DCR State Parkways Climate Change Vulnerability Assessment

May 2025

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dcr

This document was prepared by:

Stantec EBP Civic Space COLLABORATIVE

Morrissey Boulevard During a Flood Event in January 2024

Acknowledgements

Thank you to all of our state, local, and community partners for their continued participation and support of this process. Through collaboration we can improve the resiliency of the Parkways to flooding and create a safe and reliable transportation and recreation network for the Commonwealth.

A special thank you to the DCR Operations Staff for their time and knowledge shared during the Flood History Workshops that helped inform the assessment. Thank you for your ongoing efforts to keep the Parkways safe and clean for the residents of Massachusetts.

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EXECUTIVE SUMMARY

Why Assess the Flood Vulnerability of DCR Parkways?

The DCR Parkways Climate Change Vulnerability Assessment (CCVA) evaluates the flood vulnerability of 200 miles of parkways within Route 128. DCR Parkways are a diverse collection of roads that facilitate travel between DCR parks and many provide multi-modal options for travel without a car. The CCVA uses models that consider factors such as current and future climate scenarios and daily usage patterns.

The CCVA is a strategic assessment by DCR. It builds on the 2020 Parkways Master Plan. Assessing the flood vulnerability of DCR parkways is crucial because these parkways are integral to Boston's culture, economy, and natural environment. They facilitate movement, employment access, and affordable recreation for the region's residents and workers. With climate change leading to rising sea levels and more intense precipitation, the risk of coastal, riverine, and urban flooding is increasing. The assessment is vital for protecting the parkways from current and future flood impacts.

DCR will use the assessment to inform their continued efforts to improve the resilience of the parkway system to flooding in the near- and long-term. The assessment aims to identify potential locations of flood disruptions due to flooding and areas where future adaptive measures could reduce the impact of flooding on users and communities. The timing of the assessment aligns with available funding for climate-resilient infrastructure and updated flood modeling data. The assessment will support DCR's broader climate strategy.

Definitions:

Vulnerability: *a function of a transportation asset's sensitivity to climate effects, exposure to extreme weather and adaptive capacity.*

Exposure: *whether an asset or system is located in an area experiencing direct effects of climate change.*

Sensitivity: *how the system fares when exposed to a climate variable.*

Adaptive capacity: *ability to cope with climate variability now and in the future.*

Federal Highway Administration, *Vulnerability Assessment and Adaptation Framework, 3rd Edition*

How Was Vulnerability Assessed?

The Federal Highway Administration (FHWA) Vulnerability Assessment framework was employed as a proven approach to roadway vulnerability analysis, aligning with the parkways assessment objectives.

The framework recommends three data-gathering methods:

1. Desktop review of vulnerability indicators.

2. Collection of stakeholder experiences.

3. Engineering-informed analysis for specific locations.

For the assessment, the first two methods were utilized for a system-level analysis, while the third was applied selectively for low-lying areas.

A GIS-based tool was used to spatially score 100-foot parkway segments. A 100-foot long segment is short enough to allow for specificity in the exposure analysis to flooding hazards, yet large enough to support a broader system-level geographic analysis.

Vulnerability is calculated by summing three weighted indicators: exposure, sensitivity, and adaptive capacity (Figure 1). The vulnerability score for each parkway segment is the weighted average of these indicators. The resulting score allows for each parkway segment to receive a low, medium, high or very high vulnerability rating as shown in Figure 2.

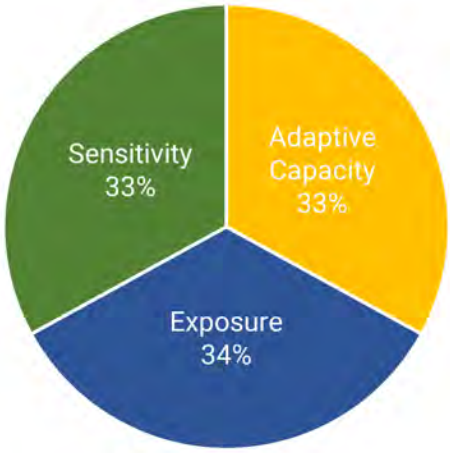


Figure 1.Vulnerability Metrics.

The assessment considers probabilistic flood conditions for 2030 and 2070, calculating exposure scores for both time horizons to inform near-term and long-term planning.

Stakeholder input, including DCR Operations Staff and public workshops with local and regional agencies and organizations, was integral to the assessment, providing insights into parkway flood exposure, historical events, and recurrent damages.

This methodology allows DCR to systematically prioritize actions and investment decisions to enhance the resilience of the parkway network over time.

Figure 2. Vulnerability Scoring.

How Does Vulnerability Change From 2030 to 2070?

In 2030, 59% of the parkways in the study area have a medium or high vulnerability.

Parkways proximal to the ocean and rivers tend to have higher vulnerability due to higher exposure levels. Parkways with higher traffic volumes, bus routes with high ridership, and high costs of replacement are factors that reduce a parkways' adaptive capacity and increase their vulnerability.

By 2070, 66% of parkways have medium or high vulnerability. Nearly 2% of parkways have a very high vulnerability to flooding.

This reflects an increase in the likelihood of parkways exposed to flooding between 2030 and 2070.

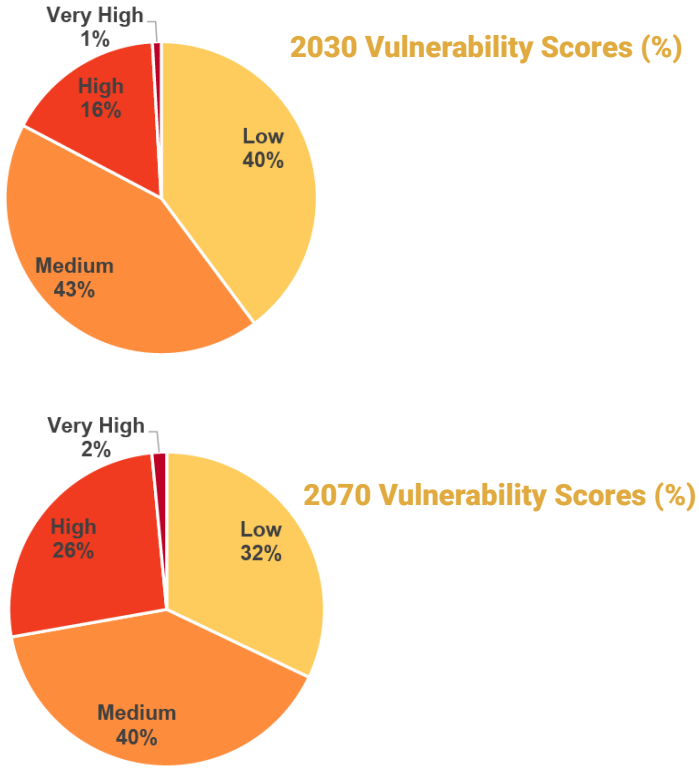


Figure 3a. Percentage of DCR Parkways within each flood vulnerability score class. in 2030 (top) and 2070 (bottom).

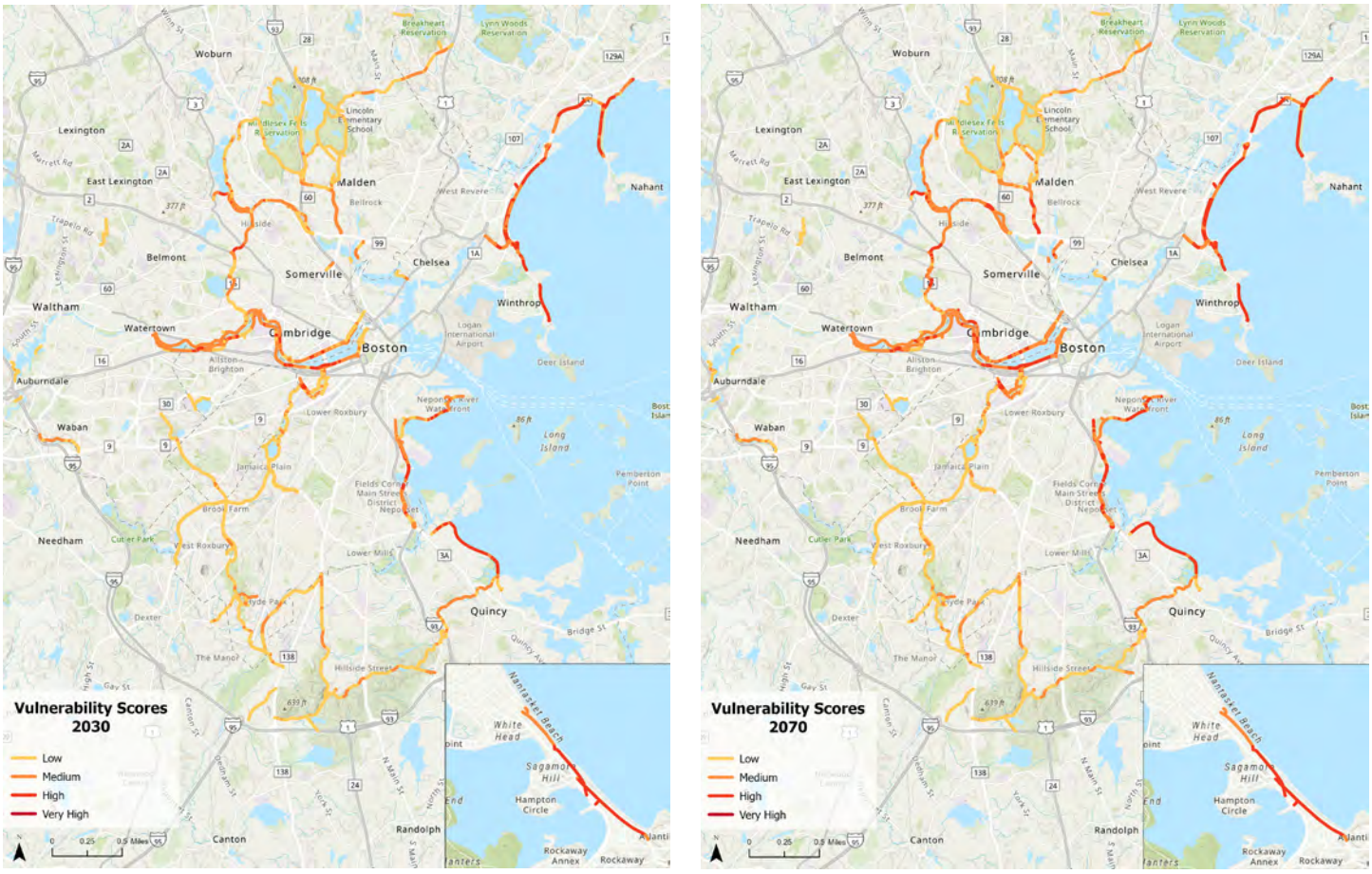


Figure 3b. DCR Parkways Flood Vulnerability in 2030 (left) and 2070 (right).

What are the Most Vulnerable Parkways?

The most vulnerable parkways in the study area tend to be located near coastal areas as they are impacted by both precipitation-based and coastal flooding.

The vulnerability across the study area increased from 2030 to 2070 where there is a total of 112 miles of parkways with a medium or high vulnerability in 2070.

There are nine parkways that, when flooded, create eight isolated communities. A flooded parkway that creates an isolated community causes a greater disruption to the transportation network and cascading economic impacts to these communities and the people living and working there. These parkways tend to have a lower adaptive capacity and a higher vulnerability than parkways that do not create isolated communities. Figure 4a highlights the most vulnerable parkways in 2070.

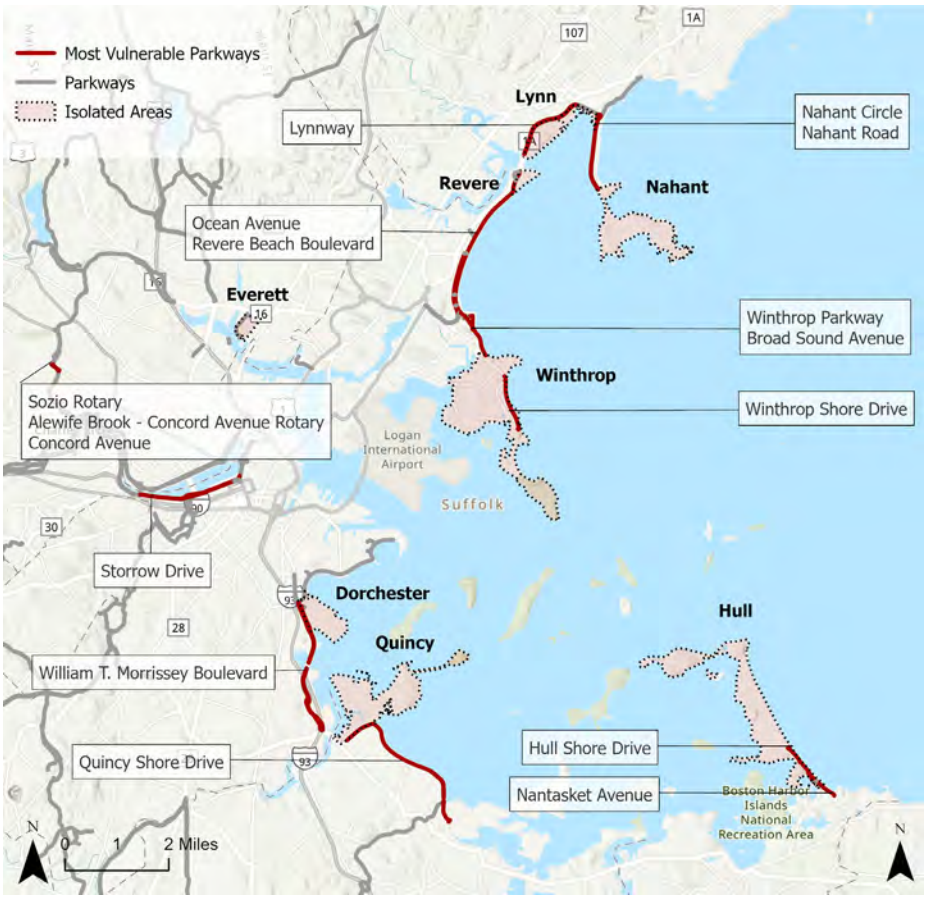


Figure 4a. Most vulnerable parkways to flooding in 2070 and isolated areas.

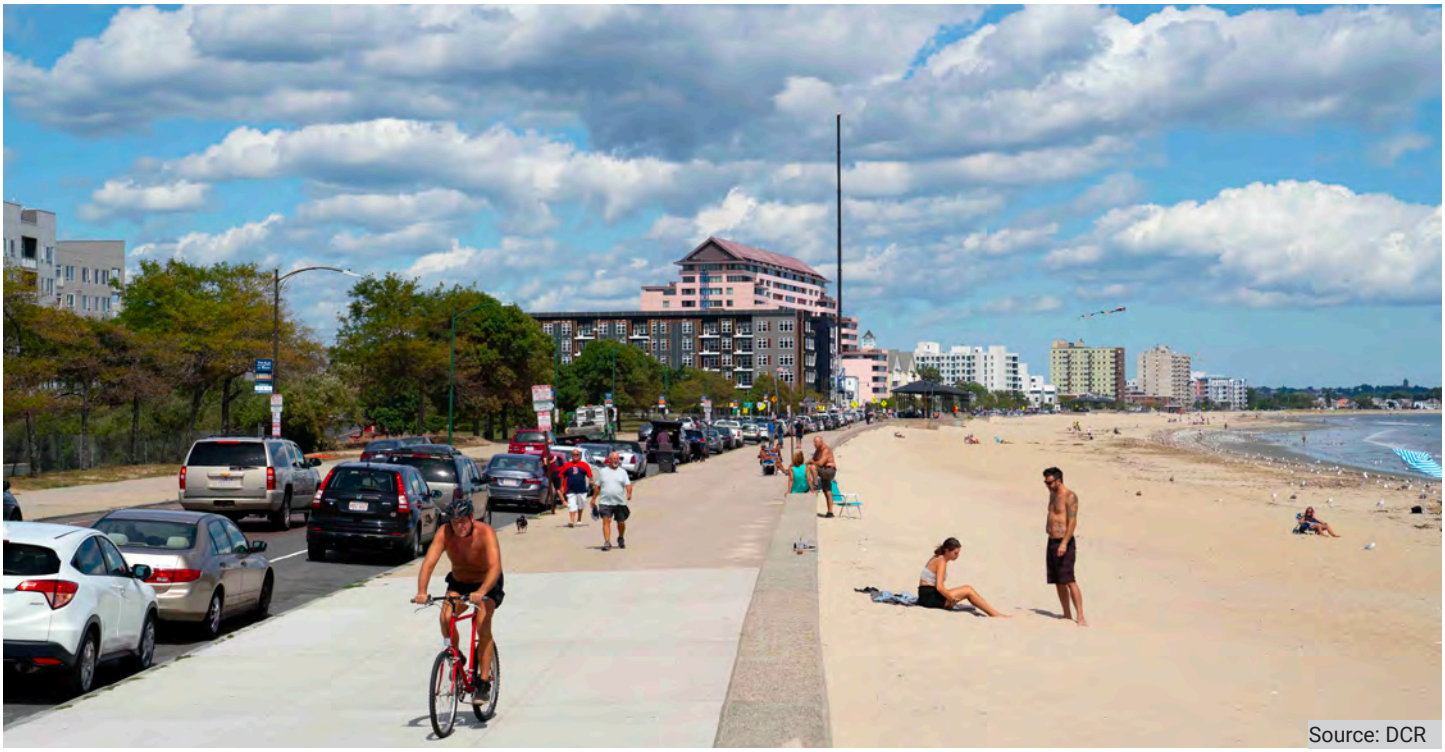
How Can Parkway Vulnerability be reduced?

The CCVA results provide valuable information on specific areas within the Metro Boston parkway system that are vulnerable to coastal and precipitation-based flooding in 2030 and 2070. These results have the potential to be immediately integrated into existing DCR programs, projects, policies, and procedures, and help set the stage for future actions, adaptation strategies, and implementation phases.

The assessment identified each parkway's adaptive capacity to flooding. Many parkways have a medium or high adaptive capacity. DCR can use these scores to identify an appropriate adaptation strategy for each parkway.

Improving a parkway's resilience to flooding will require a combination of physical, environmental, and organizational adaptation strategies. This is an iterative and cyclical process where the DCR can continually re-evaluate the parkways' vulnerability and resilience based on the latest climate and infrastructure data, changing socio-political circumstances, and grant/funding availability.

To learn about the CCVA with interative maps, see the CCVA StoryMap.



Source: DCR

"A parkway is not a road, but a park with a road in it."

- Historic Parkways Initiative, 2002

Source: DCR

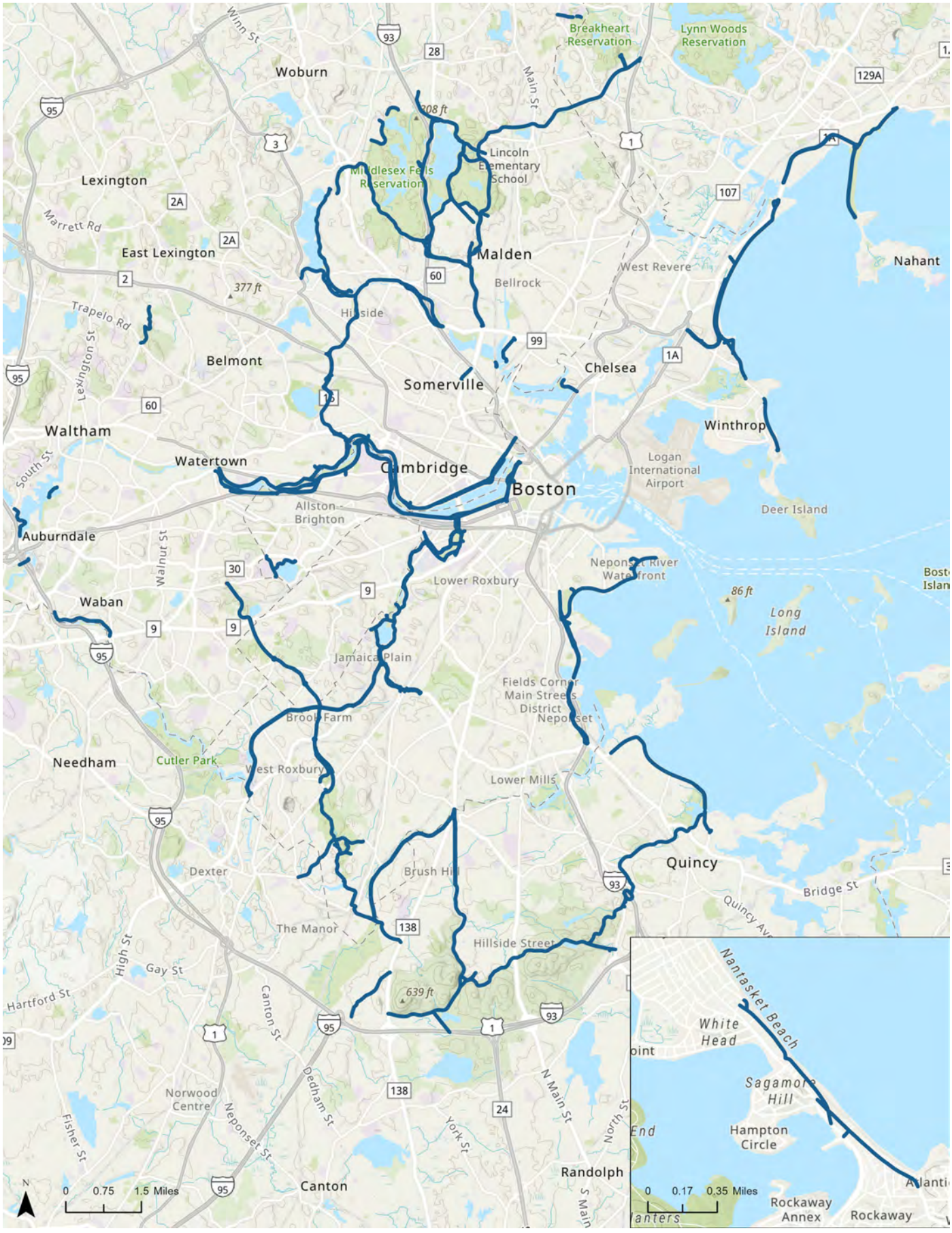


Figure 4b. DCR Parkways (blue) within 2025 CCVA Study Area.

1 INTRODUCTION

BACKGROUND

The Massachusetts Department of Conservation and Recreation (DCR) is responsible for protecting, promoting, and enhancing the common wealth of natural, cultural and recreational resources for the well-being of all. This responsibility includes safeguarding the parkways from the short and long-term impacts of present and future climatic conditions.

The Massachusetts DCR parkways help shape, define, and support Greater Boston metropolitan area's culture, economy, and natural landscapes. There are nearly 200 miles of parkway in the greater Boston area. These parkways serve a critical role in enhancing mobility, enabling access to employment, and providing access to affordable recreation opportunities to residents and workers across the forty municipalities of the Greater Boston metropolitan area.

Like most transportation infrastructure in the region, DCR's parkway system is impacted by coastal, riverine, and precipitation-based flooding. As climate change causes rising sea levels and intensifying precipitation, these impacts will continue to increase in frequency and severity. Coastal parkways will increasingly experience flooding as sea levels rise and storm surge intensifies with extreme weather events. Riverine flooding threatens inland parkways that traverse rivers and streams. These urbanized waterways can overflow their banks during heavy rainfalls, which are becoming more frequent due to climate change. Even inland parkways can experience flooding from intense rainfall in low-lying areas. Paved areas cannot absorb rainwater. Intensified land use in current and historic floodplains and tidelands, coupled with ecosystem degradation, create prime conditions for urban flooding.

PURPOSE AND GOALS

Building from DCR's 2021 Parks Climate Change Vulnerability Assessment, as well as the 2020 Parkways Master Plan, this document provides a planning-level assessment of the vulnerability of nearly 200 miles of parkways inside of Route 128. The assessment identifies the parkways most vulnerable to climate-related flood risks, based on flood exposure models that reflect current and future climate conditions, as well as sensitivity and adaptive capacity indicators, such as each parkway's average daily usage by motorists and bus riders. Results will inform DCR's capital planning process and enable the Department to prioritize investments to avoid or reduce long-term flood risks.

A parkway's overall vulnerability is derived from three components: the parkway's exposure to climate-driven hazards, the sensitivity to the hazard, and adaptive capacity – the extent to which the parkway, or the system it is part of, can cope with or adapt to associated impacts. While there is some variation in calculation, the methodology sets vulnerability equal to the weighted average of exposure, sensitivity, and adaptive capacity.

Repairing flood-related damages to infrastructure can be very costly. Flooding of DCR parkways can isolate certain communities, affecting access to schools, jobs, and healthcare services. Parkway closures can cause delays throughout the transportation network and pose safety risks to users of the parkway system. By understanding the relative vulnerability of DCR parkways, the assessment highlights locations of potential flood-related disruptions to the parkway network where adaptive strategies may help reduce the impacts of current and future flooding to system users and nearby communities. Flooding can have several common impacts.

With state and federal funding available for climate-resilient infrastructure investments, and the release of updated flood modeling data for the Commonwealth, it was timely for DCR to commission the assessment as part of the department's broader climate strategy.

PLANNING PROCESS

This project was led by DCR Climate Office and Design and Engineering Team, with assistance from Stantec, EBP US, and Civic Space Collaborative. The assessment used local and regional flooding models, a stakeholder engagement process, and other quantitative datasets (Appendix A) to calculate the vulnerability of parkways within Metro-Boston. Certain datasets were collected, and results validated, directly from input received from DCR Operations Staff in the fall of 2023.

After kicking off the project in February 2023, the project team met regularly over the course of two years. The team collaborated throughout the project process and provided input on issues and opportunities in the assessment and weighed in on the assessment framework, development of methodologies to assess exposure and vulnerability, and the draft versions of the assessment and accompanying publicly available StoryMap.

In addition to a stakeholder engagement process, DCR organized three workshops with DCR Operations Staff to collect data on flooding history and two virtual public presentations. One gathered feedback on the assessment framework and parkway system vulnerabilities, and the second shared the final results.

ASSESSMENT STRUCTURE

The assessment is organized into five sections:

1. Introduction: describes the background, purpose and goals of the report.

2. Methodology: details how the vulnerability assessment was performed.

3. Results: highlights the key vulnerability results based on the Parkway Focus Areas described in the DCR Parkways Master Plan.

4. Next Steps: discusses ways the vulnerability results can be used to meet DCR's Climate Adaptation Goals.

5. References: sources cited, providing details for readers to locate and verify the information used

6. Appendices: supporting documentation and the Economic Impact Assessment.

Study Area

The assessment focuses on the group of parkways that span the metropolitan Boston region. This includes:

8
WATERSHEDS

44
MUNICIPALITIES

200
PARKWAY CENTERLINE MILES

1.8 Million
DAILY USERS IN VEHICLES (2023)

Focus Areas

The assessment is organized based on the Focus Areas (FA) included in the 2020 DCR Parkways Master Plan. The parkways included in each FA are listed in the Results section and in Appendix C.

FA 1: Revere Beach and Lynn Shore

FA 2: Middlesex Fells

FA 3: Lynn Fells and Breakheart

FA 4: Mystic Valley

FA 5: Upper Charles

FA 6: Charles River Basin West

FA 7: Charles River Basin East

FA 8: Old Harbor

FA 9: Back Bay Fens

FA 10: Chestnut Hill

FA 11: Jamaica Pond

FA 12: VFW Parkway

FA 13: Hammond Pond Parkway

FA 14: West Roxbury

FA 15: Stony Brook and Neponset

FA 16: Blue Hills

FA 17: South Shore

FA 18: Nantasket

FA 19: Morrissey

FA 20: Alewife Brook

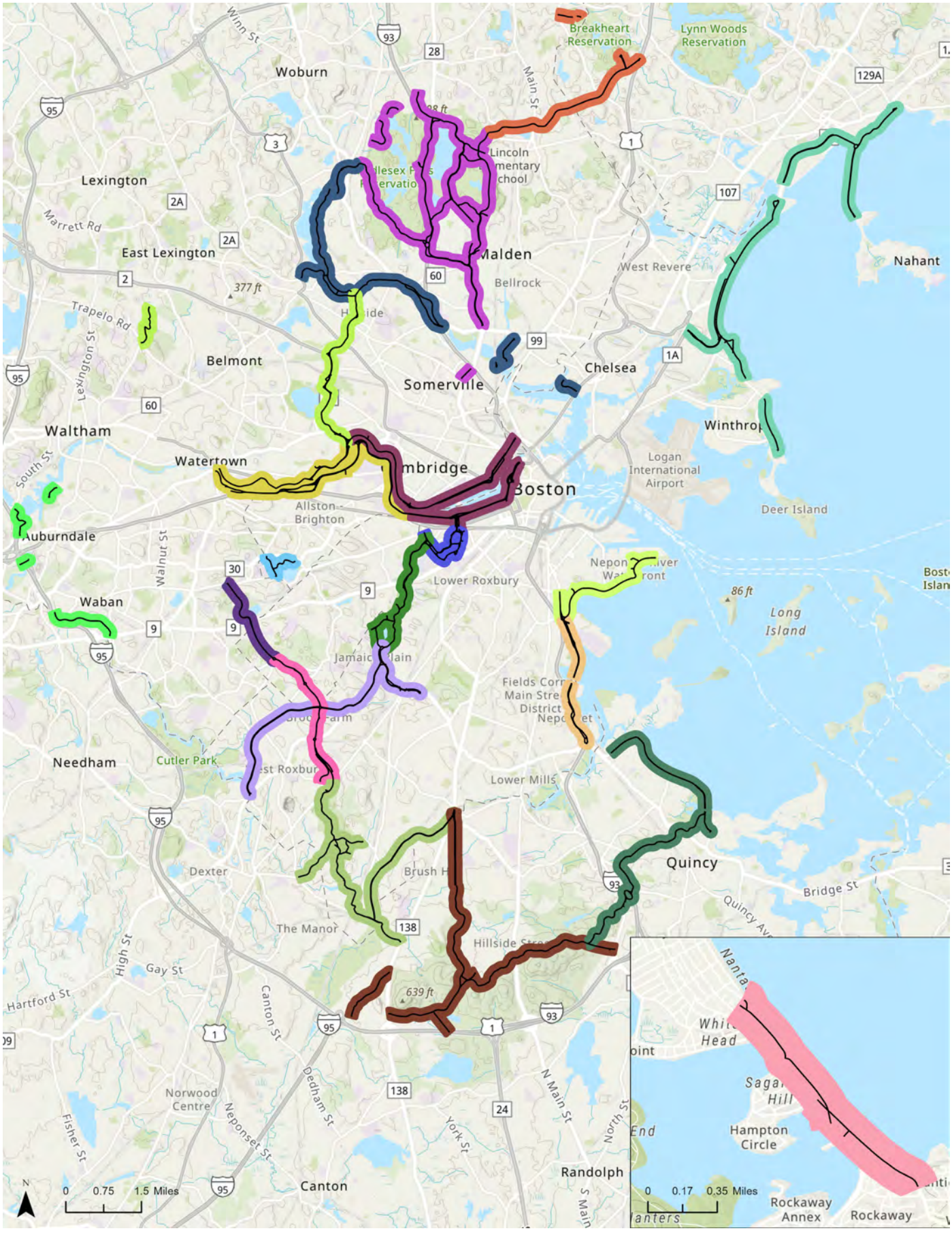


Figure 5. DCR Parkways within 2025 CCVA Study Area symbolized by Focus Area designation.

2 METHODOLOGY

Framework Overview

This section outlines the methodology used for the assessment, starting with a general overview of the framework, and then detailing how vulnerability is calculated.

The Federal Highway Administration (FHWA) Vulnerability Assessment framework was used to develop the DCR Parkways Climate Change Vulnerability Assessment (CCVA). This framework was selected because the methodology included a tested and verified approach to analyzing the vulnerability of roadways (parkways), which aligned well with the goals of the parkways assessment.

The FHWA framework outlines three data-gathering methods for vulnerability assessments:

(1) conducting a desktop-based review of vulnerability indicators,

(2) gathering stakeholder experiences with asset vulnerability issues, and

(3) performing an engineering-informed analysis.

Approaches one and two are preferred for system-level vulnerability analysis and were appropriate in the assessment. Engineering-informed analysis, which is more appropriate for loction-specific contexts, was only used for the low-lying exposure analyses.

Definitions:

Vulnerability: *a function of a transportation asset's sensitivity to climate effects, exposure to extreme weather and adaptive capacity.*

Exposure: *whether an asset or system is located in an area experiencing direct effects of climate change.*

Sensitivity: *how the system fares when exposed to a climate variable.*

Adaptive capacity: *ability to cope with climate variability now and in the future.*

Federal Highway Administration, *Vulnerability Assessment and Adaptation Framework, 3rd Edition*

Vulnerability of each parkway segment in 2030 and 2070 was calculated using the following formula as described by the FWHA's Vulnerability Assessment Scoring Tool (VAST) as depicted by the following equation and graphic:

$$\text{Vulnerability}_{2030} = \text{Average}[(34\%)\text{Exposure}_{2030} + (33\%)\text{Sensitivity} + (33\%)\text{Adaptive Capacity}]$$

and

$$\text{Vulnerability}_{2070} = \text{Average}[(34\%)\text{Exposure}_{2070} + (33\%)\text{Sensitivity} + (33\%)\text{Adaptive Capacity}]$$

Sensitivity and adaptive capacity remain constant, because there is limited information regarding future asset conditions or updates to change for future climate scenarios, so current conditions were assumed to apply.

Each parkway was divided into 100-foot segments to calculate vulnerability. There were 10,567 parkway segments analyzed. A 100-foot long segment is short enough to allow for specificity in the exposure analysis to flooding hazards, yet large enough to support a broader system-level geographic analysis.

This framework calculates the vulnerability of each parkway segment based on three weighted metrics: exposure, sensitivity, and adaptive capacity. The sum of the weighted average of each indicator determines the degree of vulnerability for each road.

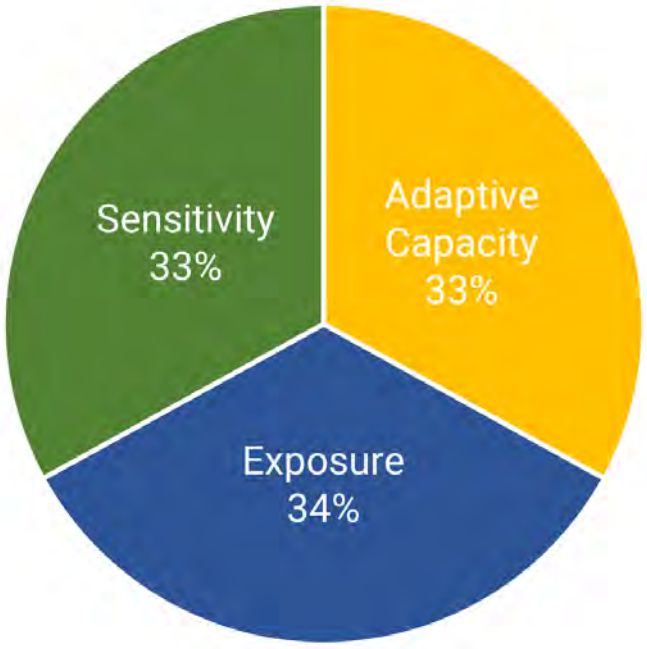


Figure 6. Metrics of Vunerability and corresponding weight in the equation.

To improve the consistency of the GIS-based parkway lines, the parkway centerlines were offset by 25 feet to represent each parkway's footprint for the purpose of the vulnerability analysis.

The assessment was based on probabilistic flood conditions in 2030 and 2070 with an exposure score calculated for each time horizon to reflect near-term (2030) and long-term (2070) impacts.

An average vulnerability score was calculated for the time horizons for each parkway segment to help DCR prioritize its actions and next steps to prepare for flooding-based impacts over time.

Each 100-foot parkway segment received a 1- 4 score for each metric (exposure, sensitivity, and adaptive capacity, Figure 6 and 7b and 7c), which supported the calculation of an overall vulnerability score for each segment in 2030 and 2070. A GIS-based tool was utilized to spatially score segments and calculate final results.

Vulnerability was determined through a desktop-based GIS analysis with supplemental input from DCR Operations Staff during a three-part workshop series. Staff provided institutional knowledge on parkway exposure to flooding. Group exercises included mapping historical flooding events and noting locations with recurrent damages. Exposure mapping results depicting parkway susceptibility to coastal and inland flooding were then presented and validated using DCR Operations Staff input.

Finally, stakeholder input was gathered via a virtual public workshop held with municipal governments, state agencies, and local nonprofit organizations. Feedback was solicited on sensitivity and adaptive capacity indicators.

Figure 7a. Sozio Rotary (Brodette Memorial Circle) connecting Alewife Brook Parkway to Fresh Pond Parkway, Cambridge, MA.

Figure 7b. Vulnerability Score Classes.

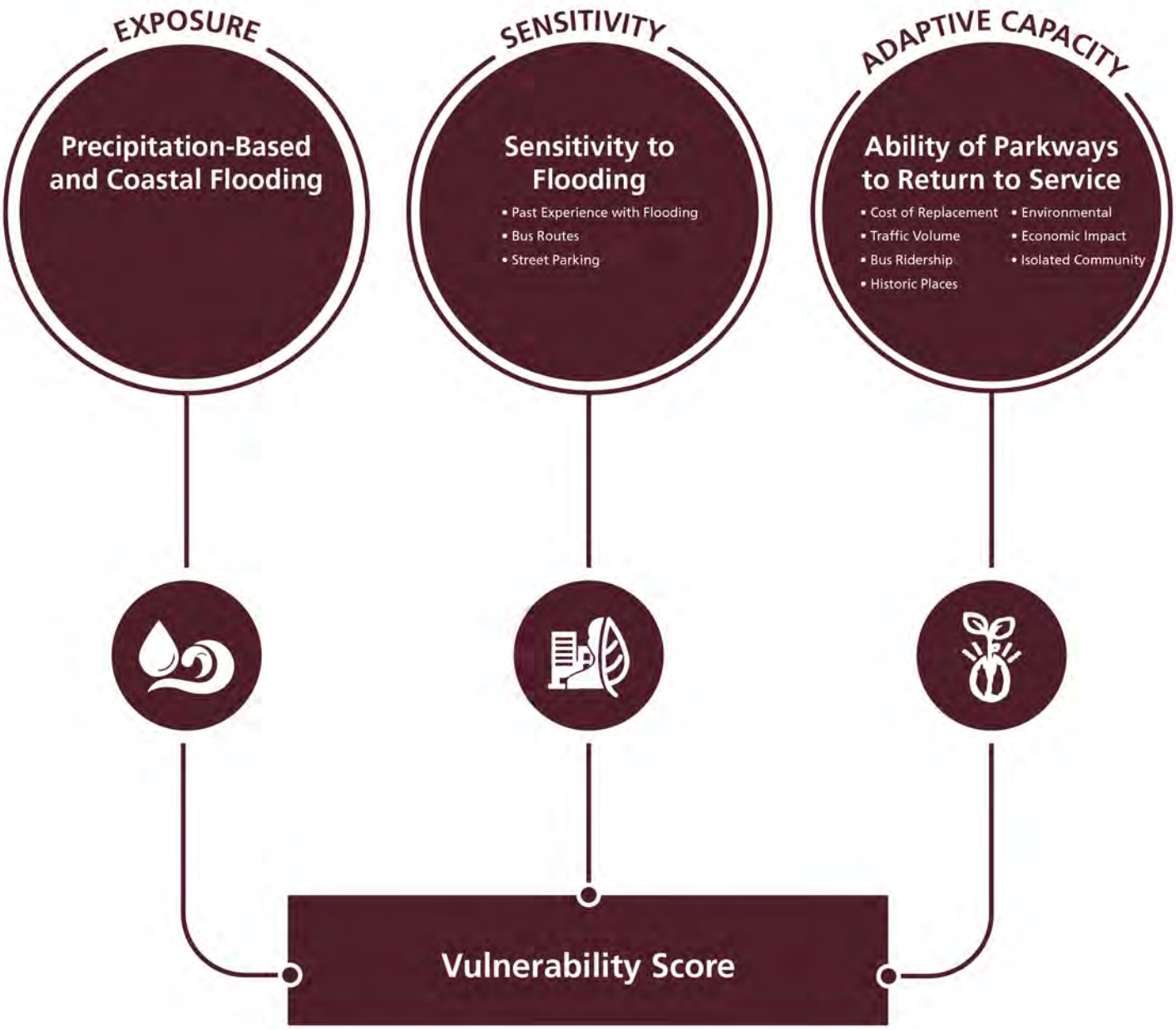


Figure 7c. Overview of the Indicators of Flood Vulnerability.

EXPOSURE

Exposure scores were calculated using two indicators: (1) exposure to precipitation-based flooding, and (2) exposure to coastal flooding due to sea level rise and storm surge.

Each indicator was assessed under modeled results in 2030 and 2070. Indicators of exposure are defined as follows:

PRECIPITATION-BASED FLOODING

This flooding includes a variety of wet weather events (rain or snow) and flooding scenarios that could occur in Boston. Several exisiting regional watershed-based flood models were combined into a composite flood model to identify locations of precipitation-based flooding within the study area in 2030 and 2070.

Exposure to precipitation-based flooding in 2030 was assessed with the composite model, comprised of the 2030 inundation extents from the Charles River Watershed Association (CRWA) 10yr 24hr storm model, the Mystic River Watershed Association (Mystic) 10yr 24hr storm model, the Boston Water and Sewer Commission (BWSC) Nor'easter 10yr 48hr storm model, Federal Emergency Management Agency (FEMA) 100-year floodplain, and the low-lying roads analysis.

Exposure to precipitation-based flooding in 2070 utilized the CRWA 2070 100yr 24hr storm, Mystic 2070 100 yr. 24hr, the BWSC Tropical 100yr 48h storm, the FEMA 500-year floodplain, and the low-lying roads analysis.

The FEMA 100-year and 500-year floodplain extents were incorporated into the composite model to supplement the watershed-based flood models. This floodplain shows areas of high and moderate to low-flood risk.

Exposure: ***whether an asset or system is located in an area experiencing direct effects of climate change.***

FEMA zones classified as A, AE null, AE floodway, AO, AH were incorporated into the composite model extents. Zones beginning with 'A' or 'V' represent "Special Flood Hazard Areas" considered high-risk areas as they have a 25% chance of flooding during a 30-year period.

For parkway segments outside the composite model, a low-lying roads analysis was conducted to identify parkways at risk of precipitation-based flooding. The composite model and the low-lying roads analysis were combined to create the Total Inundation Extent. This allowed for a system-wide assessment of precipitation-based flooding.

Parkway segments outside of the Total Inundation Extent were considered to have low exposure to precipitation-based flooding.

Presence within the total inundation extent is the indicator for precipitation-based flooding exposure.

Low-Lying Roads Analysis

A Low-Lying Roads Analysis was conducted for parkways outside the composite model extent and was a substitute measure of assessing precipitation-based flood risk. LiDAR elevation data imported to AutoCAD was used to create centerline profiles for the 62 miles of roadways outside the flood model extents, identifying 149 local low points.

Cross-section analysis at these low points was used to assess potential for flooding, including variables such as adjacent topography and the presence or absence of closed drainage systems. Of the 149 low points identified by low elevation, six low points (totaling 0.2 cumulative miles) were found to have flooding/ponding potential (Figure 8).

Precipitation Models:

These models represent storm conditions based on the probability of a geographic region to experience a specific storm intensity or rainfall amount in a given time period.

FEMA flood models and maps used in this assessment do not include future climate change projections.

This analysis considered a segment to be flooded if it would accrue water up to one foot in depth (ponding). This depth was selected because, one foot of water will float most vehicles (US Department of Commerce, 2018). This increases risks of injury and damage to persons and vehicles.

As some DCR parkway segments exist both within and outside of flood model extents, these results were reviewed to confirm that flood-prone segments were not double-counted in both analyses. The ponding potential in these low points was determined under 2030 and 2070 precipitation conditions.

For 2030 conditions, a flood accumulation depth of 12.0 inches (the depth at which cars float) was used. For 2070 conditions, the flood accumulation depth was increased by 2.4 inches (total 14.4"), reflecting predicted precipitation increase ("Massachusetts Climate Change Projections," n.d).

Precipitation-based flooding scoring: Parkways segments within the total inundation extent received a score of four, while those outside the inundation extent received a score of one.

SEA LEVEL RISE / STORM SURGE

Susceptibility to coastal flooding related to sea level rise and storm surge was calculated by a segment's presence within the inundation polygons determined by the Massachusetts Coast Flood Risk Model (MC-FRM).

Scoring Filter	Score
The segment is present in the 10% model	4
The segment is present ONLY in the 1% model	2
The segment is not impacted	1

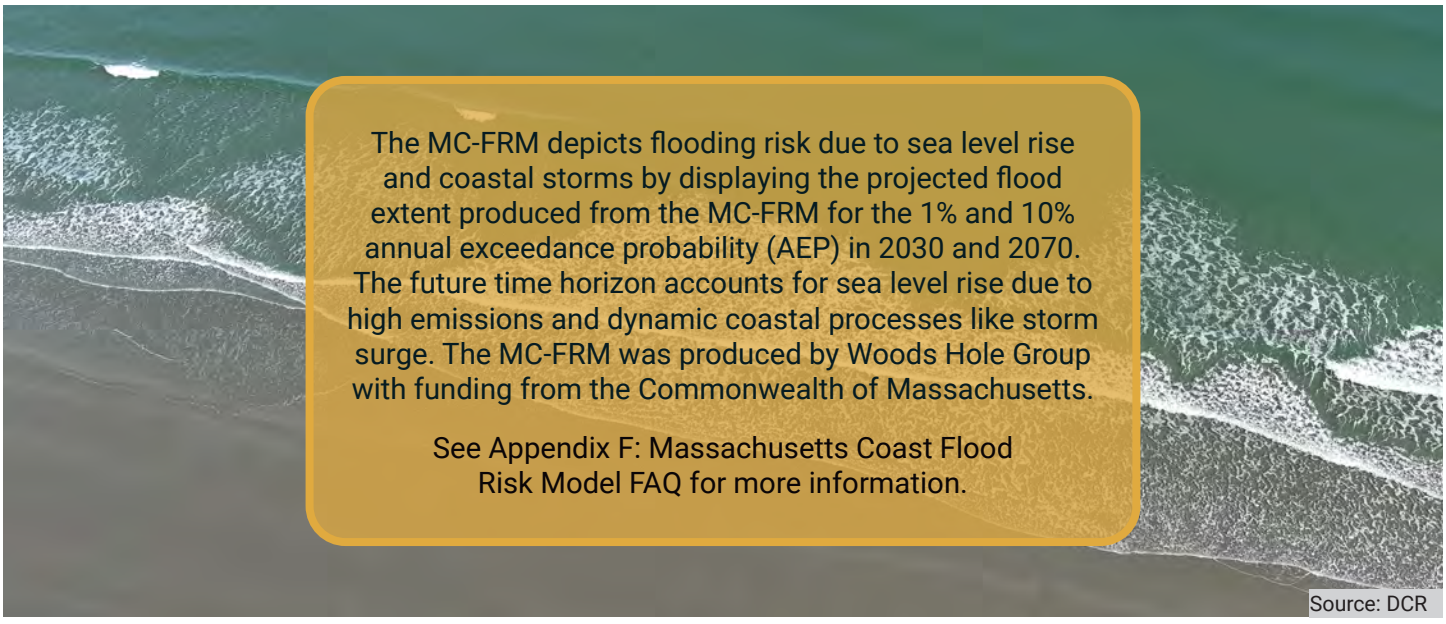
Presence in the 2030 MC-FRM

This indicator represents current exposure to coastal flooding, as determined by 2030 MC-FRM scenarios. Parkway segments were scored according to the table above.

Since a 10% storm is more likely to occur than the 1% storm, this ranking scheme reflects a scenario where segments impacted by more frequent storms are flooded more often.

Presence in the 2070 MC-FRM

The same scoring and evaluation scheme described above was used for segments evaluated for presence within the 2070 MC-FRM scenarios.



The MC-FRM depicts flooding risk due to sea level rise and coastal storms by displaying the projected flood extent produced from the MC-FRM for the 1% and 10% annual exceedance probability (AEP) in 2030 and 2070. The future time horizon accounts for sea level rise due to high emissions and dynamic coastal processes like storm surge. The MC-FRM was produced by Woods Hole Group with funding from the Commonwealth of Massachusetts.

See Appendix F: Massachusetts Coast Flood Risk Model FAQ for more information.

Source: DCR

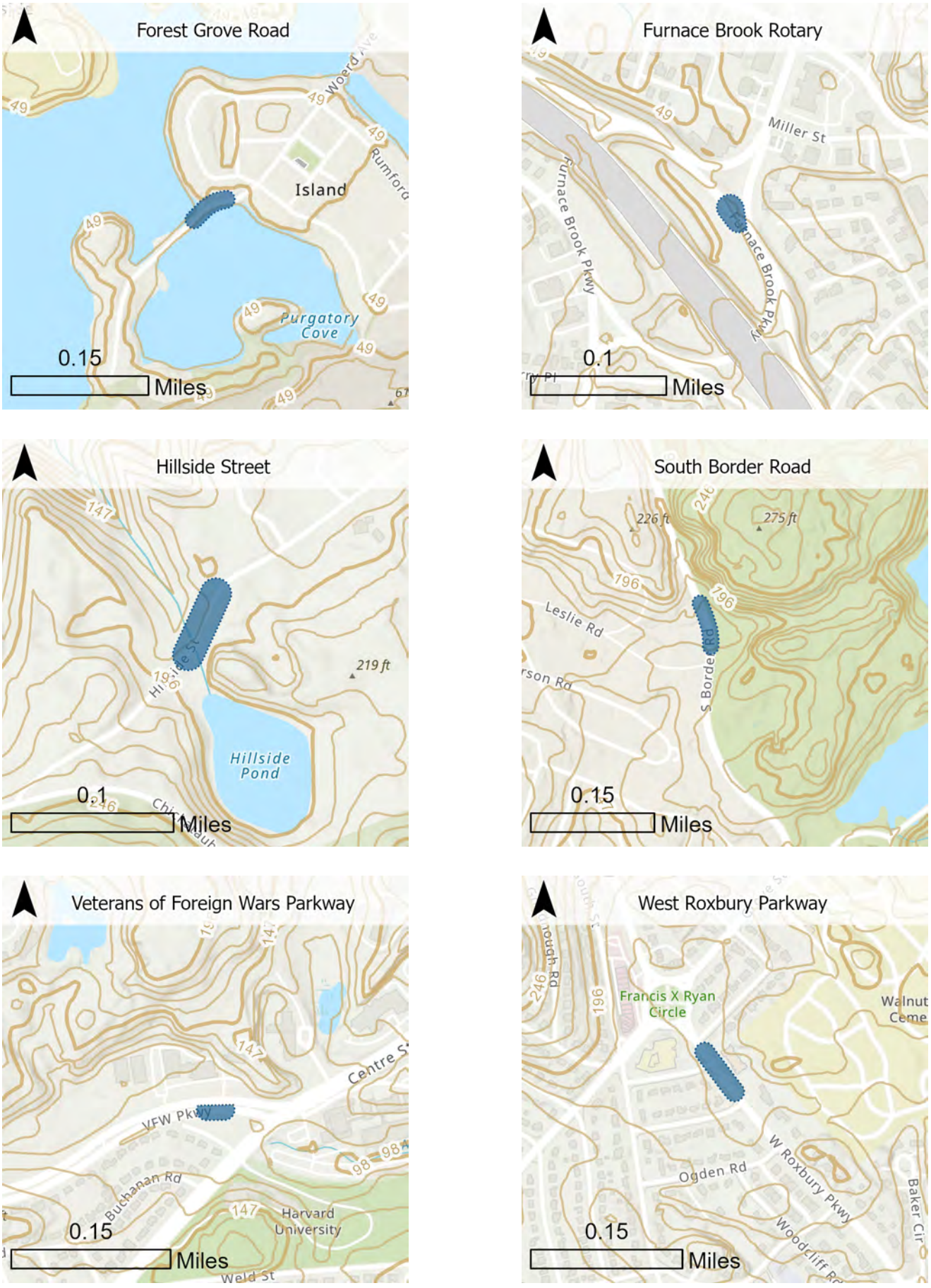


Figure 8. The six low-lying areas with ponding potential based on 2070 analysis of 14.4" flood depth.

SENSITIVITY

Three indicators were used to assess each parkway segment's sensitivity to flooding: (1) past experience with flooding, (2) bus routes, and (3) street parking. These indicators capture road attributes that would make the impact of flood exposure more severe.

Sensitivity: ***how the system fares when exposed to a climate variable.***

PAST EXPERIENCE WITH FLOODING

Scoring Filter	Score
The segment has a past experience with flooding.	4
The segment does not have a past experience with flooding.	1

Parkways that have experienced flooding during past heavy rain or extreme high tide events are more likely to be damaged if exposed to flooding events in the future. To assess historic flooding, DCR Operations Staff were asked to use DCR's internal Damage Collection Tool to document flood incidents.

Parkway segments were scored according to the table above.

BUS ROUTES

Scoring Filter	Score
There is a bus route along or intersecting the segment.	4
There is not a bus route along or intersecting the segment.	1

Parkways with bus routes have higher cascading impacts across the transportation network if bus service is suspended or delayed due to flooding. Since bus routes are a form of mass transit that serves a higher percentage of low-income individuals, a loss of service due to flooding would have a larger impact to the community.

Parkway segments were scored according to the table above.

STREET PARKING

Scoring Filter	Score
There is street parking present along the segment.	4
There is not street parking present along the segment.	1

The presence of street parking increases a parkway's sensitivity to flooding. Parkways with street parking require a more robust evacuation and emergency notification system, and the presence of parked cars leads to a higher potential for vehicle damage, as well as difficulty accessing and repairing potentially damaged infrastructure.

Parkway segments were scored according to the table above.

Figure 9. Flooded William T. Morrissey Boulevard near Savin Hill, Boston, MA.

ADAPTIVE CAPACITY

Adaptive capacity indicators assess the ability of the parkway and its stewards to return the impacted segments to service following a flood event. For instance, parkways with historic significance or proximity to environmental resources may require careful permitting or design considerations, increasing the complexity of restoring them to full function and therefore reducing their adaptive capacity. Because the vulnerability equation adds adaptive capacity, a segment's adaptive capacity score reflects an inverse relationship to the segment's true adaptive capacity. For example, a segment with a low adaptive capacity will incur a high adaptive capacity score as the parkway will not easily withstand and recover from a flood event.

Adaptive capacity: ***ability to cope with climate variability (now and in the future).***

EXPOSURE-BASED COST OF REPLACEMENT

Scoring Filter	Score
The cost of replacement is within the 75% - 100% range for the dataset.	4
50-75 %	3
25-50 %	2
0-25 %	1

The in-kind replacement (reconstruction) cost for each parkway segment was calculated in 2023 dollars using the following unit costs:

Travel Lane = $215 per lane foot

Sidewalk = $170 per sidewalk foot

Sideslope =$195 per sideslope linear foot

Drainage System = $200 per linear foot

These unit costs were derived from MassDOT cost-estimating standards. To assign the unit costs to each segment, the number of travel lanes, sidewalk and sideslope widths, and drainage system attributes (from MassDOT linework) were spatially assigned to the parkway segments. Those results were validated and verified throughout the project area using satellite imagery and the in-kind replacement cost revised where appropriate.

2030 Exposure Score	Proportion of Standard Cost
4	100%
3	70%
2	40%
1	10%

The in-kind replacement cost was then prorated based on the segment's corresponding 2030 exposure score to calculate an exposure-based cost of replacement.

Sample:

If the in-kind replacement cost = $120,000 and the exposure score for the segment is 4, then:

$120,000 X 100% = $120,000.00 = Exposure-based cost of replacement

If exposure is 3 then:

$120,000 X 70% = $84,000.00 = Exposure-based cost of replacement

If exposure is 2 then:

$120,000 X 40% = $48,000.00 = Exposure-based cost of replacement

If exposure is 1 then:

$120,000 X 10% = $12,000.00 = Exposure-based cost of replacement

Finally, the exposure-based cost of replacement is scored based on the quartile in which the segment's cost falls.

Segments with a higher cost of replacement have a lower adaptive capacity and therefore receive a higher adaptive capacity score.

AVERAGE TRAFFIC VOLUME

Scoring Filter	Score
The Traffic Volume is within the 75-100 % range for the dataset.	4
50-75 %	3
25-50 %	2
0-25 %	1

Average Daily Traffic (ADT) volumes were obtained for all parkways in the study area during summer 2023. Parkways with higher traffic volumes will experience more traffic impacts following a flood event, and roadway repair will be inhibited by user pressures. As such, parkways with higher volumes receive a higher adaptive capacity score (indicating a lower degree of adaptive capacity).

Scores are based on the quartile in which the segment's traffic volume falls:

AVERAGE BUS RIDERSHIP

Scoring Filter	Score
The Average Bus Ridership is within the 67 -100 % range for the dataset.	4
33 - 67 %	3
0 - 33 %	2
The segment has no ridership data because there is not a bus route along the segment.	1

Using Massachusetts Bay Transportation Authority (MBTA) bus ridership data, the average weekday bus ridership was calculated for MBTA bus routes along or across DCR parkways. Flooding along parkways that serve a greater number of bus riders is more disruptive, so those parkways receive a higher adaptive capacity score. The specific score is determined by the quantile in which the segment's ridership falls.

HISTORIC

Parkways listed on the National Register of Historic Places (NRHP) or eligible for listing on the National

Scoring Filter	Score
The segment is listed or eligible to be listed on the NRHP.	4
The segment is not listed or eligible to be listed on the NRHP.	1

Register of Historic Places will have a lower adaptive capacity, given the additional permitting, design, and construction considerations related to restoring these parkways' historic character.

As such, parkway segments listed or eligible for listing on the National Register of Historic Places received a higher adaptive capacity score of 4 and those without this designation received a lower adaptive capacity score of 1.

Parkway segments were scored according to the table above.

ENVIRONMENTAL

Parkways within 50 feet of an Area of Critical Environmental Concern (ACEC), MassWildlife's Natural Heritage & Endangered Species Program (NHESP) (Estimated and Priority Habitats), or

Scoring Filter	Score
The segment is within 50 FT of an ACEC or NHESP area.	4
The segment is not within 50 FT of an ACEC or NHESP area.	1

MassWildlife's Natural Heritage & Endangered Species Program Natural Communities require extra permitting, design and construction considerations given the environmental sensitivity of the areas.

Parkway segments were scored according to the table above.

2030 Economic Impact

Scoring Filter	Score
The 2030 Economic Impact is within the 67 -100 % range for the dataset.	4
33 - 67 %	3
0 - 33 %	2
The segment has no economic impact data because it is not impacted under the 2030 study scenario.	1

The Economic Impact Assessment (See Appendix D for more information) calculated the total cost (2023 USD) from a one-day disruption based on the MC-FRM 2030 1% scenario. For parkways within the flood extent of this scenario, disruption assumed the parkway closes to vehicle traffic due to flood conditions. Parkways with higher costs associated with a service outage will have higher economic and usage impacts across the parkways system and lower adaptive capacity.

The segments are scored across three quantiles similar to the average bus ridership breakdown. A score of 1 indicates the segment has no economic impact data because it's not impacted under the study scenario.

Isolated Communitv

Scoring Filter	Score
The segment creates an isolated community under 2030 and 2070 1% Scenarios.	4
The segment creates an isolated community under only the 2030 1% Scenario.	3
The segment creates an isolated community under only the 2070 1% Scenario.	2
The segment does not create an isolated community.	1

As part of the Economic Impact Assessment, eight isolated communities were identified based

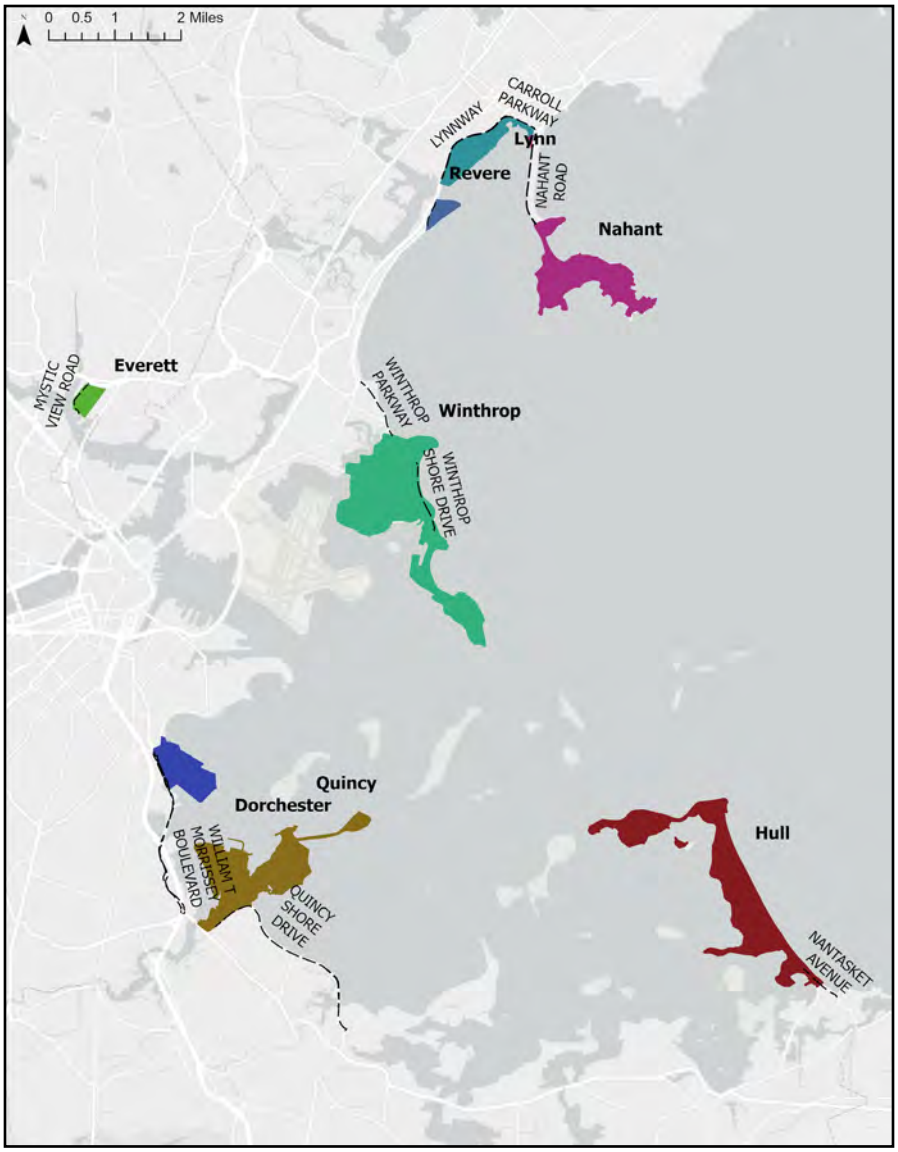


Figure 10. Map of eight isolated communities and parkways causing an isolated community.

on flooding scenarios where a flooded parkway is one of the only transportation routes into and out of an area, with a secondary route also flooded under the same scenario. A flooded parkway that creates an isolated community causes a greater disruption to the transportation network and cascading economic impacts to these communities and the people living and working there.

Such parkways have a lower adaptive capacity. Segments are scored based on whether they cause an isolated community and under what flooding scenario.

A parkway causing an isolated community only in 2070 would have a higher adaptive capacity as there is more time to plan for this scenario and implement an adaptation strategy. If a parkway causes isolated communities in both the 2030 and 2070 1% MC-FRM flooding scenarios it should receive the highest score as it has the lowest adaptive capacity and greatest impacts.

Study Limitations

In conducting the vulnerability assessment, several limitations were identified that may impact on the overall findings and interpretations. These limitations are useful to consider for a comprehensive understanding of the assessment's scope and accuracy.

Some parkways have elevated segments, such as on-ramps, overpasses, or bridges. These elevated parkway segments could not be scored according to the exposure scoring methodology because the precipitation-based and coastal flooding data are two-dimensional (2D), wherein they provide a flooding extend or boundary. The data does not provide information on flood depth. The GIS-based analysis screens parkways based on whether they intersect the boundary of the 2D flood boundaries. Therefore, it was not possible to determine if an elevated parkway would be flooded by any of the flood scenarios. Consequently, elevated parkways received a score of 1 for low exposure to flooding, which may not reflect real-world conditions. Additional ground truthing would be needed to validate exposure.

Limited available data is another limitation of this vulnerability assessment. First, there is uncertainty regarding climate data projections and future greenhouse gas (GHG) concentrations. This assessment relied on the best available data at the time it was conducted, using information that was consistent with other state initiatives. Second, the absence of defined evacuation routes within the project area. While the availability of such data would have provided valuable insights into flood vulnerability, its absence does not significantly impact the overall evaluation. Having this information would have enhanced our understanding of the area's preparedness and resilience against potential flooding events.

Moreover, another limitation of this vulnerability assessment is the potential skew in results when reporting average vulnerability for entire parkways. Shorter parkways are more likely to exhibit higher average vulnerability scores due to the mathematical nature of averaging. This inherent bias can affect the overall interpretation of flood risk. To mitigate this, the assessment was conducted on 100-foot segments, and results were reported for entire focus areas or parkways to provide a more accurate representation of vulnerability.

While the Economic Impact Assessment focused exclusively on parkways exposed to coastal flooding, as determined by the MC-FRM, this focus represents a potential limitation. By concentrating solely on coastal flooding, the assessment may underestimate broader impacts and economic consequences in areas affected by precipitation-based flooding. However, this approach was chosen because coastal flooding represents more extreme flood conditions, and we aimed to ensure the economic analysis reported on the most exposed and impacted areas. The coastal model offered the best coverage, and the order of magnitude flooding impacts were significantly greater than those predicted by precipitation models. Consequently, the Economic Impact Assessment prioritized coastal flooding to highlight the most critical impacts.

3 Results

This chapter is organized into five sub-sections:

1. Study Area Summary
The flood vulnerability results across the entire study area.

2. Most Vulnerable Parkways in 2070
The parkways that are most vulnerable to flooding, in 2070 conditions, and explains the indicators contributing to higher vulnerability.

3. Economic Impacts
The economic impacts projected to occur based on the findings from the Economic Impact Assessment.

4. Isolated Communities
The isolated communities and the economic impact projected if specific parkways were to close from flooding.

5. Focus Area Vulnerability Hot Spots and Community Vulnerability Impacts.
The average vulnerability scores for each of the 20 Focus Areas. Within each Focus Area, locations of relative higher vulnerability are identified and described for specific areas, called Hot Spots. Each Focus Area contains a six-page section describing vulnerability scores, vulnerability maps, Hot Spots, and Community Vulnerability Impacts, and key parkland features within each Hot Spot.

Study Area Summary

This sub-section provides an overview of the flood vulnerability results across the entire 200 miles of study area and includes information on 2070 flood exposure, 2030 and 2070 vulnerability results, and the most adaptable parkways.

Vulnerability from 2030 to 2070

Parkway vulnerability increased across the study area from 2030 to 2070 as more segments move from medium to high vulnerability. In 2070, there is a total of 125 miles of parkways with a medium or high vulnerability in 2070 (Fig 11). This is caused, in part, by more segments being exposed to flooding in 2070.

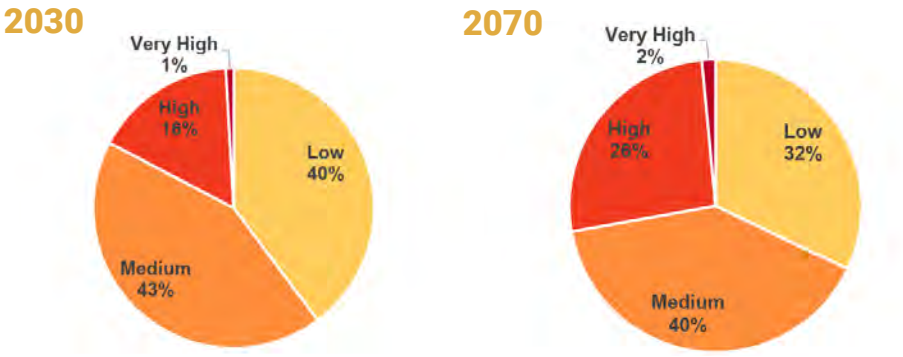


Figure 11. Overall DCR Parkway Vulnerability to Flooding.

2070 Flood Exposure

In 2070, 55.63 miles of parkway have a very high (3.5) exposure score (Fig. 12a). This means they are predicted to experience flooding in every precipitation and coastal flood scenario studied. Parkways with very high exposure to flooding can face significant operational challenges, including closures, damage to infrastructure, and disruptions to traffic flow. This can lead to economic losses, especially in communities that rely on these roads for commuting and business activities. These parkways tend to be located near a water body, especially coastal/harbor areas.

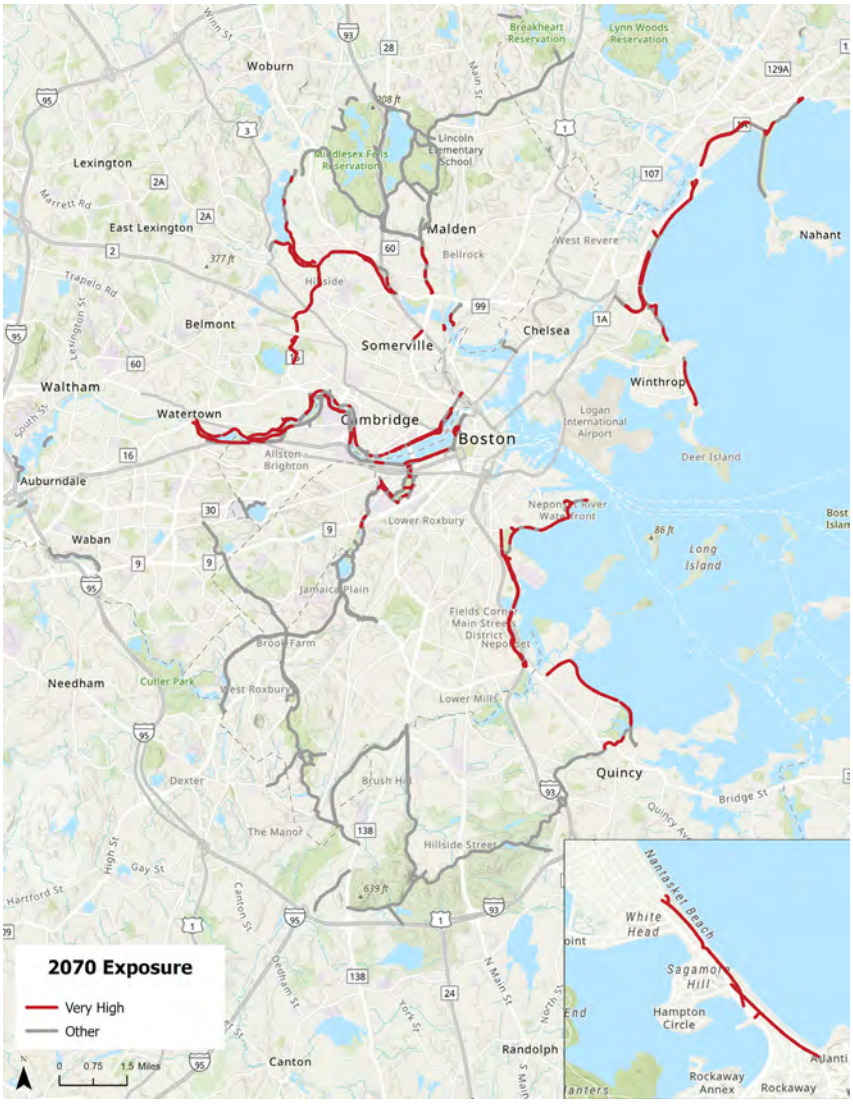


Figure 12a. Parkways (red) with a very high (3.5-4) exposure score in 2070 flood conditions.

To view an online version of the results with interative maps, see the CCVA StoryMap.

Adaptive Capacity

Out of the 200 miles of parkways in the study area, 140.40 miles (or 70%) have a high or very high ability to handle and recover from flood events (Fig. 12b). Parkways with high adaptive capacity are more likely to not be historic, not be near environmentally sensitive areas, have low traffic volumes, and low economic impacts. These factors reduce the impact a closed parkway might have on the transportation network and make the parkway more adaptable to flooding. Therefore, the parkway can better withstand and recover from the impacts of the flooded parkway.

Of the 140.40 miles of most adaptable parkways, 33.30 miles (or 24%) of parkways do not have a historic designation and are not near environmentally sensitive areas. This helps improve their ability to handle flooding because adaptation projects would not need to consider additional permitting requirements related to historic structures or environmentally sensitive areas. This makes it easier to add flood protection measures, like improved drainage systems and infrastructure upgrades.

Traffic volume is a more direct indicator of a parkway's adaptive capacity. Vehicle traffic is immediately disrupted by the impacts of a flooded parkway. Of the 140.40 miles of most adaptable parkways, approximately 91.40 miles (65%) have a low or medium traffic volume. This equals an average daily traffic volume of less than 15,000 vehicles per day. Since parkways with lower traffic volumes are better able to adapt to and recover from flooding, this minimizes disruptions to daily commutes and transportation. Parkways with high traffic volumes will have a greater impact on the transportation network when they flood as road closures will cause major traffic delays from mandatory detours around flooded areas.

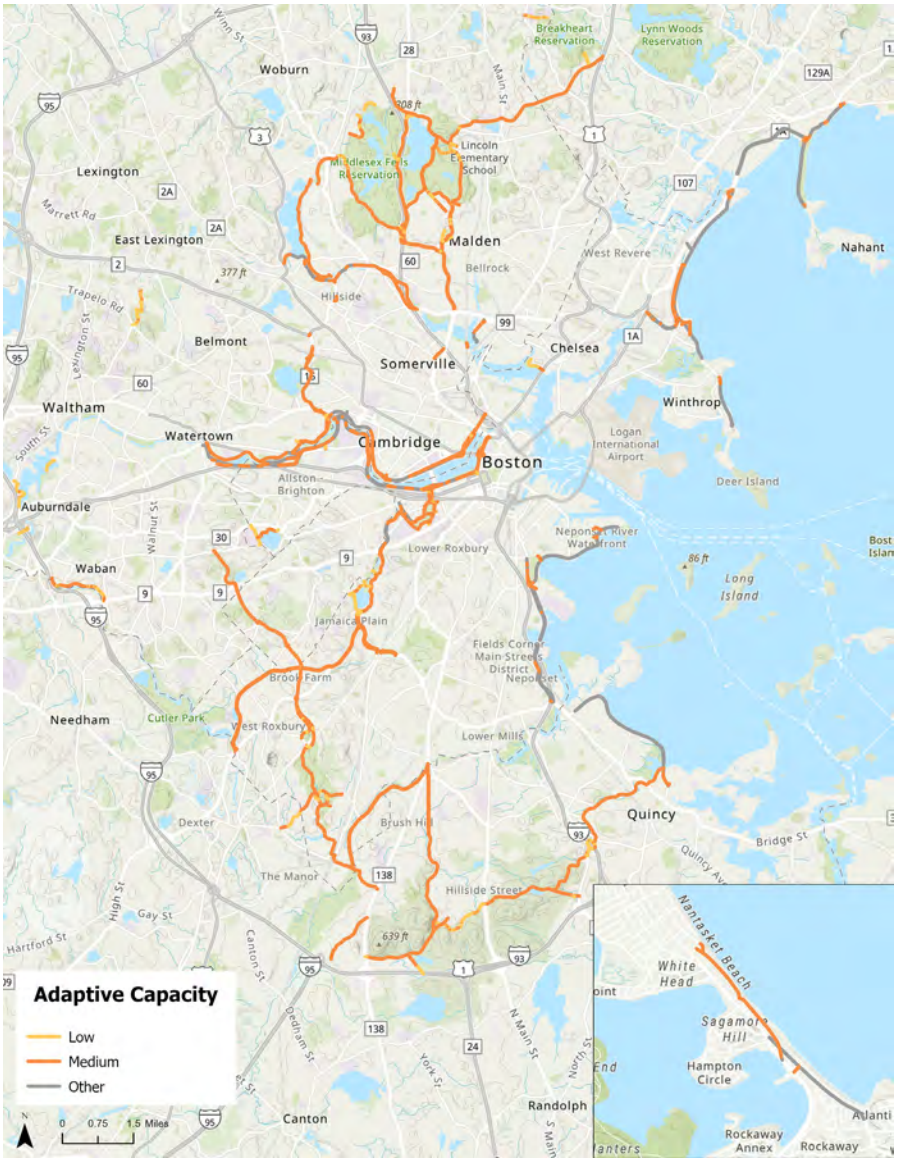


Figure 12b. Parkways with a low or medium adaptive capacity score.

Out of the 200 miles of parkway within the study area, 95 miles have high or very high traffic volume of 15,000 to 99,000 vehicles per day. Moreover, 49 miles have a very high traffic volume of 29,000 to 99,000 vehicles per day. Some parkways with very high traffic volumes include: Storrow Drive, Memorial Drive, Soldiers Field Road, Lynnway, Arborway, William T. Morrissey Boulevard, Quincy Shore Drive, and William Day Boulevard. Disruptions along these parkways would impact many users across the transportation network and make the parkways less adaptable to flooding.

There are 2.7 miles of parkway with both a very high traffic volume and a very high vulnerability score. These parkways are: Lynnway, Ramp-Soldiers Field WB to N Harvard St, Storrow Drive, William Day Boulevard, and William T. Morrissey Boulevard. Parkways with very high traffic volumes and vulnerability scores are at greater risk of severe disruptions. Addressing the vulnerabilities of these high-traffic parkways is crucial increase the resilience of the transportation network and reduce the impacts on daily commutes and economic activities.

Most Vulnerable Parkways 2070

Based on the methodology discussed in Section 2, the analysis determined 15 parkways with a very high vulnerability to flooding in 2070. These parkways are likely to be highly impacted by coastal and precipitation-based flooding. This sub-section discusses the parkways that are most vulnerable to flooding, in 2070 conditions, and explains the indicators contributing to higher vulnerability. Some parkways face challenges in adaptive capacity, which affect their ability to withstand and recover from flood events.

Hull Shore Drive

Hull Shore Drive is a road near Nantasket Avenue on the South Shore of Boston. It has high exposure to precipitation-based and coastal flooding. Hull Shore Drive has low sensitivity because it does not have a bus route or on-street parking. It has medium adaptive capacity to handle and recover from floods. This is because it has medium traffic (about 30,000 cars a day) and has a low cost of replacement ($90,000 for every 100 feet). When Hull Shore Drive floods, it does not cut off any communities, but it does cause some economic impacts. Closing the parkway for one day due to flooding would cost about $70,000 in lost recreational visits and travel delay costs.

Lynnway

The Lynnway has very high exposure to flooding in all coastal and precipitation-based scenarios. It also has high sensitivity to flooding because of a bus route and a history of past flooding.

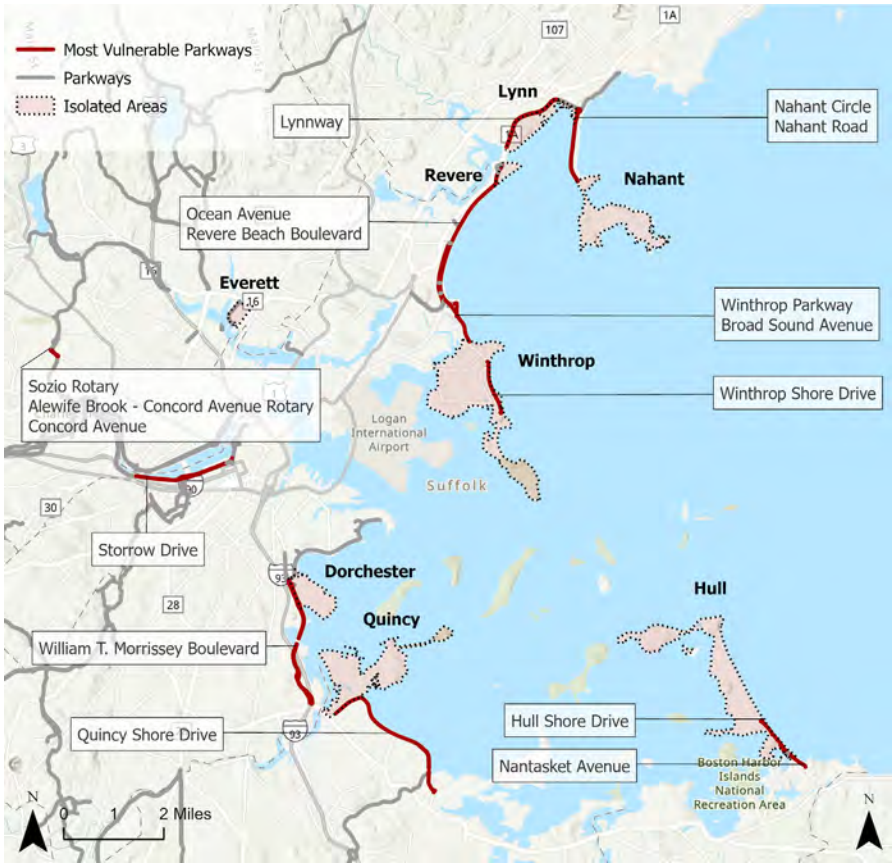


Figure 12c. Most Vulnerable Parkways to Flooding in 2070, and Isolated Communities.

The Lynnway has high traffic (40,000 vehicles per day) and high bus ridership. When it floods, it isolates commercial and industrial areas of Lynn and residential areas of Revere, causing significant community and economic disruptions. Closing the parkway for one day, due to flooding, would cost about $948,200. Most of the cost is realized in lost wages from residents who rely on Lynnway to commute to their job. These factors reduce the Lynnway's adaptive capacity and increase its vulnerability to flooding.

Nahant Circle and Nahant Road

Nahant Circle and Nahant Road have high exposure to coastal flooding and very high sensitivity due to past flooding and a bus route. When Nahant Road floods, it isolates the entire community of Nahant, causing an economic impact of $400,000 per day. This cost is mostly from lost commuter wages and business output. These parkways have a medium adaptive capacity because of low traffic,

Figure 12d. Maximillian X. Carbone Lifeguard Station at Nahant Beach with Nahant Road behind.

Source: DCR

low bus ridership, and a medium cost of replacement ($80,000 per 100 feet).

Nantasket Avenue

Nantasket Avenue has very high exposure to precipitation-based and coastal flooding. It has on-street parking, a bus route, and a history of past flooding, making its sensitivity very high. If Nantasket Avenue were to flood, it would isolate Hull and cause economic losses. Closing the parkway for one day, due to flooding, would cost about $970,000 in lost out-commuter wages and lost business output. Economic losses contribute to a parkway's lower adaptive capacity. Moreover, the high cost of replacement ($150,000 per 100 feet), high bus ridership, and historic designation reduce Nantasket Avenue's adaptive capacity and increase flood vulnerability.

Ocean Avenue / Revere Beach Boulevard

Ocean Avenue is exposed to precipitation-based and coastal flooding from Broad Sound and Diamond Creek Marsh. It has very high sensitivity due to bus routes, on-street parking, and past flooding. Ocean Avenue has a medium adaptive capacity because of its high cost of replacement ($150,000 per 100 feet) and medium traffic (10,000 vehicles per day). It is not historic or near an environmentally sensitive area and does not isolate communities when flooded, which improves its adaptive capacity.

Revere Beach Boulevard is exposed to precipitation-based and coastal flooding. It has medium sensitivity because a bus route only runs along the northern section. Many segments have a high cost of replacement (over $150,000 per 100 feet). The parkway has a medium adaptive capacity due to its historic designation, moderate traffic, and medium economic impact ($400,000 per day). It does not isolate communities when flooded, which improves its adaptive capacity.

Quincy Shore Drive

Quincy Shore Drive has very high exposure to precipitation-based and coastal flooding. It has medium sensitivity due to on-street parking and a documented history of flooding events. When flooded, it isolates part of Quincy and Squantum, further reducing its adaptive capacity. The very high economic impact ($6.5 million per day), high cost of replacement ($200,000 per 100 feet), and very high traffic (23,000 vehicles per day) reduce its adaptive capacity.

Sozio Rotary / Alewife Brook-Concord Ave Rotary / Concord Avenue

These parkways near Fresh Pond and Alewife Brook in Cambridge have very high exposure to precipitation-based and coastal flooding, especially if the Mystic River Dam were to be overtopped from storm surge. They have medium sensitivity due to a bus route but no street parking or a documented history of flooding. They have medium adaptive capacity due to high traffic (30,000 vehicles per day), medium bus ridership, and low cost of replacement ($90,000 per 100 feet). The rotaries have slightly lower adaptive capacity due to their historic designations. If this area floods, it would not isolate nearby communities. However, closing the parkway for one day, due to flooding, would cost about $240,000 in lost recreational visits and travel delay costs. These factors make the parkway more vulnerable to flooding.

Figure 12e. Quincy Shore Drive, Quincy MA.

Source: DCR

Storrow Drive Storrow

Storrow Drive has high exposure to coastal flooding, especially when the Charles River Dam overtops. It is heavily traveled by over 60,000 vehicles per day. This reduces its adaptive capacity, and flooding would have a major impact on the regional transportation network. It has a medium cost of replacement ($85,000 per 100 feet) and medium economic impact ($300,000 per day) from lost recreational visits. These factors reduce its adaptive capacity. It has high sensitivity due to past flooding and very high exposure to precipitation-based and coastal flooding.

William T. Morrissey Boulevard

William T. Morrissey Boulevard has very high exposure to precipitation-based and coastal flooding. It has medium sensitivity because there is no on-street parking or bus route. Its adaptive capacity is low due to a high cost of replacement ($130,000 per 100 feet), high economic impact (over $2 million per day) from lost out-commuter wages and business output, and medium traffic (10,000 vehicles per day). Flooding isolates the Columbia Point neighborhood and UMass Boston, further reducing the parkway's adaptive capacity and increasing flood vulnerability.

Winthrop Shore Drive / Broad Sound Avenue / Winthrop Parkway

These connecting parkways are in Revere and Winthrop. Winthrop Shore Drive has the highest vulnerability due to very high exposure and sensitivity. Winthrop Shore Drive and Broad Sound Avenue are exposed to precipitation-based and coastal flooding, while Winthrop Parkway is only exposed to coastal flooding. Winthrop Shore Drive has high sensitivity due to on-street parking and high adaptive capacity due to low traffic (5,000 vehicles per day) and high cost of replacement ($100,000 per 100 feet). Flooding isolates Winthrop, causing a high economic impact ($45.6 Million per day) from lost out-commuter wages and business output, reducing adaptive capacity.

In summary, these parkways exhibit high vulnerability to flooding based on their specific exposure, sensitivity, and adaptive capacity scores. The results highlight the urgent need for targeted mitigation strategies and infrastructure improvements to enhance resilience to flooding. By addressing these vulnerabilities through adaptation strategies, DCR can reduce the risk of significant economic disruptions, prevent community isolation during flood events, and improve the safety and accessibility of these critical transportation routes. Proactive measures, such as improved drainage systems, elevated roadways, and enhanced flood defenses, will be essential in safeguarding these parkways against future flooding and maintaining the continuity of daily life for the residents and businesses that rely on them.

Figure 12f. William T. Morrissey Boulevard near Savin Hill, Boston, MA.

Source: DCR

Economic Impacts

This sub-section provides a summary of the economic impacts projected to occur based on the findings from the Economic Impact Assessment.

The Economic Impact Assessment analyzed four distinct types of economic impacts: travel delay costs, lost recreational visits, isolated community (which includes lost wage income out-commuters and lost business output), and lost parking revenue. Parkways inundated under the MC-FRM 2030 and 2070 1% flood scenarios were assessed for economic impacts. These scenarios account for 60 miles and 92 miles of parkway in 2030 and 2070, respectively.

The economic impacts of these parkways closing for 24 hours, due to flooding, across all categories are projected to total $24.77 million in 2030 and $29.69 million in 2070. The largest cost in both scenarios is due to lost recreational visits, amounting to $12 million in 2030 and increasing to $15.9 million in 2070.The second largest cost is from lost business output in isolated communities, which is estimated to be $8.26 million in 2030 and slightly rising to $8.53 million in 2070. These projections underscore the financial burden that flooding can impose on communities, affecting both recreational activities, wages, and local businesses.

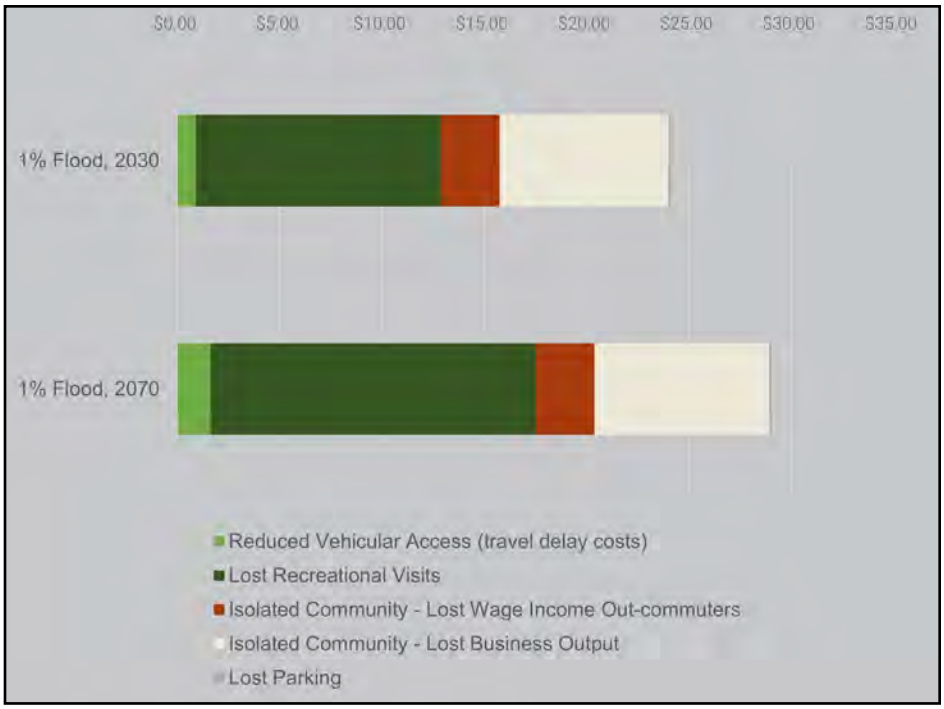


Figure 12g. Summary of Economic Impacts by Flood Scenario and Time Period (Millions of USD)

Isolated Communities

This sub-section discusses the isolated communities and the economic impact projected if specific parkways were to close from flooding.

There are eight communities in the Boston metro region that, due to their geography and the road network, can only be reached by vehicles using a specific DCR Parkway:
Hull, Quincy and Squantum, Dorchester near UMASS Boston, Lynn, Nahant, Everett, Revere, and Winthrop. These

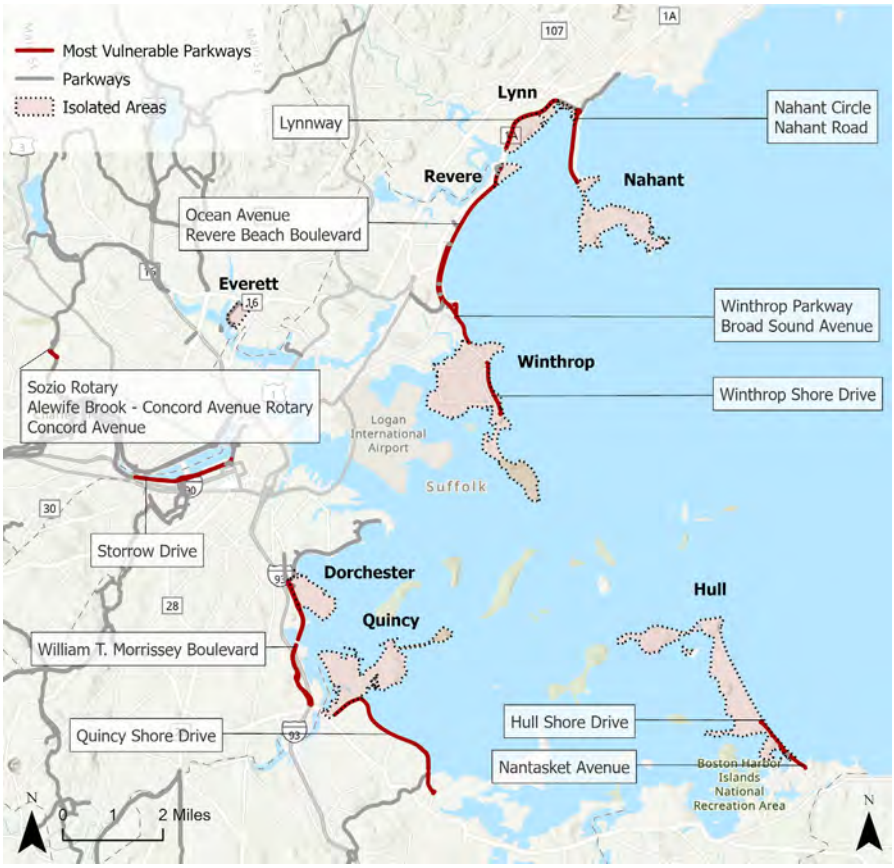


Figure 12h. Most Vulnerable Parkways to Flooding in 2070, and Isolated Communities.

communities, which tend to be areas surrounded by water bodies, are generally accessed by narrow causeway-type parkways. These communities would be isolated from others in the event of a major flood event and are served by the following parkways: Nantasket Avenue (Hull), Quincy Shore Drive (Quincy and Squantum), William T Morrissey Boulevard (Dorchester), Lynnway (Lynn), Carroll Parkway (Lynn), Nahant Road (Nahant), Mystic View Road (Everett), Revere Beach Boulevard (Revere), and Winthrop Parkway (Winthrop). For isolated communities, there are two major types of economic consequences of flooding. The first economic consequence is from lost wages for workers who reside in those communities and commute to jobs outside of their communities. The second economic consequence is from lost business output for lost activity from businesses that cannot be accessed (by employees or customers) in isolated areas. These impacts were adjusted based on local telecommuting rates (Fig 12i).

Quincy Shore Drive has the highest economic costs across the study area due to isolation, with a cost of $6.5 million per one-day parkway closure. Nearly $5.6 million of this is from lost business output because businesses could not operate if Quincy Shore Drive were closed for 24 hours due to flooding. Across the study area, the second most costly impacts from flooding are seen on William T Morrissey Boulevard, with a total economic loss of $2.0 million, mostly from lost business output. Both parkways serve communities with many out-commuters and businesses within the community, adding to the high economic costs. Quincy Shore Drive's economic cost is more than three times higher than William T Morrissey Boulevard, showing a significant difference in business output between these parkways.

Mystic View Road presents a unique scenario with no lost wage income from out-commuters because this parkway serves an area of Everett that is commercial and industrial, and people do not live there. Other parkways, like Winthrop Parkway, Nantasket Avenue, Nahant Road, Lynnway, and Carroll Parkway, show a mix of economic losses from both lost wages and lost business output, indicating these parkways serve areas with both homes and businesses. Overall, the total economic impact of flooding across all parkways highlights the financial consequences for these communities.

Figure 12i. The cost of lost wages and lost business output for each of the parkways causing the eight isolated communities (2022 USD).

Focus Area Vulnerability, Hot Spots, and Community Vulnerability Impacts

This sub-section reports the average vulnerability scores for each of the 20 Focus Areas. Within the Focus Area, locations of relative higher vulnerability are identified and described for specific areas, called Hot Spots. Each Focus Area contains a six-page section describing vulnerability scores, vulnerability maps, Hot Spots, and Community Vulnerability Impacts, and key parkland features within each Hot Spot. Some Focus Areas do not have high vulnerability Hot Spots and, therefore, will not have a description of Community Vulnerability Impacts or key parkland features.

The multi-page series is designed to be a complete package of results for each Focus Area and can be separated from the assessment, as needed (Fig. 12j). **The Focus Area pages are designed to stand-alone and therefore some information may be repeated in each FA to give context.**

The community within each Hot Spot is identified based on U.S. Census Tracts. Each community contains up to five adjacent Census Tracts. The demographic summary statistics represent the average values from the Census Tracts within the community for each Hot Spot. The demographic summary statistics were used to analyze the potential flood vulnerability impacts to the community members and are described in this section.

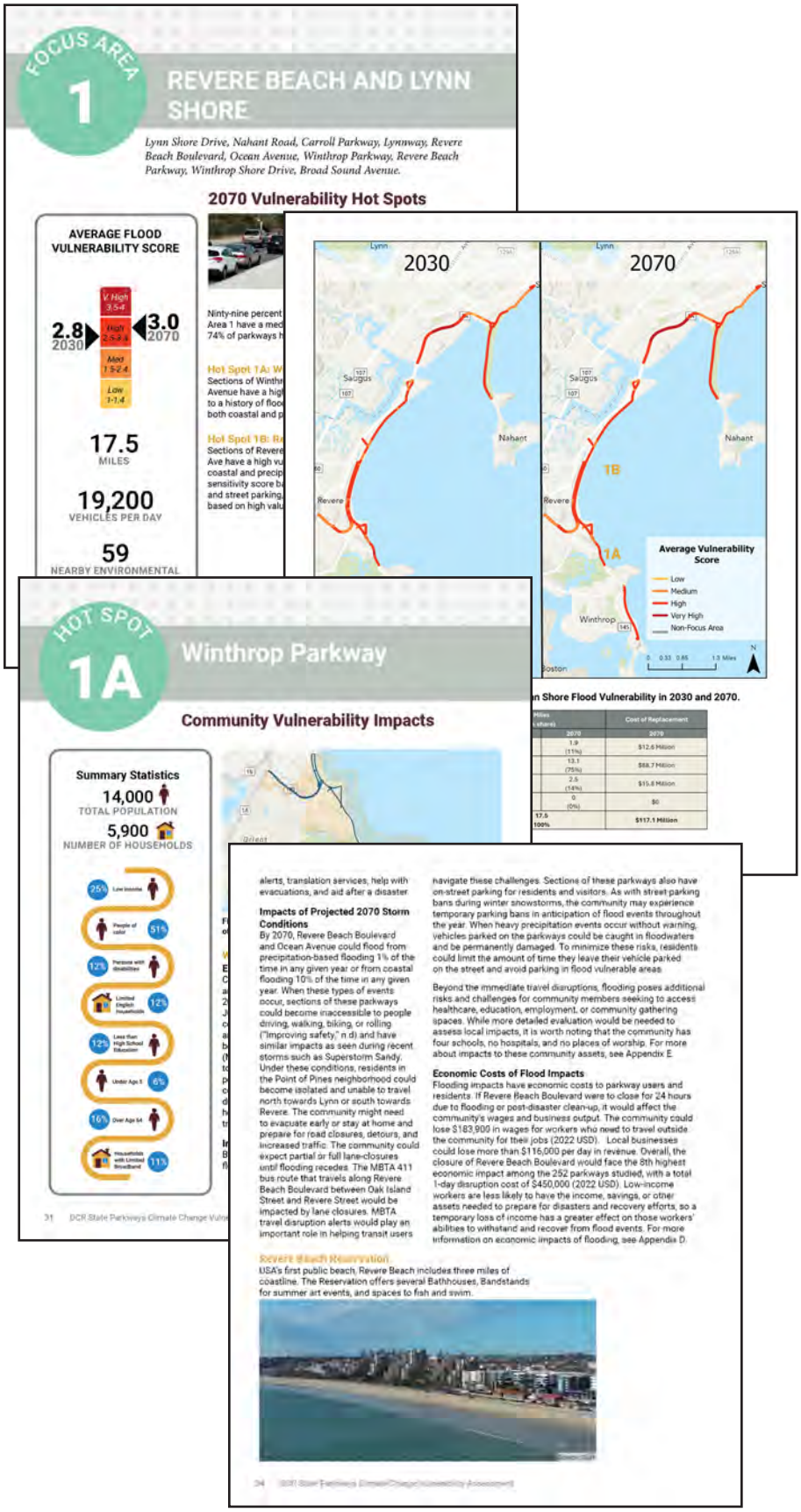


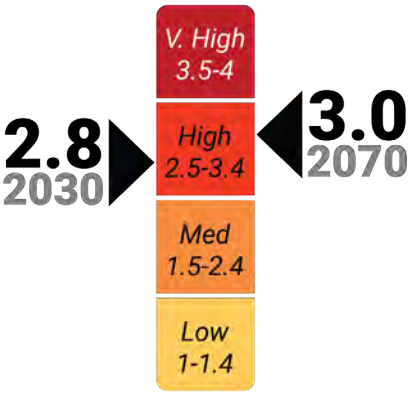
Figure 12j. Example of Focus Area Vulnerability and Community Vulnerability Impacts Results pages.

FOCUS AREA 1

REVERE BEACH AND LYNN SHORE

Lynn Shore Drive, Nahant Road, Carroll Parkway, Lynnway, Revere Beach Boulevard, Ocean Avenue, Winthrop Parkway, Revere Beach Parkway, Winthrop Shore Drive, Broad Sound Avenue.

AVERAGE FLOOD VULNERABILITY SCORE



17.5
MILES

19,200
VEHICLES PER DAY

59
NEARBY ENVIRONMENTAL JUSTICE BLOCK GROUPS

2070 Vulnerability Hot Spots


Source: DCR

Ninty-nine percent of the parkways in Focus Area 1 have a medium or high vulnerability and 74% of parkways have a high vulnerability.

Hot Spot 1A: Winthrop Parkway

Sections of Winthrop Parkway and Broad Sound Avenue have a high vulnerability to flooding due to a history of flooding and being impacted by both coastal and precipitation-based flooding.

Hot Spot 1B: Revere Beach

Sections of Revere Beach Boulevard and Ocean Ave have a high vulnerability due to exposure to coastal and precipitation-based flooding, a high sensitivity score based on the presence of bus routes and street parking, and a low adaptive capacity based on high values for cost of replacement.

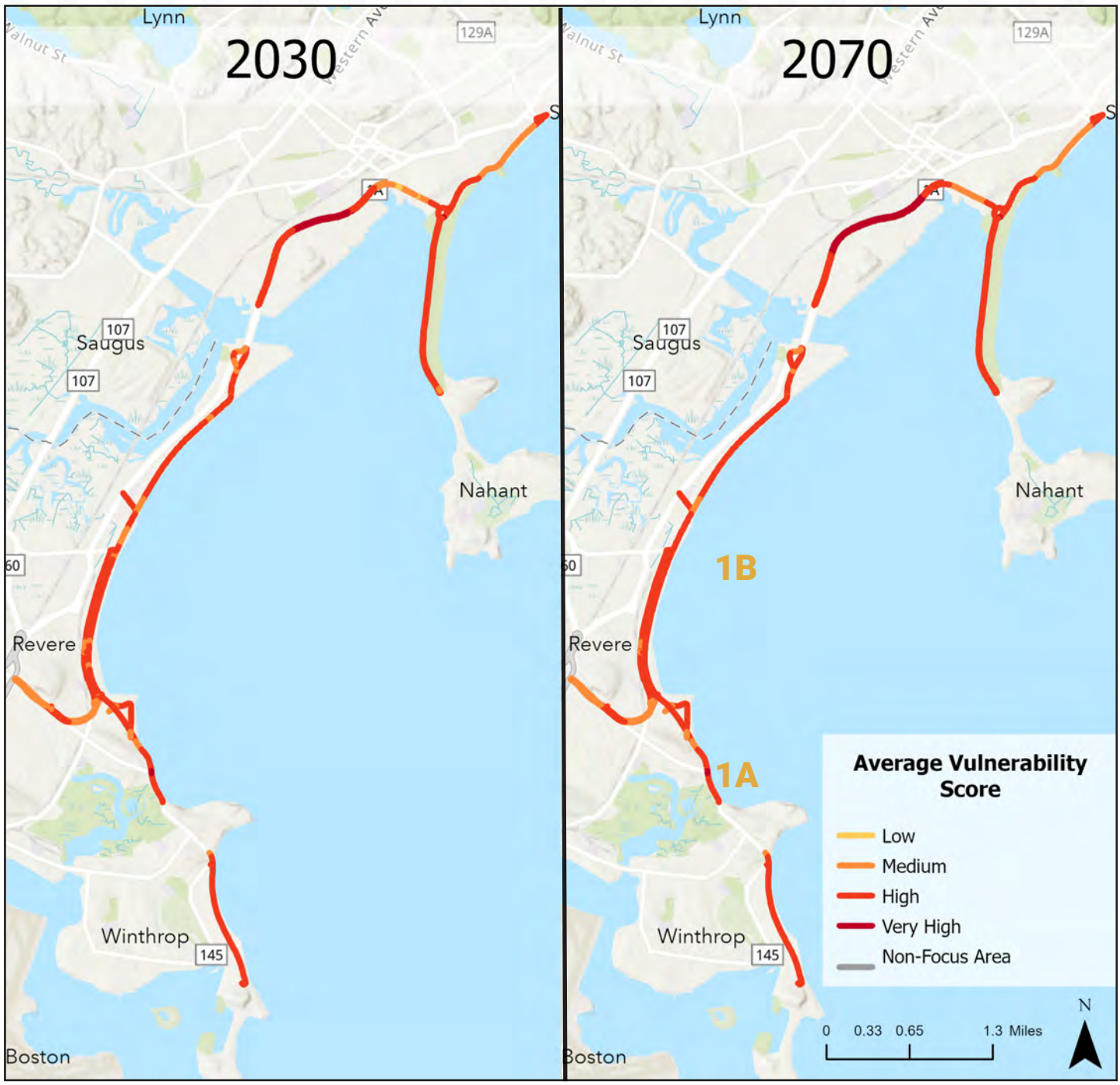


Figure 13a. Focus Area 1- Revere Beach and Lynn Shore Flood Vulnerability in 2030 and 2070.

Vulnerability	Miles (% share)		Cost of Replacement
	2030	2070	2070
Very High	1 (6%)	1.9 (11%)	$12.6 Million
High	13.2 (75%)	13.1 (75%)	$88.7 Million
Medium	3.3 (19%)	2.5 (14%)	$15.8 Million
Low	0 (0%)	0 (0%)	$0
Total	**17.5 100%**		**$117.1 Million**

HOT SPOT 1A

Winthrop Parkway

Community Vulnerability Impacts

Summary Statistics

14,000
TOTAL POPULATION

5,900
NUMBER OF HOUSEHOLDS

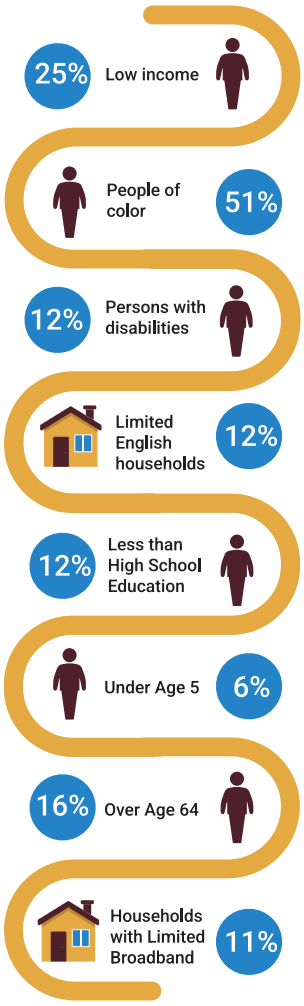


Figure 13b. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

Winthrop Parkway

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded roadway (Smith, 2024). The community around Winthrop Parkway contains several Justice40-designated disadvantaged areas. Residents in Justice40 communities are considered more disadvantaged because they are typically exposed to more pollution and there has historically been less investment in infrastructure and services in these areas (National Archives and Records Administration, n.d.). Compared to the rest of the state, this community has higher percentages of people of color and limited English-speaking households. These community members would benefit from extra support before, during, and after a flood. This support could include training on how to prepare for a big storm, multilingual emergency alerts , translation services, help with evacuations, and aid after a disaster.

Impacts of Projected 2070 Storm Conditions

By 2070, the Winthrop Parkway and Broadsound Avenue could flood from precipitation-based flooding 1% of the time annually or from coastal flooding 10% of the time annually. During such events, segments of these parkways could become impossible to use by people driving, walking, biking, or rolling ("Improving safety," n.d). Under these conditions, residents in the Winthrop Highlands would not be able to travel north towards Revere via Winthrop Parkway when it is flooded. However, alternative, non DCR owned and maintained roads, may be accessible. Community members might need to evacuate early or stay at home and prepare for road closures, detours, and more traffic around the community. The presence of a brownfield site at 400 Revere Beach Parkway (RTN: 3-0026209) means that flooding could release pollutants and debris into the community. This could increase health risks and damage nearby parks and other public open spaces that provides critical habitat and recreational opportunities, like Winthrop Beach and Belle Isle Marsh.

Beyond the immediate travel disruptions, flooding in this area poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While a more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has no hospitals or places of worship and seven schools and would need to travel outside of the community to access these services. For more about impacts to these community assets, see Appendix E.

Economic Costs of Flood Impacts

Flooding impacts have economic costs to parkway users and residents. If Winthrop Parkway were to close for 24 hours due to flooding or post-flood clean-up, it would affect the community's wages and business output. The community could lose $262,600 in wages for workers who need to travel outside the community for their jobs (2022 USD). Local businesses could lose more than $6,700 per day in revenue. Overall, the community would face the 9th highest economic impact among 252 parkways studied, with a total 1-day disruption cost of $410,500 (2022 USD). Low-income workers are less likely to have the income, savings or other assets needed to prepare for disasters and recovery efforts, so a temporary loss of income has a greater effect on those workers' abilities to withstand and recover from flood events. For more information on economic impacts of flooding, see Appendix D.

Belle Isle Marsh Reservation

Boston's last remaining salt marsh offers unique views of plants and wildlife as you follow paths to the observation tower.

Source: DCR

HOT SPOT 1B

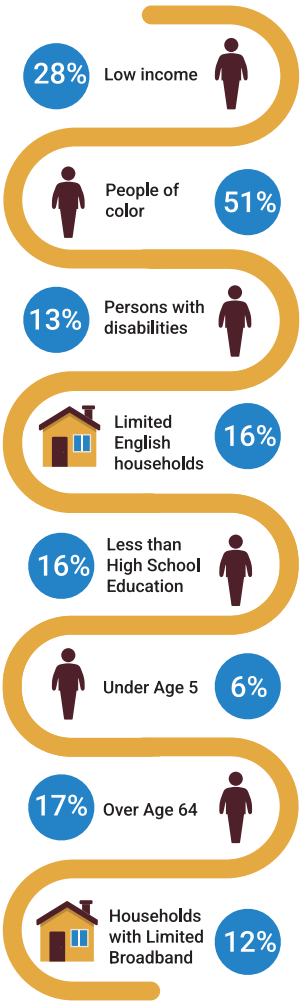
Revere Beach

Community Vulnerability Impacts

Summary Statistics

17,000
TOTAL POPULATION

7,000
NUMBER OF HOUSEHOLDS



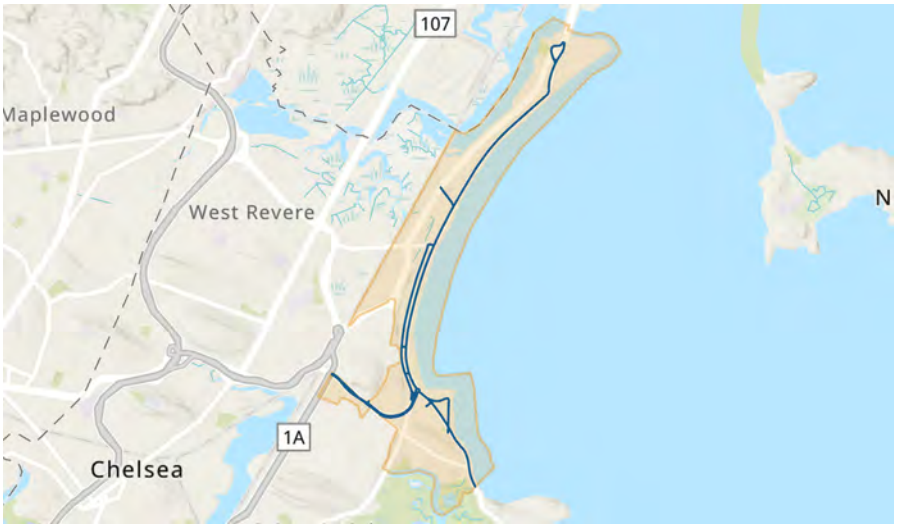


Figure 13c. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

Revere Beach

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway (Smith, 2024). The community around Revere Beach contains several Justice40-designated disadvantaged communities where residents have historically been exposed to more pollution and less investment in infrastructure and services (National Archives and Records Administration, n.d.). Compared to the rest of the state, the Revere Beach community has higher percentages of non-white residents, low-income residents, limited English-speaking households, those with less than a high school education, and those under age 5 or over age 64. People in these groups who face social and economic challenges are more vulnerable to the impacts of a flooded parkway and would benefit from extra support before, during, and after a flood. This support could include training on how to prepare for a big storm, multilingual emergency

alerts, translation services, help with evacuations, and aid after a disaster.

Impacts of Projected 2070 Storm Conditions

By 2070, Revere Beach Boulevard and Ocean Avenue could flood from precipitation-based flooding 1% of the time in any given year or from coastal flooding 10% of the time in any given year. When these types of events occur, sections of these parkways could become inaccessible to people driving, walking, biking, or rolling ("Improving safety," n.d) and have similar impacts as seen during recent storms such as Superstorm Sandy. Under these conditions, residents in the Point of Pines neighborhood could become isolated and unable to travel north towards Lynn or south towards Revere. The community might need to evacuate early or stay at home and prepare for road closures, detours, and increased traffic. The community could expect partial or full lane-closures until flooding recedes. The MBTA 411 bus route that travels along Revere Beach Boulevard between Oak Island Street and Revere Street would be impacted by lane closures. MBTA travel disruption alerts would play an important role in helping transit users navigate these challenges. Sections of these parkways also have on-street parking for residents and visitors. As with street parking bans during winter snowstorms, the community may experience temporary parking bans in anticipation of flood events throughout the year. When heavy precipitation events occur without warning, vehicles parked on the parkways could be caught in floodwaters and be permanently damaged. To minimize these risks, residents could limit the amount of time they leave their vehicle parked on the street and avoid parking in flood vulnerable areas.

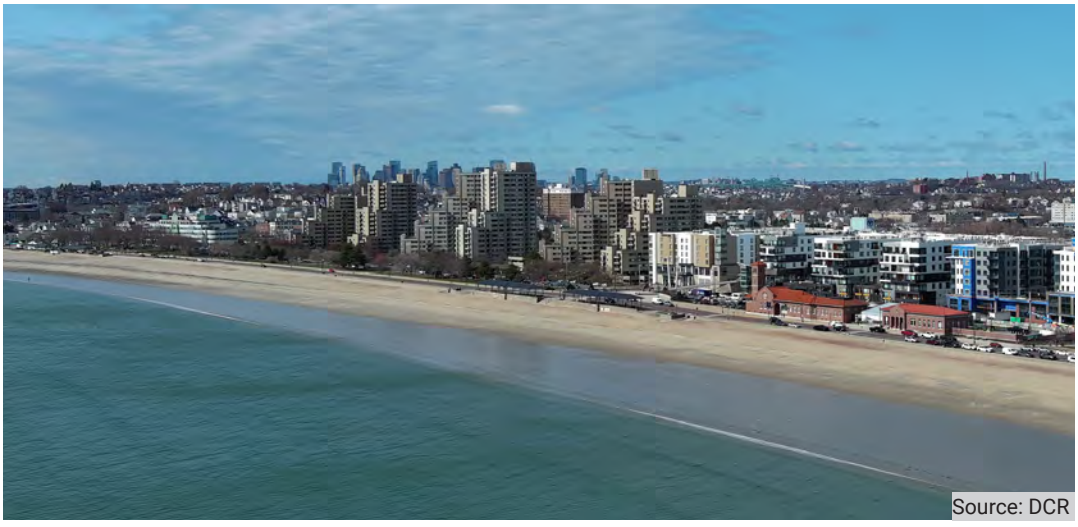
Beyond the immediate travel disruptions, flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has four schools, no hospitals, and no places of worship. For more about impacts to these community assets, see Appendix E.

Economic Costs of Flood Impacts

Flooding impacts have economic costs to parkway users and residents. If Revere Beach Boulevard were to close for 24 hours due to flooding or post-disaster clean-up, it would affect the community's wages and business output. The community could lose $183,900 in wages for workers who need to travel outside the community for their jobs (2022 USD). Local businesses could lose more than $116,000 per day in revenue. Overall, the closure of Revere Beach Boulevard would face the 8th highest economic impact among the 252 parkways studied, with a total 1-day disruption cost of $450,000 (2022 USD). Low-income workers are less likely to have the income, savings, or other assets needed to prepare for disasters and recovery efforts, so a temporary loss of income has a greater effect on those workers' abilities to withstand and recover from flood events. For more information on economic impacts of flooding, see Appendix D.

Revere Beach Reservation

USA's first public beach, Revere Beach includes three miles of coastline. The Reservation offers several Bathhouses, Bandstands for summer art events, and spaces to fish and swim.



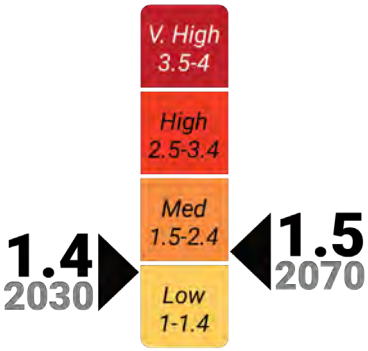
Source: DCR

FOCUS AREA 2

MIDDLESEX FELLS

Fellsway, Fellsway West, South Border Road, Elm Street, South Street, North Border Road, Park Street, Hillcrest Parkway, Fellsway East, East Border Road

AVERAGE FLOOD VULNERABILITY SCORE

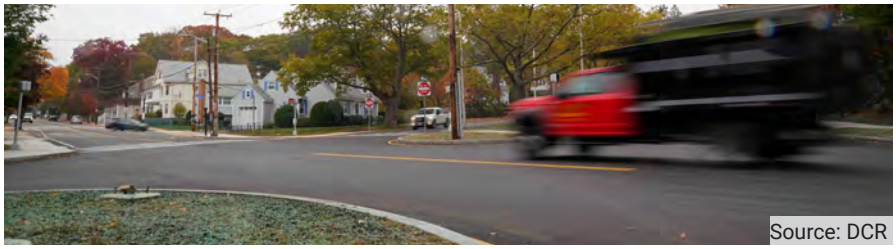


25
MILES

10,300
VEHICLES PER DAY

65
NEARBY ENVIRONMENTAL JUSTICE BLOCK GROUPS

2070 Vulnerability Hot Spots


Source: DCR

In 2070, 6% of the of the parkways in Focus Area 2 have high vulnerability, 24% have medium vulnerability and 70% have low vulnerability.

Hot Spot 2A: Fellsway West

The southern end of Fellsway West is exposed to precipitation-based flooding and has a medium vulnerability due to the presence of MBTA 100 bus route, and a half-mile of on street parking. Nearby sections of Elm Street and Highland Avenue have medium vulnerability for similar reasons.

Hot Spot 2B: Fellsway from Route 16 to Devir Park

This mile and a half long section of the Fellsway is the only section in the Focus Area with a high vulnerability. This section has a high sensitivity to flooding because of the MBTA 100, 134, and 108 bus routes and on street parking. The bus routes have high ridership, these sections have a medium cost of replacement, and a medium economic impact, which reduces adaptive capacity and increases vulnerability. By 2070, this section of the Fellsway is predicted to be exposed to coastal and precipitation-based flooding, due to proximity to the Malden and Mystic Rivers, which can become tidally influenced and back up during infrequeny coastal storm events.

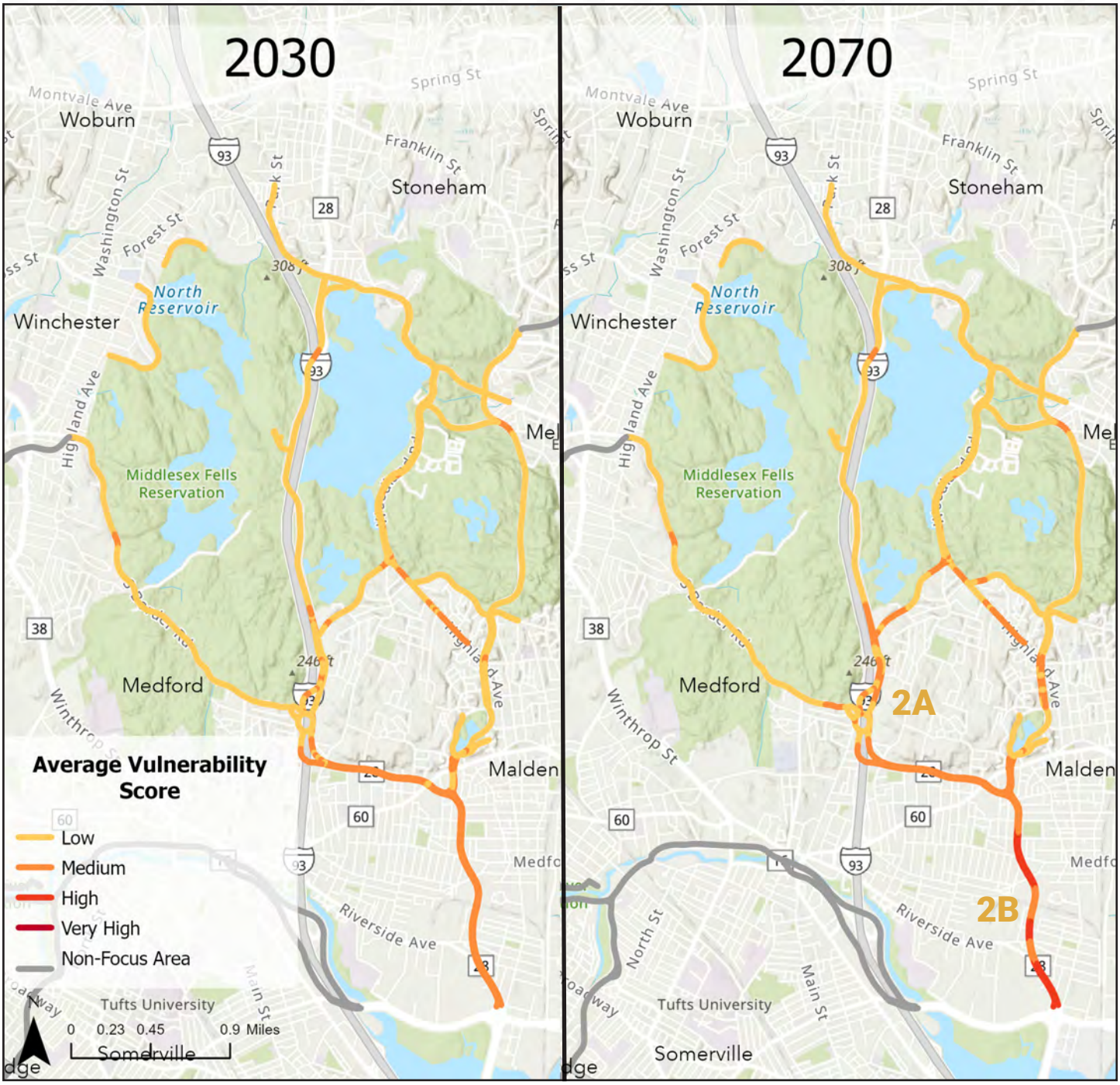


Figure 14a. Focus Area 2 - Middlesex Fells Flood Vulnerability in 2030 and 2070.

Vulnerability	Miles (% share)		Cost of Replacement
	2030	2070	2070
Very High	0 (0%)	0 (0%)	$0
High	0.04 (0%)	1.7 (7%)	$9.5 Million
Medium	10.5 (42%)	10.2 (41%)	$50.1 Million
Low	14.4 (58%)	13 (52%)	$58.6 Million
Total	**24.9 100%**		**$118.2 Million**

HOT SPOT 2A

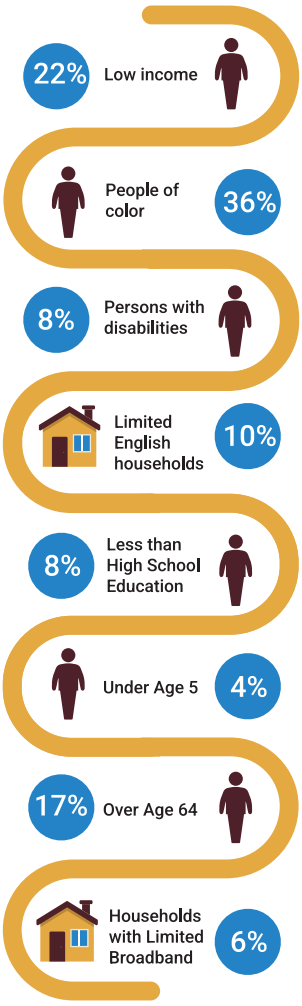
Fellsway West

Community Vulnerability Impacts

Summary Statistics

22,500
TOTAL POPULATION

8,900
NUMBER OF HOUSEHOLDS



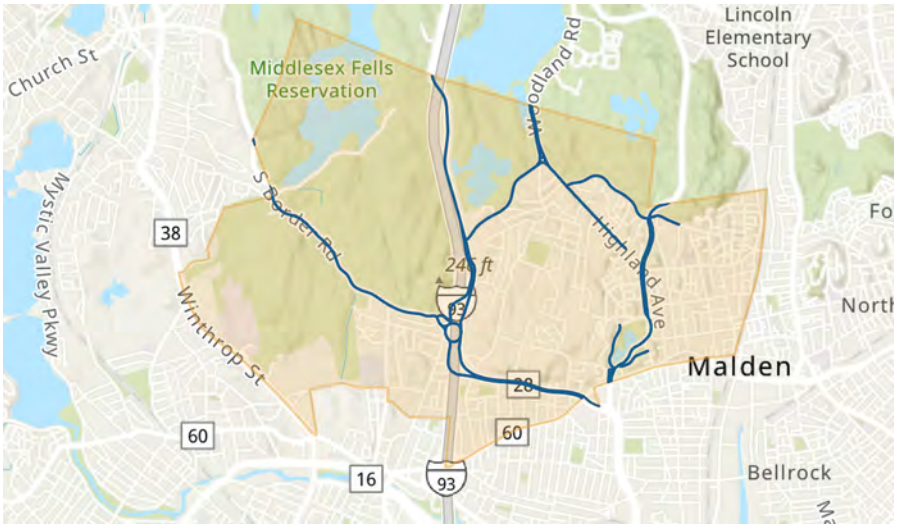


Figure 14b. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

Fellsway West

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway (Smith, 2024). Co mpared to the rest of the state, this community has a higher percentage of limited English-speaking households. People in these groups who face social and economic challenges are more vulnerable to the impacts of a flooded parkway and would benefit from extra support before, during, and after a flood. This support could include training on how to prepare for a big storm, multilingual emergency alerts, translation services, help with evacuations, and aid after a disaster.

Impacts of Projected 2070 Storm Conditions

By 2070, Fellsway West, Elm Street, and Highland Avenue could flood from precipitation-based flooding 1% of the time in any given year. Flooded sections of these parkways could become impossible to use

by people driving, walking, biking, or rolling ("Improving safety," n.d). The community could expect partial or full lane-closures until flood waters recede. The MBTA 100 bus route would be impacted by lane closures, and residents in the community would expect temporary detours and more traffic around the area. MBTA travel disruption alerts would play an important role in helping transit users navigate these challenges. Sections of these parkways also have on-street parking for residents and visitors. As with street parking bans during winter snowstorms, the community may experience temporary parking bans in anticipation of flood events throughout the year. When heavy precipitation events occur without warning, vehicles parked on the Fellsway could be caught in floodwaters and permanently damaged. To minimize these risks, residents could limit the amount of time they leave their vehicle parked on the street and avoid parking in flood vulnerable areas.

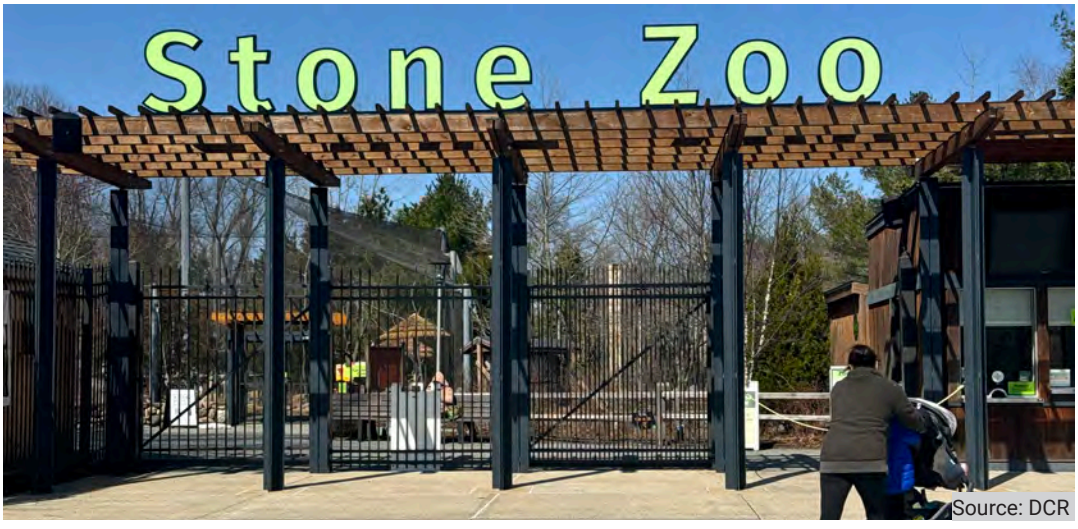
Beyond the immediate travel disruptions, flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has three hospitals, three schools, and four places of worship. For more about impacts to these community assets, see Appendix E.

Economic Costs of Flood Impacts

These impacts have economic costs to parkway users and residents. If Fellsway West were to close for 24 hours due to active flooding or post-disaster clean-up, the total disruption cost would be $37,600 (2022 USD). The largest economic impact in this area is the cost of lost recreational visits. Fellsway West is a major access road to the Middlesex Fells Reservation and flood-related travel disruptions would make it harder for people to access this environmental and recreation resource. Since the community is not isolated from the closure of this parkway, the community would not be impacted by lost business output or income from people commuting out of the community. In the event of a closure of Fellsway West, individuals who rely on MBTA 100 bus route or use street-parking along the parkway may be impacted by flooding. Individuals who rely on these travel modes for employment, access to income, or other social services will experience compounded economic losses. For more information on economic impacts of flooding, see Appendix D.

Zoo New England: Stone Zoo

This 26-acre zoo features a diverse array of animals, including snow leopards, Mexican gray wolves, and playful river otters. The zoo offers educational programs, live animal cams, and seasonal events, making it a fun and engaging destination for families and nature enthusiasts.



Source: DCR

HOT SPOT 2B

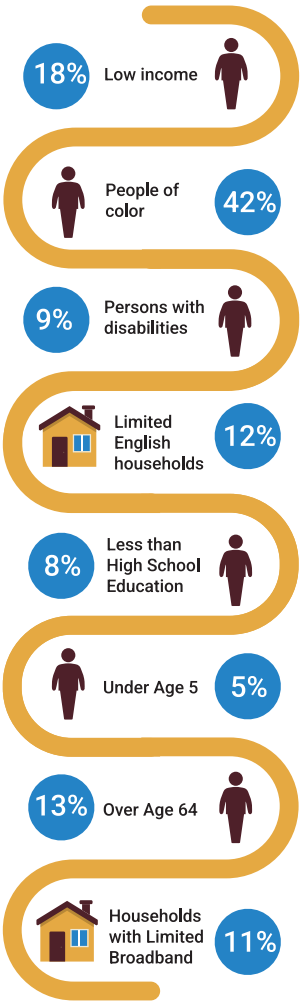
Fellsway from Route 16 to Devir Park

Community Vulnerability Impacts

Summary Statistics

21,100
TOTAL POPULATION

8,300
NUMBER OF HOUSEHOLDS



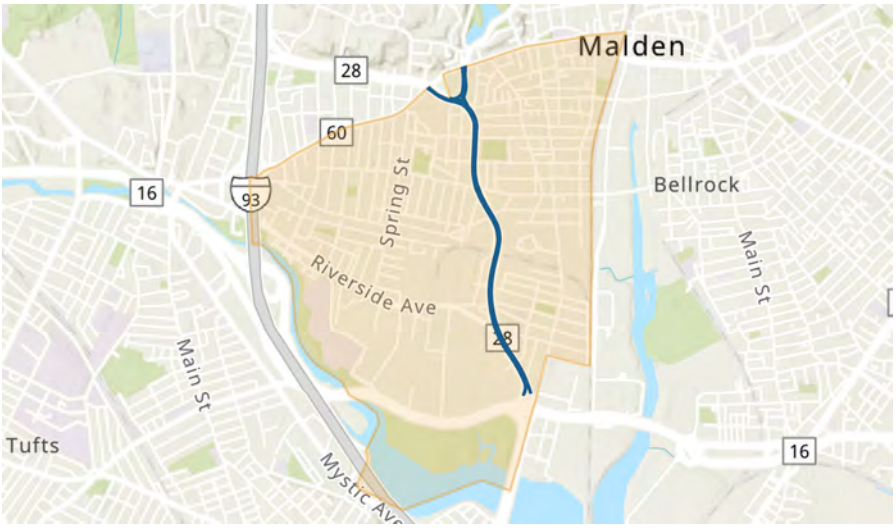


Figure 14c. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

Fellsway from Route 16 to Devir Park

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway (Smith, 2024). The community around the Fellsway contains several Justice40-designated disadvantaged communities where residents have historically been exposed to more pollution, and less investment in infrastructure and services (National Archives and Records Administration, n.d.). Compared to the rest of the state, the community has higher percentages of limited English-speaking households and people of color. These residents would benefit from extra support before, during, and after a flood. This support could include training on how to prepare for a big storm, multilingual emergency alerts, translation services, evacuation assistance, and post-disaster aid.

Impacts of Projected 2070 Storm Conditions

By 2070, the Fellsway could flood from precipitation-based flooding 1% of the time in any given year or from coastal flooding when storm surge overtops the Mystic River Dam and backs up the Mystic and Malden Rivers. The coastal event will have a 10% chance of occurring in any given year. When these types of events occur, sections of this parkway could become inaccessible to people driving, walking, biking, or rolling ("Improving safety," n.d). Community members should expect partial or full lane closures until flood waters recede. The MBTA 100, 134, and 108 bus routes would be impacted by lane closures, and residents in the community would expect temporary detours and more traffic around the area. The nearby Wellington MBTA stop on the Orange Line and commuters using MBTA buses or personal vehicles to get to this MBTA train stop could be impacted by reduced access to the Fellsway. MBTA travel disruption alerts would play an important role in helping transit users navigate these challenges. Sections of these parkways also have on-street parking for residents and visitors. As with street parking bans during winter snowstorms, the community may experience temporary parking bans in anticipation of flood events throughout the year. When heavy precipitation events occur without warning, vehicles parked on the Fellsway could be caught in floodwaters and permanently damaged. To minimize these risks, residents could limit the amount of time they leave their vehicle parked on the street and avoid parking in flood vulnerable areas.

Beyond the immediate travel disruptions, flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has no hospitals, three schools, and two places of worship. For more about impacts to these community assets, see Appendix E.

Economic Costs of Flood Impacts

These impacts have economic costs to parkway users and residents. If Fellsway were to close for 24 hours due to active flooding or post-disaster clean-up, the total disruption cost would be $66,800 (2022 USD). The largest economic impact in this area is the cost of lost recreational visits. The Fellsway is a major access road to the Mystic River Reservation and flood-related travel disruptions would make it harder for people to access this environmental and recreation resource. While the community is not isolated in the event of a closure of the Fellsway, individuals who rely on the MBTA bus routes or use street-parking along the parkway may be impacted by flooding and if these travel modes are tied to their employment, access to income, or other social services. These individuals will incur compounded economic losses. For more information on economic impacts of flooding, see Appendix D.

Fellsmere Park

One of Malden's true gems, Fellsmere Park provides residents with a quiet retreat. Accessible via Fellsway East, the Park features a walking path, pond with a fountain, open grass and wooded areas.

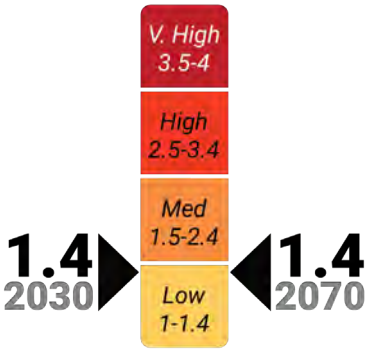
Source: Marissa Babin via flickr

FOCUS AREA 3

Lynn Fells and Breakheart

Lynn Fells Parkway, Hemlock Road, Forest Street

AVERAGE FLOOD VULNERABILITY SCORE



4.7
MILES

5,000
VEHICLES PER DAY

6
NEARBY ENVIRONMENTAL JUSTICE BLOCK GROUPS

2070 Vulnerability Hot Spots


Source: DCR

This inland Focus Area is protected from the impacts of coastal flooding and there are no parkways with a high vulnerability score. Fifty-seven percent of the parkways have a low vulnerability and 43% have a medium vulnerability based on their historic designation and exposure to precipitation-based flooding. The 2.3 miles of parkway with a medium vulnerability is along the Lynn Fells Parkway.

Hot Spot 3A: Eli Pond Recreation Area

The section of Lynn Fells Parkway between Melrose Street and Vinton Street has a medium vulnerability due to exposure to precipitation-based flooding.

Hot Spot 3B: Bennetts Pond Brook

The sections of Lynn Fells Parkway in Saugus have a medium vulnerability because of their exposure to precipitation-based flooding. These sections of the parkway are proximate to Bennetts Pond Brook, and it is likely the parkway is within the historical course of this waterway.

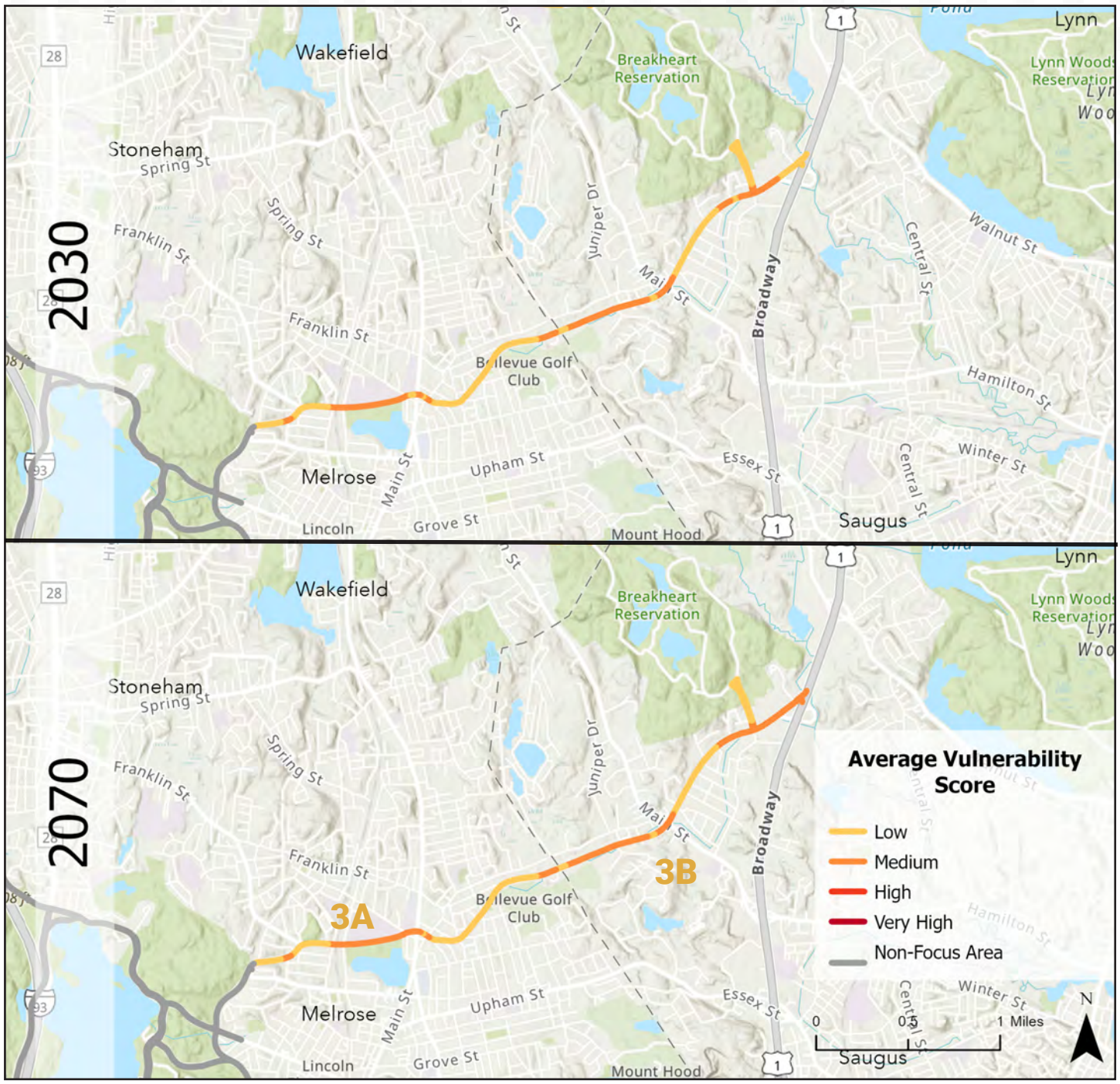


Figure 15a. Focus Area 3 - Lynn Fells and Breakheart Flood Vulnerability in 2030 and 2070.

Vulnerability	Miles (% share)		Cost of Replacement
	2030	2070	2070
Very High	0 (0%)	0 (0%)	$0
High	0 (0%)	0 (0%)	$0
Medium	1.8 (38%)	2.1 (45%)	$12.2 Million
Low	2.9 (62%)	2.6 (55%)	$13.7 Million
Total	**4.7 100%**		**$26.0 Million**

HOT SPOT 3AB

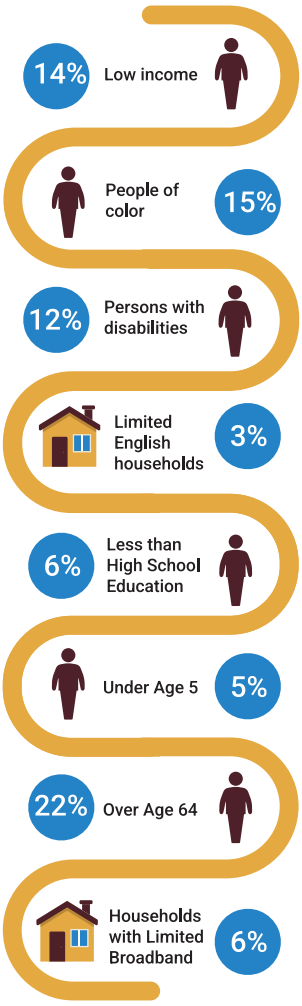
Eli Pond Recreation Area and Bennetts Pond Brook

Community Vulnerability Impacts

Summary Statistics

17,500
TOTAL POPULATION

7,300
NUMBER OF HOUSEHOLDS



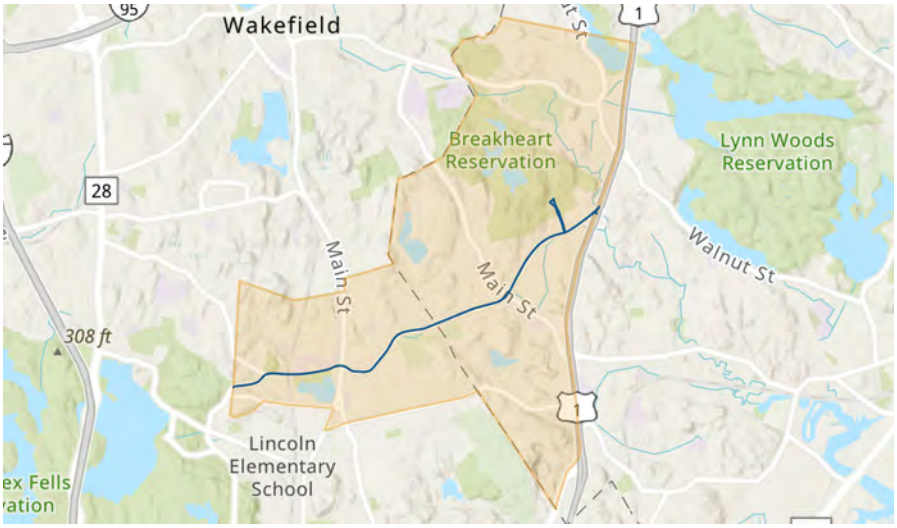


Figure 15b. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

Eli Pond Recreation Area and Bennetts Pond Brook

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway (Smith, 2024). Compared to the rest of the state, the community has more limited English-speaking households, people over age 64, and people under age 5. People in these age categories are more vulnerable to the impacts of a flooded parkway and would benefit from extra physical support before, during, and after a flood, especially if evacuation is necessary. This support could include training on how to prepare for a big storm, multilingual emergency alerts, translation services, help with evacuations, and aid after a disaster.

Impacts of Projected 2070 Storm Conditions

By 2070, Lynn Fells Parkway could flood from precipitation-based flooding 1% of the time in any given year. When these types of events occur, sections of this parkway could become inaccessible to people driving, walking, biking, or rolling ("Improving safety," n.d). Under these conditions, the community could expect partial or full lane closures until flood waters recede. Residents should be prepared for temporary access restrictions to their normal travel patterns, detours around the most vulnerable sections of the parkway, and increased local traffic during flood events as traffic is re-routed.

Beyond the immediate travel disruptions, flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has one hospital, six schools, and thirteen places of worship. For more about impacts to these community assets, see Appendix E.

Economic Costs of Flood Impacts

This parkway was not studied in the economic analysis because it is not impacted by coastal flooding. Since this area has nearby neighborhood roads that connect to other main roads, the community would not become isolated in the event of a closure of Lynn Fells Parkway.

Lloyd Swimming Pool

Lloyd Swimming Pool is a recreational swimming pool open seasonally between June and August and is accessible via Lynn Fells Parkway. The pool offers a lifeguard on duty, lockers, restrooms, showers, and swimming lessons.

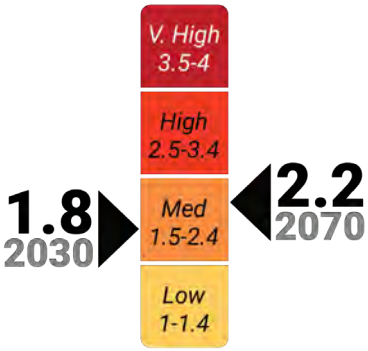
Source: Robert James via Google

FOCUS AREA 4

MYSTIC VALLEY

Mystic Valley Parkway, Mystic River Road

AVERAGE FLOOD VULNERABILITY SCORE



10.4
MILES

12,500
VEHICLES PER DAY

68
NEARBY ENVIRONMENTAL JUSTICE BLOCK GROUPS

2070 Vulnerability Hot Spots


Source: DCR

Across Focus Area 4, 77% of the parkways have a medium vulnerability score in 2070. In 2030, there is a 0.5 mile of parkways with a high vulnerability, and by 2070, there is 1.3 miles of parkway (non-continuous) with a high vulnerability. Sections of Mystic Valley Parkway have a documented history of flooding, which is a primary driver of medium and high vulnerability.

Hot Spot 4A: Mystic Valley Parkway near Medford Square

This area has a medium sensitivity due to the presence of the MBTA 94, 95, 96, and 101 bus routes, and a low adaptive capacity due to a high cost of replacement, medium traffic volume, historic designation, and a medium level of bus ridership.

Hot Spot 4B: Lower Mystic Lake

The sections of Mystic Valley Parkway located between Lower Mystic Lake and Mount Pleasant Cemetery have a high vulnerability due to the documented history of flooding by DCR Operations Staff, high traffic volumes, high cost of replacement and exposure to precipitation-based flooding.

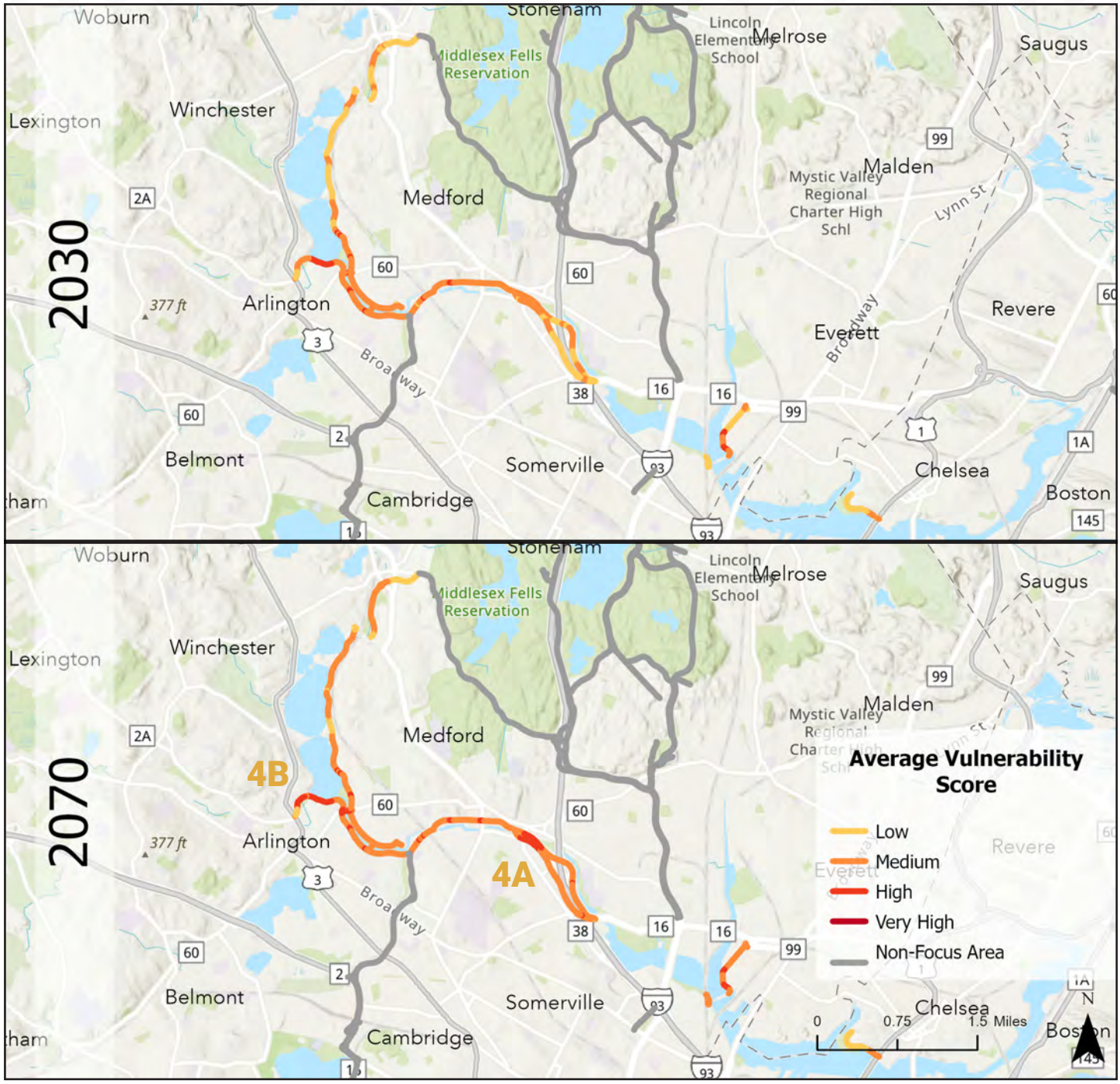


Figure 16a. Focus Area 4 - Mystic Valley Flood Vulnerability in 2030 and 2070.

Vulnerability	Miles (% share)		Cost of Replacement
	2030	2070	2070
Very High	0 (0%)	0 (0%)	$0
High	1.4 (13%)	3.3 (32%)	$14.3 Million
Medium	6 (58%)	6.1 (59%)	$26.6 Million
Low	3.1 (30%)	1.1 (11%)	$5.4 Million
Total	**10.4 100%**		**$46.3 Million**

HOT SPOT 4A

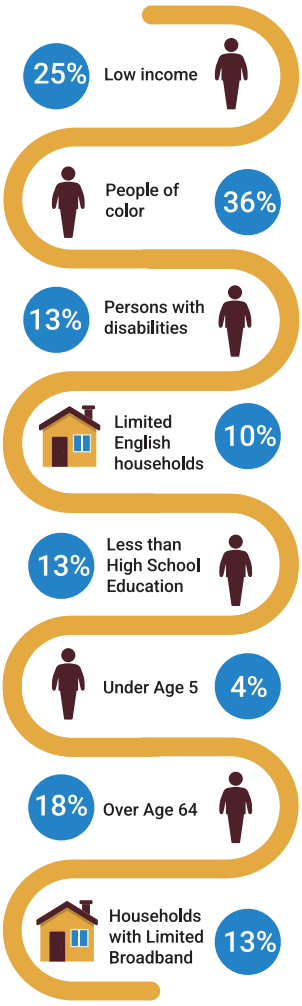
Mystic Valley Parkway near Medford Square

Community Vulnerability Impacts

Summary Statistics

12,500
TOTAL POPULATION

5,400
NUMBER OF HOUSEHOLDS



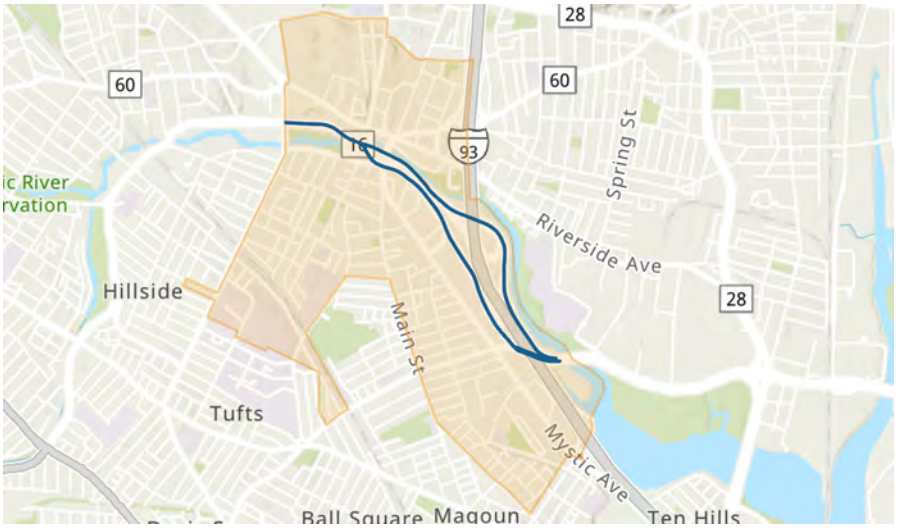


Figure 16b. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

Mystic Valley Parkway near Medford Square

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway (Smith, 2024). Compared to the rest of the state, the community has higher percentages of limited English-speaking households, people with less than a high school education, and households with limited broadband access. Communication of flood events and how to best prepare for, stay safe during, and access recovery resources after flood events could be a challenge for people in the community. This is a community that would benefit from multiple forms of communication, in multiple languages, from agencies about pre- and post-disaster efforts.

Impacts of Projected 2070 Storm Conditions

By 2070, this area of Mystic Valley Parkway could flood from precipitation-based flooding 1% of the time in any given year or from coastal flooding when storm surge overtops the Mystic River Dam and backs up the Mystic River. The coastal event will have a 10% chance of occurring. When these types of events occur, sections of this parkway could become inaccessible. Under these conditions, the community could expect partial or full lane closures until flood waters recede. In these conditions, the community could expect partial or full lane closures until flood waters recede. The MBTA 94, 95, 96, and 101 bus routes would be impacted by lane closures and residents in the community should expect temporary detours and more traffic around the area. MBTA travel disruption alerts would play an important role in helping transit users navigate these challenges. This section of Mystic Valley Parkway serves as the primary connection to I-93 North and South and could impact the community's ability to safely evacuate the area in the event of an emergency.

Beyond the immediate travel disruptions, flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has no hospitals, one school, and seven places of worship. For more about impacts to these community assets, see Appendix E.

Economic Costs of Flood Impacts

These impacts have economic costs to parkway users and residents. If Mystic Valley Parkway were to close for 24 hours due to active flooding or post-disaster clean-up, the total disruption cost would be $167,600 (2022 USD). The largest economic impact in this area is the cost of lost recreational visits. This parkway is a major access road to the Mystic River Reservation, Mystic Lakes, and Alewife Brook Reservation. Flood-related travel disruptions would make it harder for people to access these environmental and recreation resources. For more information on economic impacts of flooding, see Appendix D.

Condon Shell

Within the Mystic River Reservation, the Condon Shell hosts various events, including concerts and community events. The venue is also popular for its proximity to the Mystic River, where you can rent canoes, paddleboard, and kayak, or take a stroll along the Mystic River Bike Path.

Source: meaganobrien.com

HOT SPOT 4B

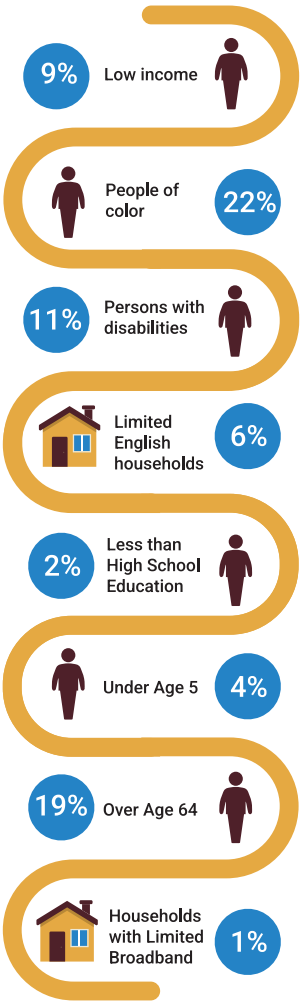
Lower Mystic Lake

Community Vulnerability Impacts

Summary Statistics

8,000
TOTAL POPULATION

2,800
NUMBER OF HOUSEHOLDS



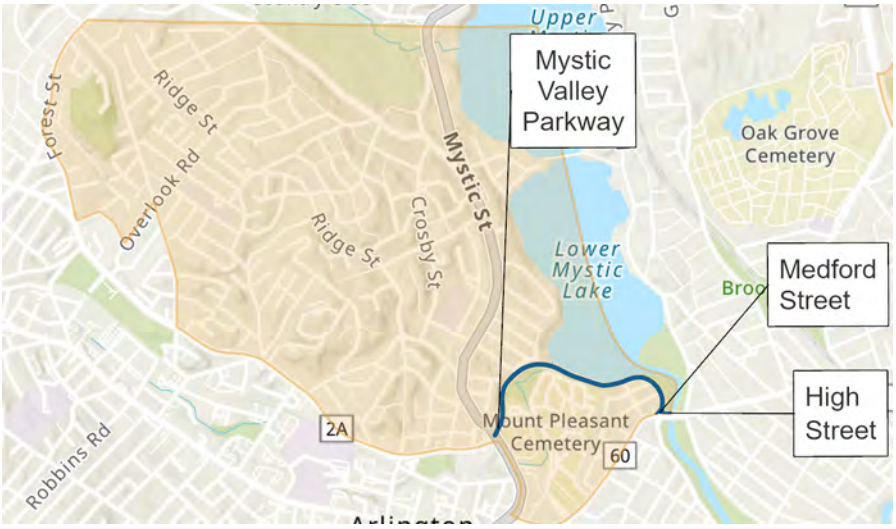


Figure 16c. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

Lower Mystic Lake

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway (Smith, 2024). Compared to the rest of the state, this community has a higher percentage of limited English-speaking households. Communicating about flood events, preparation, safety, and recovery resources can be challenging. This community would benefit from multiple forms of communication from agencies regarding pre- and post-disaster efforts. Since most of the community has broadband internet access, communication efforts could be tailored to utilize electronic forms, provided they are distributed in the languages spoken by community members.

Impacts of Projected 2070 Storm Conditions

When this section of Mystic Valley Parkway floods due to precipitation-based flooding, it could become impossible to access the parkway by driving, walking, biking, or rolling ("Improving safety," n.d). This type of precipitation-based event is likely to occur 1% of the time in any given year by 2070. In these conditions, the community could expect partial or full lane closures until flood waters recede, with ensuing detours and heavier than normal traffic along these detour routes.

Beyond the immediate travel disruptions, flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has two hospitals, two schools, and no places of worship. For more about impacts to these community assets, see Appendix E.

Economic Costs of Flood Impacts

These impacts have economic costs to parkway users and residents. If Mystic Valley Parkway were to close for 24 hours due to active flooding or post-disaster clean-up, the total disruption cost would be $167,600 (2022 USD). The largest economic impact in this area is the cost of lost recreational visits. This parkway is a major access road to the Mystic River Reservation, Mystic Lakes, and Alewife Brook Reservation. Flood-related travel disruptions would make it harder for people to access these environmental and recreation resources. For more information on economic impacts of flooding, see Appendix D.

Shannon Beach

The beach is perfect for swimming or sunbathing and nearby boat launches allow for rowing or sailing on the lake. In 2023, the Shannon Beach Bathhouse was renovated to be universally accessible and have net-zero emissions, supporting the Commonwealth's clean-energy transition. The new bathhouse is equipped with solar panels, on-site battery storage, and other updates to achieve net-zero emissions. The beach is now universally accessible, with accessible paths from the parking lot to the beach and the adjacent shoreline picnic grove.

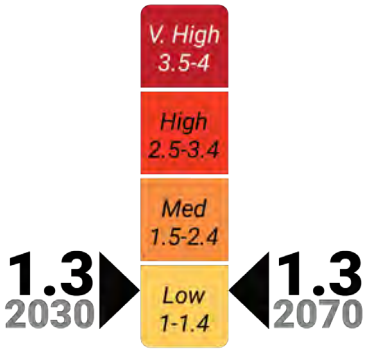
Source: DCR

FOCUS AREA 5

UPPER CHARLES

Forest Grove Road, Norumbega Road, Recreation Road, Park Road, Boulevard Road, Quinobequin Road

AVERAGE FLOOD VULNERABILITY SCORE



2.7
MILES

900
VEHICLES PER DAY

8
NEARBY ENVIRONMENTAL JUSTICE BLOCK GROUPS

2070 Vulnerability Hot Spots

There are no parkways with a high vulnerability in Focus Area 5. Thirty-three percent of the parkways have a medium vulnerability. These parkways are exposed to precipitation-based flooding and have historic designations, which increases their sensitivity to flooding.

Hot Spot 5A: Quinobequin Road

Approximately 59% of Quinobequin Road is exposed to precipitation-based flooding. This 1.5 mile parkway is also historic.

Hot Spot 5B: Norumbega Road

Sections of Norumbega Road have a medium vulnerability to flooding due to exposure to precipitation-based flooding in 2030 and 2070. Approximately 5% of the parkway is exposed to flooding.

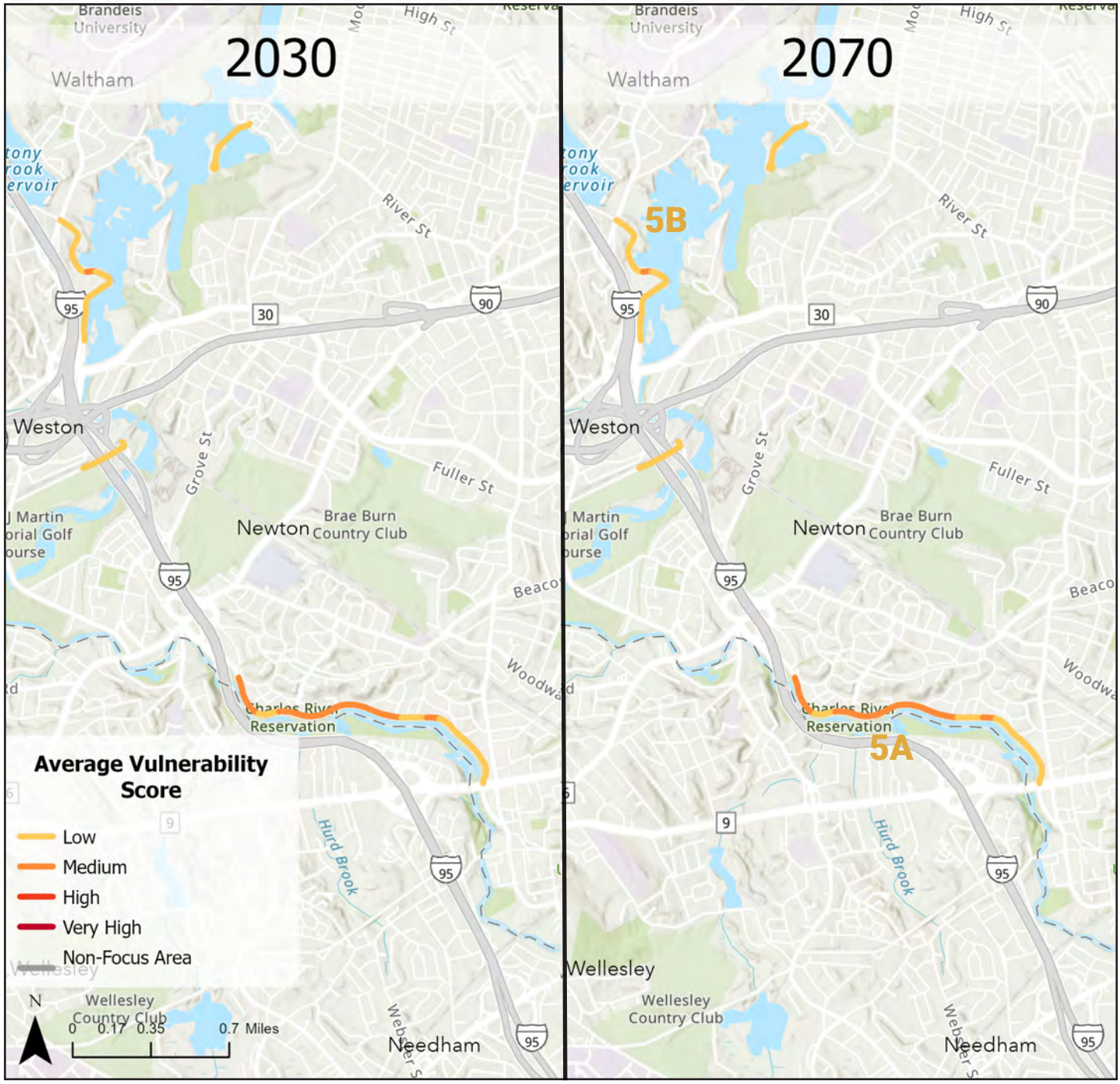


Figure 17a. Focus Area 5 - Upper Charles Flood Vulnerability in 2030 and 2070.

Vulnerability	Miles (% share)		Cost of Replacement
	2030	2070	2070
Very High	0 (0%)	0 (0%)	$0
High	0 (0%)	0 (0%)	$0
Medium	1 (37%)	1.1 (41%)	$4.4 Million
Low	1.7 (63%)	1.6 (59%)	$5.8 Million
Total	**2.7 100%**		**$10.3 Million**

HOT SPOT 5A

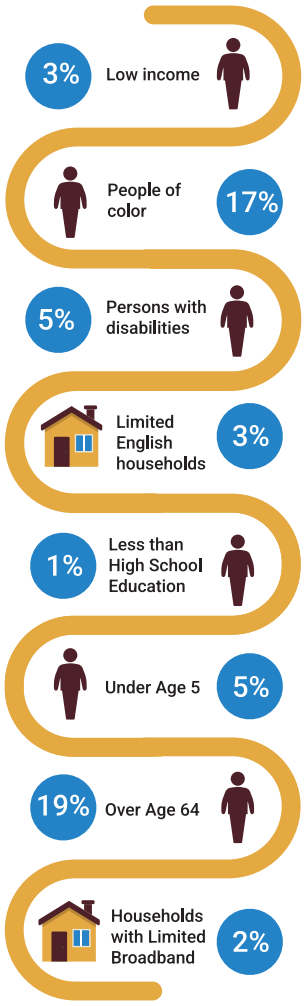
Quinobequin Road

Community Vulnerability Impacts

Summary Statistics

3,800
TOTAL POPULATION

1,300
NUMBER OF HOUSEHOLDS



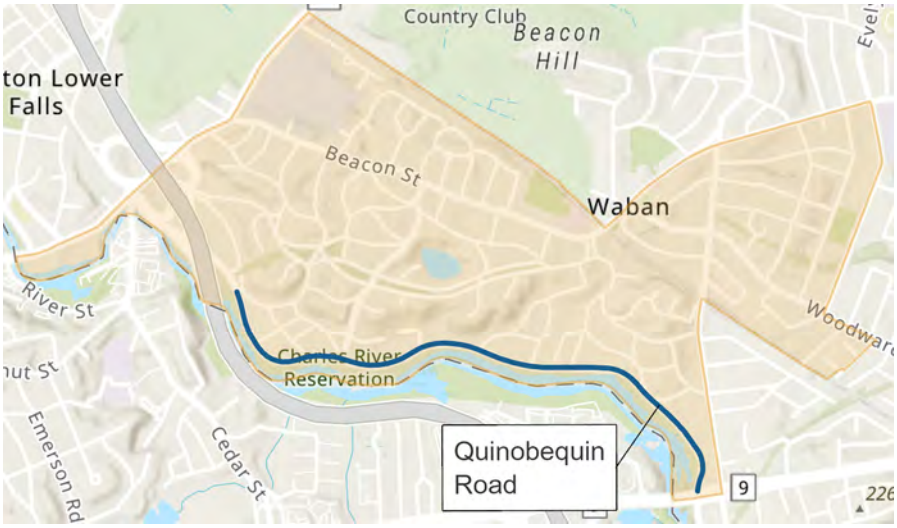


Figure 17b. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

Quinobequin Road

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway (Smith, 2024). Compared to the rest of the state, the community has higher percentages of people under age 5 and over age 64, and lower percentages of people with disabilities and households lacking broadband internet access. Very young and elderly people can be more vulnerable to the impacts of a flooded parkway and would benefit from extra physical support before, during, and after a flood, especially if evacuation is necessary. The community's above-average access to broadband internet suggests electronic forms of communication will effectively reach these individuals and can help them better prepare and recover from flood-related impacts.

Impacts of Projected 2070 Storm Conditions

When Quinobequin Road floods due to precipitation-based flooding, sections of the parkway could become impossible to use by people driving, walking, biking, or rolling ("Improving safety," n.d). By 2070, this type of event is likely to occur 1% of the time in any given year. Under these conditions, residents could expect partial or full lane closures and could see more traffic along detour routes and other neighborhood roads as people avoid flooded areas. Quinobequin Road also provides direct access to recreation trails within the Charles River Reservation. Access to these conservation and recreational spaces may be restricted during flood-events.

Beyond the immediate travel disruptions, flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has one hospital, one school, and one place of worship. For more about impacts to these community assets, see Appendix E.

Economic Costs of Flood Impacts

This parkway was not studied in the economic analysis because it is not impacted by coastal flooding. Since this area has many neighborhood roads that connect to another main road, Beacon Street, the community would not become isolated in the event of a closure of Quinobequin Road. Residents would be able to seek alternative travel routes, which reduces compounding economic impacts.

Hemlock Gorge Reservation

This small wild area along the banks of the Charles River in Newton, Mass, just west of Boston, spans 23 acres. Echo Bridge is a major attraction and offers amazing views of the river. Make sure to check out the platform under the bridge and test the echo for which it's named.

Source: Lorianne DiSabato via flickr

HOT SPOT 5B

Norumbega Road

Community Vulnerability Impacts

Summary Statistics

6,800
TOTAL POPULATION

2,000
NUMBER OF HOUSEHOLDS

- 8% Low income
- People of color 22%
- 6% Persons with disabilities
- Limited English households 3%
- 2% Less than High School Education
- Under Age 5 5%
- 19% Over Age 64
- Households with Limited Broadband 6%

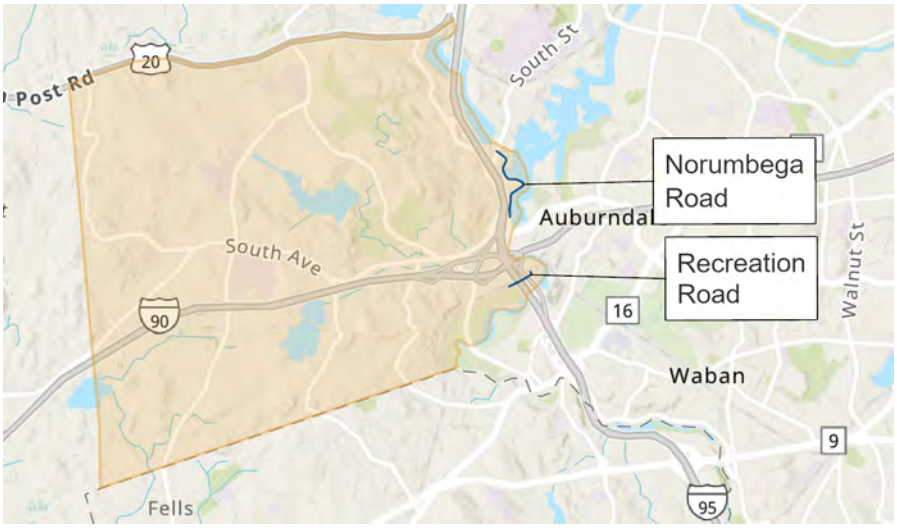


Figure 17c. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

Norumbega Road

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway (Smith, 2024). Compared to the rest of the state, the community has more households with access to broadband internet, fewer low-income earners, and fewer people with disabilities. Residents are less likely to be disadvantaged and may be more prepared to plan for, withstand, and recover from flood events. Electronic forms of communication can effectively reach these individuals and help them better prepare and recover from flood-related impacts. While most of Norumbega Road borders the Charles River Reservation, the most vulnerable section of this parkway is adjacent to Maplewood at Weston, an assisted living facility.

Maplewood residents may be more likely to be socially disadvantaged, have pre-existing medical conditions, or mobility issues, which would impact their ability to evacuate quickly and may require specialized evacuation planning or post-disaster resources.

Impacts of Projected 2070 Storm Conditions

When Norumbega Road floods due to precipitation-based flooding from extreme-precipitation events, sections of the parkway could become impossible to use by people driving, walking, biking, or rolling ("Improving safety," n.d). This type of event is likely to occur 1% of the time in any given year by 2070. Under these conditions, residents could expect partial or full lane closures and could see more traffic along detour routes and other neighborhood roads as people avoid flooded areas. This road also provides direct access to recreation trails within the Charles River Reservation. Access to these conservation and recreational spaces may be restricted during flood-events. The southern end of Norumbega Road leads to a dead end at the Charles River where the public Newton Boathouse Parking is located.

Beyond the immediate travel disruptions, flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has no hospitals, five schools, and four places of worship. For more about impacts to these community assets, see Appendix E.

Economic Costs of Flood Impacts

This parkway was not studied in the economic analysis because it is not impacted by coastal flooding. Since this area has nearby neighborhood roads that connect to other main roads, the community would not become isolated in the event of a closure of Norumbega Road. The Maplewood assisted living facility is the only residence requiring access via this parkway. The inability of employees or emergency personnel to reach Maplewood could result in heightened mortality for residents, as well compounding economic impacts from employees unable to perform their jobs.

Paddle Boston: Newton Historic Boathouse

This historic boathouse offers canoe, kayak, and stand-up paddleboard rentals, allowing visitors to explore a six-mile stretch of flatwater bordered by parkland and forest. It's a perfect spot for both novice and experienced paddlers to enjoy the natural beauty and tranquility of the Charles River.

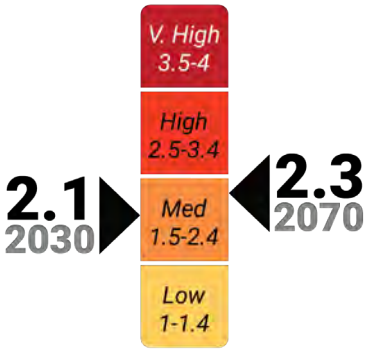
Source: DCR

FOCUS AREA 6

CHARLES RIVER BASIN WEST

Arsenal Street, Birmingham Parkway, Charles River Road, Everett Street, Greenough Boulevard, North Beacon Street, Soldiers Field Road, Nonantum Road

AVERAGE FLOOD VULNERABILITY SCORE



22
MILES

27,500
VEHICLES PER DAY

80
NEARBY ENVIRONMENTAL JUSTICE BLOCK GROUPS

2070 Vulnerability Hot Spots

Source: DCR

Eighty percent of the parkways within Focus Area 6 have a medium vulnerability and 13% of the parkways have a high vulnerability. While the parkways with medium or high vulnerability have similar exposure scores, parkways with a high vulnerability scored higher for sensitivity and adaptive capacity to flooding.

Hot Spot 6A: Soldiers Field Road Underpasses

High vulnerability sections of Soldiers Field Road exhibit a higher sensitivity score compared to areas of medium vulnerability. The underpasses have a higher sensitivity to flooding because they have a history of flooding and are more likely to flood in the future.

Hot Spot 6B: Arsenal Street

The high vulnerability sections of Arsenal Street are due to the presence of the MBTA 70 bus route. This bus route is in the highest percentile for average bus ridership. Unlike much of Soldiers Field Road, Arsenal Street is also exposed to both coastal and precipitation-based flooding.

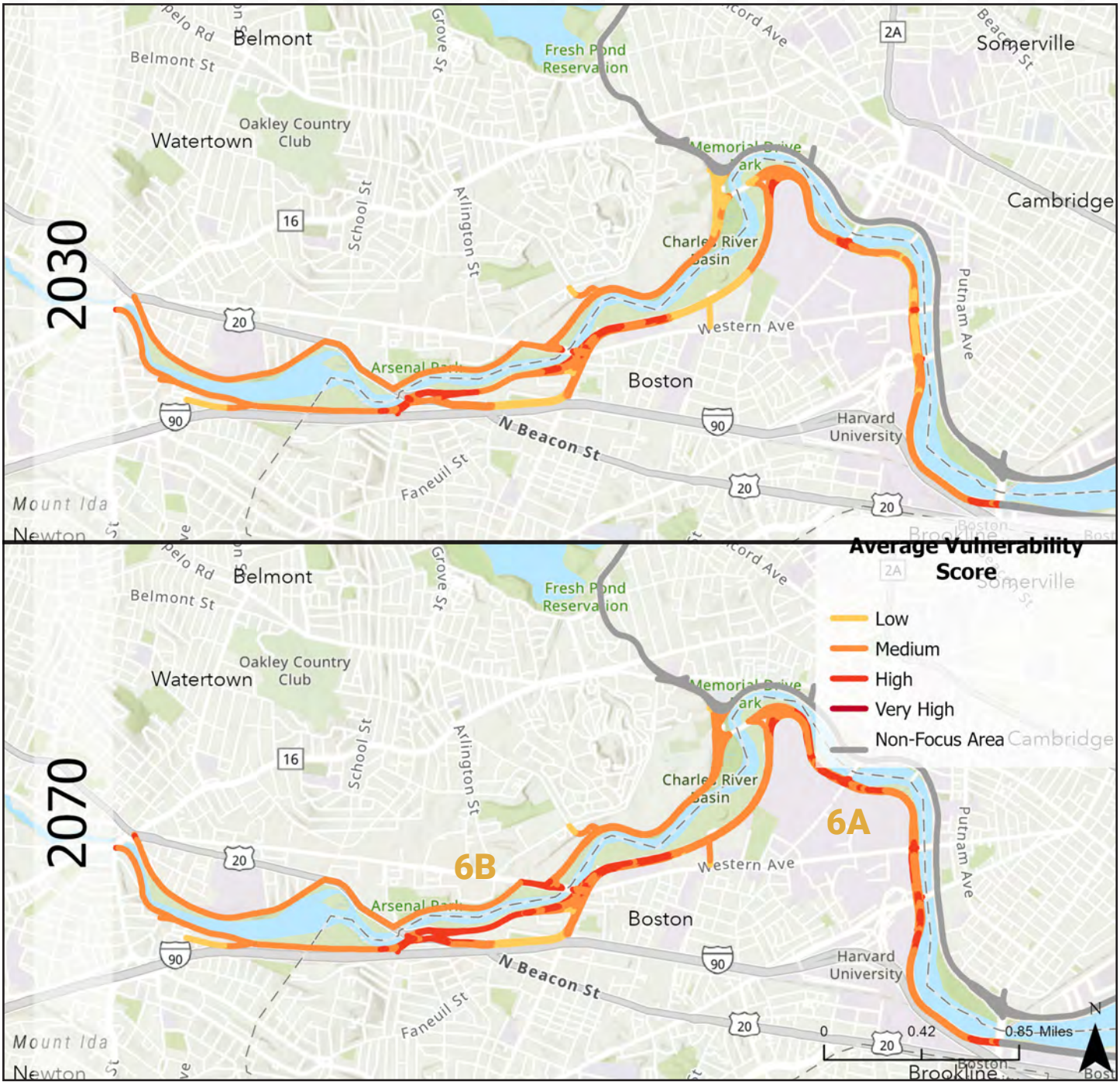


Figure 18a. Focus Area 6 - Charles River Basin West Flood Vulnerability in 2030 and 2070.

Vulnerability	Miles (% share)		Cost of Replacement
	2030	2070	2070
Very High	0 (0%)	0.02 (0.1%)	$41,000
High	4.8 (22%)	7.9 (36%)	$39.3 Million
Medium	13.8 (63%)	12.9 (59%)	$60.8 Million
Low	3.1 (14%)	0.9 (4%)	$4.4 Million
Total	**21.8 100%**		**$104.6 Million**

HOT SPOT 6A

Soldiers Field Road Underpasses

Community Vulnerability Impacts

Summary Statistics

5,500
TOTAL POPULATION

800
NUMBER OF HOUSEHOLDS

- 35% Low income
- People of color 44%
- 5% Persons with disabilities
- Limited English households 0%
- 0% Less than High School Education
- Under Age 5 2%
- 0% Over Age 64
- Households with Limited Broadband 28%

Figure 18b. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

Soldiers Field Road Underpasses

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway (Smith, 2024). Compared to the rest of the state, the community has higher percentages of people of color, low-income earners, and households lacking broadband internet access. These residents may benefit from extra support before, during, and after a flood. This support could include training on how to prepare for a big storm, multilingual emergency alerts, translation services, evacuation assistance, and post-disaster assistance.

Impacts of Projected 2070 Storm Conditions

By 2070, the Soldiers Field Road Underpasses will have a 1% annual risk of precipitation-based flooding. They'll also be at risk of coastal flooding when storm surge overtops the Charles River Dam and backs up the Charles Rivers. This coastal event will have a 10%

chance of occurring in any given year by 2070. When these sections of the parkway flood, traffic would be detoured to the surface roads at Cambridge Street, Western Avenue, and Harvard Street. Residents could expect more traffic along detour routes and other neighborhood roads as drivers avoid the flooded areas. While the underpasses of the parkway would become impossible to use by car, alternative modes may be less impacted. For example, the Dr. Paul Dudley White Bike Path provides access along the waterfront parallel to Soldiers Field Road specifically for people on bikes and pedestrians. Overall, the mobility disruption to residents may be less impacted by underpass flooding since there are safe, alternative modes of travel.

Beyond the immediate travel disruptions, flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has no hospitals, one school, and no places of worship.

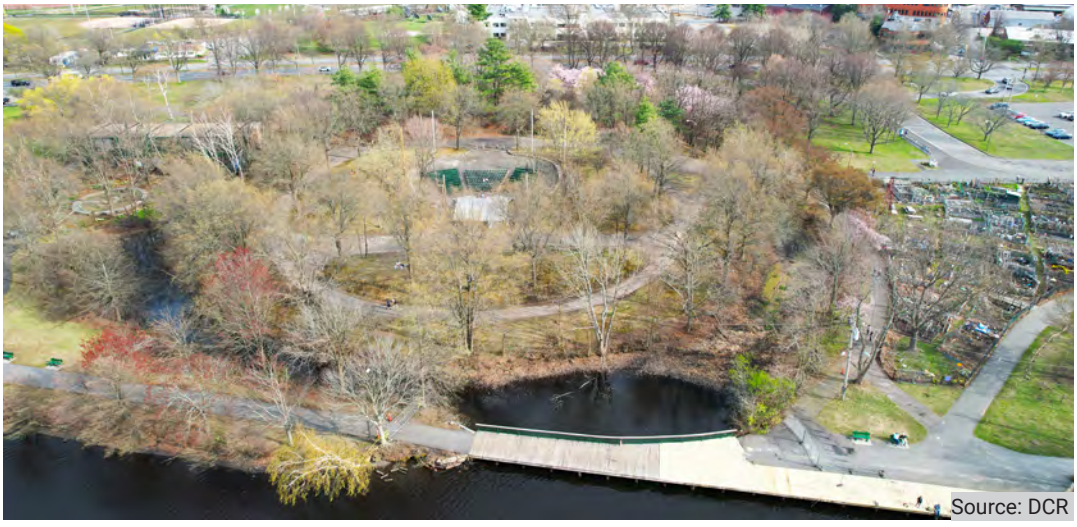
For more about impacts to these community assets, see Appendix E.

Economic Costs of Flood Impacts

These impacts have economic costs to parkway users and residents. If Soldiers Field Road were to close for 24 hours due to active flooding or post-disaster clean-up, the total disruption cost would be $468,200 (2022 USD). Soldiers Field Road provides access to many parkland features along the Charles River Reservation, which would result in a cost of $242,100 of lost recreational visits. This parkway also carries some of the highest traffic volumes in the study area and serves both local and regional traffic. The travel delay costs for lost vehicular access would be $226,100. Residents near the parkway may not be impacted economically by a service disruption, but their commutes may still be impacted by heavier traffic on surface roads. For more information on economic impacts of flooding, see Appendix D.

Christian A. Herter Park

This park is a riverfront respite from urban life, critical habitat, and an important green transportation link. Moreover, it is heavily programmed—in addition to informal art classes, community gardens, drum circles and family reunions, Herter Park is DCR's most permitted site, with numerous charity events each year.



Source: DCR

HOT SPOT 6B

Arsenal Street

Community Vulnerability Impacts

Summary Statistics

5,900
TOTAL POPULATION

2,400
NUMBER OF HOUSEHOLDS

- 29% Low income
- People of color 51%
- 14% Persons with disabilities
- Limited English households 16%
- 15% Less than High School Education
- Under Age 5 3%
- 14% Over Age 64
- Households with Limited Broadband 9%

Figure 18c. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

Arsenal Street

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway (Smith, 2024). Compared to the rest of the state, the community has more residents who are non-white, low-income, have less than a high school education, reside in limited English-speaking households, and have disabilities. People in these groups face social and economic challenges that make them more vulnerable to the impacts of a flooded parkway. For example, people with disabilities may struggle to evacuate or access recovery resources due to mobility, communication, and health challenges. Similarly, those with limited English proficiency may face language and cultural barriers that hinder their ability to act during a flood or apply for disaster recovery aid. Extra support for these groups could include training on storm preparation, multilingual emergency alerts, translation services, evacuation assistance, and post-disaster aid.

Impacts of Projected 2070 Storm Conditions

By 2070, Arsenal Road will have a 1% annual chance of flooding from heavy precipitation or from coastal flooding when storm surge overtops the Charles River Dam and backs up the Charles River. This coastal event will have a 10% chance of occurring in any given year. Under these conditions, residents could expect partial or full lane closures and could see more traffic along detour routes and other neighborhood roads as people avoid flooded areas. The MBTA 70 bus route would be impacted by road closures. MBTA travel disruption alerts would play an important role in helping transit users navigate these challenges.

Beyond the immediate travel disruptions, flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has no hospitals, no schools, and one place of worship. For more about impacts to these community assets, see Appendix E.

Economic Costs of Flood Impacts

These impacts have economic costs to parkway users and residents. Arsenal Road provides direct access to recreation trails within the Charles River Reservation. Access to these conservation and recreational spaces may be restricted during flood-events. If Arsenal Road were to close for 24 hours due to active flooding or post-disaster clean-up, the largest economic impact, $75,900 (2022 USD), would be the cost of lost recreational visits. While the community would not become isolated, many people may be economically impacted by longer travel times to work. For more information on economic impacts of flooding, see Appendix D.

The Charles River Speedway

The Speedway is a vibrant, dynamic marketplace where you can eat and drink, work and create, shop and gather with family and friends. Located on Western Avenue in Brighton, these historic buildings and their central courtyard have been transformed into a space for community and a source of year-round fun.

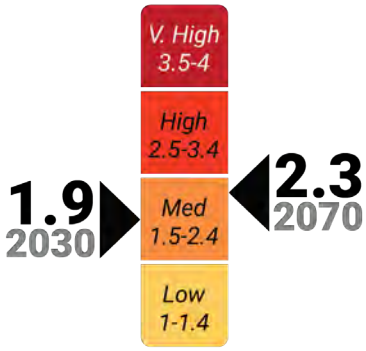
Source: Boston Preservation Alliance

FOCUS AREA 7

CHARLES RIVER BASIN EAST

Land Boulevard, Storrow Drive, Memorial Drive, Embankment Road, Cambridge Parkway, Charlesgate

AVERAGE FLOOD VULNERABILITY SCORE



19.3
MILES

39,500
VEHICLES PER DAY

116
NEARBY ENVIRONMENTAL JUSTICE BLOCK GROUPS

2070 Vulnerability Hot Spots


Source: DCR

Under 2030 conditions, 56% of the parkways in Focus Area 7 have a medium vulnerability due to exposure to coastal flooding. By 2070, 94% of the parkways in this Focus Area have a medium or high vulnerability.

Hot Spot 7A: Storrow Drive

Between Hereford Street and Berkeley Street, Storrow Drive's high vulnerability scores are driven by impacts from both coastal and precipitation-based flooding. Storrow Drive has a very high traffic volume, a high cost of replacement and a medium economic impact. These factors significantly decrease the parkway's adaptive capacity and contribute to its high vulnerability.

Hot Spot 7B: Memorial Drive

Several segments of Memorial Drive have high vulnerability scores in 2030 and 2070, driven both by exposure to coastal flooding, documented history of flooding, and high traffic volumes. These segments extend between Western Avenue and River Street, between Fowler Street and the Harvard Bridge, and under the Longfellow Bridge.

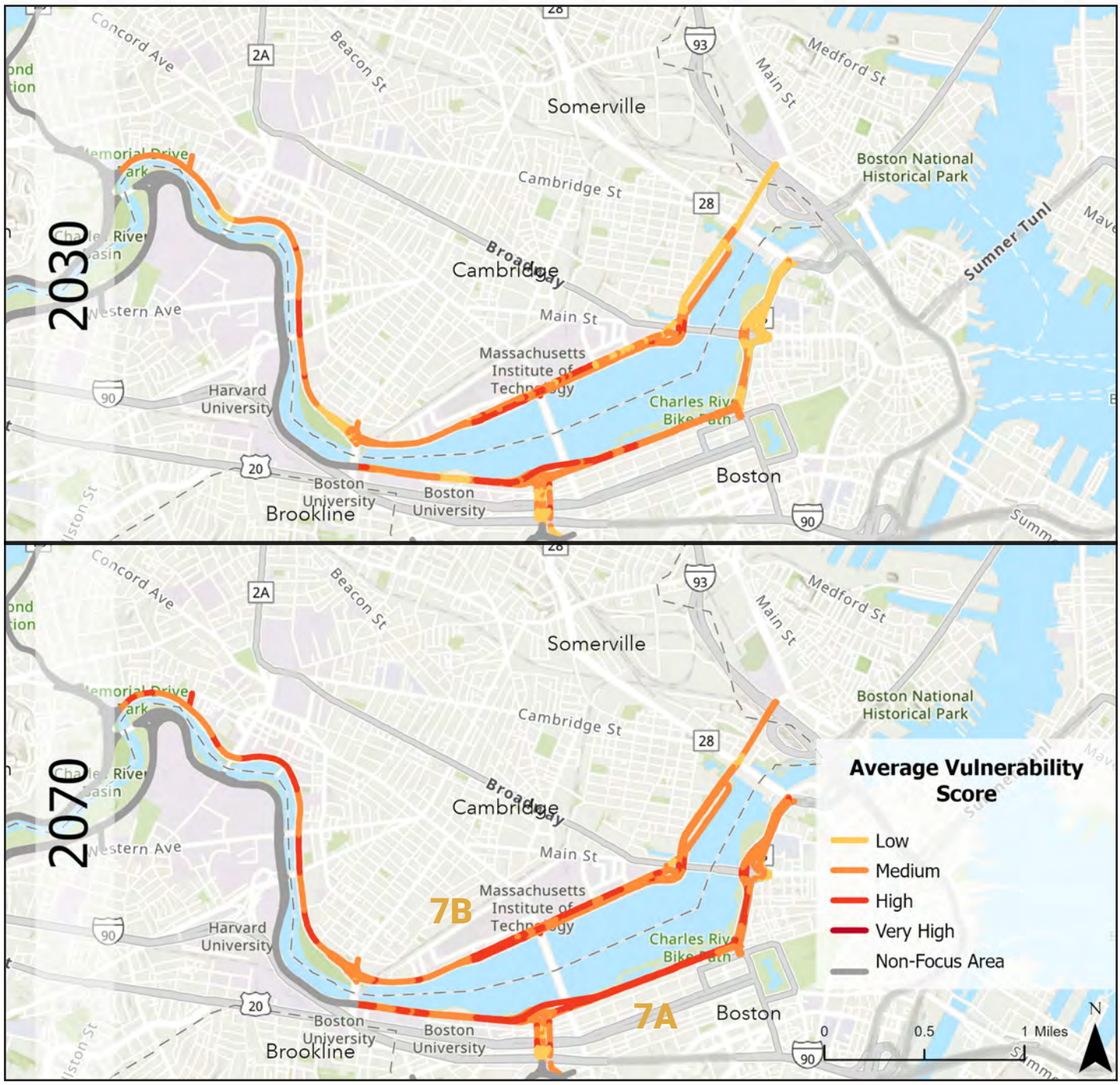


Figure 19a. Focus Area 7 - Charles River Basin East Flood Vulnerability in 2030 and 2070.

Vulnerability	Miles (% share)		Cost of Replacement
	2030	2070	2070
Very High	0 (0%)	0.04 (0.2%)	$214,000
High	3.5 (18%)	8.1 (42%)	$45.6 Million
Medium	11 (56%)	10.7 (55%)	$58.0 Million
Low	4.9 (25%)	0.6 (3%)	$3.2 Million
Total	**19.5 100%**		**$107.0 Million**

HOT SPOT 7A

Storrow Drive

Community Vulnerability Impacts

Summary Statistics

18,300
TOTAL POPULATION

8,000
NUMBER OF HOUSEHOLDS

- 17% Low income
- People of color 27%
- 6% Persons with disabilities
- Limited English households 4%
- 1% Less than High School Education
- Under Age 5 1%
- 12% Over Age 64
- Households with Limited Broadband 5%

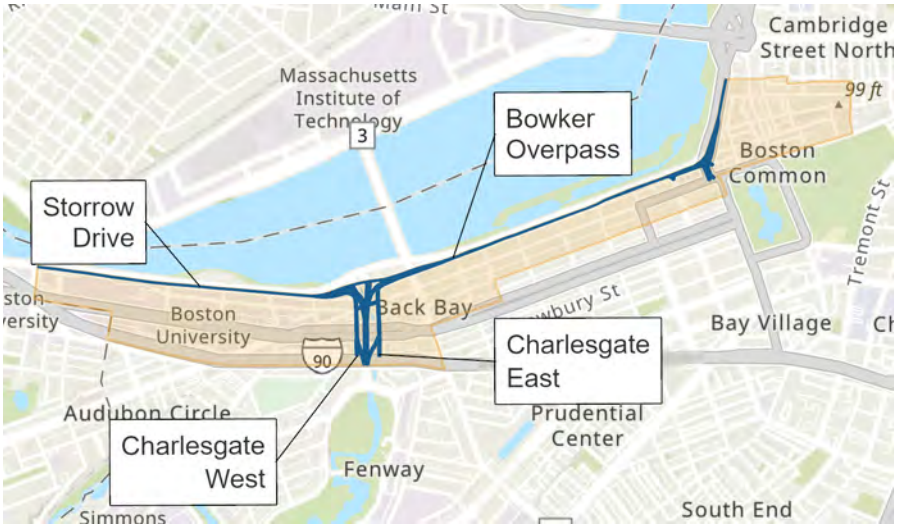


Figure 19b. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

Storrow Drive

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway (Smith, 2024). Compared to the rest of the state, the community around Storrow Drive has few socioeconomic and demographic features that indicate vulnerability. Residents are more likely to have the resources to plan for, withstand, and recover from flood-related impacts. Nonetheless, as Storrow Drive is one of the most vulnerable parkways in the study area, residents should be prepared for flood impacts and agencies should be prepared to provide both communication in advance of flooding and aid for post-disaster recovery.

Impacts of Projected 2070 Storm Conditions

By 2070, Storrow Drive will have a 1% annual risk of flooding from heavy precipitation and a 10% annual risk of inundation from coastal flooding. Under these conditions, residents could expect partial or full lane closures and could see more traffic along detour routes and other neighborhood roads as people avoid flooded areas. Storrow Drive is a critical parkway serving the needs of local and regional transportation users and has one of the highest traffic volumes in the study area. When there is a service disruption on Storrow Drive and cars are detoured, nearby secondary roads, like Commonwealth Avenue, will experience heavy traffic or potentially gridlock. In a flood event where detours are mandatory, residents should plan to avoid driving, if possible, to reduce congestion on detoured roads.

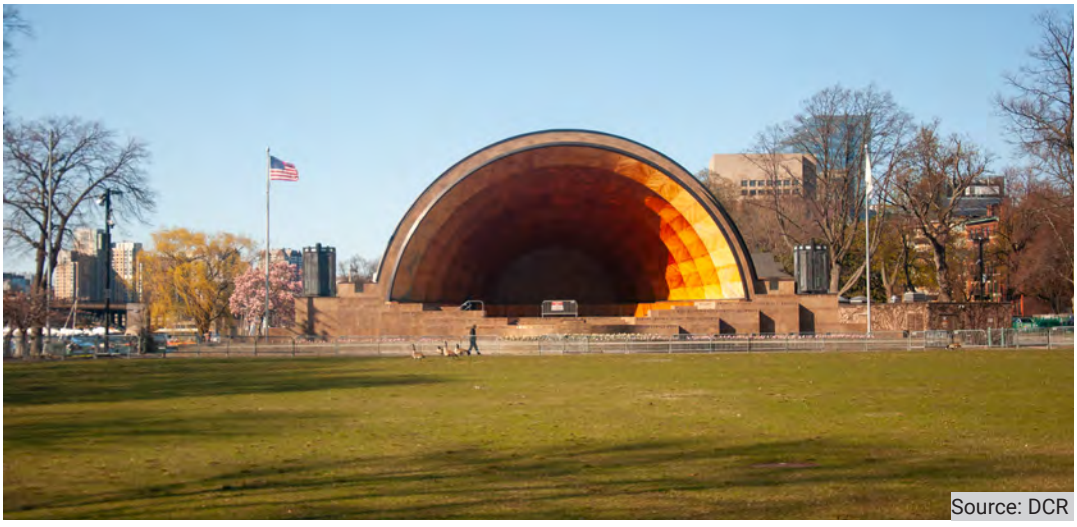
Beyond the immediate travel disruptions, the flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has no hospitals, no schools, and six places of worship. For more about impacts to these community assets, see Appendix E.

Economic Costs of Flood Impacts

These impacts have economic costs to parkway users and residents. If Storrow Drive were to close for 24 hours due to active flooding or post-disaster clean-up, the total disruption cost would be $554,700 (2022 USD) and is the 6th highest disruption cost across the study area. The largest economic portion of the impact is the cost of lost recreational visits. Storrow Drive is a major access road to several points of interest along the Charles River Reservation. Flood-related travel disruptions would make it harder for people to access the environmental and recreation resources. For more information on economic impacts of flooding, see Appendix D.

Charles River Esplanade

The Esplanade is a three-mile long park along the Charles River that features a variety of amenities, including the iconic Hatch Shell (below). Visitors can enjoy scenic walking and biking paths, playgrounds, and picnic areas. Additionally, the Esplanade is home to several fitness stations and outdoor exercise classes, making it a hub for both relaxation and recreation.



Source: DCR

HOT SPOT 7B

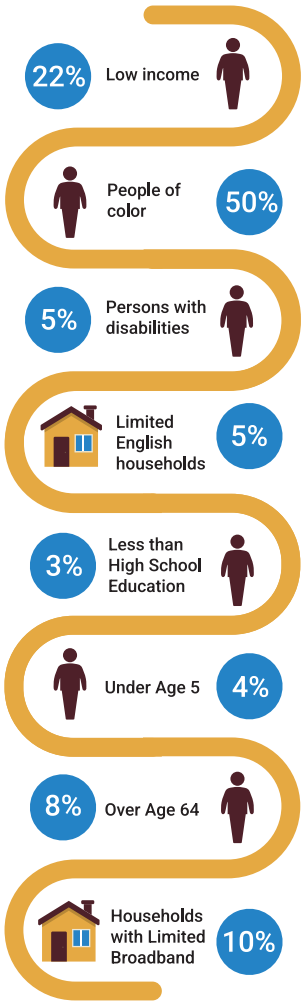
Memorial Drive

Community Vulnerability Impacts

Summary Statistics

26,900
TOTAL POPULATION

9,400
NUMBER OF HOUSEHOLDS



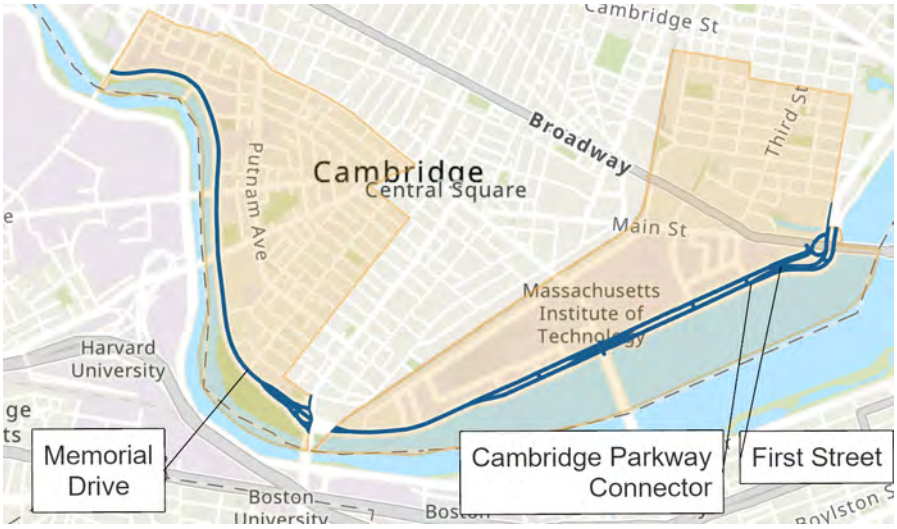


Figure 19c. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

Memorial Drive

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway (Smith, 2024). The community around Memorial Drive contains several Justice40-designated disadvantaged communities where residents have historically been exposed to more pollution, and less investment in infrastructure and services (National Archives and Records Administration, n.d.). Compared to the rest of the state, the community has a higher percentage of people of color, and a slightly higher percentage of residents who lack broadband access. These characteristics make this community more vulnerable to flood impacts: historic underinvestment in non-white neighborhoods can make communities of color more susceptible to severe flood impacts, while limited internet access impedes emergency alerts and other communication during flood events. To support more vulnerable residents, agencies could provide

alternative communication methods, such as radio alerts and physical community notice boards, and invest in improving drainage infrastructure.

Impacts of Projected 2070 Storm Conditions

Memorial Drive could experience coastal flooding when storm surge overtops the Charles River Dam. By 2070, this type of event will have a 10% chance of occurring in any given year. Under these conditions, residents could expect partial or full lane closures and could see more traffic along detour routes and other neighborhood roads as people avoid flooded areas. Memorial Drive is a critical parkway serving the needs of local and regional transportation users and has one of the highest traffic volumes in the study area. When there is a service disruption on Memorial Drive and cars are detoured, nearby secondary roads, like Putnam Avenue or Massachusetts Avenue, will experience heavy traffic or potentially gridlock. In a flood event where detours are mandatory, residents should plan to avoid driving to reduce congestion on detoured roads. Sections of these parkways also have on-street parking for residents and visitors. As with street parking bans during winter snowstorms, the community may experience temporary parking bans in anticipation of flood events throughout the year. When heavy precipitation events occur without warning, vehicles parked on Memorial Drive could be caught in floodwaters and permanently damaged. To minimize these risks, residents could limit the amount of time they leave their vehicle parked on the street and avoid parking in flood vulnerable areas.

Beyond the immediate travel disruptions, flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has six hospitals, two schools, and eleven places of worship. For more about impacts to these community assets, see Appendix E.

Economic Costs of Flood Impacts

These impacts have economic costs to parkway users and residents. If Memorial Drive were to close for 24 hours due to active flooding or post-disaster clean-up, the total disruption cost would be $359,700 (2022 USD). The largest economic impacts are the costs of lost recreational visits ($242,100, 2022 USD), travel delay costs due to detours ($101,700, USD 2022), and the cost of lost parking revenue from paid on-street parking ($15,900, USD 2022). Memorial Drive is a major access road to several points of interest along the Charles River Reservation, and flood-related travel disruptions would make it harder for people to access these environmental and recreational resources. For more information on economic impacts of flooding, see Appendix D.

Magazine Beach Park

At 17 acres, Magazine Beach is Cambridge's second-largest park. Magazine Beach houses a free, outdoor, Olympic-sized swimming pool. As a green space, the park is home to playing fields, shade trees, and natural habitats.

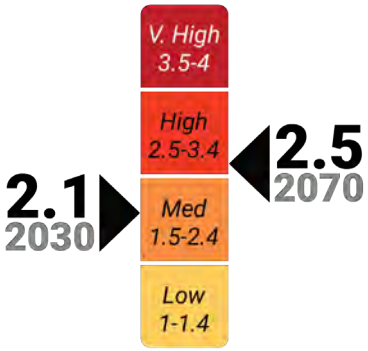
Source: magazinebeach.org

FOCUS AREA 8

OLD HARBOR

William Day Boulevard, Old Colony Avenue, Babe Ruth Park Drive, Shore Road JFK-UMass Station Road, Kosciuszko Circle

AVERAGE FLOOD VULNERABILITY SCORE



4.2
MILES

38,000
VEHICLES PER DAY

17
NEARBY ENVIRONMENTAL JUSTICE BLOCK GROUPS

2070 Vulnerability Hot Spots


Source: DCR

Ninety-three percent of Focus Area 8's parkways have a medium or high vulnerability in 2030. The proportion of high vulnerability parkways more than doubles from 11% in 2030 to 38% in 2070. While most of the high vulnerability sections of parkway are along William Day Boulevard, Old Colony Avenue also has widespread areas of high vulnerability.

Hot Spot 8A: William Day Boulevard

William Day Boulevard from L Street through East 1st Street has high vulnerability from exposure to both coastal and precipitation-based flooding. This parkway has a low adaptive capacity due to high traffic volume, high cost of replacement, and a high sensitivity due to documented history of flooding.

Hot Spot 8B: Old Colony Avenue

Old Colony Avenue's vulnerability score is driven both by coastal flooding exposures as well as a high cost of replacement, high traffic volume, historic designation, and featuring a MBTA bus route. While Old Colony Avenue has a lower flood exposure than William Day Boulevard, Old Colony's heightened sensitivity and low adaptive capacity make it equally as vulnerable to flooding as William Day Boulevard.

Figure 20a. Focus Area 8 - Old Harbor Flood Vulnerability in 2030 and 2070.

Vulnerability	Miles (% share)		Cost of Replacement
	2030	2070	2070
Very High	0.02 (0.5%)	0.02 (0.5%)	$147,000
High	0.5 (12%)	2.3 (55%)	$18.4 Million
Medium	3.5 (83%)	1.8 (43%)	$13.4 Million
Low	0.3 (7%)	0.1 (2%)	$449,656
Total	**4.2 100%**		**$32.5 Million**

HOT SPOT 8A

William Day Boulevard

Community Vulnerability Impacts

Summary Statistics

14,800
TOTAL POPULATION

6,800
NUMBER OF HOUSEHOLDS

- 10% Low income
- People of color 5%
- 7% Persons with disabilities
- Limited English households 0%
- 2% Less than High School Education
- Under Age 5 5%
- 10% Over Age 64
- Households with Limited Broadband 8%

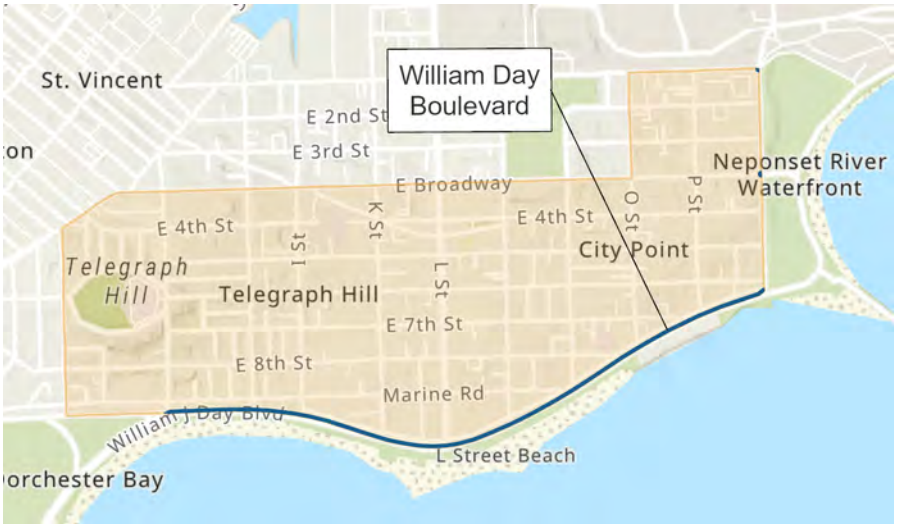


Figure 20b. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

William Day Boulevard

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway (Smith, 2024). Compared to the rest of the state, the community has fewer socio-demographic characteristics that indicate greater vulnerability. However, 8% of the population lacks broadband internet access. While slightly below the state average, this lack of internet access could make it harder for people to receive timely emergency alerts and slow down communication during flood events. Agencies could offer alternative communication methods, such as radio alerts and physical community notice boards, to increase the community's resilience to flooding.

Impacts of Projected 2070 Storm Conditions

By 2070, William Day Boulevard will have a 1% annual chance of flooding from heavy precipitation, and a 10% annual chance of inundation from coastal flooding. Under these conditions, residents could expect partial or full lane closures and could see more traffic along detour routes and other neighborhood roads as people avoid flooded areas. The adjacent Harbor Walk biking and walking path would also flood, so residents should expect to not be able to travel safely by driving, walking, biking, or rolling ("Improving safety," n.d). In a flood event where detours are mandatory, residents should plan to avoid driving, if possible, to reduce congestion on detoured roads. As with street parking bans during winter snowstorms, the community may experience temporary parking bans in anticipation of flood events throughout the year. When heavy precipitation events occur without warning, vehicles parked on William Day Boulevard could be caught in floodwaters and permanently damaged. To minimize these risks, residents could limit the amount of time they leave their vehicles parked on the street and avoid parking in flood vulnerable areas.

Beyond the immediate travel disruptions, flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has no hospitals, three schools, and one place of worship. For more about impacts to these community assets, see Appendix E.

Economic Costs of Flood Impacts

These impacts have economic costs to parkway users and residents. If William Day Boulevard were to close for 24 hours due to active flooding or post-disaster clean-up, the total disruption cost would be $391,400 (2022 USD). The largest economic impact is the cost of lost recreational visits ($285,300, 2022 USD). William Day Boulevard provides access to Castle Island, Carson Beach, and several other public parks. While the community would not become isolated, flood-related travel disruptions would make it harder for people to access these environmental and recreational resources. For more information on economic impacts of flooding, see Appendix D.

Castle Island

A visit to Castle Island combines history and recreation. Tour Fort Independence or take a walk around it. Continue the day sunbathing or swimming at one of the nearby beaches.

Source: Adobe Stock

HOT SPOT 8B

Old Colony Avenue

Community Vulnerability Impacts

Summary Statistics

3,900
TOTAL POPULATION

2,000
NUMBER OF HOUSEHOLDS

- 51% Low income
- People of color 46%
- 19% Persons with disabilities
- Limited English households 17%
- 10% Less than High School Education
- Under Age 5 7%
- 4% Over Age 64
- Households with Limited Broadband 24%

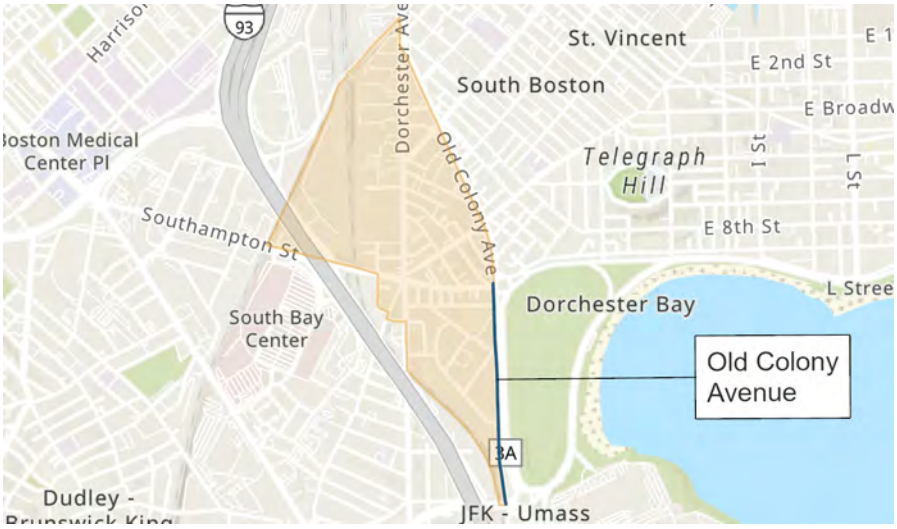


Figure 20c. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

Old Colony Avenue

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway (Smith, 2024). The community around Old Colony Avenue contains several Justice40-designated disadvantaged communities where residents have historically been exposed to more pollution, and less investment in infrastructure and services (National Archives and Records Administration, n.d.). Compared to the rest of the state, the community has higher percentages of residents who are low-income, reside in limited-English speaking households, have a disability, and lack broadband internet access.

Overall, these characteristics make this community more vulnerable to flood impacts: low-income earners are more likely to lack the financial resources to prepare for, respond to, and recover from flooding. Language barriers can prevent understanding emergency instructions and accessing disaster recovery aid. Limited internet access impedes emergency alerts and other communication during flood events, while those with disabilities may struggle to evacuate

and access recovery resources due to mobility, communication, and health challenges. Residents would benefit from accessible evacuation plans for people with mobility challenges, community education programs to inform people about emergency preparedness protocols, and the provisioning of multilingual emergency alerts and translation services in both electronic and written communication.

Impacts of Projected 2070 Storm Conditions

By 2070, Old Colony Avenue will have a 1% annual chance of flooding from heavy precipitation, and a 10% annual chance of coastal flooding. Under these conditions, residents could expect partial or full lane closures and could see more traffic along detour routes and other neighborhood roads as people avoid flooded areas. In a flood event where detours are mandatory, residents should plan to avoid driving, if possible, to reduce congestion on detoured roads. As with street parking bans during winter snowstorms, the community may experience temporary parking bans in anticipation of flood events throughout the year. When heavy precipitation events occur without warning, vehicles on Old Colony Ave could be caught in floodwaters and permanently damaged. To minimize these risks, residents could limit the amount of time they leave their vehicles parked on the street and avoid parking in flood vulnerable areas. Furthermore, the MBTA 16 bus route travels along the parkway and residents could expect this bus route to be delayed or canceled during flood events. Finally, Old Colony Ave provides access to the JFK/UMass train station, which serves the MBTA's Red Line and the Commuter Rail. While the flood impact to the station was not part of this assessment, access to the station via Old Colony Avenue could be disrupted in a flood event. Residents who use these transit services should stay up to date on MBTA alerts and, if possible, proactively plan to use alternative travel modes or stay-at-home in anticipation of and during flood events.

Beyond the immediate travel disruptions, flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has no hospitals, schools, or places of worship. For more about impacts to these community assets, see Appendix E.

Economic Costs of Flood Impacts

These impacts have economic costs to parkway users and residents. If Old Colony Avenue were to close for 24 hours due to active flooding or post-disaster clean-up, the total disruption cost would be $81,400 (2022 USD). The largest economic impact is the cost of lost recreational visits at $67,800 (2022 USD). While the community would not become isolated, people would be unable to access Joe Moakley Park or Carson Beach. It is likely that these resources would be flooded, at least partially, if Old Colony Avenue were flooded. For more information on economic impacts of flooding, see Appendix D.

Carson Beach

Carson Beach is a popular waterfront destination offering stunning views of the Boston skyline. The beach features amenities such as restrooms, showers, and picnic areas. Visitors can enjoy swimming, sunbathing, and beach volleyball, as well as walking or biking along the scenic HarborWalk.

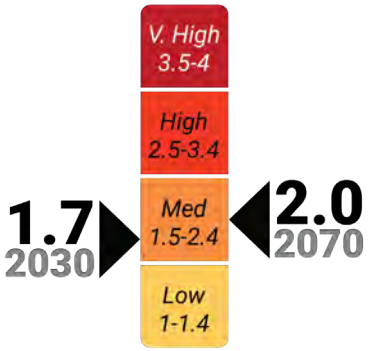
Source: Adobe Stock

FOCUS AREA 9

BACK BAY FENS

Fenway, Park Drive

AVERAGE FLOOD VULNERABILITY SCORE



4.5
MILES

18,800
VEHICLES PER DAY

69
NEARBY ENVIRONMENTAL JUSTICE BLOCK GROUPS

2070 Vulnerability Hot Spots


Source: DCR

Thirteen percent, or 0.5 miles of the parkways in Focus Area 9 have a high vulnerability in 2070. The portion of the parkways adjacent to the Muddy River have a medium or high vulnerability due to presence of on-street parking and exposure to flooding.

Hot Spot 9A: Higginson Circle

The western section of Park Drive has a high and medium vulnerability to flooding in 2070. Much of this area has a medium sensitivity score due to the presence of on-street parking and an MBTA bus route. The sections with high vulnerability also have a medium adaptive capacity due to higher replacement costs and a high ridership for the bus route along this section of Park Drive. The key difference between high and medium vulnerability sections in this Focus Area is the exposure level, where high vulnerability sections are exposed to precipitation-based and coastal flooding in 2030 and 2070 due to the Muddy River and its connection to the Charles River.

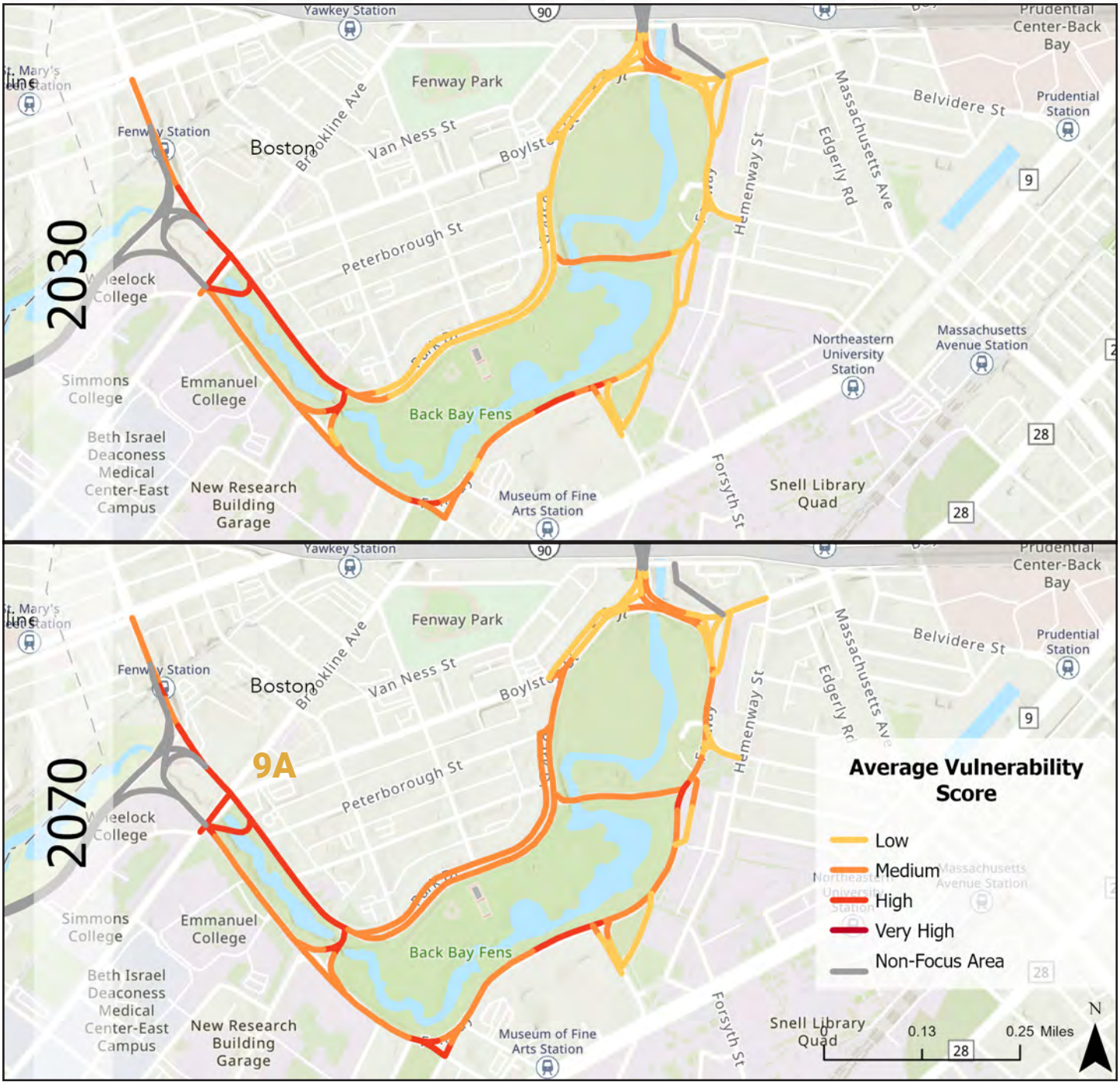


Figure 21a. Focus Area 9 - Back Bay Fens Flood Vulnerability in 2030 and 2070.

Vulnerability	Miles (% share)		Cost of Replacement
	2030	2070	2070
Very High	0 (0%)	0 (0%)	$0
High	0.7 (16%)	1 (22%)	$7.0 Million
Medium	1.5 (33%)	2.5 (56%)	$16.8 Million
Low	2.2 (49%)	1 (22%)	$7.1 Million
Total	**4.5 100%**		**$30.8 Million**

HOT SPOT 9A

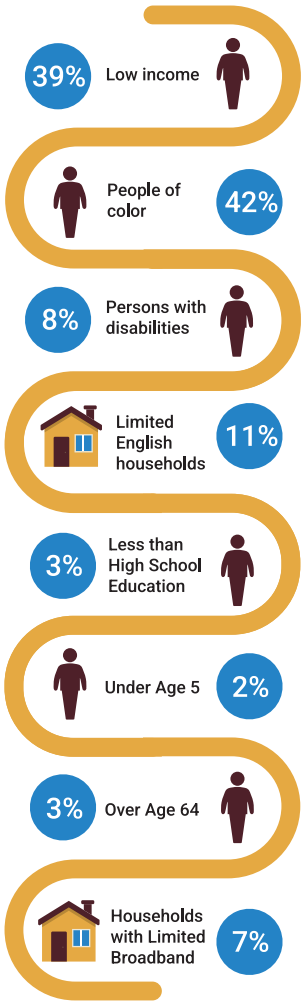
Higginson Circle

Community Vulnerability Impacts

Summary Statistics

12,200
TOTAL POPULATION

3,900
NUMBER OF HOUSEHOLDS



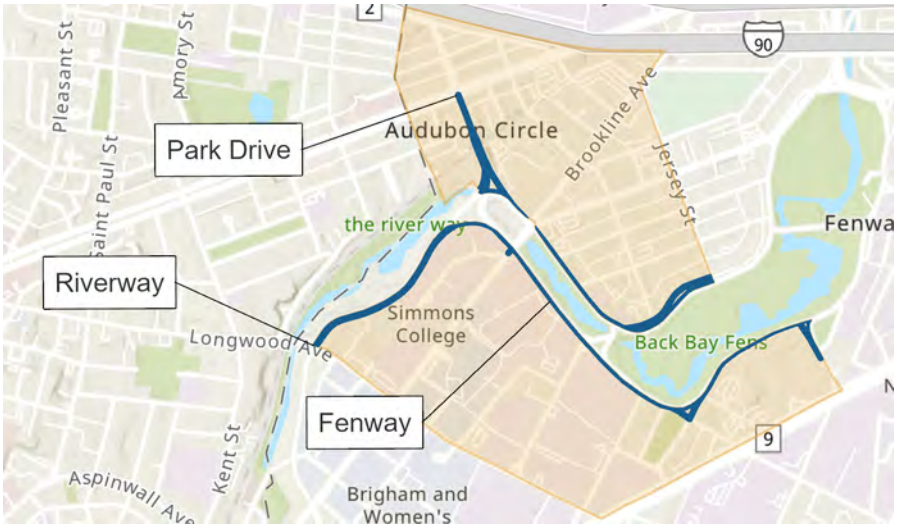


Figure 21b. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

Higginson Circle

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway (Smith, 2024). Compared to the rest of the state, the community aro9und Higginson Circle has higher percentages of residents who are low-income, non-white, reside in limited-English speaking households. These characteristics make this community more vulnerable to flood impacts: historic underinvestment in non-white neighborhoods can make communities of color more susceptible to severe flood impacts, while low-income earners often lack the financial resources to prepare for, respond to, and recover from flooding. Language barriers can prevent understanding emergency instructions and accessing disaster recovery aid. To support these residents, agencies could provide multilingual emergency alerts, translation services, financial assistance, and community-based support programs.

Impacts of Projected 2070 Storm Conditions

Park Drive, at Higginson Circle, could experience coastal flooding when storm surge overtops the Charles River Dam and backs up the Muddy River. By 2070, this type of event will have a 10% chance of occurring in any given year. Park Drive will also have a 1% annual chance of flooding from heavy precipitation. Under these conditions, residents could expect partial or full lane closures and could see more traffic along detour routes and other neighborhood roads as people avoid flooded areas. In a flood event where detours are mandatory, residents should plan to avoid driving, if possible, to reduce congestion on detoured roads. As with street parking bans during winter snowstorms, the community may experience temporary parking bans in anticipation of flood events throughout the year. When heavy precipitation events occur without warning, vehicles on Park Drive could be caught in floodwaters and permanently damaged. To minimize these risks, residents could limit the amount of time they leave their vehicle parked on the street and avoid parking in flood vulnerable areas.

Furthermore, the MBTA 47, 57, and CT2 bus routes travels along the parkway, and MBTA 8, 9, 19, and 60 bus routes intersect Park Drive and residents could expect these bus routes to be delayed or canceled during flood events. Finally, Park Drive provides access to the MBTA Green Line's Fenway Station. While the flood impact to the station was not part of this assessment, access to the station via Park Drive could be disrupted in a flood event. Residents who use these transit services should stay up to date on MBTA alerts and, if possible, plan to use alternative travel modes or stay home in anticipation of and during flood events.

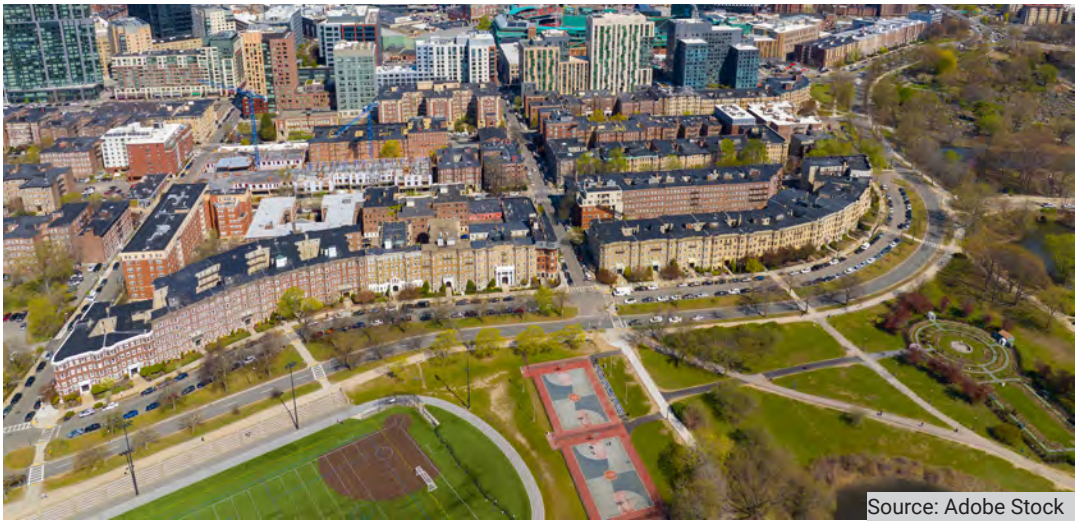
Beyond the immediate travel disruptions, flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has six hospitals, one school, and two places of worship. For more about impacts to these community assets, see Appendix E.

Economic Costs of Flood Impacts

These impacts have economic costs to parkway users and residents. If Park Drive were to close for 24 hours due to active flooding or post-disaster clean-up, the total disruption cost would be $11,200 (2022 USD). The largest economic portion of this impact is ascribed to the associated loss of recreational visits, as Park Drive provides access to portions of the Back Bay Fens. Since this area has nearby neighborhood roads that connect to other main roads, the community would not become isolated in the event of Park Drive's closure. Travelers might need to seek alternate routes to or across the Back Bay Fens. Flooding within Back Bay Fens would make it harder for people to access this environmental and recreational resource. For more information on economic impacts of flooding, see Appendix D.

Back Bay Fens

Back Bay Fens, a key part of Boston's Emerald Necklace, offers a diverse range of lesiure and recreation amenities for visitors. The park also houses several historic memorials, including those dedicated to World War II. With its blend of formal gardens, sports fields, memorials, and historic structures, Back Bay Fens is a versatile destination for both relaxation and activity.



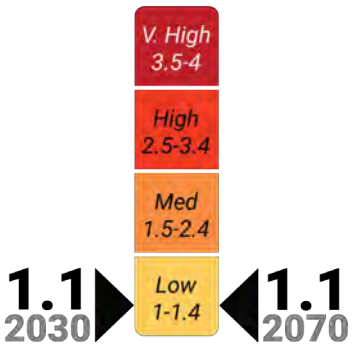
Source: Adobe Stock

FOCUS AREA 10

CHESTNUT HILL

Chestnut Hill Driveway, Saint Thomas More Road

AVERAGE FLOOD VULNERABILITY SCORE

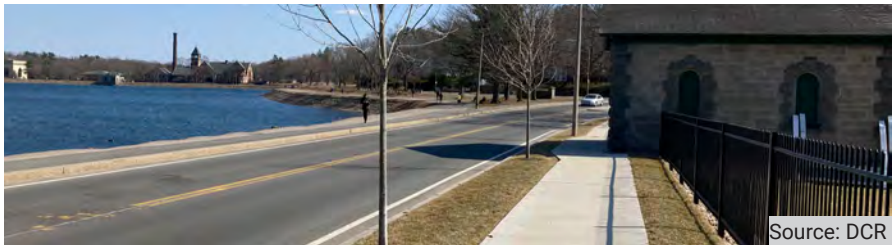


1.1
MILES

3,800
VEHICLES PER DAY

21
NEARBY ENVIRONMENTAL JUSTICE BLOCK GROUPS

2070 Vulnerability Hot Spots


Source: DCR

The parkways in Focus Area 10 are not vulnerable to flooding because they are not predicted to be exposed to precipitation-based or coastal flooding. The parkways scored low for sensitivity and adaptive capacity, due to low traffic volumes and cost of replacement. Therefore, if these parkways do become impacted by an infrequent flood event, their adaptive capacity is high and restoring these parkways to service should be feasible and cost efficient for DCR.

Figure 22. Focus Area 10 - Chesnut Hill Flood Vulnerability in 2030 and 2070.

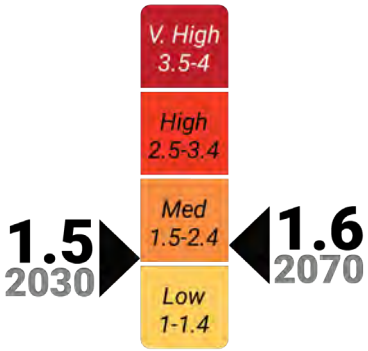
Vulnerability	Miles (% share)		Cost of Replacement
	2030	2070	2070
Very High	0 (0%)	0 (0%)	$0
High	0 (0%)	0 (0%)	$0
Medium	0 (0%)	0 (0%)	$0
Low	1.1 (100%)	1.1 (100%)	$8.0 Million
Total	**1.1 100%**		**$8.0 Million**

FOCUS AREA 11

JAMAICA POND

Jamaicaway, Perkins Street, Parkman Drive, Riverway

AVERAGE FLOOD VULNERABILITY SCORE



6.3
MILES

24,500
VEHICLES PER DAY

66
NEARBY ENVIRONMENTAL JUSTICE BLOCK GROUPS

2070 Vulnerability Hot Spots


Source: DCR

In Focus Area 11, 1.4 miles of parkways have a medium vulnerability to flooding. Less than a half-mile of the parkways have a high vulnerability to flooding.

Hot Spot 11A: Riverway Near Fenway Station

The Riverway has sections of high and medium vulnerability due to the the MBTA 47 bus route and predicted exposure to coastal and precipitation-based flooding in 2030 and 2070. This parkway has a medium adaptive capacity due to it having a historic designation, and a high traffic volume.

Hot Spot 11B: Riverway Station

The Riverway and the Jamaicaway near Riverway Station have medium and high vulnerability sections due to their high traffic volumes and exposure to precipitation-based flooding. The section of the Riverway with a high vulnerability is due to its exposure to precipitation-based and coastal flooding. This parkway crosses paths with MBTA Bus Route 66 which has a very high ridership level and decreases adaptive capacity. The cost of replacement is low, which increases the Riverway's adaptive capacity. Finally, this section intersects Boylston Street, and is the most vulnerable part of the Riverway as its closure would impact a key roadway in the metro-Boston transportation system.

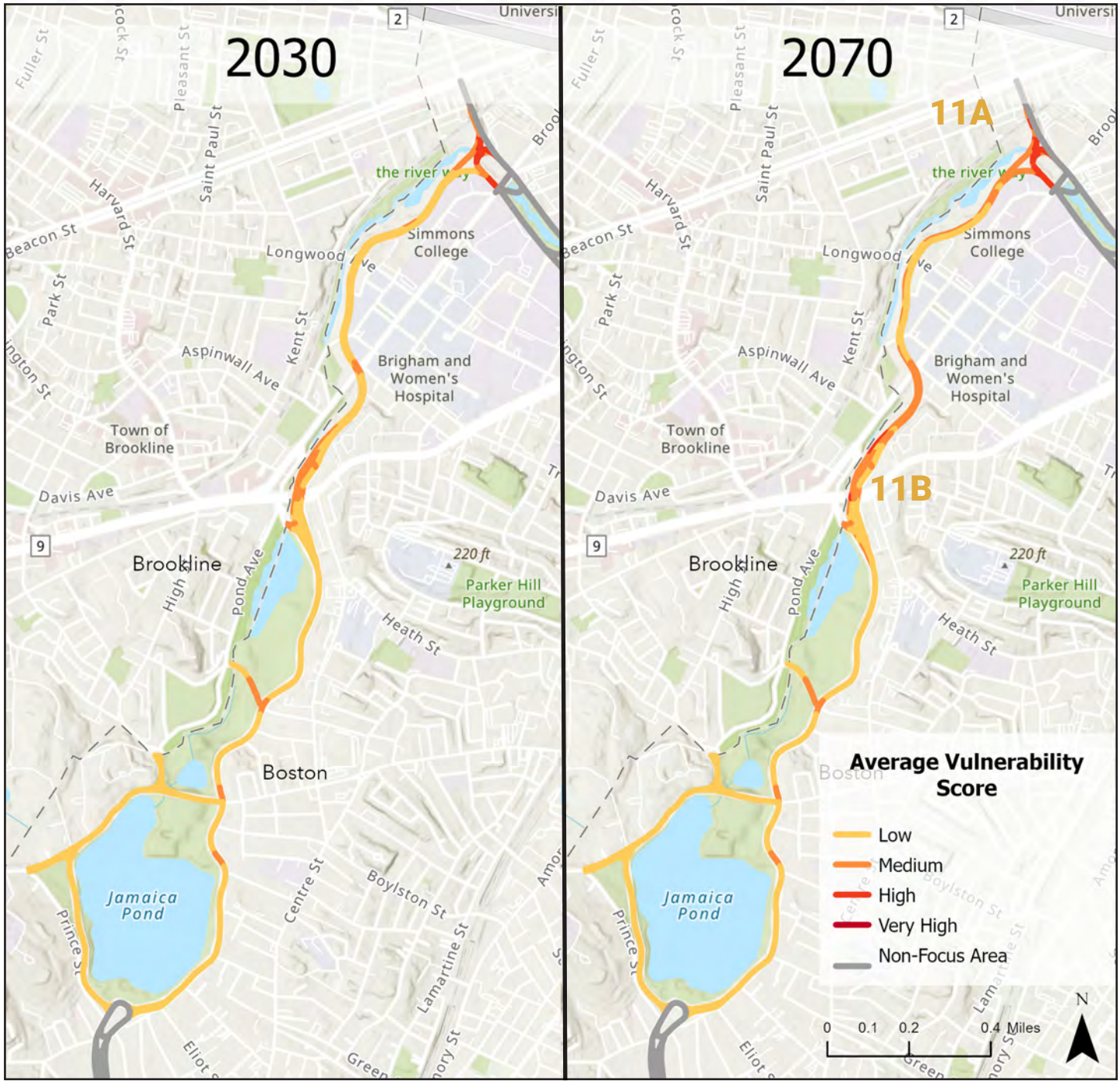


Figure 23a. Focus Area 11 - Jamaica Pond Flood Vulnerability in 2030 and 2070.

Vulnerability	Miles (% share)		Cost of Replacement
	2030	2070	2070
Very High	0 (0%)	0 (0%)	$0
High	0.4 (6%)	0.6 (9%)	$3.0 Million
Medium	2.5 (39%)	2.4 (38%)	$19.5 Million
Low	3.5 (55%)	3.3 (52%)	$18.7 Million
Total	**6.4 100%**		**$41.2 Million**

HOT SPOT 11A

Riverway Near Fenway Station

Community Vulnerability Impacts

Summary Statistics

4,800
TOTAL POPULATION

250
NUMBER OF HOUSEHOLDS

- 25% Low income
- People of color 36%
- 13% Persons with disabilities
- Limited English households 10%
- 9% Less than High School Education
- Under Age 5 2%
- 1% Over Age 64
- Households with Limited Broadband 11%

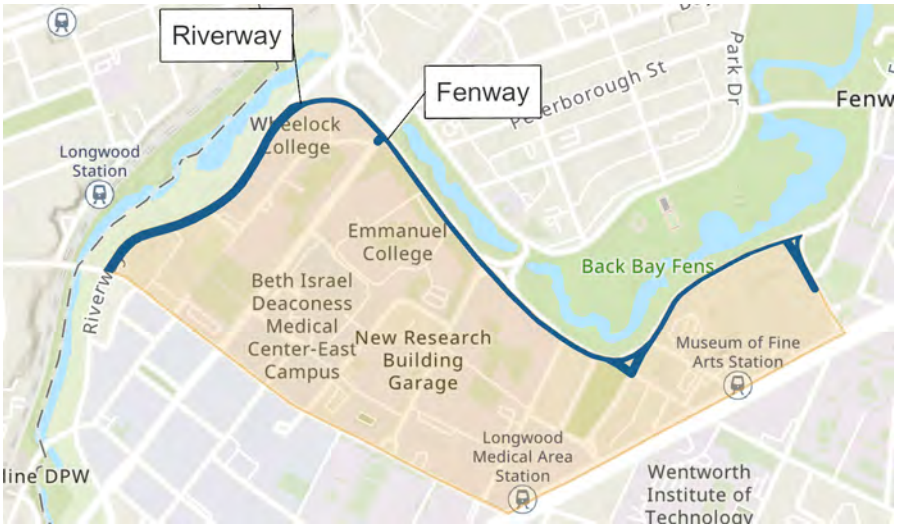


Figure 23b. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

Riverway Near Fenway Station

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway (Smith, 2024). Compared to the rest of the state, the community near Fenway station has a higher percentage of residents living in limited English-speaking households. Language barriers can prevent understanding emergency instructions and accessing disaster recovery aid. Residents here would benefit from multilingual emergency alerts, translation services in multiple forms of electronic and written communication, financial assistance, and community-based support programs.

Impacts of Projected 2070 Storm Conditions

By 2070, the section of the Riverway near Fenway Station, could flood from precipitation-based flooding 1% of the time in any given year or from coastal flooding when storm surge overtops the Charles River Dam

and backup the Muddy River. This coastal event will have 10% chance of occurring in any given year. Under these conditions, residents could expect partial or full lane closures and could see more traffic along detour routes and other neighborhood roads, like Brookline Avenue, as people avoid flooded areas. People walking, biking, and rolling ("Improving safety," n.d) may also be impacted. While the Muddy River Bike Path is nearby, it may experience flooding when the Riverway floods. In a flood event where detours are mandatory, residents should plan to avoid driving, if possible, to reduce congestion on detoured roads. Finally, Riverway provides access to the MBTA Green Line's Fenway Station. While the flood impact to the station was not part of this assessment, access to the station via Riverway could be disrupted in a flood event. Residents who use these transit services should stay up to date on MBTA alerts and, if possible, plan to use alternative travel modes or stay home in anticipation of and during flood events.

Beyond the immediate travel disruptions, flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has five hospitals, one school, and no places of worship. For more about impacts to these community assets, see Appendix E.

Economic Costs of Flood Impacts

These impacts have economic costs to parkway users and residents. If Riverway were to close for 24 hours due to active flooding or post-disaster clean-up, the total disruption cost would be $110,600 (2022 USD). The largest economic impact is the cost of lost recreational visits ($76,800, 2022 USD) as the Riverway runs along the Emerald Necklace, connecting the Riverway Park and Jamaica Pond. Since this area has nearby neighborhood roads that connect to other main roads, the community would not become isolated in the event of the Riverways closure. However, in conjunction with Brookline Avenue, this segment of the Riverway connects the neighborhoods to the south and east of the Muddy River with the communities to the north and west, providing access to the MBTA Green Line's Fenway Station. Flood-related travel disruptions to these sections of the Riverway would make it harder for people to cross the Muddy River and access the Green Line, potentially requiring lengthy detours. For more information on economic impacts of flooding, see Appendix D.

Isabella Stewart Gardner Museum

The museum houses an impressive collection of European, Asian, and American art, including paintings, sculptures, and decorative arts. The museum is renowned for its unique design, modeled after a 15th-century Venetian palace, and its lush courtyard garden.

Source: Adobe Stock

HOT SPOT 11B

Riverway Station

Community Vulnerability Impacts

Summary Statistics

12,900
TOTAL POPULATION

6,300
NUMBER OF HOUSEHOLDS

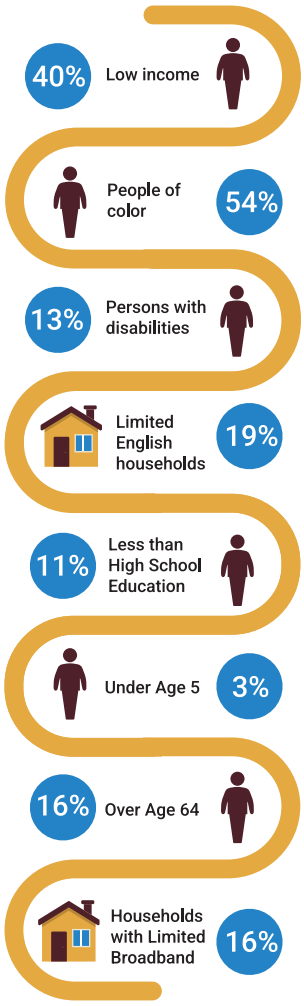


Figure 23c. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

Riverway Station

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway (Smith, 2024). The community near Riverway Station contains several Justice40-designated disadvantaged communities where residents have historically been exposed to more pollution, and less investment in infrastructure and services (National Archives and Records Administration, n.d.). Compared to the rest of the state, the community has higher percentages of residents who are non-white, reside in limited English-speaking households, are low-income, lack internet access, and have less than a high school education. Overall, these characteristics make this community more vulnerable to flood impacts: language barriers can prevent understanding emergency instructions and accessing disaster recovery aid, while limited internet access impedes emergency alerts and other communication during flood events. Individuals with less than a high school education may have limited access to information and resources needed to effectively respond to flood emergencies. Historic underinvestment in non-white neighborhoods can make communities of color more susceptible to severe flood impacts,

while low-income earners often lack the financial resources to prepare for, respond to, and recover from flooding. To support these residents, agencies could provide multilingual emergency alerts, translation services, financial assistance, community-based support programs, and alternative communication methods like radio alerts and community notice boards.

Impacts of Projected 2070 Storm Conditions

By 2070, the sections of Riverway and Jamaicaway near Riverway Station could flood from precipitation-based flooding 1% of the time in any given year or from coastal flooding when storm surge overtops the Charles River Dam and backs up the Muddy River. By 2070, this coastal event will have a 10% chance of occurring in any given year.

Under these conditions, residents could expect partial or full lane closures and could see more traffic along detour routes and other neighborhood roads, like Brookline Avenue, Pond Avenue, and Washington Street, as people avoid flooded areas. People biking, walking, and rolling ("Improving safety," n.d) may also be impacted. In a flood event where detours are mandatory, residents should plan to avoid driving, if possible, to reduce congestion on detoured roads. Finally, Riverway provides access to the MBTA Green Line's Riverway Station. While the flood impact to the station was not part of this assessment, access to the station via Riverway could be disrupted in a flood event. Residents who use this transit service should stay up to date on MBTA alerts and, if possible, plan to use alternative travel modes or stay home in anticipation of and during flood events.

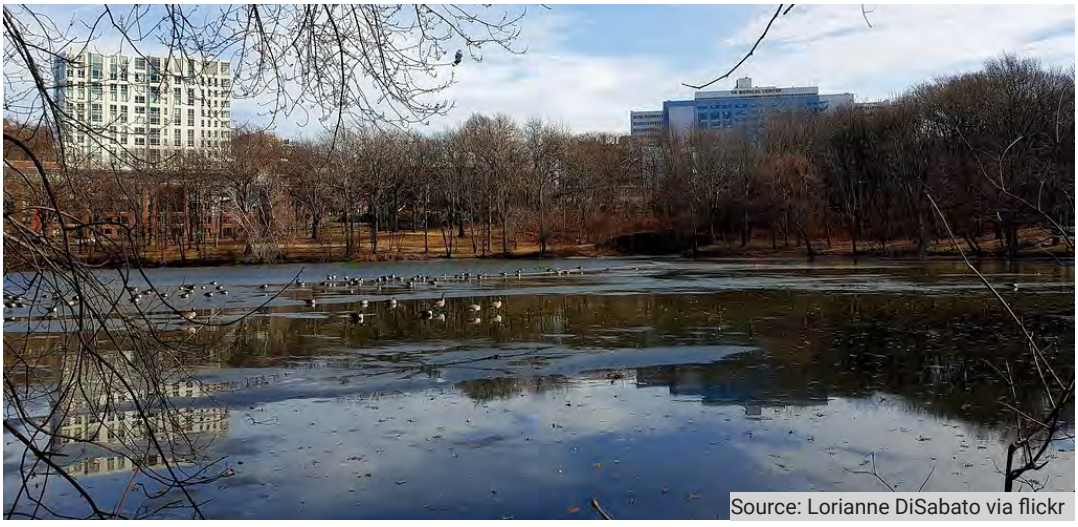
Beyond the immediate travel disruptions, flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has six hospitals, two schools, and four places of worship. For more about impacts to these community assets, see Appendix E.

Economic Costs of Flood Impacts

These impacts have economic costs to parkway users and residents. If the Riverway were to close for 24 hours due to active flooding or post-disaster clean-up, the total disruption cost would be $110,600 (2022 USD). The largest economic impact is the cost of lost recreational visits ($76,800, 2022 USD) as the Riverway runs along the Emerald Necklace, connecting the Riverway Park and Jamaica Pond. Since this area has nearby neighborhood roads that connect to other main roads, the community would not become isolated in the event of the Riverways closure. However, in conjunction with Brookline Avenue, this segment of the Riverway connects the neighborhoods to the south and east of the Muddy River with the communities to the north and west, providing access to the MBTA Green Line's Fenway Station. Flood-related travel disruptions to these sections of the Riverway and Brookline Avenue would make it harder for people to cross the Muddy River and access the Green Line, potentially requiring lengthy detours. For more information on economic impacts of flooding, see Appendix D.

Olmsted Park

Part of Boston's Emerald Necklace, Olmsted Park offers a serene escape with its picturesque ponds, meadows, and woodlands. People are drawn to the athletic fields, and Allerton Overlook. The park's natural beauty and thoughtfully designed landscapes make it a perfect spot for relaxation and outdoor activities.



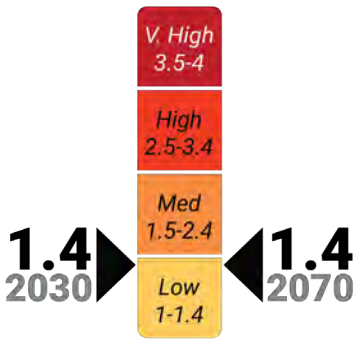
Source: Lorianne DiSabato via flickr

FOCUS AREA 12

VFW PARKWAY

Veterans of Foreign Wars Parkway, Centre Street, Arborway

AVERAGE FLOOD VULNERABILITY SCORE



13.7
MILES

30,300
VEHICLES PER DAY

28
NEARBY ENVIRONMENTAL JUSTICE BLOCK GROUPS

2070 Vulnerability Hot Spots


Source: DCR

Ninety-nine percent of parkways in Focus Area 12 have a low vulnerability because they are not exposed to coastal or precipitation-based flooding and have a high adaptive capacity. There are no parkways with a high vulnerability, and 22% of the parkways have a medium vulnerability. The sections with medium vulnerability are because of high traffic volumes and exposure to precipitation-based flooding.

Hot Spot 12A: Arborway to Forest Hills

Arborway between Center Street and Custer Street: This stretch of the Arborway is predicted to be exposed to precipitation-based flooding in 2070. This section has a medium adaptive capacity. Factors such as the absence of a bus route and not near environmentally sensitive areas increase the parkway's adaptive capacity, but its historic designation also reduces the adaptive capacity.

South of Custer Street, DCR Operations Staff have identified a history of flooding. This flooding occurs where the Arborway passes the Forest Hills MBTA bus stop, located between South Street and Washington Avenue, and further north, from Custer Street to Saint Rose Street.

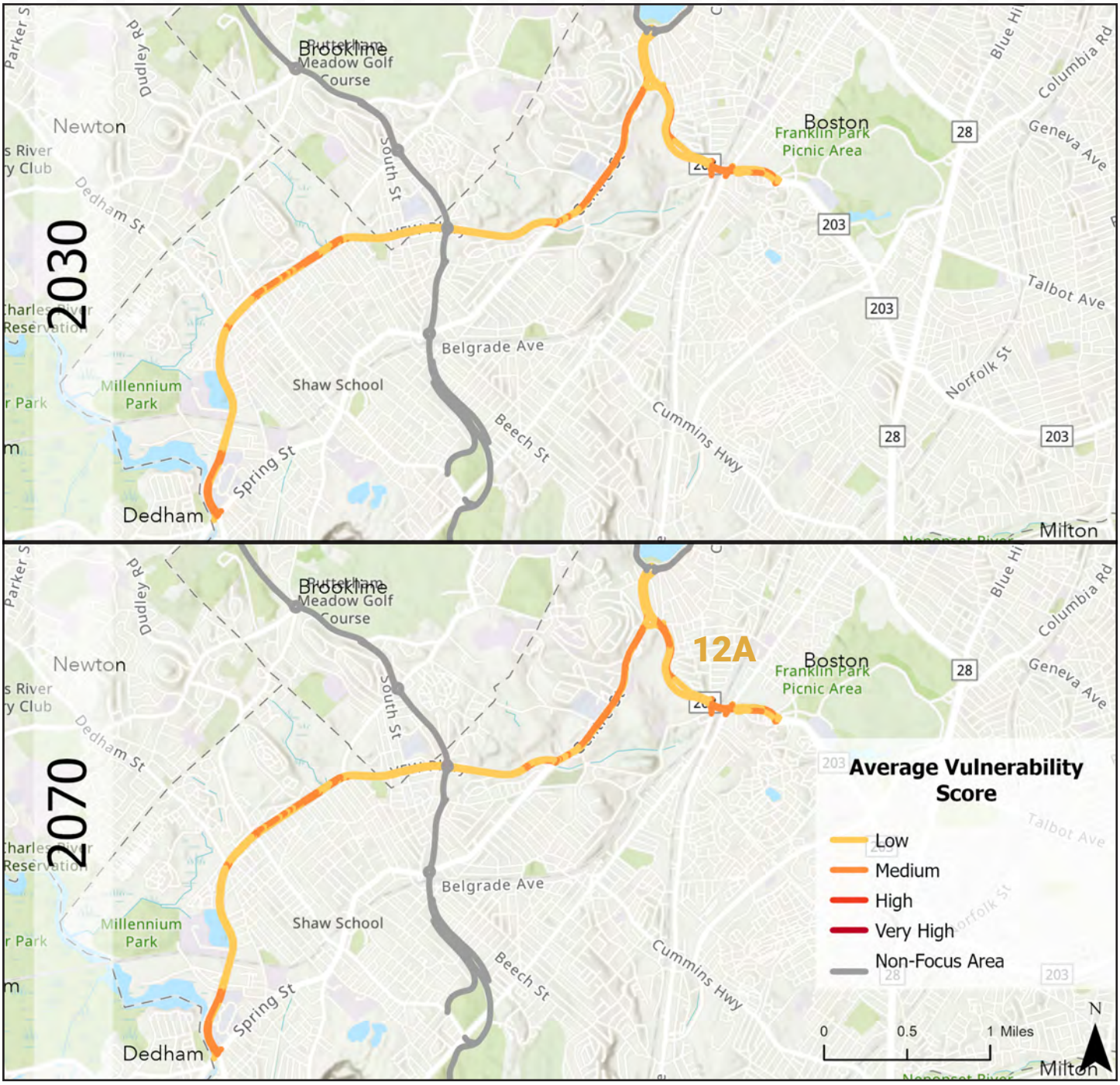


Figure 24a. Focus Area 12 - VFW Parkway Flood Vulnerability in 2030 and 2070.

Vulnerability	Miles (% share)		Cost of Replacement
	2030	2070	2070
Very High	0 (0%)	0 (0%)	$0
High	0 (0%)	0 (0%)	$0
Medium	5.3 (39%)	5.8 (42%)	$33.5 Million
Low	8.4 (61%)	7.9 (58%)	$42.0 Million
Total	**13.7 100%**		**$75.6 Million**

HOT SPOT 12A

Arborway to Forest Hills

Community Vulnerability Impacts

Summary Statistics

11,200
TOTAL POPULATION

5,200
NUMBER OF HOUSEHOLDS

- 16% Low income
- People of color 39%
- 6% Persons with disabilities
- Limited English households 4%
- 3% Less than High School Education
- Under Age 5 7%
- 10% Over Age 64
- Households with Limited Broadband 6%

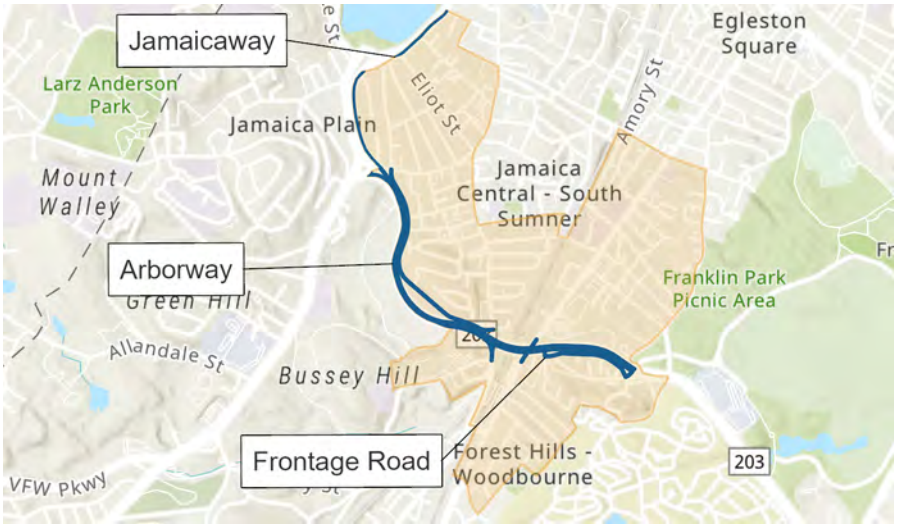


Figure 24b. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

Arborway to Forest Hills

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway (Smith, 2024). Compared to the state average, the community around the Arborway has higher percentages of non-white residents, young children, and households lacking internet access. These characteristics make this community more vulnerable to flood impacts: Historic underinvestment in non-white neighborhoods can make communities of color more susceptible to severe flood impacts, while limited internet access impedes emergency alerts and other communication during flood events. Young children are particularly vulnerable during floods due to their increased health risks and mobility challenges. To support these residents, agencies could provide targeted evacuation assistance and health services for young children and their families, improve infrastructure in high-risk areas, and offer alternative

communication methods such as radio alerts and community notice boards.

Impacts of Projected 2070 Storm Conditions

By 2070, the most vulnerable sections of Arborway could flood from precipitation-based flooding at least 1% of the time in any given year. Under these conditions, residents could expect partial or full lane closures and experience more traffic along detour routes and other neighborhood roads, like South Street or Center Street, as people avoid flooded areas. The Arborway provides access to the MBTA's Forest Hills Station, which includes access to three commuter rail lines and 18 bus routes. While the flood impact to the station was not part of this assessment, access to the station via the parkway could be disrupted in a flood event. Residents who use these transit services or service connections should stay up to date on MBTA alerts and, if possible, plan to use alternative travel modes or stay home in anticipation of and during flood events.

Beyond the immediate travel disruptions, flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has no hospitals, two schools, and four places of worship. For more about impacts to these community assets, see Appendix E.

Economic Costs of Flood Impacts

This parkway was not studied in the economic analysis because it is not impacted by coastal flooding. Since this area has many neighborhood roads that connect to another main road, South Street, the community would not become isolated in the event of a closure of this section of the Arborway Road. Residents would be able to seek alternative travel routes easily, which reduces compounding economic impacts.

Arnold Arboretum of Harvard University

The Arboretum is a botanical research and educational institution. It features a diverse collection of trees, shrubs, and plants spread across 281 acres, offering a beautiful and serene environment for visitors.

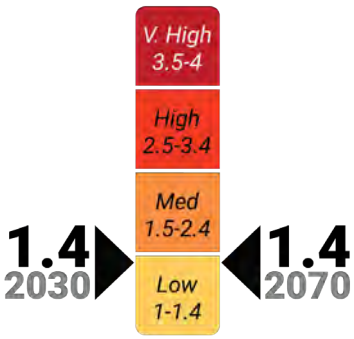
Source: Adobe Stock

FOCUS AREA 13

HAMMOND POND PARKWAY

Hammond Pond Parkway, Horace James Circle

AVERAGE FLOOD VULNERABILITY SCORE



2.4
MILES

21,800
VEHICLES PER DAY

7
NEARBY ENVIRONMENTAL JUSTICE BLOCK GROUPS

2070 Vulnerability Hot Spots


Source: DCR

Ninety-two percent of parkways in Focus Area 13 have low vulnerability scores in both 2030 and 2070. The parkway is far from the coast and is not exposed to coastal flooding. Where Hammond Pond Parkway passes between the Webster Conservation Area and Old Deer Park, the parkway appears unexposed to precipitation-based flooding.

Hot Spot 13A: Chestnut Hill Mall

Where Hammond Pond Parkway crosses Route 9, factors including historic flooding, a MBTA Bus Route 60 with high ridership contribute to increased sensitivity and lower adaptive capacity. Directly north of this crossing, as Hammond Pond Parkway bends around Hammond Pond Reservation, the parkway is exposed to precipitation-based flooding.

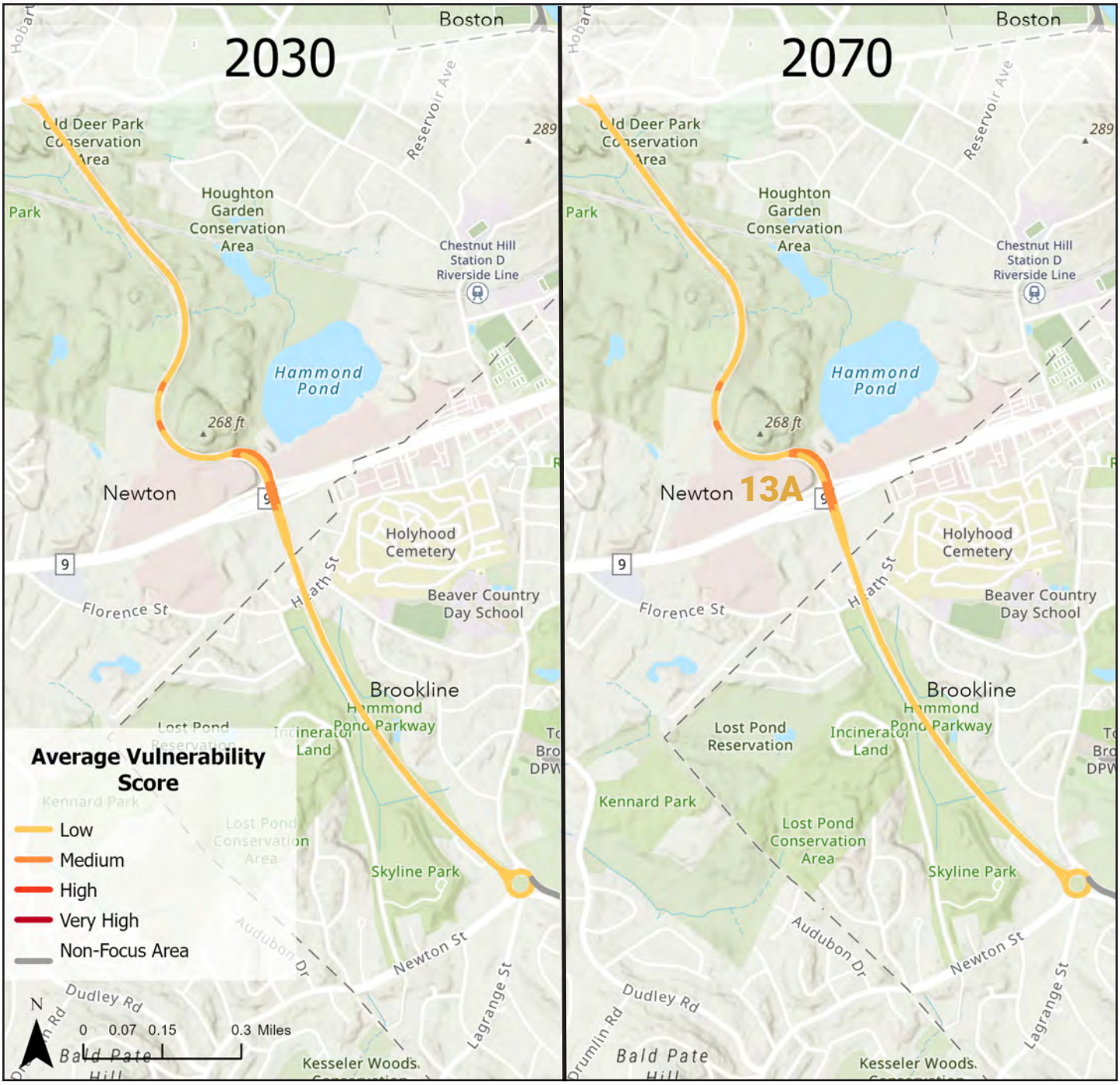


Figure 25a. Focus Area 13 - Hammond Pond Parkway Flood Vulnerability in 2030 and 2070.

Vulnerability	Miles (% share)		Cost of Replacement
	2030	2070	2070
Very High	0 (0%)	0 (0%)	$0
High	0 (0%)	0 (0%)	$0
Medium	0.6 (25%)	0.6 (25%)	$2.8 Million
Low	1.8 (75%)	1.8 (75%)	$11.0 Million
Total	**2.4 100%**		**$13.8 Million**

HOT SPOT 13A

Chestnut Hill Mall

Community Vulnerability Impacts

Summary Statistics

9,800
TOTAL POPULATION

2,400
NUMBER OF HOUSEHOLDS

- 9% Low income
- People of color 27%
- 8% Persons with disabilities
- Limited English households 2%
- 0% Less than High School Education
- Under Age 5 3%
- 18% Over Age 64
- Households with Limited Broadband 3%

Figure 25b. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

Chestnut Hill Mall

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway (Smith, 2024). Compared to the state average, the community's demographic statistics suggest lower vulnerability to flood impacts. However, the community also has a higher percentage of residents over age 64. Older adults are particularly vulnerable during floods due to mobility issues and increased health risks. To support these residents, agencies could provide targeted evacuation assistance and health services for older adults, offer alternative communication methods such as radio alerts and community notice boards, and ensure that emergency information is accessible and easy to understand.

Impacts of Projected 2070 Storm Conditions

By 2070, this section of Hammond Pond Parkway could flood from precipitation-based flooding at least 1% of the time in any given year. Under these conditions, residents could expect partial or full lane closures and could see more traffic along detour routes and other neighborhood roads, Hammond Street or Langlet Road as people avoid flooded areas.

Beyond the immediate travel disruptions, flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has no hospitals, three schools, and three places of worship. For more about impacts to these community assets, see Appendix E.

Economic Costs of Flood Impacts

While this parkway was not studied in the economic analysis because it is not impacted by coastal flooding, residents may experience economic impacts from increased travel time due to detours and traffic from road closures. Access to Hammond Pond Trailhead Parking may be restricted if the parkway floods. Access to Hammond Pond, the surrounding Hammond Pond Reservation, and Webster Park would also be reduced, requiring residents to enter the Reservation through the northern entrance.

Hammond Pond Reservation

The reservation is a protected woodland park featuring Hammond Pond, hiking trails, and unique rock formations popular for climbing. Fishing and canoeing is also allowed in the pond. It's a great destination for outdoor enthusiasts looking to connect with nature.

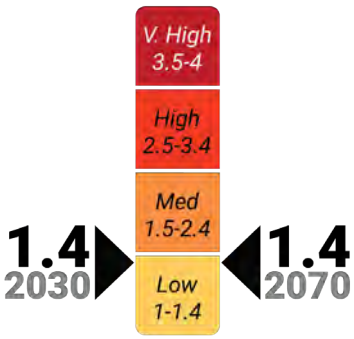
Source: Lorianne DiSabato viaflickr

FOCUS AREA 14

WEST ROXBURY

West Roxbury Parkway, Bellevue Hill Road

AVERAGE FLOOD VULNERABILITY SCORE



5.2
MILES

13,400
VEHICLES PER DAY

21
NEARBY ENVIRONMENTAL JUSTICE BLOCK GROUPS

2070 Vulnerability Hot Spots


Source: DCR

Under 2070 conditions, 82% of Focus Area 14 has a low vulnerability, while 18% has a medium vulnerability. There are no parkways with a high vulnerability. Most medium vulnerability sections are the result of being located within a historic district.

Hot Spot 14A: Bellevue Hill

The 2% increase in medium vulnerability scores from 2030 to 2070 is the result of more segments being flooded from precipitation-based flooding in 2070. This affects the intersection of West Roxbury Parkway and Beaver Street.

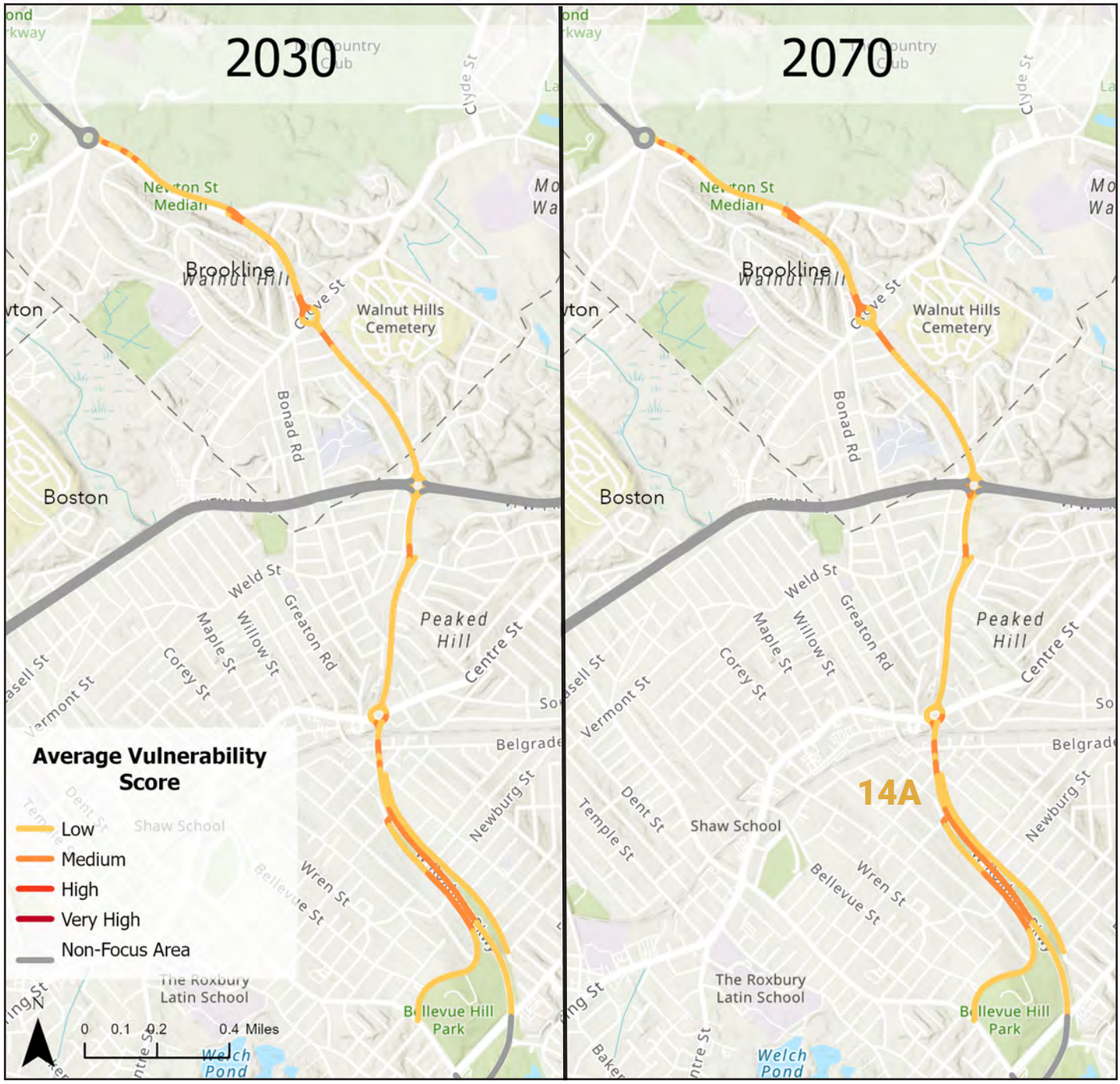


Figure 26a. Focus Area 14 - West Roxbury Flood Vulnerability in 2030 and 2070.

Vulnerability	Miles (% share)		Cost of Replacement
	2030	2070	2070
Very High	0 (0%)	0 (0%)	$0
High	0 (0%)	0 (0%)	$0
Medium	2 (38%)	2.1 (40%)	$9.8 Million
Low	3.1 (60%)	3 (58%)	$16.5 Million
Total	**5.2 100%**		**$26.3 Million**

HOT SPOT 14A

Bellevue Hill

Community Vulnerability Impacts

Summary Statistics

7,600
TOTAL POPULATION

3,000
NUMBER OF HOUSEHOLDS

- 8% Low income
- People of color 18%
- 9% Persons with disabilities
- Limited English households 2%
- 2% Less than High School Education
- Under Age 5 6%
- 16% Over Age 64
- Households with Limited Broadband 5%

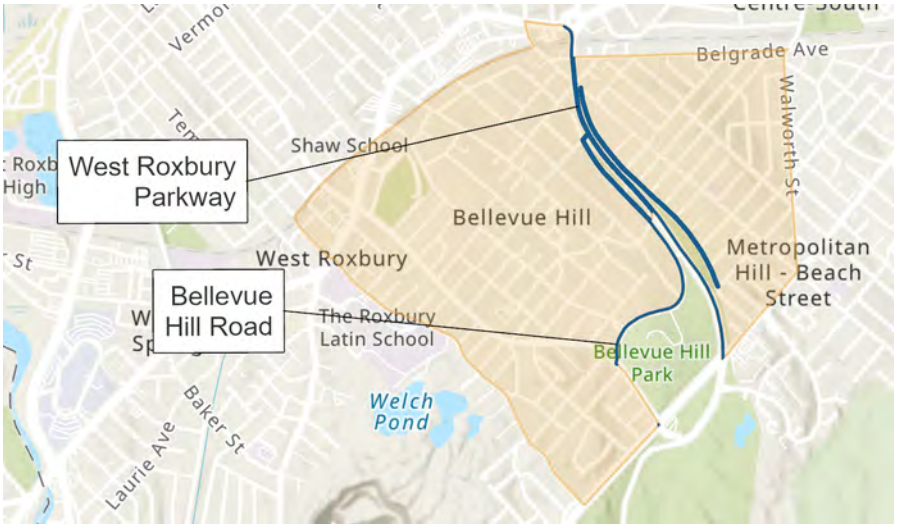


Figure 26b. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

Bellevue Hill

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway (Smith, 2024). Compared to the rest of the state, the community has a higher percentage of children under age 5. Overall, this community's demographic statistics suggest lower vulnerability to flood impacts. However, young children are particularly vulnerable during floods due to their increased health risks and mobility challenges. To support families with young children, agencies could provide targeted evacuation assistance and health services for young children and their families, ensure emergency information is accessible and easy to understand, and offer community-based support programs. Additionally, maintaining strong communication channels through various methods, such as radio alerts and community notice boards, would be beneficial regardless of socioeconomic and demographic characteristics.

Impacts of Projected 2070 Storm Conditions

This section of West Roxbury Parkway has a history of flooding from heavy precipitation. When this occurs, residents can expect partial or full lane closures and could see more traffic along detour routes and neighborhood roads Beech Street or Belgrade Avenue as people avoid flooded areas. Bellevue Station, a stop on the MBTA's Commuter Rail's Needham Line, is located nearby. Needham Line riders may be impacted by detour routes, traffic, and travel delays. Residents who use this transit service should stay up to date on MBTA alerts and, if possible, plan to use alternative travel modes or stay home in anticipation of and during flood events.

Beyond the immediate travel disruptions, flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has no hospitals, one school, and two places of worship. For more about impacts to these community assets, see Appendix E.

Economic Co sts of Flood Impacts

West Roxbury Parkway was not studied in the economic analysis because it is not impacted by coastal flooding. The community is unlikely to become isolated in the event of the Parkway's closure. Residents would be able to seek alternative travel routes by detouring along the numerous alternative neighborhood routes.

Bellevue Hill Park

At 330 feet, Bellevue Hill Park is the highest natural point in the city of Boston. Take in the stunning views of Boston from this park's elevated vantage point. The park has a few short hiking trails and cement paths, including a loop at the top of the park where you'll find the Bellevue Standpipe, a historic water storage tank. It is a great place for a walk, and dogs are allowed.

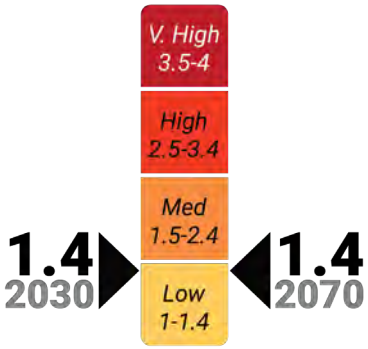
Source: DCR

FOCUS AREA 15

STONY BROOK & NEPONSET

Neponset Valley Parkway, Turtle Pond Parkway, Dedham Parkway, Dedham Boulevard, Smithfield Road, Enneking Parkway

AVERAGE FLOOD VULNERABILITY SCORE

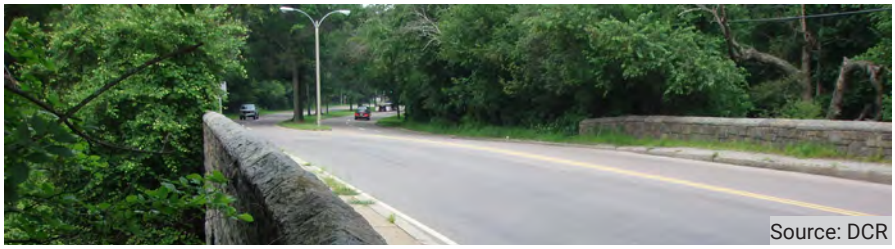


13.2
MILES

12,900
VEHICLES PER DAY

59
NEARBY ENVIRONMENTAL JUSTICE BLOCK GROUPS

2070 Vulnerability Hot Spots


Source: DCR

There are no parkways within Focus Area 15 with a high vulnerability. Seventy-four percent of the parkways have a low vulnerability and the remaining 25% have a medium vulnerability.

Hot Spot 15A: Enneking Parkway

Enneking Parkway, which travels through Stony Brook Reservation, is a 2-mile-long parkway where over a half a mile is exposed to precipitation-based flooding. Enneking Parkway has a medium vulnerability due to a medium adaptive capacity. Factors such as a medium traffic volume, historic designation, and medium replacement cost increase the parkway's vulnerability. Lastly, sections of Smith Field Road have a medium vulnerability due to exposure to precipitation-based flooding likely from the nearby Smith Field wetland system and Stony Brook.

Hot Spot 15B: Truman Parkway near Fairmount Hill

Truman Parkway is a 6-mile-long parkway with a medium vulnerability. However, less than 0.5 miles of the parkway is predicted to be exposed to precipitation-based flooding. Its medium vulnerability is due to its high sensitivity and medium adaptive capacity. The parkway is very sensitive to flooding because of the presence of the MBTA 24 bus route and street-parking along its entirety. Truman Parkway has a lower adaptive capacity, because the bus route is heavily utilized, there is a medium traffic volume, and the parkway is historic. These factors will make it difficult to reroute traffic and restore the road to service following a flood event.

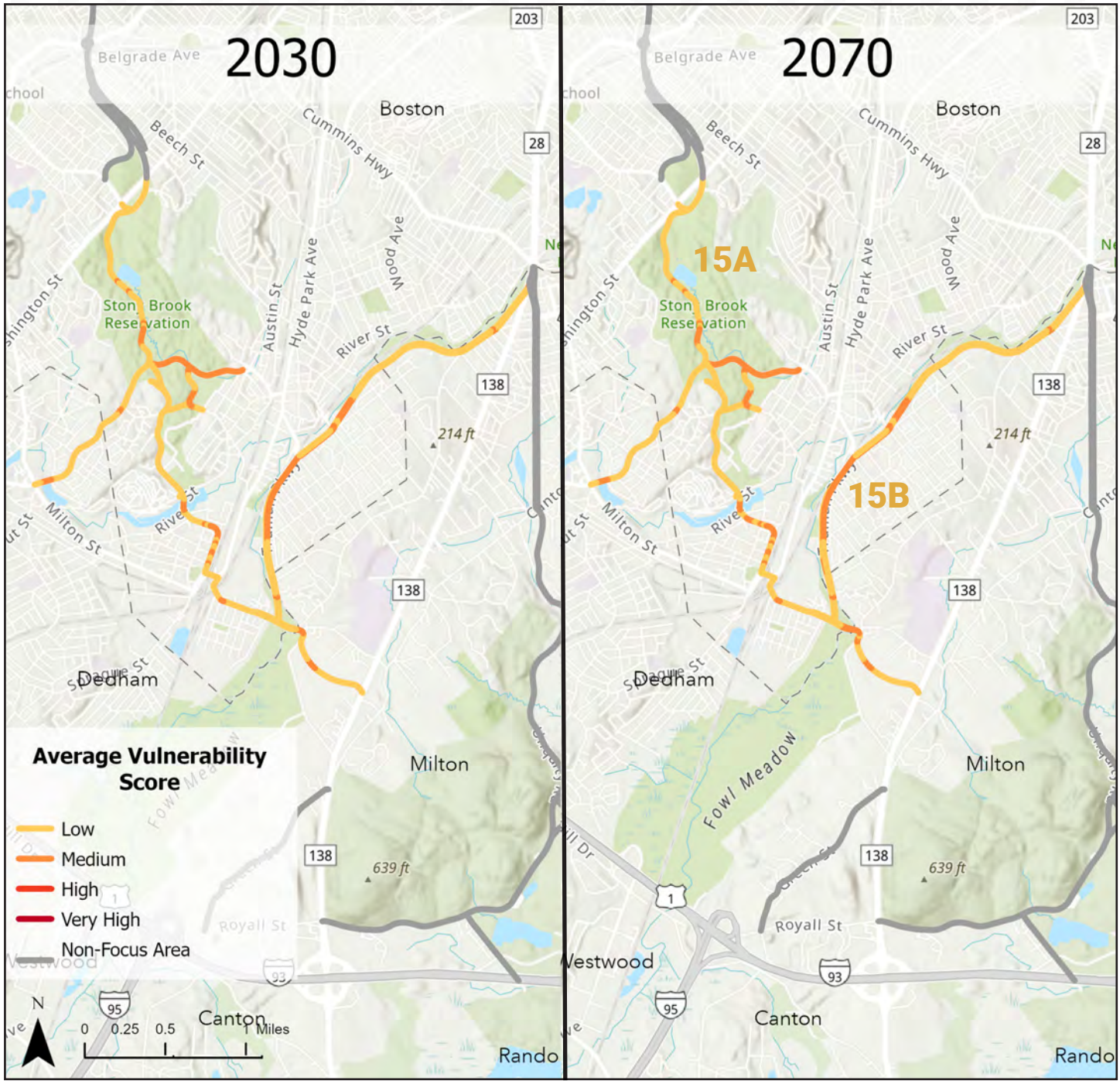


Figure 27a. Focus Area 15 - Stony Brook & Neponset Flood Vulnerability in 2030 and 2070.

Vulnerability	Miles (% share)		Cost of Replacement
	2030	2070	2070
Very High	0 (0%)	0 (0%)	$0
High	0 (0%)	0 (0%)	$0
Medium	4.9 (37%)	5.2 (40%)	$25.0 Million
Low	8.2 (63%)	7.9 (60%)	$36.5 Million
Total	**13.1 100%**		**$61.5 Million**

HOT SPOT 15A

Enneking Parkway

Community Vulnerability Impacts

Summary Statistics

8,500
TOTAL POPULATION

3,000
NUMBER OF HOUSEHOLDS

- 17% Low income
- People of color 65%
- 12% Persons with disabilities
- Limited English households 14%
- 8% Less than High School Education
- Under Age 5 5%
- 15% Over Age 64
- Households with Limited Broadband 7%

Figure 27b. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

Enneking Parkway

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway (Smith, 2024). Compared to the rest of the state, the community has higher percentages of non-white residents and residents from limited-English speaking households. The overall demographic characteristics suggest the community has a mix of higher and lower vulnerability residents: historic underinvestment in non-white neighborhoods can make communities of color more susceptible to severe flood impacts, while language barriers can inhibit efforts to understand emergency instructions and access disaster recovery aid. Those with disabilities may face challenges with evacuation and accessing recovery resources. To support these community members, agencies could provide multilingual emergency alerts, translation services, improved infrastructure, and community-based support programs.

Impacts of Projected 2070 Storm Conditions

By 2070, Enneking Parkway will experience precipitation-based flooding at least 1% of the time in any given year. Under these conditions, residents could expect partial or full lane closures of the parkway between Turtle Pond Parkway and Gordon Avenue, where the parkway follows the Stony Brook. Residents could see more traffic along detour routes and other neighborhood roads, like Reservation Road, as people avoid flooded areas. In a flood event where detours are mandatory, residents should plan to avoid driving through Stony Brook Reservation, if possible, to reduce congestion on detoured roads.

Beyond the immediate travel disruptions, flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has no hospitals, three schools, and no places of worship. For more about impacts to these community assets, see Appendix E.

Economic Costs of Flood Impacts

Enneking Parkway was not studied in the economic analysis because it is not impacted by coastal flooding. The community is unlikely to become isolated in the event of a closure of this section of the Parkway. Residents would be able to seek alternative travel routes by detouring along the numerous alternative neighborhood routes, which reduces compounding economic impacts.

Stony Brook Reservation

This small forest in the middle of Boston offers activities to the whole family. Explore the trails on foot or bike, or head to Turtle Pond for some fishing.

Source: DCR

HOT SPOT 15B

Truman Parkway near Fairmount Hill

Community Vulnerability Impacts

Summary Statistics

15,900
TOTAL POPULATION

5,400
NUMBER OF HOUSEHOLDS

- 21% Low income
- People of color 60%
- 7% Persons with disabilities
- Limited English households 5%
- 7% Less than High School Education
- Under Age 5 6%
- 17% Over Age 64
- Households with Limited Broadband 6%

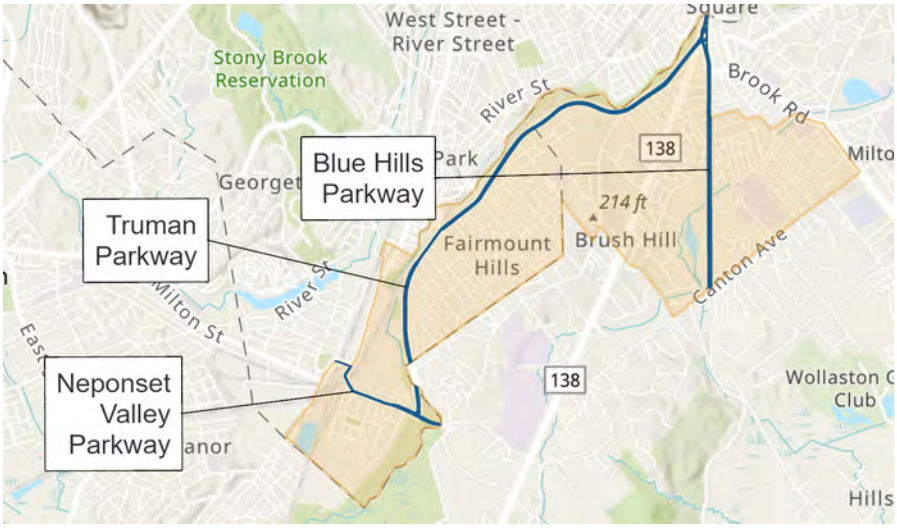


Figure 27c. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

Truman Parkway near Fairmount Hill

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway (Smith, 2024). Compared to the rest of the state, the community around Truman Parkway has a higher-than-average percentage of non-white residents. Historic underinvestment in non-white neighborhoods can make communities of color more susceptible to severe flood impacts. To support this community, agencies could provide improved infrastructure, multilingual emergency alerts, translation services, and community-based support programs. Ensuring accessible and easy-to-understand emergency information and maintaining strong communication channels through various methods, such as radio alerts and community notice boards, would also be beneficial.

Impacts of Projected 2070 Storm Conditions

Truman Parkway has a history of flooding and, by 2070, will have a 1% chance of experiencing precipitation-based flooding in any given year. Under these conditions, residents could expect partial or full lane closures of the parkway between Amor Road and Washington Street, where the parkway follows the Neponset River. Residents could experience more traffic along detour routes and other neighborhood roads, like Brush Hill Road or Blue Hill Avenue, as people avoid flooded areas. When detours are mandatory, residents should plan to avoid driving through Stony Brook Reservation, if possible, to reduce congestion on detoured roads. The MBTA 24 bus route would be impacted by lane or road closures, and it could be more difficult for residents to access the nearby MBTA Fairmont Station on the Fairmount Commuter Rail Line. This could affect residents' ability to reach employment destinations safely and on time. MBTA travel disruption alerts would play an important role in helping transit users navigate these challenges.

Finally, the bike and pedestrian path along the parkway could provide alternative travel options for people during a flood.

Beyond the immediate travel disruptions, flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has no hospitals, four schools, and two places of worship. For more about impacts to these community assets, see Appendix E.

Economic Costs of Flood Impacts

Truman Parkway was not studied in the economic analysis because it is not impacted by coastal flooding. The community is unlikely to become isolated in the event of a closure of this section of the Parkway. Residents would be able to seek alternative travel routes somewhat easily by detouring along the numerous alternative neighborhood routes, which reduces compounding economic impacts.

Alexander S. Bajko Skating Rink

The Rink offers public skating sessions, hockey stick time, and adaptive skating equipment. The rink is a popular spot for ice skating enthusiasts and hosts various community events throughout the season. DCR recently updated the building to install solar panels, reducing dependency on fossil-fuels, and new stormwater features to improve drainage.

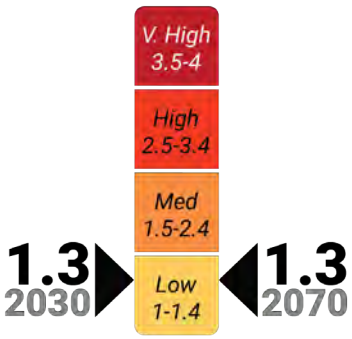
Source: DCR

FOCUS AREA 16

BLUE HILLS

Chickatawbut Road, Hillside Street, Blue Hill River Road, Unquity Road, Blue Hills Parkway, Green Street

AVERAGE FLOOD VULNERABILITY SCORE

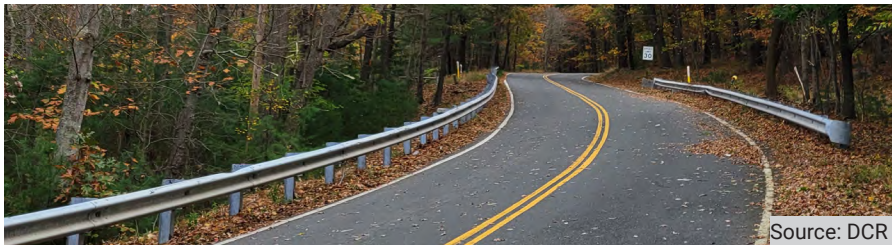


12.9
MILES

7,500
VEHICLES PER DAY

23
NEARBY ENVIRONMENTAL JUSTICE BLOCK GROUPS

2070 Vulnerability Hot Spots


Source: DCR

Elevated exposure scores in Focus Area 16 are primarily driven by precipitation-based flooding. Overall vulnerability scores remain consistent from 2030 to 2070, with over 70% of the Focus Area's parkways having low vulnerability scores.

Hotspot 16A: Pine Hill Cemetery

South of Pine Hill Cemetery, a small portion of Chickatawbut Road is exposed to precipitation-based flooding under 2030 and 2070 conditions, associated with overflow from Quincy Reservoir Stream. Historic flood indicators on a larger portion of Chickatawbut Road elevate the road's vulnerability to the immediate west.

Hotspot 16B: Stream Crossings

Throughout the Focus Area, parkways parallel to or crossing over streams have medium vulnerability due to precipitation-based flooding and documented history of flooding. Streams impacting parkways include Furnace Brook, Blue Hills Stream, Cooks Brook, Pine Tree Brook, and the Hillside Pond stream.

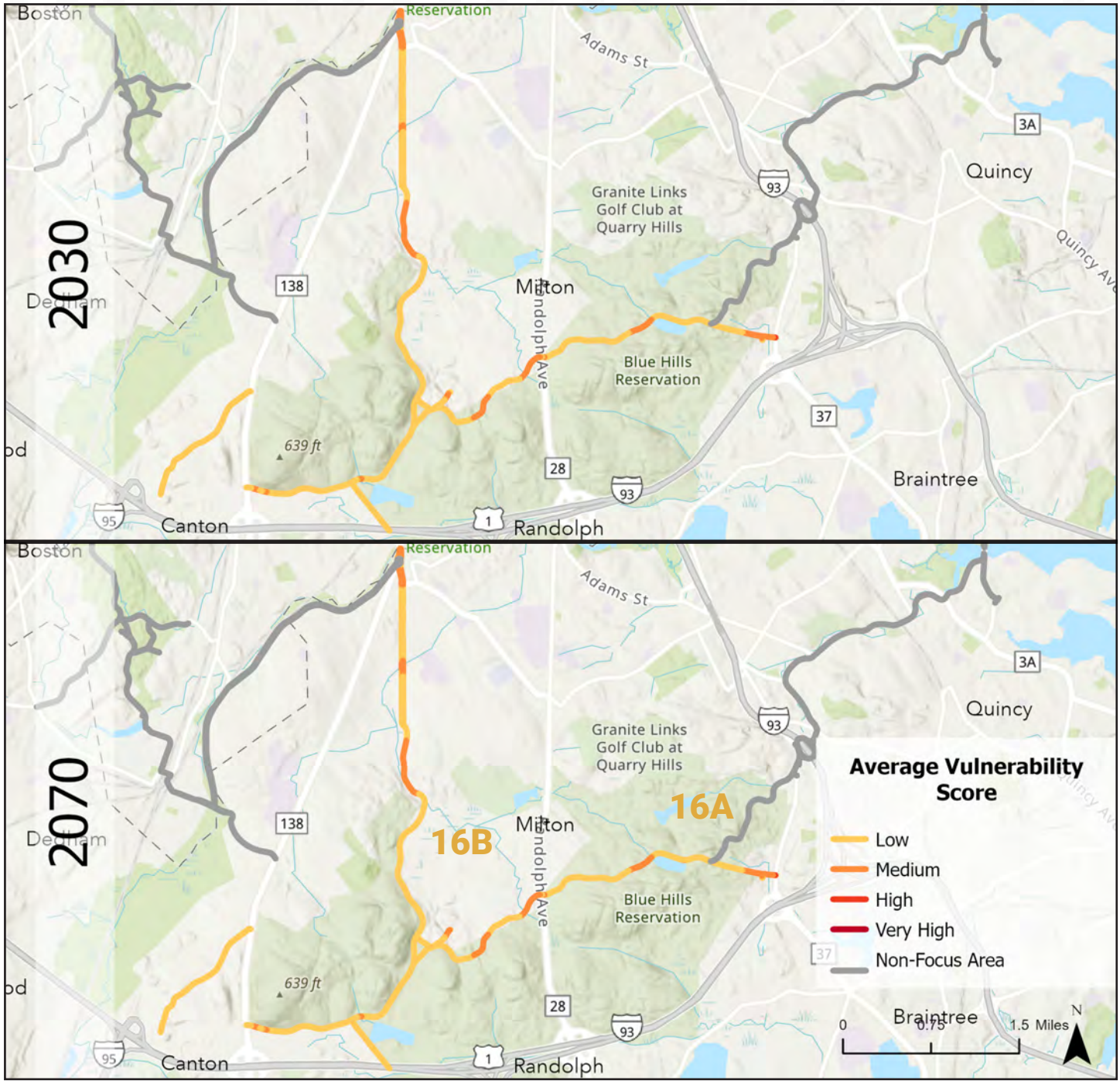


Figure 28a. Focus Area 16 - Blue Hills Flood Vulnerability in 2030 and 2070.

Vulnerability	Miles (% share)		Cost of Replacement
	2030	2070	2070
Very High	0 (0%)	0 (0%)	$0
High	0.02 (0.2%)	0.02 (0.2%)	$85,000
Medium	2.6 (20%)	2.7 (21%)	$12.8 Million
Low	10.3 (80%)	10.1 (78%)	$44.0 Million
Total	**12.9 100%**		**$57.0 Million**

HOT SPOT 16A

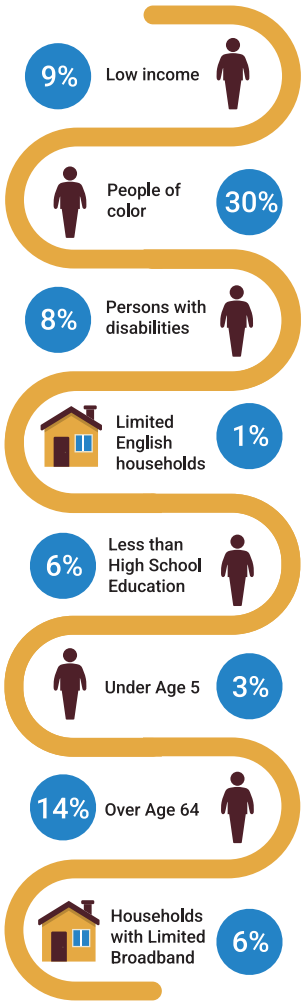
Pine Hill Cemetery

Community Vulnerability Impacts

Summary Statistics

6,000
TOTAL POPULATION

2,200
NUMBER OF HOUSEHOLDS



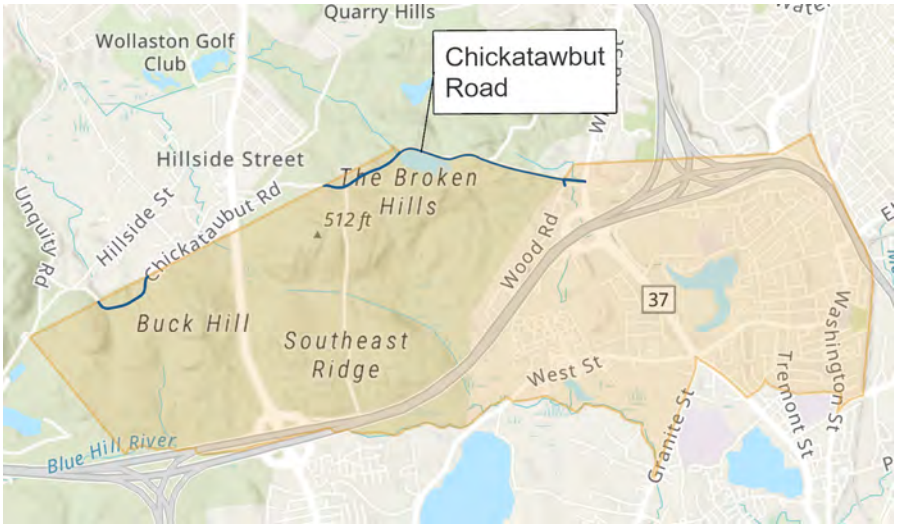


Figure 28b. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

Pine Hill Cemetery

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway (Smith, 2024). Compared to the rest of the state, the community's demographic characteristics suggest that the community is less vulnerable to flood impacts. Residents are likely to have better access to resources, communication, and support systems. To maintain and enhance this resilience, agencies could continue to provide comprehensive emergency preparedness programs, ensure clear and accessible communication channels, and support community-based initiatives that promote safety and readiness.

Impacts of Projected 2070 Storm Conditions

Sections of this parkway have experienced historical flooding. Residents could expect occasional ponding along Chickatawbut Road during extreme precipitation events. Under these conditions, residents could expect partial or full lane closures of the parkway between Blue Hills Reservoir and Granite Street. Residents could experience more traffic along detour routes and other neighborhood roads, like Wampatuck Road, as people avoid flooded areas. When detours are mandatory, residents should plan to avoid driving, if possible, to reduce congestion on detoured roads.

Beyond the immediate travel disruptions, flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has no hospitals, three schools, and five places of worship. For more about impacts to these community assets, see Appendix E.

Economic Costs of Flood Impacts

Chickatawbut Road was not studied in the economic analysis because it is not impacted by coastal flooding.

Chickatawbut Observation Tower

The Tower was built by the Civilian Conservation Corps (CCC) in the 1930s and was later added to the National Register of Historic Places in 1980.

Source: Dana Smith, livingnewdeal.org

HOT SPOT 16B

Stream Crossings

Community Vulnerability Impacts

Summary Statistics

17,000
TOTAL POPULATION

5,300
NUMBER OF HOUSEHOLDS

- 15% Low income
- People of color 38%
- 8% Persons with disabilities
- Limited English households 0%
- 4% Less than High School Education
- Under Age 5 4%
- 17% Over Age 64
- Households with Limited Broadband 5%

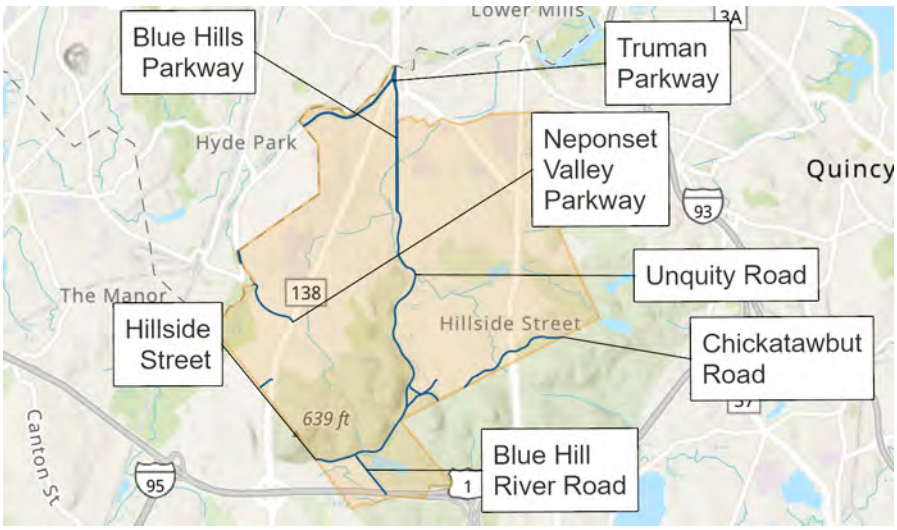


Figure 28c. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

Stream Crossings

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway (Smith, 2024). Compared to the rest of the state, the community has a greater than average percentage of non-white residents. Historic underinvestment in non-white neighborhoods can make communities of color more susceptible to severe flood impacts. To support these residents, agencies could focus on maintaining and improving infrastructure, providing clear and accessible communication channels, and supporting community-based initiatives that promote safety and readiness.

Impacts of Projected 2070 Storm Conditions

This parkway has sections with a history of flooding. Residents could expect occasional ponding along on Chickatawbut Road, near Hillside Pond, and where Unquity Road crosses streams during extreme precipitation events. Under these conditions, residents could expect partial or full lane closures of Unquity Road. Residents could experience more traffic along detour routes and other neighborhood roads, like Harland Street and Hillside Street, as people avoid flooded areas. When detours are mandatory, residents should plan to avoid driving through Blue Hills Reservation between Route 28 and Route 138, if possible, to reduce congestion on detoured roads.

Beyond the immediate travel disruptions, flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has one hospital, three schools, and five places of worship. For more about impacts to these community assets, see Appendix E.

Economic Costs of Flood Impacts

The parkways throughout the Blue Hill Reservation were not studied in the economic analysis because they are not impacted by coastal flooding. These roads predominantly provide passage throughout the Blue Hills Reservation, which has numerous alternate routes. The community is unlikely to become isolated in the event of a closure of these parkway sections, as residents would be able to seek alternative travel routes by detouring along Massachusetts Route 138 or I-95. This alternative route reduces compounding economic impacts. However, flooded sections of roadway within the Blue Hills Reservation may limit recreational access.

Eliot Tower - Great Blue Hill

The Tower offers panoramic views of Boston, Boston Harbor, and the South Shore. Attached to the tower is a pavilion, providing a scenic spot for picnics and relaxation. The tower is part of the Blue Hills Reservation and is a popular destination for hikers and visitors seeking to enjoy the natural beauty and historic significance of the area.

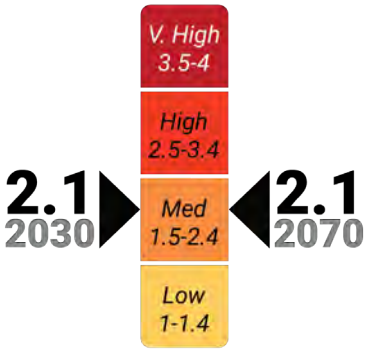
Source: DCR

FOCUS AREA 17

SOUTH SHORE

Quincy Shore Drive, Furnace Brook Parkway

AVERAGE FLOOD VULNERABILITY SCORE



9
MILES

15,400
VEHICLES PER DAY

64
NEARBY ENVIRONMENTAL JUSTICE BLOCK GROUPS

2070 Vulnerability Hot Spots


Source: DCR

Most parkways (64%) in Focus Area 17 have a medium or low vulnerability in 2070. Thirty-six percent of the parkways have a high vulnerability.

Hotspot 17A: Quincy Bay

Quincy Shore Drive has a high exposure to precipitation-based and coastal flooding. This historic road, with on-street parking and high traffic volumes, results in an increased sensitivity score and a lower adaptive capacity.

Hotspot 17B: Furnace Brook Parkway

Furnace Brook Parkway closely follows the path of Furnace Brook. Two miles of this three-mile-long parkway are impacted by precipitation-based flooding, and smaller sections are also exposed to coastal flooding where Furnace Brook flows into the intertidal Blacks Creek and eventually into Quincy Bay. Lastly, there is a section of the parkway that has a low-lying area.

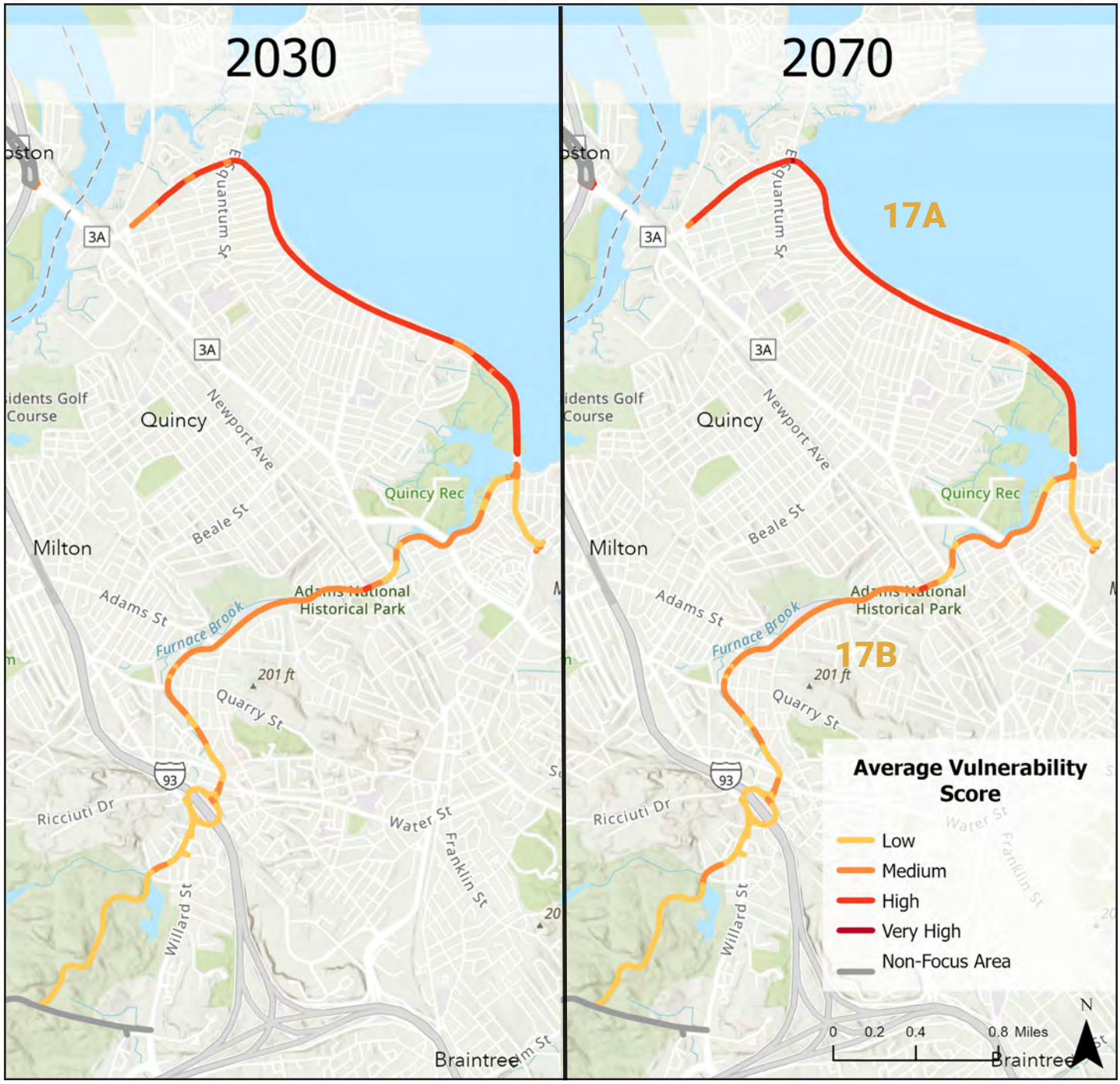


Figure 29a. Focus Area 17 - South Shore Flood Vulnerability in 2030 and 2070.

Vulnerability	Miles (% share)		Cost of Replacement
	2030	2070	2070
Very High	0.1 (1%)	0.3 (3%)	$2.2 Million
High	3.1 (34%)	2.9 (32%)	$21.2 Million
Medium	3.1 (34%)	3.1 (34%)	$16.5 Million
Low	2.8 (31%)	2.7 (30%)	$12.4 Million
Total	**9.1 100%**		**$52.3 Million**

HOT SPOT 17A

Quincy Bay

Community Vulnerability Impacts

Summary Statistics

24,000
TOTAL POPULATION

9,500
NUMBER OF HOUSEHOLDS

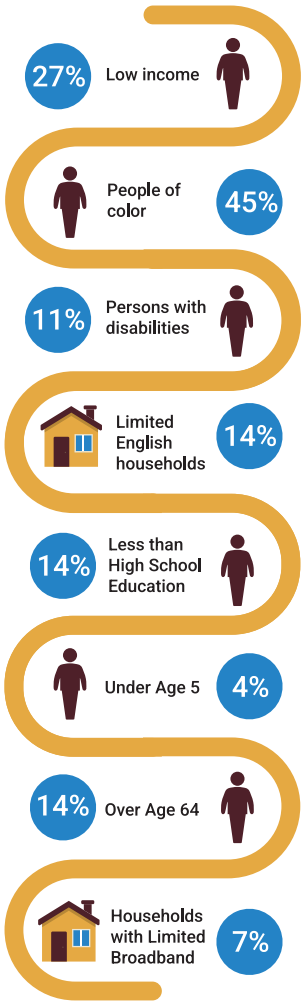


Figure 29b. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

Quincy Bay

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway (Smith, 2024). In addition, the community around Quincy Bay contains several Justice40-designated disadvantaged communities where residents have historically been exposed to more pollution, and less investment in infrastructure and services (National Archives and Records Administration, n.d.). Compared to the rest of the state, the community on Quincy Bay contains higher than average percentages of residents who are non-white, low-income, reside in limited English-speaking households, and possess less than a high school education. Historic underinvestment in non-white neighborhoods can make communities of color more susceptible to severe flood impacts, while low-income earners frequently lack the financial resources to prepare for, respond to, and recover from flooding. Individuals with less

than a high school education may have limited access to information and resources needed to effectively respond to flood emergencies, while language barriers can further inhibit understanding emergency instructions and accessing disaster recovery aid. To support these residents, agencies could provide, multilingual emergency alerts, translation services, financial assistance, community-based support programs, and easy-to-understand emergency preparedness materials.

Impacts of Projected 2070 Storm Conditions

By 2070, Quincy Shore Drive will have a 1% annual risk of flooding from heavy precipitation, and a 10% annual risk of inundation from coastal flooding. Under these conditions, residents could expect partial or full lane closures and could see more traffic along detour routes, such as Route 3A, as people avoid flooded areas. People walking, biking, or rolling ("Improving safety," n.d) may also be impacted. In a flood event where detours are mandatory, residents should plan to avoid driving, if possible, to reduce congestion on detoured roads.

Beyond the immediate travel disruptions, flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has no hospitals, seven schools, and eight places of worship. For more about impacts to these community assets, see Appendix E

Economic Costs of Flood Impacts

These impacts have economic costs to parkway users and residents. If Quincy Shore Drive were to close for 24 hours due to active flooding or post-disaster clean-up, the total disruption cost would be $6.8 million (2022 USD), which is the highest disruption cost across the study area. This is, in part, due to the resulting isolation of Squantum, which impacts the area's wages and business output. There are numerous large and small commercial entities located at Squantum's Marina Bay commercial complex, with local businesses at risk of losing more than $5.6 million per day in revenue in the event of flooding-induced isolation. The community could lose $949,700 in wages for workers who need to travel outside the community for their jobs (2022 USD). Low-income workers are less likely to have the income, savings, or assets needed to prepare for disasters and recovery efforts, so a temporary loss of income has a greater effect on those workers' abilities to withstand and recover from flood events. For more information on economic impacts of flooding, see Appendix D.

Wollaston Beach

Part of Quincy Shore Reservation, Wollaston Beach is the largest public beach in Boston Harbor, stretching over 2.3 miles along Quincy Shore Drive. The beach features a promenade, seasonal restaurants, making it a popular spot for walking, running, and enjoying coastal views. Visitors can also explore the nearby Moswetuset Hummock, a Native American historical site.

Source: DCR

HOT SPOT 17B

Furnace Brook Parkway

Community Vulnerability Impacts

Summary Statistics

23,100
TOTAL POPULATION

10,700
NUMBER OF HOUSEHOLDS

- 21% Low income
- People of color 39%
- 11% Persons with disabilities
- Limited English households 9%
- 10% Less than High School Education
- Under Age 5 6%
- 16% Over Age 64
- Households with Limited Broadband 8%

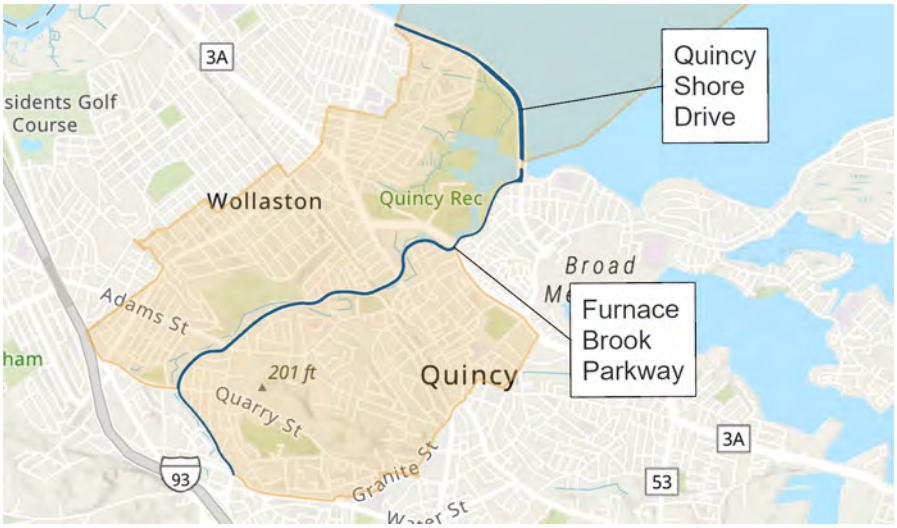


Figure 29c. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

Furnace Brook Parkway

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway (Smith, 2024). Compared to the rest of the state, the community around Furnace Brook Parkway has higher percentages of non-white residents and limited English-speaking households. Historic underinvestment in non-white neighborhoods can make communities of color more susceptible to severe flood impacts, while language barriers can inhibit understanding emergency instructions and accessing disaster recovery aid. To support these residents, agencies could invest in infrastructure improvements, multilingual emergency alerts, translation services, and community-based support programs. Ensuring that emergency information is accessible and easy to understand would also be beneficial.

Impacts of Projected 2070 Storm Conditions

By 2070, Furnace Brook Parkway will have a 1% annual risk of flooding from heavy precipitation and a 10% annual risk of inundation from coastal flooding. Under these conditions, residents could expect partial or full lane closures and could see more traffic along detour routes and other neighborhood roads as people avoid flooded areas. In a flood event where detours are mandatory, residents should plan to avoid driving, if possible, to reduce congestion on detoured roads.

Beyond the immediate travel disruptions, flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has two hospitals, five schools, and ten places of worship. For more about impacts to these community assets, see Appendix E.

Economic Costs of Flood Impacts

These impacts have economic costs to parkway users and residents. If Furnace Brook Parkway were to close for 24 hours due to active flooding or post-disaster clean-up, the total disruption cost would be $29,000 (2022 USD). The largest economic portion of the impact is the cost of lost recreational visits ($22,900, 2022 USD). Furnace Brook provides access to Caddy Memorial Park, Merrymount Park, Adams National Historical Park, and the Quincy Quarries Reservation. These environmental and recreational resources are accessible via other neighborhood roads. However, a complete closure of Furnace Brook Parkway would delay travel between Quincy and North Quincy. For more information on economic impacts of flooding, see Appendix D.

Dorothy Quincy Homestead

The Dorothy Quincy Homestead, represents five generations of Quincys and three centuries of architecture—Colonial, Georgian and Victorian—all under one roof. This home provides a glimpse into early Colonial history, a taste of daily life and intriguing family stories.

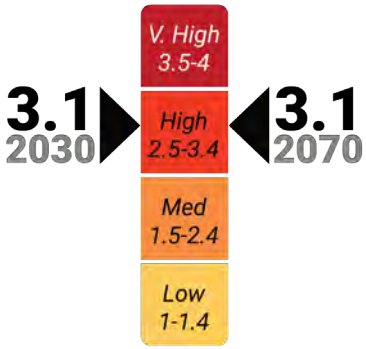
Source: Dana Smith 2 via flickr

FOCUS AREA 18

NANTASKET

Nantasket Avenue, Hull Shore Drive

AVERAGE FLOOD VULNERABILITY SCORE



1.6
MILES

9,800
VEHICLES PER DAY

0
NEARBY ENVIRONMENTAL JUSTICE BLOCK GROUPS

2070 Vulnerability Hot Spots

Source: Jeff Cutler, via flickr

Sixty-nine percent of the parkways in this Focus Area have a high vulnerability due to a very high exposure to coastal precipitation-based and coastal flooding which elevates its vulnerability score.

The entire Focus Area is a hot spot with high vulnerability throughout both parkways. Nantasket Avenue is the most vulnerable parkway in the study area, and Hull Shore Drive is the fifth most vulnerable parkway. In addition to very high exposure, the vulnerability is high because these parkways have the highest sensitivity of the entire study area because of a documented history of flooding, bus routes, and street parking. The bus ridership is low, which increases adaptive capacity. Finally, the replacement cost is very high, which reduces adaptive capacity and increases vulnerability.

While the likelihood of flooding is high, the traffic volume on these parkways is low, so the impact to the regional transportation system is less serve than in other focus areas.

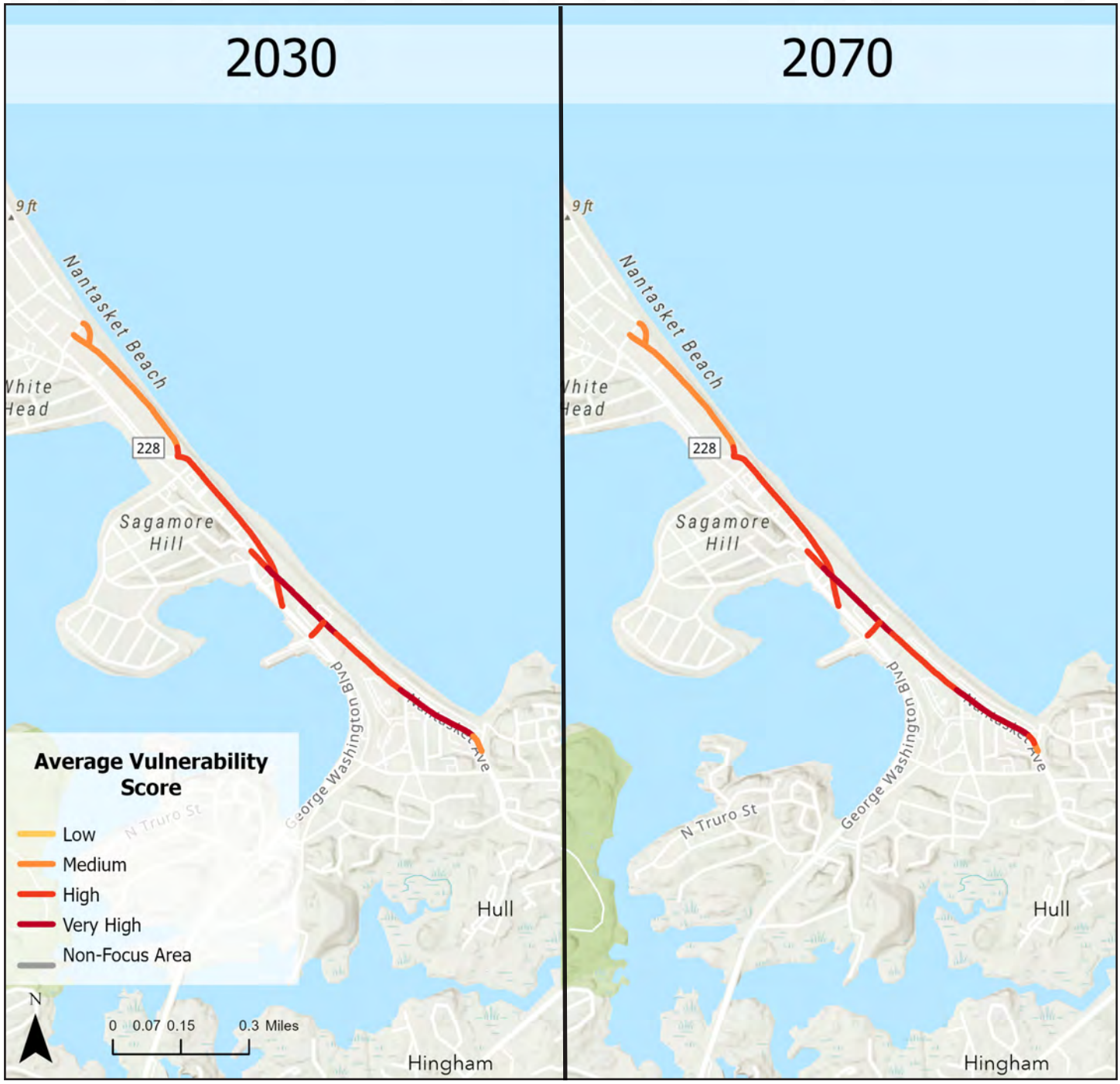


Figure 30a. Focus Area 18 - Nantasket Flood Vulnerability in 2030 and 2070.

Vulnerability	Miles (% share)		Cost of Replacement
	2030	2070	2070
Very High	0.4 (27%)	0.4 (27%)	$3.5 Million
High	0.7 (47%)	0.8 (53%)	$5.0 Million
Medium	0.4 (27%)	0.4 (27%)	$1.7 Million
Low	0 (0%)	0 (0%)	$0
Total	**1.5 100%**		**$10.2 Million**

HOT SPOT 18A

Nantasket Beach

Community Vulnerability Impacts

Summary Statistics

10,100
TOTAL POPULATION

4,500
NUMBER OF HOUSEHOLDS

- 9% Low income
- People of color 5%
- 10% Persons with disabilities
- Limited English households 0%
- 2% Less than High School Education
- Under Age 5 3%
- 23% Over Age 64
- Households with Limited Broadband 5%

Figure 30b. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

Hot Spot 18A: Nantasket Beach

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway (Smith, 2024). However, demographic and geographic factors can influence a community's vulnerability in unique and sometimes contradictory ways. Hull's unique geography increases its potential for isolation in the event of flooding, which increases residents' vulnerability regardless of demographic status. Compared to the rest of the state, Hull has a higher percentage of older adult residents, who are particularly vulnerable during floods due to mobility issues and increased health risks. To support older residents, agencies could provide targeted evacuation assistance and health services. All residents could benefit from efforts to ensure emergency information is accessible and easy to understand, and community resource programs such as flood preparedness training.

Impacts of Projected 2070 Storm Conditions

By 2070, Nantasket Avenue and Hull Shore Drive will have a 1% risk of precipitation-based flooding in any given year and a 10% risk of coastal flooding in any given year. Under these conditions, residents could expect partial or full lane closures and could see more traffic along detour routes and other neighborhood roads as people avoid flooded areas. These coastal parkways could experience more frequent flooding from king tide events. Should the entire parkway flood, the community will be physically isolated from the mainland. While Massachusetts State Route 228 and George Washington Boulevard also traverse the peninsula, these roads would likely also be impassable if Nantasket Avenue and Hull Shore Drive were closed. Moreover, even partial road closures would greatly increase travel times given the shared exposure faced by Route 228 and George Washington Boulevard plus the high rate of traffic during summer months. In anticipation of these 10% coastal storms, residents should plan to avoid driving, be prepared to remain in their home for, at least, the duration of the storm, and plan for power outages. They may also consider evacuating.

Beyond the immediate travel disruptions, flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has three schools, no hospitals, and two places of worship. For more about impacts to these community assets, see Appendix E. A lack of medical services within the community means it could be dangerous for older residents, who are more likely to have mobility challenges and rely on electric medical devices or refrigerated medicine, to remain in the area during a storm if the community were to become isolated from flooding.

Economic Costs of Flood Impacts

These impacts have economic costs to parkway users and residents. Nantasket Avenue and Hull Shore Drive provide access to the Hull peninsula and together face economic losses in the event of a 24-hour closure due to active flooding or post-disaster clean-up. The combined total disruption cost for these parkways amounts to $1,036,700 (2022 USD). Nantasket Avenue alone accounts for $966,500 (2022 USD) of this total, with the largest economic impacts being lost wages ($559,100, 2022 USD) and lost business output ($347,300, 2022 USD). Hull Shore Drive contributes an additional $70,200 (2022 USD) to the total disruption cost, primarily due to lost recreational visits ($64,900, 2022 USD). Low-income workers are less likely to have the income, savings, or other assets needed to prepare for disasters and recovery efforts, so a temporary loss of income has a greater effect on those workers' abilities to withstand and recover from flood events. For more information on economic impacts of flooding, see Appendix D.

Nantasket Beach

This beach offers a mile of Atlantic shoreline, along Nantasket Avenue, with fine, light gray sand and picturesque tide pools. The beach is a popular summer destination, featuring concerts, dance lessons, and various recreational activities.

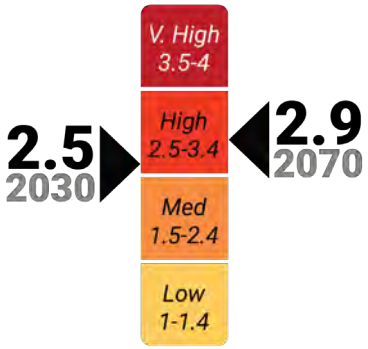
Source: DCR

FOCUS AREA 19

MORRISSEY BOULEVARD

Morrissey Service Road, Mount Vernon Street, William T. Morrissey Boulevard

AVERAGE FLOOD VULNERABILITY SCORE



6.6
MILES

23,600
VEHICLES PER DAY

33
NEARBY ENVIRONMENTAL JUSTICE BLOCK GROUPS

2070 Vulnerability Hot Spots


Source: DCR

By 2070, 99% of the parkways in this Focus Area will have a high or medium vulnerability. From 2030 to 2070, the average exposure score increases from 2.5 to 3.5. Two miles of Morrissey Boulevard have a history of flooding, but there is only three-quarters of a mile with a bus route and there is no on-street parking, which gives this parkway a lower sensitivity score and reduces its overall vulnerability. Considering its high exposure to flooding, the parkway has a high traffic volume, which further increases its vulnerability.

Hot Spot 19A: South Morrissey

The southern section of Morrissey Boulevard is a high vulnerability hot spot exposed to coastal and precipitation-based flooding. This section of the parkway has a very low adaptive capacity due to factors such as high traffic volumes, high replacement cost, medium bus ridership, and high economic impact. This section of Morrissey Boulevard provides connections to Neponset Ave, Rt-203, Rt 3A, and I-93 (Southeast Expressway).

Hot Spot 19B: North and Center Morrissey

The northern section of Morrissey Boulevard has medium and high vulnerability to flooding. Factors such as history of flooding increase the sensitivity of the parkway to flooding and results in a higher vulnerability score. This section of the parkway also has a low adaptive capacity due to high cost of replacement and a high economic impact.

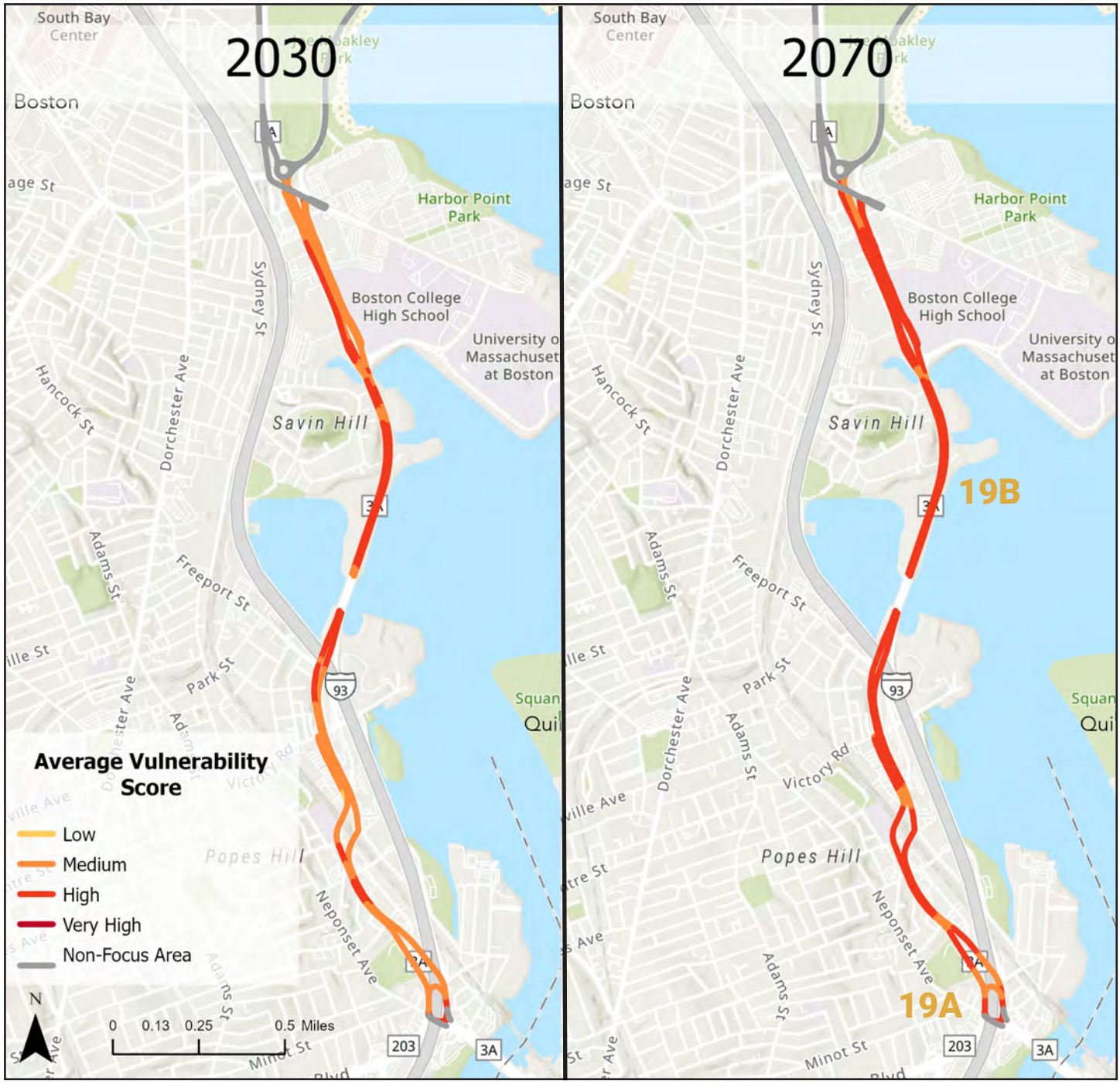


Figure 31a. Focus Area 19 - Morrissey Boulevard Flood Vulnerability in 2030 and 2070.

Vulnerability	Miles (% share)		Cost of Replacement
	2030	2070	2070
Very High	0.3 (5%)	0.4 (6%)	$2.8 Million
High	2.6 (39%)	5.4 (82%)	$31.7 Million
Medium	3.7 (56%)	0.8 (12%)	$4.1 Million
Low	0.02 (0%)	0 (0%)	$2.8 Million
Total	**6.6 100%**		**$38.5 Million**

HOT SPOT 19A

Hot Spot: South Morrissey

Community Vulnerability Impacts

Summary Statistics

13,100
TOTAL POPULATION

5,500
NUMBER OF HOUSEHOLDS

- 26% Low income
- People of color 43%
- 12% Persons with disabilities
- Limited English households 11%
- 20% Less than High School Education
- Under Age 5 3%
- 16% Over Age 64
- Households with Limited Broadband 9%

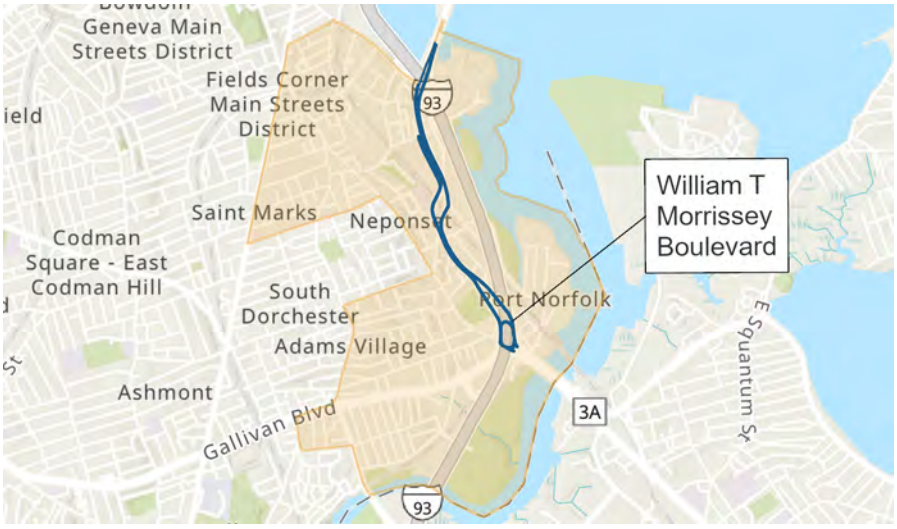


Figure 31b. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

South Morrissey

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway. The community around Morrissey Boulevard contains several Justice40-designated disadvantaged communities where residents have historically been exposed to more pollution, and less investment in infrastructure and services (National Archives and Records Administration, n.d.). Compared to the rest of the state, the community around the southern portion of Morrissey Boulevard has higher percentages of residents who are non-white, low-income, reside in a limited English-speaking household, possess less than a high school education, and lack broadband access. Overall, these characteristics make this community more vulnerable to flood impacts: language barriers can prevent understanding emergency instructions and accessing disaster recovery aid, while limited internet access impedes emergency alerts and other communication during flood events. Individuals with less than a high school education may have limited access to information and resources needed to effectively respond to flood emergencies.

Historic underinvestment in non-white neighborhoods can make communities of color more susceptible to severe flood impacts, while low-income earners often lack the financial resources to prepare for, respond to, and recover from flooding. To support these residents, agencies could provide multilingual emergency alerts, translation services, financial assistance, community-based support programs, and easy-to-understand emergency preparedness materials. Improving infrastructure in high-risk areas would also be beneficial.

Impacts of Projected 2070 Storm Conditions

By 2070, this section of Morrissey Boulevard will have a 1% annual risk of flooding from heavy precipitation and a 10% annual risk of inundation from coastal flooding. Under these conditions, residents could expect partial or full lane closures and could see more traffic along detour routes and other neighborhood roads, such as Neponset Avenue, as people bypass flooded areas. Residents should plan to avoid driving, if possible, during flood events. Morrissey Boulevard already experiences flooding during coastal storms and king tides that closes the parkway, and this will become more frequent in the coming decades. Residents should plan to avoid driving, if possible, during coastal storms, and be mindful of upcoming king tides or storm surge.

Beyond the immediate travel disruptions, flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has three schools, no hospitals, and one place of worship. For more about impacts to these community assets, see Appendix E.

Economic Costs of Flood Impacts

These impacts have economic costs to parkway users and residents. Morrissey Boulevard is a crucial regional and local transportation corridor, connecting South Shore communities and Dorchester with the rest of Boston ("Morrissey Boulevard Commission - Draft Status Report," n.d). If all of Morrissey Boulevard were to close for 24 hours due to active flooding or post-disaster clean-up, the total disruption cost would be $2,271,200 (2022 USD), which is the second highest disruption cost across the study area. The largest economic impact is the cost of lost business output ($1,906,800, 2022 USD), followed by lost wages ($171,000, 2022 USD), lost recreational visits ($100,500, 2022 USD), and reduced vehicular access and associated travel delays ($91,800, 2022 USD). Closure of the parkway would reduce a resident's ability to get to and from work or school, and access nearby conservation and recreation destinations, such as Malibu Beach, Tenean Beach, the HarborWalk, and Carson Beach. Low-income workers are less likely to have the income, savings, or other assets needed to prepare for disasters and recovery efforts, so a temporary loss of income has a greater effect on those workers' abilities to withstand and recover from flood events.

Tenean Beach

The beach offers more than just swimming with its playground, tennis courts, and basketball courts. The beach provides a fun and active environment for families and visitors of all ages.

Source: DCR

HOT SPOT 19B

North and Center Morrissey

Community Vulnerability Impacts

Summary Statistics

6,200
TOTAL POPULATION

2,800
NUMBER OF HOUSEHOLDS

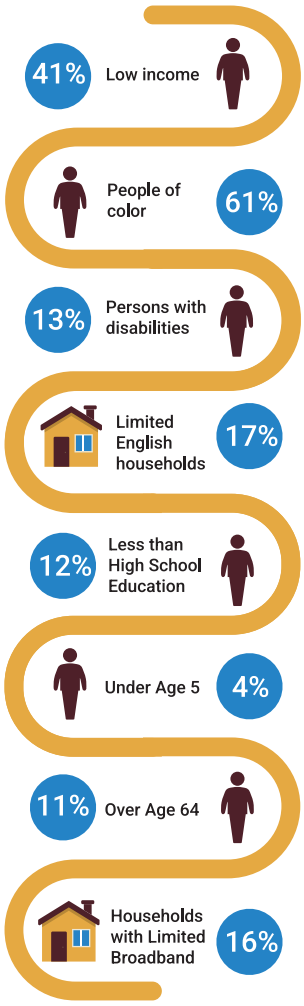


Figure 31c. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

North and Center Morrissey

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway (Smith, 2024). The community around North and Center Morrissey Boulevard contains several Justice40-designated disadvantaged communities where residents have historically been exposed to more pollution, and less investment in infrastructure and services (National Archives and Records Administration, n.d.). Compared to the rest of the state, the community around North and Center Morrissey Boulevard has much higher percentages of residents who are non-white, low-income, reside in a limited English-speaking household, possess less than a high school education, and lack broadband access. Overall, these characteristics make this community more vulnerable to flood impacts: language barriers can prevent understanding emergency instructions and accessing disaster recovery aid, while limited internet access impedes emergency alerts and other communication during flood events. Individuals with less than a high school education may have limited access to information and resources needed

to effectively respond to flood emergencies. Historic underinvestment in non-white neighborhoods can make communities of color more susceptible to severe flood impacts, while low-income earners often lack the financial resources to prepare for, respond to, and recover from flooding. To support these residents, agencies could provide multilingual emergency alerts, translation services, financial assistance, community-based support programs, and easy-to-understand emergency preparedness materials. Improving infrastructure in high-risk areas would also be beneficial.

Impacts of Projected 2070 Storm Conditions

By 2070, this section of Morrissey Boulevard will have a 1% annual risk of flooding from heavy precipitation and a 10% annual risk of inundation from coastal flooding. Under these conditions, residents could expect partial or full lane closures and could see more traffic along detour routes and other neighborhood roads, such as Freeport Street and Old Colony Terrace as an access point through the Savin Hill neighborhood. The section of Morrissey Boulevard providing access to Malibu Beach already experiences flooding during coastal storms and king tides that closes the parkway, and this will become more frequent in the coming decades. Residents should plan to avoid driving, if possible, during coastal storms, and be mindful of upcoming king tides or storm surge.

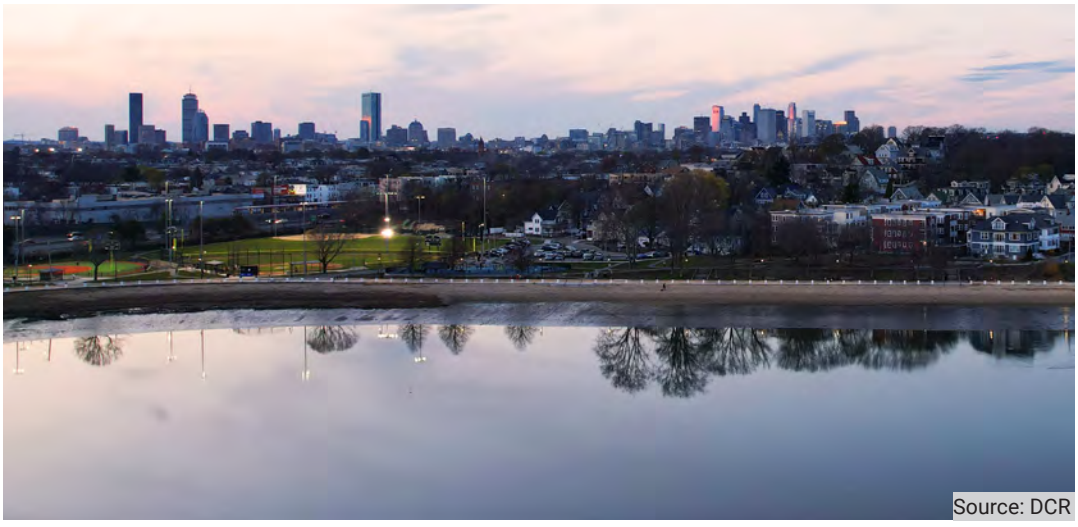
Beyond the immediate travel disruptions, flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has two schools, no hospitals, and no places of worship. For more about impacts to these community assets, see Appendix E. Inundation of the northern portion of Morrissey Boulevard may also isolate the community, with substantial compounding economic consequences.

Economic Costs of Flood Impacts

These impacts have economic costs to parkway users and residents. Morrissey Boulevard is a crucial regional and local transportation corridor, connecting South Shore communities and Dorchester with the rest of Boston ("Morrissey Boulevard Commission - Draft Status Report," n.d). If all of Morrissey Boulevard were to close for 24 hours due to active flooding or post-disaster clean-up, the total disruption cost would be $2,271,200 (2022 USD), which is the second highest disruption cost across the study area. The largest economic portion of the impact is the cost of lost business output ($1,906,800, 2022 USD), followed by lost wages ($171,000, 2022 USD), lost recreational visits ($100,500, 2022 USD), and reduced vehicular access and associated travel delays ($91,800, 2022 USD). Low-income workers are less likely to have the income, savings, or other assets needed to prepare for disasters and recovery efforts, so a temporary loss of income has a greater effect on those workers' abilities to withstand and recover from flood events. For more information on economic impacts of flooding, see Appendix D.

Savin Hill and Malibu Beach

Head to Savin Hill or Malibu Beach for a beach day without leaving the city. A playground and ball fields are nearby for even more summertime fun.



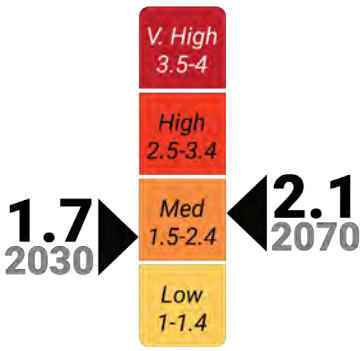
Source: DCR

FOCUS AREA 20

ALEWIFE BROOK

Alewife Brook-Concord Ave Rotary, Alewife Brook Parkway, Concord Avenue, Mount Auburn Street, Sozio Rotary

AVERAGE FLOOD VULNERABILITY SCORE



6.8
MILES

21,000
VEHICLES PER DAY

49
NEARBY ENVIRONMENTAL JUSTICE BLOCK GROUPS

2070 Vulnerability Hot Spots

Source: DCR

Fifty-five percent of parkways in Focus Area 20 Alewife Brook have a medium vulnerability and 17% have a high vulnerability. These parkways are exposed to coastal flooding during infrequent coastal storms where the Mystic River backs up into the Alewife Brook. The Alewife Brook is an urbanized waterway with much of the river corridor being channelized, which increases the likelihood of flooding into adjacent parkways during heavy precipitation.

Hot Spot 20A : Fresh Pond

The continuous stretch of parkway comprised of Alewife Brook-Concord Ave Rotary, Concord Ave, and Sozio Rotary near Fresh Pond has a high vulnerability to flooding because of exposure to precipitation-based and coastal flooding, and factors such as historic designations, presence of a MBTA bus route 74 and 78 and high traffic volumes. The section of Fresh Pond Parkway with a high vulnerability is due to a very high exposure score.

Hot Spot 20B: Alewife Station

The section of Alewife Brook Parkway that travels by the MBTA Alewife Station have high vulnerability due to a very high exposure score, because of exposure to precipitation and coastal flooding, the presence of numerous MBTA bus routes with the Alewife Station as their destination, and high traffic volumes.

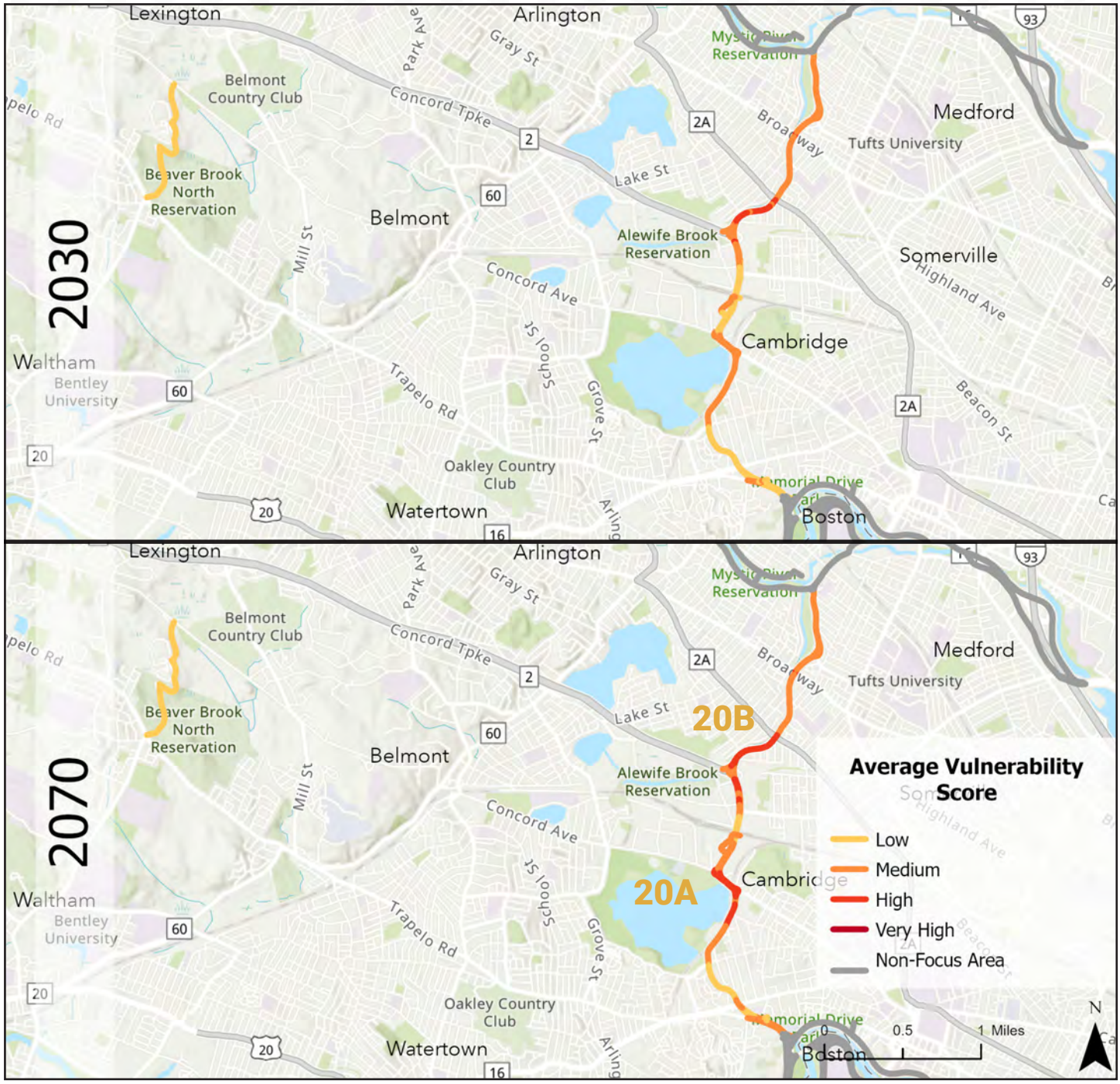


Figure 32a. Focus Area 20 - Alewife Brook Flood Vulnerability in 2030 and 2070.

Vulnerability	Miles (% share)		Cost of Replacement
	2030	2070	2070
Very High	0 (0%)	0 (0%)	$0
High	0.7 (10%)	3.1 (46%)	$20.0 Million
Medium	3.2 (47%)	1.9 (28%)	$11.9 Million
Low	3 (44%)	1.8 (26%)	$9.9 Million
Total	**6.8 100%**		**$41.8 Million**

HOT SPOT 20A

Fresh Pond

Community Vulnerability Impacts

Summary Statistics

11,300
TOTAL POPULATION

5,100
NUMBER OF HOUSEHOLDS

- 12% Low income
- People of color 40%
- 5% Persons with disabilities
- Limited English households 2%
- 3% Less than High School Education
- Under Age 5 5%
- 15% Over Age 64
- Households with Limited Broadband 7%

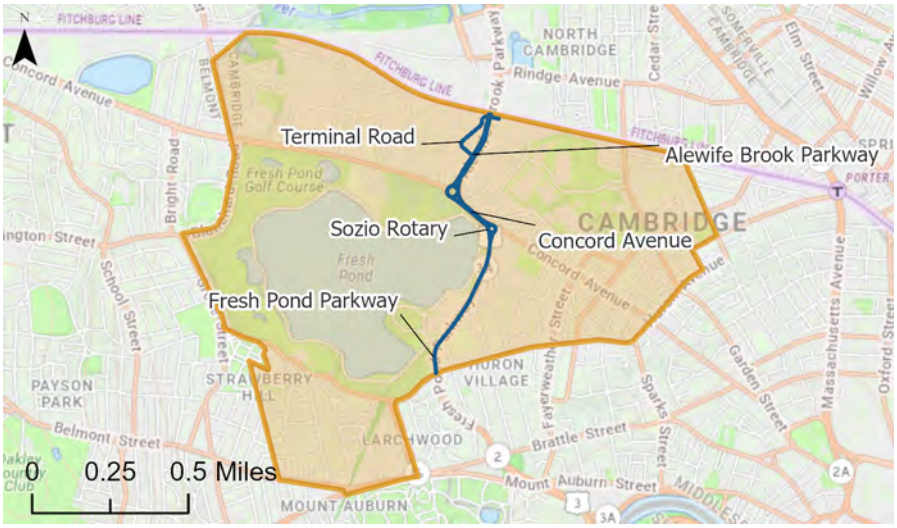


Figure 32b. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

Fresh Pond

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway (Smith, 2024). Compared to the rest of the state, the community around Fresh Pond has a higher percentage of people of color. While historic underinvestment in non-white neighborhoods can make communities of color more susceptible to severe flood impacts, this community's overall demographic statistics suggest lower overall vulnerability to flood impacts. For all residents, agencies could focus on improving infrastructure in high-risk areas, providing clear and accessible communication channels, and supporting community-based initiatives that promote safety and readiness. Additionally, offering regular training on flood preparedness and ensuring that emergency information is easy to understand would further enhance the community's resilience.

Impacts of Projected 2070 Storm Conditions

By 2070, Alewife Brook Parkway will have a 1% annual chance of flooding from heavy precipitation events and a 10% annual chance of inundation from coastal flooding events that affect the level of the Alewife Brook. When this area floods sections of the parkways could become impossible to use for people driving, walking, biking, and rolling ("Improving safety," n.d). Flooding along these parkway segments would likely mean that Fresh Pond's walking and biking trails were also experiencing inundation, which impact commutes to work and school and reduce access to recreational and conservation resources. The community could expect partial or full lane-closures until flood waters recede. The MBTA 74 and 78 bus routes would experience delays or routes cancelled by lane closures, and residents in the community should expect temporary detours and more traffic around the area. MBTA travel disruption alerts would play an important role in helping transit users navigate these challenges.

Beyond the immediate travel disruptions, flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has three hospitals, three schools, and no places of worship. For more about impacts to these community assets, see Appendix E.

Economic Costs of Flood Impacts

These impacts have economic costs to parkway users and residents. If Fresh Pond Parkway were to close for 24 hours due to active flooding or post-disaster clean-up, the total disruption cost would be $71,200 (2022 USD), with the largest economic portion of this impact stemming from lost recreational visits ($64,000, 2022 USD). Closure of adjacent parkway segments results in similar total disruption costs and recreational visit lost contribution. Implicated parkway segments include Alewife Brook-Concord Ave Rotary at $79,800 (2022 USD) with lost recreational visits at $77,400 (2022 USD); Concord Ave at $84,400 (2022 USD), with lost recreational visits at $77,400 (2022 USD), and Sozio Rotary at $79,200 (2022 USD), with recreational visits valued at $77,400 (2022 USD). For more information on economic impacts of flooding, see Appendix D.

Fresh Pond

The pond is a vital water supply source for the City of Cambridge and a popular recreational area. The resevoir and surrounding Fresh Pond Reservation features walking and biking trails, offering scenic views and opportunities for birdwatching.

Source: Wikimedia Commons

HOT SPOT 20B

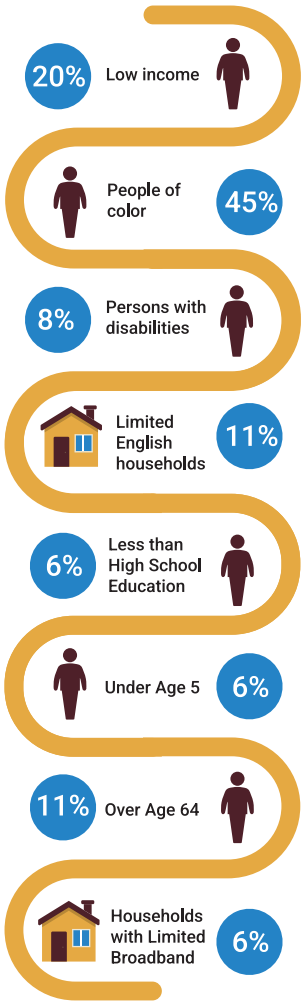
Alewife Station

Community Vulnerability Impacts

Summary Statistics

15,300
TOTAL POPULATION

6,700
NUMBER OF HOUSEHOLDS



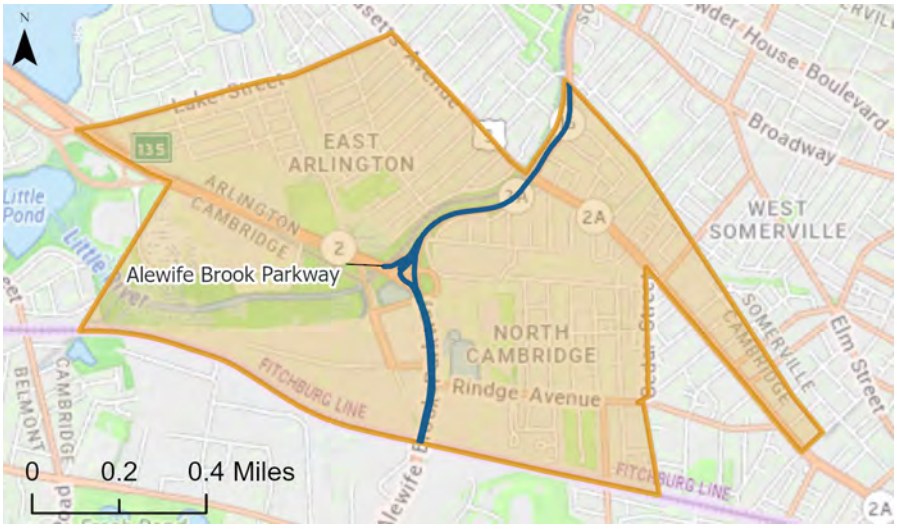


Figure 32c. The census-tract defined community (orange) near Hot Spot of parkway flood vulnerability (blue).

Alewife Station

EJ Communities

Communities considered socially or economically disadvantaged are more vulnerable to the impacts of a flooded parkway (Smith, 2024). Compared to the rest of the state, the community surrounding Alewife Stations has higher percentages of non-white residents, limited English-speaking households, and children under age 5. Historic underinvestment in non-white neighborhoods can make communities of color more susceptible to severe flood impacts, while language barriers can prevent residents with limited English from understanding emergency instructions and accessing disaster recovery aid. Finally, young children are particularly vulnerable during floods due to their increased health risks and mobility challenges. To support these residents, agencies could provide multilingual emergency alerts, translation services, and community-based support programs, as well as invest in improving drainage infrastructure. Compared to the rest of the state, this community also has fewer

residents who are low-income, have less than a high school education, have a disability, or lack broadband access. These demographic characteristics suggest lower overall vulnerability to flood impacts.

Impacts of Projected 2070 Storm Conditions

When this area floods due to precipitation-based flooding or coastal flooding from the Alewife Brook backing up, sections of the parkways could become impassable to people driving, biking, walking, or rolling ("Improving safety," n.d). By 2070, precipitation-based flooding is expected to occur at least 1% of the time annually and coastal flooding at least 10% of the time annually. Under these conditions, the community could expect partial or full lane closures until flood waters recede, leading to temporary detours and increased traffic around the area. Alewife Brook Parkway connects Fresh Pond and the Alewife Brook Reservation and provides access to the MBTA's Alewife Station. While alternate routes exist throughout the neighborhood, Alewife Brook Parkway offers the most direct connection over the Fitchburg Rail Line, and a closure would reduce access to North Cambridge. MBTA travel disruption alerts would play an important role in helping transit users navigate these challenges.

Beyond the immediate travel disruptions, flooding poses additional risks and challenges for community members seeking to access healthcare, education, employment, or community gathering spaces. While more detailed evaluation would be needed to assess local impacts, it is worth noting that the community has no hospitals, no schools, and two places of worship. For more about impacts to these community assets, see Appendix E.

Economic Costs of 2070 Storm Conditions

These impacts have economic costs to parkway users and residents. If Alewife Brook Parkway were to close for 24 hours due to active flooding or post-disaster clean-up, the total disruption cost would be $127,800 (2022 USD), with the largest economic portion of this impact stemming from lost recreational visits ($77,400, 2022 USD) and travel delays ($50,400, 2022 USD). For more information on economic impacts of flooding, see Appendix D.

Alewife Wetland Boardwalk

The boardwalk provides a short walking trail around a functioning stormwater wetland system that naturally treats stormwater before water is discharged into the Little River.

Source: Chris Rycroft via flickr

4 NEXT STEPS

The 2025 Parkways Climate Vulnerability Assessment provided valuable information about specific areas within the metro-Boston parkway system that are vulnerable to coastal and precipitation-based flooding in 2030 and 2070. This information can be used to update current programs and plans, and guide future actions to protect these areas.

DCR recently developed **11 Climate Adaptation Goals** to guide their efforts. These goals are consistent with the 2023 ResilientMass Plan, Executive Orders 594, 569, 604, and 618, the Recommendations of the Climate Chief, and the 2023 Advisory Council on Historic Preservation Climate Change and Historic Preservation Policy Statement. The following list describes how the Climate Adaptation Goals can be implemented to improve parkway flood vulnerability.

1. Adjust Recreational Facility Operations

By analyzing vulnerability results, DCR can identify parkways most at risk of flooding and adjust operational schedules accordingly. This might include closing certain sections during peak flood periods or reallocating staff to manage flood-prone areas, ensuring visitor safety and access.

2. Prioritize Critical Infrastructure for Safety and Access

The assessment identifies which parkway segments are most vulnerable to flooding. DCR can prioritize these areas for further development of adaptation strategies and infrastructure improvements, such as elevating roadways, enhancing drainage systems, or reinforcing embankments to mitigate flood risks.

3. Adapt Vulnerable Cultural Resources

Flood vulnerability data can help DCR identify cultural resources along parkways that are at risk. DCR can then implement protective measures, such as relocating artifacts or reinforcing structures, to preserve these resources from flood damage.

4. Learn from the Resilience of Tribal Nations and Indigenous People

By understanding flood vulnerabilities, DCR can collaborate with Tribal Nations and Indigenous communities to integrate traditional knowledge and practices that enhance resilience. This might include using natural flood barriers or sustainable land management techniques.

5. Prioritize Ecological Stewardship and Restoration

Vulnerability results can guide DCR in restoring ecosystems around flood-prone parkways. For example, parkways that are flood vulnerable and near an environmentally sensitive area may benefit from ecological restoration with features to improve flood resilience. Efforts can include planting flood-resistant vegetation, creating wetlands to absorb floodwaters, and improving soil health to enhance water infiltration and reduce runoff.

6. Increase the Pace of Land Acquisition

Identifying flood-prone areas can help DCR target land acquisitions that serve as natural buffers. Acquiring and conserving these lands can protect parkways by absorbing excess floodwaters and reducing the impact on infrastructure.

7. Develop a Proactive Policy for Relocation of Vulnerable Agency Assets

Flood vulnerability assessments can inform decisions on relocating parkway sections that are highly susceptible to flooding. DCR can plan for the strategic relocation of assets to safer areas, ensuring long-term resilience.

8. Design with Resilience in Mind

Using flood vulnerability data, DCR can update design standards to incorporate flood-resistant features.

9. Incorporate Climate-Smart Criteria into Capital Planning

Flood vulnerability results can be integrated into capital planning processes, ensuring that investments in parkway infrastructure are made with a focus on reducing flood risks. This strategic approach ensures that funds are used effectively to enhance resilience.

10. Empower Staff and Provide Oversight to Achieve Agency Goals

Training staff to understand and use flood vulnerability data will empower them to make informed decisions.

11. Communicate DCR's Climate Actions

Sharing flood vulnerability results with the public and stakeholders can enhance transparency and support for DCR's adaptation efforts.

Guided by their Climate Adaptation Goals, DCR will use this vulnerability data to keep improving the parkways' ability to handle flooding now and in the future. Making the parkways more flood-resistant will involve a mix of physical changes, environmental efforts, and organizational plans. This is an ongoing process where DCR will keep checking and updating their strategies based on new climate data and changing conditions.

5 REFERENCES

Improving safety for walking, biking, and rolling. U.S. Department of Transportation. (n.d.). https://www.transportation.gov/pedestrian-bicycle-safety

Smith Ph. D., Kristin. (2024, September 26). *The unequal impacts of flooding*. Headwaters Economics. https://headwaterseconomics.org/natural-hazards/unequal-impacts-of-flooding/

Massachusetts Climate Change Projections. (n.d.). https://www.mass.gov/files/ma-statewide-and-majorbasins-climate-projections-final.pdf

Morrissey Boulevard Commission - Draft Status Report. MorrisseyCommission_DraftStatusUpdateReport.pdf | Mass.gov. (n.d.). https://www.mass.gov/doc/morrissey-boulevard-commission-draft-status-report/

National Archives and Records Administration. (n.d.). *Justice40 Initiative | Environmental justice | The White House*. National Archives and Records Administration. https://bidenwhitehouse.archives.gov/environmentaljustice/justice40/

US Department of Commerce. (2018, March 12). *During a flood*. National Weather Service. https://www.weather.gov/safety/flood-during

Appendices

Appendix A: Vulnerability Assessment Indicator Tables

Appendix B: Parkway Average Metric and Vulnerability Scores

Appendix C: Parkways by Focus Area

Appendix D: Economic Impact Assessment

Appendix E: Impacts to Community Assets

Appendix F: The Massachusetts Coast Flood Risk Model FAQ

Table 1. Description and Summary of Indicators Used to Quantify Exposure in 2030 an 2070.							
Climate Parameter	**Indicator**	**Definition**	**Dataset**	**Question/Filter**	**Response / Score**	**Weighting (%)**	**Comment**
Present Conditions (2030)							
Precipitation 2030	Presence in the 2030 Total Inundation Extent.	Current (2030) exposure to precipitation-based flooding during a 10yr storm, as determined by a risk hazard polygon built out of three flood models (Charles 10yr 24hr, Mystic 10yr 24hr, BWSC Nor'easter 10 yr. 48 hr.), as well as the low-lying analysis and the FEMA 100 yr. area.	2030 Total Inundation Extent (made of Charles 10yr 24hr, Mystic 10yr 24hr, BWSC Nor'easter 10 yr. 48 hr.; low-lying analysis; FEMA 100 yr.).	Is the parkway segment present in the 2030 Total Inundation Extent?	Yes = 4 No = 1	40	25 ft Buffer on Parkways
Sea Level Rise/Storm Surge 2030	Presence in the MC-FRM.	This indicator shows current (2030) exposure to coastal flooding, as determined by 1% and 10% MC-FRM 2030 scenarios.	MC-FRM 2030 1% and 10%	In what MC-FRM 2030 scenario is the segment impacted?	The segment is present in the 10% model. = 4 The segment is present ONLY in the 1% model. = 2 The segment is not impacted. =	60	
Future Conditions (2070)							
Precipitation 2070	Presence in the 2070 total inundation extent.	Future (2070) exposure to precipitation-based flooding during a 100yr storm, as determined by a risk hazard polygon built out of three flood models (Mystic 2070 100 yr. 24hr, Charles 2070 100yr 24hr, BWSC 2030 Tropical 100yr 48h, FEMA 500-yr, and the low-lying analysis [precip increase])	2070 Total Inundation Extent (made of Charles 100yr 24hr, Mystic 100yr 24hr, BWSC Nor'easter 100 yr. 48 hr.; low-lying analysis; FEMA 500 yr.).	Is the parkway segment present in the 2070 Total Inundation Extent?	Yes = 4 No = 1	40	25 ft Buffer on Parkways
Sea Level Rise/Storm Surge 2070	Presence in the MC-FRM.	Future (2070) exposure to coastal flooding, as determined by the 1% and 10% MC-FRM 2070 scenarios.	MC-FRM 2070 1% and 10%	In what MC-FRM 2070 scenario is the segment impacted?	The segment is present in the 10% model. = 4 The segment is present ONLY in the 1% model. = 2 The segment is not impacted. = 1	60	

Table 2. Description and Summary of Indicators Used to Quantify Sensitivity.							
Climate Parameter	**Indicator**	**Definition**	**Dataset**	**Question/Filter**	**Response / Score**	**Weighting (%)**	**Comment**
SLR/SS and Precipitation	Past Experience with Flooding	Parkways that have experienced flooding during past heavy rain and/or flooding during extreme high tide events, and/or storm surge are more likely to be damaged if exposed in the future.	Historic Flooding Damage Assessment Tool (DCR)	Has the road segment experienced flooding in the past?	Yes = 4 No = 1	60	Data Collected during Fall 2023 workshops with Maintenance Staff
	Bus Route	Parkways with bus routes will be adversely impacted by loss of service from flood events. Parkways with bus routes are more critical than others without this service. Bus routes along or intersect (cross) a parkway will be included.	MBTA Bus Routes (MassGIS)	Is there a bus route along or intersecting the road segment?	Yes = 4 No = 1	25	25 ft Buffer on the Parkway
	Street Parking	The presence or absence of on-street parking. Parkways with on-street parking would require a more robust evacuation and emergency notification system/ plan. Higher potential for damage to parked vehicles.	List of allowable on-street parking locations (DCR).	Is there on-street parking (paid or unpaid) along the road segment?	Yes = 4 No = 1	15	N/A

Table 3. Description and Summary of Indicators Used to Quantify Adaptive Capacity.							
Climate Parameter	**Indicator**	**Definition**	**Dataset**	**Question/Filter**	**Response / Score**	**Weighting (%)**	**Comment**
SLR/SS and Precipitation	Exposure-Based Cost of Replacement	The in-kind replacement (reconstruction) cost for each flood impacted parkway segment was calculated in 2023 dollars using unit costs. The in-kind replacement was prorated based on the segment's exposure score where a lower exposure score reduces the replacement cost.	Estimated Cost of Replacement (Stantec). Unit costs based on MassDOR Average Weighted Bid Prices	The cost of replacement is within what % range for the dataset?	75% - 100% = 4 50% - 75% = 3 25% - 50% = 2 0% - 25% = 1	20	Quartiles based on data.
	Traffic Volume	Average Total Daily Volume of vehicles using the parkway as of Summer 2023 count data. Parkways with higher traffic volumes would experience more traffic impacts following a flood event.	Average Total Daily Volume across the three-day observation period (DCR, 2023 Count Program)	The Traffic Volume value is within what % range for the dataset?	75% - 100% = 4 50% - 75% = 3 25% - 50% = 2 0% - 25% = 1	15	Quartiles based on data.
	Average Bus Ridership	Average weekly ridership numbers for bus routes along a parkway or that intersect (cross) a parkway.	MBTA Bus Ridership data (MBTA/MassDOT) (Average weekly numbers from July 2022 to July 2023)	The average weekly Bus Ridership is within what % range of the dataset?	The bus ridership is within the 67-100% range for the dataset = 4 33-67% range for the dataset = 3 0-33% range for the dataset = 2 The segment has no ridership data because there is not a bus route along the segment = 1	10	Three Quantiles based on data and segments without bus ridership score= 1.
	Historic	Parkways listed on the National Register of Historic Places or eligible for listing on the National Register of Historic Places will have a lower adaptive capacity.	National Register of Historic Places https://www.mass.gov/doc/national-register-list-urban-parkways-0	The segment is listed on the National Register of Historic Places	Yes = 4 No = 1	5	N/A

Table 3. Description and Summary of Indicators Used to Quantify Adaptive Capacity.							
Climate Parameter	**Indicator**	**Definition**	**Dataset**	**Question/Filter**	**Response / Score**	**Weighting (%)**	**Comment**
Quartiles based on data. SLR/SS and Precipitation	Environmental	Parkways that overlap with area designated as ACEC, NHESP Species, or NHESP Natural Communities would require extra effort to replacement, design, permit, and construct and have a decreased adaptive capacity.	MassGIS Database. https://www.mass.gov/info-details/massgis-data-areas-of-critical-environmental-concern, https://www.mass.gov/info-details/massgis-data-nhesp-priority-habitats-of-rare-species, https://www.mass.gov/info-details/massgis-data-nhesp-natural-communities	The segment is within an ACEC or NHESP area.	75% - 100% = 4 50% - 75% = 3 25% - 50% = 2 0% - 25% = 1	5	25 Ft Buffer on Parkways
	2030 Economic Impact	The economic impact assessment calculated the total cost in 2022 dollars from a one-day disruption based on the MC-FRM 2030 1% scenario. Parkways with higher costs associated with a service outage will have higher economic and usage impacts across the parkways system and have a lower adaptive capacity.	Economic Impact Assessment. See appendix of CCVA.	The Economic Impact is within what % range of the dataset?	The economic impact is within the 67-100% range for the dataset. 33-67% range for the dataset. 0-33% range for the dataset. The segment has no economic impact data because there it is not impacted under the two study scenarios.	20	Three Quantiles
	Isolated Community	As part of the economic impact assessment, eight isolated communities (towns) were determined based on the flooding scenarios where a flooded parkway is the only transportation route into and out of these eight areas. A flooded parkway that creates an isolated community has a greater disruption to the transportation network and cascading economic impacts to these communities and the people therein. Such parkways have a lower adaptive capacity.	Economic Impact Assessment. See appendix of CCVA.	Under what MC-FRM Scenario does the segment create an isolated area?	The segment creates an isolated community under the 2030 and 2070 1% Scenario = 4 The segment creates an isolated community under only the 2030 1% Scenario = 3 The segment creates an isolated community under only 2070 1% Scenario = 2 The segment does not create an isolated community = 1	20	

Table 4. Exposure, Sensitivity, Adaptive Capacity, and Vulnerability Scores per Parkway.						
Parkway Name	Exposure		Sensitivity	Adaptive Capacity	Vulnerability	
	2030	2070			2030	2070
Agassiz Road	3.0	3.8	1.0	2.0	2.0	2.3
Arborway	1.0	1.1	1.3	1.8	1.4	1.4
Arlington Street	2.7	4.0	1.1	1.7	1.8	2.3
Babe Ruth Park Drive	1.5	3.7	1.0	1.7	1.4	2.1
Beacon Street	3.3	3.7	1.8	1.9	2.3	2.5
Beaver Place	1.0	2.8	1.0	1.0	1.0	1.6
Bellevue Hill Road	1.0	1.0	1.2	1.5	1.2	1.2
Berkeley Street	1.0	3.3	2.8	1.5	1.8	2.6
Birmingham Parkway	1.2	1.2	1.5	2.1	1.6	1.6
Blue Hill Avenue	1.0	1.0	1.8	1.3	1.3	1.3
Blue Hill River Road	1.0	1.0	1.3	1.5	1.2	1.2
Blue Hills Parkway	1.1	1.1	1.6	1.7	1.5	1.5
Boston University Bridge	1.0	1.0	1.8	1.7	1.5	1.5
Boundary Road	1.0	1.0	1.0	1.3	1.1	1.1
Bowker Overpass	1.2	1.5	2.5	1.7	1.8	1.9
Boylston Street	1.7	1.8	1.0	2.1	1.6	1.7
Boylston Street Service Road	1.0	1.5	1.0	1.6	1.2	1.4
Broad Sound Avenue	3.7	3.7	2.8	1.8	2.8	2.8
Brook Road	1.0	1.0	2.8	1.2	1.6	1.6
Brookline Avenue	3.6	4.0	1.8	2.4	2.6	2.7
Brookline Street	1.0	2.8	1.8	1.8	1.5	2.1
Brooks Street	3.4	4.0	1.8	2.3	2.5	2.7
Cambridge Parkway	3.0	3.2	1.4	2.1	2.2	2.2
Cambridge Parkway Connector	3.7	3.9	1.3	2.1	2.3	2.4
Cambridge Street	2.2	2.8	3.6	1.9	2.5	2.8
Centre Street	1.0	1.0	1.8	1.9	1.5	1.5
Charles River Road	3.7	3.8	1.0	2.1	2.3	2.3
Charles Street	1.0	2.7	1.0	1.7	1.2	1.8
Charles Street Circle	1.0	1.6	1.0	1.6	1.2	1.4

Table 4. Exposure, Sensitivity, Adaptive Capacity, and Vulnerability Scores per Parkway.						
Parkway Name	Exposure		Sensitivity	Adaptive Capacity	Vulnerability	
	2030	2070			2030	2070
Charlesbank Road	1.9	1.9	1.0	1.8	1.6	1.6
Charlesgate East	2.1	2.7	2.0	1.6	1.9	2.1
Charlesgate West	1.0	2.7	2.4	1.3	1.6	2.1
Chestnut Hill Driveway	1.0	1.0	1.0	1.6	1.2	1.2
Chestnut Street	1.0	1.0	1.0	1.3	1.1	1.1
Chickatawbut Road	1.0	1.0	1.5	1.5	1.3	1.3
Commandant'S Way	1.5	1.6	1.1	1.5	1.4	1.4
Concord Avenue	1.1	4.0	1.8	2.1	1.6	2.6
Connector Mystic Valley Parkway	2.0	3.1	1.4	1.8	1.7	2.1
Connector To Eliot Bridge	1.1	3.2	1.0	1.4	1.2	1.9
David G Mugar Way	1.0	2.8	1.7	1.0	1.2	1.8
Dedham Boulevard	1.0	1.0	1.0	1.3	1.1	1.1
Dedham Parkway	1.0	1.0	1.6	1.6	1.4	1.4
Earhart Dam Access Road - Somerville Side	1.6	4.0	1.0	1.9	1.5	2.3
East Border Road	1.0	1.1	1.0	1.6	1.2	1.2
East Broadway	1.2	2.6	1.1	2.1	1.5	1.9
Eliot Circle	2.2	2.8	3.0	2.1	2.4	2.6
Elm Street	1.2	1.7	1.1	1.9	1.4	1.6
Embankment Road	1.0	3.1	1.4	2.3	1.6	2.3
Enneking Parkway	1.3	1.3	1.3	1.5	1.4	1.4
Enneking Parkway Branch	1.0	1.0	1.1	1.2	1.1	1.1
Evans Way	2.4	3.1	1.2	1.8	1.8	2.0
Everett Street	1.0	2.5	1.1	1.2	1.1	1.6
Fellsway	1.3	2.4	1.9	1.9	1.7	2.1
Fellsway East	1.2	1.4	1.1	1.6	1.3	1.4
Fellsway West	1.2	1.8	1.6	1.9	1.6	1.8
Fenway	1.6	2.6	1.5	2.2	1.8	2.1
Fenway Connector To Park Drive	2.9	3.1	1.7	2.0	2.2	2.3

Table 4. Exposure, Sensitivity, Adaptive Capacity, and Vulnerability Scores per Parkway.						
Parkway Name	Exposure		Sensitivity	Adaptive Capacity	Vulnerability	
	2030	2070			2030	2070
Fenway Service Road	1.0	1.0	1.0	1.7	1.2	1.2
First Street	2.8	3.9	1.5	2.0	2.1	2.5
Forest Grove Road	1.6	1.6	1.0	1.2	1.2	1.2
Forest Street	1.1	1.1	1.2	1.3	1.2	1.2
Forsyth Way	1.3	1.9	1.0	1.6	1.3	1.5
Franklin Park Circle	1.0	1.0	2.2	1.7	1.6	1.6
Fresh Pond Parkway	1.0	2.1	1.3	2.2	1.5	1.9
Frontage Road	1.0	1.0	1.7	1.8	1.5	1.5
Fulton Street	1.0	2.2	1.8	1.3	1.3	1.7
Furnace Brook Parkway	2.1	2.2	1.3	1.8	1.7	1.8
Furnace Brook Rotary	1.1	1.1	1.0	1.4	1.2	1.2
Gerrys Landing Road	1.0	2.2	1.0	1.0	1.0	1.4
Gilmore Bridge	1.3	2.9	1.1	1.8	1.4	1.9
Green Street	1.0	1.0	1.0	1.5	1.2	1.2
Greenough Boulevard	2.8	3.6	1.0	2.0	2.0	2.2
Grove Street	2.3	3.6	1.0	1.4	1.6	2.0
Hammond Pond Parkway	1.0	1.0	1.2	1.9	1.4	1.4
Harvard Avenue	3.0	4.0	1.0	1.8	1.9	2.3
Hayden Street	1.8	1.8	1.0	1.3	1.4	1.4
Hemlock Road	1.0	1.0	1.0	1.3	1.1	1.1
High Street	3.1	4.0	1.8	1.9	2.3	2.6
Highland Avenue	1.0	1.5	2.2	1.5	1.6	1.7
Hillcrest Parkway	1.0	1.0	1.0	1.5	1.2	1.2
Hillside Street	1.0	1.1	1.0	1.5	1.2	1.2
Horace James Circle	1.0	1.0	1.6	1.6	1.4	1.4
Hull Shore Drive	4.0	4.0	2.2	2.3	2.8	2.8
Hyde Park Avenue	1.0	1.0	1.8	1.9	1.5	1.5
Jamaicaway	1.1	1.1	1.1	2.3	1.5	1.5
Jamaicaway Frontage Road	1.0	1.0	1.5	1.8	1.5	1.5
Jerome Street	2.4	4.0	1.0	1.7	1.7	2.3

Table 4. Exposure, Sensitivity, Adaptive Capacity, and Vulnerability Scores per Parkway.						
Parkway Name	Exposure		Sensitivity	Adaptive Capacity	Vulnerability	
	2030	2070			2030	2070
Jfk-Umass Station Road	1.3	3.5	2.0	2.1	1.8	2.5
Kelley Circle	1.0	1.0	1.0	1.3	1.1	1.1
Kosciuszko Circle	1.0	1.1	1.6	1.8	1.4	1.5
Land Boulevard	1.4	2.9	1.0	2.0	1.5	2.0
Louis Prang Street	1.3	4.0	2.7	2.1	2.0	2.9
Lynn Fells Parkway	1.5	1.6	1.1	1.7	1.4	1.5
Lynnway Underpass - Rt 1A Sb To Lynnway	2.8	3.6	1.7	2.3	2.3	2.5
Massachusetts Avenue	3.2	3.2	3.0	2.4	2.9	2.9
Medford Street	3.0	4.0	1.8	2.3	2.4	2.7
Metropolitan Road North	1.0	1.0	1.0	1.3	1.1	1.1
Metropolitan Road South	1.0	1.0	1.0	1.3	1.1	1.1
Middlesex Rotary	1.0	1.7	1.8	1.7	1.5	1.7
Milton Street	1.0	1.0	1.8	1.8	1.5	1.5
Morrissey Service Road	2.0	3.8	1.8	1.9	1.9	2.5
Morton Street	1.0	1.0	1.4	2.0	1.5	1.5
Mount Auburn Street	1.0	1.8	1.7	1.9	1.5	1.8
Mount Vernon Street	2.7	4.0	1.8	2.3	2.2	2.7
Murray Circle	1.0	1.0	1.8	1.5	1.4	1.4
Mystic River Road	3.1	4.0	1.5	1.7	2.1	2.4
Mystic Valley Parkway	2.0	3.2	1.2	2.2	1.8	2.2
Mystic Valley-Alewife Brook Rotary	1.4	4.0	1.0	2.2	1.5	2.4
Mystic View Road	1.8	2.9	1.7	2.2	1.9	2.3
Nahant Circle	3.5	3.5	3.6	2.2	3.1	3.1
Neponset Valley Parkway	1.0	1.2	1.4	1.8	1.4	1.5
New South Street	1.0	1.0	1.5	1.1	1.2	1.2
Noble Street	2.8	2.8	2.8	1.9	2.5	2.5
Nonantum Road Branch	3.7	3.7	1.0	2.1	2.3	2.3
North Border Road	1.0	1.0	1.0	1.4	1.1	1.1
North Harvard Street	1.0	1.0	3.6	2.4	2.3	2.3

Table 4. Exposure, Sensitivity, Adaptive Capacity, and Vulnerability Scores per Parkway.						
Parkway Name	Exposure		Sensitivity	Adaptive Capacity	Vulnerability	
	2030	2070			2030	2070
Norumbega Road	1.1	1.2	1.0	1.3	1.1	1.2
Ocean Avenue	3.2	3.8	3.2	2.0	2.8	3.0
Ocean Street	4.0	4.0	1.8	2.4	2.7	2.7
Orchardhill Road	1.0	1.0	1.8	1.8	1.5	1.5
Park Street	1.0	1.0	1.0	1.6	1.2	1.2
Parkman Drive	1.0	1.0	1.0	1.2	1.1	1.1
Pelton Street	1.0	1.0	1.9	1.4	1.4	1.4
Perkins Street	1.0	1.0	1.3	1.3	1.2	1.2
Pine Street	1.0	2.2	1.0	1.2	1.0	1.5
Pond Street	1.0	1.0	1.7	1.7	1.5	1.5
Ponkapoag Trail	1.0	1.0	1.0	1.2	1.1	1.1
Quinobequin Road	1.7	1.7	1.0	1.6	1.4	1.4
Ramp To Charles Circle	1.0	2.8	1.0	1.9	1.3	1.9
Ramp-Berkeley St To Rt 28 Nb	1.0	2.8	2.0	1.8	1.6	2.2
Ramp-Bu Bridge To Memorial Dr Eb	1.5	1.8	1.7	2.2	1.8	1.9
Ramp-Cambridgeprt Cir To Bu Bridge	1.0	1.0	1.8	2.0	1.6	1.6
Ramp-Cambridgeprt Cir To Mem Dr Wb	1.0	2.8	1.1	1.8	1.3	1.9
Ramp-Charles St To Longfellow Bridge	1.0	3.1	1.0	1.8	1.3	2.0
Ramp-Charlesgate Overpass To Charlesgate	1.4	1.6	1.6	2.0	1.7	1.7
Ramp-Jamaicaway To Rt 9	2.8	4.0	1.0	2.4	2.1	2.5
Ramp-Main Street To Rt 16 Wb	2.8	4.0	1.1	2.1	2.0	2.4
Ramp-Mem Dr To Cambridgeprt Cir Eb	1.0	2.8	1.1	1.8	1.3	1.9
Ramp-N Harvard St To Soldiers Field Eb	1.8	2.8	1.4	2.4	1.9	2.2
Ramp-Roosevelt Cir To Valley St	1.5	1.7	1.8	1.4	1.6	1.6

Table 4. Exposure, Sensitivity, Adaptive Capacity, and Vulnerability Scores per Parkway.						
Parkway Name	Exposure		Sensitivity	Adaptive Capacity	Vulnerability	
	2030	2070			2030	2070
Ramp-Rt 16 Wb To Main Street	2.8	3.9	1.8	2.2	2.2	2.6
Ramp-Rt 28 Nb To Cambridge St	1.0	2.2	1.0	1.8	1.2	1.7
Ramp-Rt 3 To Rt 28 Sb	1.0	3.0	1.0	2.2	1.4	2.1
Ramp-Rt 9 To Jamaicaway	1.9	2.5	1.0	2.2	1.7	1.9
Ramp-Soldiers Field Rd Eb To Western Ave	1.0	2.8	1.1	1.4	1.2	1.8
Ramp-Soldiers Field Rd Wb To Birmingham	1.6	1.6	1.1	2.0	1.6	1.6
Ramp-Soldiers Field Rd Wb To Western Ave	3.2	3.5	1.2	2.3	2.2	2.4
Ramp-Storrow Dr To Rt 2A Wb	1.7	2.8	2.9	2.1	2.2	2.6
Ramp-Western Ave To Soldiers Field Rd Eb	1.5	2.3	2.3	2.1	2.0	2.2
Ravine Road	1.0	1.0	1.1	1.4	1.1	1.1
Recreation Road	1.0	1.0	1.2	1.4	1.2	1.2
Reid Rotary	1.0	1.9	1.8	2.0	1.6	1.9
Reservation Road	1.3	1.3	1.8	1.7	1.6	1.6
Reservoir Street	1.0	1.0	1.0	1.2	1.1	1.1
River Street	1.7	1.7	1.8	1.9	1.8	1.8
Riverway Frontage Road	1.0	1.1	1.5	2.0	1.5	1.6
Roosevelt Circle	1.0	1.1	1.8	1.4	1.4	1.4
Saint Thomas More Road	1.0	1.0	1.0	1.2	1.1	1.1
Salem Street	1.0	2.2	1.8	1.5	1.4	1.8
Sawmill Lane	1.8	1.8	1.0	1.6	1.5	1.5
Sheepfold Driveway	1.0	1.0	1.0	1.0	1.0	1.0
Shirley Avenue	1.9	2.2	2.8	2.2	2.3	2.4
Shore Road	3.7	3.9	1.5	1.8	2.3	2.4
Smith Field Road	1.5	1.5	1.3	1.6	1.5	1.5
Soldiers Field Road Extension	2.6	3.0	1.0	2.4	2.0	2.1
South Border Extension	1.0	1.7	1.0	1.2	1.1	1.3

Table 4. Exposure, Sensitivity, Adaptive Capacity, and Vulnerability Scores per Parkway.						
Parkway Name	Exposure		Sensitivity	Adaptive Capacity	Vulnerability	
	2030	2070			2030	2070
South Border Road	1.0	1.1	1.0	1.5	1.2	1.2
South Street	1.0	1.0	1.8	1.9	1.5	1.5
Sozio Rotary	1.0	4.0	1.8	2.2	1.6	2.6
State Road	3.7	4.0	1.9	2.0	2.5	2.6
Terminal Road	1.4	4.0	1.0	1.9	1.4	2.3
Truman Parkway	1.0	1.0	1.7	1.7	1.5	1.5
Turtle Pond Parkway	1.0	1.0	1.7	1.6	1.4	1.4
Turtle Pond Parkway Branch	1.0	1.0	1.3	1.1	1.1	1.1
Unnamed Road - Boylston St & Fenway	1.0	1.0	1.0	1.5	1.2	1.2
Unnamed Road - Fellsway East	1.0	1.0	1.0	1.2	1.0	1.0
Unnamed Road - Fellsway West 1	2.2	2.2	1.8	1.6	1.8	1.8
Unnamed Road - Fellsway West 2	2.2	2.2	1.8	1.5	1.8	1.8
Unnamed Road - Fenway	1.0	2.2	1.0	1.6	1.2	1.6
Unnamed Road - First Street & Memorial Dr	3.2	3.2	1.6	2.0	2.3	2.3
Unnamed Road - Fresh Pond Parkway	1.0	2.2	1.0	1.0	1.0	1.4
Unnamed Road - Greenough Boulevard	3.6	4.0	1.0	1.6	2.1	2.2
Unnamed Road - Land Boulevard	1.0	2.8	1.0	1.3	1.1	1.7
Unnamed Road - Main St & Memorial Dr	1.6	2.8	1.0	1.6	1.4	1.8
Unnamed Road - Memorial Dr & Land Boulevard	1.2	3.6	1.0	1.7	1.3	2.1
Unnamed Road - Memorial Dr 1	2.2	2.8	2.8	2.1	2.4	2.6
Unnamed Road - Memorial Dr 2	2.8	4.0	1.0	1.9	1.9	2.3

Table 4. Exposure, Sensitivity, Adaptive Capacity, and Vulnerability Scores per Parkway.						
Parkway Name	Exposure		Sensitivity	Adaptive Capacity	Vulnerability	
	2030	2070			2030	2070
Unnamed Road - Memorial Dr 3	1.9	3.4	1.0	1.7	1.5	2.0
Unnamed Road - Memorial Dr 4	4.0	4.0	1.0	2.0	2.4	2.4
Unnamed Road - Memorial Dr 5	1.9	4.0	1.0	1.8	1.6	2.3
Unnamed Road - Memorial Dr 6	2.8	2.8	1.0	1.9	1.9	1.9
Unnamed Road - Park Dr	1.2	2.8	1.4	1.7	1.4	2.0
Unnamed Road - Storrow Dr & David G Mugar Way	1.0	2.8	2.8	1.4	1.7	2.4
Unquity Road	1.0	1.0	1.4	1.5	1.3	1.3
Valley Street	2.0	2.2	1.8	1.6	1.8	1.8
Veterans Of Foreign Wars Parkway	1.0	1.0	1.2	1.9	1.4	1.4
Wampatuck Road	1.0	1.1	1.0	1.5	1.2	1.2
Washington Street	1.0	1.0	1.8	2.0	1.6	1.6
Wave Avenue	2.8	2.8	1.6	1.8	2.1	2.1
West Border Road	1.0	1.1	1.0	1.2	1.1	1.1
West Roxbury Centre Street Rotary	1.0	1.0	1.8	1.9	1.5	1.5
West Roxbury Parkway	1.0	1.0	1.5	1.7	1.4	1.4
West Roxbury Vfw Parkway Rotary	1.0	1.3	1.0	1.7	1.2	1.4
West Street	4.0	4.0	2.8	2.3	3.0	3.0
Western Avenue	1.5	1.8	2.9	2.3	2.2	2.3
Westland Entrance	1.0	1.6	1.0	1.4	1.1	1.3
Wharf Avenue	4.0	4.0	3.6	1.8	3.1	3.1
Wiley Street	1.0	2.2	1.0	1.2	1.0	1.5
Willard Street	1.2	1.2	1.0	1.0	1.1	1.1
Willow Pond Road	1.0	1.0	2.0	1.2	1.4	1.4
Woerd Avenue	1.6	1.6	1.0	1.2	1.3	1.3
Wood Street Spur	1.0	1.0	1.9	1.2	1.3	1.3

Table 4. Exposure, Sensitivity, Adaptive Capacity, and Vulnerability Scores per Parkway.						
Parkway Name	Exposure		Sensitivity	Adaptive Capacity	Vulnerability	
	2030	2070			2030	2070
Woodland Road	1.0	1.0	1.5	1.7	1.4	1.4
Wyoming Avenue	1.0	1.0	1.8	1.5	1.4	1.4

Parkways

Organized by Focus Area (FA) (based on the Focus Areas in the 2020 Parkways Master Plan), the following parkways are included in the study area:

FA 1: Revere Beach and Lynn Shore

Broad Sound Avenue

Carroll Parkway

Eastern Avenue

Eliot Circle

Humphrey Street

Lynn Shore Drive

Lynnway

Lynnway Underpass - Rt 1a Sb to Lynnway

Nahant Circle

Nahant Road

Noble Street

Oak Island Street

Ocean Avenue

Ocean Street

Revere Beach Boulevard

Revere Beach Parkway

Revere Street

Shirley Avenue

State Road

Wave Avenue

West Street

Winthrop Parkway

Winthrop Shore Drive

FA 2: Middlesex Fells

Boundary Road

East Border Road

Elm Street

Fellsway

Fellsway East

Fellsway West

Fulton Street

Highland Avenue

Hillcrest Parkway

Middlesex Rotary

New South Street

North Border Road

Park Street

Pine Street

Pond Street

Ramp-Roosevelt Circle to Valley St

Ravine Road

Reservoir Street

Roosevelt Circle

Salem Street

Sheepfold Driveway

South Border Extension

South Border Road

South Street

Unnamed Road - Fellsway East

Unnamed Road - Fellsway West 1

Unnamed Road - Fellsway West 2

Valley Street

West Border Road

Wiley Street

Woodland Road

Wyoming Avenue

FA 3: Lynn Fells and Breakheart

Forest Street

Hemlock Road

Lynn Fells Parkway

FA 4: Mystic Valley

Arlington Street

Commandant's Way

Connector Mystic Valley Parkway

Earhart Dam Access Road - Somerville Side

Earhart Dam Road

Harvard Avenue

High Street

Jerome Street

Medford Street

Mystic River Road

Mystic Valley Parkway

Ramp-Main Street to Rt 16 Wb

Ramp-Rt 16 Wb to Main Street

FA 5: Upper Charles

Forest Grove Road

Norumbega Road

Quinobequin Road

Recreation Road

Woerd Avenue

FA 6: Charles River Basin West

Arsenal Street

Birmingham Parkway

Brooks Street

Cambridge Street

Charles River Road

Charlesbank Road

Connector To Eliot Bridge

Everett Street

Gerrys Landing Road

Greenough Boulevard

Grove Street

Nonantum Road

Nonantum Road Branch

North Beacon Street

North Harvard Street

Ramp-N Harvard St to Soldiers Field Eb

Ramp-N Harvard St to Soldiers Field Wb

Ramp-Soldiers Field Eb to N Harvard St

Ramp-Soldiers Field Rd Eb to Western Ave

Ramp-Soldiers Field Rd Wb to Birmingham

Ramp-Soldiers Field Rd Wb to Western Ave

Ramp-Soldiers Field Wb to N Harvard St

Ramp-Western Ave to Soldiers Field Rd Eb

Ramp-Western Ave to Soldiers Field Rd Wb

Soldiers Field Road

Soldiers Field Road Extension

Unnamed Road - Greenough Boulevard

Western Avenue

FA 7: Charles River Basin East

Beacon Street

Beaver Place

Berkeley Street

Boston University Bridge

Bowker Overpass

Brookline Street

Cambridge Parkway

Cambridge Parkway Connector

Charles Street

Charles Street Circle

Charlesgate East

Charlesgate West

David G Mugar Way

Embankment Road

First Street

Gilmore Bridge

Land Boulevard

Memorial Drive

Memorial Drive Underpass

Ramp-Berkeley St to Rt 28 Nb

Ramp-Bu Bridge to Memorial Dr Eb

Ramp-Cambridgeport Cir to Bu Bridge

Ramp-Cambridgeport Cir to Mem Dr Wb

Ramp-Charles St to Longfellow Bridge

Ramp-Charlesgate Overpass to Charlesgate

Ramp-Mem Dr to Cambridgeport Cir Eb

Ramp-Mem Dr to Cambridgeport Cir Wb

Ramp-Rt 28 Nb to Cambridge St

Ramp-Rt 3 To Rt 28 Sb

Ramp To Charles Circle

Reid Rotary

Storrow Drive

Unnamed Road - First Street & Memorial Dr

Unnamed Road - Land Boulevard

Unnamed Road - Main St & Memorial Dr

Unnamed Road - Memorial Dr & Land Boulevard

Unnamed Road - Memorial Dr 1

Unnamed Road - Memorial Dr 2

Unnamed Road - Memorial Dr 3

Unnamed Road - Memorial Dr 4

Unnamed Road - Memorial Dr 5

Unnamed Road - Memorial Dr 6

Unnamed Road - Storrow Dr & David G Mugar Way

FA 8: Old Harbor

Babe Ruth Park Drive

East Broadway

JFK-UMass Station Road

Kosciuszko Circle

Old Colony Avenue

Shore Road

William Day Boulevard

FA 9: Back Bay Fens

Agassiz Road

Boylston Street

Boylston Street Service Road?

Brookline Avenue

Evans Way

Fenway

Fenway Connector to Park Drive

Fenway Service Road?

Forsyth Way

Louis Prang Street

Massachusetts Avenue

Park Drive

Ramp-Storrow Dr to Rt 2a Wb

Unnamed Road - Boylston St & Fenway

Unnamed Road - Fenway

Unnamed Road - Fenway & Park Dr

Unnamed Road - Park Dr

Westland Entrance

FA 10: Chestnut Hill

Chestnut Hill Driveway

FA 11: Jamaica Pond

Chestnut Street

Jamaicaway

Jamaicaway Frontage Road

Parkman Drive

Perkins Street

Ramp-Jamaicaway to Rt 9

Ramp-Rt 9 to Jamaicaway

Riverway

Riverway Frontage Road

Unnamed Road - Riverway

Willow Pond Road

FA 12: VFW Parkway

Arborway

Centre Street

Frontage Road

Hyde Park Avenue

Kelley Circle

Morton Street

Murray Circle

Orchardhill Road

South Street

Veterans Of Foreign Wars Parkway

Washington Street

FA 13: Hammond Pond Parkway

Hammond Pond Parkway

Horace James Circle

FA 14: West Roxbury

Bellevue Hill Road

Franklin Park Circle

Pelton Street

West Roxbury Centre Street Rotary

West Roxbury Parkway

West Roxbury VFW Parkway Rotary

FA 15: Stony Brook and Neponset

Blue Hill Avenue

Brook Road

Dedham Boulevard

Dedham Parkway

Enneking Parkway

Enneking Parkway Branch

Hyde Park Avenue

Milton Street

Neponset Valley Parkway

Reservation Road

River Street

Sawmill Lane

Smith Field Road

Truman Parkway

Turtle Pond Parkway

Turtle Pond Parkway Branch

FA 16: Blue Hills

Blue Hill River Road

Blue Hills Parkway

Chickatawbut Road

Green Street

Hillside Street

Ponkapoag Trail

Unquity Road

Wood Street Spur

FA 17: South Shore

Furnace Brook Parkway

Furnace Brook Rotary

Hayden Street

Neponset Avenue

Quincy Shore Drive

Wampatuck Road

Willard Street

FA 18: Nantasket

Hull Shore Drive

Nantasket Avenue

Wharf Avenue

FA 19: Morrissey

Morrissey Service Road

Mount Vernon Street

William T Morrissey Boulevard

FA 20: Alewife Brook

Alewife Brook- Concord Ave Rotary

Alewife Brook Parkway

Concord Avenue

Fresh Pond Parkway

Metropolitan Road North

Metropolitan Road South

Mount Auburn Street

Mystic Valley-Alewife Brook Rotary

Sozio Rotary

Terminal Road

Unnamed Road - Fresh Pond Parkway

Economic Impacts of Flood Scenarios

Massachusetts Department of Conservation and Recreation
Parkways System

APRIL 2024

EBP

Contents

Summary of Approach

This supplementary report details the methodology and results of the economic consequences analysis of flood disruption scenarios that may impact the DCR Parkway network through 2070. Vulnerability and flood hydrology analyses conducted for this study identified over 3400 individual DCR Parkway segments that would be flooded under the flood scenarios considered. These individual segments – generally short sections of one hundred to several hundred feet in length -- were ultimately rolled up to approximately 110 distinct roadways within the overall DCR Parkway network that would experience flood disruption over significant portions of their overall length. The list of named DCR Parkways are given in the Results section of this technical report, along with the economic impacts incurred for each roadway.

Economic impacts measured in this analysis comprise four types of disruption costs:

1. General disruption of traffic – DCR Parkways are major thoroughfares throughout the Boston metropolitan region. Utilizing in-street monitors, traffic counts were compiled as part of this study. These counts were combined with assumptions about detour time penalties (% reduction in travel speeds from posted speed limits during periods of roadway flooding) to estimate increased vehicle hours of travel for all vehicular traffic for all impacted roadway segments. These increases were then monetized utilizing USDOT monetization factors for the economic value of travel time.
2. Loss of recreational visitor access – While general disruption to traffic applies to all vehicle trips for all travel purposes, and is independent of origin and destination, the DCR parkways also provide recreational opportunities along the roadways themselves. Parkway land adjacencies feature a variety of recreational amenity destinations, including bike and pedestrian paths, picnic facilities, boating facilities, etc. Flood events would restrict access to these amenities, significantly impacting a core part of DCR's mission to provide recreational access to the Commonwealth's people. To estimate the value of lost recreational access, the traffic counts were combined with modeled estimates of inbound vehicular trips for recreational purposes to impacted parkways to estimate inbound recreational trips per day. These trips would be lost during periods of disruption. Our analysis monetized these lost recreational trips based on a survey of research regarding users' valuation of recreational visits to urban parks. That survey (detailed in Appendix A of this report) determined that urban park visitors value a person visit at $35 per day.
3. Isolated Area Economic Losses – There are a limited number of communities in the Boston metro region that, due to the geography of the region, can only be reached by vehicles using a particular DCR Parkway. These communities, which tend to be areas surrounded by water bodies, are generally accessed by narrow causeway-type parkway segments. These communities would be isolated from vehicular access in the event of a major flood event, and are served by the following parkways:

    - Nantasket Avenue
    - Quincy Shore Drive
    - William T Morrissey Boulevard

- Lynnway
- Carroll Parkway
- Nahant Road
- Mystic View Road
- Winthrop Parkway

For these areas, the economic consequences of a major flood event include:

- lost wages for workers who reside in those communities who commute to jobs outside of their communities (adjusted for telecommuting)
- lost business output for businesses located within the isolated communities, which would not be able to be reached by their employees or customers (also adjusted for telecommuting)

Most individual Parkway flood events would not create an isolated community. Therefore, for most of the more than 100 Parkways or parkway segments included in the analysis, no economic losses of this type were included in the total impact.

4. Lost On Street Parking Economic Value – DCR parkways also provide economic value through the curbside real estate they have available for parking. DCR provided data on the linear feet of curb space available for parking on parkways where on-street parking is available. We divided that length by the assumed length of a parking space (22 feet). We then multiplied that value by a cost per parking space per hour that was determined by conducting a survey of on-street parking rates in the Boston metropolitan area available online through city websites and services such as SpotHero. Cambridge Parkway and Memorial Drive are the only parkways in the system with revenue-generating parking. Those two parkways were valued at the highest on-street parking rate in the area seen online ($3.75 per spot per hour), while other parkways were valued at a lower rate determined using the same sources ($1 per spot per hour).

In addition to those four impacts which were measured and monetized, flooding of DCR parkways will likely result in some degree of immediate damage, which can extend from minor and easily rectified conditions such as debris on the roadway, downed trees, to physical damages to roadway surfaces, curbs, sidewalks and bike paths, recreational facilities, and utilities. In addition, flooding conditions may require police and other interventions to control and redirect traffic, or to even conduct rescue operations. However, each parkway is constructed differently, is in presently different condition, and consists of considerably different adjoining infrastructure. We have therefore made no attempt in this study to predict how each affected parkway segment would be damaged or how much repair would be required, and thus no costs have been assigned in the economic analysis. However, as described in the primary report for this study, estimates were made of the costs to completely replace damaged parkways to the previous condition and design.

Scenarios Analyzed

The environmental and hydrological assessments resulted in two analysis scenarios. Both scenarios are defined as the 1% flood, which is the probability of the flood of that severity occurring in any given year. It may also be understood as the "one hundred year" flood event. For that level of flood severity, a 2030 and a 2070 scenario are considered. The flood disruption may be greater in year 2070 as climate change progresses, and impacts may be more severe due to both higher flood severity and greater vulnerability arising from population, employment, and traffic growth in impacted parkway areas.

- Scenario 1: 1% flood, 2030 (Figure 1.)
- Scenario 2: 1% flood, 2070 (Figure 2.)

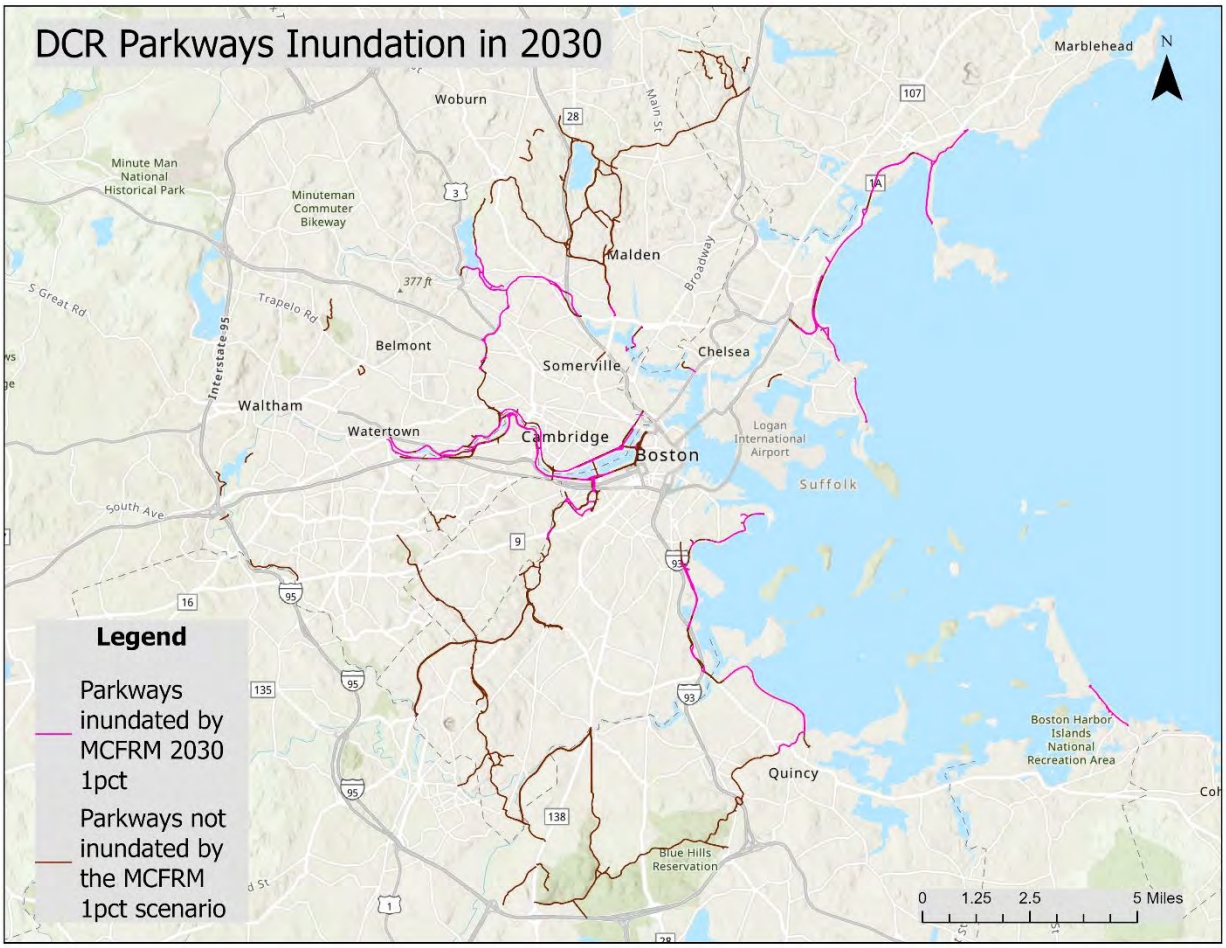


Figure 1. DCR Parkways inundated (pink) by the MCFRM 2030 1% scenario.

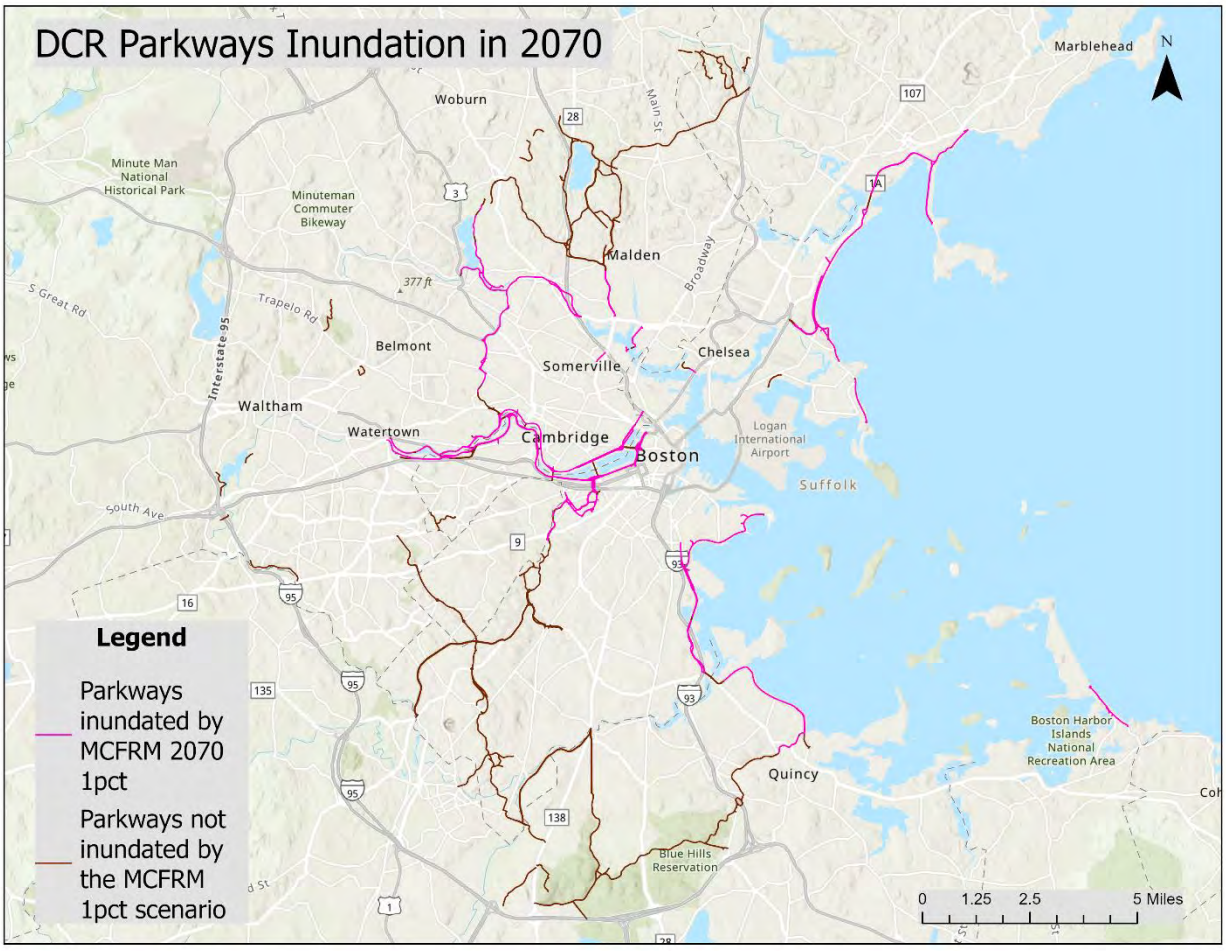


Figure 2. DCR Parkways inundated (pink) by the MCFRM 2070 1% scenario.

Furthermore, based on hydrological studies of the dynamics of flood waters, Stantec determined that flood waters would recede from the roadways and surrounding parkland in less than one day – more typically waters would recede in around 8 hours. However, it has been assumed that in each scenario, additional cleanup and road inspections and traffic controls would result in a road disruption duration of 24 hours – one day.

Methodology Details by Impact Type

General Traffic Disruption Impact

This section calculated the general cost of traffic disruption along flooded parkways.

- We utilized average daily traffic (ADT) counts, truck mixes, and speed limits for 100-foot roadway segments as the basis for this analysis. The traffic counts and truck mixes provided by Stantec corresponded to the years 2030 and 2070 and were used to conduct the respective analyses. It is important to note that not all parkways allow trucks. Our analysis reflects the actual traffic mix between automobiles/SUVs and trucks as registered in the traffic counts. Thus, parkways that do not allow trucks would not register any truck traffic and truck costs would not apply.
- Stantec also estimated travel time penalties of 60 and 70 percent in the 2030 and 2070 flood scenarios, respectively.
- Vehicle occupancy and values of time were taken from the 2023 USDOT benefit cost analysis (BCA) guidance [1].
- These values are shown in Table 1 below.
-

Table 1. Parameter Values Used to Calculate Traffic Disruption Impacts

Parameter	Value	Source
Traffic Count (ADT)	Varies by parkway	Study Team Analyses
Truck Share	Varies by parkway	Study Team Analyses
Speed Limit	Varies by parkway	Study Team Analyses
Travel Time Penalty (2030)	60%	Study Team Analyses
Travel Time Penalty (2070)	70%	Study Team Analyses
Occupancy per Passenger Vehicle	1.67	USDOT BCA Guidance
Average Hourly Value of Passenger Time	$19.60	USDOT BCA Guidance
Average Hourly Value of Truck Driver Time	$32.40	USDOT BCA Guidance

- Increases in Vehicle Hours Traveled (VHT) along each parkway calculated derived using the follow equation:

$$\Delta\text{VHT} = \frac{\text{ADT} \times \text{Distance Impacted}}{\text{Average Speed}} \times \text{Travel Time Penalty}$$

- Increases in passenger hours of travel per day along each parkway were calculated using the following equation:

$$\Delta\text{Passenger Hours} = \Delta\text{VHT} \times (1 - \text{Truck Share}) \times 1.67 \text{ persons/vehicle}$$

- Increases in truck hours of travel per day along each parkway were calculated using the following equation:

$$\Delta\text{Truck Hours} = \Delta\text{VHT} \times (\text{Truck Share})$$

- The increase in passenger hours was multiplied by the USDOT 2023 BCA Guidance's value of time for all trip purposes ($19.60 per hour) to compute a value per day for passenger traffic disruption.
- The increase in truck hours was multiplied by the USDOT 2023 BCA Guidance's value of time for truck operators ($32.40) to compute a value per day for truck traffic disruption.
- The total value of traffic disruption was calculated as the sum of passenger and truck traffic disruption values.

Loss of Recreational Visitor Access

Loss of recreational visitor access costs are a combination of representative Replica data for all travel modes [2], previously cross tabbed for inbound trips x share of vehicular trips that are for recreational visit purposes, multiplied by $35 per person per visit. The $35 per visit per day was determined based on earlier research summarizing visitor value and agreed upon with DCR. That memo is attached in Appendix A.

- Value per day of lost visitor access = Average peak ADT x inbound share of traffic into the disruption zone for recreational purposes (drivers and passengers into the zone + Taxi/TNC transit riders) x $35
- Shares indicated above are derived from cross tabulated Replica data for four representative parkway catchment zones, previously provided to EBP by Stantec and processed for cross tabulation by EBP. See Replica cross tab data in Table 2 below, extracted from Replica data for Quincy Shore Drive.

Table 2. Example Replica Data (Quincy Shore Drive)

Quincy Shore Drive				Mode Distribution							
ID	Label	Count	Percent	Other	Walking	Biking	Public Transit	Taxi/TNC	Private Auto	Auto Passenger	Commercial Vehicle (freight)
Destination				1.20%	15.60%	0.37%	2.89%	0.98%	41.93%	34.99%	2.04%
0	Other	108	0.82%	0.01%	0.13%	0.00%	0.02%	0.01%	0.34%	0.29%	0.02%
1	Home	5860	44.44%	0.53%	6.93%	0.17%	1.28%	0.43%	18.63%	15.55%	0.91%
2	Work	807	6.12%	0.07%	0.95%	0.02%	0.18%	0.06%	2.57%	2.14%	0.12%
3	School	1	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
4	Eat	1166	8.84%	0.11%	1.38%	0.03%	0.26%	0.09%	3.71%	3.09%	0.18%
5	Shop	1582	12.00%	0.14%	1.87%	0.04%	0.35%	0.12%	5.03%	4.20%	0.24%
6	Social	1716	13.01%	0.16%	2.03%	0.05%	0.38%	0.13%	5.46%	4.55%	0.27%
7	Recreation	1340	10.16%	0.12%	1.59%	0.04%	0.29%	0.10%	4.26%	3.56%	0.21%
8	Errands	257	1.95%	0.02%	0.30%	0.01%	0.06%	0.02%	0.82%	0.68%	0.04%

10	Pass-through traffic	0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
12	Lodging (hotels etc.)	79	0.60%	0.01%	0.09%	0.00%	0.02%	0.01%	0.25%	0.21%	0.01%
14	Region departure (airport etc.)	0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
15	Commercial (freight)	269	2.04%	0.02%	0.32%	0.01%	0.06%	0.02%	0.86%	0.71%	0.04%

Isolated Areas Economic Losses

The restriction of vehicular access in the event of a major flood along eight DCR parkways was expected to isolate communities. The communities that would be isolated and the parkways that serve those communities are shown in 3.

Figure 3. Communities Isolated by Flood Scenarios and Parkways that Serve Them

As seen in the figure, floods on the following parkways would isolate communities:

- Nantasket Avenue
- Quincy Shore Drive
- William T Morrissey Boulevard
- Lynnway
- Carroll Parkway
- Nahant Road
- Mystic View Road
- Winthrop Parkway

The daily cost of lost vehicular access along these parkways was estimated by calculating the lost income from workers who cannot commute to their jobs and the lost business activity within isolated communities. Lost income was calculated by determining the number of out-commuters that work outside the isolated community using US Census Longitudinal Employer Household Dynamics Journey to Work data [3], multiplying that number by the average annual wage income for Massachusetts [4], and then adjusting for post-COVID telecommuting rates estimated by RSG [5]. Lost business activity was estimated using the amount of in-place employment in each community, average annual wage income, data on output per employee [6], and then adjusting for post-COVID telecommuting rates.

Lost On-Street Parking

DCR provided data on the linear feet of curb space available for parking on select parkways. The number of parking spaces available on parkways with space available for parking was found by dividing the linear feet of curb space available for parking by the assumed length of a parking space (22 feet). That value was multiplied by a cost per parking space per hour that was determined by conducting a survey of on-street parking rates in the Boston metropolitan area available online through city websites and services such as SpotHero.

- Cambridge Parkway and Memorial Drive are the only parkways in the system with revenue-generating parking. Those two parkways were valued at the highest on-street parking rate in the area seen online ($3.75 per spot per hour).
- Parking spots on other parkways were valued at a lower rate determined using the same sources ($1 per spot per hour).

Results

The economic cost for each of the categories described above, as well as the total cost, calculated as the sum of the four categories, is shown in Table 3 below. All costs are calculated for a one-day disruption event. All economic costs are in 2022 dollars to align with USDOT benefit cost analysis guidance.

The largest of the costs shown in both scenarios analyzed is the cost of lost recreational visits, followed by lost business output, lost wage income, reduced vehicular access, and the cost of lost parking. The cost of lost recreational visits is the largest cost associated with the scenarios analyzed because all parkways in the DCR system serve recreational users and the assumption that these users' vehicular trips would disappear during flooding events that inundate recreational facilities.

The costs associated with lost wage income and lost business output are also substantial, especially for the communities that are isolated by parkway flooding. However, the total cost of community isolation is moderated by the low number of communities that would be isolated during the flood scenarios analyzed.

While our analysis does not consider equity this would be important to investigate in a next phase. The specific consideration is the extent to which the 100-year flood event would disproportionately impact lower income individuals and their families who either work, reside, or do business in the isolated areas identified. We estimated the total economic costs of a one-day isolation resulting from parkway flooding, including an overall adjustment for telecommuting rates. However, the ability to telecommute is not evenly distributed across the income spectrum. Lower income workers (who either cannot commute out or who cannot reach their jobs located inside the isolated areas) are less able to telecommute, as occupations for lower income workers tend to require a greater onsite presence. There should be ample data and research to support an analysis that would determine how low-income populations may be differently impacted, although the research may not be specific to the Boston metro area.

Costs associated with reduced vehicular access are substantial, though lower than several of the other categories due to the assumption that these trips would not disappear during a flooding event and would instead suffer moderate travel time penalties. Finally, the cost of lost parking is the lowest of the costs estimated since not all parkways in the DCR system have curb space available for parking, and due to the relatively low value of parking (ranging between $1 and $3.75 per space per hour) as compared to the other costs studied.

Table 3. Total Economic Costs by Category for Each Scenario (Millions of Dollars)

Scenario	Summary Cost of Reduced Vehicular Access (travel delay costs)	Summary Cost of Lost Recreational Visits	Summary Cost of Isolated Community - Lost Wage Income Out-commuters	Summary Cost of Isolated Community - Lost Business Output	Summary Cost of Lost Parking	Total 1-Day Disruption Cost
1% Flood, 2030	$0.90	$12.00	$2.86	$8.26	$0.11	$24.77
1% Flood, 2070	$1.64	$15.90	$2.86	$8.53	$0.11	$29.69

Results are disaggregated by parkway and organized alphabetically and by total cost in Appendix A and Appendix B, respectively.

References

[1] United States Department of Transportation, "Benefit-Cost Analysis Guidance for Discretionary Grant Programs, December 2023," United States Department of Transportation, Accessed December 2023. https://www.transportation.gov/sites/dot.gov/files/2023-12/Benefit%20Cost%20Analysis%20Guidance%202024%20Update.pdf

[2] Replica, "Replica Fall 2022 Transportation Data," Replica, 2022. Accessed July 2023.

[3] United States Census Bureau, "Longitudinal Employer-Household Dynamics Origin-Destination Employment Statistics, Version 8," United States Census Bureau, 2023. Accessed December 2023. https://lehd.ces.census.gov/data/

[4] United States Bureau of Labor Statistics, "May 2022 State Occupational Employment and Wage Estimates," United States Bureau of Labor Statistics, 2023. Accessed December 2023. https://www.bls.gov/oes/current/oes_ma.htm

[5] RSG, "MassDOT Telework Impact Study: Literature Review," Massachusetts Department of Transportation, 2021, Accessed Decemeber 2023.

[6] United States Bureau of Labor Statistics, "Employment and Output by Industry," United States Bureau of Labor Statistics, 2023. Accessed December 2023. https://www.bls.gov/emp/tables/industry-employment-and-output.htm

References Included in the Visitor Valuation Memo (Appendix C)

[1] Commonwealth of Massachusetts, “Parking at Massachusetts State Parks,” Commonwealth of Massachusetts, 2023, Accessed June 2023. https://www.mass.gov/guides/parking-at-massachusetts-state-parks.

[2] Rosenberger, R.S., White, E.M., Kline, J.D., Cvitanovich, C., “Recreation economic values for estimating outdoor recreation economic benefits from the National Forest System,” United States Department of Agriculture, 2017, Accessed June 2023. https://www.fs.usda.gov/pnw/pubs/pnw_gtr957.pdf.

[3] Bowker, J.M., Bergstrom, J.C., Gill, J., “Estimating the economic value and impacts of recreational trails: a case study of the Virginia Creeper Rail Trail,” 2007, Tourism Economics, Vol. 13, Pg. 241-260, Accessed June 2023. http://dx.doi.org/10.5367/000000007780823203.

[4] United States Department of Transportation “Benefit-Cost Analysis Guidance for Discretionary Grant Programs, January 2020,” 2020, United States Department of Transportation. Accessed

June 2023. https://www.transportation.gov/sites/dot.gov/files/2020-01/benefit-cost-analysis-guidance-2020_0.pdf.

[5] Mulley, C., Tyson, R., McCue, P., Rissel, C., Munro, C, "Valuing active travel: Including the health benefits of sustainable transport in transportation appraisal frameworks," 2013, Research in Transportation Business and Management, Vol. 7, Pg. 27-34, Accessed June 2023. https://doi.org/10.1016/j.rtbm.2013.01.001.

[6] Harnik, P., Welle, B., Keenan, L.S., "Measuring the Economic Value of a City Park System," 2009, The Trust for Public Land, Accessed June 2023. https://www.tpl.org/wp-content/uploads/2014/03/ccpe-econvalueparks-rpt.pdf.

[7] United States Bureau of Labor Statistics, "CPI Inflation Calculator," N.D., United States Bureau of Labor Statistics, Accessed June 2023. https://www.bls.gov/data/inflation_calculator.htm.

Appendix A: Summary Results by Parkway (Sorted Alphabetically)

This appendix provides summary results by parkway for each of the parkways expected to be disrupted by floods in the scenarios studied. Parkways are organized alphabetically. All costs in the table are in 2022 dollars to align with USDOT guidance on benefit cost analysis. Costs in Appendix Table A are expressed in thousands of dollars.

Parkway Name	Scenario	Year	Duration of Disruption (days)	Cost of Reduced Vehicular Access (travel delay costs)	Cost of Lost Recreational Visits	Isolated Community - Lost Wage Income Out-commuters	Isolated Community - Lost Business Output	Cost of Lost Parking	Total 1-Day Disruption Cost
Agassiz Road	Scenario 1%	2030	1	$2.5	$63.9	$0.0	$0.0	$0.0	$66.4
Agassiz Road	Scenario 1%	2070	1	$3.0	$63.9	$0.0	$0.0	$0.0	$67.0
Alewife Brook- Concord Ave Rotary	Scenario 1%	2030	1	$1.9	$77.4	$0.0	$0.0	$0.0	$79.3
Alewife Brook- Concord Ave Rotary	Scenario 1%	2070	1	$2.4	$77.4	$0.0	$0.0	$0.0	$79.8
Alewife Brook Parkway	Scenario 1%	2030	1	$24.3	$77.4	$0.0	$0.0	$0.0	$101.7
Alewife Brook Parkway	Scenario 1%	2070	1	$50.4	$77.4	$0.0	$0.0	$0.0	$127.8
Arlington Street	Scenario 1%	2030	1	$0.7	$36.9	$0.0	$0.0	$0.0	$37.6
Arlington Street	Scenario 1%	2070	1	$0.7	$36.9	$0.0	$0.0	$0.0	$37.7
Arsenal Street	Scenario 1%	2030	1	$0.5	$72.0	$0.0	$0.0	$0.0	$72.5
Arsenal Street	Scenario 1%	2070	1	$3.9	$72.0	$0.0	$0.0	$0.0	$75.9
Babe Ruth Park Drive	Scenario 1%	2030	1	$0.1	$20.6	$0.0	$0.0	$0.0	$20.7
Babe Ruth Park Drive	Scenario 1%	2070	1	$0.3	$20.6	$0.0	$0.0	$0.0	$20.9
Beacon Street	Scenario 1%	2030	1	$0.2	$41.7	$0.0	$0.0	$0.0	$41.9
Beacon Street	Scenario 1%	2070	1	$0.4	$41.7	$0.0	$0.0	$0.0	$42.1
Beaver Place	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Beaver Place	Scenario 1%	2070	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Berkeley Street	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Berkeley Street	Scenario 1%	2070	1	$5.3	$258.1	$0.0	$0.0	$0.0	$263.4

Parkway Name	Scenario	Year	Duration of Disruption (days)	Cost of Reduced Vehicular Access (travel delay costs)	Cost of Lost Recreational Visits	Isolated Community - Lost Wage Income Out-commuters	Isolated Community - Lost Business Output	Cost of Lost Parking	Total 1-Day Disruption Cost
Bowker Overpass	Scenario 1%	2030	1	$14.5	$168.4	$0.0	$0.0	$0.0	$183.0
Bowker Overpass	Scenario 1%	2070	1	$22.2	$168.4	$0.0	$0.0	$0.0	$190.6
Boylston Street	Scenario 1%	2030	1	$3.9	$145.8	$0.0	$0.0	$0.0	$149.7
Boylston Street	Scenario 1%	2070	1	$8.1	$145.8	$0.0	$0.0	$0.0	$153.9
Boylston Street Service Road	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Boylston Street Service Road	Scenario 1%	2070	1	$1.4	$63.9	$0.0	$0.0	$0.0	$65.3
Broad Sound Avenue	Scenario 1%	2030	1	$0.1	$1.5	$0.0	$0.0	$0.0	$1.6
Broad Sound Avenue	Scenario 1%	2070	1	$0.1	$1.5	$0.0	$0.0	$0.0	$1.6
Brookline Avenue	Scenario 1%	2030	1	$0.8	$64.9	$0.0	$0.0	$0.0	$65.7
Brookline Avenue	Scenario 1%	2070	1	$1.2	$64.9	$0.0	$0.0	$0.0	$66.1
Brookline Street	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Brookline Street	Scenario 1%	2070	1	$0.6	$63.9	$0.0	$0.0	$0.0	$64.6
Brooks Street	Scenario 1%	2030	1	$1.7	$77.6	$0.0	$0.0	$0.0	$79.3
Brooks Street	Scenario 1%	2070	1	$2.8	$77.6	$0.0	$0.0	$0.0	$80.4
Cambridge Parkway	Scenario 1%	2030	1	$0.1	$4.0	$0.0	$0.0	$8.1	$12.2
Cambridge Parkway	Scenario 1%	2070	1	$0.2	$4.0	$0.0	$0.0	$8.1	$12.2
Cambridge Parkway Connector	Scenario 1%	2030	1	$4.1	$63.9	$0.0	$0.0	$0.0	$68.1
Cambridge Parkway Connector	Scenario 1%	2070	1	$4.4	$63.9	$0.0	$0.0	$0.0	$68.3
Cambridge Street	Scenario 1%	2030	1	$0.1	$15.1	$0.0	$0.0	$0.0	$15.1
Cambridge Street	Scenario 1%	2070	1	$0.1	$15.1	$0.0	$0.0	$0.0	$15.2
Carroll Parkway**	Scenario 1%	2030	1	$8.5	$233.6	$517.9	$117.5	$0.0	$877.4
Carroll Parkway**	Scenario 1%	2070	1	$11.6	$233.6	$517.9	$117.5	$0.0	$880.6
Charles River Road	Scenario 1%	2030	1	$1.2	$8.1	$0.0	$0.0	$0.0	$9.3
Charles River Road	Scenario 1%	2070	1	$1.3	$8.1	$0.0	$0.0	$0.0	$9.4

Parkway Name	Scenario	Year	Duration of Disruption (days)	Cost of Reduced Vehicular Access (travel delay costs)	Cost of Lost Recreational Visits	Isolated Community - Lost Wage Income Out-commuters	Isolated Community - Lost Business Output	Cost of Lost Parking	Total 1-Day Disruption Cost
Charles Street	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Charles Street	Scenario 1%	2070	1	$18.6	$273.7	$0.0	$0.0	$0.0	$292.3
Charles Street Circle	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Charles Street Circle	Scenario 1%	2070	1	$11.1	$273.7	$0.0	$0.0	$0.0	$284.8
Charlesbank Road	Scenario 1%	2030	1	$0.6	$77.6	$0.0	$0.0	$0.0	$78.2
Charlesbank Road	Scenario 1%	2070	1	$0.6	$77.6	$0.0	$0.0	$0.0	$78.2
Charlesgate East	Scenario 1%	2030	1	$1.3	$29.3	$0.0	$0.0	$0.9	$31.5
Charlesgate East	Scenario 1%	2070	1	$2.3	$29.3	$0.0	$0.0	$0.9	$32.5
Charlesgate West	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Charlesgate West	Scenario 1%	2070	1	$1.9	$17.9	$0.0	$0.0	$0.0	$19.9
Commandant's Way	Scenario 1%	2030	1	$0.1	$3.9	$0.0	$0.0	$0.0	$4.0
Commandant's Way	Scenario 1%	2070	1	$0.1	$3.9	$0.0	$0.0	$0.0	$4.0
Concord Avenue	Scenario 1%	2030	1	$0.6	$77.4	$0.0	$0.0	$0.0	$78.0
Concord Avenue	Scenario 1%	2070	1	$7.0	$77.4	$0.0	$0.0	$0.0	$84.4
Connector Mystic Valley Parkway	Scenario 1%	2030	1	$6.0	$55.9	$0.0	$0.0	$0.0	$61.9
Connector Mystic Valley Parkway	Scenario 1%	2070	1	$7.8	$55.9	$0.0	$0.0	$0.0	$63.7
Connector To Eliot Bridge	Scenario 1%	2030	1	$0.2	$12.9	$0.0	$0.0	$0.0	$13.1
Connector To Eliot Bridge	Scenario 1%	2070	1	$1.5	$98.1	$0.0	$0.0	$0.0	$99.6
David G Mugar Way	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
David G Mugar Way	Scenario 1%	2070	1	$1.9	$24.3	$0.0	$0.0	$0.0	$26.3
Earhart Dam Access Road - Somerville Side	Scenario 1%	2030	1	$2.0	$76.0	$0.0	$0.0	$0.0	$78.0

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Earhart Dam Access Road - Somerville Side	Scenario 1%	2070	1	$2.1	$76.0	$0.0	$0.0	$0.0	$78.0
Mystic View Road	Scenario 1%	2030	1	$3.8	$76.0	$0.0	$0.0	$0.0	$79.8
Mystic View Road	Scenario 1%	2070	1	$8.4	$76.0	$0.0	$269.0	$0.0	$353.4
East Broadway	Scenario 1%	2030	1	$1.2	$285.3	$0.0	$0.0	$0.0	$286.5
East Broadway	Scenario 1%	2070	1	$2.9	$285.3	$0.0	$0.0	$0.0	$288.2
Eastern Avenue	Scenario 1%	2030	1	$0.8	$152.2	$0.0	$0.0	$0.0	$153.0
Eastern Avenue	Scenario 1%	2070	1	$0.9	$152.2	$0.0	$0.0	$0.0	$153.1
Eliot Circle	Scenario 1%	2030	1	$0.7	$106.2	$0.0	$0.0	$0.2	$107.1
Eliot Circle	Scenario 1%	2070	1	$0.9	$106.2	$0.0	$0.0	$0.2	$107.3
Embankment Road	Scenario 1%	2030	1	$2.2	$390.7	$0.0	$0.0	$0.0	$392.9
Embankment Road	Scenario 1%	2070	1	$98.4	$390.7	$0.0	$0.0	$0.0	$489.1
Evans Way	Scenario 1%	2030	1	$0.2	$24.8	$0.0	$0.0	$0.0	$24.9
Evans Way	Scenario 1%	2070	1	$0.3	$24.8	$0.0	$0.0	$0.0	$25.1
Everett Street	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Everett Street	Scenario 1%	2070	1	$0.5	$25.0	$0.0	$0.0	$0.0	$25.4
Fellsway	Scenario 1%	2030	1	$3.8	$28.5	$0.0	$0.0	$23.6	$55.9
Fellsway	Scenario 1%	2070	1	$14.7	$28.5	$0.0	$0.0	$23.6	$66.8
Fellsway West	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$2.6	$2.6
Fellsway West	Scenario 1%	2070	1	$2.5	$32.5	$0.0	$0.0	$2.6	$37.6
Fenway	Scenario 1%	2030	1	$2.6	$33.8	$0.0	$0.0	$3.1	$39.6
Fenway	Scenario 1%	2070	1	$9.7	$64.9	$0.0	$0.0	$3.1	$77.8
Fenway Connector To Park Drive	Scenario 1%	2030	1	$1.0	$33.8	$0.0	$0.0	$0.0	$34.8
Fenway Connector To Park Drive	Scenario 1%	2070	1	$1.4	$33.8	$0.0	$0.0	$0.0	$35.2
First Street	Scenario 1%	2030	1	$2.3	$63.9	$0.0	$0.0	$0.0	$66.3

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First Street	Scenario 1%	2070	1	$3.9	$100.7	$0.0	$0.0	$0.0	$104.6
Forsyth Way	Scenario 1%	2030	1	$0.1	$24.8	$0.0	$0.0	$0.0	$24.9
Forsyth Way	Scenario 1%	2070	1	$1.8	$24.8	$0.0	$0.0	$0.0	$26.5
Fresh Pond Parkway	Scenario 1%	2030	1	$0.6	$64.0	$0.0	$0.0	$0.0	$64.5
Fresh Pond Parkway	Scenario 1%	2070	1	$7.2	$64.0	$0.0	$0.0	$0.0	$71.2
Furnace Brook Parkway	Scenario 1%	2030	1	$5.4	$22.9	$0.0	$0.0	$0.0	$28.3
Furnace Brook Parkway	Scenario 1%	2070	1	$6.0	$22.9	$0.0	$0.0	$0.0	$29.0
Gilmore Bridge	Scenario 1%	2030	1	$2.5	$63.9	$0.0	$0.0	$0.0	$66.4
Gilmore Bridge	Scenario 1%	2070	1	$5.8	$63.9	$0.0	$0.0	$0.0	$69.8
Greenough Boulevard	Scenario 1%	2030	1	$10.1	$72.0	$0.0	$0.0	$0.0	$82.1
Greenough Boulevard	Scenario 1%	2070	1	$13.2	$72.0	$0.0	$0.0	$0.0	$85.2
Grove Street	Scenario 1%	2030	1	$0.1	$12.9	$0.0	$0.0	$0.0	$12.9
Grove Street	Scenario 1%	2070	1	$0.3	$12.9	$0.0	$0.0	$0.0	$13.2
Harvard Avenue	Scenario 1%	2030	1	$0.0	$2.4	$0.0	$0.0	$0.0	$2.5
Harvard Avenue	Scenario 1%	2070	1	$0.0	$2.4	$0.0	$0.0	$0.0	$2.5
High Street	Scenario 1%	2030	1	$0.8	$25.1	$0.0	$0.0	$0.0	$25.9
High Street	Scenario 1%	2070	1	$0.8	$25.1	$0.0	$0.0	$0.0	$26.0
Hull Shore Drive	Scenario 1%	2030	1	$5.2	$64.9	$0.0	$0.0	$0.0	$70.0
Hull Shore Drive	Scenario 1%	2070	1	$5.4	$64.9	$0.0	$0.0	$0.0	$70.2
Humphrey Street	Scenario 1%	2030	1	$1.7	$152.2	$0.0	$0.0	$0.0	$153.9
Humphrey Street	Scenario 1%	2070	1	$1.8	$152.2	$0.0	$0.0	$0.0	$154.0
Jamaicaway	Scenario 1%	2030	1	$1.0	$79.7	$0.0	$0.0	$0.0	$80.7
Jamaicaway	Scenario 1%	2070	1	$1.5	$79.7	$0.0	$0.0	$0.0	$81.2
Jerome Street	Scenario 1%	2030	1	$0.0	$2.4	$0.0	$0.0	$0.0	$2.4
Jerome Street	Scenario 1%	2070	1	$0.0	$2.4	$0.0	$0.0	$0.0	$2.4

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Jfk-umass Station Road	Scenario 1%	2030	1	$2.7	$67.8	$0.0	$0.0	$0.0	$70.5
Jfk-umass Station Road	Scenario 1%	2070	1	$6.5	$67.8	$0.0	$0.0	$0.0	$74.3
Kosciuszko Circle	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Kosciuszko Circle	Scenario 1%	2070	1	$0.4	$67.8	$0.0	$0.0	$0.0	$68.2
Land Boulevard	Scenario 1%	2030	1	$3.1	$100.7	$0.0	$0.0	$0.0	$103.8
Land Boulevard	Scenario 1%	2070	1	$19.5	$100.7	$0.0	$0.0	$0.0	$120.2
Louis Prang Street	Scenario 1%	2030	1	$0.1	$24.8	$0.0	$0.0	$0.0	$24.9
Louis Prang Street	Scenario 1%	2070	1	$0.2	$24.8	$0.0	$0.0	$0.0	$25.0
Lynn Shore Drive	Scenario 1%	2030	1	$19.8	$152.2	$0.0	$0.0	$5.6	$177.5
Lynn Shore Drive	Scenario 1%	2070	1	$21.0	$152.2	$0.0	$0.0	$5.6	$178.7
Lynnway**	Scenario 1%	2030	1	$66.6	$233.6	$517.9	$117.5	$0.0	$935.6
Lynnway**	Scenario 1%	2070	1	$79.3	$233.6	$517.9	$117.5	$0.0	$948.2
Lynnway Underpass - Rt 1a Sb To Lynnway	Scenario 1%	2030	1	$2.2	$233.6	$0.0	$0.0	$0.0	$235.8
Lynnway Underpass - Rt 1a Sb To Lynnway	Scenario 1%	2070	1	$3.8	$233.6	$0.0	$0.0	$0.0	$237.4
Massachusetts Avenue	Scenario 1%	2030	1	$0.6	$93.0	$0.0	$0.0	$0.0	$93.6
Massachusetts Avenue	Scenario 1%	2070	1	$0.6	$93.0	$0.0	$0.0	$0.0	$93.6
Medford Street	Scenario 1%	2030	1	$1.1	$103.1	$0.0	$0.0	$0.0	$104.2
Medford Street	Scenario 1%	2070	1	$1.2	$103.1	$0.0	$0.0	$0.0	$104.3
Memorial Drive	Scenario 1%	2030	1	$55.1	$242.1	$0.0	$0.0	$15.9	$313.2
Memorial Drive	Scenario 1%	2070	1	$101.7	$242.1	$0.0	$0.0	$15.9	$359.7
Memorial Drive Underpass	Scenario 1%	2030	1	$6.5	$93.0	$0.0	$0.0	$0.1	$99.6
Memorial Drive Underpass	Scenario 1%	2070	1	$7.5	$93.0	$0.0	$0.0	$0.1	$100.7
Morrissey Service Road	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0

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Morrissey Service Road	Scenario 1%	2070	1	$6.9	$100.5	$0.0	$0.0	$0.0	$107.5
Mount Vernon Street	Scenario 1%	2030	1	$3.6	$67.8	$0.0	$0.0	$0.0	$71.4
Mount Vernon Street	Scenario 1%	2070	1	$3.8	$67.8	$0.0	$0.0	$0.0	$71.6
Mystic River Road	Scenario 1%	2030	1	$0.2	$2.4	$0.0	$0.0	$2.8	$5.4
Mystic River Road	Scenario 1%	2070	1	$0.2	$2.4	$0.0	$0.0	$2.8	$5.5
Mystic Valley Parkway	Scenario 1%	2030	1	$42.1	$103.1	$0.0	$0.0	$0.0	$145.2
Mystic Valley Parkway	Scenario 1%	2070	1	$64.5	$103.1	$0.0	$0.0	$0.0	$167.6
Mystic Valley-alewife Brook Rotary	Scenario 1%	2030	1	$0.6	$91.4	$0.0	$0.0	$0.0	$92.0
Mystic Valley-alewife Brook Rotary	Scenario 1%	2070	1	$1.1	$91.4	$0.0	$0.0	$0.0	$92.5
Nahant Circle	Scenario 1%	2030	1	$1.3	$51.4	$0.0	$0.0	$0.0	$52.7
Nahant Circle	Scenario 1%	2070	1	$1.4	$51.4	$0.0	$0.0	$0.0	$52.8
Nahant Road	Scenario 1%	2030	1	$21.1	$51.4	$215.0	$109.9	$0.0	$397.5
Nahant Road	Scenario 1%	2070	1	$23.0	$51.4	$215.0	$109.9	$0.0	$399.4
Nantasket Avenue	Scenario 1%	2030	1	$4.1	$51.8	$559.1	$347.3	$3.9	$966.1
Nantasket Avenue	Scenario 1%	2070	1	$4.5	$51.8	$559.1	$347.3	$3.9	$966.5
Neponset Avenue	Scenario 1%	2030	1	$2.3	$100.5	$0.0	$0.0	$0.0	$102.8
Neponset Avenue	Scenario 1%	2070	1	$2.4	$100.5	$0.0	$0.0	$0.0	$102.9
Noble Street	Scenario 1%	2030	1	$0.2	$70.7	$0.0	$0.0	$0.0	$70.9
Noble Street	Scenario 1%	2070	1	$0.2	$70.7	$0.0	$0.0	$0.0	$70.9
Nonantum Road	Scenario 1%	2030	1	$15.1	$77.6	$0.0	$0.0	$0.0	$92.7
Nonantum Road	Scenario 1%	2070	1	$18.1	$77.6	$0.0	$0.0	$0.0	$95.7
Nonantum Road Branch	Scenario 1%	2030	1	$0.8	$77.6	$0.0	$0.0	$0.0	$78.4
Nonantum Road Branch	Scenario 1%	2070	1	$0.8	$77.6	$0.0	$0.0	$0.0	$78.4

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North Beacon Street	Scenario 1%	2030	1	$7.4	$69.0	$0.0	$0.0	$0.0	$76.4
North Beacon Street	Scenario 1%	2070	1	$11.5	$69.0	$0.0	$0.0	$0.0	$80.6
North Harvard Street	Scenario 1%	2030	1	$0.7	$242.1	$0.0	$0.0	$0.0	$242.8
North Harvard Street	Scenario 1%	2070	1	$0.8	$242.1	$0.0	$0.0	$0.0	$242.9
Oak Island Street	Scenario 1%	2030	1	$1.6	$106.2	$0.0	$0.0	$0.0	$107.8
Oak Island Street	Scenario 1%	2070	1	$1.7	$106.2	$0.0	$0.0	$0.0	$107.8
Ocean Avenue	Scenario 1%	2030	1	$9.4	$40.9	$0.0	$0.0	$5.7	$56.0
Ocean Avenue	Scenario 1%	2070	1	$11.4	$40.9	$0.0	$0.0	$5.7	$58.0
Ocean Street	Scenario 1%	2030	1	$0.1	$152.2	$0.0	$0.0	$0.0	$152.3
Ocean Street	Scenario 1%	2070	1	$0.1	$152.2	$0.0	$0.0	$0.0	$152.3
Old Colony Avenue	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$3.0	$3.0
Old Colony Avenue	Scenario 1%	2070	1	$10.6	$67.8	$0.0	$0.0	$3.0	$81.4
Park Drive	Scenario 1%	2030	1	$4.5	$99.5	$0.0	$0.0	$1.6	$105.7
Park Drive	Scenario 1%	2070	1	$10.8	$99.5	$0.0	$0.0	$1.6	$112.0
Quincy Shore Drive	Scenario 1%	2030	1	$41.8	$199.9	$949.7	$5,598.4	$5.3	$6,795.1
Quincy Shore Drive	Scenario 1%	2070	1	$42.2	$199.9	$949.7	$5,598.4	$5.3	$6,795.6
Ramp To Charles Circle	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Ramp To Charles Circle	Scenario 1%	2070	1	$3.4	$390.7	$0.0	$0.0	$0.0	$394.1
Ramp-berkeley St To Rt 28 Nb	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Ramp-berkeley St To Rt 28 Nb	Scenario 1%	2070	1	$5.7	$145.8	$0.0	$0.0	$0.0	$151.5
Ramp-bu Bridge To Memorial Dr Eb	Scenario 1%	2030	1	$0.9	$63.9	$0.0	$0.0	$0.0	$64.8
Ramp-bu Bridge To Memorial Dr Eb	Scenario 1%	2070	1	$1.7	$63.9	$0.0	$0.0	$0.0	$65.6

Parkway Name	Scenario	Year	Duration of Disruption (days)	Cost of Reduced Vehicular Access (travel delay costs)	Cost of Lost Recreational Visits	Isolated Community - Lost Wage Income Out-commuters	Isolated Community - Lost Business Output	Cost of Lost Parking	Total 1-Day Disruption Cost
Ramp-cambridgeprt Cir To Mem Dr Wb	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Ramp-cambridgeprt Cir To Mem Dr Wb	Scenario 1%	2070	1	$2.5	$63.9	$0.0	$0.0	$0.0	$66.5
Ramp-charles St To Longfellow Bridge	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Ramp-charles St To Longfellow Bridge	Scenario 1%	2070	1	$14.8	$390.7	$0.0	$0.0	$0.0	$405.5
Ramp-charlesgate Overpass To Charlesgate	Scenario 1%	2030	1	$0.9	$95.1	$0.0	$0.0	$0.0	$96.0
Ramp-charlesgate Overpass To Charlesgate	Scenario 1%	2070	1	$1.8	$95.1	$0.0	$0.0	$0.0	$96.9
Ramp-jamaicaway To Rt 9	Scenario 1%	2030	1	$0.4	$76.8	$0.0	$0.0	$0.0	$77.2
Ramp-jamaicaway To Rt 9	Scenario 1%	2070	1	$0.5	$76.8	$0.0	$0.0	$0.0	$77.3
Ramp-main Street To Rt 16 Wb	Scenario 1%	2030	1	$1.2	$55.9	$0.0	$0.0	$0.0	$57.1
Ramp-main Street To Rt 16 Wb	Scenario 1%	2070	1	$1.3	$55.9	$0.0	$0.0	$0.0	$57.2
Ramp-mem Dr To Cambridgeprt Cir Eb	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Ramp-mem Dr To Cambridgeprt Cir Eb	Scenario 1%	2070	1	$2.9	$63.9	$0.0	$0.0	$0.0	$66.8
Ramp-mem Dr To Cambridgeprt Cir Wb	Scenario 1%	2030	1	$0.8	$103.5	$0.0	$0.0	$0.0	$104.3
Ramp-mem Dr To Cambridgeprt Cir Wb	Scenario 1%	2070	1	$1.6	$103.5	$0.0	$0.0	$0.0	$105.0

Parkway Name	Scenario	Year	Duration of Disruption (days)	Cost of Reduced Vehicular Access (travel delay costs)	Cost of Lost Recreational Visits	Isolated Community - Lost Wage Income Out-commuters	Isolated Community - Lost Business Output	Cost of Lost Parking	Total 1-Day Disruption Cost
Ramp-n Harvard St To Soldiers Field Eb	Scenario 1%	2030	1	$2.4	$242.1	$0.0	$0.0	$0.0	$244.5
Ramp-n Harvard St To Soldiers Field Eb	Scenario 1%	2070	1	$4.1	$242.1	$0.0	$0.0	$0.0	$246.1
Ramp-n Harvard St To Soldiers Field Wb	Scenario 1%	2030	1	$3.9	$242.1	$0.0	$0.0	$0.0	$246.0
Ramp-n Harvard St To Soldiers Field Wb	Scenario 1%	2070	1	$4.1	$242.1	$0.0	$0.0	$0.0	$246.2
Ramp-rt 16 Wb To Main Street	Scenario 1%	2030	1	$1.6	$55.9	$0.0	$0.0	$0.0	$57.4
Ramp-rt 16 Wb To Main Street	Scenario 1%	2070	1	$1.6	$55.9	$0.0	$0.0	$0.0	$57.5
Ramp-rt 28 Nb To Cambridge St	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Ramp-rt 28 Nb To Cambridge St	Scenario 1%	2070	1	$4.5	$390.7	$0.0	$0.0	$0.0	$395.2
Ramp-rt 3 To Rt 28 Sb	Scenario 1%	2030	1	$0.9	$273.7	$0.0	$0.0	$0.0	$274.6
Ramp-rt 3 To Rt 28 Sb	Scenario 1%	2070	1	$12.8	$273.7	$0.0	$0.0	$0.0	$286.6
Ramp-rt 9 To Jamaicaway	Scenario 1%	2030	1	$0.5	$76.8	$0.0	$0.0	$0.0	$77.3
Ramp-rt 9 To Jamaicaway	Scenario 1%	2070	1	$0.5	$76.8	$0.0	$0.0	$0.0	$77.3
Ramp-soldiers Field Eb To N Harvard St	Scenario 1%	2030	1	$1.7	$242.1	$0.0	$0.0	$0.0	$243.8
Ramp-soldiers Field Eb To N Harvard St	Scenario 1%	2070	1	$2.2	$242.1	$0.0	$0.0	$0.0	$244.3
Ramp-soldiers Field Rd Eb To Western Ave	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0

Parkway Name	Scenario	Year	Duration of Disruption (days)	Cost of Reduced Vehicular Access (travel delay costs)	Cost of Lost Recreational Visits	Isolated Community - Lost Wage Income Out-commuters	Isolated Community - Lost Business Output	Cost of Lost Parking	Total 1-Day Disruption Cost
Ramp-soldiers Field Rd Eb To Western Ave	Scenario 1%	2070	1	$0.3	$15.1	$0.0	$0.0	$0.0	$15.3
Ramp-soldiers Field Rd Wb To Western Ave	Scenario 1%	2030	1	$6.0	$242.1	$0.0	$0.0	$0.0	$248.1
Ramp-soldiers Field Rd Wb To Western Ave	Scenario 1%	2070	1	$6.4	$242.1	$0.0	$0.0	$0.0	$248.5
Ramp-soldiers Field Wb To N Harvard St	Scenario 1%	2030	1	$4.5	$242.1	$0.0	$0.0	$0.0	$246.6
Ramp-soldiers Field Wb To N Harvard St	Scenario 1%	2070	1	$4.8	$242.1	$0.0	$0.0	$0.0	$246.9
Ramp-storrow Dr To Rt 2a Wb	Scenario 1%	2030	1	$0.9	$258.1	$0.0	$0.0	$0.0	$259.1
Ramp-storrow Dr To Rt 2a Wb	Scenario 1%	2070	1	$1.2	$258.1	$0.0	$0.0	$0.0	$259.3
Ramp-western Ave To Soldiers Field Rd Eb	Scenario 1%	2030	1	$0.0	$15.1	$0.0	$0.0	$0.0	$15.1
Ramp-western Ave To Soldiers Field Rd Eb	Scenario 1%	2070	1	$3.0	$122.0	$0.0	$0.0	$0.0	$125.0
Ramp-western Ave To Soldiers Field Rd Wb	Scenario 1%	2030	1	$8.9	$242.1	$0.0	$0.0	$0.0	$251.0
Ramp-western Ave To Soldiers Field Rd Wb	Scenario 1%	2070	1	$9.4	$242.1	$0.0	$0.0	$0.0	$251.5
Reid Rotary	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Reid Rotary	Scenario 1%	2070	1	$1.7	$63.9	$0.0	$0.0	$0.0	$65.7
Revere Beach Boulevard	Scenario 1%	2030	1	$16.6	$106.2	$183.9	$116.0	$15.3	$437.9
Revere Beach Boulevard	Scenario 1%	2070	1	$28.7	$106.2	$183.9	$116.0	$15.3	$450.0
Revere Beach Parkway	Scenario 1%	2030	1	$19.7	$113.7	$0.0	$0.0	$0.0	$133.3

Parkway Name	Scenario	Year	Duration of Disruption (days)	Cost of Reduced Vehicular Access (travel delay costs)	Cost of Lost Recreational Visits	Isolated Community - Lost Wage Income Out-commuters	Isolated Community - Lost Business Output	Cost of Lost Parking	Total 1-Day Disruption Cost
Revere Beach Parkway	Scenario 1%	2070	1	$26.3	$113.7	$0.0	$0.0	$0.0	$139.9
Revere Street	Scenario 1%	2030	1	$0.4	$106.2	$0.0	$0.0	$0.0	$106.6
Revere Street	Scenario 1%	2070	1	$0.4	$106.2	$0.0	$0.0	$0.0	$106.6
Riverway	Scenario 1%	2030	1	$13.7	$76.8	$0.0	$0.0	$0.0	$90.5
Riverway	Scenario 1%	2070	1	$33.8	$76.8	$0.0	$0.0	$0.0	$110.6
Riverway Frontage Road	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$1.0	$1.0
Riverway Frontage Road	Scenario 1%	2070	1	$1.1	$76.8	$0.0	$0.0	$1.0	$78.9
Shirley Avenue	Scenario 1%	2030	1	$0.1	$106.2	$0.0	$0.0	$0.0	$106.3
Shirley Avenue	Scenario 1%	2070	1	$0.3	$106.2	$0.0	$0.0	$0.0	$106.5
Shore Road	Scenario 1%	2030	1	$0.2	$4.1	$0.0	$0.0	$1.1	$5.3
Shore Road	Scenario 1%	2070	1	$0.2	$4.1	$0.0	$0.0	$1.1	$5.4
Soldiers Field Road	Scenario 1%	2030	1	$150.7	$242.1	$0.0	$0.0	$0.0	$392.8
Soldiers Field Road	Scenario 1%	2070	1	$226.1	$242.1	$0.0	$0.0	$0.0	$468.2
Soldiers Field Road Extension	Scenario 1%	2030	1	$15.4	$131.2	$0.0	$0.0	$0.0	$146.6
Soldiers Field Road Extension	Scenario 1%	2070	1	$17.4	$131.2	$0.0	$0.0	$0.0	$148.6
Sozio Rotary	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Sozio Rotary	Scenario 1%	2070	1	$1.9	$77.4	$0.0	$0.0	$0.0	$79.2
State Road	Scenario 1%	2030	1	$0.9	$74.2	$0.0	$0.0	$0.0	$75.1
State Road	Scenario 1%	2070	1	$1.0	$74.2	$0.0	$0.0	$0.0	$75.2
Storrow Drive	Scenario 1%	2030	1	$78.0	$258.1	$0.0	$0.0	$0.0	$336.1
Storrow Drive	Scenario 1%	2070	1	$164.1	$390.7	$0.0	$0.0	$0.0	$554.7
Terminal Road	Scenario 1%	2030	1	$3.2	$77.4	$0.0	$0.0	$0.0	$80.5
Terminal Road	Scenario 1%	2070	1	$4.8	$77.4	$0.0	$0.0	$0.0	$82.2
Unnamed Road - Fenway	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0

Parkway Name	Scenario	Year	Duration of Disruption (days)	Cost of Reduced Vehicular Access (travel delay costs)	Cost of Lost Recreational Visits	Isolated Community - Lost Wage Income Out-commuters	Isolated Community - Lost Business Output	Cost of Lost Parking	Total 1-Day Disruption Cost
Unnamed Road - Fenway	Scenario 1%	2070	1	$1.3	$63.9	$0.0	$0.0	$0.0	$65.3
Unnamed Road - Fenway & Park Drive	Scenario 1%	2030	1	$0.7	$99.5	$0.0	$0.0	$0.0	$100.3
Unnamed Road - Fenway & Park Drive	Scenario 1%	2070	1	$0.8	$99.5	$0.0	$0.0	$0.0	$100.3
Unnamed Road - First Street & Memorial Dr	Scenario 1%	2030	1	$0.5	$63.9	$0.0	$0.0	$0.0	$64.5
Unnamed Road - First Street & Memorial Dr	Scenario 1%	2070	1	$0.6	$63.9	$0.0	$0.0	$0.0	$64.5
Unnamed Road - Greenough Boulevard	Scenario 1%	2030	1	$0.1	$12.9	$0.0	$0.0	$0.0	$13.0
Unnamed Road - Greenough Boulevard	Scenario 1%	2070	1	$0.1	$12.9	$0.0	$0.0	$0.0	$13.0
Unnamed Road - Land Boulevard	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Unnamed Road - Land Boulevard	Scenario 1%	2070	1	$0.2	$100.7	$0.0	$0.0	$0.0	$100.9
Unnamed Road - Main St & Memorial Dr	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Unnamed Road - Main St & Memorial Dr	Scenario 1%	2070	1	$0.7	$63.9	$0.0	$0.0	$0.0	$64.6
Unnamed Road - Memorial Dr & Land Boulevard	Scenario 1%	2030	1	$0.1	$100.7	$0.0	$0.0	$0.0	$100.8
Unnamed Road - Memorial Dr & Land Boulevard	Scenario 1%	2070	1	$0.4	$100.7	$0.0	$0.0	$0.0	$101.1
Unnamed Road - Memorial Dr 1	Scenario 1%	2030	1	$0.3	$93.0	$0.0	$0.0	$0.0	$93.4

Parkway Name	Scenario	Year	Duration of Disruption (days)	Cost of Reduced Vehicular Access (travel delay costs)	Cost of Lost Recreational Visits	Isolated Community - Lost Wage Income Out-commuters	Isolated Community - Lost Business Output	Cost of Lost Parking	Total 1-Day Disruption Cost
Unnamed Road - Memorial Dr 1	Scenario 1%	2070	1	$0.4	$93.0	$0.0	$0.0	$0.0	$93.4
Unnamed Road - Memorial Dr 2	Scenario 1%	2030	1	$0.3	$63.9	$0.0	$0.0	$0.0	$64.2
Unnamed Road - Memorial Dr 2	Scenario 1%	2070	1	$0.3	$63.9	$0.0	$0.0	$0.0	$64.2
Unnamed Road - Memorial Dr 3	Scenario 1%	2030	1	$0.3	$63.9	$0.0	$0.0	$0.0	$64.2
Unnamed Road - Memorial Dr 3	Scenario 1%	2070	1	$0.3	$63.9	$0.0	$0.0	$0.0	$64.3
Unnamed Road - Memorial Dr 4	Scenario 1%	2030	1	$0.3	$63.9	$0.0	$0.0	$0.0	$64.3
Unnamed Road - Memorial Dr 4	Scenario 1%	2070	1	$0.4	$63.9	$0.0	$0.0	$0.0	$64.3
Unnamed Road - Memorial Dr 5	Scenario 1%	2030	1	$0.2	$63.9	$0.0	$0.0	$0.0	$64.2
Unnamed Road - Memorial Dr 5	Scenario 1%	2070	1	$0.3	$63.9	$0.0	$0.0	$0.0	$64.2
Unnamed Road - Memorial Dr 6	Scenario 1%	2030	1	$0.2	$63.9	$0.0	$0.0	$0.0	$64.1
Unnamed Road - Memorial Dr 6	Scenario 1%	2070	1	$0.2	$63.9	$0.0	$0.0	$0.0	$64.1
Unnamed Road - Park Drive	Scenario 1%	2030	1	$0.2	$51.9	$0.0	$0.0	$0.0	$52.0
Unnamed Road - Park Drive	Scenario 1%	2070	1	$4.0	$63.9	$0.0	$0.0	$0.0	$67.9
Unnamed Road - Riverway	Scenario 1%	2030	1	$0.3	$117.7	$0.0	$0.0	$0.0	$118.0
Unnamed Road - Riverway	Scenario 1%	2070	1	$0.4	$117.7	$0.0	$0.0	$0.0	$118.1
Unnamed Road - Storrow Dr & David G Mugar Way	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Unnamed Road - Storrow Dr & David G Mugar Way	Scenario 1%	2070	1	$4.9	$258.1	$0.0	$0.0	$0.0	$263.0

Parkway Name	Scenario	Year	Duration of Disruption (days)	Cost of Reduced Vehicular Access (travel delay costs)	Cost of Lost Recreational Visits	Isolated Community - Lost Wage Income Out-commuters	Isolated Community - Lost Business Output	Cost of Lost Parking	Total 1-Day Disruption Cost
Wave Avenue	Scenario 1%	2030	1	$0.1	$70.7	$0.0	$0.0	$0.0	$70.8
Wave Avenue	Scenario 1%	2070	1	$0.1	$70.7	$0.0	$0.0	$0.0	$70.8
West Street	Scenario 1%	2030	1	$0.5	$172.5	$0.0	$0.0	$0.0	$173.0
West Street	Scenario 1%	2070	1	$0.5	$172.5	$0.0	$0.0	$0.0	$173.0
Western Avenue	Scenario 1%	2030	1	$1.9	$242.1	$0.0	$0.0	$0.0	$244.0
Western Avenue	Scenario 1%	2070	1	$2.1	$242.1	$0.0	$0.0	$0.0	$244.1
Westland Entrance	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Westland Entrance	Scenario 1%	2070	1	$1.0	$63.9	$0.0	$0.0	$0.0	$65.0
Wharf Avenue	Scenario 1%	2030	1	$0.3	$51.8	$0.0	$0.0	$0.0	$52.0
Wharf Avenue	Scenario 1%	2070	1	$0.3	$51.8	$0.0	$0.0	$0.0	$52.0
William Day Boulevard	Scenario 1%	2030	1	$56.5	$285.3	$0.0	$0.0	$8.6	$350.4
William Day Boulevard	Scenario 1%	2070	1	$97.4	$285.3	$0.0	$0.0	$8.6	$391.4
William T Morrissey Boulevard	Scenario 1%	2030	1	$49.5	$100.5	$171.0	$1,907.8	$0.0	$2,228.8
William T Morrissey Boulevard	Scenario 1%	2070	1	$91.8	$100.5	$171.0	$1,907.8	$0.0	$2,271.2
Winthrop Parkway	Scenario 1%	2030	1	$8.5	$70.7	$263.6	$67.2	$0.0	$409.9
Winthrop Parkway	Scenario 1%	2070	1	$9.1	$70.7	$263.6	$67.2	$0.0	$410.5
Winthrop Shore Drive	Scenario 1%	2030	1	$4.5	$32.9	$0.0	$0.0	$6.6	$44.0
Winthrop Shore Drive	Scenario 1%	2070	1	$4.9	$32.9	$0.0	$0.0	$6.6	$44.3

** The same isolated community impact values are reported for both Lynnway and Carroll Parkway in this table. The geographies of these parkways, the communities they would isolate, and the Census tracts for which socioeconomic data were pulled make it impossible to disentangle what impacts would occur if only one of these parkways was flooded. These impacts are only counted once in the summary table in the main body of the report to avoid double-counting of impacts.

Appendix B: Summary Results by Parkway (Sorted by Total 1-Day Disruption Cost)

This appendix provides summary results by parkway for each of the parkways expected to be disrupted by floods in the scenarios studied. Parkways are shown from highest to lowest total cost. All costs in the table are in 2022 dollars to align with USDOT guidance on benefit cost analysis. Costs in Appendix Table B are expressed in thousands of dollars.

Parkway Name	Scenario	Year	Duration of Disruption (days)	Cost of Reduced Vehicular Access (travel delay costs)	Cost of Lost Recreational Visits	Isolated Community - Lost Wage Income Out-commuters	Isolated Community - Lost Business Output	Cost of Lost Parking	Total 1-Day Disruption Cost
Quincy Shore Drive	Scenario 1%	2070	1	$42.2	$199.9	$949.7	$5,598.4	$5.3	$6,795.6
Quincy Shore Drive	Scenario 1%	2030	1	$41.8	$199.9	$949.7	$5,598.4	$5.3	$6,795.1
William T Morrissey Boulevard	Scenario 1%	2070	1	$91.8	$100.5	$171.0	$1,907.8	$0.0	$2,271.2
William T Morrissey Boulevard	Scenario 1%	2030	1	$49.5	$100.5	$171.0	$1,907.8	$0.0	$2,228.8
Nantasket Avenue	Scenario 1%	2070	1	$4.5	$51.8	$559.1	$347.3	$3.9	$966.5
Nantasket Avenue	Scenario 1%	2030	1	$4.1	$51.8	$559.1	$347.3	$3.9	$966.1
Lynnway**	Scenario 1%	2070	1	$79.3	$233.6	$517.9	$117.5	$0.0	$948.2
Lynnway**	Scenario 1%	2030	1	$66.6	$233.6	$517.9	$117.5	$0.0	$935.6
Carroll Parkway**	Scenario 1%	2070	1	$11.6	$233.6	$517.9	$117.5	$0.0	$880.6
Carroll Parkway**	Scenario 1%	2030	1	$8.5	$233.6	$517.9	$117.5	$0.0	$877.4
Storrow Drive	Scenario 1%	2070	1	$164.1	$390.7	$0.0	$0.0	$0.0	$554.7
Embankment Road	Scenario 1%	2070	1	$98.4	$390.7	$0.0	$0.0	$0.0	$489.1
Soldiers Field Road	Scenario 1%	2070	1	$226.1	$242.1	$0.0	$0.0	$0.0	$468.2
Revere Beach Boulevard	Scenario 1%	2070	1	$28.7	$106.2	$183.9	$116.0	$15.3	$450.0
Revere Beach Boulevard	Scenario 1%	2030	1	$16.6	$106.2	$183.9	$116.0	$15.3	$437.9
Winthrop Parkway	Scenario 1%	2070	1	$9.1	$70.7	$263.6	$67.2	$0.0	$410.5

Parkway Name	Scenario	Year	Duration of Disruption (days)	Cost of Reduced Vehicular Access (travel delay costs)	Cost of Lost Recreational Visits	Isolated Community - Lost Wage Income Out-commuters	Isolated Community - Lost Business Output	Cost of Lost Parking	Total 1-Day Disruption Cost
Winthrop Parkway	Scenario 1%	2030	1	$8.5	$70.7	$263.6	$67.2	$0.0	$409.9
Ramp-charles St To Longfellow Bridge	Scenario 1%	2070	1	$14.8	$390.7	$0.0	$0.0	$0.0	$405.5
Nahant Road	Scenario 1%	2070	1	$23.0	$51.4	$215.0	$109.9	$0.0	$399.4
Nahant Road	Scenario 1%	2030	1	$21.1	$51.4	$215.0	$109.9	$0.0	$397.5
Ramp-rt 28 Nb To Cambridge St	Scenario 1%	2070	1	$4.5	$390.7	$0.0	$0.0	$0.0	$395.2
Ramp To Charles Circle	Scenario 1%	2070	1	$3.4	$390.7	$0.0	$0.0	$0.0	$394.1
Embankment Road	Scenario 1%	2030	1	$2.2	$390.7	$0.0	$0.0	$0.0	$392.9
Soldiers Field Road	Scenario 1%	2030	1	$150.7	$242.1	$0.0	$0.0	$0.0	$392.8
William Day Boulevard	Scenario 1%	2070	1	$97.4	$285.3	$0.0	$0.0	$8.6	$391.4
Memorial Drive	Scenario 1%	2070	1	$101.7	$242.1	$0.0	$0.0	$15.9	$359.7
Mystic View Road	Scenario 1%	2070	1	$8.4	$76.0	$0.0	$269.0	$0.0	$353.4
William Day Boulevard	Scenario 1%	2030	1	$56.5	$285.3	$0.0	$0.0	$8.6	$350.4
Storrow Drive	Scenario 1%	2030	1	$78.0	$258.1	$0.0	$0.0	$0.0	$336.1
Memorial Drive	Scenario 1%	2030	1	$55.1	$242.1	$0.0	$0.0	$15.9	$313.2
Charles Street	Scenario 1%	2070	1	$18.6	$273.7	$0.0	$0.0	$0.0	$292.3
East Broadway	Scenario 1%	2070	1	$2.9	$285.3	$0.0	$0.0	$0.0	$288.2
Ramp-rt 3 To Rt 28 Sb	Scenario 1%	2070	1	$12.8	$273.7	$0.0	$0.0	$0.0	$286.6
East Broadway	Scenario 1%	2030	1	$1.2	$285.3	$0.0	$0.0	$0.0	$286.5
Charles Street Circle	Scenario 1%	2070	1	$11.1	$273.7	$0.0	$0.0	$0.0	$284.8
Ramp-rt 3 To Rt 28 Sb	Scenario 1%	2030	1	$0.9	$273.7	$0.0	$0.0	$0.0	$274.6
Berkeley Street	Scenario 1%	2070	1	$5.3	$258.1	$0.0	$0.0	$0.0	$263.4

Parkway Name	Scenario	Year	Duration of Disruption (days)	Cost of Reduced Vehicular Access (travel delay costs)	Cost of Lost Recreational Visits	Isolated Community - Lost Wage Income Out-commuters	Isolated Community - Lost Business Output	Cost of Lost Parking	Total 1-Day Disruption Cost
Unnamed Road - Storrow Dr & David G Mugar Way	Scenario 1%	2070	1	$4.9	$258.1	$0.0	$0.0	$0.0	$263.0
Ramp-storrow Dr To Rt 2a Wb	Scenario 1%	2070	1	$1.2	$258.1	$0.0	$0.0	$0.0	$259.3
Ramp-storrow Dr To Rt 2a Wb	Scenario 1%	2030	1	$0.9	$258.1	$0.0	$0.0	$0.0	$259.1
Ramp-western Ave To Soldiers Field Rd Wb	Scenario 1%	2070	1	$9.4	$242.1	$0.0	$0.0	$0.0	$251.5
Ramp-western Ave To Soldiers Field Rd Wb	Scenario 1%	2030	1	$8.9	$242.1	$0.0	$0.0	$0.0	$251.0
Ramp-soldiers Field Rd Wb To Western Ave	Scenario 1%	2070	1	$6.4	$242.1	$0.0	$0.0	$0.0	$248.5
Ramp-soldiers Field Rd Wb To Western Ave	Scenario 1%	2030	1	$6.0	$242.1	$0.0	$0.0	$0.0	$248.1
Ramp-soldiers Field Wb To N Harvard St	Scenario 1%	2070	1	$4.8	$242.1	$0.0	$0.0	$0.0	$246.9
Ramp-soldiers Field Wb To N Harvard St	Scenario 1%	2030	1	$4.5	$242.1	$0.0	$0.0	$0.0	$246.6
Ramp-n Harvard St To Soldiers Field Wb	Scenario 1%	2070	1	$4.1	$242.1	$0.0	$0.0	$0.0	$246.2
Ramp-n Harvard St To Soldiers Field Eb	Scenario 1%	2070	1	$4.1	$242.1	$0.0	$0.0	$0.0	$246.1
Ramp-n Harvard St To Soldiers Field Wb	Scenario 1%	2030	1	$3.9	$242.1	$0.0	$0.0	$0.0	$246.0
Ramp-n Harvard St To Soldiers Field Eb	Scenario 1%	2030	1	$2.4	$242.1	$0.0	$0.0	$0.0	$244.5
Ramp-soldiers Field Eb To N Harvard St	Scenario 1%	2070	1	$2.2	$242.1	$0.0	$0.0	$0.0	$244.3

Parkway Name	Scenario	Year	Duration of Disruption (days)	Cost of Reduced Vehicular Access (travel delay costs)	Cost of Lost Recreational Visits	Isolated Community - Lost Wage Income Out-commuters	Isolated Community - Lost Business Output	Cost of Lost Parking	Total 1-Day Disruption Cost
Western Avenue	Scenario 1%	2070	1	$2.1	$242.1	$0.0	$0.0	$0.0	$244.1
Western Avenue	Scenario 1%	2030	1	$1.9	$242.1	$0.0	$0.0	$0.0	$244.0
Ramp-soldiers Field Eb To N Harvard St	Scenario 1%	2030	1	$1.7	$242.1	$0.0	$0.0	$0.0	$243.8
North Harvard Street	Scenario 1%	2070	1	$0.8	$242.1	$0.0	$0.0	$0.0	$242.9
North Harvard Street	Scenario 1%	2030	1	$0.7	$242.1	$0.0	$0.0	$0.0	$242.8
Lynnway Underpass - Rt 1a Sb To Lynnway	Scenario 1%	2070	1	$3.8	$233.6	$0.0	$0.0	$0.0	$237.4
Lynnway Underpass - Rt 1a Sb To Lynnway	Scenario 1%	2030	1	$2.2	$233.6	$0.0	$0.0	$0.0	$235.8
Bowker Overpass	Scenario 1%	2070	1	$22.2	$168.4	$0.0	$0.0	$0.0	$190.6
Bowker Overpass	Scenario 1%	2030	1	$14.5	$168.4	$0.0	$0.0	$0.0	$183.0
Lynn Shore Drive	Scenario 1%	2070	1	$21.0	$152.2	$0.0	$0.0	$5.6	$178.7
Lynn Shore Drive	Scenario 1%	2030	1	$19.8	$152.2	$0.0	$0.0	$5.6	$177.5
West Street	Scenario 1%	2070	1	$0.5	$172.5	$0.0	$0.0	$0.0	$173.0
West Street	Scenario 1%	2030	1	$0.5	$172.5	$0.0	$0.0	$0.0	$173.0
Mystic Valley Parkway	Scenario 1%	2070	1	$64.5	$103.1	$0.0	$0.0	$0.0	$167.6
Humphrey Street	Scenario 1%	2070	1	$1.8	$152.2	$0.0	$0.0	$0.0	$154.0
Boylston Street	Scenario 1%	2070	1	$8.1	$145.8	$0.0	$0.0	$0.0	$153.9
Humphrey Street	Scenario 1%	2030	1	$1.7	$152.2	$0.0	$0.0	$0.0	$153.9
Eastern Avenue	Scenario 1%	2070	1	$0.9	$152.2	$0.0	$0.0	$0.0	$153.1
Eastern Avenue	Scenario 1%	2030	1	$0.8	$152.2	$0.0	$0.0	$0.0	$153.0
Ocean Street	Scenario 1%	2070	1	$0.1	$152.2	$0.0	$0.0	$0.0	$152.3
Ocean Street	Scenario 1%	2030	1	$0.1	$152.2	$0.0	$0.0	$0.0	$152.3
Ramp-berkeley St To Rt 28 Nb	Scenario 1%	2070	1	$5.7	$145.8	$0.0	$0.0	$0.0	$151.5

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Boylston Street	Scenario 1%	2030	1	$3.9	$145.8	$0.0	$0.0	$0.0	$149.7
Soldiers Field Road Extension	Scenario 1%	2070	1	$17.4	$131.2	$0.0	$0.0	$0.0	$148.6
Soldiers Field Road Extension	Scenario 1%	2030	1	$15.4	$131.2	$0.0	$0.0	$0.0	$146.6
Mystic Valley Parkway	Scenario 1%	2030	1	$42.1	$103.1	$0.0	$0.0	$0.0	$145.2
Revere Beach Parkway	Scenario 1%	2070	1	$26.3	$113.7	$0.0	$0.0	$0.0	$139.9
Revere Beach Parkway	Scenario 1%	2030	1	$19.7	$113.7	$0.0	$0.0	$0.0	$133.3
Alewife Brook Parkway	Scenario 1%	2070	1	$50.4	$77.4	$0.0	$0.0	$0.0	$127.8
Ramp-western Ave To Soldiers Field Rd Eb	Scenario 1%	2070	1	$3.0	$122.0	$0.0	$0.0	$0.0	$125.0
Land Boulevard	Scenario 1%	2070	1	$19.5	$100.7	$0.0	$0.0	$0.0	$120.2
Unnamed Road - Riverway	Scenario 1%	2070	1	$0.4	$117.7	$0.0	$0.0	$0.0	$118.1
Unnamed Road - Riverway	Scenario 1%	2030	1	$0.3	$117.7	$0.0	$0.0	$0.0	$118.0
Park Drive	Scenario 1%	2070	1	$10.8	$99.5	$0.0	$0.0	$1.6	$112.0
Riverway	Scenario 1%	2070	1	$33.8	$76.8	$0.0	$0.0	$0.0	$110.6
Oak Island Street	Scenario 1%	2070	1	$1.7	$106.2	$0.0	$0.0	$0.0	$107.8
Oak Island Street	Scenario 1%	2030	1	$1.6	$106.2	$0.0	$0.0	$0.0	$107.8
Morrissey Service Road	Scenario 1%	2070	1	$6.9	$100.5	$0.0	$0.0	$0.0	$107.5
Eliot Circle	Scenario 1%	2070	1	$0.9	$106.2	$0.0	$0.0	$0.2	$107.3
Eliot Circle	Scenario 1%	2030	1	$0.7	$106.2	$0.0	$0.0	$0.2	$107.1
Revere Street	Scenario 1%	2070	1	$0.4	$106.2	$0.0	$0.0	$0.0	$106.6
Revere Street	Scenario 1%	2030	1	$0.4	$106.2	$0.0	$0.0	$0.0	$106.6
Shirley Avenue	Scenario 1%	2070	1	$0.3	$106.2	$0.0	$0.0	$0.0	$106.5
Shirley Avenue	Scenario 1%	2030	1	$0.1	$106.2	$0.0	$0.0	$0.0	$106.3

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Park Drive	Scenario 1%	2030	1	$4.5	$99.5	$0.0	$0.0	$1.6	$105.7
Ramp-mem Dr To Cambridgeprt Cir Wb	Scenario 1%	2070	1	$1.6	$103.5	$0.0	$0.0	$0.0	$105.0
First Street	Scenario 1%	2070	1	$3.9	$100.7	$0.0	$0.0	$0.0	$104.6
Medford Street	Scenario 1%	2070	1	$1.2	$103.1	$0.0	$0.0	$0.0	$104.3
Ramp-mem Dr To Cambridgeprt Cir Wb	Scenario 1%	2030	1	$0.8	$103.5	$0.0	$0.0	$0.0	$104.3
Medford Street	Scenario 1%	2030	1	$1.1	$103.1	$0.0	$0.0	$0.0	$104.2
Land Boulevard	Scenario 1%	2030	1	$3.1	$100.7	$0.0	$0.0	$0.0	$103.8
Neponset Avenue	Scenario 1%	2070	1	$2.4	$100.5	$0.0	$0.0	$0.0	$102.9
Neponset Avenue	Scenario 1%	2030	1	$2.3	$100.5	$0.0	$0.0	$0.0	$102.8
Alewife Brook Parkway	Scenario 1%	2030	1	$24.3	$77.4	$0.0	$0.0	$0.0	$101.7
Unnamed Road - Memorial Dr & Land Boulevard	Scenario 1%	2070	1	$0.4	$100.7	$0.0	$0.0	$0.0	$101.1
Unnamed Road - Land Boulevard	Scenario 1%	2070	1	$0.2	$100.7	$0.0	$0.0	$0.0	$100.9
Unnamed Road - Memorial Dr & Land Boulevard	Scenario 1%	2030	1	$0.1	$100.7	$0.0	$0.0	$0.0	$100.8
Memorial Drive Underpass	Scenario 1%	2070	1	$7.5	$93.0	$0.0	$0.0	$0.1	$100.7
Unnamed Road - Fenway & Park Drive	Scenario 1%	2070	1	$0.8	$99.5	$0.0	$0.0	$0.0	$100.3
Unnamed Road - Fenway & Park Drive	Scenario 1%	2030	1	$0.7	$99.5	$0.0	$0.0	$0.0	$100.3

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Memorial Drive Underpass	Scenario 1%	2030	1	$6.5	$93.0	$0.0	$0.0	$0.1	$99.6
Connector To Eliot Bridge	Scenario 1%	2070	1	$1.5	$98.1	$0.0	$0.0	$0.0	$99.6
Ramp-charlesgate Overpass To Charlesgate	Scenario 1%	2070	1	$1.8	$95.1	$0.0	$0.0	$0.0	$96.9
Ramp-charlesgate Overpass To Charlesgate	Scenario 1%	2030	1	$0.9	$95.1	$0.0	$0.0	$0.0	$96.0
Nonantum Road	Scenario 1%	2070	1	$18.1	$77.6	$0.0	$0.0	$0.0	$95.7
Massachusetts Avenue	Scenario 1%	2070	1	$0.6	$93.0	$0.0	$0.0	$0.0	$93.6
Massachusetts Avenue	Scenario 1%	2030	1	$0.6	$93.0	$0.0	$0.0	$0.0	$93.6
Unnamed Road - Memorial Dr 1	Scenario 1%	2070	1	$0.4	$93.0	$0.0	$0.0	$0.0	$93.4
Unnamed Road - Memorial Dr 1	Scenario 1%	2030	1	$0.3	$93.0	$0.0	$0.0	$0.0	$93.4
Nonantum Road	Scenario 1%	2030	1	$15.1	$77.6	$0.0	$0.0	$0.0	$92.7
Mystic Valley-alewife Brook Rotary	Scenario 1%	2070	1	$1.1	$91.4	$0.0	$0.0	$0.0	$92.5
Mystic Valley-alewife Brook Rotary	Scenario 1%	2030	1	$0.6	$91.4	$0.0	$0.0	$0.0	$92.0
Riverway	Scenario 1%	2030	1	$13.7	$76.8	$0.0	$0.0	$0.0	$90.5
Greenough Boulevard	Scenario 1%	2070	1	$13.2	$72.0	$0.0	$0.0	$0.0	$85.2
Concord Avenue	Scenario 1%	2070	1	$7.0	$77.4	$0.0	$0.0	$0.0	$84.4
Terminal Road	Scenario 1%	2070	1	$4.8	$77.4	$0.0	$0.0	$0.0	$82.2
Greenough Boulevard	Scenario 1%	2030	1	$10.1	$72.0	$0.0	$0.0	$0.0	$82.1
Old Colony Avenue	Scenario 1%	2070	1	$10.6	$67.8	$0.0	$0.0	$3.0	$81.4
Jamaicaway	Scenario 1%	2070	1	$1.5	$79.7	$0.0	$0.0	$0.0	$81.2

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Jamaicaway	Scenario 1%	2030	1	$1.0	$79.7	$0.0	$0.0	$0.0	$80.7
North Beacon Street	Scenario 1%	2070	1	$11.5	$69.0	$0.0	$0.0	$0.0	$80.6
Terminal Road	Scenario 1%	2030	1	$3.2	$77.4	$0.0	$0.0	$0.0	$80.5
Brooks Street	Scenario 1%	2070	1	$2.8	$77.6	$0.0	$0.0	$0.0	$80.4
Alewife Brook- Concord Ave Rotary	Scenario 1%	2070	1	$2.4	$77.4	$0.0	$0.0	$0.0	$79.8
Mystic View Road	Scenario 1%	2030	1	$3.8	$76.0	$0.0	$0.0	$0.0	$79.8
Brooks Street	Scenario 1%	2030	1	$1.7	$77.6	$0.0	$0.0	$0.0	$79.3
Alewife Brook- Concord Ave Rotary	Scenario 1%	2030	1	$1.9	$77.4	$0.0	$0.0	$0.0	$79.3
Sozio Rotary	Scenario 1%	2070	1	$1.9	$77.4	$0.0	$0.0	$0.0	$79.2
Riverway Frontage Road	Scenario 1%	2070	1	$1.1	$76.8	$0.0	$0.0	$1.0	$78.9
Nonantum Road Branch	Scenario 1%	2070	1	$0.8	$77.6	$0.0	$0.0	$0.0	$78.4
Nonantum Road Branch	Scenario 1%	2030	1	$0.8	$77.6	$0.0	$0.0	$0.0	$78.4
Charlesbank Road	Scenario 1%	2070	1	$0.6	$77.6	$0.0	$0.0	$0.0	$78.2
Charlesbank Road	Scenario 1%	2030	1	$0.6	$77.6	$0.0	$0.0	$0.0	$78.2
Earhart Dam Access Road - Somerville Side	Scenario 1%	2070	1	$2.1	$76.0	$0.0	$0.0	$0.0	$78.0
Concord Avenue	Scenario 1%	2030	1	$0.6	$77.4	$0.0	$0.0	$0.0	$78.0
Earhart Dam Access Road - Somerville Side	Scenario 1%	2030	1	$2.0	$76.0	$0.0	$0.0	$0.0	$78.0
Fenway	Scenario 1%	2070	1	$9.7	$64.9	$0.0	$0.0	$3.1	$77.8
Ramp-rt 9 To Jamaicaway	Scenario 1%	2070	1	$0.5	$76.8	$0.0	$0.0	$0.0	$77.3
Ramp-jamaicaway To Rt 9	Scenario 1%	2070	1	$0.5	$76.8	$0.0	$0.0	$0.0	$77.3

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Ramp-rt 9 To Jamaicaway	Scenario 1%	2030	1	$0.5	$76.8	$0.0	$0.0	$0.0	$77.3
Ramp-jamaicaway To Rt 9	Scenario 1%	2030	1	$0.4	$76.8	$0.0	$0.0	$0.0	$77.2
North Beacon Street	Scenario 1%	2030	1	$7.4	$69.0	$0.0	$0.0	$0.0	$76.4
Arsenal Street	Scenario 1%	2070	1	$3.9	$72.0	$0.0	$0.0	$0.0	$75.9
State Road	Scenario 1%	2070	1	$1.0	$74.2	$0.0	$0.0	$0.0	$75.2
State Road	Scenario 1%	2030	1	$0.9	$74.2	$0.0	$0.0	$0.0	$75.1
Jfk-umass Station Road	Scenario 1%	2070	1	$6.5	$67.8	$0.0	$0.0	$0.0	$74.3
Arsenal Street	Scenario 1%	2030	1	$0.5	$72.0	$0.0	$0.0	$0.0	$72.5
Mount Vernon Street	Scenario 1%	2070	1	$3.8	$67.8	$0.0	$0.0	$0.0	$71.6
Mount Vernon Street	Scenario 1%	2030	1	$3.6	$67.8	$0.0	$0.0	$0.0	$71.4
Fresh Pond Parkway	Scenario 1%	2070	1	$7.2	$64.0	$0.0	$0.0	$0.0	$71.2
Noble Street	Scenario 1%	2070	1	$0.2	$70.7	$0.0	$0.0	$0.0	$70.9
Noble Street	Scenario 1%	2030	1	$0.2	$70.7	$0.0	$0.0	$0.0	$70.9
Wave Avenue	Scenario 1%	2070	1	$0.1	$70.7	$0.0	$0.0	$0.0	$70.8
Wave Avenue	Scenario 1%	2030	1	$0.1	$70.7	$0.0	$0.0	$0.0	$70.8
Jfk-umass Station Road	Scenario 1%	2030	1	$2.7	$67.8	$0.0	$0.0	$0.0	$70.5
Hull Shore Drive	Scenario 1%	2070	1	$5.4	$64.9	$0.0	$0.0	$0.0	$70.2
Hull Shore Drive	Scenario 1%	2030	1	$5.2	$64.9	$0.0	$0.0	$0.0	$70.0
Gilmore Bridge	Scenario 1%	2070	1	$5.8	$63.9	$0.0	$0.0	$0.0	$69.8
Cambridge Parkway Connector	Scenario 1%	2070	1	$4.4	$63.9	$0.0	$0.0	$0.0	$68.3
Kosciuszko Circle	Scenario 1%	2070	1	$0.4	$67.8	$0.0	$0.0	$0.0	$68.2
Cambridge Parkway Connector	Scenario 1%	2030	1	$4.1	$63.9	$0.0	$0.0	$0.0	$68.1
Unnamed Road - Park Drive	Scenario 1%	2070	1	$4.0	$63.9	$0.0	$0.0	$0.0	$67.9

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Agassiz Road	Scenario 1%	2070	1	$3.0	$63.9	$0.0	$0.0	$0.0	$67.0
Ramp-mem Dr To Cambridgeprt Cir Eb	Scenario 1%	2070	1	$2.9	$63.9	$0.0	$0.0	$0.0	$66.8
Fellsway	Scenario 1%	2070	1	$14.7	$28.5	$0.0	$0.0	$23.6	$66.8
Ramp-cambridgeprt Cir To Mem Dr Wb	Scenario 1%	2070	1	$2.5	$63.9	$0.0	$0.0	$0.0	$66.5
Gilmore Bridge	Scenario 1%	2030	1	$2.5	$63.9	$0.0	$0.0	$0.0	$66.4
Agassiz Road	Scenario 1%	2030	1	$2.5	$63.9	$0.0	$0.0	$0.0	$66.4
First Street	Scenario 1%	2030	1	$2.3	$63.9	$0.0	$0.0	$0.0	$66.3
Brookline Avenue	Scenario 1%	2070	1	$1.2	$64.9	$0.0	$0.0	$0.0	$66.1
Brookline Avenue	Scenario 1%	2030	1	$0.8	$64.9	$0.0	$0.0	$0.0	$65.7
Reid Rotary	Scenario 1%	2070	1	$1.7	$63.9	$0.0	$0.0	$0.0	$65.7
Ramp-bu Bridge To Memorial Dr Eb	Scenario 1%	2070	1	$1.7	$63.9	$0.0	$0.0	$0.0	$65.6
Boylston Street Service Road	Scenario 1%	2070	1	$1.4	$63.9	$0.0	$0.0	$0.0	$65.3
Unnamed Road - Fenway	Scenario 1%	2070	1	$1.3	$63.9	$0.0	$0.0	$0.0	$65.3
Westland Entrance	Scenario 1%	2070	1	$1.0	$63.9	$0.0	$0.0	$0.0	$65.0
Ramp-bu Bridge To Memorial Dr Eb	Scenario 1%	2030	1	$0.9	$63.9	$0.0	$0.0	$0.0	$64.8
Unnamed Road - Main St & Memorial Dr	Scenario 1%	2070	1	$0.7	$63.9	$0.0	$0.0	$0.0	$64.6
Brookline Street	Scenario 1%	2070	1	$0.6	$63.9	$0.0	$0.0	$0.0	$64.6
Fresh Pond Parkway	Scenario 1%	2030	1	$0.6	$64.0	$0.0	$0.0	$0.0	$64.5
Unnamed Road - First Street & Memorial Dr	Scenario 1%	2070	1	$0.6	$63.9	$0.0	$0.0	$0.0	$64.5

Parkway Name	Scenario	Year	Duration of Disruption (days)	Cost of Reduced Vehicular Access (travel delay costs)	Cost of Lost Recreational Visits	Isolated Community - Lost Wage Income Out-commuters	Isolated Community - Lost Business Output	Cost of Lost Parking	Total 1-Day Disruption Cost
Unnamed Road - First Street & Memorial Dr	Scenario 1%	2030	1	$0.5	$63.9	$0.0	$0.0	$0.0	$64.5
Unnamed Road - Memorial Dr 4	Scenario 1%	2070	1	$0.4	$63.9	$0.0	$0.0	$0.0	$64.3
Unnamed Road - Memorial Dr 4	Scenario 1%	2030	1	$0.3	$63.9	$0.0	$0.0	$0.0	$64.3
Unnamed Road - Memorial Dr 3	Scenario 1%	2070	1	$0.3	$63.9	$0.0	$0.0	$0.0	$64.3
Unnamed Road - Memorial Dr 3	Scenario 1%	2030	1	$0.3	$63.9	$0.0	$0.0	$0.0	$64.2
Unnamed Road - Memorial Dr 2	Scenario 1%	2070	1	$0.3	$63.9	$0.0	$0.0	$0.0	$64.2
Unnamed Road - Memorial Dr 5	Scenario 1%	2070	1	$0.3	$63.9	$0.0	$0.0	$0.0	$64.2
Unnamed Road - Memorial Dr 2	Scenario 1%	2030	1	$0.3	$63.9	$0.0	$0.0	$0.0	$64.2
Unnamed Road - Memorial Dr 5	Scenario 1%	2030	1	$0.2	$63.9	$0.0	$0.0	$0.0	$64.2
Unnamed Road - Memorial Dr 6	Scenario 1%	2070	1	$0.2	$63.9	$0.0	$0.0	$0.0	$64.1
Unnamed Road - Memorial Dr 6	Scenario 1%	2030	1	$0.2	$63.9	$0.0	$0.0	$0.0	$64.1
Connector Mystic Valley Parkway	Scenario 1%	2070	1	$7.8	$55.9	$0.0	$0.0	$0.0	$63.7
Connector Mystic Valley Parkway	Scenario 1%	2030	1	$6.0	$55.9	$0.0	$0.0	$0.0	$61.9
Ocean Avenue	Scenario 1%	2070	1	$11.4	$40.9	$0.0	$0.0	$5.7	$58.0
Ramp-rt 16 Wb To Main Street	Scenario 1%	2070	1	$1.6	$55.9	$0.0	$0.0	$0.0	$57.5
Ramp-rt 16 Wb To Main Street	Scenario 1%	2030	1	$1.6	$55.9	$0.0	$0.0	$0.0	$57.4
Ramp-main Street To Rt 16 Wb	Scenario 1%	2070	1	$1.3	$55.9	$0.0	$0.0	$0.0	$57.2

Parkway Name	Scenario	Year	Duration of Disruption (days)	Cost of Reduced Vehicular Access (travel delay costs)	Cost of Lost Recreational Visits	Isolated Community - Lost Wage Income Out-commuters	Isolated Community - Lost Business Output	Cost of Lost Parking	Total 1-Day Disruption Cost
Ramp-main Street To Rt 16 Wb	Scenario 1%	2030	1	$1.2	$55.9	$0.0	$0.0	$0.0	$57.1
Ocean Avenue	Scenario 1%	2030	1	$9.4	$40.9	$0.0	$0.0	$5.7	$56.0
Fellsway	Scenario 1%	2030	1	$3.8	$28.5	$0.0	$0.0	$23.6	$55.9
Nahant Circle	Scenario 1%	2070	1	$1.4	$51.4	$0.0	$0.0	$0.0	$52.8
Nahant Circle	Scenario 1%	2030	1	$1.3	$51.4	$0.0	$0.0	$0.0	$52.7
Wharf Avenue	Scenario 1%	2070	1	$0.3	$51.8	$0.0	$0.0	$0.0	$52.0
Unnamed Road - Park Drive	Scenario 1%	2030	1	$0.2	$51.9	$0.0	$0.0	$0.0	$52.0
Wharf Avenue	Scenario 1%	2030	1	$0.3	$51.8	$0.0	$0.0	$0.0	$52.0
Winthrop Shore Drive	Scenario 1%	2070	1	$4.9	$32.9	$0.0	$0.0	$6.6	$44.3
Winthrop Shore Drive	Scenario 1%	2030	1	$4.5	$32.9	$0.0	$0.0	$6.6	$44.0
Beacon Street	Scenario 1%	2070	1	$0.4	$41.7	$0.0	$0.0	$0.0	$42.1
Beacon Street	Scenario 1%	2030	1	$0.2	$41.7	$0.0	$0.0	$0.0	$41.9
Fenway	Scenario 1%	2030	1	$2.6	$33.8	$0.0	$0.0	$3.1	$39.6
Arlington Street	Scenario 1%	2070	1	$0.7	$36.9	$0.0	$0.0	$0.0	$37.7
Fellsway West	Scenario 1%	2070	1	$2.5	$32.5	$0.0	$0.0	$2.6	$37.6
Arlington Street	Scenario 1%	2030	1	$0.7	$36.9	$0.0	$0.0	$0.0	$37.6
Fenway Connector To Park Drive	Scenario 1%	2070	1	$1.4	$33.8	$0.0	$0.0	$0.0	$35.2
Fenway Connector To Park Drive	Scenario 1%	2030	1	$1.0	$33.8	$0.0	$0.0	$0.0	$34.8
Charlesgate East	Scenario 1%	2070	1	$2.3	$29.3	$0.0	$0.0	$0.9	$32.5
Charlesgate East	Scenario 1%	2030	1	$1.3	$29.3	$0.0	$0.0	$0.9	$31.5
Furnace Brook Parkway	Scenario 1%	2070	1	$6.0	$22.9	$0.0	$0.0	$0.0	$29.0
Furnace Brook Parkway	Scenario 1%	2030	1	$5.4	$22.9	$0.0	$0.0	$0.0	$28.3
Forsyth Way	Scenario 1%	2070	1	$1.8	$24.8	$0.0	$0.0	$0.0	$26.5
David G Mugar Way	Scenario 1%	2070	1	$1.9	$24.3	$0.0	$0.0	$0.0	$26.3

Parkway Name	Scenario	Year	Duration of Disruption (days)	Cost of Reduced Vehicular Access (travel delay costs)	Cost of Lost Recreational Visits	Isolated Community - Lost Wage Income Out-commuters	Isolated Community - Lost Business Output	Cost of Lost Parking	Total 1-Day Disruption Cost
High Street	Scenario 1%	2070	1	$0.8	$25.1	$0.0	$0.0	$0.0	$26.0
High Street	Scenario 1%	2030	1	$0.8	$25.1	$0.0	$0.0	$0.0	$25.9
Everett Street	Scenario 1%	2070	1	$0.5	$25.0	$0.0	$0.0	$0.0	$25.4
Evans Way	Scenario 1%	2070	1	$0.3	$24.8	$0.0	$0.0	$0.0	$25.1
Louis Prang Street	Scenario 1%	2070	1	$0.2	$24.8	$0.0	$0.0	$0.0	$25.0
Evans Way	Scenario 1%	2030	1	$0.2	$24.8	$0.0	$0.0	$0.0	$24.9
Forsyth Way	Scenario 1%	2030	1	$0.1	$24.8	$0.0	$0.0	$0.0	$24.9
Louis Prang Street	Scenario 1%	2030	1	$0.1	$24.8	$0.0	$0.0	$0.0	$24.9
Babe Ruth Park Drive	Scenario 1%	2070	1	$0.3	$20.6	$0.0	$0.0	$0.0	$20.9
Babe Ruth Park Drive	Scenario 1%	2030	1	$0.1	$20.6	$0.0	$0.0	$0.0	$20.7
Charlesgate West	Scenario 1%	2070	1	$1.9	$17.9	$0.0	$0.0	$0.0	$19.9
Ramp-soldiers Field Rd Eb To Western Ave	Scenario 1%	2070	1	$0.3	$15.1	$0.0	$0.0	$0.0	$15.3
Cambridge Street	Scenario 1%	2070	1	$0.1	$15.1	$0.0	$0.0	$0.0	$15.2
Cambridge Street	Scenario 1%	2030	1	$0.1	$15.1	$0.0	$0.0	$0.0	$15.1
Ramp-western Ave To Soldiers Field Rd Eb	Scenario 1%	2030	1	$0.0	$15.1	$0.0	$0.0	$0.0	$15.1
Grove Street	Scenario 1%	2070	1	$0.3	$12.9	$0.0	$0.0	$0.0	$13.2
Connector To Eliot Bridge	Scenario 1%	2030	1	$0.2	$12.9	$0.0	$0.0	$0.0	$13.1
Unnamed Road - Greenough Boulevard	Scenario 1%	2070	1	$0.1	$12.9	$0.0	$0.0	$0.0	$13.0
Unnamed Road - Greenough Boulevard	Scenario 1%	2030	1	$0.1	$12.9	$0.0	$0.0	$0.0	$13.0
Grove Street	Scenario 1%	2030	1	$0.1	$12.9	$0.0	$0.0	$0.0	$12.9
Cambridge Parkway	Scenario 1%	2070	1	$0.2	$4.0	$0.0	$0.0	$8.1	$12.2

Parkway Name	Scenario	Year	Duration of Disruption (days)	Cost of Reduced Vehicular Access (travel delay costs)	Cost of Lost Recreational Visits	Isolated Community - Lost Wage Income Out-commuters	Isolated Community - Lost Business Output	Cost of Lost Parking	Total 1-Day Disruption Cost
Cambridge Parkway	Scenario 1%	2030	1	$0.1	$4.0	$0.0	$0.0	$8.1	$12.2
Charles River Road	Scenario 1%	2070	1	$1.3	$8.1	$0.0	$0.0	$0.0	$9.4
Charles River Road	Scenario 1%	2030	1	$1.2	$8.1	$0.0	$0.0	$0.0	$9.3
Mystic River Road	Scenario 1%	2070	1	$0.2	$2.4	$0.0	$0.0	$2.8	$5.5
Mystic River Road	Scenario 1%	2030	1	$0.2	$2.4	$0.0	$0.0	$2.8	$5.4
Shore Road	Scenario 1%	2070	1	$0.2	$4.1	$0.0	$0.0	$1.1	$5.4
Shore Road	Scenario 1%	2030	1	$0.2	$4.1	$0.0	$0.0	$1.1	$5.3
Commandant's Way	Scenario 1%	2070	1	$0.1	$3.9	$0.0	$0.0	$0.0	$4.0
Commandant's Way	Scenario 1%	2030	1	$0.1	$3.9	$0.0	$0.0	$0.0	$4.0
Old Colony Avenue	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$3.0	$3.0
Fellsway West	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$2.6	$2.6
Harvard Avenue	Scenario 1%	2070	1	$0.0	$2.4	$0.0	$0.0	$0.0	$2.5
Harvard Avenue	Scenario 1%	2030	1	$0.0	$2.4	$0.0	$0.0	$0.0	$2.5
Jerome Street	Scenario 1%	2070	1	$0.0	$2.4	$0.0	$0.0	$0.0	$2.4
Jerome Street	Scenario 1%	2030	1	$0.0	$2.4	$0.0	$0.0	$0.0	$2.4
Broad Sound Avenue	Scenario 1%	2070	1	$0.1	$1.5	$0.0	$0.0	$0.0	$1.6
Broad Sound Avenue	Scenario 1%	2030	1	$0.1	$1.5	$0.0	$0.0	$0.0	$1.6
Riverway Frontage Road	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$1.0	$1.0
Beaver Place	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Beaver Place	Scenario 1%	2070	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Berkeley Street	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Boylston Street Service Road	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Brookline Street	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Charles Street	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Charles Street Circle	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0

Parkway Name	Scenario	Year	Duration of Disruption (days)	Cost of Reduced Vehicular Access (travel delay costs)	Cost of Lost Recreational Visits	Isolated Community - Lost Wage Income Out-commuters	Isolated Community - Lost Business Output	Cost of Lost Parking	Total 1-Day Disruption Cost
Charlesgate West	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
David G Mugar Way	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Everett Street	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Kosciuszko Circle	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Morrissey Service Road	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Ramp To Charles Circle	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Ramp-berkeley St To Rt 28 Nb	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Ramp-cambridgeprt Cir To Mem Dr Wb	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Ramp-charles St To Longfellow Bridge	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Ramp-mem Dr To Cambridgeprt Cir Eb	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Ramp-rt 28 Nb To Cambridge St	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Ramp-soldiers Field Rd Eb To Western Ave	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Reid Rotary	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Sozio Rotary	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Unnamed Road - Fenway	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Unnamed Road - Land Boulevard	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Unnamed Road - Main St & Memorial Dr	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Unnamed Road - Storrow Dr & David G Mugar Way	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0

Parkway Name	Scenario	Year	Duration of Disruption (days)	Cost of Reduced Vehicular Access (travel delay costs)	Cost of Lost Recreational Visits	Isolated Community - Lost Wage Income Out-commuters	Isolated Community - Lost Business Output	Cost of Lost Parking	Total 1-Day Disruption Cost
Westland Entrance	Scenario 1%	2030	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0

** The same isolated community impact values are reported for both Lynnway and Carroll Parkway in this table. The geographies of these parkways, the communities they would isolate, and the Census tracts for which socioeconomic data were pulled make it impossible to disentangle what impacts would occur if only one of these parkways was flooded. These impacts are only counted once in the summary table in the main body of the report to avoid double-counting of impacts.

Appendix C: Memo on Visitor Valuation (Previously Transmitted)

TO: Jennifer Ducey, Peter Federico (Stantec)

FROM: Hajra Shahab, Ira Hirschman, Cecilia Viggiano (EBP US)

DATE: 08-08-2023

RE: 2nd Revision - Loss of service valuation- user's willingness to pay to access urban parks

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1 Introduction

Urban parks provide several recreational benefits to users and nearby residents. Benefits accrue directly to those who access these facilities as well as to the region more generally, as urban parks can generate economic value and stimulate growth for the region. Benefits and impacts can vary depending on different amenities available, such as bike trails, pedestrian tracks, picnic spots, etc.

As parks strive to attract users, it is important to understand a user's willingness to pay to access these services. Different users place different value on accessing these services depending on the type of activity engaged in and the level of utility derived. These rates may also be partly reflected in different forms of charges including parking fees, general fees to access bike trails, etc.

2 Project Scope: Loss of Service Valuation

In the case of a flood impacting parkways, there is a high chance of loss of access to DCR parkways and recreational facilities for varying periods of time, depending on the intensity of flooding. In such cases, users will be temporarily unable to access those DCR recreational facilities and they will experience an economic loss that can be approximated based on willingness to pay studies and/or by proxy indicators of willingness to pay, such as admissions fees or parking fees to access urban parks, including DCR parks.

The purpose of this memo is to review studies and data which can help to put a range of monetary value on what recreational visitors/users may be willing to pay to access urban parks, such as those that are part of the larger corridors within which DCR's parkways are routed. To estimate these losses, this memo explores different sources to understand what value users place on these services and what can be a good range of dollar amount to assess this damage for the state of Massachusetts.

3 Massachusetts Parks - Parking Fee

While Massachusetts state parks are free to enter and enjoy, users are required to pay for parking at selected facilities. Hence, it serves as a potential, albeit limited proxy to understand what users are willing to pay to access these parks. In the case of Massachusetts, we found that state residents are charged a lower fee ranging between $5-$35 as compared to non-MA residents who are usually required to pay between $20-$40 to access parks.[1] Given our project area of study, only Nahant and Hull parkways charge a parking fee. This analysis does not consider the metered parking options along the parkway themselves.

4 Recreation Economic Benefits from National Forest System

The United States Department of Agriculture (USDA) conducted a study to estimate outdoor recreation economic benefits from the National Forest System. Estimates for these were calculated based on outdoor recreation activities that are currently recognized by the Forest Service NVUM program (USDA Forest Service 2017). While the activities captured by this study reflect those specific to national forests, some of them (such as biking, hiking and picnicking) can be extended to urban parks as well, with appropriate adjustments to reflect the relative scale of national forests compared to urban parks.

In terms of valuation, the national average for hiking in a Forest Service area is set at $95.31, biking at $97.69, picnicking at $60.03 and the overall weighted average for all activities is set at $79.96 per person per primary activity day[2]. While we have no basis for deriving a fractional benefit, we can assume that a user's valuation for an urban park for the same activities is probably no more than half the value, and more in the range of a quarter of the value when compared to national forests. Users likely place a higher value on national forests and derive a higher utility from it than from a walk in an urban park.

5 Virginia Trails Study

Another study conducted for the Virginia Creeper Trail (VCT) estimated the economic value and impacts of recreational trails on a per person per trip basis to be $22.78 and also assumes an opportunity cost of one quarter the household wage making the per person per trip consumer surplus equivalent to $38.90.[3] The study created an empirical travel cost demand model for visitor behavior looking at data of on-site visitors listing their reason to access park as their primary purpose or destination and looking at variables such as distance travelled, annual household income, number of people in a household, age, sex, and a binary variable to check whether a viable substitute for VCT was available.

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[1] Parking at Massachusetts State Parks | Mass.gov
[2] pnw_gtr957.pdf (usda.gov)
[3] (PDF) Estimating the Economic Value and Impacts of Recreational Trails: A Case Study of the Virginia Creeper Rail Trail (researchgate.net)

6 USDOT BCA Guidance

United States Department of Transportation (USDOT) Benefit Cost Analysis guidance[4] for different potential infrastructure projects also assigns values to different modes such as walking and cycling. The recommended value per induced trip (2021 $) for walking is $7.20 and $6.42 for cycling. The guideline assumes an average walking trip distance of 0.86 miles and following our assumption for a per person per day trip of ~3 miles, this sums up to $25.11. On the other hand, it assumes an average cycling trip of 2.38 miles which approximately adds up to $16.18 (assuming 6 miles per person per day).

7 Health Benefits of Active Transportation

Apart from recreation benefits, there are multiple health benefits that active transportation such as biking and walking generates, which often encourages user to pay for these services. A user's willingness to pay for active transportation stems from their interest in seeking an active, healthy lifestyle along with a desire to avoid incurring any cost on healthcare services.

Mulley, et al. (2013) developed a framework for the Australian context where they estimated that reduced mortality and morbidity provided by an active lifestyle provides benefits worth on average AU$1.68 per km (range $1.23–$2.50) for walking and AU$1.12 per km (range $0.82–$1.67) for bicycling.[5] Assuming each walking and bicycle trip to be roughly around ~3 miles and 6 miles daily respectively, the per day valuation roughly sums up to $25 and $16.7 for walking and bicycling, respectively.

8 Direct Use Value of Urban Parks – Boston Parks

There are multiple tangible direct benefits that urban parks provide such as walking, picnicking, etc. While most of these services are free of charge, economists calculate overall valuation to understand how much a user would be willing to pay for the same services in a commercial facility. A method developed by U.S. Army Corps of Engineers based on the "Unit Day Value" was applied by the Trust for Public Land in a study of Boston parks to estimate average value per visit for picnicking and trail to be $1.91 and bicycling to be $3.05.[6] As these values are in 2006 dollars, we used a CPI Inflation calculator[7] to adjust these to 2023 dollars. This results in $2.88 for picnicking and trail and $4.60 for bicycling. The number of park visits and the activities users engaged in were determined through a professionally conducted telephone survey of 600 Boston residents.

[4] benefit-cost-analysis-guidance-2020_0.pdf (transportation.gov)
[5] Valuing active travel: Including the health benefits of sustainable transport in transportation appraisal frameworks - ScienceDirect
[6] Trust for Public Land, Measuring the Economic Value of an City Park System, 2009. ccpe-econvalueparks-rpt.pdf (tpl.org)
[7] CPI Inflation Calculator (bls.gov)

9 Limitations

This analysis comes with its own set of limitations. All studies and data found online are assumed to give a proxy value for consumer's willingness to pay to access urban parks. Secondly, there could be multiple external factors affecting consumers' willingness to pay for these services which may or may not be fully captured, such as increasing fuel prices to drive to the park, etc.[8] Lastly, except for parking fees and valuation of city park system, none of the studies directly cover parks within Massachusetts and there could be state-level differences that are not fully captured in this memo.

10 Summary and Conclusion

Based on our analysis, we estimate an average visitor's valuation of a DCR parkway facility at **$35 per visit**.

The following bullet points and accompanying table summarize the results of our research.

- A USDA study of the National Forest system found a range of values per visit of up to $90. We assume that a user's valuation for an urban park for the same activities is probably in the range of a third of the value when compared to national forests. We estimate the equivalent value of an urban park visit, based on this study, to be in the upper bound range of about $30 to $40 per visit.

- We looked at parking fees in Massachusetts as a limited proxy to understand what users are willing to pay to access some parks. Fees ranged from $5 for residents too $35 for non-Massachusetts residents.

- An Australian study observed reduced mortality and morbidity because of active lifestyle. These health benefits are valued for a daily ~3 miles walk and ~6 miles bike trip – yielding value of $25 per visit.

- A study of Virginia Creeper Trail (VCT) estimated the economic value and impacts of recreational trails on a per person per trip basis using an empirical travel cost demand model for visitor behavior looking at data of on-site visitors. Values ranged from about $17 to $25 per visit depending on the activity.

- United States Department of Transportation (USDOT) Benefit Cost Analysis guidance for different potential infrastructure projects assigns values to different modes such as walking and cycling. Applying this yielded recreational and health benefits of around $20 for an equivalent DCR parkway visit.

- A method by U.S. Army Corps of Engineers was applied by the Trust for Public Land in a study of Boston parks to estimate average value per visit for picnicking and trail use. Adjusted for

[8] (PDF) Estimating the Economic Value and Impacts of Recreational Trails: A Case Study of the Virginia Creeper Rail Trail (researchgate.net)

inflation, the Trust found values of $2.88 for picnicking and trail and $4.60 for bicycling. Based on the other research findings, as well as input from the DCR Project Team, we believe this result is a an unusually low outlier value, and we thus discount these results in offering an estimate of the average user valuation of a recreational visit to a DCR Parkway facility.

	Walking	Hiking	Biking	Picnicking
Massachusetts Parking Fee	$5-$35 (MA residents only)			
National Forest System Recreation Benefits	NA	$47.66	$48.85	$30.02
Valuing Active Transportation Through Health Benefits	$25	NA	$16.7	NA
Virginia Creeper Trail (VCT)	$22.78			
United States Department of Transportation	$25.11	NA	$16.18	NA
Direct Use Value of Boston Parks	$2.88	$2.88	$4.60	$2.88

Our estimate of $35 per visit also recognizes that health benefits from recreational activities may be additive with the pure "enjoyment use" benefit uncovered in stated preference surveys such as the USDA study of National Forests or the Boston Parks study. Therefore, we feel a relatively high value is justified, as the benefits are partially additive.

The effects of having community assets located within or outside of flood-impacted communities is multifaceted. Assets can strengthen overall resilience or expose key resources to flood damage and disruption. The following table summarizes potential advantages and disadvantages of having community assets present or absent during localized flooding events.

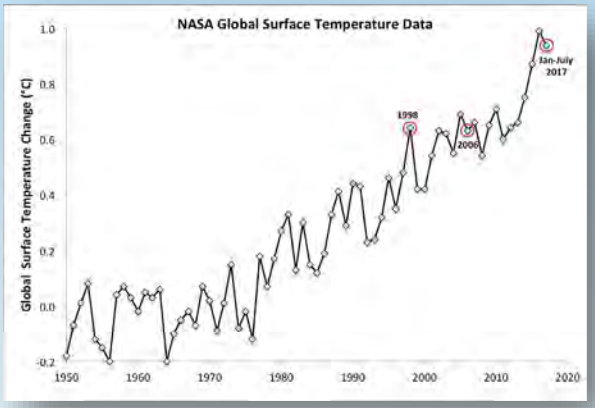
Community Asset	Within the Community		Outside of Community	
	Potential Advantages	Potential Disadvantages	Potential Advantages	Potential Disadvantages
Community Gathering Places (Schools and Places of Worship)	Some schools and places of worship may be prepared to serve as emergency shelters for displaced residents. Schools and places of worship may be centrally located and used as staging areas to distribute aid.	Schools and places of worship in flood prone areas could face traffic congestion during evacuations. Schools and places of worship in flood prone areas have a higher risk of flooding and impacts to students, staff, congregants, and those sheltering there.	Schools and places of worship outside of flood prone areas may be able to evacuate more quickly if roadways are unaffected. Schools and places of worship outside of flood prone areas may have a lower risk of building damage from flooding.	There may be a lack of options for emergency shelter and aid distribution without a school or place of worship in the area. Schools and places of worship outside of flood prone areas may be farther away and more difficult to access.
Hospitals	Hospitals can provide access to immediate medical care for flood-related injuries. Hospitals can provide centralized healthcare services.	Hospitals in flood prone areas could be vulnerable to flooding impacts, which could reduce their capacities. Hospitals in flood prone areas may experience high demand for hospital resources during flooding.	Hospitals outside of flood prone areas may have a lower risk of healthcare facility damages. Hospitals outside of flood prone areas may be able to reduce the strain on emergency services.	Hospitals in less vulnerable locations may be more difficult for residents to access during emergencies, leading to untreated injuries and illnesses.

The Massachusetts Coast Flood Risk Model

Modeling Overview and Frequently Asked Questions

Background

Massachusetts' coastal communities were settled during a time when sea levels were remarkably stable. For centuries, natural and built infrastructure such as salt marshes, dune communities, seawalls and bulkheads have allowed people to live, work and play at the edge of the ocean with well-understood, manageable risks of flood damage. However, increases in global temperatures have resulted in 16 of the 17 warmest years on record occurring from 2001 to 2017. People born after 1980 have never experienced a cooler-than-average year. As global temperatures rise, so do sea levels (melting ice sheets, expansion of water), and the Mid-Atlantic and Northeast US coasts are experiencing faster-than-average sea level rise. As seas rise and storms impact our coastlines, communities need access to the most comprehensive information to determine when, where, and how much to invest to decrease potential damages from coastal flooding. The Massachusetts Coast Flood Risk Model (MC-FRM)[1] helps property owners, planners and policy makers consider ways to cost-effectively build resilience and plan for the expected changes.



Change in average global surface temperatures 1950-2017 (0.0 = historic average temperature; courtesy NASA).

Flooding in Boston during Storm Grayson (January 4, 2018).

[1]Funding for the development of the MC-FRM was provided by the Commonwealth of Massachusetts.

What is special about the MC-FRM?

Sea level rise (SLR), combined with storms, has commonly been evaluated with a "bathtub" approach that simply increases the water surface elevation and compares that to topographic elevations of the land (i.e., fills the land up like a bathtub). When incorporating the effects of storms, the bathtub approach assumes the ocean stays perfectly flat. Anyone who has been to the coastline understands that the ocean is not a flat body of water during a storm. Water is aggressively being moved in various directions by waves, winds, and currents. As such, the bathtub approach does not account for critical physical processes during a storm, including waves, winds, and overtopping, and is unable to represent the dynamic nature of flooding. In many cases, the bathtub approach predicts flooding where none will occur, while misidentifying dry areas that would actually flood. Even some models that appear to be more complex only model the water levels up to the shoreline, then use bathtub approaches over land, ignoring important processes of over land flow. These models also tend to be low resolution, lacking details that can have a significant impact on the movement of water. The MC-FRM simulates the physics-based flow of water not only in water bodies, but also over land; including the time-varying, physical movement of water as it propagates inland. The MC-FRM also includes wave run-up and overtopping flow, and the physical based spreading inland of that water, in areas where waves intermittently overtop major coastal structures (e.g., seawalls, revetments). Areas with critical infrastructure and/or complex landscapes need to consider dynamic modeling of the changing climate and storms in order to ensure proper siting, design, and construction of significant investments.

Accurate storm surge probability modeling requires detailed representation of the physical processes (beyond a bathtub model), as well as high resolution inundation predictions based on a combination of sea level rise and storm surge. When simulating hurricanes and nor'easters, the MC-FRM dynamically includes the expected impacts of tides, waves, wave run-up and overtopping, storm surge, winds, and currents over a range of storm conditions and at high spatial resolution.

The Massachusetts Coast Flood Risk Model

Modeling Overview and Frequently Asked Questions

What makes the MC-FRM more accurate than other inundation models and flood maps that have been created for the region?

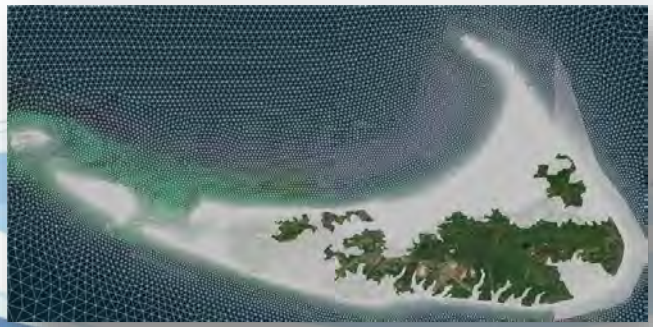
The MC-FRM is a more accurate representation of flooding risk because it is (1) a dynamic model that includes the critical processes associated with storm induced flooding (winds, waves, wave-setup, storm surge, wave run-up and overtopping, etc.), (2) calibrated to historical storm events that impacted Massachusetts with observed high water data and measurements, (3) high enough resolution to capture flood pathways in complex urban topographies, (4) a model that includes both hurricanes and nor'easters under changing climate conditions, and (5) able to capture the net effect of varying storm types, magnitudes, and frequencies.

How do the MC-FRM results relate/compare to the FEMA Flood Insurance Rate Maps (FIRMs)?

The MC-FRM is focused on present and future flooding projections based on a robust set of storm events, while FEMA results estimate present flood risk based on single historical based event. The methods used to produce the FIRMs are substantially different and FIRMs have a completely different purpose. ***They should not be directly compared.***

What is the resolution of the MC-FRM model grid?

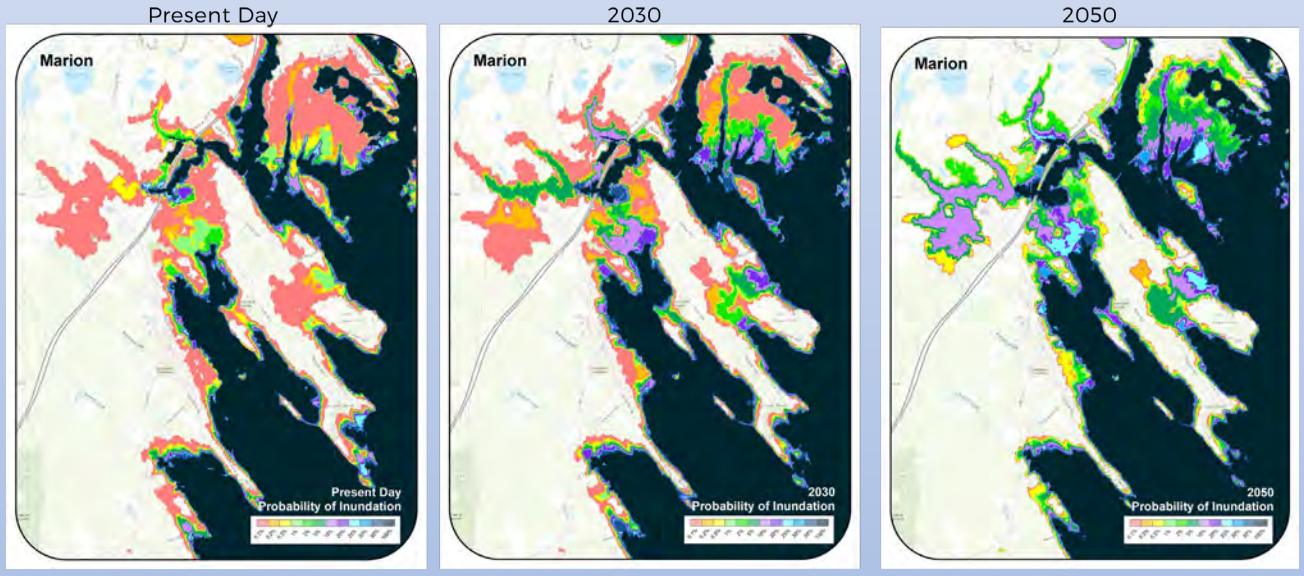
In order to turn complex mathematical equations into high resolution maps, the MC-FRM uses a detailed modeling mesh, in which every intersecting point represents a specific set of data where the model equations are solved. Flood risk data are calculated as frequently as every ten (10) feet in populated areas on land. This provides more localized and accurate data for flood risk analysis and planning.



Example of the high-resolution MC-FRM modeling mesh for Boston (above) and Nantucket (below).

The MC-FRM is a probabilistic model. What does that mean?

Coastal storm events striking an area result in different impacts depending on factors, such as the timing of the storm with the tide cycle, the storm track, radius to maximum wind of the tropical storm, the amount of precipitation, etc. Probabilistic modeling evaluates a statistically robust set of viable coastal storm conditions that produce spatially distributed flood probabilities. The MC-FRM doesn't just simulate one storm or a few storms – the MC-FRM dynamically simulates hundreds to thousands of storms to produce flood exceedance probabilities at high spatial resolution. Using this statistically robust approach, the coastal flood exceedance probability (CFEP) can be defined as the probability of flood water inundating the land surface at a particular location. For example, a building that lies within the 2% CFEP zone would have a 2% chance (50-year return period) of flooding. In other words, there is a 2% percent chance that this location will get wet with salt water during a coastal storm event. Stakeholders can then determine if that is tolerable, or if some action may be required to improve resiliency, engineer an adaptation, consider relocation, or implement an operational plan. Critical assets, such as hospitals and evacuation routes, have different risk tolerances than parklands or parking lots.



By mapping various future years (e.g., 2030 to 2050), individual structures, assets, and areas can be compared to determine how coastal flooding is changing over time. The overall influence of climate change projections can also be evaluated. These maps can also be used to assess flood entry points and pathways and identify potential regional adaptations. In many cases, large upland areas are flooded by a relatively small and distinct entry point (e.g., a low elevation area along the coastline). In cases like this, a more cost-effective and regional solution (rather than evaluating local adaptation options at each building in the area) can be prioritized. A targeted coastal protection project at the flood entry point (e.g., increasing seawall elevation, installing a natural berm, etc.) could protect a whole neighborhood. Maps showing the probability of flooding provide stakeholders the ability to identify areas expected to be flooded, and the probability of flooding. This helps them weigh their tolerance for risk, evaluate when adaptation options may need to be considered, and most importantly, prioritize funding to higher consequence areas.

The Massachusetts Coast Flood Risk Model

Modeling Overview and Frequently Asked Questions

What timeframes and sea level rise scenarios are being simulated in the MC-FRM?

MC-FRM scenarios currently include present day, 2030, 2050, and 2070 climate conditions. The sea level rise projections utilized for these scenarios are based on Massachusetts specific analysis (DeConto and Kopp, 2017) and include Antarctic ice sheet projections as of 2017. Sea level rise values vary for the north and south portions of the state. These scenarios are consistent with the projections being used by the Commonwealth of Massachusetts[1].

Location	Relative Mean Sea Level (feet, NAVD88)		
	2030	2050	2070
North	1.2	2.4	4.2
South	1.2	2.5	4.3

Will the MC-FRM results of flooding risk be publicly available?

Yes. MC-FRM flood probabilities and depths will be publicly available through the Commonwealth's Climate Change Clearinghouse.

Are the results of the MC-FRM available for the entire coastline?

Yes. The model includes every Massachusetts coastal city and town potentially influenced by future coastal storm surge-induced flooding during this century. GIS data will be available for download.

Are the results precise enough to be applied to specific buildings or structures?

Yes. The model predicts the likelihood and depth of flooding at a resolution high enough to be able to analyze individual buildings.

What types of flooding does the model cover?

It simulates storm surge-induced coastal flooding from hurricanes and nor'easters, which differ in speed, direction and duration. The model also includes climate-change induced increases in river discharge from precipitation for major rivers. Upstream freshwater flooding events that have no ocean-based component are not included in the analysis.

[1]https://resilientma.org/changes/sea-level-rise

The Massachusetts Coast Flood Risk Model

Modeling Overview and Frequently Asked Questions

What types of storms does the MC-FRM simulate?

The MC-FRM simulates storm surge induced flooding that could occur from both tropical (hurricanes) or extra-tropical (nor'easter) storm events. The intensity and frequency of these storm events change with the changing climate conditions. The model also includes climate-change induced increases in river discharge from precipitation within major rivers. It does not include flooding caused by rainfall that does not drain adequately to a water body, such as ponding in a low spot in a parking lot.

How has the MC-FRM changed from the Boston Harbor Flood Risk Model (BH-FRM)?

The MC-FRM improves upon the BH-FRM in numerous ways. Beyond the inclusion of the entire coastal area of Massachusetts, the MC-FRM also (1) includes updated sea level rise projections consistent with the state standard; (2) expands the storm sets used to include more historical and recent storms as well as hundreds of additional future storms; (3) includes dynamic wave runup and overtopping of coastal structures like seawalls; and (4) adds regular nuisance flooding by projecting future tidal datums.

I'm a town official. How do I use this information?

The MC-FRM provides the public with the best available science-based projections on coastal flooding during this century, helping you understand the level of risk potentially faced by areas within your community. This information can help prioritize adaptation actions across multiple assets throughout a town, therefore allowing more cost-effective, science-based approaches and timing for building resilience.

I'm concerned about a specific property. How do I use this information?

By examining the MC-FRM flood risk projections, property managers can assess the potential timing and depth of saltwater flooding over time for a given location. Buildings and infrastructure exposed to periodic storm flooding—especially in the absence of damaging waves—can be retrofitted to prevent harm. However, every specific property should also consider regional level protection approaches when evaluating risk.

Are dams included in the model?

Major dams, and dam operations, are included in the model.

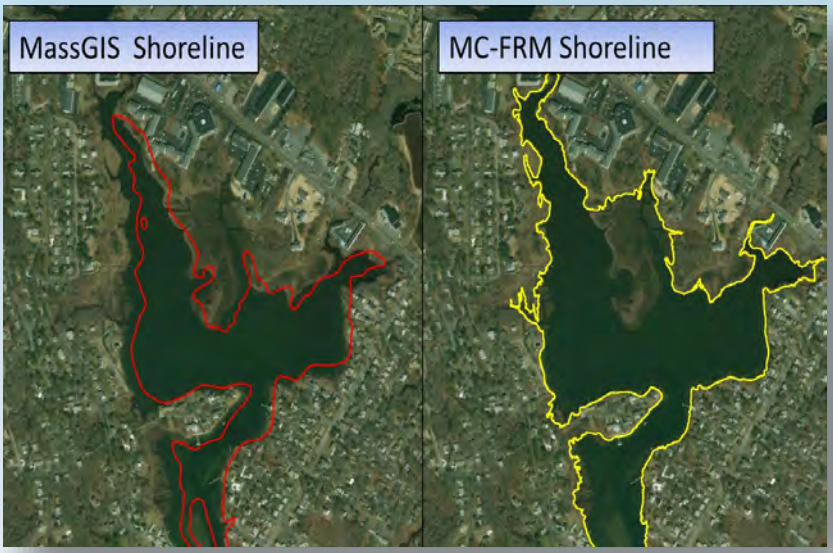
How is the MC-FRM assisting resiliency projects and engineering designs?

The MC-FRM results, at a site-specific scale, provide a breadth of information useful for informing decisions as to where protection may be required, selecting potential adaptations, planning, and assisting with engineering design. The high-resolution model results offer detailed information at an individual building and parcel level for assessment of existing or developing sites. While potential inundation probability and depths may be manageable under current risk levels, this may change over the service life of the asset. The dynamic model can also provide flood pathways to the site, which gives an indication of how long the flooding is expected to last for a given probability level. In many cases, this is important for determining economic impacts related to out-of-service time frames. Understanding the volume of water and flood pathways gives another layer of information that helps inform design and consideration of local and/or regional adaptation measures. The flood pathway insight allows stakeholders to consider local measures (e.g., raising the elevations of the buildings on the parcel, flood proofing structures, local on-site berms or walls), and regional approaches (e.g., berms, tide gates, flood walls, etc.) to control the source of flooding for a region that may co-benefit other properties.

Towns, communities, and stakeholders throughout the Commonwealth of Massachusetts can use, and have already been using, MC-FRM results to complete comprehensive vulnerability assessments, develop engineering adaptations, and design resilient green, gray, or hybrid solutions. The probabilistic results have given communities the ability to prioritize adaptations and start to build resilience in fiscally manageable ways. Communities and landowners can take action to manage projected imminent risks, while waiting for more certainty when dealing with long-term climate change projections that may not have near-term impacts.

What about non-storm based flooding or flooding that will occur just due to sea level rise?

The MC-FRM results are also being used to define the present and anticipated future (e.g., 2030) mean high water shorelines across the state, resulting in a marked improvement over some current shorelines. These shorelines also provide an indication of where nuisance (daily) flooding can be expected in the future climate.

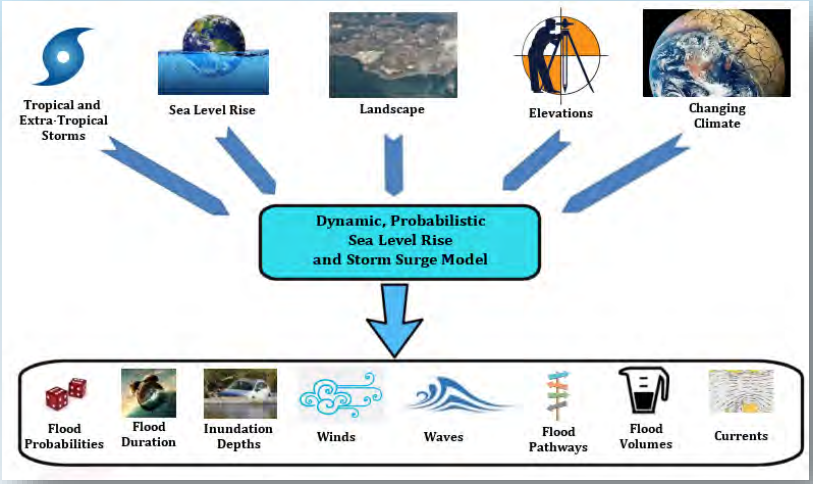


How does wave run-up and overtopping impact flooding?

In addition to the numerical simulation of the physical flow of water directly over land, the MC-FRM also incorporates dynamic wave run-up and overtopping to determine the volume of water that is thrown over coastal structures during storm events. The MC-FRM accounts for this volume overtopping coastal structures for each wave during the storm event and models the flow of this water behind the structure as it propagates inland or is returned to the ocean. This volume of water is incorporated into the dynamic results of over land water movement that is already simulated in the model.

What are the products from the MC-FRM?

MC-FRM products for the Commonwealth include data for every community in Massachusetts that could be impacted by coastal flooding this century. Data products include the probability of flooding in each year (present day, 2030, 2050, and 2070) and water depths associated with the 1% (100-year), 0.5% (200-year), and 0.1% (1000-year) annual exceedance probability levels. Additionally, the water surface elevations associated with the 5% (20-year), 2% (50-year), 1% (100-year), 0.5% (200-year), 0.2% (500-year), and 0.1% (1000-year) annual exceedance probability levels are provided.



Overarching approach using dynamic probabilistic modeling to create the MC-FRM. Outputs provided by the dynamic model provide the ability for a more comprehensive assessment.

These water surface elevations include the effects of tides, storm surge, and wave setup. Further outputs include wave heights and distributions, wave action water elevations, and full tidal datums. Projected wave action water elevations are flood elevations that are calculated from the MC-FRM results by including the site-specific projected wave crest amplitudes above the water surface elevations.