Main Street, Hampden
Flooding Assessment Report

Prepared for
Town of Hampden, Massachusetts

Prepared by
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June 2021

HOWARD STEIN HUDSON

Engineers + Planners

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Introduction

The Town of Hampden was awarded a Fiscal Year 2021 (FY21) Executive Office of Energy and Environmental Affairs (EEA) Municipal Vulnerability Preparedness (MVP) Program Planning Grant for an expanded scope to conduct a climate change vulnerability assessment to evaluate existing conditions and flooding concerns at two critical Main Street stream crossings: Big Brook and East Brook, in order to identify grey and green solutions, and to educate stakeholders and others about nature-based solutions to alleviate flooding on Main Street. This project includes consideration of the flood mitigation vulnerabilities and strengths associated with built infrastructure and the natural resources surrounding the project area, also including, but not limited to, the Mass Audubon Laughing Brook Wildlife Sanctuary.

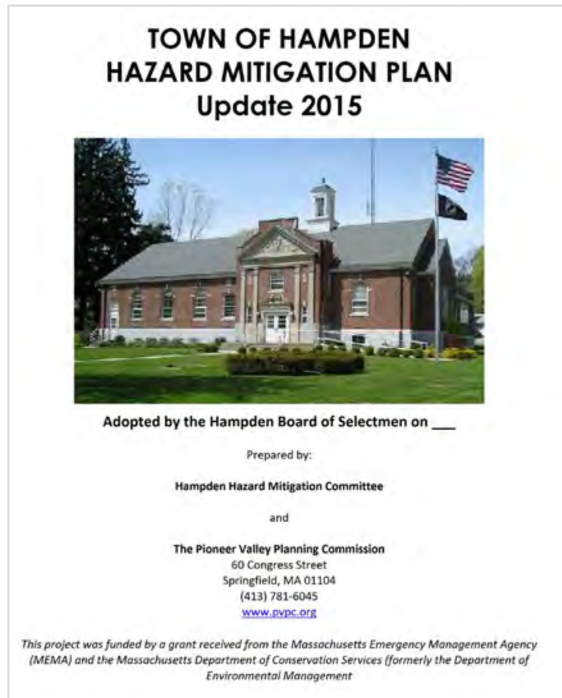
The findings of this Main Street flooding assessment have been incorporated into Hampden's MVP Summary of Findings, Community Resilience Building workshops, and Listening Session. The Community Resilience Building Workshop Day 2 also included an introduction to nature-based solutions and green infrastructure. Not everyone understands the purpose and function of nature-based solutions, including swales, rain gardens, retention ponds, and more. Providing a better understanding of nature-based solutions will contribute to increased stakeholder support to pursue and prioritize green solutions over built infrastructure when appropriate.

This assessment furthered the understanding of the how the bridge and culvert contribute to the Main Street flooding events. The assessment provided the Town of Hampden information and impetus to apply for the latest round of grant assistance from the Division of Ecological Restoration (DER) Culvert Replacement Program. The Town of Hampden, using the increased knowledge gleaned from this assessment, will be applying for assistance from the Massachusetts Department of Transportation (MassDOT) Municipal Small Bridge Program. This assessment also identified the need for the community to investigate opportunities to alleviate flooding, exacerbated by climate change, by expanding the project area beyond the limits of this initial focus to identify Town-wide opportunities to begin to identify needs and priorities to address many other similar culvert and flooding issues including opportunities to incorporate green infrastructure. A common theme of the MVP discussions was the fact that the Town of Hampden includes wetlands and green spaces that support consideration for nature-based solutions.

Purpose and Need

The Town has consistently identified Main Street flooding as a priority community concern. Observed and projected increases in precipitation and storm events will exacerbate flooding concerns that affect Main Street, as identified in the Town's 2021 MVP and 2015 Hazard Mitigation Plans.

> *Main Street (near confluence of East Brook and Scantic River/Laughing Brook) – An undersized culvert that tends to flood during heavy storm events. There are no critical facilities at this location, but it is major intersection for the Town. Not only is it located on Main Street, a key evacuation route, it is near the split with Glendale Road (a northward evacuation route) and Scantic Road (a southward evacuation route). In addition, the flooding tends to impact access to several nearby critical facilities, including the Town House (the primary Emergency Operations Center (EOC)), Fire Department, and Police Department. Furthermore, this culvert tends to flood during the same conditions as the other problem culvert on Main Street, thereby cutting off these critical facilities from the rest of Town.*[1]


TOWN OF HAMPDEN
HAZARD MITIGATION PLAN
Update 2015

Adopted by the Hampden Board of Selectmen on ___

Prepared by:

Hampden Hazard Mitigation Committee

and

The Pioneer Valley Planning Commission
60 Congress Street
Springfield, MA 01104
(413) 781-6045
www.pvpc.org

This project was funded by a grant received from the Massachusetts Emergency Management Agency (MEMA) and the Massachusetts Department of Conservation Services (formerly the Department of Environmental Management

Over the past several decades, the northeast has experienced an increase in the frequency and intensity of extreme precipitation events. Regional increases in heavy precipitation events exceed that of the rest of the United States with a 74% increase in the heaviest 1% of all precipitation events since 1958. Flood events have risen in association with increases in precipitation, particularly extreme events. This puts fish, wildlife, and their habitats at increased risk to direct impacts, such as physical damage, displacement, and mortality, as well as indirect impacts that result from increased inputs of sediments, nutrients, and pollution to aquatic systems. The largest increases in heavy precipitation extremes are projected to occur in the northern, coastal, and mountainous areas of the region. The Connecticut River basin has experienced more than a doubling of heavy rainfall

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[1] Source: Town of Hampden's 2015 Hazard Mitigation Plan.

events over the last 60 years. Regionally, most heavy precipitation events have occurred during the summer months of May through September.[2]

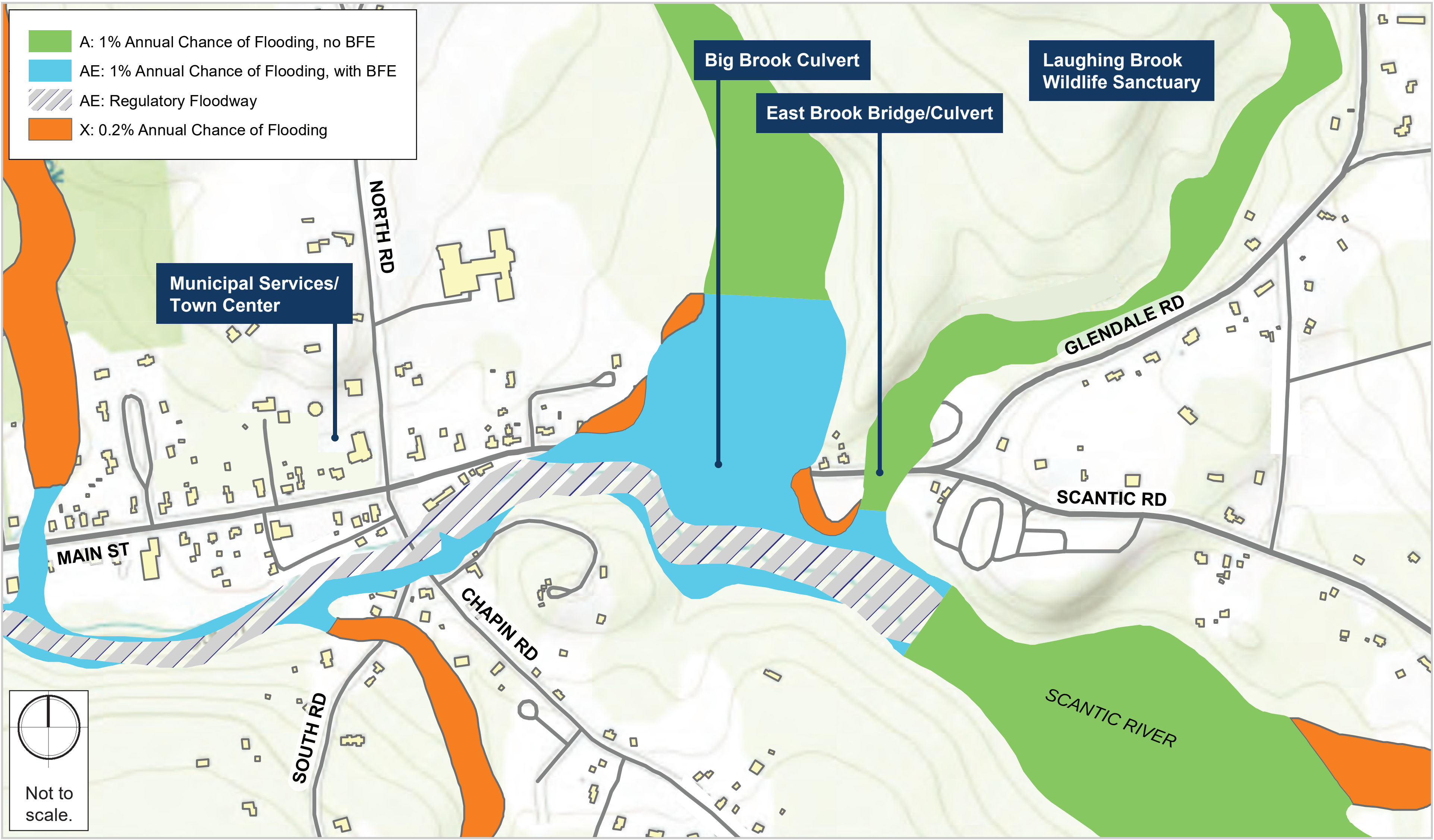
Inadequate or undersized road-stream crossings can create flooding and washout hazards and can be barriers to the passage of fish and other aquatic or amphibious organisms. As precipitation events become more intense and less predictable as a result of climate change, inadequate or undersized road-stream crossings along Main Street and throughout the Town of Hampden are expected to pose an increased threat of failure; increase potential flooding damage to homes and businesses; adversely impact transportation infrastructure, including emergency response capabilities and evacuation routes; impacting utilities and services (i.e., water, sewer, electricity, gas, telecommunications, fiber, etc.); and causing stream channel erosion and other adverse impacts to the natural environment.

Methodology

This assessment includes consideration of the threats and opportunities associated with built infrastructure (i.e., Main Street culverts/bridges) and natural resources (open spaces, Laughing Brook Wildlife Refuge) in the project area. This initial assessment will inform residents, officials, Mass Audubon, and others on opportunities to incorporate resiliency into their project planning within the project area and beyond. See **Figure 1** for the Main Street flooding study area and culvert locations.

[2] Source: Massachusetts Wildlife Climate Action Toolkit

Figure 1. *Main Street Flooding Study Area / Culvert Locations*



The Main Street Flooding Assessment:

- Evaluates existing flooding conditions in the project area, including the Big Brook and East Brook watersheds and stream crossings.
- Considers future flooding conditions due to climate change.
- Evaluates existing conditions of Big Brook culvert and East Brook Bridge Main Street stream crossings and their abilities to handle present and future flood demands both ecologically and structurally.
- Identifies nature-based solutions to reduce Hampden's Main Street corridor vulnerability to current flooding concerns and increased climate change flooding concerns by assessing the watershed area(s) contributing the flooding concerns along Main Street.
- Develops recommendations for green and grey infrastructure improvements within the watershed, which will help address the flooding, reduce erosion and other negative environmental impacts, and that can be implemented soon.
- Incorporates findings into MVP Community Workshop discussion and Hampden's ongoing planning initiatives.
- Educates and informs the community, including a targeted program for students, on local climate change impacts and the opportunities to reduce risks through nature-based solutions and green infrastructure.

Main Street Culvert and Bridge Assessments

Main Street road-stream crossings included in the assessment include the two highest priority locations identified in the Town of Hampden's 2015 *Hazard Mitigation Plan*: the culvert crossing at Big Brook, and the bridge/culvert crossing at East Brook (see **Figure 1**). The assessments consisted of field surveys of individual stream crossing structures using established road-stream crossing assessment protocols to determine structural condition, geomorphic risk, opening suitability with respect to the Massachusetts stream crossing standards, transportation and emergency services, other flooding impacts, and climate change considerations. The results of the stream crossing assessments will inform the selection of grey infrastructure alternatives including natural system solutions to increase flood resilience at each crossing.

The existing condition assessments of the selected crossings structures were performed on December 16, 2020 using road-stream crossing assessment procedures and field data collection forms adapted from the 2017 North Atlantic Aquatic Connectivity Collaborative (NAACC) Culvert Condition Assessment Manual and collection of other field data for evaluating geomorphic vulnerability, hydraulic capacity, and potential flooding impacts to infrastructure and public services.

Digital photographs were also taken at each crossing. The completed copy of the field data collection Culvert Assessment Form for each structure is provided in **Appendix A**. Copies of the FEMA Firmette Map for the study area and the United States Geological Survey (USGS) StreamStats reports for each stream crossing location are provided **Appendix B**.

BRIDGE H-04-008: MAIN STREET OVER EAST BROOK

South Fascia – East Brook Culvert / Bridge No. H-04-008

The bridge is a simple span steel stringer bridge with a reinforced concrete deck and is supported by concrete gravity abutments. The bridge has a span length of 17'-8" with an out-to-out width of 44'-0" and a curb-to-curb width of 40'-0". The bridge carries two 12'-0" travel lanes (one each direction) with 4' shoulders, 4'-wide grass strips and no sidewalks. The bridge has been on an ongoing 12-month MassDOT inspection cycle since the superstructure was given a condition assessment equal to 4 or "Poor Condition" due to the fascia stringers having areas of 100% section loss. The deck has a condition assessment of 5 or "Fair Condition" and the substructure has a condition assessment of 6 or "Satisfactory Condition." Copies of the latest Bridge Inspection Reports and bridge plans for Bridge No. H-04-008, Main Street over East Brook, are provided in **Appendix D**.

Flooding has also eroded the embankment next to the roadway and bridge abutments. Continued erosion will undermine the road and bridge and could result in long-term closure, which will impact travel routes, emergency response times, and the Town's primary emergency evacuation routes to the north and east. Residents in the project area are subject to surface flooding and basement flooding during flooding events as well.

A preliminary hydraulic analysis was performed for this structure and it appears that 25-year design storm exceeds the capacity of the structure and the stream flows flood the roadway. As flooding has been an issue in the past, it would be recommended to replace this structure with a longer span structure to provide more hydraulic capacity and reduce the risks of flooding at this location. As this structure has a span length greater than 10 feet but less than 20 feet, it meets the requirements of MassDOT's Small Bridge Program. The Small Bridge Program provides funding for bridge projects with a maximum total annual benefit of up to $500,000, where the municipality is responsible for costs exceeding that limit. This structure also qualifies for the DER Culvert Replacement Municipal Assistance Grant, if design follows DER's specific methodology. Lastly, the Town can also use the Massachusetts Chapter 90 program to assist in funding a replacement bridge.

CULVERT: MAIN STREET OVER BIG BROOK

The culvert is a Corrugated Metal Pipe (CMP) Arch with a span of 8'-8" and a rise of 5'-11" with random stone headwalls. The culvert carries two 12'-0" travel lanes (one each direction) with 2' shoulders, no sidewalks, and has w-beam guardrail. This culvert is not on MassDOT's bridge or culvert inventory list and is not being inspected since it is a municipally owned structure with a span less than 10 feet. HSH performed a visual inspection of this structure on December 16, 2020 and found the structure to be in relatively good condition with no major deficiencies to note.

North End (Inlet) – Big Brook at Main Street Culvert

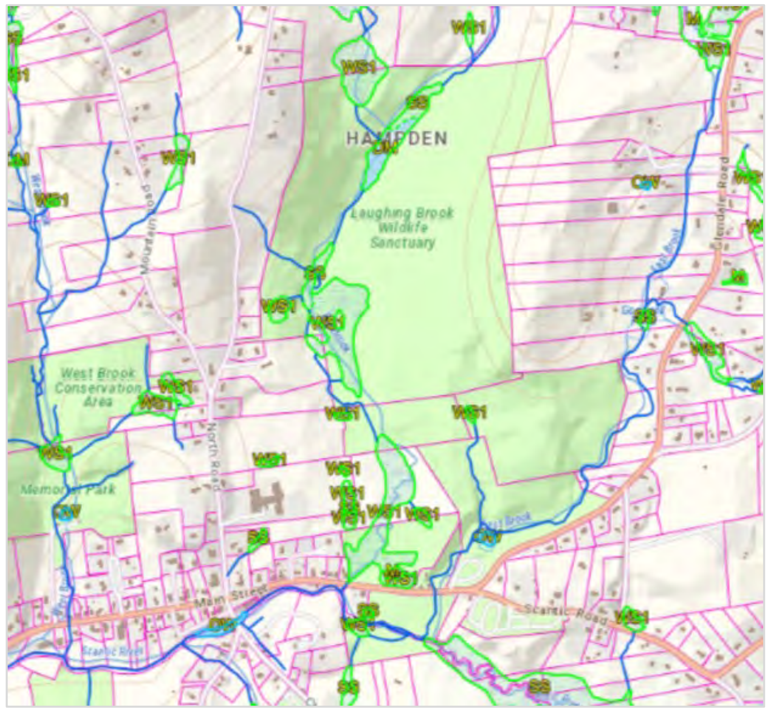
The conceptual StreamStats hydraulic analysis (see **Appendix B**) for this structure also appears to indicate that the 25-year design storm overtops the roadway. As flooding has been an issue in the past, when it comes time for the replacement of this structure, it is also recommended to replace this structure with a longer span structure to provide more hydraulic capacity and reduce the risks of flooding at this location.

This structure would also qualify for the DER Culvert Replacement Municipal Assistance Grant, if design follows DER's specific methodology and is identified by the Massachusetts Wildlife Climate Action Tool as a top 5% for culvert replacement. However, the condition of the existing structure does not currently warrant replacement. Lastly, the Town can also use the Massachusetts Chapter 90 program to assist in funding a replacement culvert.

Green Infrastructure Assessments and Projected Future Flooding

According to USGS StreamStats online modelling (**Appendix B**), the watershed areas contributing to the Main Street flooding at Big Brook and East Brook are 2.7 square miles (1,750 acres) and 3.7 square miles (2,360 acres), respectively, and includes a significant portion of Mass Audubon's Laughing Brook Wildlife Sanctuary.

The contributing watershed lands are primarily open space and protected wildlife sanctuary land, which provide additional opportunities for the development of green infrastructure to capture and reduce flows associated with storm events before they overwhelm the existing grey infrastructure resulting in flooding.



Laughing Brook Wildlife Sanctuary, Hampden, MA

According to the information from ResilientMA.org (**Appendix C**) it is projected that the Town of Hampden will see an increase in a.) extreme precipitation greater than 1-inch of approximately 1.5 – 1.8 days per year; b.) extreme precipitation greater than 2-inches of approximately 0.17 – 0.23 days per year; c.) extreme precipitation greater than 4-inches of approximately 0.00 – 0.01 days per year; d.) have a total precipitation increase of approximately 3.0 – 3.4 inches per year; and e.) have an approximately 0.8 – 1.0 increase of consecutive dry days per year. These projections document the likelihood that increases in total precipitation and frequency will certainly rise in the future, increasing the need for the Town of Hampden to be proactive in addressing these concerns through the implementation of green infrastructure solutions as proposed herein.

The sanctuary land in and of itself, consisting of approximately 356 acres, is a nature-based solution. Protection of these wooded open spaces will continue to provide a nature-based solution to the Main Street concerns. GIS Maps for the community documenting infrastructure assets, flood plains and environmental resources within the community are provided in **Appendix E**.

In addition, Mass Audubon has identified sanctuary land areas adjacent to East Brook within the wildlife sanctuary, upstream of the East Brook crossing on Main Street, where stream flood plain morphology restoration, as a nature-based solution, that could benefit the Town by further alleviating early flooding concerns along Main Street. This represents an opportunity for the identification of a significant nature-based solution to the ongoing flooding problem as well as an excellent educational opportunity for the community, Mass Audubon, and the region overall.

Opportunities for Green Infrastructure Solutions

A primary objective included in this Main Street Flooding Assessment is the identification of nature-based green infrastructure solutions to reduce Hampden's Main Street corridor vulnerability to current flooding and increased climate change flooding concerns after assessing the watershed area(s) contributing to the flooding along Main Street. These green infrastructure solutions can be implemented at relatively low additional design and construction costs and will help address the flooding, reduce erosion and other negative environmental impacts. As illustrated on **Figure 2**, the following three (3) green infrastructure solutions have been identified as potential Main Street flood mitigation strategies, which will provide nature-based solutions benefit to flood resiliency. The geographical locations of these green infrastructure solutions are shown on **Figure 3**.

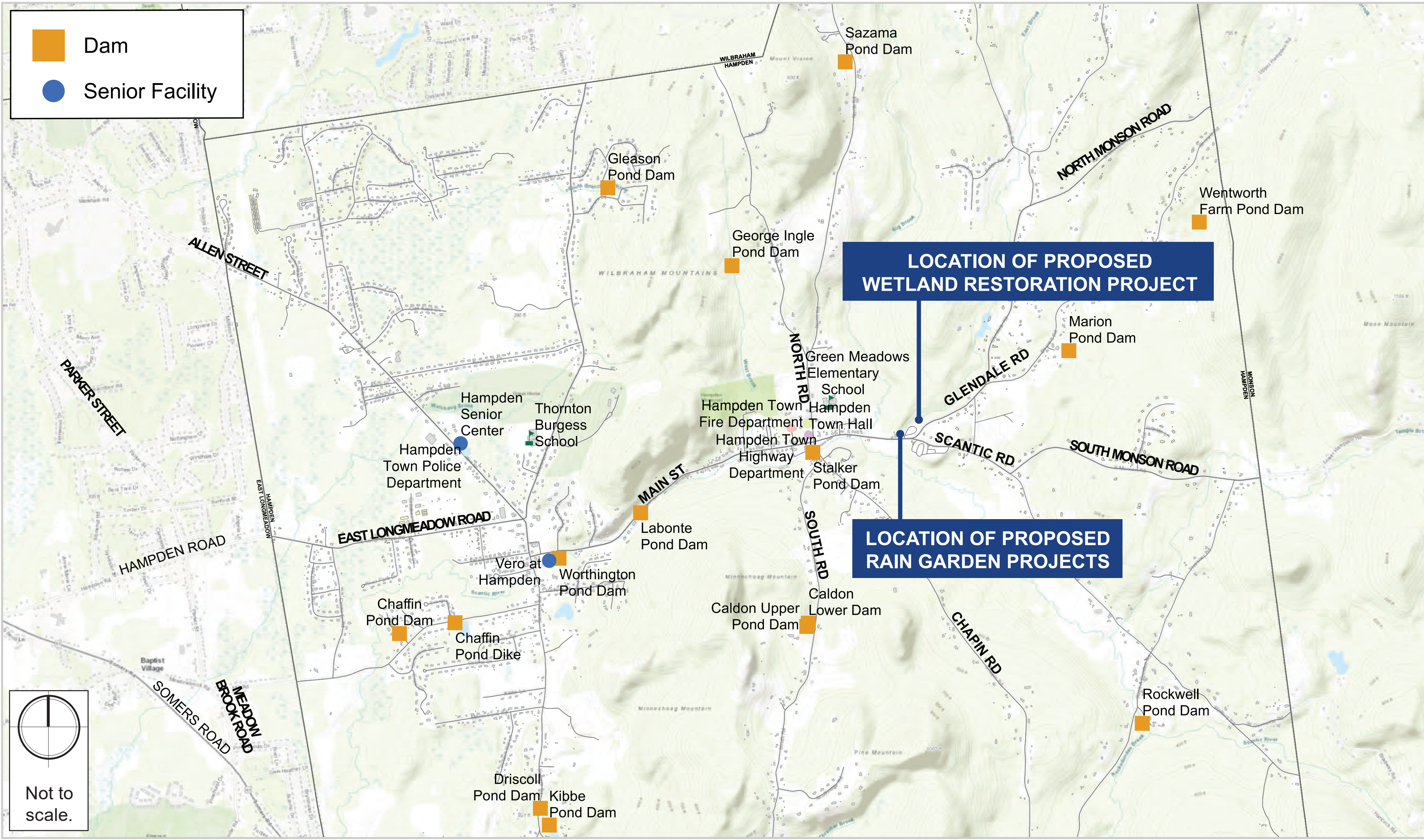
- Construct a vegetated “rain garden” that also serves as a stormwater quality and infiltration swale along the roadway right-of-way bordering on the Laughing Brook Wildlife Sanctuary parking area. This nature-based green solution would accumulate stormwater from the roadway including the existing catch basin and treat, store and infiltrate stormwater, thereby, improving flood storage, water quality and groundwater infiltration within the project area.
- Construct a vegetated “rain garden” treats stormwater runoff from the Laughing Brook Wildlife Sanctuary parking areas, as well as Main Street roadway stormwater runoff and/or provide secondary treatment from the above-described rain garden swale prior to discharge into East Brook. This solution would also treat, store and infiltrate stormwater, thereby improving flood storage, water quality and groundwater infiltration within the project area. In addition, both first 2 “rain garden” solutions also provide an exceptional stormwater quality improvement benefit and could be credited for as a betterment measure in the town’s NPDES Stormwater permit.
- Implement a wetlands habitat restoration project consisting of removing the existing man-made pond and nature-made dam structure, converting the entire area a more natural wetland riverine flood plain area like it once was. Removing the man-made pond and restoring natural stream morphology flood flow conditions utilizes the available flood plain rather than creating channels. These channels cause further erosion as well as preventing

floodwaters from utilizing available stream flood plain. The removal of the man-made pond and restoration of the wetland would help restore naturally occurring flood resiliency within the watershed as well as preventing the ongoing problems from worsening in the future due to increased storm frequencies and intensities.

It is important to note that all the above green infrastructure improvements are in very close proximity to, and may require work directly within, regulated wetlands resource areas; therefore, all design and permitting must strictly adhere to all applicable federal, state, and local laws and regulations. Further, this project has demonstrated that Big Brook, East Brook, and the Scantic River provide unique opportunities to consider nature-based solutions beyond this initial study area. Presently, within the community of Hampden, development is not encroaching into these watersheds. In fact, it is flooding, exacerbated by climate change, that is encroaching on established development: roads, structures, residences, etc. A broader study into potential additional green infrastructure solutions town-wide would connect and identify further low-cost opportunities to consider nature-based solutions to reduce these threats.

Figure 2. *Green Infrastructure Main Street Flood Mitigation Strategies*

Figure 3. *Location of Green Infrastructure Main Street Flood Mitigation Strategies*



Next Steps and Estimated Costs

The next steps for implementation of the green infrastructure solutions described above include, but are not necessarily limited to, topographic site survey, wetlands delineation, wildlife habitat assessment, test pits to determine soil conditions and depth to groundwater, design, permitting, and construction. The Town would need to decide which projects provide the most benefit to the community overall. Given the location and extent of the 100-year flood plain in this area, the proposed green infrastructure solutions would not provide much, if any, benefit for the high-volume, low-frequency storms; however, they would improve water quality and provide some benefit for flood mitigation during the more common higher frequency storms and flood events.

For cost estimating purposes, it is assumed that the two rain garden projects would be designed and permitted together, and that test pits and construction would utilize Town forces to reduce total overall costs compared to publicly bidding for construction. The total estimated costs for survey, wetlands delineation, wildlife habitat assessment, test pits, design, and permitting of the two rain garden projects is approximately $20,000 to $30,000. Estimated costs for materials with construction by Town forces varies between $20 to $35 per square foot depending upon the type and number of plantings, whether a liner is required due to shallow groundwater elevations, and the type and amount of stormwater infrastructure to be included (i.e., deep sump catch basins, piping, etc.).

Assuming the proposed rain garden located to the west of the Laughing Brook Wildlife Sanctuary driveway is 800 square feet (approx. 20’ x 40’), a liner would be required due to proximity to groundwater with stormwater piping infrastructure limited to the rain garden itself; the total estimated materials costs is anticipated to be $16,000 to $24,000.

Assuming the proposed rain garden located to the east of the Laughing Brook Wildlife Sanctuary driveway is 720 square feet (approx. 120’ x 6’), it does <u>not</u> require a liner due to proximity to groundwater, and includes up to two deep sump catch basins with necessary interconnecting stormwater piping infrastructure; the total estimated materials costs is anticipated to be $25,000 to $35,000.

Design and permitting for the wetlands and habitat restoration project – consisting of removing the existing man-made pond and nature-made dam structure and converting the entire area a more natural wetland riverine flood plain – is likely higher that the above-described rain garden projects and is estimated to be approximately between $30,000 and $40,000. Construction costs will also vary depending upon the total amount of excavation and fill materials required as well as the planting program implemented. Also, given the specialty nature and size of this project, it is believed to be beyond the capabilities of the Hampden Highway Department. Therefore, the estimated construction cost assumes this project will be publicly bid for construction. The estimated construction cost this project are expected to be in the range of $5 to $10 per square foot. The approximate size of the existing man-made pond is about 200 feet by 150 feet (i.e., 30,000 square feet); thus, the total estimated costs for this project is in the range of approximately $150,000 to $300,000.

Public Education and Outreach

MUNICIPAL VULNERABILITY PREPAREDNESS (MVP) COMMUNITY ASSESSMENT AND WORKSHOPS

The findings of the Main Street flooding assessment are included in the Summary of Findings and were incorporated into Hampden's MVP Community Resilience Building Workshop Day 2 also included an introduction to nature-based solutions and green infrastructure (see **Appendix F**). These and other related resources can also be found in the Town of Hampden's Community Building Workshop Summary of Findings, April 2021, for additional relevant information, reports, maps, agendas, and presentations.

COMMUNITY WORKSHOP

Additionally, Mass Audubon led a virtual workshop for all Hampden residents in March 2021. Participants learned how climate change is and will be affecting this region, what impacts it will have on our infrastructure, and how nature-based solutions are an effective tool for adapting to the changing climate. The presentation has been recorded and shared along with the slides so that community members who are unable to join will have access to the information. A copy of the agenda and community workshop presentation by Mass Audubon is provided in **Appendix G**.

HOWARD STEIN HUDSON

Engineers + Planners

Appendix A

Culvert Assessment Forms and Photographs

Culvert Assessment Form

CROSSING DATA

For multiple culvert crossings use one sheet per culvert. Go from left to right, standing at inlet looking downstream.

Crossing Code: N/A **Local ID:** (Optional) N/A **Date Observed:** (00/00/0000) 12/16/20 Lead **Observer:** Paul Berthiaume, P.E.

Number of Culverts: 1 **Culvert** 1 **of** 1 **Stream:** Big Brook **Road:** Main Street

Location: (St.#, Pole#, Etc.) NET&T Co. #10 **Town:** Hampden **County:** Hampden State: MA

GPS Coordinates: 42.06444 °N Latitude 72.40889 °W Longitude Time: 10:00 am Weather: Cloudy, Cold, 20° F

Crossing Type: ☐Bridge ☑Culvert ☐Multiple Culvert ☐Ford ☐No Crossing ☐Removed Crossing ☐Buried Stream ☐Inaccessible ☐Partially Inaccessible ☐No Upstream Channel

Culvert Material: ☑Metal ☐Concrete ☐Plastic ☐Wood ☐Rock/Stone ☐Fiberglass ☐Combination **Length of Culvert:** 45'-0" (Skew); 33'-0" (Square)

INLET

Appurtenance: ☐Headwall ☐Wingwalls ☐Headwall & Wingwalls ☑Mitered To Slope ☐Projecting ☐Flush ☐Recessed ☐Other ☐None

Inlet Shape: ☐1 ☑2 ☐3 ☐4 ☐5 ☐6 ☐7 **Inlet Dimensions: A. Width:** 8'-8" **B. Height:** 5'-11" **C. Substrate/Water Width:** 7'-11" **D. Water Depth:** 0'-9" **E. Abutment Height:** ____

Inlet Grade: ☑At Stream Grade ☐Inlet Drop ☐Perched ☐Clogged/Collapsed/Submerged ☐Unknown

OUTLET

Appurtenance: ☐Headwall ☐Wingwalls ☐Headwall & Wingwalls ☑Mitered To Slope ☐Projecting ☐Flush ☐Recessed ☐Other ☐None

Outlet Shape: ☐1 ☑2 ☐3 ☐4 ☐5 ☐6 ☐7 **Outlet Dimensions: A. Width:** 8'-8" **B. Height:** 5'-11" **C. Substrate/Water Width:** 7'-1"* **D. Water Depth:** 0'-7" **E. Abutment Height:** 3'-9"

Outlet Grade: ☑At Stream Grade ☐Free Fall ☐Cascade ☐Free Fall Onto Cascade ☐Clogged/Collapsed/Submerged ☐Unknown * Water Only

	INLET *Please check only one level for each item*					OUTLET *Please check only one level for each item*				
	Adequate	Poor	Critical	Unknown	N/A	Adequate	Poor	Critical	Unknown	N/A
Structural (Longitudinal) Alignment	☑	☐	☐	☐	☐	☑	☐	☐	☐	☐
Channel Alignment	☑	☐	☐	☐	☐	☑	☐	☐	☐	☐
Level of Blockage	☑	☐	☐	☐	☐	☑	☐	☐	☐	☐
Flared End Section	☑	☐	☐	☐	☐	☑	☐	☐	☐	☐
Invert Deterioration	☑	☐	☐	☐	☐	☑	☐	☐	☐	☐
Buoyancy or Crushing	☑	☐	☐	☐	☐	☑	☐	☐	☐	☐
Cross-Section Deformation	☑	☐	☐	☐	☐	☑	☐	☐	☐	☐
Structural Integrity of Barrel	☑	☐	☐	☐	☐	☑	☐	☐	☐	☐
Joints and Seams	☑	☐	☐	☐	☐	☑	☐	☐	☐	☐
Footings	☐	☐	☐	☐	☑	☐	☐	☐	☐	☑
Headwall/Wingwalls	☐	☑	☐	☐	☐	☐	☑	☐	☐	☐
Armoring	☑	☐	☐	☐	☐	☑	☐	☐	☐	☐
Apron	☑	☐	☐	☐	☐	☑	☐	☐	☐	☐
Embankment Piping	☑	☐	☐	☐	☐	☐	☐	☐	☐	☑

To provide additional feedback on performance problems use the optional second sheet

Performance Problems Requiring Action

Debris/Veg Blockage >1/3 of rise	☐	Local Outlet Scour	☐	Embankment Slope Instability	☐
Sediment Blockage >1/2 the opening	☐	Previous and/or Frequent Overtopping	☐	No Access/Ends Totally Buried/Submerged	☐
Buoyancy or Crushing-Related Inlet Failure	☐	Embankment Piping	☐	Aggressive Abrasion/Corrosion/Chemical	☐
Poor Channel Alignment	☐	Channel Degradation/Headcut	☐	Exposed Footing (Open-Bottom Culvert Only)	☐

Notes: Minor vegetation/debris collection at inlet (west side). Culvert is skewed approximately 45° to roadway. Headwalls comprised of large stones which are exhibiting some minor soil losses.

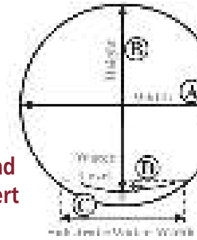
Photo #:____	Description: Pictures saved separately with descriptions	Photo #:____	Description:
Photo #:____	Description:	Photo #:____	Description:
Photo #:____	Description:	Photo #:____	Description:
Photo #:____	Description:	Photo #:____	Description:

2019

Culvert Assessment Reference Chart

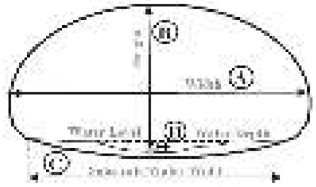
CULVERT SHAPE & DIMENSIONS

1.



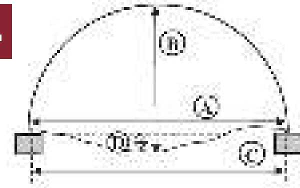
Round Culvert

2.



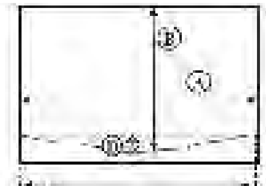
Pipe Arch/Elliptical Culvert

3.



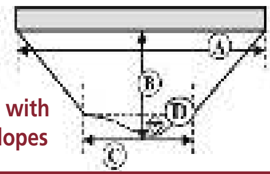
Open Bottom Arch Bridge/Culvert

4.



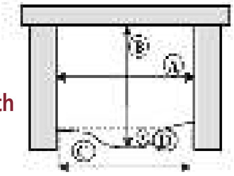
Box Culvert

5.



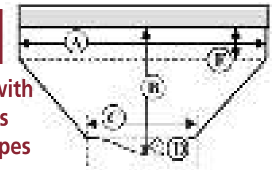
Bridge with Side Slopes

6.



Box/Bridge with Abutments

7.



Box/Bridge with Abutments and Side Slopes

CULVERT CONDITION REFERENCE

Structural (Longitudinal) Alignment

Poor: Significant horizontal or vertical misalignment of the pipe (Note: do not confuse this with constructed pipe bends).

Critical: Significant misalignment resulting in deformation of pipe or embankment/roadway damage.

Channel Alignment

Poor: The stream channel approaches the crossing at an angle of 45-70 degrees from the centerline of the structure.

Critical: The stream channel approaches the crossing at an angle of 70-90 degrees from the centerline of the structure.

Level of Blockage

Poor: Debris/sediment/vegetation blocks 1/3 of more of the inlet/outlet opening.

Critical: Sediment blocks more than ½ the inlet/outlet opening (and not designed that way for aquatic organism passage).

Flared End Section

Poor: Significant cracks, piping or undermining affects >50% of section. End crushed or separated from barrel.

Critical: Deterioration is significantly affecting performance and/or causing embankment/roadway damage.

Invert Deterioration

Poor: Perforations visible and/or connection hardware failing (metal). Heavy abrasion and scaling with exposed steel reinforcement (concrete). Heavy abrasion or scour damage (plastic). Displaced mortar and/or blocks, holes in invert area (masonry)

Critical: Holes or section loss with extensive voids beneath invert and/or embankment/roadway damage. Holes and gaps with extensive infiltration of soil, bedding or backfill material (masonry).

Bouyancy or Crushing

Poor: Light to moderate denting or deformation of inlet and/or outlet end of fl exible pipe culvert. The invert of the inlet is at the streambed elevation (no uplift).

Critical: Invert of inlet bent upward above streambed or mitered edges crumpled inward.

Cross-Section Deformation

Poor: Significant perceptible deformation. Deformation with accompanying longitudinal cracking (concrete).

Critical: Excessive deformation resulting in significant reduction of available flow area, and/or extensive infiltration of soil, voids, structural failure or embankment/roadway damage.

Structural Integrity of Barrel

Poor: *Concrete:* Open cracks >1/8" wide with voids and significant infiltration of soil and/or leakage of water. Heavy rust staining and/or exposed steel reinforcement in sides and top of barrel.
Masonry: Missing and/or displaced blocks
Plastic: Several splits, tears and cracks >6" long. Significant deformation of liner or wall buckling.

Critical: Cracks, tears, splits, bulges, holes or section loss have led to extensive infiltration of soil, structural failure, voids and embankment/roadway damage.

Joints and Seams

Poor: Open or displaced with significant infiltration of soil and/or leakage of water and voids visible. Missing mortar or displaced blocks (masonry).

Critical: Open or displaced with significant infiltration of soil and accompanying embankment/roadway damage.

Footings

Poor: Top portion of footing exposed, but no cracking or breaking off of flakes or chips.

Critical: Footing exposed with signs of cracking or breaking off of flakes or chips. Bottom of footing exposed and/or undercut.

Headwall/Wingwalls

Poor: Cracking or breaking off of flakes or chips affecting >50% of area and/or exposed steel reinforcement. Gap >4" between barrel and wall. Footing exposed and undermined.

Critical: Partially or totally collapsed with damage to embankment/roadway.

Armoring

Poor: Significant displacements, undermining or deterioration affecting the performance of the culvert structure.

Critical: Partially or totally failed, significantly affecting performance and/or causing embankment/roadway damage or undermining of the culvert barrel or footings.

Apron

Poor: Significant cracking affects >50% of apron. Significant piping or undermining.

Critical: Partially or totally collapsed, significantly affecting performance and/or causing embankment/roadway damage.

Embankment Piping

Poor: Slight pavement cracking above the culvert, perhaps with a noticeable bump/depression when driving, but no evidence of holes in the embankment or soil infiltration in the culvert barrel.

Critical: Partially or totally failed, significantly affecting performance and/or causing embankment/roadway damage or undermining of the culvert barrel or footings.

GLOSSARY

Appurtenance	Structures, such as aprons, flared end structures, headwalls and wingwalls, that give support to the culvert end or header.
Apron	Erosion protection at the inlet or outlet consisting of rip rap or concrete.
Armoring	Artificial surfacing of a channel bed, bank, or embankment slope to resist scour or erosion.
Bridge	Deck supported by abutments (or stream banks). It may have more than one cell or section separated by one or more piers.
Buoyancy	Water exerting upward pressure on the culvert.
Buried Stream	Segment of stream that flows within a pipe extending well beyond the road crossing. The planned crossing site does not include an inlet and/or outlet, likely because a stream previously in this location has been rerouted, probably underground.
Cascade	The outlet of the structure is raised above the stream bottom at the outlet such that water flows very steeply downward across rock or other hard material when flowing from the structure.
Channel Alignment	Indicates the alignment of the crossing structure relative to the stream at the inlet. Compare the crossing centerline to a centerline of the stream where it enters the crossing.
Corrosion	Deterioration and rusting of metal through oxidation.
Crossing Code	A unique ID for each crossing in the database provided by the assigning authority (NAACC xycode).
Culvert	A culvert consists of a structure buried under some amount of fill. Culverts can be made of stone, brick or masonry.
Delamination	Splitting or separating of concrete or asphalt in the culvert.
Flush	The end of the culvert is not recessed nor does it extend beyond the headwall.
Ford	A ford is a shallow, open stream crossing, in which vehicles pass through the water. Fords may be armored to decrease erosion, and may include pipes to allow flow through the ford (vented ford).
Free Fall	The outlet of the structure is above the stream bottom such that water drops vertically when flowing out of the structure.
Free Fall onto Cascade	The outlet of the structure is raised above the stream bottom at the outlet such that water drops vertically onto a steep area of rock or other hard material, then flows very steeply downward until it reaches the stream.
Headwall	A structure at either end of the culvert whose purpose is to hold back the embankment, retain the culvert and prevent erosion.
Inlet	The in-flow end of the culvert.
Inlet Drop	Water in the stream has a near-vertical drop from the stream channel down into the inlet of the structure. This usually occurs because sediment has accumulated above the inlet.
Lead Observer	Person responsible for data collection and data quality.
Leaching	Water that is penetrating through the culvert and traveling along the outside of the barrel.
Local ID	Identification code assigned by local agency or organization.
Location	Description that will allow another person to locate the culvert using only the supplied information.
Mitered to Slope	The end of the culvert is cut at an angle to match that of the topography.
Multiple Culvert	Two or more adjacent culverts at a single crossing.
No Crossing	A crossing that exists on a map that does not exist in the field.
No Upstream Channel	Areas where water crosses a road through a culvert but no road-stream crossing occurs because there is no channel up-gradient of the road. This can occur at the very headwaters of a stream or where a road crosses a wetland that lacks a stream channel (at least on the up-gradient side).
Outlet	The out-flow end of the culvert.
Overtopping	When the amount of flowing water exceeds the capacity of the culvert and flows over the road surface.
Perched	When the outlet is above the level of the stream bottom causing water leaving the culvert to form a waterfall or cascade.
Recessed	The end of the culvert does not protrude through the headwall, nor is it flush with the headwall.
Removed Crossing	A crossing apparently existed previously at the site but has been removed, so the stream now flows through the site with no provision for vehicles to cross over it.
Scaling	Loss of concrete in thin, plate-like pieces, lamina, or flakes that peel off from a surface due to freeze/thaw.
Scour	Removal of sediment such as sand and gravel from a channel bed or bank caused by swiftly moving water.
Soil Infiltration	Soil entering a culvert through a joint or hole.
Spalling	Breaking or splitting off of surface concrete in chips or bits.
Stream Grade	Elevation at which the water flows.
Substrate/Water Width	The widest width of the water or substrate within a culvert, whichever is wider.
Structural (Longitudinal) Alignment	Pertaining to the horizontal or vertical alignment of the pipe. (Note: do not confuse this with constructed pipe bends).
Wingwall	A short section of wall connected to the side of a headwall used as a retaining wall and to stabilize abutment and guide stream into culvert.

Big Brook Culvert Photos

Roadway Topside Looking Downstream (South)

North End (Inlet)

Big Brook Culvert Photos


Typical Plate Pipe Condition, Looking Downstream (South)


South End Retaining Appurtenance (West)

Big Brook Culvert Photos

Looking Upstream (North)

Big Brook & Scantic River Confluence

Culvert Assessment Form

CROSSING DATA

For multiple culvert crossings use one sheet per culvert. Go from left to right, standing at inlet looking downstream.

Crossing Code: H-04-008 **Local ID:** (Optional) BIN = 5MQ **Date Observed:** (00/00/0000) 12/16/20 **Lead Observer:** Paul Berthiaume, P.E.

Number of Culverts: 1 **Culvert** 1 **of** 1 **Stream:** East Brook **Road:** Main Street

Location: (St.#, Pole#, Etc.) NET&T Co. #17 **Town:** Hampden **County:** Hampden **State:** MA

GPS Coordinates: 42.06417°N Latitude 72.40556°W Longitude **Time:** 9:00 am **Weather:** Cloudy, Cold, 20° F

Crossing Type: ☑ Bridge ☐ Culvert ☐ Multiple Culvert ☐ Ford ☐ No Crossing ☐ Removed Crossing ☐ Buried Stream ☐ Inaccessible ☐ Partially Inaccessible ☐ No Upstream Channel

Culvert Material: ☐ Metal ☑ Concrete ☐ Plastic ☐ Wood ☐ Rock/Stone ☐ Fiberglass ☐ Combination **Length of Culvert:** 44'-0" (Square)

INLET

Appurtenance: ☐ Headwall ☑ Wingwalls ☐ Headwall & Wingwalls ☐ Mitered To Slope ☐ Projecting ☐ Flush ☐ Recessed ☐ Other ☐ None

Inlet Shape: ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☑ 6 ☐ 7 **Inlet Dimensions: A. Width:** 15'-11" **B. Height:** 4'-4" **C. Substrate/Water Width:** 15'-11" **D. Water Depth:** 1'-11" **E. Abutment Height:** ____

Inlet Grade: ☑ At Stream Grade ☐ Inlet Drop ☐ Perched ☐ Clogged/Collapsed/Submerged ☐ Unknown

OUTLET

Appurtenance: ☐ Headwall ☑ Wingwalls ☐ Headwall & Wingwalls ☐ Mitered To Slope ☐ Projecting ☐ Flush ☐ Recessed ☐ Other ☐ None

Outlet Shape: ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☑ 6 ☐ 7 **Outlet Dimensions: A. Width:** 15'-10" **B. Height:** 4'-4" **C. Substrate/Water Width:** 15'-10" **D. Water Depth:** 0'-11" **E. Abutment Height:** ____

Outlet Grade: ☑ At Stream Grade ☐ Free Fall ☐ Cascade ☐ Free Fall Onto Cascade ☐ Clogged/Collapsed/Submerged ☐ Unknown

	INLET (Please check only one level for each item)					OUTLET (Please check only one level for each item)				
	Adequate	Poor	Critical	Unknown	N/A	Adequate	Poor	Critical	Unknown	N/A
Structural (Longitudinal) Alignment	☑	☐	☐	☐	☐	☑	☐	☐	☐	☐
Channel Alignment	☑	☐	☐	☐	☐	☑	☐	☐	☐	☐
Level of Blockage	☑	☐	☐	☐	☐	☑	☐	☐	☐	☐
Flared End Section	☐	☐	☐	☐	☑	☐	☐	☐	☐	☑
Invert Deterioration	☐	☐	☐	☐	☑	☐	☐	☐	☐	☑
Buoyancy or Crushing	☐	☐	☐	☐	☑	☐	☐	☐	☐	☑
Cross-Section Deformation	☐	☐	☐	☐	☑	☐	☐	☐	☐	☑
Structural Integrity of Barrel	☐	☐	☐	☐	☑	☐	☐	☐	☐	☑
Joints and Seams	☐	☐	☐	☐	☑	☐	☐	☐	☐	☑
Footings	☑	☐	☐	☐	☐	☑	☐	☐	☐	☐
Headwall/Wingwalls	☐	☑	☐	☐	☐	☐	☑	☐	☐	☐
Armoring	☑	☐	☐	☐	☐	☑	☐	☐	☐	☐
Apron	☑	☐	☐	☐	☐	☑	☐	☐	☐	☐
Embankment Piping	☑	☐	☐	☐	☐	☐	☐	☐	☐	☑

To provide additional feedback on performance problems use the optional second sheet

Performance Problems Requiring Action

Debris/Veg Blockage >1/3 of rise	☐	Local Outlet Scour	☐	Embankment Slope Instability	☐
Sediment Blockage >1/2 the opening	☐	Previous and/or Frequent Overtopping	☐	No Access/Ends Totally Buried/Submerged	☐
Buoyancy or Crushing-Related Inlet Failure	☐	Embankment Piping	☐	Aggressive Abrasion/Corrosion/Chemical	☐
Poor Channel Alignment	☐	Channel Degradation/Headcut	☐	Exposed Footing (Open-Bottom Culvert Only)	☐

Notes: Wingwalls are generally exhibiting delamination and spalling. Bank-to-bank measures 18'-8" at the inlet (North) and 24'-7" at the outlet (South).

Photo #:____ Description: Pictures saved separately with descriptions Photo #:____ Description:____

Photo #:____ Description:____ Photo #:____ Description:____

Photo #:____ Description:____ Photo #:____ Description:____

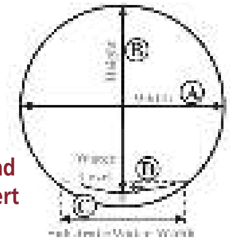
Photo #:____ Description:____ Photo #:____ Description:____

2019

Culvert Assessment Reference Chart

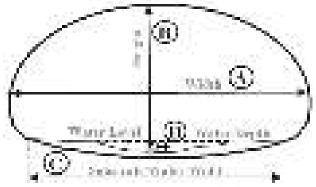
CULVERT SHAPE & DIMENSIONS

1.



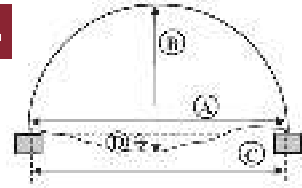
Round Culvert

2.



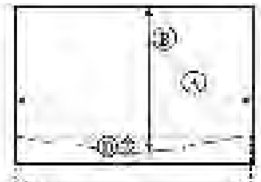
Pipe Arch/Elliptical Culvert

3.



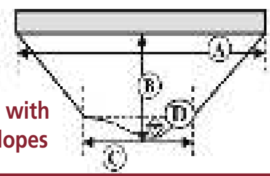
Open Bottom Arch Bridge/Culvert

4.



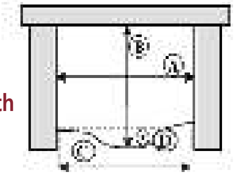
Box Culvert

5.



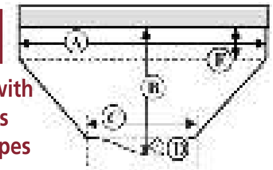
Bridge with Side Slopes

6.



Box/Bridge with Abutments

7.



Box/Bridge with Abutments and Side Slopes

CULVERT CONDITION REFERENCE

Structural (Longitudinal) Alignment

Poor: Significant horizontal or vertical misalignment of the pipe (Note: do not confuse this with constructed pipe bends).

Critical: Significant misalignment resulting in deformation of pipe or embankment/ roadway damage.

Channel Alignment

Poor: The stream channel approaches the crossing at an angle of 45-70 degrees from the centerline of the structure.

Critical: The stream channel approaches the crossing at an angle of 70-90 degrees from the centerline of the structure.

Level of Blockage

Poor: Debris/sediment/vegetation blocks 1/3 of more of the inlet/outlet opening.

Critical: Sediment blocks more than ½ the inlet/outlet opening (and not designed that way for aquatic organism passage).

Flared End Section

Poor: Significant cracks, piping or undermining affects >50% of section. End crushed or separated from barrel.

Critical: Deterioration is significantly affecting performance and/or causing embankment/ roadway damage.

Invert Deterioration

Poor: Perforations visible and/or connection hardware failing (metal). Heavy abrasion and scaling with exposed steel reinforcement (concrete). Heavy abrasion or scour damage (plastic). Displaced mortar and/or blocks, holes in invert area (masonry)

Critical: Holes or section loss with extensive voids beneath invert and/or embankment/ roadway damage. Holes and gaps with extensive infiltration of soil, bedding or backfill material (masonry).

Bouyancy or Crushing

Poor: Light to moderate denting or deformation of inlet and/or outlet end of fl exible pipe culvert. The invert of the inlet is at the streambed elevation (no uplift).

Critical: Invert of inlet bent upward above streambed or mitered edges crumpled inward.

Cross-Section Deformation

Poor: Significant perceptible deformation. Deformation with accompanying longitudinal cracking (concrete).

Critical: Excessive deformation resulting in significant reduction of available flow area, and/or extensive infiltration of soil, voids, structural failure or embankment/roadway damage.

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Poor: *Concrete:* Open cracks >1/8" wide with voids and significant infiltration of soil and/or leakage of water. Heavy rust staining and/or exposed steel reinforcement in sides and top of barrel.
Masonry: Missing and/or displaced blocks
Plastic: Several splits, tears and cracks >6" long. Significant deformation of liner or wall buckling.

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Joints and Seams

Poor: Open or displaced with significant infiltration of soil and/or leakage of water and voids visible. Missing mortar or displaced blocks (masonry).

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Footings

Poor: Top portion of footing exposed, but no cracking or breaking off of flakes or chips.

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Headwall/Wingwalls

Poor: Cracking or breaking off of flakes or chips affecting >50% of area and/or exposed steel reinforcement. Gap >4" between barrel and wall. Footing exposed and undermined.

Critical: Partially or totally collapsed with damage to embankment/roadway.

Armoring

Poor: Significant displacements, undermining or deterioration affecting the performance of the culvert structure.

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Apron

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Poor: Slight pavement cracking above the culvert, perhaps with a noticeable bump/ depression when driving, but no evidence of holes in the embankment or soil infiltration in the culvert barrel.

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Inlet Drop	Water in the stream has a near-vertical drop from the stream channel down into the inlet of the structure. This usually occurs because sediment has accumulated above the inlet.
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East Brook Culvert Photos (MassDOT Bridge No. H-04-008)

Overhead HSH Drone Photo, December 2020

North Fascia

East Brook Culvert Photos (MassDOT Bridge No. H-04-008)

North Fascia Wall & Erosion at Bridge Abutment Wall / Drainpipe

Erosion at Northeast Wing Wall & Drain Pipe

East Brook Culvert Photos (MassDOT Bridge No. H-04-008)


South Fascia


Typical Rotted End of Floor Beam

East Brook Culvert Photos (MassDOT Bridge No. H-04-008)

Looking Upstream (North)

Looking Downstream (South)

HOWARD STEIN HUDSON

Engineers + Planners

Appendix B

FEMA Firmette Map and StreamStats reports

National Flood Hazard Layer FIRMette

FEMA

72°24'46"W 42°4'2"N

72°24'8"W 42°3'36"N

0 250 500 1,000 1,500 2,000 Feet

1:6,000

Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- B 20.2 17.5 Cross Sections with 1% Annual Chance Water Surface Elevation
- 8 Coastal Transect
- 513 Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 4/28/2021 at 9:18 AM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

StreamStats Report - Big Brook at Main St, Hampden, MA

Region ID: MA
Workspace ID: MA20210407141656122000
Clicked Point (Latitude, Longitude): 42.06446, -72.40891
Time: 2021-04-07 10:20:14 -0400

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	2.74	square miles
ELEV	Mean Basin Elevation	564	feet
LC06STOR	Percentage of water bodies and wetlands determined from the NLCD 2006	13.65	percent
BSLDEM250	Mean basin slope computed from 1:250K DEM	8.306	percent

Parameter Code	Parameter Description	Value	Unit
DRFTPERSTR	Area of stratified drift per unit of stream length	0.13	square mile per mile
MAREGION	Region of Massachusetts 0 for Eastern 1 for Western	1	dimensionless
BSLDEM10M	Mean basin slope computed from 10 m DEM	13.612	percent
PCTSNDGRV	Percentage of land surface underlain by sand and gravel deposits	23.55	percent
FOREST	Percentage of area covered by forest	70.02	percent

Peak-Flow Statistics Parameters [Peak Statewide 2016 5156]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	2.74	square miles	0.16	512
ELEV	Mean Basin Elevation	564	feet	80.6	1948
LC06STOR	Percent Storage from NLCD2006	13.65	percent	0	32.3

Peak-Flow Statistics Flow Report [Peak Statewide 2016 5156]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PIl	PIu	SEp
50-percent AEP flood	84.7	ft^3/s	43.2	166	42.3
20-percent AEP flood	142	ft^3/s	71.4	282	43.4
10-percent AEP flood	188	ft^3/s	92.3	383	44.7
4-percent AEP flood	256	ft^3/s	121	539	47.1
2-percent AEP flood	313	ft^3/s	144	681	49.4
1-percent AEP flood	374	ft^3/s	167	839	51.8
0.5-percent AEP flood	440	ft^3/s	190	1020	54.1
0.2-percent AEP flood	535	ft^3/s	221	1300	57.6

Peak-Flow Statistics Citations

Zarriello, P.J.,2017, Magnitude of flood flows at selected annual exceedance probabilities for streams in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2016–5156, 99 p. (https://dx.doi.org/10.3133/sir20165156)

Low-Flow Statistics Parameters [Statewide Low Flow WRIR00 4135]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	2.74	square miles	1.61	149
BSLDEM250	Mean Basin Slope from 250K DEM	8.306	percent	0.32	24.6
DRFTPERSTR	Stratified Drift per Stream Length	0.13	square mile per mile	0	1.29
MAREGION	Massachusetts Region	1	dimensionless	0	1

Low-Flow Statistics Flow Report [Statewide Low Flow WRIR00 4135]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PIl	PIu	SE	SEp
7 Day 2 Year Low Flow	0.431	ft^3/s	0.119	1.51	49.5	49.5
7 Day 10 Year Low Flow	0.248	ft^3/s	0.0549	1.04	70.8	70.8

Low-Flow Statistics Citations

Ries, K.G., III,2000, Methods for estimating low-flow statistics for Massachusetts streams: U.S. Geological Survey Water Resources Investigations Report 00-4135, 81 p. (http://pubs.usgs.gov/wri/wri004135/)

Flow-Duration Statistics Parameters [Statewide Low Flow WRIR00 4135]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	2.74	square miles	1.61	149
DRFTPERSTR	Stratified Drift per Stream Length	0.13	square mile per mile	0	1.29
MAREGION	Massachusetts Region	1	dimensionless	0	1
BSLDEM250	Mean Basin Slope from 250K DEM	8.306	percent	0.32	24.6

Flow-Duration Statistics Flow Report [Statewide Low Flow WRIR00 4135]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PIl	PIu	SE	SEp
50 Percent Duration	2.67	ft^3/s	1.13	6.27	17.6	17.6
60 Percent Duration	1.84	ft^3/s	0.829	4.06	19.8	19.8
70 Percent Duration	1.4	ft^3/s	0.532	3.65	23.5	23.5
75 Percent Duration	1.15	ft^3/s	0.441	2.97	25.8	25.8
80 Percent Duration	1.12	ft^3/s	0.393	3.15	28.4	28.4
85 Percent Duration	0.896	ft^3/s	0.304	2.59	31.9	31.9
90 Percent Duration	0.768	ft^3/s	0.257	2.24	36.6	36.6
95 Percent Duration	0.496	ft^3/s	0.144	1.66	45.6	45.6
98 Percent Duration	0.337	ft^3/s	0.0848	1.27	60.3	60.3
99 Percent Duration	0.251	ft^3/s	0.0583	1.02	65.1	65.1

Flow-Duration Statistics Citations

Ries, K.G., III,2000, Methods for estimating low-flow statistics for Massachusetts streams: U.S. Geological Survey Water Resources Investigations Report 00-4135, 81 p. (http://pubs.usgs.gov/wri/wri004135/)

August Flow-Duration Statistics Parameters [Statewide Low Flow WRIR00 4135]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	2.74	square miles	1.61	149
BSLDEM250	Mean Basin Slope from 250K DEM	8.306	percent	0.32	24.6
DRFTPERSTR	Stratified Drift per Stream Length	0.13	square mile per mile	0	1.29
MAREGION	Massachusetts Region	1	dimensionless	0	1

August Flow-Duration Statistics Flow Report [Statewide Low Flow WRIR00 4135]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PIl	PIu	SE	SEp

Statistic	Value	Unit	PIl	PIu	SE	SEp
August 50 Percent Duration	0.936	ft^3/s	0.306	2.81	33.2	33.2

August Flow-Duration Statistics Citations

Ries, K.G., III,2000, Methods for estimating low-flow statistics for Massachusetts streams: U.S. Geological Survey Water Resources Investigations Report 00-4135, 81 p. (http://pubs.usgs.gov/wri/wri004135/)

Bankfull Statistics Parameters [Bankfull Statewide SIR2013 5155]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	2.74	square miles	0.6	329
BSLDEM10M	Mean Basin Slope from 10m DEM	13.612	percent	2.2	23.9

Bankfull Statistics Flow Report [Bankfull Statewide SIR2013 5155]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	SEp
Bankfull Width	25	ft	21.3
Bankfull Depth	1.39	ft	19.8
Bankfull Area	34.4	ft^2	29
Bankfull Streamflow	130	ft^3/s	55

Bankfull Statistics Citations

Bent, G.C., and Waite, A.M.,2013, Equations for estimating bankfull channel geometry and discharge for streams in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2013–5155, 62 p., (http://pubs.usgs.gov/sir/2013/5155/)

Probability Statistics Parameters [Perennial Flow Probability]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	2.74	square miles	0.01	1.99

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
PCTSNDGRV	Percent Underlain By Sand And Gravel	23.55	percent	0	100
FOREST	Percent Forest	70.02	percent	0	100
MAREGION	Massachusetts Region	1	dimensionless	0	1

Probability Statistics Disclaimers [Perennial Flow Probability]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Probability Statistics Flow Report [Perennial Flow Probability]

Statistic	Value	Unit
Probability Stream Flowing Perennially	0.96	dim

Probability Statistics Citations

Bent, G.C., and Steeves, P.A.,2006, A revised logistic regression equation and an automated procedure for mapping the probability of a stream flowing perennially in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2006–5031, 107 p. (http://pubs.usgs.gov/sir/2006/5031/pdfs/SIR_2006-5031rev.pdf)

Application Version: 4.5.1
StreamStats Services Version: 1.2.22
NSS Services Version: 2.1.1

StreamStats Report - East Brook at Main St, Hampden, MA

Region ID: MA
Workspace ID: MA20210407140951611000
Clicked Point (Latitude, Longitude): 42.06427, -72.40550
Time: 2021-04-07 10:13:09 -0400

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	3.69	square miles
ELEV	Mean Basin Elevation	620	feet
LC06STOR	Percentage of water bodies and wetlands determined from the NLCD 2006	14.08	percent
BSLDEM250	Mean basin slope computed from 1:250K DEM	5.313	percent

Parameter Code	Parameter Description	Value	Unit
DRFTPERSTR	Area of stratified drift per unit of stream length	0.0921	square mile per mile
MAREGION	Region of Massachusetts 0 for Eastern 1 for Western	1	dimensionless
BSLDEM10M	Mean basin slope computed from 10 m DEM	9.124	percent
PCTSNDGRV	Percentage of land surface underlain by sand and gravel deposits	21.04	percent
FOREST	Percentage of area covered by forest	83.24	percent

Peak-Flow Statistics Parameters [Peak Statewide 2016 5156]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.69	square miles	0.16	512
ELEV	Mean Basin Elevation	620	feet	80.6	1948
LC06STOR	Percent Storage from NLCD2006	14.08	percent	0	32.3

Peak-Flow Statistics Flow Report [Peak Statewide 2016 5156]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PIl	PIu	SEp
50-percent AEP flood	109	ft^3/s	55.6	214	42.3
20-percent AEP flood	182	ft^3/s	91.5	362	43.4
10-percent AEP flood	241	ft^3/s	118	491	44.7
4-percent AEP flood	328	ft^3/s	156	691	47.1
2-percent AEP flood	401	ft^3/s	184	873	49.4
1-percent AEP flood	479	ft^3/s	213	1080	51.8
0.5-percent AEP flood	563	ft^3/s	243	1300	54.1
0.2-percent AEP flood	686	ft^3/s	283	1660	57.6

Peak-Flow Statistics Citations

Zarriello, P.J.,2017, Magnitude of flood flows at selected annual exceedance probabilities for streams in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2016–5156, 99 p. (https://dx.doi.org/10.3133/sir20165156)

Low-Flow Statistics Parameters [Statewide Low Flow WRIR00 4135]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.69	square miles	1.61	149
BSLDEM250	Mean Basin Slope from 250K DEM	5.313	percent	0.32	24.6
DRFTPERSTR	Stratified Drift per Stream Length	0.0921	square mile per mile	0	1.29
MAREGION	Massachusetts Region	1	dimensionless	0	1

Low-Flow Statistics Flow Report [Statewide Low Flow WRIR00 4135]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PIl	PIu	SE	SEp
7 Day 2 Year Low Flow	0.457	ft^3/s	0.152	1.33	49.5	49.5
7 Day 10 Year Low Flow	0.226	ft^3/s	0.059	0.806	70.8	70.8

Low-Flow Statistics Citations

Ries, K.G., III,2000, Methods for estimating low-flow statistics for Massachusetts streams: U.S. Geological Survey Water Resources Investigations Report 00-4135, 81 p. (http://pubs.usgs.gov/wri/wri004135/)

Flow-Duration Statistics Parameters [Statewide Low Flow WRIR00 4135]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.69	square miles	1.61	149
DRFTPERSTR	Stratified Drift per Stream Length	0.0921	square mile per mile	0	1.29
MAREGION	Massachusetts Region	1	dimensionless	0	1
BSLDEM250	Mean Basin Slope from 250K DEM	5.313	percent	0.32	24.6

Flow-Duration Statistics Flow Report [Statewide Low Flow WRIR00 4135]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PIl	PIu	SE	SEp
50 Percent Duration	3.62	ft^3/s	1.66	7.85	17.6	17.6
60 Percent Duration	2.45	ft^3/s	1.19	5.03	19.8	19.8
70 Percent Duration	1.8	ft^3/s	0.763	4.21	23.5	23.5
75 Percent Duration	1.47	ft^3/s	0.626	3.41	25.8	25.8
80 Percent Duration	1.24	ft^3/s	0.523	2.9	28.4	28.4
85 Percent Duration	0.964	ft^3/s	0.39	2.34	31.9	31.9
90 Percent Duration	0.743	ft^3/s	0.289	1.87	36.6	36.6
95 Percent Duration	0.472	ft^3/s	0.166	1.3	45.6	45.6
98 Percent Duration	0.326	ft^3/s	0.0978	1.03	60.3	60.3
99 Percent Duration	0.242	ft^3/s	0.0682	0.807	65.1	65.1

Flow-Duration Statistics Citations

Ries, K.G., III,2000, Methods for estimating low-flow statistics for Massachusetts streams: U.S. Geological Survey Water Resources Investigations Report 00-4135, 81 p. (http://pubs.usgs.gov/wri/wri004135/)

August Flow-Duration Statistics Parameters [Statewide Low Flow WRIR00 4135]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.69	square miles	1.61	149
BSLDEM250	Mean Basin Slope from 250K DEM	5.313	percent	0.32	24.6
DRFTPERSTR	Stratified Drift per Stream Length	0.0921	square mile per mile	0	1.29
MAREGION	Massachusetts Region	1	dimensionless	0	1

August Flow-Duration Statistics Flow Report [Statewide Low Flow WRIR00 4135]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PIl	PIu	SE	SEp

Statistic	Value	Unit	PII	PIu	SE	SEp
August 50 Percent Duration	1.04	ft^3/s	0.411	2.58	33.2	33.2

August Flow-Duration Statistics Citations

Ries, K.G., III,2000, Methods for estimating low-flow statistics for Massachusetts streams: U.S. Geological Survey Water Resources Investigations Report 00-4135, 81 p. (http://pubs.usgs.gov/wri/wri004135/)

Bankfull Statistics Parameters [Bankfull Statewide SIR2013 5155]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.69	square miles	0.6	329
BSLDEM10M	Mean Basin Slope from 10m DEM	9.124	percent	2.2	23.9

Bankfull Statistics Flow Report [Bankfull Statewide SIR2013 5155]

PII: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	SEp
Bankfull Width	26.3	ft	21.3
Bankfull Depth	1.43	ft	19.8
Bankfull Area	37.2	ft^2	29
Bankfull Streamflow	120	ft^3/s	55

Bankfull Statistics Citations

Bent, G.C., and Waite, A.M.,2013, Equations for estimating bankfull channel geometry and discharge for streams in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2013–5155, 62 p., (http://pubs.usgs.gov/sir/2013/5155/)

Probability Statistics Parameters [Perennial Flow Probability]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	3.69	square miles	0.01	1.99

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
PCTSNDGRV	Percent Underlain By Sand And Gravel	21.04	percent	0	100
FOREST	Percent Forest	83.24	percent	0	100
MAREGION	Massachusetts Region	1	dimensionless	0	1

Probability Statistics Disclaimers [Perennial Flow Probability]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Probability Statistics Flow Report [Perennial Flow Probability]

Statistic	Value	Unit
Probability Stream Flowing Perennially	0.959	dim

Probability Statistics Citations

Bent, G.C., and Steeves, P.A.,2006, A revised logistic regression equation and an automated procedure for mapping the probability of a stream flowing perennially in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2006–5031, 107 p. (http://pubs.usgs.gov/sir/2006/5031/pdfs/SIR_2006-5031rev.pdf)

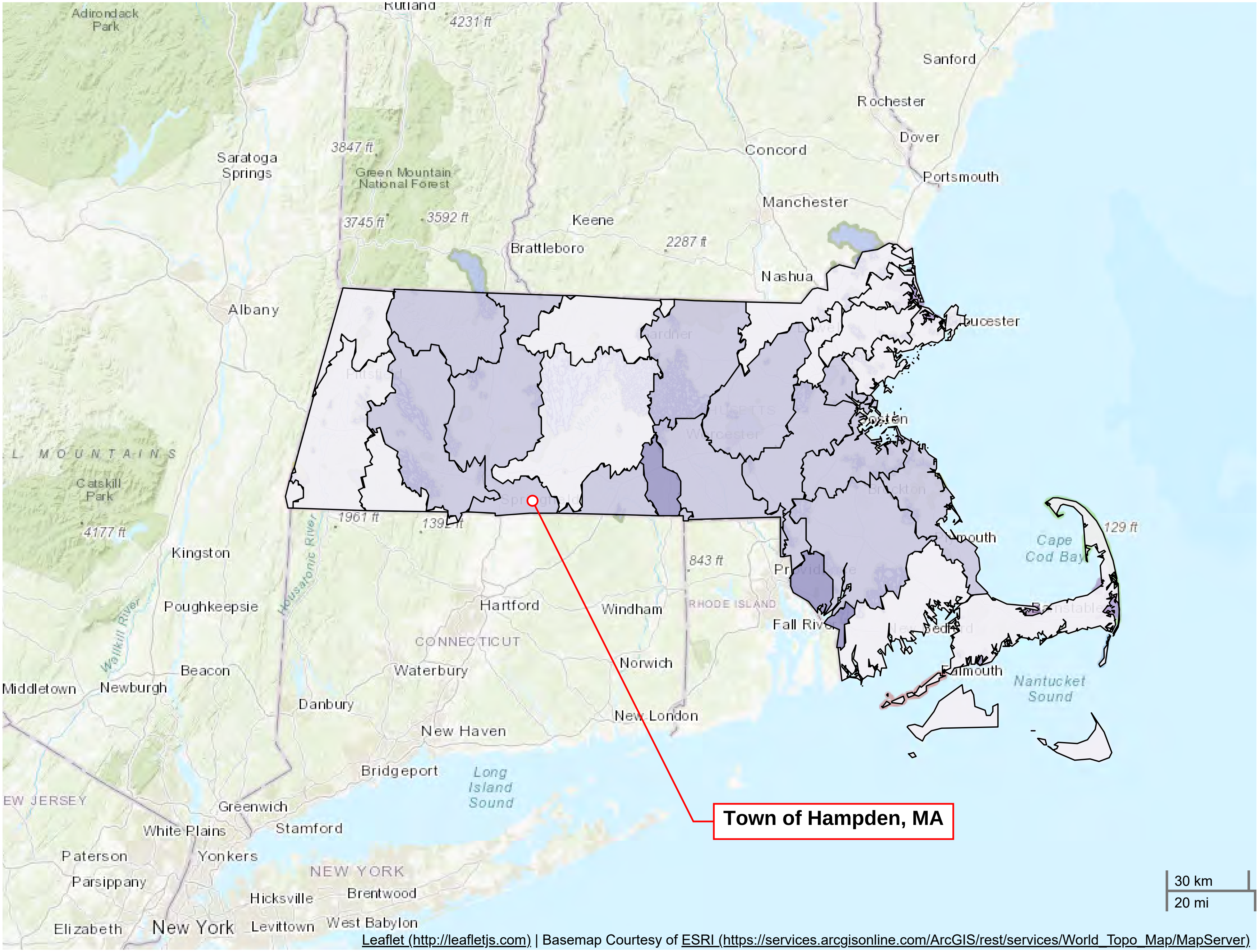
Application Version: 4.5.1
StreamStats Services Version: 1.2.22
NSS Services Version: 2.1.1

HOWARD STEIN HUDSON

Engineers + Planners

Appendix C

Projected Future Flooding Maps from ResilientMA.org


Town of Hampden, MA
Rutland
4231 ft
Adirondack Park
Sanford
Rochester
Dover
Concord
Portsmouth
Saratoga Springs
3847 ft
Green Mountain National Forest
Manchester
3745 ft
3592 ft
Keene
Brattleboro
2287 ft
Nashua
Albany
Gloucester
Boston
Worcester
Brockton
Catskill Park
1961 ft
1392 ft
4177 ft
129 ft
Cape Cod Bay
Kingston
843 ft
Poughkeepsie
Hartford
Windham
RHODE ISLAND
Fall River
CONNECTICUT
Waterbury
Norwich
Beacon
Middletown
Newburgh
Falmouth
Nantucket Sound
Danbury
New London
New Haven
Bridgeport
Long Island Sound
Greenwich
White Plains
Stamford
Paterson
Yonkers
NEW YORK
Parsippany
Hicksville
Brentwood
Elizabeth
New York
Levittown
West Babylon
30 km
20 mi
Leaflet (http://leafletjs.com) | Basemap Courtesy of ESRI (https://services.arcgisonline.com/ArcGIS/rest/services/World_Topo_Map/MapServer)

Extreme Precipitation > 1" (Projected)

Scenario: High RCP8.5

Summary: Drainage Basin

Season: Annual

Projected change in # Days with precipitation > 1 inch

+1.1 +1.5 +1.8 +2.3

Open Space by Owner

Legend:

- Federal
- DCR-State Parks_Recreation
- DCRS/DFG
- Department of Fish_Game
- DCR-Urban Parks_Recreation
- DCR-Water Supply Protection
- Department of Agricultural Resources
- Commonwealth of Massachusetts
- County
- Municipal
- Public Non-Profit
- Land Trust
- Conservation Organization
- Non-Profit
- Private
- Other
- Unknown

Surface Water Protection

Variable: Zone A

Public Water Supplies

Legend:

- Communtiy Groundwater Well
- Non-Communtiy Groundwater Well
- Surface Water Intake
- Emergency Surface Water Intake
- Community Labels
- Non-Community Labels

Outstanding Resource Waters

Legend:

- ACEC
- Cape Cod National Seashore
- Protected Shoreline
- Public Water Supply Watershed
- Retired Public Water Supply
- Scenic/Protected River
- Wildlife Refuge

MassDEP Wetlands

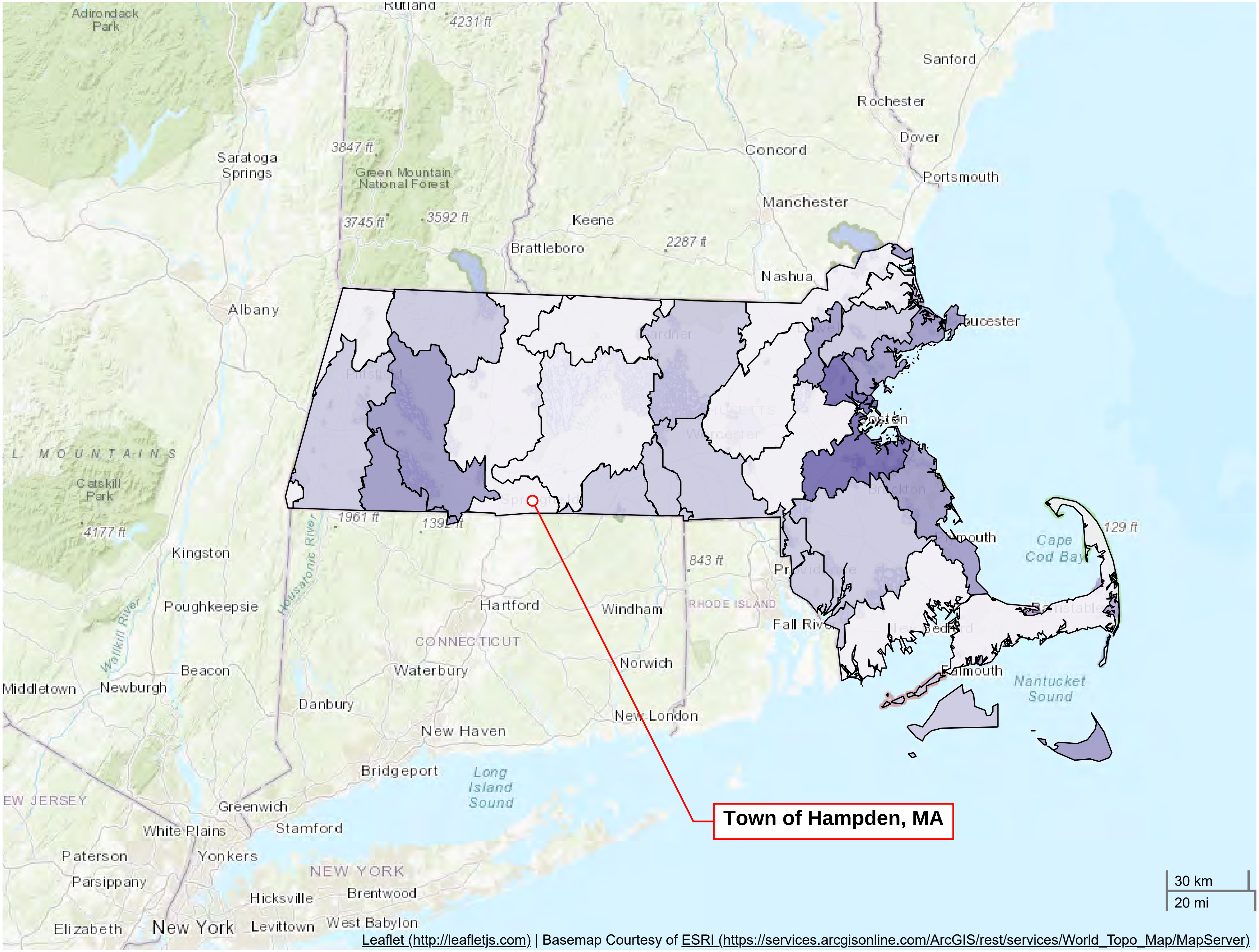
Legend:

- Barrier Beach System
- Barrier Beach-Deep Marsh
- Barrier Beach-Wooded Swamp Mixed Trees
- Barrier Beach-Coastal Beach
- Barrier Beach-Coastal Dune
- Barrier Beach-Marsh

30 km
20 mi

- Barrier Beach-Salt Marsh
- Barrier Beach-Shrub Swamp
- Barrier Beach-Wooded Swamp Coniferous
- Barrier Beach-Wooded Swamp Deciduous
- Bog
- Coastal Bank Bluff or Sea Cliff
- Coastal Beach
- Coastal Dune
- Cranberry Bog
- Deep Marsh
- Barrier Beach-Open Water
- Open Water
- Rocky Intertidal Shore
- Salt Marsh
- Shallow Marsh Meadow or Fen
- Shrub Swamp
- Tidal Flat
- Wooded Swamp Coniferous
- Wooded Swamp Deciduous
- Wooded Swamp Mixed Trees

30 km
20 mi


Town of Hampden, MA
Albany
Saratoga Springs
Keene
Brattleboro
Concord
Manchester
Nashua
Portsmouth
Dover
Rochester
Sanford
Green Mountain National Forest
Adirondack Park
Catskill Park
Kingston
Poughkeepsie
Beacon
Newburgh
Middletown
Hartford
Windham
Norwich
New London
Waterbury
Danbury
New Haven
Bridgeport
CONNECTICUT
RHODE ISLAND
Fall River
Long Island Sound
Cape Cod Bay
Nantucket Sound
Greenwich
Stamford
White Plains
Yonkers
Paterson
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New York
NEW YORK
Hicksville
Brentwood
Levittown
West Babylon
30 km
20 mi
Leaflet (http://leafletjs.com) | Basemap Courtesy of ESRI (https://services.arcgisonline.com/ArcGIS/rest/services/World_Topo_Map/MapServer)

Extreme Precipitation > 2" (Projected)

Scenario: High RCP8.5

Summary: Drainage Basin

Season: Annual

Projected change in # Days with precipitation > 2 inches

+0.17 +0.23 +0.31 +0.39

Open Space by Owner

Legend:

- Federal
- DCR-State Parks_Recreation
- DCRS/DFG
- Department of Fish_Game
- DCR-Urban Parks_Recreation
- DCR-Water Supply Protection
- Department of Agricultural Resources
- Commonwealth of Massachusetts
- County
- Municipal
- Public Non-Profit
- Land Trust
- Conservation Organization
- Non-Profit
- Private
- Other
- Unknown

Surface Water Protection

Variable: Zone A

Public Water Supplies

Legend:

- Communtiy Groundwater Well
- Non-Communtiy Groundwater Well
- Surface Water Intake
- Emergency Surface Water Intake
- Community Labels
- Non-Community Labels

Outstanding Resource Waters

Legend:

- ACEC
- Cape Cod National Seashore
- Protected Shoreline
- Public Water Supply Watershed
- Retired Public Water Supply
- Scenic/Protected River
- Wildlife Refuge

MassDEP Wetlands

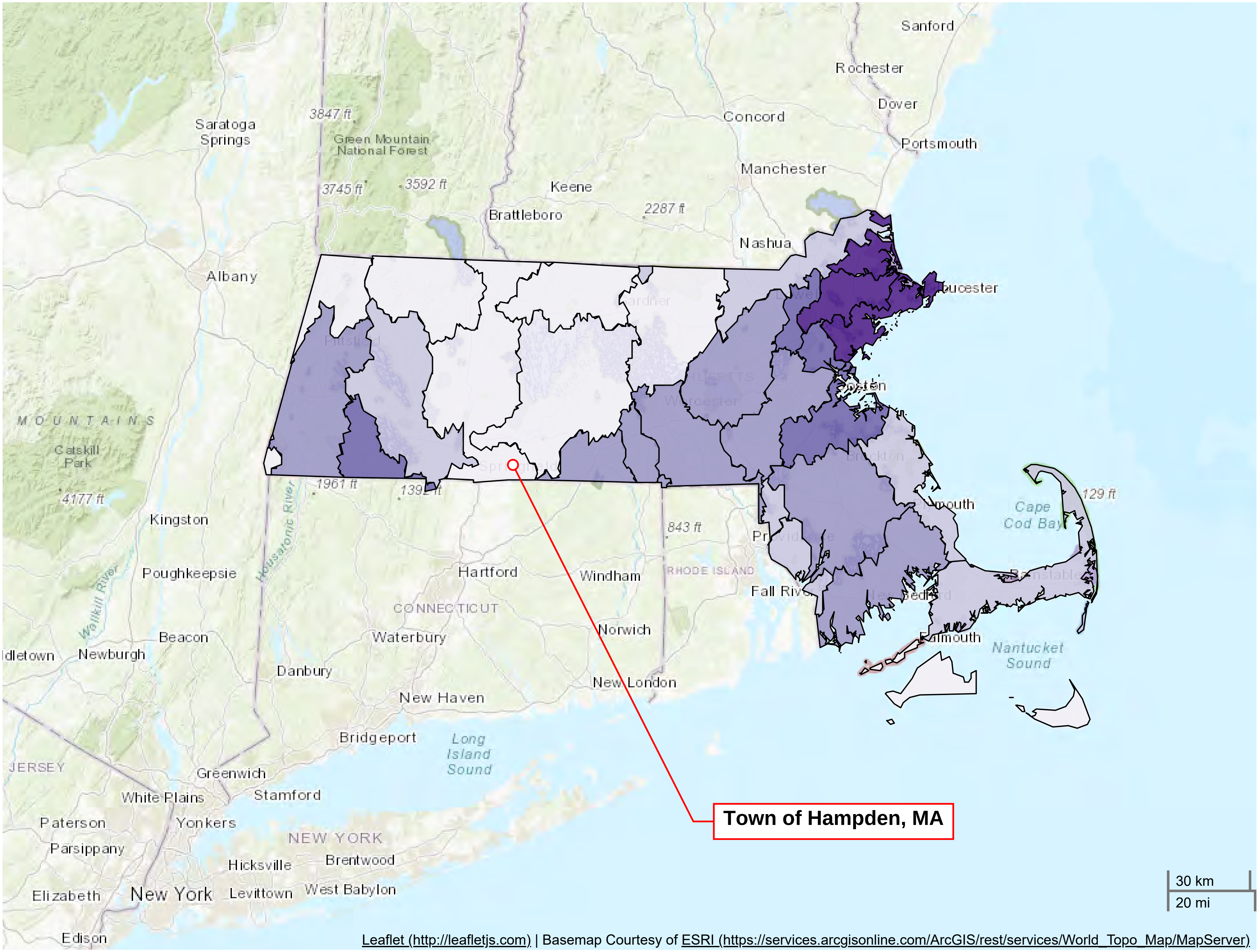
Legend:

- Barrier Beach System
- Barrier Beach-Deep Marsh
- Barrier Beach-Wooded Swamp Mixed Trees
- Barrier Beach-Coastal Beach
- Barrier Beach-Coastal Dune
- Barrier Beach-Marsh

30 km
20 mi

- Barrier Beach-Salt Marsh
- Barrier Beach-Shrub Swamp
- Barrier Beach-Wooded Swamp Coniferous
- Barrier Beach-Wooded Swamp Deciduous
- Bog
- Coastal Bank Bluff or Sea Cliff
- Coastal Beach
- Coastal Dune
- Cranberry Bog
- Deep Marsh
- Barrier Beach-Open Water
- Open Water
- Rocky Intertidal Shore
- Salt Marsh
- Shallow Marsh Meadow or Fen
- Shrub Swamp
- Tidal Flat
- Wooded Swamp Coniferous
- Wooded Swamp Deciduous
- Wooded Swamp Mixed Trees

30 km
20 mi


Town of Hampden, MA
Sanford
Rochester
Dover
Concord
Portsmouth
Manchester
Saratoga Springs
Green Mountain National Forest
Keene
Brattleboro
Nashua
Albany
Boston
Worcester
Pittsfield
Springfield
Hartford
Windham
CONNECTICUT
RHODE ISLAND
Providence
Fall River
New Bedford
Plymouth
Cape Cod Bay
Barnstable
Falmouth
Nantucket Sound
Norwich
New London
New Haven
Waterbury
Danbury
Bridgeport
Long Island Sound
Kingston
Poughkeepsie
Beacon
Newburgh
Catskill Park
Greenwich
Stamford
White Plains
Yonkers
Paterson
Parsippany
NEW YORK
Hicksville
Brentwood
Levittown
West Babylon
New York
Elizabeth
Edison
30 km
20 mi
Leaflet (http://leafletjs.com) | Basemap Courtesy of ESRI (https://services.arcgisonline.com/ArcGIS/rest/services/World_Topo_Map/MapServer)

Extreme Precipitation > 4" (Projected)

Scenario: High RCP8.5

Summary: Drainage Basin

Season: Annual

Projected change in # Days with precipitation > 4 inches

0 +0.01 +0.02 +0.04

Surface Water Protection

Variable: Zone A

Outstanding Resource Waters

Legend:

- ACEC
- Cape Cod National Seashore
- Protected Shoreline
- Public Water Supply Watershed
- Retired Public Water Supply
- Scenic/Protected River
- Wildlife Refuge

Open Space by Owner

Legend:

- Federal
- DCR-State Parks_Recreation
- DCRS/DFG
- Department of Fish_Game
- DCR-Urban Parks_Recreation
- DCR-Water Supply Protection
- Department of Agricultural Resources
- Commonwealth of Massachusetts
- County
- Municipal
- Public Non-Profit
- Land Trust
- Conservation Organization
- Non-Profit
- Private
- Other
- Unknown

Public Water Supplies

Legend:

- Communtiy Groundwater Well
- Non-Communtiy Groundwater Well
- Surface Water Intake
- Emergency Surface Water Intake
- Community Labels
- Non-Community Labels

MassDEP Wetlands

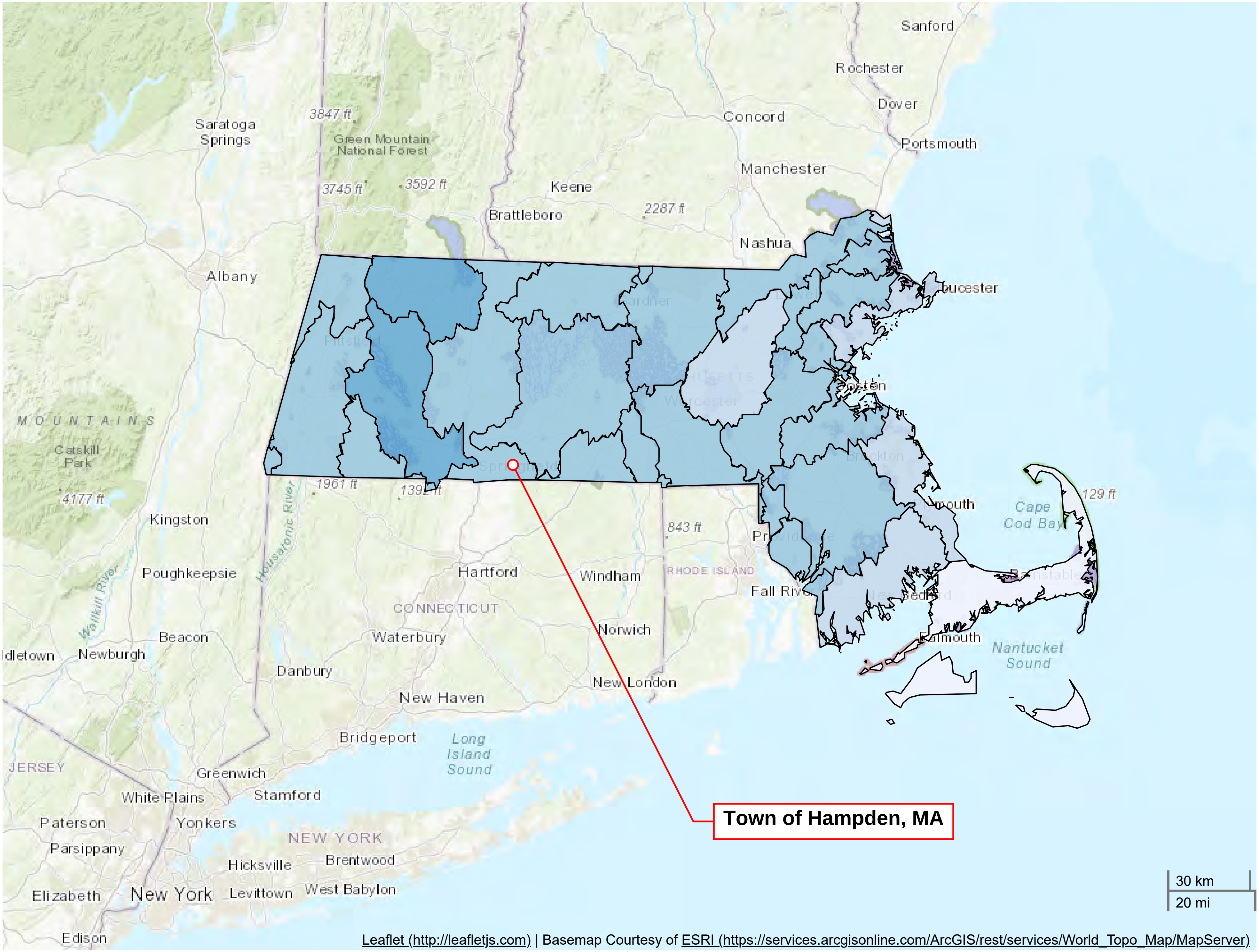
Legend:

- Barrier Beach System
- Barrier Beach-Deep Marsh
- Barrier Beach-Wooded Swamp Mixed Trees
- Barrier Beach-Coastal Beach
- Barrier Beach-Coastal Dune
- Barrier Beach-Marsh

30 km
20 mi

- Barrier Beach-Salt Marsh
- Barrier Beach-Shrub Swamp
- Barrier Beach-Wooded Swamp Coniferous
- Barrier Beach-Wooded Swamp Deciduous
- Bog
- Coastal Bank Bluff or Sea Cliff
- Coastal Beach
- Coastal Dune
- Cranberry Bog
- Deep Marsh
- Barrier Beach-Open Water
- Open Water
- Rocky Intertidal Shore
- Salt Marsh
- Shallow Marsh Meadow or Fen
- Shrub Swamp
- Tidal Flat
- Wooded Swamp Coniferous
- Wooded Swamp Deciduous
- Wooded Swamp Mixed Trees

30 km
20 mi


Town of Hampden, MA
Sanford
Rochester
Dover
Concord
Portsmouth
Manchester
Saratoga Springs
Green Mountain National Forest
3847 ft
3745 ft
3592 ft
Keene
Brattleboro
2287 ft
Nashua
Albany
MOUNTAINS
Catskill Park
4177 ft
Kingston
Poughkeepsie
1961 ft
1392 ft
843 ft
Hartford
Windham
RHODE ISLAND
CONNECTICUT
Waterbury
Norwich
Beacon
Newburgh
Danbury
New London
New Haven
Bridgeport
Long Island Sound
Greenwich
Stamford
White Plains
Yonkers
Paterson
Parsippany
NEW YORK
Hicksville
Brentwood
Elizabeth
New York
Levittown
West Babylon
Edison
JERSEY
Cape Cod Bay
129 ft
Nantucket Sound
30 km
20 mi
Leaflet (http://leafletjs.com) | Basemap Courtesy of ESRI (https://services.arcgisonline.com/ArcGIS/rest/services/World_Topo_Map/MapServer)

Total Precipitation (Projected)

Scenario: High RCP8.5

Summary: Drainage Basin

Season: Annual

Projected change in inches of total precipitation

+1.9 +2.5 +3 +3.4 +3.9 +4.5

Open Space by Owner

Legend:

- Federal
- DCR-State Parks_Recreation
- DCRS/DFG
- Department of Fish_Game
- DCR-Urban Parks_Recreation
- DCR-Water Supply Protection
- Department of Agricultural Resources
- Commonwealth of Massachusetts
- County
- Municipal
- Public Non-Profit
- Land Trust
- Conservation Organization
- Non-Profit
- Private
- Other
- Unknown

Surface Water Protection

Variable: Zone A

Public Water Supplies

Legend:

- Communtiy Groundwater Well
- Non-Communtiy Groundwater Well
- Surface Water Intake
- Emergency Surface Water Intake
- Community Labels
- Non-Community Labels

Outstanding Resource Waters

Legend:

- ACEC
- Cape Cod National Seashore
- Protected Shoreline
- Public Water Supply Watershed
- Retired Public Water Supply
- Scenic/Protected River
- Wildlife Refuge

MassDEP Wetlands

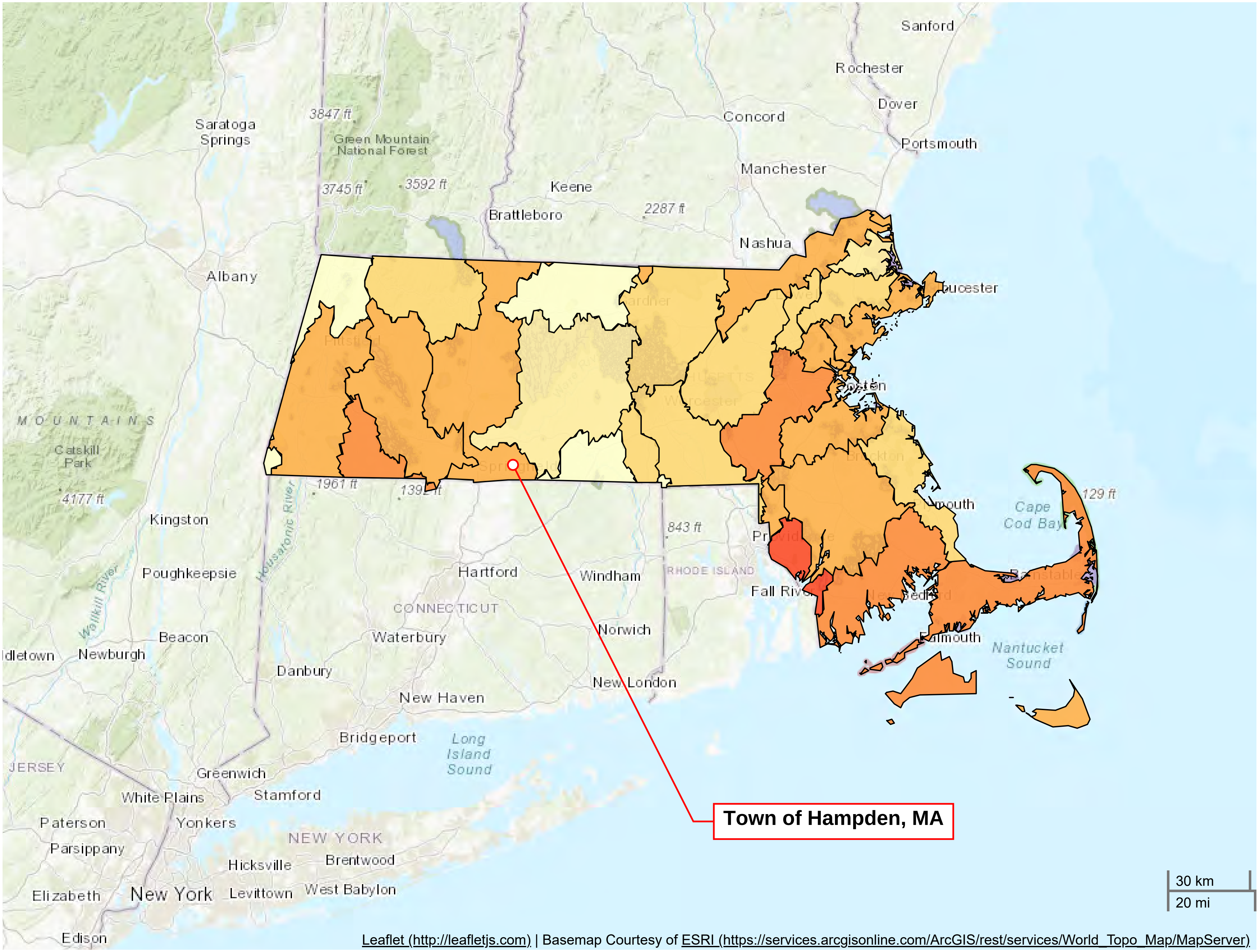
Legend:

- Barrier Beach System
- Barrier Beach-Deep Marsh
- Barrier Beach-Wooded Swamp Mixed Trees
- Barrier Beach-Coastal Beach
- Barrier Beach-Coastal Dune
- Barrier Beach-Marsh

30 km
20 mi

- Barrier Beach-Salt Marsh
- Barrier Beach-Shrub Swamp
- Barrier Beach-Wooded Swamp Coniferous
- Barrier Beach-Wooded Swamp Deciduous
- Bog
- Coastal Bank Bluff or Sea Cliff
- Coastal Beach
- Coastal Dune
- Cranberry Bog
- Deep Marsh
- Barrier Beach-Open Water
- Open Water
- Rocky Intertidal Shore
- Salt Marsh
- Shallow Marsh Meadow or Fen
- Shrub Swamp
- Tidal Flat
- Wooded Swamp Coniferous
- Wooded Swamp Deciduous
- Wooded Swamp Mixed Trees

30 km
20 mi


Sanford
Rochester
Dover
Concord
Portsmouth
Saratoga Springs
3847 ft
Green Mountain National Forest
Manchester
3745 ft
3592 ft
Keene
Brattleboro
2287 ft
Nashua
Albany
MOUNTAINS
Catskill Park
4177 ft
1961 ft
1392 ft
Kingston
843 ft
Poughkeepsie
Housatonic River
Wallkill River
Hartford
Windham
RHODE ISLAND
CONNECTICUT
Beacon
Waterbury
Norwich
Newburgh
Danbury
New London
New Haven
Bridgeport
Long Island Sound
JERSEY
Greenwich
White Plains
Stamford
Paterson
Yonkers
NEW YORK
Parsippany
Hicksville
Brentwood
Elizabeth
New York
Levittown
West Babylon
Edison
Cape Cod Bay
129 ft
Nantucket Sound
Town of Hampden, MA
30 km
20 mi
Leaflet (http://leafletjs.com) | Basemap Courtesy of ESRI (https://services.arcgisonline.com/ArcGIS/rest/services/World_Topo_Map/MapServer)

Consecutive Dry Days (Projected)

Scenario: High RCP8.5

Summary: Drainage Basin

Season: Annual

Projected change in # of consecutive dry days

+0.4 +0.5 +0.7 +0.8 +1 +1.2 +1.7

Open Space by Owner

Legend:

- Federal
- DCR-State Parks_Recreation
- DCRS/DFG
- Department of Fish_Game
- DCR-Urban Parks_Recreation
- DCR-Water Supply Protection
- Department of Agricultural Resources
- Commonwealth of Massachusetts
- County
- Municipal
- Public Non-Profit
- Land Trust
- Conservation Organization
- Non-Profit
- Private
- Other
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Surface Water Protection

Variable: Zone A

Public Water Supplies

Legend:

- Communtiy Groundwater Well
- Non-Communtiy Groundwater Well
- Surface Water Intake
- Emergency Surface Water Intake
- Community Labels
- Non-Community Labels

Outstanding Resource Waters

Legend:

- ACEC
- Cape Cod National Seashore
- Protected Shoreline
- Public Water Supply Watershed
- Retired Public Water Supply
- Scenic/Protected River
- Wildlife Refuge

MassDEP Wetlands

Legend:

- Barrier Beach System
- Barrier Beach-Deep Marsh
- Barrier Beach-Wooded Swamp Mixed Trees
- Barrier Beach-Coastal Beach
- Barrier Beach-Coastal Dune
- Barrier Beach-Marsh

30 km
20 mi

- Barrier Beach-Salt Marsh
- Barrier Beach-Shrub Swamp
- Barrier Beach-Wooded Swamp Coniferous
- Barrier Beach-Wooded Swamp Deciduous
- Bog
- Coastal Bank Bluff or Sea Cliff
- Coastal Beach
- Coastal Dune
- Cranberry Bog
- Deep Marsh
- Barrier Beach-Open Water
- Open Water
- Rocky Intertidal Shore
- Salt Marsh
- Shallow Marsh Meadow or Fen
- Shrub Swamp
- Tidal Flat
- Wooded Swamp Coniferous
- Wooded Swamp Deciduous
- Wooded Swamp Mixed Trees

30 km
20 mi

HOWARD STEIN HUDSON

Engineers + Planners

Appendix D

Latest Bridge Inspection Reports and Plans for H-04-008

MASSACHUSETTS DEPARTMENT OF TRANSPORTATION
STRUCTURES INSPECTION FIELD REPORT
ROUTINE & SPECIAL MEMBER INSPECTION

2-DIST	B.I.N.	BR. DEPT. NO.
02	5MQ	H-04-008

CITY/TOWN	8.-STRUCTURE NO.	11-Kilo. POINT	41-STATUS	90-ROUTINE INSP. DATE
HAMPDEN	H04008-5MQ-MUN-BRI	000.000	A:OPEN	DEC 15, 2020

07-FACILITY CARRIED	MEMORIAL NAME/LOCAL NAME	27-YR BUILT	106-YR REBUILT	YR REHAB'D (NON 106)
HWY MAIN ST		1938	0000	0000

06-FEATURES INTERSECTED	26-FUNCTIONAL CLASS	DIST. BRIDGE INSPECTION ENGINEER
WATER EAST BROOK	Major Collector	M. Barrett

43-STRUCTURE TYPE	22-OWNER	21-MAINTAINER	TEAM LEADER
302 : Steel Stringer/Girder	Town Agency	Town Agency	T. P. Penna

107-DECK TYPE	WEATHER	TEMP. (air)	TEAM MEMBERS
1 : Concrete Cast-in-Place	Sunny	7°C	L. R. LYNCH

ITEM 58 — DECK: 5

DECK		DEF
1. Wearing Surface	7	-
2. Deck Condition	5	S-A
3. Stay in Place Forms	N	-
4. Curbs	N	-
5. Median	N	-
6. Sidewalks	N	-
7. Parapets	N	-
8. Railing	5	S-A
9. Anti Missile Fence	N	-
10. Drainage System	N	-
11. Lighting Standards	N	-
12. Utilities	N	-
13. Deck Joints	N	-
14.	N	-
15.	N	-
16.	N	-

CURB REVEAL (In millimeters)	N	S
	N	N

APPROACHES		DEF
a. Appr. pavement condition	7	-
b. Appr. Roadway Settlement	7	-
c. Appr. Sidewalk Settlement	N	-
d.	N	-

OVERHEAD SIGNS (Attached to bridge) (Y/N): N

		DEF
a. Condition of Welds	N	-
b. Condition of Bolts	N	-
c. Condition of Signs	N	-

ITEM 59 — SUPERSTRUCTURE: 4

SUPERSTRUCTURE		DEF
1. Stringers	N	-
2. Floorbeams	N	-
3. Floor System Bracing	N	-
4. Girders or Beams	4	S-A
5. Trusses - General	N	-
a. Upper Chords	N	-
b. Lower Chords	N	-
c. Web Members	N	-
d. Lateral Bracing	N	-
e. Sway Bracings	N	-
f. Portals	N	-
g. End Posts	N	-
6. Pin & Hangers	N	-
7. Conn Plt's, Gussets & Angles	N	-
8. Cover Plates	N	-
9. Bearing Devices	5	S-A
10. Diaphragms/Cross Frames	5	S-A
11. Rivets & Bolts	N	-
12. Welds	N	-
13. Member Alignment	N	-
14. Paint/Coating	5	M-P
15.	N	-

Year Painted: X

COLLISION DAMAGE: *Please explain*
None (X) Minor ( ) Moderate ( ) Severe ( )

LOAD DEFLECTION: *Please explain*
None (X) Minor ( ) Moderate ( ) Severe ( )

LOAD VIBRATION: *Please explain*
None (X) Minor ( ) Moderate ( ) Severe ( )

Any Fracture Critical Member: (Y/N) N

Any Cracks: (Y/N) N

ITEM 60 — SUBSTRUCTURE: 6

SUBSTRUCTURE	Dive	Cur	DEF
1. Abutments		6	
a. Pedestals	N	6	-
b. Bridge Seats	N	6	M-P
c. Backwalls	N	6	M-P
d. Breastwalls	N	6	M-P
e. Wingwalls	N	5	S-A
f. Slope Paving/Rip-Rap	N	N	-
g. Pointing	N	N	-
h. Footings	N	H	-
i. Piles	N	H	-
j. Scour	N	7	-
k. Settlement	N	7	-
l.	N	N	-
m.	N	N	-
2. Piers or Bents		N	
a. Pedestals	N	N	-
b. Caps	N	N	-
c. Columns	N	N	-
d. Stems/Webs/Pierwalls	N	N	-
e. Pointing	N	N	-
f. Footing	N	N	-
g. Piles	N	N	-
h. Scour	N	N	-
i. Settlement	N	N	-
j.	N	N	-
k.	N	N	-
3. Pile Bents		N	
a. Pile Caps	N	N	-
b. Piles	N	N	-
c. Diagonal Bracing	N	N	-
d. Horizontal Bracing	N	N	-
e. Fasteners	N	N	-

UNDERMINING (Y/N) If YES please explain: N

COLLISION DAMAGE:
None (X) Minor ( ) Moderate ( ) Severe ( )

SCOUR: *Please explain*
None (X) Minor ( ) Moderate ( ) Severe ( )

I-60 (Dive Report): N *I-60 (This Report):* 6

93B-U/W (DIVE) Insp 00/00/0000

X=UNKNOWN N=NOT APPLICABLE H=HIDDEN/INACCESSIBLE R=REMOVED

CITY/TOWN	B.I.N.	BR. DEPT. NO.	8.-STRUCTURE NO.	INSPECTION DATE
HAMPDEN	5MQ	H-04-008	H04008-5MQ-MUN-BRI	DEC 15, 2020

ITEM 61 7

CHANNEL & CHANNEL PROTECTION

	Dive	Cur	DEF
1.Channel Scour	N	7	-
2.Embankment Erosion	N	7	-
3.Debris	N	7	-
4.Vegetation	N	7	-
5.Utilities	N	N	-
6.Rip-Rap/Slope Protection	N	7	-
7.Aggradation	N	7	-
8.Fender System	N	N	-

STREAM FLOW VELOCITY:
Tidal ( ) High ( ) Moderate ( ) Low (X) None ( )

ITEM 61 (Dive Report): N *ITEM 61 (This Report):* 7

93b-U/W INSP. DATE: 00/00/0000

ITEM 36 ***TRAFFIC SAFETY***

	36	COND	DEF
A. Bridge Railing	0	5	S-A
B. Transitions	0	0	S-A
C. Approach Guardrail	0	0	S-A
D. Approach Guardrail Ends	0	0	S-A

WEIGHT POSTING ***Not Applicable*** X

	H	3	3S2	Single
Actual Posting	N	N	N	N
Recommended Posting	N	N	N	N

Waived Date: 00/00/0000 EJDMT Date: 00/00/0000

	At bridge E	At bridge W	Other Advance E	Other Advance W
Signs In Place (Y=Yes,N=No, NR=NotRequired)				
Legibility/ Visibility				

CLEARANCE POSTING

Not X

	N ft	N in	S ft	S in	meter
Actual Field Measurement		0		0	
Posted Clearance		0		0	

	At bridge N	At bridge S	Advance N	Advance S
Signs In Place (Y=Yes,N=No, NR=Not Required)				
Legibility/ Visibility				

ACCESSIBILITY (Y/N/P)

	Needed	Used
Lift Bucket	N	N
Ladder	N	N
Boat	N	N
Waders	Y	Y
Inspector 50	N	N
Rigging	N	N
Staging	N	N
Traffic Control	N	N
RR Flagger	N	N
Police	N	N
Other:		
	N	N

TOTAL HOURS 6

PLANS (Y/N): Y

(V.C.R.) (Y/N): N

TAPE#:

List of field tests performed:
Visual and Hands-on Insp.

RATING
Rating Report (Y/N): N
Date: 00/00/0000
Inspection data at time of existing rating
I 58: - I 59: - I 60: - Date : 00/00/0000

Recommend for Rating or Rerating (Y/N): Y

If YES please give priority:
HIGH ( ) MEDIUM (X) LOW ( )

REASON: Deterioration of Beams 1 & 10.

CONDITION RATING GUIDE

(For Items 58, 59, 60 and 61)

	CODE	CONDITION	DEFECTS
	N	NOT APPLICABLE	
G	9	EXCELLENT	Excellent condition.
G	8	VERY GOOD	No problem noted.
G	7	GOOD	Some minor problems.
F	6	SATISFACTORY	Structural elements show some minor deterioration.
F	5	FAIR	All primary structural elements are sound but may have minor section loss, cracking, spalling or scour.
P	4	POOR	Advanced section loss, deterioration, spalling or scour.
P	3	SERIOUS	Loss of section, deterioration, spalling or scour have seriously affected primary structural components. Local failures are possible. Fatigue cracks in steel or shear cracks in concrete may be present.
C	2	CRITICAL	Advanced deterioration of primary structural elements. Fatigue cracks in steel or shear cracks in concrete may be present or scour may have removed substructure support. Unless closely monitored it may be necessary to close the bridge until corrective action is taken.
C	1	"IMMINENT" FAILURE	Major deterioration or section loss present in critical structural components or obvious vertical or horizontal movement affecting structure stablility. Bridge is closed to traffic but corrective action may put it back in light service.
	0	FAILED	Out of service - beyond corrective action.

DEFICIENCY REPORTING GUIDE

DEFICIENCY: A defect in a structure that requires corrective action.

CATEGORIES OF DEFICIENCIES:

M= Minor Deficiency - Deficiencies which are minor in nature, generally do not impact the structural integrity of the bridge and could easily be repaired. Examples include but are not limited to: Spalled concrete, Minor pot holes, Minor corrosion of steel, Minor scouring, Clogged drainage, etc.

S= Severe/Major Deficiency - Deficiencies which are more extensive in nature and need more planning and effort to repair. Examples include but are not limited to: Moderate to major deterioration in concrete, Exposed and corroded rebars, Considerable settlement, Considerable scouring or undermining, Moderate to extensive corrosion to structural steel with measurable loss of section, etc.

C-S= Critical Structural Deficiency - A deficiency in a structural element of a bridge that poses an extreme unsafe condition due to the failure or imminent failure of the element which will affect the structural integrity of the bridge.

C-H= Critical Hazard Deficiency - A deficiency in a component or element of a bridge that poses an extreme hazard or unsafe condition to the public, but does not impair the structural integrity of the bridge. Examples include but are not limited to: Loose concrete hanging down over traffic or pedestrians, A hole in a sidewalk that may cause injuries to pedestrians, Missing section of bridge railing, etc.

URGENCY OF REPAIR:

I = Immediate- [Inspector(s) immediately contact District Bridge Inspection Engineer (DBIE) to report the Deficiency and to receive further instruction from him/her].

A = ASAP- [Action/Repair should be initiated by District Maintenance Engineer or the Responsible Party (if not a State owned bridge) upon receipt of the Inspection Report].

P = Prioritize- [Shall be prioritized by District Maintenance Engineer or the Responsible Party (if not a State owned bridge) and repairs made when funds and/or manpower is available].

MASSACHUSETTS DEPARTMENT OF TRANSPORTATION

STRUCTURES INSPECTION FIELD REPORT

ROUTINE & SPECIAL MEMBER INSPECTION

2-DIST	B.I.N.	BR. DEPT. NO.
02	5MQ	H-04-008

CITY/TOWN	8.-STRUCTURE NO.	11-Kilo. POINT	90-ROUTINE INSP. DATE	93*-SPEC. MEMB. INSP. DATE
HAMPDEN	H04008-5MQ-MUN-BRI	000.000	Dec 15, 2020	Dec 15, 2020

07-FACILITY CARRIED	MEMORIAL NAME/LOCAL NAME	27-YR BUILT	106-YR REBUILT	*YR REHAB'D (NON 106)
HWY MAIN ST		1938	0000	0000

06-FEATURES INTERSECTED	26-FUNCTIONAL CLASS	DIST. BRIDGE INSPECTION ENGINEER
WATER EAST BROOK	Major Collector	M. Barrett

43-STRUCTURE TYPE	22-OWNER	21-MAINTAINER	TEAM LEADER
302 : Steel Stringer/Girder	Town Agency	Town Agency	T. P. Penna

107-DECK TYPE	WEATHER	TEMP. (air)	TEAM MEMBERS
1 : Concrete Cast-in-Place	Sunny	7°C	L. R. LYNCH

WEIGHT POSTING

Not Applicable: X

	H	3	3S2	Single
Actual Posting	N	N	N	N
Recommended Posting	N	N	N	N

Waived Date: 00/00/0000 EJDMT Date: 00/00/0000

Signs In Place (Y=Yes,N=No, NR=Not Required)
Legibility/ Visibility

At bridge E	At bridge W	Advance E	Advance W

PLANS (Y/N): Y

(V.C.R.) (Y/N): N

TAPE#:

RATING

Rating Report (Y/N): N Date: ----

Recommend for Rating or Rerating (Y/N): Y

If YES please give priority: HIGH ( ) MEDIUM (X) LOW ( )

REASON: Deterioration of Beams 1 & 10.

Inspection data at time of existing rating
I 58: - I 59: - I 60: - I 62: - Date : 00/00/0000

SPECIAL MEMBER(S):

	MEMBER	CRACK (Y/N):	WELD'S CONDITION (0-9)	LOCATION OF CORROSION, SECTION LOSS (%), CRACKS, COLLISION DAMAGE, STRESS CONCENTRATION, ETC.	CONDITION PREVIOUS (0-9)	CONDITION PRESENT (0-9)	INV. RATING OF MEMBER FROM RATING ANALYSIS H-20	3	3S2	Deficiencies
A	Item 59.4 - Girders or Beams	N		See remarks in comments section.	4	4	Not Rated			S-A
B										
C										
D										
E										

List of field tests performed:
Visual and Hands-on Insp.

	I-58	I-59	I-60	I-62
(Overall Previous Condition)	5	4	6	-
(Overall Current Condition)	5	4	6	-

DEFICIENCY: A defect in a structure that requires corrective action.

CATEGORIES OF DEFICIENCIES:

M= Minor Deficiency - Deficiencies which are minor in nature, generally do not impact the structural integrity of the bridge and could easily be repaired. Examples include but are not limited to: Spalled concrete, Minor pot holes, Minor corrosion of steel, Minor scouring, Clogged drainage, etc.

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X=UNKNOWN N=NOT APPLICABLE H=HIDDEN/INACCESSIBLE R=REMOVED

CITY/TOWN	B.I.N.	BR. DEPT. NO.	8.-STRUCTURE NO.	INSPECTION DATE
HAMPDEN	**5MQ**	**H-04-008**	**H04008-5MQ-MUN-BRI**	**DEC 15, 2020**

REMARKS

BRIDGE ORIENTATION

Structure carries Main Street, east and west, over the East Brook which flows from north to south.

This steel multi-girder bridge has a span of 17' - 8" and is 44'-1" wide. The beams are numbered from south to north. **See Sketches 1 - 3.**

ITEM 58 - DECK

Item 58.1 - Wearing Surface

Hot mix asphalt (HMA) Wearing Surface has a few random longitudinal and transverse hairline cracks.

Item 58.2 - Deck Condition

Deck Underside has longitudinal hairline cracks. Some of the cracks have efflorescence with & without stalactites. **See Photo 1.**

South Elevation (Beam 1 area) has a spall in the underside of the overhang, 4' long x 5" wide x 1" deep, with 2 exposed bars.

North Elevation (Beam 10 area) has an edge spall, 8'-4" long x 7" high x 6" wide x 3" deep, with multiple exposed bars. **See Photo 2.**

Item 58.8 - Railing

Bridge Railing consists of 2 steel pipe rails on steel H-posts.

- Railing has light to moderate rust throughout.
- North Railing has a slight bend in the upper pipe at midspan and is missing the northwest end of the upper pipe. **See Photos 2 & 3.**
- North Railing, the 4 posts starting from the east all have exposed anchor bolts. The 4th post is the worst with up to 3" exposed and up to 50% section loss.

North Railbase:

- Railbase & Northeast Wingwall (about 29') have severe scale for their entire length with many exposed rebar.
- Areas are up to 3" deep on each side & up to the full width (12") along the top. **See Photos 2 & 3.**
- Remaining concrete is very soft and punky.

South Railbase:

- Railbase has severe scale for 10' starting at the southwest end of the bridge span with many exposed rebar.
- Southeast Wingwall has scale for the full length (10').
- Areas are up to 5" deep on both the bridge span & wingwall and up to full width (12") along the top. **See Photo 4.**

Remaining concrete is very soft and punky.

APPROACHES

Approaches a - Appr. pavement condition

East & West Approach roadways has a few random longitudinal & transverse hairline cracks.

CITY/TOWN	B.I.N.	BR. DEPT. NO.	8.-STRUCTURE NO.	INSPECTION DATE
HAMPDEN	5MQ	H-04-008	H04008-5MQ-MUN-BRI	DEC 15, 2020

REMARKS

ITEM 59 - SUPERSTRUCTURE

Item 59.4 - Girders or Beams
Beams 1 &10 are W16x50 (original web = 0.38" and flange = 0.63" thick)
Beams 2 - 9 are W16x45 (original web = 0.345" and flange = 0.565" thick)

Beam 1 has severe rust and holes through the beam at both ends. **See Sketch 4 and Photos 5 & 6.**

Beam 10:
- West end has severe rust and a through hole. **See Sketch 5 and Photo 7.**
- East end has severe rust and delamination. **See Photo 8.**

Item 59.9 - Bearing Devices
Beam 1, at both abutments the anchor bolts and nuts have rusted away and the plate is heavily rusted.
See Photos 5 & 6.

Beam 10:
- West Abutment anchor bolts and nuts have rusted away and the plate is severely rusted. **See Photo 7.**
- East Abutment anchor bolts nuts have rusted away and the plate is severely rusted. **See Photo 8.**

Beams 2 - 9, all anchor bolts and nuts have light to moderate rust with minor section loss.

Item 59.10 - Diaphragms/Cross Frames
There are steel rods (2-3/4") embedded in 6" of concrete at the beam ends acting as diaphragms.

Beam 1:
- Both rods at the East Abutment have lost all section where they were exposed and are now nonfunctional.
- Lower rod at the West Abutment has lost all section where it was exposed and is now nonfunctional.

Beam 10:
- Exposed portion of the rods have heavy rust and section loss. **See Photos 7 & 8.**
- Lower rod at the West Abutment has lost all section where it was exposed and is now nonfunctional.

Item 59.14 - Paint/Coating
Paint Coating on Beams 1 & 10 has failed over 60% of the beams and the remainder is peeling and flaking.
See Photos 5 - 9.

Paint Coating on the reaming beams is starting to fail and many of the bottom flanges are starting to rust.

ITEM 60 - SUBSTRUCTURE

Item 60.1 - Abutments
Item 60.1.a - Pedestals
Most of the pedestals have random hairline cracks.

A few of the pedestals have minor spalls on the corners.

Beam 2, Pedestal at the East Abutment has a full width x 4" deep spall exposing part of the masonry plate.

CITY/TOWN	B.I.N.	BR. DEPT. NO.	8.-STRUCTURE NO.	INSPECTION DATE
HAMPDEN	5MQ	H-04-008	H04008-5MQ-MUN-BRI	DEC 15, 2020

REMARKS

Item 60.1.b - Bridge Seats
West Bridge Seat, south end has an edge spall, 18" long x 24" wide x 24" high x 2" deep. **See Photo 5.**

East Bridge Seat, south end has an edge spall, 18" long x 9" wide x 17" high x 2-1/2" deep. **See Photo 6.**

Item 60.1.c - Backwalls
Visible portions (outside edges at Beams 1 & 10) of the Backwalls have hairline cracks and heavy efflorescence.

Remainder of the Backwalls are not visible due to the concrete diaphragms.

Item 60.1.d - Breastwalls
East & West Breastwalls have spalls at the south ends. **See Item 60.1.b - Bridge Seats.**

East & West Breastwalls have full-height cracks, hairline to 1/16" wide, at random locations. **See Photo 9.**

Item 60.1.e - Wingwalls
Southeast Wingwall has severe scaling:
- 3' high x 4' long x 5" deep.
- 5' long x 14" high x 5" deep. **See Photo 10.**

Northeast Wingwall has severe scaling:
- 6' long x 15" high x 2" deep.
- 4' long x 13" high x 2" deep. **See Photo 11.**

TRAFFIC SAFETY

Item 36a - Bridge Railing
See Item 58.8 - Railing.

Item 36b - Transitions
There are no approach guardrails nor transitions.

Item 36c - Approach Guardrail
There are no approach guardrails.

Item 36d - Approach Guardrail Ends
There are no approach guardrails nor guardrail ends.

Sketch / Photo Log
Sketch 1 : Plan
Sketch 2 : Elevation
Sketch 3 : Cross Section
Sketch 4 : Beam 1 - Defects
Sketch 5 : Beam 10 - Defects
Photo 1 : Deck Underside has longitudinal hairline cracks.
Photo 2 : North Deck Elevation has a spall with multiple exposed rebar.
Photo 3 : North Railing has a bend in the top rail at mid-span
Photo 4 : South Railbase has severe scaling
Photo 5 : Beam 1, west end, has a large hole in the web & bottom flange.
Photo 6 : Beam 1, east end, has a large hole in the web & bottom flange.

CITY/TOWN	B.I.N.	BR. DEPT. NO.	8.-STRUCTURE NO.	INSPECTION DATE
HAMPDEN	5MQ	H-04-008	H04008-5MQ-MUN-BRI	DEC 15, 2020

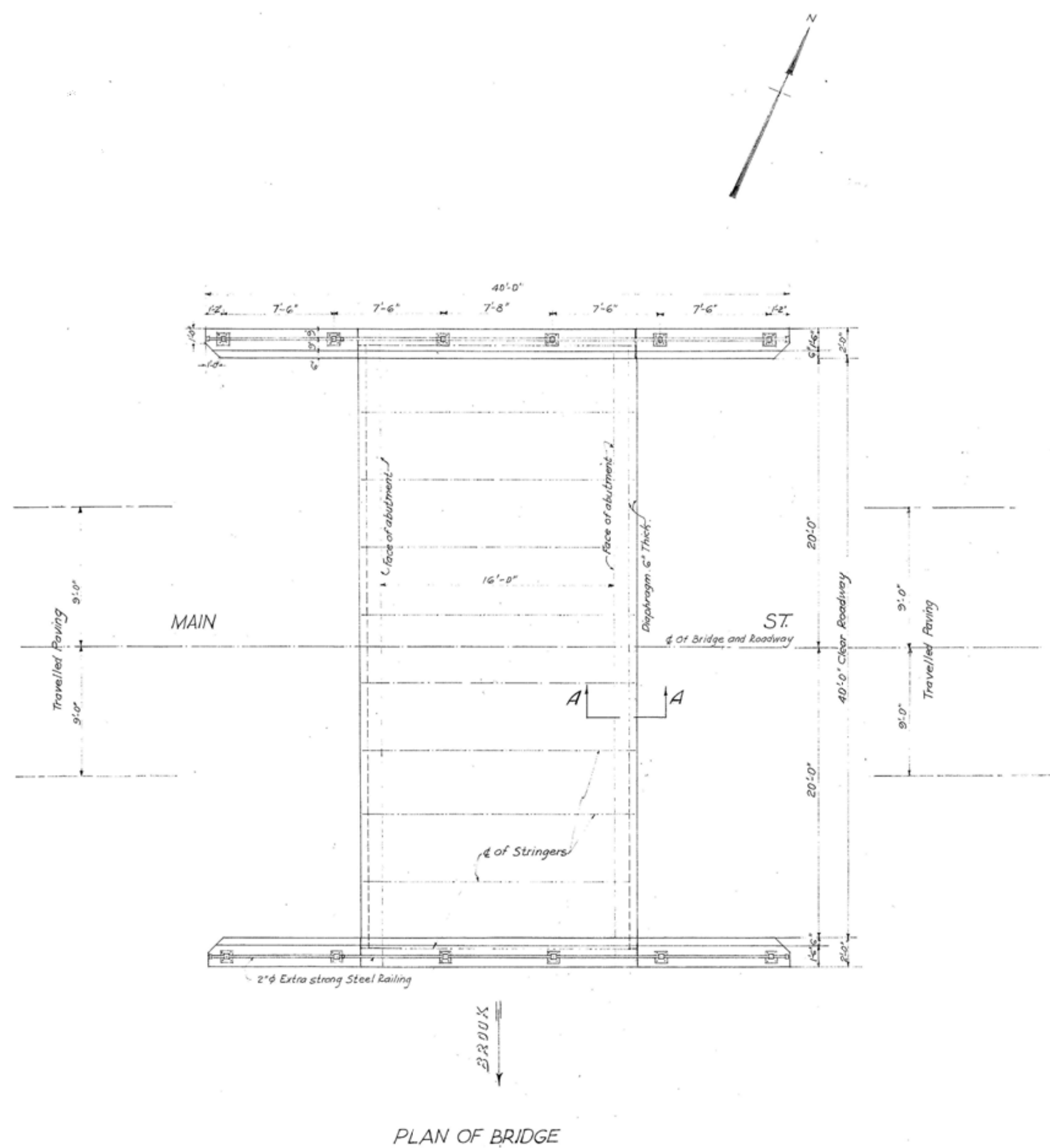
REMARKS

Sketch / Photo Log (Cont'd)

Photo 7 : Beam 10, west end, has a large hole in the web & bottom flange.
Photo 8 : Beam 10, east end, has severe deterioration.
Photo 9 : East Abutment has hairline cracks
Photo 10 : Southeast Wingwall has severe scaling with efflorescence.
Photo 11 : Northeast Wingwall has severe scaling with efflorescence.

CITY/TOWN	B.I.N.	BR. DEPT. NO.	8.-STRUCTURE NO.	INSPECTION DATE
HAMPDEN	**5MQ**	**H-04-008**	**H04008-5MQ-MUN-BRI**	**DEC 15, 2020**

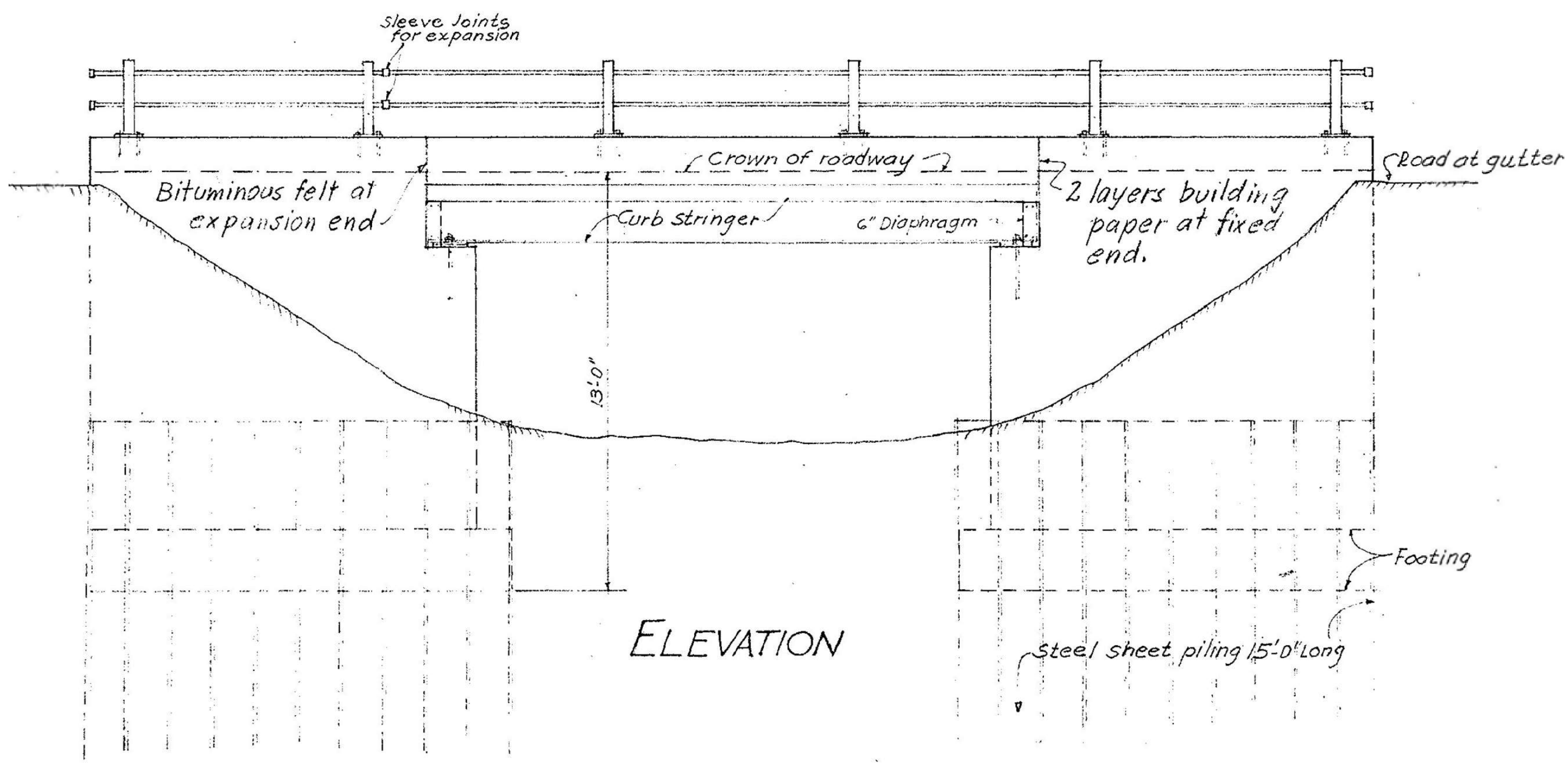
SKETCHES



Sketch 1: Plan

CITY/TOWN	B.I.N.	BR. DEPT. NO.	8.-STRUCTURE NO.	INSPECTION DATE
HAMPDEN	5MQ	H-04-008	H04008-5MQ-MUN-BRI	DEC 15, 2020

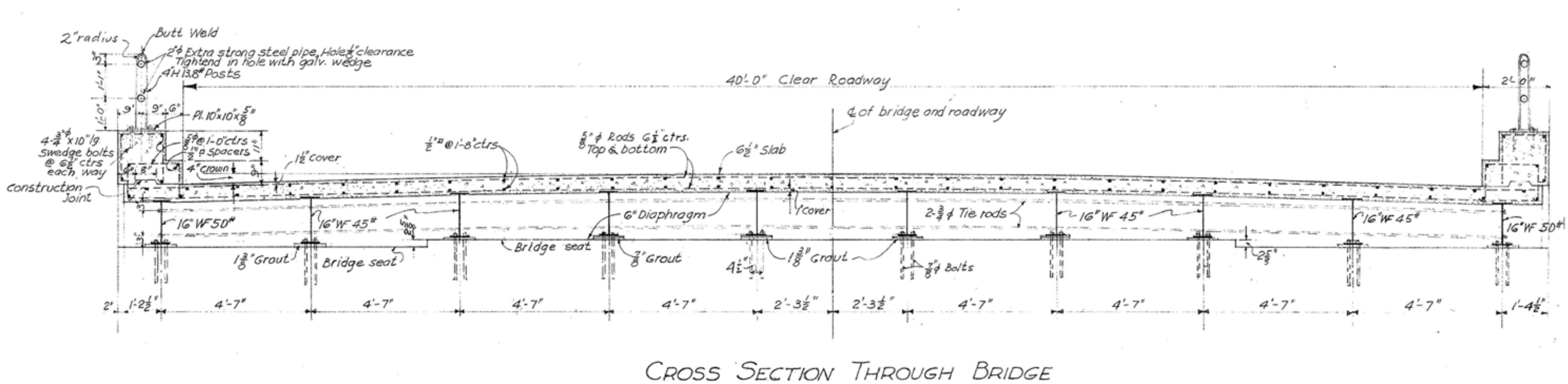
SKETCHES



Sketch 2: Elevation

CITY/TOWN	B.I.N.	BR. DEPT. NO.	8.-STRUCTURE NO.	INSPECTION DATE
HAMPDEN	**5MQ**	**H-04-008**	**H04008-5MQ-MUN-BRI**	**DEC 15, 2020**

SKETCHES

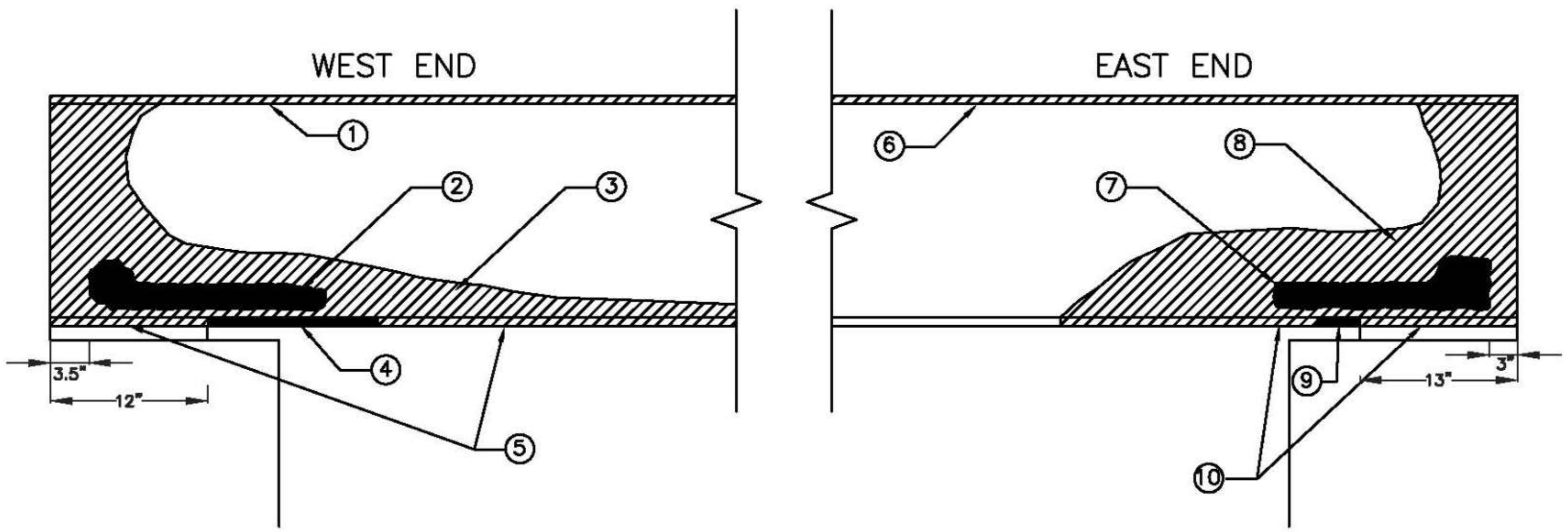


Sketch 3: Cross Section

CITY/TOWN	B.I.N.	BR. DEPT. NO.	8.-STRUCTURE NO.	INSPECTION DATE
HAMPDEN	5MQ	H-04-008	H04008-5MQ-MUN-BRI	DEC 15, 2020

SKETCHES

BEAM SHAPE: W16x50
(original web = 0.38" and flange = 0.63" thick)



NOTES:

1. 4' LONG x $3\frac{1}{2}$" WIDE x $\frac{1}{8}$" DEEP (0.50" rem.) SECTION LOSS IN TF
2. 23" LONG x $5\frac{1}{2}$" HIGH RUST HOLE IN WEB
3. UP TO 5' LONG x FULL HEIGHT x $\frac{1}{16}$" DEEP (0.31" rem.) SECTION LOSS
4. 11" LONG x $2\frac{1}{2}$" WIDE RUST HOLE IN BF ON S. ELEV.
   7" LONG X $2\frac{1}{2}$" WIDE RUST HOLE IN BF ON N. ELEV.
5. UP TO 5' LONG x $3\frac{1}{2}$" WIDE x $\frac{1}{8}$" DEEP (0.50" rem.) SECTION LOSS IN BF
6. 4' LONG x 3.5" WIDE x $\frac{1}{8}$" DEEP (0.50" rem.) SECTION LOSS IN TF
7. 13" LONG x $3\frac{1}{2}$" HIGH RUST HOLE IN WEB
8. UP TO 3' LONG x FULL HEIGHT x $\frac{1}{8}$" DEEP (0.25" rem.) SECTION LOSS IN WEB
9. 3" LONG x $2\frac{1}{2}$" WIDE RUST HOLE IN BF ON S. ELEV.
   2" LONG X $2\frac{1}{2}$" WIDE RUST HOLE IN BF ON N. ELEV.
10. UP TO 3' LONG x 3 $\frac{1}{2}$" WIDE x $\frac{1}{8}$" DEEP (0.50" rem.) SECTION LOSS IN BF

LEGEND:
- RUST HOLE
- SECTION LOSS

BEAM 1 – SOUTH ELEVATION

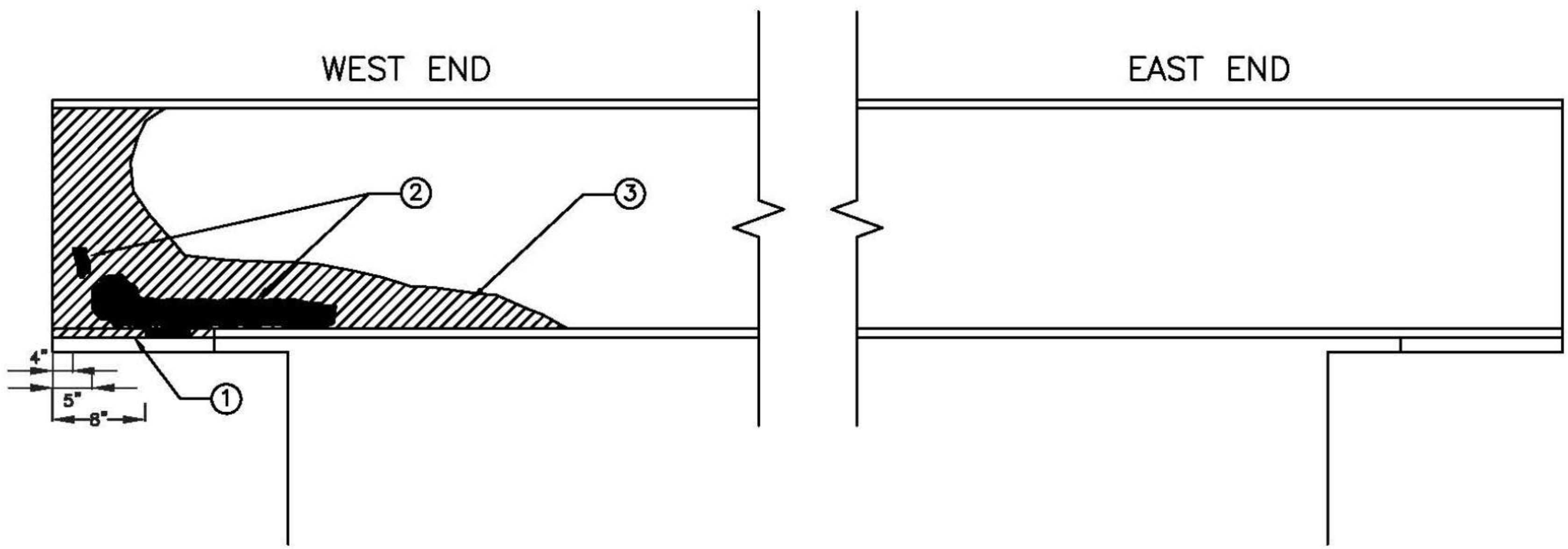
SCALE: NTS

Sketch 4: Beam 1 - Defects

CITY/TOWN	B.I.N.	BR. DEPT. NO.	8.-STRUCTURE NO.	INSPECTION DATE
HAMPDEN	5MQ	H-04-008	H04008-5MQ-MUN-BRI	DEC 15, 2020

SKETCHES

BEAM SHAPE: W16x50
(original web = 0.38" and flange = 0.63" thick)



NOTES:
1. 13" LONG x 3" WIDE x 1/4" DEEP (0.38" rem.) SECTION LOSS WITH 5" LONG X 3" WIDE RUST HOLE IN BF
2. 18" LONG x 5" HIGH RUST HOLE IN WEB
3. 3' LONG x FULL HEIGHT x 1/32" DEEP (0.35" rem.) SECTION LOSS

LEGEND:
RUST HOLE
SECTION LOSS

BEAM 10 – SOUTH ELEVATION
SCALE: NTS

Sketch 5: Beam 10 - Defects

CITY/TOWN	B.I.N.	BR. DEPT. NO.	8.-STRUCTURE NO.	INSPECTION DATE
HAMPDEN	**5MQ**	**H-04-008**	**H04008-5MQ-MUN-BRI**	**DEC 15, 2020**

PHOTOS

Photo 1: Deck Underside has longitudinal hairline cracks.

Photo 2: North Deck Elevation has a spall with multiple exposed rebar.

CITY/TOWN	B.I.N.	BR. DEPT. NO.	8.-STRUCTURE NO.	INSPECTION DATE
HAMPDEN	**5MQ**	**H-04-008**	**H04008-5MQ-MUN-BRI**	**DEC 15, 2020**

PHOTOS

Photo 3: North Railing has a bend in the top rail at mid-span

Photo 4: South Railbase has severe scaling

CITY/TOWN	B.I.N.	BR. DEPT. NO.	8.-STRUCTURE NO.	INSPECTION DATE
HAMPDEN	5MQ	H-04-008	H04008-5MQ-MUN-BRI	DEC 15, 2020

PHOTOS

Photo 5: **Beam 1, west end, has a large hole in the web & bottom flange.**

Photo 6: **Beam 1, east end, has a large hole in the web & bottom flange.**

CITY/TOWN	B.I.N.	BR. DEPT. NO.	8.-STRUCTURE NO.	INSPECTION DATE
HAMPDEN	**5MQ**	**H-04-008**	**H04008-5MQ-MUN-BRI**	**DEC 15, 2020**

PHOTOS

Photo 7: **Beam 10, west end, has a large hole in the web & bottom flange.**

Photo 8: **Beam 10, east end, has severe deterioration.**

CITY/TOWN	B.I.N.	BR. DEPT. NO.	8.-STRUCTURE NO.	INSPECTION DATE
HAMPDEN	**5MQ**	**H-04-008**	**H04008-5MQ-MUN-BRI**	**DEC 15, 2020**

PHOTOS

Photo 9: **East Abutment has hairline cracks**

Photo 10: **Southeast Wingwall has severe scaling with efflorescence.**

CITY/TOWN	B.I.N.	BR. DEPT. NO.	8.-STRUCTURE NO.	INSPECTION DATE
HAMPDEN	**5MQ**	**H-04-008**	**H04008-5MQ-MUN-BRI**	**DEC 15, 2020**

PHOTOS

Photo 11: Northeast Wingwall has severe scaling with efflorescence.

Report Date: April 26, 2021

State Information

BDEPT#= H04008 Agency Br.No.

Town= Hampden L.O.

B.I.N= 5MQ AASHTO= 024.0

RANK= 0 H.I.= NA FHWA Select List= N (6/21/2017)

Identification

(8) Structure Number	H040085MQMUNBRI
(5) Inventory Route	151000000
(2) State Highway Department District	02
(3) County Code 013 (4) Place code	28075
(6) Features Intersected	**WATER EAST BROOK**
(7) Facility Carried	**HWY MAIN ST**
(9) Location	0.1 M W. OF N.MONSON RD.
(11) Kilometerpoint	0000.000
(12) Base Highway Network	N
(13) LRS Inventory Route & Subroute	000000000000
(16) Latitude	42 DEG 03 MIN 51.10 SEC
(17) Longitude	72 DEG 24 MIN 19.70 SEC
(98) Border Bridge State Code	Share %
(99) Border Bridge Structure No. #	

Structure Type and Material

(43) Structure Type Main: Steel Code 302

Stringer/Girder Jointless bridge type: Not applicable

(44) Structure Type Appr:

Other Code 000

(45) Number of spans in main unit	001
(46) Number of approach spans	0000
(107) Deck Structure Type - Concrete Cast-in-Place	Code 1

(108) Wearing Surface / Protective System:

A) Type of wearing surface -	Bituminous	Code 6
B) Type of membrane -	Unknown	Code 8
C) Type of deck protection -	None	Code 0

Age and Service

(27) Year Built	1938
(106) Year Reconstructed	0000
(42) Type of Service: On - Highway	
Under - Waterway	Code 15
(28) Lanes: On Structure 02	Under structure 00
(29) Average Daily Traffic	011121
(30) Year of ADT 2016 (109) Truck ADT	04 %
(19) Bypass, detour length	010 KM

Geometric Data

(48) Length of maximum span	0005.4 M
(49) Structure Length	00005.8 M
(50) Curb or sidewalk: Left 00.0 M	Right 00.0 M
(51) Bridge Roadway Width Curb to Curb	012.2 M
(52) Deck Width Out to Out	013.4 M
(32) Approach Roadway Width (w/shoulders)	009.1 M
(33) Bridge Median - No median	Code 0
(34) Skew 00 DEG (35) Structure Flared	N
(10) Inventory Route MIN Vert Clear	99.99 M
(47) Inventory Route Total Horiz Clear	12.2 M
(53) Min Vert Clear Over Bridge Rdwy	99.99 M
(54) Min Vert Underclear ref N	00.00 M
(55) Min Lat Underclear RT ref N	00.0 M
(56) Min Lat Underclear LT	00.0 M

Navigation Data

(38) Navigation Control - No navigation control on waterway	Code 0
(111) Pier Protection	Code
(39) Navigation Vertical Clearance	000.0 M
(116) Vert-lift Bridge Nav Min Vert Clear	M
(40) Navigation Horizontal Clearance	0000.0 M

Classification

		Code
(112) NBIS Bridge Length		N
(104) Highway System		N
(26) Functional Class -	Major Collector	07
(100) Defense Highway		0
(101) Parallel Structure		N
(102) Direction of Traffic -	2-way traffic	2
(103) Temporary Structure		N
(105) Federal Lands Highways		0
(110) Designated National Network		N
(20) Toll -	On free road	3
(21) Maintain -	Town Agency	03
(22) Owner -	Town Agency	03
(37) Historical Significance	undetermined	

Condition

	Code
(58) Deck	5
(59) Superstructure	4
(60) Substructure	6
(61) Channel & Channel Protection	7
(62) Culverts	N

Load Rating and Posting

		Code
(31) Design Load -	H 15=M 13.5	2
(63) Operating Rating Method -	Allowable Stress (AS)	2
(64) Operating Rating		00.0
(65) Inventory Rating Method -	Allowable Stress (AS)	2
(66) Inventory Rating		00.0
(70) Bridge Posting		0
(41) Structure -	Open	A

Appraisal

	Code
(67) Structural Evaluation	3
(68) Deck Geometry	5
(69) Underclearances, vert. and horiz.	N
(71) Waterway adequacy	6
(72) Approach Roadway Alignment	6
(36) Traffic Safety Features	0 0 0 0
(113) Scour Critical Bridges	6

Inspections

(90) Inspection Date 12/15/20 (91) Frequency 12 MO

(92) Critical Feature Inspection: (93) CFI DATE

(A) Fracture Critical Detail	N	00	MO A)	00/00/00
(B) Underwater Inspection	N	00	MO B)	00/00/00
(C) Other Special Inspection	Y	12	MO C)	12/15/20
(*) Other Inspection ()	N	00	MO *)	00/00/00
(*) Closed Bridge	N	00	MO *)	00/00/00
(*) UW Special Inspection	N	00	MO *)	00/00/00
(*) Damage Inspection			MO *)	00/00/00

Rating Loads

Report Date 00/00/00	H20	Type 3	Type 3S2	Type HS
Operating	0.0	0.0	0.0	0.0
Inventory	0.0	0.0	0.0	0.0

Field Posting

Status Posting Date 00/00/00

	2 Axle	3 Axle	5 Axle	Single
Actual				
Recommended				

Missing Signs N

Misc.

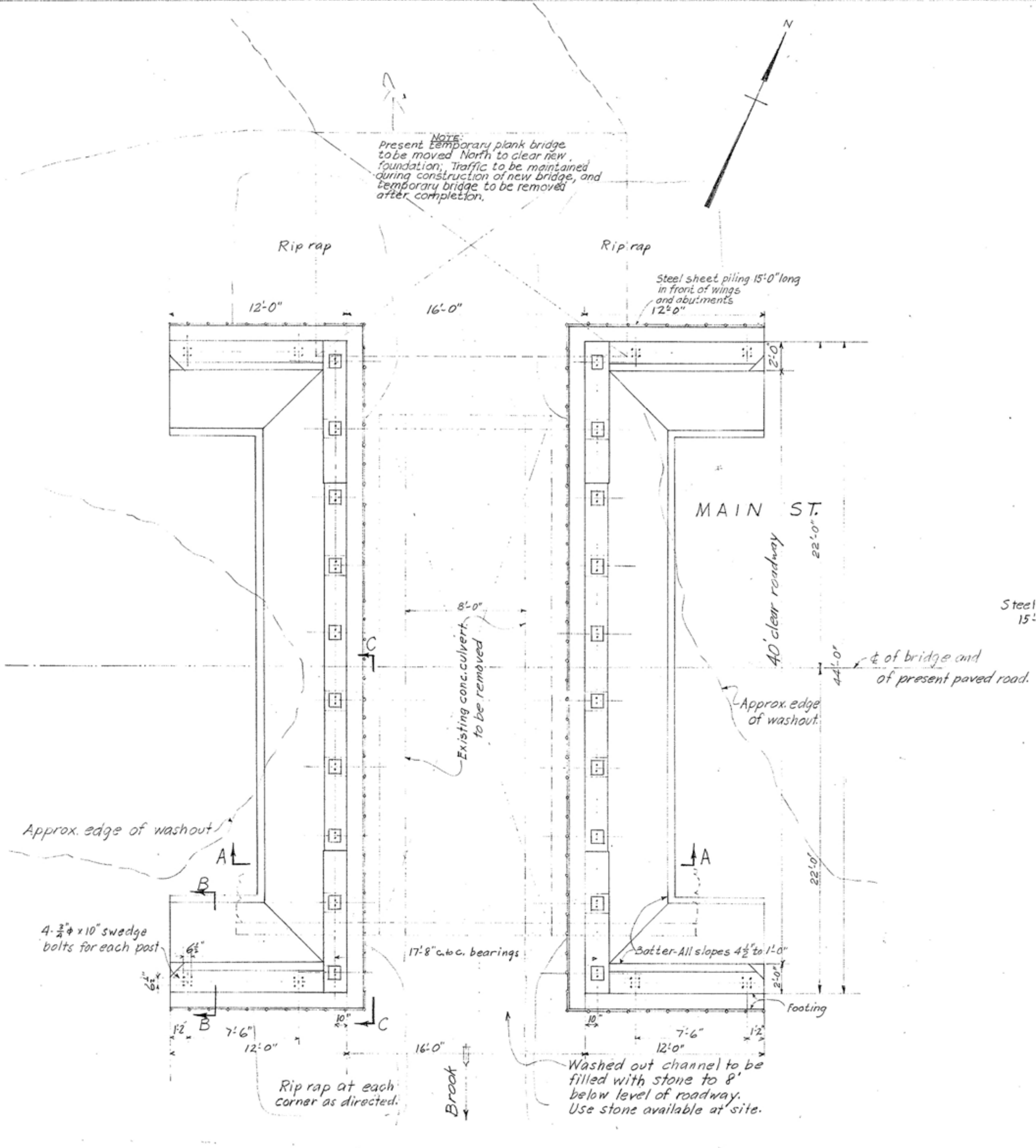
Bridge Name

N Anti-missile fence N Acrow Panel N Jointless Bridge

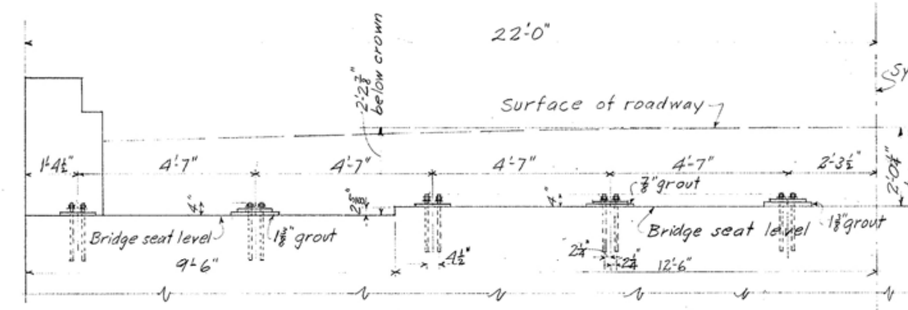
Freeze/Thaw

Accessibility (Needed/Used)

N / N Liftbucket	N / N Rigging	N / N Other
N / N Ladder	N / N Staging	
N / N Boat	N / N Traffic Control	
Y / Y Wader	N / N RR Flagperson	Inspection Hours: 006
N / N Inspector 50	N / N Police	

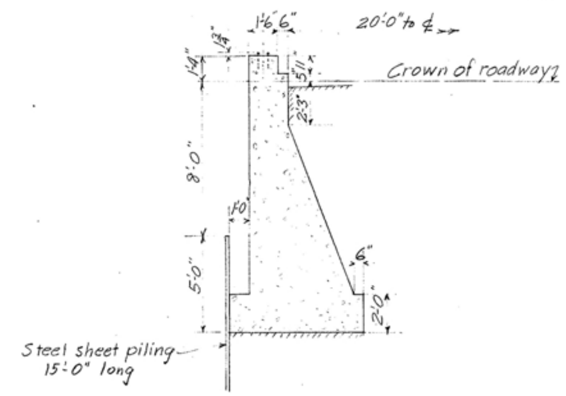


PLAN OF ABUTMENT
Scale 1/4" = 1'-0"

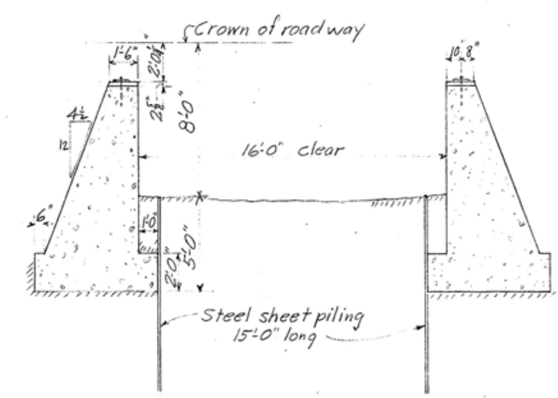


Bed plates - 10" x 7/8" x 0'-11"
Bolts - 2-7/8"ø x 1'-6" swedge bolts each bearing.

ELEVATION C-C
SAME FOR BOTH ABUTMENTS
SCALE 1/2" = 1'-0"



SECTION B-B
TYPICAL FOR ALL WINGS
SCALE 1/4" = 1'-0"



SECTION A-A
SCALE 1/4" = 1'-0"

ESTIMATED QUANTITIES

CONCRETE EXCAVATION	70 - C.Y.
BRIDGE EXCAVATION	400 C.Y.
TRENCH LEDGE EXCAVATION	40 C.Y.
STEEL SHEETING	50,000 LBS
CONCRETE CLASS A	24 - C.Y.
CONCRETE CLASS C	210 - C.Y.
REINFORCING STEEL	4800 LBS
STRUCTURAL STEEL	9700 LBS
2 RAIL STEEL FENCE	80 - L.F.
GRAVEL BORROW	250 - C.Y.
TEMPORARY BRIDGE	L.S.
RIP RAP	25 - C.Y.
CHANNEL EXCAVATION	20 C.Y.
LEDGE EXCAVATION	5 C.Y.

GENERAL NOTES

FINISH: All exposed concrete surfaces to be rubbed smooth with corundum brick and left free from all for marks and imperfections.

FOUNDATIONS: May be altered if necessary to suit conditions of construction

DESIGN: According to specifications of American Association of State Highway Officials (1935 Ed.) for H-15 loading.

WEEP HOLES: To be provided in wing walls and abutments as directed by engineer.

CONCRETE: All concrete in superstructure. Class A
All concrete in wings and abutments. Class C

RIP RAP: To be placed as directed by the Engineer.

STEEL SHEETING: 23 Pounds per square foot.

FOR CONSTRUCTION
DATE 11/19/38

THE COMMONWEALTH OF MASSACHUSETTS
PROPOSED BRIDGE
HAMPDEN
COATES BRIDGE
ON MAIN STREET
SCALES AS NOTED
OFFICE OF
DEPARTMENT OF PUBLIC WORKS
100 NASHUA ST. BOSTON, MASS.
OCTOBER-1938

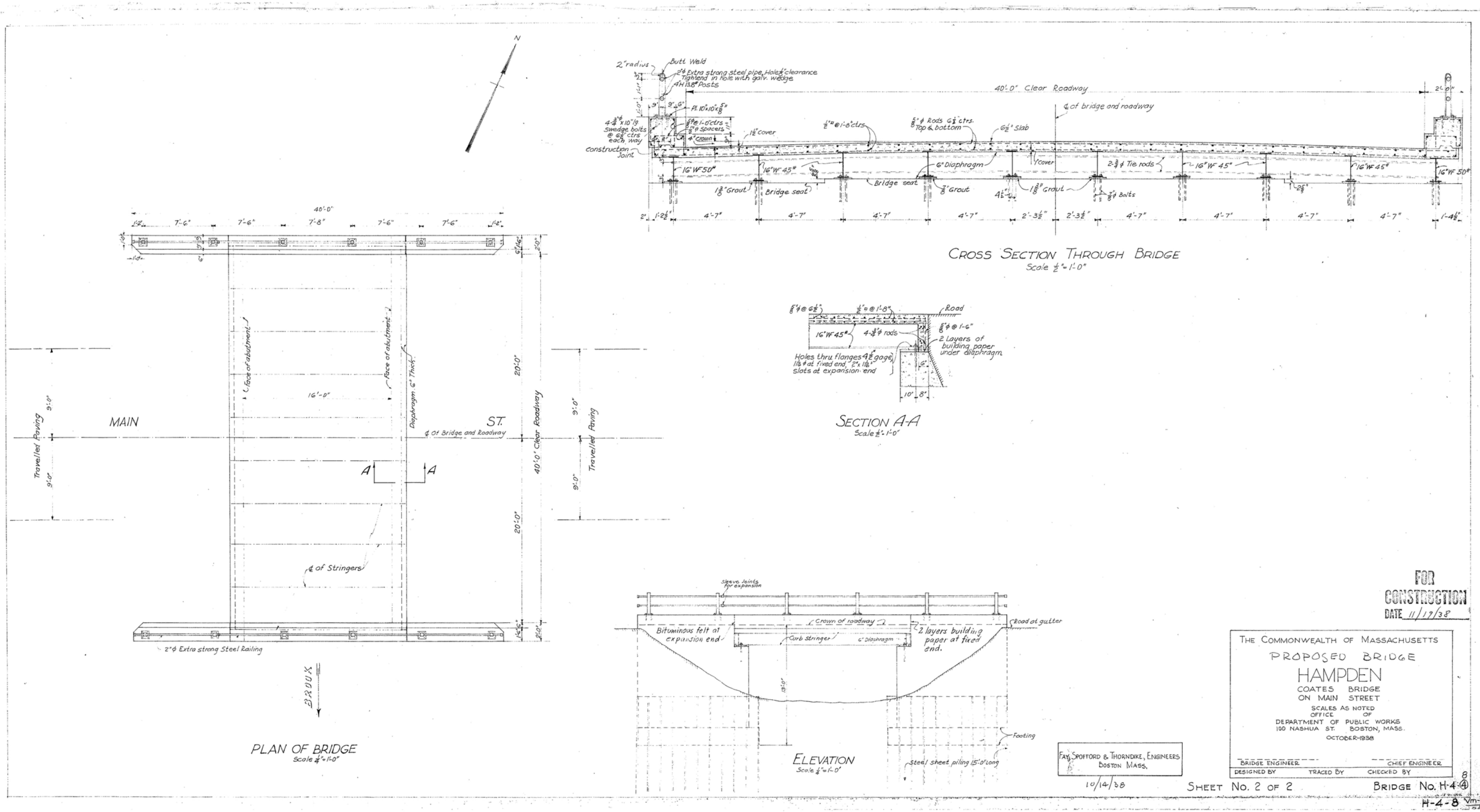
BRIDGE ENGINEER — CHIEF ENGINEER
DESIGNED BY — TRACED BY — CHECKED BY

FAY, SPOFFORD & THORNDIKE, ENGINEERS
BOSTON, MASS.
10/14/38

SHEET No. 1 OF 2

BRIDGE No. H-4-4

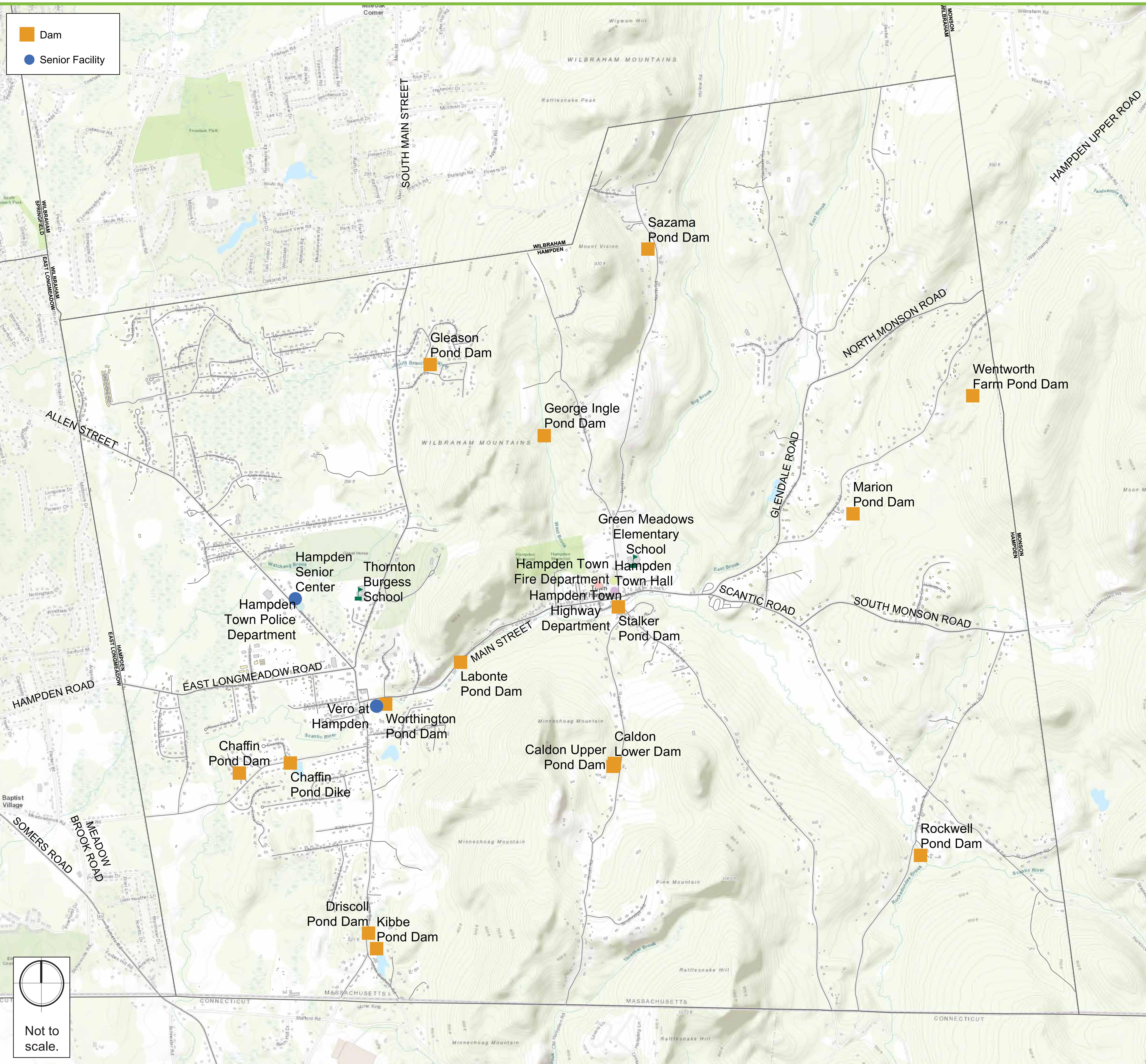
H-4-8



CROSS SECTION THROUGH BRIDGE
Scale 1/2" = 1'-0"
40'-0" Clear Roadway
℄ of bridge and roadway
Butt Weld
2" radius
4H13.8# Posts
6 1/2" Slab
1 1/2" Cover
6" Diaphragm
Bridge seat
Construction Joint
16"WF 50#
16"WF 45#
2-3/4" ϕ Tie rods
3/4" ϕ Bolts
4'-7"
2'-3 1/2"
SECTION A-A
Scale 1/2" = 1'-0"
Road
16"WF 45#
2 Layers of building paper under diaphragm
Holes thru flanges 4 1/2" gage, 1 1/16" ϕ at fixed end, 2" x 1 1/16" slots at expansion end
PLAN OF BRIDGE
Scale 1/4" = 1'-0"
MAIN
ST.
40'-0"
7'-6"
16'-0"
20'-0"
9'-0"
Travelled Paving
℄ of Bridge and Roadway
40'-0" Clear Roadway
Face of abutment
Diaphragm 6" Thick
℄ of Stringers
2" ϕ Extra strong Steel Railing
A
A
N
BROUX
ELEVATION
Scale 1/4" = 1'-0"
Sleeve Joints for expansion
Crown of roadway
Road at gutter
Bituminous felt at expansion end
2 layers building paper at fixed end
Curb Stringer
6" Diaphragm
13'-0"
Footing
Steel sheet piling 15'-0" long
FOR CONSTRUCTION
DATE 11/19/38
THE COMMONWEALTH OF MASSACHUSETTS
PROPOSED BRIDGE
HAMPDEN
COATES BRIDGE
ON MAIN STREET
SCALES AS NOTED
OFFICE OF
DEPARTMENT OF PUBLIC WORKS
100 NASHUA ST. BOSTON, MASS.
OCTOBER-1938
BRIDGE ENGINEER
CHIEF ENGINEER
DESIGNED BY
TRACED BY
CHECKED BY
FAY, SPOFFORD & THORNDIKE, ENGINEERS
BOSTON MASS.
10/14/38
SHEET No. 2 of 2
BRIDGE No. H-4-8
H-4-8

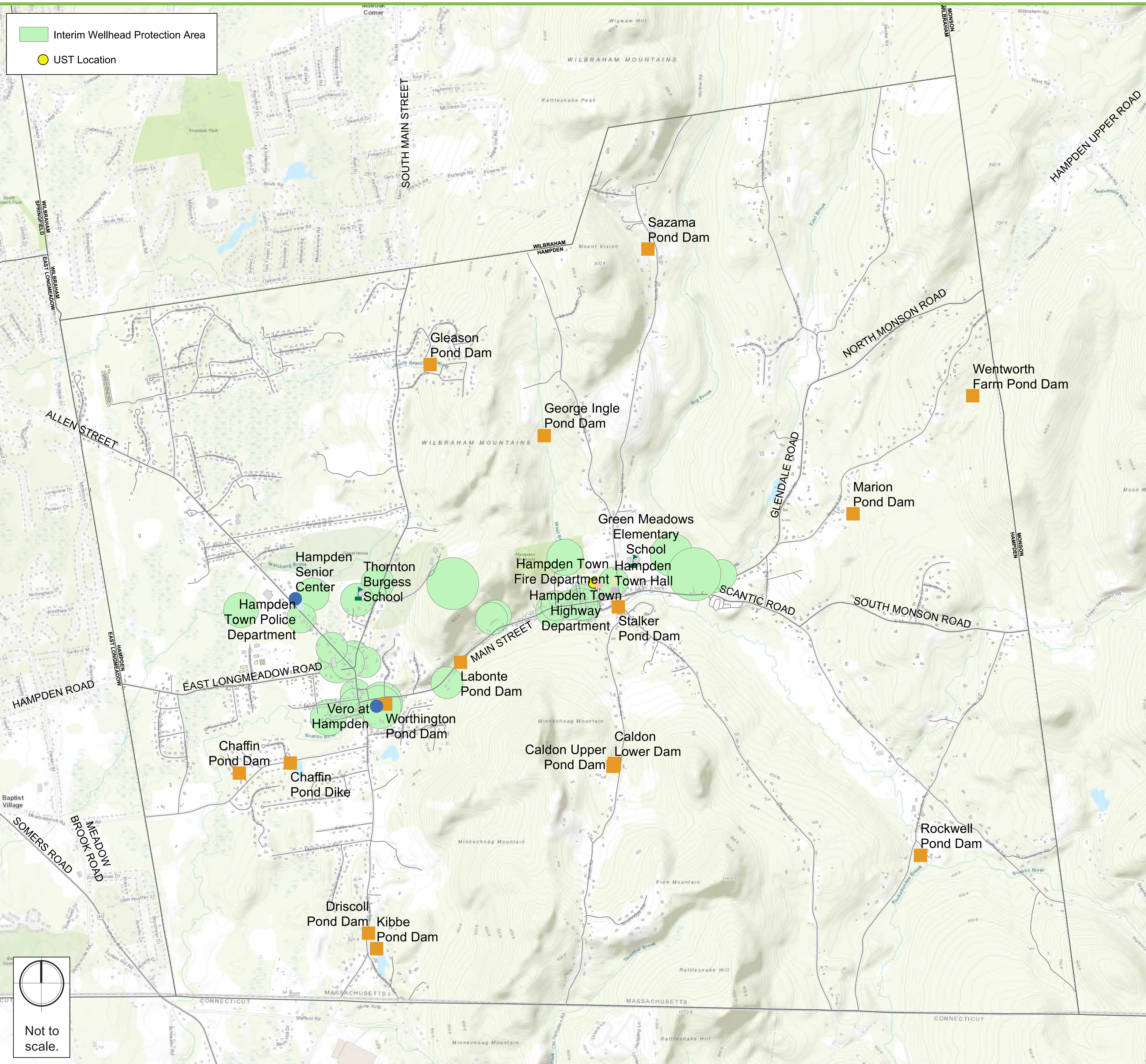
Appendix E

GIS Maps



COMMUNITY FEEDBACK

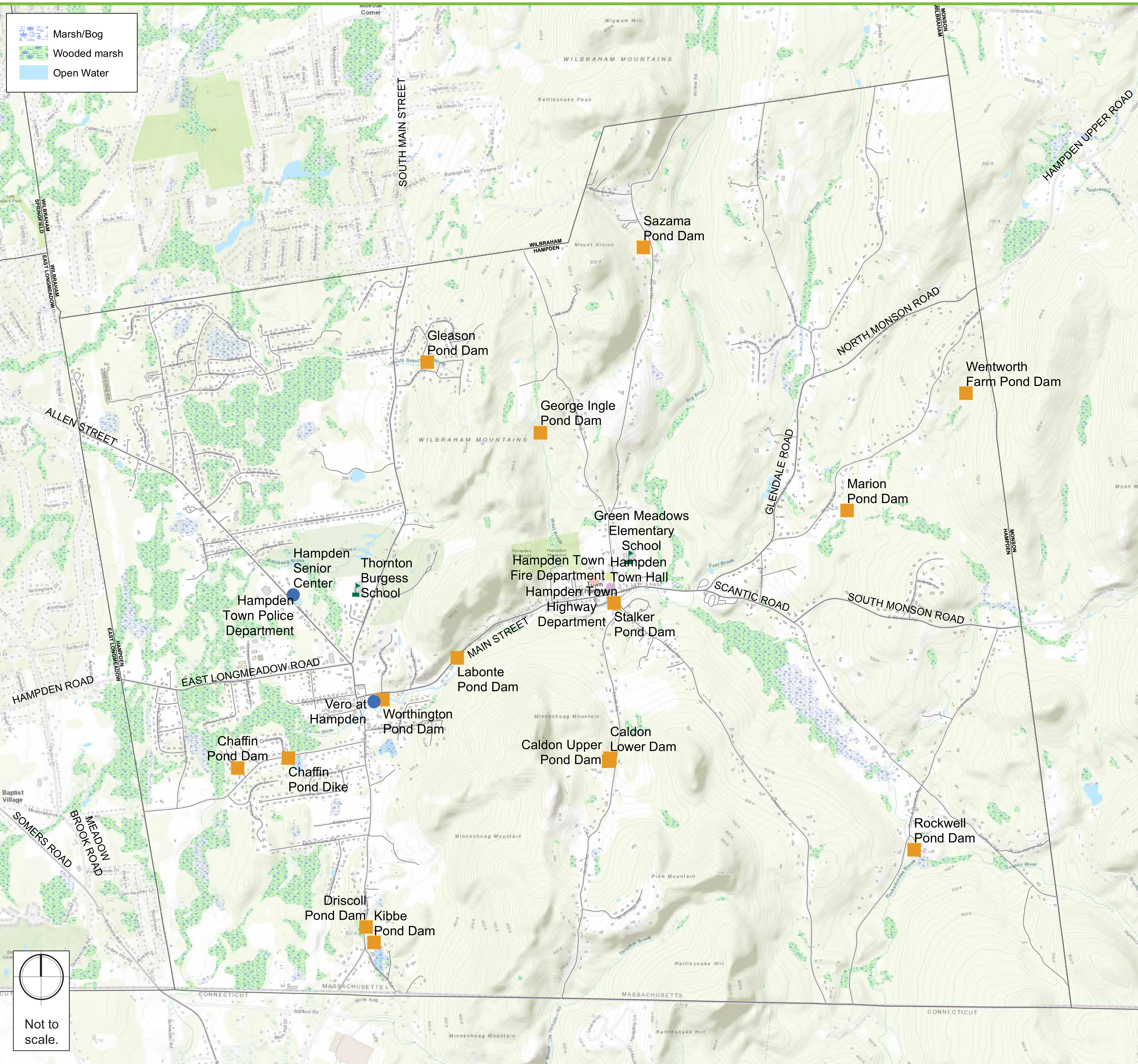
Town of Hampden | Municipal Vulnerability Preparedness (MVP) Program and Main Street Flooding Study



COMMUNITY FEEDBACK

HOWARD STEIN HUDSON

Town of Hampden | Municipal Vulnerability Preparedness (MVP) Program and Main Street Flooding Study



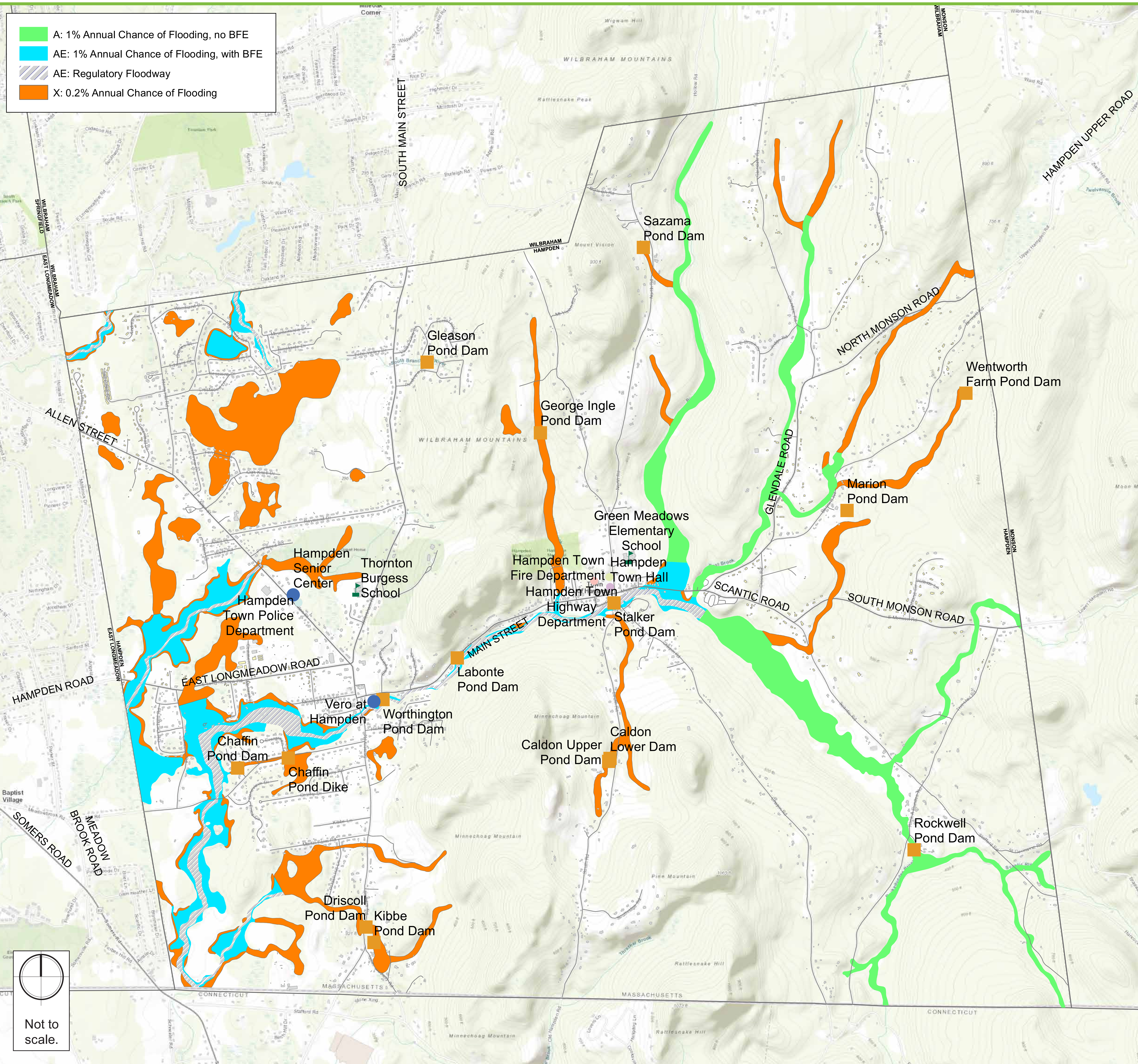
COMMUNITY FEEDBACK

HOWARD STEIN HUDSON

MLM(e)

Mass Audubon

Town of Hampden | Municipal Vulnerability Preparedness (MVP) Program and Main Street Flooding Study



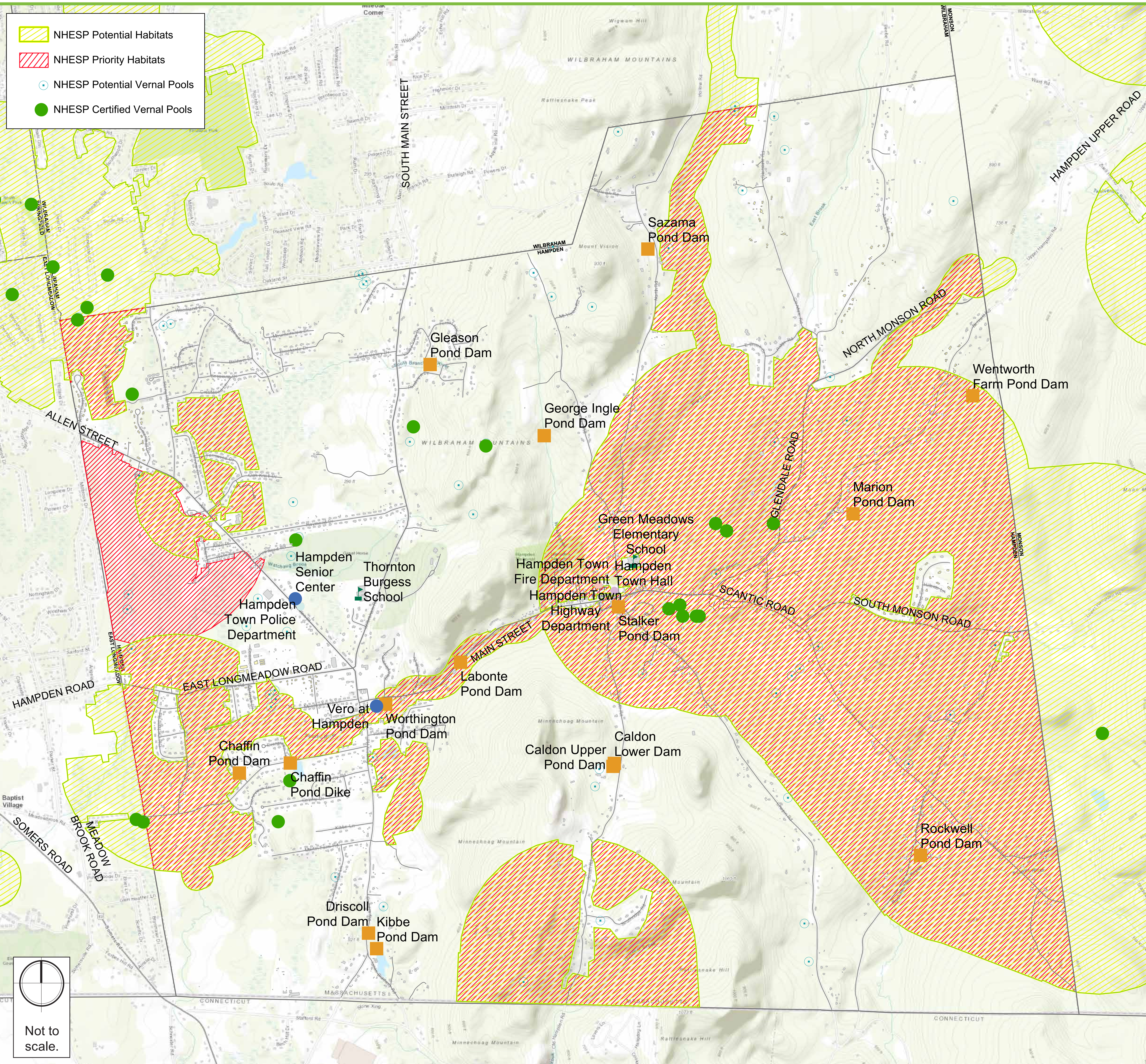
COMMUNITY FEEDBACK

HOWARD STEIN HUDSON

MLM(e)

Mass Audubon

Town of Hampden | Municipal Vulnerability Preparedness (MVP) Program and Main Street Flooding Study



COMMUNITY FEEDBACK

HOWARD STEIN HUDSON

MLM(e)

Mass Audubon

HOWARD STEIN HUDSON

Engineers + Planners

Appendix F

Community Resilience Building Workshop Day 2

Community Resilience Building Workshop *Day 2*

Presented by
Mary Monahan
Steven Tyler
Jonah Keane

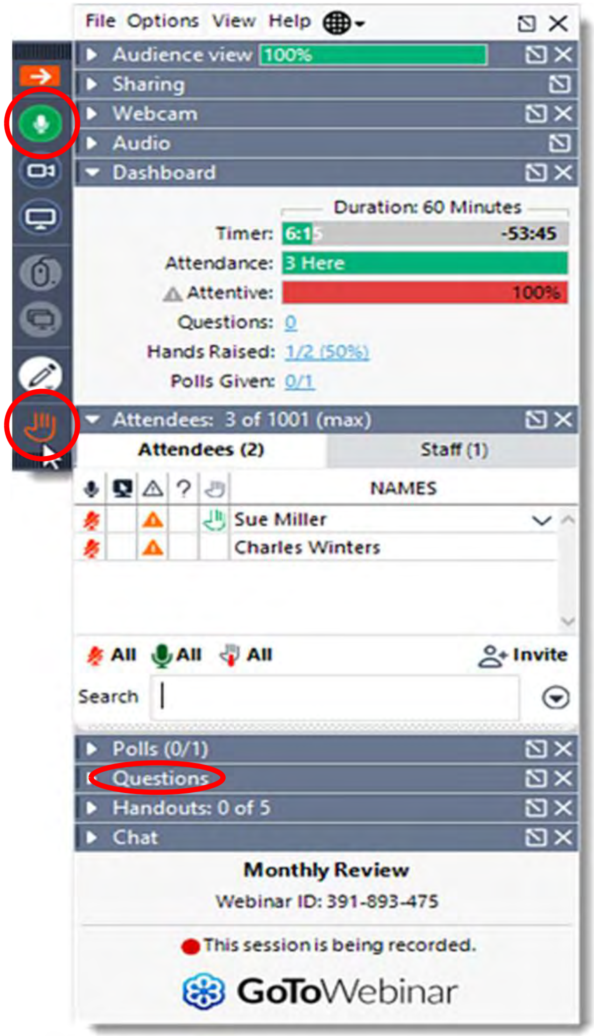
Presented to
Town of Hampden

January 28, 2021 | 9AM – 1PM

HOWARD STEIN HUDSON
Engineers + Planners

Control Panel

Engineers + Planners



Raise your hand

Unmute to speak

Questions Send a question

Note: Today's presentation is being recorded

HOWARD STEIN HUDSON

Agenda

Engineers + Planners

- Welcome and Reintroductions
- Summary of Workshop Day 1
- Green Infrastructure and Low Impact Development
- Sector impacts
- Completed Risk Matrix
- Climate change priorities for Hampden
- Next steps

HOWARD STEIN HUDSON

Welcome Elected & Appointed Officials

Engineers + Planners

- Hampden Officials
- State Senator
- State Representative

HOWARD STEIN HUDSON

Project Team

Engineers + Planners

- **Mary Monahan**
  - Public Works Consultant
    - *Municipal Vulnerability Planning*

Mary Louise Monahan Enterprises

- **Steven Tyler, P.E.**
  - Civil Engineer
    - *Main Street Flooding Assessment*

HOWARD STEIN HUDSON

- **Jonah Keane**
  - CT Valley Sanctuaries Director
    - *Workshops in Green Infrastructure*

Mass Audubon

HOWARD STEIN HUDSON

Municipal Vulnerabilities Preparedness (MVP) $40,000 Planning Grant

- **Municipal Vulnerability Planning Process**
  - Community-led planning process to develop and prioritize actions and opportunities to reduce climate change risks and build resilience
- **Main Street Flood Assessment**
  - Watershed approach to evaluate, identify, and educate stakeholders and others about nature-based solutions to alleviate flooding on Main Street

Executive Office of Energy and Environmental Affairs

Summary of Workshop Day 1

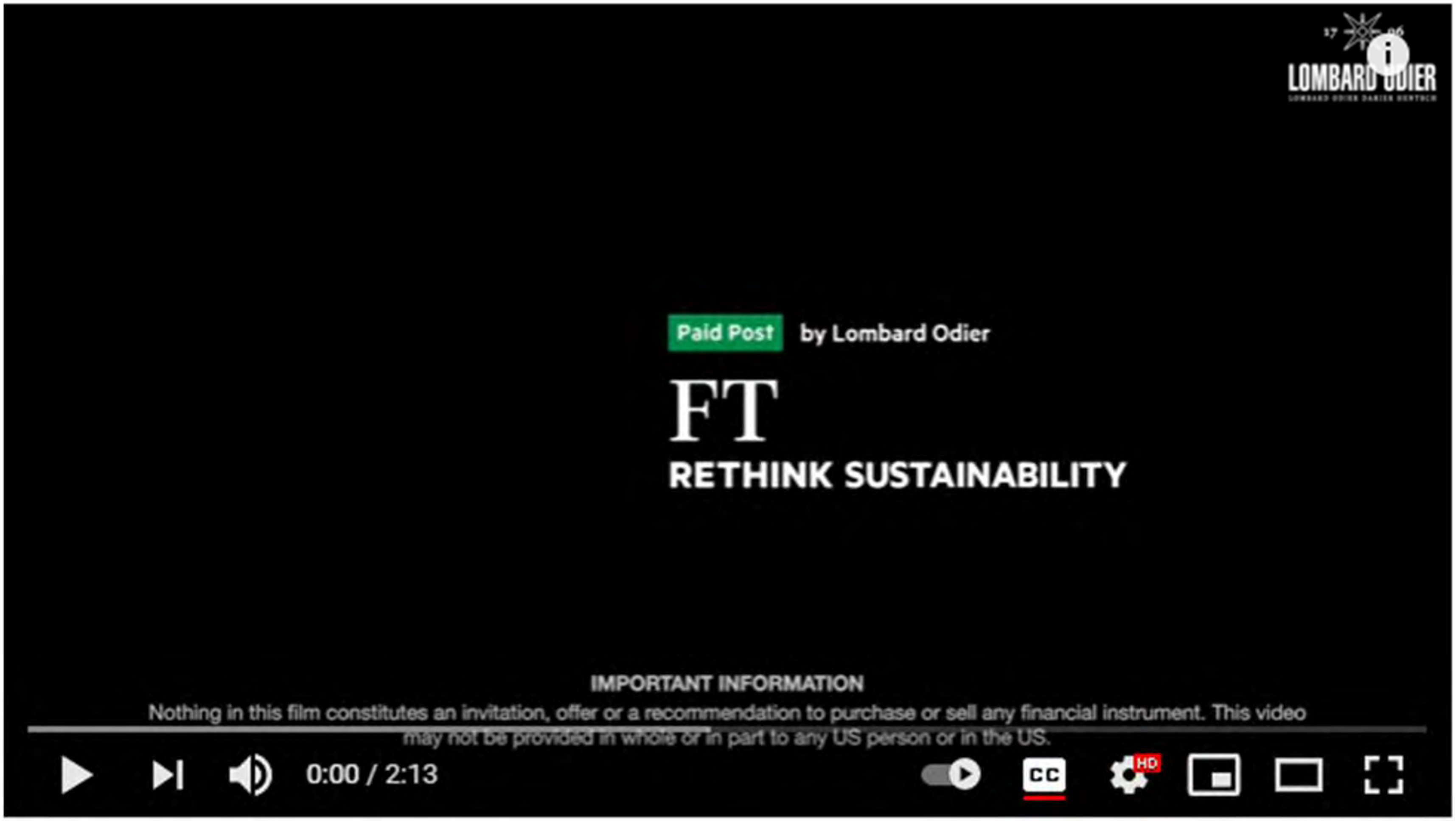
Engineers + Planners

- Great Job!

HOWARD STEIN HUDSON

Absorbing Risk

Engineers + Planners



Green Infrastructure and Low Impact Development

Engineers + Planners

- Jonah Keane from Mass Audubon
- Main Street Flood Assessment: green and grey solutions

HOWARD STEIN HUDSON

Green Infrastructure and Low Impact Development

Engineers + Planners

Lowell
Pittsfield
Worcester
Springfield
Boston
New Bedford
Sanctuaries with Nature Centers
Berkshires
1. Pleasant Valley, Lenox
2. Canoe Meadows, Pittsfield
3. Lime Kiln Farm, Sheffield
Connecticut River Valley
4. West Mountain, Plainfield
5. Road's End, Worthington
6. High Ledges, Shelburne
7. Conway Hills, Conway
Greater Boston
31. Habitat Education Center, Belmont


37 -051-001
37 -004-001
37 -049-001
45 -018-001
38D-075-001
45 -031-001
B
C
D
A
A
45 -019-001
45 -045-001
45 -010-001
44 -014-001
44 -054-001
44 -129-001

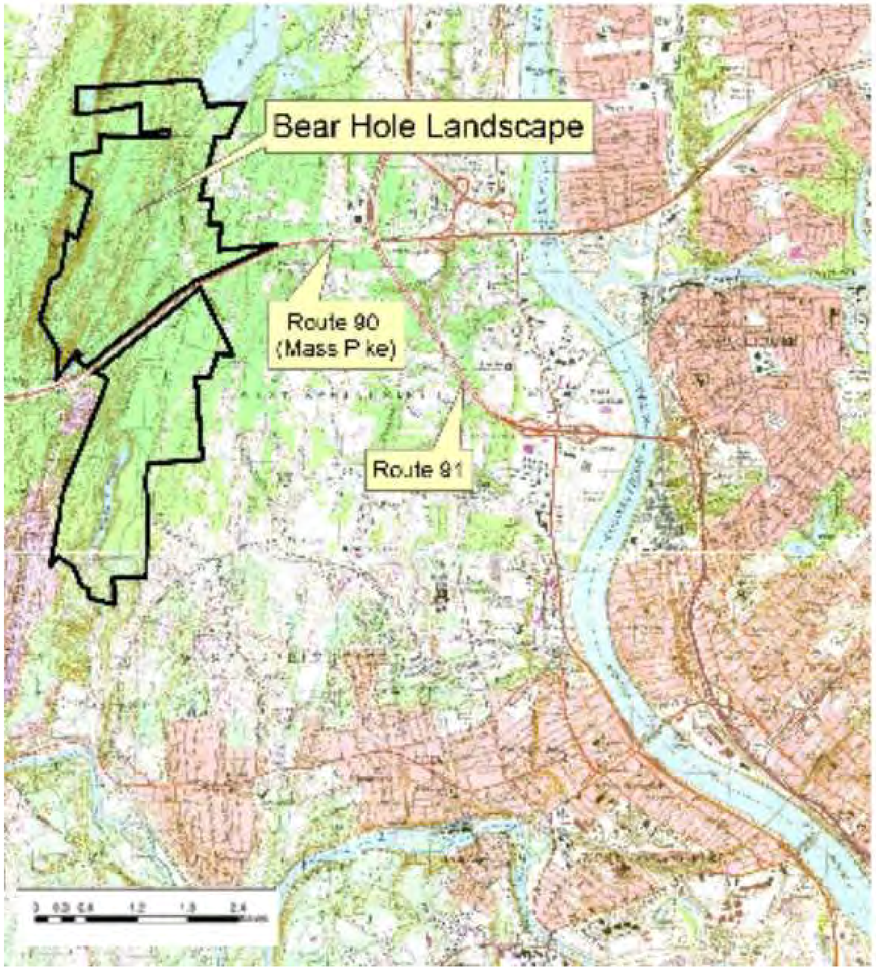
Youth Climate Summit

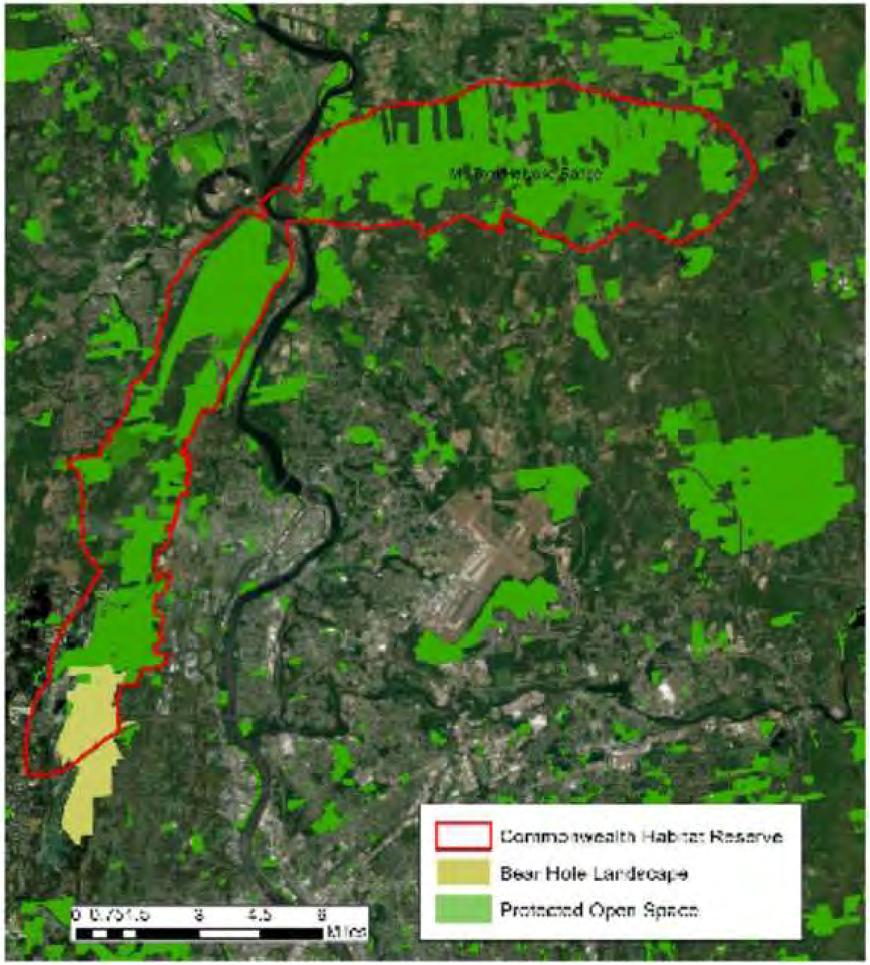
Engineers + Planners

HOWARD STEIN HUDSON

Bear Hole

Engineers + Planners





HOWARD STEIN HUDSON

Laughing Brook

Engineers + Planners

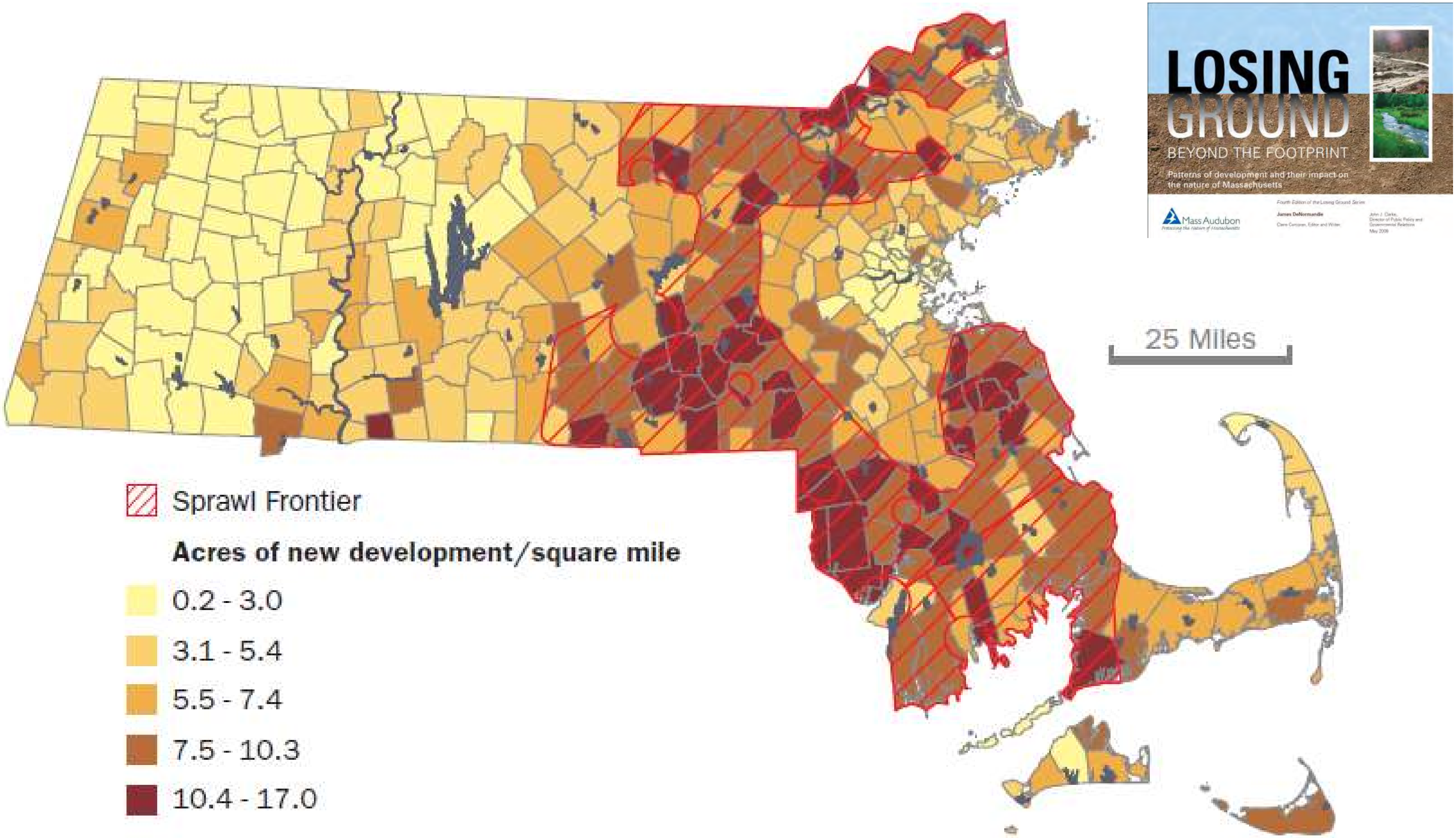
Laughing Brook

Engineers + Planners

Almost 400 Acres

Recent Development Trends in MA (1999-2005)

Engineers + Planners



Sprawling Development Impacts

Engineers + Planners

Climate change

Sprawling Development

increased precipitation

increased temperature

impervious surfaces

stormwater & WQ issues

flooding & infrastructure damage

heat-related illnesses

fish and aquatic life impacts

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Mitigation

- Actions to reduce or prevent emission of GHGs

Adaptation

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- Actions taken to help communities and ecosystems cope with actual/expected effects of climate change

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Green Infrastructure

- Natural features (forests, wetlands)
- Engineered landscapes that mimic natural features (rain gardens)

Low Impact Development (LID)

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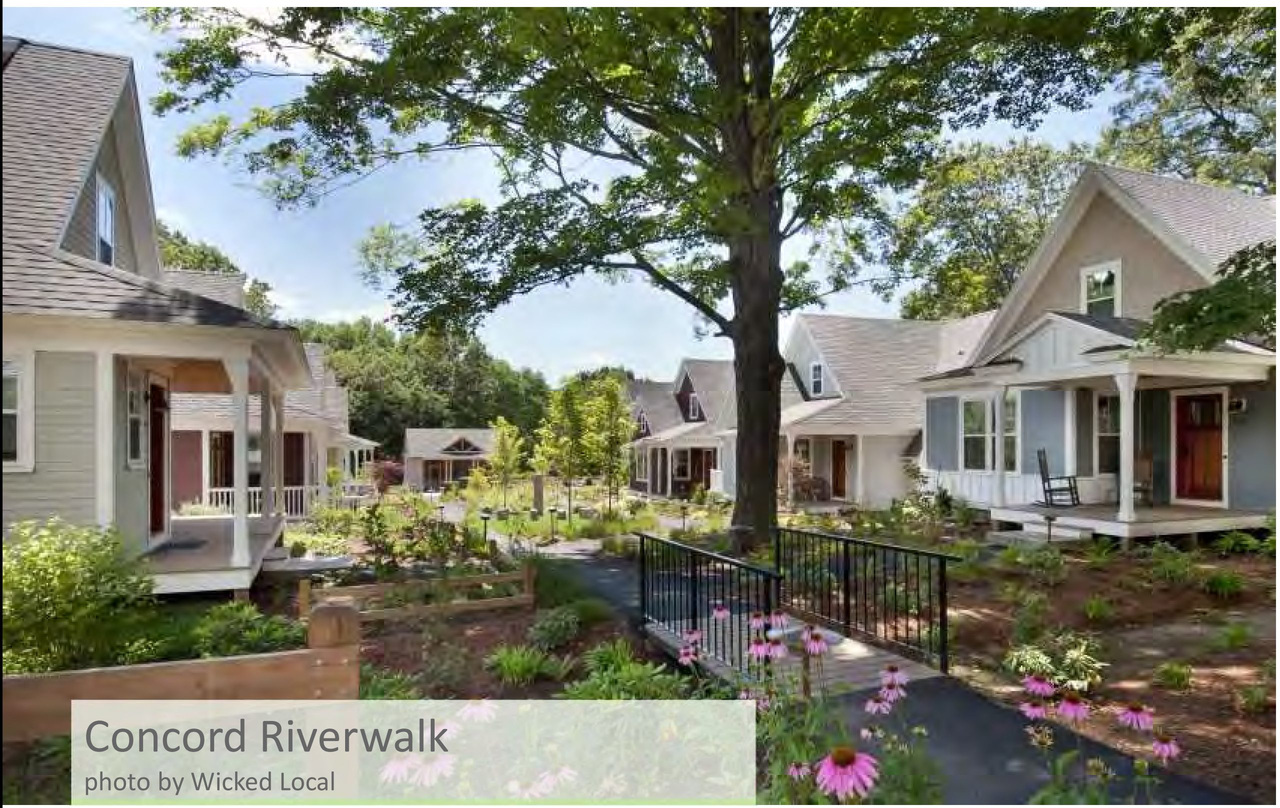

Concord Riverwalk
photo by Wicked Local

- Treats water as a resource, not just a waste product
- Manages stormwater as close to its source as possible
- Preserves natural landscape by recreating natural features

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LID Examples

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Rain gardens

This rain garden in Devens, MA gathers runoff from a curb-less road and sidewalk to infiltrate stormwater back into the ground while also offering beautiful home landscaping. Rain gardens can be made in any size and shape to fit your location.

Green roofs

U.S. General Services Administration

Boston, MA: John W. McCormack US Post Office and Courthouse. This 9,654 ft^2 green roof sits atop the EPA Region I Headquarters on a historic 1933 building.

EPA

A small, slanted green roof in Craftsbury, VT.

Permeable pavement

Horsley Witten Group

This parking lot in Narragansett, RI shows traditional asphalt on the left, where puddles have formed, and permeable pavement on the right, where it has soaked through.

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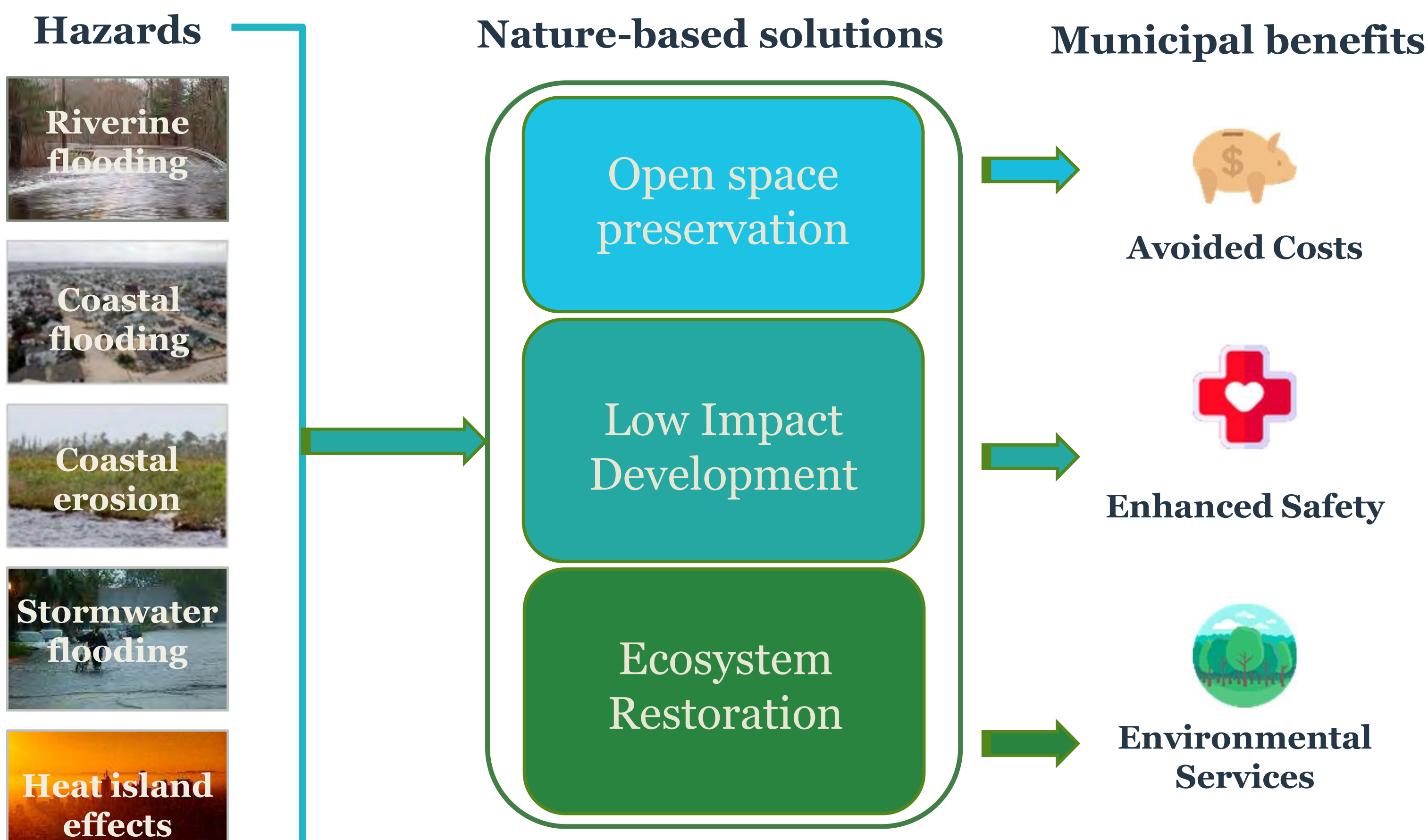
Nature-based Solutions



Nature-based Solutions at Every Scale

1. Conserve the natural green infrastructure already providing free services
2. Integrate LID and green infrastructure design into development
3. Restore local resilience through LID in redevelopment

Low Impact Development: Cost Savings & More

- **Valuing Green Infrastructure**
  - How saving land saves water and money
- **Conservation Design**
  - Financial benefits and local examples
- **LID Techniques**
  - Costs and benefits of 5 LID techniques, site design to reduce pavement and costs
- **LID in Regulations**
  - Review municipal bylaws
- **Urban Waters**
  - Leominster stormwater case study

LID Fact Sheets

massaudubon.org/lidcost

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Case Study - LID Fact Sheet #5

Engineers + Planners

- **Leominster LID Project - Monoosnoc Brook**
  - Engaged wide variety of stakeholders
  - Numerous LID best management practices (BMPs) installed
  - Pollutant loading significantly reduced
  - Project significantly less expensive compared to cost of conventional stormwater practices

massaudubon.org/lidcost

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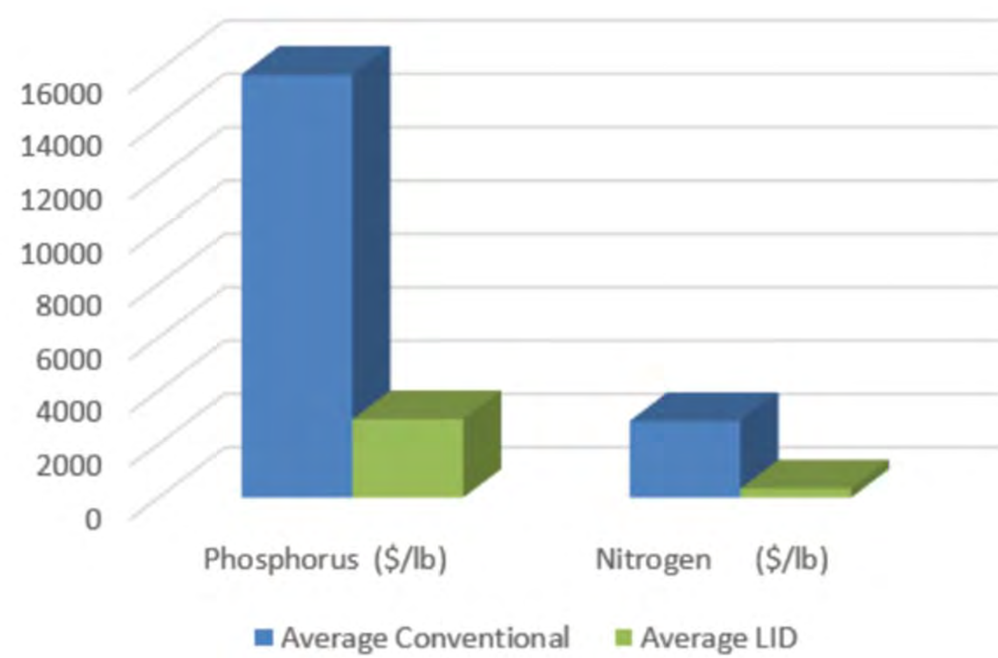
Case Study - LID Fact Sheet #5

Engineers + Planners

- **Comparison of Present Value Costs in Nitrogen and Phosphorus Reduction: LID vs. Conventional Detention Systems**



Cost comparison by Scott Horsley, Horsley Witten Group, Inc. based on comparison between a conventional detention basin vs. gravel wetland and bioretention. See supplemental information online for more details on how this was calculated.

massaudubon.org/lidcost

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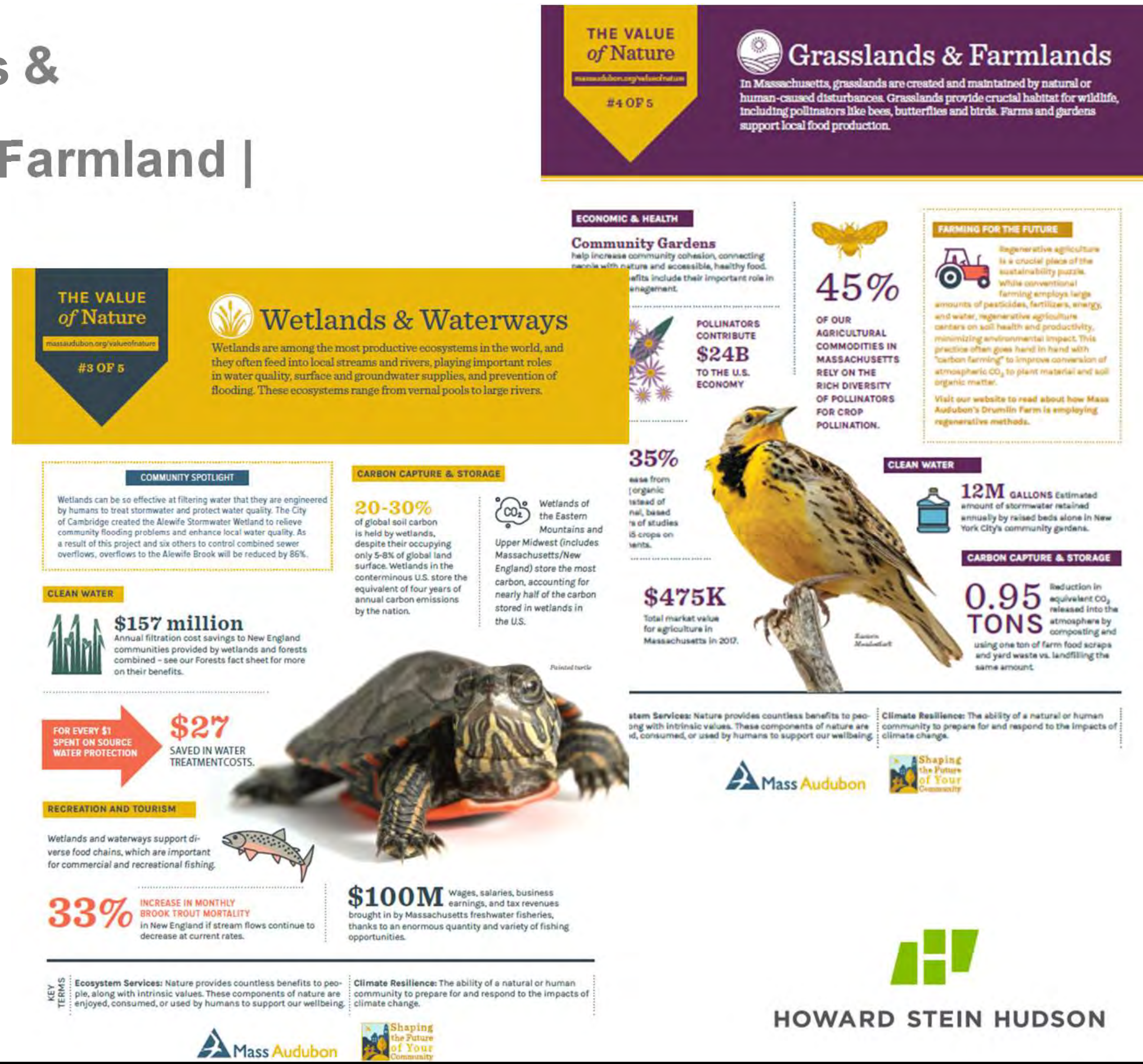
Value of Nature Fact Sheets

Engineers + Planners

- **Forests| Coastal | Wetlands & Waterways | Grasslands & Farmland | Urban Green Space**
  - Climate Resilience
  - Clean Air and Water
  - Carbon Capture & Storage
  - Economic & Health
  - Recreation & Tourism



massaudubon.org/valueofnature

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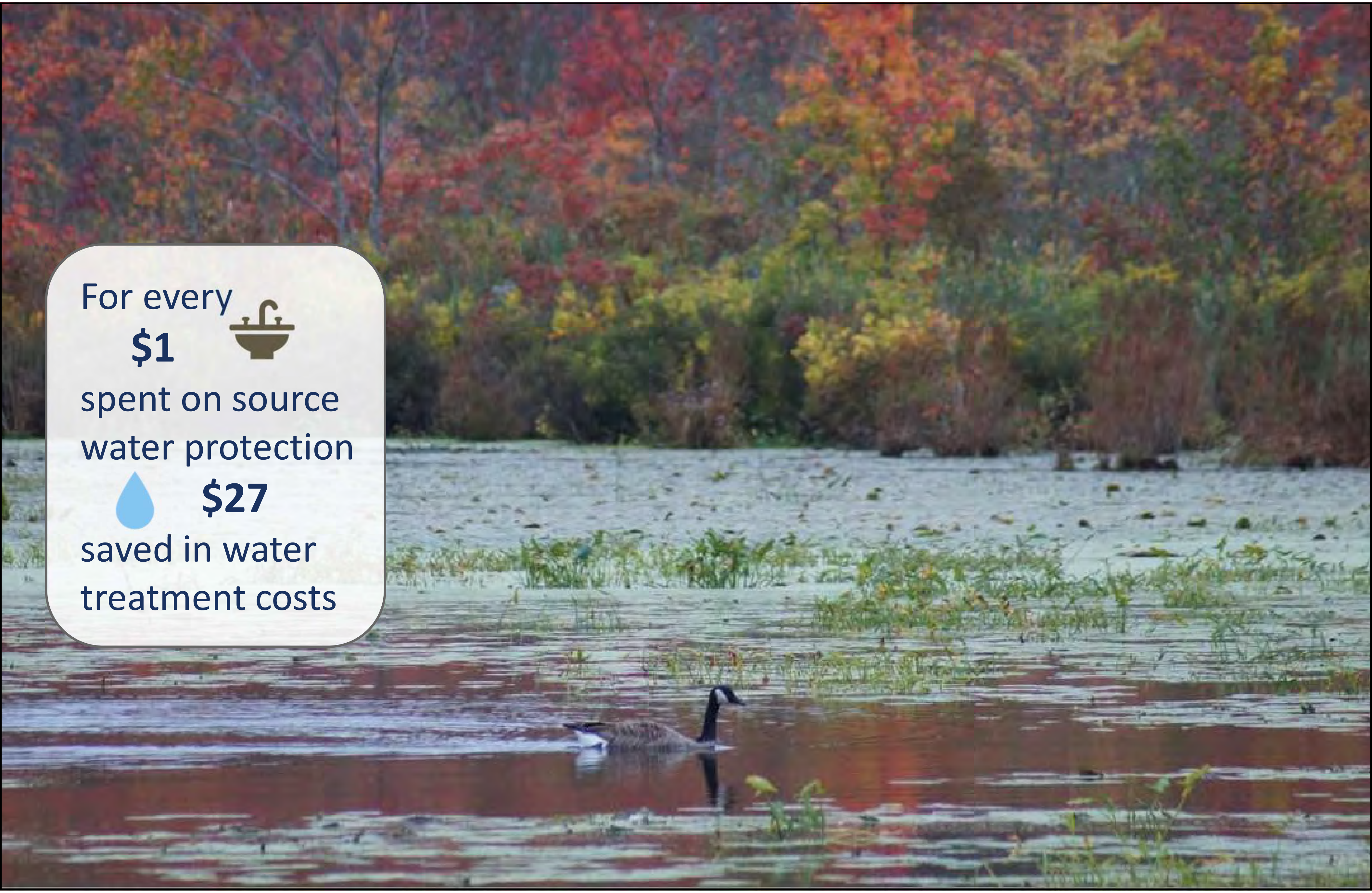
7% of MA's greenhouse
gas emissions are offset by our forests


Coastal wetlands in the northeastern U.S. saved
$625,000,000
in flooding damages by Hurricane Sandy


For every
$1
spent on source
water protection
$27
saved in water
treatment costs

Pollinators contribute
$24 billion
to the U.S. economy
45% of our agricultural goods in Massachusetts rely on the rich diversity of pollinators for crop pollination

Every year, urban forests in the 15 communities of MetroWest Boston

BU Urban Climate Initiative

Source: Hong-Hanh et al. 2018

Remove
7.5 million
pounds of air pollutants

Help avoid
527 million gal.
of stormwater runoff, worth
$4.7 million

Store
962,000 tons
of carbon, worth
$125 million

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iTree

- **Free, peer-reviewed, web-based tools**
- **Quantify the benefits of forests or single trees and set priorities for decision-making!**

i-Tree

Tools for Assessing and Managing
Forests & Community Trees

iTreetools.org

iTree

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MyTree

Easily assess value of *one to several trees*

- input addresses
- describe each tree
- see values

i-Tree Design

Analyze current and future benefits of *up to 25 trees*

- input address
- describe trees
- place trees on map
- get estimate of benefits

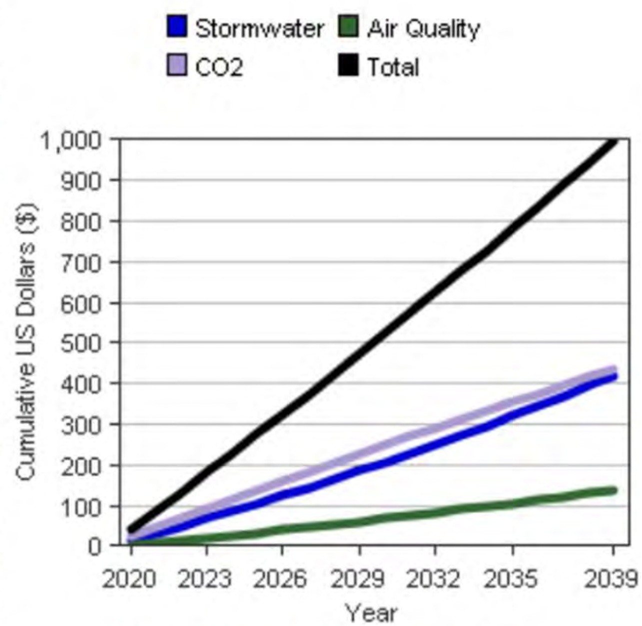
iTreetools.org

MyTree Benefits

Eastern white pine, *(Pinus strobus)*

Serving Size: 15.00 in. diameter
Condition: Good

Total benefits for this year:	$77.88
Carbon Dioxide (CO_2) Sequestered	**$2.03**
Annual CO_2 equivalent of carbon[1]	192.33 lbs
Storm Water Runoff Avoided	**$1.32**
Runoff Avoided	147.79 gal
Rainfall Intercepted	887.38 gal
Air Pollution Removed Each Year	**$0.55**
Carbon Monoxide	0.24 oz
Ozone	22.85 oz
Nitrogen Dioxide	6.45 oz
Sulfur Dioxide	0.52 oz
$PM_{2.5}$	1.84 oz
Energy Usage Per Year[2]	**$62.94**
Electricity Savings (A/C)	172.82 kWh
Fuel Savings (natural gas, oil)	1.65 MMBtu
Avoided Energy Emissions	**$11.04**
Carbon Dioxide	205.75 lbs
Carbon Monoxide	14.6 oz
Nitrogen Dioxide	2.31 oz
Sulfur Dioxide	29.59 oz
$PM_{2.5}$	1.59 oz
CO_2 Stored To Date[3]	**$30.77**
Lifetime CO_2 equivalent of carbon[3]	2,916.42 lbs



Breakdown of tree benefits

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The “MVP” of Nature-Based Solutions

Engineers + Planners

- **The Municipal Vulnerability Preparedness (MVP) Program helps communities prepare for the impacts of climate change.**
  - Encourages nature-based solutions

Step 1. **Planning**

Step 2. **Action!**

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MVP Action: Mattapoisett, MA

Engineers + Planners

- **Land Acquisition**
  - Purchased 120 acres of forest, streams, freshwater wetlands and coastal salt marsh to prevent development in vulnerable areas

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LID

Engineers + Planners

- **Communities often unintentionally discourage LID by…**
  - Requiring large lots, strict dimensional requirements
  - Requiring wide, curbed roads
  - Requiring non-native species
  - Not prioritizing LID or preservation of natural features

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MVP Action: Deerfield, MA

Engineers + Planners

Town of Deerfield
Green Infrastructure and Climate Resiliency Policy
Draft updated 2/18/2020

Section 1. Goals:

The goals of this Town of Deerfield policy are to:

1. promote the use of green street facilities and green infrastructure in public and private development as a cost-effective and sustainable practice for stormwater management in current and future projects wherever possible. This includes: road construction and reconstruction projects; sewer projects; and new development and redevelopment projects.
2. promote climate resiliency in public buildings and infrastructure and private development.

Section 2. Definitions:

Green Infrastructure: Keeps rain close to where it falls, using structures to improve on-site infiltration, such as rain gardens, green roofs and permeable pavements, to promote cleaner, slower, and smaller storm flows to nearby rivers and streams.

Green Streets: Green Streets are a subset of Green Infrastructure in which the street handles significant amounts of stormwater on site through use of vegetated and/or soil-infiltration facilities. Green Streets can include landscaped street-side planters or swales or tree box filters or porous pavement that capture stormwater runoff and allow it to soak into the ground as soil and vegetation filter pollutants.

Section 3. Policies:

WHEREAS,

The Town of Deerfield recognizes:

1. Stormwater runoff from streets, roads, parking lots, and other impervious urban surfaces is a significant source of water pollution to our rivers, streams and water bodies;
2. The local impacts of climate change in Deerfield include more frequent 100-year floods and more severe storms; an increase in insect populations and insect-borne diseases; rising water tables and increases in invasive species.
3. Green Streets can provide cost-effective infrastructure solutions to reduce and manage stormwater runoff and flooding from more intense storm and flooding events and can reduce localized flooding from surcharging, providing some adaptation to climate change.
4. Green Streets can improve water quality by filtering stormwater, removing contaminants, including total suspended solids (TSS), organic pollutants /oils, and heavy metals, and cooling the stormwater before it encounters groundwater or surface water bodies, which benefits watershed health.
5. Green Streets foster unique and attractive streetscapes that protect and enhance neighborhood livability, integrate the built and natural environments, enhance the pedestrian environment, and introduce park-like elements into neighborhoods.
6. Green Streets encourage the planting of landscapes and trees which contribute environmental benefits such as reduced summer air temperatures, reductions in global warming through carbon sequestration and air pollution screening.
7. Green infrastructure can reduce the long-term costs of gray infrastructure maintenance, and complement gray infrastructure with hybrid systems of gray, piped infrastructure combined with green, vegetated infrastructure.
8. Green infrastructure will be an investment in Deerfield's village centers. The costs for installing green infrastructure may be initially higher, but long term costs ***of climate changes, storm damages and flooding will be mitigated. Green infrastructure, when built in tandem with grey infrastructure, extends the lifespan of both green and grey infrastructure. Green infrastructure reduces water pollution more cost effectively than grey infrastructure alone.***
9. Recharge of groundwater sources is a key mitigation activity under the Massachusetts Water Management Act regulations 310 CMR 36.00.

NOW, THEREFORE BE IT ORDERED,

The Town of Deerfield policy is to promote the use of green street facilities and green infrastructure in public and private development through regulation, capital investment, and management mechanisms as a cost-effective and sustainable practice for stormwater management in current and future projects when technically and economically feasible. This includes road development and reconstruction, bicycle and pedestrian projects, stormwater projects, and other development and redevelopment.

It is Town of Deerfield policy to:

1. Incorporate and maintain green street facilities and green infrastructure into all publicly-funded development, redevelopment, and enhancement projects, to the extent technically and economically feasible. To achieve this, ***where feasible,*** Deerfield will:

   a) Evaluate new municipal projects to determine if they will make the town more climate resilient and green, and will provide long-term benefits to the town.
   b) Install new and replacement culverts that are open-bottom culverts designed for fish and wildlife passage, and sized to handle larger storm events expected with climate change.
   c) As streets and parking lots are replaced, re-paved or installed, utilize green streets and parking lot designs with tree box filters, permeable pavement, and curbless planted medians and shoulders.
   d) Purchase electric or hybrid municipal vehicles.
   e) Install EV charging stations and priority EV parking spaces
   f) Support "Solarize" neighborhood programs to incentivize group solar panel purchases
   g) Conduct ***and periodically update*** energy audits and upgrades in energy efficiency for all municipal buildings, ***and utilize Mass Energy Insight data to track and reduce energy use.***

Resilience Policy

- Updating zoning and development controls in the floodplain.
- Incorporating new flood maps into bylaw updates.
- Revising zoning/bylaws to promote climate resilience and low impact development.
- Creating a town-wide green infrastructure policy for public projects.
- Public climate awareness engagement.
- Emergency flood evacuation planning.
- Design, permitting and construction for replacing priority culverts.
- Installing green stormwater infrastructure.

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Bylaw Review

Engineers + Planners

- **Why?**
  - Are your resilience goals reflected in your bylaws?
  - If so, how?
  - If not, what might barriers be?
- **How?**
  - Review existing bylaws
  - ID conventional vs. best practices
  - ID administrative vs. town meeting changes
  - Draft summary and recommendations

massaudubon.org/bylawreview

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MVP Website: resilientma.org/mvp

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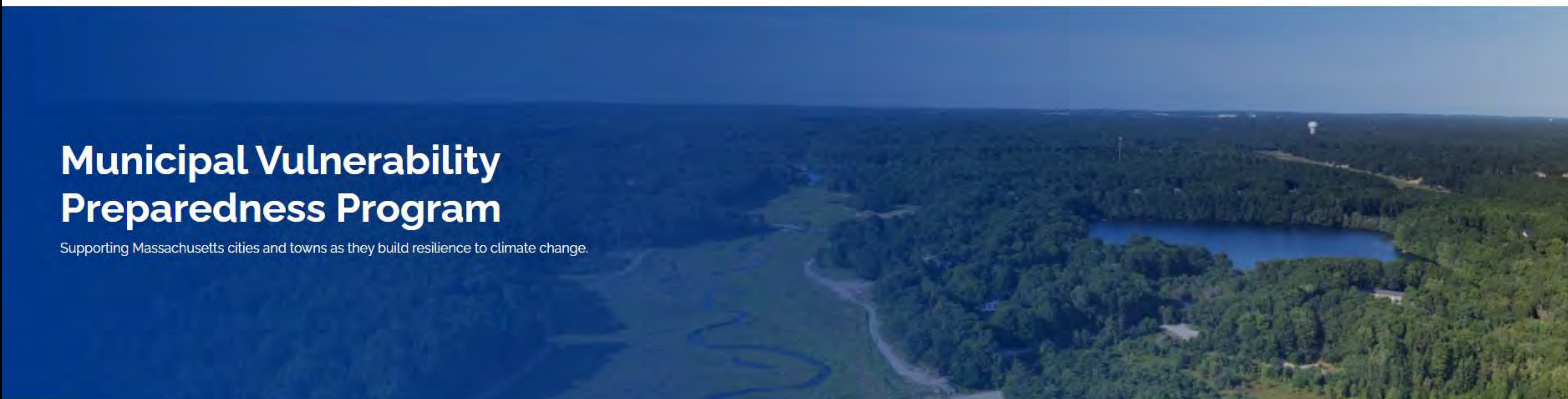
MVP
Municipal Vulnerability Preparedness

MENU



MVP
Municipal Vulnerability Preparedness

Improve resilience & adapt to climate change

The Municipal Vulnerability Preparedness (MVP) grant program created in 2017 as part of Governor Baker's Executive Order 569 provides support for cities and towns in Massachusetts to identify climate hazards, assess vulnerabilities, and develop action plans to improve resilience to climate change. Communities that complete the MVP Planning Grant process become designated as an MVP Community and are eligible for MVP Action Grant funding to implement the priority actions identified through the planning process.

WHAT'S ON THIS PAGE

- Grant Map Viewer
- MVP Grant Types
- MVP Toolkits
- Stay Up-To-Date
- Other Funding
- Contact MVP Team

Main Street Flooding Assessment

Engineers + Planners

- Identify opportunities to address Main Street flooding concerns
- Educate residents and stakeholders about the benefits of nature-based solutions
- Engage students in a mini-MVP Community Resilience Building Workshop
- Develop recommendations for green and grey infrastructure improvements within the watershed and at two brook crossings along Main Street

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Main Street Flood Map

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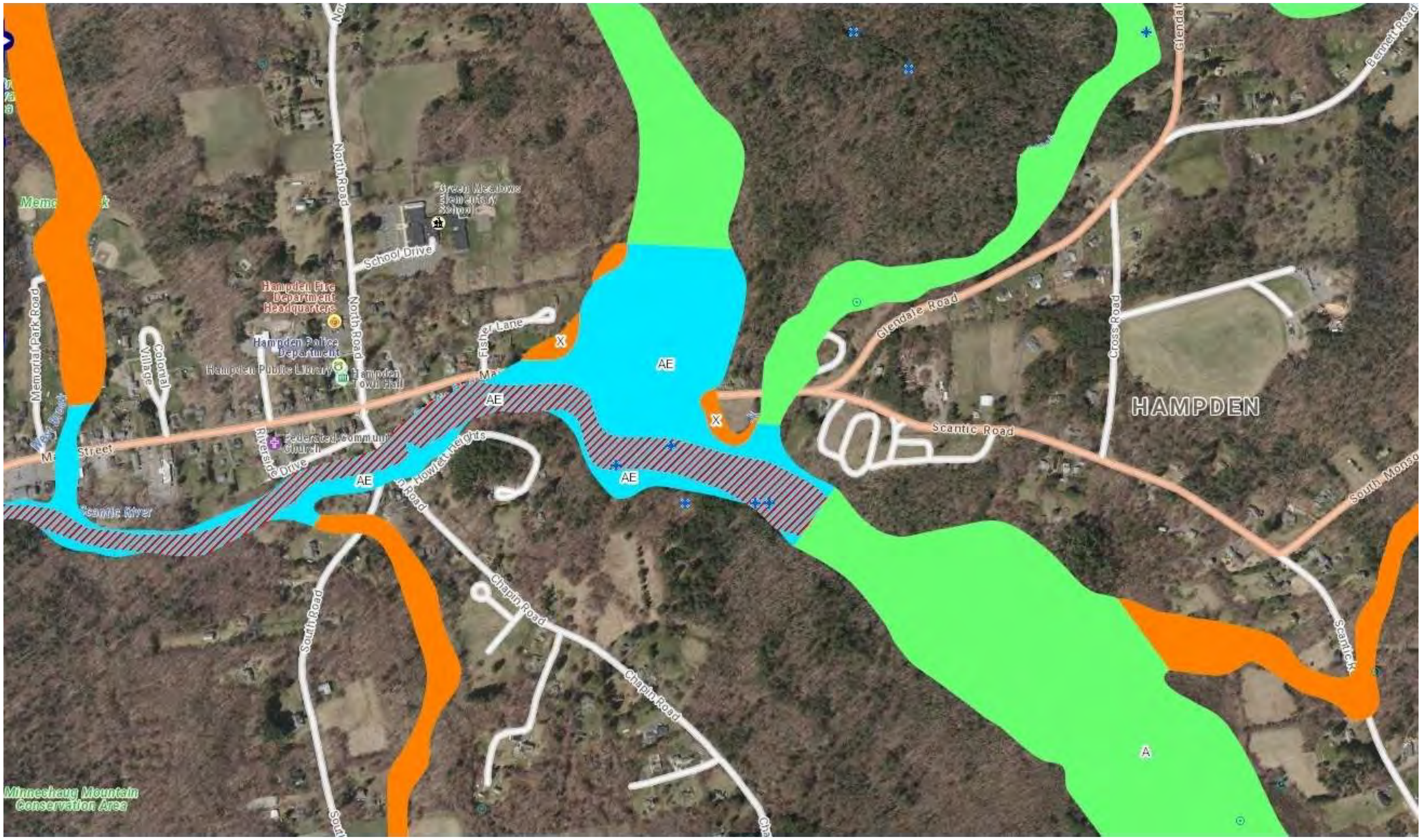

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Big Brook Culvert – Main Street Looking East

Engineers + Planners

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Big Brook Culvert Watershed – USGS StreamStats

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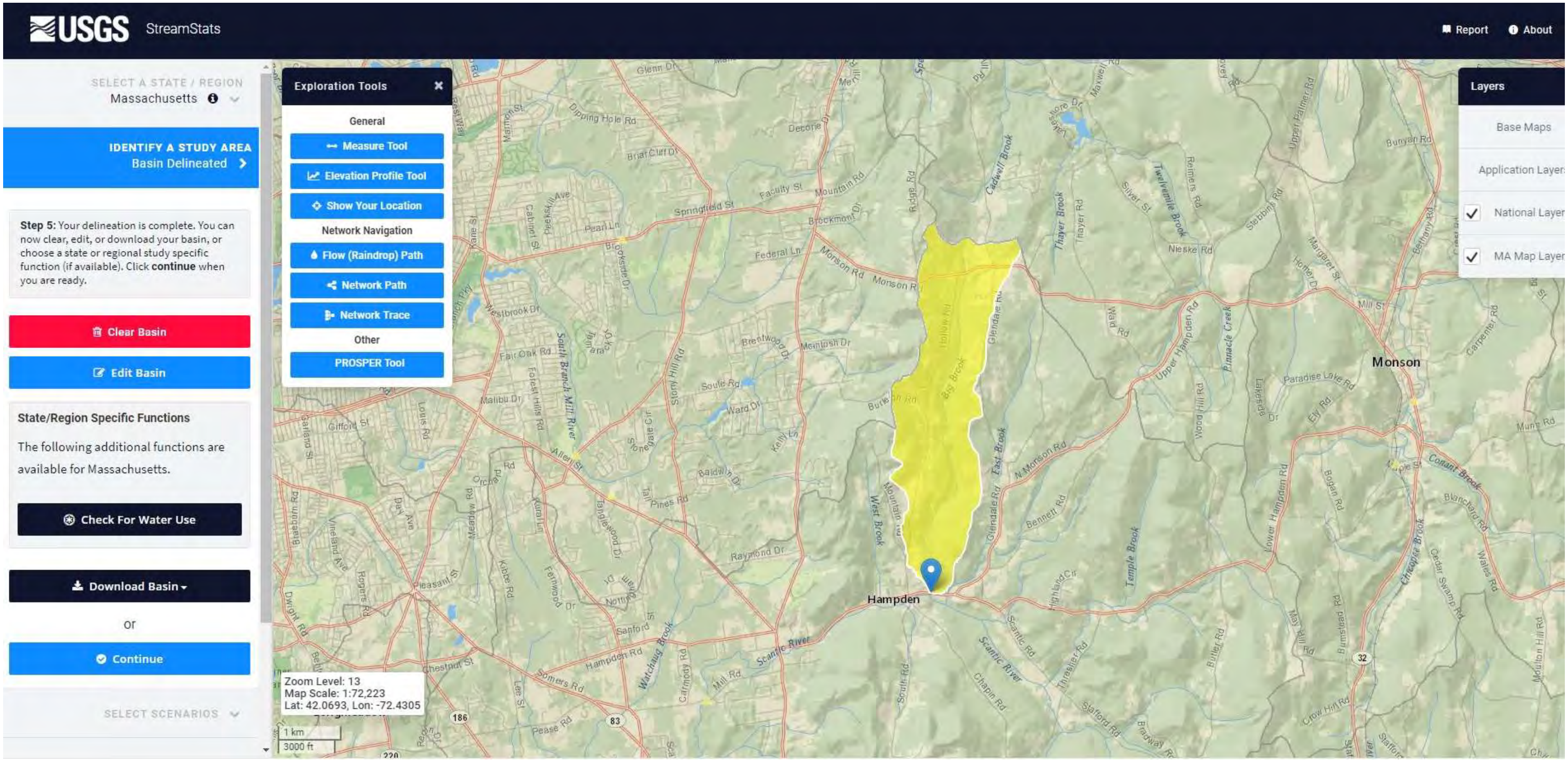

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Hampden Main Street over Big Brook Culvert

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Hampden Main Street over Big Brook Culvert

Engineers + Planners

HOWARD STEIN HUDSON

Hampden Main Street over Big Brook Culvert

East Brook Culvert (Bridge No. H-04-008)

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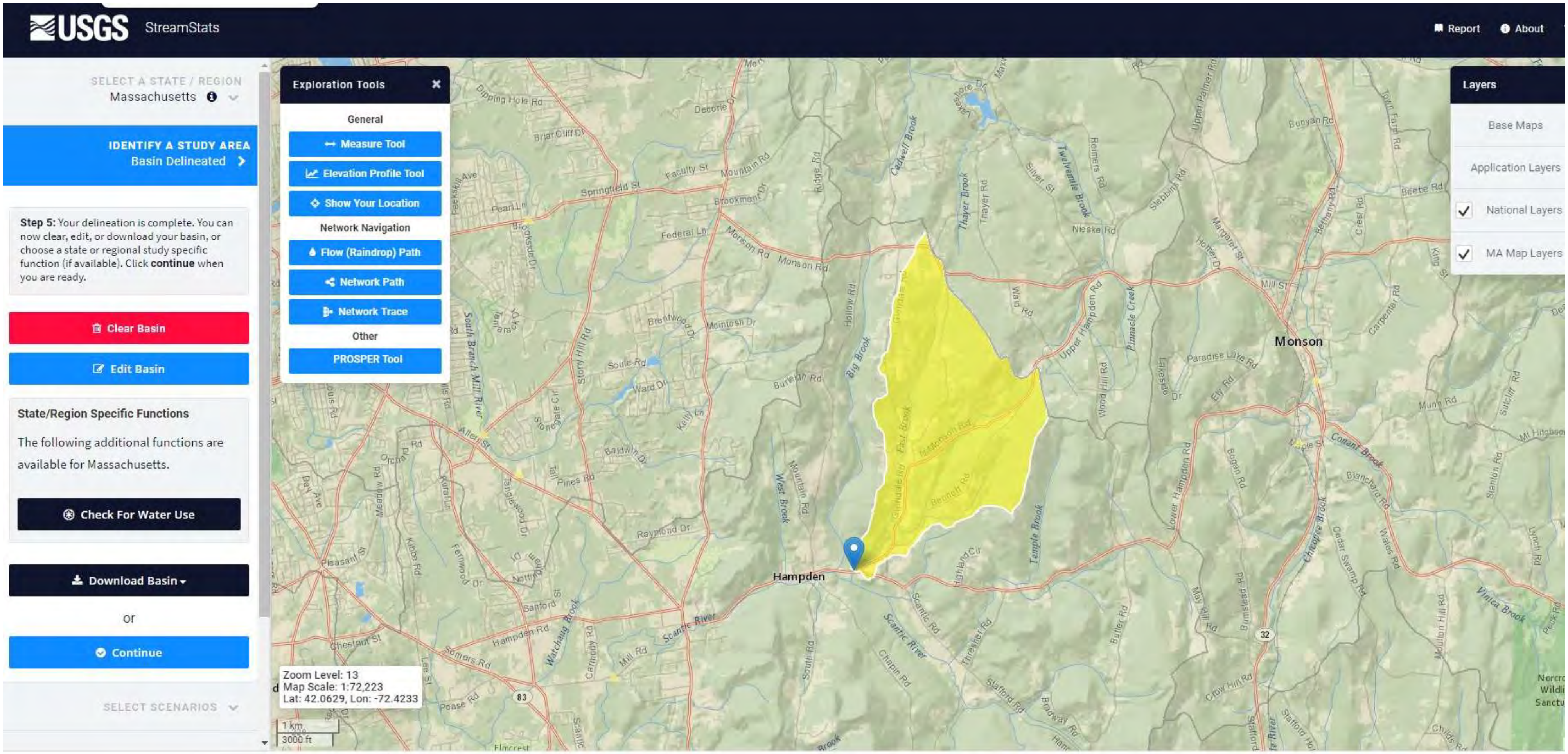
East Brook Culvert Watershed – USGS StreamStats

Engineers + Planners



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Hampden Main Street over East Brook Culvert (Bridge No. H-04-008)

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Hampden Main Street over East Brook Culvert (Bridge No. H-04-008)

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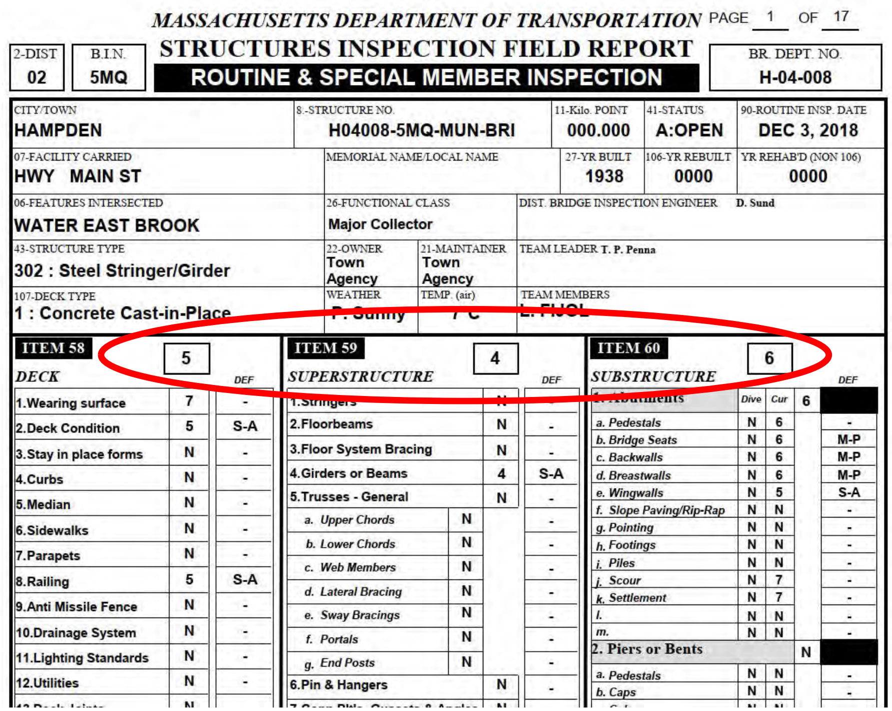
Hampden Main Street over East Brook Culvert (Bridge No. H-04-008)



MASSACHUSETTS DEPARTMENT OF TRANSPORTATION PAGE 1 OF 17

STRUCTURES INSPECTION FIELD REPORT

ROUTINE & SPECIAL MEMBER INSPECTION

2-DIST	B.I.N.	BR. DEPT. NO.
02	5MQ	H-04-008

CITY/TOWN	8.-STRUCTURE NO.	11-Kilo. POINT	41-STATUS	90-ROUTINE INSP. DATE
HAMPDEN	H04008-5MQ-MUN-BRI	000.000	A:OPEN	DEC 3, 2018

07-FACILITY CARRIED	MEMORIAL NAME/LOCAL NAME	27-YR BUILT	106-YR REBUILT	YR REHAB'D (NON 106)
HWY MAIN ST		1938	0000	0000

06-FEATURES INTERSECTED	26-FUNCTIONAL CLASS	DIST. BRIDGE INSPECTION ENGINEER
WATER EAST BROOK	Major Collector	D. Sund

43-STRUCTURE TYPE	22-OWNER	21-MAINTAINER	TEAM LEADER
302 : Steel Stringer/Girder	Town Agency	Town Agency	T. P. Penna

107-DECK TYPE	WEATHER	TEMP. (air)	TEAM MEMBERS
1 : Concrete Cast-in-Place	P: Sunny	7 C	[illegible]

ITEM 58 5

DECK

		DEF
1.Wearing surface	7	-
2.Deck Condition	5	S-A
3.Stay in place forms	N	-
4.Curbs	N	-
5.Median	N	-
6.Sidewalks	N	-
7.Parapets	N	-
8.Railing	5	S-A
9.Anti Missile Fence	N	-
10.Drainage System	N	-
11.Lighting Standards	N	-
12.Utilities	N	-

ITEM 59 4

SUPERSTRUCTURE

		DEF
1.Stringers	N	-
2.Floorbeams	N	-
3.Floor System Bracing	N	-
4.Girders or Beams	4	S-A
5.Trusses - General	N	-
a. Upper Chords	N	-
b. Lower Chords	N	-
c. Web Members	N	-
d. Lateral Bracing	N	-
e. Sway Bracings	N	-
f. Portals	N	-
g. End Posts	N	-
6.Pin & Hangers	N	-

ITEM 60 6

SUBSTRUCTURE

	Dive	Cur		DEF
1. Abutments			6	
a. Pedestals	N	6		-
b. Bridge Seats	N	6		M-P
c. Backwalls	N	6		M-P
d. Breastwalls	N	6		M-P
e. Wingwalls	N	5		S-A
f. Slope Paving/Rip-Rap	N	N		-
g. Pointing	N	N		-
h. Footings	N	N		-
i. Piles	N	N		-
j. Scour	N	7		-
k. Settlement	N	7		-
l.	N	N		-
m.	N	N		-
2. Piers or Bents			N	
a. Pedestals	N	N		-
b. Caps	N	N		-

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Hampden Main Street over East Brook Culvert (Bridge No. H-04-008) – Upstream / Downstream

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Hampden Main Street over East Brook Culvert (Bridge No. H-04-008) - Upstream

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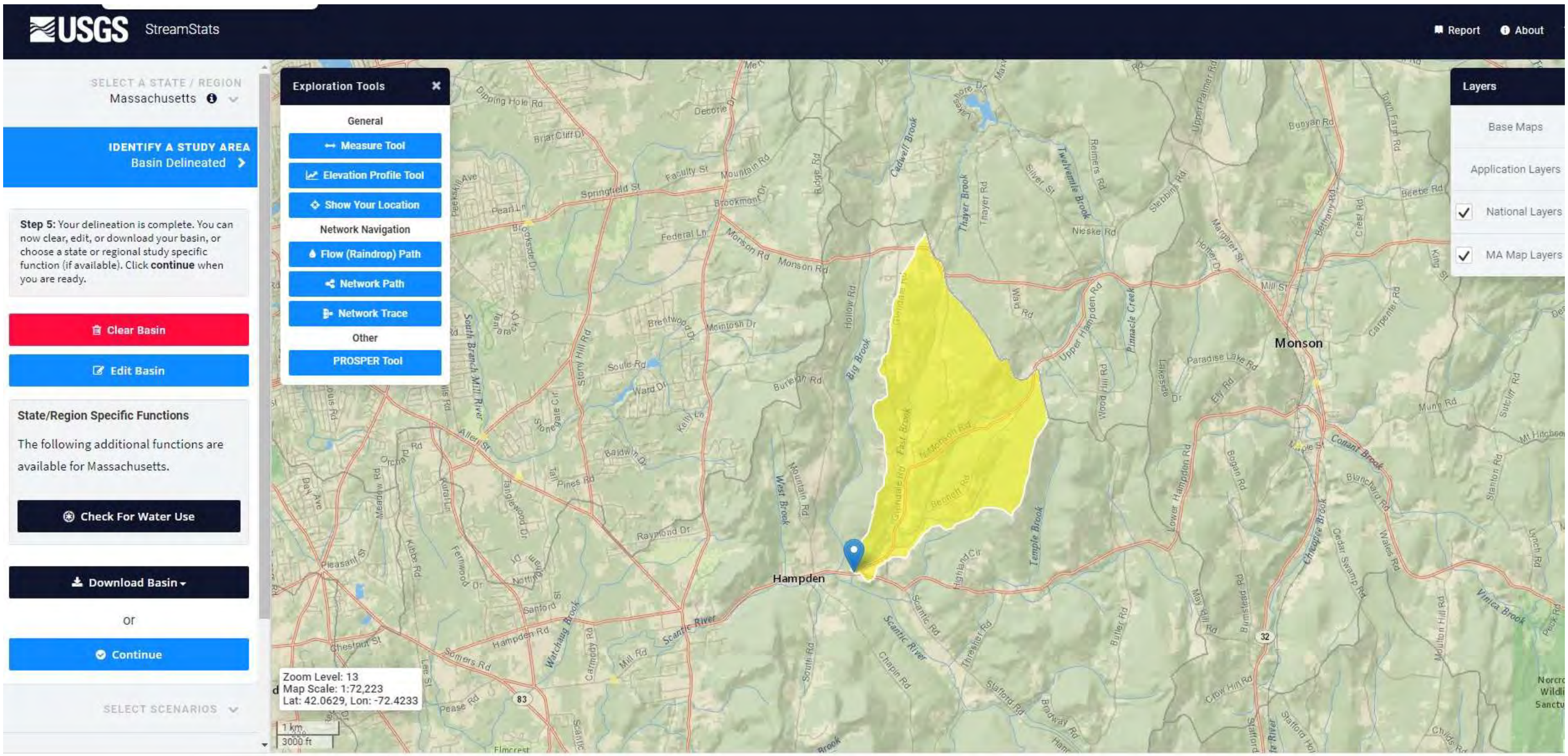
Mass Audubon Laughing Brook Wildlife Sanctuary

Engineers + Planners



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Mass Audubon Laughing Brook Wildlife Sanctuary

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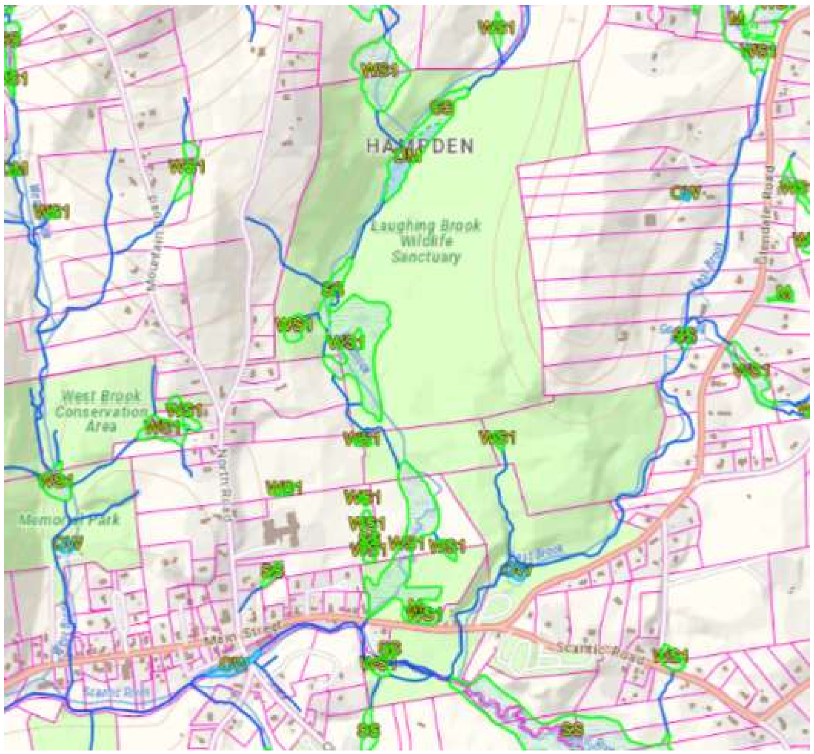
Mass Audubon Laughing Brook Wildlife Sanctuary

Engineers + Planners



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12/16/2020 Hampden MVP Core Team Meeting

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2020-12 Hampden MVP Laughing Brook Flyover

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Mass Audubon Laughing Brook Wildlife Sanctuary
Potential Green Solution – Wetlands Restoration Site

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Mass Audubon Laughing Brook Wildlife Sanctuary
Potential Green Solution – Wetlands Restoration Site

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Mass Audubon Laughing Brook Wildlife Sanctuary
Potential Green / Gray Stormwater Treatment Solutions

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Mass Audubon Laughing Brook Wildlife Sanctuary
Potential Green / Gray Stormwater Treatment Solutions

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Mass Audubon Laughing Brook Wildlife Sanctuary
Potential Green / Gray Stormwater Treatment Solutions

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Town of Hampden, MA
Main Street Town Center Looking East

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Town of Hampden, MA
Main Street Town Center Looking West

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Stalker Pond Dam (MA02689), Hampden, MA

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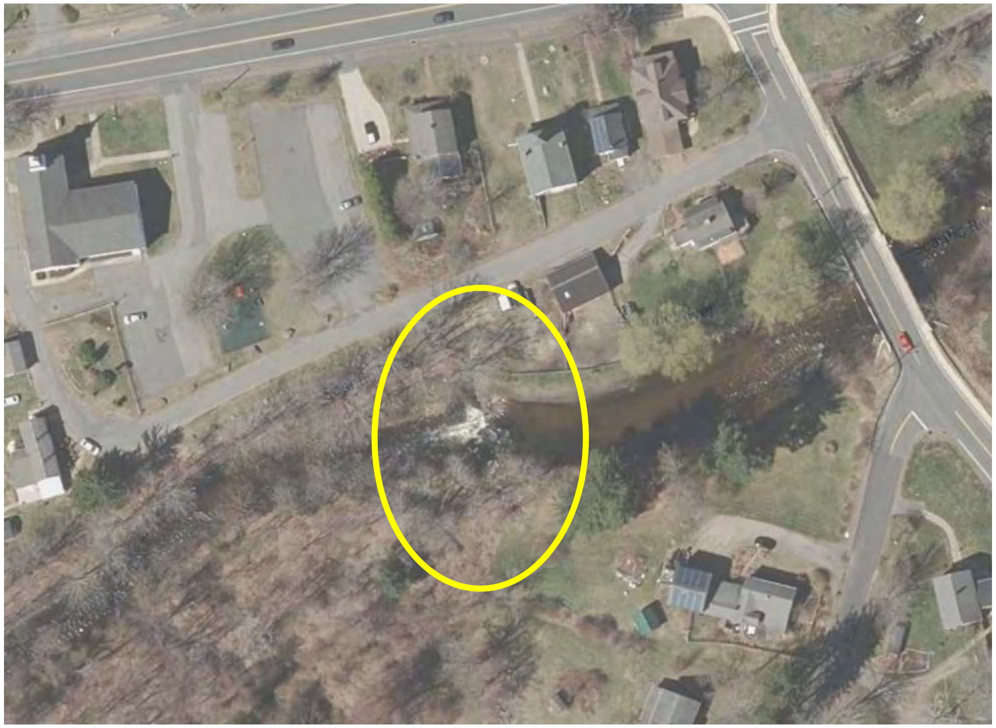

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Climate Change and Plants and Animals

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Sector Impacts

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- Economic
- Agriculture
- Health
- Infrastructure
- Environment
- Natural Habitat

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Hampden Base Map

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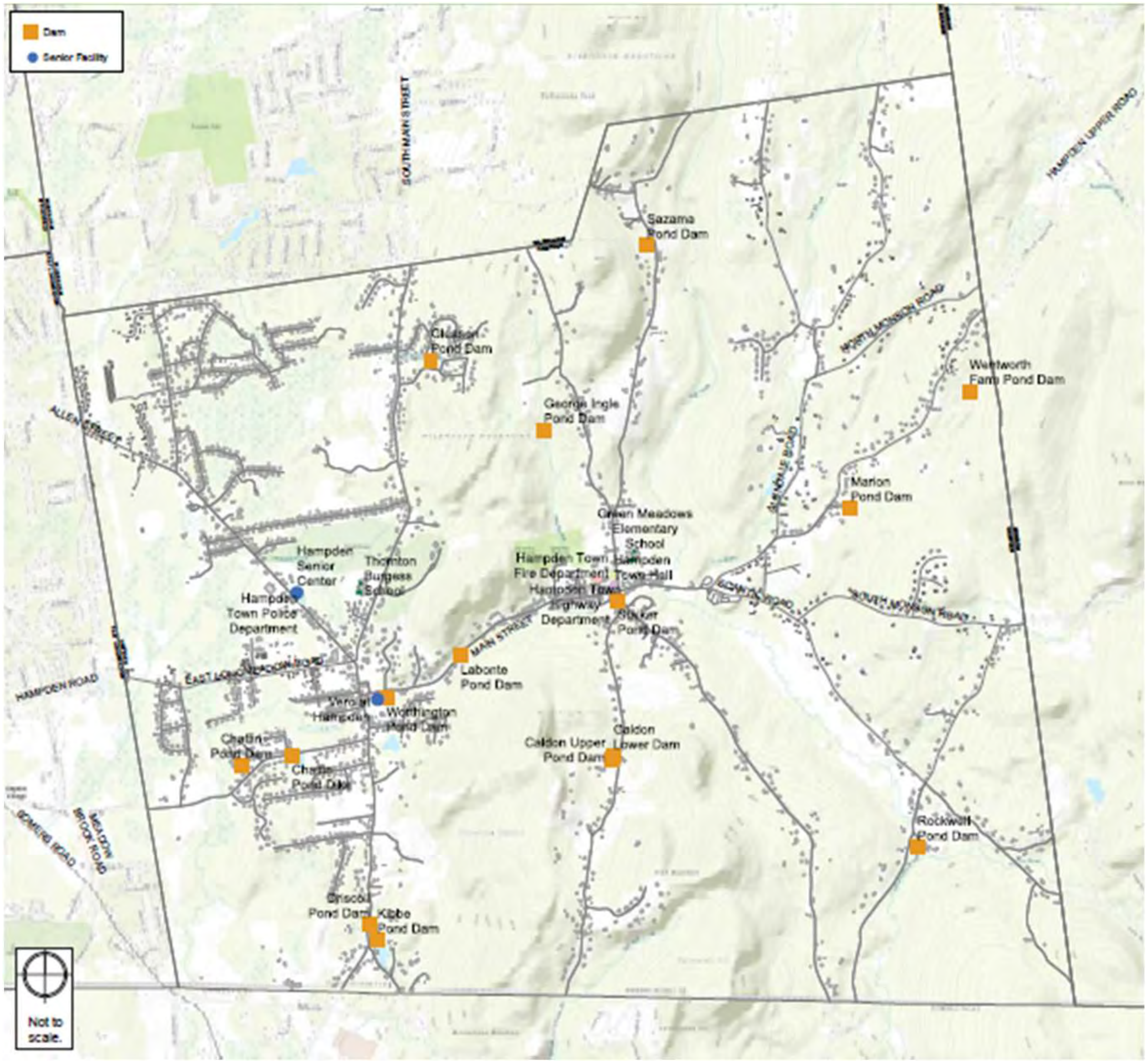

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Hampden Flood Map

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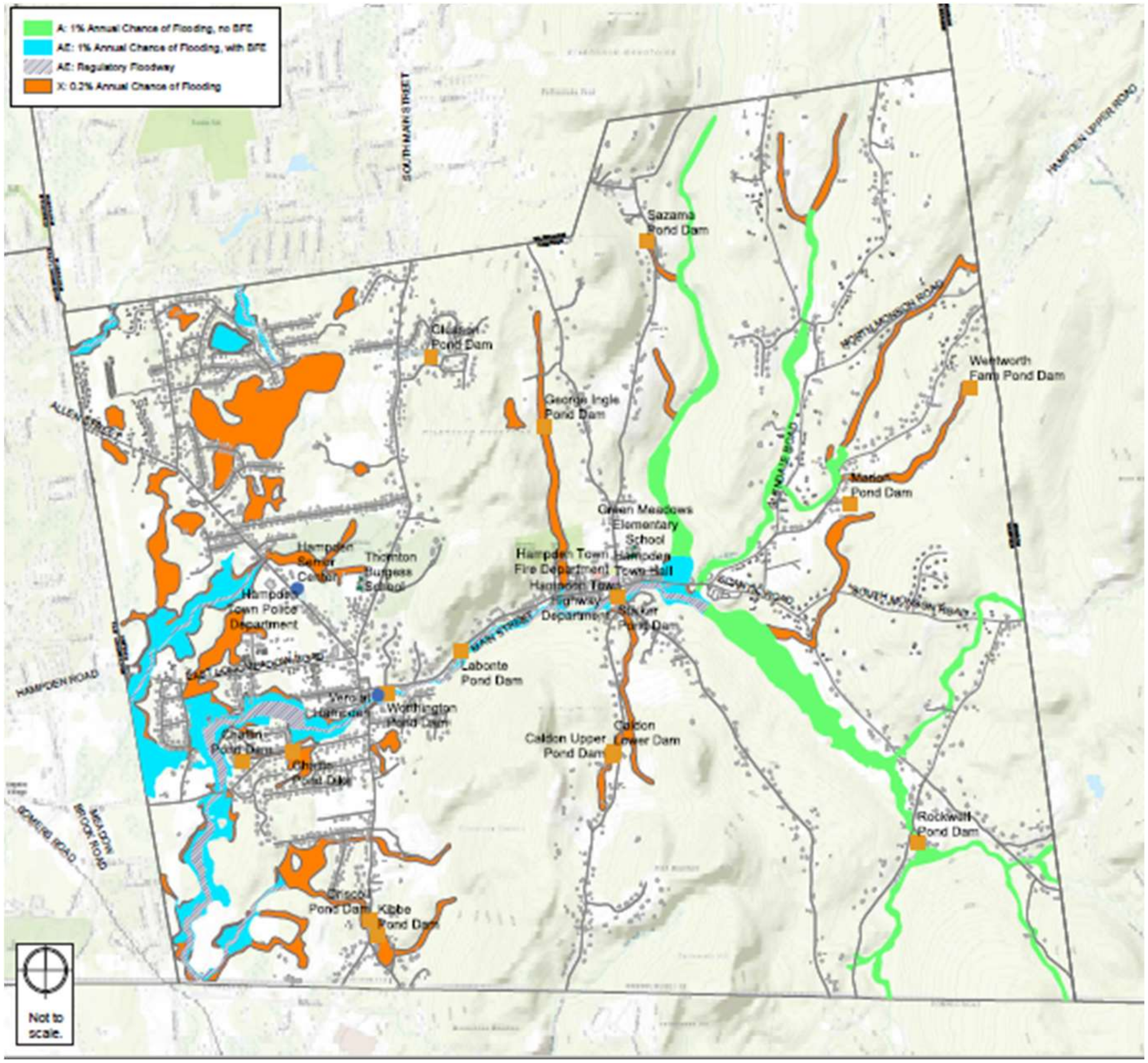

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Complete Risk Matrix

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Community Resilience Building Risk Matrix

www.CommunityResilienceBuilding.org

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

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

Features	Location	Ownership	V or S	Flooding/Drought	Extreme precipitation events/wind/tornados	Heat	Wildfire	Priority H - M - L	Time Short Long Ongoing
Infrastructural									
Main Stree culvert/bridge. Ongoing flooding is documented and prioritized in HMP. Town received MVP planning assistance to assess green solutions and recommend next steps:	Main Street	Town of Hampden	V	X	X			H	O
Culverts and bridges: due to increased rainfall/snow in individual weather events exiting infrastucture, inclusing bridges, culverts, country drainage are overwhelmed by stormwater flows. DPW Director and other stakeholders noted new and increased flooding on private property leading to structural flooding. Regarding the failure of existing infrastructur to handle increased flows, DPW Director stated "We don't know where the problems are until they pop up." A prioroty for the Town is a bridge/culvert assessment which identifies problem locations, green infrastructure opportunities, and next steps.	Town wide	Town of Hampden	V	X	x			H	O
There are many dams in Hampden. In many cases the original function is no longer relevant. The dam across the street from the Town House suppoirts fire suppression response. There are questions about the capcity of the dam to provide consistent, long term water for fire fighting needs.	Town wide and across from Town House	Town/private	V/S	X	x		X		

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Complete Risk Matrix

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Societal									
Students, residents, municipal workers are at risk from vector borne illnesses from outdoor sports and other activities . Climate change has exacerbated the threats from Lyme disease, EEE, and other illnessess spread by ticks, mosquitoes, and potentially other pests migrating into the region as a result of winter warming trends and extended summer heat.	Town wide		V			X			
Integrity of private wells and Title V systems: see Environmental									
Schools and other public facilities may serve as emergency shelters, charging stations, cooling/warming facilities.	Town wide	Town	V/S	X	x	x			

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Complete Risk Matrix

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Environmental

There are several solar fields in the Town of Hampden. The town shopuld set an example for adopting renewable energy options for municipal facilities. The close proximity of the Town House, Green Meadows School, and Highway Department present an opportunity to study the feasibility of providing green and emergency power generation. The Town is a designated Green Community	Town Center	Town	V		X				
Tree and forest health is impacted by extended drought, temperature extremes, and wind events. In the Town's Haard Mitigation Plan the Town prioritized tree trimming by the local utilty to reduce the threat of pwer outages from trees falling on power liones. That has been done. There is concern about the health of both public and provate trees. The Town percieves an increase in gypsy moths, associated with changing climate conditions. Excessive tree decay from droughts,m wind storms, and pests are creating a wildfire risk such as the one that the Town expereinced during this summer's drought	Town wide	Town/private	V	X	x	x	X		
Private wells ans Title V systems are at risk from driought and flooding conssditions. Concerns include the impact of increased runoff on provate wells due to increased preciptation associated with climate change, especially to those wells located in the proximity of Great Horse golf course. There are also concerns about Title V systems due to expanded flooding and grounwater breakouts already noted.	Town wide	Town/private	V	X	x				
The Town of Hampden protects its wetlands through diligent stwardship provided by the Conservation Commission. These wetlands serve as buffers during flooding events. The river and other streams routinely receive debris such as fallen trees and other natural materials discharged as a result of runoff. An accumulation of this dbris creates changes in shoreline and flooding.	Town wide	Town/private	V/S	X	x				

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Climate Change Priorities for Hampden

Engineers + Planners

- Confirm Matrix

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Next Steps

Engineers + Planners

- Summary of findings
- Listening Session
- Mass Audubon Program
- Municipal Vulnerability Preparedness Action Grant April 2021

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Contact Information

Engineers + Planners

Thank you!

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Mass Audubon

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Appendix G

Mass Audubon March 2021 Community Workshop Agenda and Presentation

Climate Change in Hampden

Understanding Local Impacts and How to Adapt

Via Zoom

Monday, March 22, 4:00pm

The Town of Hampden is participating in the state's Municipal Vulnerability Preparedness (MVP) Program. The MVP program works with towns to identify climate hazards, assess vulnerabilities and develop action plans to make communities more resilient.

Join Mass Audubon's Director for the Connecticut River Valley to learn more about the MVP program, how climate change will be affecting us locally, and how we can adapt.

Free program—registration required at the link below.

Mass Audubon
Laughing Brook Wildlife Sanctuary
Jonah Keane—Director
jkeane@massaudubon.org | massaudubon.org

FREE COMMUNITY WORKSHOP

www.massaudubon.org/hampdenclimate

Climate Change in Hampden

Understanding Local Impacts and How to Adapt

Jonah Keane
CT River Valley Director
Mass Audubon
jkeane@massaudubon.org

Mass Audubon

Berkshires

1. **Pleasant Valley, Lenox**
2. Canoe Meadows, Pittsfield
3. Lime Kiln Farm, Sheffield

Connecticut River Valley

4. West Mountain, Plainfield
5. Road's End, Worthington

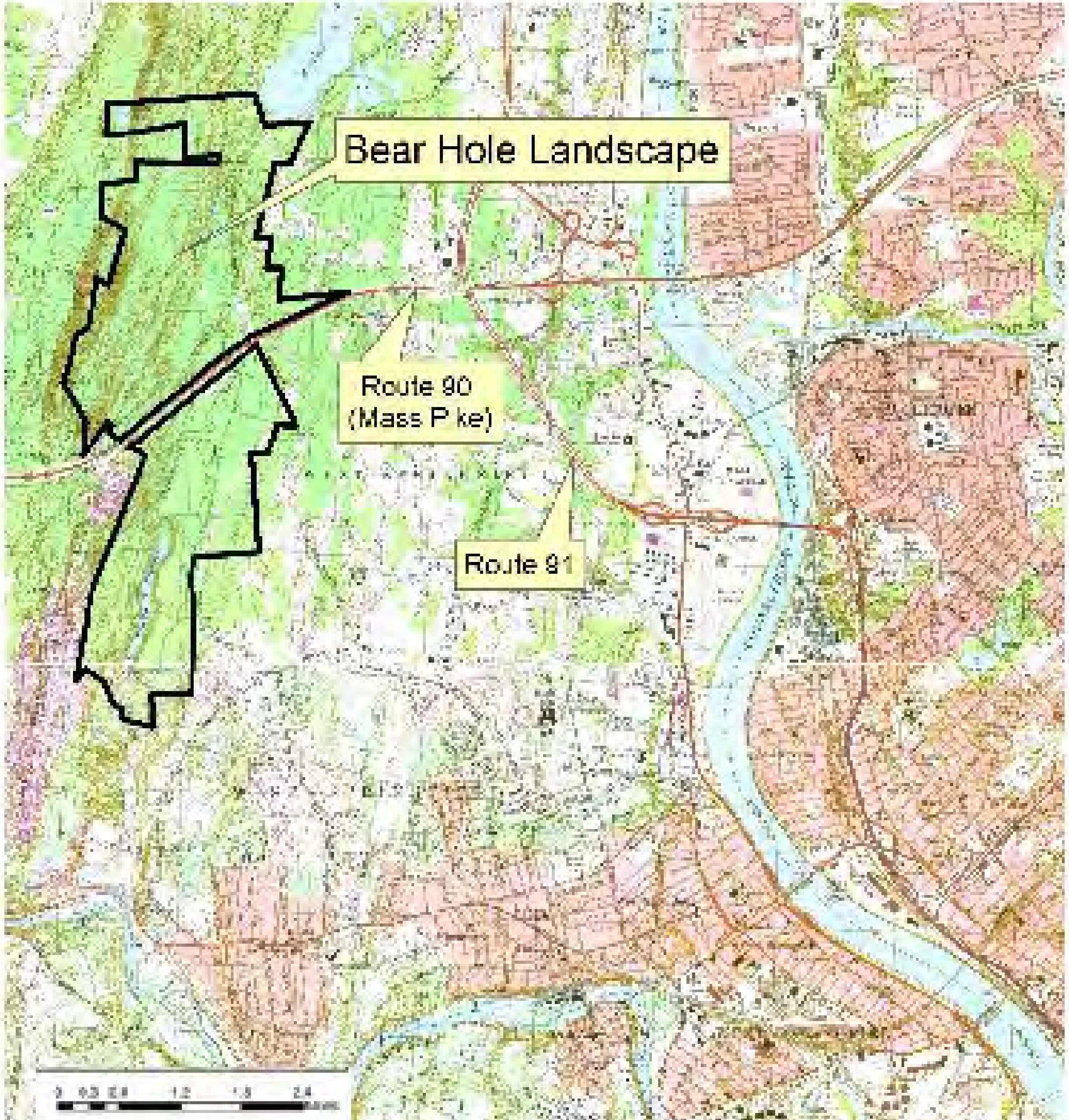
Greater Boston


37 -056-001
37 -022-000
37 -120-001
37 -076-001
37 -030-001
37 -051-001
38C-013-001
37 -090-001
37 -004-001
37 -049-001
B
45 -018-001
38D-075-001
45 -031-001
44 -026-001
44 -011-001
C
44 -029-001
44 -115-001
45 -019-001
44 -030-001
44 -014-001
44 -129-001
44 -050-001
D
A
A
45 -010-001
45 -045-001
44 -054-001
44 -114-001
51 -008-001
51 -010-001
51 -007-001

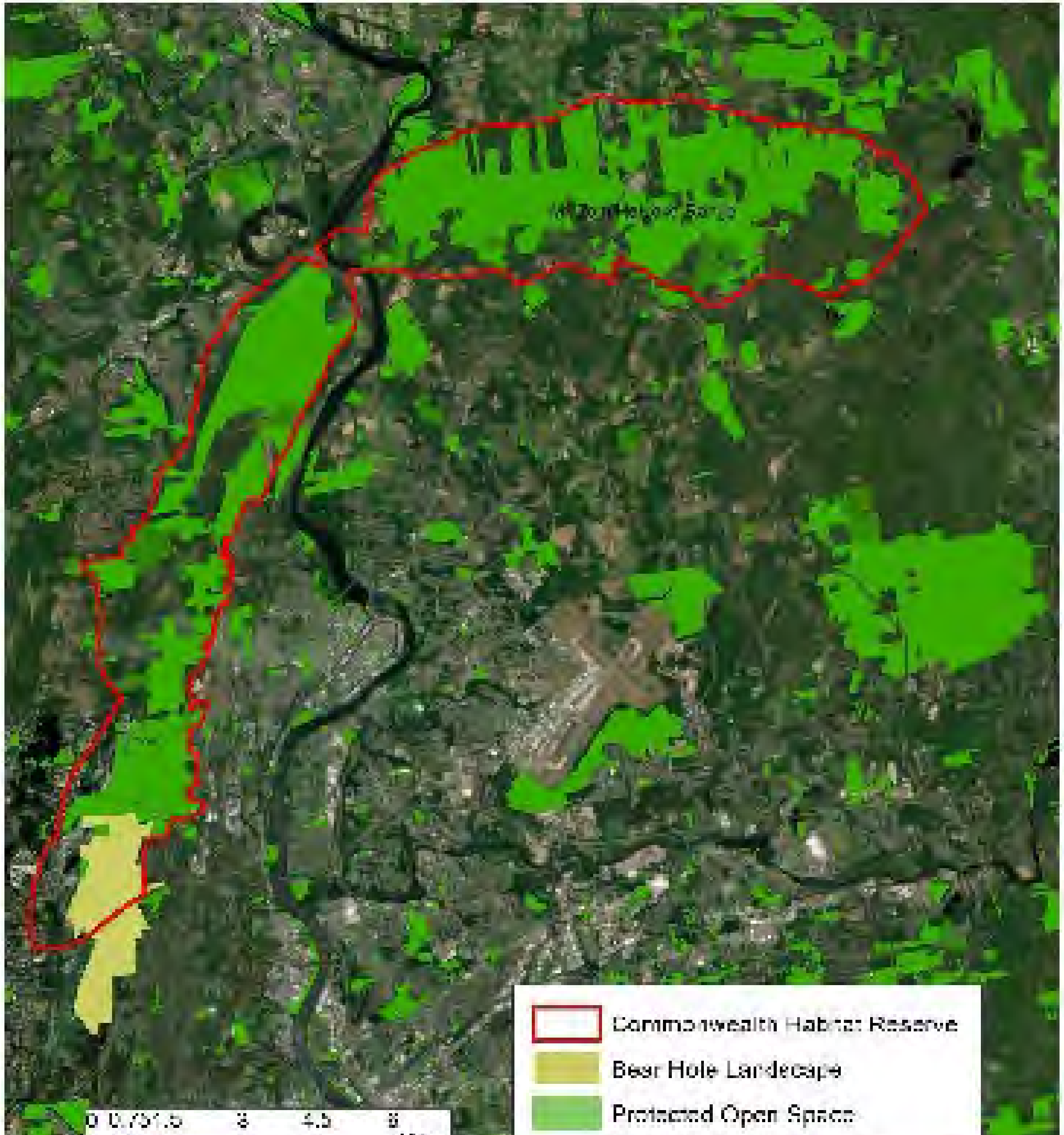

STAFF

Youth Climate Summit

Bear Hole

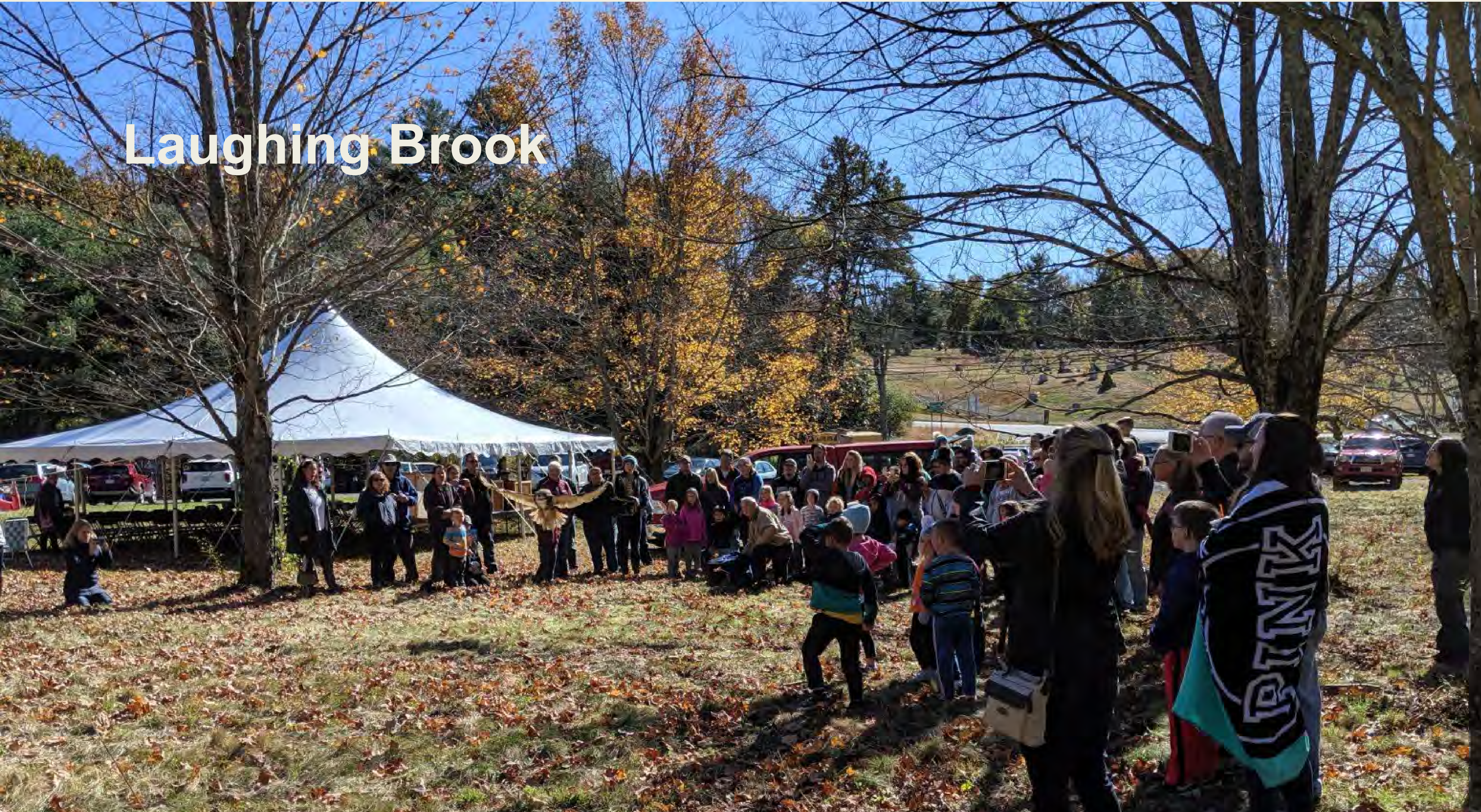


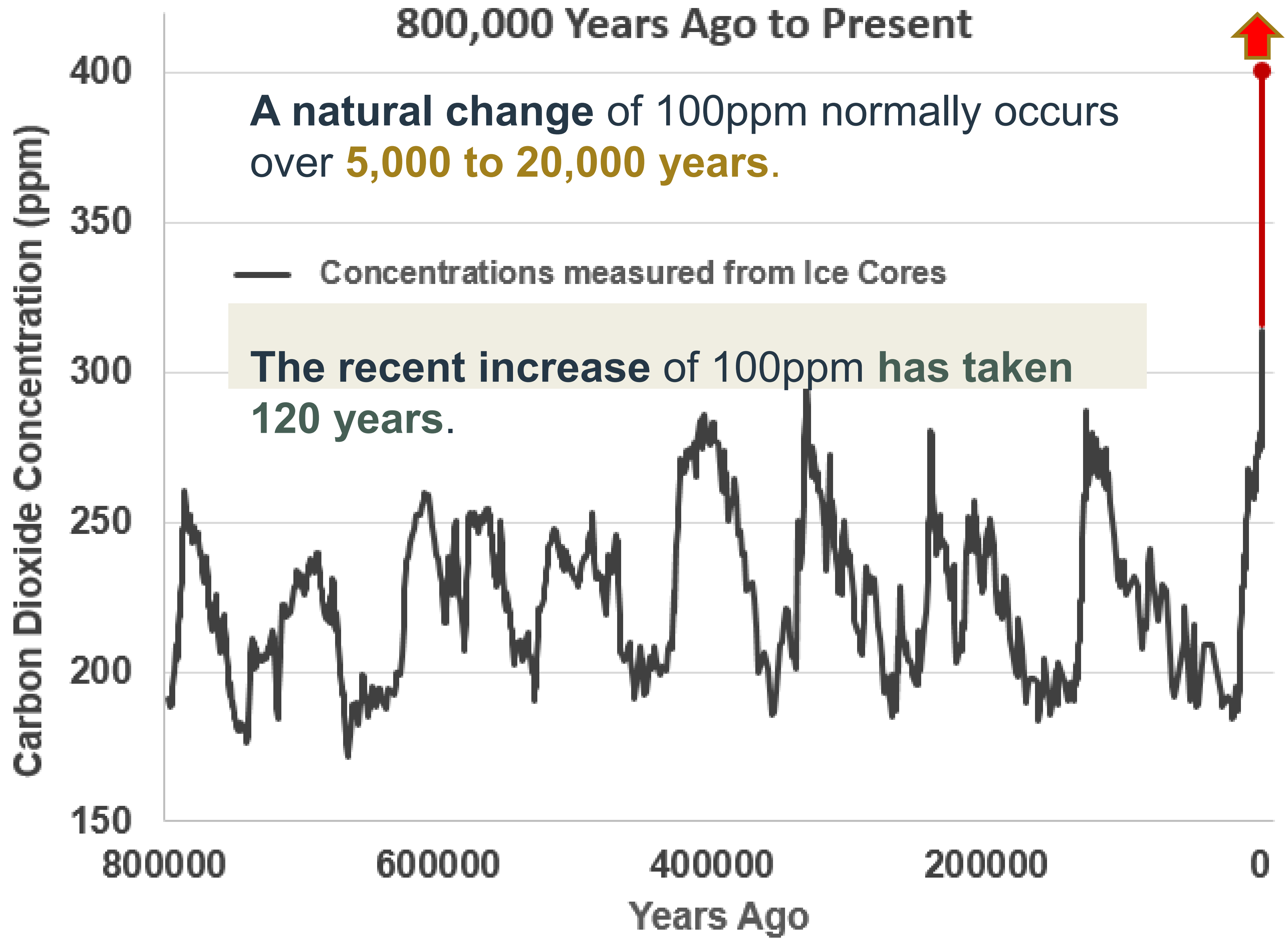
Bear Hole Landscape
Route 90
(Mass P ke)
Route 91



Commonwealth Habitat Reserve
Bear Hole Landscape
Protected Open Space

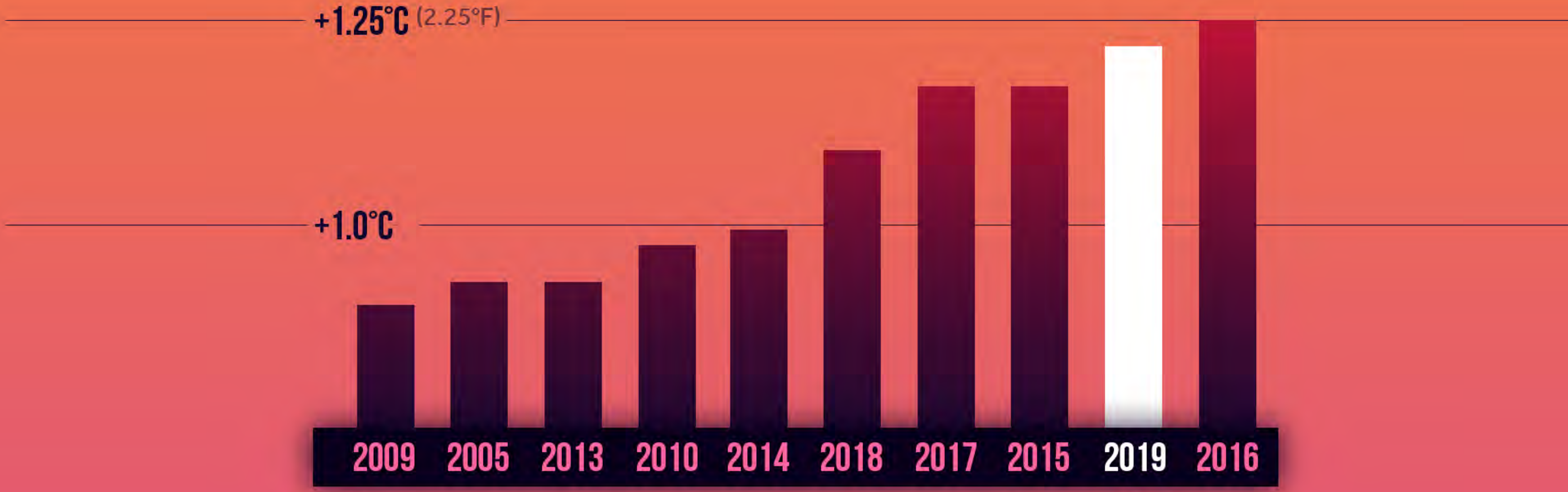
Laughing Brook




800,000 Years Ago to Present
A natural change of 100ppm normally occurs over 5,000 to 20,000 years.
Concentrations measured from Ice Cores
The recent increase of 100ppm has taken 120 years.
Carbon Dioxide Concentration (ppm)
400
350
300
250
200
150
800000
600000
400000
200000
0
Years Ago

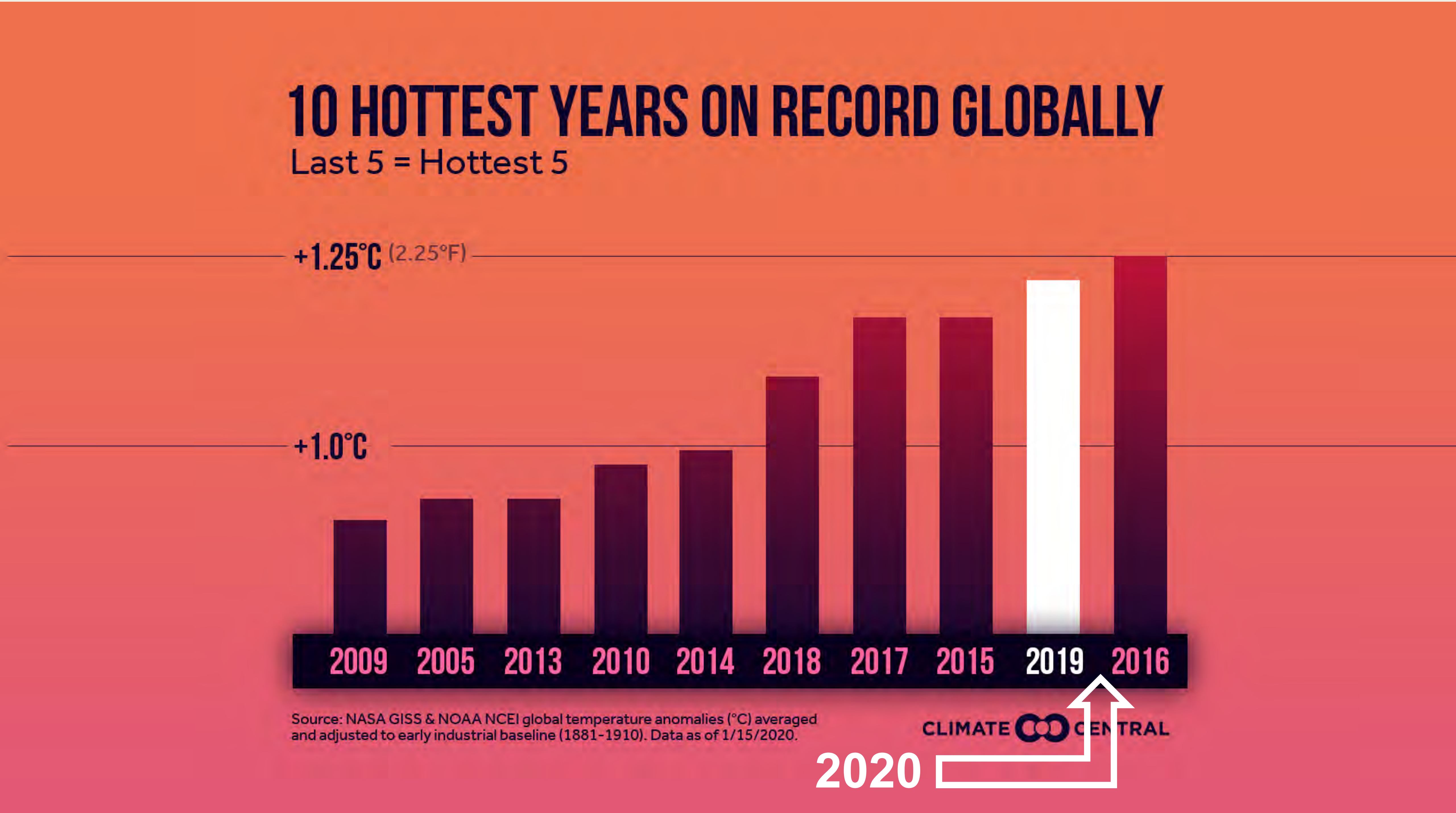
10 HOTTEST YEARS ON RECORD GLOBALLY

Last 5 = Hottest 5



Source: NASA GISS & NOAA NCEI global temperature anomalies (°C) averaged and adjusted to early industrial baseline (1881-1910). Data as of 1/15/2020.

CLIMATE CENTRAL


10 HOTTEST YEARS ON RECORD GLOBALLY
Last 5 = Hottest 5
+1.25°C (2.25°F)
+1.0°C
2009
2005
2013
2010
2014
2018
2017
2015
2019
2016
Source: NASA GISS & NOAA NCEI global temperature anomalies (°C) averaged and adjusted to early industrial baseline (1881-1910). Data as of 1/15/2020.
CLIMATE CENTRAL
2020

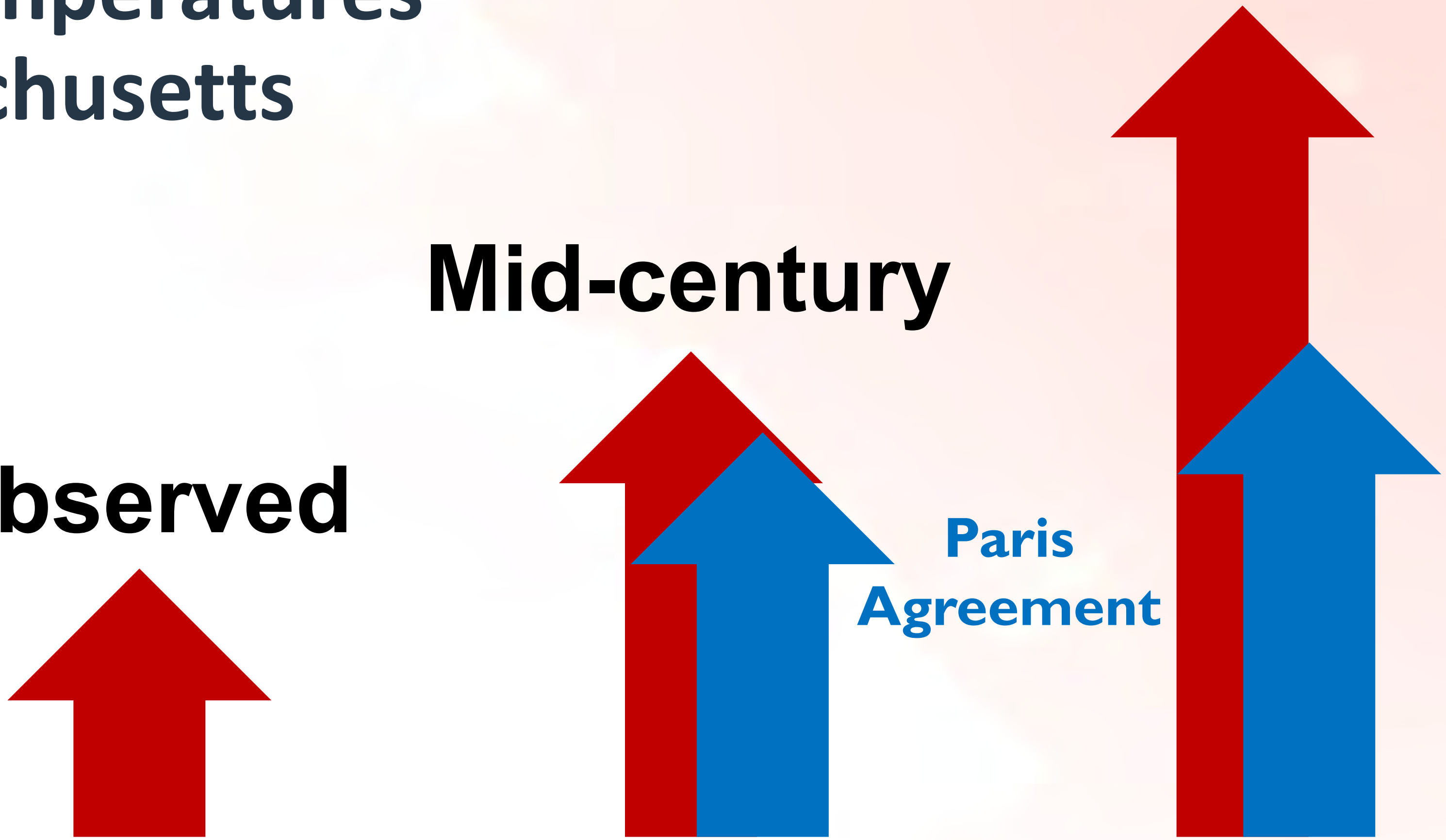
Impacts in Massachusetts

Temperature: ↑ **2.8°F** Since 1895

Growing Season: ↑ **10 Days** Since 1950

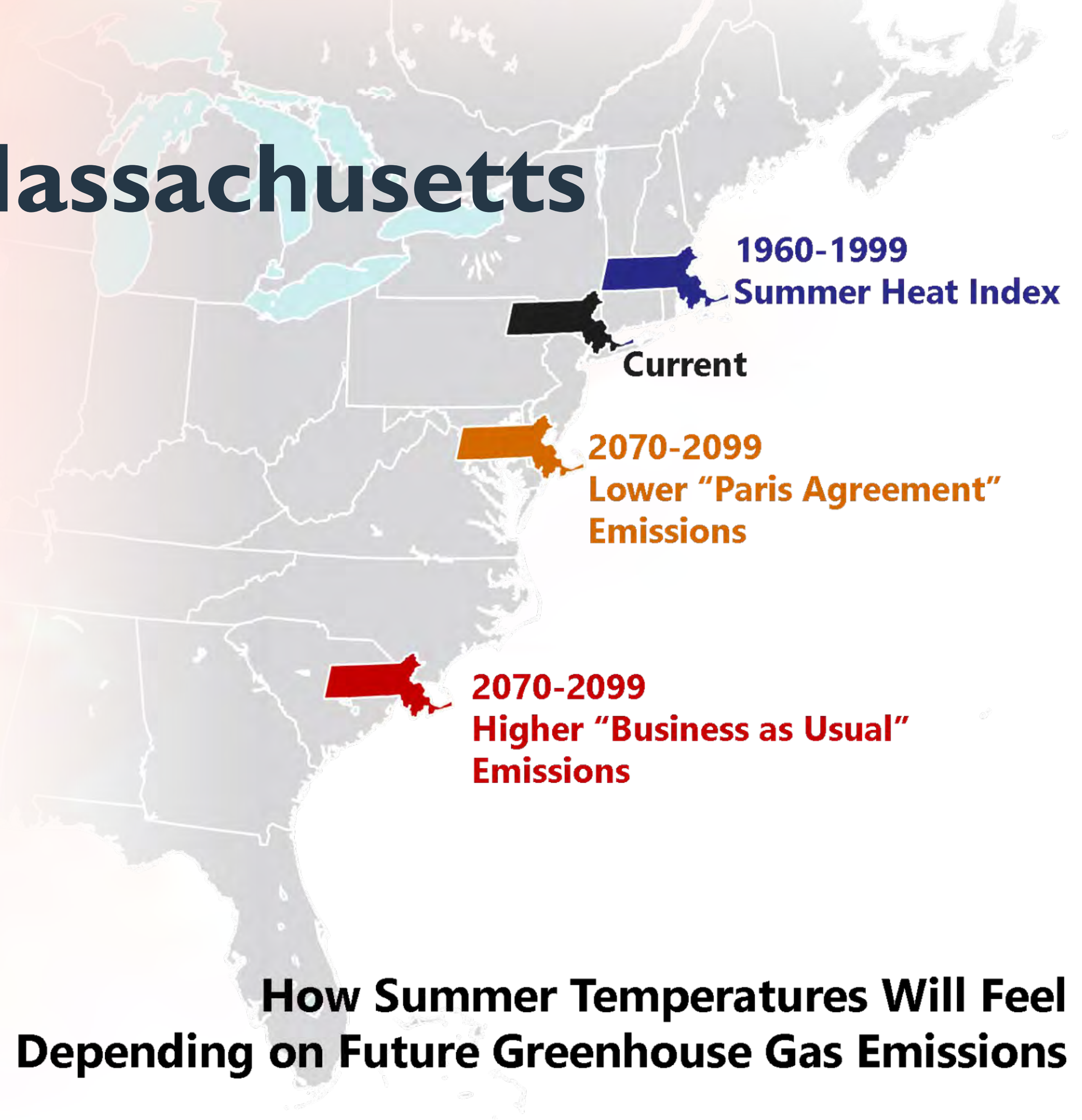
Strong Storms: ↑ **71%** Since 1958

Rising Temperatures in Massachusetts

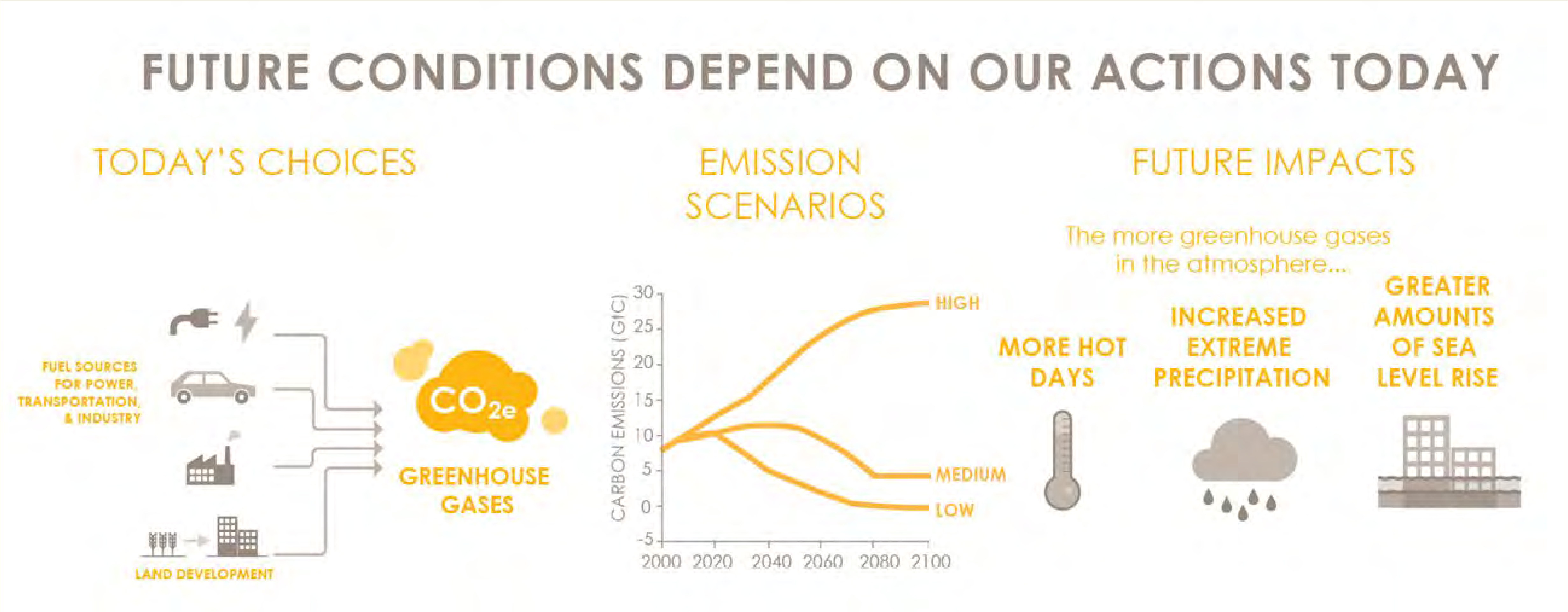


Sources: UMass-Amherst, Northeast Climate Science Center, Third National Climate Assessment, NOAA CLIMDIV dataset.

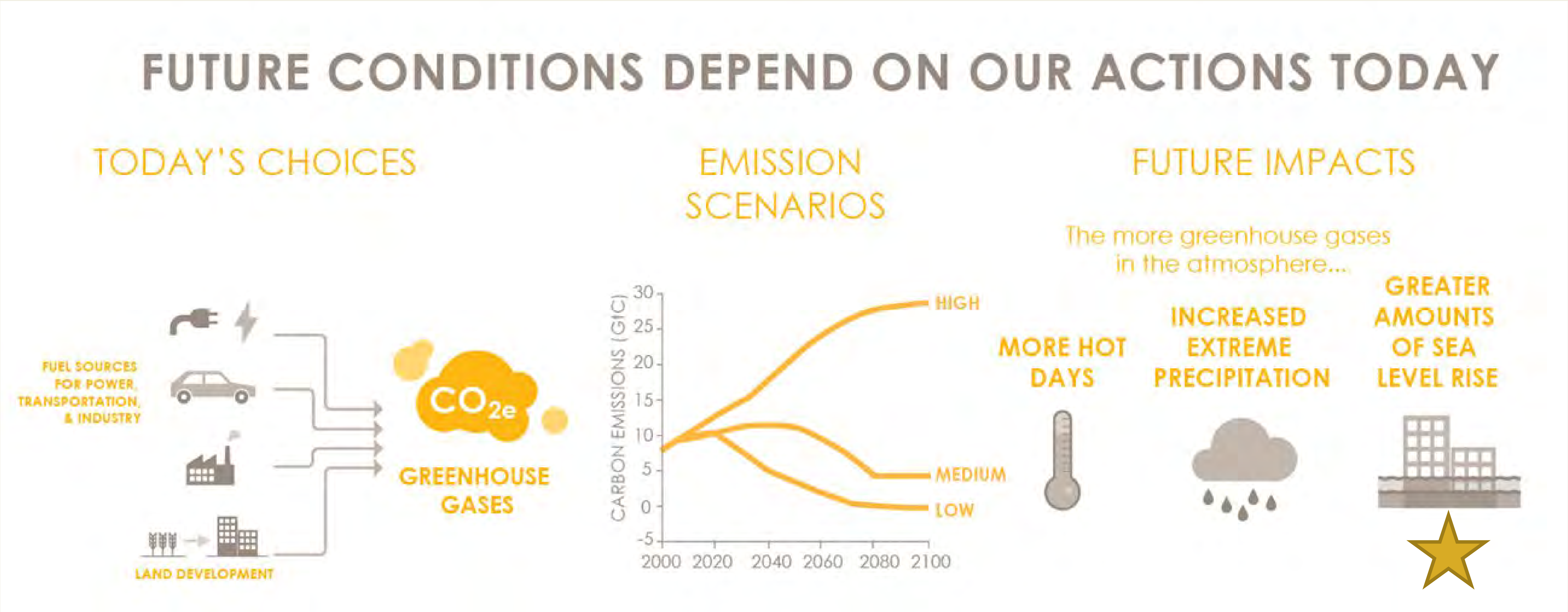
Migrating Massachusetts



How Summer Temperatures Will Feel Depending on Future Greenhouse Gas Emissions



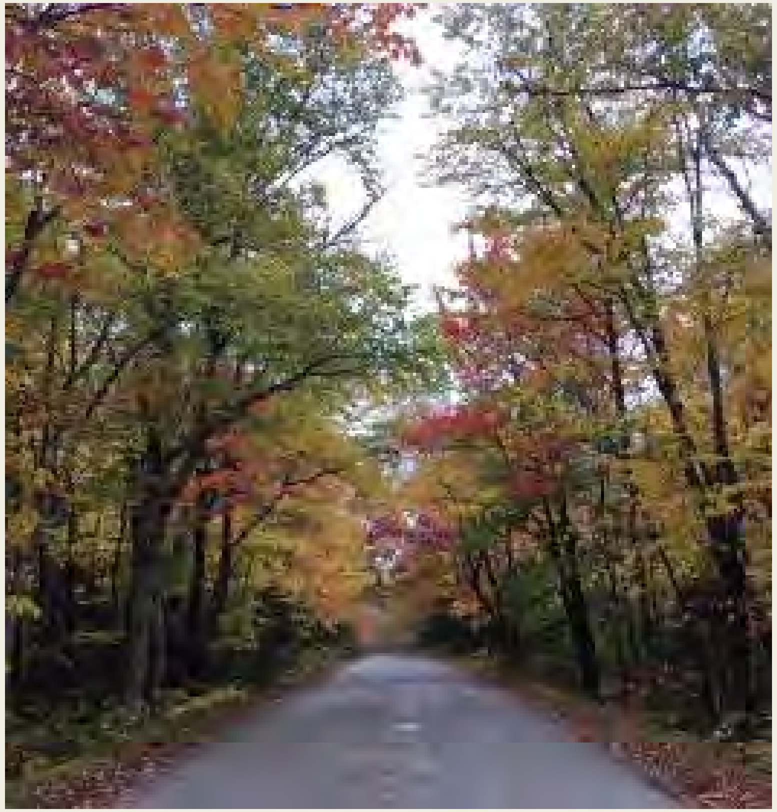
How Do We Affect Climate?

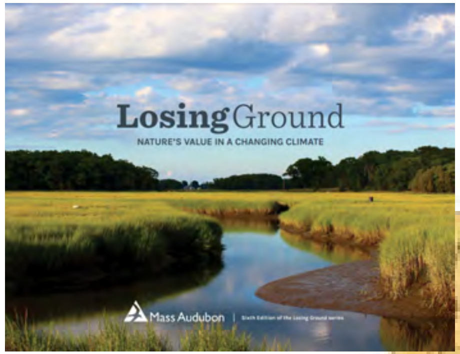


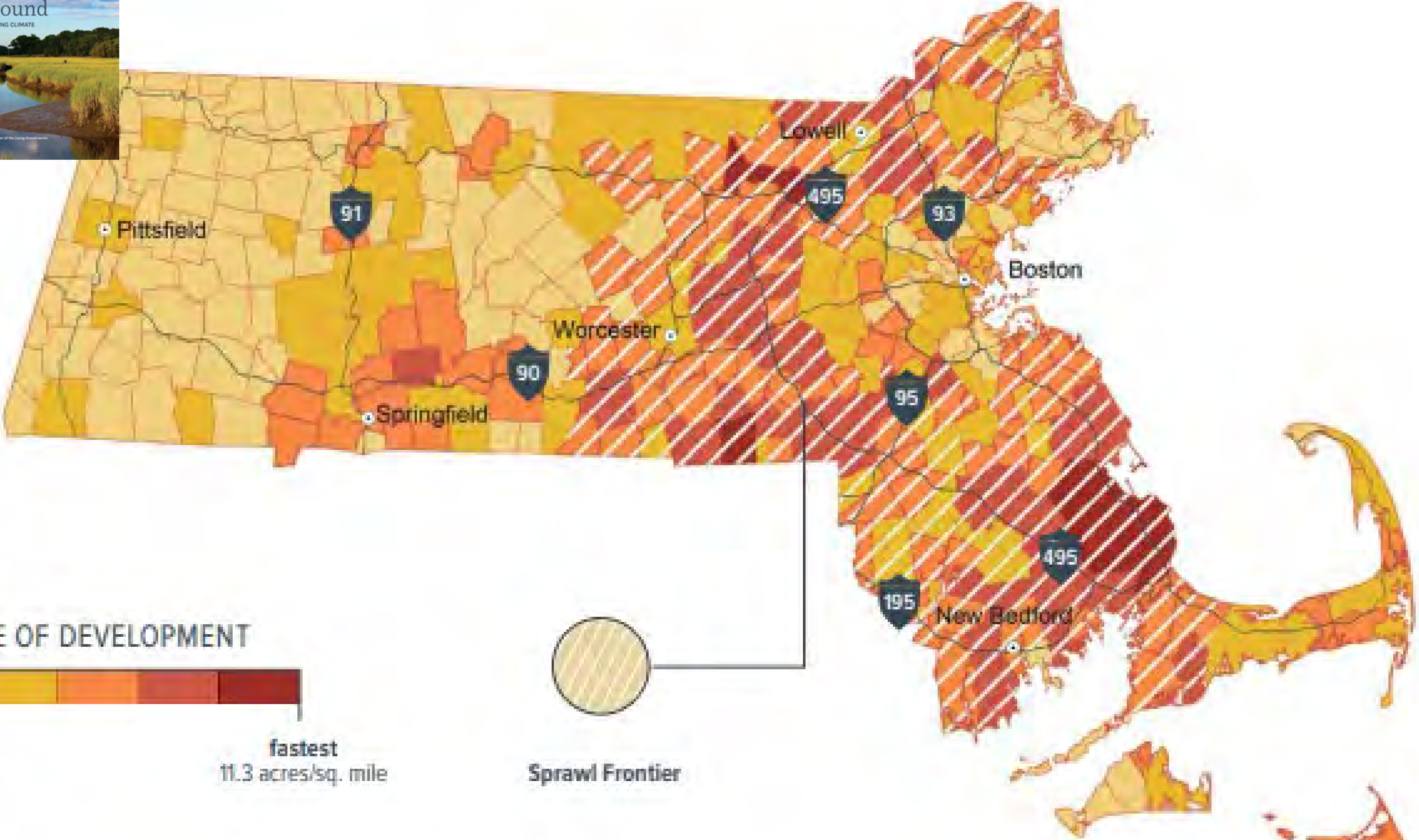
How Do We Affect Climate?

Mitigation: Actions to reduce or prevent emission of Greenhouse Gases

Adaptation: Actions taken to help communities and ecosystems cope with actual/expected effects of climate change




Losing Ground
NATURE'S VALUE IN A CHANGING CLIMATE
Mass Audubon


Lowell
495
93
91
Pittsfield
Boston
Worcester
90
Springfield
95
495
195
New Bedford
RATE OF DEVELOPMENT
slowest
0 acres/sq. mile
fastest
11.3 acres/sq. mile
Sprawl Frontier

Climate change

Sprawling Development

increased precipitation

increased temperature

impervious surfaces

stormwater & WQ issues

flooding & infrastructure damage

heat-related illnesses

fish and aquatic life impacts

Green Infrastructure

Natural features
(eg forests, wetlands)
and
Engineered landscapes that mimic natural features
(eg rain gardens)

Low Impact Development (LID)

Concord Riverwalk

photo by Wicked Local

- Treats **water as a resource**, not just a waste product
- Manages stormwater as **close to its source** as possible
- **Preserves** natural landscape by recreating natural features

Examples - LID

Rain gardens

This rain garden in Devens, MA gathers runoff from a curb-less road and sidewalk to infiltrate stormwater back into the ground while also offering beautiful home landscaping. Rain gardens can be made in any size and shape to fit your location.

Green roofs

U.S. General Services Administration

Boston, MA: John W. McCormack US Post Office and Courthouse. This 9,654 ft^2 green roof sits atop the EPA Region 1 Headquarters on a historic 1933 building.

EPA

A small, slanted green roof in Craftsbury, VT.

Permeable pavement

Horsley Witten Group

This parking lot in Narragansett, RI shows traditional asphalt on the left, where puddles have formed, and permeable pavement on the right, where it has soaked through.

Nature-based Solutions at Every Scale

1. **Conserve** the natural green infrastructure already providing free services
2. **Integrate** LID and green infrastructure design into development
3. **Restore** local resilience through LID in redevelopment

Low Impact Development: Cost Savings & More

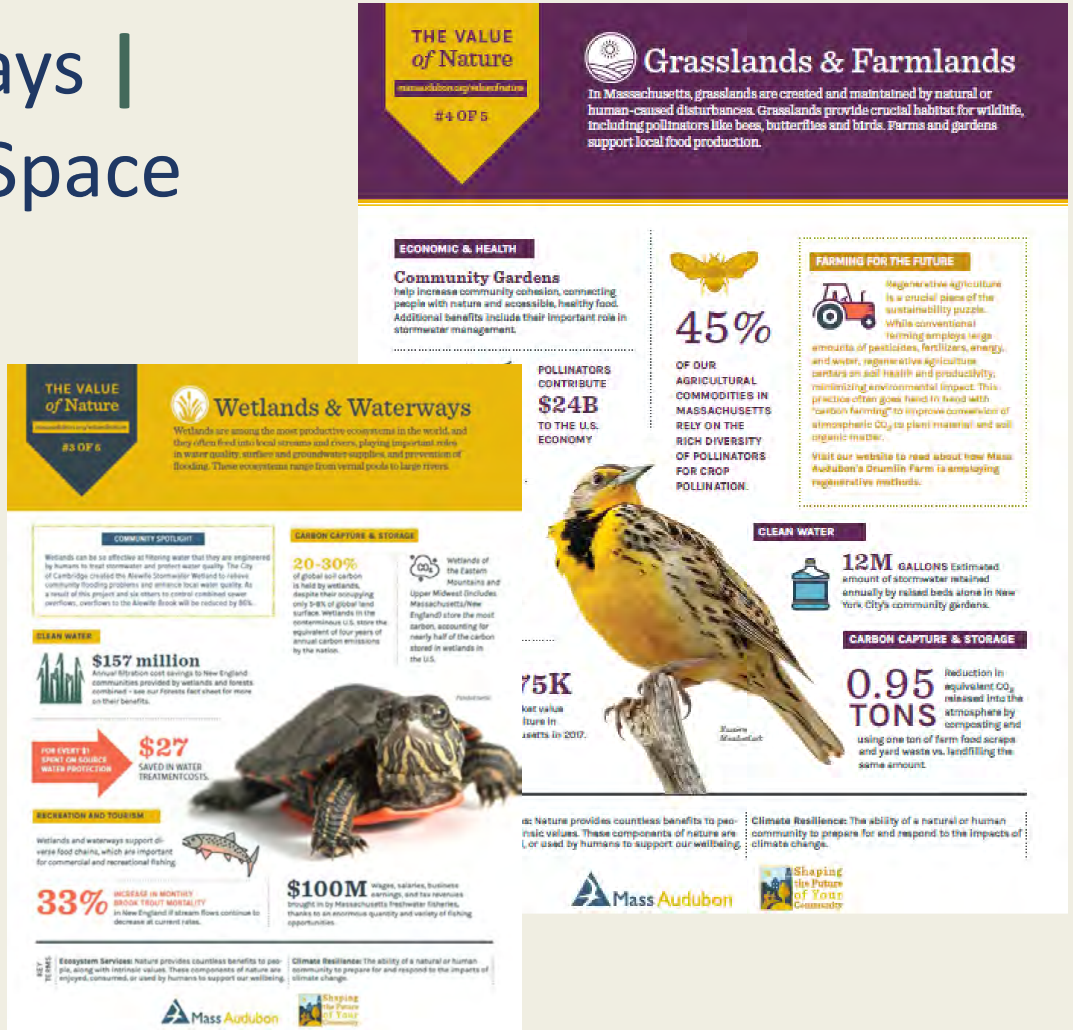
1. **Valuing Green Infrastructure**
   - How saving land *saves water and money*
2. **Conservation Design**
   - *Financial benefits* and local examples
3. **LID Techniques**
   - *Costs and benefits* of 5 LID techniques, site design to reduce pavement and costs
4. **LID in Regulations**
   - Review municipal bylaws
5. **Urban Waters**
   - Leominster stormwater case study

massaudubon.org/lidcost

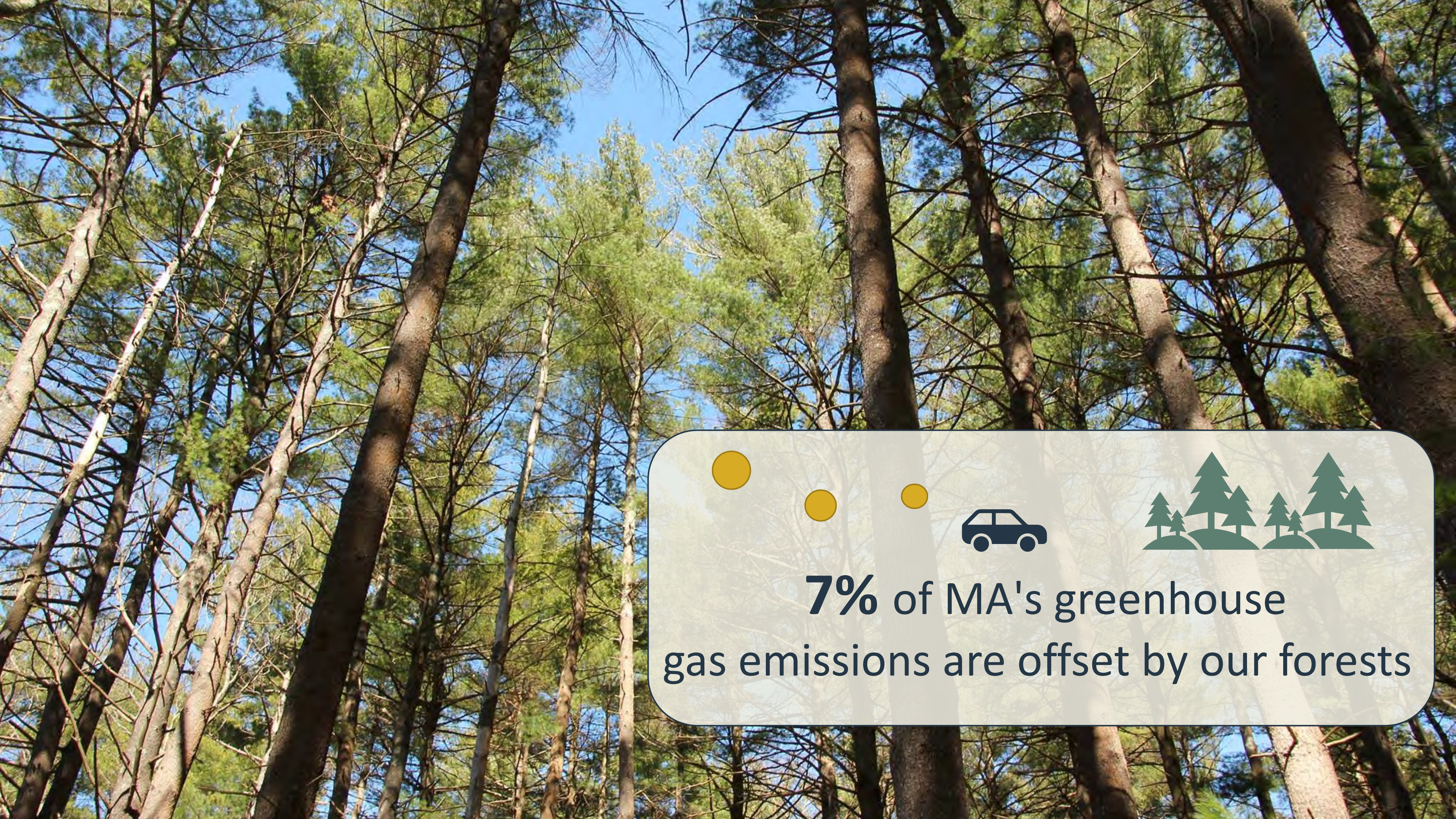
Value of Nature fact sheets

Forests | Coastal | Wetlands & Waterways | Grasslands & Farmland | Urban Green Space

- *Climate Resilience*
- *Clean Air and Water*
- *Carbon Capture & Storage*
- *Economic & Health*
- *Recreation & Tourism*



massaudubon.org/valueofnature


7% of MA's greenhouse
gas emissions are offset by our forests


For every
$1
spent on source
water protection
$27
saved in water
treatment costs

Every year, urban forests in the 15 communities of MetroWest Boston

Source: Hong-Hanh et al. 2018

Remove **7.5 million** pounds of air pollutants

Help avoid **527 million gal.** of stormwater runoff, worth **$4.7 million**

Store **962,000 tons** of carbon, worth **$125 million**

The “MVP” of Nature-Based Solutions

The **Municipal Vulnerability Preparedness (MVP) Program** helps communities prepare for the impacts of climate change.

→ Encourages **nature-based solutions**

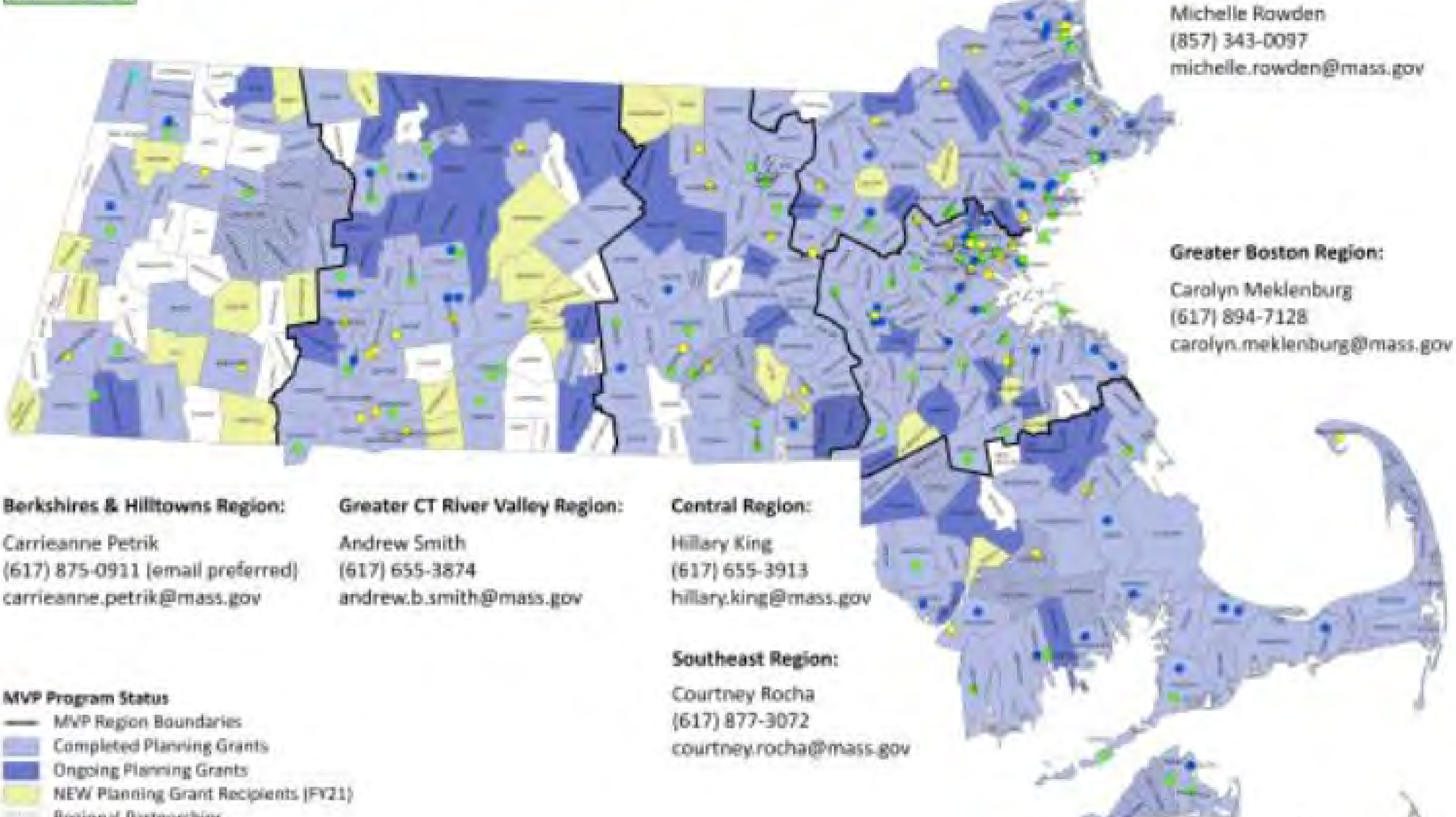
Step 1. **Planning**

The Harvard Gazette

Step 2. **Action!**

Municipal Vulnerability Preparedness (MVP) Program

Program Manager: Kara Runsten, (617) 312-1594, kara.runsten@mass.gov



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Greater CT River Valley Region:

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Central Region:

Hillary King
(617) 655-3913
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Southeast Region:

Courtney Rocha
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courtney.rocha@mass.gov

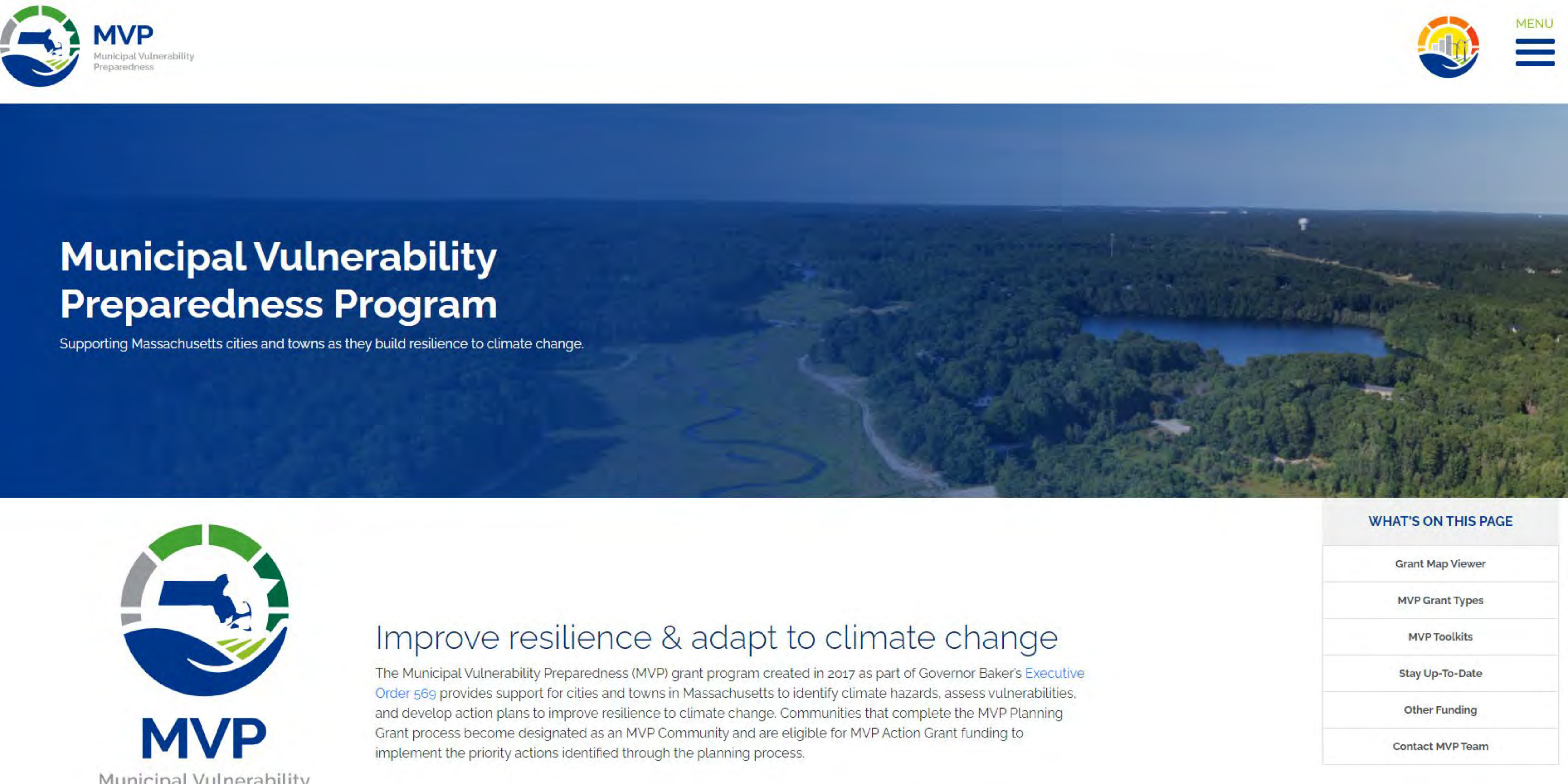
MVP Action: Mattapoisett, MA

Land Acquisition

Buzzards Bay Coalition

Purchased 120 acres of forest, streams, freshwater wetlands and coastal salt marsh to prevent development in vulnerable areas

MVP Website: resilientma.org/mvp

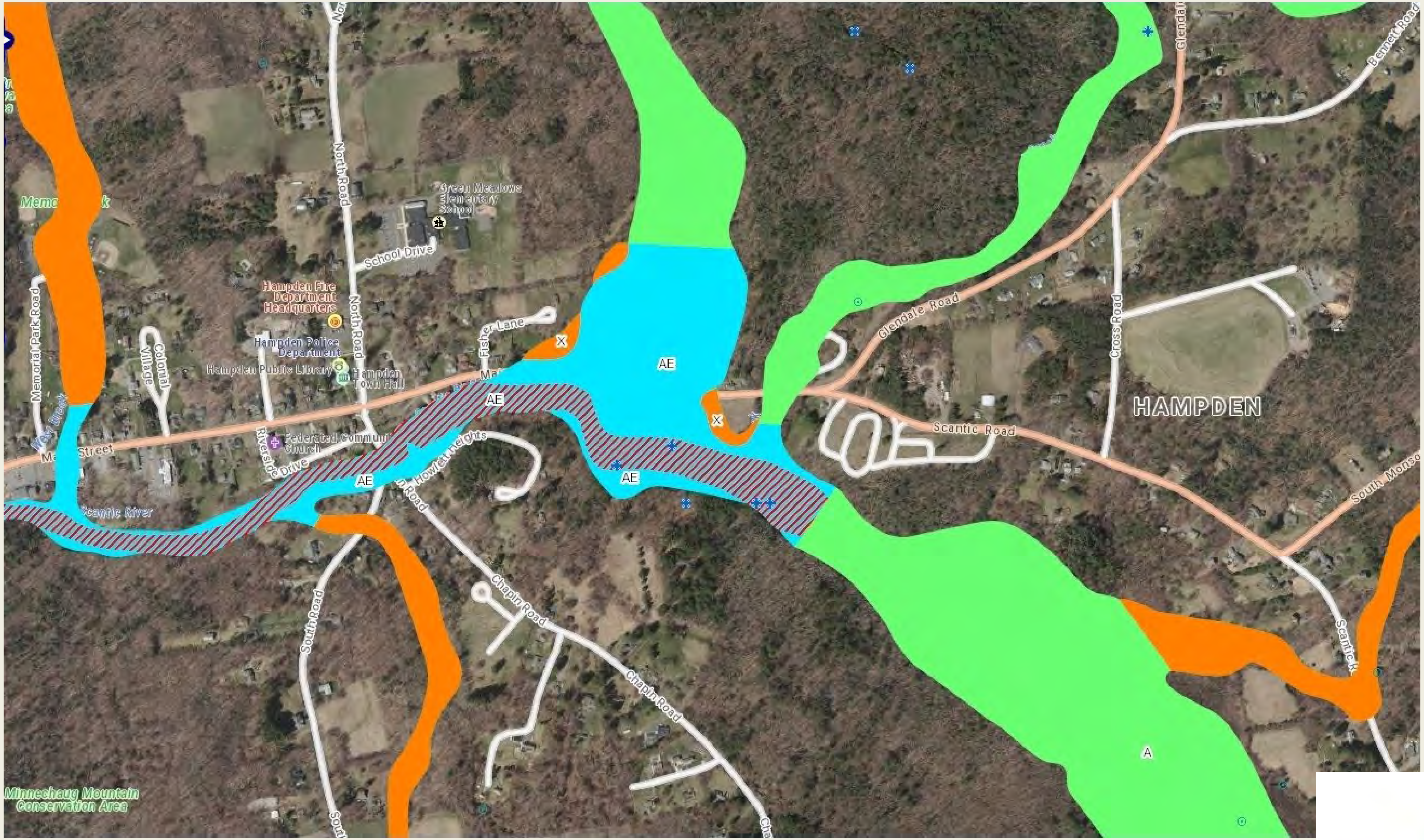


MVP Planning Process

Community Resilience Building Workshop

- Core team meeting
- Community Resilience Building Workshop
- Summary of findings
- Listening session
- Implementation

Main Street Flood Map



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Hampden Main Street over Big Brook Culvert

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Hampden Main Street over East Brook Culvert (Bridge No. H-04-008)

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Questions?

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