



Medford Climate Change Vulnerability Assessment









CITY OF MEDFORD

JULY 2025



On the cover: photos from the City of Medford and Weston & Sampson

Letter from the Mayor

Dear Members of the Medford Community,

I'm excited to share this update to the City of Medford Climate Change Vulnerability Assessment. Since the release of our first vulnerability assessment in 2019, we've used that information to prioritize stormwater investments, develop our Climate Action and Adaptation Plan, and much more. In this version, we've added updated data about flooding and extreme heat from new state data sources, as well as updated federal data on social vulnerability. We also incorporated a new analysis of Medford's urban forest. As we quickly approach 2030, we've extended our planning timelines to 2050 and 2070. While none of this changes our goals or sense of urgency, it does highlight our commitment to using the best available data to make informed decisions so that Medford continues to be a vibrant community for generations to come.

In recent years, Medford has committed to acting on climate change in a range of ways. In 2015, Medford joined thousands of cities around the world in signing on to the Paris Climate Accord and affirming the scientific findings that climate change is real and committing to act within our power to curb it. Medford is also a proud Massachusetts Green Community and a member of the Global Covenant of Mayors for Climate and Energy. Along with thirteen other local cities and towns, Medford signed the Boston Metro Mayors' Coalition commitment in 2015 to make the region carbon neutral by 2050 and renewed that commitment earlier in 2025.

This assessment shows us the importance of our regional efforts, as well as the need to reduce carbon emissions on a global scale. It continues to make clear that Medford is increasingly at risk from extreme flooding, heat, and winter and tropical storms. Our proximity to the Mystic River and Amelia Earhart Dam means that we are particularly likely to be affected by sea level rise and storm surges. These risks make planning and assessments, like this one, essential to mitigating the effects of climate change on our city.

The Medford community has always shown a willingness to address environmental problems, including tackling flooding, encouraging composting, and protecting public health during snowstorms and extreme heat. We're ready to face the challenges of climate change, and this updated assessment will help guide and support our efforts.

Sincerely,



Mayor Breanna Lungo-Koehn

FOUNDED 1630 & INCOR

2025 Acknowledgments

Thank you to Secretary Rebecca Tepper of the Massachusetts Executive Office of Energy & Environmental Affairs, as well as Governor Maura Healey for their support of the Municipal Vulnerability Preparedness Program.

Consultants from Weston & Sampson provided updated data, report sections and graphics for the 2025 update.

Thank you to the Metropolitan Area Planning Council and the Metro Mayors Climate Preparedness Task Force members for sharing their data, resources, and graphics with us for the 2019 report, in particular to the City of Boston, City of Cambridge, and City of Somerville for including us in their climate change vulnerability planning processes.

The following offices, institutions and organizations contributed to this assessment through their participation in the Municipal Vulnerability Preparedness Stakeholder Workshop in March 2018:

City of Medford Offices: Office of the Mayor; Health Department; Office of Energy & Environment; Office of Community Development; Council on Aging; Community Preservation Committee; School Department; Diversity Director; Chamber of Commerce; Fire Department; Police Department; Department of Public Works including the Engineering Division, the Highway Division, the Park Division, and the Water & Sewer Division; Building Department; Tree Warden; Conservation Commission; Finance Department; and the Historic Commission

State Offices: Massachusetts Emergency Management Agency, Massachusetts Department of Transportation, Massachusetts Department of Public Health, Massachusetts Water Resources Authority, Massachusetts Bay Transportation Authority, and Metropolitan Area Planning Council

Businesses and Organizations: Century Bank; Comcast; Cummings Property; Friends of the Fells; Friends of the Mystic River; Medford Interfaith Council; Mystic River Watershed Association; New England Development; Preotle, Lane & Associates, Ltd.; Tufts University; Verizon Corporation; The Welcome Project; Wynn Boston Harbor

Thank you to Adam Welchel, PhD, Drew Goldsman, Kristie Giannetto, Cary White, Steve Long and Eric Roberts from the Nature Conservancy and Yve Torrie, the Director of Sustainability Programs at A Better City for donating their time and resources to support the Municipal Vulnerability Preparedness Stakeholder Workshop in March 2018.

The 2019 report was researched, compiled, and written by Alicia Hunt, Director of Office of Energy & Environment, and the following graduate student interns from Tufts University: Ryan Bailey, Amanda Formica, Darya Mattes, Carolyn Meklenburg, and Ivy Mlsna.

Consultants from Linnean Solutions provided facilitation support for the June 2018 community meeting, as well as for the writing and formatting of the 2019 report.

Thank you to members of the Medford community for their support and input during this process, particularly Bryan Hamlin and Henry Milorin, who offered their stories to be included in this document.

Updates

HOW THE 2019 MEDFORD CLIMATE CHANGE VULNERABILITY ASSESSMENT (CCVA) WAS UPDATED:

The 2025 update to the City of Medford's Climate Change Vulnerability Assessment (CCVA) incorporates significant updates in climate data, modeling techniques, and assessment frameworks. The updated CCVA integrates new inland and coastal flood modeling, updated heat and precipitation projections, and a revised methodology that includes sensitivity and adaptive capacity in addition to exposure. The updated assessment uses the latest data from the MA Climate and Hydrologic Risk Project, the Massachusetts Coast Flood Risk Model (MC-FRM), the 2022 Climate Resilience Design Standards Tool and Guidance, and the 2022 Massachusetts Climate Change Assessment.

The planning horizons have been revised from 2030 and 2070 to 2050 and 2070 to better reflect near- and long-term infrastructure planning needs. The updated CCVA also adopts the high-emissions RCP 8.5 scenario, consistent with State guidance, to represent the upper bound of future climate risk.

The vulnerability assessment framework has been expanded to include a more comprehensive evaluation of assets, incorporating exposure, sensitivity, and adaptive capacity. This allows for a more realistic and actionable understanding of how climate hazards may impact infrastructure, natural systems, and vulnerable populations.

KEY DATA UPDATES:

The updated CCVA includes new data and findings across several climate hazards and asset categories:



Inland Flooding: Updated flood risk maps based on modeling by Kleinfelder[1] to identify assets at risk of flooding under future precipitation scenarios.



Heat: Updated projections for 2050 and 2070 include new urban heat island data from the 2024 Medford Urban Forest Vulnerability Assessment.



Sea Level Rise and Coastal Flooding: The MC-FRM provides updated projections for sea level rise, storm surge, and tidal flooding.



Social Vulnerability: Updated demographic data from the 2019–2023 American Community Survey, the 2022 CDC Social Vulnerability Index, and the Massachusetts Environmental Justice Populations dataset provide a more current view of community vulnerability.



Asset Categories: New and updated asset categories include hazardous facilities and updated infrastructure data from MassMapper and City sources.

1 Citywide Drainage Model for Medford. Prepared for the City of Medford, MA. Prepared by Kleinfelder.

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A. Citywide Stormwater Drainage Model

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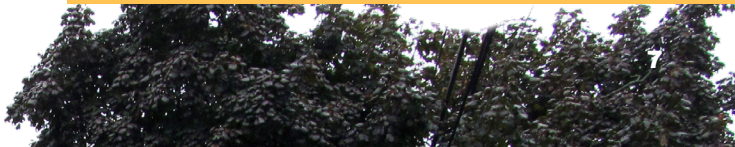
C. Vulnerability Assessment Tables

PLUS: Check out these pages!

Meet a Medford Resident: Bryan Hamlin (29)

Meet a Medford Resident: Henry Milorin (113)







“While we're working to slow the effects of climate change, we're taking actions to ensure that our community is resilient and adaptable to its impacts.”

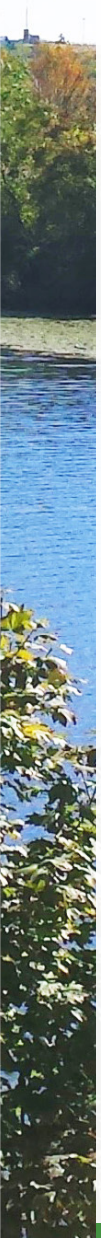
Breanna Lungo-Koehn,
Mayor of Medford

Image by Ellie Hoyt

SECTION A

Climate Change in Medford

As our climate is changing, it is important for residents and businesses to understand how these changes will impact us and our natural surroundings here in Medford. This document outlines the hazards that climate change is expected to bring to our city, and reviews Medford's strengths and vulnerabilities in relation to these hazards.



1. Purpose

Science shows us that the earth's climate is changing. Since the Industrial Revolution, the amount of greenhouse gases (GHG) in the earth's atmosphere has increased. These gases, including carbon dioxide, methane, nitrous oxide, and others, have reached levels that have not existed for at least 800,000 years.[1] Our technology, economic development, and resources needed for a growing population are putting carbon into the atmosphere and causing the changes we have seen in weather and ecosystems since the mid-20th century.

Some of these changes include warmer oceans, warmer and more variable weather, less snow and ice in the arctic, and higher sea levels.[2] How dramatic the changes will be in coming years depends on us acting now to stop adding GHGs to the atmosphere. We do know, however, that some changes are already happening and are inevitable even if we stopped all GHG emissions tomorrow. For that reason, our Medford Community needs to anticipate what changes are coming in order to know how to adapt to them.

The City of Medford completed this Climate Change Vulnerability Assessment to better understand how the changing climate will affect our city, both now and in the future, and identify vulnerabilities to our people, natural environment, built infrastructure, and economy. Throughout this assessment we adopt, where possible, the definitions for terms developed by the Intergovernmental Panel on Climate Change (IPCC) because they are internationally accepted and make it easier for readers to compare Medford with other communities. **Climate vulnerability** is, "the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes." This vulnerability is determined by how **sensitive** something is to changes in climate and its **ability to adapt** to those changes.

The extent of the changes to our climate in coming years all depends on us acting now to stop adding greenhouse gases to the atmosphere.

Definitions

Climate Vulnerability is, "the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes."

Sensitivity refers to how much a system is affected by climate change.[3]

Adaptive capacity is the ability of a system to adjust to climate change, including climate variability and extremes, to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.[4]

Join us!

How to get involved:

Medford welcomes further participation from the wider community and will include information on the Medford Go Green website (medfordenergy.org/gogreen) with details on how to get involved.

For example, the trees and plants that grow well in the Middlesex Fells may be sensitive to wetter, warmer weather and residents might need to introduce new plant varieties that can adapt and withstand these changes. An apartment complex located near the Mystic River might be sensitive to future flooding and rising temperatures because it cannot be moved, but it has a high adaptive capacity because generators can be moved to a higher floor and it can be better insulated and equipped with energy efficient air conditioners.

An in-depth understanding of our vulnerabilities as outlined here formed the basis for our City of Medford Climate Adaptation and Resiliency Plan. The adaptation plan identifies specific steps that the City, residents, businesses, and community groups will take to protect our community, to adapt to climate change, and to continue our efforts to be a carbon neutral city by 2050.

The steering committee coordinating Medford's adaptation plan included the Office of the Mayor, Medford Office of Energy and Environment, the City Engineer, and Medford Board of Health, with support from Medford Fire and Police, other city departments, and community leaders. The Office of Energy and Environment held two meetings during the creation of the 2019 version of this report to gather feedback on the report's findings: a stakeholder meeting on March 7, 2018, and a public meeting on June 13, 2018. This feedback is integrated throughout this document as appropriate.

The 2025 update of this report consists of updated methodologies and data sources.

Community members exhibiting at the Medford's Harvest Your Energy Festival.



Image by the City of Medford.



Image by the City of Medford.


Image by the City of Medford.

2. Key Findings

In this report, we identify the hazards posed by climate change that impact Medford, including specific populations and infrastructure within our city that may be the most vulnerable to these hazards.



A car attempts to drive through flooding on City Hall Mall, Medford (2017).

2.1 Hazards Caused by Climate Change

Climate change is expected to bring rising temperatures, increased precipitation intensity, and rising sea levels to Medford and the surrounding region.

Rising temperatures: We can expect more days over 90 degrees and more frequent heatwaves. Periods of extreme cold will persist during the winter season, although their intensity and frequency may decrease.

Increased precipitation intensity: Individual precipitation events are expected to bring more intense precipitation, straining our current drainage, snow removal, and flood prevention systems.

Rising sea levels: While the Amelia Earhart Dam currently separates the Mystic River from Boston Harbor, it is expected that with rising sea levels and storm surges, the dam will be overwhelmed by 2050. This will greatly increase flooding in Medford, particularly in combination with increased precipitation and resulting storm surges.

2.2 Medford's Vulnerable Infrastructure

Some infrastructure is more important than others. We have identified the following infrastructure to be critical to health, safety and quality of life here in Medford: utilities including electric, natural gas, and water; dams; emergency services; roads and public transit; schools and universities; community resources including pharmacies and affordable housing; hazardous facilities; food distribution centers; and the natural environment including trees, parks and open spaces.

The critical infrastructure listed above may be vulnerable to climate change related hazards. Inland flooding from extreme precipitation events can damage built infrastructure, limit transportation, pose human health hazards, and damage environmental resources from storm overflows. Extreme heat and prolonged storms can overwhelm energy and electricity grids, pose health risks, compromise telecommunications systems, and disrupt food distribution routes. In Medford, critical infrastructure located closest to the Mystic River, as well as in areas that already experience high surface temperatures in warm months, will see increased vulnerability in the future.

Because these hazards pose a general threat to the built and natural environments, climate change will also have an economic impact on the City. Resulting damages will lower property values and therefore reduce property tax revenue for the City, while the cost of disaster response will also increase, straining the City's financial resources.

2.3 Impacts on Medford Communities

The hazards we've discussed so far will bring more extreme heat, flooding, insect-borne diseases and stress—all of which will influence life here in Medford. While everyone in Medford will experience these impacts, some groups of people may be more impacted than others, such as: adults over 65 years old, children under 5, people with limited English proficiency, people of color, people of low and moderately-low income, people living with disabilities, and people with less than a high school education.

Some of the impacts of climate change-related hazards on Medford residents include the following.

- **Heat:** Longer heat waves can lead to illnesses such as heat exhaustion and heat stroke, and can exacerbate existing conditions such as asthma, heart disease and diabetes. Extreme heat can even cause death.
- **Flooding:** In addition to damaging personal property and causing financial strain, increased flooding can interrupt transportation throughout the City. It can also lead to chemical leaks and sewage backups, which may lead to water contamination and associated health risks.
- **Vector-borne disease:** With more flooding and increased temperatures, populations of insects that thrive in warmer, wetter weather such as ticks and mosquitoes will also increase, leading to increased incidences of diseases that are transmitted by these insects, such as Lyme disease and Eastern Equine Encephalitis (EEE).
- **Psychological impacts:** The increased uncertainty around extreme weather and the rapid changes that result may lead to increased anxiety and depression. Such degraded mental health can further degrade physical health by weakening the immune system, disrupting sleep, and interfering with healthy digestion.

The following populations in Medford may be especially vulnerable to the effects of climate change: adults over 65 years old, children under 5, people with limited English proficiency, people of color, people of low and moderately-low income, people living with disabilities, and people with less than a high school education.

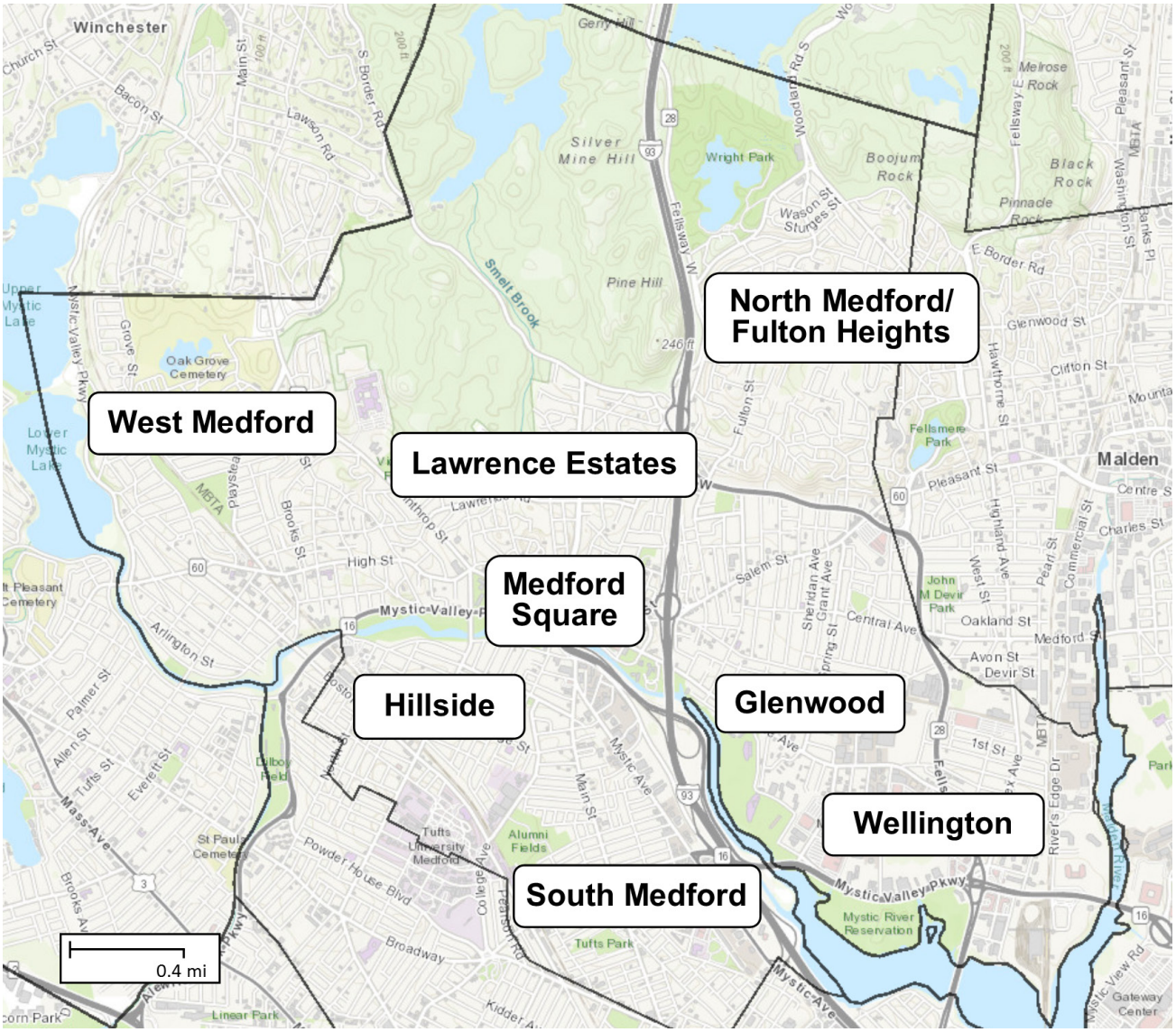
While these populations can be found throughout the City, they are highly concentrated within the neighborhoods of South Medford, Wellington, and Glenwood, which are especially vulnerable to flooding and extreme heat.



Residents explore and exhibit at Medford's Harvest Your Energy Festival.

Medford neighborhoods

Figure 1: *Map of neighborhoods in Medford. Note that in Medford, neighborhoods are not a legal classification, but are generally agreed upon by residents.*[5]



These populations already face obstacles in affording and accessing critical services—such as public transit, affordable housing, and healthcare—which will only be made worse by climate-change related hazards and their impacts. The City must improve our emergency communication strategies with these populations, particularly for those who primarily speak Haitian Kreyol, Portuguese or Spanish, which are the predominant languages spoken in Medford besides English.

3. Methods and Data Sources

Climate change doesn't stop at city limits: these impacts will be felt by our whole region. It is therefore reasonable for communities to share data, resources, and methodology when assessing our shared vulnerabilities. This report draws on information from our neighboring cities—Boston, Cambridge, and Somerville—and regional groups and organizations such as the Massachusetts Department of Transportation, the Metropolitan Area Planning Council, and the Metro Mayors Climate Preparedness Task Force.

3.1 Community Collaboration

Each city or town must identify its vulnerabilities to the changing climate, but it is also critical for neighboring communities to collaborate. Impacts such as flooding are not confined by town lines, and each assessment is stronger when communities work together.

Sharing data and best practices helps limited resources go further. Much of the data used in this report came from the cities of Boston, Cambridge, and Somerville, and the Massachusetts Department of Transportation (MassDOT) who have already developed their climate vulnerability assessments and have created or are in the process of creating adaptation plans. Other sources of data and collaboration include:

- Sea level rise and storm surge modeling conducted for the Massachusetts Department of Transportation and the City of Cambridge that includes the Mystic and Malden Rivers;
- Boston, Cambridge, and Somerville's regional inland precipitation and temperature change modeling;
- A regional mapping tool created by the Trust for Public Land in collaboration with the Metropolitan Area Planning Council (MAPC) and the Metro Mayors Coalition, of which Medford is a member (The tool enables municipalities to visualize projected temperature change and sea level rise alongside critical infrastructure and vulnerable populations, so that we can use data to inform our planning);
- The Municipal Vulnerability Preparedness (MVP) program of the Massachusetts Executive Office of Energy and Environmental Affairs (As an MVP awardee, Medford has used the funds to engage the community, strengthen our climate change preparedness planning, and update relevant data); and
- Local university funding: Tufts University, Harvard University, and Massachusetts Institute of Technology all funded student fellowships for Medford-specific research to assist in the completion of this report.

In these ways and others, this vulnerability assessment benefits tremendously from the work of neighboring communities, our region, and our Commonwealth.

A note on standardizing climate models

One challenge is that different studies of climate impacts sometimes use different assumptions about how the climate will change. Local climate scientists continue to work to standardize projections, but because of the complexity of the models, this is still a work in progress. For example, the Massachusetts Coast Flood Risk Model (MC-FRM) cited in this report derives its base scenarios from a different set of projections than much of the rest of the research referenced here. It is therefore important to consider not only projections for a particular year, which may vary somewhat between models, but also each model's assumptions about sea level rise, heat, and other factors. At this stage of the vulnerability assessment process, the models included here have valuable information to offer the City of Medford and its residents.

3.2 Emissions Scenarios

This report looks at the impact of climate change based on three scenarios:

1. **The Low Emissions Scenario**

The low scenario shows the effects of climate change if we can reduce greenhouse gas emissions significantly by 2050;

2. **The Moderate Emissions Scenario**

The moderate scenario shows the effects if we reduce greenhouse gas emissions at a slower pace; and

3. **The High Emissions Scenario**

The high scenario shows what would happen if we choose to take little action.

It is important to consider that even if we were able to stop all man-made greenhouse gas emissions tomorrow, the climate will continue to have some level of warming and sea level rise because greenhouse gases that are already in the atmosphere take up to a century to disappear. Nevertheless, reducing man-made greenhouse gas emissions can mitigate the most extreme climate hazards.

Globally, as of 2018, the most current and widely-used and reported models for **emissions scenarios**, or models projecting future greenhouse gas (GHG) emissions and increases in average global temperature come from the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report.[6] Each of the three emissions scenarios are called "representative concentration pathways," or RCPs that refer to the amount of heat that will be trapped in the earth's atmosphere with different amounts of GHG emissions. These estimates are developed using global climate models and are then scaled down for cities and regions.

The Boston Research Advisory Group (BRAG) was formed in 2015 to develop a consensus set of climate projections for the Boston region. It measured climate change hazards under three different globally accepted greenhouse gas emissions scenarios developed by climate scientists. This Assessment uses the same projections and emissions scenarios as the BRAG report.[7]

Reducing man-made greenhouse gas emissions can mitigate the impact from the most extreme climate hazards.

Definitions

RCP is an acronym for Representative Concentration Pathways, which refer to the amount of heat that will be trapped in the earth's atmosphere with different amounts of GHG emissions. RCP 2.6, RCP 4.5, and RCP 8.5 are the three different carbon emissions scenarios that this report considers.These three scenarios are defined as follows:[8]

1. The Low Emissions Scenario (RCP 2.6)

Low (RCP 2.6): We will achieve this if we decrease $C0_2$ emissions to 80% below 1990 levels by 2050 and have zero man-made greenhouse gas emissions by 2080. This is the target of the Paris Climate Conference because it keeps warming below 3.6°F (2°C) and avoids the worst consequences of global warming.

2. The Moderate Emissions Scenario (RCP 4.5)

Moderate (RCP 4.5): This is what is estimated if little action is taken to reduce man-made greenhouse gas emissions before 2050, then emissions are reduced to zero by 2100. Global temperatures increase by 3.4°-5.9°F (1.9°-3.3°C).

3. The High Emissions Scenario (RCP 8.5)

High (RCP 8.5): The highest emissions scenario represents business as usual. This is what is expected if we continue our current path and do little to reduce our greenhouse gas emissions. C02 concentrations increase by 250% by 2100 in this scenario. Global temperatures increase by 5.9°-9.9°F (3.3°-5.5°C).

These scenarios represent the uncertainty around the choices we are making globally regarding our greenhouse gas emissions today. Note that we will stay on the high (RCP 8.5) path if we continue with "business as usual," meaning if we choose to take little action to reduce man-made GHG gas emissions.


Photo from the City of Medford


Image in the public domain.

A substantial proportion of greenhouse gas emissions in Medford come from gasoline and diesel use in vehicles, as well as the heating and cooling of buildings.

Note that we will stay on the high (RCP 8.5) path if we continue with "business as usual," meaning if we choose to take little action to reduce man-made GHG gas emissions.

A note on planning horizons for Medford

This assessment looks at the climate change impacts that we will see by 2050 and 2070. These planning horizons allow us to envision both near-term and longer-term climate change hazards.

Temperature, sea level rise and storm surge, and precipitation have been modeled for our region under both the 2050 and the 2070 planning horizons and are important in Medford's decision-making. Investments in built infrastructure made today, such as for education, public safety, health, transportation, housing, and commercial real estate, will need to consider one or both planning horizons depending on the life of the investment.

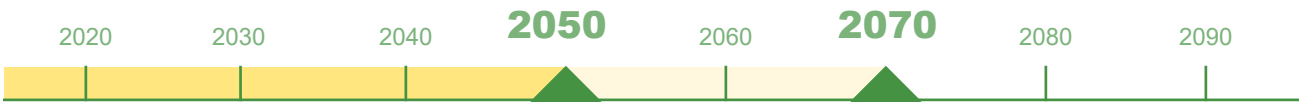
3.3 Planning Horizons

This assessment looks at the climate change impacts that we are likely to experience by 2050 and 2070. These planning horizons allow us to envision both near-term and longer-term climate change hazards.

Temperature, sea level rise and storm surge, and precipitation have been modeled for our region under both the 2050 and the 2070 planning horizons and are important in Medford's decision-making. Investments in built infrastructure made today, such as for education, public safety, health, transportation, housing, and commercial real estate, will need to consider one or both planning horizons depending on the life of the investment.

Definitions

Planning horizons are lengths of time into the future that are considered in a planning process. This report primarily focuses on two planning horizons: 2050 and 2070. In other words, this plan evaluates the climate change impacts that Medford is likely to experience by 2050 and 2070.



2050 and 2070 planning horizons.

Endnotes | Section A

1 Intergovernmental Panel on Climate Change, *Climate Change 2014: Synthesis Report, Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, ed. R.K. Pachauri and L.A. Meyer (Geneva, Switzerland: IPCC, November 1, 2014), http://www.ipcc.ch/report/ar5/syr/.

2 Intergovernmental Panel on Climate Change, *Climate Change 2014*.

3 **Note**: IPCC definition of sensitivity: "the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. Climate-related stimuli encompass all the elements of climate change, including mean climate characteristics, climate variability, and the frequency and magnitude of extremes. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea-level rise)." See footnote 4 for source.

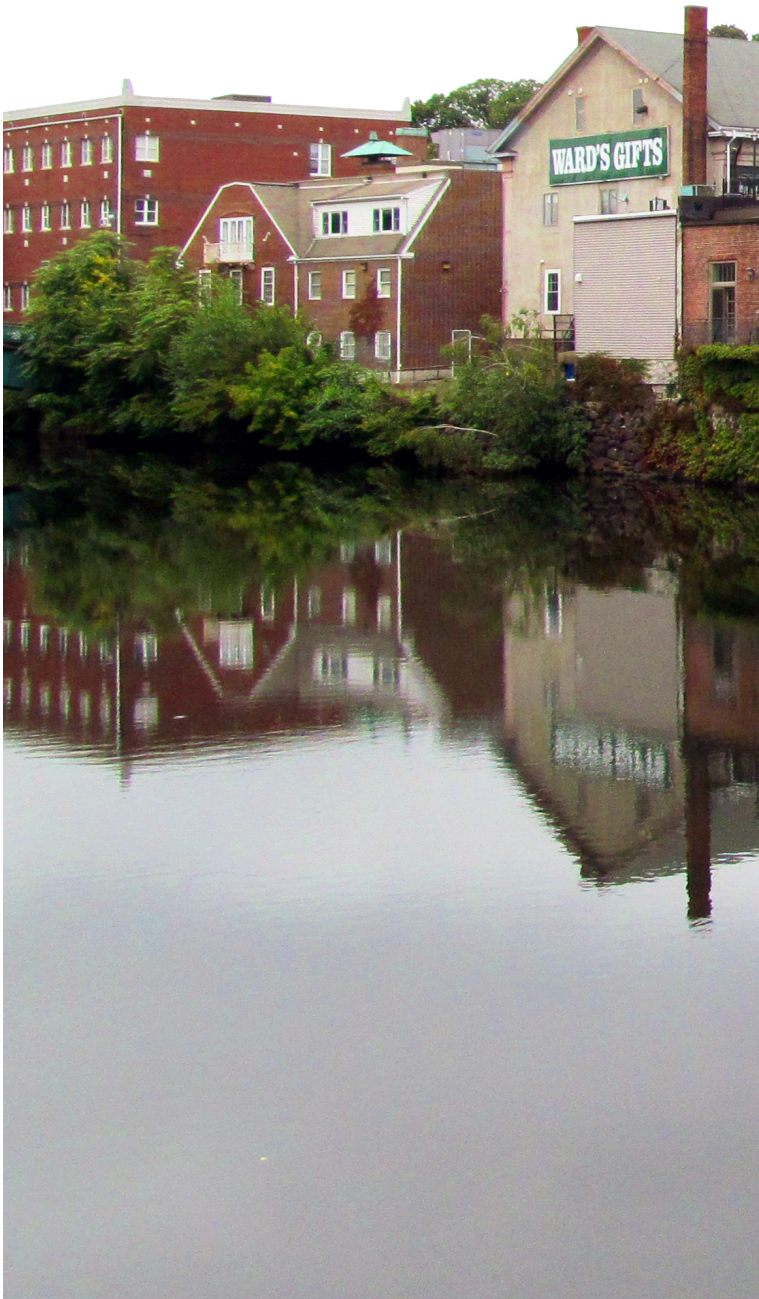
4 Intergovernmental Panel on Climate Change, *Technical Summary: Climate Change 2001: Impacts Adaptation, and Vulnerability, A Report of Working Group II of the Intergovernmental Panel on Climate Change*, ed. M. Manning and C. Nobre (Geneva, Switzerland: IPCC, 2001), https://www.ipcc.ch/ipccreports/tar/vol4/pdf/wg2ts.pdf.

5 Metropolitan Area Planning Council and the Trust for Public Land, *Climate Smart Cities Boston Metro Mayors*, accessed August 30, 2018, 2018, https://web.tplgis.org/bostonmetromayorsecure/viewer/.

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7 The Boston Research Advisory Group, *Climate Ready Boston: Climate Change and Sea Level Rise Projections for Boston* (Boston, MA: City of Boston, 2016), https://www.boston.gov/sites/default/files/document-file-12-2016/brag_report_-_final.pdf.

8 City of Boston, *Climate Projection Census* (Boston, MA: City of Boston, 2016) https://www.boston.gov/sites/default/files/03_climate_ready_boston_digital_climateprojectioncensus.pdf.





Mystic River; Image by Ellie Hoyt.

B

“Climate change is no longer some far-off problem. It is happening here. It is happening now.”

Barack Obama,
44th President of the United States



Flooding in Medford at the intersection of Princeton Street and Radcliffe Street after 1/2 inch of rainfall in fifteen minutes, August 2017.

Intersection of Princeton Street and Radcliffe Street. Image by John Gravelin

SECTION B

Climate Change Hazards

The City of Medford is likely to experience three major changes due to climate change: 1) Rising temperatures; 2) Increased precipitation intensity; and 3) Rising sea levels. These changes present risks to the community. However, the level of risk goes down when we can anticipate and adapt to these hazards. This section describes each of the hazards.

1. Rising Temperatures

Medford is already experiencing higher temperatures than what we would expect based on historical averages. Over the next decade, Medford is likely to have more and more hot days where the temperature reaches over 90 degrees, and more heat waves.[9] This hot weather is uncomfortable for everyone, and can be dangerous for children, seniors, and people with existing health conditions.

Definitions

Heat Wave: A heat wave is defined locally as a period when three or more consecutive days exceed 90 °F.

a. Increase in Average Temperatures

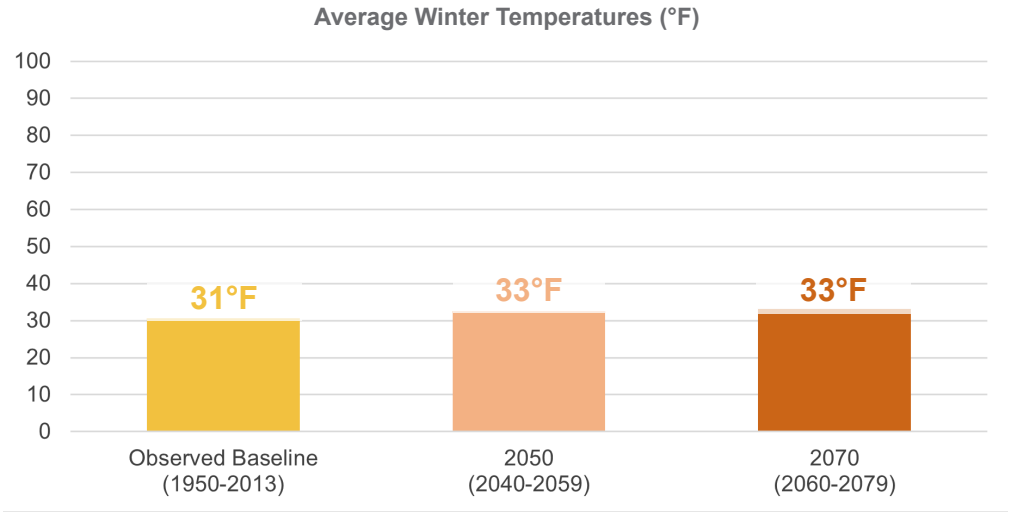
Since record keeping began in 1895, the average U.S. temperature has increased by 1.3° - 1.9°F, and the most recent decade has been the warmest one on record.[10] In Medford, annual average temperatures are projected to increase by approximately 3.8°F by 2050 and by 5.6°F by 2070, compared to the 1950–2013 baseline.[11]

Based on 2017 Massachusetts' statewide climate projections for the Boston Harbor drainage basin, the average summer temperature in our area has historically been around 69°F, but is expected to increase to 73°F by 2050, and to 75°F by 2070 (**Figure 2**). In the winter, average temperatures are predicted to increase from a baseline average of about 30°F to 32°F in 2050 and 33°F in 2070.[12] These differences may not seem very large, but small changes to average temperatures can have major impacts on climate conditions. For example, during the last ice age, average temperatures were around 10°F cooler than they are today.



Average winter and summer temperatures

Figure 2: *Projected annual average temperatures in Medford by season under the high-emissions (RCP 8.5) scenario, based on data from the ResilientMass Climate Change Projections Dashboard.[13] This reflects a change from the 2019 CCVA, which showed projected annual high temperatures.*



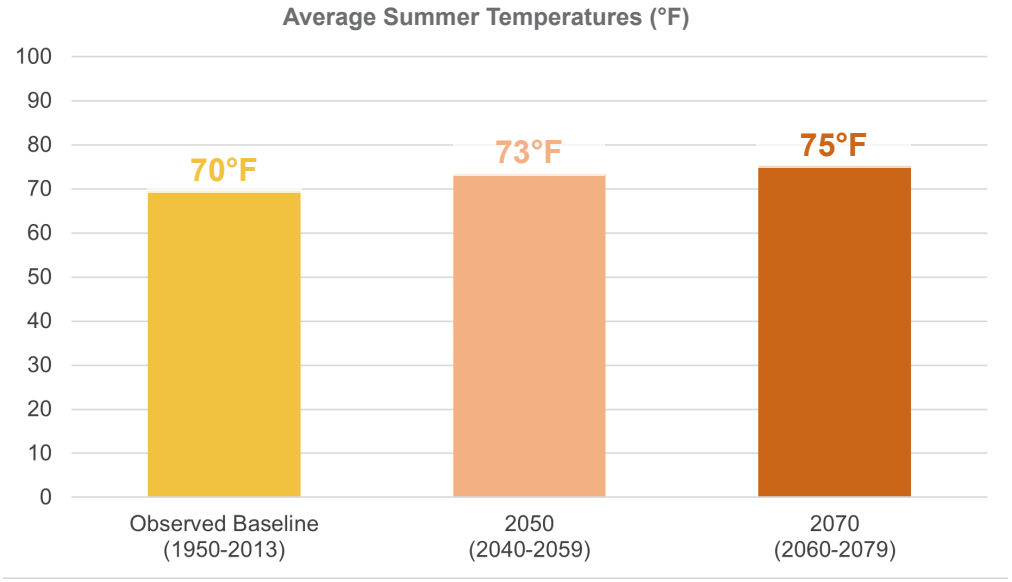


Photo from the City of Medford

A note on average annual temperatures

Average annual temperature projections offer a more complete picture of temperature changes in the region, though they can be less intuitive to interpret. In Medford, average annual temperatures are projected to increase from approximately 50.1°F (based on the 1950–2013 baseline) to about 53.0°F by 2050 and 55.2°F by 2070, under the high emissions scenario (RCP 8.5). This represents an increase of roughly 3°F to 5.1°F over the baseline. These projections reflect a future in which greenhouse gas emissions continue at a "business as usual" rate, without significant global mitigation efforts.[14]

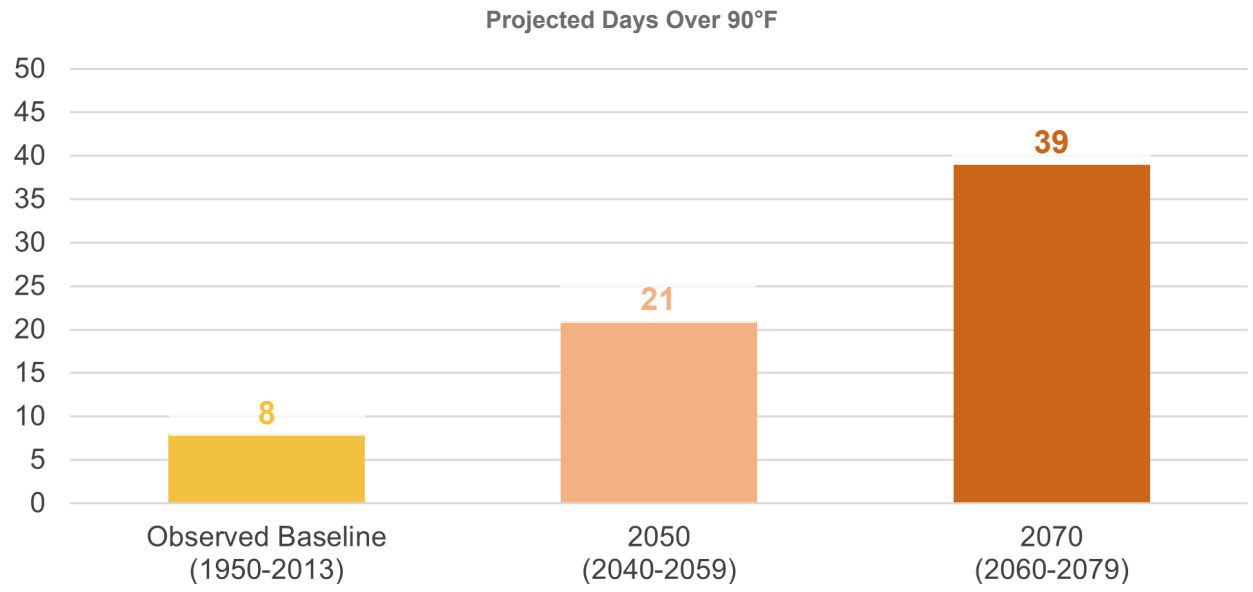
b. More days of Extreme Heat

Along with increases in temperature averages, climate change is expected to bring more days of extreme heat, which is a particular hazard in the summer months. We expect the number of days above 90°F to increase from a historical average of 8 days per year to 21 days per year in the 2050s, and 39 days per year by the 2070s, under the high emissions scenarios (**Figure 3**).[15]

These differences in temperature may not seem very large, but small changes to average temperature can have major impacts on climate conditions. For example, during the last ice age, average temperatures were around 10°F cooler than they are today!

Number of days over 90°F

Figure 3: *Projected Annual Days over 90°F under high emission (RCP 8.5) scenario in Medford. Data from the ResilientMass Climate Change Projections Dashboard.*[20]



*Please note that this information is based on the best available climate projections data developed by the Executive Office of Energy and Environmental Affairs (EEA) and adopted by the Commonwealth of Massachusetts.

Similarly, the number of days where the maximum temperature exceeds 100°F is projected to increase significantly. Historically, such extreme heat occurred less than once per year. Under the high emissions scenario, this is expected to rise to about 1 day per year by 2050 and 4 days per year by 2070. These projections highlight a substantial increase in extreme heat events, which can have serious implications for public health, infrastructure, and energy demand.[16]

Changes in extreme temperatures can also be described through the **heat index**, which is a measure of how hot it feels, taking into consideration both temperature and humidity (moisture in the air). Because the heat index considers humidity, it gives a more detailed picture of which days may be most harmful to human health.[17] Cooler days with high humidity can be just as dangerous as hotter days with low humidity. **Figure 4**, the National Weather Service chart, depicts which combinations of temperature and humidity will have a dangerous impact on human health, particularly when people are exposed to these conditions for long periods of time or during strenuous activity.

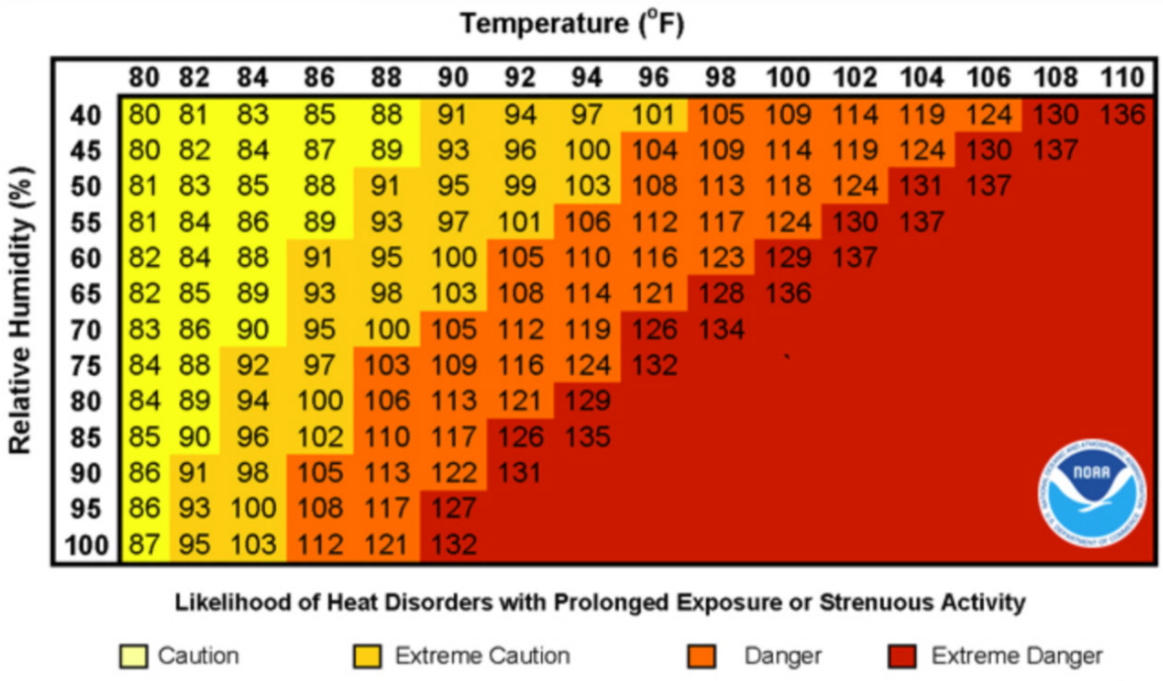
Definitions

Heat Index: A measure of how hot it feels, taking into consideration both air temperature and relative humidity (moisture in the air).

As temperatures rise, it is likely that the average **heat index** in Medford will also rise. Historically, summer temperatures averaged around 70°F, with average daytime heat indexes of 85°F.[18] With climate change, daytime heat indexes are expected to increase to 95°F by 2030, and to 100° or 110°F by 2070, under the medium and high scenarios, respectively. Based on this chart, Medford residents are unlikely to experience heat-related disorders (such as heatstroke) now, but dangerous conditions will become likely by 2070.[19]

National Weather Service Heat Index

Figure 4: *Heat Index Impact on Human Health. Data from the National Weather Service and NOAA.*[21]



c. More Heat Waves

Climate change is expected to bring more heat waves, or several days in a row above 90°F. Multiple days in a row where the weather doesn't cool off, even at night, can be dangerous to human health.

Heat waves, or long duration high temperature events, pose a unique risk to human health because as high temperatures persist, the human physiology becomes more sensitive to high temperatures. As the number of days above 90° and 100°F increase, the likelihood of heat waves increases.

The chart below (**Figure 5**) provides a graphical representation of this increased likelihood if all of the maximum temperatures for a given year occurred in the three summer months, June, July and August.

Definitions

Heat Wave: As mentioned in the introduction, a heat wave for Medford is when three or more consecutive days exceed 90°F.

Projected number of days over 90°F and 100°F

Figure 5: *Total Projected Days over 90°F and 100°F under high emissions (RCP 8.5) scenario. Data from the ResilientMass Climate Change Projections Dashboard.*[22]



*Please note that this information is based on the best available climate projections data developed by the Executive Office of Energy and Environmental Affairs (EEA) and adopted by the Commonwealth of Massachusetts.

d. Increased Surface Temperatures

These longer heat waves and higher temperatures will be exacerbated by the **urban heat island effect**.[23] In other words, urban areas like Medford do not cool off as easily as rural areas, because they have large amounts of impervious cover, such as buildings, roadways, sidewalks, and parking lots. This **impervious cover** readily absorbs and retains heat, much more so than green spaces like forests and wetlands. Approximately 39% of the land area in Medford is covered by impervious surfaces.[24]

Heat retention impacts people in a number of ways. It makes outdoor and indoor living spaces less comfortable and increases heat-related health problems like heat exhaustion and heat strokes. It also impairs the city's air and water quality and increases energy usage.[25]

A map of current average land surface temperatures in Medford indicates that the most densely populated and developed parts of the city already reach a temperature of over 100°F on the hottest days of the year. Data is gathered by satellites, so the hottest temperatures come from rooftops of large buildings surrounded by paved areas, and the coolest temperatures come from the city's forested and wetland areas. As temperatures increase over time, it is expected that residents, businesses, and critical infrastructure in the southern half of Medford will be most severely impacted by heat.

Definitions

Urban Heat Island Effect: Areas in cities that are covered by asphalt, concrete, steel, and buildings, and that have few trees and green space, retain more heat. This makes them hotter than forested and greener areas. For example, on the same 90°F day, you will be hotter in the parking lot in Wellington Circle than you will be in the forests of the Middlesex Fells Reservation.

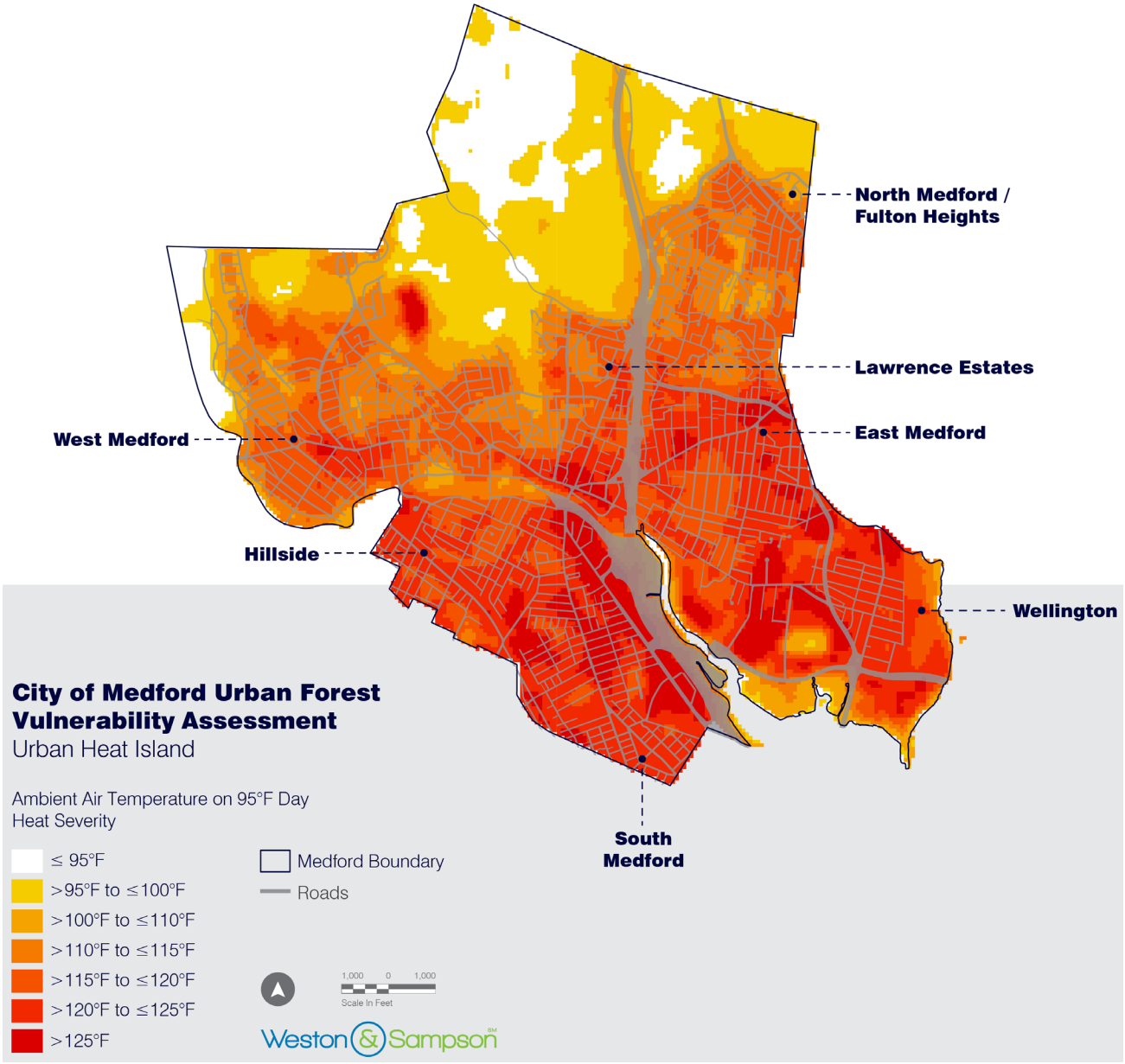
Impervious Cover: Ground surface materials that do not allow for water to pass through, like asphalt, concrete, steel buildings, streets, and parking lots, are referred to as impervious surfaces. These same surfaces retain more heat. For example, you would be more uncomfortable on a 90°F day in bare feet standing on the asphalted street than you would be if standing in your yard.



Ashalt, concrete, steel, and buildings retain more heat, which makes them hotter than vegetated areas. As temperatures increase due to climate change, the built environment will amplify the heat in certain areas in the city.

Medford heat island effect

Figure 6: *Map of Urban Heat Island (UHI) effects in Medford from the 2024 Medford Urban Forest Vulnerability Assessment* [26]



Definitions

Cold Air Outbreak: A cold air outbreak is a period of very cold winter temperatures, caused by a flow of air from one of the poles. Climate scientists are uncertain about how and if climate change affects these cold snaps; some believe they are a result of natural variations in weather, while others believe they may be increasing in frequency due to the melting of arctic sea ice and the rapid increase in air temperature in the arctic.[27]

e. Change in Number of Cold Days

In spite of this overall warming trend, **cold air outbreaks** will continue throughout the 21st century, although their intensity and frequency may decrease. Consequently, risks from frost and freeze damage will persist.

In addition, temperatures in our area have already begun to cycle between cold and warm extremes during the winter months. These fluctuations can have negative impacts on both natural features, such as trees, and infrastructure, such as roads and water pipes.

Middlesex Fells Reservation in December.



Image by Milikamp (public domain).

Meet a Medford resident thinking about climate vulnerability



Vegetation in Middlesex Fells. Image by John Gravelin.

Bryan Hamlin

Medford resident Bryan Hamlin is well-informed on the challenges facing Medford's plants, especially in the Middlesex Fells Reservation, a 3,400 acre state forest and recreation area that covers parts of Medford and neighboring towns. He is a longtime member and former chairman of the board of the Friends of the Fells, and is a former president of the New England Botanical Club. In addition, he led a recent study of the plants in the Fells, which was published in 2012. The team of researchers documented changes that have occurred since a study in the late 19th century, shortly after the Fells was established as a park in 1894.

Hamlin and his team found that there are a range of challenges that native plants have already begun to face in a warmer, probably wetter climate. Some plants, like skunk cabbage, have bloomed steadily earlier in recent years. Others, like the flowering shrub rhodora, can no longer be found in the Fells, but are still in the northern part of Massachusetts. As precipitation has increased in recent years, some areas of the Fells have become more swamp-like, benefiting some plants that were once uncommon in the Fells. "It's a mix of good news and bad news, depending on the plant," Hamlin said.

Warmer temperatures have also led to an increase of invasive pests that previously could not have survived in Medford's cooler climate. The woolly adelgid, an insect that is native to Asia and that feeds on the sap of hemlock trees, entered the United States in the 1950s and decimated hemlock populations in Virginia. In recent decades, it has moved north as temperatures increased, and has now killed or is killing most hemlock trees in the Fells, where eastern hemlocks have been an important component.

Hamlin also described a climate impact that Medford experienced very recently: trees are threatened by storms such as nor'easters, which will become more powerful as a result of climate change. In March of 2018, a series of four nor'easters brought down huge numbers of trees throughout the Fells, including many that had been standing for over a century. "It is tragic to walk through the Middlesex Fells and to see the many hundreds of trees that have been brought down," Hamlin said.



Image from Bryan Hamlin

Bryan Hamlin

Warmer temperatures have also led to an increase of invasive pests that previously could not have survived in Medford's cooler climate.

Part of this profile comes from the article "To understand climate change, look no further than Medford's trees" by Miranda Wilson, published on 2/21/18 in the Medford Transcript.

Changes in heavy precipitation

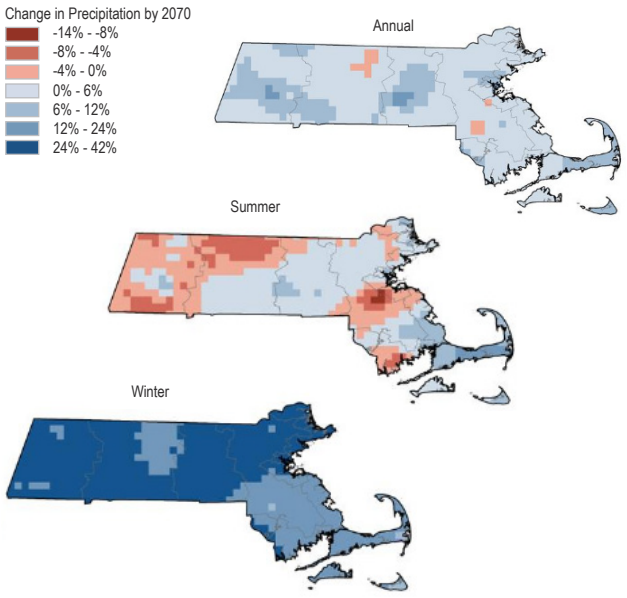


Figure 7: *Change in annual, summer, and winter season precipitation in 2070 compared to current climate. Source: 2023 ResilientMass Plan*[34]

2. Increased Precipitation Intensity

Climate change in Medford will lead to more annual precipitation overall, in the form of both rain and snow. While this change may not be very noticeable, the intensity of this precipitation will also increase, which presents a larger concern. Heavy storms will bring larger amounts of rain and snow, overwhelming our systems for drainage, snow removal, and flood mitigation on a more frequent basis.

As **Figure 7** shows, precipitation intensity, or the amount of rain or snow that falls on the days with the greatest precipitation, has already begun to increase across the country, with the greatest increases occurring in the Northeast.[28]

Precipitation intensity has increased by 70% from 1958 to 2010 in the Northeast.[29] With warmer temperatures leading to higher evaporation events and higher moisture levels in the air, the intensity of precipitation is expected to continue to increase. Increases in precipitation intensity will strain the capacity of our rivers and stormwater systems to move this water out of our city, increasing the likelihood of inland and riverine flooding.

In Medford, the 10-year, 24-hour storm is projected to increase from approximately 5.2 inches historically to around 6.5 inches by 2050 and around 7.0 inches by 2070, reflecting more than a one-third increase in



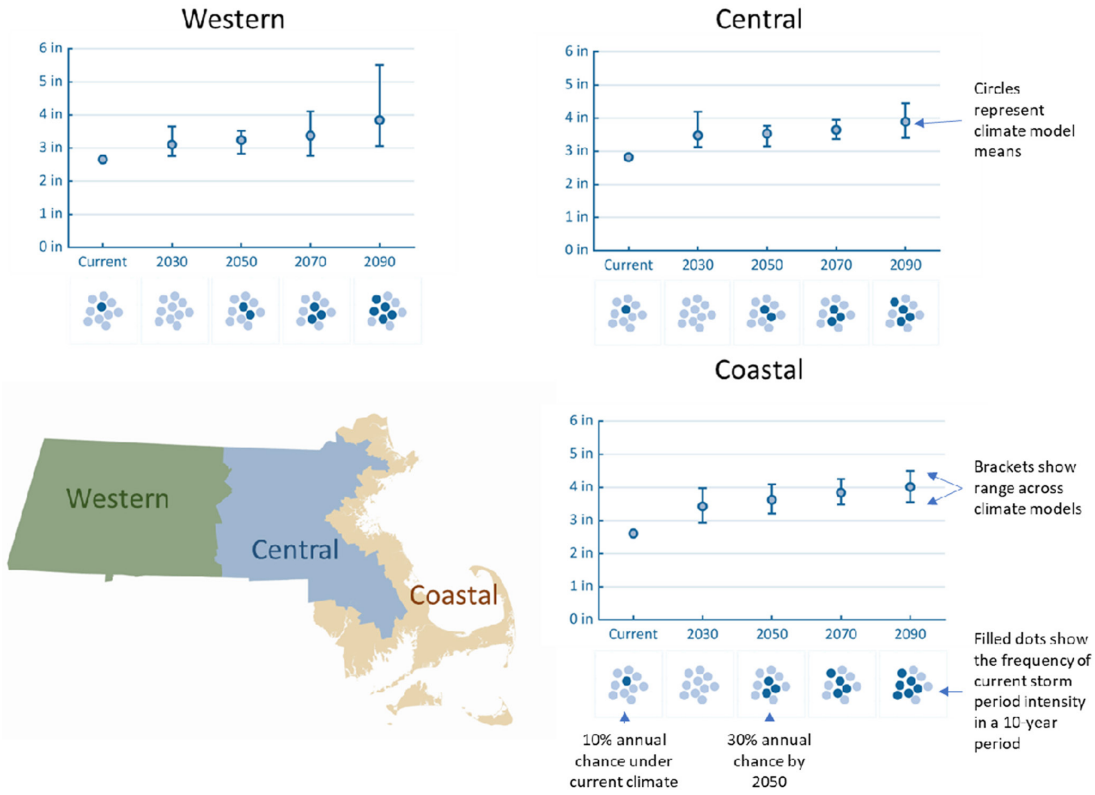
Flooding on City Hall Mall, Medford (August 2017).

Why we're concerned about heavy precipitation:

Heavy storms will bring larger amounts of rain and snow, overwhelming our systems for drainage, snow removal, and flood prevention on a more frequent basis.

Increasing size of major storms

Figure 8: *Changes in how strong and how often 10-year rainstorms are expected to be. Data from the 2022 MA Climate Assessment* [38]



depth under high emissions scenarios by 2070.[30] Unlike temperatures, there is not a major difference between the medium and high emissions scenarios.

While winter and spring precipitation is projected to increase, the average winter snow depth is likely to decrease by 31-48% by 2100. Despite this reduction in average snow depth, heavy snowfall events will still be possible throughout the 21st century.[31]

The factors that influence which areas will flood during intense precipitation events are varied and complex. They include elevation, the proportion of impervious surfaces, the effectiveness of storm drains, and the proximity to water bodies that may be prone to flooding. The City of Medford has undergone a comprehensive study of the City's storm drain system; see **Appendix A** for the technical memorandum from Kleinfelder.[32]

Another useful resource, however, is past experience. Areas that have flooded during precipitation events in the past are likely to continue to do so in the future, with greater frequency as intense storms become more common.

Definitions

10-year storm: A storm that produces a certain amount of precipitation within 24 hours that has a 10% chance of occurring in any given year. For example, a 10-year storm in Medford is **currently** defined as one in which we see about 5.2 inches of rain in a 24-hour period.[35]

100-year storm: A "100-year" storm has a 1% chance of occurring in any given year; in Medford, the **current** 100-year storm drops about 8.2 inches of rain in a 24-hour period.[36]

Terms like "100-year storm" and "10-year storm" can be misleading. Referring to a large precipitation event as an "100-year storm" does not mean that a storm like it will happen only once every 100 years. In fact, a region may experience several "100-year" rain events within just a few years.[37]

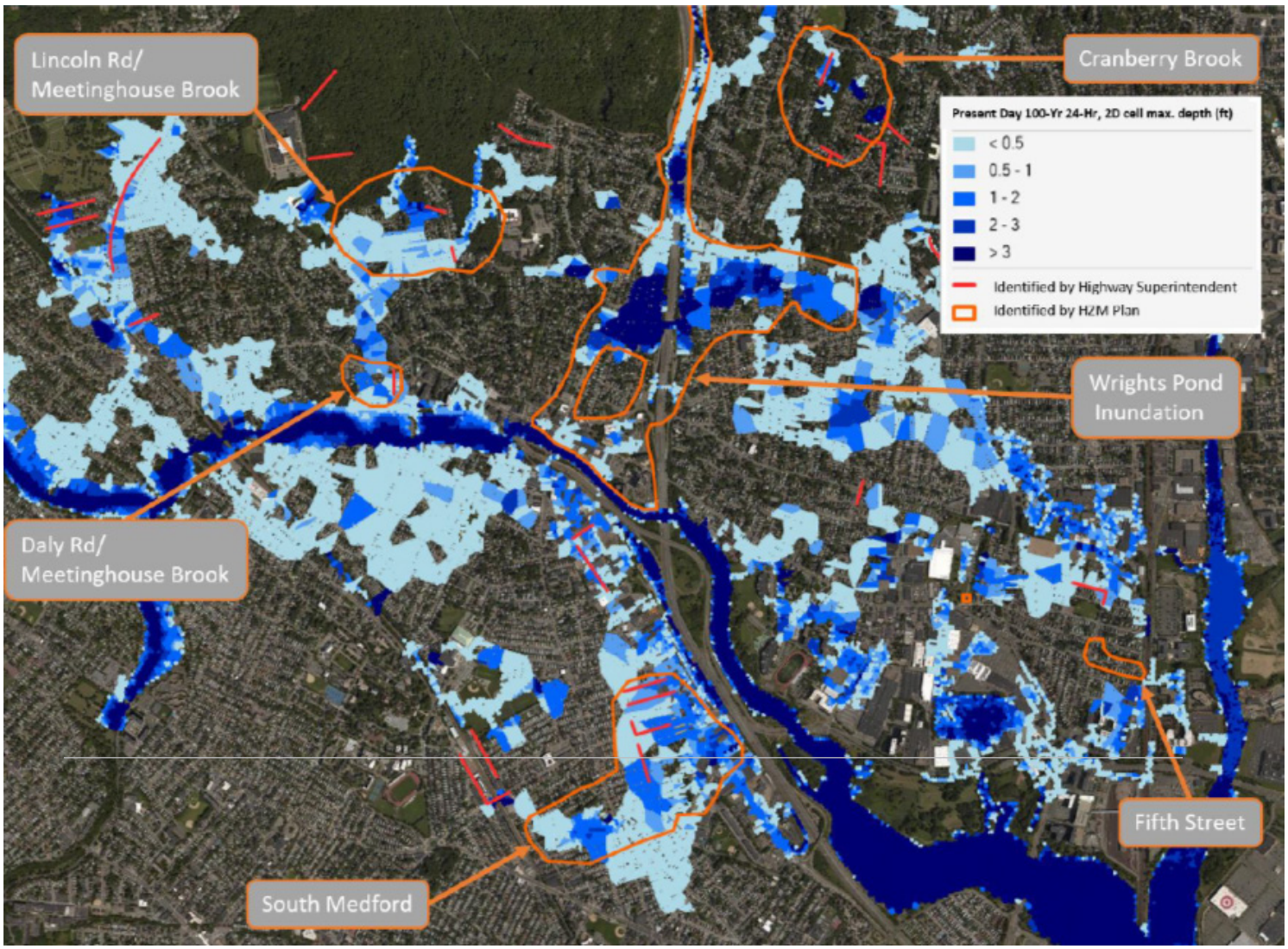
From Vulnerabilities to Adaptations!

When Medford experienced intense flooding from a storm in 2010, the City took action and analyzed its flood-control infrastructure. Appropriate modifications were made to the Wright's Pond Dam to significantly reduce the likelihood of dam failure or overtopping.

Figure 9 is a map from the aforementioned precipitation modeling study (**Appendix A**), including information from Medford's 2013 *Hazard Mitigation Plan*[33] and institutional knowledge from the City's Highway Superintendent, that shows areas that are currently prone to flooding as a result of a 100-year, 24-hour storm, as well as the area that would be inundated if the Wright's Pond Dam were to overtop or fail. These areas will continue to be vulnerable as precipitation increases over the course of this century.

Areas prone to flooding in Medford

Figure 9: *Currently Flood-Prone Areas in Medford as of March, 2017. Data from City of Medford Engineering Department.*[39]



3. Rising Sea Levels

Medford is not on the coast, so it's easy to assume we won't be affected by rising sea levels. However, the Mystic River and Malden Rivers were originally tidal, with saltwater coming all the way up to the lower Mystic Lakes. This changed when the Amelia Earhart Dam was built in 1966 to separate the river from the ocean. As sea levels rise, the dam is likely to be flanked and overtopped, which can cause coastal floodwaters to enter the Mystic-. More intense storms, with more precipitation, will also cause storm surges that will make the sea level even higher during storms, increasing the risk of flooding.

From 1921 to 2015, **relative sea levels** have risen on average of 0.11 inches per year. Sea levels will continue to rise regardless of which emissions scenario we follow, due to the persistent nature of greenhouse gas emissions, regional effects of ice sheet melting, and ocean dynamics.

Definitions

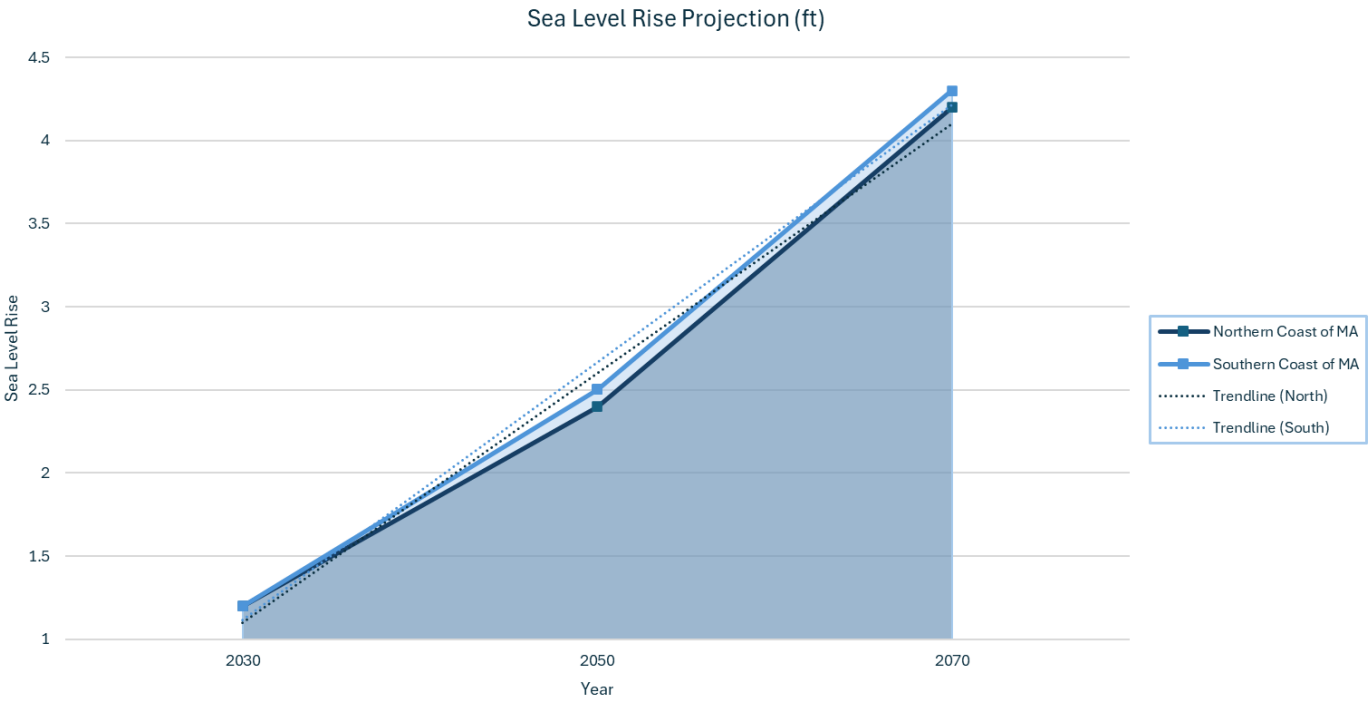
Relative Sea Level Rise: Relative sea level rise (RSLR) includes the increase in sea level due to climate change and the decrease in land level that occurs due to land subsidence.

The *2023 ResilientMass Plan* projects that relative sea levels will increase 28.8 (two feet) inches by 2050 and 50.4 inches (four feet) by 2070.[40]

The Amelia Earhart Dam (**Figure 11**), spanning the Mystic River just downstream of Medford, between Everett and Somerville, protects the City of Medford from sea level rise under these scenarios.[41]

Sea level rise projections for the Boston area

Figure 10: *Sea level rise projections for the Boston area. Data from the 2023 ResilientMass State Hazard Mitigation Plan.*[45]



According to current estimates, projected relative sea level rise alone will not overtop the Amelia Earhart Dam until close to 2100; however, this does not consider increased frequency and intensity of major storms (such as tropical storms and nor'easters) and precipitation. These, in turn, will lead to storm surge, the increase in sea level that occurs during a storm.[42]

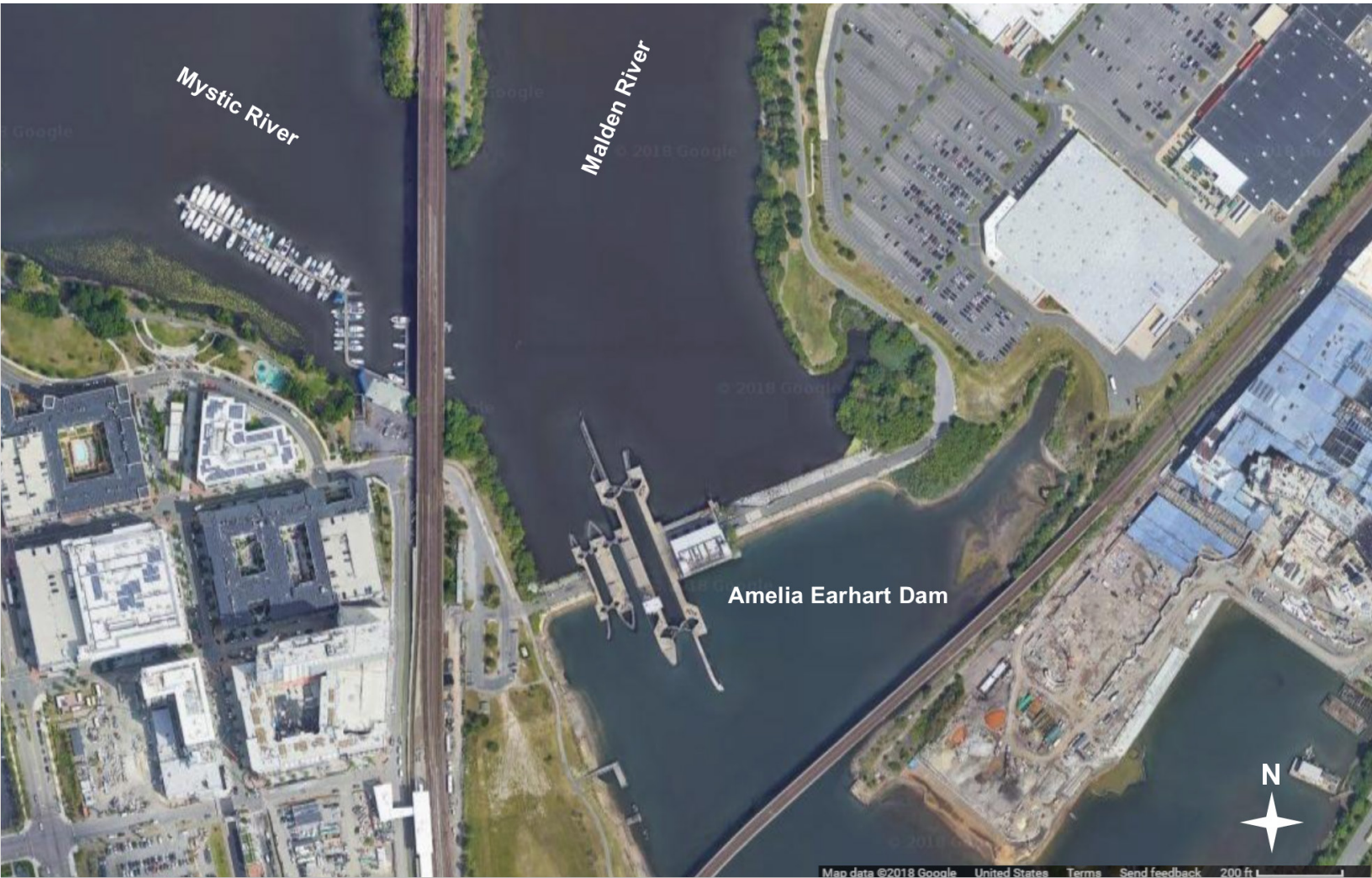
Figure 13 shows areas with a high likelihood of coastal flooding from a 100-year storm in 2050, while **Figure 14** illustrates how that risk expands further inland by 2070 due to rising sea levels and more intense storm surge**.** However, by 2050, storm surge and precipitation from a 100-year storm in combination with sea level rise is likely to overtop the dam, leading to flooding throughout a large part of Medford. Areas vulnerable to



The Mystic River and Medford Pipe Bridge in Medford, viewed from the Cradock Bridge.

Amelia Earhart Dam

Figure 11: *Aerial view of the Amelia Earhart dam, with Medford to the north, Everett to the east, and Somerville to the west.*[46]



flooding in 2070 from storm surge and from sea level rise are predicted to be the same. Increased intensity of each 100-year storm, in combination with sea level rise, is another contributing factor to increased flood vulnerability.

Both major storm surges and precipitation events large enough to overwhelm the current capacity of the dam pumps are expected to increase in frequency and intensity. Coupled with sea level rise, under the moderate and high emissions scenarios, there will be occasional but regular flooding from overtopping and precipitation by 2050.[43] Due to these changes, even less violent storms will cause significant coastal flooding in the future.[44]

The effects of climate change on the frequency of storms is still unknown, but local studies indicate that more hurricanes, tropical storms, and nor'easters will impact Medford as climate patterns change.

In addition, sea level rise and increased rainfall are likely to build on each other to create an even greater flood risk. If the baseline sea level is higher and a significant rainfall event occurs, flooding becomes that much more likely.

Definitions

Storm surge: Storm surge is the increase in sea level rise that occurs during a storm above typical tide levels.

Tropical storms: Tropical storms, also called tropical cyclones, are rotating storms that originate in tropical waters.

Hurricanes: Hurricanes are a type of tropical storm with very high winds. They are rated on a scale of 1-5 based on sustained wind speeds. Category 4 and 5 hurricanes both cause catastrophic damage to homes, buildings, and power lines, with wind speeds over 130 miles per hour.

Nor'easters: Nor'easters are much like tropical storms, but they form off of the east coast of the United States and tend to become very intense in the New England region. Their name derives from the fact that their winds blow toward the northeast.

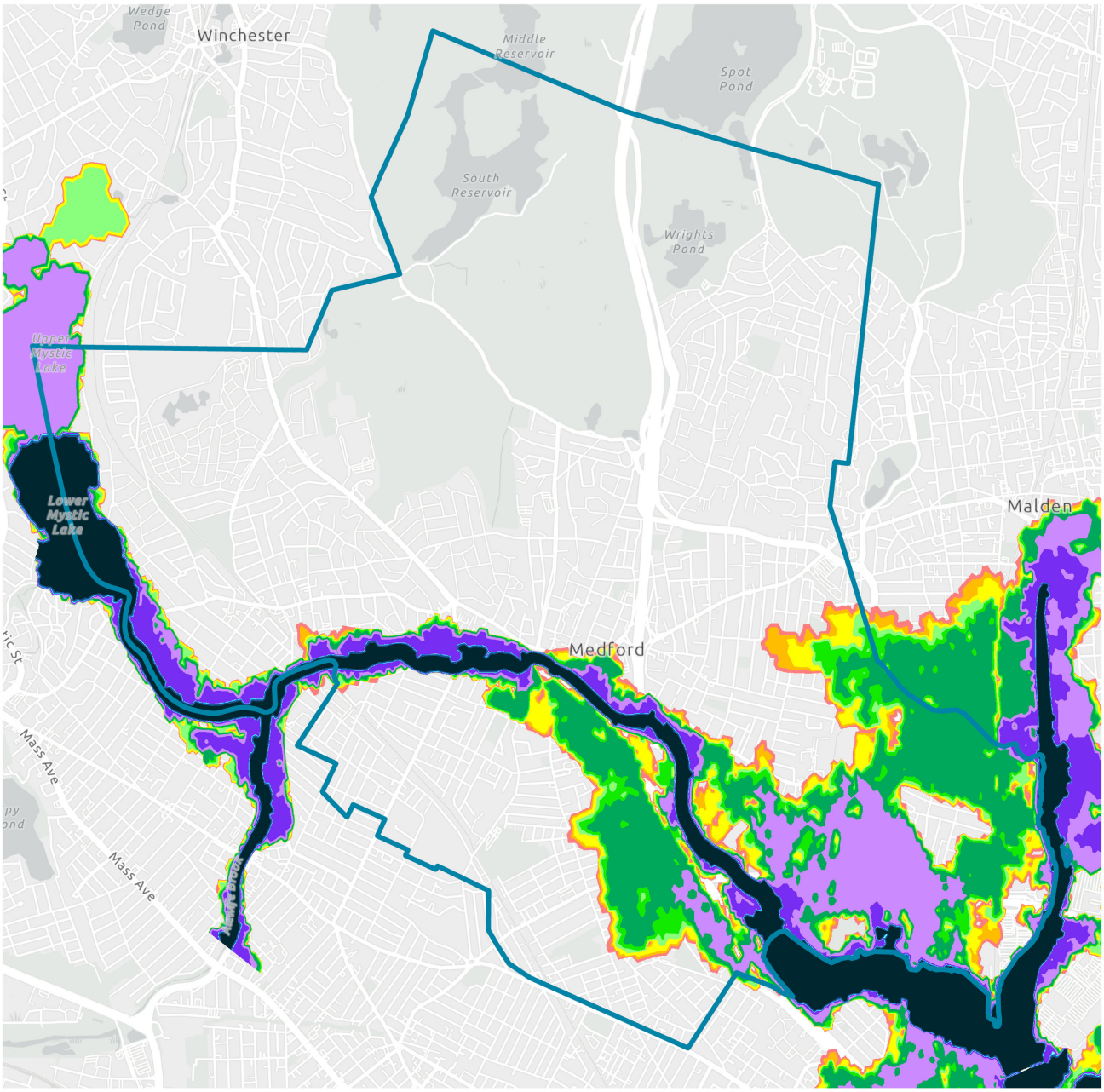
Sea level rise and storm intensity projections

Figure 12: Sea level rise and the intensity of 10-year storms in MA. Data from the 2023 ResilientMass State Hazard Mitigation Plan and NOAA Atlas 14.[47]

Likely Years of Initial Occurrence	Projected Sea Level Rise	10-Year 24-Hour Rainfall Depth
2050 (2040-2059)	28.8 inches	6.5 inches
2070 (2060-2079)	50.4 inches	7.0 inches

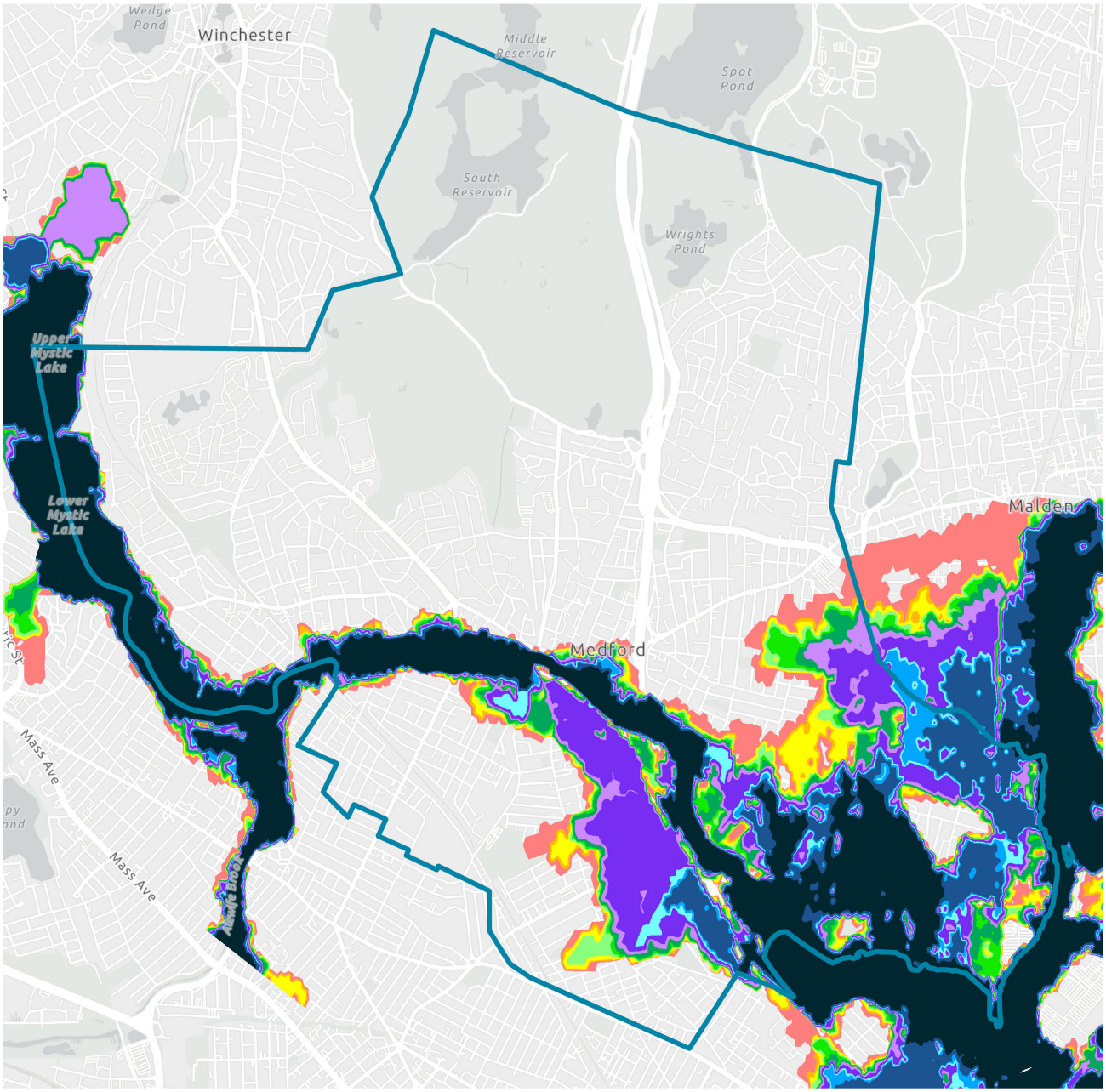
2050 Flood Zones

Figure 13: *This map shows areas at risk of coastal flooding in 2050, based on detailed modeling that includes sea level rise, tides, storm surge, and wave action. The MC-FRM simulates several historical and hypothetical storms, and considers both present and future climate scenarios, which generates probabilistic flood risks across the City.*[48]



2070 Flood Zones

Figure 14: *This map shows areas at risk of coastal flooding in 2070, based on detailed modeling that includes sea level rise, tides, storm surge, and wave action. The MC-FRM simulates several historical and hypothetical storms, and considers both present and future climate scenarios, which generates probabilistic flood risks across the City.*[49]



4. What about storms?

Since the climatology of large storms is quite complex, there is not yet definitive science linking this increase in storms with climate change. According to the 2014 National Climate Assessment—compiled by over 300 experts and leaders of relevant federal agencies—evidence suggests that winter storms have "increased slightly in frequency and intensity, and that their tracks have shifted northward over the U.S."[50] There is not as much evidence, however, that demonstrates an increase in "the intensity and frequency of tornadoes, hail, and damaging thunderstorm winds"[51] including nor'easters.

While scientists have noted an increase in frequency and intensity of North Atlantic hurricanes since the 1980's, they have not yet definitively determined if this increase is directly related to climate change.[52] It is important to differentiate between an increase in the number of storms and the increase in precipitation that is discussed earlier in this section. Science demonstrates that we can expect more precipitation to fall in single weather events. However, the question remains as to whether we can expect to see more extreme storms overall as a direct result of climate change.

Regardless of whether increasing storms are directly related to climate change or not, it is important for the City to consider their impacts in discussions of vulnerabilities in Medford.



Image by Ellie Hoyt.

Storm on Traincroft Street, Medford (Winter, 2016).



Endnotes | Section B

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“There is a new participant in this conversation: Mother Nature. Climate-related events are having a pretty massive impact.”

Al Gore,
45th Vice President of the United States
Quoted at Tufts University, February 2018

Shoveling snow in February of 2015 when Medford received a series of large snowstorms.

Image by City of Medford.

SECTION C

Vulnerability Assessment

This section considers how the climate hazards covered in Section B will impact Medford's, infrastructure, people, and economy. We also identify groups of people in our community that may experience enhanced vulnerability when exposed to climate hazards.

Climate Vulnerability

Now that we have discussed the hazards, we will consider how they will impact Medford's infrastructure, people, and economy, the consequences of this impact, and how particular groups may be more vulnerable to climate hazards. Many groups and entities in Medford have existing social, economic, and physical vulnerabilities that are likely to be exacerbated with climate hazards.

Many groups and entities in Medford have existing social, economic, and physical vulnerabilities that will be exacerbated with climate hazards.



Image by MassDOT.


Image by City of Medford.



Image by Ellie Hoyt.

Left: Green Line Extension phase one construction. Middle: Medford community members at the Harvest Your Energy Festival. Right: Shops in West Medford Square.

1. Climate Change Impacts on Critical Infrastructure

Much of Medford's critical infrastructure is vulnerable to future effects of climate change from sea level rise, storm surges, increased precipitation, and more intense heat.

In this assessment, we are considering the following infrastructure to be critical for the health, safety, and quality of life for Medford residents and businesses:

- **Utilities including electric, natural gas and water**
- **Dams**
- **Emergency services**
- **Roads and public transit**
- **Schools and universities**
- **Food distribution centers**
- **Natural environment, including Medford's tree canopy, parks, and open spaces.**
- **Community Resources**
- **Hazardous Facilities**

Community stakeholders and members of the public expressed particular concern about the negative effects of flooding and heat on Medford's infrastructure:

- Inland flooding from extreme precipitation events can damage the built infrastructure, limit transportation, pose human health hazards, and damage environmental resources from storm overflows;
- Extreme heat and prolonged storms can overwhelm energy and electricity grids, pose health risks, compromise telecommunications systems, and disrupt food distribution routes.[53]

In Medford, the critical infrastructure located closest to the Mystic River and other flood-prone areas, as well as in areas that already experience high surface temperatures in warm months, will see increased vulnerability in the future.



A Commuter Rail train passes south of the Harvard Street Bridge, Medford.

From Vulnerabilities to Adaptations!

It is important to note that while the Mystic River and other bodies of water in and around Medford pose a flood risk, they can also help to reduce the urban heat island effect by cooling the surrounding area. In this sense, some features in Medford can serve as both vulnerabilities and assets, which is important to consider as we begin to think about adaptation strategies.

a. Utilities: Electricity

During heat waves, more people turn on their air conditioning which puts a strain on the regional electrical grid. This might cause more power outages, which then put more people at risk of heat-related illnesses. More extreme storms may also cause more power outages by damaging the electrical grid, although the City and National Grid have been working together to protect Medford's power lines.

Extreme heat will increase electricity demand and reduce the performance of some electrical infrastructure, potentially causing outages and infrastructural damage. As temperatures increase, more air conditioning units turn on, increasing demand on the generation, transmission, and distribution systems. Outages also exacerbate the human health effects of heat since they prohibit the use of air conditioning or fans.

Most electricity consumed in the city is produced outside of Medford. As of 2017, Medford residents relied on a combination of electricity (10%), natural gas (52%) and oil (38%) for residential and commercial heating.

b. Utilities: Natural Gas

National Grid—who also supplies Medford with natural gas in addition to electricity—is in process of replacing Medford's aging gas lines, reducing the chances of gas leaks and any further damage brought by climate change-related hazards.

National Grid also serves as the natural gas supplier for Medford. The City is aware that there are a high number of natural gas leaks within city limits, indicating infrastructure that may be older and weaker and therefore more susceptible to damage from climate change-related hazards. National Grid has been actively working to replace the aging gas lines in Medford with newer, plastic pipes, working in 2-3 neighborhoods each year and hopefully reducing this vulnerability.

From Vulnerabilities to Adaptations!

While historically the electricity grid in Medford has been very vulnerable to power outages, in recent years, work by the City and the local utility, National Grid, has noticeably improved the resiliency of the power grid. In addition to infrastructure work done internally by National Grid, there has been a concerted effort to reduce the vulnerability of power lines from trees and storm damage. In particular, the Medford Tree Warden has worked with the utility on selective pruning of trees where branches were at risk of falling on power lines. The Tree Warden has given particular attention to locations of trees and their mature height with regards to power lines when planting new trees.



Utility pole installation along Harvard Street, Medford.

In addition to local distribution, there is an Algonquin Gas natural gas transmission pipeline that runs through Medford along the Mystic River, and an Eversource electricity high voltage transmission line that runs underground from Winchester, down Winthrop Street, under the Mystic River and down Rt. 38 into Somerville. The City has not identified any climate related vulnerabilities to these transmission lines.

c. Utilities: Drinking Water and Sanitary Sewer

The Massachusetts Water Resource Authority (MWRA) provides Medford with drinking water from the Quabbin Reservoir. This reservoir is so large that there is very little risk of a drought for Medford's drinking water even in the face of extreme heat.

Medford's sanitary sewer services are also provided by MWRA. The MWRA is a leader in the state in climate resilience. As of 2015, they were designing new infrastructure and renovations with the anticipation of 2.5' of sea level rise and to withstand 100-year floods. They anticipate renovating each of their pump stations and facilities every 15-20 years; therefore they design to a 20-year climate change horizon.

While the MWRA assisted in the creation of a state-wide drought management plan, water-use restrictions would only be implemented in MWRA's service area in the case of "a long-term drought more severe than the 1960's drought of record" because of the sheer size of the Quabbin Reservoir.[54] Thus, there is little risk of drought for Medford's drinking water.

d. Utilities: Stormwater

While many residents have expressed concerns about Medford's aging stormwater system, new EPA regulations will dictate that stormwater is managed better so that less water will enter the City's drainage systems.



View of the Quabbin Reservoir in Ware, MA.

The quality of Medford's stormwater system was a concern for residents at the Medford Community Resilience Building Workshop. One concern raised during the workshop was related to the age and current capacity of Medford's system. Medford has begun requiring new construction of any size to attempt to provide infiltration for the first one inch of rain, in compliance with EPA regulations.[55]

In the future, greater on-site retention may be needed for stormwater prior to entering the storm drain system. Participants were also concerned with citizen adherence to regulations, the need for overall system upgrades, pump station and outfall vulnerability, and a need to prioritize upgrade and stormwater retention needs. Medford has engaged Kleinfelder to do an analysis of the storm drain system and its functionality under future storm scenarios. See **Appendix A** for the complete technical memorandum.

e. Dams

Dams serve as critical infrastructure for Medford since their failure would result in significant damage within the city. There are three dams with the potential to cause such damage if they were to fail: the Mystic

Lakes dam, the Wright's Pond Dam and the Amelia Earhart Dam.

The management and long-term maintenance needs of the dams in and near Medford were a topic of concern for participants at the Medford Community Resilience Building Workshop.

The Amelia Earhart Dam is located on the Mystic River between Everett and Somerville, and is managed by the Massachusetts Department of Conservation and Recreation. It prevents salt water and tides from reaching Medford, and controls the level of the water in the main stem of the Mystic River. As is mentioned in Section B: *3. Rising Sea Levels* (page 33) of this report, there is an expectation that a combination of sea level rise and storm surges will result in salt water flows around and over the dam as early as 2035. Heavy precipitation on January 4 and March 2, 2018 combined with high tide put water levels at within 2.5 feet of overtopping, making it the highest level recorded since the Blizzard of 1978.[56] The Wellington and Medford Square neighborhoods would be among the first to experience flooding in the event of the Amelia Earhart Dam being breached.

There is also significant concern about the functioning of the pumps at the dam. The pumps serve to discharge water out of the Mystic River when the water level in Boston Harbor is too high for the water to flow from the Mystic through the dam's lock system and into the Harbor. The dam was built with space for four pumps, but only three have been installed. Three pumps have been adequate thus far, but sea level rise, storm surges, and increased precipitation may require the installation of the fourth pump. This is particularly critical for Medford since any inadequacies in this pump system leaves the City vulnerable to more flooding: Medford's stormdrain system drains primarily into the Mystic River, so the inability for water to pass through the locks and into the Harbor would prohibit proper drainage.

The Mystic Lakes Dam separates the Upper and Lower Mystic Lakes and is managed by the MA Department of Conservation and Recreation. Currently, there are no concerns about it failing under future storm scenarios.

Medford's other dam, the Wright's Pond Dam, is managed by the City, and is not currently in danger of breaching in the near future as a result of any identified climate change-related hazards. Water from Wright's Pond routinely flows out through a spillway and into a 48" culvert where it enters Medford's stormdrain system and flows out to the Mystic River. The City has operational guidelines to follow to reduce downstream flooding, resulting from precipitation and overflow from Wright's Pond.

f. Emergency Services

Emergency services include fire and police stations, hospitals, and ambulatory facilities. Some facilities may be vulnerable to flooding due to sea level rise, while others may be vulnerable to precipitation-related flooding.

The Fire Headquarters on Main Street, Medford's municipal police station on Main Street, and the State Police office on the Fellsway, are located in areas that are expected to flood under 2070 storm surge scenarios. Medford's four other fire stations and Lawrence Memorial Hospital lie outside of projected 2070 storm surge flood areas, but could be vulnerable to increased precipitation events.



Image by EMW (public domain).

Engine Five fire truck at the Medford Fire Department firehouse on Medford Street, Medford.

g. Transportation: Roads & Public Transit

Both extreme heat and flooding may negatively impact Medford's roads and railway infrastructure, preventing people from driving and using public transportation, as well as increasing maintenance costs.

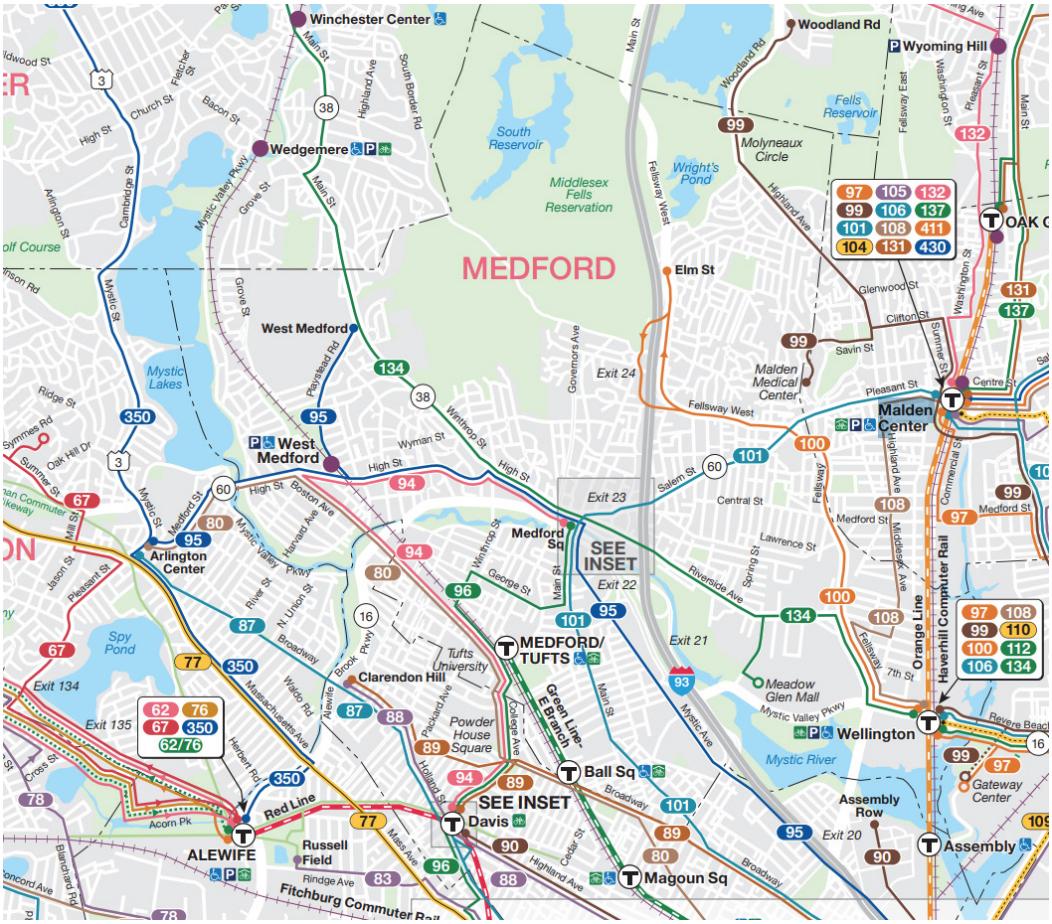
The public transportation system in the City of Medford is owned and managed by a state agency, the Massachusetts Bay Transportation Authority (MBTA). According to U.S. Census data, over 23% of Medford residents rely on public transit, walking, and bicycles to commute.[57] Others rely on public transit indirectly, as a means of transportation for people who provide important services in Medford. The City of Medford is in touch with the MBTA to understand what hazards are most likely to cause service disruption in Medford.

Increased temperatures can cause railway tracks to expand, potentially causing buckling and other maintenance issues. To reduce stress on the railways, transit authorities often reduce train speeds when temperatures exceed 90 degrees;[58] with more than 62 90-degree days expected by the 2070s, the efficiency and reliability of the rail systems through Medford will be strained.

Roads are also susceptible to extreme temperatures, with asphalt buckling due to thermal expansion.[59] The City's ability to maintain the roadways will be challenged as extreme temperatures will reduce the ability of maintenance workers to repair roads; although this may be

MBTA transit in Medford

Figure 16: *Section of MBTA systemwide map portraying MBTA bus and rapid transit routes and stops in Medford, accessed 2025.*[61]



mitigated with a shorter winter season, enabling more road work in the fall and spring. The MassDOT and Department of Conservation and Recreation together maintain a total of 18.01 miles of road (70.83 total lane miles) within Medford, as depicted in **Figure 17**, while the City maintains 118.57 miles of road (234.9 total lane miles).[60] Areas that are vulnerable to increased flooding, as seen in **Figure 9**, indicate that many of the state-maintained roads will be highly vulnerable to future flooding.

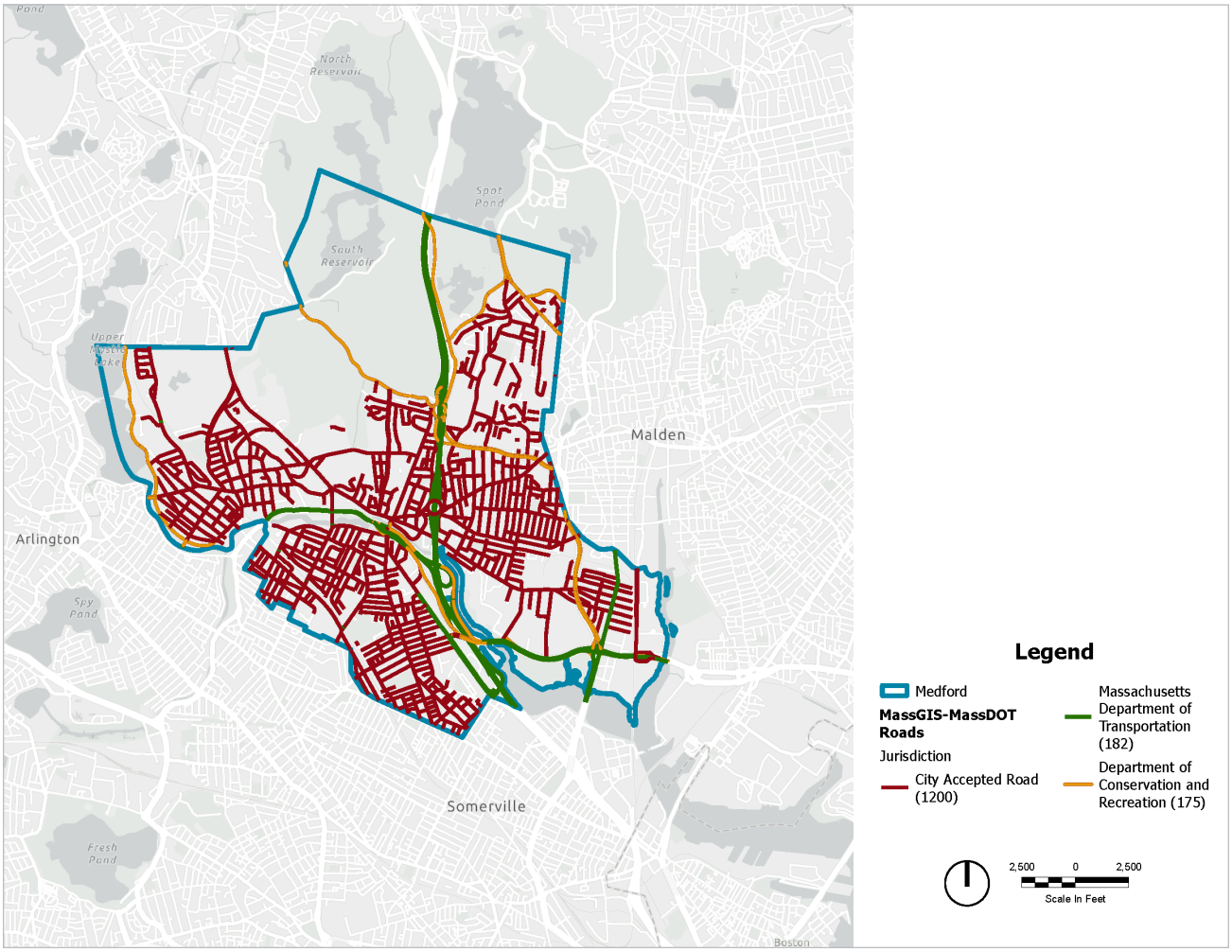
It is also important to consider the vulnerability of primary roads and public transit lines that provide access to critical infrastructure. It is critical during extreme weather events that medical facilities and emergency services remain accessible.

From Vulnerabilities to Adaptations!

While more extreme weather conditions may make it more difficult for the Massachusetts Department of Transportation (MassDOT) to maintain our aging roadways, MassDOT has a facility where they are testing and experimenting with different road construction techniques and materials to find what may work better under future climate conditions.[62]

Roadways in Medford

Figure 17: *Map of Medford area roads depicting the MassDOT jurisdictional roadways from MassGIS.*[63]



h. Schools and Universities

Some schools, such as the Andrews and McGlynn Middle Schools and the McGlynn and Columbus Elementary Schools, are in areas of Medford that are most vulnerable to flooding and extreme heat, while others serve students and families that live in vulnerable neighborhoods.

The Andrews and McGlynn Middle Schools and McGlynn and Columbus Elementary Schools are located in areas that are vulnerable to future flooding. They are also located in areas that already experience the greatest urban heat island effect in Medford and can expect to experience more extreme heat in the future.

Medford High School, Roberts Elementary, and Brooks Elementary are not located in areas of high probability of flooding under future scenarios or in urban heat island areas. However, some students and their families may live in vulnerable areas and are likely to have trouble accessing the schools during flooding events.

Tufts University is a private institution that is located in the Hillside neighborhood above current storm surge flood projections. Tufts Emergency Management staff and the City of Medford Emergency Management staff work together to understand the needs of our community. In 2018 Tufts University began its own climate vulnerability and adaptation planning work, and included City of Medford staff in the process. Tufts understands that while the main portion of the campus is not vulnerable to flooding, members of their community live throughout the greater Boston area and are likely to be impacted by future hazards. As Tufts moves forward with its own vulnerability assessment and planning, future iterations of this report and Medford's Climate Adaptation and Resiliency Plan will take that work into account.



Main entrance to the John J. McGlynn Sr. Elementary School at 3002 Mystic Valley Parkway, Medford.

From Vulnerabilities to Adaptations!

While all of the city's schools have backup generators, the electrical systems are designed only to facilitate evacuation. The city has recently updated the Andrews School to be used as a shelter in the event of an area power outage by rewiring many more circuits to the building's backup generator.

i. Food Security

Any extreme weather could impact the distribution, transportation and freshness of groceries supplied to Medford's four major supermarkets plus many smaller corner stores. Two of Medford's large grocery stores are currently located in areas that are vulnerable to flooding under 2070 projections.

Hurricanes, winter storms, and heavy precipitation events that affect entire regions can disrupt regional transportation networks by shutting down food distribution centers, slowing down or halting the transport of food, and causing food spoilage due to power outages. Additionally, there could be localized flooding emergencies that could affect a single store or the distribution center for one supermarket chain. Extreme weather events or climate hazards could also affect short-term changes in food prices.

The four principal supermarkets that serve Medford residents within city limits include Stop and Shop, Wegmans, Whole Foods, and BJ's Wholesale. In speaking with supermarket staff, we learned that the supermarkets have in-house generators that can supply power to the stores for several days in the event of a regional power outage. Beyond several days, stores would either need a continued supply of diesel fuel or access to additional generators that would be provided by central distribution centers. Some stores also include access to refrigeration trucks in their risk management planning for storage of frozen perishable goods.

In the event of a blockage to regional transportation, it is difficult for stores to gauge for how long in-store inventory would last without a fresh shipment because of the fluctuation in demand and the difference in demand by product. However, in the event of a long-term blockage to major transportation networks, each store has approximately one week's worth of grocery inventory.

Each supermarket chain operates its own distribution center, with some operating in central Massachusetts, and others as far as Connecticut, upstate New York, and eastern Pennsylvania. The locations of distribution centers are not, in most cases, located in vulnerable coastal communities or do not utilize transit networks that are vulnerable to projected sea level rise.

I-93, viewed from Middlesex Fells Reservation, Medford.



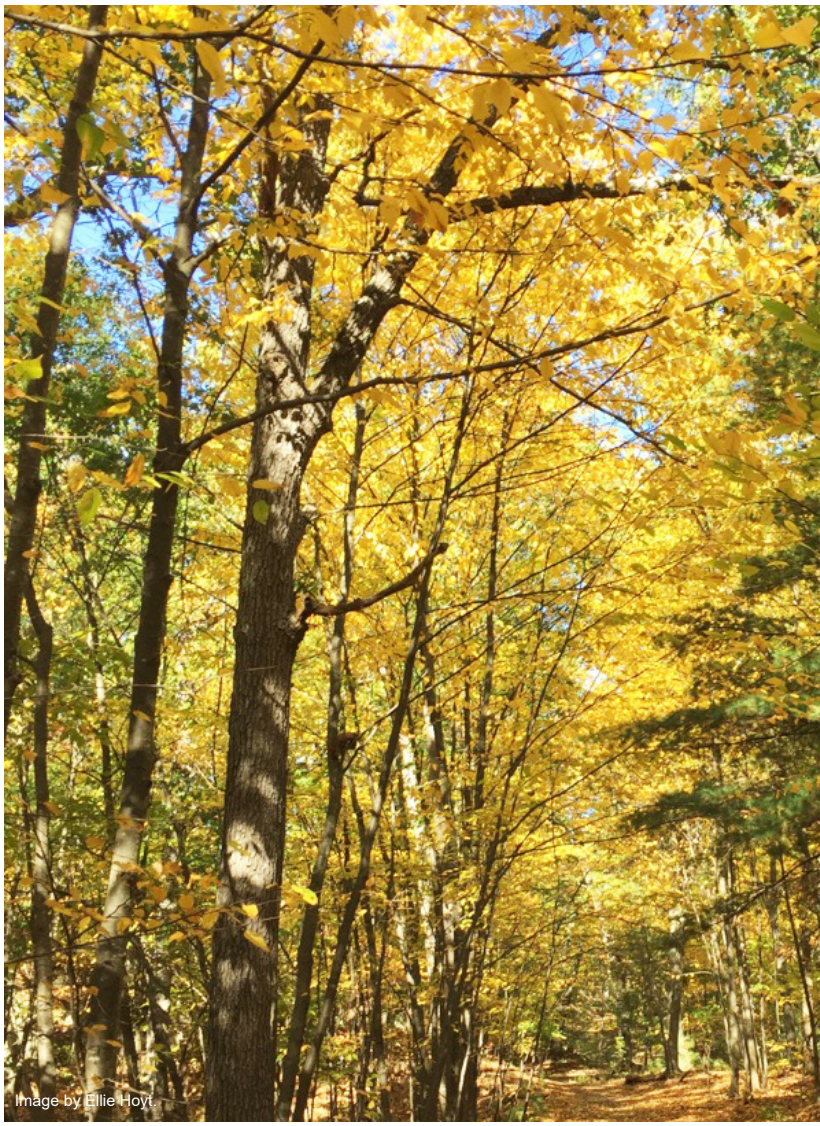
Image by Robbie Shade (public domain).

j. Natural Environment

The city's green infrastructure includes tree canopy, parks, and open grassy areas, which are an important part of protecting the city from the impacts of climate change. Trees and grass help keep the city cooler both by evapotranspiration (a tree's version of sweating!) and by providing shade. Additionally, vegetation absorbs water, which helps reduce flooding, and cleans the water before it enters rivers which helps keep Medford's water systems clean.

As Medford's average annual temperature continues to increase, some species of trees that are used to colder climates will no longer be able to thrive, and are likely to experience heat stress and potential death. These trees will need to be replaced by trees native to more southern areas. Without replanting or planning in the short term to introduce more heat resistant tree varieties, the loss of these resources could result in the creation of more "urban heat islands."

At the time of publication, Medford's Tree Warden has been actively working to diversify the species of trees planted in the city, paying special attention to trees that will withstand higher temperatures and increased precipitation intensity in anticipation of climate change impacts. She has made an effort to increase plantings in parts of the city that have fewer trees, but sometimes meets resistance from property owners that prefer not to have trees in front of their property.



Middlesex Fells Reservation and other parks and open spaces in Medford help protect against the impacts of climate change.

Definitions

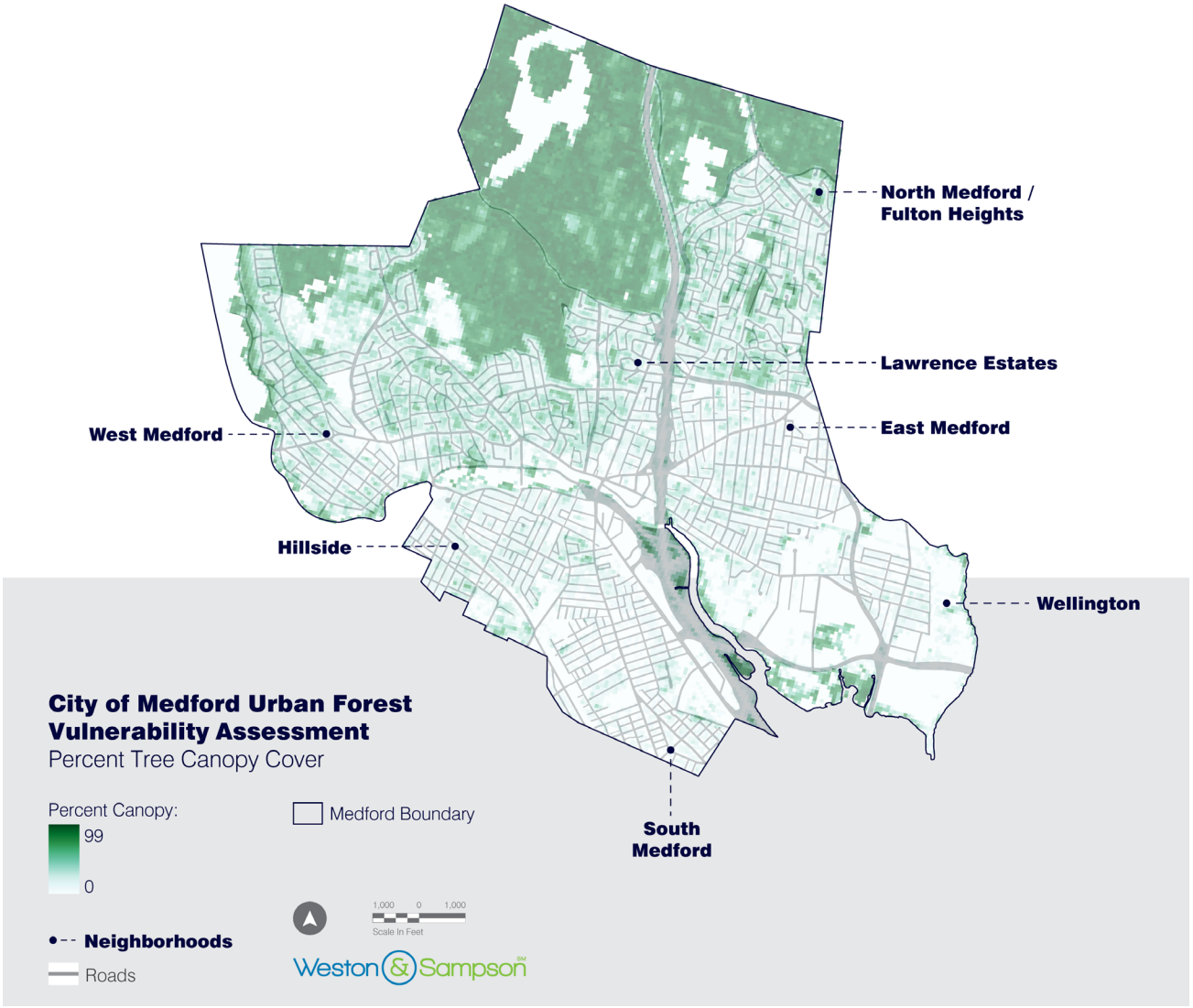
Urban Heat Island Effect: (See page 24 of this assessment for definition.) The Trust for Public Land identified South Medford as an existing "Urban Heat Island," but other communities are at risk if the City does not proactively manage its urban forest and green infrastructure.

k. Community Resources

Many people when asked about Medford's strengths and why they live here start their response with "the community." Medford is frequently described as a medium-sized city that feels like a small town. The relationships and connections that foster this small-town feeling are some of Medford's greatest strengths in the face of climate change hazards.

Tree Canopy (NLCD)

Figure 18: *Map of Tree Canopy Cover in Medford. Darker green areas represent a higher concentration of trees, whereas lighter green areas represent a lower concentration of trees.*[65]



Studies after Hurricane Sandy and conversations with community leaders after Hurricane Katrina have shown that cities with strong communities and strong social networks recover faster and more completely than those that are just bedroom communities.[64] Medford has a large number of religious communities and a strong interfaith network, as evidenced by the number of interfaith events held annually in Medford and frequency in which multiple religious communities, sometimes of different faiths, share buildings.

The West Medford Community Center is a particular source of fellowship, hosting many groups, clubs, and activities, and bringing together people of different cultures and backgrounds. It is located in a historically black neighborhood and has a historically black membership. It also brings together Girl Scout troops from across the city, an afterschool program for middle schoolers, a lunch program for seniors, and houses a French preschool.

Additional community resources with physical locations in Medford include the Medford Public Library, the Senior Center, and the Chevalier Theater, which houses the Medford Boys and Girls Club.

2. Vulnerability Assessment

This chapter presents an updated climate vulnerability assessment for the City of Medford, structured around three interrelated components: exposure, sensitivity, and adaptive capacity. Building upon the 2019 assessment, this update reflects methodological refinement, extended planning horizons, and incorporates new and enhanced data sources, the details of which are described under Appendix B.

Vulnerability is defined as **the degree to which a system is susceptible to and unable to cope with the adverse impacts of climate change**, including both gradual changes and extreme events. For this analysis, vulnerability is calculated using the following equation:

$$Vulnerability = \frac{Exposure \times Sensitivity}{Adaptive\ Capacity}$$

Each component is described in detail below with a narrative explanation of the scoring indicators. The vulnerability assessment was conducted on critical assets identified through multiple sources, including the City of Medford's Geographic Information System (GIS) Department, MassGIS, FEMA's Resilience Analysis and Planning Tool (RAPT), and input from the Steering Committee. These assets, both built and natural infrastructure, are evaluated to quantify their vulnerability **across four climate hazards:**

- coastal flooding (sea level rise and storm surge)
- precipitation urban flooding
- precipitation riverine flooding
- extreme heat

Scores are normalized on a 1 through 4 scale to allow comparison across hazards and planning horizons (2050 and 2070). A general overview of the future climate projections for each of the climate hazards considered in this assessment is provided under Section B.

2.1 Evaluated Assets

The vulnerability assessment for the City of Medford encompassed a comprehensive inventory of critical assets spanning public infrastructure, community resources, and environmental features. These assets were compiled from municipal sources, public datasets, and local input, and evaluated for their exposure, sensitivity, and adaptive capacity to climate-related hazards. The dataset included **more than 6000 assets** across the City, categorized as follows:

Transportation (> 5000 assets)

This transportation category makes the largest portion of the assets and represent the physical backbone of the City's transportation, utility, and service delivery systems and were analyzed for their vulnerability to climate hazards.

Transportation assets include discrete, location-specific infrastructure such as bridges, train stops, MBTA bus stops, and MBTA rapid transit stations (243 in total). These

assets are evaluated individually based on their specific geographic location and functional importance.

Transportation infrastructure systems that are spatially continuous and extend over long distances, typically following transportation or utility corridors were also evaluated. These include **more than 5,000 assets, such as:**

- Roadways (local, collector, arterial, and interstate)
- Sidewalks and bike lanes
- Public transit routes (e.g., MBTA bus and rail lines)
- Stormwater and sewer pipelines
- Utility corridors (e.g., electric, water, or gas lines)

Natural Resources (154 assets)

Assets in this category include parks, wetlands, forests, and other open spaces that provide critical ecosystem services such as stormwater management, heat mitigation, and biodiversity support. These natural systems also act as buffers during extreme weather events.

Community Services (38 assets)

This includes Medford City Hall, Public Library, community centers, churches, healthcare services, USPS, grocery stores etc. that play a key role in delivering services and supporting residents during and after emergencies.

Schools (32 assets)

K–12 schools and higher education facilities were assessed for their structural vulnerability and their function as emergency shelters or critical community anchors.

Emergency Services (29 assets)

Fire stations, police stations, and EMS facilities were included due to their frontline roles in hazard response. Maintaining access and functionality of these facilities during climate events is essential for effective emergency management.

Hazardous Facilities (28 assets)

These assets store, handle, or produce materials that could pose environmental or health risks if exposed to hazards like flooding. Their inclusion reflects the potential for cascading impacts.

Utilities (20 assets)

This group includes water and wastewater infrastructure, electric substations, and pumping stations. These facilities are critical for maintaining essential services, and their disruption can severely impact daily life and emergency operations.

Food Distribution Centers (19 assets)

Grocery stores, food pantries, and warehouses are essential to maintaining food access, particularly for vulnerable populations during disruptions.

Dams (6 assets)

Assessed for hazard classification and proximity to downstream populations, these assets are important for flood control measures.

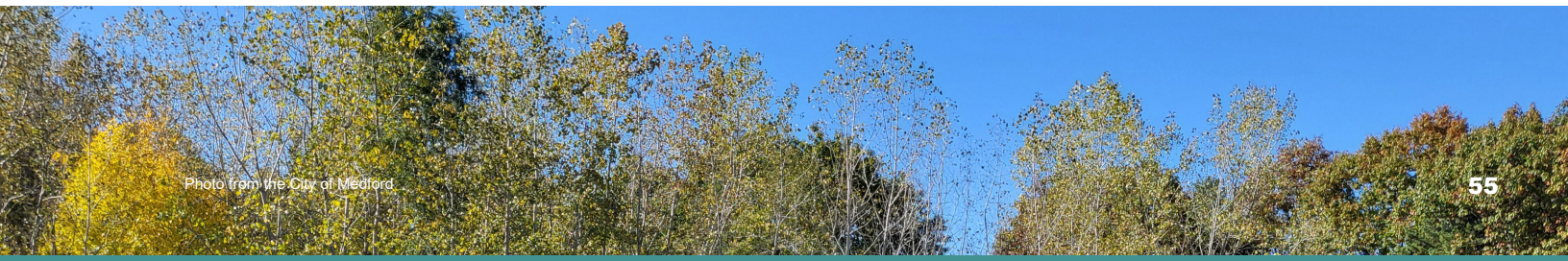
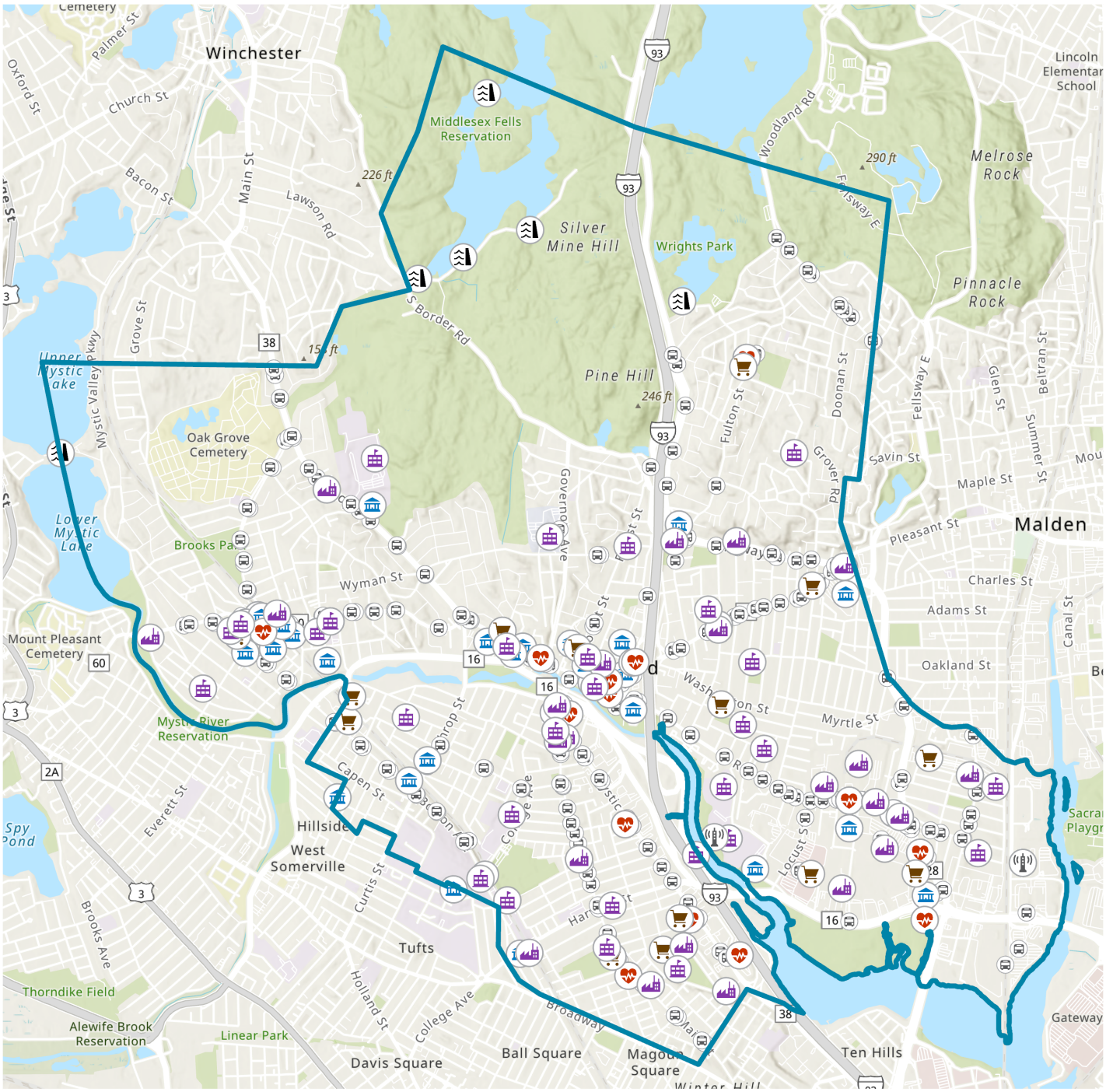


Photo from the City of Medford



Critical Assets

- Medford
- Transportation
- Community Services
- Dams
- Emergency Services
- Food Distribution
- Hazardous Facilities
- Schools
- Utilities

While Medford receives all of its water supply from the MWRA reservoir in Central MA, one of the reservoirs for the Town of Winchester is partially located within the City of Medford, as well as its treatment plant.

2.2 Exposure Methodology

Exposure evaluates the degree to which an asset is physically located in areas subject to climate-related hazards in the near term or in the future.[66] In this assessment, the more frequently or severely an asset is expected to experience climate stress, the higher its exposure score.

This component of the assessment uses geospatial datasets and climate projections to assess the likelihood and severity of exposure to threats such as sea level rise, storm surge, extreme precipitation, riverine flooding, and extreme heat. The exposure methodology builds on the framework used in the State adopted Climate Resilience Design Standards Tool, which applies threshold-based scoring to evaluate preliminary exposure risks across asset types. Each indicator is selected based on its relevance to projected climate impacts in Medford and scored using thresholds derived from authoritative datasets. This scoring helps identify which assets are most likely to be directly affected by climate hazards, providing a foundation for prioritizing adaptation and mitigation efforts.

For hazards with multiple indicators, the final exposure score for that hazard was calculated by summing the scores from each applicable indicator.

The exposure scoring methodology is provided in Table 1.

Table 1: Exposure Scoring Methodology

Climate Hazard	GIS Dataset (if applicable)	Question / Filter	Response / Score	Data Source
Sea Level Rise / Storm Surge*	MC-FRM (2050, 2070)	The asset is located within the projected 1% annual coastal flood exceedance probability (ACFEP) (2050, 2070)	Yes = 2	Massachusetts Coast Flood Risk Model - Woods Hole Group. (2023, September 27). Woods Hole Group. https://www.woodsholegroup.com/innovation/massachusetts-coast-flood-risk-model
		The asset is NOT located within the projected 1% annual coastal flood exceedance probability (ACFEP) (2050, 2070)	No = 0	
	MC-FRM (2050, 2070)	The asset is located within the projected 0.1% annual coastal flood exceedance probability (ACFEP) (2050, 2070)	Yes = 1	
		The asset is NOT located within the projected 0.1% annual coastal flood exceedance probability (ACFEP) (2050, 2070)	No = 0	

Table 1: Exposure Scoring Methodology

Climate Hazard	GIS Dataset (if applicable)	Question / Filter	Response / Score	Data Source
Extreme Precipitation *Urban Flooding*	**100-yr 24-hr flood depth (2050 and 2070)**	Projected max flood depth from a 100-yr 24-hr design storm	>3 ft = 5	Medford. (2018). Citywide Drainage Model for Medford. Prepared for the City of Medford, MA. Prepared by Kleinfelder.
			2 - 3 ft = 4	
			1 - 2 ft = 3	
			0.5 - 1 ft = 2	
			0.1 - 0.5 ft = 1	
			<0.1 ft = 0	
		Assets landlocked by flooding from a 100-yr 24-hr design storm	Yes = 2	
			No = 0	
Extreme Precipitation *Riverine Flooding*	**FEMA flood zones**	The asset is within the current 1% annual chance (100-year floodplain)	Yes = 4	Federal Emergency Management Agency. (2021). Preliminary Flood Insurance Rate Maps for Middlesex County, MA. https://msc.fema.gov/portal/home
		The asset is within the current 0.2% annual chance (500-year floodplain)	Yes = 2	
		The site is NOT located within the 0.2% or 1% annual chance	No= 0	
Extreme Heat	**Ambient Air Temperature on a 95°F Day (2050) and 100°F Day (2070)**	The ambient air temperature at the site of the asset is greater than or equal to 105°F	>105°F = 5	Urban heat island model developed for the City of Medford by Weston & Sampson (2024)
		The ambient air temperature at the site of the asset is greater than or equal to 100°F and less than 105°F	100°F - 105°F = 4	
		The ambient air temperature at the site of the asset is greater than or equal to 95°F and less than 100°F	95°F - 100°F = 3	
		The ambient air temperature at the site of the asset is greater than or equal to 90°F and less than 95°F	90°F - 95°F = 2	
		The ambient air temperature at the site of the asset is below 90°F	< 90°F = 1	

The indicators from the table are described below to illustrate the rationale for their inclusion, the data sources used, and the criteria applied to assign scores.

Sea Level Rise and Storm Surge (MC-FRM 2050, 2070, RCP8.5)

Assets were evaluated for their location within the projected 1% and 0.1% Annual Coastal Flood Exceedance Probability (ACFEP) zones using the Massachusetts Coast Flood Risk Model (MC-FRM). These indicators were considered to reflect the increasing threat of coastal inundation due to sea level rise and to align with the methodology adopted by the State of MA in the Climate Resilient Design Standards Tool. Assets located within the 1% ACFEP zone received a score of 2, while those within the 0.1% ACFEP zone received a score of one (1). Assets outside both zones are scored at zero (0).

The ACFEP zones represent the likelihood of coastal flooding in any given year, with the 1% ACFEP zone corresponding to what is commonly referred to as the "100-year flood" and the 0.1% ACFEP zone to the "1000-year flood." These probabilities are based on statistical analyses of storm surge, sea level rise, and tidal conditions, and are used to estimate the extent of flooding under future climate scenarios. The 1% zone indicates areas with a higher probability of flooding and thus greater exposure risk. Therefore, assets exposed to 1% flooding are scored higher (2), whereas the assets that are located within the 0.1% ACFEP Zone receive a lower score (1).

Extreme Precipitation – Urban Flooding (100-year, 24-hour storm depth)

Flood depth projections, based on the City's integrated stormwater flood model developed for the City in 2018,[67] are used to assess the severity of urban stormwater flooding under the 2050 and the 2070 planning horizons. This is an integrated flood model that combines the impacts of precipitation driven piped infrastructure flooding and riverine flooding. The model considered the City's stormwater infrastructure, ground elevation, bathymetry, and rainfall depth projections to estimate the depth of flooding across the City under future scenarios. Assets were scored on a scale from 0 to 5 based on projected flood depth under 100-yr 24-hr duration storms as shown in the table above.

Additionally, a score of 2 was assigned to assets that would be landlocked by flooding under the same 100-yr 24-hr duration storms conditions, meaning that the access roads to and from the asset would be inundated and impassable. This condition was identified in GIS by overlaying the flood depth raster generated from the City's stormwater model with the road network layer. For each asset, the surrounding street segments within a defined buffer (e.g., 200 feet) were analyzed to assess if they were projected to experience flood depths exceeding 6 inches, generally considered impassable for passenger vehicles. Assets for which the access routes were found to be above this threshold were flagged as landlocked. This indicator captures functional isolation during flood events, reflecting the compounding effects of infrastructure interdependence and the growing intensity of precipitation events on emergency response and mobility. The scoring thresholds were aligned with engineering standards for flood risk and emergency vehicle accessibility.

Extreme Precipitation – Riverine Flooding (FEMA Flood Zones)

In addition to extreme precipitation driven stormwater flooding data as obtained from the City's 2018 stormwater flood model, riverine flooding exposure is assessed by considering the latest pending FEMA flood hazards zones for Medford. Pending FEMA floodplain data was used because it is expected to be adopted soon and includes greater coverage for the City of Medford. The FEMA flood layers are included to assess any additional riverine flood risks areas in the City that may not have been identified in the City's stormwater flood model.

The assets were scored based on their location within FEMA designated 1% ACFEP and 0.2% ACFEP flood zones using the pending updated data from the National

Flood Hazard Layer (NFHL). Assets located within the 1% annual chance (100-year) floodplain received a score of 4, while those within the 0.2% (500-year) floodplain received a score of 2. Assets outside both zones scored 0. The assets within the 100-year floodplain were assigned a higher score compared to the 500-year flood zone since the 100-yr flood (or 1% annual probability of flooding) is more frequent compared to the 500-yr flood (or 0.2% annual probability of flooding). This scoring methodology for riverine flooding is also consistent with the scoring methodology used in the Climate Resilience Design Standards Tool.

Extreme Heat (Ambient Air Temperature Projections)

Modeled ambient air temperatures were developed in 2024 using Medford-specific data as part of the MVP-funded Urban Forest Master Plan. These projections are used to estimate future heat exposure, with a 95°F citywide average temperature representing typical conditions expected by the 2050 planning horizon, and a 100°F average representing those expected by 2070. Assets were assigned scores from 1 to 4 based on the estimated temperature as shown in the table above. This indicator reflects both the increasing number of extreme hot days and the urban heat island effect, where more dense and impervious areas retain more heat than surrounding regions. Higher temperatures increase risks to public health, strain infrastructure, and challenge energy systems. The scoring thresholds were designed to align with temperature ranges known to elevate health risks and stress critical services.

Overall exposure scores are calculated based on the individual exposure scores calculated for each of the above-mentioned climate hazards. For hazards with multiple indicators, the final exposure score for each hazard was calculated by summing the exposure scores for each of the relevant indicators. The assets with zero score for SLR/SS flooding and extreme precipitation riverine flooding are marked as not exposed. Possible scores for each climate hazard are shown in Table 2.

Table 2: Scores Possible for Each Climate Hazard

Climate Hazard	Max Possible Score	Min Possible Score
SLR/SS	3	0
Extreme precipitation riverine	4	0
Extreme precipitation drainage (urban)	7	0
Extreme heat	5	1

For consistent comparison of asset exposure scores for each climate hazard, raw exposure scores were normalized to a standard scale from 1 to 4. This approach was adopted so that each asset's exposure score is proportionally scaled based on the full range of possible values across the planning period and allows for meaningful comparisons both **within** and **across** planning horizons.

The normalization formula used is (2050 planning horizon is shown as an example here):

$$\textbf{Normalized Score} = 1 + \frac{(\textit{Actual Score} - \textit{Minimum Possible Score}_{2050}) \times 3}{\textit{Maximum Possible Score}_{2070} - \textit{Minimum Possible Score}_{2050}}$$

Where:

- Actual Score = the raw score assigned to the asset
- Minimum Possible $Score_{(2050)}$ = the lowest possible raw score for that hazard in 2050
- Maximum Possible $Score_{(2070)}$ = the highest possible raw score for that hazard in 2070
- The constant 3 represents the scaling range (4 - 1) on a normalized 1–4 scale

The resulting normalized scores for each hazard were then used to classify assets into exposure categories ranging from **low** to **high**, as shown in Table 3.

Table 3: Normalized Scoring Schema	
0	Not Exposed
< 1.5	Low Exposure
1.5 - < 2.0	Medium Exposure
2.0 - < 3.0	Medium-High Exposure
> = 3.0	High Exposure

Climate Change Projections and Hazard Data Limitations

The projections and climate analysis in this report are grounded in current, region-specific climate science and publicly available data. However, these projections involve assumptions and inherent uncertainties. Actual climate change impacts may differ, potentially being more or less severe than those projected. The Commonwealth of Massachusetts intends to revise its climate projections at least every five years as part of the State Hazard Mitigation and Climate Adaptation Plan. Hence, relevant climate change projections for the City should be assessed and updated accordingly.

2.3 Sensitivity & Adaptive Capacity

Sensitivity is assessed by how likely an asset or its functionality could be damaged or disrupted from exposure to climate hazard. Adaptive capacity is assessed by how well the asset/system can cope with damage or disruption. Sensitivity and adaptive capacity are estimated based on indicators as explained in the following section.

Sensitivity Indicators

Sensitivity was evaluated using twenty-one indicators derived from a combination of publicly available datasets and custom data gathered through this project. The number of indicators and type of indicators varied within asset categories as illustrated under Table 4.

Each indicator was scored on a scale from 1 to 4, where 4 represents the highest level of sensitivity, indicating significant risk to human life, infrastructure, or ecological systems, and 1 indicates the least sensitivity. The following sections describe each sensitivity indicator, including the rationale for its inclusion, the data source, and the criteria applied to assign scores.

The sensitivity indicators and associated scoring are shown in Table 4.

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Sensitivity Indicators

Table 4: Sensitivity Indicators and Associated Scoring					
Indicator	**Asset Subcategory**	**4**	**3**	**2**	**1**
What is the proximity to EJ neighborhoods?	Library Post Office Town Services Elderly Care Facilities Affordable Housing Pharmacies Places of Worship Police Fire Emergency Medical Assistance Hospitals Grocery Stores Food Pantries K-12 Schools Daycares Universities/Colleges Elderly Housing Parks Water Bodies Hazardous Facilities Brownfield Sites	Within 0.5 mi	Within 1.0 mi	Within 1.5 mi	Greater Than 1.5 mi
Is the asset in a historic area or designated as a historical site?	Library Post Office Town Services Elderly Care Facilities Affordable Housing Pharmacies Places of Worship Police Fire Emergency Medical Assistance Hospitals Grocery Stores Food Pantries K-12 Schools Daycares Universities/Colleges Elderly Housing Parks Water Bodies Hazardous Facilities Brownfield Sites	Yes			No
Does the road have a bike lane?	Roads	Yes			No
What type of street is this?	Roads	Interstate	Arterial	Collector	Local

Table 4: Sensitivity Indicators and Associated Scoring					
Indicator	**Asset Subcategory**	**4**	**3**	**2**	**1**
Are the MBTA T routes susceptible to >1ft flooding?	MBTA T Routes		>2' = 3	6" - 2' = 2	<6" = 1
How much flooding would an asset potentially experience?	Roads	Roads: greater than 6"			Roads: less than 6"
	Library Post Office Town Services Elderly Care Facilities Affordable Housing Pharmacies Places of Worship Police Fire Emergency Medical Assistance Hospitals Grocery Stores Food Pantries K-12 Schools Daycares Universities/Colleges Elderly Housing Hazardous Facilities Brownfield Sites	Buildings: greater than 2'			Buildings: less than 2'
Is there a drinking water surface water source (zone A) on site?	Library Post Office Town Services Elderly Care Facilities Affordable Housing Pharmacies Places of Worship Police Fire Emergency Medical Assistance Hospitals Grocery Stores Food Pantries K-12 Schools Daycares Universities/Colleges Elderly Housing Parks Water Bodies Hazardous Facilities Brownfield Sites	Yes			No

Table 4: Sensitivity Indicators and Associated Scoring					
Indicator	**Asset Subcategory**	**4**	**3**	**2**	**1**
Does the asset contain multiple Biomap core components?	Library Post Office Town Services Elderly Care Facilities Affordable Housing Pharmacies Places of Worship Police Fire Emergency Medical Assistance Hospitals Grocery Stores Food Pantries K-12 Schools Daycares Universities/Colleges Elderly Housing Parks Water Bodies Hazardous Facilities Brownfield Sites	5 or more	3 or 4	2 or 1	0
Hazard level of the dam	Dams	High Hazard	Significant Hazard	Low Hazard	
Is the dam publicly owned?	Dams	Yes			No
Does the dam provide drinking water?	Dams	Yes			No
Are there electrical or mechanical equipment in the basement of the building?	Brownfield Sites Hazardous Facilities Town Services Daycares Electric Water (Built Infrastructure) Fire Stations Food Pantries Library Police Stations Schools Health Department Schools Town Offices	Yes			No

Table 4: Sensitivity Indicators and Associated Scoring					
Indicator	**Asset Subcategory**	**4**	**3**	**2**	**1**
Is there any impact if this asset fails?	Brownfield Sites Hazardous Facilities Town Services Daycares Electric Water (Built Infrastructure) Fire Stations Food Pantries Library Police Stations Schools Health Department Schools Town Offices	Regional	Local		None

Environmental Justice (EJ) Proximity

Proximity of an asset to Environmental Justice neighborhoods is a key sensitivity indicator because these communities often face systemic barriers to resources, healthcare, and infrastructure. Using MassGIS 2020 Environmental Justice[68] data, assets that are located within **0.5 miles** of an EJ neighborhood receive the highest score of **4**, reflecting the heightened impacts to nearby EJ population group(s) if that asset is affected due to climate hazards. As distance between the asset and nearest EJ population group(s) increases, the score decreases: **1.0 mile = 3, 1.5 miles = 2**, and **beyond 1.5 miles = 1**, indicating reduced direct exposure to vulnerable populations.

Historic Designation

Assets listed in the Massachusetts Historical Commission (MHC) Historic Inventory are considered highly sensitive due to their irreplaceable cultural and architectural value. The point dataset is used for the analysis. These assets are scored **4** because they are more susceptible to irreversible damage from extreme weather events or long-term climate shifts. Non-designated assets receive a **1**, indicating relatively lower sensitivity in this context.

Street Classification

The classification of roads reflects their importance in emergency response and evacuation. Interstates score **4** due to their critical role in regional mobility, serving as major transportation arteries essential for mass evacuations and emergency logistics. Arterial roads score **3**, as they connect interstates to local areas and support high traffic volumes during emergencies. Collector roads score **2**, providing connections between local roads and arterials, helping move people out of neighborhoods. Local roads score **1**, reflecting their limited capacity and strategic importance, often offering restricted access during emergency situations.

Bike Lane Presence

The presence of bike lanes is used as a proxy for multimodal transportation access and urban resilience. Roads with bike lanes are an important asset to the City as they support alternative transportation options and reduce reliance on cars, which is especially important during fuel shortages or road closures. Therefore, roads with bike lanes receive a score of **4** and the ones without bike lanes get a score of **1**, indicating limited mobility options.

Flood Susceptibility of MBTA Routes

Flooding of public transit infrastructure can severely disrupt mobility and access to essential services. Using the City's flood model,[69] MBTA routes[70] projected to experience **more than 6 inches of flooding are scored 4**, indicating high sensitivity. Routes with **less than 6 inches score 1**, reflecting lower sensitivity since water at that depth drains away from the street faster.

Drinking Water Protection (Zone A)

Assets intersecting **Zone A** of the Surface Water Supply Protection Areas[71] are scored **4** because contamination or disruption here could compromise public drinking water supplies. Assets outside this zone receive a **1**, indicating lower sensitivity in terms of water resource protection.

BioMap Core Habitat Components

Ecological sensitivity is assessed through the number of BioMap Core habitat components.[72] Assets with **five or more** components score **4**, indicating the highest biodiversity and ecological value and therefore highest sensitivity to climate change. Assets with **three to four components= 3, one to two components= 2**, and **none = 1**, with lower scores reflecting reduced ecological sensitivity.

Dam Hazard Classification

Dams are evaluated based on their hazard classification, which reflects the potential consequences of failure rather than the condition or likelihood of failure. A **high hazard** classification indicates that dam failure could result in significant downstream damage, including potential loss of life; these dams are assigned a sensitivity score of **4**. **Significant hazard** dams, where failure could cause substantial property or environmental damage without likely loss of life, receive a score of **3**. **Low hazard** dams, which are expected to cause minimal impact if they fail, are scored **2**. This scoring reflects decreasing sensitivity as the potential consequences of failure diminish.

Public Ownership and Drinking Water Supply from Dams

Dams that are **publicly owned** or **supply drinking water**[73] are each scored **4** due to their critical role in public safety and infrastructure. Privately owned or non-drinking water dams score **1**, indicating less direct public impact.

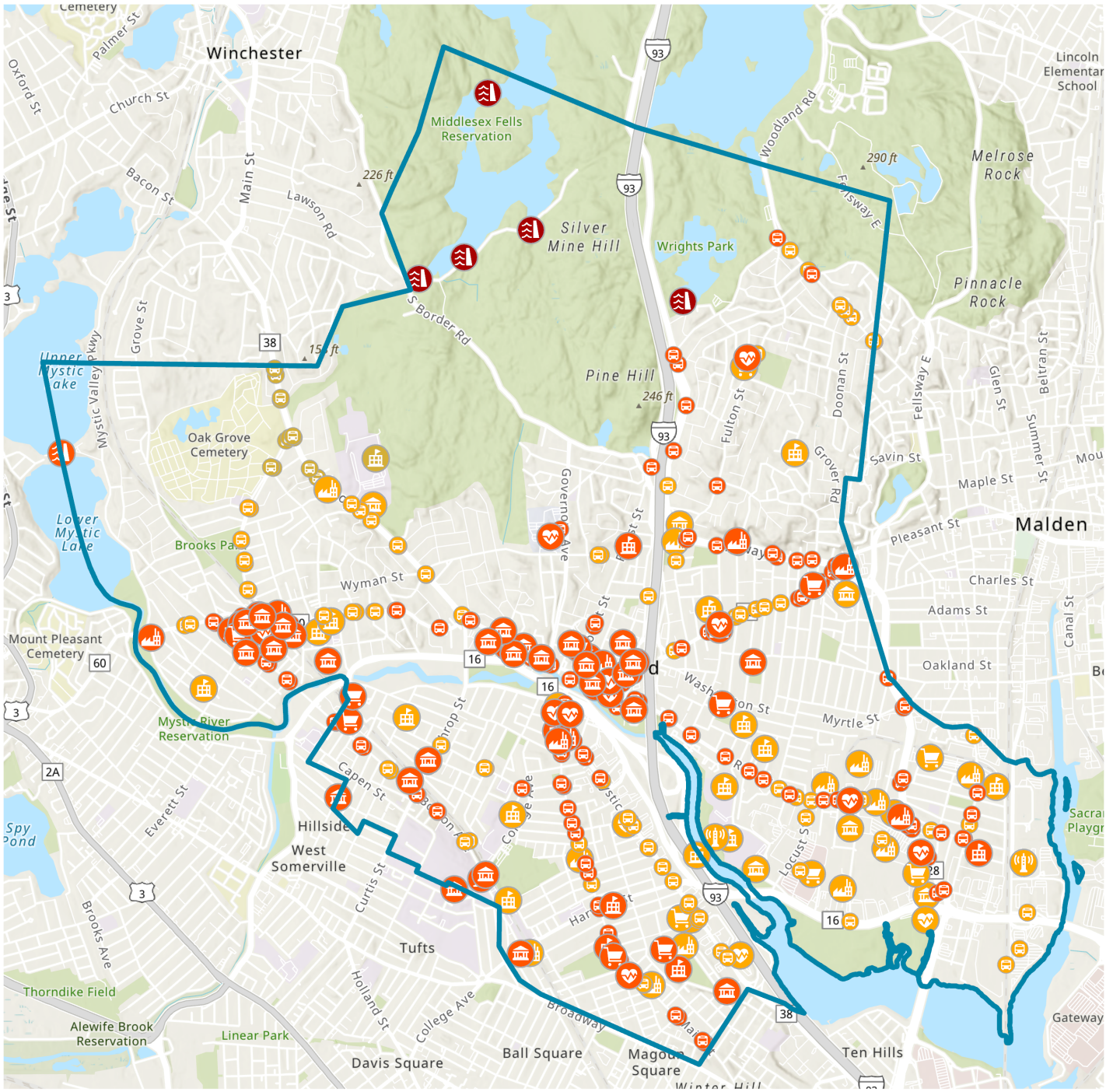
In addition to the sensitivity indicators described above, City-owned assets were evaluated using a set of additional indicators to capture more accurate and actionable assessment of community vulnerability to key assets under the City's jurisdiction. Since the City has jurisdiction over these assets and access to more detailed information about their function, condition, and operations, it is better positioned to assess their vulnerability and implement targeted resilience strategies. These additional indicators include:

- **Presence of Electrical or Mechanical Equipment in Basements:** Assets with critical infrastructure located in basements are scored **4** due to their heightened vulnerability to flooding and the potential for service disruption. Assets without such equipment receive a score of **1**.
- **Impact of Asset Failure:** Assets whose failure would have regional consequences—such as widespread service outages or major disruptions to emergency response are scored **4**. Those with primarily local impacts receive a score of **2**, reflecting a lower but still some level of sensitivity.

Sensitivity Results Findings

Each asset was given a sensitivity score by adding up the points from the indicators relevant to that asset. While the indicators are weighed equally in the analysis, those with higher possible point values have a greater influence on an asset's total sensitivity score. To have consistency across assets, total scores from applicable indicators are normalized on a scale of 1–4 and classified as:

- **1.0 – 1.5:** Low Sensitivity
- **1.5 – 2.0:** Medium
- **2.0 – 3.0:** Medium-High
- **≥3.0:** High Sensitivity



Critical Assets
Sensitivity

- Medford
- Transportation
- Community Services
- Dams
- Emergency Services
- Food Distribution
- Hazardous Facilities
- Schools
- Utilities
- Low Sensitivity
- Medium Sensitivity
- Medium-High Sensitivity
- High Sensitivity

2.4 Adaptive Capacity

Adaptive capacity refers to the **ability of infrastructure and communities to prepare for, respond to, and recover from climate-related hazards.** In the context of this assessment, adaptive capacity indicators were selected to reflect both physical resilience and institutional preparedness. These indicators were scored based on available data and, in some cases, information provided directly by the City for municipally owned assets. Adaptive capacity scoring is included in the analysis to include not only environmental and structural conditions but also operational readiness and redundancy.

Some indicators, such as backup power availability, emergency management planning, and equipment vulnerability, are specific to City-owned assets and rely on internal data collection. These indicators help identify where municipal infrastructure may be prepared and to what extent to maintain critical services during extreme weather events.

8
Adaptive Capacity Indicators

The adaptive capacity indicators used in scoring are shown in Table 5.

Table 5: Adaptive Capacity Scoring Methodology

Indicator	Asset Subcategory	4	3	2	1
What percentage of streets have street trees?	Roads	If there is more than 40% existing canopy area	If there is 25 to 40% existing canopy area	If there is 10 to 25% existing canopy area	If there is less than 10% existing canopy area
Is there more than one of this asset in the community?	Library Post Office Town Services Elderly Care Facilities Affordable Housing Pharmacies Places of Worship Police Fire Emergency Medical Assistance Hospitals Grocery Stores Food Pantries K-12 Schools Daycares Universities/Colleges Elderly Housing Parks Water Bodies	Yes			No
Was the dam inspected within the last two years?	Dams	Yes			No

Table 5: Adaptive Capacity Scoring Methodology					
Indicator	**Asset Subcategory**	**4**	**3**	**2**	**1**
What is the proximity to bus or T stops?	Library Post Office Town Services Elderly Care Facilities Affordable Housing Pharmacies Places of Worship Police Fire Emergency Medical Assistance Hospitals Grocery Stores Food Pantries K-12 Schools Daycares Universities/Colleges Elderly Housing Parks Water Bodies	Within 0.5 mi	Within 1.0 mi	Within 1.5 mi	Greater Than 1.5 mi
For City-Owned Assets					
Does it have backup power?	Brownfield Sites Hazardous Facilities Town Services Daycares Electric Water (Built Infrastructure) Fire Stations Food Pantries Library Police Stations Schools Health Department Schools Town Offices	Yes	No, but have the ability to add a generator	No, unable to add a generator	N/A
Are there existing flood control measures on the property?	Brownfield Sites Hazardous Facilities Town Services Daycares Electric Water (Built Infrastructure) Fire Stations Food Pantries Library Police Stations Schools Health Department Schools Town Offices	Yes			No

Table 5: Adaptive Capacity Scoring Methodology					
Indicator	**Asset Subcategory**	**4**	**3**	**2**	**1**
Does the site have an emergency management plan (EMP)?	Brownfield Sites Hazardous Facilities Town Services Daycares Electric Water (Built Infrastructure) Fire Stations Food Pantries Library Police Stations Schools Health Department Schools Town Offices	Has an EMP that explicitly addresses extreme weather events and has adequate staff capacity or familiarity to execute plan	Has an EMP but it does not explicitly address extreme weather events and/or has limited staff capacity or familiarity to execute the plan.	Has an EMP but it does not explicitly address extreme weather events, and no staff identified to execute the plan.	No EMP

Street Tree Canopy Coverage (Transportation assets only)

Tree canopy coverage[74] is a key indicator of adaptive capacity due to its role in mitigating urban heat and managing stormwater. Streets where more than **40%** of street tree canopy coverage receive the highest score of **4**, reflecting strong natural resilience. Coverage between **25–40%** scores **3**, **10–25%** scores **2**, and **less than 10%** scores **1**, indicating progressively lower adaptive capacity.

Redundancy of Assets

Redundancy enhances resilience by providing service continuity if one asset fails. If there is more than one of the same asset types in the community, it scores **4**. If the asset is unique, and does not have any redundancy, it scores **1**, indicating higher vulnerability due to lack of alternatives.

Dam Inspection Recency (Dams only)

Regular inspections are critical for dam safety and emergency preparedness. Dams inspected[75] within the last **two years** receive a score of **4**, indicating proactive risk management. Dams not inspected in that timeframe score **1**, reflecting potential oversight.

Proximity to Public Transit

Access to public transit supports emergency response and community resilience. Assets within **0.5 miles** of a bus[76] or T[77] stop score **4**, within **1.0 mile = 3**, within **1.5 miles = 2**, and **beyond 1.5 miles = 1**, with lower scores indicating reduced accessibility.

City-owned assets were evaluated using additional adaptive capacity indicators to better capture their capacity to maintain operations during extreme events and disruptions. These indicators provide a more nuanced understanding of infrastructure resilience and community preparedness. These include:

- **Backup Power Availability:** The ability to maintain operations during power outages is critical. Assets with **existing backup power** systems are scored **4**. Those without backup power but with the capacity to accommodate a generator score **2**. Assets that cannot support backup power due to capacity issues receive a score of **1**. If backup power is not applicable to the asset, this indicator is excluded from scoring.
- **Flood Control Measures:** The presence of flood mitigation infrastructure significantly enhances an

asset's resilience. Assets equipped with flood control measures (such as elevated assets, presence of permanent or deployable flood barrier etc.) are scored **4**, while those lacking such protection are scored **1**, indicating greater vulnerability to flood-related disruptions.

- **Emergency Management Plan (EMP):** An asset-specific EMP that addresses extreme weather events is essential for emergency preparedness. Assets with a comprehensive EMP and trained personnel are scored **4**. A score of **3** is assigned when the plan exists but lacks climate-specific content and staff have limited familiarity with it. If the plan lacks climate-specific content and no staff are identified to implement it, the asset is scored **2**. Assets without an EMP are scored **1**, reflecting minimal preparedness.

Adaptive Capacity Results

Raw Adaptive Capacity (AC) scores were used to calculate the total vulnerability scores for each climate parameter. To facilitate comparison across assets, these raw scores were also normalized on a 1–4 scale. This normalized scale enables consistent ranking of assets into categories of low, medium, medium-high, and high adaptive capacity.

Sensitivity and Adaptive Capacity Data Limitations

The sensitivity data used in this report does not include every important asset or system in Medford. The analysis and conclusions are based on the data collected during this project, as described in the report. If Medford updates or adds new asset data, the results of the analysis could change. Because of this, the vulnerability assessment should be reviewed and updated whenever new information, updates to existing assets, or updated climate projections become available.

2.5 Vulnerability Assessment Results

The City of Medford's vulnerability assessment evaluated a wide range of critical assets—including transportation infrastructure, public facilities, utilities, schools, and natural resources—against projected climate hazards for the 2050 and 2070 planning horizons. Each asset was scored based on its exposure to climate hazards, sensitivity to damage or disruption, and adaptive capacity, or its ability to withstand and recover from climate impacts. These components were combined to produce a composite vulnerability score normalized on a scale from 1 (low) to 4 (high).

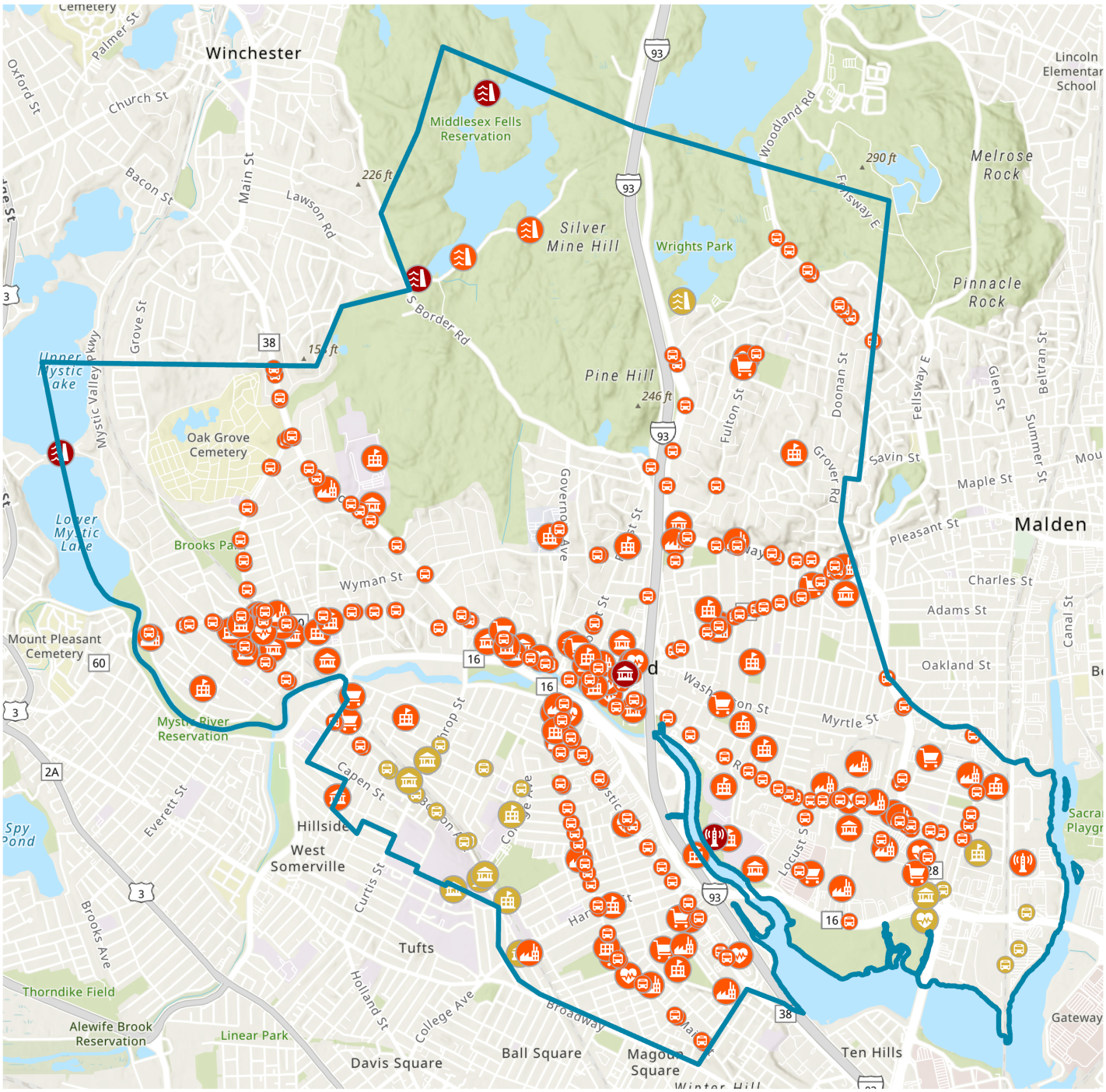
Vulnerability was calculated for each of the climate hazards for both planning horizons (2050 and 2070). In addition, total vulnerability scores were calculated for each asset for 2050 and 2070 by summing up the individual hazard-specific vulnerability scores for 2050 and 2070. As a result, each asset has a total of 11 vulnerability scores, one for each hazard per year, plus two total vulnerability scores (one for 2050 and one for 2070).

1. $\text{Vulnerability}_{\text{climate parameter, 2050}}$ ($\text{Exp}_{\text{climate parameter. 2050}}$ * Sensitivity / Adaptive Capacity)
2. $\text{Vulnerability}_{\text{climate parameter, 2070}}$ ($\text{Exp}_{\text{climate parameter. 2070}}$ * Sensitivity / Adaptive Capacity)
3. $\text{Vulnerability}_{\text{total 2050}}$ ($\text{Vul}_{\text{SLR 2050}} + \text{Vul}_{\text{PU 2050}} + \text{Vul}_{\text{PR}} + \text{Vul}_{\text{Heat 2050}}$)
4. $\text{Vulnerability}_{\text{total 2070}}$ ($\text{Vul}_{\text{SLR 2070}} + \text{Vul}_{\text{PU 2070}} + \text{Vul}_{\text{PR}} + \text{Vul}_{\text{Heat 2070}}$)

Where:

- Exp: Exposure
- SLR: Sea level rise/storm surge
- PU: Precipitation Urban flooding
- PR: Precipitation Riverine flooding
- Heat: Extreme heat

To support consistent comparison of vulnerability scores across both planning horizons, the scores were normalized to a standard scale from **1 to 4 where a score of 1 represents lowest vulnerability and a score of 4 represents highest vulnerability.** This normalization allowed for meaningful ranking of assets by vulnerability



Critical Assets

Adaptive Capacity

2,500 0 2,500

Scale In Feet

- Medford
- Transportation
- Community Services
- Dams
- Emergency Services
- Food Distribution
- Hazardous Facilities
- Schools
- Utilities
- High Adaptive Capacity
- Medium Adaptive Capacity
- Medium-High Adaptive Capacity
- Low Adaptive Capacity

within and across planning horizons and are worded as follows:

Table 6: Normalized Vulnerability Scoring		
< 1.5	Low	Assets face minimal exposure or sensitivity to climate hazards and are generally well-positioned to withstand impacts.
1.5 - < 2.0	Medium	Assets have moderate vulnerability and may experience disruptions under certain hazard conditions.
2.0 - < 3.0	Medium - High	Assets are increasingly at risk, with limited adaptive capacity or higher exposure to multiple hazards.
> = 3.0	High	Assets are highly vulnerable and are likely to experience significant impacts during hazard events.

Vulnerability of Key Community Locations:

The key community locations within the City of Medford include buildings, facilities, services, natural resources. The vulnerability assessment reveals that, as of 2050, most assets are concentrated in the low to medium vulnerability categories, indicating a moderate overall risk level in the near term for 608 key community locations. However, projections for 2070 show a clear upward trend, with a growing number of assets shifting into the medium-high and high vulnerability tiers. This shift signals an increasing urgency for proactive climate adaptation planning. By 2070, the number of highly vulnerable assets increases significantly, particularly for heat and urban flooding. This underscores the urgency of forward-looking investments in resilience infrastructure, climate-responsive design, and hazard mitigation.

The increase in vulnerability is primarily driven by greater exposure to projected flooding and extreme heat, both of which are expected to intensify under future climate scenarios. Assets located in low-lying flood zones or urban heat islands are particularly at risk, especially when compounded by limited adaptive capacity, such as outdated infrastructure, lack of redundancy, or inadequate protective measures.

Key Findings by Asset Category

- **Emergency Services and Community Facilities** (e.g., fire stations, city buildings): These assets generally scored medium to medium-high vulnerability. Facilities with basement mechanical systems, limited flood defenses, or aging infrastructure were flagged for resilience upgrades because of their level of vulnerability.
- **Schools and Community Centers:** While many had moderate sensitivity, their potential role as shelters during emergencies makes them strategic priorities. Vulnerability increased for facilities located in high-heat zones or floodplains.
- **Utilities:** Water, sewer, and electric facilities showed some of the highest vulnerability scores, particularly where redundancy was limited and exposure to flooding or heat was severe.
- **Dams:** High hazard dams showed some of the highest vulnerability scores, particularly because of their level of hazard. Even for some of the climate hazards where the dam exposure is low (extreme heat for example), the vulnerability is still high because of their existing sensitivity and reduced adaptive capacity.
- **Natural Resources:** While structurally less vulnerable, these assets are critical for heat mitigation and stormwater management. Their scores highlight ecological sensitivity and the need to protect and integrate them into citywide adaptation strategies.
- **Hazardous Facilities and Food Distribution Sites:** These assets pose unique risks if compromised. Several were identified in high-risk flood zones, reinforcing the need for protective measures and contingency planning.

Vulnerability of City-Owned Assets:

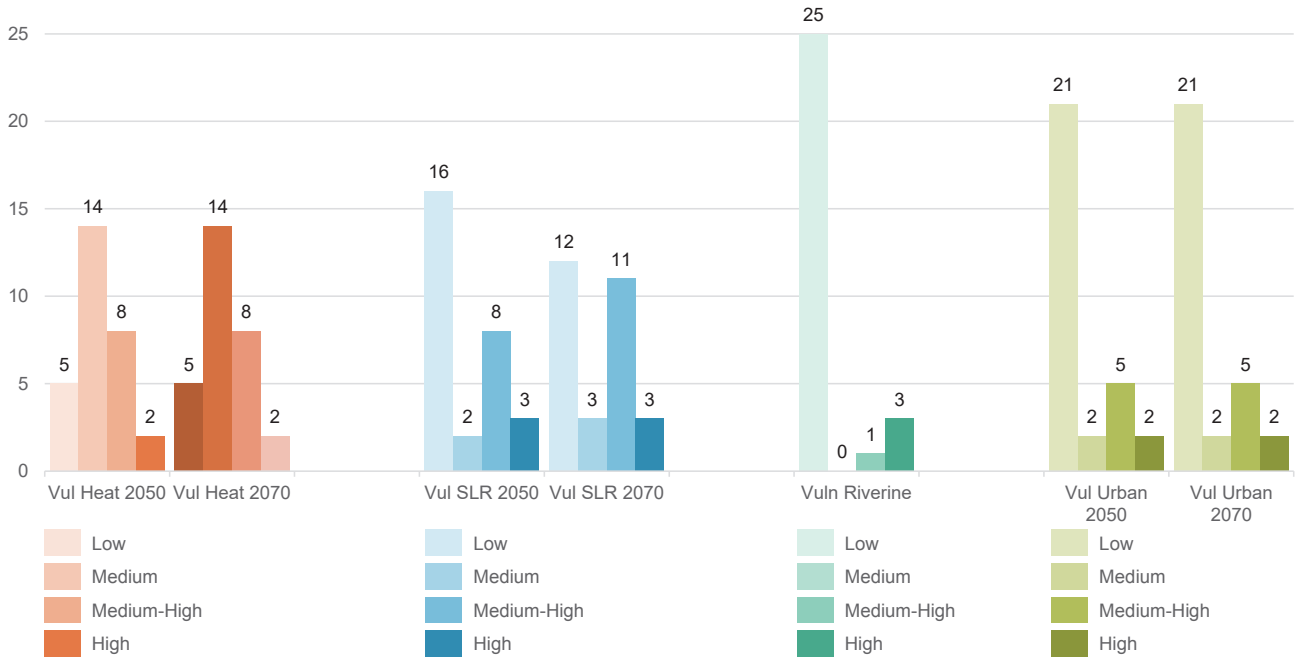
The assessment indicates that City-owned assets are generally less vulnerable compared to the broader asset base, where higher numbers of assets fall into medium vulnerability tiers in terms of total vulnerability. Among the hazards addressed in this study, extreme heat stands out as the most persistent and pressing threat as shown in Figure 19. In both 2050 and 2070, the number of assets in the high vulnerability category remains unchanged at 14. Likewise, medium-high vulnerability assets hold steady

at 8 in both years, suggesting that without intervention, these assets will remain highly exposed to temperature extremes. This trend underscores the urgent need for urban heat adaptation strategies such as increased vegetation, shaded structures, and cooling infrastructure in city facilities.

Sea level rise vulnerability among City-owned assets is projected to increase over time, with a decline in low-risk assets and a rise in medium and medium-high vulnerability by 2070, signaling growing exposure in coastal or low-lying areas. In contrast, riverine flooding presents minimal risk for most assets, with only a few located in flood-prone zones near rivers. Urban precipitation-driven flooding shows a stable pattern dominated by low-vulnerability assets, though small increases in higher-risk categories suggest localized stress points that may worsen with more intense rainfall.

Overall, the assessment illustrates a broad trend: while many City-owned assets are relatively well-positioned in terms of location and current adaptive capacity, vulnerability to climate hazards is increasing over time, particularly for extreme heat and sea level rise. This growing risk reinforces the importance of forward-looking adaptation measures tailored to each hazard.

Figure 19: *Vulnerability of City-Owned Assets by Hazard*

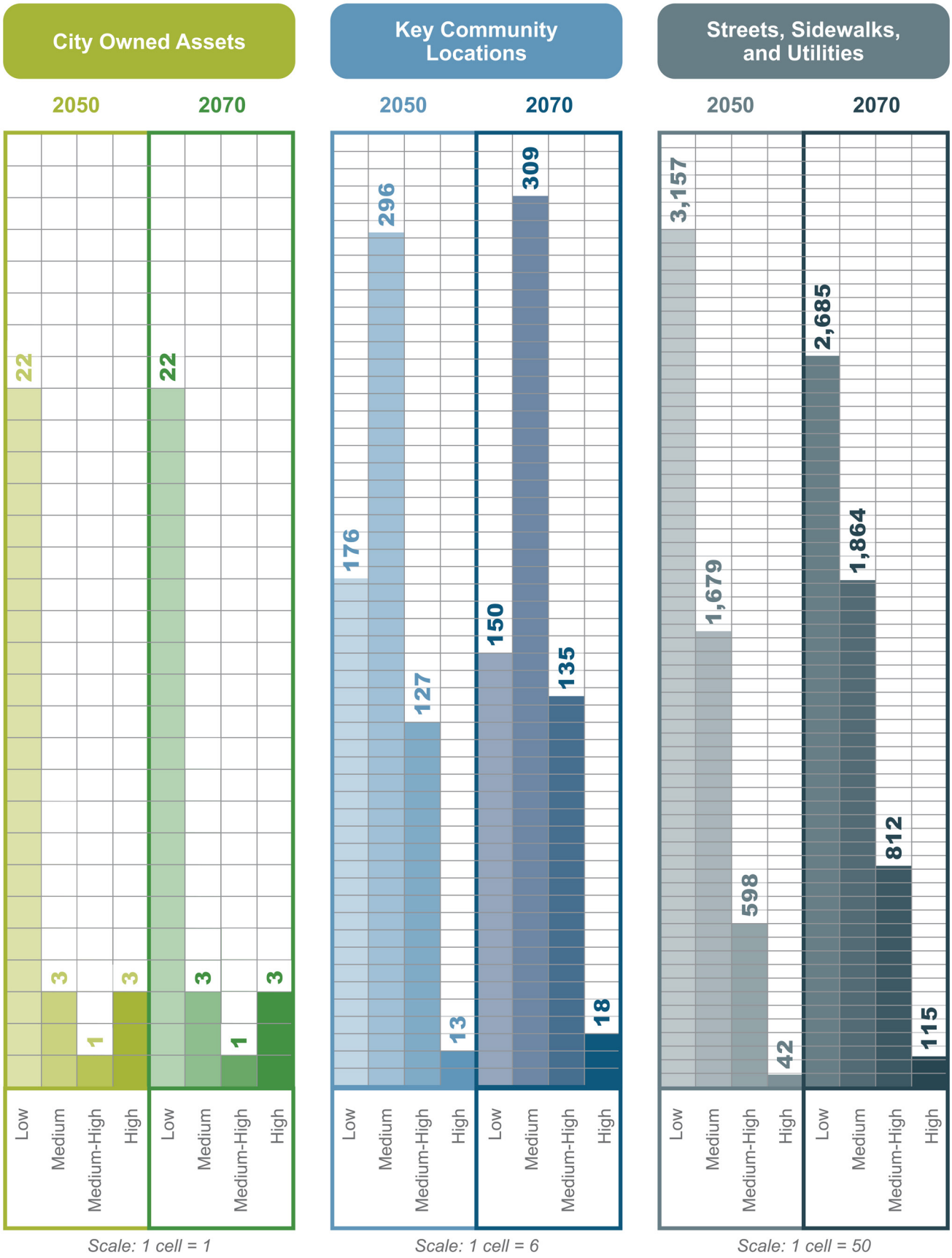


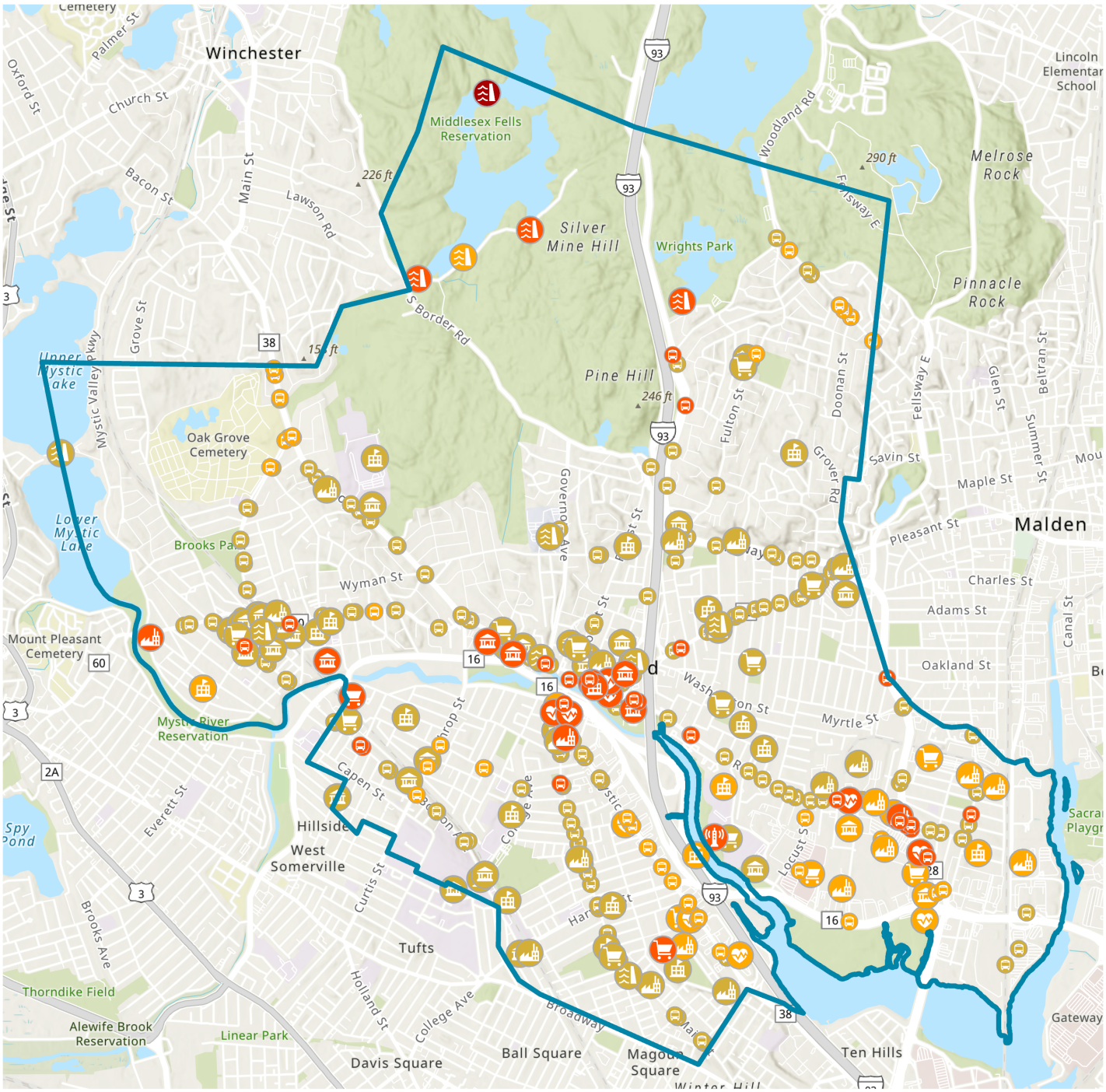
Vulnerability of Streets, Sidewalks, and Utilities:

Around 5,500 public assets in this category were evaluated to assess their vulnerability to climate-related hazards across two planning horizons of 2050 and 2070. Like other assets, vulnerability scores were derived by integrating each asset's exposure, sensitivity, and adaptive capacity, and normalized on a scale from 1 (low vulnerability) to 4 (high vulnerability). The vulnerability scores are listed under Appendix C.

- **The average vulnerability score** across the evaluated assets show an increasing vulnerability from 2050 to 2070, reflecting a general rise in climate vulnerability over time.
- **The range of vulnerability scores** remained consistent across both horizons, with minimum values of 1.0 and maximum values of 4.0, indicating that some assets are already highly vulnerable and will continue to be in the future.
- **The number of highly vulnerable assets** nearly triples from 42 in 2050 to 115 by 2070, highlighting critical locations where targeted resilience measures may be necessary.
- **The majority of assets** currently fall within the low to medium vulnerability range, which offers an opportunity for proactive intervention before conditions worsen.

TOTAL ASSET VULNERABILITY



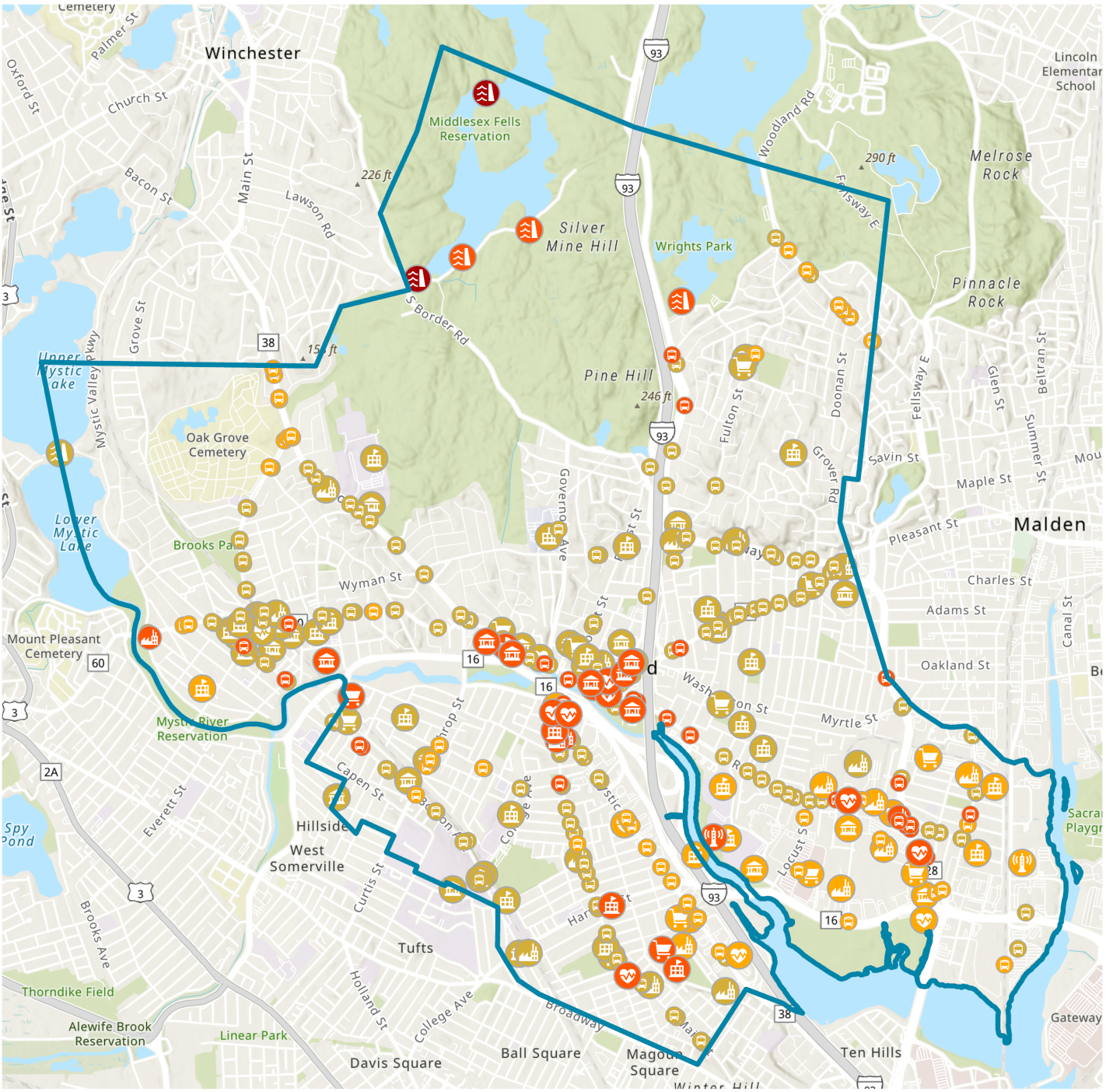


Critical Assets 2050 Vulnerability

Extreme Precipitation - Sea Level Rise/Storm Surge

2,500 0 2,500
Scale In Feet

- Medford
- Transportation
- Community Services
- Dams
- Emergency Services
- Food Distribution
- Hazardous Facilities
- Schools
- Utilities
- Low Vulnerability
- Medium Vulnerability
- Medium-High Vulnerability
- High Vulnerability

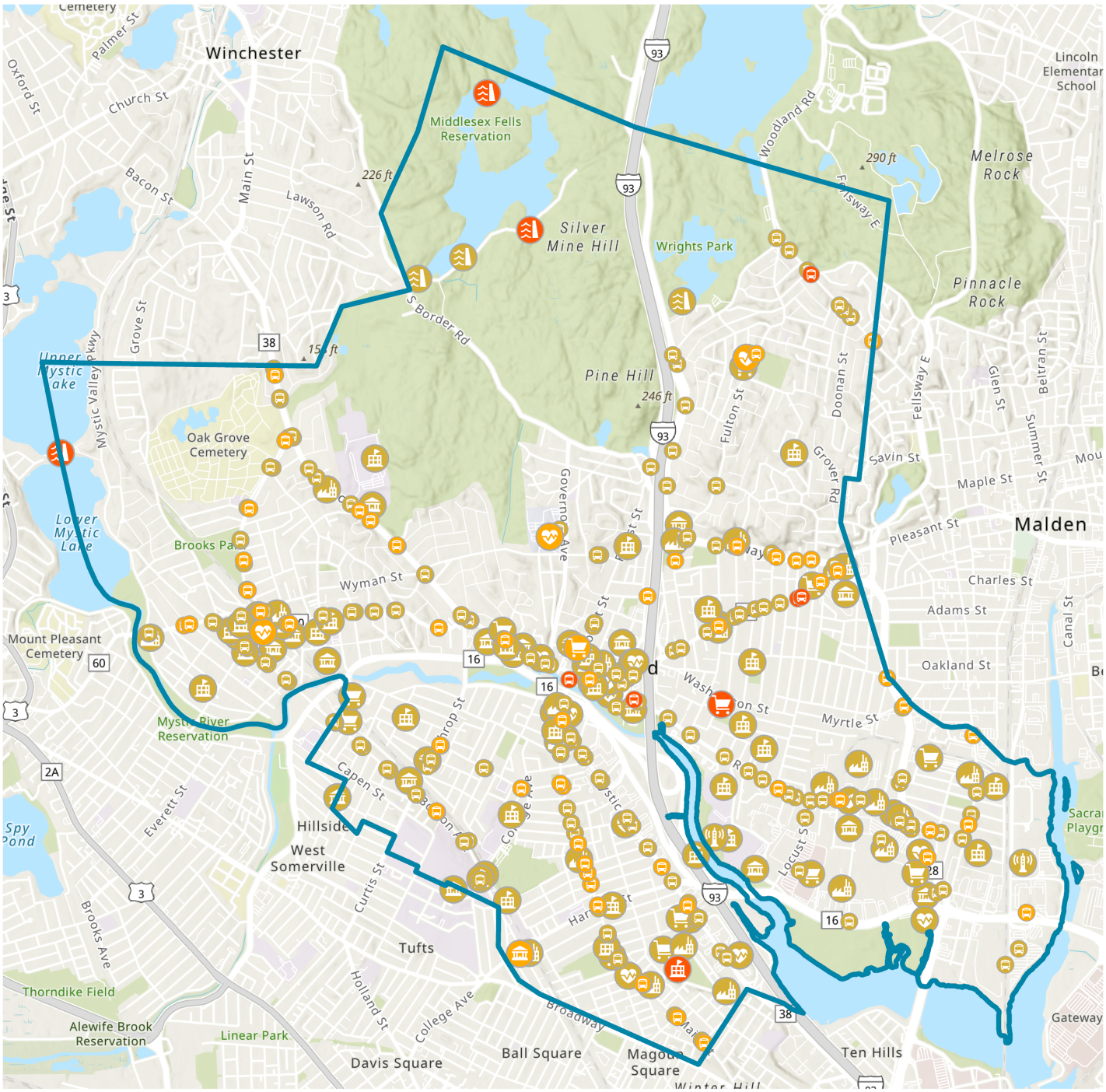


Critical Assets 2070 Vulnerability

Extreme Precipitation - Sea Level Rise/Storm Surge

2,500 0 2,500
Scale In Feet

- Medford
- Transportation
- Community Services
- Dams
- Emergency Services
- Food Distribution
- Hazardous Facilities
- Schools
- Utilities
- Low Vulnerability
- Medium Vulnerability
- Medium-High Vulnerability
- High Vulnerability



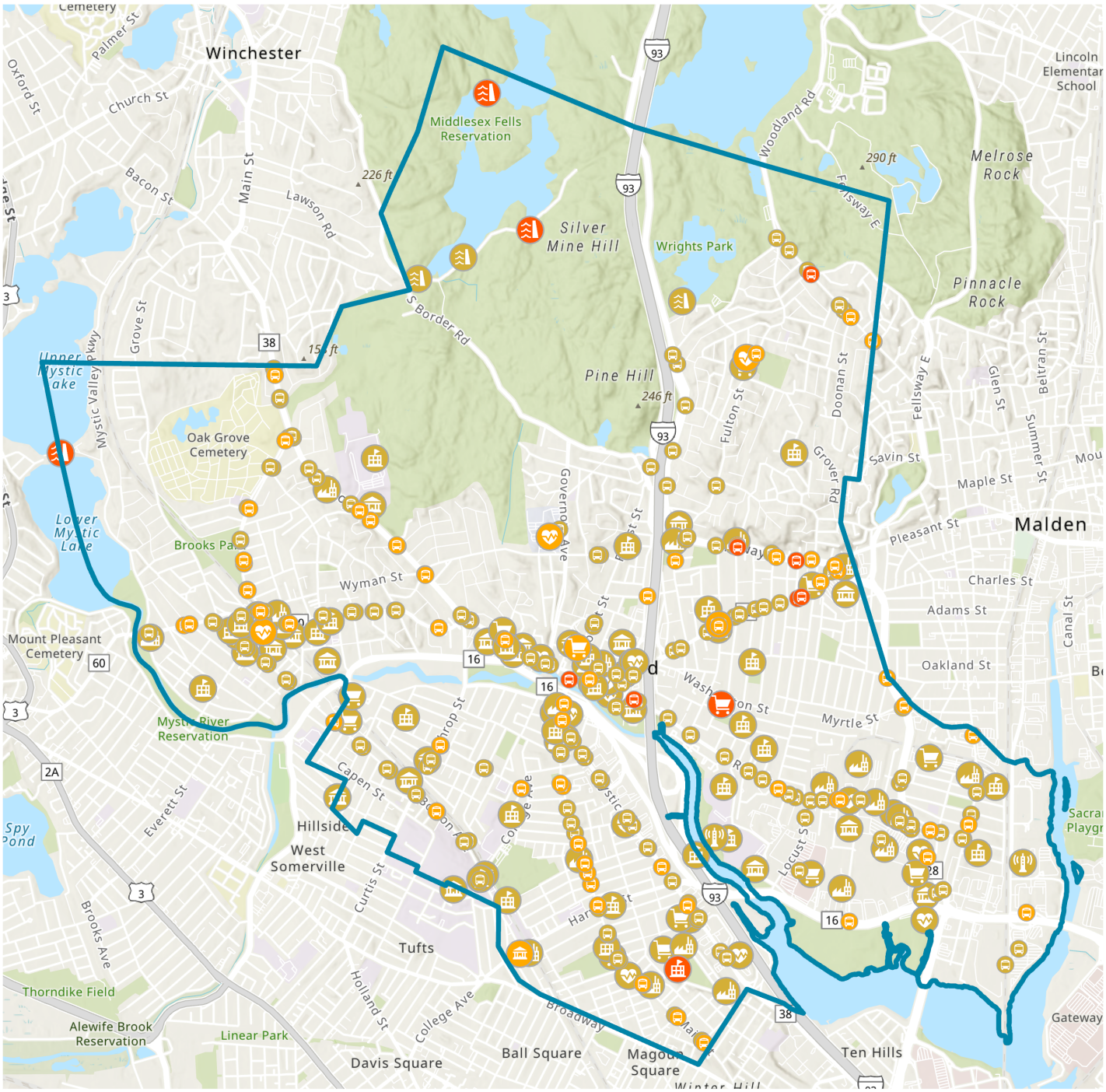
Critical Assets 2050 Vulnerability

Extreme Precipitation - Urban Flooding

2,500 0 2,500

Scale In Feet

- Medford
- Transportation
- Community Services
- Dams
- Emergency Services
- Food Distribution
- Hazardous Facilities
- Schools
- Utilities
- Low Vulnerability
- Medium Vulnerability
- Medium-High Vulnerability
- High Vulnerability



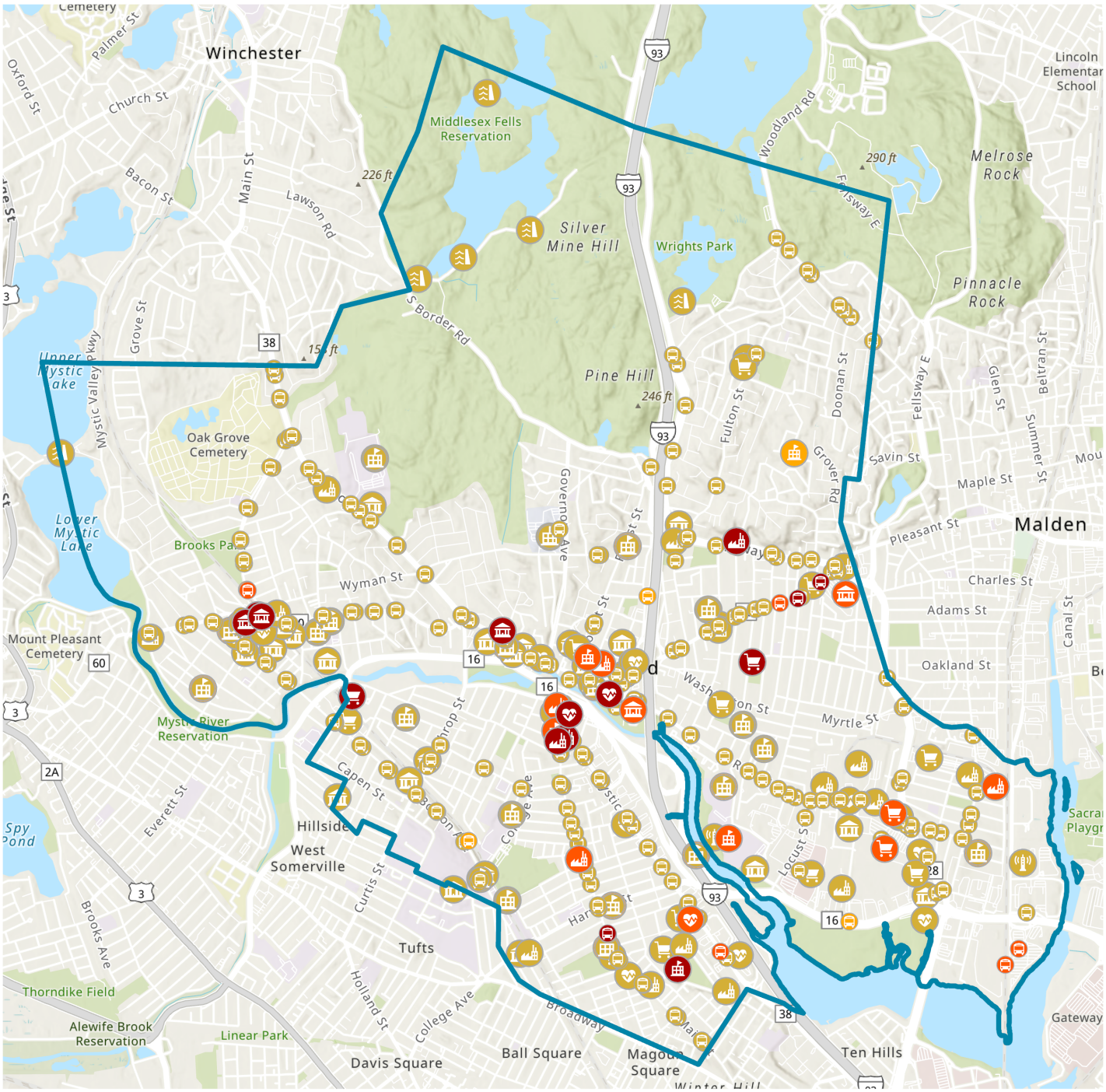
Critical Assets 2070 Vulnerability

Extreme Precipitation - Urban Flooding

2,500 0 2,500

Scale In Feet

- Medford
- Transportation
- Community Services
- Dams
- Emergency Services
- Food Distribution
- Hazardous Facilities
- Schools
- Utilities
- Low Vulnerability
- Medium Vulnerability
- Medium-High Vulnerability
- High Vulnerability



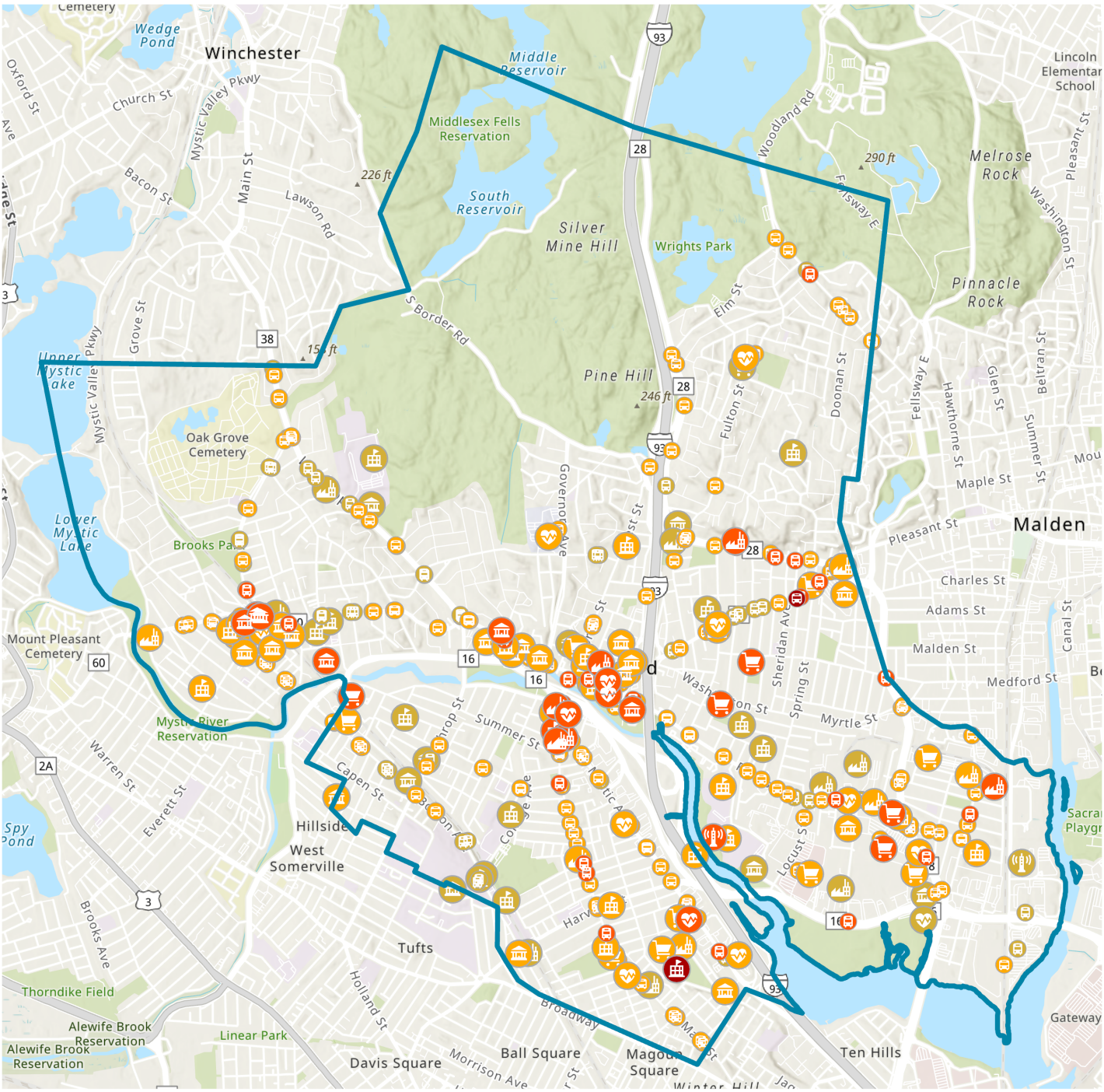
Critical Assets Vulnerability

Extreme Precipitation - Riverine Flooding

2,500 0 2,500
Scale In Feet

- Medford
- Transportation
- Community Services
- Dams
- Emergency Services
- Food Distribution
- Hazardous Facilities
- Schools
- Utilities

- Low Vulnerability
- Medium Vulnerability
- Medium-High Vulnerability
- High Vulnerability



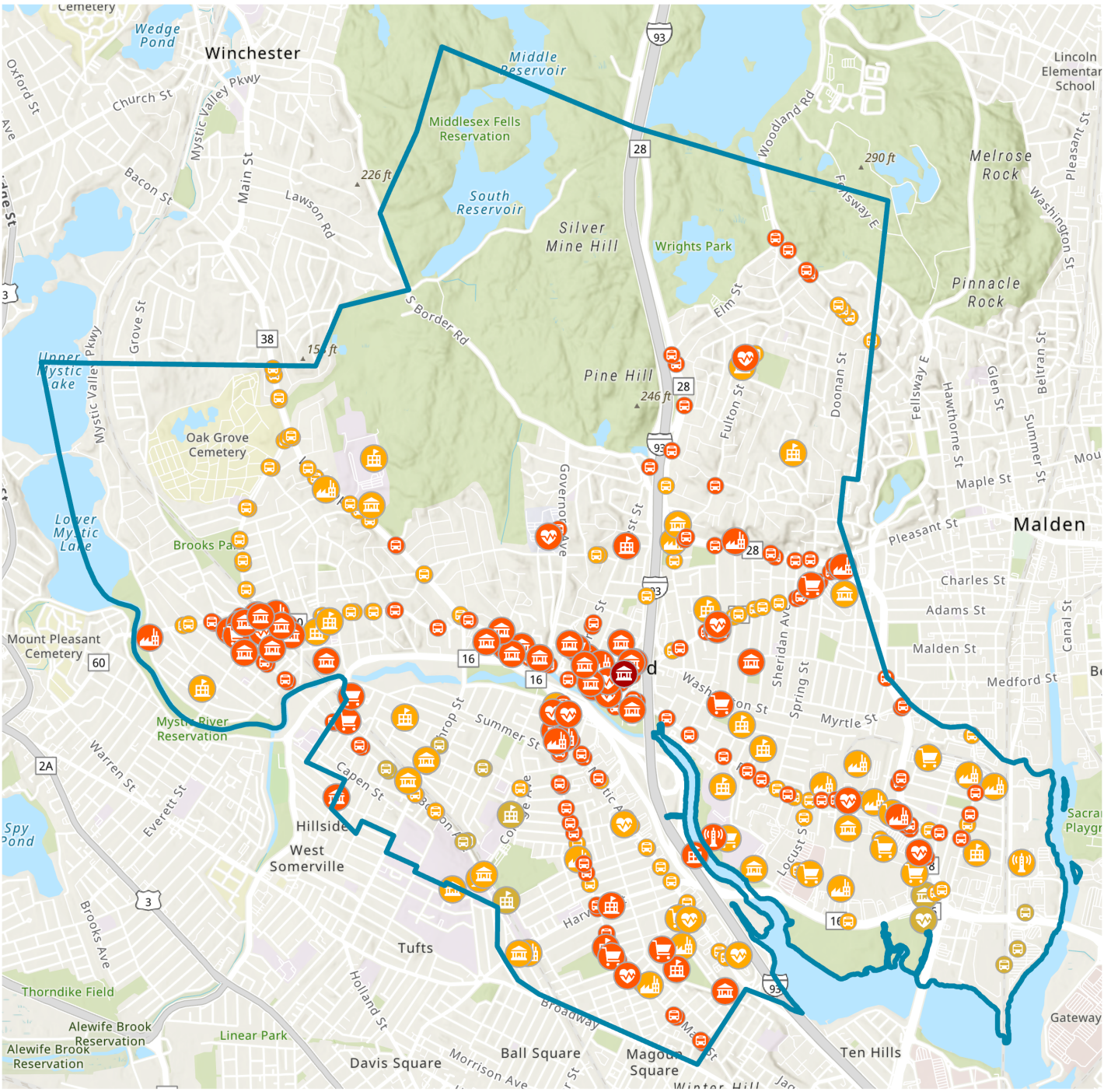
Critical Assets 2050 Vulnerability

Extreme Heat

2,500 0 2,500

Scale In Feet

- Medford
- Transportation
- Community Services
- Dams
- Emergency Services
- Food Distribution
- Hazardous Facilities
- Schools
- Utilities
- Low Vulnerability
- Medium Vulnerability
- Medium-High Vulnerability
- High Vulnerability

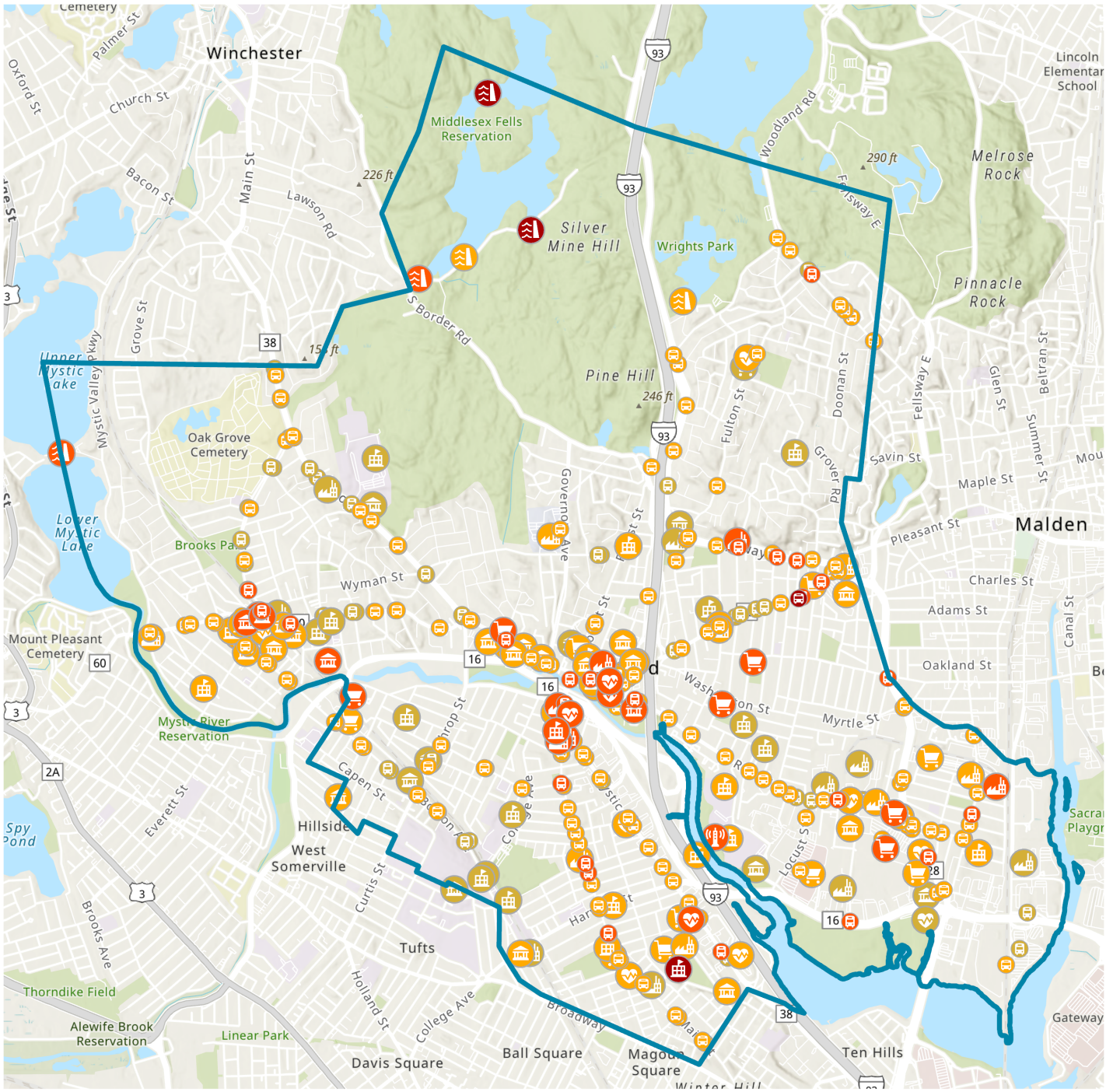


Critical Assets 2070 Vulnerability

Extreme Heat

2,500 0 2,500
Scale In Feet

- Medford
- Transportation
- Community Services
- Dams
- Emergency Services
- Food Distribution
- Hazardous Facilities
- Schools
- Utilities
- Low Vulnerability
- Medium Vulnerability
- Medium-High Vulnerability
- High Vulnerability



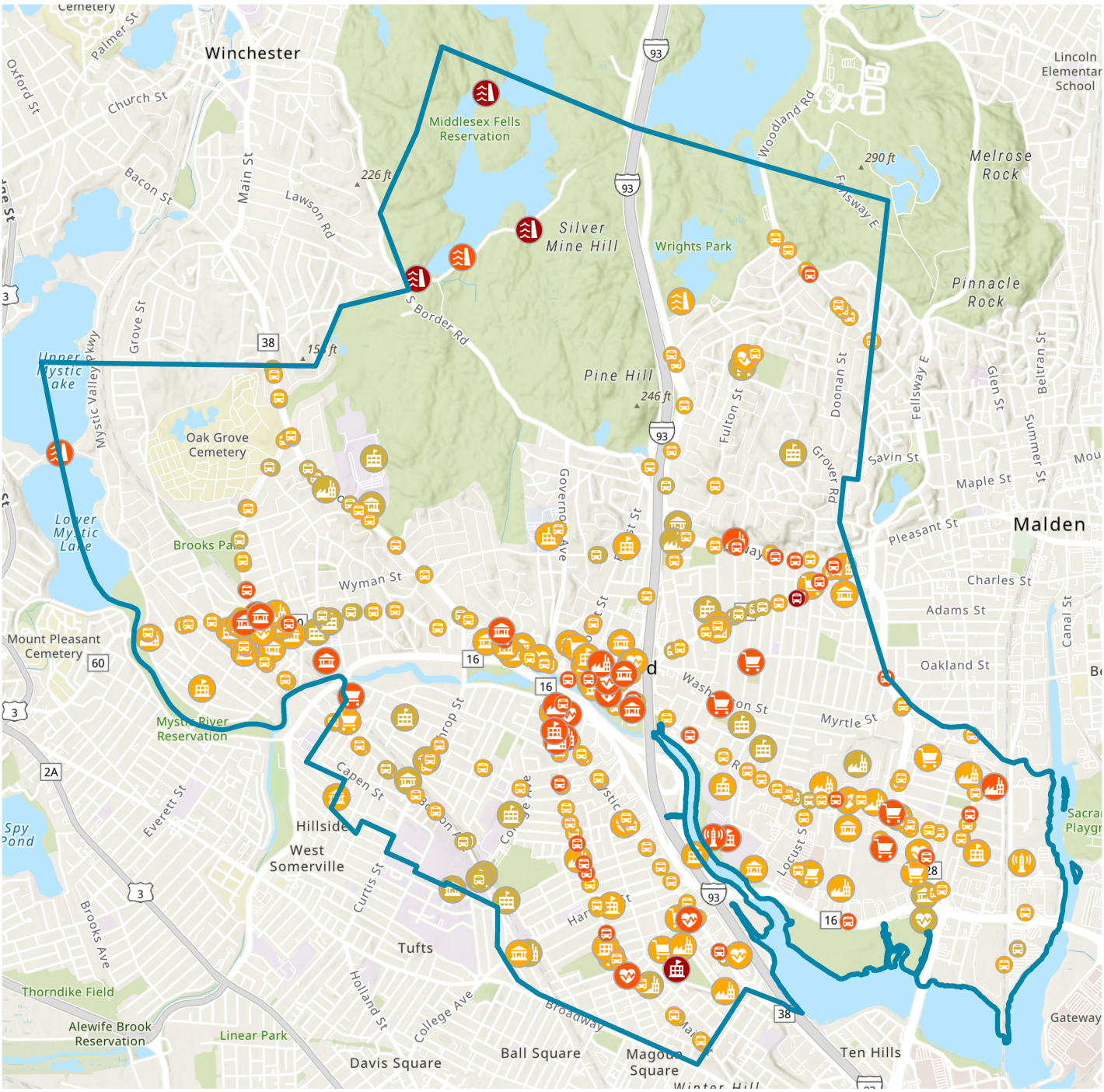
Critical Assets 2050 Vulnerability

Total Vulnerability

2,500 0 2,500

Scale In Feet

- Medford
- Transportation
- Community Services
- Dams
- Emergency Services
- Food Distribution
- Hazardous Facilities
- Schools
- Utilities
- Low Vulnerability
- Medium Vulnerability
- Medium-High Vulnerability
- High Vulnerability



Critical Assets 2070 Vulnerability

Total Vulnerability

2,500 0 2,500

Scale In Feet

- Medford
- Transportation
- Community Services
- Dams
- Emergency Services
- Food Distribution
- Hazardous Facilities
- Schools
- Utilities
- Low Vulnerability
- Medium Vulnerability
- Medium-High Vulnerability
- High Vulnerability

2.6 Summary

The vulnerability assessment demonstrates that Medford's climate risk is projected to intensify by 2070, with a growing number of assets shifting into higher vulnerability categories over time.

- **Most assets** currently fall in the low to medium vulnerability range across the hazards addressed in this study in 2050. However, these change markedly by 2070, with a significant increase in the number of assets classified as medium-high or high vulnerability, particularly for heat and flooding hazards.

- **This rise in vulnerability** is driven by increasing climate exposure (e.g., higher temperatures, more intense storms), compounded by structural sensitivity (e.g., aging infrastructure, basement utilities), and limited adaptive capacity (e.g., lack of backup power or flood protection).

- **For example, among streets, sidewalks and utilities alone**, the number of assets with high vulnerability nearly triples from 42 in 2050 to 115 in 2070.

- **The most at-risk asset categories include:**
  - **Utilities and emergency services**, which are essential for public health and safety.
  - **Schools and community centers**, which serve as shelters and service hubs.
  - **Dams**, where even minor climate exposure translates to high overall vulnerability due to their hazard classification and infrastructure condition.
  - **Natural resources and food distribution centers**, which face both ecological and operational risks.

By using a normalized 1–4 scale and applying a consistent methodology across asset types, the assessment allows for direct comparison and prioritization of adaptation needs. **The results are intended to inform the City's capital planning, emergency preparedness, and future updates to its Hazard Mitigation Plan and MVP strategies.**



Photo from Weston & Sampson

3. Climate Change Impacts on Medford's Communities

Increased heat, precipitation, and sea level rise all pose risks to people in Medford, as is outlined in the Massachusetts Climate Adaptation Report.[81] These risks will present even greater challenges for people who are vulnerable for other reasons, such as low-income households or people with disabilities.

We will first describe some of the consequences that residents could face when exposed to these hazards. Both community stakeholders and Medford residents expressed concern about these negative impacts that climate-related hazards will have on public health, as well as the social and economic wellbeing of the City.

In the next section we will discuss the groups in Medford that will be most vulnerable to these impacts, in order to inform our forthcoming adaptation plan and prevent these vulnerabilities from becoming reality. Community stakeholders and residents have also identified engagement with these vulnerable populations as a top priority as the City transitions into climate change adaptation planning to meet community needs.

The information in this assessment is not meant to be exhaustive, but instead provides a starting point for further dialogue with residents about how Medford can plan for and adapt to climate vulnerabilities in an equitable way.



Community members exploring and exhibiting at Medford's Harvest Your Energy Festival.

From Vulnerabilities to Adaptations!

The Medford Conversations Project is in its third year of active organizing with a vision that "Building a stronger Medford starts with open conversations about the issues impacting our communities." It is a volunteer organization that arranges small discussion circles guided by trained facilitators to talk about issues impacting our community. Recognizing the long-term value of this type of community-building, the Project is supported by the City and Tufts University through staff time and grants to help move the project forward.

a. Heat-Related Community Impacts

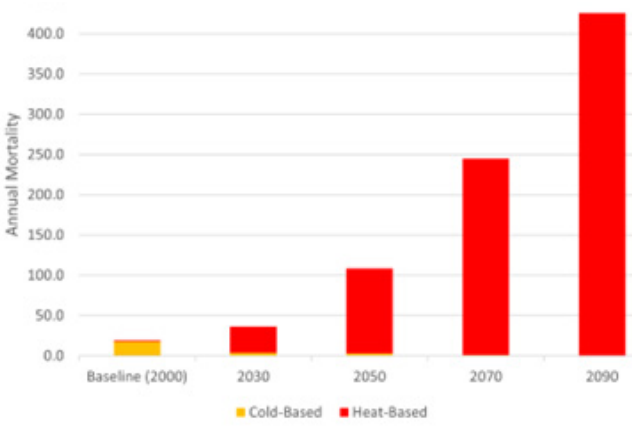
Extreme heat poses a known and quantifiable health risk to Medford residents. Heat can cause health problems including heat exhaustion, heat stroke, and heat cramps, and can exacerbate existing medical conditions such as asthma, heart disease, and diabetes.

Data from the Centers for Disease Control (CDC) show that 31% of deaths resulting from extreme weather are related to heat, whereas 6% are related to storms, flooding, and lightening combined. The remaining percentage accounts for deaths from extreme cold.[78]

Extreme heat is often accompanied by stagnant air, resulting in higher levels of air pollutants like ground level ozone. This can exacerbate respiratory and cardiovascular health risks.[79] The risk to human health increases in a heat wave, which is defined locally as when the temperature reaches 90°F or above on at least three consecutive days (see Section B, part 1. “Rising Temperatures” for more information).

Projected deaths from heat

Figure 20: *Projected annual deaths from temperature-related mortality from the 2022 MA Climate Assessment.*[82]



Higher temperatures and longer heat waves also mean greater electricity consumption for cooling, which raises overall energy demand on the electricity grid and results in higher cooling costs for individual households and businesses.

People who do not have access to air-conditioned spaces, who normally get around by walking or riding a bicycle, or who work primarily outdoors, will be disproportionately exposed to heat hazards. They might switch to cars, which use more fossil fuels, or stay inside, which increases social isolation. People who do not have either of these options will risk hyperthermia, dehydration, and heat stroke. People who live in parts of Medford that are considered urban heat islands due to fewer trees and lots of paved surfaces, such as near Medford Square, Wellington, and South Medford, will be most exposed to heat hazards.

Extreme heat and increased periods of drought are not expected to have major impacts on Medford’s drinking water supply because of existing climate resiliency work that is being done by the Massachusetts Water Resources Authority (MWRA) which provides our water (see Section C, part 1.c. “Climate Change Impacts on Critical Infrastructure: Utilities: Drinking Water and Sanitary Sewer”). However, the trees and plants that keep Medford cool will be under much greater stress from future extreme heat and drought.[80] Plant species that traditionally grow well in Medford will be subject to new invasive insects, diseases, and heat stress. Any decreases in the city’s tree canopy or the health of the vegetation will contribute to the urban heat island effect and cause greater heat stress for people.

b. Flooding-Related Community Impacts

Increased precipitation and sea level rise will affect the well-being of people in Medford, especially people who are already vulnerable in other ways, including low-income residents, non-English speakers, and people with disabilities. Residents may experience flooded homes, leading to displacement for both owners and renters, and to the loss of personal property. Flooding can also damage and disrupt use of public infrastructure, and can bring health problems.

With increased precipitation and sea level rise, more frequent and severe flooding will impact populations in Medford. For renters and property owners alike, flooding may lead to displacement, personal property damage, or property loss. Furthermore, properties located in chronic flood zones lose value, which can have an economic impact on homeowners.

Flooding of homes results in significant disruption to people's lives, including the need to pay for hotels, stay with friends or rely on local shelters. Flood damage can displace residents for extended periods of time, as electrical systems, heating and cooling systems, and appliances can be ruined by water. Extended displacement causes both economic and emotional stress for residents.

Flooding can destroy cars and disrupt public transit systems, affecting residents' ability to get around. If electrical lines are downed in a heavy storm, people may lose electricity or heat/cooling at home. If roads are flooded and bus service is limited, people might not be able to get to work or school: data for 2016 from the U.S. Census American Community Survey indicate that on average, Medford residents over age 16 have a 32-minute commute to work.[83] Roughly 70% of those commuters drive to work, 19% use public transit, and over 5% walk to work. Flooded roads and interrupted public transit service may also prevent some residents from accessing emergency services. Wheelchair users may be completely homebound when sidewalks are flooded.

Flooding in Medford at the intersection of Princeton Street and Radcliffe Street after 1/2 inch of rainfall in fifteen minutes, August 2017.



Image by John Gravelin.

Flooding, when serious enough, can cause death, injuries, and illness. It can cause chemical leaks and sewage backups that expose people to a variety of harmful contaminants. Standing water causes substantial harm to health from mold growth, which can continue growing after most of the water subsides. Standing water also attracts insects that can potentially carry diseases.

c. Vector-Borne Disease

Insects and animals that can spread diseases, such as ticks, mosquitoes, and mice, tend to thrive in warmer weather, so their populations may grow in Medford as temperatures increase.

Higher temperatures in Medford will also lead to larger insect populations, as some species begin to thrive in our region that could only previously live farther south. Additionally, their predators may migrate on a different timeline, resulting in uneven ecological balances. The anticipated shorter, milder winters, earlier springs and longer summers may introduce more vector-borne diseases to New England. As is mentioned in the flooding section above, increased amounts of standing water from flooding and new chronic flood areas will also attract insects like mosquitoes that can potentially carry diseases.

In Massachusetts, Lyme disease, babesiosis, human granulocytic anaplasmosis, tularemia, and Rocky Mountain spotted fever are spread by ticks. West Nile virus and Eastern Equine Encephalitis virus are spread by mosquitoes; the most dangerous disease among these is Eastern Equine Encephalitis.[84] Mice and rat populations also increase in warmer and wetter weather.

d. Psychological Impacts

Climate change is stressful. When there are so many changes to our surroundings, we may feel more fearful and less in control of our own lives. Climate hazards thus take a toll on psychological wellbeing.

Definitions

Vector: A vector is "any organism—such as fleas, ticks, or mosquitos—that can transmit a pathogen, or infectious agent, from one host to another."[86]

Research by the American Psychological Association (APA) describes the acute and chronic mental health affects resulting from climate change. The APA indicates that psychological stress can weaken the immune system and lead to physical health problems "such as memory loss, sleep disorders, immune suppression, and changes in digestion."[85] Some of these psychological effects from climate change include anxiety from increased uncertainty around extreme weather, a sense of helplessness and depression when faced with rapid changes, and strains on social relationships and communities if people need to move or change jobs because of extreme weather.



Image by André Karwath.

Deer tick magnified in comparison to a matchstick. Deer ticks are prevalent in the northeast and are the primary transmitter of Lyme disease.

4. Social Vulnerability

When we say that some groups in Medford may be more impacted by climate change hazards, we mean that these groups are more socially vulnerable than others. In the context of climate change, socially vulnerable groups are defined as those that are disproportionately susceptible to the effects of climate hazards and who have the least ability to adapt.

While climate change is affecting everyone in Medford, existing vulnerability caused by long-standing patterns of poverty, systemic racism, segregation, gentrification, lack of political representation, weak or nonexistent social networks and connections, physical limitations, and quality of built infrastructure around people make some people more vulnerable than others.

There exists a need to understand how these long-standing patterns affect people in Medford, and how city government can better work alongside people most affected by these patterns in order for all community members and institutions to truly become climate change resilient.



Pedestrians waiting for the light to turn to cross Medford Square.

From Vulnerabilities to Adaptations!

This information will help the City to evaluate how to work with community members to decrease physical vulnerabilities to climate change, design better systems of communication, provide information so residents can plan for themselves, and other forms of support.

The objective of our social vulnerability assessment is to identify where social vulnerabilities in Medford from heat, flooding/precipitation, vector-borne diseases, and mental health overlay with our city's physical vulnerabilities, described in the previous section on vulnerable infrastructure.

4.1 Data Sources

In order to assess social vulnerability in Medford, we relied on a combination of census data and interviews with organizational leaders across the city who work with and/or are members of socially vulnerable populations.

The following individuals were interviewed for their expertise and experience with a wide variety of communities within Medford:

- **Arthur Botelho**, St. Raphael Church Food Pantry
- **Marie Cassidy**, Family Specialist, Medford Family Network
- **Pastor Edson**, Igreja Assembleia de Deus Vida
- **Bill Hager**, Executive Director, West Medford Community Center
- **Pam Kelly**, Director of Elder Affairs, Medford Council on Aging
- **Alison Kuah**, Youth Programs Coordinator, The Welcome Project
- **Syrah McGivern**, Mass in Motion Coordinator, City of Medford
- **Neil Osborne**, Director of Diversity & Inclusion, City of Medford
- **Rachel Tanenhaus**, Chair, Medford Commission for Persons with Disabilities
- **Lisa Tonello**, Ross Coordinator, Medford Housing Authority

Definitions

Social Vulnerability: A combination of characteristics that weaken a population's ability to prepare for, withstand, and recover from a disaster, including poverty status, racial or ethnic minority, employment opportunities, etc.[92]

This assessment aligns social vulnerability with definitions from state and federal Environmental Justice (EJ) policies, the Metro Mayors Climate Preparedness Task Force, and the U.S. Census.

The Massachusetts Environmental Justice (EJ) Policy states that "all communities must have a strong voice in environmental decision-making regardless of race, color, national origin, income, or English language proficiency," and that increased attention should be paid to "residents who have elevated rates of disease and health burdens."[87] This policy and other Environmental Justice efforts address the fact that people in racial and minority ethnic groups, and people with an income below 65% of the area median income are more likely to live in or near areas that pose an environmental hazard (including hazards from climate change), while also having lower access to health services.[88]

A note on social vulnerability data

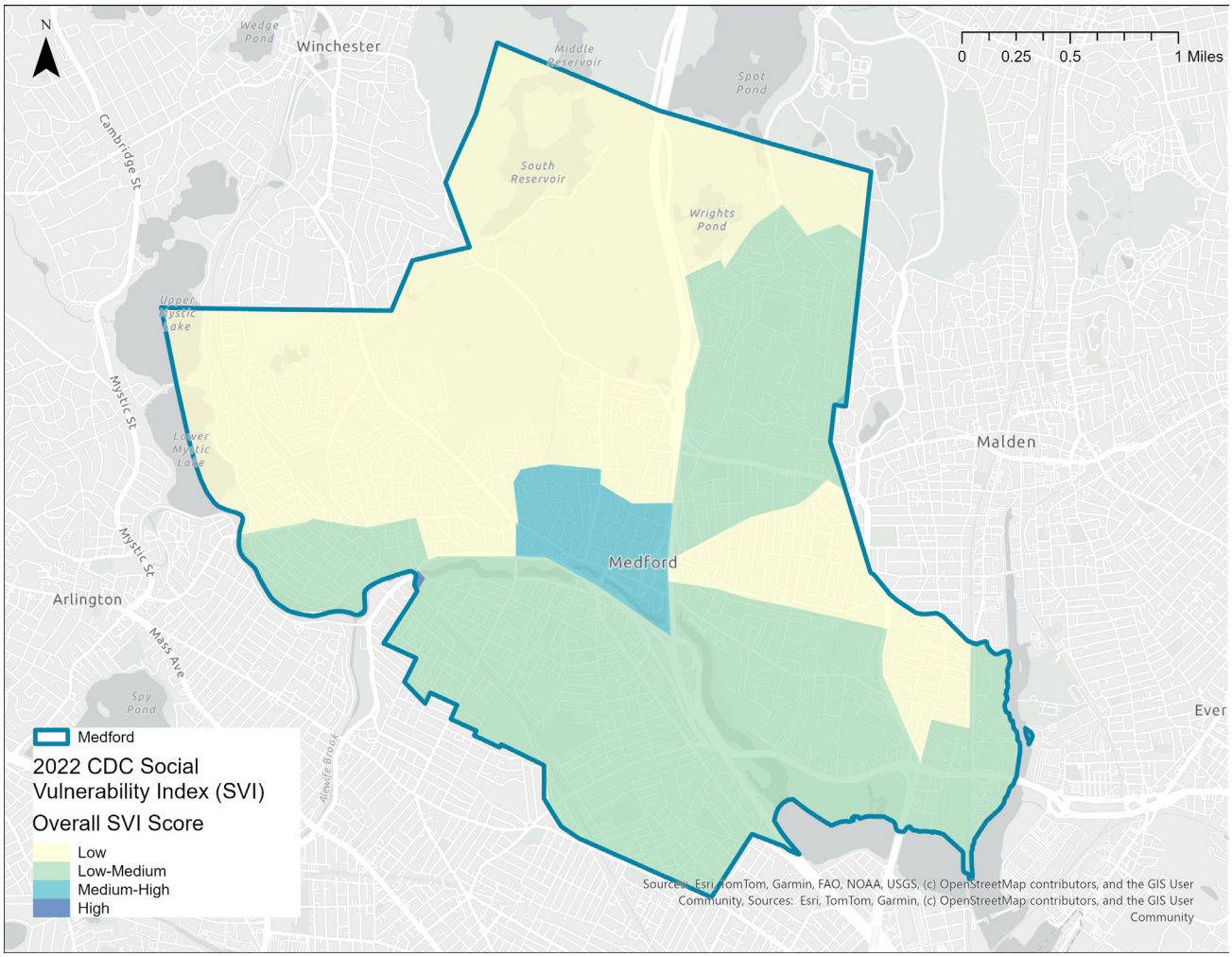
The maps and tables included in this section reflect census data, but many interviewees reported that various types of social vulnerability are not geographically concentrated in our city outside of Medford Housing Authority buildings. Caution is therefore advised in giving too much weight to maps, but they are presented here as part of the available data. More work remains to be done to gain a deeper understanding of social vulnerability in Medford. The city's climate adaptation planning process will include space for both public collaboration and participation.

To align with analyses from other communities involved in the Greater Boston's Metro Mayors Climate Preparedness Task Force, we use the following categories to illustrate **social vulnerability** in Medford:

- Adults over 65 years old;
- Children under 5 years old;
- People whose primary language(s) are not English;
- People of color, including anyone who identifies as multiracial or with any racial group besides white/ European and anyone who identifies as ethnically Hispanic;
- People with low or moderately-low income;
- People with less than a high school education; and
- People living with disabilities.[89]

Communities with high social vulnerability in Medford

Figure 21: *Map of Social Vulnerability in Medford from the Center for Disease Control's (CDC) Social Vulnerabilty Index. This map considers different categories of social vulnerability and shows which areas of Medford have the highest concentrations overall of socially vulnerable populations.*[93]



Statewide data reflects that in Medford, 39% of residents reside in a census block group where one or more of the Environmental Justice criteria are met.[90]

Figure 21 indicates that there are several census block groups in Medford where there is a concentration of people that belong to more than one vulnerable group, with larger concentrations of Environmental Justice populations in the southern half of the city. Each of the areas highlighted in the map reflect areas where at least 25% of residents fall into the areas of social vulnerability outlined in the map legend.[91]

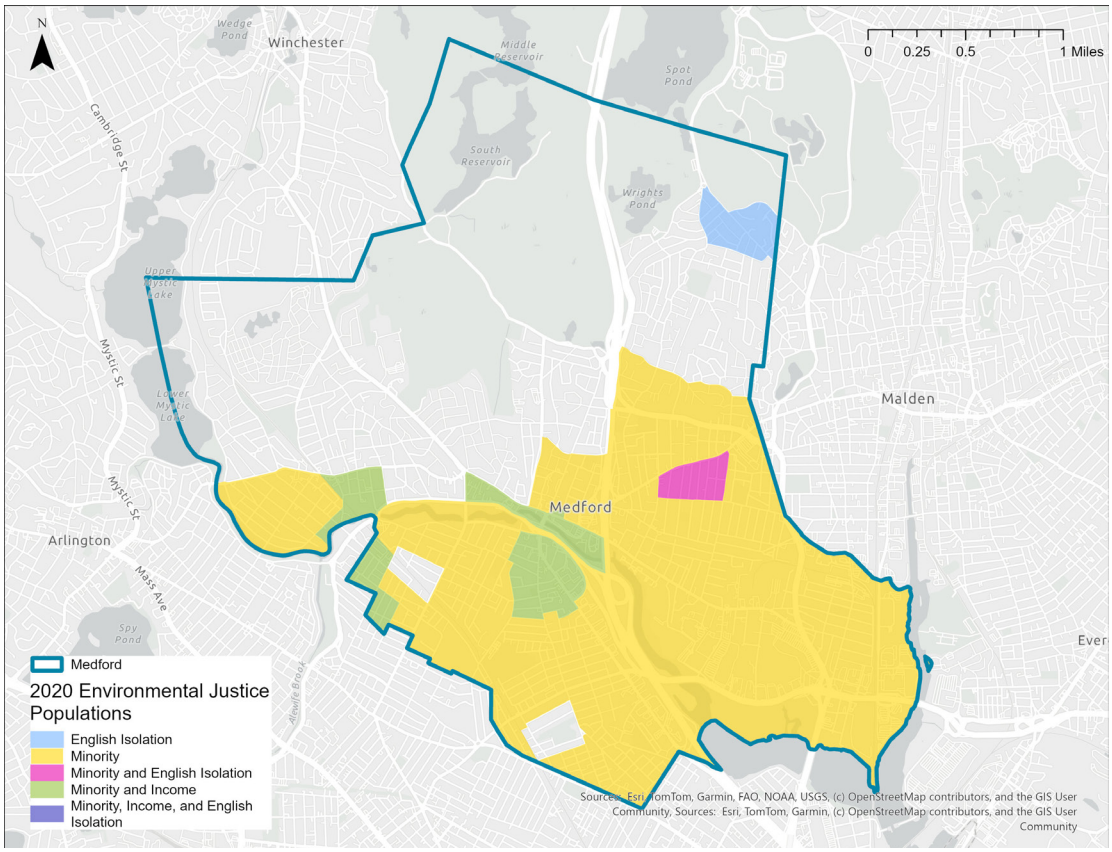
Definitions

Environmental Justice Neighborhoods: The Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA) defines Environmental Justice neighborhoods as census block groups where at least one of the following is true:

- Median annual household income is at or below 65% of the statewide median income;
- 25% or more of the residents are a racial or ethnic minority; or
- 25% or more of the residents are not fluent in the English language.

Environmental Justice populations in Medford

Figure 22: *Map of 2020 Massachusetts Environmental Justice (EJ) data by census block group highlights areas in Medford where 25% or more of the population meets criteria that increase vulnerability to climate change impacts, such as low income, minority status, or limited English proficiency.*[94]



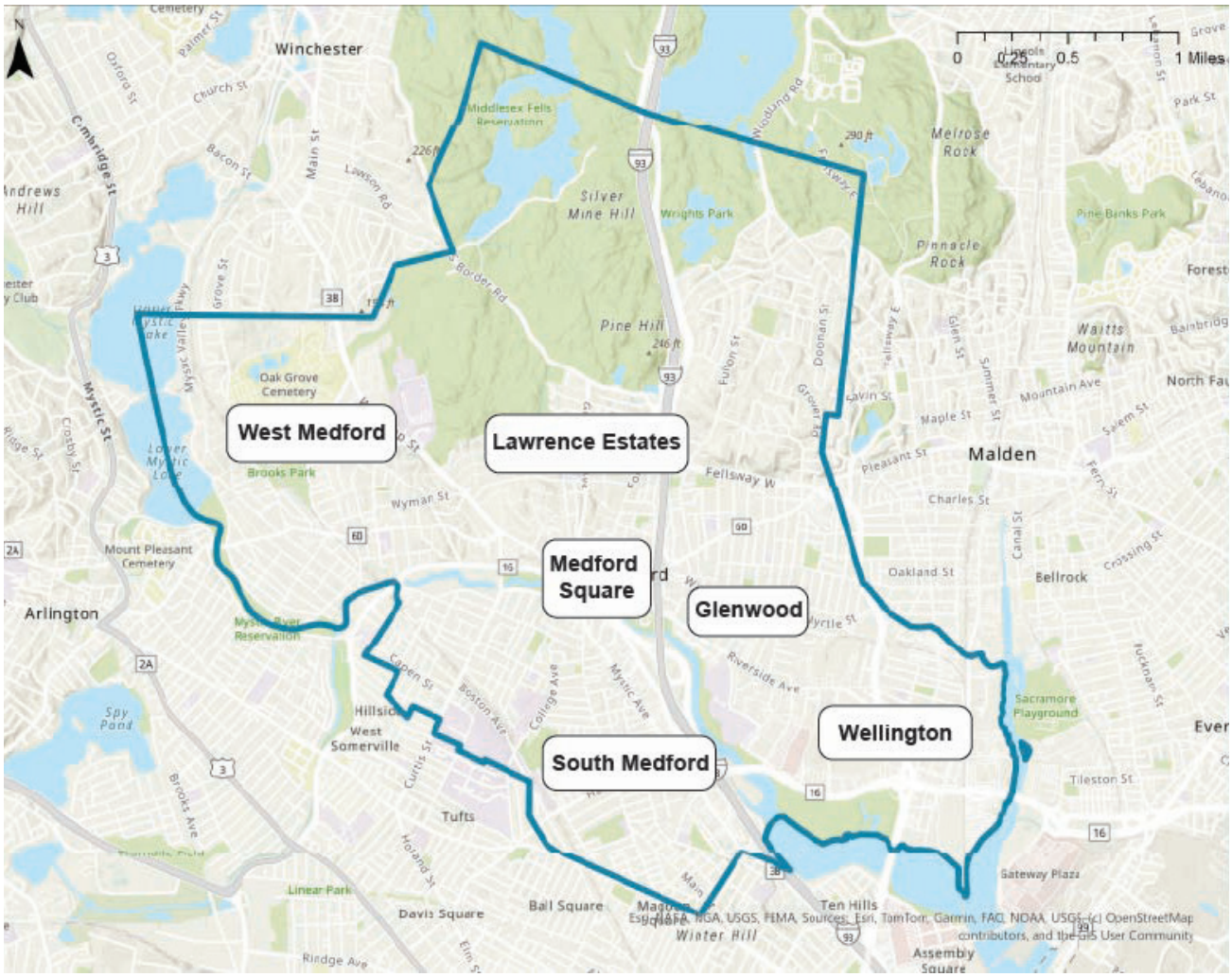
4.2 Geographic and Social Vulnerability: Priority Neighborhoods

When Environmental Justice data from EJ Screen and the Social Vulnerability Index is placed beside maps on flood and heat vulnerability from previous sections of this report, we see that there are areas of Medford where social vulnerability and geographic vulnerability overlap.

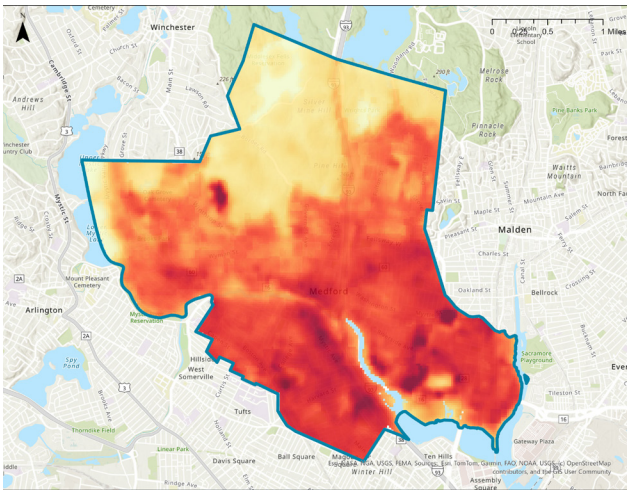
This indicates that in the case of our city, people with existing social vulnerability will be the first ones affected by extreme heat and flooding over time. Glenwood, Medford Square, South Medford, Wellington, part of West Medford, and Lawrence Estates stand out as neighborhoods with overlapping physical and social vulnerability to climate change.

Areas in Medford where social and geographic vulnerability overlap

Figure 23: *Map of Medford neighborhoods where social and physical vulnerabilities overlap.*[95]



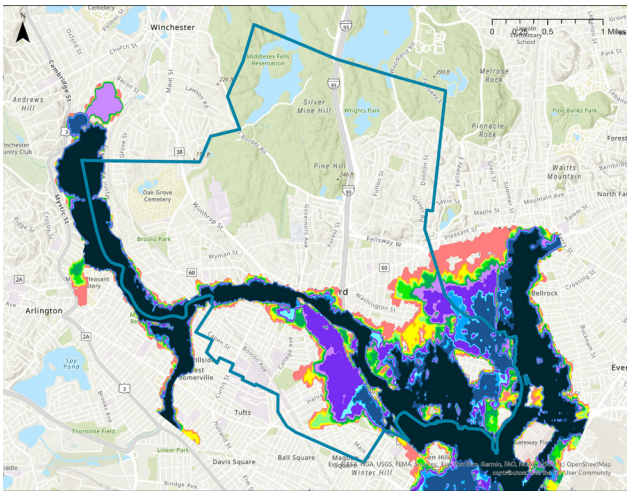
Heat Island Effect



Average Daytime Land Surface Temperature (LandSat)

- High : 139.746
- Low : 64.0012

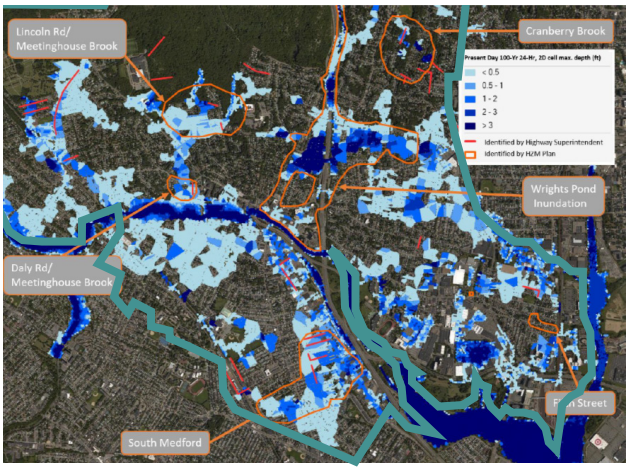
Flood Probability



2070 Coastal Flood Exceedance Probabilities

- Dry
- 0.1%
- 0.2%
- 0.5%
- 1%
- 2%
- 5%
- 10%
- 20%
- 25%
- 30%
- 50%
- 100%

Flood Prone Areas



Present Day 100-Yr 24-Hr, 2D cell max. depth (ft)

- < 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- > 3
- Identified by Highway Superintendent
- Identified by HZM Plan

4.3 Vulnerable Populations

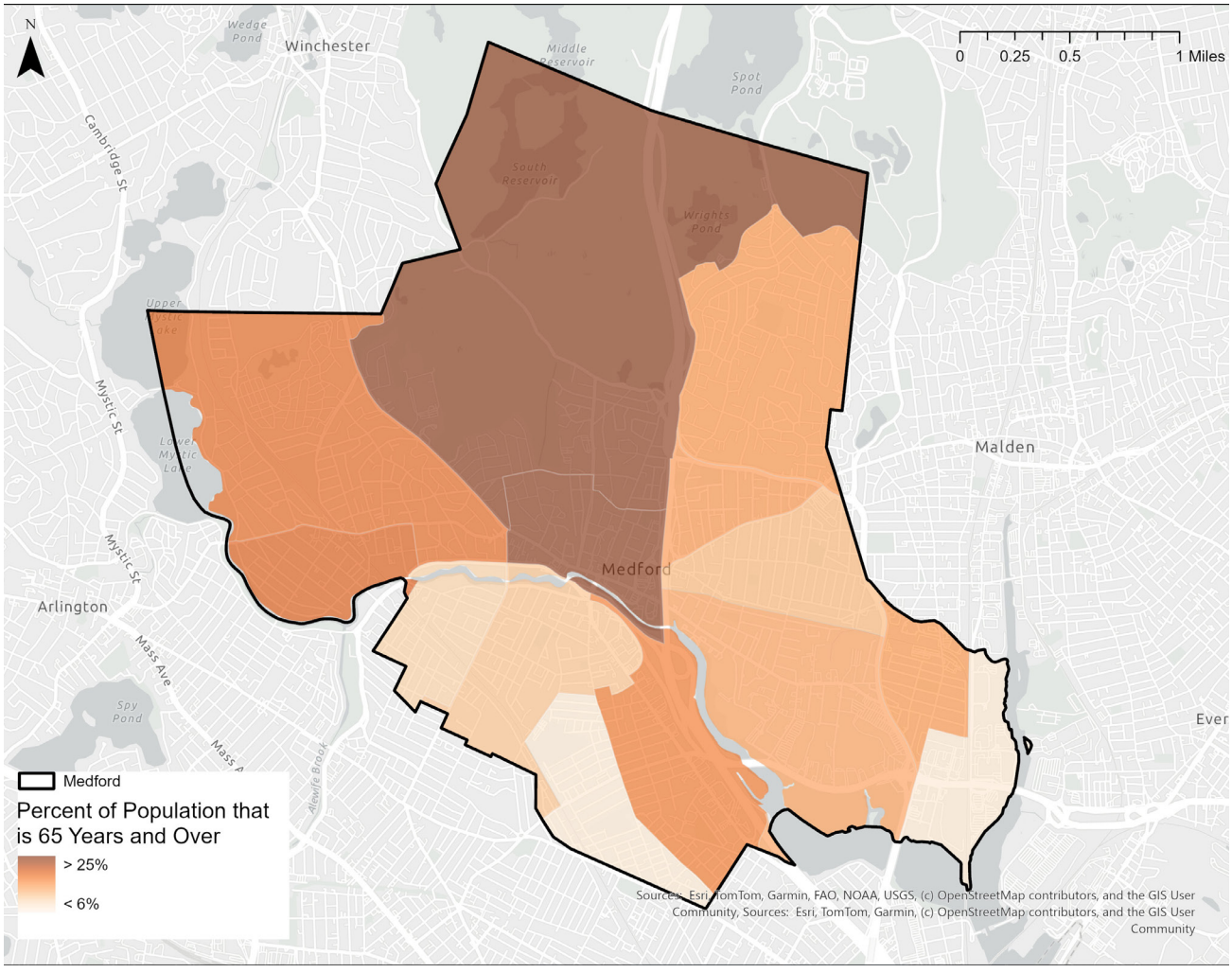
a. Residents Over 65 Years Old

Lower incomes, limited transportation and a greater likelihood of health problems make it more difficult for Medford's older adults to prepare for and recover from climate change related hazards. Because they are less likely to have access to the internet or a cell phone, it is more difficult to reach older residents in the case of an emergency.

In Medford, roughly 17% of the population was over 65 as of 2023, with that population expected to grow to 18% of the total population by 2030.[96] According to 2015 data, 10% of Medford residents over 65 also have a disability.[97] Moreover, 4.2% of adults over 65 in Medford live alone.[98]

Adults over 65 years old are clustered in central Medford, although some live throughout the city. This geography should be considered in both the distribution of information and planning for future climate related hazards.

Figure 24: *Map of Population over 65 years old.*[153]



Mobility

According to the staff at the Medford Senior Center, many adults over 65 in Medford do not drive and instead rely on walking and public transit to get around. The City of Medford also provides transportation for seniors based on age to prevent social isolation among this population.[99] However, if there was a need to evacuate due to flooding or other extreme weather events, this population will have limited transportation options for leaving the city.

Since this age group is particularly vulnerable to the effects of extreme heat, walking and waiting outdoors for transit will pose a greater health risk as temperatures increase.[100] As with many vulnerable populations, flooding could also prevent adults over 65 from accessing important services, such as food, pharmacies, medical care, and social outlets.

Communication

In Medford, people over 65 are less likely to have smart phones or computers at home and are much more likely to rely on the Medford Senior Center, the reverse 911 calls from the Medford Police Department, the Medford Senior Center newsletter, and the local newspaper as sources of information.[101] With the existing communication systems, there might be challenges in spreading information quickly to the entire community of senior citizens, especially those who primarily communicate in languages other than English.

Shelter

There are several senior citizen apartment buildings in Medford, some of which are overseen by the Medford Housing Authority. One of these is the Walkling Court building, which is geographically isolated from many city services, is located near the Mystic River, and houses residents over the age of 65, most of whom speak primarily Haitian Kreyol.[102]

According to the Medford Senior Center, 6% of seniors who use their services live alone.[103] Although this is a relatively small percentage, it is possible that there are more seniors who live alone in the community but, because of their isolation, do not use the senior center, and are thus not included in this number. Seniors that live alone may have a more difficult time getting the assistance they need during a hazard-related emergency.

Health

Older adults are more susceptible to the risks posed by higher temperatures and heat waves, vector-borne diseases, and mold from flooding.[104] Their immune systems are more likely to be compromised and they are more likely to have other preexisting health conditions. Limited transportation and income or lack of information might make them less likely to seek medical help during the early warning signs of a medical emergency related to these risks. The health needs of the elderly mean that in the event of an emergency requiring evacuation, such as a flash flood or prolonged power outage, some require more resources than others to get to safety. Medford Housing Authority, for example, has several residents in each of its senior housing buildings that are bed ridden, rely on oxygen tanks, and/or have severe mobility limitations because of their health.[105]

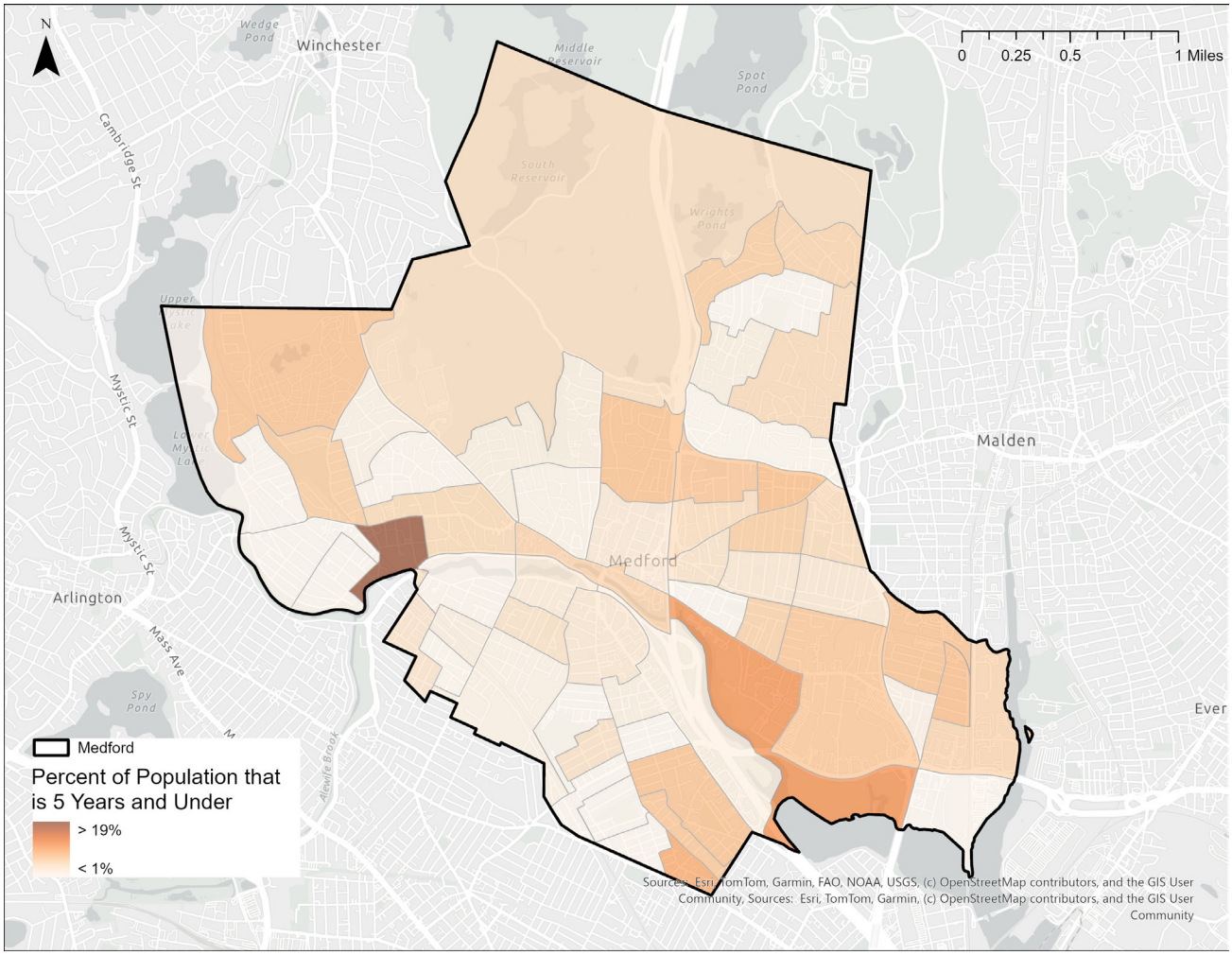
Economic Resources

Older adults tend to live on limited and fixed incomes, meaning that they are less able than working adults to afford higher costs and emergency expenses that increased temperatures, precipitation, and storms may bring. In addition to being more susceptible to the health risks of higher temperatures, especially in the case of a widespread power outage, they are less likely to be able to pay for air conditioning. Lack of economic resources may make it more difficult for those over 65 to prepare for climate impacts and to recover from them afterwards.

b. Children Under 5 Years Old

With the added expense of raising a child, families with children under five may have less money for emergencies and will not be able to react as quickly if there is a need to evacuate. This risk is even greater for immigrant families who may not have as much family in the area and may not speak English—making it harder for them to access community resources. Young children are more susceptible to illness than adults.

Figure 25: *Map of population under 5 years old.*[154]



Roughly 6% of Medford residents were under age 5 as of 2023, which is expected to decrease slightly to 5% by 2030.[106] Young children and their families are spread throughout Medford, with census data showing higher concentrations in West Medford, North Medford, South Medford, Glenwood, and Wellington. In Medford, the Medford Family Network and the West Medford Community Center are two organizations that have much experience working with young children and their families.

Mobility

Young children are completely reliant on their families for transportation.[107] In times of extreme hot or cold weather, they are more likely to stay at home with family where they are less likely to socialize and interact with other children. The Medford Family Network reports that many parents living within city limits need to take two buses to get to their facility at Medford High School. Many of the same parents have had to advocate to maintain bus service as construction and transit funding challenges have resulted in service and bus stop changes.[108] With increased amounts of extreme weather and transportation barriers, parents might be less likely to access services for their children in order to avoid the health risks of extreme heat.

Communication

Over the last two decades, the Medford Family Network has seen an increase in the number of families with young children who have moved to Medford from other states or countries and who have little or no family living in the area.[109] This social isolation means that these families have fewer supports to rely on in the event of an emergency, such as a grandparent or other family member. It also means that these families might feel less comfortable or be less familiar with services or programs they can access for support with their children, including information related to climate change and how it connects to family health and safety.

The Welcome Project and Medford Family Network report that there has been an increase in Medford in the number of parents of young children who speak a native language other than English. At the same time, although some language translation services may exist, it is more often English speakers who know about them.[110] Families who do not speak English as their primary language are less likely to receive critical information in a timely manner, especially in an emergency. Few or no staff in the Medford school system or working in city services speak the languages that are now common in Medford, which include Haitian Kreyol, Portuguese, Vietnamese, and Spanish.[111]

Shelter

As of Spring 2018 there are 29 children from birth to 18 months old living in Medford public housing.[112] The Medford Housing Authority manages 300 units of family affordable housing, although only some of the families have children under 5.[113] There is no evacuation plan for these units in the event of an emergency, such as a flood, which would displace people from their housing.[114] There is also one small transitional shelter in Medford for mothers with young children experiencing homelessness.[115]

Families with young children might be more likely to stay inside during heat waves and other extreme weather and will incur higher costs due to keeping their homes cool during the day. Families who experience damage to their property from storms and flooding may not be able to afford repairs or may be displaced if they are renters, which could disrupt childcare and cause stress to children.

Health

Like the elderly, young children are at higher risk of heat-related health complications and vector-borne illnesses. Research looking at children under 18 in Massachusetts shows that youth living in areas with few green spaces and higher air pollution experience higher rates of asthma and end up being absent more often from school, leading to worse educational outcomes and opportunities as kids get older.[116] In South Medford and around Medford Square there are high concentrations of young children, as well as higher temperatures from the heat island effect and lower amounts of tree cover and green space than in other parts of the city.[117]

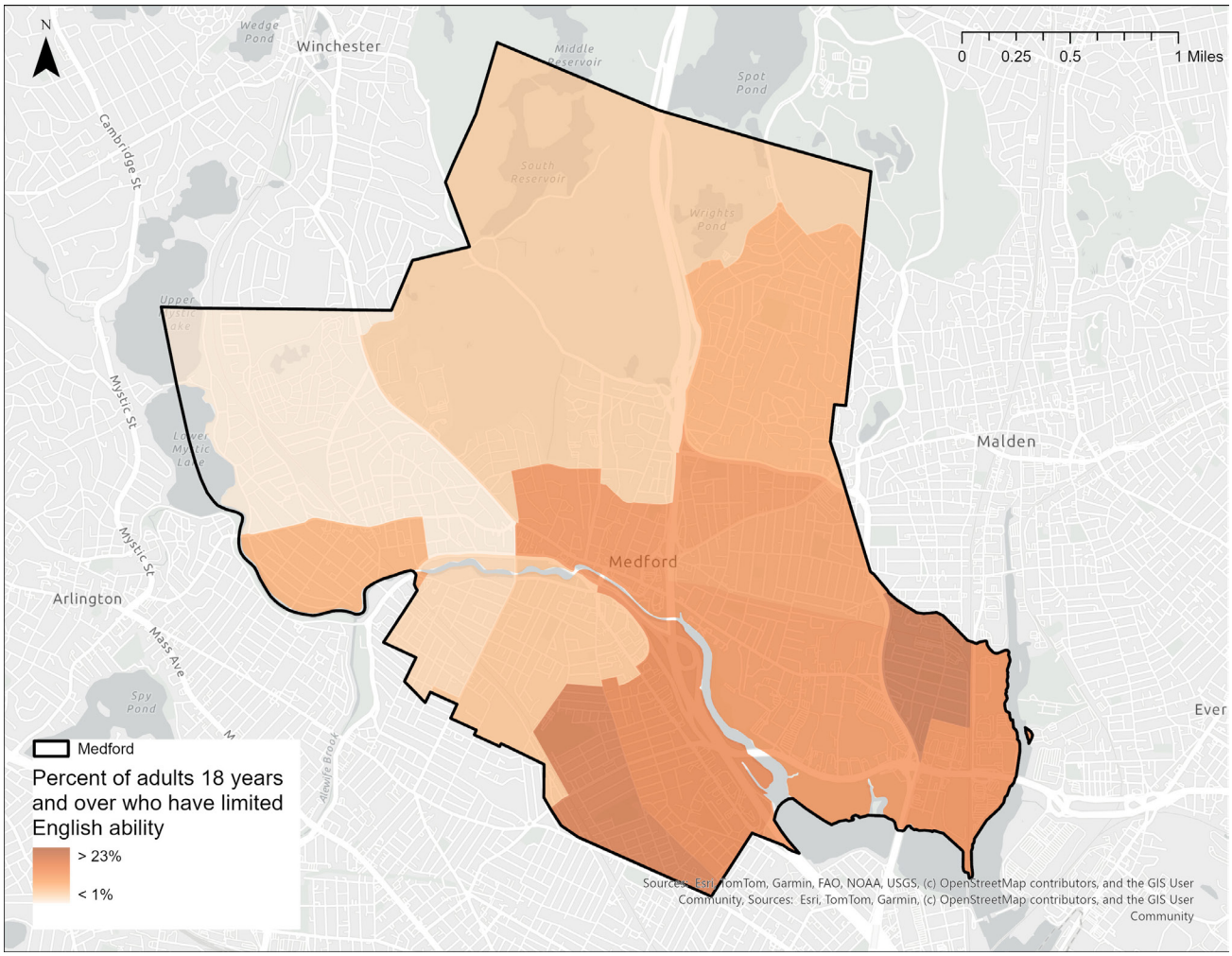
Economic Resources

Raising children comes with an economic expense; therefore, with all else equal, people with children have less money to respond to or prepare for climate events. Childcare can pose a challenge to families in the event of a climate event, requiring parents to stay home from work if schools are closed. Parents of young children might not have jobs that provide flexible time off, especially jobs that are paid hourly, meaning that parents might lose their jobs if public transportation and childcare facilities are compromised in the event of a climate emergency. Additional costs to repair homes from storm/flood damage, to cool homes in hotter weather, to pay higher rent to property owners with added costs, or to cope with the possibility of displacement in the event of an emergency are risks for families with young children who might already be economically vulnerable.

b. People with Limited English Proficiency

People who do not speak English very well will face more challenges responding to emergencies and getting access to resources they need in the face of climate change hazards due to limited translation services in the city and limited knowledge as to how to access these services.

Figure 26: *Map of households with limited English proficiency.*[155]



According to 2023 ACS Census data, 10.7% of Medford households have limited English-speaking ability.[118] In Medford Public Schools, 23.6% of students have a native language other than English, and 10.6% are categorized as English language learners.[119] The most common languages spoken other than English in Medford are Spanish, Haitian Kreyol, and Portuguese (**Figure 26**).

The number of Medford residents who are immigrants was 16.2% in 2000, 20.9% in 2010, and 21.5% in 2016.[120] Some of the people who have limited English proficiency living in Medford may be undocumented immigrants. We do not know how many people fall into this category, but research by Pew Research Center using 2014 Census data says that 180,000 people live undocumented in the Boston metro area, with 145,000 of those people living outside the city limits of Boston.[121]

This data suggests that language and ethnic diversity in Medford has grown over the last 20 years and is on a path toward further growth. Although there are some services available in other languages, there are still many barriers to full community participation and service access for someone who is a non-native English speaker and immigrant.

Mobility

The MBTA gives its announcements at the stations in English. People who speak a language other than English will have more difficulty understanding the extent of service interruptions. Additionally, both the RIDE and the SCM transportation service that the Medford Housing Authority uses do not offer translation services, based on the experience of Medford residents.[122]

Communication

The City of Medford uses a service called Language Line Solutions for its translation and interpretation services, which connects people to a language interpreter over the phone. However, there is no information available about the number of City staff and community members who feel well informed about how to use this tool or know that it is available. It is not uncommon in the Medford school system for parents to instead rely on multilingual children to interpret voicemails and flyers from teachers.[123] Information might therefore take more time to reach families in Medford with parents who do not speak English and might arrive incomplete. In the event of an emergency, or in the case of an important community meeting, these same Medford residents might not receive information in time or at all.

Several community organizations suggested that older residents with limited English proficiency are less likely to have access to a computer.[124] The reverse 911 service is available in several languages via email; however, reverse 911 phone calls (and the online system to register for reverse 911 calls) are only currently available in English.

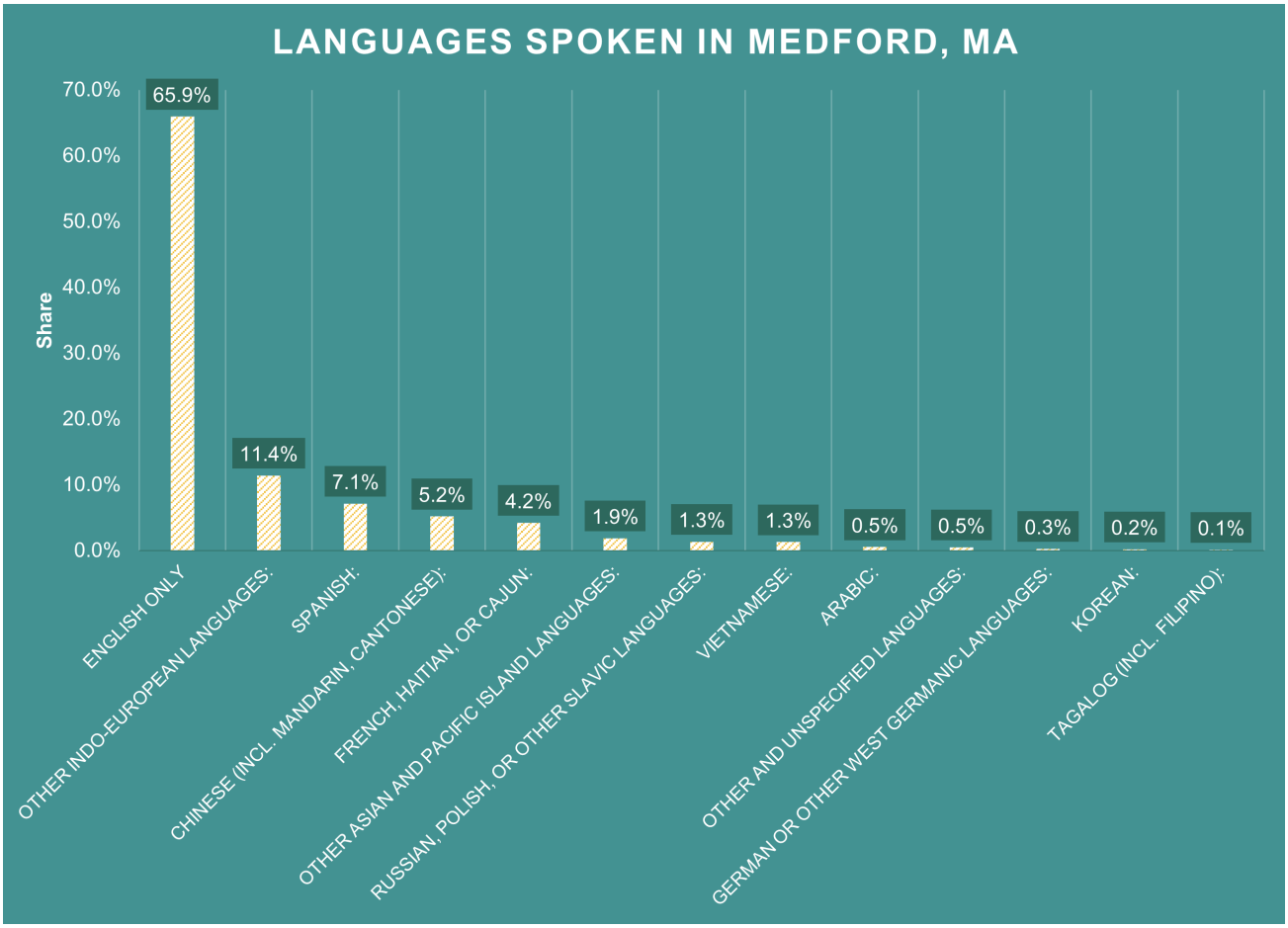
Shelter

For anyone with limited English proficiency, it may be difficult in an emergency to obtain information about safe places to stay dry and warm, or cool (in extreme heat).

Many individuals with limited English proficiency in Medford also have lower incomes, making it more difficult to retain or repair their residence if damaged from extreme weather.[125] See Section C, part 3.3.d: “People of Low and Moderately-low Income” for the shelter vulnerability created by climate change for low income populations.

Native languages spoken by residents in Medford, MA

Figure 27: *Graph of native language distribution in the Medford area (Malden and Medford Cities PUMA, MA).*[156]



Health

According to interviews, some people with limited English proficiency in Medford have moved from countries where they survived trauma from violence or unsafe conditions from natural disasters. A natural disaster in Medford, such as flooding or hurricane that could affect electricity supply or cause significant damage, could cause the additional emotional and psychological stress of re-traumatization.[126]

Language barriers also create vulnerabilities in the event of a medical or climate related emergency because people might be slower to call fire and police departments, or have difficulty explaining the situation. Interviewees reported that some undocumented Medford residents may be afraid to call law enforcement for fear that their call for help might be misinterpreted and result in arrest or fines.[127]

Economic Resources

Interviewees reported that many people with limited English proficiency in Medford are also low income. See Section C, part 3.3.d: "People of Low and Moderately-low Income" for more on the vulnerabilities of low-income populations.

c. People of Color

While the needs of people of color in Medford are diverse, neighborhoods that have concentrations of communities of color are geographically more likely to flood. Studies also show that people of color are more likely to have fewer financial resources than white populations and are more likely to be exposed to pollution that can lead to more health problems, particularly with higher temperatures from climate change.

According to US census data from the American Community Survey, in Medford there are 5,089 residents (8.91%) who identify as black or African American, 4,297 residents (7.52%) who identify as Asian, 3,395 residents (5.94%) who identify as Hispanic or Latino, 1,480 residents (2.59%) who identify with multiple race/ethnicity categories, and 42,530 residents (74.4%) who identify as white non-Hispanic.[128]

While the experiences of people of color in Medford are extremely diverse and there is limited data for Medford comparing quality of life by racial and ethnic groups, it is an important category to note. Even for people who share the same income level, educational attainment, and zip code, studies done at the state and national level show different levels of health, exposure to environmental toxins, access to economic opportunity, and physical access to services and resources for people of different racial and ethnic groups. For example, a 2014 national study of air pollution exposure and negative health consequences from nitrogen dioxide shows that people of color are 38% more exposed to air pollution than white non-Hispanic people.[129] Climate change, particularly increasing heat, is expected to further degrade air quality and increase the rates of respiratory diseases like asthma,[130] and thus can have a disproportionate effect on communities of color.

Mobility

As cited below in "Economic Resources," communities of color tend to have lower incomes than white communities, indicating that fewer people of color may have access to a personal vehicle. People who travel primarily via public transit, walking, and biking will experience greater exposure to the health effects from extreme heat. Flooding that will damage roads or disrupt traffic or public transit service will affect residents' ability to drop children off at school and childcare, get to work, and access medical care and other services.

Communication

While the City of Medford Director of Diversity, West Medford Community Center, and Medford Conversations Project have been working to provide better opportunities for people of color to communicate issues and concerns, the needs of people of color in Medford are diverse. People who are not engaged with one of these organizations or who are not registered on the Medford reverse 911 system are less likely to know about how to engage with city government or find out about public meetings and public input processes.[131]

Health

As previously mentioned, people of color are more likely than white people to be exposed to air pollution and toxic chemical sites across Massachusetts and the U.S., even when income and education are taken into

account. The Unequal Exposure Report published by researchers at Northeastern University in 2005 found that MA communities with a 25% or higher population of people of color are 20 times more likely to be exposed to environmentally hazardous facilities and sites than communities with fewer people of color.[132]

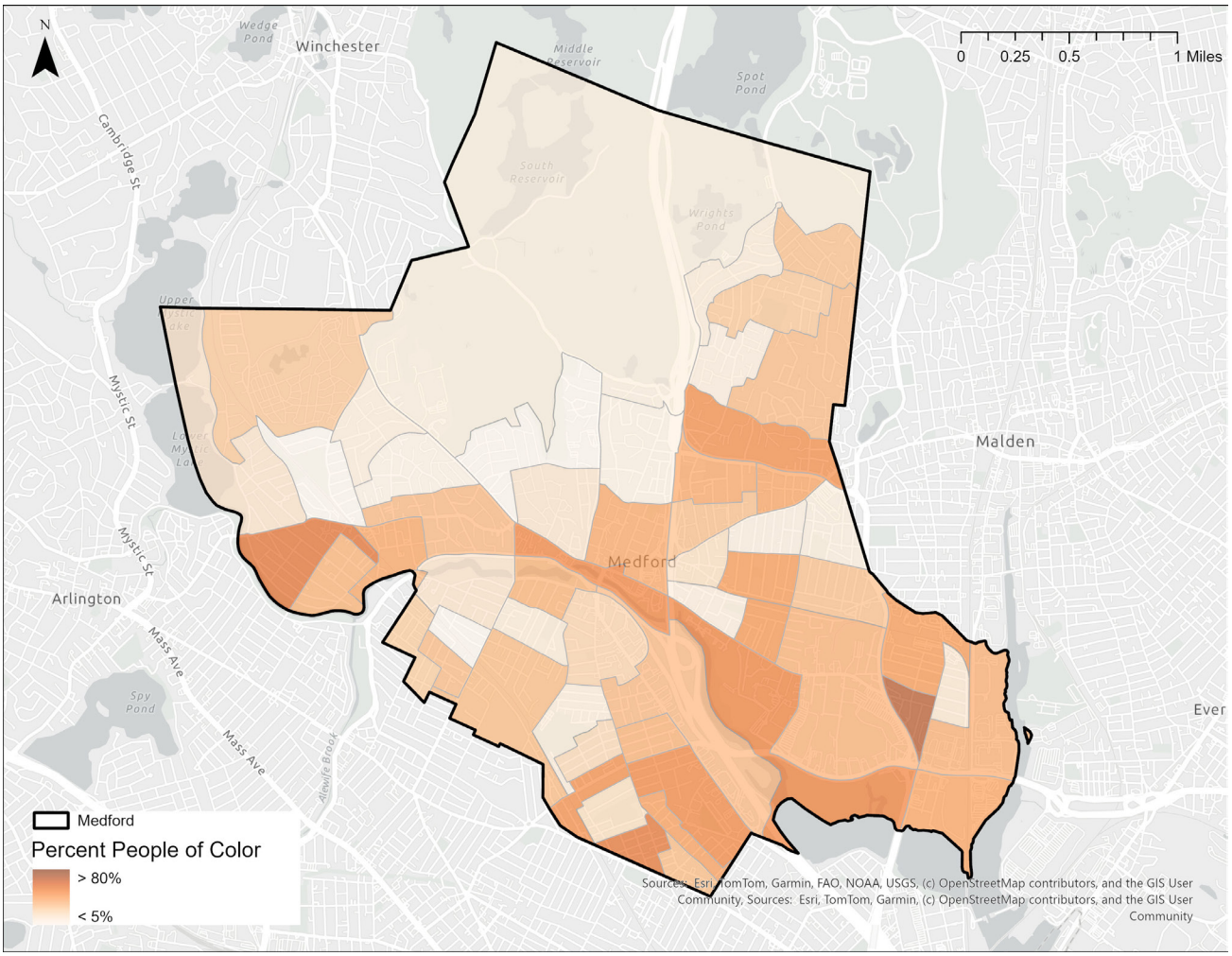
There are other existing inequities in access to healthcare, quality of services received, and day-to-day stress from racism experienced by many people of color.[133] These preexisting inequities exacerbate vulnerabilities to the negative health consequences of climate change from extreme heat, vector-borne diseases, and flooding.

Asthma rates, for example, are predicted to increase with more extreme heat. Data from the MA Department of Public Health from 2005 (**Figures 28 and 29**) shows that asthma-related emergency room visits already disproportionately affect African Americans and Latinos, including in our region of the state.[134]

Shelter

Census data shown in **Figure 27.** indicate that there are concentrations of communities of color in West Medford, South Medford, Wellington, and near Medford Square. These neighborhoods are expected to be directly impacted by flooding from increased precipitation and

Figure 28: *Map of Communities of Color.*[157]



Disproportionate emergency department visits for asthma in the U.S.

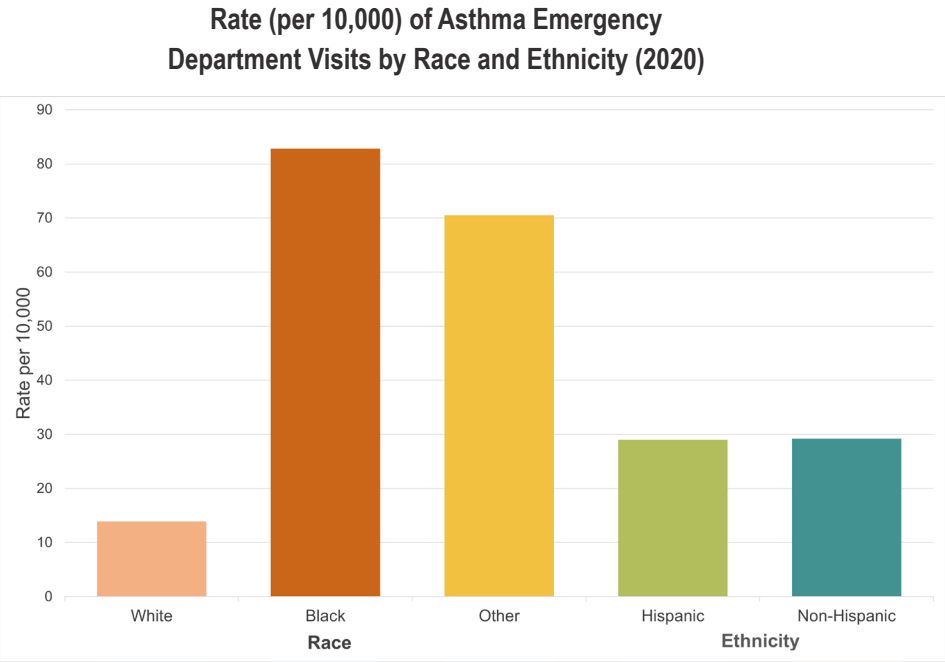


Figure 29: *Emergency department visit rates for asthma by race/ethnicity, 2020.*[158]

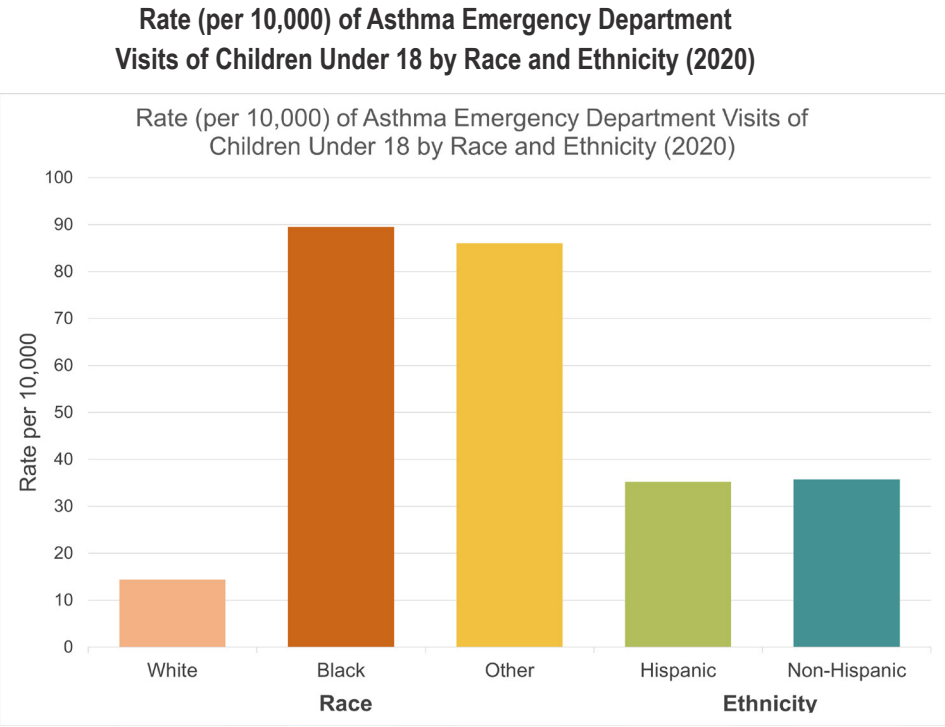


Figure 30: *Emergency department visit rates for asthma for children under 18 by race/ethnicity, 2020.*[159]

sea level rise, especially after 2050 when the Amelia Earhart Dam is expected to be overtopped.[135] People in these neighborhoods would be the most likely in Medford to experience damage to their home and potentially be displaced by flooding.

The neighborhood of West Medford is a historically African-American community,[136] with several historic landmarks that are mapped by the Tufts African-American Freedom Trail project. West Medford is also a low-lying neighborhood by the Mystic River that is vulnerable to

future flooding. In addition to the vulnerability of housing along the river, these historic sites are also vulnerable to flood damage from precipitation and storm surge from sea level rise.

Economic Resources

People of color are more likely than other groups in Medford to experience negative economic impacts from climate change, and for those negative impacts to be more extreme than other groups. The Color of Wealth report published in 2015 by the Federal Reserve Bank of Boston for the Metro Boston Statistical Area, of which Medford is a part, describes some of these effects.[137]

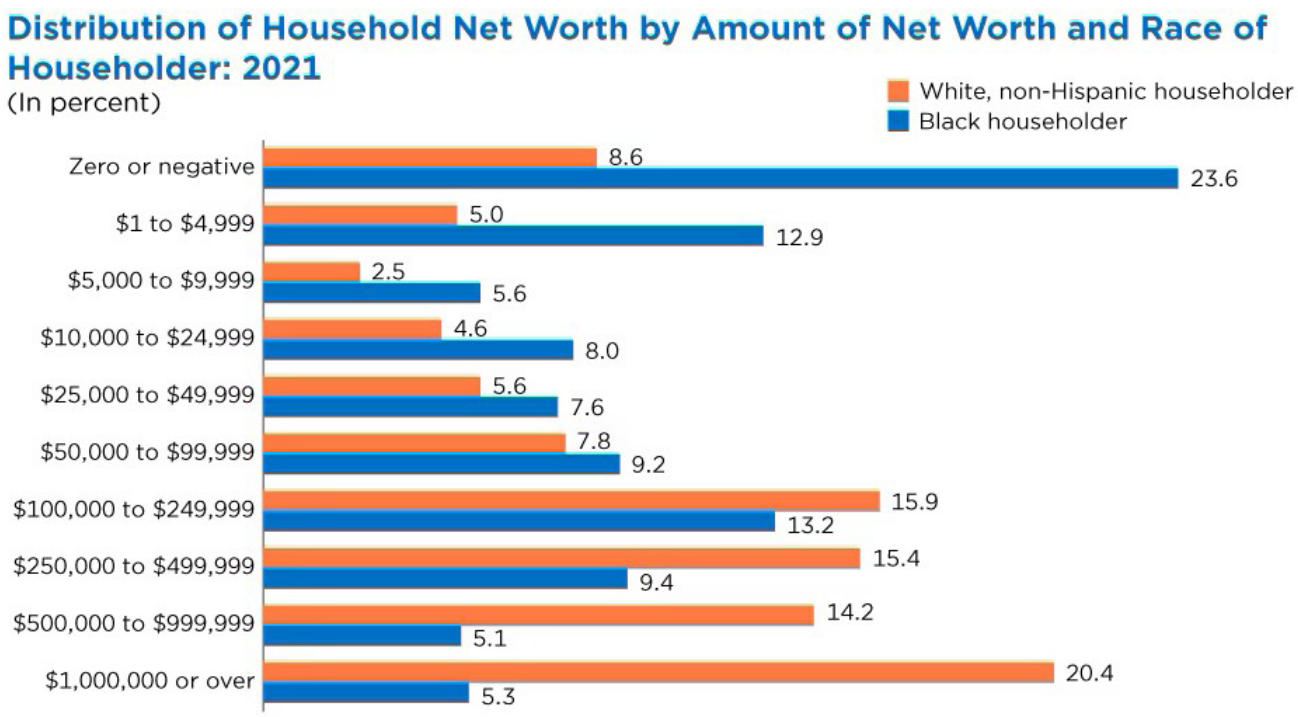
As depicted in **Figure 30**, people of color in our region, especially African Americans and Latinos, have considerably lower net worth than white residents, and are more likely to have student loans and medical debt than their white neighbors. As a result, increased costs for healthcare, emergency room visits, energy, and home repair will disproportionately affect people of color in Medford and cause greater economic vulnerability.

Definitions

Net Worth: Net worth represents a person's assets (such as their cash, investments, home, car, and anything else of value) minus how much they owe in debt.

Disproportionate median net worth

Figure 31: *Comparison of Nationwide white and nonwhite household median net worth.*[160]



Source: U.S. Census Bureau, 2022 Survey of Income and Program Participation, public-use data.

d. People of Low and Moderately-low Income[138]

Low-income residents have less money for dealing with health emergencies and/or property damage brought on by climate change related hazards. They are also more likely to rely on public transportation, which may be interrupted during emergencies.

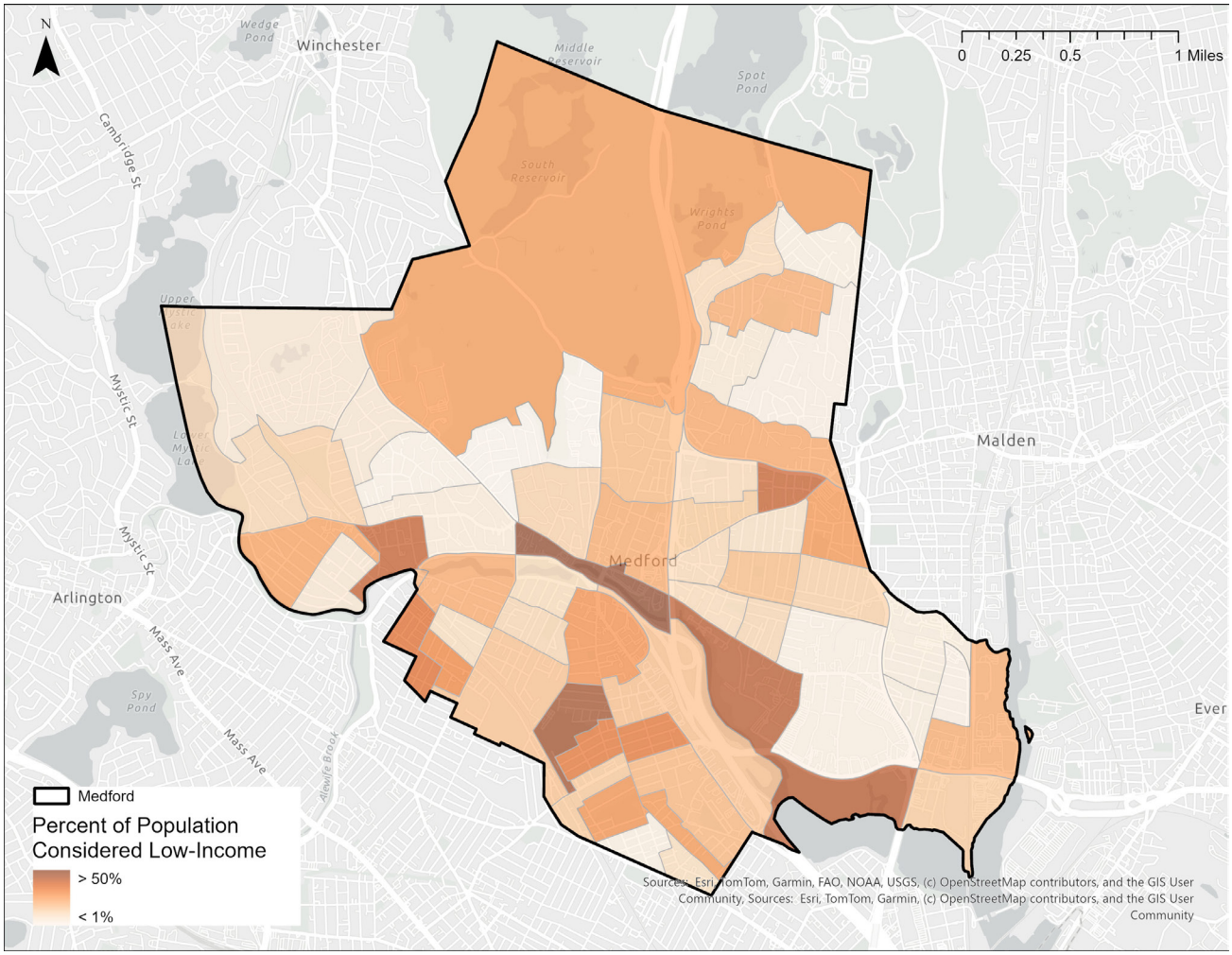
According to 2023 ACS Census data, 8.2% of Medford residents live at or below the federal poverty line.[139] Since the federal poverty line is extremely low, many vulnerability assessments look at families that live on less than double the income dictated by the poverty line to capture the low-income and moderately low-income residents.

Homeless individuals are not accounted for by the census. Local organization ABCD engages in mobile homeless outreach in Medford and identified 21 Medford residents experiencing homelessness in 2017. Most of their clients are located in Medford Square and Wellington, but some are living in their cars in other parts of Medford.[140]

Mobility

Because many Medford residents with low incomes

Figure 32: *Map of low-income population.*[161]



have jobs that pay an hourly wage and rely on public transportation, they are vulnerable to any disruption to public transit from climate-related events.

People with low income own fewer cars per household than other income groups and might have difficulty affording maintenance and gas. In the event of an emergency they would be less likely to be able to evacuate quickly to safety than other people. Anyone relying on walking, biking, or public transit as their primary form of transportation will be exposed to increased health risk from air pollution and heat that will come with hotter weather.

Communication

People with low incomes are more likely than other groups to be working two or more jobs, have long commutes on public transit, and serve as caretakers for elderly or young family members. They are therefore less likely to have the time and/or schedule flexibility to attend public meetings or to follow Medford social media and news, meaning they are also less likely to be included in conversations about awareness and preparedness for climate change.[141]

Some lower-income people in Medford live in housing managed by the Medford Housing Authority, and can be directly contacted by the Housing Authority about emergencies. However, for low-income people who are not in the housing system, even if they are on the waiting list or receiving other services, there is no communication system in place to explicitly contact those residents.[142] According to the Medford Housing Authority, most, but not all, of MHA residents have access to cell phones, which can be a useful way to communicate with them.

Health

People who are low income in Medford are most likely to live in South Medford, between I-93, the Fellsway, and Route 16, based on the census data shown in **Figure 31**. This part of the city also experiences strong heat island effect and will only get hotter as average daily temperatures increase. Residents of these neighborhoods will therefore more likely experience the negative health effects of high heat.

While people in Medford living near the poverty line might have health insurance through MassHealth or through their employer, they are less likely to be able to afford healthcare. Researchers at Northeastern University found that in Massachusetts, low-income communities face four times the exposure rate to environmentally hazardous facilities and sites when compared to high-income communities.[143] According to the same report, Medford is ranked 19th in the state on a list of most intensively overburdened communities based on the number of environmental hazard points per square mile.[144] Such exposure would only compound any existing health problems, and thus drive up health costs.

Shelter

Individuals and households with incomes near or below the poverty line tend to have fewer financial safety nets, such as access to credit or home insurance. They are thus at the highest risk of losing their homes or apartments, whether from rising costs of rent or the inability to pay for necessary repairs from storm damage. Some parts of Medford that are more affordable relative to the rest of the city, like South Medford and Medford Square, are also at the highest risk for flooding, so there would be limited options for these residents to return to Medford if a flood event forced them to leave their homes in these parts of the City.[145] There is not currently a plan for where residents of Medford Housing Authority facilities would go in the event of major damage to those properties.[146] It is also more difficult for people in this income bracket to find a safe place to stay if they were to be displaced by a climate-related emergency.

Economic resources

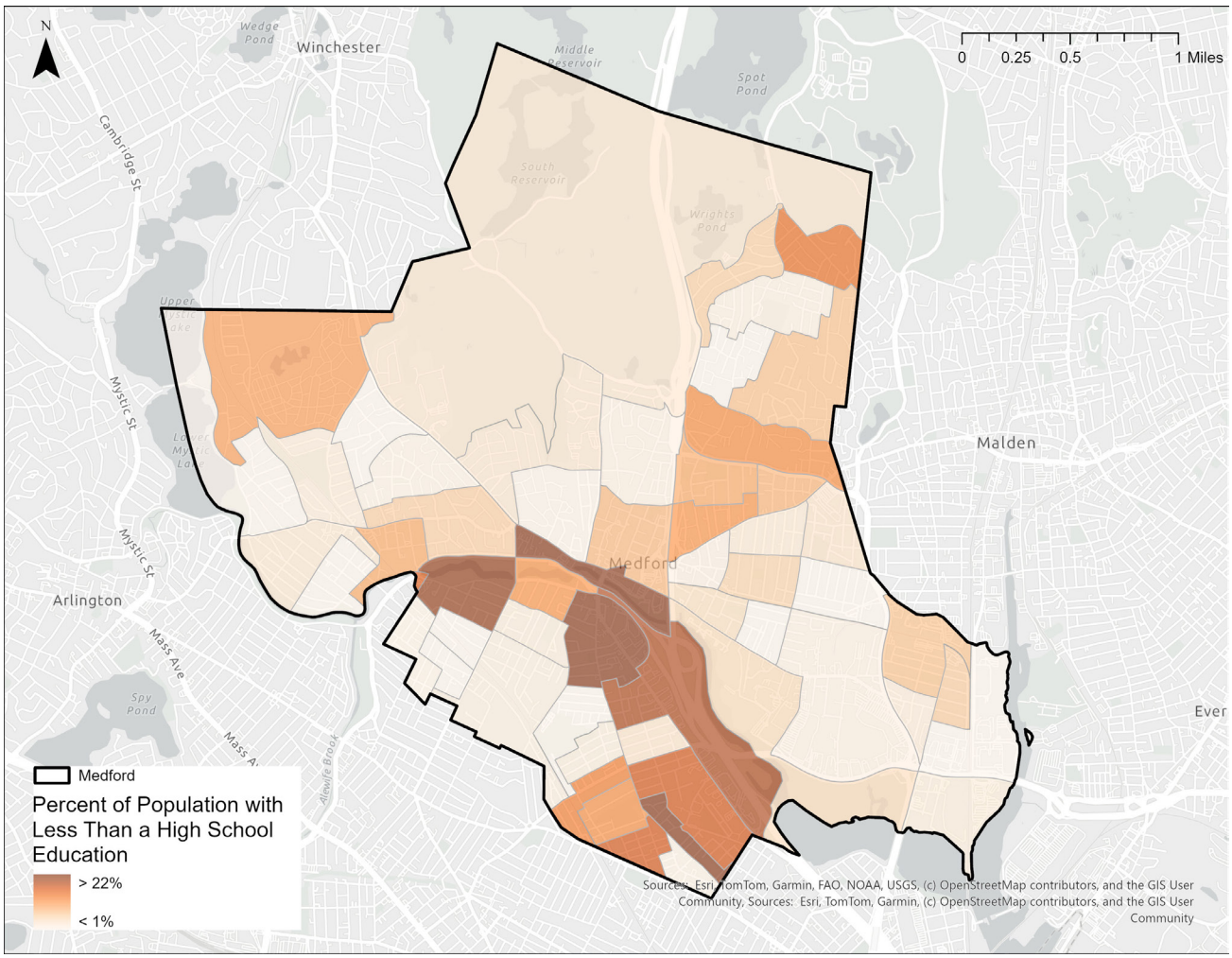
People in Medford who earn an income less than twice the yearly income classified as the federal poverty level are less likely than other residents to be able to afford home repairs or increased energy costs, less likely to be able to afford an adequate vehicle to get to safety in an emergency, less likely to have relatives or friends who could provide money or resources in an emergency, and less likely to be able to afford increased healthcare costs from exposure to extreme weather and air pollution.

e. People with Less than a High School Education

People with less than a high school education are more likely to have lower incomes, and therefore share many of the same challenges faced by low-income residents: they may have less money to cope with health and weather emergencies, may not have access to a car, and may have less time for emergency preparations.

According to 2023 ACS U.S. Census Data, about 7% of Medford residents over age 25 have less than a high school education.[147] The Massachusetts Budget and Policy Center's research on education and income compares people in Massachusetts with a high school degree to people with at least a bachelor's degree. They found that people with a high school degree earn 99% less than people with a bachelor's degree or higher.[148] They also found that real wages for people with a high school degree in Massachusetts are slightly lower than they were nearly 40 years ago (**Figure 34**).

Figure 33: *Map of people with less than a high school education.*[162]

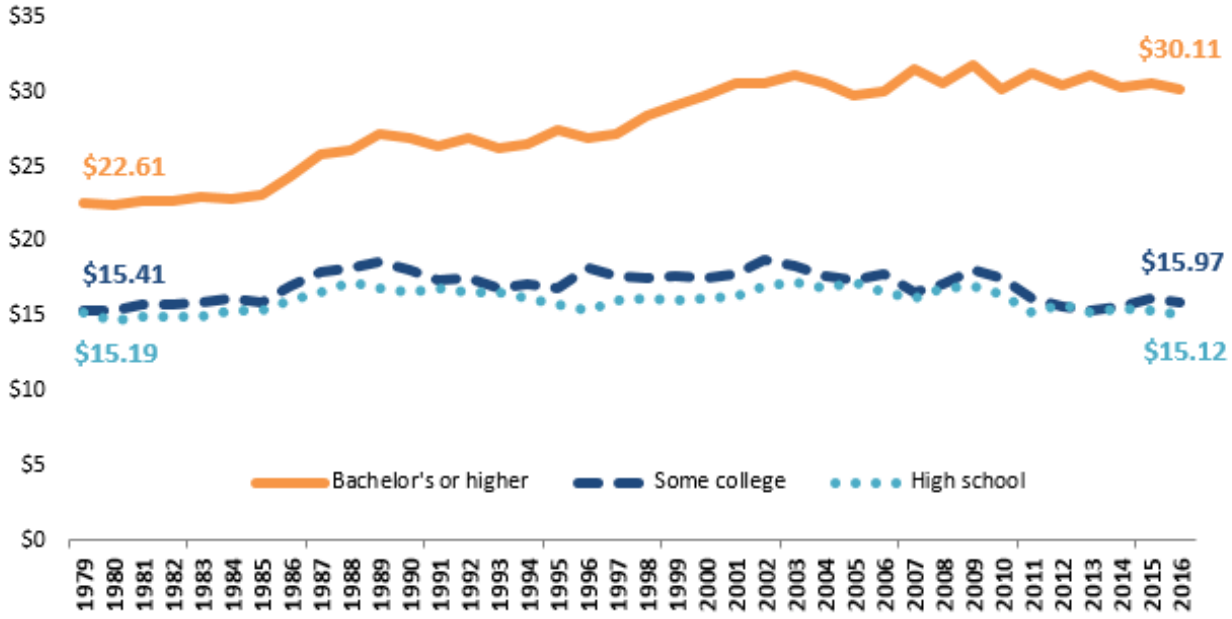


Residents with a high school diploma or less are already economically vulnerable, and this economic vulnerability is likely to be exacerbated by climate change, as described in the prior section on low-income populations.

Because the vulnerabilities of this demographic heavily overlap with the vulnerabilities of people with low/moderately-low income, see Section C, part 3.3.d: “People of Low and Moderately-low Income” for more details.

Wages grew faster for workers in MA with higher levels of education

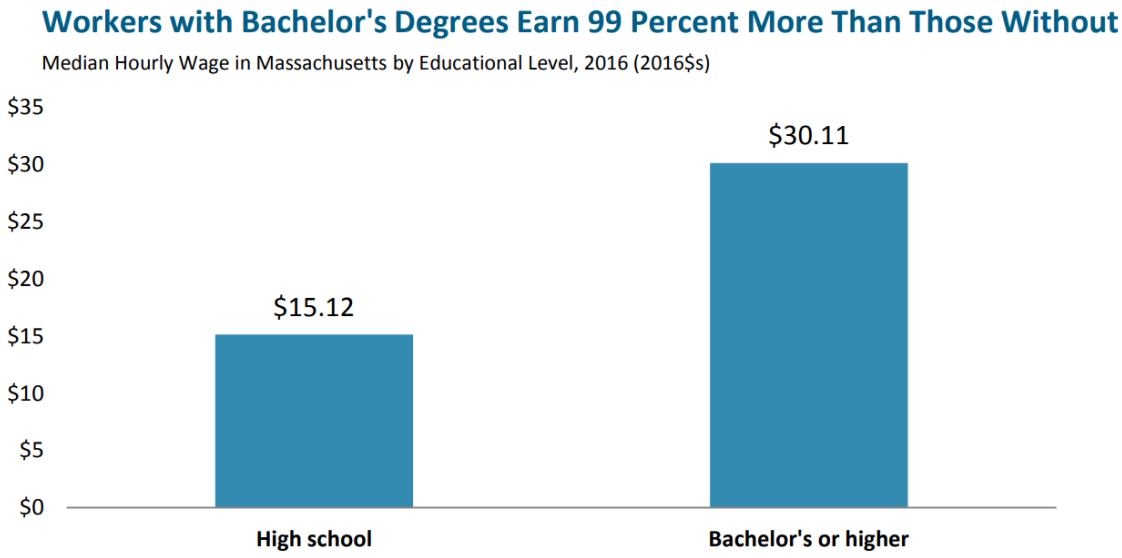
Figure 34: *Real median hourly wage in Massachusetts by educational level, 1979-2016 (2016 US dollars).*[163]



Source: Economic Policy Institute analysis of Current Population Survey data, values deflated using CPI-U-RS

Workers with Bachelor’s degrees earn 99% more than those without

Figure 35: *Median hourly wage in Massachusetts by educational level, 2016 (2016 US dollars).*[164]



Source: Economic Policy Institute analysis of Current Population Survey data

f. People Living with Disabilities

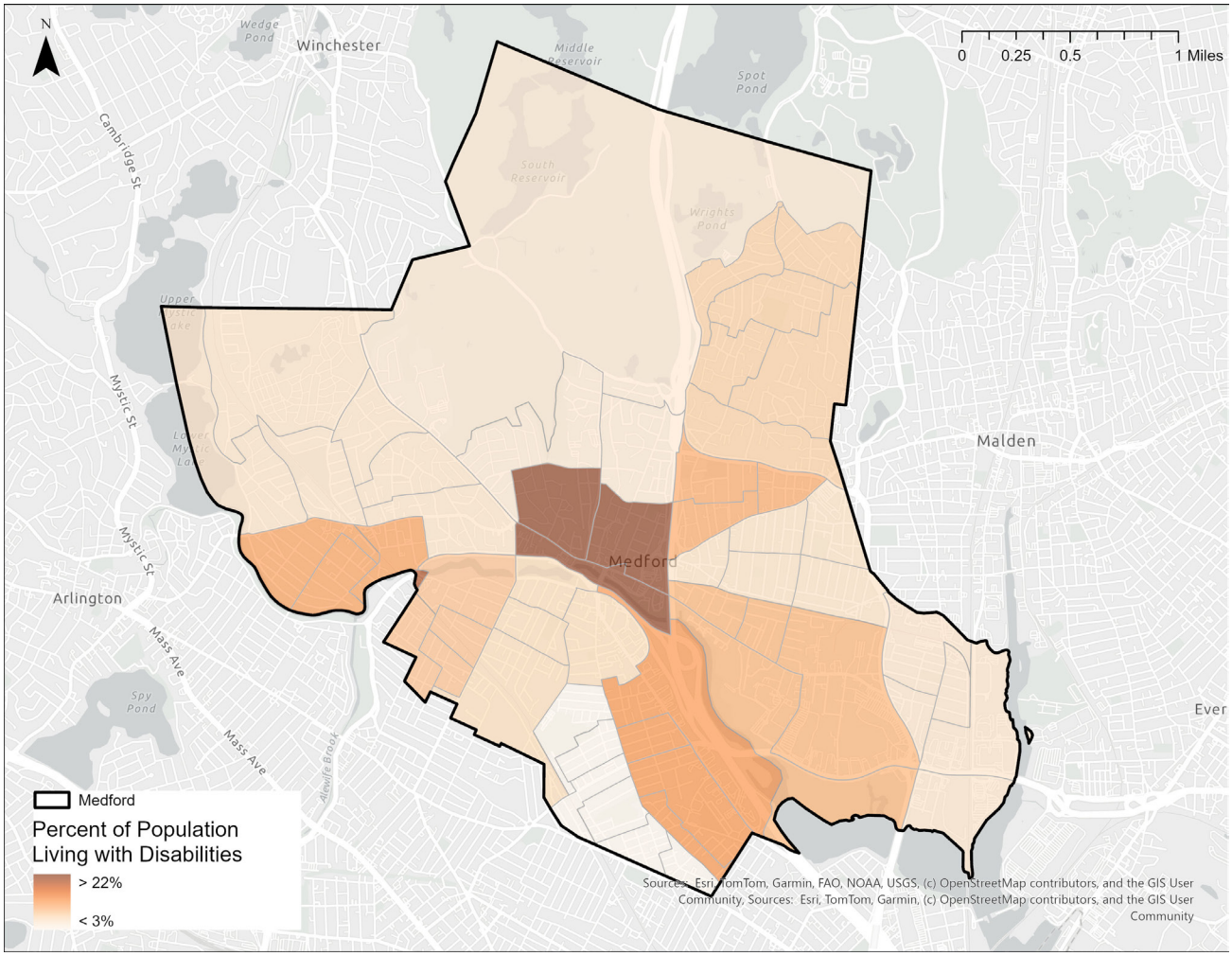
People in Medford who have disabilities are more likely to have greater healthcare needs and costs, and may face more challenges getting around—a particular problem in an emergency. They are also more likely to live on a fixed income and have less resources for emergency preparation and recovery.

This category includes people with a wide range of disabilities, including impairments of sight, hearing, mobility, and other physical and neurological limitations. The percentage of Medford residents with a disability who are under the age of 65 as of 2023 is 5.6%.[149] Medford has a Commission for Persons with Disabilities that liaises with the Medford Diversity Director's office.

Mobility

Interviewees reported that there are many persons with disabilities in Medford who cannot drive and rely on public transit to get around. Any disruption in service would make it more difficult to get to work, school, or medical appointments, as well as to evacuate in an emergency.

Figure 36: *Map of people living with disabilities.*[165]



While Medford Housing Authority residents who require oxygen tanks and have mobility limitations may sign up to be included in an emergency evacuation plan for their residence, there is currently no plan in place for supporting the evacuation of persons with mobility limitations throughout Medford. Unless apartment buildings have backup generation, persons with disabilities and elderly residents who rely on elevators will have trouble evacuating their residences during power outages. People who rely on outside caretakers would be at risk if flooding or other extreme weather prevents caretakers from arriving on time, if at all.

Communication

Persons with disabilities in Medford might not receive information regarding climate change preparedness in a timely way. Respondents from the Commission for Persons with Disabilities shared that people with autism are unlikely to use social media to get information, for example.[150] There are also some adults living in Medford who are non-verbal and would not be able to call for help easily in an emergency.[151]

Health

For people with disabilities, there are extra health concerns to consider with climate change. In preparation for extreme heat, flooding, or other weather, people may want to stock up on necessary medications, but medical insurance often does not allow them to do so. Not being able to access medication could create an emergency or life-threatening situation.[152] Some people in Medford rely on medical equipment that requires electricity, which could malfunction in the event of a power outage.

Shelter

Living with disabilities might make it more challenging to find an accessible apartment or house, as most houses in Medford have stairs or might not be within walking distance to public transit.

Some people with disabilities are not able to work and therefore live on a fixed income. Similar to other people living on a fixed income, proper maintenance and repairs to a home from flood or extreme weather damage might be unaffordable. People who rent could also become displaced because of storm/flood damage to their apartment, or from rising costs associated with climate change.

In the event of an evacuation due to extreme weather, any temporary shelters would need to account for the needs of people with disabilities.

Economic resources

People with disabilities who rely on a fixed income are less able to withstand the higher costs and emergency expenses that higher temperatures and increased precipitation and storms may require. They are also less likely to be able to pay for air conditioning, or for repairs to keep their homes and apartments safe after storm damage. This leaves them at risk of displacement.



Community members living with disabilities, such as those in wheelchairs, may experience greater difficulty responding to climate change hazards.

What can we learn from this information?

Social vulnerability analysis and implications

In summary, although social vulnerability is spread throughout Medford and the needs of residents are diverse, there are certain patterns that emerge in the location of socially vulnerable populations, highlighted through a combination of Census data and interviews with community leaders:

- The neighborhoods of South Medford, Wellington, and Glenwood are home to concentrations of several socially vulnerable populations. These same neighborhoods are also at high risk for flooding and extreme heat in the future.
- There is a growing population of Medford residents whose native language is not English and who have very few ways to communicate and engage with local government and schools. Haitian Kreyol, Portuguese, and Spanish are the languages most spoken besides English in Medford.
- Periods of extreme heat will disproportionately affect elderly and young children, as well as residents with asthma or compromised health. The impact on residents' health will be worse for people who live in one of Medford's urban heat islands (areas without many trees or green space) or in an area with poor air quality. Because oftentimes these areas are also home to residents who have lower incomes, heat is likely to disproportionately affect residents with lower incomes.

- Medford residents who already face challenges affording and accessing key services will face greater challenges in adapting to climate change. These services include:
  - **Public transit access** and affordable transportation;
  - **Affordable housing**, including the ability to afford heating and cooling, energy efficiency upgrades, repairs from damage caused by extreme weather, and where to go in the event of short-term displacement; and
  - **Health and healthcare access** and affordability, including directly for an individual or indirectly for caretakers of family members with high health risks.
- The need for greater communication and engagement with people with social vulnerability in Medford was a reoccurring theme in interviews with local leaders, in terms of emergency preparedness, involvement in planning for present and future climate change, and understanding how people are already being affected by climate change.

Meet a Medford resident thinking about climate vulnerability



West Medford; Image by John Phelan (public domain).

Henry Milorin

Henry Milorin thinks a lot about what his son, Reggie, would do in case of an emergency such as a major flood or hurricane. Milorin's son is autistic and speech impaired, and he lives in a group home with a part-time support person, not far from the home in West Medford where his parents have lived for 43 years.

Milorin and his wife, who are both semi-retired now, started thinking about worst-case scenarios after Hurricane Katrina hit New Orleans in 2005 and his wife attended an emergency preparedness seminar at work. Milorin recalls, "I said that's something we need to know in the city, because they have evacuations for different types of disabilities [in New Orleans]." Soon after, he approached Medford's Commission for Persons with Disabilities to discuss what might happen to his son in the case of an emergency. Milorin's activism led to a forum and the creation of emergency preparedness kits, and he is now a member of the Commission for Persons with Disabilities, but he notes that "we may never be fully prepared." And as climate change makes extreme weather events more likely, the need for better emergency planning has only increased.

Milorin is particularly aware that different populations in Medford will have different needs in the case of an emergency that requires evacuation, sheltering in place, or other emergency measures. He says that while Medford does have a reverse 911 system, residents must opt in, and those who don't won't get those calls. In addition, online messages won't reach everyone; he noted that "The most vulnerable folks don't go online – so how do we get that message out?"

Milorin continues to advocate for training for emergency personnel in working with people with disabilities, as well as a more comprehensive and inclusive plan for getting the word out about emergency planning in Medford. His goal is greater education and preparedness for his own son, and for all Medford's residents, regardless of their abilities and life circumstances.



Image from Henry Milorin.

Reggie Milorin (left) and Henry Milorin (right).

Milorin is particularly aware that different populations in Medford will have different needs in the case of an emergency that requires evacuation, sheltering in place, or other emergency measures.

5. Economic Vulnerability

A less commonly studied impact of climate change is its impact on property values, and thus on local property tax revenues. Property tax is Medford's largest source of revenue, and so any potential decrease in property values may have a negative impact on the City's finances.



Forest Street, Medford.

Climate change-related hazards and their resulting negative impacts on property are problematic for both homeowners and the City in the ways that they may reduce property values and thus incoming tax revenues, challenging the City's future capacity to provide residents with public goods and services. The City of Medford therefore has considered how property tax revenue could be affected by property depreciation related to the increased flooding risk associated with climate change.

This summary is based on a 2017 report, *Fiscal and Flooding Risk Cause by Climate Change in the City of Medford*, by Fernando Gabriel Cafferata, a graduate student at Harvard's Kennedy School. The full report is available online at the following link: http://medfordenergy.org/gogreen/wp-content/uploads/2018/11/Fiscal-Risk-Climate-Medford.pdf

Natural disasters always pose some financial risk for local governments, which must consider pre-disaster, disaster response, and post-disaster recovery costs in local planning. The increase in magnitude and frequency of natural disasters associated with climate change may ideally alter local governments' approach to these risks: for a city to be "fiscal[ly] resilient" it must have adequate funds available for disaster planning, response, and recovery.

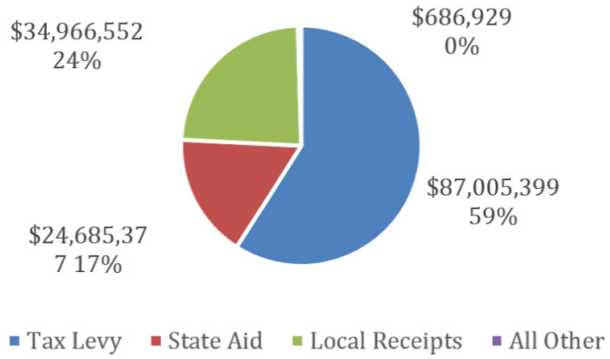
Studies have shown that in the case of rare flooding, the price of affected homes falls immediately after a flood event, recovers fully after repairs, and remains at this higher level until the next rare flood. In this case, neither past nor prospective flood damages affect the property value over the long term. However, if flooding occurs so frequently that there is no time to make repairs before the next flood occurs, house prices remain low. In this case, property values drop dramatically overall.[166] With an increasing flood risk over the long term, as Medford will see with climate change, the question remains: at what point will flooding become so frequent that it will begin to destabilize the local housing market?

Specific flood risks can be associated with specific magnitudes of property value decline. Using data from around the US, a comprehensive study on the impact of flooding on property values found that, for a given property, a 1% increase in the probability of flood risk per year is associated with a 0.6% decrease in the transaction

price for that property compared to an otherwise similar home. Additionally, the standardized relative change in price for a property located in the 100-year flood plain is −2.6%.[167] By combining this estimate with flood risk projections, it is possible to calculate an expected change in property values for the city of Medford.

Medford revenue (2012)

Figure 37: *Medford fiscal year 2012 revenue by source.*



First, it is useful to describe Medford's current financial situation. Because the most recently available property value estimates at the time that Cafferata's study was written were from 2012, the fiscal data used here is also from 2012. As was mentioned earlier, the most important source of revenue for the city comes from taxes (59%), followed by local receipts (24%) and state aid (17%).

The majority of tax revenue comes from property taxes, particularly residential property, which represented $67.1 million in 2012. For the year 2012, government spending in Medford totaled $123 million. The single largest budget item was education (37%), followed by unclassified spending and public safety. These important municipal services would be in jeopardy if property values decline.

Parcels at risk of flooding

Figure 39: *Projected Parcels at Risk of Flooding in Medford.*

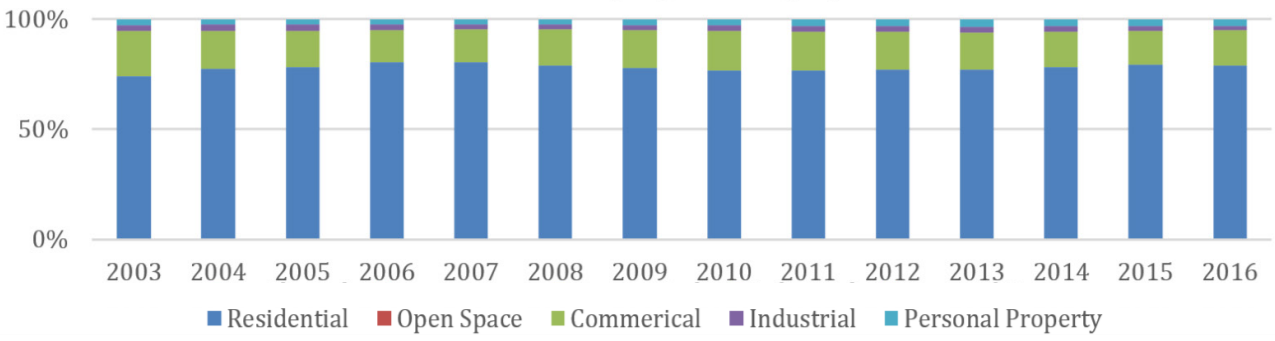
	Parcels at risk of flooding			
Year	**Residential**	**Commercial**	**Industrial**	**Exempt**
2013	33	0	0	2
2030	33	0	0	2
2070	2,248	135	46	48
Total	16,210	632	75	579

To calculate the impact of climate change-related flood risk on property tax revenues, the City used the Kleinfelder Flood Modeling produced for the City.[168] This model shows very little change in flood risk due to sea level rise between the present and 2030 (**Figure 38**). However, by 2070, the number of properties at risk of flooding increases substantially to 2,477, 14% of all properties in Medford. The situation varies by property type, as 61% of the industrial property is at risk of flooding by 2070, compared with 21% of the commercial property and 14% of the residential property.

Considering that property values decrease by 2.6% for properties in the 100-year floodplain, the City calculated the change in property values and the corresponding change in tax revenues that can be attributed to the increased risk of flooding associated with sea level rise.

Medford levy tax by class

Figure 38: *Medford tax levy by class (%), 2003-2016.*



We found that Medford can expect to collect $433,368 less in property taxes from sea level rise-affected properties by 2070. This represents only a small fraction of Medford's total budget, and does not seem like a significant cause for concern. However, there are two important caveats regarding this finding:

1. Perhaps most importantly, the flooding data used in these calculations accounts only for sea level rise, and not increased precipitation. However, as described in the previous sections of this report, we know that increased precipitation will also pose significant flooding risks for Medford, including in areas that will not be impacted by sea level rise-related flooding. See **Appendix A** for a technical memorandum on precipitation and drainage in Medford.
2. These numbers are based on a linear analysis of the impact of flooding risk on property value—that is, that each property newly in the 100-year floodplain will experience a decline in value of 2.6%. However, there is evidence that the impact might be in fact non-linear. As it was mentioned above, after reaching certain tipping points, property values might decline suddenly.

This study determined that increased flood risk due to sea level rise does not pose a major fiscal risk for Medford by 2070. However, these calculations should be revisited in the future, as more data, both about the physical risks from climate change and the impact of increasing flood risk on property values, become available.

Key findings:

This study determined that increased flood risk due to sea level rise does not pose a major fiscal risk for Medford by 2070. However, these calculations should be revisited in the future, as more data, both about the physical risks from climate change and the impact of increasing flood risk on property values, become available.



Forest Street, Medford; Image by Ellie Hoyt.

6. Next Steps

This update of the Medford Climate Change Vulnerability Assessment shows that this is a living document. As new scientific data becomes available relevant to how climate change will affect the City of Medford, both updates and new versions will continue to be created in the years ahead to reflect new information. If readers of this report have access to relevant data or feel that important considerations were not included in the assessment, the City of Medford welcomes additional input.

Since the release of our first vulnerability assessment in 2019, we've used that information in many ways, including to prioritize stormwater investments and to develop our Climate Action and Adaptation Plan.

We've updated the city's stormwater regulations, adopted the Opt-In Specialized Energy Code, and developed a Green Score, to reduce the environmental impact of new development. We've launched the Electrify Medford outreach program, to help residents understand resources for energy efficiency, solar, and electric vehicles. We've prepared the Andrews school to be used as an emergency shelter. We've also launched the Climate Equity Council and the Medford Connects program, to connect underserved populations with resources that will help make them more resilient in the face of disasters.

As we continue to make progress on our Climate Action and Adaptation Plan, we're developing an urban forest master plan, creating a building rehab program for rental properties, developing a strategic energy management plan with National Grid, continuing to install solar on City buildings, and creating resilience hubs within the city that will serve as shelters during emergencies and resource centers all year long. Visit medfordenergy.org/gogreen to stay up to date and explore ways you can be part of Medford's climate efforts.

Snowshoeing in Middlesex Fells Reservation, Medford Image by Bonnie Kittle (public domain).

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Photo from Weston & Sampson



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Forest Street; Image by Ellie Hoyt.

APPENDIX A

Citywide Stormwater Drainage Model

See following pages for assessment.

MEMORANDUM

TO: Alicia Hunt, City of Medford;
Cassandra Koutalidis, City of Medford

FROM: Betsy Fredrick, Kleinfelder;
Indrani Ghosh, Kleinfelder

DATE : July 20, 2018

SUBJECT: Final Citywide Drainage Model for Medford

CC: Penny Antononglou, City of Medford;
Dingfang Liu, Kleinfelder;
Kenneth Yu, Kleinfelder

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1 INTRODUCTION

1.1 BACKGROUND

The City of Medford has taken a prominent role in the Mystic River Watershed through the development of a Citywide vulnerability assessment. This assessment has already influenced the design of new municipal buildings, such as the new Public Safety Complex, which factored the effects of sea level rise and storm surge flooding in design elevations. Significant areas of the City and critical infrastructure assets have experienced flooding from extreme rainfall events in the recent past. Flooding during extreme rainfall events is likely to be exacerbated in the future under various climate change scenarios, particularly if they are coupled with high coastal surge conditions, such as those that occurred in the Boston area in January and March of 2018.

The City is aware of the need to understand stormwater flooding risks under different storm conditions and how these risks can be amplified under future climate change scenarios.

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As a part of this effort, the City of Medford contracted Kleinfelder Northeast, Inc., under Task Order Acceptance #2 of Contract No. 16-0088 Citywide Stormwater Management, to develop a citywide drainage model and conduct model simulations with current and future predicted model storms. Neighboring communities in the Boston area, including Cambridge, Boston and Somerville have developed similar models to study the performance of their drainage systems. The results from these studies show that risk related to flooding from extreme precipitation (street flooding, drainage backups, capacity issues, riverine flooding) is a critical issue for these communities.

The City of Medford acknowledged the need to identify areas and infrastructure that are at risk from extreme precipitation flooding. These include:

- Areas and infrastructure that have not experienced flooding in the past, and
- Areas and infrastructure that may be vulnerable to future flooding from precipitation due to predicted increases in the return frequency and intensity of rainfall due to climate change.

The flooding vulnerability is even more of a concern if these more extreme precipitation events occurred during high coastal flooding conditions due to sea level rise and storm surge. Traditionally, drainage infrastructure system improvements have been designed based on historical precipitation patterns, which may not be able to maintain the desired level of service under future design storm scenarios.

1.2 PURPOSE

The purpose of this study was to develop a Citywide drainage model for Medford, which can be used to:

- Evaluate if the existing main storm drainage pipes in the City have sufficient conveyance capacity under future design storm scenarios.

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- Identify additional areas and infrastructure that may be at risk of flooding from extreme rainfall events, especially when combined with high storm tidal elevation scenarios due to sea level rise and storm surge.
- Evaluate flooding impacts during extreme precipitation events at critical infrastructure locations (e.g. electrical substations, roadways, train stations, emergency shelters, schools, housing for vulnerable population groups, hospitals and emergency services) in terms of:
    - Peak flood depth
    - Peak flood elevation, and
    - Flood duration.

2 STORMWATER SYSTEM OVERVIEW

The stormwater drainage system in the City of Medford has approximately 115 miles of storm drain pipes, with approximately 7,000 acres of tributary area spanning across 18 sub-basins. All flows from the City's storm drainage system discharge into the Mystic River and the Malden River via more than 70 stormwater outfalls.

The City of Medford is among the downstream communities of the Mystic River Watershed, hence the water levels within the watershed have significant implications for the performance of the City's stormwater drainage system. The Mystic River Watershed includes all the land areas that drain into the Mystic River. Beginning in Reading, MA, the headwaters flow southward through Woburn, Winchester, Arlington, Somerville, Cambridge, Medford and ultimately discharge into the Boston Harbor at the Amelia Earhart Dam.

Figure 1 provides an overview of major rivers and water bodies upstream of the Amelia Earhart Dam, including the Mystic River Watershed and the Malden River system.

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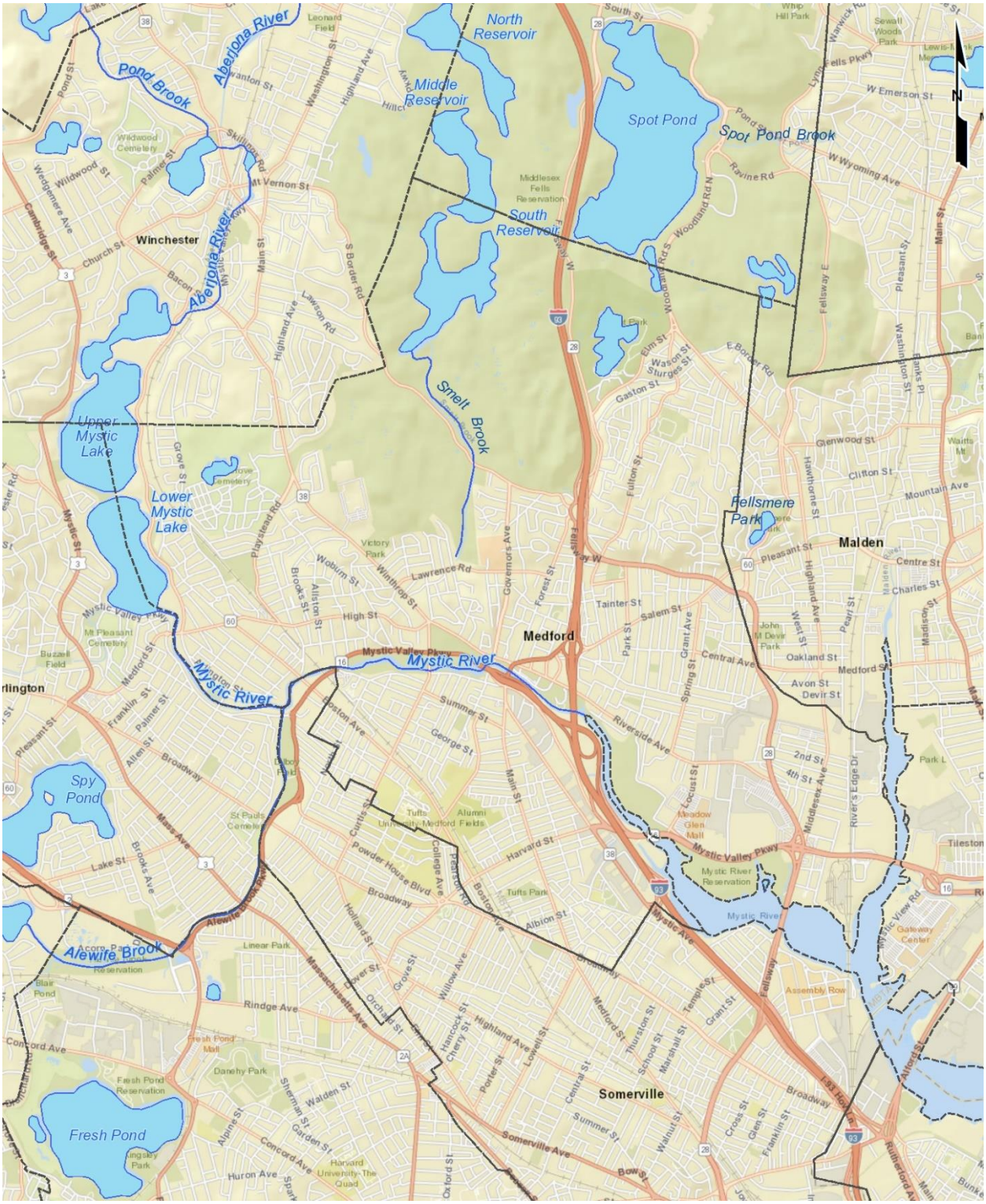


Figure 1 – Major rivers and water bodies surrounding City of Medford *(Source: Esri, USGS, OpenStreetMap)*

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Smelt Brook (known locally as Meetinghouse Brook) connects the Winchester Reservoirs in the western part of the Middlesex Fells Reservation to upstream pipes near the Lawrence Memorial Hospital. Reports from the City's Engineering Division have indicated that operations at the reservoir can have a negative impact to the City's drainage system when flow releases are not timed properly against storm events. For instance, the reservoir release should be timed early, ahead of an intense rainstorm, allowing the released waters to have adequate time to be routed through the City's drainage system. The released water flows, therefore, would not be taking up valuable drainage capacity when surface runoff is drained into the system.

Flows contributing to the Mystic River mainly come from the Aberjona River and Alewife Brook. The Aberjona River originates in Reading, connecting through Woburn and Winchester before discharging into the Upper Mystic Lake. Mystic Lake gatehouse regulates flows between Lower and Upper Mystic Lake prior to releasing into the Mystic River. Alewife Brook connects Fresh Pond in Cambridge and carries flows from Belmont and East Arlington.

The Malden River has a tributary area significantly smaller than that of the Mystic River. Flows in the Malden River originate from Spot Pond in the eastern side of the Middlesex Fells Reservation. Spot Pond is connected to the Malden River via Spot Pond Brook, carrying flows along Melrose and Malden. There are sections of pipes near Fellsmere Park in northern Medford that connect into the Edgeworth Brook culvert carrying flow towards the Malden River. This configuration is further discussed later in Section 4.2.

The two rivers connect at the confluence just upstream of the Amelia Earhart Dam, located next to Assembly Square. The dam operation[1] regulates upstream waterbodies

[1] *City of Cambridge Critical Assets and Community Resources, Nov 2015* https://www.cambridgema.gov/CDD/Projects/Climate/~/media/13E112045F904992B0953849E9846011.ashx

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to maintain a water level between -1.93 ft-NAVD (104.5 ft MDC datum) and 0.07 ft-NAVD (106.5 ft MDC datum), which includes the Malden River, the Mystic River and the Lower Mystic Lake.

3 STORMWATER MODEL OVERVIEW

Kleinfelder consolidated data from the City's GIS database and MassGIS to develop a one-dimensional (1D) hydrologic/hydraulic model of the drainage pipe network in the City, which is capable of simulating flooding out of manholes and catch basins. The model has been developed in PCSWMM, a software developed by Computational Hydraulics International (CHI, Inc.) that is based on the same computation engine as the EPA Stormwater Management Model (SWMM) with an improved user interface. Only drainage trunk lines with a diameter greater than or equal to 18" were included in the 1D model.

A limitation of the 1D model, however, is that once a manhole or catch basin floods, the model is not able to spread the floodwaters on the ground surface, which makes the flooding impacts in terms of extent and depth difficult to visualize. To account for this, Kleinfelder developed a two-dimensional (2D) surface model that can simulate the dynamic spreading of floodwaters on the ground surface, which can help predict the extent and depth of inundation. The 1D-2D integrated stormwater hydrologic/hydraulic model (or inundation model) was validated with historical flood reports obtained from personal communication with the City, as well as from the City's 2013 Hazard Mitigation Plan Update[2]. The validated model was used to simulate eight future scenarios with different design storms under present, 2030 and 2070 conditions, as well as combinations of future rainfall and sea level rise and storm surge scenarios. Results of these simulations were used to generate inundation maps, providing a high-level overview of the drainage system's performance under extreme weather conditions.

[2] http://www.medfordma.org/wp-content/uploads/2013/06/Medford_DRAFT_06-12-13.pdf

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4 STORMWATER MODEL DEVELOPMENT

The City's stormwater model developed by Kleinfelder consists of three main components that were developed independently:

1. 1D model of upper reaches outside the City boundary
2. Detailed 1D model within the City boundary, including all known drain pipes greater than and equal to 18" diameter
3. 2D surface model from Digital Elevation Model (DEM)

4.1 1D MODEL OF UPPER REACHES

The upstream floodplain of the Mystic River/ Malden River watershed has a well-defined boundary, and unidirectional flow paths. This indicates that a simplified large area delineation is sufficient to simulate the river hydraulics and flow routing. The basin delineation for the upper reaches was acquired using the USGS StreamStats delineation tool. Figure 2 shows the model boundaries of the upper reaches along with the modeled river sections for flow routing.

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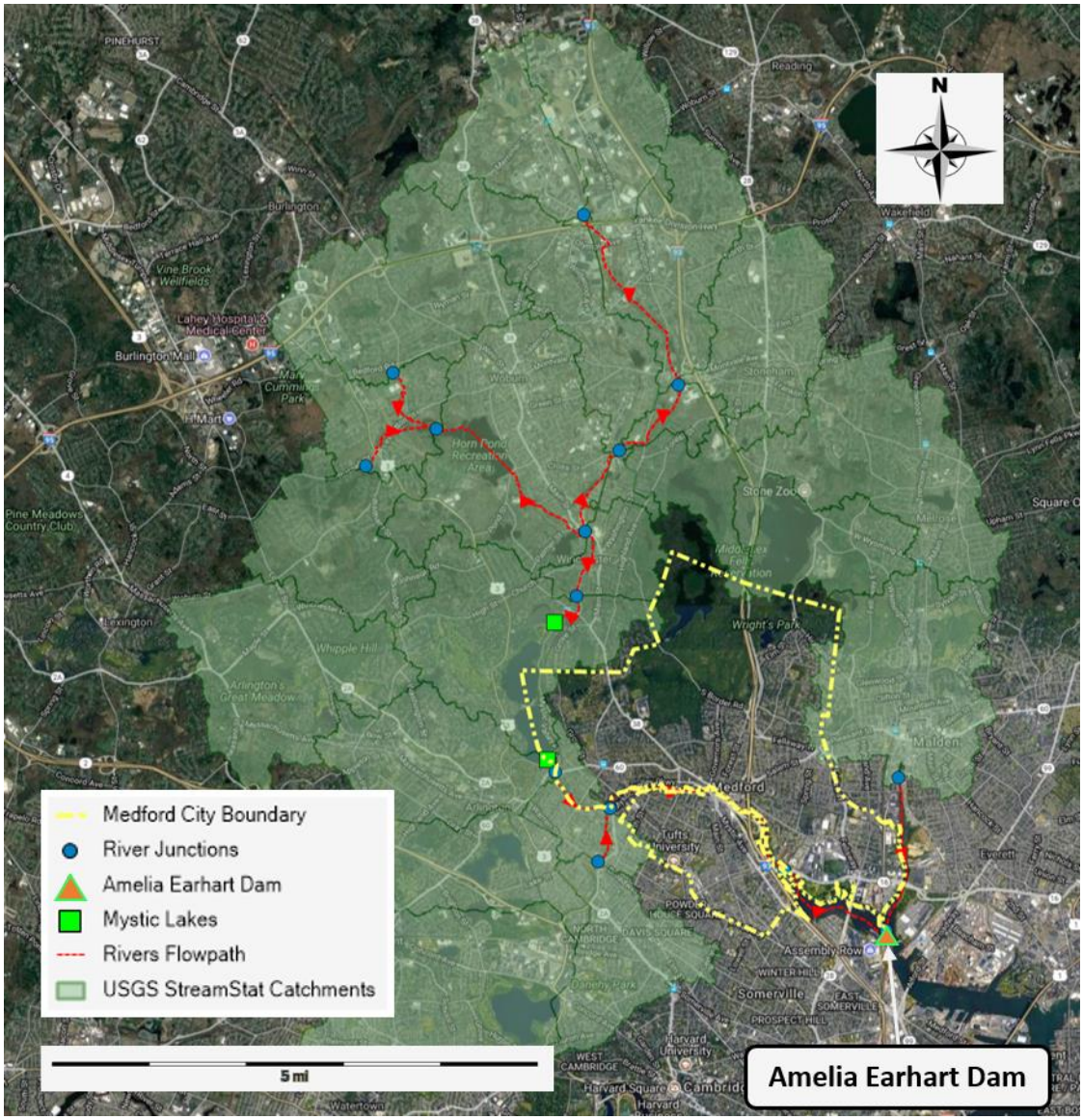


Figure 2 – River flow paths and upstream catchments in PCSWMM *(Source: USGS, MassGIS)*

4.2 1D DRAINAGE NETWORK MODEL WITHIN THE CITY OF MEDFORD

Kleinfelder developed the 1D drainage network model to include most drain pipes larger than or equal to 18” in diameter. This model provides sufficient level of detail to support the 2D surface mesh and adequately represents the characteristics of the City’s stormwater system for this high-level planning study.

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The 1D model was developed from the City's GIS database to include a main network of manholes, drain pipes and outfalls. The original 18 drainage sub-basins in the City's GIS were further refined to more than 700 subcatchments to improve surface hydrology simulation and predictability of the model. Figure 3 illustrates the subcatchments, drainage pipes, manholes, catch basins and outfalls that are included in the City's 1D model.

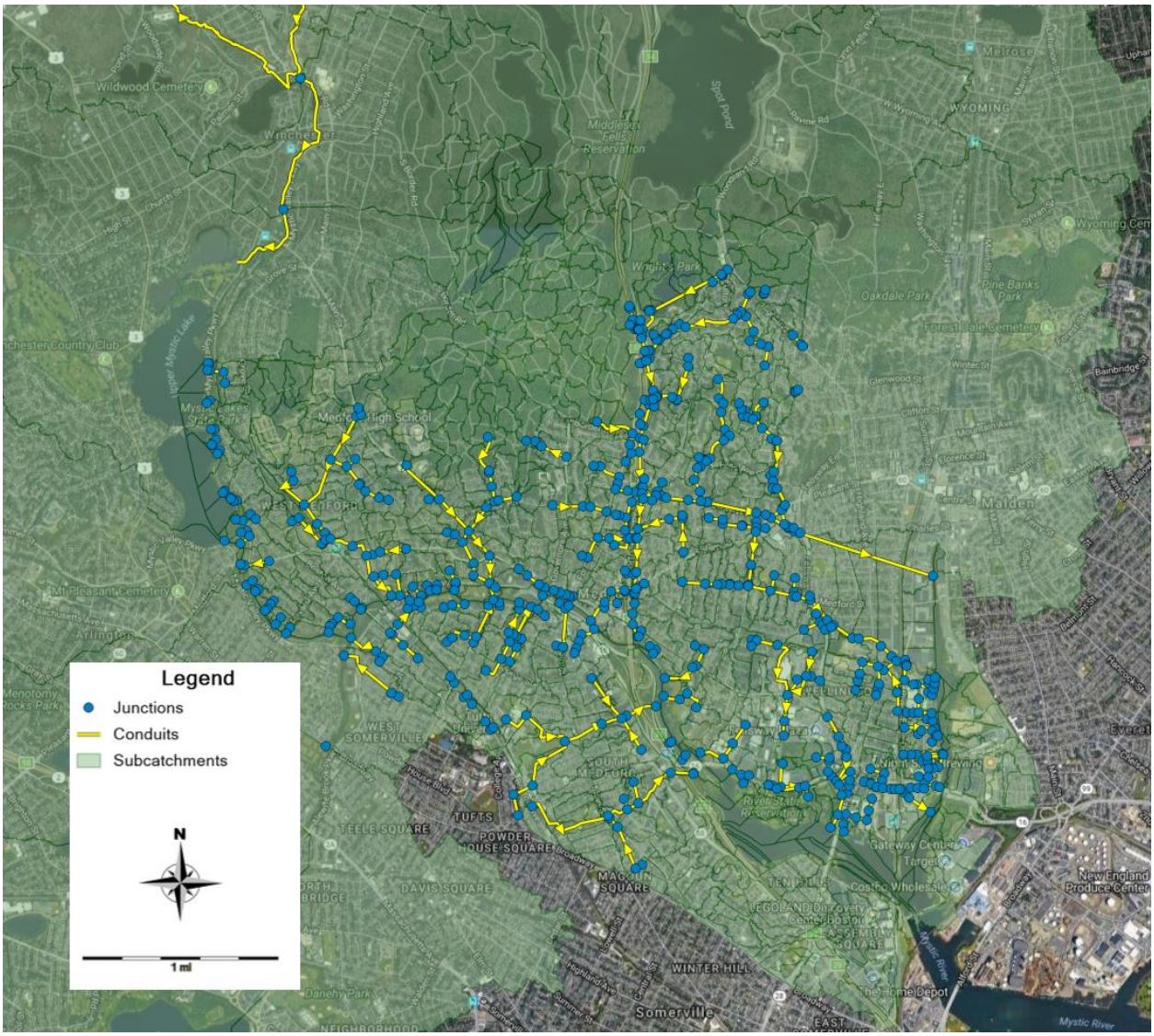


Figure 3 – PCSWMM Simplified Drainage System *(Source: City of Medford, USGS, MassGIS)*

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The City's GIS data had some missing information for certain pipe sections with missing invert elevations and/or pipe diameters. For these locations, the City assisted to reference record drawings, facilitate communications between neighboring towns and share institutional knowledge to improve the 1D model.

The City operates a pump station on Sydney Street with three pumps that activate sequentially during wet weather events, totaling to a full capacity of 1,000 gpm. The pump station drains a small network of low lying pipes in the nearby industrial park as well as areas near the intersection of 2nd Street and Fellsway West. After reviewing the hydraulic profiles between the upstream flood areas and tailwater conditions at the wetland behind the Fellsway Plaza, Kleinfelder determined that the wetland is the limiting factor to trigger a flood event in the upstream area, rendering the Sydney street pump station insignificant for this stormwater model that is designed to study flood inundation at a Citywide scale.

A section of the pipes between Fellsmere Park and Fellsway West appear to flow towards Malden via the Edgeworth Brook culvert. The culvert begins near the intersection of Charles Street and Fellsway West, cutting through the City of Malden and continues eastward to the Malden River. Since Medford's drainage model does not include pipes within Malden's drainage system, and since limited information/record drawings were available for the Edgeworth Brook culvert, Medford's 1D model assumes the culvert to directly discharge at an upstream location of the Malden River near Charles Street.

The completed City 1D model includes a total of 524 pipes spanning 34 miles with 595 junctions; water levels at Mystic Lakes and Wright's Pond are simulated by storage nodes. Operations at the Wright's Pond are simplified, assuming the pond to discharge flow through a 36" outfall pipe when water level reaches 139.1 ft-NAVD, and the spillway at 141.7 ft-NAVD is not simulated in any of the scenarios.

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4.3 MODEL CALIBRATION

Kleinfelder included the entire upper reaches of the Mystic River watershed and the City's drainage system in the 1D model. Before a 2D surface mesh was added to the 1D model, a series of calibrations was conducted to improve the accuracy of the 1D model. A recent storm event was selected to calibrate the model, such that model results would closely match the observed data after the calibrations were completed.

Five USGS water stream gage locations with observed stream flow or depth were referenced for the calibration, summarized in Table 1 and presented in Figure 4.

Table 1 – USGS Stream Gages referenced for calibration

Stream	Gage ID	Location	Google Maps location pin
Aberjona River	01102500	Upstream of Upper Mystic Lake	https://goo.gl/maps/jnL6kyoR5Hr
Alewife Brook	01103025	Broadway	https://goo.gl/maps/PDPVFADmGsJ2
Amelia Earhart Dam	01103050	Right Lock 2	https://goo.gl/maps/Cj94qgnhFNs
Malden River	01103038	Medford Street	https://goo.gl/maps/J6f1AGKWjJN2
Mystic River	01103010	Lower Mystic Lake Outlet	https://goo.gl/maps/8vFHz5g8wEv
Mystic River	01103040	Route 16	https://goo.gl/maps/e4UpCn7d4Sx

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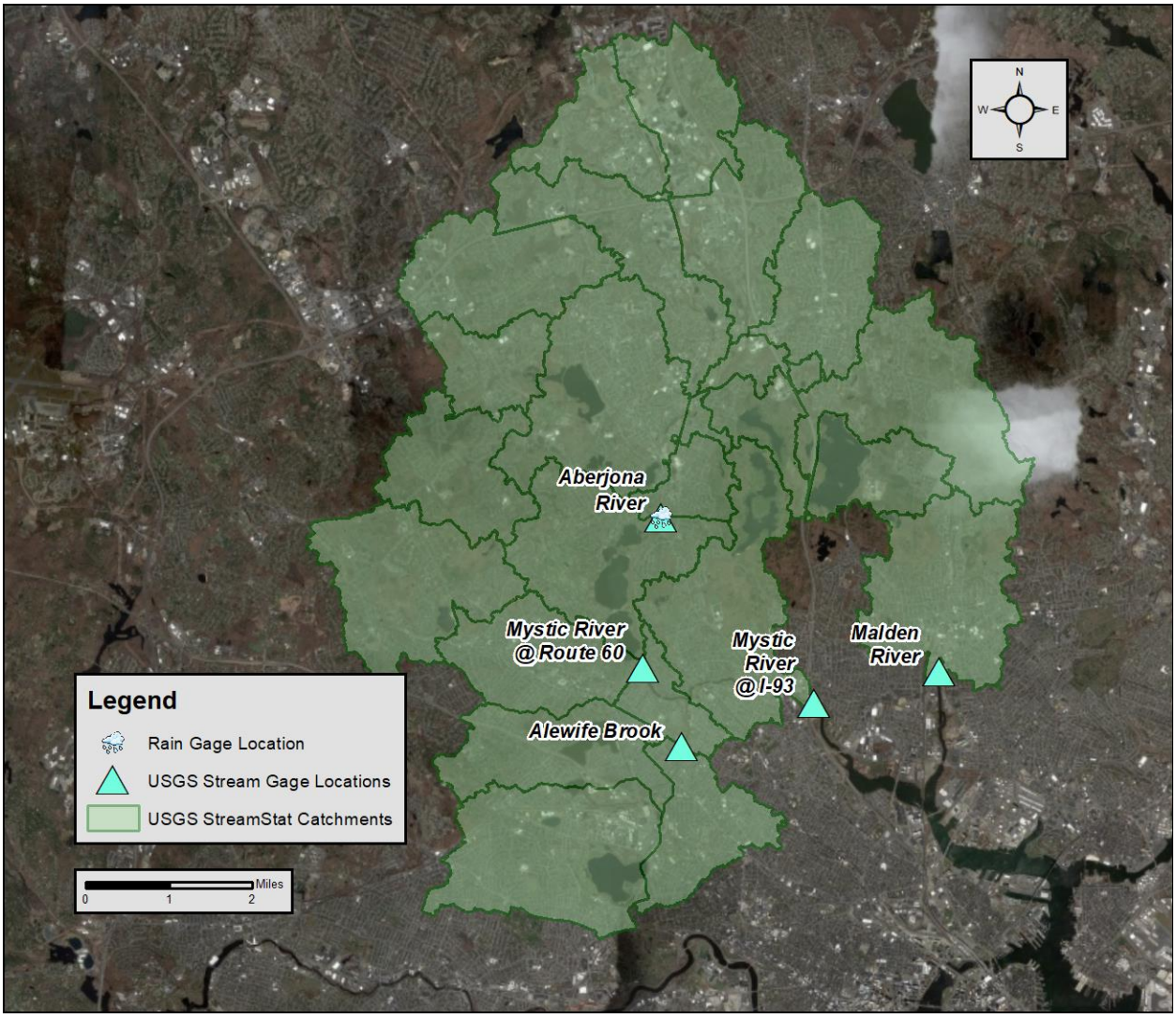
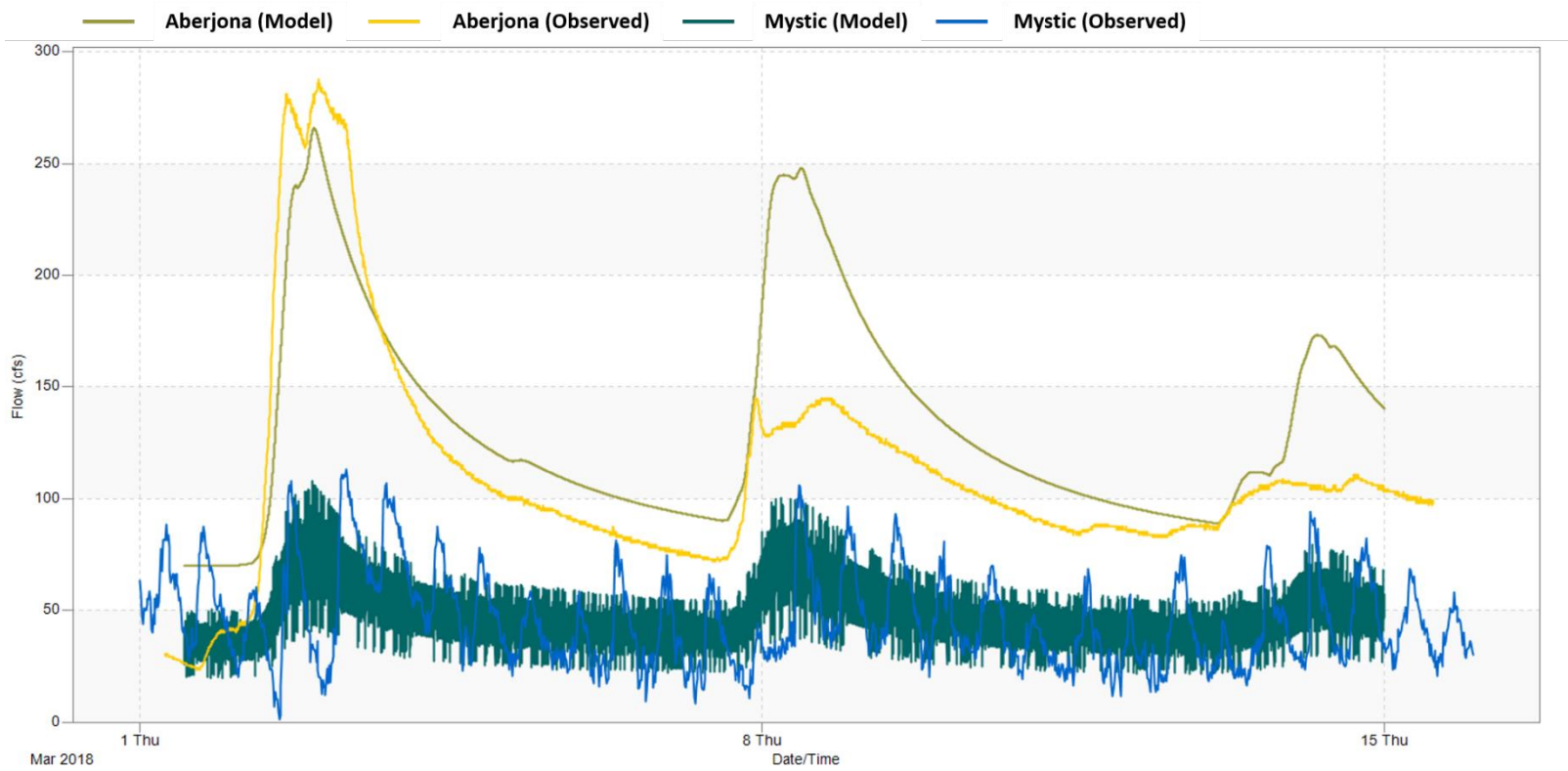


Figure 4 – USGS Gage locations for model calibration *(Source: USGS, MassGIS, Kleinfelder)*

The flow data used for calibration were acquired from the Aberjona River Stream Gage, and included three consecutive rain events on March 2nd, March 8th and March 13th. The three rain events respectively distributed approximately 1.48 in., 1.23 in. and 0.77 in. of precipitation over the watershed during the span of two weeks.

An example of the calibration results is presented in Figure 5 that shows the hydrograph and table of modeled versus observed results at the Aberjona Gage and the Mystic River Gage.

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March 2nd Storm	Aberjona River		Mystic River	
	Model	Observed	Model	Observed
Maximum Flow (cfs)	265.9	288	108.1	113
Mean Flow (cfs)	149.6	143.6	53.18	57.4
Total Flow (ft^3)	43,050,000	43,700,000	15,300,000	17,460,000

Figure 5 – Calibration Timeseries for March 2nd storm *(Source: PCSWMM, Kleinfelder)*

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4.4 2D MODEL DEVELOPMENT

After the 1D model calibration, a 2D mesh was added to the model to simulate and visualize flooding on the ground surface. The mesh was generated using a combination of terrain data sources:

1. Digital terrain model (DTM)
2. River bathymetry
3. Building Footprints

As shown in Figure 6, the completed 2D surface mesh contains a combination of various mesh shapes and sizes depending on the type of terrain, location and risks of flooding as observed from the 1D model calibration.

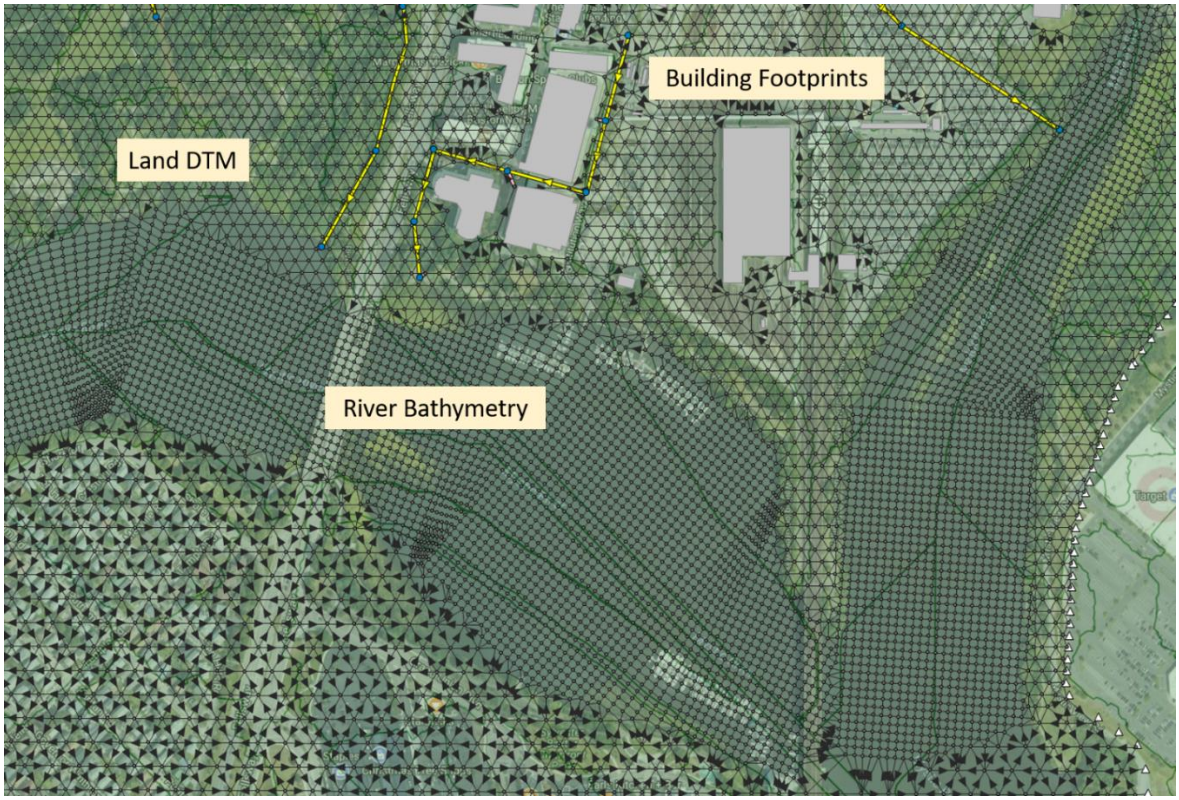


Figure 6 – 2D surface mesh components *(Source: USGS, MassGIS)*

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The 2D surface mesh on land was developed with a digital terrain model that represents a terrain's surface on GIS. The bathymetry data provides the necessary information to develop river cross sections and help to improve flow interactions along the Mystic and Malden Rivers. Building footprints are acknowledged in the 2D surface mesh to ensure that the flood flow paths recognize the buildings as obstruction.

5 2D MODEL VERIFICATION

Kleinfelder incorporated the 2D surface mesh to develop a complete 1D-2D integrated stormwater model. To verify the integrated stormwater model, a 100-Year, 24-Hour storm in present day condition, which has a similar intensity as the March 2010 rainstorm, was simulated to identify possible flood locations.

The 2013 City of Medford Hazard Mitigation Plan[3], reported seven locations with chronic flood concerns. These chronic flooding locations were compared with the model verification results. This comparison shows a good match as shown in Figure 7. Additional institutional knowledge of flood reports provided by the City's Highway Superintendent were also compared and showed good agreement with model results.

[3] http://www.medfordma.org/wp-content/uploads/2013/06/Medford_DRAFT_06-12-13.pdf

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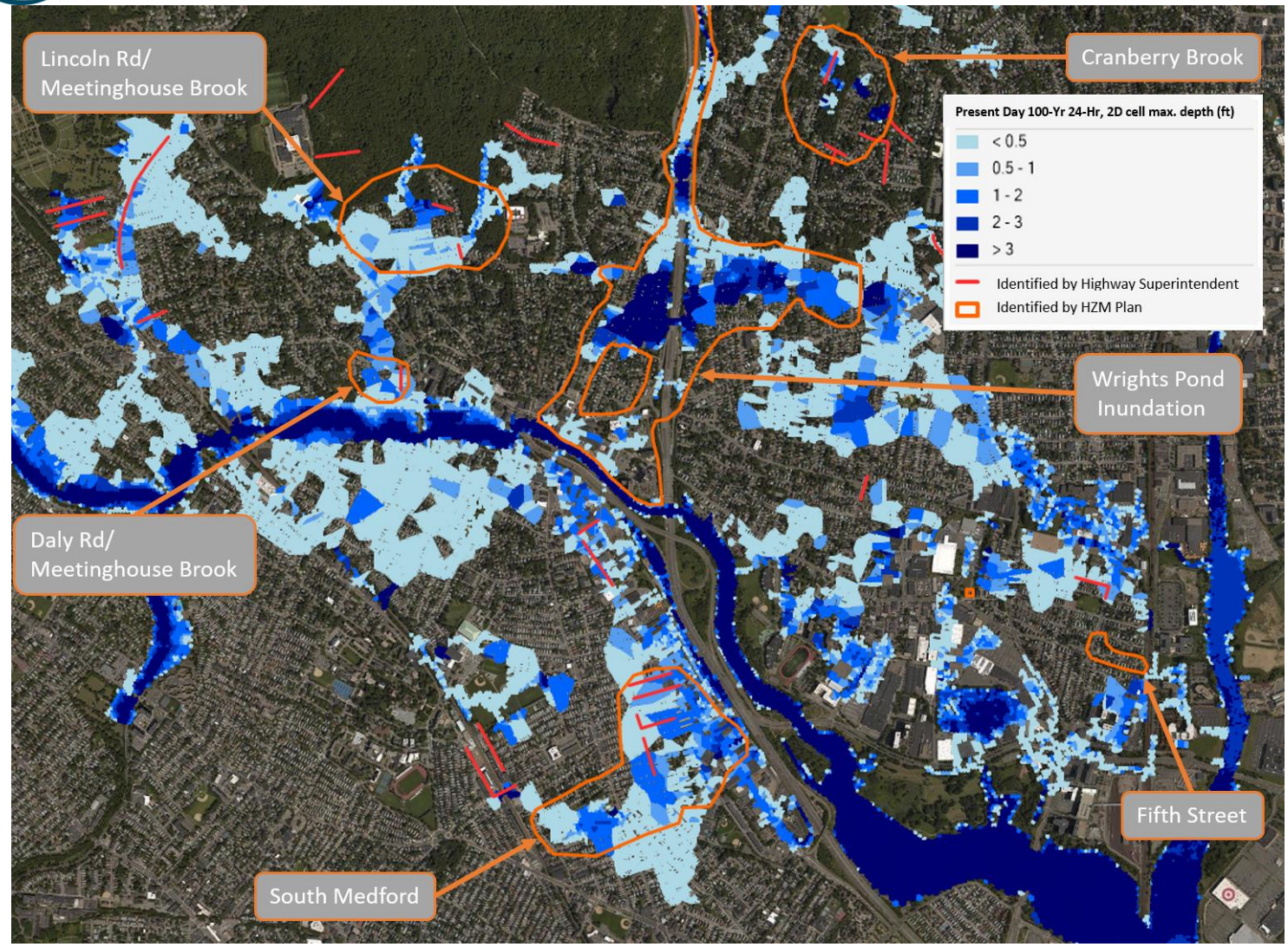


Figure 7 – Verification of flooding locations

(Source: USGS, MassGIS, 2013 Hazard Mitigation Plan Update for Medford, personal communication from City's Highway Superintendent)

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6 MODEL SCENARIOS

The validated model was used to simulate surface flooding during present and future design storms for a total of eight scenarios as presented in Table 2. Kleinfelder selected the first six scenarios (Scenarios 1 through 6 in Table 2) with the assumption that the Amelia Earhart Dam is maintaining normal operations to regulate the river stages in the Mystic River basin and its associated sub-basins elevation between -1.93 ft-NAVD (104.5 ft MDC datum) and 0.07 ft-NAVD (106.5 ft MDC datum). Normal operations also assume that there are three pumps at the Dam, each rated at 1,400 cfs, totaling to a pumping capacity of 4,200 cfs. The pump facility at the dam has an additional bay to accommodate a forth pump in the future, however, this study does not consider the implementation of a forth pump in any of the scenarios.

The Amelia Earhart Dam functions as a flood protection barrier for Medford and prevents the City from being flooded under coastal storm surge conditions. However, based on the results of a regional sea level rise and storm surge model, the Boston Harbor Flood Risk Model (BH-FRM), it is projected that the Amelia Earhart Dam is likely to be flanked (when floodwaters bypass the Dam structure) and overtopped by mid-century. The Amelia Earhart Dam is likely to be flanked as soon as 2030-2035 by a 500-year flood and by 2045-2050 by a 100-year flood. The Amelia Earhart Dam is likely to be overtopped by 2040 by a 500-year flood and by 2055-2060 by a 100-year flood.

These first six model scenarios were selected to study the impacts of precipitation flooding to the drainage system and to help identify capacity issues under the 10-year (10% annual probability) 24-hour, and the 100-year (1% annual probability) 24-hour design storms at three different time horizons: present-day condition, 2030 and 2070. Two additional 2070 scenarios were selected to evaluate the combined impacts of precipitation flooding and storm surge flooding with sea level rise, since by 2070 the Amelia Earhart Dam is likely to be overtopped under extreme storm surge conditions, and

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Medford will be exposed to storm surge flooding. Table 2 provides a comparison among the eight scenarios simulated in this study.

Table 2 – Summary of model scenarios

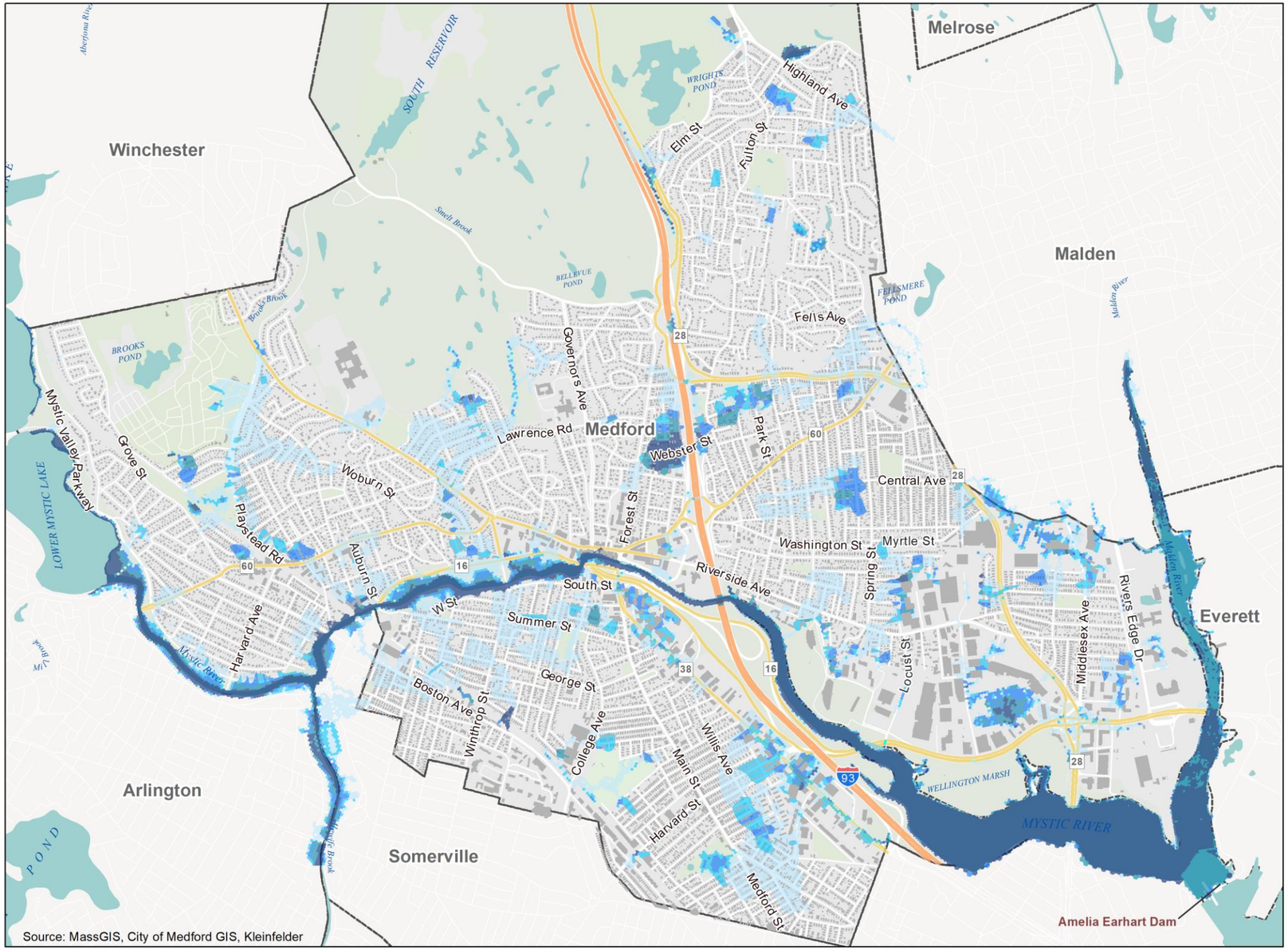
	Scenario	Total Precipitation (in.)	Peak Intensity (in. / hr)	Amelia Earhart Dam Operation
1)	**Present 10-Year 24-Hour Storm**	4.91	1.23	Normal ; Basin water level maintained between -2 ft-NAVD88 to 0 ft-NAVD88
2)	**2030 10-Year 24-Hour Storm**	5.63	1.41	
3)	**2070 10-Year 24-Hour Storm**	6.38	1.6	
4)	**Present 100-Year 24-Hour Storm**	8.88	2.22	
5)	**2030 100-Year 24-Hour Storm**	10.19	2.55	
6)	**2070 100-Year 24-Hour Storm**	11.7	2.93	
7)	**2070 10-Year 24-Hour Storm with 100-Year Storm Surge and Sea Level Rise**	4.91	1.23	Dam is flanked and overtopped. Peak tide elevation = 13.26 ft-NAVD88 Dam flanking elevation = 10.52 ft-NAVD88 Overtopping elevation = 11.66 ft-NAVD88 Pump operating at max capacity (4,200 cfs)
8)	**2070 100-Year 24-Hour Storm with 100-Year Storm Surge and Sea Level Rise**	11.7	2.93	

7 RESULTS

7.1 INUNDATION MAPS

Kleinfelder developed a series of inundation maps using the results of the 2D simulations, as shown in Figure 8 through Figure 15. The maps help to visualize the depths and extents of flooding, presented in the same order of the model scenarios as described above.

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FLOOD INUNDATION MAP

City-Wide Drainage Model City of Medford July 20, 2018

Legend

10Yr 24Hr Storm (4.9 in) Present Day Conditions

Max Flood Depth Above Ground

- < 0.5 ft
- 0.5 - 1.0 ft
- 1.0 - 2.0 ft
- 2.0 - 3.0 ft
- > 3.0 ft
- Town Boundaries

This information was developed specifically and for the exclusive use for the City of Medford's City-Wide Drainage Model.

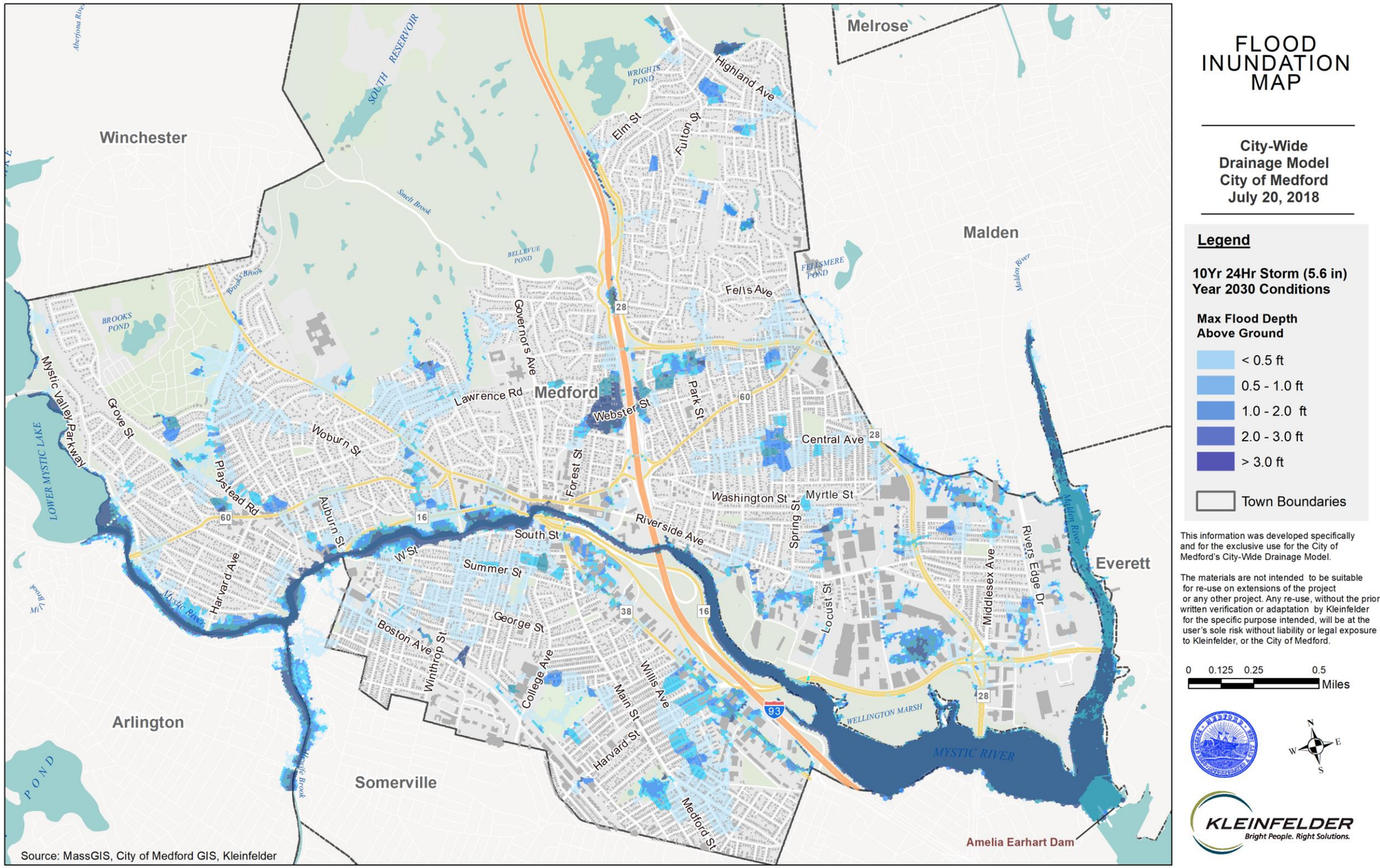
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0 0.125 0.25 0.5 Miles

N E S W

Figure 8 – Scenario 1: Present 10-Year 24-Hour Storm

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FLOOD INUNDATION MAP

City-Wide Drainage Model
City of Medford
July 20, 2018

Legend

10Yr 24Hr Storm (5.6 in)
Year 2030 Conditions

Max Flood Depth Above Ground

- < 0.5 ft
- 0.5 - 1.0 ft
- 1.0 - 2.0 ft
- 2.0 - 3.0 ft
- > 3.0 ft
- Town Boundaries

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0 0.125 0.25 0.5 Miles

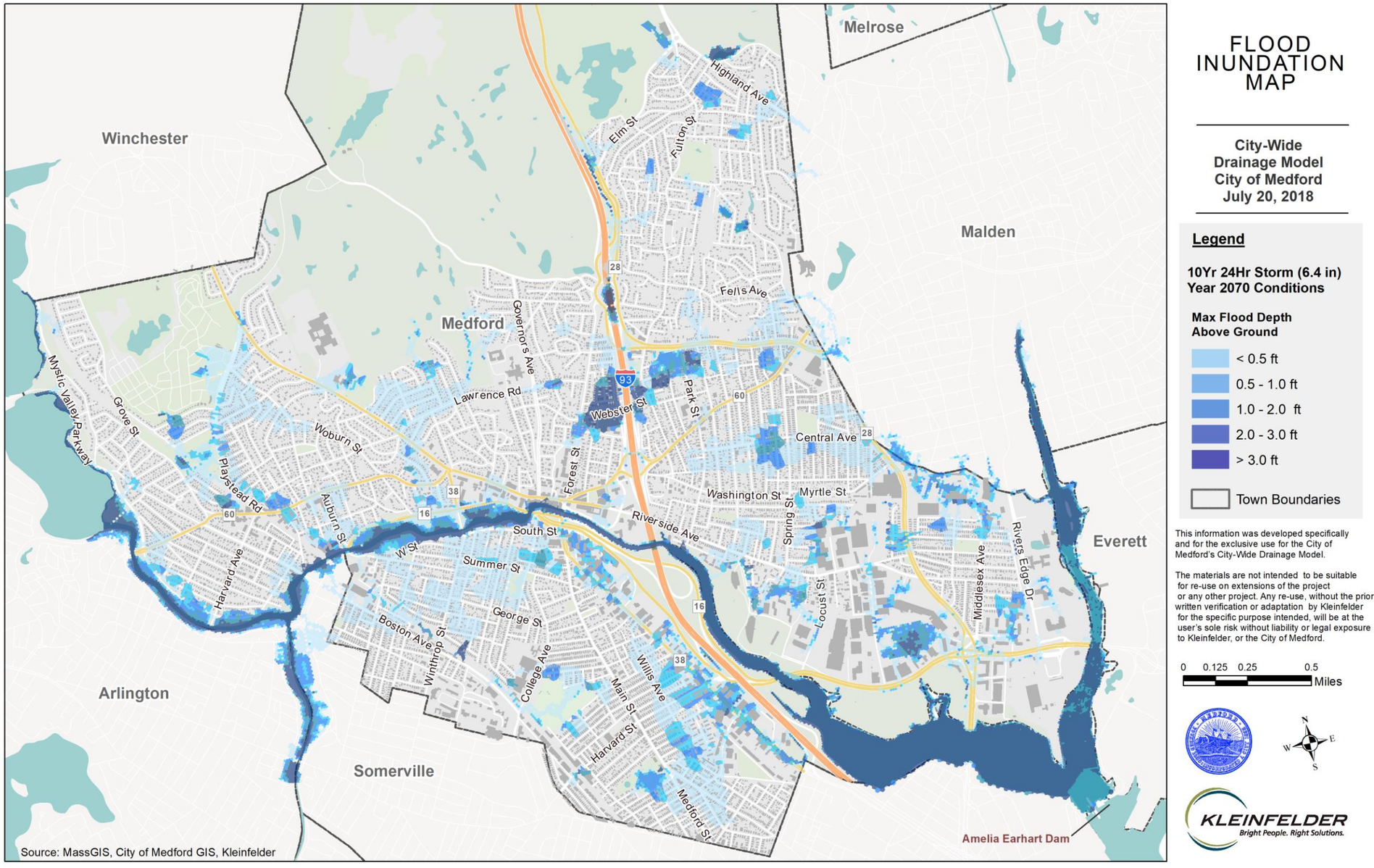
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Figure 9 – Scenario 2: 2030 10-Year 24-Hour Storm

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FLOOD INUNDATION MAP

City-Wide
Drainage Model
City of Medford
July 20, 2018

Legend

10Yr 24Hr Storm (6.4 in)
Year 2070 Conditions

Max Flood Depth Above Ground

- < 0.5 ft
- 0.5 - 1.0 ft
- 1.0 - 2.0 ft
- 2.0 - 3.0 ft
- > 3.0 ft
- Town Boundaries

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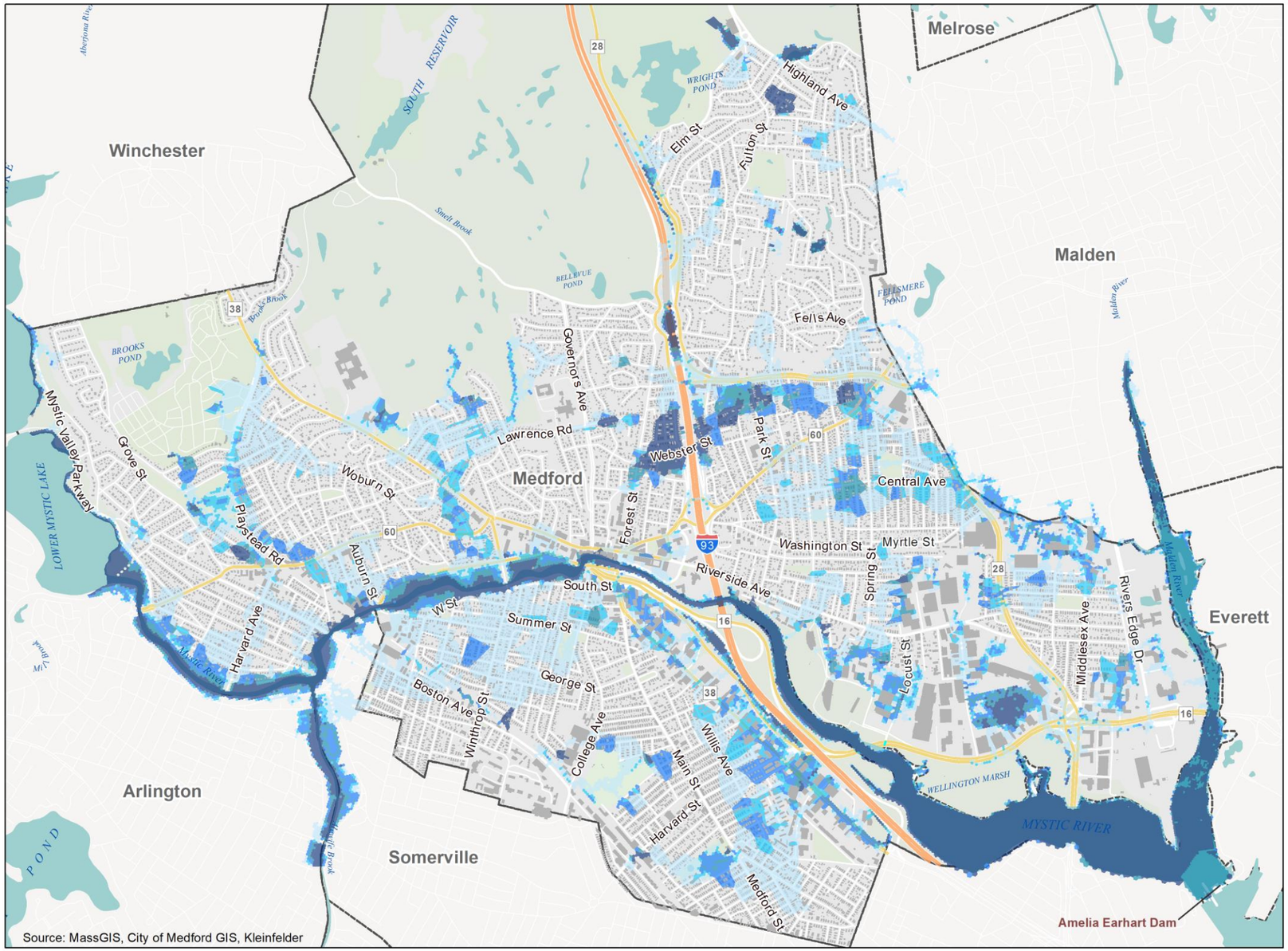
0 0.125 0.25 0.5 Miles

N W E S

Figure 10 – Scenario 3: 2070 10-Year 24-Hour Storm

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FLOOD INUNDATION MAP

City-Wide Drainage Model
City of Medford
July 20, 2018

Legend

100Yr 24Hr Storm (8.9 in)
Present Day Conditions

Max Flood Depth Above Ground

- < 0.5 ft
- 0.5 - 1.0 ft
- 1.0 - 2.0 ft
- 2.0 - 3.0 ft
- > 3.0 ft
- Town Boundaries

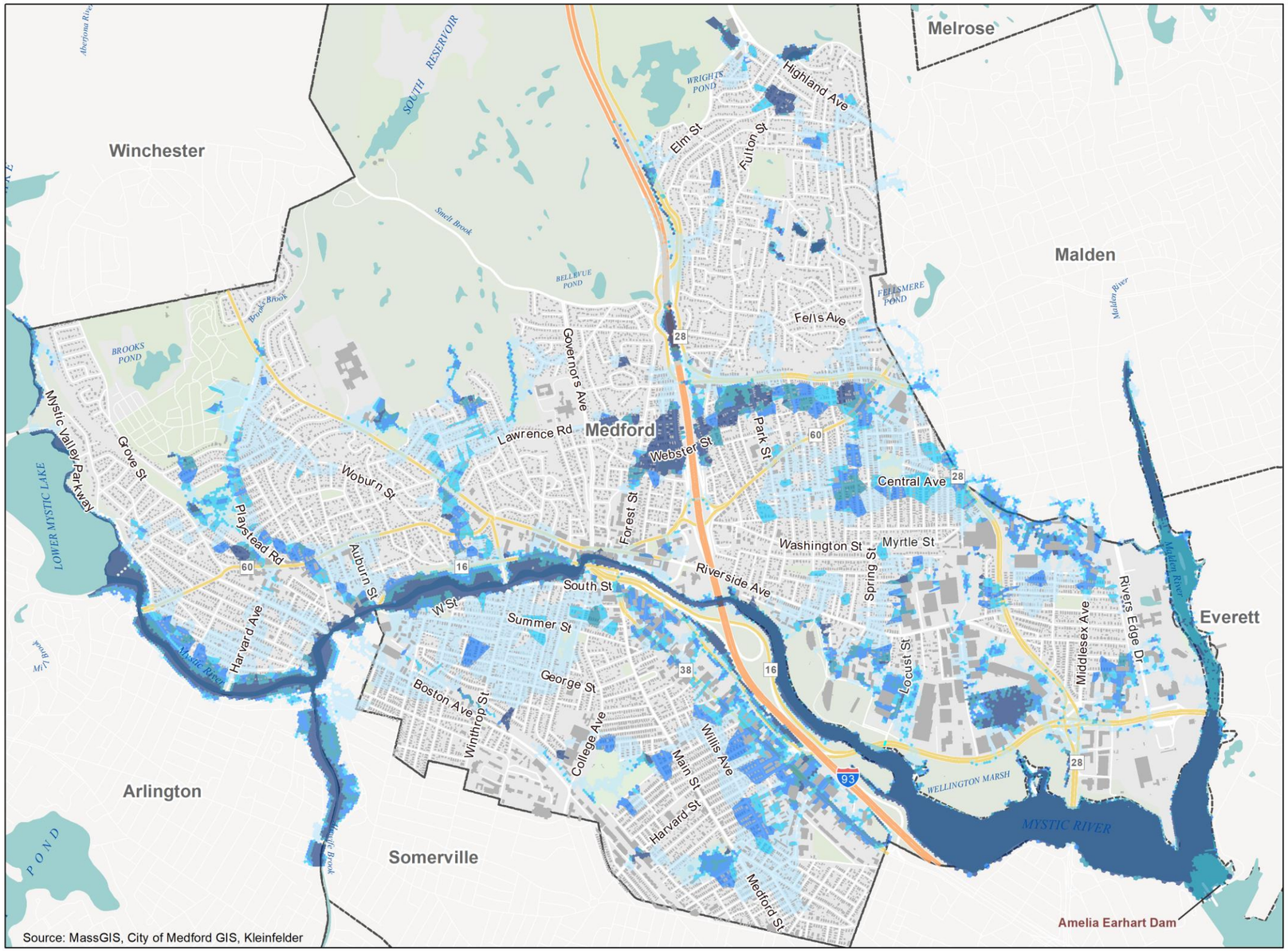
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0 0.125 0.25 0.5 Miles

Figure 11 – Scenario 4: Present 100-Year 24-Hour Storm

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FLOOD INUNDATION MAP

City-Wide Drainage Model
City of Medford
July 20, 2018

Legend

100Yr 24Hr Storm (10.2 in)
Year 2030 Conditions

Max Flood Depth Above Ground

- < 0.5 ft
- 0.5 - 1.0 ft
- 1.0 - 2.0 ft
- 2.0 - 3.0 ft
- > 3.0 ft

Town Boundaries

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0 0.125 0.25 0.5 Miles

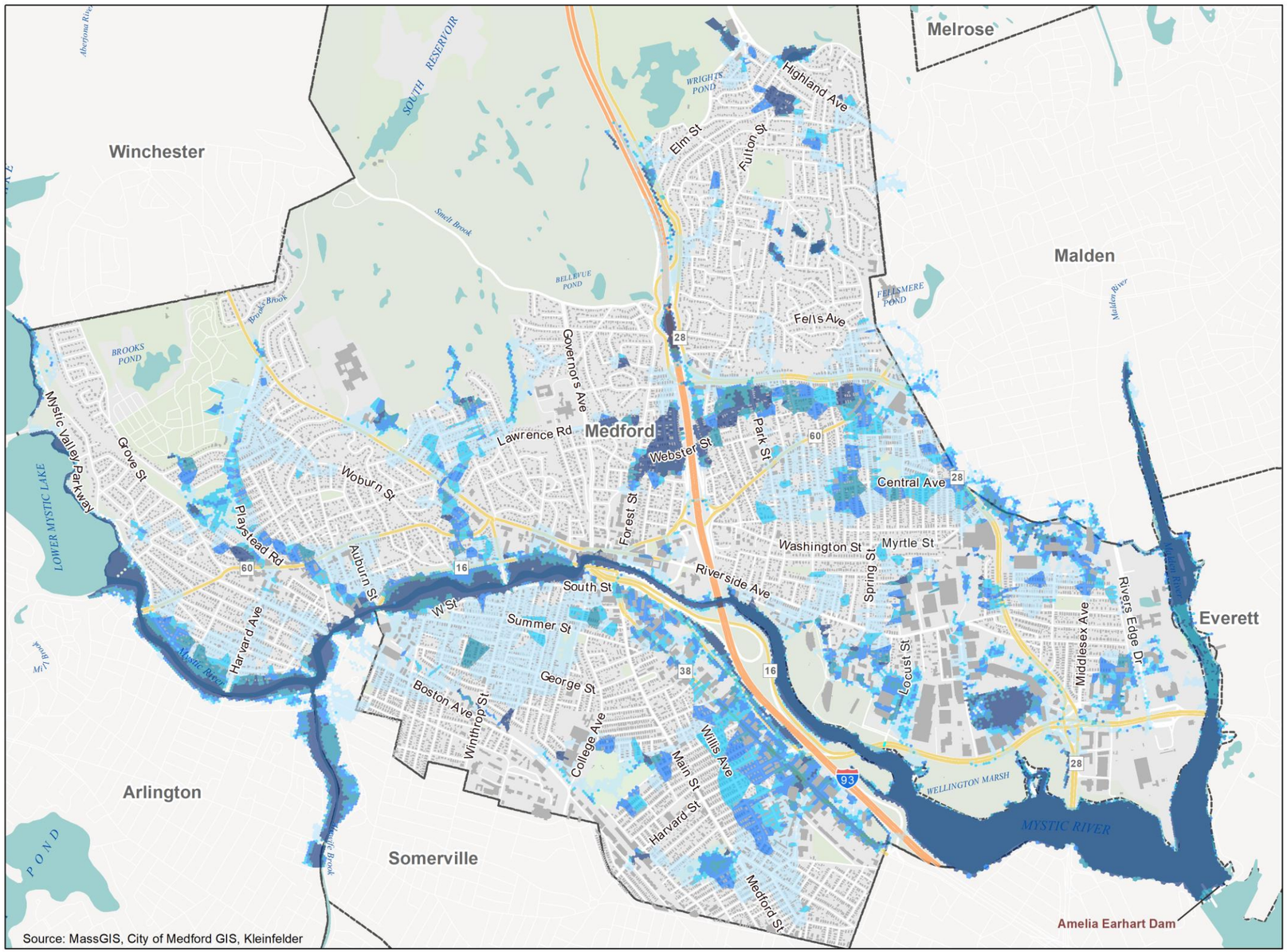
N W E S

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Figure 12 – Scenario 5: 2030 100-Year 24-Hour Storm

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FLOOD INUNDATION MAP

City-Wide Drainage Model
City of Medford
July 20, 2018

Legend

100Yr 24Hr Storm (11.7 in)
Year 2070 Conditions

Max Flood Depth Above Ground

- < 0.5 ft
- 0.5 - 1.0 ft
- 1.0 - 2.0 ft
- 2.0 - 3.0 ft
- > 3.0 ft
- Town Boundaries

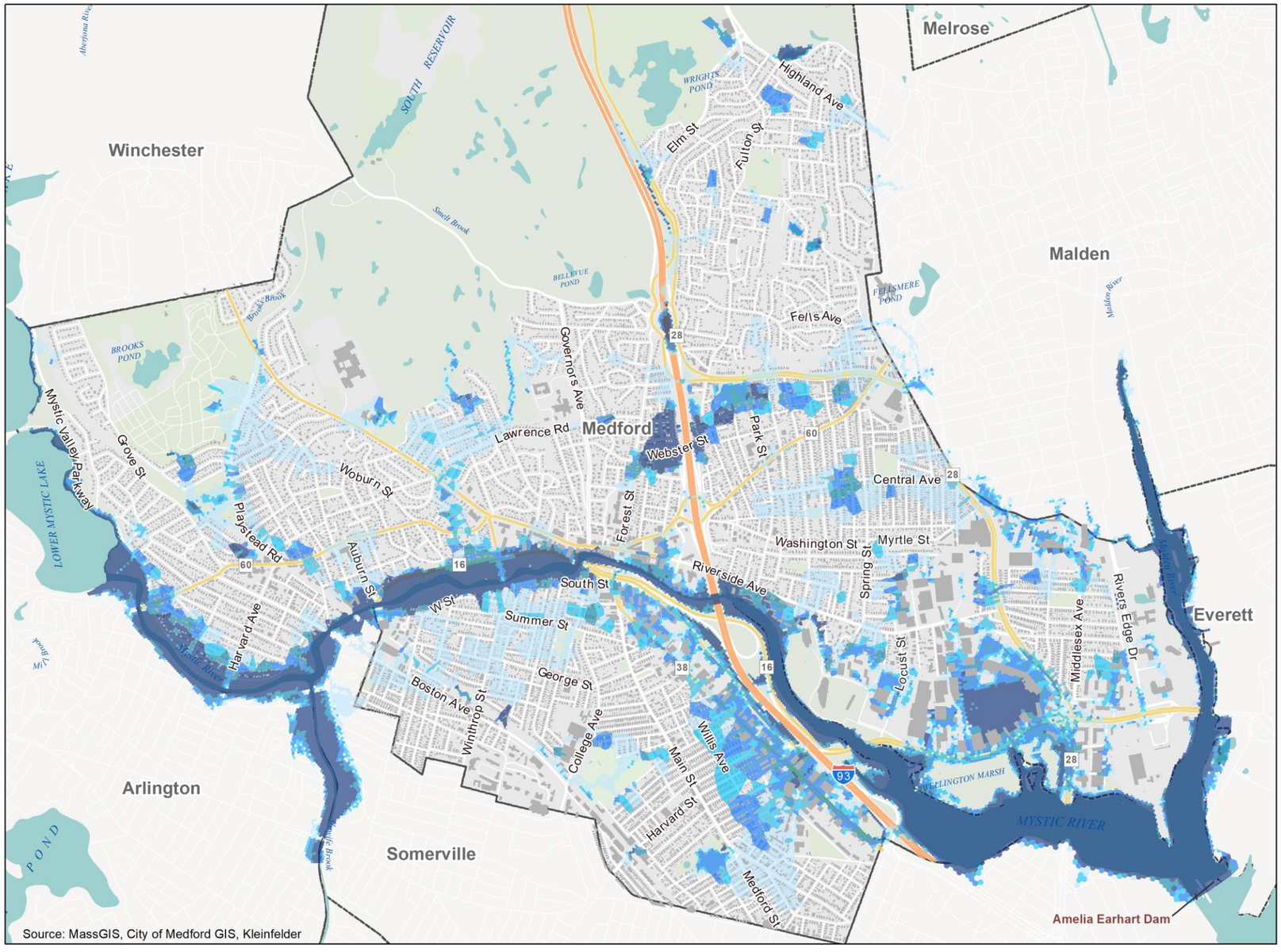
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0 0.125 0.25 0.5 Miles

Figure 13 – Scenario 6: 2070 100-Year 24-Hour Storm

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FLOOD INUNDATION MAP

City-Wide Drainage Model
City of Medford
July 20, 2018

Legend

Year 2070 Condition
10Yr-24Hr (6.4 in)
100 Yr Surge w/ SLR

Max Flood Depth Above Ground

- < 0.5 ft
- 0.5 - 1.0 ft
- 1.0 - 2.0 ft
- 2.0 - 3.0 ft
- > 3.0 ft
- Town Boundaries

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0 0.125 0.25 0.5 Miles

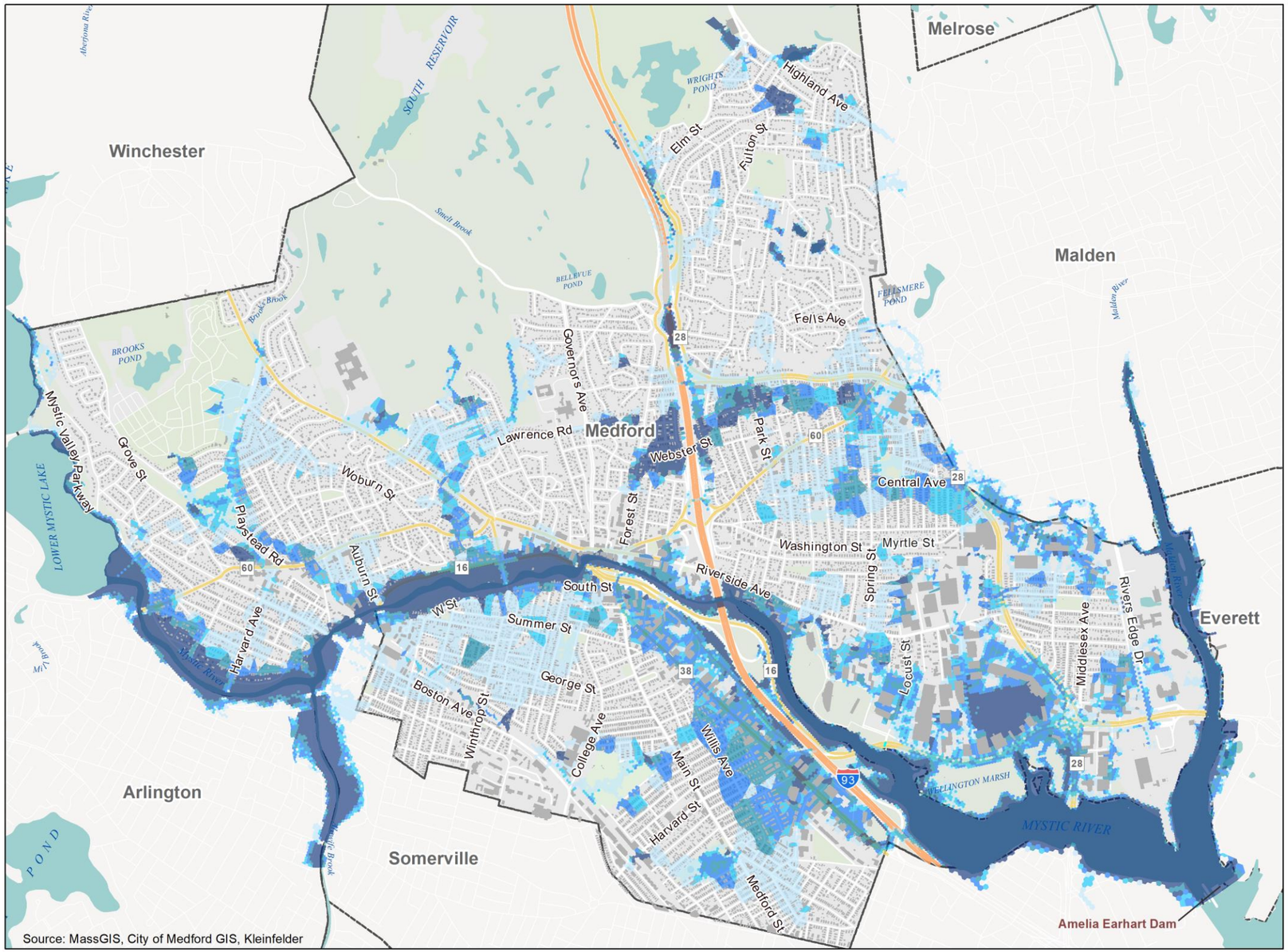
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Figure 14 – Scenario 7: 2070 10-Year 24-Hour Storm with 100-Year Storm Surge and Sea Level Rise

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FLOOD INUNDATION MAP

City-Wide Drainage Model
City of Medford
July 20, 2018

Legend

Year 2070 Condition
100Yr-24Hr (11.7 in)
100 Yr Surge w/ SLR

Max Flood Depth Above Ground

- < 0.5 ft
- 0.5 - 1.0 ft
- 1.0 - 2.0 ft
- 2.0 - 3.0 ft
- > 3.0 ft
- Town Boundaries

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0 0.125 0.25 0.5 Miles

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Figure 15 – Scenario 8: 2070 100-Year 24-Hour Storm with 100-Year Storm Surge and Sea Level Rise

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7.2 DISCUSSION

The inundation maps presented in Figure 8 through Figure 15 show the extent and depth of flooding in the City under the different rainfall design storm scenarios. The flooding shown on these maps results from a combination of conveyance capacity issues in the City's drainage system and overbank flooding from the Mystic River. River overbank flooding occurs particularly in areas of constrictions to the river channel geometry, such as at river sections between Winthrop Street and Mystic Valley Parkway, as well as at river sections between Harvard Avenue and Route 60/High Street.

One purpose of developing this Citywide drainage model is to identify additional areas in the City that may be at risk of flooding from future events. Analysis of the inundation maps for the 10-year 24-hour design storm over the three time periods show that the total area of the City projected to flood increases from 13.19% in the present to 14.96% by 2030, to 16.59% by 2070 and to 21.75% by 2070 when combined with a 100-year storm surge with sea level rise. For the 100-year 24-hour design storm over the three time periods, the area of the City projected to flood increases from 21.07% in the present to 22.52% by 2030, to 23.38% by 2070, and to 27.03% by 2070 when combined with a 100-year storm surge with sea level rise. Figure 14 and Figure 15 illustrate the 2070 horizon plus storm surge/sea level rise scenarios. Figure 16 presents a comparison of areas in the City that are flooded under a 10-year storm of today and areas of the City that are flooded under a possibly worst-case scenario by 2070 when a 100-year rainfall coincides with a 100-year storm surge with sea level rise. This figure shows that there are some areas in the City where the existing flooding gets deeper and more extensive, such as at Winthrop Street in South Medford, Mystic Avenue at Harvard Street and Fellsway Plaza (identified by green circles in Figure 16). However, there are some new areas in the City that are likely to be flooded under future extreme storm scenarios, such as at Harvard Avenue near Boston Avenue and Medford Plaza near Fellsway (identified by purple circles in Figure 16).

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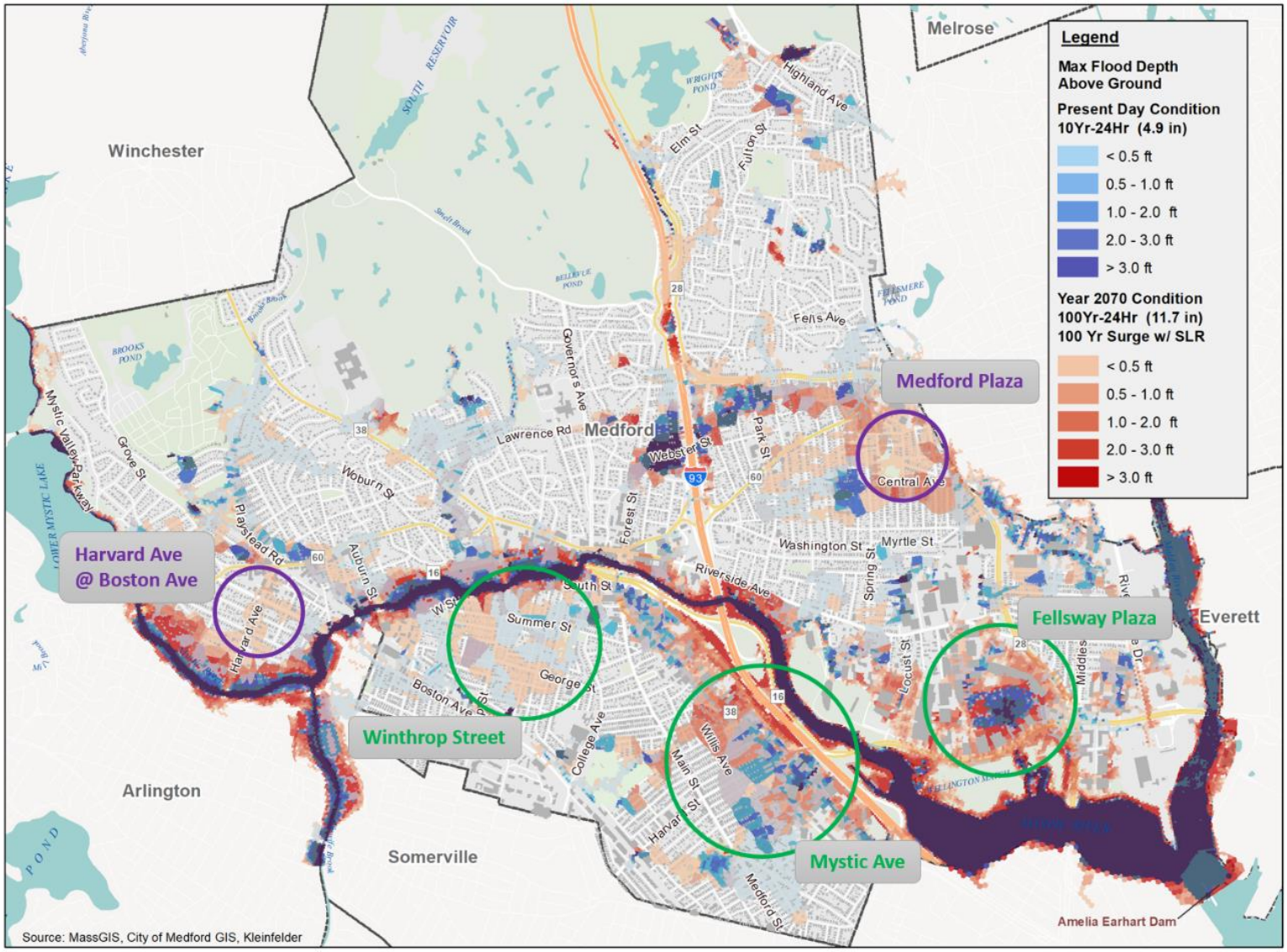


Figure 16 – Flood depths and extent comparison: Present Day Condition vs. Year 2070

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Another purpose of the Citywide drainage model is to evaluate future flooding impacts to critical assets in the City, such as electrical substations, roadways, train stations, emergency shelters, schools, housing for vulnerable population groups, hospitals and emergency services. To better understand the severity of these flooding events, Figure 17 summarizes the flooding conditions at 10 critical asset locations across the City based on:

- Peak flood depths, relative to nearby ground surface for
  Scenario 2, 6 and 7 (depth of surface water in feet above existing grade)
- Peak flood elevations (ft-NAVD) for scenario 2, 6 and 7
  (maximum elevation of flood water surface in feet using NAVD-88 datum)
- Flood durations (hours) for scenario 2, 6 and 7
  (estimated from 2D surface mesh results and pipe cross-sections)

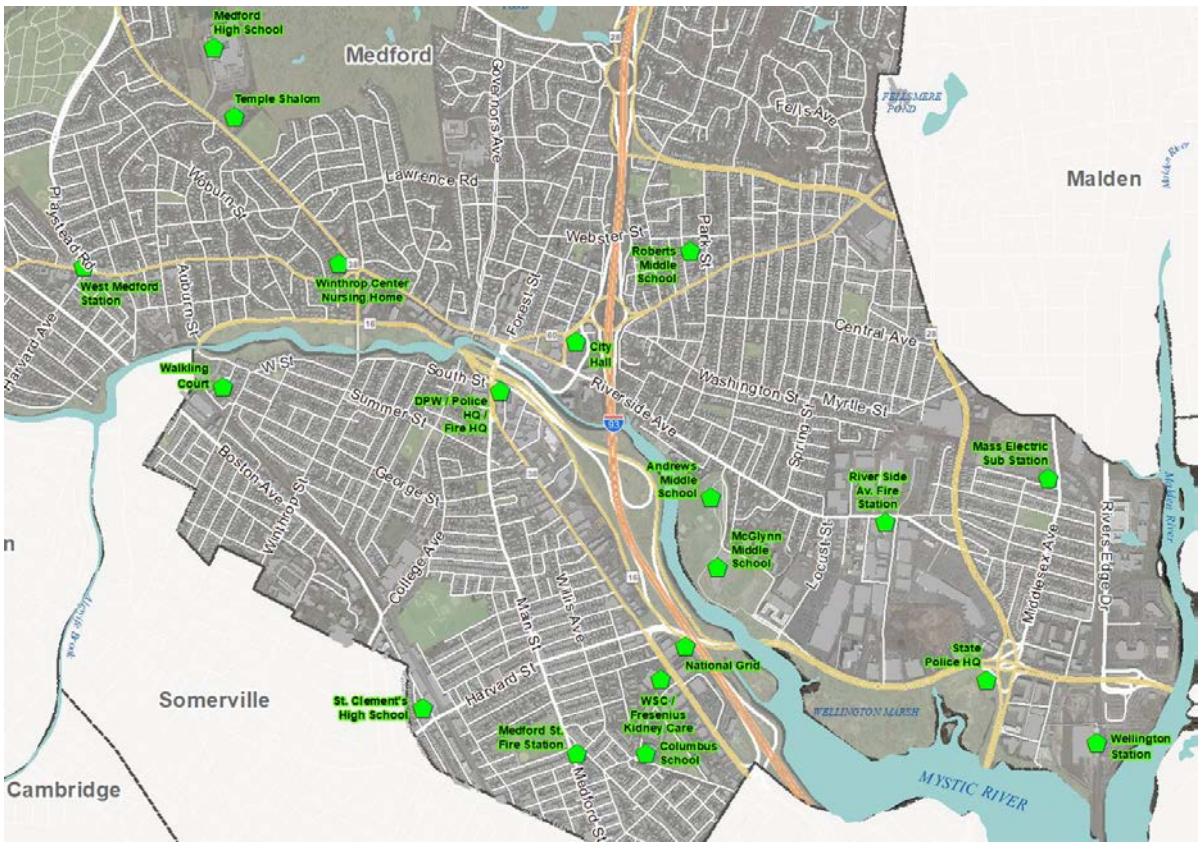


Figure 17 – Reported infrastructure locations in Table 3 *(Source: City of Medford, USGS, MassGIS)*

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Table 3 – Flooding Severity for 10 critical asset locations

Storm Scenario	2)	6)	7)		2)	6)	7)		2)	6)	7)
	2030 10-Year 24-Hour, 5.6in (AED Normal Operation)	2070 100Yr-24Hr,11.7in (AED Normal Operation)	2070 10Yr-24Hr,6.4in 2070 100Yr Sea Level Rise Storm Surge (AED Flanked and		2030 10-Year 24-Hour, 5.6in (AED Normal Operation)	2070 100Yr-24Hr,11.7in (AED Normal Operation)	2070 10Yr-24Hr,6.4in 2070 100Yr Sea Level Rise Storm Surge (AED Flanked and		2030 10-Year 24-Hour, 5.6in (AED Normal Operation)	2070 100Yr-24Hr,11.7in (AED Normal Operation)	2070 10Yr-24Hr,6.4in 2070 100Yr Sea Level Rise Storm Surge (AED Flanked and
Locations	Peak Flood Depth				Peak Flood Elevation				Flood Duration (Hour)		
WSC / Fresenius Kidney Care	2.21	3.12	3.24		8.86	9.77	9.89		12	24+	24+
Temple Shalom	1.59	3.37	2.46		39.23	41.01	40.1		5	7	7
Winthrop Center Nursing Home	-	-	-		-	-	-		-	-	-
Walkling Court	-	0.01	0.38		-	9.73	10.1		-	6	5
DPW / Police HQ / Fire HQ	2.3	2.64	2.69		9.53	9.87	9.92		12	24+	24+
Medford St Fire Station	0.08	0.75	0.3		13.13	13.8	13.35		1	4	2
River Side Av. Fire Station	0.58	1.2	1.1		9.82	10.44	10.34		6	7	10
National Grid	2.11	3.01	3.13		8.87	9.77	9.89		12	24+	24+
City Hall	0.02	0.05	0.57		9.57	9.6	10.12		8	8	24+
State Police HQ	0.32	0.36	0.77		9.62	9.66	10.07		5	12	12
Mass Electric Sub Station	0.41	1.03	0.49		7.29	7.91	7.37		8	10	10
McGlynn Middle School	-	-	-		-	-	-		-	-	-
Andrews Middle School	1.01	1.27	3.11		8	8.26	10.1		6	8	10
Columbus School	0.88	0.95	0.89		11.28	11.36	11.29		6	12	7
St. Clement's High School	0.05	0.11	0.06		25.46	25.52	25.47		2	4	2
Roberts Middle School	-	0.01	-		-	19.02	-		-	3	-
Medford High School	0.16	0.26	0.18		51.55	51.65	51.57		3	6	3
West Medford Train Station	0.53	1.51	0.6		18.32	19.3	18.39		3	5	3
Wellington Station	0.16	0.24	0.54		8.76	8.84	9.14		2	3	4

West Medford train station on Playstead Road and Six Acres Day Care upstream of the Meetinghouse Brook are some of the locations vulnerable to precipitation flooding. The flooding observed is linked to drainage system capacity restrictions identified on Playstead Road and Winthrop Street.

The green space behind the Fellsway Plaza provides some level of stormwater runoff detention, protecting upstream neighborhoods. However, the storage volume in the green space can be filled quickly under intense storms, creating inlet capacity issues in the surrounding mall area and the Wellington Circle Route 16 / Route 28 Intersection.

South Medford, being a low-lying area by nature, is highly vulnerable to storm surge flooding. The DPW building, the Police and the Fire Headquarters located in South Medford are likely to experience more than 2.5 ft of flood depths under future flooding

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scenarios. The elderly housing at Walkling Court in South Medford is likely to experience only nuisance flooding (flood depths less than 0.5 ft contained within the curb) for most of the future scenarios. The area near Harvard Street and Mystic Avenue is likely to experience 12 to 24 hours of flooding in many of the scenarios.

For locations at a higher elevation and away from the Mystic River vicinity, such as the Columbus School and Medford High School, storms with higher intensity will have a greater impact that is mostly governed by the upstream hydraulics of the nearby drain system. For locations along the Mystic River, the storm surge/sea level rise impacts from tidal flows flanking the Amelia Earhart Dam will trump most of the precipitation flood impacts from intense rainfall.

8 CONCLUSIONS

The Citywide drainage model is a good planning level representation of the key flooding locations in the City under present and future scenarios. The purpose of the model was to evaluate if the existing main storm drainage pipes in the City have sufficient conveyance capacity under future design storm scenarios, to identify additional areas and infrastructure (e.g. electrical substations, roadways, train stations, emergency shelters, schools, housing for vulnerable population groups, hospitals and emergency services) that may be at risk of flooding from extreme rainfall events, especially when combined with sea level rise and storm surge; and to evaluate flooding impacts (in terms of flood depth and duration) during extreme precipitation events at these critical infrastructure locations.

Since factors that influence flooding are not contained within City geographic boundaries, the model developed by Kleinfelder also includes all the upper Mystic River watershed upstream of the Amelia Earhart Dam as well as the City. This regional watershed model is capable of simulating upstream hydrology, river hydraulics and flow routing that are important to evaluate in terms of downstream flooding impacts in Medford. The one-dimensional (1D) hydrologic/hydraulic drainage model for the City includes the drainage

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trunk lines with a diameter greater than or equal to 18 inches, which is sufficient level of detail to adequately represent the characteristics of the City's stormwater system for this type of planning level study. Since capacity issues in the City's stormwater system result in surface flooding from manholes and catch basins, Kleinfelder developed a two-dimensional (2D) surface model that can simulate the dynamic spreading of floodwaters on the ground surface, which can help predict the extent and depth of inundation.

The regional model of the watershed along with the integrated 1D-2D model for the City was run for six scenarios to study the impacts of precipitation flooding to the drainage system and to help identify capacity issues under the 10-year 24-hour and the 100-year 24-hour design storms at three different time horizons: present-day condition, 2030 and 2070. Two additional 2070 scenarios were selected to include running the 2070 10- and 100-year 24-hr precipitation flooding events along with the 2070 100-year storm surge with sea level rise. This is because by 2070 the Amelia Earhart Dam is likely to be overtopped under extreme storm surge conditions, and Medford will be exposed to storm surge flooding. The flooding results from these scenarios show a combination of conveyance capacity issues in the City's drainage system and overbank flooding from the Mystic River. River overbank flooding occurs particularly in areas of constrictions to the river channel geometry, such as at river sections between Winthrop Street and Mystic Valley Parkway, as well as at river sections between Harvard Avenue and Route 60/High Street.

Results of the model were instructive with respect to several major areas of interest:

- Areas of chronic flooding under a present day 10-year storm will see exacerbated flooding of greater inundation extents and depth in the cited worst case future scenario. Examples are Winthrop Street in South Medford, Mystic Avenue at Harvard Street and Fellsway Plaza.

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- New areas that have not been subject to flooding in the past are likely to be inundated under future extreme storm scenarios. Examples are Harvard Avenue near Boston Avenue and Medford Plaza near Fellsway.
- South Medford, being a low-lying area by nature, is highly vulnerable to storm surge flooding at critical assets, such as the DPW building, the Police and the Fire Headquarters. The area near Harvard Street and Mystic Avenue is likely to experience 12 to 24 hours of flooding in many of the scenarios.

The City can use the findings for this planning level study to further refine the 1D-2D model. For example, the model can incorporate flow release controls for the Wright's Pond Dam and the Winchester Reservoir to better simulate the hydraulics under various conditions. For certain flood prone areas of the City, such as the South Medford area which has a high concentration of critical infrastructure assets, a refined model can help to better understand the flooding issues at the street-level, for both short (e.g. the July 10, 2010 flash flood) and long duration storms (e.g. March 2010 flooding). The model can also be used as an efficient tool to evaluate flood mitigation alternatives, such neighborhood-wide flow reduction and flood attenuation alternatives or grey infrastructure and green infrastructure options to mitigate volume, extent, depth and duration of flooding.

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APPENDIX B

Summary of Changes from 2019 Climate Change Vulnerability Assessment

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Tel: 978.532.1900

M E M O R A N D U M

TO:	Alicia Hunt, Director of Planning, Development & Sustainability, City of Medford Brenda Pike, Staff Planner, Planning, Development & Sustainability
FROM:	Weston & Sampson
DATE:	March 27, 2025
SUBJECT:	Resilient Medford Urban Forest Master Plan MVP Grant 2025 Task 7.1 Review 2019 CCVA and Revise Methodology

Introduction

Weston & Sampson (W&S) is pleased to present this memorandum to the City of Medford ("City") summarizing the work completed under *Task 7.1 Review of 2019 CCVA and Revise Methodology*. As part of this effort, we have developed the Data Sources Tracking Spreadsheet and conducted a Data Gap Analysis. These tools are intended to serve as the framework for updating the 2019 Climate Change Vulnerability Assessment (CCVA), using the latest climate and asset data and a robust CCVA framework discussed below.

Data Gap Analysis Summary of Findings

The 2019 CCVA for Medford was reviewed to identify key hazard data, asset data, statistics, and graphics, providing a framework for updating the vulnerability assessment. The 2019 CCVA includes 2030 and 2070 as the future planning horizons, assessing climate exposure of assets to temperature, precipitation, and rising sea levels under low (RCP 2.6), moderate (RCP 4.5), and high (RCP 8.5) Greenhouse Gas (GHG) emissions scenarios. The City uses the emissions scenarios from the 2015 Boston Research Advisory Group. Climate data in the 2019 CCVA is derived from a variety of sources and demographic data is mostly retrieved from 2015 and 2016 Census data. The 2019 CCVA also includes detailed demographic insights on vulnerable populations. The findings of this report are supported by visuals, maps, and graphics that enhance the presentation of climate data.

As part of the 2025 CCVA update, the following parameters are suggested to be updated to reflect the latest climate data (recommended by the state of Massachusetts in their Climate Resilient Design

Standards Guidance and integrated into the Climate Resilience Design Standards Too[1]l), new planning horizon recommendations, and an updated CCVA framework that factors in sensitivity and adaptive capacity as well as exposure which were not explicitly included in the 2019 assessment.

Planning Horizons

As previously mentioned, the earlier CCVA utilized the 2030 and 2070 planning horizons. For this update, the project team proposes using the 2050 and 2070 planning horizons. The 2030 planning horizon represents the bounding years of 2020-2039, which is now considered too close to present-day conditions for meaningful future risk assessment. The 2050 planning horizon, with bounding years 2040-2059, offers a better representation of the near-term future based on the useful life of existing infrastructure assets. This planning horizon captures the most immediate impacts/vulnerabilities and will likely be received better and increase buy-in from communities. The project team also recommends retaining the 2070 (2060-2079) planning horizon as the long-term future, as it aligns with the 2019 CCVA and other plans in the Boston area, is one of the recommended planning horizons adopted by the State and falls within the useful life of new and existing City's infrastructure assets, providing a better understanding of long-term impacts on infrastructure and vulnerable population groups.

Climate Change Projections Data

The 2019 CCVA report, while well-organized and well-documented at the time of its production, has since been surpassed by major updates to the state's climate change projection scenarios through the 2022 MA Climate Change Assessment[2], MA Climate and Hydrologic Risk Project (Phase 1)[3] and the Massachusetts Coastal Flood Risk Model (MC-FRM)[4]. The results from these models were integrated into the MA Climate Resilient Design Standards Tool, published in 2022, which incorporates updated projections and methodology. Additionally, the State has adopted high-emission scenarios within the Tool as the upper bound of uncertainty to factor the variations in climate change projections for resilience standards and planning.

MA Climate and Hydrologic Risk Project is a collaboration between the Executive Office of Energy and Environmental Affairs (EEA), Cornell University, Tufts University, and the U.S. Geological Survey. The

---

[1] *MA Climate Change Clearinghouse*. (2021). https://dev.resilientma.org/rmat_home/designstandards/

[2] *Volume II -Statewide Report*. (2022). https://www.mass.gov/doc/2022-massachusetts-climate-change-assessment-december-2022-volume-ii-statewide-report/download

[3] Massachusetts Climate and Hydrologic Risk Project (Phase 1) – Stochastic Weather Generator Climate Projections XLSX, 2023, https://resilientma-mapcenter-mass-eoeea.hub.arcgis.com/documents/Mass-EOEEA::massachusetts-climate-and-hydrologic-risk-project-phase-1-stochastic-weather-generator-climate-projections-xlsx/about.

[4] MA Sea Level Rise and Coastal Flooding Viewer, 2022, https://experience.arcgis.com/experience/23d861b79aed450eb8972013dd28579b/

project's goal is to develop climate change projections for Massachusetts on a HUC8 watershed scale.[5] As part of Phase 1, Cornell University has developed future projections for total rainfall depths using Intensity-Duration-Frequency (IDF) datasets under 0.5 to 8.5-degree warming scenarios for 5-minutes to 48-hour duration intervals to estimate extreme precipitation for 1-year to 100-year future design storm scenarios.

MC-FRM is a high-resolution, probabilistic flood model developed by Woods Hole Group to assess current and future coastal flood risks in Massachusetts. The model incorporates storm surge, sea level rise, tides, and extreme weather events to provide coastal flooding probability projections under different climate scenarios.[6]

W&S will incorporate this latest climate projection data from several key sources, including the data used in the MA Climate Resilient Design Standards Tool, the Resilient MA Map Viewer, MA 2021 Lidar Data[7], and the urban heat island modeling and inland flood modeling data developed specifically for the City. Additionally, W&S will integrate relevant information from the MA Climate Change Assessment 2022[8], the MA State Hazard Mitigation Plan (Resilient Mass) 2023[9], and the 2024 Urban Forest Vulnerability Assessment for Medford[10].

Table 1: Summary of Key Changes Since 2019	
Data Category	Changes
Assets	Updates include mapping critical infrastructure using data provided by the City, adding new data sources from MassMapper such as hazardous facilities, MBTA bus stops, and integrating the 2021 Road Inventory from MassMapper.
Inland Precipitation	Updates include using the latest data from inland flood models developed by Kleinfelder for the City to look at projected parcels at risk of flooding.

[5] ResilientMass Climate Hub. (2022). Arcgis.com. *https://resilientma-mapcenter-mass-eoeea.hub.arcgis.com/*

[6] Massachusetts Coast Flood Risk Model - Woods Hole Group. (2023, September 27). Woods Hole Group. *https://www.woodsholegroup.com/innovation/massachusetts-coast-flood-risk-model*

[7] *MassGIS Data: Lidar Terrain Data | Mass.gov*. (n.d.). Retrieved March 11, 2025, from https://www.mass.gov/info-details/massgis-data-lidar-terrain-data

[8] Massachusetts Climate Change Assessment, 2022 https://www.mass.gov/doc/2022-massachusetts-climate-change-assessment-december-2022-volume-i-executive-summary/download#page=11

[9] MA State Hazard Mitigation Plan (Resilient Mass) 2023, https://www.mass.gov/info-details/2023-resilientmass-plan

[10] Weston & Sampson. (2024). *City of Medford Urban Forest Vulnerability Assessment*.

Table 1: Summary of Key Changes Since 2019	
Data Category	Changes
Heat	Updates include using the latest data from Resilient MA (2021) for the years 2050 and 2070, the latest heat island data from the 2024 Medford Urban Vulnerability Assessment, and EPA data on heat-related deaths to illustrate the community impact of heat.
Sea Level Rise	Updates include SLR/SS data from Massachusetts Coastal Flood Risk Model (MCFRM).
Social Vulnerability	Updates include an updated map showing social vulnerability using the CDC Social Vulnerability Index (2022), the latest Massachusetts Environmental Justice Populations data, and areas where social vulnerability and EJ populations overlap. Additionally, there are updated maps for other vulnerable populations from GEAR Tool from ACS (2019-2023).
Tree	Updates include creating a new tree canopy cover map using the 2024 Medford Urban Forest Vulnerability Assessment and using the latest canopy data from National Land Cover Database (NLCD).
GHG Emissions Scenarios	The updated report and vulnerability assessment will only utilize and describe the RCP 8.5 greenhouse gas emissions scenario (high emissions) based on State adopted emission scenario in Climate Resilient Design Standard Tool.

More details about the updated data set can be found under Appendix A: Data Sources Tracking Spreadsheet.

Asset Data

The project team has reviewed the asset data from the 2019 CCVA and compared it with the latest data provided by the City. This comprehensive analysis has led the project team to propose the inclusion of the following types of assets as listed in Table 1. Asset categories are primarily influenced by the 2019 CCVA Report with a few changes such as Dams asset category has been separated from overall Utilities category to address the vulnerability from high hazard dams separately. Hazardous Facilities asset category has been added as a new asset category to assess the present day and future vulnerability from hazardous facilities under different climate hazards.

Table 2: Asset Categories Proposed in 2025 CCVA	
Asset Category	**Asset Subcategories**
Community resources	Library Post Office Town Services Elderly Care Facilities Affordable Housing Pharmacies Places of Worship
Dams	High Hazard Dams Significant Hazard Dams
Emergency services	Police Fire Emergency Medical Assistance Hospitals
Food distribution centers	Grocery Stores Food Pantries
Hazardous Facilities	Hazardous Facilities Gas Stations
Natural environment	Medford's Urban Forest Middlesex Fells Parks Open Space Water Bodies
Schools and universities	K-12 Schools Daycares Universities/Colleges

Table 2: Asset Categories Proposed in 2025 CCVA	
Asset Category	Asset Subcategories
Transportation	Road System Public Transit Pedestrian and Bike Infrastructure Transit Stops Evacuation Routes
Utilities	Electric Natural Gas Water (Surface Water Bodies and Built Infrastructure) Wastewater (Built Wastewater Infrastructure) Telecommunications

Framework for Sensitivity and Adaptive Capacity

The project team will implement an updated framework for vulnerability assessment, which incorporates indicators of exposure, sensitivity, and adaptive capacity. This updated framework provides a comprehensive assessment of asset vulnerability by considering not only climate exposure but also two other important parameters that constitute vulnerability: sensitivity, which reflects an asset's current susceptibility to failure due to climate-related stressors, and adaptive capacity, which evaluates its ability to withstand and recover from climate-induced damages. By using this updated framework, the team aims to provide a comprehensive understanding of how different assets may be impacted, which can also inform better understanding of the overall resilience and preparedness of the City's infrastructure.

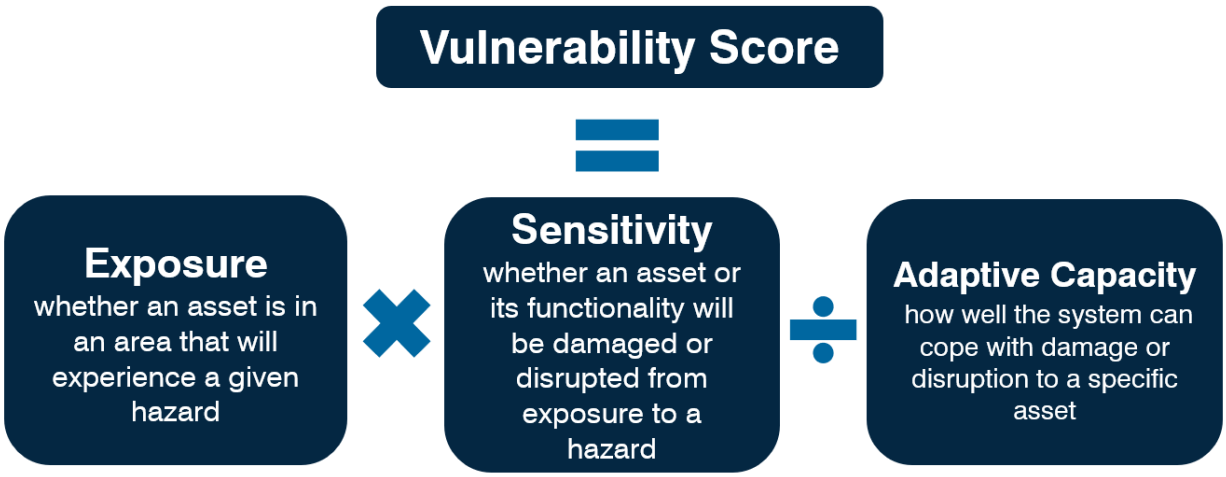


Figure 1. Framework for sensitive and adaptive capacity for the City of Medford.

Updated Social Vulnerability and Demographic Data

The project team will update the demographic data included in the 2019 CCVA to reflect the most recent data from the American Community Survey (ACS) Census for the years 2019-2023[11], from the GEAR Tool[12], as well as the 2022 CDC Social Vulnerability Index (SVI)[13]. This updated demographic data will provide a current and comprehensive view of the community, allowing for a more accurate assessment of social vulnerabilities.

Final Deliverables

The final report will adhere to the 2019 format, updating relevant sections and incorporating new data where applicable.

Furthermore, a GIS based data visualization tool will be developed to provide the City with an interactive and user-friendly platform for analyzing and interpreting localized extreme heat and flood risks across the identified asset categories. This tool will integrate high-resolution climate data, GIS mapping, and vulnerability assessment to highlight assets susceptible to climate change under both present day and future. This tool will enable the City to assess infrastructure vulnerabilities under different planning horizons and identify priority population groups at higher risk due to socio-economic or health-related factors, both now and in the future.

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[11] U.S. Census Bureau. (2019-2023). *American Community Survey 5-Year Estimates*. Retrieved from https://www.census.gov/programs-surveys/acs

[12] Esri. (n.d.). *GEAR Maps*. ArcGIS Experience. Retrieved March 11, 2025, from https://experience.arcgis.com/experience/60e419d78cb5493a91641ffa3c160dd6/page/GEAR-Maps?views=Map-Navigation-How-To-View

[13] Centers for Disease Control and Prevention/Agency for Toxic Substances and Disease Registry/Geospatial Research, Analysis, and Services Program. (2022). *CDC/ATSDR Social Vulnerability Index 2022 Database*. Retrieved from https://www.atsdr.cdc.gov/place-health/php/svi/svi-data-documentation-download.html?CDC_AAref_Val=https://www.atsdr.cdc.gov/placeandhealth/svi/data_documentation_download.html

APPENDIX C

Vulnerability Assessment Tables

The Vulnerability Assessment Tables have been transmitted to the city electronically and can be made available upon request.

CITY OF MEDFORD CLIMATE CHANGE

Vulnerability Assessment

July 2025