant and thriving** community.

In the fall of 2017, the City of Northampton joined the Massachusetts Municipal Vulnerability Preparedness (MVP) program (https://tinyurl.com/ycs5kv8r). This program supports municipalities in leading workshops to 1) identify vulnerabilities and strengths to climate change, and 2) develop prioritized actions for improving the city's resilience. Participation in the program also makes Northampton eligible for future funding to implement climate adaptation measures.

The City hosted two workshops on May 8th and 9th, 2018, which used a community-driven planning process called the Community Resilience Building (CRB) Planning Framework (www.CommunityResilienceBuilding.org).

The workshops' central objectives were to:

- Define top local natural and climate-related hazards of concern;
- Identify existing and future strengths and vulnerabilities;
- Develop prioritized actions for the community; and
- Identify immediate opportunities to collaboratively advance actions to increase resilience.

The City engaged MVP certified providers Linnean Solutions, Kim Lundgren Associates, Inc., and Fuss & O'Neill, Inc. to help facilitate this process as well as to support the city in subsequent climate mitigation and adaptation planning.

Workshop participants were provided with a series of maps that used city data and visualizations from the Department of Public Works to illustrate flood vulnerability and infrastructural, social, and environmental features. These maps served as a resource for discussing risk perceptions, shared values, strategies, and priorities. Content discussed during the workshop was recorded in the CRB "Risk Matrices"—a template for organizing the workshops' discussions and findings—and participants also notated large "storyboard maps" with their concerns and ideas. Images of the maps and risk matrices are included in the appendix of this report.

The easterly edge of Main Street in downtown Northampton, along with most of the connecting roads to the southeast, are in the floodplain, but protected for the time being by a levee system.

Photo credit: Alexius Horatius

This report compiles the rich information and conversations that came out of Northampton's Community Resilience Building workshop process. It highlights the hazards that were focused on during the workshop, key vulnerabilities and strengths identified by the participants, and proposed actions for enhancing Northampton's resilience.

This report compiles the **rich information and conversations** that came out of Northampton's Community Resilience Building workshop process.

The earth dike and concrete flood wall along the Mill River, which can be considered both a vulnerability and a strength for Northampton.

Photo credit: Holly Jacobson

Defining "Strengths" and "Vulnerabilities"

For the purpose of the workshop, **"vulnerabilities"** were considered to be aspects of the city that may lose function due to climate change hazards or that may feel the effects of climate change more acutely. **"Strengths"** were aspects of Northampton that would help the city adapt and thrive even in the face of climate change. Some features—such as the city's flood control infrastructure—could be seen as both a strength and a vulnerability.

All of the content that is transcribed in this report is open to comments, corrections, and updates from the workshop participants as well as additional stakeholders. Adapting to climate change will be an ongoing process, and one that will benefit from the insight of many voices in shaping the pathway to a more resilient and thriving Northampton.

Signage in Look Memorial Park in Florence, sharing the impacts of past hurricanes and floods.

Photo credit: Holly Jacobson

II. Top Hazards and Vulnerable Areas

Each group in the Community Resilience Building Workshops focused on vulnerabilities, strengths, and action items with respect to four main climate change hazards in Northampton: flooding, increased temperatures, drought, and extreme weather. These hazards were pre-identified by a core team of city representatives as the top climate change hazards that would bring a number of implications for Northampton. The ability of participants to recall past hazards—such as the flooding from Hurricane Irene, or the water restrictions during the 2016 drought—helped to frame discussions around what future events might entail.

Top hazards:

- Flooding
- Increased temperatures
- Drought
- Extreme weather

A. Current Concerns and Challenges Presented by the Hazards

1. Flooding

With climate change we expect slightly more precipitation on an annual basis, but more significantly, we expect greater frequency and intensity of major storms. With these major storms, Northampton faces three types of flood risk: 1) The risk of riverine flooding from the Connecticut River, the Mill River, the Manhan River, and unnamed streams in and beyond the floodplain; 2) The risk of localized flooding when infiltration and the stormwater system reaches maximum capacity; and 3) The risk of downtown flooding if floodwaters overtop the dike. Downtown Northampton sits between the Connecticut River and the Mill River, and much of the southeast corner of the city sits within the floodplain. The flood control system, which was built in the 1940s after two major floods in the 1930s damaged much of the city, currently affords the city protection from major floods. However, the system was designed to protect against a maximum predicted flood in the 1940s, with additional freeboard of two to five feet along the earthen dikes and concrete walls. Although this is a conservative design, it may not be sufficient for the higher intensity storms expected with climate change. Furthermore, more frequent high-intensity rain events are likely to surpass the capacity of the city's culvert systems and stormwater storage, causing more localized flooding. Without updated infrastructure design standards and new strategies for infiltrating and storing water, flooding is likely to increasingly impact roads, buildings, and communities.

2. Increasing temperatures

Average annual temperatures in Northampton are predicted to increase by 3° – 6°F by the 2050s, and by 4° – 9°F by the 2070s. Along with potential impacts to the city's agriculture, its air quality, and its water supplies, these temperature increases are already showing effects on ecosystems, degrading the health of tree species that are accustomed to colder climates, contributing to pest outbreaks, and facilitating the spread of invasive species. Insects are less likely to die off in the winter with higher winter temperatures, allowing more species to breed. Northampton has seen higher rates of Lyme disease cases (carried by ticks) and may see increases in mosquito- and other vector-borne disease. In addition to increasing average temperatures, Northampton is likely to see more days where the maximum temperature exceeds 95°F, as well as more extended heat waves, which may produce more challenges than the occasional hotter day. Extreme heat and heat waves can lead to heat-related illness, particularly for people with compromised immune systems or without access to spaces with air conditioning.

3. Drought

Northampton has a relatively robust water supply, drawing from three surface level aquifers located within Conway, West Hatley, Williamsburg, and Hatfield. Roughly one percent of the city's water supply comes from wells, which have the capacity to provide up to half the city's water supply if needed. The city additionally has an emergency backup water source. Nevertheless, climate change may bring longer periods of dry weather which may affect the health of the city's water supply. In 2016, Massachusetts issued a drought declaration in which the Connecticut River Region reached "warning" status. Although the city had implemented water restrictions in years past (e.g., 2010), this level of drought instigated further discussions around water use and conservation in the city. Additionally, the vast majority of Northampton's farmland is not irrigated, making the city's agriculture especially vulnerable to drought.

4. Extreme weather

Although Northampton's average annual precipitation is not expected to increase drastically in the next 50 years, climate projections do suggest that the city will see greater extremes in weather—including heavy rainfall, hurricanes, and snowstorms. Without strategies to increase the resiliency of the city's systems, these extreme weather events will likely bring power outages, interruptions in transportation services, heavier reliance on homeless and emergency shelters, and business and service closures. Resilience strategies will be necessary for reducing the impact that these events will have on residents' health, wellbeing, and livelihoods.

Bike path where it crosses under the train tracks, which is one of the identified "Areas of Concern" for localized flooding.

Photo credit: Holly Jacobson

Areas of Concern

In discussing the top climate hazards, a number of specific locations were identified as being particularly vulnerable. These locations include:

- Road segments
  - *Vulnerable to flooding:* Island Road; lower Elm Street; the intersection between Gothic and Main Street; Bay State; the underpass on North Street; the end of Church and State Street; the bike path where it crosses under the train tracks.

- Utility infrastructure
  - *Vulnerable to flooding:* The wastewater treatment facility (although behind the dike); power substations; buried powerlines in the downtown.
  - *Vulnerable to extreme weather:* Non-buried powerlines outside of the downtown.
  - *Vulnerable to erosion:* Sewer infrastructure along the Mill River Corridor.

- Sites and/or services
  - *Vulnerable to flooding:* The Senior Center; the Dialysis Center; the Meals on Wheels kitchen; the homeless tent encampment; the Meadows (agricultural land).
  - *Vulnerable to heat:* Bridge Street Elementary School; Jackson Street Elementary School; Leeds Elementary School; RK Finn Ryan Road School; JKF Middle School; Northampton High School.
  - *Limited transportation/access:* The VA Medical Center; The county shelter near Cooley Dickinson Hospital; The back-up shelter at UMass; Rainbow Beach and Reservoir/Reservoir Road (for cooling off in extreme heat); residential areas outside the downtown.

- Natural resources
  - *Vulnerable to erosion/sedimentation:* The Connecticut River; The Mill River; Paradise Pond.
  - *Vulnerable to nutrient loading:* The Mill River; The Oxbow.

B. Specific Categories of Concerns and Challenges

Certain features in Northampton—including places, communities, natural resources, and infrastructure systems—may be particularly vulnerable to the effects of climate change. Workshop participants identified the following items as key vulnerabilities and areas of concern in Northampton.

INFRASTRUCTURAL
VULNERABILITIES

For example: Where might Northampton's electrical grid or stormwater infrastructure fail in a climate hazard?

Vulnerability of flood control infrastructure

- High maintenance costs are needed to ensure that the flood control infrastructure remains effective;
- Invasive species cause degradation to the levee slopes;
- Uncertainty exists regarding the sufficiency of the flood control infrastructure to weather future storms;
- Current citywide flood mapping does not accurately reflect climate change;
- The flood control infrastructure only serves the downtown area.

Vulnerabilities in water and wastewater infrastructure systems

- There is potentially a limited number of days in which the water pumps could run on diesel generators if the city loses power;
- In extended power outages, people with wells lose access to water;
- Water main breaks have been more frequent in recent years;
- The wastewater treatment facility is in the flood zone (although not mapped as such by FEMA because it is behind the dikes)—if anything were to happen to the pump station, this would be one of the first facilities to flood.

Vulnerabilities in the stormwater infrastructure system

- The city has aging infrastructure and deferred maintenance;
- The stormwater system has limited capacity, particularly in the downtown;
- Current stormwater infrastructure design standards will not be sufficient for future storm events;
- There are substantial local flooding vulnerabilities, both within FEMA-mapped floodplains and outside of them, throughout the city;
- Undersized culverts create pinch points for localized flooding.

Vulnerability of electrical lines and power substations

- Above-ground lines are vulnerable to wind, ice, and downed trees;
- Buried power lines (in the downtown) are vulnerable to flooding;
- Power substations are currently vulnerable to flooding.

Vulnerability of residential building stock

- A large proportion of homes are poorly insulated;
- Much of the building stock, and large multifamily residential buildings in particular, lack design qualities for "passive survivability" during power outages.

Vulnerability of Northampton schools

- Schools do not have air conditioning, making students and teachers vulnerable in periods of high heat.

Limitations in transportation access

- There are limited transportation options for non-car users, especially outside downtown;
- There are limited mobility/transit options for handicap persons, particularly in accessing the VA Medical Center;
- There is currently no transit station in Northampton where the Pioneer Valley Transit Authority (PVTA) can charge electric buses (although there is a bus maintenance facility which could be retrofitted for electric bus charging).

Pinch points for evacuation / frequently flooded roads

- Coolidge Bridge across the Connecticut River (Route 9) is the only crossing for nine miles, which may be a problem in a citywide evacuation;

Concrete flood wall and critical electric substation on West Street on the bank of the Mill River.

Photo credit: Holly Jacobson

- Certain roads tend to flood easily and it is unclear whether these will become increasingly problematic for evacuation or access to critical services;
- Participants noted the following roads frequently experience flooding: Island Road (eight properties are considered to be repetitive flood zones—but only those with insurance are known), lower Elm Street, the Gothic and Main Street intersection, Bay State, the underpass on North Street, and the end of Church and State Street.

SOCIETAL

VULNERABILITIES

For example: Which communities might feel the effects of extreme weather more than others?

Enhanced vulnerability of particular populations
- Populations facing homelessness (resource limitations, shelter limitations, etc.);
- Households with low or fixed incomes (resource limitations, etc.);
- Student populations (transient, potentially less familiar with Northampton);
- Elderly populations (limited mobility, networks, physical capacity, etc.);
- Non-English-speaking populations (limited communication capacity, etc.);
- Populations with mental health challenges (limited personal capacity to respond to emergencies, etc.).

High flood vulnerability of specific social service locations
- Certain locations that provide critical social services or that support vulnerable populations are exposed to flooding, including the Senior Center, the Dialysis Center, the Meals on Wheels kitchen, the bike path where it crosses under the train tracks, and the homeless tent encampment.

Sheltering strategy challenges
- The needs of the sheltering organizations can come into conflict with the needs of the populations seeking shelter;
- Roles and responsibilities in decision-making can be unclear;
- There are limitations and challenges in the current system for sheltering pets;
- There does not seem to be widespread awareness of emergency shelters;
- People have trouble accessing the county's emergency shelter near Cooley Dickinson Hospital;
- The back-up shelter is at UMass (Smith Vocational and Agricultural High School can hold 650 people), but a major flood event would cut off access.

Limited locations for recreational swimming (problematic during extreme heat)
- Rainbow beach is not accessible by car (only by boat);
- Reservoir Road is the only legal swimming spot and people must pay to access.

Limitations in the Emergency Communication System (Reverse 911)

- Only a portion of the population is signed up for these alerts;
- Immigrant communities are hesitant to provide contact information to the City;
- The alerts could be better at telling people where to go to get help;
- There is a danger that the system gets overused (i.e., for snow parking bans), causing people to opt out.

Housing unaffordability, particularly in downtown

- Employees who work in downtown often must commute from other areas, with limited transit options, because they are priced out of the downtown;
- Economic stress from housing unaffordability creates less stable living situations.

Economic implications of climate hazards

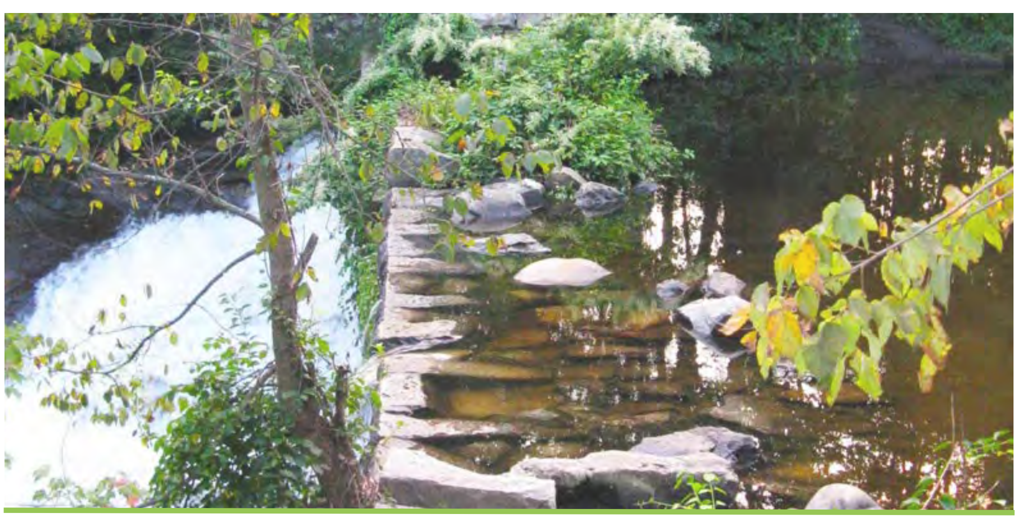
- Power interruptions caused by extreme heat (brownouts) and storms interrupt business continuity (e.g., power interruptions caused Coca-Cola to temporarily close the plant);
- Drought creates economic vulnerability (e.g., there is the possibility that Coca-Cola may need to reduce production or temporarily close during droughts).

More limited social capital and connectedness in areas outside downtown

- There is more limited access to services such as grocery stores, shelters, medical services, etc. outside of the downtown;
- It's harder to access places by walking, biking, or taking public transit;
- There are further distances between neighbors if social support is needed.

Psychological stress

- Climate change can cause psychological stress and impact mental health due to repeated trauma;
- The outdoors becomes less welcoming as it becomes seen as "a scary place";
- Decision-making may become driven by fear as opposed to effective planning.



The Mill River north of Mulberry Street in Leeds.

Photo credit: John Phelan

For example: How might changes in the climate affect the health of Northampton's tree canopy or native ecosystems?

Threat posed by waterways and watershed hydrology

- Rivers, streams, and the watershed's hydrology pose high flood risk, particularly the Connecticut River, the Mill River, and small watershed unnamed streams;
- Lack of natural storage areas makes for flashier flooding, especially in small watersheds.

Increased risk of vector-borne diseases

- Tires in yards and waste areas collect water, creating mosquito breeding grounds;
- Tires also create warmer water temperatures, attracting mosquito species that are otherwise at the northerly edge of their territories;
- Increased temperatures and reforestation are amplifying the risk of diseases spread by ticks;
- A lack of awareness of the risk of Lyme disease, symptoms, and the need for treatment causes a public health risk and underreporting of tick-borne disease;
- Lab work to identify Lyme disease is expensive.

Risk of drought

- Drought in 2016 indicated that the water supply could be vulnerable;
- Based on experience in adjacent towns, wells may have the potential of running dry and supplying these households with water through other means is expensive;
- Communication around drought risk and response strategies or requirements (particularly for businesses) is not necessarily clear;
- The health of trees and soils will likely be compromised by drought.

Soil degradation, sedimentation, erosion

- Increasing storm intensity creates more sedimentation and erosion;
- Extreme weather events lead to significant losses of agricultural top soil;
- Soils which are critical for water infiltration are losing their capacity to absorb water due to paving, lawns, or getting compacted;
- Smith is no longer responsible for dredging the sediment from Paradise Pond—the sediment filling up the pond may reduce the pond's capacity and degrade the flood control system;
- Erosion along the Mill River and Connecticut River impacts utilities (such as sewer infrastructure along the Mill River Corridor).

Vulnerability of tree health and native ecosystems

- Changing climatic conditions can encourage the growth and dispersal of non-native invasive plants and animals;
- Tree species in Northampton are becoming increasingly vulnerable to climatic changes, new pests, and invasive species;
- Tree die-offs can lead to blocked roads and downed powerlines, as well as increased erosion and wild fire risk;
- Flooding can spread invasive species.

Vulnerabilities of agricultural land and the food system

- Only a quarter of the Meadows is permanently protected by ownership or farmland preservation ordinances.
- Agricultural uses may become no longer viable (due to loss of topsoil, drought, etc.) and these changes may hinder local food production;
- It remains unclear how hazards that impact Northampton's food system (hindering transportation, storage, etc.) may impact the city's food security.
- Households in Northampton tend to "eat fresh" and therefore do not have much food stored for emergencies;
- Power outages have a substantial impact on grocery stores (e.g., unable to operate registers, forced to throw out all perishable food, etc.).

Nutrient loading

- Increases in nutrient loading have been observed, particularly in the Mill River and the Oxbow;
- No entity has a complete understanding of the extent of the problem;
- There is a lack of nutrient coverage by stormwater regulations.

Regional scale challenges

- Many environmental vulnerabilities are regional in scale and are therefore hard to address at the level of the local municipality.

The Oxbow on the Connecticut River, Northampton.

Image Source: Google Earth

Summary of Vulnerabilities

BY HAZARD

INFRASTRUCTURE VULNERABILITIES

SOCIETAL VULNERABILITIES

ENVIRONMENTAL VULNERABILITIES

<table>
<tr><th>FLOODING</th><th>EXTREME WEATHER</th><th>INCREASED TEMPERATURES</th><th>DROUGHT</th></tr>
<tr><td colspan="2">Stormwater system
(limited capacity)</td><td>Schools
(no air conditioning)</td><td></td></tr>
<tr><td colspan="2">Roads with localized flooding
(and other pinch points for evacuation)</td><td>Swimming sites
(lack of access)</td><td></td></tr>
<tr><td colspan="2">Flood control infrastructure
(uncertainty, high maintenance costs)</td><td>Vector-borne disease</td><td></td></tr>
<tr><td>Social services in floodplain</td><td colspan="2">Residential building stock
(poorly insulated)</td><td></td></tr>
<tr><td colspan="3">Public transportation system
(route and accessibility limitations)</td><td></td></tr>
<tr><td colspan="3">Power substations and electrical lines
(failure due to flooding, high winds, and/or extreme heat)</td><td></td></tr>
<tr><td colspan="2">Water and wastewater systems
(in floodplain, pump failures)</td><td colspan="2">Water quality and supply
(potential for shortages, impacted quality)</td></tr>
<tr><td colspan="4">Populations with greater vulnerability
(non-English-speaking; homeless; low income; elderly; students; people with disabilities)</td></tr>
<tr><td colspan="4">Reverse 911 and systems for communication
(not universally effective; need for new forms of outreach and public education)</td></tr>
<tr><td colspan="3">Sheltering strategy
(challenges and uncertainties with the current system)</td><td></td></tr>
<tr><td colspan="4">Business continuity
(interruptions and potential for business closures from all four hazards)</td></tr>
<tr><td colspan="4">Mental health
(increased psychological stress, repeat trauma)</td></tr>
<tr><td colspan="4">Tree canopy and ecosystem health
(decreased health from climatic changes, pest outbreaks, and non-native invasive species)</td></tr>
<tr><td colspan="2">Soil degradation
(poor infiltration, erosion, sedimentation)</td><td></td><td></td></tr>
<tr><td colspan="2">Hydrology and water storage
(riverine flooding, limited storage)</td><td></td><td></td></tr>
<tr><td colspan="4">Agriculture and food system
(mostly non-irrigated farmland; reduced viability of agriculture; distribution interruptions)</td></tr>
</table>

III. Current Strengths and Assets

While certain features in Northampton—including places, communities, natural resources, and infrastructure systems—may be particularly vulnerable to climate change hazards, others may serve as key assets or strengths in helping Northampton's communities adapt. Participants highlighted the city's strong social resources and services; institutions such as Smith Vocational and Agricultural High School, Smith College, and Cooley Dickinson Hospital that can offer physical and institutional capacity in emergencies; as well as the city's robust natural resources, including agricultural and conservation land, tree canopy, and water supply. The strengths identified by participants are included below.

INFRASTRUCTURAL

STRENGTHS

For example: Which decentralized energy systems in Northampton will strengthen the city's resilience?

Critical emergency services with back-up power

- The shared back-up power system (microgrid) between Smith Vocational and Agricultural High School (an American Red Cross emergency shelter), Cooley Dickinson Hospital, and the Department of Public Works enhances resilience across these facilities.

Protection offered by the flood control system

- Currently, dikes and levees are able to protect areas of the city that would otherwise be vulnerable to flooding.

Capacity of Cooley Dickinson Hospital to weather extreme events

- The hospital is in a fairly good position to withstand flooding events based on its location and building design;
- The hospital's back-up systems can operate even in a week-long power outage.

Capacity of Smith College to weather extreme events

- Smith College has an independent power station that uses gas (a strength during a storm as long as there is a gas supply, and during extreme heat when there may be brownouts);
- The campus is located mostly outside of the floodplain;
- The campus has some redundancy / back-up power systems (but there is potential in its systems for cascading failure).

Bike path system

- The bike path connects people out-of-town to Northampton's downtown;
- It provides an alternative route to access Easthampton;
- It creates less of a reliance on cars.

Easy access to I-91

- Easy access to I-91 allows some Northampton residents to leave the city in an emergency if needed.

Stormwater regulations

- The stormwater utility brings in money to support stormwater system upgrades.

Bridge on the Norwottuck Rail-Trail.

Photo credit: John Phelan.

SOCIETAL

STRENGTHS

For example: How do the institutions and social services in Northampton help our communities become more resilient?

Strong social resources

- Northampton is home to strong social services for supporting residents facing poverty, homelessness, addiction, mental illness, and other challenges;
- Northampton tends to be a hub for surrounding communities in terms of tourism, as well as social services (but the City needs to consider what this role means to effectively serve as a location that may welcome populations from other towns, climate refugees, during a hazard).

Smith Vocational and Agricultural High School serves as shelter

- Smith Voc. serves as a regional shelter;
- The shelter serves both humans and pets, which encourages households with pets to feel comfortable seeking shelter.

Smith College capacity and services

- Smith has the capacity to shelter its student body;
- The college offers institutional support and collaboration with the City.

National Grid support for "critical care customers"

- National Grid keeps a list of critical care customers who live in their own homes and need electricity for in-home care, and reaches out prior to a storm (to make preparations) and during a storm (to check in).

Relatively wealthy population with education and resources

- Northampton's relatively wealthy population allows it access to resources to deploy in emergency situations (although it's important to consider the biases and blind spots that this position may create, particularly when this wealth is not universal in Northampton).

ENVIRONMENTAL

STRENGTHS

For example: Which areas of open space act as a flood buffer?

Regulations and zoning to support conservation and agricultural land

- Conservation land maintains green space, areas for water infiltration, healthy ecosystems, and cooling capacity;
- Forested uplands help absorb rainwater before it burdens the stormwater system;
- Northampton's wetland regulations protect ecosystem and human health, surface water quality, and persons and property from flooding;
- Development limitations in flood-prone areas help maintain the city's resilience;
- Agricultural land in the Meadows creates a buffer to absorb flood water.

Tree canopy, parks, and green space

- The city's parks and green space absorb stormwater;
- The green space helps to cool the city in periods of high heat;
- There are ongoing efforts to plant shade trees (by the Shade Tree Commission) and trees accustomed to more southern regions to prepare for climate change.

Redundancy of water sources

- Northampton has multiple water sources and backup water sources.

IV. Recommendations to Improve Resilience

In response to the identified vulnerabilities and strengths, workshop participants collaborated in small groups to discuss policy strategies, capital investments, planning processes, and public outreach strategies to enhance Northampton's climate resilience.

Homes in Laurel Park.
Photo credit: Holly Jacobson

How could we encourage households to improve the insulation in their homes?

What types of nature-based solutions could cost-effectively manage stormwater and floodwater?

Could a shelter operations plan focus on better strategies to support people with mental illness in an emergency?

The range of backgrounds of the workshop participants helped to develop approaches that were new, more comprehensive, cross-disciplinary, and/or forward-thinking. All of these strategies are listed below, grouped by order of prioritization, in sections B, D, and E. Section A highlights particular themes or top areas of focus that were discussed consistently across the groups.

A. Top Areas of Focus / Cross-Cutting Themes

Workshop participants identified short-term, long-term, and ongoing strategies that could help reduce the vulnerabilities and/or enhance the strengths that were listed in Section III. While there were a wide range of strategies, certain recurring themes emerged as the top areas of focus between the groups. These included:

1. Flood Resiliency and Green Infrastructure Planning and Investment
Northampton's flood control infrastructure was designed for a maximum predicted storm in the 1940s—making it vulnerable to overtopping with the effects of climate change. Discussions made it clear that infiltrating and storing stormwater and managing the floodwater from the Connecticut and Mill Rivers (among other smaller streams and brooks) were significant concerns. Groups focused on a number of assessments and strategies for using nature-based solutions to store and potentially treat stormwater and floodwater, and to improve the soil's ability to infiltrate water.

These strategies were coupled with ideas for infrastructure assessments and investments to upgrade the city's culverts to design standards that account for the water flows that the city will likely see with climate change.

2. Energy Security

Many groups discussed the ways in which improved backup power systems, energy islanding, and microgrids could allow for redundancy in the city's energy system to ensure that critical services (such as hospitals, shelters, and critical city operations) continue to operate during a climate hazard. Alternative energy and community aggregation programs were strategies that dovetail with the above strategies, facilitating redundancy in the City's energy system and reducing the city's reliance on fossil fuels. Likewise, many participants focused on developing incentives and campaigns to help residents improve the insulation of their homes, and to enhance the "passive survivability" of buildings, particularly multifamily housing complexes. With these strategies, residents would be able to remain more comfortable in their homes during a power outage in hot or cold temperatures—as well as reduce their energy consumption on a day-to-day basis.

3. Strategies for Effective Communication and Outreach

Workshop participants noted that effective communication and public education strategies would support a large number of resilience-based initiatives, ranging from efforts to control invasive species, to signing up for the Reverse 911 system, to understanding the risk of tick-borne disease. Simultaneously, workshop participants discussed strategies for better reaching diverse communities in this process, including attending meetings or events in neighborhoods and working with trusted community partners. It was noted that in order to design strategies that focus on equity or that focus on the needs of certain populations, it will be important to have the insight of these populations in the planning process.

Navigational sign on the Mass-Central Rail Trail helps bikers and pedestrians travel between key points of interest.

Photo credit: Holly Jacobson

B. High Priorities

INFRASTRUCTURAL

HIGH PRIORITIES

Ideas include expanding green infrastructure, incentivizing energy efficiency retrofits, and updating floodwater design standards.

Flood Resilience and Green Infrastructure

- Conduct a Comprehensive Flood Resilience Plan that would consider implementation of green infrastructure, culvert upgrades, and priority project concept design;
- Conduct a town-wide assessment for culvert replacement and aquatic activity;
- Identify "pinch points" such as road segments on evacuation routes or that connect neighborhoods to critical resources that frequently flood;
- Identify and prioritize upgrades to the most vulnerable infrastructure focusing on nature-based solutions;
- Expand projects currently in the pipeline to have a larger focus on green infrastructure and rainwater catchment, including an education component on the importance of these design features;
- Expand strategies for more stormwater and flood storage in open space, capturing water that would otherwise flow through culverts and gray infrastructure in a way that is more cost-effective than increasing the size of that infrastructure;
- Use open-bottom culverts to create more nature-based treatment, slow the velocity of stormwater, and/or provide co-benefits for wildlife;
- Develop the flood resilience plan through a whole-watershed approach (versus isolated green infrastructure projects), focusing on soil health and infiltration.

Passive Survivability of Critical Buildings and Residential Building Stock

- Encourage passive survivability of critical buildings, including large multifamily housing buildings and emergency shelters, in order to ensure greater resiliency of occupants in power outages, as well as reduce energy consumption and greenhouse gas emissions;
- Adjust tax incentive structures to better encourage energy retrofits to older houses;
- Identify opportunities to install combined heat and power (CHP) systems (with natural gas fuel source), which would provide electricity;
- Encourage installation of air-source heat pumps;
- Prioritize low-income and minority communities, incorporating a tandem goal of making staying in one's home more affordable;
- Work with the Northampton Housing Authority and other affordable housing providers, who are pursuing energy efficiency and weatherization strategies;
- Set a "passive survivability bar" as a success metric or require passive survivability modeling on all new construction or substantial renovations as part of permitting.

Stormwater / Floodwater Regulatory Review

- Update stormwater / floodwater design standards;
- Assess and revise freeboard regulations to consider climate projections;
- Determine design standards for areas protected by the dikes, but that are below 125’ elevation (and thus still potentially vulnerable);
- Develop a new standard of construction for building in areas outside the floodplain, but that still see frequent localized or riverine flooding.

Design and Implementation of the Microgrid Project

- Use study results from Northwestern to issue a request for proposals (RFP) for microgrid project to create a resilient power source for Cooley Dickinson Hospital, Smith Vocational and Agricultural High School (emergency shelter), and the Department of Public Works;
- Proceed with design and construction of the microgrid.

Improved Transportation Access, Focusing on Equity

- Accelerate expansion of the bike share program, particularly in areas with larger minority or low-income populations, in order to improve access to affordable modes of transportation;
- Consider strategies to better serve unbanked populations;
- Advocate for public transportation improvements, ensuring that routes and service times aim to support the needs of low-income and minority communities;
- Ensure that low-income and minority neighborhoods have access to conservation land and green space (i.e., areas that will be cooler in extreme heat) via bike or pedestrian paths.

SOCIETAL

HIGH PRIORITIES

Ideas include outreach and educational campaigns, an emergency shelter operations plan, and recreational spaces to help with heat.

Targeted Outreach and Listening Sessions

- Conduct outreach sessions with specific communities so that the knowledge and insight of vulnerable communities (e.g., people experiencing poverty or homelessness, households with limited English proficiency, individuals that are elderly or disabled, etc.) directly shape the strategies that are developed to support vulnerable populations;
- Conduct outreach sessions by attending (rather than hosting at a City-chosen venue) community meetings / functions designed to reach diverse community groups “where they’re at.”
- Work with “local neighborhood trust networks” to help share information;

- Potentially recreate a previously existing mentoring program, whereby community members who feel comfortable interacting with City government act as a liaison between the City and residents.

Emergency Shelter Assessment and Operations Plan

- Develop an Emergency Shelter Operations Plan that formally defines lines of decision-making, and a line of command even if personnel change;
- Expand shelters' backup generation capacity and diesel supplies, pairing with implementation of the microgrid(s), to lengthen the duration that shelters are operable during a citywide power outage;
- Assess the ability of shelters and schools to house people/students during periods of extreme heat, and consider strategies for enhancing passive survivability;
- Assess transportation access to shelters and whether extreme weather events (such as flooding) will prevent access;
- Assess strategies to cluster services (healthcare, food provision, etc.) nearby shelters to enhance accessibility in an emergency, and to increase the capacity of shelters to serve as "resilience hubs;"
- Ensure strategies for effectively supporting people with mental illness, and include clinical support experts in the development of these strategies;
- Involve people who have limited English proficiency, who are elderly, and who have experienced/are experiencing homelessness (as well as representatives of social services who support these populations) in the development of this plan;
- Increase shelter capacity by expanding shelter space or by reducing need for them (e.g., work with hotels to ensure prices are kept low during an emergency, that they have capacity to house emergency responders, and/or other agreements);
- Develop a memorandum of understanding (MOU) with Smith College to delineate sharing of resources in an emergency.

Cross-cutting (External & Internal) Communication & Public Education Plan

- Develop a multi-pronged strategy for various levels of resilience-based communication, including emergency alerts, regular notifications (i.e., parking bans), as well as ongoing public education and outreach on a variety of topics;
- Develop ongoing public education and outreach programs focused on topics including invasive species management, tick-borne diseases, land-use strategies, resilience strategies (through table-top exercises), the value of the city's stormwater utility and green infrastructure implementation, native plant gardens, drought mitigation and water conservation strategies, among others.
- Identify ways to better use the City's webpage and social media (Facebook, Twitter, Instagram) in a way that is coordinated and engages people;
- Identify ways to better connect with diverse populations and underrepresented communities, including using trusted community partners (e.g., the Northampton Survival Center) to encourage individuals to sign up for Reverse 911 and to disseminate other resilience-based information on an ongoing basis.

Strong Neighborhood Program

- Define what makes a “strong neighborhood” (access to resources, services, etc.) and assess neighborhoods based on those characteristics;
- Share this assessment with City Emergency Response;
- Create more spaces for shelters, temporary housing, and social centers as needed;
- Enhance inter-municipal cooperation beyond emergencies to better develop networks of resilient neighborhoods;
- Identify public/private partnership opportunities to provide resources or services;
- Help businesses develop strategies for business continuity;
- Foster interest in building neighborhood cohesion.

Food Resilience Plan

- Understand the vulnerability of the Meals on Wheels program (e.g., many of the drivers for this program are elderly and are less able to deliver in a storm); plan for emergency events (e.g., How reliant are people on these meals? How can we ensure customers have a back-up food supply?);
- Develop alternative strategies and public/private partnerships that may be able to help provide resources or services (i.e., identify barriers to having restaurants support distribution of food in emergency events);
- Help businesses, such as restaurants and grocery stores, become better prepared to maintain business continuity and prevent food loss.

Urban Heat Island / High Heat Day Plan

- Identify ways to increase public access to swimmable areas in Northampton;
- Identify key urban heat island areas and prioritize tree planting in those locations;
- Determine if schools can be used to create more neighborhood splash parks;
- Identify parks that are in vulnerable communities and add water features;
- Fund low-income memberships to parks with water features / access.

Hazard Mitigation, Emergency Response, and Resilience Plan Alignment

- Revise FEMA Multi-Hazard Mitigation Plan to reflect MVP Process;
- Provide crosswalk study between Multi-Hazard Mitigation Plan, Emergency Response Plan, and Climate Resiliency Plan.

ENVIRONMENTAL

HIGH PRIORITIES

Ideas include soil retention demonstration projects, and launching a campaign for controlling ticks and invasive species.

Forest Vulnerability Assessment

- Conduct an inventory of tree populations, identifying locations of large stands of tree species that are vulnerable to invasive species, pests, and changes in climate;
- Assess tree populations at a town-wide scale, including conservation land as well as private property (since ecosystems don't follow property boundaries);
- Develop City strategies (monitoring, selective harvesting) in tandem with a public campaign to help address vulnerabilities in tree stocks and ecosystems.

Comprehensive Control and Education Strategy for Ticks and Invasive Species

- Develop a comprehensive strategy to address ticks and invasive species that includes land management, invasive species control strategies, and the integration of more permaculture practices;
- Apply for funding to further research tick-borne illness, as well as funding and personnel for implementation of a comprehensive control and education program.

Soil Retention Demonstration Projects

- Conduct demonstration projects in collaboration with Smith Vocational and Agricultural High School to incentivize perennial plantings along the river that also serve as a harvest crop for farmers;
- Link the demonstration projects with development of the horticulture program to align career development with strategies to increase local food production (sold and consumed locally) to enhance local food security / resilience.

C. Moderate Priorities

INFRASTRUCTURAL

MODERATE PRIORITIES

Downtown Resilience and Business Continuity

- Ensure that downtown businesses are equipped to handle increased risk of flooding, power outages, and extreme heat;
- Identify top critical services in the floodplain and create redundancies for them elsewhere (e.g., potentially a back-up dialysis center);
- Ensure infrastructure in downtown is designed to withstand predicted heat wave intensities and durations;
- Consider the implementation of a microgrid for King Street;
- Increase the tree canopy in the downtown area.

Energy Security

- Acquire grant funding / personnel to complete an assessment on community choice aggregation, local solar generation, and the implementation of microgrids (to improve resilience and advance the City's renewable energy goals);
- Consider strategies for islanding / energy resilience in not only hospitals and campuses, but also in neighborhoods, grocery stores, etc.;
- Potentially collaborate with Amherst and Pelham who are interested in advancing similar initiatives.

Housing Insulation Campaign

- Develop an outreach campaign to encourage households to upgrade building envelopes with better insulation (larger apartment complexes can fall under the PACE for commercial program; encourage households to use Mass Save);
- Partner with universities who have good energy efficiency data analyses to support the argument for investing in building upgrades.

Ongoing Evaluation and Upgrades to the Flood Control Infrastructure

- Continue ongoing evaluations to look at the capacity of the pump station, its location, needed repairs, and its backup power supply;
- Maintain existing inspections and oversight programs for repair, maintenance, and upgrades of flood control infrastructure, and strengthen drills and inspections as needed.

Dike System as Public Green Space and Public Education

- Enhance the area around the dike to be better used as a public park that could help with heat island mitigation;
- Invite the public to see how the dike system works, air the event on Google TV, and invite stakeholders and interested residents from nearby communities in order to enhance people's understanding of the flood management system, its limitations, and its maintenance/investment needs.

Alternative Transportation Programs

- Collaborate with a local entrepreneur who could expand transportation access by running a minibus between neighborhoods and shopping centers within Northampton, as well as to nearby towns.

Preparation for Transition to Electric Vehicles and Buses

- Assess how the city will accommodate the increasing need for charging stations;
- Work with businesses to come up with a transition plan that will allow private entities to implement charging station networks.

SOCIETAL

MODERATE PRIORITIES

Strengthened Partnerships and New Social Capital

- Strengthen partnerships between the City and existing community groups and work with communities to create new groups to help build social capital;
- Revisit strategies from the *Re-Energize Democracy* plan in order to make sure people feel a part of the city and the planning processes.

Neighborhood-Scale Emergency Planning

- Facilitate planning for emergency management, focusing on responses at a neighborhood scale with access issues in mind;
- Start this process by reviewing existing strategies with the Board of Health.

Emergency Transportation Plan

- Understand PVTA's emergency management plan;
- Clarify roles in decision-making and execution during a citywide evacuation;
- Investigate models to enlist private cars in an evacuation ride-share program.

ENVIRONMENTAL

MODERATE PRIORITIES

Policies / Planning to Maintain Health of Water Supply

- Assess impacts from climate change on water sources and the water treatment system (from contamination due to flooding, from drought, etc.);
- Investigate whether households with wells are having trouble / seeing shortages;
- Plan for a phased drought mitigation and action plan, and develop a strategy for advanced notice protocols to large water users;
- Explore strategies for better data collection to give a more accurate representation of drought conditions and water supply;
- Develop a public education strategy to raise awareness about water restrictions;
- Ensure that strategies for source protection (e.g., the City buying land) continue.

Acquisition of Land for Flood Management

- Continue land acquisition in flood plain;
- Buy out homes in places with high vulnerability to flooding;
- Continue buying land (must be near the floodplain) where water can be stored before it hits the floodplain;
- Complete land acquisition in accordance with City's open space prioritization list.

Erosion and Sedimentation Control

- Assess erosion in the Mill River channel, and ways to improve river bank stability;
- Examine the island south of Paradise Pond and the Route 66 bridge to assess whether it is growing due to erosion and sedimentation;
- Assess the old dams and the role they may be playing in increasing sedimentation;
- Remove old dams that are not viable for power production when funds are available;
- Engage interested players (e.g., Smith, Audubon, etc.);
- Assess street sweeping, and where sediment may be coming off the streets.

D. Lower Priorities

INFRASTRUCTURAL

LOWER PRIORITIES

Strategy for Reuse of Industrial / Commercial Graywater

- Conduct a City regulatory review of the reuse of Coca-Cola graywater;
- Design a study for transport (for irrigation use) or infiltration of Coca-Cola water (secondary, beneficial use, non-potable);
- Look into potential collection from other entities (e.g., breweries in Northampton and Williamsburg, cardboard manufacturer near Mt. Tom on Route 5, Smith College, Cooley Dickinson Hospital, etc.) for further water reuse.

Strengthen Transportation Linkages

- Identify locations that offer critical services in an emergency and ensure that there is a range of transportation options that link those services to neighborhoods;
- Ensure redundancies in transportation routes and networks so that no neighborhoods are cut off from critical services.

SOCIETAL

LOWER PRIORITIES

Pet Emergency Management

- Strengthen ties with pet rescue;
- Develop pet disaster kits and records.

ENVIRONMENTAL

LOWER PRIORITIES

Comprehensive Approach for Increasing Infiltration and Recharge

- Develop an approach to how the City and private land owners would work together on increasing infiltration and recharge;
- Conduct an education and outreach program on the best methods and priorities for how private landowners can increase rainwater infiltration.

Daylighting the Mill River to Increase Flood Storage

- 'Daylight' the historical Mill River and create more flood storage to mitigate flooding around the wastewater treatment plant and pump station.

Prioritize Local Supply Food Production

- Ensure continuation of productive land use in the Meadows as farmers age and may transition ownership;
- Assess how to ensure food production (and not mono-cropping) in the Meadows to be used for local food consumption.

Nutrient Loading Regulations

- Conduct a study to understand nutrient loadings and sources;
- Host regional farmers' meetings to discuss nutrient loadings;
- Create local nutrient release regulations that surpass state regulations.

V. Next Steps

Through the MVP Program, Northampton has highlighted a number of challenges that the city will face (or already faces!) with a changing climate. The insight and ideas provided by the workshop participants also identified assets that will help us adapt as a community, as well as short-term and long-term action items to make Northampton more resilient.

And the City has started acting on these recommendations! In June, Northampton received a follow-up grant from the MVP Program to fund one of the top priorities that came out of the Community Resilience Building Workshops. The findings from these workshops will also directly influence the development of the city's Resiliency and Regeneration Plan, which will serve as a guiding framework for how the city will continue to adapt and play our role in preventing climate change. Further details on these initial steps are included below.

MVP Action Grant

On June 4, 2018, the City of Northampton was awarded a Municipal Vulnerability Preparedness (MVP) Action Grant for $400,000 by the Commonwealth of Massachusetts Office Executive Office of Energy and Environmental Affairs. One of the top concerns that came out of the Community Resilience Building Workshops was the need to better store and slow rainwater in order to prevent flooding. The award will support the design of green infrastructure to catch stormwater before it reaches stormwater pipes, floodplains, and other areas of local flooding.

Public Listening Session

On June 5, 2018, the City hosted a public meeting at the Northampton Senior Center to discuss the findings from the Community Resilience Building Workshops; to share information on the new MVP Action Grant for green infrastructure; and to seek ideas and perspectives that will help shape the city's ongoing climate adaptation and mitigation efforts. Nearly 50 community members attended and participated in the discussion.

Resiliency and Regeneration Planning

Through the end of 2018, the City of Northampton will be developing the Resiliency and Regeneration Plan, which will incorporate insight from the Community Resilience Building Workshop, the listening session, new findings from the city's updated greenhouse gas inventory, as well as ongoing outreach events throughout the year.

If you would like to help this planning process, sign up at the link below!
Link: https://tinyurl.com/y9a6bopu

VI. Appendix

A. CRB Workshop Participants

Price Armstrong, Pioneer Valley Transit Authority
Reid Bertone-Johnson, Smith College – Landscape Studies
Stephanie Ciccarello, City of Amherst – Sustainability (Conservation Department)
Joanne DeRose, National Grid
Wayne Feiden, City of Northampton – Planning and Sustainability Department
Adele Franks, Grow Food Northampton
Jody Kasper, City of Northampton – Police Department
Sarah LaValley, City of Northampton – Planning and Sustainability Department
Denise Lello, Mothers Out Front and Climate Action Now
Andrew Linkenhoker, Smith Vocational and Agricultural High School
John Lombardi, Cooley Dickinson Hospital
Doug McDonald, City of Northampton – Department of Public Works
Chris Mason, City of Northampton – Central Services
Darci Maresca, UMass Amherst – School of Earth and Sustainability
Terry Masterson, City of Northampton – Economic Development
Claire McCoy, City of Northampton intern; Smith College student
Jenny Meyer, City of Northampton – Board of Health
Carolyn Misch, City of Northampton – Planning and Sustainability Department
Sharon Moulton, First Churches and Climate Action Now
David Pomerantz, City of Northampton – Central Services
Catherine Ratté, Pioneer Valley Planning Commission
Lyn Simmons, City of Northampton – Mayor's Office
Emily Slotnik, Pioneer Valley Planning Commission; Northampton resident
Irvine Sobelman, Climate Action Now; Northampton resident
Ron Vandendolder, Coca-Cola
David Veleta, City of Northampton – Department of Public Works
Ben Weil, UMass Amherst – Clean Energy Extension; Northampton resident
Dano Weisbord, Smith College – Sustainability and Campus Planning
Marie Westburg, Northampton Senior Center
Peter Wingate, Community Action of the Pioneer Valley
Keith Zaltzberg, Regenerative Design Group

B. CRB Workshop Project Team

Northampton Core Team

Carolyn Misch, Senior Land Use Planner, Planning and Sustainability Department
Chris Mason, Energy and Sustainability Officer, Central Services
David Veleta, City Engineer, Department of Public Works
Donna LaScaleia, Director, Department of Public Works [invited]
Doug McDonald, Stormwater Coordinator, Department of Public Works
Jody Kasper, Police Chief, Police Department
Jon Davine, Fire Deputy Chief/Emergency Management Coordinator [invited]
Lyn Simmons, Mayor's Chief of Staff, Mayor's Office
Merridith O'Leary, Director of Public Health, Health Department [invited]
Sarah LaValley, Conservation/Land Use Planner, Planning and Sustainability Department
Wayne Feiden, Director, Planning and Sustainability Department

Facilitation Team

Jim Newman, Principal, Linnean Solutions (Lead Facilitator)
Holly Jacobson, Resilience Consultant, Linnean Solutions (Facilitator)
Kim Lundgren, CEO, Kim Lundgren Associates (Facilitator)
Mary Monahan, Associate/Director of Business Development, Fuss & O'Neill (Facilitator)
Julie Busa, Environmental Scientist, Fuss & O'Neill (Facilitator)
Kelsey Powers, Sustainability Consultant, Linnean Solutions (Notetaker)
Ellie Hoyt, Sustainability Consultant, Linnean Solutions (Notetaker)
Rachael Weiter, Water Resources Engineer, Fuss & O'Neill (Notetaker)
Claire McCoy, Intern, City of Northampton (Notetaker)
Jean Palma, Fellow, City of Northampton (Notetaker)

C. Acknowledgments

Special thanks to the City of Northampton and the Northampton Core Team for their work in supporting, developing, and executing the MVP Program. Thank you also to the Northampton Senior Center for providing space to convene. These workshops were made possible through funding from the Massachusetts Municipal Vulnerability Preparedness Program.

D. Recommended Citation

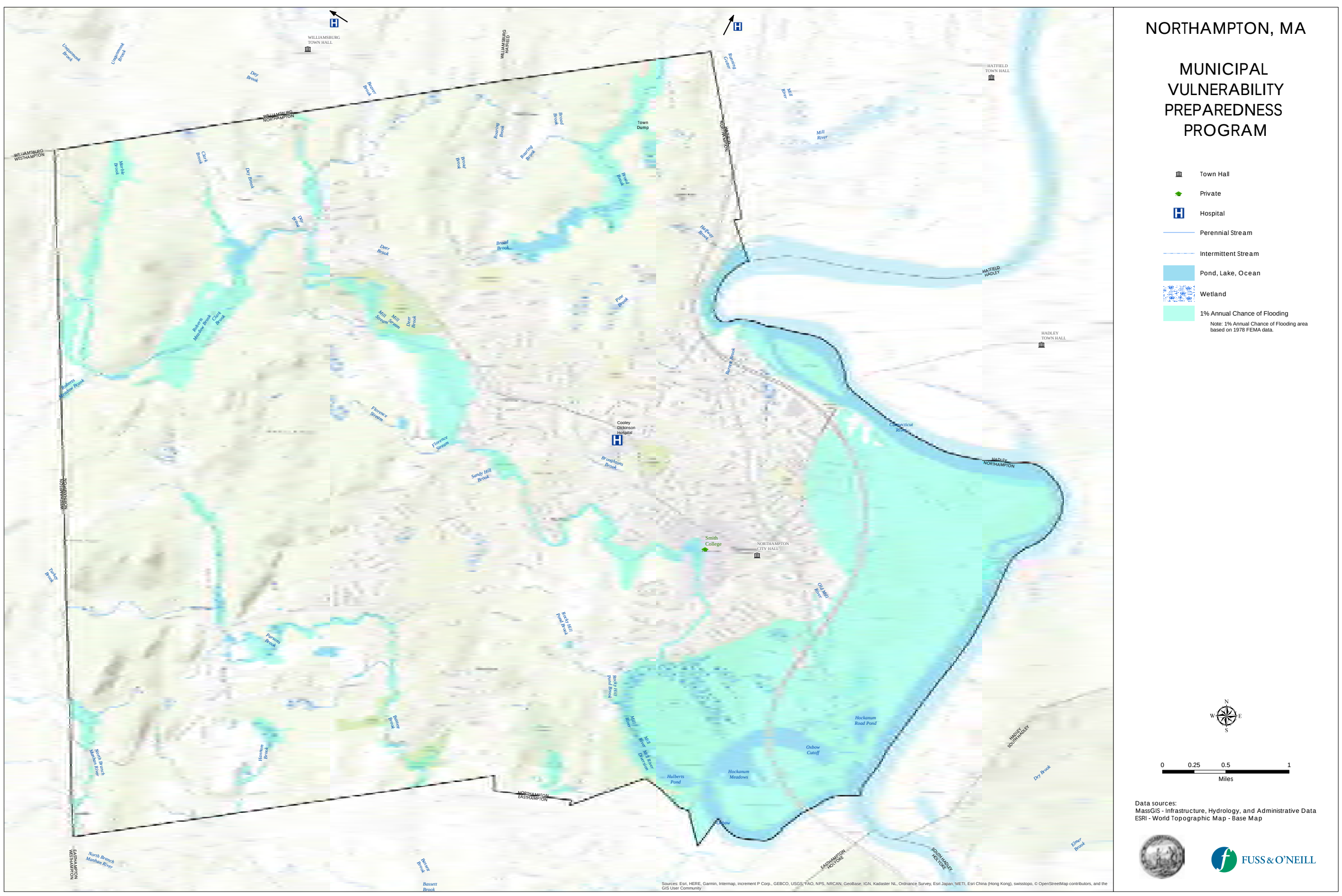
Feiden, W., Jacobson, H., and Newman, J. (2018). Community Resilience Building Workshop Summary of Findings. City of Northampton, Linnean Solutions, Kim Lundgren Associates, Inc., and Fuss & O'Neill, Inc. Northampton, MA.

E. Workshop Maps and Resources

Base "Storyboard Map"

The base "storyboard map" facilitated participatory mapping during the workshop. Workshop participants annotated this map as a way to visually represent their thoughts, tell stories of past experiences, flag particularly vulnerable locations, and highlight areas that might serve as a strengths.

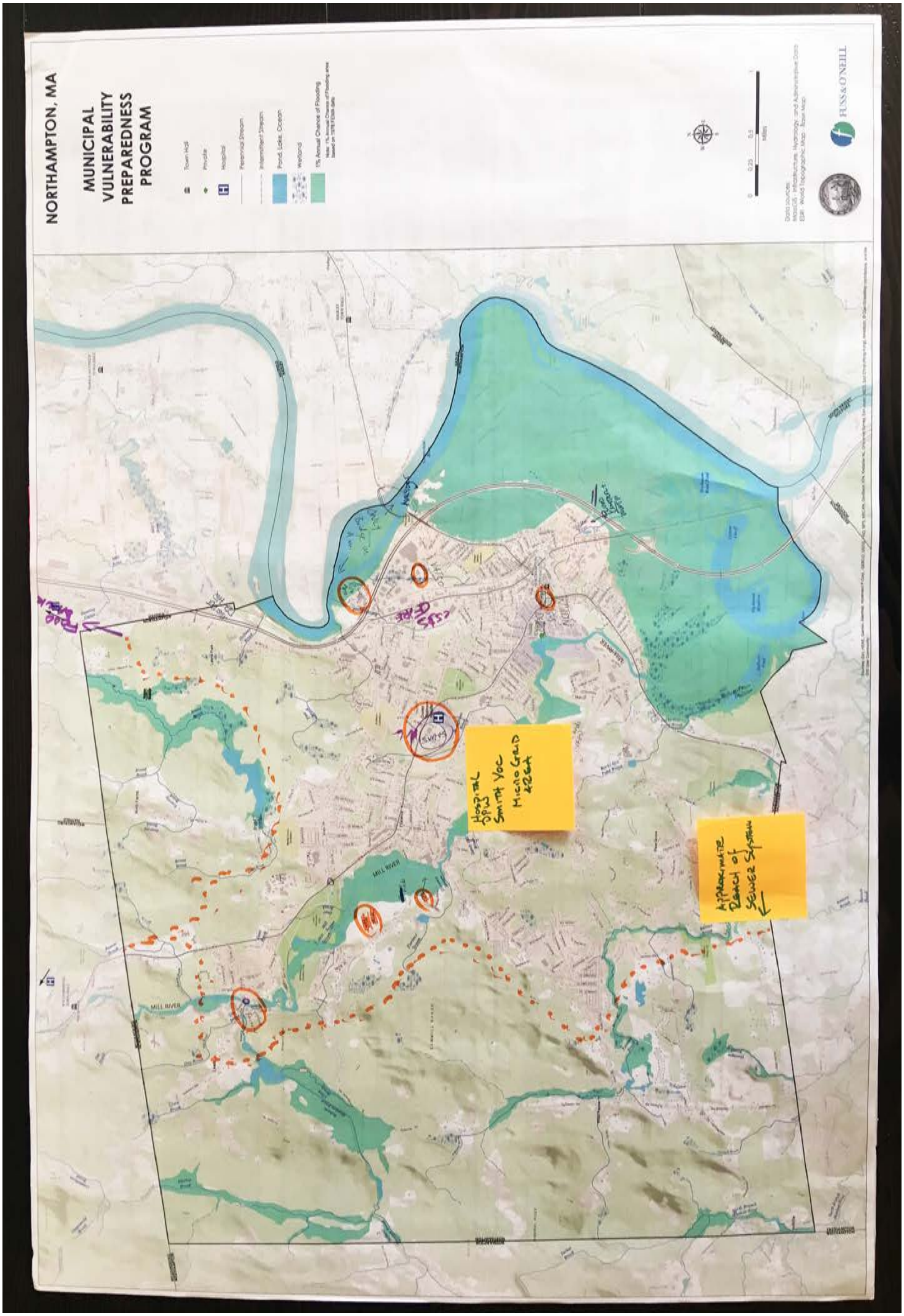
The annotated maps from each of the groups are included below the original.



STORYBOARD MAP
[ORIGINAL]

Workshop participants used a copy of this map to visually represent their thoughts.

STORYBOARD MAP
[BLUE GROUP]



STORYBOARD MAP
[RED GROUP]

STORYBOARD MAP
[GREEN GROUP]

STORYBOARD MAP
[YELLOW GROUP]

Risk Matrices

Each group used a risk matrix to record vulnerabilities and strengths; locations and ownership of those features; action items to reduce vulnerability and enhance strengths; and then the relative level of priority and urgency of those action items.

The annotated risk matrices from each group are included on the following pages, followed by the Final Risk Matrix, which compiles the findings from all of the groups.

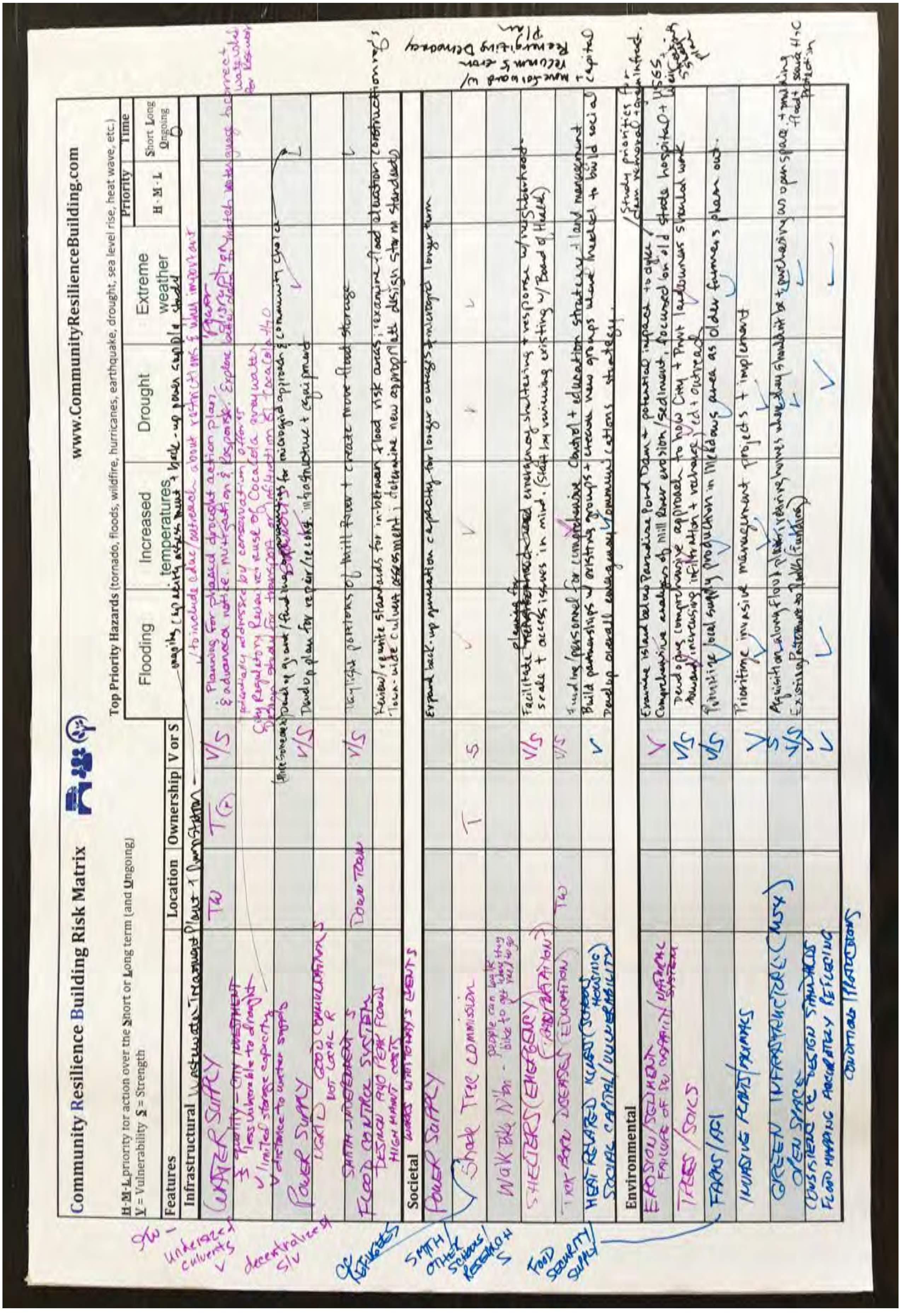
Community Resilience Building Risk Matrix www.CommunityResilienceBuilding.com

H-M-L priority for action over the Short or Long term (and Ongoing)
V = Vulnerability S = Strength

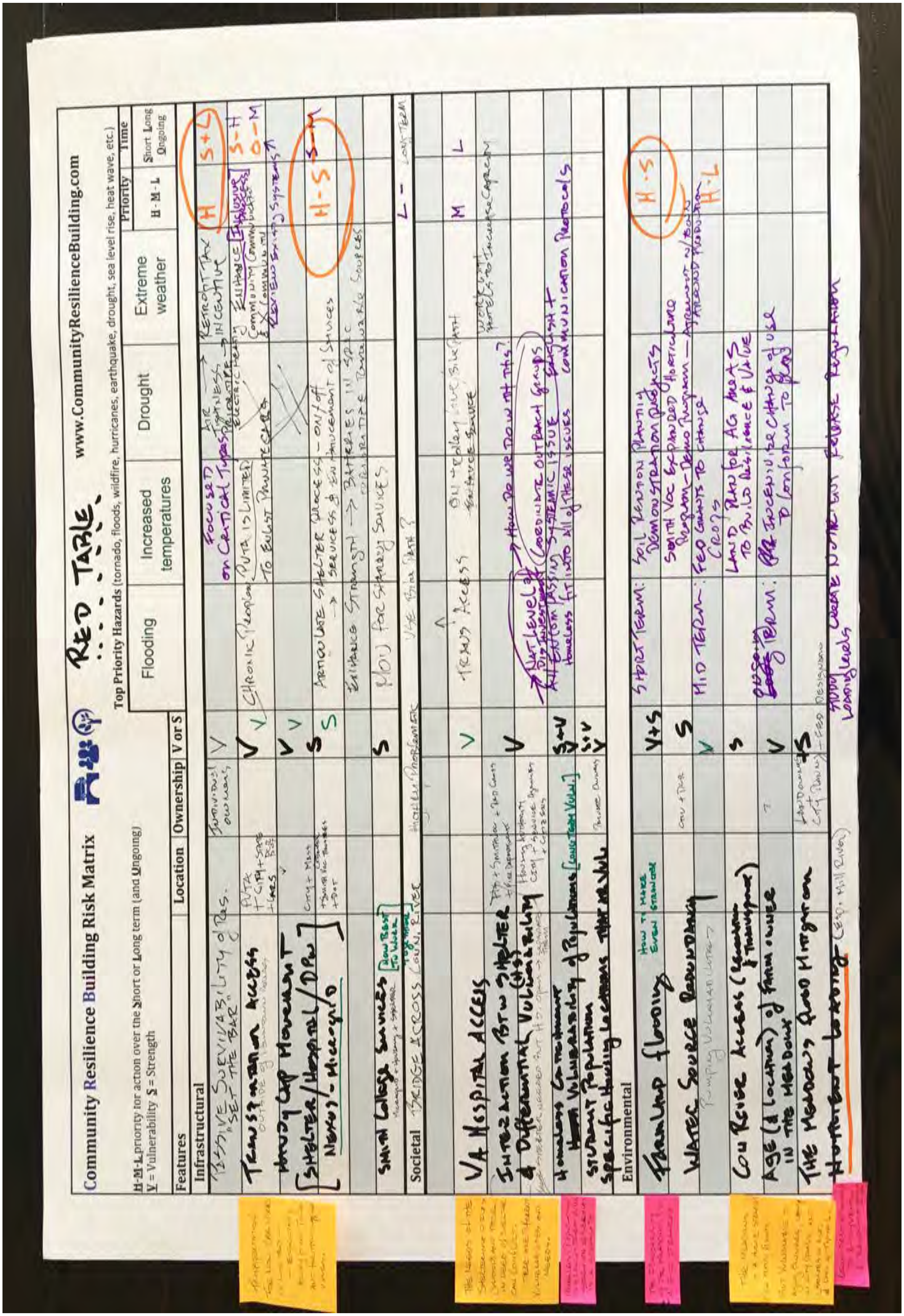
				Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)				Priority	Time
Features	Location	Ownership	V or S	Flooding	Increased temperatures	Drought	Extreme weather	H - M - L	Short Long Ongoing
Infrastructural									
Societal									
Environmental									

RISK MATRIX
[ORIGINAL]

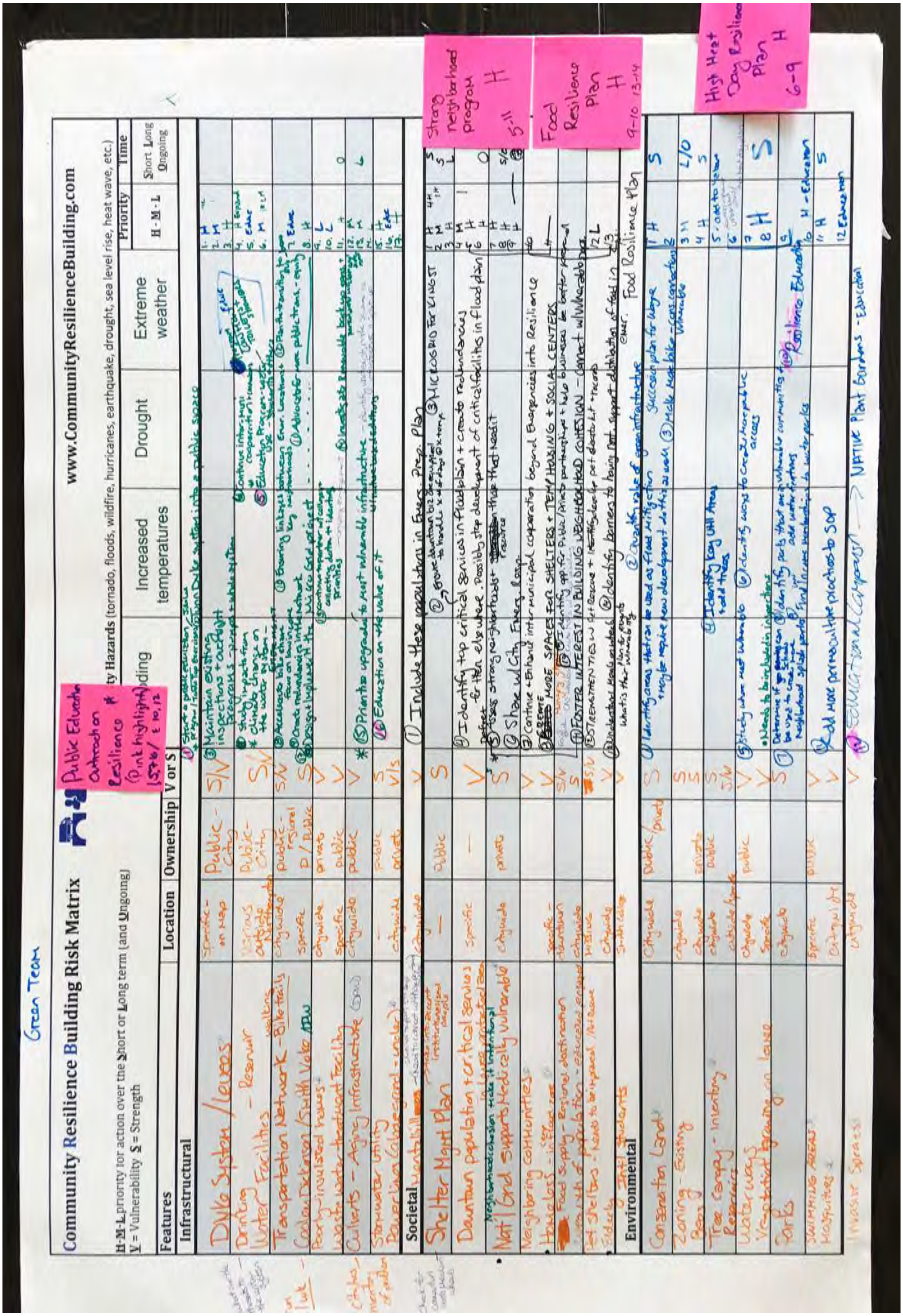
Workshop facilitators used a copy of this risk matrix to record the findings from the group discussions.



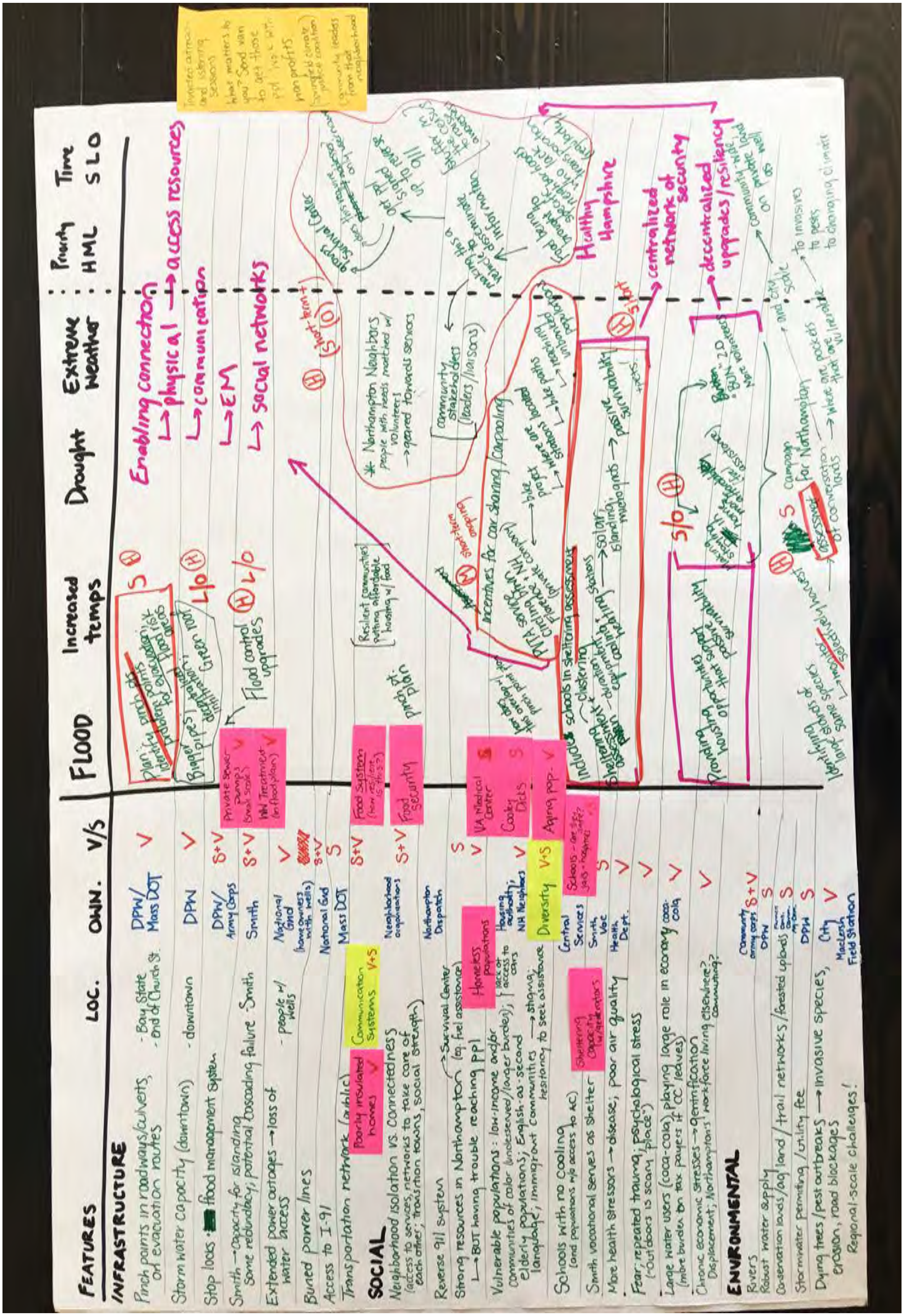
RISK MATRIX
[BLUE GROUP]



RISK MATRIX
[RED GROUP]



RISK MATRIX
[GREEN GROUP]



RISK MATRIX
[YELLOW GROUP]

Community Resilience Building Risk Matrix

www.CommunityResilienceBuilding.org

H-**M**-**L** priority for action over the **S**hort or **L**ong term (and **O**ngoing)
V = Vulnerability **S** = Strength

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

Features	Location	Ownership	V or S	Flooding / Increased Temperatures / Drought / Extreme Weather	Priority H - M - L	Time Short Long Ongoing
Infrastructural						
Stormwater system (undersized culverts and capacity)	Citywide	DPW	V	Conduct a Comprehensive Flood Resilience Plan; Conduct citywide assessment of culvert upgrades and aquatic activity; Identify priority upgrades and focus on nature-based solutions, including open-bottom culverts; Expand current projects to emphasize green infrastructure and rainwater catchment, including an education component; Expand strategies for more water storage in open space; Develop flood resilience plan through a whole-watershed approach, focusing on soil health and infiltration. **[Flooding, Extreme Weather]**	H	S + L
Roads with frequent localized flooding	Localized areas	DPW	V	Identify "pinch points" such as road segments on evacuation routes or that connect neighborhoods to critical resources that frequently flood. **[Flooding, Extreme Weather]**	H	S
Residential building stock (poor insulation)	Citywide	Private, NHA / affordable housing providers	V	A) - Encourage passive survivability of critical buildings, including large multifamily housing; Retrofit tax incentive structure to better encourage energy retrofits to older houses; Identify opportunities for combined heat and power (CHP) systems; Encourage installation of air-source heat pumps; Prioritize low-income and minority communities; Work with Northampton Housing Authority and other affordable housing providers, who are pursuing energy efficiency and weatherization strategies; Set a "passive survivability bar" as metric of success or require passive survivability modeling on all new construction or substantial renovations as part of permitting. **[Extreme Weather, Increased Temperatures]** B) - Develop an outreach campaign to encourage households to upgrade building envelopes with better insulation; Partner with universities who have good energy efficiency data analyses to support the argument for investing in building upgrades. **[Extreme Weather, Increased Temperatures]**	A) - H B) - M	A) - S + L B) - L
Flood control infrastructure	Downtown	City / Army Corps	V/S	A) - Assess and revise freeboard regulations to consider climate projections; Determine design standards for areas protected by the dikes, but that are below 125' elevation; Develop new standard of construction for building in areas outside the floodplain, but that still see frequent localized or riverine flooding. **[Flooding, Extreme Weather]** B) - Maintain existing inspections and oversight programs for repair, maintenance, and upgrades of flood control infrastructure, and strengthen drills and inspections as needed; Continue ongoing evaluations to look at the capacity of the pump station, its location, needed repairs, and its backup power supply. **[Flooding, Extreme Weather]** C) Enhance area around dike to be better used as a public park that could help with heat island mitigation; Invite public to see how the dike system works to enhance people's understanding of the flood management system, its limitations, and its maintenance/investment needs. **[Flooding, Extreme Weather, Increased Temperatures]**	A) - H B) - M C) - M	A) - S B) - O C) - L

[CONTINUED]

Microgrid	Smith Voc / Hospital / DPW	City	S	Use study results from Northwestern to issue request for proposals (RFP) for microgrid project to create a resilient power source for Cooley Dickinson Hospital, Smith Vocational and Agricultural High School (emergency shelter), and the Department of Public Works; Proceed with design and construction of the microgrid. **[Extreme Weather, Increased Temperatures, Flooding]**	H	S
Public transportation system (route/access limitations)	Citywide	City / PVTA	V	A) - Accelerate expansion of bike share program, particularly in areas with larger minority or low-income populations; Consider strategies to better serve unbanked populations; Advocate for more public transportation improvements, ensuring that routes and service times aim to specifically support the needs of low-income and minority communities. **[Resilience generally]** B) - Assess how to accommodate increasing need for charging stations; Work with businesses to establish transition plan to allow private entities to implement charging station networks. **[Resilience generally]** C) - Collaborate with local entrepreneur to expand transportation access by running minibus between neighborhoods / shopping centers within Northampton and nearby towns. **[Resilience generally]** D) - Identify locations that offer critical emergency services and ensure that there is a range of transportation options that link those services to neighborhoods; Ensure redundancies in transportation routes and networks so that no neighborhoods are cut off from critical services. **[Resilience generally]**	A) - H B) - M C) - M D) - L	A) - S B) - S C) - L D) - O
Bike path system	Citywide	City	S	Ensure that low-income and minority neighborhoods have access to conservation land and green space (i.e., areas that will be cooler in extreme heat) via bike or pedestrian paths. **[Increased Temperatures]**	H	L
Power substations and electrical lines (some are in floodplain; vulnerable in storms and heat)	Citywide	National Grid	V	A) - Acquire grant funding / personnel to complete assessment of community choice aggregation, local solar generation, and the implementation of microgrids; Consider strategies for islanding / energy resilience in not only hospitals and campuses, but also neighborhoods, grocery stores, etc.; Potentially collaborate with Amherst and Pelham who may be advancing similar initiatives. **[Extreme weather; Increased Temperatures; Flooding]** B) - Ensure that downtown businesses are equipped to handle increased risk of power outages, flooding, and extreme heat; Ensure infrastructure in downtown is designed to withstand predicted heat wave intensities and durations; Consider the implementation of a microgrid for King Street. **[Extreme weather; Increased Temperatures; Flooding]**	A) - M B) - M	A) - L B) - L
Water and wastewater infrastructure system	Citywide	DPW / NWD	V	A) - Continue ongoing evaluations to look at the capacity of the pump station, its location, needed repairs, and its backup power supply. **[Flooding, Extreme Weather]** B) - Conduct city regulatory review of the reuse of Coca-Cola graywater; Design a study for transport (for irrigation use) or infiltration of Coca-Cola water (secondary, beneficial use, non-potable); Look into potential collection from other entities for further water reuse. **[Drought]**	A) - M B) - L	A) - O B) - L
Northampton schools (lack of air conditioning)	Specific locations	City	V	Assess the ability of schools to house people/students during periods of extreme heat, and consider strategies for enhancing passive survivability. **[Increased Temperatures, Extreme Weather]**	L	O

[CONTINUED]

Coolidge Bridge (Route 9) (pinch point for evacuation)	Route 9 at Connecticut River	MassDOT	V	See "Roads with frequent localized flooding" above for relevant recommendations.	N/A	N/A
Cooley Dickinson Hospital (capacity to weather extreme events)	Locust Street	Private	S	No specific actions identified.	N/A	N/A
Smith College (capacity to weather extreme events)	Downtown	Private	S	No specific actions identified.	N/A	N/A
I-91 (easy access for evacuation)	Citywide	USDOT	S	No specific actions identified.	N/A	N/A
Stormwater utility	Citywide	City	S	No specific actions identified.	N/A	N/A
Societal						
Non-English-speaking populations (communication and participation limitations)	Downtown (primarily)	Private	V	A) - Conduct outreach with specific communities so that the knowledge and insight of vulnerable communities directly shape strategies that are developed to support vulnerable populations; Conduct outreach sessions by attending (rather than hosting at a City-chosen venue) community meetings / functions designed to reach diverse community groups “where they’re at”; Work with “local neighborhood trust networks” to help disseminate and gather information; Potentially re-create a previously existing mentoring program, whereby community members who feel comfortable interacting with City government act as a liaison between the City and residents. **[Resilience generally]** B) - Strengthen partnerships between the City and existing community groups and work with communities to create new groups to help build social capital; Revisit strategies from the Re-Energize Democracy plan to make sure people feel a part of the City planning processes. **[Resilience generally]**	A) - H B) - M	A) - O B) - O
Households with income below the poverty level (resource limitations)	Citywide	Private	V	Same as above.	H	O
Elderly populations (limited mobility, networks, physical capacity)	Citywide	Private	V	Same as above.	H	O
Persons facing homelessness (resource + shelter limitations)	Citywide	Private	V	Same as above.	H	O
Persons with mental health challenges (limited personal capacity to respond)	Citywide	Private	V	Same as above.	H	O
Student population (transient population, many new to Northampton)	Citywide	Private	V/S	Same as above.	H	O

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Reverse 911 system and need for improved communication	Citywide	City	V	A) - Develop multi-pronged strategy for various levels of resilience-based communication, including emergency alerts, regular notifications (i.e., snow parking bans), and ongoing public outreach; Develop ongoing public education and outreach programs focused on topics including invasive species management, tick-borne diseases, land-use strategies, resilience strategies, the value of the city's stormwater utility and green infrastructure implementation, native plant gardens, drought mitigation and water conservation strategies, among others; Identify ways to better use the City's webpage and social media in a way that is coordinated and engages people. **[Resilience generally]** B) - Identify ways to better connect with diverse populations and underrepresented communities, including using trusted community partners, to encourage individuals to sign up for Reverse 911 and to disseminate other resilience-based information on an ongoing basis. **[Resilience generally]**	A) - H B) - H	A) - O B) - O
Social resources and services	Citywide	City / Private	S	A) - Define what makes a "strong neighborhood," and assess neighborhoods accordingly; Share assessment with City Emergency Response; Create more spaces for shelters, temporary housing, and social centers as needed; Enhance inter-municipal coordination beyond emergencies to better develop networks of resilient neighborhoods; Identify opportunities for public/private partnerships to provide resources or services; Foster interest in building neighborhood cohesion. **[Resilience generally]** B) - Facilitate planning for emergency management, focusing on responses at a neighborhood scale with access issues in mind; Start this process by reviewing existing strategies with the Board of Health. **[Resilience generally]**	A) - H B) - M	A) - O B) - O
Sheltering strategy and emergency management (limitations, lack of clarity)	Shelter sites	City	V	A) - Develop Emergency Shelter Operations Plan that defines lines of decision-making and command; Expand shelters' backup generation capacity and diesel supplies, pairing with microgrid implementation; Assess ability of both shelters and schools to house people/students during extreme heat, and consider strategies for enhancing passive survivability; Assess transportation access to shelters and whether climate hazards will prevent access; Assess strategies to cluster services (healthcare, food provision, etc.) near shelters to serve as "resilience hubs;" Ensure strategies for effectively supporting people with mental illness, and include clinical support experts in sheltering plan development; Involve people who have limited English proficiency, who are elderly, and who have experienced/are experiencing homelessness (and social service representatives) in the plan development; Expand shelter capacity by expanding shelter space or by reducing sheltering need (e.g., establish agreements with hotels). **[Flooding, Increased Temperatures, Extreme Weather]** B) - Revise FEMA Multi-Hazard Mitigation Plan to reflect MVP Process; Provide crosswalk study between Multi-Hazard Mitigation Plan, Emergency Response Plan, and Climate Resiliency Plan. **[Resilience generally]** C) - Develop Emergency Transportation Plan; Understand PVTA's emergency management plan; Clarify roles in decision-making and execution during a citywide evacuation; Investigate models to enlist private cars in evacuation ride-share program. **[Resilience generally]** D) - Enhance planning for pet emergency management; Strengthen ties with pet rescue; Develop pet disaster kits and records. **[Resilience generally]**	A) - H B) - H C) - M D) - L	A) - S B) - S C) - L D) - L

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Senior Center (vulnerable to flooding)	Conz Street	City	V	Identify top critical services in the floodplain and create redundancies for them elsewhere (e.g., potentially a back-up dialysis center). **[Flooding]**	H	O
Dialysis Center (vulnerable to flooding)	Conz Street	Private	V	Same as above.	H	O
Meals on Wheels Kitchen (vulnerable to flooding)	Conz Street	Private	V	Same as above. Develop a food resilience plan; Understand the vulnerability of the Meals on Wheels program (e.g., many of the drivers are elderly and less able to deliver in a storm) and plan for emergency events; Develop alternative strategies and public/private partnerships that may be able to help provide resources or services; Help businesses, such as restaurants and grocery stores, become better prepared to maintain business continuity and prevent food loss. **[Flooding, Extreme Weather]**	H	L
Swimming locations (lack of access)	Rainbow Beach / Reservoir	City / Private	V	Develop a High Heat Day Plan; Identify ways to increase public access to swimmable areas in Northampton; Identify key urban heat island areas and prioritize tree planting in those locations; Determine if schools can be used to create more neighborhood splash parks; Identify parks that are in vulnerable communities and add water features; Fund low-income memberships to parks with water features. **[Increased Temperatures]**	H	S
Smith College capacity and services	Downtown	Private	S	Develop a memorandum of understanding (MOU) with Smith College to delineate sharing of resources in an emergency. **[Flooding, Extreme Weather, Increased Temperatures]**	H	S
Housing unaffordability	Downtown	City / Private	V	Prioritize low-income and minority communities for energy efficiency, weatherization, and passive survivability programs, incorporating a tandem goal of making staying in one's home more affordable. **[Extreme Weather, Increased Temperatures]**	H	O
Business continuity (impacted due to hazards)	Citywide	Private	V	Ensure businesses are equipped to handle increased risk of power outages, flooding, and extreme heat; Ensure infrastructure in downtown is designed to withstand predicted heat wave intensities and durations; Consider the implementation of a microgrid for King Street; Develop strategies to preemptively communicate with businesses citywide on drought and water restrictions. **[Extreme weather; Increased Temperatures; Flooding; Drought]**	M	L
Homeless tent encampment (vulnerable to flooding)	Adjacent to downtown	Private	V	No specific actions identified, although the above strategies to enhance sheltering services are relevant.	N/A	N/A
Psychological stress	Citywide	Private	V	No specific actions identified.	N/A	N/A
Shelter at Smith Vocational and Agricultural High School	Locust Street	City	S	See "Sheltering strategy and emergency management" above for relevant recommendations.	N/A	N/A
National Grid support for "critical care customers"	Citywide	National Grid / Private	S	No specific actions identified.	N/A	N/A
Relatively wealthy population with education and resources	Citywide	Private	S	No specific actions identified.	N/A	N/A

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Environmental						
Trees / tree canopy	Citywide	City / Private	V/S	Conduct inventory of tree populations, identifying locations of large stands of tree species that are vulnerable to invasive species, pests, and changes in climate; Assess tree populations at citywide scale, including conservation land and private property; Develop City strategies (monitoring, selective harvesting) in tandem with a public campaign to help address vulnerabilities. **[Resilience generally]**	H	O
Vector-borne disease	Citywide	City / Private	V	Develop comprehensive strategy to address ticks and invasive species that includes land management, invasive species control strategies, and the integration of more permaculture practices; Apply for funding to further research tick-borne illness, as well as funding and personnel for implementation of comprehensive control and education program. **[Resilience generally]**	H	S
Soil degredation, sedimentation, erosion	Citywide	City / Private	V	A) - Conduct demonstration projects in collaboration with Smith Vocational and Agricultural High School to incentivize perennial plantings along the Connecticut river that also serve as a harvest crop for farmers; Link the demonstration projects with development of the horticulture program to align career development with strategies to increase local food production (sold and consumed locally) to enhance local food security / resilience. **[Resilience generally]** B) - Assess erosion in the Mill River channel and strategies for improving river bank stability; Examine island south of Paradise Pond and the Route 66 bridge to assess whether it is growing due to erosion and sedimentation; Assess old dams and the role they may be playing in increasing sedimentation; Remove old dams that are not viable for power production when funds are available; Engage interested players (e.g., Smith, Audubon, etc.); Assess street sweeping, and where sediment may be coming off streets. **[Resilience generally]**	A) - H B) - M	A) - L B) - L
Water supply	Local wells / reservoirs outside NH	City / NWD	V/S	Assess impacts from climate change on water sources and water treatment system (from contamination due to flooding, from drought, etc.); Investigate whether households with wells are seeing problems; Plan for phased drought mitigation and action plan, and develop advanced notice protocols for large water users; Detail necessary conservation efforts; Explore strategies for better data collection to give a more accurate representation of drought conditions and water supply; Develop public education strategy to raise awareness about water restrictions; Ensure strategies for source protection continue (e.g., the City buying land). **[Drought, Increased Temperatures, Flooding]**	M	L
Waterways, hydrology, and natural water storage	Citywide	City / Private	V	A) - Continue land acquisition in flood plain; Buy out homes in places with high vulnerability to flooding; Continue buying land (must be near the floodplain) where water can be stored before it hits the floodplain; Complete land acquisition in accordance with City's open space prioritization list. **[Flooding]** B) - Develop approach to how the City and private land owners would work together on increasing infiltration and recharge; Conduct education and outreach program on the best methods and priorities for how private landowners can increase rainwater infiltration. **[Flooding]** C) - 'Daylight' the historical Mill River and create more flood storage to mitigate flooding around the wastewater treatment plant and pump station. **[Flooding]**	A) - M B) - L C) - L	A) - L B) - L C) - L

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Agricultural land and food system	Meadows / Citywide	Private	V/S	See "Soil degredation, sedimentation, erosion" above for relevant recommendations. Ensure continuation of productive land use in the Meadows as farmers age and may transition ownership; Assess how to ensure food production (and not mono-cropping) in the Meadows to be used for local food consumption. **[Resilience generally]**	L	O
Nutrient loading	Mill River, Oxbow	City / Private	V	Conduct a study to understand nutrient loadings and sources; Host regional farmers' meetings to discuss nutrient loadings; Create local nutrient release regulations that surpass state regulations. **[Resilience generally]**	L	L
Non-native invasive plants and animals	Citywide	City / Private	V	See "Trees / tree canopy" and "Vector-borne disease" above for relevant recommendations.	N/A	N/A
Parks and green space	Citywide	City / Private	S	See "Trees / tree canopy" for relevant recommendations.	N/A	N/A
Regulations and zoning supporting agriculture and conservation land	Citywide	City	S	See "Waterways, hydrology, and natural water storage" and "Agricultural land and food system" for relevant recommendations.	N/A	N/A
The fact that challenges are regional in scale	Regional	City / Neighboring towns / PVPC	V	No specific actions identified.	N/A	N/A

Provided Resource Maps

The following maps were provided at the workshop tables to serve as resources for discussion.

FLOOD MAPS

The following flood maps are adapted from the *City of Northampton Local Emergency Flood Plan,* revised February 2018. They illustrate the extent of flooding to be expected in the southeast portion of the city when the water surface elevation reach 112 feet, 115 feet, and 135 feet, respectively.

Phase C - "Flood Stage"
Water surface elevation: 112 ft.

Based on National Weather Service Flood Stages for the Connecticut River.

At this flood stage, flooding causes minimal or no property damage, but possibly some public threat. Manhan Meadows starts flooding into Fort Hill Sewer interceptor.

Flooded Area

Levee-Protected Area

Figure adapted from "City of Northampton Local Emergency Flood Plan," revised February 21, 2018. Flood data from City of Northampton Public Works is layered on ESRI World Topo base map.

FLOOD MAPS
CONTINUED

Phase D - "Moderate Flood Stage"
Water surface elevation: 115 ft.

Based on National Weather Service Flood Stages for the Connecticut River.

At this flood stage, there is some inundation of structures and roads. Some evacuations of people and/or transfer of property to higher elevations may be necessary. Route 5 / Mt. Tom Road floods near the Easthampton line and/or Island Road. Venturer's Field Road and Hockanum Road near flooding.

Flooded Area
Levee-Protected Area

LINNEAN Solutions

Figure adapted from "City of Northampton Local Emergency Flood Plan," revised February 21, 2018. Flood data from City of Northampton Public Works is layered on ESRI World Topo base map.

FLOOD MAPS
CONTINUED

Phases F1, F2, F3 - "Major Flood Stages"
Water surface elevation: 135 ft.

Based on National Weather Service Flood Stages for the Connecticut River.

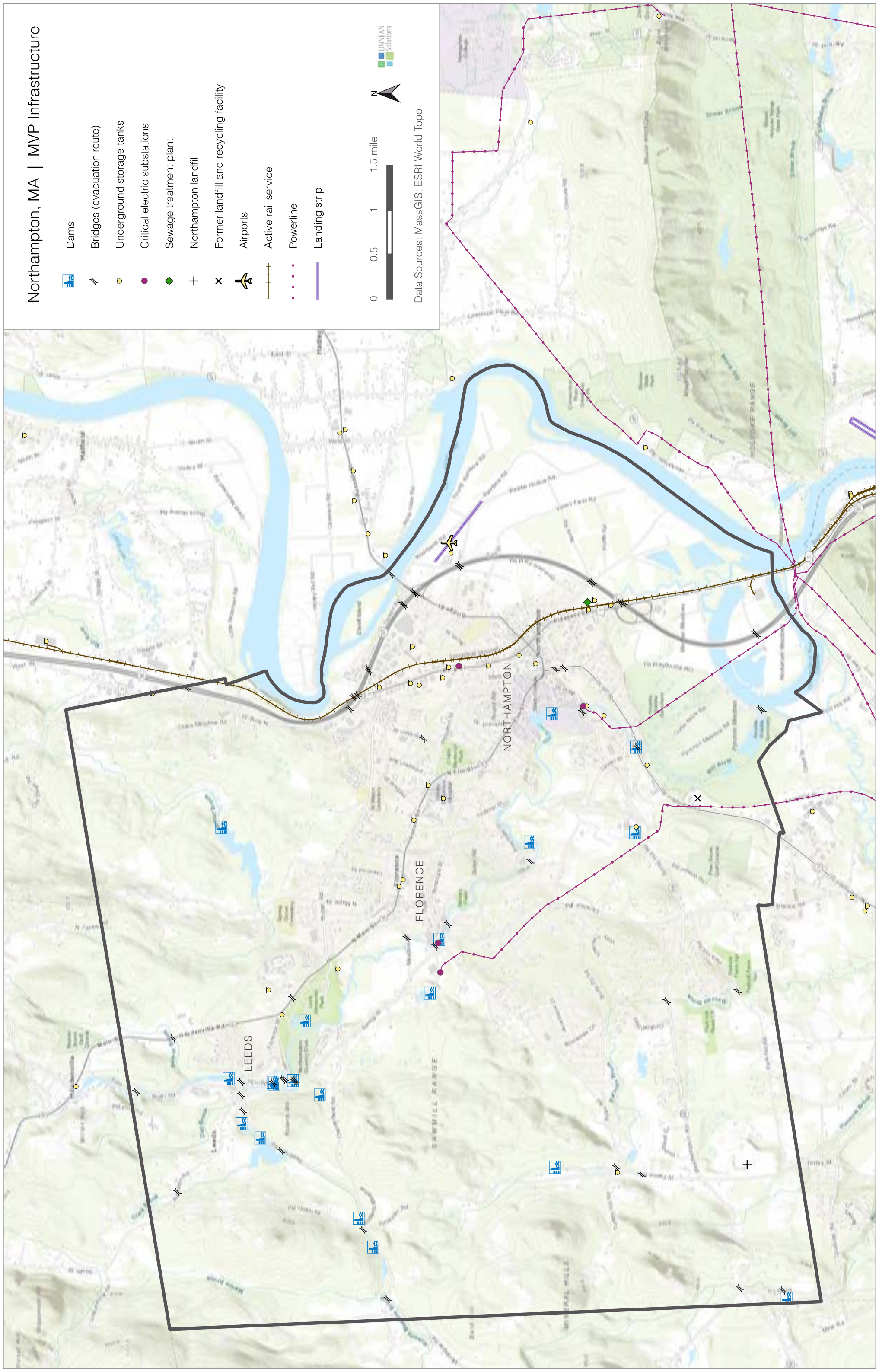
At this flood stage, there is extensive inundation of structures and roads. Significant evacuations of people and/or transfer of property to higher elevations is necessary. Flooding reaches the top of the floodwall at 130 feet, and overtops the Connecticut River dikes at 132 feet.

Flooded Area

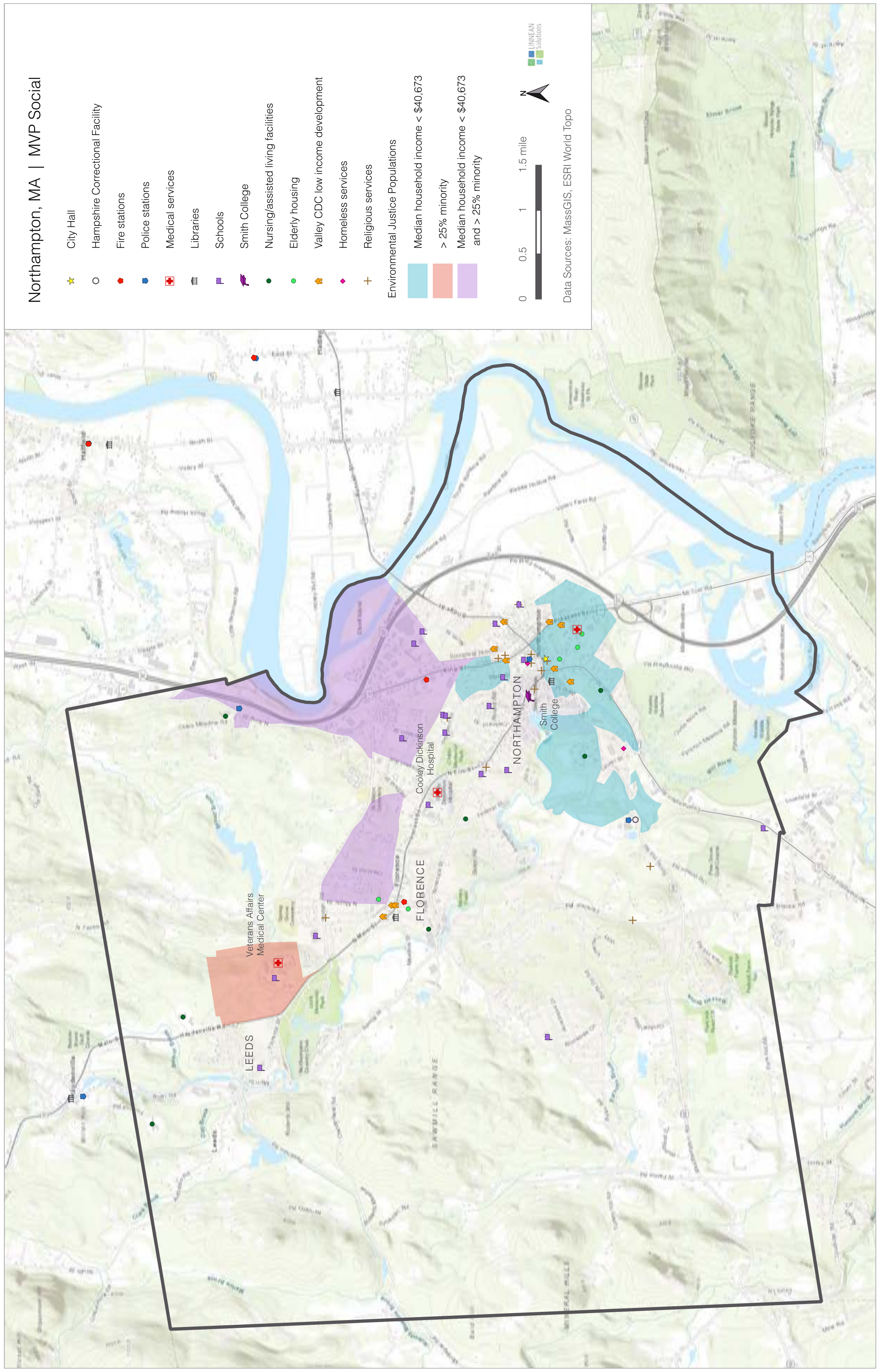
Figure adapted from "City of Northampton Local Emergency Flood Plan," revised February 21, 2018. Flood data from City of Northampton Public Works is layered on ESRI World Topo base map.

REFERENCE MAPS

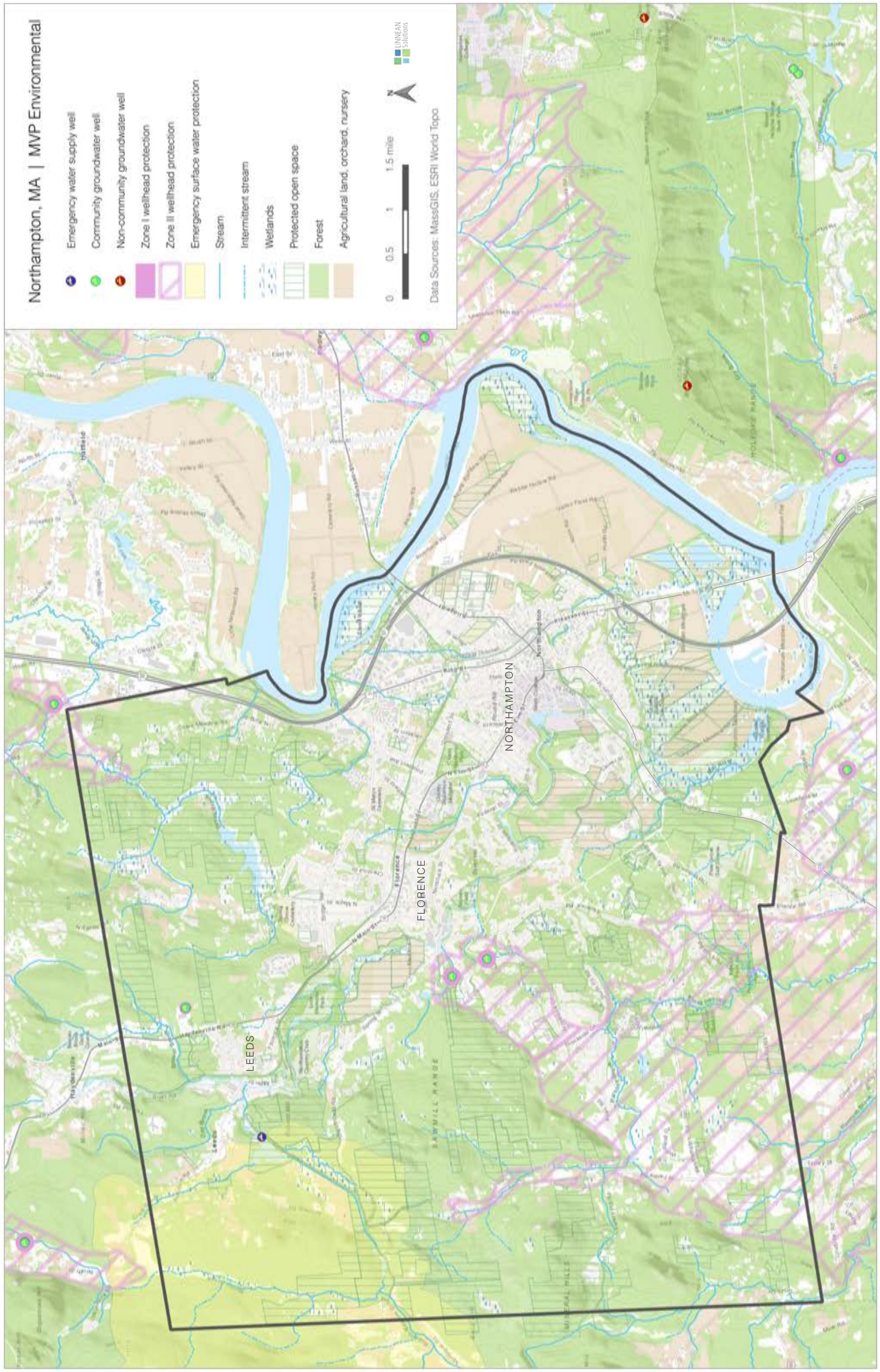
The following maps show infrastructural, societal, and environmental features, respectively, within Northampton. They are designed to serve as a reference for discussion.



REFERENCE MAPS
CONTINUED



REFERENCE MAPS
CONTINUED



F. Downscaled Climate Data

Below are downscaled climate data for the Connecticut River Watershed, developed by the Northeast Climate Science Center at the University of Massachusetts Amherst with support from the Massachusetts Executive Office of Energy and Environmental Affairs. These standardized, peer-reviewed set of climate change projections show the changes in temperature and precipitation that we can expect due to climate change through the end of the century.

Changes in average, maximum, and minimum temperatures

Average temperatures for the Connecticut River Watershed are expected to increase throughout the 21st century, reaching a 2° - 4°F increase by the 2030s, and a 4° - 11°F increase by the 2090s (Figure 1). We are expected to see higher maximum temperatures in the summer, and higher minimum temperatures in the winter as well.

Connecticut Basin		Observed Baseline 1971-2000 (°F)	Projected Change in 2030s (°F)			Mid-Century Projected Change in 2050s (°F)			Projected Change in 2070s (°F)			End of Century Projected Change in 2090s (°F)		
Average Temperature	Annual	46.98	+2.18	to	+4.46	+3.00	to	+6.43	+3.57	to	+9.00	+4.04	to	+10.94
	Winter	25.01	+2.36	to	+5.37	+3.02	to	+7.99	+3.95	to	+9.54	+4.18	to	+10.83
	Spring	45.35	+1.51	to	+3.30	+2.26	to	+5.21	+2.76	to	+7.23	+3.11	to	+8.81
	Summer	67.93	+2.19	to	+4.54	+3.05	to	+7.24	+3.44	to	+10.52	+3.91	to	+12.94
	Fall	49.24	+2.27	to	+5.23	+3.81	to	+6.81	+3.75	to	+9.57	+4.21	to	+11.69
Maximum Temperature	Annual	58.45	+2.03	to	+4.24	+2.65	to	+6.56	+3.18	to	+9.13	+3.63	to	+11.03
	Winter	35.23	+1.96	to	+4.66	+2.61	to	+7.11	+3.19	to	+8.53	+3.43	to	+9.63
	Spring	57.16	+1.38	to	+3.23	+2.13	to	+5.16	+2.66	to	+7.53	+3.17	to	+8.99
	Summer	80.18	+1.89	to	+4.67	+2.75	to	+7.45	+3.25	to	+10.93	+3.76	to	+13.41
	Fall	60.8	+2.47	to	+5.04	+3.65	to	+7.16	+3.54	to	+9.91	+4.21	to	+12.20
Minimum Temperature	Annual	35.51	+2.38	to	+4.81	+3.35	to	+6.64	+3.93	to	+8.89	+4.37	to	+10.89
	Winter	14.8	+2.63	to	+6.03	+3.56	to	+8.76	+4.51	to	+10.54	+4.94	to	+11.83
	Spring	33.53	+1.62	to	+3.63	+2.38	to	+5.64	+2.96	to	+7.07	+3.29	to	+8.59
	Summer	55.67	+2.34	to	+4.62	+3.21	to	+7.33	+3.63	to	+10.13	+4.07	to	+12.49
	Fall	37.68	+1.97	to	+5.33	+3.58	to	+6.64	+3.82	to	+9.22	+4.21	to	+11.37

Figure 1. Average, maximum, and minimum temperature projections for the Connecticut River Watershed.

Changes in the number of days above 90°, 95°, and 100°F

The number of days where maximum temperatures reach above 90°F in the Connecticut River Watershed is expected to increase throughout the 21st century, reaching a total of 13 - 26 days in the 2030s, and a total of 21 - 82 days by the 2090s (Figure 2). The number of days above 95° and 100°F are likewise expected to increase.

Connecticut Basin		Observed Baseline 1971-2000 (Days)	Projected Change in 2030s (Days)	Mid-Century Projected Change in 2050s (Days)	Projected Change in 2070s (Days)	End of Century Projected Change in 2090s (Days)
Days with Maximum Temperature Over 90°F	Annual	6.41	+6.36 to +19.72	+9.87 to +35.35	+11.98 to +57.07	+14.50 to +76.01
	Winter	0.00	+0.00 to +0.00	+0.00 to +0.00	+0.00 to +0.00	+0.00 to +0.00
	Spring	0.39	+0.14 to +0.91	+0.30 to +1.76	+0.37 to +3.31	+0.28 to +5.00
	Summer	5.73	+5.53 to +16.97	+8.31 to +29.50	10.37 to +46.30	+12.47 to +60.30
	Fall	0.29	+0.44 to +2.09	+0.51 to +4.58	+0.61 to +8.80	+1.02 to +11.94
Days with Maximum Temperature Over 95°F	Annual	0.46	+1.74 to +7.34	+2.77 to +16.31	+3.55 to +32.96	+4.56 to +49.67
	Winter	0.00	+0.00 to +0.00	+0.00 to +0.00	+0.00 to +0.00	+0.00 to +0.00
	Spring	0.00	+0.00 to +0.26	+0.02 to +0.49	+0.04 to +1.03	+0.03 to +1.93
	Summer	0.45	+1.71 to +6.53	+2.54 to +14.84	+3.05 to +28.97	+4.16 to +43.03
	Fall	0.01	+0.06 to +0.63	+0.09 to +1.19	+0.13 to +3.23	+0.20 to +4.87
Days with Maximum Temperature Over 100°F	Annual	0.00	+0.14 to +1.54	+0.22 to +4.35	+0.41 to +11.64	+0.38 to +23.33
	Winter	0.00	+0.00 to +0.00	+0.00 to +0.00	+0.00 to +0.00	+0.00 to +0.00
	Spring	0.00	+0.00 to +0.03	+0.00 to +0.06	+0.00 to +0.21	+0.00 to +0.45
	Summer	0.00	+0.13 to +1.45	+0.20 to +4.17	+0.36 to +10.72	+0.33 to +21.46
	Fall	0.00	+0.00 to +0.14	+0.00 to +0.37	+0.01 to +0.75	+0.00 to +1.29

Figure 2. Number of days above 90°, 95°, and 100°F for the Connecticut River Watershed.

Number of days with a minimum temperature below 0° and 32°F

The number of days where minimum temperatures are below 0°F in the Connecticut River Watershed is expected to decrease throughout the 21st century, dropping to a total of 4 - 7 days in the 2030s, and a total of 2 - 6 days by the 2090s (Figure 3). The total number of days below 32°F are likewise expected to decrease.

Connecticut Basin		Observed Baseline 1971-2000 (Days)	Projected Change in 2030s (Days)	Mid-Century Projected Change in 2050s (Days)	Projected Change in 2070s (Days)	End of Century Projected Change in 2090s (Days)
Days with Minimum Temperature Below 0°F	Annual	11.33	-4.01 to -7.02	-4.88 to -8.3	-5.42 to -8.76	-5.53 to -9.57
	Winter	11	-3.84 to -6.82	-4.67 to -7.96	-5.11 to -8.52	-5.33 to -9.1
	Spring	0.38	-0.08 to -0.44	-0.12 to -0.44	-0.18 to -0.49	-0.18 to -0.55
	Summer	0.00	-0.00 to -0.00	-0.00 to -0.00	-0.00 to -0.00	-0.00 to -0.00
	Fall	0.01	-0.02 to -0.00	-0.02 to -0.00	-0.02 to -0.00	-0.02 to -0.00
Days with Minimum Temperature Below 32°F	Annual	158.63	-10.58 to -28.13	-18.57 to -37.28	-22.18 to -50.76	-22.88 to -59.79
	Winter	85.33	-1.15 to -5.9	-2.37 to -8.5	-3.50 to -15.82	-4.26 to -19.49
	Spring	41.52	-3.47 to -9.56	-6.03 to -13.97	-6.70 to -17.87	-8.82 to -19.42
	Summer	0.02	-0.01 to -0.17	-0.01 to -0.27	-0.01 to -0.23	-0.01 to -0.26
	Fall	31.7	-4.87 to -12.57	-9.60 to -15.50	-8.89 to -19.96	-9.36 to -22.29

Figure 3. Number of days below 0° and 32°F for the Connecticut River Watershed.

Number of heating, cooling, and growing degree days

Over the 21st century, the number of heating degree days are expected to decrease, and the number of cooling degree days and growing degree days are predicted to increase in the Connecticut River Watershed (Figure 4). This suggests, in particular, that buildings will need to be heated less, but cooled more than they are currently on an annual basis. See the caption of Figure 4 for an explanation of these metrics.

Connecticut Basin		Observed Baseline 1971-2000 (Degree-Days)	Projected Change in 2030s (Degree-Days)	Mid-Century Projected Change in 2050s (Degree-Days)	Projected Change in 2070s (Degree-Days)	End of Century Projected Change in 2090s (Degree-Days)
Heating Degree-Days (Base 65°F)	Annual	7038.04	-579.08 to -1220.89	-807.65 to -1696.71	-932.31 to -2213.81	-1061.27 to -2563.22
	Winter	3617.34	-196.64 to -492.19	-267.53 to -731.67	-348.79 to -867.16	-385.45 to -997.60
	Spring	1827.32	-122.30 to -279.16	-188.81 to -436.93	-225.95 to -566.74	-272.18 to -666.52
	Summer	127	-45.72 to -80.45	-63.18 to -101.77	-66.76 to -116.60	-72.74 to -119.29
	Fall	1471.22	-176.19 to -404.39	-298.62 to -486.71	-283.22 to -674.74	-306.64 to -768.06
Cooling Degree-Days (Base 65°F)	Annual	459.27	+200.92 to +430.52	+272.64 to +749.47	+326.52 to +1142.40	+379.72 to +1504.58
	Winter	nan	-0.39 to +2.36	+0.05 to +6.58	-0.14 to +3.38	-0.29 to +7.15
	Spring	20.23	+10.02 to +28.89	+17.52 to +55.39	+21.11 to +92.67	+20.81 to +121.55
	Summer	396.24	+162.41 to +335.42	+204.13 to +564.51	+235.28 to +853.52	+270.64 to +1075.43
	Fall	37.72	+25.68 to +84.68	+40.57 to +136.51	+49.64 to +225.83	+63.95 to +304.46
Growing Degree-Days (Base 50°F)	Annual	2348.43	+392.37 to +801.41	+536.06 to +1252.31	+652.08 to +1894.77	+739.11 to +2379.52
	Winter	3.8	-0.26 to +8.95	+0.09 to +9.32	+0.51 to +14.24	+1.70 to +19.27
	Spring	278.98	+59.68 to +130.77	+91.58 to +225.48	+117.65 to +331.37	+117.61 to +434.70
	Summer	1649.87	+201.11 to +416.74	+279.05 to +664.79	+315.32 to +966.48	+358.57 to +1190.01
	Fall	403.13	+105.14 to +284.19	+169.55 to +395.11	+166.52 to +591.21	+211.39 to +734.09

Figure 4. Number of heating degree days (HDD), cooling degree days (CDD), and growing degree days (GDD) in the Connecticut River Watershed. Note: HDDs are defined as the number of degrees that a day's average temperature is below 65°F; CDDs are the number of degrees that a day's average temperature is above 65°F; and GDDs are the number of degrees that a day's average temperature is above 50°F.

Number of days with precipitation over one inch, two inches, and four inches

The number of days receiving over one inch of precipitation is expected to increase over the 21st century in the Connecticut River Watershed, with most of that increase coming in the winter and spring (summer and fall on the other hand may become drier) (Figure 5). The number of days with precipitation over two inches and over four inches may fluctuate, but are not projected to increase or decrease substantially.

Connecticut Basin		Observed Baseline 1971-2000 (Days)	Projected Change in 2030s (Days)	Mid-Century Projected Change in 2050s (Days)	Projected Change in 2070s (Days)	End of Century Projected Change in 2090s (Days)
Days with Precipitation Over 1"	Annual	6.5	+0.05 to +2.22	+0.52 to +3.15	+0.80 to +2.82	+0.67 to +4.35
	Winter	1.04	-0.04 to +0.74	+0.05 to +1.01	+0.06 to +1.30	+0.22 to +1.64
	Spring	1.56	-0.08 to +0.62	+0.08 to +0.81	+0.17 to +1.20	+0.21 to +1.62
	Summer	1.98	-0.37 to +0.57	-0.19 to +0.97	-0.34 to +0.66	-0.38 to +0.74
	Fall	1.89	-0.28 to +0.70	-0.17 to +0.82	-0.27 to +1.00	-0.40 to +1.17
Days with Precipitation Over 2"	Annual	0.55	-0.05 to +0.40	-0.01 to +0.39	+0.00 to +0.45	+0.04 to +0.58
	Winter	0.03	-0.02 to +0.05	-0.02 to +0.07	-0.01 to +0.08	-0.01 to +0.09
	Spring	0.1	-0.03 to +0.10	-0.03 to +0.09	-0.02 to +0.17	+0.00 to +0.25
	Summer	0.26	-0.06 to +0.16	-0.07 to +0.17	-0.06 to +0.17	-0.09 to +0.19
	Fall	0.16	-0.06 to +0.17	-0.06 to +0.16	-0.04 to +0.18	-0.05 to +0.19
Days with Precipitation Over 4"	Annual	0.00	-0.03 to +0.03	-0.02 to +0.03	-0.01 to +0.05	-0.01 to +0.05
	Winter	0.00	+0.00 to +0.00	+0.00 to +0.00	+0.00 to +0.00	+0.00 to +0.00
	Spring	0.00	+0.00 to +0.00	+0.00 to +0.00	+0.00 to +0.00	+0.00 to +0.00
	Summer	0.00	-0.02 to +0.02	-0.02 to +0.02	-0.02 to +0.03	-0.02 to +0.03
	Fall	0.00	-0.02 to +0.03	-0.01 to +0.03	-0.01 to +0.04	-0.01 to +0.04

Figure 5. Number of days with over one inch, two inches, and four inches of rain.

Total precipitation

Annual precipitation for the Connecticut River Watershed is expected to increase throughout the 21st century, increasing by 1 - 6 inches by the 2050s and by 2 - 8 inches by the 2090s (Figure 6). We are expected to see most of that increase occurring in the winter and spring (the summer and fall, in fact, may become drier).

Connecticut Basin		Observed Baseline 1971-2000 (Inches)	Projected Change in 2030s (Inches)			Mid-Century Projected Change in 2050s (Inches)			Projected Change in 2070s (Inches)			End of Century Projected Change in 2090s (Inches)		
Total Precipitation	Annual	46.39	-0.40	to	+4.99	+1.25	to	+6.22	+1.95	to	+7.26	+1.68	to	+8.30
	Winter	10.34	-0.39	to	+2.08	+0.07	to	+2.59	+0.30	to	+3.03	+0.73	to	+3.87
	Spring	12.12	-0.05	to	+2.09	+0.32	to	+2.13	+0.57	to	+2.80	+0.45	to	+2.87
	Summer	11.98	-0.37	to	+1.76	-0.17	to	+2.13	-0.34	to	+1.85	-1.03	to	+1.90
	Fall	11.94	-1.20	to	+1.48	-1.26	to	+1.65	-1.50	to	+1.78	-1.73	to	+1.49

Figure 6. Total precipitation for the Connecticut River Watershed.

Consecutive dry days

Annual and seasonal projections for the number of consecutive dry days are variable for the Connecticut River Watershed throughout the 21st century (Figure 7). See the caption of Figure 7 for an explanation of the metric.

Connecticut Basin		Observed Baseline 1971-2000 (Days)	Projected Change in 2030s (Days)			Mid-Century Projected Change in 2050s (Days)			Projected Change in 2070s (Days)			End of Century Projected Change in 2090s (Days)		
Consecutive Dry Days	Annual	16.41	-0.18	to	+1.34	-0.42	to	+1.75	-0.73	to	+2.26	-0.35	to	+2.44
	Winter	11.4	-0.77	to	+1.14	-0.57	to	+1.30	-0.80	to	+1.18	-1.21	to	+1.47
	Spring	11.95	-1.05	to	+0.50	-0.91	to	+1.05	-1.24	to	+1.13	-1.24	to	+0.76
	Summer	11.57	-0.70	to	+1.46	-0.61	to	+1.07	-0.91	to	+1.61	-1.37	to	+1.87
	Fall	12.03	-0.12	to	+1.72	-0.21	to	+2.35	-0.61	to	+2.61	-0.13	to	+2.78

Figure 7. Number of consecutive dry days for the Connecticut River Watershed. Consecutive dry days are defined as the largest number of consecutive days within a particular period with precipitation less than 1mm (approximately 0.04 inches).

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