Town of Hanson Community Resilience Building Workshop Summary of Findings

Old Colony Planning Council, January 2021

Community Resilience Building Workshop

Summary of Findings

To prepare for the development of this MVP-HMP Plan, the Town of Hanson followed the process described in the Community Resilience Building Workshop Guidebook, which was developed by The Nature Conservancy. [1]

The Guidebook provides a clear approach on how to organize the public process for mitigating the impacts of, and increasing resilience against, natural hazards and climate change. An important aspect of the natural hazard and climate change impact mitigation planning process is the discussion it promotes among community members about creating a safer, more resilient community.

The Workshop's central objectives were to:

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

Developing a plan that reflects the Town of Hanson's values and priorities is likely to produce greater community support and result in greater success in implementing mitigation strategies that reduce risk.

The natural hazard mitigation planning process for the Town of Hanson included the following tasks:

- ► Integrating with the Municipal Vulnerability Preparedness (MVP) certification process.
- ► Identifying the natural hazards that may impact the community.
- ► Conducting a Vulnerability/Risk Assessment to identify the infrastructure at the highest risk for being damaged by the identified natural hazards, particularly flooding.
- ► Identifying and assessing the policies, programs, and regulations the community is currently implementing to protect against future disaster damages.
- ► Identifying deficiencies in the current strategies and establishing goals for updating, revising, or adopting new strategies

The key product of the Hazard Mitigation portion of this integrated process is the development of a Hazard Mitigation Action Plan with a Prioritized Implementation Schedule.

[1] **The Nature Conservancy, "Community Resilience Building Workshop Guide."**

Stakeholder Engagement and Public Participation

Hazard Mitigation portion of this integrated process is the development of a Hazard Mitigation Action Plan with a Prioritized Implementation Schedule. The process for developing Hanson's Hazard Mitigation Plan 2020 is summarized below.

Table 1: Stakeholder Engagement

Section	Reviews and Updates
Committee Meetings and Public Meeting	This Local Hazard Mitigation Plan update took place during the COVID-19 pandemic, so in person community engagement was not possible on the final plan so we transitioned from in-person to virtual and on-line meetings. A virtual community meeting was scheduled after the plan update was posted on the town website for public comment. The hazard mitigation plan process was integrated with the MVP Community resilience Building (CRB), there was significant stakeholder participation prior to the pandemic at the CRB workshop on 02/07/2020.
Risk Assessment	OCPC gathered the most recently available hazard and land use data and met with Town staff to identify changes in local hazard areas and development trends. Town planner reviewed critical infrastructure with OCPC staff to create an up-to-date list. The hazard mitigation process was complemented by the Town's MVP process and CRB workshop process that engaged key community, regional and state stakeholders.
Hazard Mitigation and Climate Adaptation Strategies	The list of existing mitigation measures was updated to reflect current mitigation activities in the town and enhanced by the concurrent MVP CRB process.
Hazard Mitigation and Climate Adaptation Strategies; Prioritized Implementation Schedule	Mitigation measures from the 2015 OCPC Regional Hazard Mitigation Plan were reviewed and assessed as to whether they were completed, in progress, or deferred. The Committee determined whether to carry forward measures into the 2020 Plan update or modify or delete them. The Plan Update's hazard mitigation strategy reflects both new measures and measures carried forward from the 2015 plan. The Core Team prioritized all these measures based on current conditions.
Plan Adoption and Maintenance	This section of the plan was updated with a new on-going plan implementation review and five-year update process that will assist the Town in incorporating hazard mitigation issues into other Town planning and regulatory review processes and better prepare the Town for the next comprehensive plan update.

Community Resilience Building (CRB) Workshop

FEMA has developed a Local Mitigation Plan Review Guide to assist federal and state officials in their efforts to ensure Local Mitigation Plans meet the Stafford Act and Title 44 Code of Federal Enforcement requirements in a fair, equitable, and consistent manner. FEMA utilizes the review guide as an official source for interpreting and defining the statutory and regulatory requirements of Local Mitigation Plans. It also is designed to help practitioners have a clear understanding of technical requirements and approaches to meet the requirements as they facilitate the development of plans.

Community Resilience Building Workbook Guidebook

The Community Resilience Building Workshop Guidebook provides a process for developing resilience action plans. The process has been implemented and successful in over three hundred communities. [2]

Federal regulation for HMP approval requires that stakeholders and the public be provided opportunities to be involved during the planning process and in the plan's maintenance and implementation. Community members can therefore provide input that can affect the content and outcomes of the mitigation plan. The planning and outreach strategy used to develop this MVP-HMP Plan had three tiers:

1. The ***Core Team,*** with representation from municipal leadership at the Town of Hanson
2. ***Stakeholders*** who could be vulnerable to, or provide strength against, natural hazards and/or climate change.
3. The ***public***, who live and work in the Town.

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[2] **The Nature Conservancy, "Community Resilience Building."**

Hanson CRB Planning Activities

The CRB process began with the establishment of a Core Team comprised of municipal staff members. Core Team meetings involved developing a broad understanding of the Hazards, Vulnerabilities, and Strengths that characterize the Town of Hanson, and to identify a list of Preliminary Resilience Actions that the community may consider at the CRB Workshops. Core Team meetings were also used to identify the goals of the workshop within the context of community interests and needs. Public climate data sources provided on the Massachusetts Data Clearinghouse Website, www.resilientma.org were also introduced to workshop participants.

Workshop participants included a diverse set of community stakeholders from municipal departments, local businesses, non-government entities, and local interest groups. The Workshop involved a series of stakeholder breakout working sessions, group discussion, interactive online GIS data presentations, and presentations focused on Nature-based solutions, Hazard Mitigation Planning, and Social Vulnerability in the community.

The Core Team provided information on hazards affecting the Town, identified critical infrastructure, identified key stakeholders, reviewed the status of existing mitigation measures, and developed proposed mitigation measures for this plan. The combination of institutional knowledge within workshop group planning efforts expanded upon Core team Planning efforts to prioritize actions. The workshop concluded with a group discussion intended to identify interdependent project types that may be eligible for funding under the MVP program or other Massachusetts grant sources. Climate resilience planning requires an ongoing effort by community stakeholders. Workshop attendees and other interested stakeholders are encouraged to provide comments, corrections, updates, or additional information of findings transcribed in this report to Laurie Muncy at lmuncy@ocpcrpa.org. The success of climate resilience planning in Hanson is contingent upon ongoing participation of community stakeholders.

Figure 1: CRB Workshop Discussions

Core Team

CORE TEAM MEMBER	DEPARTMENT
Deborah Pettey, Esquire	Town Planner
Michael Miksch	Police Chief
Jerry Thompson	Fire Chief, Emergency Management
Jerry Davis	Water Department
Philip Clemons	Conservation Commission Chair
Mathew Dyer	Hanson Selectmen
Merry Marini	Board of Selectmen, Administrative Assistant
David Hanlon	Highway Department
Jamison Shaves	Highway Department
Curt Maclean	Highway Department
Gil Amado	Board of Health Agent
Mary Collins	Elder Affairs, Director
Robert Moran, Jr.	National Grid
Ernie Sandland	WH Regional School District
Joe Cardinal	National Grid
Kathleen Clark	Housing Authority
Tim White	Veterans Agent
Tim Harhen	East Bridgewater Fire Chief
Frank Schellenger	Hanson Conservation Agent
Jeff Szymaniak	Superintendent WH Regional School District
Matthew Cahill	Hanson Highway Dept
George Ferris	WH Regional School District
Josh Bowen	All American Assisted Living
Don Howard	Hanson Water Commissioner
Bruce Hughes	Old Colony Planning Council

Core Team Meetings

CORE TEAM MEETING DATES	TOPICS
Planning Grant Kickoff Meeting 10/28/2019	MVP Kickoff Goals and Objectives
Core Team Meeting	Core Team Community Engagement Plan
Task Force Meeting #1 11/26/2019	MVP Kickoff Meeting – Project Introduction, Climate Vulnerability Assessment, Municipal Vulnerability Preparedness, Community Engagement Plan, Task Force Role and Meetings
Task Force Meeting #2 01/09/2020	Identification of Climate Concerns: Precipitation, Drought, Flooding, Fire, Windstorms
CRB Workshop 02/07/2020 Part 1	Intro to Climate Change and MVP, Hanson Climate Change Vulnerability, Identification of Risk Areas and Community Strengths
CRB Workshop 02/07/20 Part 2	Create Climate Actions, Prioritize Climate Actions, Large Group Report Out, Community Resilience Building, Prioritize Top Resilience Actions – Engagement Exercise
February 2, 2021	Public Listening Session #1 – Integrated MVP/HMP Planning On-line

Workshop Participants

CRB Workshop Attendees	Department or Agency
Curt MacLean	Hanson Highway Department
David Hanlon	Hanson Highway Department
Gilbert Amado	Hanson Board of Health
Michael Miksch	Hanson Police Department
Jerome Thompson	Hanson Fire Department
Robert Moran, Jr.	National Grid
Ryan McGonigh	Hanson Technology
Mary Collins	Hanson Elder Affairs
John Stanbrook	Hanson Town Administrator
Allan Clemons	Town Historian
Philip Clemons	Chairman, Hanson Conservation Commission
Frank Schellenger	Hanson Conservation Agent
Wesley Blaus	Hanson Selectmen
Donald Ellis	Chairman, Hanson Planning Board
Bill Boyle	Hanson Recreation
Dori Jamieson	Hanson Recreation
Matthew Dyer	Hanson Selectmen
Ernest Sandland	WHRSD
Courtney Rocha	Massachusetts State MVP Program
Josh Bowen	AAAL
Laurie Muncy	Old Colony Planning Council
Bruce Hughes	Old Colony Planning Council
Joanne Zygmunt	Old Colony Planning Council
Jimmy Pereira	Old Colony Planning Council
Bill Napalitano	SRPEDD
Sara Burns	The Nature Conservatory

Figure 2: CRB Workshop

Top Hazards

The following hazards were identified by Hanson stakeholders during the MVP CRB planning process and community engagement efforts:

1. ***Flood/Drought*** – The Northeast has already experienced a larger increase in the intensity of rainfall events than any other region in the US in the last fifty years, a trend that is expected to continue.
2. ***Extreme Storms/Wind*** – Hazardous wind conditions most commonly accompany extreme storm events. High winds and microburst conditions present unique hazards to infrastructure, public safety, and important natural resources.
3. ***Extreme Temperature Fluctuations*** – Extreme heat events are expected to become more frequent and intense. Storm events fueled by higher temperatures, increased evaporation, and atmospheric moisture leads to stormy weather of increased duration and intensity.
4. ***Fire*** – Rising temperatures and changes in precipitation increase the risk of wildfire/brushfire.

Figure 3: CRB Core Team Meeting #2

Previous Federal/State Disasters

Since 1978, there have been 26 natural hazard events that triggered federal or state disaster declarations that included Plymouth County. These are listed in Table 2 below. Most of these events involved flooding, while others were due to hurricanes or nor'easters, and severe winter weather.

Table 2: Presidentially Declared Disasters, 1978 to 2018

Disaster Name & Declaration Number	Disaster Declaration Number	Date of Event	Declared Areas
Blizzard & Snowstorms	EM-3059 MA	Feb 7, 1978	Statewide
Coastal Storm, Flood, Ice & Snow	DR-546 MA	Feb 6, 1978	Statewide
Hurricane Gloria MA	DR-751	Sept. 27, 1985	Statewide
Hurricane Bob MA	DR-914	August 1991	Counties of Barnstable, Bristol, Dukes, Essex, Hampden, Middlesex, Plymouth, Nantucket, Norfolk, Suffolk
Severe Coastal Storm (The Perfect Storm) MA	DR-920	October 1991	Counties of Barnstable, Bristol, Dukes, Essex, Hampden, Middlesex, Plymouth, Nantucket, Norfolk, Suffolk
Winter Coastal Storm MA	DR-975	December 1992	Counties of Barnstable, Dukes, Essex, Plymouth, Suffolk
March Blizzard	EM-3103	March 1993	Statewide
Blizzard DR-1090		January 1996	Statewide
Severe Storms, Flood MA	DR-1142	October 20, 1996	Counties of Essex, Middlesex, Norfolk, Plymouth, Suffolk
Heavy Rain, Flood MA	DR-1224	June 1998	Counties of Bristol, Essex, Middlesex, Norfolk, Suffolk, Plymouth, Worcester
Severe Storms, Flood MA	DR-1364	March 2001	Counties of Bristol, Essex, Middlesex, Norfolk, Suffolk, Plymouth, Worcester
Snow MA	EM-3165	April 2001	Statewide
Snowstorm	EM-3175	February 2003	Statewide
Snowstorm	EM-3191	December 2003	Barnstable, Berkshire, Bristol, Essex, Franklin, Hampden, Hampshire, Middlesex, Norfolk, Plymouth, Suffolk, Worcester
Blizzard	EM-3201	January 2005	Statewide
Hurricane Katrina	EM-3252	August 2005	Statewide
Severe Storms, Flooding	DR-1614	October 2005	Statewide
Severe Storm, Inland, Coastal Flooding	DR-1701	April 2007	Statewide
Severe Storms, Flooding	DR-1813	December 2008	Statewide
Severe Storms, Flooding MA	DR-1895	March/April 2010	Bristol, Essex, Middlesex, Suffolk, Norfolk, Plymouth, Worcester
Hurricane Earl MA	EM-3315	September 2, 2010	Worcester, Middlesex, Essex, Suffolk, Norfolk, Bristol, Plymouth, Barnstable, Dukes, Nantucket
Tropical Storm Irene	EM-3330	August 2011	Barnstable, Berkshire, Bristol, Dukes, Franklin, Hampden, Hampshire, Norfolk, Plymouth
Hurricane Sandy	EM-3350/DR-4097	October/November 2012	Barnstable, Bristol, Dukes, Nantucket, Plymouth, Suffolk
Severe Winter Storm, Snowstorm and Flooding	DR-4110	February 2013	Statewide
Severe Winter Storm, Snowstorm, Flooding MA	DR-3214	January 26-28, 2015	Worcester, Middlesex, Essex, Norfolk, Suffolk, Bristol, Plymouth, Barnstable, Dukes, Nantucket
Severe Winter Storm and Flooding	DR-4372	March 2, 2018	Essex, Norfolk, Plymouth, Bristol, Barnstable, Nantucket

Source: MA State Hazard Mitigation and Climate Adaptation Plan, 2018; FEMA 2019, FEMA Disasters, 2020

Critical Infrastructure in Hazard Areas

Participants of the Workshop identified the following Critical Infrastructure located in Hazard Areas.

Table 3: Critical Infrastructure in Hazard Areas

ID	Facility	Name	Address or Water crossing	FEMA Flood Zone	100-Year Wind Event (MPH)	Average Annual Snowfall	Wildfire Susceptibility (Vegetation)	Peak Ground Acceleration Zone
1	Bridge	Main Street Bridge	Poor Meadow Brook	AE	120	36" – 48"	Mixed Deciduous Coniferous	Zone 4
2	Bridge	State Street Bridge	Indian Head River	AE	120	36" – 48"	N/A	Zone 4
3	Dam	Burrage Pond Dam	Burrage Pond	N/A	120	36" – 48"	N/A	Zone 4
4	Dam	Burrage Upper Reservoir Dam	Burrage Pond	N/A	120	36" – 48"	Coniferous Upland Forest	Zone 4
5	Dam	Chandler Mill Pond Dam	Chandler Mill Pond	N/A	120	36" – 48"	N/A	Zone 4
6	Dam	Factory Pond Dam	Factory Pond	AE	120	36" – 48"	N/A	Zone 4
7	Dam	Indian Head Dam	Indian Head River	AE	120	36" – 48"	N/A	Zone 4
8	Dam	Wampatuck Pond Dam	Wampatuck Pond	AE	120	36" – 48"	Mixed Deciduous Coniferous	Zone 4
9	Fuel Station	Cumberland Farms	2 Main St	N/A	120	36" – 48"	N/A	Zone 4
10	Fuel Station	Hess	318 Main St	N/A	120	36" – 48"	N/A	Zone 4
11	Fuel Station	Main St Auto	1158 Main St	N/A	120	36" – 48"	N/A	Zone 4
12	Fuel Station	Sunoco	527 Liberty St	N/A	120	36" – 48"	N/A	Zone 4
13	Fuel Station	Super Petroleum	507 Monponsett	N/A	120	36" – 48"	N/A	Zone 4
14	Fuel Storage	Super Petroleum	507 Monponsett	N/A	120	36" – 48"	N/A	Zone 4
15	Tier II Site	Verizon	162 Industrial Blvd	N/A	120	36" – 48"	N/A	Zone 4
16	Library	Hanson Public Library	132 Maquan St	N/A	120	36" – 48"	N/A	Zone 4
17	Public Works	Highway Department	797 Indian Head St	N/A	120	36" – 48"	N/A	Zone 4
18	School Mass Care Shelter	Hanson Middle School	111 Liberty St	N/A	120	36" – 48"	N/A	Zone 4
19	School Childcare	Indian Head School	726 Indian Head St	N/A	120	36" – 48"	N/A	Zone 4
20	School	Maquan Elementary School	38 School St. Closed	N/A	120	36" – 48"	N/A	Zone 4
21	School	Whitman-Hanson Regional High School	600 Franklin St	N/A	120	36" – 48"	N/A	Zone 4
22	Senior Center	Council on Aging	132 Maquan	N/A	120	36" – 48"	N/A	Zone 4
23	Town Hall	Town Hall	542 Liberty St	N/A	120	36" – 48"	N/A	Zone 4
24	Transfer Station	Transfer Station	201 Franklin	N/A	120	36" – 48"	N/A	Zone 4
25	Fire Emergency	Fire Station	505 Liberty St	N/A	120	36" – 48"	N/A	Zone 4

	Operations Center							
26	Fire Tower	Bonney Hill Fire Tower	N/A	N/A	120	36" – 48"	N/A	Zone 4
27	Health Medical	Closed Medical Facility	104 Liberty St	N/A	120	36" – 48"	Mixed Deciduous Coniferous	Zone 4
28	Police	Police Station	775 Main St	N/A	120	36" – 48"	N/A	Zone 4
29	Airport	Cranland Airport	777 Monponsett St	N/A	120	36" – 48"	N/A	Zone 4
30	Childcare	First Step Preschool	56 Jerrold St	N/A	120	36" – 48"	N/A	Zone 4
31	Childcare	Honey Tree Childcare Center	287 Liberty St	N/A	120	36" – 48"	N/A	Zone 4
32	Childcare	Kid's Country	572 Maquan St	N/A	120	36" – 48"	N/A	Zone 4
33	Childcare	Little Treasures Early Learning Center	27 George St	N/A	120	36" – 48"	N/A	Zone 4
34	Cultural Resource	Calvary Baptist Church	429 Monponsett St	N/A	120	36" – 48"	N/A	Zone 4
35	Cultural Resource Childcare	First Baptist Church & Christian Center	214 Main St	N/A	120	36" – 48"	N/A	Zone 4
36	Cultural Resource	First Congregational Church	639 High Street	N/A	120	36" – 48"	N/A	Zone 4
37	Cultural Resource	Hanson Historical Society	565 Main St	N/A	120	36" – 48"	N/A	Zone 4
38	Cultural Resource	Shaw's Supermarket	476 Liberty St	N/A	120	36" – 48"	N/A	Zone 4
39	Cultural Resource	St. Joseph the Worker Church	1 Maquan St	N/A	120	36" – 48"	N/A	Zone 4
40	Housing Authority	Hanson Housing Authority	0 Meetinghouse Lane	N/A	120	36" – 48"	N/A	Zone 4
41	Postal & Shipping	USPS Hanson Office	270 Main St	N/A	120	36" – 48"	N/A	Zone 4
42	Railroad	MBTA Hanson Station	1070 Main St	N/A	120	36" – 48"	N/A	Zone 4
43	Special Needs	Cardinal Cushing Centers	613 Pleasant St	N/A	120	36" – 48"	N/A	Zone 4
44	Special Needs	Cardinal Cushing Centers	5 Sydney Lane	N/A	120	36" – 48"	N/A	Zone 4
45	Special Needs	South Shore Housing	53 West Washington St	N/A	120	36" – 48"	N/A	Zone 4
46	Special Needs	Southeastern Residential Service	111 Nina Dr	N/A	120	36" – 48"	N/A	Zone 4
47	Special Needs	Vinfen	132 Woodbine Ave	N/A	120	36" – 48"	N/A	Zone 4
48	Antenna	SBA Towers II LLC	100 Hawks Ave	N/A	120	36" – 48"	N/A	Zone 4
49	Water Supply Tank	Water Supply Tank	252 High St	N/A	120	36" – 48"	N/A	Zone 4
50	Water Supply Well	Crystal Springs Well Field	1625 Main St	N/A	120	36" – 48"	N/A	Zone 4
51	Potential Well Source	Puritan Way		N/A	120	36" – 48"	N/A	Zone 4

Table 4: Critical Facilities and Evacuation Routes Potentially Affected by Hazard Areas

Critical Facilities and Evacuation Routes Potentially Affected by Hazard Areas			
Hazard Type	**Hazard Area**	**Critical Facilities Affected**	**Evacuation Routes Affected**
Flooding (100-Year)	Poor Meadow Brook	Main Street Bridge	
	Indian Head River	State Street Bridge	
Flooding (Localized)		Roadway	Rt. 14, 27, 58
Severe Snow/Ice Storm	Trees	Roadway	Rt. 14, 27, 58
Hurricane/Severe Wind	Trees	Roadway	Rt. 14, 27, 58
Wildfire/Brushfire	Forest	Roadway	
Dam Failure	Wampatuck Pond Dam	Roadway	
Drought			
Hazardous Materials			

Critical Facilities

Category 1: Emergency Response Services

The Town has identified the Emergency Response Facilities and Services as the highest priority regarding protection from natural and man-made hazards.

Table 5: Emergency Response Services

Category 1: Emergency Response Services.							
Facility	Name	Address or Water crossing	FEMA Flood Zone	100-Year Wind Event (MPH)	Average Annual Snowfall	Wildfire Susceptibility (Vegetation)	Peak Ground Acceleration Zone
Fire Emergency Operations Center	Fire Station	505 Liberty St	N/A	120	36” – 48”	N/A	Zone 4
Police	Police Station	775 Main St	N/A	120	36” – 48”	N/A	Zone 4
Public Works	Highway Department	797 Indian Head St	N/A	120	36” – 48”	N/A	Zone 4

Water Supply Tank	Water Supply Tank	252 High St	N/A	120	36” – 48”	N/A	Zone 4
Water Supply Well	Crystal Springs Well Field	1625 Main St	N/A	120	36” – 48”	N/A	Zone 4
Potential Well Source	Puritan Way		N/A	120	36” – 48”	N/A	Zone 4
Emergency Fuel Station	Highway Dept	797 Main St		120	36” – 48”	N/A	Zone 4
Emergency Electric Power Facility	Police Station	775 Main St	N/A	120	36” – 48”	N/A	Zone 4
Transfer Station	Transfer Station	201 Franklin	N/A	120	36” – 48”	N/A	Zone 4
Senior Center	Council on Aging	132 Maquan	N/A	120	36” – 48”	N/A	Zone 4
Primary Evacuation Routes	Routes 14, 27, 58		N/A		36” – 48”	N/A	Zone 4
Hanson Food Pantry	Food Pantry	228 High St	N/A	120	36” – 48”	N/A	Zone 4

Table 6: Hanson Bridges Spanning Waterways

Roadway	Waterway Spanned	Year Built	Year Rebuilt	AASHTO Rating	Deficiency
Main Street	Poor Meadow Brook	1850	1937	49.9	FO
State Street	Indian Head River	1995		77.6	FO

Category 2: Non-Emergency Response Facilities

The Town has identified these facilities as non-emergency facilities; however, they are considered essential for the everyday operation of Hanson.

Table 7: Non-Emergency Response Facilities

Category 2: Non-Emergency Response Facilities							
Facility	Name	Address	FEMA Flood Zone	100-Year Wind Event (MPH)	Average Annual Snowfall	Wildfire Susceptibility (Vegetation)	Peak Ground Acceleration Zone
Town Hall	Town Hall	542 Liberty St	N/A	120	36” – 48”	N/A	Zone 4
Animal Hospital	VCA Animal Hospital	7055 Main St	N/A	120	36” – 48”	N/A	Zone 4
Transfer Station	Transfer Station	201 Franklin	N/A	120	36” – 48”	N/A	Zone 4
Public Works	Highway Department	797 Indian Head St	N/A	120	36” – 48”	N/A	Zone 4
School Mass Care Shelter	Hanson Middle School	111 Liberty St	N/A	120	36” – 48”	N/A	Zone 4
Emergency Shelter	Senior Center	132 Maquan	N/A	120	36” – 48”	N/A	Zone 4
School Childcare	Indian Head School	726 Indian Head St	N/A	120	36” – 48”	N/A	Zone 4
School	Maquan Elementary School	38 School St. Closed	N/A	120	36” – 48”	N/A	Zone 4
School	Whitman-Hanson Regional High School	600 Franklin St	N/A	120	36” – 48”	N/A	Zone 4
Potential Staging Area	Lite Control Facility	100 Hawks Avenue	N/A	120	36” – 48”	N/A	Zone 4
Medical Flight Staging Area	Cranland Airport	777 Monponsett St	N/A	120	36” – 48”	N/A	Zone 4
Water Storage Tower	Water Tank	228 High St	N/A	120	36” – 48”	N/A	Zone 4

Category 3 – Facilities/Populations to Protect

This third category contains people and facilities that need to be protected in event of a disaster.

Table 8: Facilities and Populations to Protect

Category 3 – Facilities and Populations to Protect							
Facility	Name	Address	FEMA Flood Zone	100-Year Wind Event (MPH)	Average Annual Snowfall	Wildfire Susceptibility (Vegetation)	Peak Ground Acceleration Zone
Housing Authority	Hanson Housing Authority	0 Meetinghouse Lane	N/A	120	36” – 48”	N/A	Zone 4
Senior Living	All American Assisted Living	1074 W. Washington St	N/A	120	36” – 48”	N/A	Zone 4
Senior Center	Council on Aging	132 Maquan	N/A	120	36” – 48”	N/A	Zone 4
Library	Hanson Public Library	132 Maquan St	N/A	120	36” – 48”	N/A	Zone 4
School Mass Care Shelter	Hanson Middle School	111 Liberty St	N/A	120	36” – 48”	N/A	Zone 4
School Childcare	Indian Head School	726 Indian Head St	N/A	120	36” – 48”	N/A	Zone 4
School	Whitman-Hanson Regional High School	600 Franklin St	N/A	120	36” – 48”	N/A	Zone 4
Cultural Resource	Calvary Baptist Church	429 Monponsett St	N/A	120	36” – 48”	N/A	Zone 4
Cultural Resource Childcare	First Baptist Church & Christian Center	214 Main St	N/A	120	36” – 48”	N/A	Zone 4
Cultural Resource	First Congregational Church	639 High Street	N/A	120	36” – 48”	N/A	Zone 4
Cultural Resource	Hanson Historical Society	565 Main St	N/A	120	36” – 48”	N/A	Zone 4
Cultural Resource	St. Joseph the Worker Church	1 Maquan St	N/A	120	36” – 48”	N/A	Zone 4
Historic Cemetery	Fern Hill Cemetery	High St Hanson	N/A	120	36” – 48”	N/A	Zone 4
Employment Centers							

Category 4: Potential Resources

Contains facilities that provide potential resources for services and supplies.

Table 9: Potential Resources

Category 4: Potential Resources							
Facility	Name	Address	FEMA Flood Zone	100-Year Wind Event (MPH)	Average Annual Snowfall	Wildfire Susceptibility (Vegetation)	Peak Ground Acceleration Zone
Cultural Resource	Shaw's Supermarket	476 Liberty St	N/A	120	36" – 48"	N/A	Zone 4
Dental Facility	Hanson Family Dental	604 County Road	N/A	120	36" – 48"	N/A	Zone 4
Dental Facility	Freeman Dental Associates	7 Gorwin Drive	N/A	120	36" – 48"	N/A	Zone 4
Medical Facility	Hanover Wellness & Medical Center	20 East St. Suite 14 Hanover	N/A	120	36" – 48"	N/A	Zone 4
Medical Facility	Pediatric Associates	692 Main St Brockton	N/A	120	36" – 48"	N/A	Zone 4
Medical Facility	Compass Medical Southeast Medical Center	1 Compass Way East Bridgewater	N/A	120	36" – 48"	N/A	Zone 4
Medical Facility	South Shore Women's Heath	689 Bedford St Whitman	N/A	120	36" – 48"	N/A	Zone 4
Medical Facility	Brockton Neighborhood Health Center	63 Main St Brockton	N/A	120	36" – 48"	N/A	Zone 4
Hospital	Pembroke Hospital	199 Oak St, Pembroke					
Hospital	Brockton Hospital	680 Centre St. Brockton					
Hospital	South Shore Hospital	55 Fogg Road, So. Weymouth					
Restaurant	Spiro's Rest.	1064 Main St	N/A	120	36" – 48"	N/A	Zone 4
Restaurant	Meadowbrook	1486 Main St	N/A	120	36" – 48"	N/A	Zone 4
Restaurant	Old Hitching Post	48 Spring St	N/A	120	36" – 48"	N/A	Zone 4
Restaurant	Damien's Rest.	279 Spring St	N/A	120	36" – 48"	N/A	Zone 4
Restaurant	Venus III	252 Main St	N/A	120	36" – 48"	N/A	Zone 4

Hotel	Baymont by Wyndham	149 Main St Kingston	N/A	120	36” – 48”	N/A	Zone 4
Hotel	Country Inn & Suites	50 Christy’s Dr Brockton	N/A	120	36” – 48”	N/A	Zone 4
Hotel	Best Western Rockland	909 Hingham St Rockland	N/A	120	36” – 48”	N/A	Zone 4
Childcare	First Step Preschool	56 Jerrold St	N/A	120	36” – 48”	N/A	Zone 4
Childcare	Honey Tree Childcare Center	287 Liberty St	N/A	120	36” – 48”	N/A	Zone 4
Childcare	Kid’s Country	572 Maquan St	N/A	120	36” – 48”	N/A	Zone 4
Childcare	Little Treasures Early Learning Center	27 George St	N/A	120	36” – 48”	N/A	Zone 4
Building Materials Supply	Hanson’s Ace Hardware	1361 Main St	N/A	120	36” – 48”	N/A	Zone 4
Building Materials Supply	The Home Depot	715 Crescent St Brockton	N/A	120	36” – 48”	N/A	Zone 4
Building Materials Supply	The Home Depot	1149 Hingham St Rockland	N/A	120	36” – 48”	N/A	Zone 4
Building Materials Supply	Lowe’s Home Improvement	108 Old Church St Pembroke	N/A	120	36” – 48”	N/A	Zone 4
Building Materials Supply	Lowe’s Home Improvement	400 Bedford St Abington	N/A	120	36” – 48”	N/A	Zone 4
Heavy & Small Equipment Supply	South Shore Tractor	2 Bert Dr. West Bridgewater	N/A	120	36” – 48”	N/A	Zone 4
Heavy & Small Equipment Supply	Four Seasons Power Equipment	580 Bedford St Whitman	N/A	120	36” – 48”	N/A	Zone 4
Waste Disposal	Waste Network	17 Country Club Cir Pembroke	N/A	120	36” – 48”	N/A	Zone 4
Waste Disposal	Waste Management	207 Plympton St. Middleboro	N/A	120	36” – 48”	N/A	Zone 4
Construction Waste Disposal	James G. Grant Co.	Wolcott Court Readville	N/A	120	36” – 48”	N/A	Zone 4

Dams

There are six dams in Hanson according to the Massachusetts Department of Conservation and Recreation Office of Dam Safety. The Burrage Pond Dam is considered non-jurisdictional and does not fall under the Massachusetts Office of Dam Safety regulatory authority and therefore the information provided is limited.

Table 10: Hanson Dams

Name	Impoundment	Waterway	Hazard Code	Owner
Burrage Upper Reservoir Dam	Burrage Pond	Tri-Stump Brook	Significant	State
Chandler Mill Pond Dam	Chandler Mill Pond	N/A	Low	Private
Factory Pond Dam	Factory Pond	Drinkwater River	Significant	Towns of Hanson and Hanover
Indian Head Dam	Indian Head River	Indian Head River	Low	Town of Hanover
Wampatuck Pond Dam	Wampatuck Pond	Indian Head Brook	Significant	Town
Burrage Pond Dam	Burrage Pond	Great Cedar Swamp	Not Available	Unknown

Factory Pond Dam

Factory Pond is a 51-acre impoundment located on the Indian Head River at Winter Street at an elevation of 48-feet. The Factory Pond is in the North River watershed, on the border between Hanson and Hanover. It is an impoundment of the Drinkwater River formed by a dam near Winter Street behind the Country Ski shop (a former mill site).

The site was formerly the location for a mill and had potential for a variety of recreational uses. The Commonwealth has issued a warning of extremely high mercury levels in the Pond and the Town has posted no fishing or swimming warnings. The pond's margins consist of residential, wooded and swamp areas.

The Factory Pond dam is jointly owned by the Towns of Hanson and Hanover Conservation Commissions. In 2016, the dam was repaired in accordance with an order from the Office of Dam Safety. Hanover and Hanson equally provided the necessary funding to successfully complete the project. The dam is now considered in full compliance.

There is no public access to the lake from the Hanson side, except by abutters and walkers, and by portage. Conservation land (The “Norcross Property”) on King Street could provide access from the Hanson side for canoeing and kayaking if a pathway were built. The main access point currently is via a walkway from Waterford Drive on the Hanover side.

The lake sediment is polluted by mercury and heavy metals, and the lake and adjoining land on the Hanover side is highly contaminated by historic uses. The lake is posted to warn people not to eat the fish. More studies by DEP are ongoing.

Factory Pond is listed in Category 5 of the 2001 Integrated List of Waters due to impairment from metals (MassDEP 2003a). DWM conducted fish toxics monitoring in 1993 that resulted in a site-specific advisory by MDPH due to elevated levels of mercury (MDPH 2004a). The Former Nationals Fireworks, Inc. waste site is considered the likely source of mercury.

Areas of Concern

Infrastructural

Participants of the Workshop identified several infrastructural strengths and weakness in the Town. The new police station and reverse 911 communication systems are considered strengths for the community. Management of stormwater and impacts to groundwater are considered vulnerabilities. Several areas in Town are subject to flooding with culverts that need maintenance and/or replacement.

Table 11: Infrastructural Areas of Concern

Features	Vulnerabilities	Strengths	Priority	Timing
Police Station	Property prone to Flooding	Has a Generator on site	Low	Ongoing
Electrical Grid	Prone to outages tree limbs	National Grid does a good job at maintenance	Low	Ongoing
Road Network	Some roads prone to flooding, Maquan needs resurfacing	Most of the roads are in good condition	Medium	Ongoing
Town Center (Factory Mill Dam, Thomas Mill Dam, Wampatuck Pond Dam)	Prone to flooding, dams in need of repair	Discernable Town Center	High	Short-term
The development of a second well field	None	It is crucial to develop a secondary source of water	High	Ongoing
Septic systems (town-wide) and consideration of tying-in to Whitman sewer system.	Contamination of groundwater and standing water	Education and regulation about septic systems is good in the town	High	Short-Term
Old Dump/Transfer station	Needs to be capped potential toxin leaks in the environment	None	Medium	Short-Term
Woodman Terrace	Culverts need maintenance, High winds, and Fire	Generator	Medium	Ongoing
Helicopter site at Cranland Airport	Adjacent to wetlands, flooding	Alternative transportation mode	Low	Short-Term
Poor Meador RR Viaduct	Erosion	Alternative transportation	Low	Short-Term
Boat Ramps, (Maquan Street and other locations)	Fire, flood	Recreation	Medium	Ongoing
Active Cranberry Bogs (Various locations)	Nutrient runoff and unnatural water flows	Economy and Floodwater storage	Low	Ongoing
Senior Center and Library	No generator on site	Important channel of communication	High	Short-term
High School	None	It has a generator and could serve as cooling and warming center	Low	Ongoing
Reverse 911 system	None	Convenient for communication	Low	Ongoing
Hanover Fireworks	Heavily contaminated – health hazard	None	Low	Ongoing
Commuter Rail Station and RR Tracks	Creates traffic strain on road network	Convenience of Transportation	Low	Long-Term
Woodman Terrace	Vulnerability to high winds and fire	None		

Culverts at various locations (Maquan Street, King Street, Winter Street, Pratt Place, and Indian Head Street high concern)	Flood		High	Ongoing
Ocean Avenue emergency access	Needs Maintenance	Quicker emergency response	Low	Long-Term
Data base of residents with medical needs	Needs maintenance	Quicker emergency response	Low	Ongoing
Industrial Area – (Marijuana growing)	Potential for toxic waste	Economic Development	Medium	Short-Term
Katy Did Lane connection to Camp K and Woodman Terrace (Gated access)	Flood Hazard	Recreation	Medium	Ongoing

Societal

The following societal strengths and vulnerabilities were identified by the Workshop participants. Churches and senior housing properties are vulnerable to fire but provide strength by way of affordable housing and community cohesiveness. The Senior Center provides safety and shelter to aged citizens during inclement weather events but does not have a generator to provide electricity during power outages. This was identified as a priority by Workshop participants.

Table 12: Societal Areas of Concern

Features	Vulnerabilities	Strengths	Priority	Timing
Churches (various locations)	Fire	Community Cohesiveness	Medium	Ongoing
Senior Housing	Fire	Presents affordable living for seniors	Medium	Ongoing
Middle School	Single drive access	Community Cohesiveness	Medium	Ongoing
Evacuation plan	Lack of plan	Will allow for safer evacuation during emergencies	Low	Short-Term
Data base of Town's vulnerable residents	Needs maintenance	Aids in emergency response	Low	Ongoing
Council on Aging – Elder Service	Lack of generator for power outages	Provides shelter to seniors during emergency or storm events	High	Short-Term

Environmental

There are several open spaces in Town that were identified as strengths for use as flood storage during inclement weather events and provide health and recreation benefits. Vulnerabilities result from fire damage, injury from falling branches during windstorms and vector borne diseases.

Table 13: Environmental Areas of Concern

Features	Vulnerabilities	Strengths	Priority	Timing
Town wells at various locations	Potential contamination	Local control over water source	High	Long-Term
The Great and Little Cedar Swamps	Potential Contamination, fire hazard during drought	Conservation of Natural areas	Low	Ongoing

Town trees including street trees	Fire and falling branches on wires	Aesthetics	High	Short Term
Burrage Pond and surrounding cranberry bogs	Potential contamination (Cyanobacteria)	Recreation and water storage	Low	Ongoing
Ponds System - Wampatuck Pond to Maquan Pond to Indian Head Pond.	Flooding and high winds/storms. Drainage problems as waterways clog up, also breeding grounds for mosquitoes, coliform, and Cyanobacteria	Beach, recreation area	High	Ongoing
Overall Town Forest (Health and Management)	Fire, access to forest, vector problems	Provides open space and recreation	High	Ongoing
Little Cedar Swamp, Cushing Pond, Poor Meadow Brook, and the Spring Brook Watershed	Culverts clogging contamination	Flood Storage	Medium	Short-Term
Trail Head Access signs (vector Education)	Vector	Recreation	High	Short-Term

Priority Projects

Table 14: CRB Workshop Mitigation Actions Highest Priorities – Shaded Actions Indicate Highest Priorities

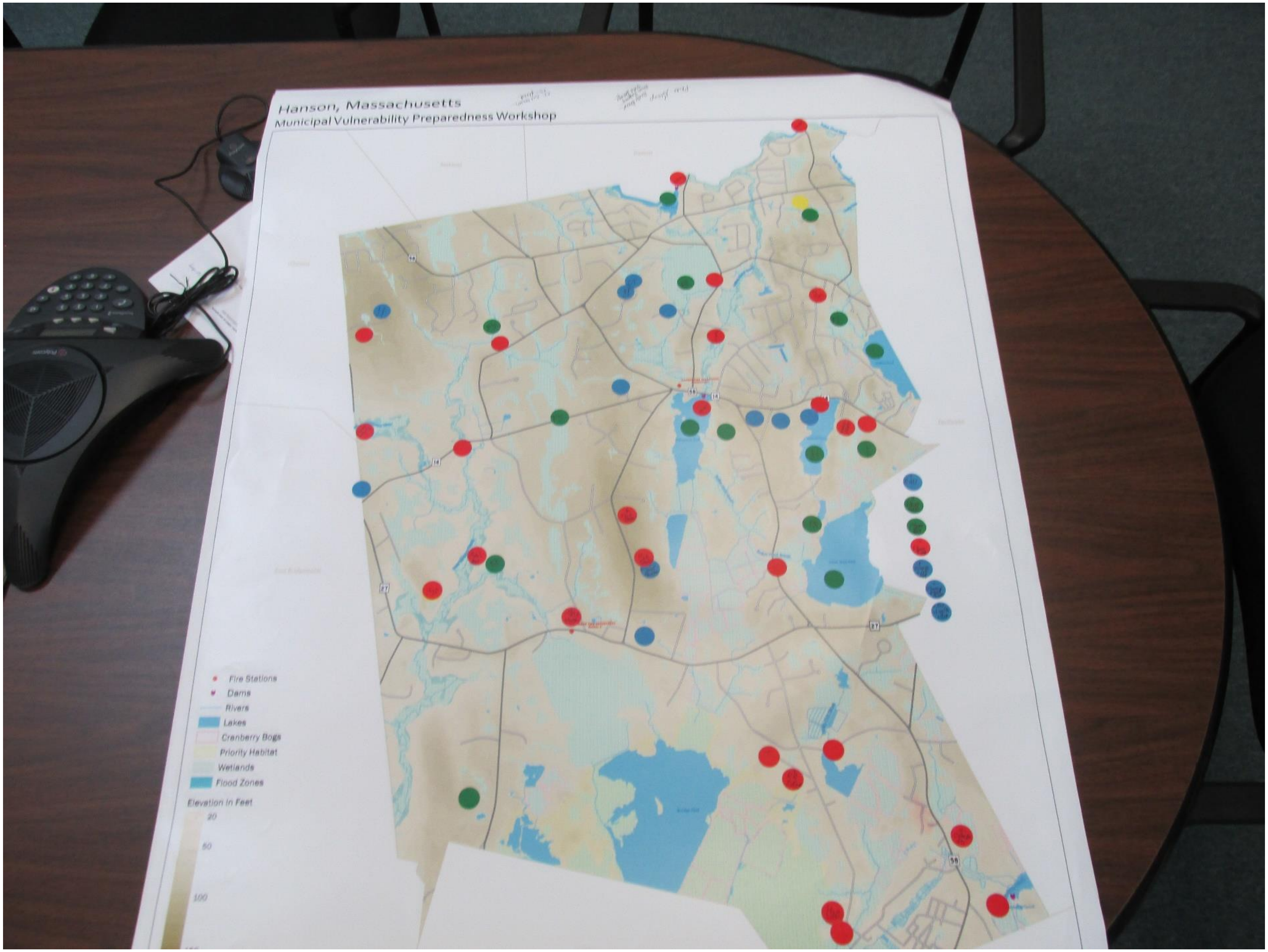
Proposed Strategy	Type of Action	Effectiveness	Lead & Supporting Departments	FEMA Lifeline Supported	Hazards Addressed	Time Frame	Funding Source	Benefit to Community
Continue to identify those areas most in need of flood hazard reduction plans with detailed engineering analysis to identify specific drainage "hot spots" to develop engineering plans to improve bridges, culverts, channels, and other infrastructure, fund the projects and complete them to lessen the likelihood that future floods will cause harm to existing and future buildings.	Infrastructure - Capital Project. ***CRB Workshop identified the former Ocean Spray property on Main Street as a "hot spot" for flooding events which prohibit past and future commercial structures and high priority.***	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact	Board of Selectmen, Conservation Commission, Planning Board, Board of Health, Building Dept	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials	Flood. Hurricane, Tropical Storm	3-5 Years	Staff time, general fund, MVP Action grant	High
As the population of Hanson is aging, it will be important to provide sheltering for seniors during extreme temperature events, power outages. **The Senior Center does not have a generator for power supply.**	Capital Investment Project ***CRB Workshop identified the Senior Center as a vital infrastructure for sheltering the elderly during severe weather events. This facility needs a generator to provide electricity during power failures.***	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact	Board of Selectmen, Elder Affairs, Board of Health, Building Dept, Library	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials	Flood. Hurricane, Tropical Storm, Extreme Temperature events, power failures	1-3 Years	General Fund, MVP Action Grant, other Grant funds	High
As climate change continues to affect the region, it will be important	Infrastructure – Capital Project	Economic Benefit-cost, Social Equity, Adaptive Capacity,	Water Commission, Board of Selectmen	Safety and Security, Food, Water, Shelter	Drought	3-5 Years	General Fund, MVP	High

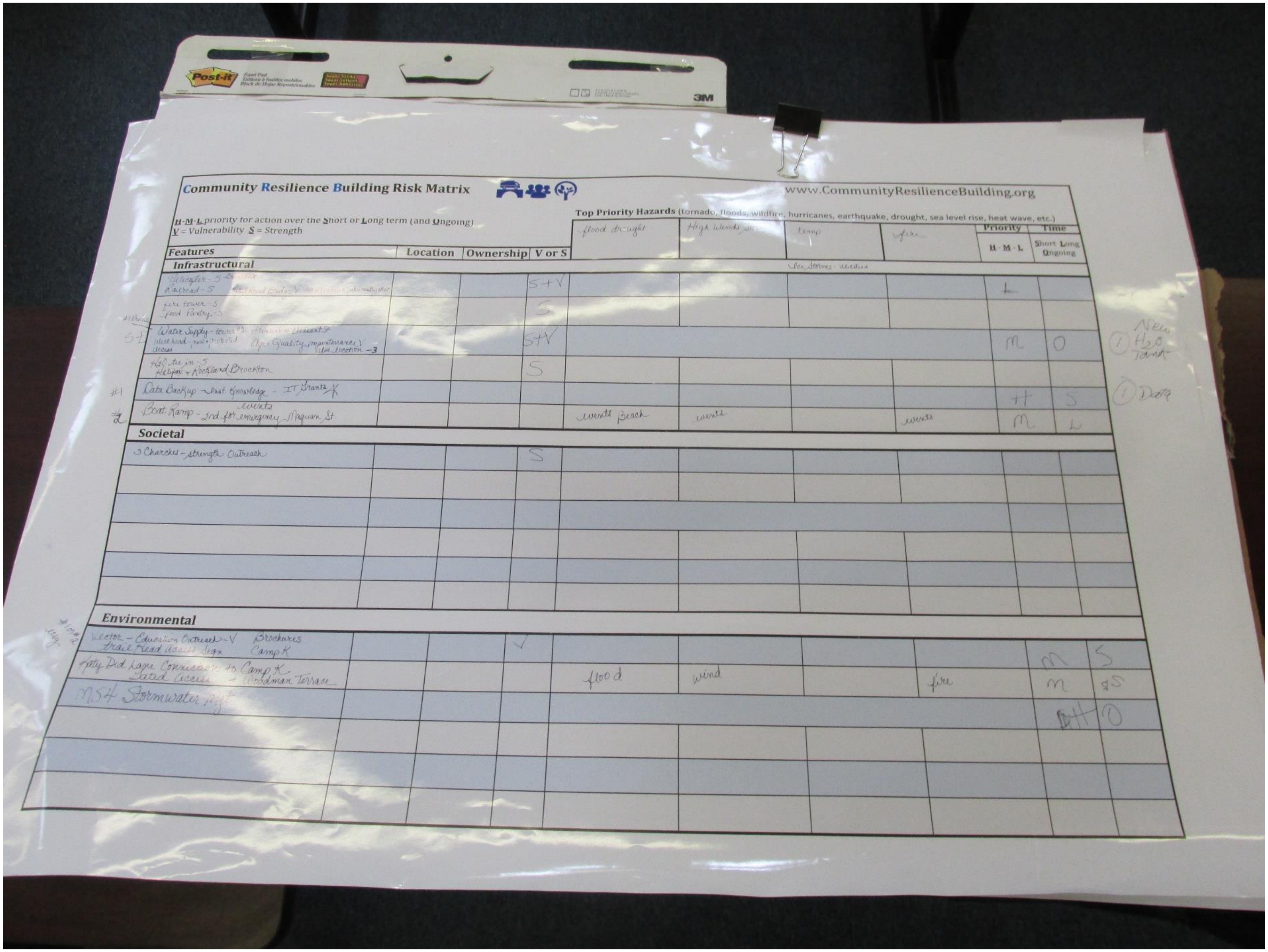
to identify alternative water supplies for time of drought. Consider the development of an alternative groundwater wellhead source.	***CRB Workshop identified funding for the development of a new wellhead on town owned property a high priority.***	Harmonize with existing activity, long-term and lasting impact.					Action Grant, Staff Time	
Research options, cost, funding, and acquisition of back up water resources including increasing storage capacity through the acquisition of a new water tower to avoid water shortages.	Infrastructure – Capital Project ***CRB Workshop identified funding for the construction of a new water storage tower to increase the storage capacity during drought events as a high priority.***	Co-Benefits, Economic Benefit-cost, Adaptive Capacity, Long-term and lasting impact	Water Commission, Board of Selectmen	Food, Water, Shelter, Safety and Security	Drought	>5 years	General Fund, staff time, MVP Action Grant	High
Culvert Maintenance and Repair Plan with long-term implementation. **Inventory and Prioritize culverts for repairs and replacement.**	Infrastructure – Capital Project ***CRB Workshop identified the following culverts at the following locations: Maquan Street, King Street, Winter Street, Pratt Place, Indian Head Street, Crooker Place, Indian Trail, Holly Ridge, Hanson/Halifax Town Line***	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact	Board of Selectmen, Highway Department	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials	Flood	1-3 Years	General Fund, Grant Funding, MVP Action Grant	High
Highway Department Facility	***The CRB Workshop identified the need for a new highway facility as a high priority item. The existing highway***	Preparedness and adaptation,	Board of Selectmen, Town Administration, Highway Dept.	Safety and Security, Transportation, Hazardous Materials	Flood, Severe Storms, Extreme Temperatures , Hurricane & Tropical	3 – 5 Years	General Fund, MVP Action Grant	High

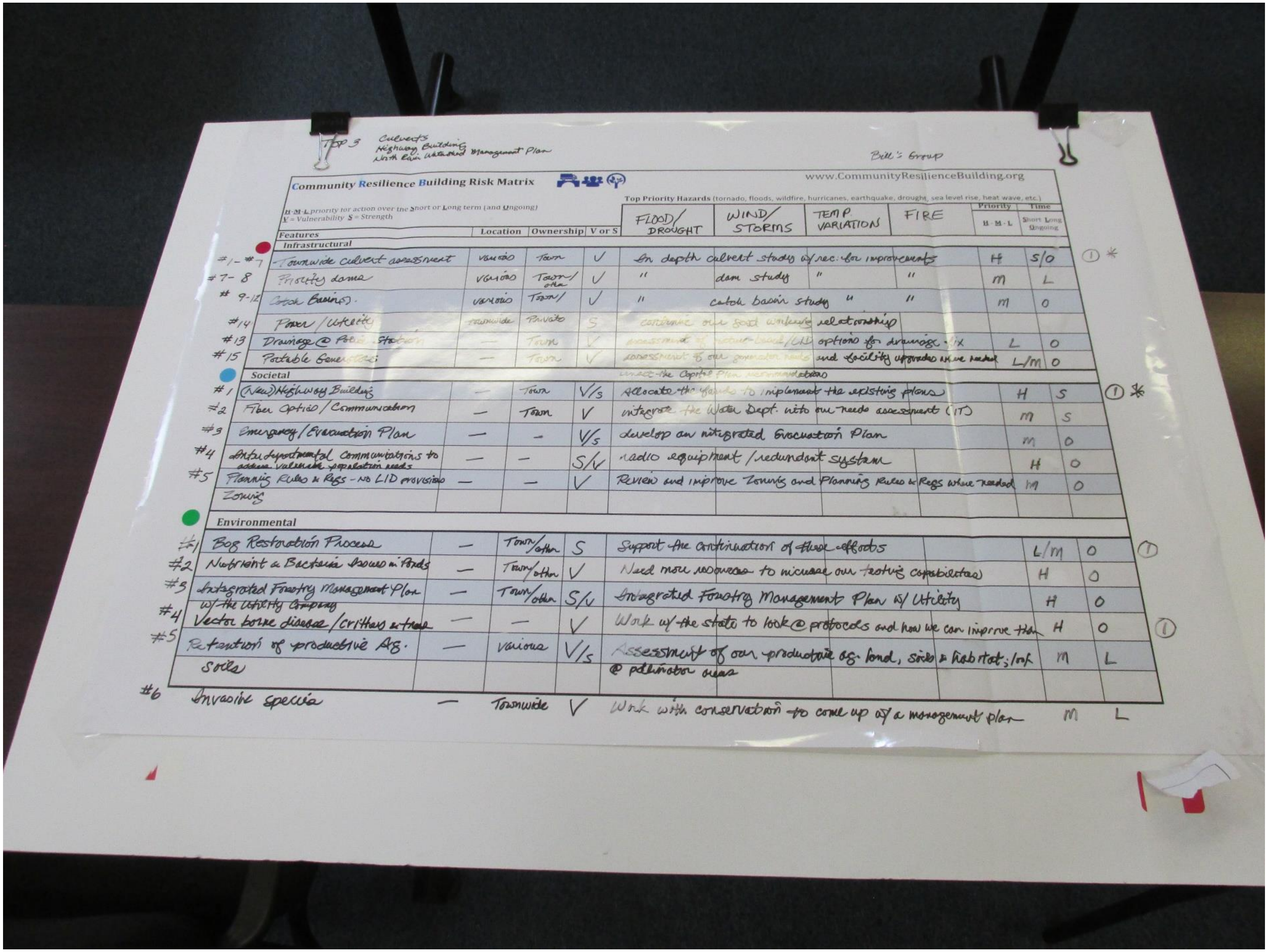
	department is old and needs to be replaced.				Storm, Nor'easters			
Fiber optics and Communication	The Town should integrate the water department into the IT needs assessment	Communication, Preparedness, Safety,	Board of Selectmen, Town Administrator, Emergency Management	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials	Flood, Severe Storms, Extreme Temperatures, Hurricane & Tropical Storm, Nor'easters, Pandemics, Infectious Disease	3 – 5 Years	General Fund, Grant	Medium Priority
Municipal Generator Maintenance	The Town should develop an assessment of generator needs and facility upgrades.	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact	Town Administrator, Facilities Management	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials	All identified hazards	Ongoing	General Fund, Staff Time	Medium
Town should consider a program to backup municipal data	Municipal data should be digitized	Economic Benefit-Cost, Technical soundness, long-term and lasting impact	Town Administrator, Town Clerk	Communications, Preparedness	All identified hazards	1-3 Years	General Fund, Staff Time	Medium
Vector-borne diseases prevention	Implement vector information outreach including placing vector information at trail heads.	Work with state for protocols and improvements to prevent vector-borne diseases in animals, trees, and plants.	Conservation Commission, Board of Health, Parks and Recreation	Safety and Security, Health and Medical, Communications, Infectious and vector-borne diseases	Changes in precipitation, extreme temperatures	1 – 3 Years	General Fund, Staff Time, Grant	High
Invasive Species Management and Integrated Forest Management Plan	Town should work with conservation to develop a management plan	Co-Benefits High Risk and Vulnerability	Conservation Commission	Safety and Security, Food, Water, Shelter, Health and	All identified hazards	1 – 3 Years	General Fund, Staff	High

	with the utility companies	Economic Benefit-Cost, Social Equity, Technical Soundness, Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact		Medical, Energy, Communications, Transportation, Hazardous Materials			Time, Grant	
Open Space Management	The Town should consider utilizing town staff or the creation of a Friends Group to maintain open spaces in Town	Co-Benefits High Risk and Vulnerability Economic Benefit-Cost, Social Equity, Technical Soundness, Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact	Conservation Commission, Highway Department	Safety and Security, Health and Medical, Transportation	Flood, Severe Storms, Extreme Temperatures, Hurricane & Tropical Storm, Nor'easters	1 – 3 Years	General Fund, Staff Time	Low
Dam Safety	Town should fund an engineering study of the Wampatuck Pond Dam and the Pleasant Street Dam at Snake River	Co-Benefits High Risk and Vulnerability Economic Benefit-Cost, Social Equity, Technical Soundness, Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact	Town Administrator, Financial Management, Board of Selectmen, Conservation Commission	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials	Flood, Severe Storms, Extreme Temperatures, Hurricane & Tropical Storm, Nor'easters	>5 Years	General Fund, Grant	Medium
Flooding, Drainage	The property next to the police station should be assessed, and if nature-based solutions can be used to ameliorate the problem.	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity	Town Administrator, Board of Selectmen	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications,	Flood, Severe Storms, Extreme Temperatures, Hurricane & Tropical	3 – 5 Years	General Fund, Grant	Medium

		Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact			Storm, Nor'easters			


Hanson, Massachusetts
Municipal Vulnerability Preparedness Workshop
Fire Stations
Dams
Rivers
Lakes
Cranberry Bogs
Priority Habitat
Wetlands
Flood Zones
Elevation in Feet
20
50
100


Post-it
3M
Community Resilience Building Risk Matrix
www.CommunityResilienceBuilding.org
H-M-L priority for action over the Short or Long term (and Ongoing)
V = Vulnerability S = Strength
Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)
Features
Location
Ownership
V or S
Priority
H-M-L
Time
Short Long
Ongoing
Infrastructural
Societal
Environmental
Data Backup
Boat Ramp
Katy Did Lane
Woodman Terrace
MSH Stormwater
flood
wind
fire



Top 3 Culverts
Highway Building
North River Watershed Management Plan

Bill's Group

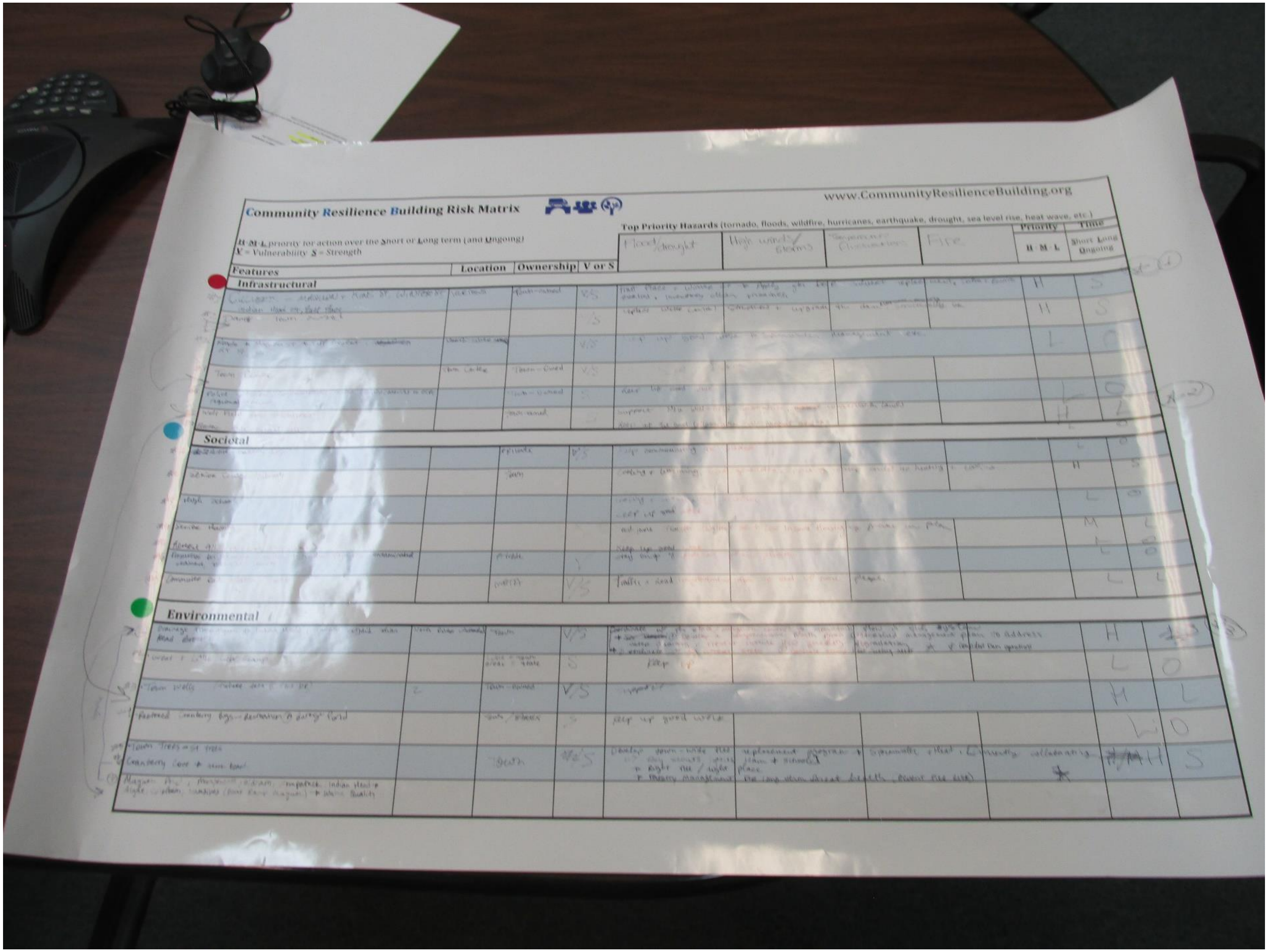
Community Resilience Building Risk Matrix

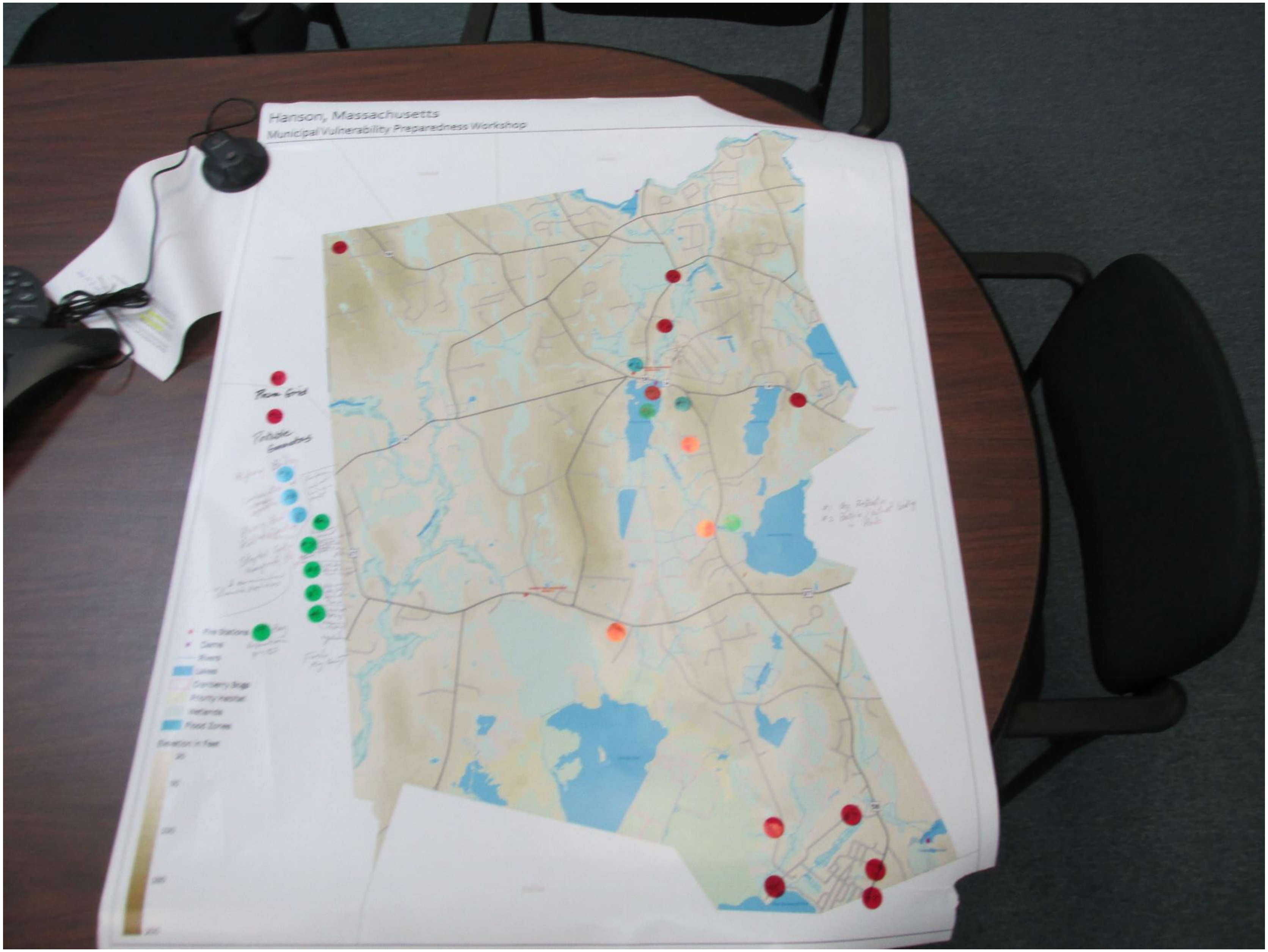
www.CommunityResilienceBuilding.org

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

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

	Features	Location	Ownership	V or S	FLOOD/ DROUGHT	WIND/ STORMS	TEMP VARIATION	FIRE	Priority H-M-L	Time Short Long Ongoing	
	Infrastructural										
#1-#7	Townwide culvert assessment	various	Town	V	In depth culvert study w/ rec. for improvements				H	S/O	① *
#7-8	Priority dams	various	Town/ other	V	"	dam study	"	"	M	L	
# 9-12	Catch Basins	various	Town/	V	"	catch basin study	"	"	M	O	
#14	Power / Utility	Townwide	Private	S	continue our good working relationship						
#13	Drainage @ Police Station	—	Town	V	assessment of nature-based/LID options for drainage fix				L	O	
#15	Portable Generators	—	Town	V	assessment of our generator needs and facility upgrades where needed				L/M	O	
	Societal				enact the Capital Plan recommendations						
#1	(New) Highway Building	—	Town	V/S	Allocate the funds to implement the existing plans				H	S	① *
#2	Fiber Optics / Communication	—	Town	V	integrate the Water Dept. into our needs assessment (IT)				M	S	
#3	Emergency / Evacuation Plan	—	—	V/S	develop an integrated Evacuation Plan				M	O	
#4	Interdepartmental communications to address vulnerable population needs	—	—	S/V	radio equipment / redundant system				H	O	
#5	Planning Rules & Regs - No LID provisions Zoning	—	—	V	Review and improve Zoning and Planning Rules & Regs where needed				M	O	
	Environmental										
#1	Bog Restoration Process	—	Town/other	S	Support the continuation of these efforts				L/M	O	①
#2	Nutrient & Bacteria Issues in Ponds	—	Town/other	V	Need more resources to increase our testing capabilities				H	O	
#3	Integrated Forestry Management Plan w/ the Utility Company	—	Town/other	S/V	Integrated Forestry Management Plan w/ Utility				H	O	
#4	Vector borne disease / critters in trees	—	—	V	Work w/ the state to look @ protocols and how we can improve them				H	O	①
#5	Retention of productive Ag. soils	—	Various	V/S	Assessment of our productive ag. land, soils & habitat; look @ pollinator areas				M	L	
#6	Invasive species	—	Townwide	V	Work with conservation to come up w/ a management plan				M	L	


Community Resilience Building Risk Matrix
www.CommunityResilienceBuilding.org
Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)
H-M-L priority for action over the Short or Long term (and Ongoing)
V = Vulnerability S = Strength
Features
Location
Ownership
V or S
Priority
H - M - L
Time
Short Long Ongoing
Infrastructural
Societal
Environmental


Hanson, Massachusetts
Municipal Vulnerability Preparedness Workshop

HANSON CLIMATE VULNERABILITY ASSESSMENT AND MUNICIPAL VULNERABILITY PREPAREDNESS
AGENDA FOR PUBLIC TASK FORCE MEETING OF
NOVEMBER 26, 2019 AT 1:00 PM
HANSON TOWN HALL, SELECTMEN'S MEETING ROOM

SIGN IN SHEET

	NAME	*AFFILIATION*
1.	DONALD H. HOWARD	WATER COMM
2.	Curt MacLean	Highway
3.	[illegible]	Highway
4.	JAMISON SHAVE	Hwy
5.	Frank Schellenger	Conservation
6.	Gilbert Amado	Health Dept
7.	Mary Collins	Elder Affairs
8.	[illegible] Thompson	Fire
9.	[illegible]	Police
10.	Philip L. Clemons	Conservation Commission
11.	Allan Clemons	C.P.C.
12.	Laurie Muncy	OCPC
13.	[illegible]	OCPC
14.	Samantha Woods	NSRWA
15.	[illegible]	Planner
16.	Meredith Marini	Town Admn
17.		
18.		

HANSON CLIMATE VULNERABILITY ASSESSMENT AND MUNICIPAL VULNERABILITY PREPAREDNESS
AGENDA FOR PUBLIC TASK FORCE MEETING OF
JANUARY 9, 2020 AT 1:00 PM
HANSON TOWN HALL, SELECTMEN'S MEETING ROOM

SIGN IN SHEET

	NAME	*AFFILIATION*
1.	Tracy Seelye	W-H Express (newspaper)
2.	Jerry Davis	Water Dept.
3.	George Ferro	WHRSD
4.	Ernie Sandland	WHRSD
5.	Bob Moran	National Grid
6.	Josh Bowen	All American Assisted Living
7.	Joe Cardinal	National Grid
8.	Kathleen Clark	Hanson Housing Authority
9.	TIM WHITE	HANSON VETERANS
10.	Tim Harhen	East Bridgewater Fire
11.	Phil Clemons	Hanson Con Com
12.	Bruce Hughes	OCPC
13.	Frank Schellenger	Conservation
14.	Mary Collins	Elder Affairs
15.	Bill Boyle	Recreation
16.	Lori Jamieson	Recreation
17.	Jeff Szymaniak	Superintendent WHRSD
18.	Matthew Cahill	Hanson Highway
19.	Don Howard	Water Dept
20.	Laurie Muncy	OCPC
21.		
22.		

Town of Hanson Hazard Mitigation and Municipal Vulnerability Preparedness Plan

Old Colony Planning Council, January 2021

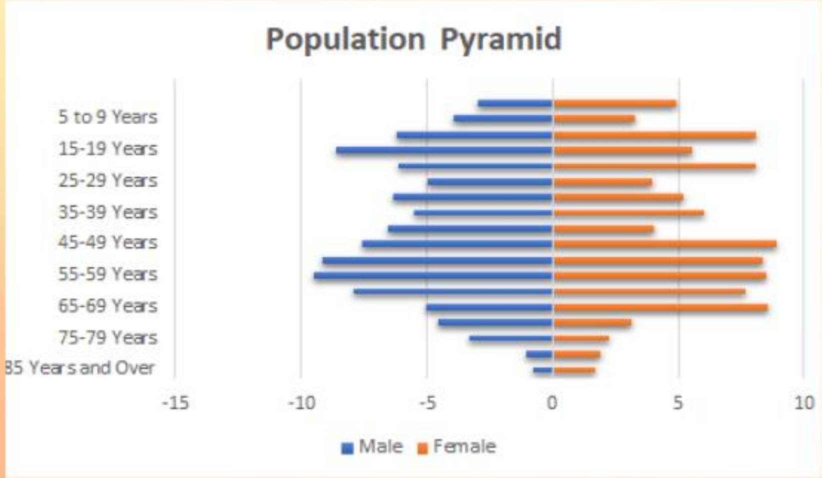
HANSON, MA EXECUTIVE SUMMARY POPULATION DEMOGRAPHICS

3,468
Households

2,711 - 78.2%
Family Households

45.4 YEARS
Female Median Age

44.3 YEARS
Male Median Age



1,378
Households with Children under the age of 18 living with them

396
Female Head of Households

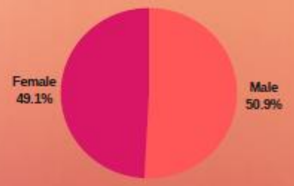
1,126
With a Disability

678
Veterans

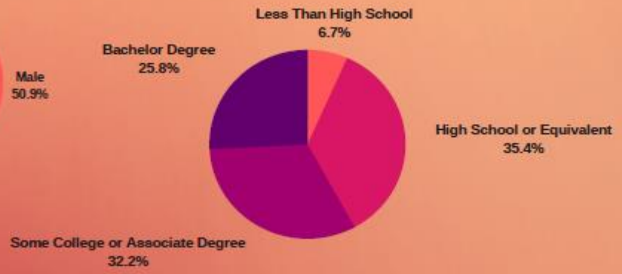
	2000 Census	2010 Census	2018 ACS
Population	9,495	10,209	10,668
Median Age	36.1	40.4	44.9
Under 5 Years	678	532	419
21 years and Over	6,498	7,184	
62 Years and Over	1,010	1,530	
85 Years and Over	59	110	130
Average Households Size	3.03	2.94	
Average Family Size	3.38	3.33	
Owner-Occupied Housing Units	3,123[3]	88.6%[4]	3,495
Renter -Occupied Housing Units	11.0%	11.4%	311
Population Density per square mile	632.5	678.2	

Census Population Data

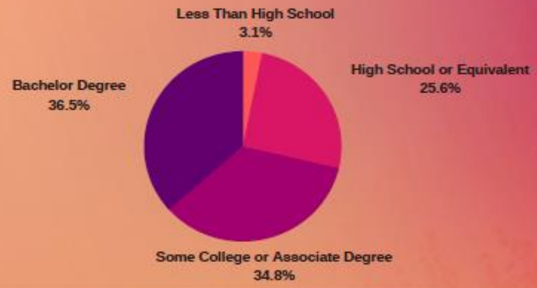
Gender



Male Educational Attainment

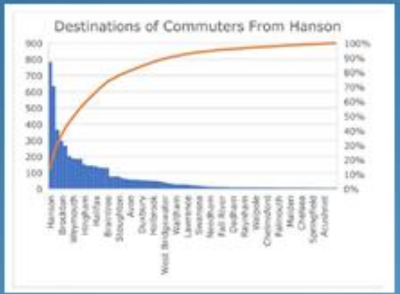


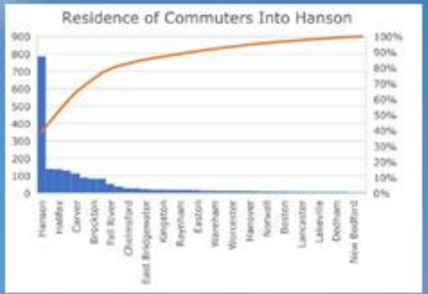
Female Educational Attainment

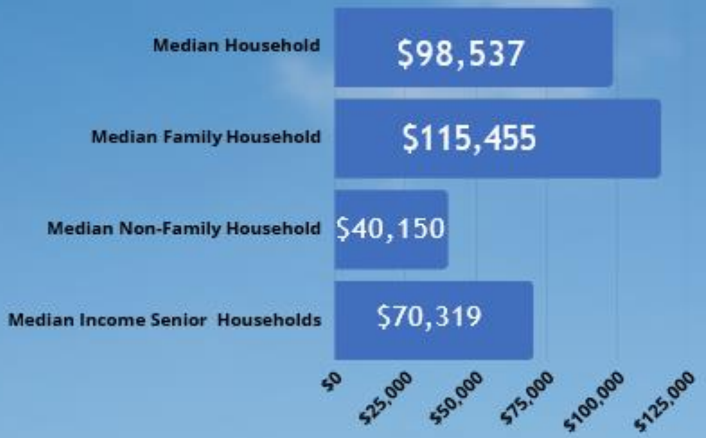


Educational Attainment by Gender

HANSON MA WORKFORCE CHARACTERISTICS







Civilian Labor Force 16+

71.3% Hanson

67.1% State

67.6% Plymouth County

Female Civilian Labor Force 16+

70.0% Hanson

63.4% State

63.7% Plymouth County

Language other than English Spoken at Home

3.5% Hanson

23.6% State

13.2% Plymouth County

People QuickFacts	Massachusetts	Plymouth County	Hanson
Housing			
Housing units, July 1, 2019 (V2019)	2,928,732	209,542	3,903
Owner-occupied housing unit rate, 2014-2018	62.3%	75.9%	91.8%
Median value of owner-occupied housing units, 2014-2018	$366,800	$356,700	$353,400
Median selected monthly owner costs – with a mortgage 2014-2018	$2,165	$2,205	$2,067
Median selected monthly owner costs – without a mortgage, 2014-2018	$786	$805	$729
Median gross rent, 2014-2018	$1,225	$1,227	$775
Building permits, 2019	17,365	1,114	

Means of Transportation	Female	Male	Total
Car, Truck, or Van (Alone)	2,383	2,517	4,900
Car, Truck, or Van (Carpool)	118	247	365
Public Transportation	214	139	353
Walked	10	11	21
Bicycle	0	0	0
Taxicab, Motorcycle, or Other	9	127	136
Worked at Home	152	180	332
Total	2,886	3,221	6,107
Mean Travel Time to Work (Minutes)	35.2	38.4	36.9

Households with Computer and Broadband Internet

94.7% Computer

91.1% Broadband

Persons in Poverty

3.3% Hanson

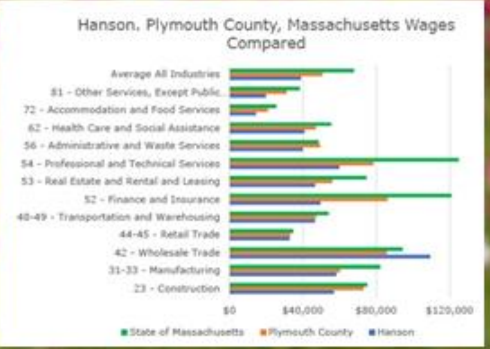
10.0% State

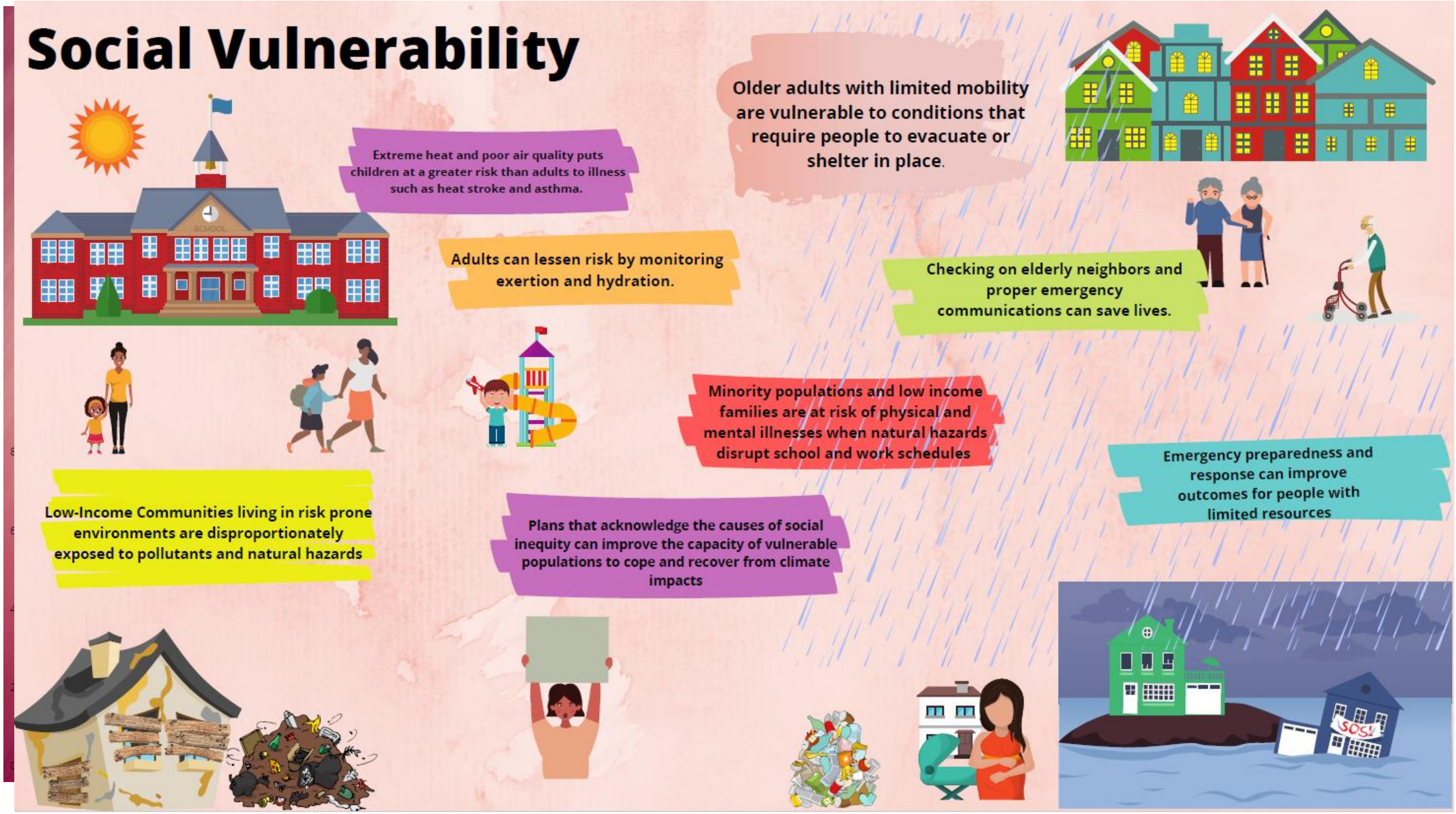
6.2% Plymouth County

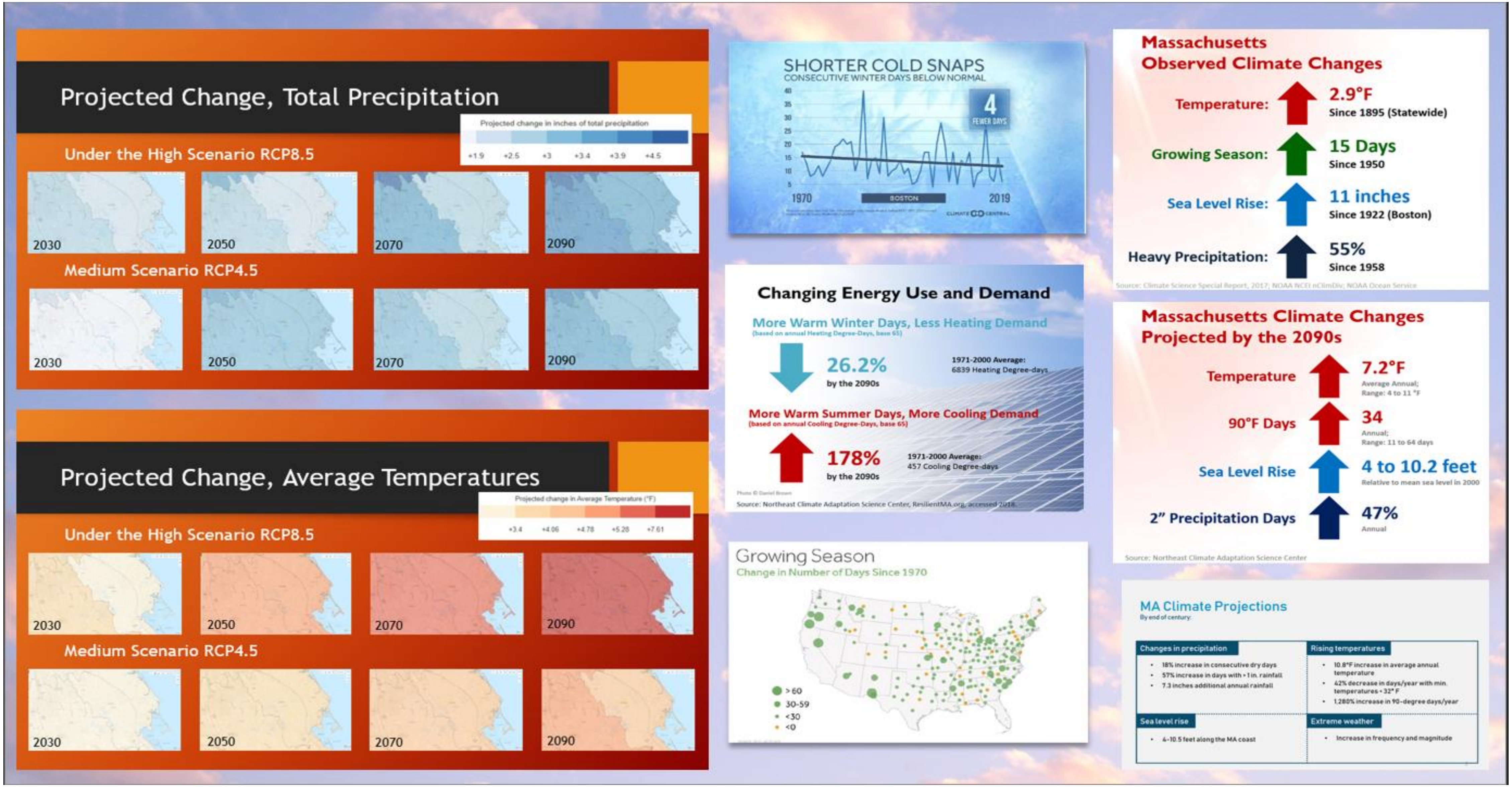
Hanson Persons in Poverty by Gender

1.5% Female

1.8% Male




Social Vulnerability
Extreme heat and poor air quality puts children at a greater risk than adults to illness such as heat stroke and asthma.
Adults can lessen risk by monitoring exertion and hydration.
Older adults with limited mobility are vulnerable to conditions that require people to evacuate or shelter in place.
Checking on elderly neighbors and proper emergency communications can save lives.
Minority populations and low income families are at risk of physical and mental illnesses when natural hazards disrupt school and work schedules
Emergency preparedness and response can improve outcomes for people with limited resources
Low-Income Communities living in risk prone environments are disproportionately exposed to pollutants and natural hazards
Plans that acknowledge the causes of social inequity can improve the capacity of vulnerable populations to cope and recover from climate impacts
SCHOOL
SOS!



Projected Change, Total Precipitation
Projected change in inches of total precipitation
+1.9 +2.5 +3 +3.4 +3.9 +4.5
Under the High Scenario RCP8.5
2030
2050
2070
2090
Medium Scenario RCP4.5
2030
2050
2070
2090
Projected Change, Average Temperatures
Projected change in Average Temperature (°F)
+3.4 +4.06 +4.78 +5.28 +7.61
Under the High Scenario RCP8.5
2030
2050
2070
2090
Medium Scenario RCP4.5
2030
2050
2070
2090
SHORTER COLD SNAPS
CONSECUTIVE WINTER DAYS BELOW NORMAL
4
FEWER DAYS
1970
BOSTON
2019
CLIMATE CENTRAL
Changing Energy Use and Demand
More Warm Winter Days, Less Heating Demand
(based on annual Heating Degree-Days, base 65)
26.2%
by the 2090s
1971-2000 Average:
6839 Heating Degree-days
More Warm Summer Days, More Cooling Demand
(based on annual Cooling Degree-Days, base 65)
178%
by the 2090s
1971-2000 Average:
457 Cooling Degree-days
Source: Northeast Climate Adaptation Science Center, ResilientMA.org, accessed 2018.
Growing Season
Change in Number of Days Since 1970
> 60
30-59
<30
<0
Massachusetts
Observed Climate Changes
Temperature: 2.9°F Since 1895 (Statewide)
Growing Season: 15 Days Since 1950
Sea Level Rise: 11 inches Since 1922 (Boston)
Heavy Precipitation: 55% Since 1958
Massachusetts Climate Changes
Projected by the 2090s
Temperature 7.2°F Average Annual; Range: 4 to 11 °F
90°F Days 34 Annual; Range: 11 to 64 days
Sea Level Rise 4 to 10.2 feet Relative to mean sea level in 2000
2" Precipitation Days 47% Annual
Source: Northeast Climate Adaptation Science Center
MA Climate Projections
By end of century:
Changes in precipitation
• 18% increase in consecutive dry days
• 57% increase in days with > 1 in. rainfall
• 7.3 inches additional annual rainfall
Rising temperatures
• 10.8°F increase in average annual temperature
• 42% decrease in days/year with min. temperatures < 32° F
• 1,280% increase in 90-degree days/year
Sea level rise
• 4-10.5 feet along the MA coast
Extreme weather
• Increase in frequency and magnitude

Acknowledgements

This plan was prepared for the Town of Hanson by the Old Colony Planning Council (OCPC) under the direction of the Massachusetts Emergency Management Agency (MEMA) and the Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA). The plan was funded by the Commonwealth's Municipal Vulnerability Preparedness program.

Old Colony Planning Council (OCPC)

OCPC Officers

President	**Christine Joy**
Treasurer	David Klein
Secretary	Sandra Wright

COMMUNITY	**DELEGATE**	**ALTERNATE**
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Avon	Frank P. Staffier	John Costa
Bridgewater	Sandra Wright	
Brockton		Preston Huckabee, P.E.
Duxbury	Valarie Massard, AICP, CFM	George D. Wadsworth
East Bridgewater		
Easton	Jeanmarie Kent Joyce	
Halifax	Amy Troup	
Hanover		
Hanson	Deborah Pettey	Philip Lindquist
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Plympton	Christine Joy	James Mulcahy
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OCPC Staff

Mary Waldron	**Executive Director**
Charles Kilmer, AICP	Assistant Director/Transportation Program Manager
Shawn Bailey	Transportation Planner
Lila Burgess	Ombudsman Program Director
Paul Chenard	Senior Transportation Planner
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Raymond Guarino	Senior Transportation Planner
Patrick Hamilton	AAA Administrator
Bruce Hughes	Economic Development/Community Planner

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Laurie Muncy, AICP	Director, Community Planning & Economic Development
Jimmy Pereira	Community/Transportation Planner
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Report Citation

Old Colony Planning Council (2021). *Community Resilience Building Workshop Summary of Findings,* Town of Hanson, Massachusetts.

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SECTION 1. INTRODUCTION

Section 1. Introduction

The Town of Hanson prepared a joint Hazard Mitigation Plan and Municipal Vulnerability Preparedness Plan (HMP-MVP Plan) to create an action plan to reduce the impacts of natural hazards and climate change within the community and the region.

To prepare and plan for emergencies that may impact the Town of Hanson and Plymouth County, it is necessary to understand potential hazards, what their history of activity is, and how vulnerable the community is to those hazards. The ***Town of Hanson Hazard Mitigation and Municipal Vulnerability Preparedness Plan*** is the first step in evaluating natural hazards that exist. The hazards identified in this document have the potential of becoming emergencies or disasters that can adversely and irreversibly affect the people, economy, environment, and property of the Town of Hanson.

Local Natural Hazard Mitigation Plans are developed to meet the requirements of federal statutes promulgated under the Stafford Act and Title 44 Code of Federal Regulations (CFR) §201.6.1, mitigation planning regulation in 44 CFR Part 201. This statute defines the requirements of original and updated local mitigation plans for the Federal Emergency Management Agency (FEMA). Old Colony Planning Council completed this Local Natural Hazard Mitigation Plan upon a request from the Town of Hanson.

In 2019, the Town of Hanson applied for and received a Municipal Vulnerability Preparedness (MVP) program planning grant from the Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA) to 1) complete a vulnerability assessment and action-oriented resilience plan (Findings Report) and, 2) update its Hazard Mitigation Plan. These efforts followed the Community Resilience Building (CRB) framework developed by The Nature Conservancy. The CRB framework uses a community-driven workshop process to identify climate-related hazards, community strengths and vulnerabilities, and develop solutions to address these considerations. Completion of the CRB process enables the Town to achieve MVP community designation status from the Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA) and receive preference for future state grants under the MVP program and other participating funding entities.

Study Purpose

The purpose of hazard mitigation is to reduce potential losses from future disasters. The intent of mitigation planning is to maintain a process that leads to hazard mitigation actions. Mitigation plans identify the natural hazards that impact communities, identify actions to reduce losses from those hazards, and establish a coordinated process to implement plans to eliminate and/or mitigate the impacts. [3]

[3] **(44 CFR §201.1(b)**

This plan serves as a basis for the development of plans, public education programs, responder training and exercises. It also lays the foundation to begin mitigation efforts to minimize these identified potential threats.

This plan contains information gathered from public information, in addition to federal, state, and local government sources. It is a living document and will be updated at regular intervals in the future, to document changes in hazards, risks, and vulnerabilities.

Hazard mitigation (including mitigation activity) is defined by FEMA as any sustained action, measure, or project taken to reduce or eliminate risk of future damage, hardship, or loss to human life and property from disasters.[4] Hazard mitigation activities may be implemented prior to, during, or after an event; however, it has been demonstrated that hazard mitigation is most effective when based on an inclusive, comprehensive, long-term plan that is developed before a natural disaster occurs.

The Commonwealth's Climate Change Strategy

The Commonwealth's Global Warming Solutions Act (GWSA) of 2008 created a framework for reducing greenhouse gas (GHG) emissions. The GWSA requires a 25 percent reduction in GHGs from all sectors of the economy below the 1990 baseline emission level in 2020, and at least an 80 percent reduction in 2050, with the goal of helping to avoid the worst impacts of climate change.

In September 2016, Massachusetts Governor Charlie Baker signed Executive Order 569[5] which established an integrated climate change strategy for the Commonwealth. This executive order expands on the objectives of the GWSA to reduce GHG emissions and directs the EOEEA to continue to accelerate efforts to mitigate and reduce GHG emissions. This includes establishing statewide GHG emissions limits for 2030 and 2040, and to promulgate regulations to ensure compliance with the 2020 emissions limit. Section

Executive Order 569 also directs GHG emissions reductions and natural hazard resilience planning to wherever possible to employ strategies that conserve and sustainably employ the natural resources of the Commonwealth to enhance climate adaptation, build resilience, and mitigate climate change. Natural resources, open spaces, and nature-based solutions provide multiple services that include resilience benefits, public health services, and contribute to environmental and restoration economies.[6]

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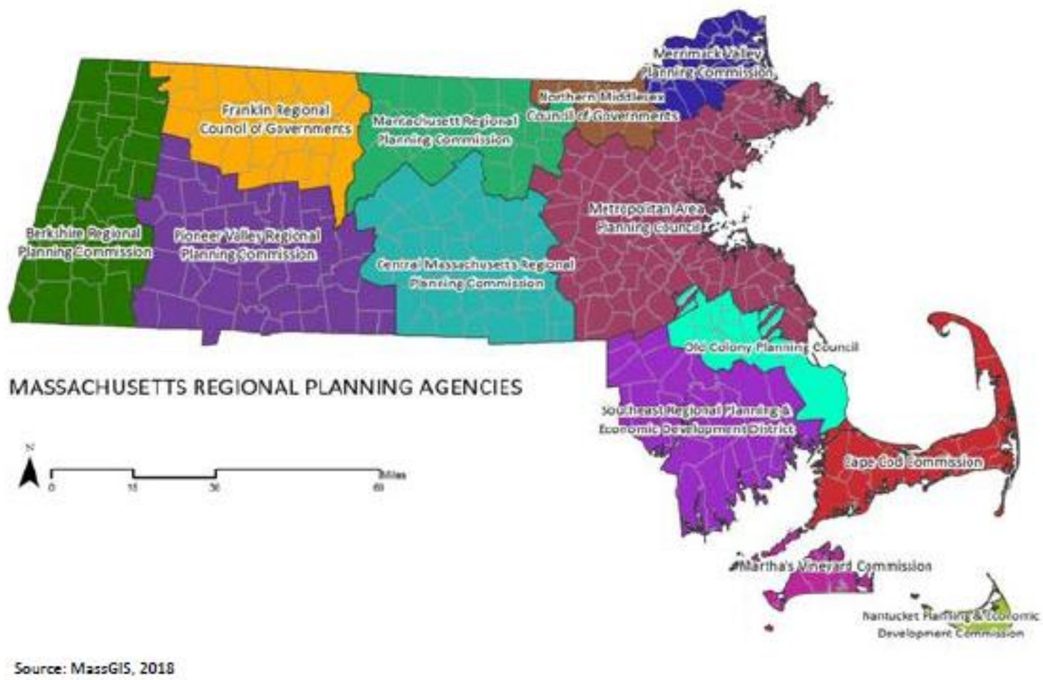
[4] (44 CFR § 201.2)

[5] https://www.mass.gov/files/documents/2016/09/nl/executive-order-climate-change-strategy.pdf

[6] Massachusetts State Hazard Mitigation and Climate Adaption Plan, Sept 2018

Coordinating Role of the Regional Planning Agency

The Old Colony Planning Council (OCPC) was established as a governmental entity under state statute in 1967 as a comprehensive planning agency to provide regional land use, transportation, and environmental planning expert in its defined region. As a regional planning agency OCPC has conducted transportation, economic development, environmental and land use studies for its member communities.



Planning Requirements under the Federal Disaster Mitigation Act

The Federal Disaster Mitigation Act, passed in 2000, requires that after November 1, 2004, all municipalities that wish to continue to be eligible to receive FEMA funding for hazard mitigation grants, must adopt a local multi-hazard mitigation plan and update this plan in five-year intervals. This planning requirement does not affect disaster assistance funding.

Federal hazard mitigation planning and grant programs are administered by the Federal Emergency Management Agency (FEMA) in collaboration with the states. These programs are administered in

Massachusetts by the Massachusetts Emergency Management Agency (MEMA) in partnership with the Department of Conservation and Recreation (DCR).

In 2004, FEMA published mitigation planning guidance with a "performance" based approach, rather than a "prescriptive" approach. This means that the requirements identify, generally, what should be done in the process and are documented in the plan, rather than specified exactly how it should be done.

What is a Hazard Mitigation and Municipal Vulnerable Preparedness Plan?

The Federal Emergency Management Agency (FEMA) and the Massachusetts Emergency Management Agency (MEMA) define Hazard Mitigation as any sustained action taken to reduce or eliminate long-term risk to people and property from natural hazards such as flooding, storms, high winds, hurricanes, wildfires, earthquakes, etc. Mitigation efforts undertaken by communities will help to minimize damages to buildings and infrastructure, such as water supplies, sewers, and utility transmission lines, as well as natural cultural and historic resources.

Natural hazard mitigation planning is the process of determining how to systematically reduce or eliminate the loss of life and property damage resulting from natural hazards such as floods, earthquakes, and hurricanes. Hazard mitigation means to permanently reduce or alleviate the losses of life, injuries, and property resulting from natural hazards through long-term strategies. These long-term strategies include planning, policy changes, programs, projects, and other activities. This plan incorporates consideration of future risks due to projections for the increased frequency and severity of extreme weather fueled by a warming planet. The resulting plan and implementation save lives and money. For every dollar spent on federal hazard mitigation grants, an average of six dollars are saved. [7]

Planning efforts, like the CRB process undertaken by the Town of Hanson and the Old Colony Planning Council, make mitigation a proactive process. Pre-disaster planning emphasizes actions that can be taken before a natural disaster occurs. Future property damage and loss of life can be reduced or prevented by a mitigation program that addresses the unique geography, demography, economy, and land use of a community within the context of each of the specific potential natural hazards that may threaten a community.

Preparing a local natural hazard mitigation plan before a disaster occurs can save the community money and facilitate post-disaster funding. Costly repairs or replacement of buildings and infrastructure, as well as the high cost of providing emergency services and rescue/recovery operations, can be avoided, or significantly lessened if a community implements the mitigation measures detailed in the plan.

[7] **Federal Emergency Management Agency (FEMA) and Federal Insurance and Mitigation Administration, "Natural Hazard Mitigation Saves Interim Report."**

This 2020 Hanson Hazard Mitigation Plan (HMP) is an update to the previous plan published in 2015. In addition to updating the plan to reflect changes in development, mitigation priorities, and recent hazards in the town, the planning team revised the content, structure, and plan update process. A primary difference between the 2015 Natural Hazard Mitigation Plan for the Old Colony Region is that this HMP update includes a new focus on climate adaptation. The integrated nature of this plan provides the opportunity to identify climate change impacts, describe the effect climate change is anticipated to have on natural hazards, and prepare an integrated strategy to understand and mitigate risks. The concurrent development of the town's Municipal Vulnerability Preparedness (MVP) planning process supported the integration of climate impacts into this HMP update, and the results of the MVP process are incorporated into this plan's Mitigation Strategy. The 2015 HMP was also a regional plan with our OCPC communities. This plan is focused on Hanson, Massachusetts.

In addition to integrating climate change, the structure of the plan was further revised and reorganized based on the integrated nature of the plan and to align with the recently published 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan (MSHMCAP, 2018).

What is a Municipal Vulnerability Preparedness Plan?

In 2017, the Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA) initiated the Commonwealth's Municipal Vulnerability Preparedness (MVP) grant program to help communities become more resilient to the impacts of climate change. The program provides two grant phases. The first grant phase is the planning grant, which funds a planning process to identify priority action items to address vulnerabilities and utilize strengths in preparation for climate change. The MVP planning process includes convening a team of municipal staff, engaging stakeholders in a Community Resilience Building Workshop following a guidebook developed by the Nature Conservancy and engaging the public. Communities that complete the planning grant program and prepare an MVP Plan become eligible for the second phase of MVP grant funding, the action grants, and receive increased standing in other state grant programs. MVP action grants fund the implementation of priority climate adaptation actions described in the MVP Plan. [8]

How does the Municipal Vulnerability Preparedness Planning Process Augment Other Hazard Mitigation Planning?

Community Resilience Building Workshops are held to ensure Local Plans go above and beyond minimum requirements for certain elements during the review process by federal and state officials. The intent of the Local Mitigation Plan Review Guide is to clearly identify where and how the Community Resilience Building Process can satisfy specific Elements of the Regulatory Checklist. FEMA

[8] **Massachusetts Executive Office of Energy & Environmental Affairs (EOEEA), "MVP Program Information."**

utilizes (and is responsible for completing) a Regulatory Checklist to determine the regulatory compliance of the plan and if the plan requires further refinement. The checklist is included in the appendix to this report.

Why Update?

By completing an HMP, municipalities also become eligible for specific federal funding and allow potential funding sources to understand a community's priorities. Hazard mitigation funding is available through the Federal Emergency Management Agency (FEMA). To be eligible for FEMA Grants, local governments are required to prepare an HMP meeting the requirements established in the Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended by the Disaster Mitigation Act of 2000.[9] A summary of disaster assistance programs offered by FEMA is included below.

Table 15: FEMA Designation Opportunities

FEMA Grants	Purpose
Hazard Mitigation Grant Program (HMGP)	Funds the implementation of long-term hazard mitigation planning and projects after a Presidential major disaster declaration [10]
Pre-Disaster Mitigation (PDM) Program	Offers annual funding for hazard mitigation planning and projects [11]
Flood Mitigation Assistance (FMA) Program	Offers annual funding for planning and projects that reduce or eliminate flood damage to buildings insured under the National Flood Insurance Program (NFIP) [12]
Public Assistance (PA) Grant Program	Facilitates recovery after disasters by providing communities with funding for debris removal, life-saving emergency protective measures, and restoring public infrastructure [13]
Fire Management Assistance Grant (FMAG) Program	Funds mitigation, management, and control of fires on forests or grasslands, to prevent major disasters [14]

[9] Federal Emergency Management Agency (FEMA), "Hazard Mitigation Grant Program."
[10] Federal Emergency Management Agency (FEMA), "Hazard Mitigation Assistance."
[11] Federal Emergency Management Agency (FEMA).
[12] Federal Emergency Management Agency (FEMA), "Public Assistance: Local, State, Tribal and Private Non-Profit."
[13] Federal Emergency Management Agency (FEMA).
[14] Federal Emergency Management Agency (FEMA), "Fire Management Assistance Grant Program."

Massachusetts Climate Change Projections

Changes in precipitation, temperature, sea level rise, and storm surge due to climate change are summarized in this section. The projections available through ResilientMA represent the best estimates for a range of scenarios for how GHG emissions may change over time, based on human decision-making.

Table 16: Geographic Scales Available for use for Massachusetts Temperature and Precipitation Projections

Geographic Scale	Definition
Statewide	**Massachusetts**
County	**Barnstable, Berkshire, Bristol, Dukes, Essex, Franklin, Hampden, Middlesex, Nantucket, Norfolk, Plymouth, Suffolk, Worcester**
Major drainage basins[4]	**Blackstone, Boston Harbor, Buzzards Bay, Cape Cod, Charles, Chicopee, Connecticut, Deerfield, Farmington, French, Housatonic, Hudson, Ipswich, Merrimack, Millers, Narragansett Bay & Mt. Hope Bay, Nashua, North Coastal, Parker, Quinebaug, Shawsheen, South Coastal, Sudbury-Assabet-Concord (SuAsCo), Taunton, Ten Mile, Westfield, and Islands (presented here as Martha's Vineyard basin and Nantucket basin)**

Definition of seasons as applied to temporal scales used for temperature and precipitation projections.

Season	Definition
Winter	**December-February**
Spring	**March-May**
Summer	**June-August**
Fall	**September-November**

Regardless of geographic scale, rising temperatures, changing precipitation, and extreme weather will continue to affect the people and resources of the Commonwealth throughout the 21st century. A first step in becoming more climate-resilient is to identify the climate changes the Town of Hanson will be exposed to, the impacts and risks to critical assets, functions, vulnerable populations arising from these changes, the underlying sensitivities to these types of changes, and the background stressors that may exacerbate overall vulnerability.

Climate Change Projections for Massachusetts

CLIMATE CHANGES	RELATED NATURAL HAZARDS	PROJECTIONS BY THE END OF THIS CENTURY
Changes in precipitation	– Inland flooding – Drought – Landslide	– Annual precipitation: Increase up to 16% (+7.3 inches) – Days with rainfall accumulation 1+ inch: Increase up to 57% (+4 days) – Consecutive dry days: Increase 18% (+3 days) – Summer precipitation: Decrease
Sea level rise	– Coastal flooding – Coastal erosion – Tsunami	– Sea level: Increase 4.0 to 10.5 feet along the Massachusetts coast
Rising temperatures	– Average/extreme temperatures – Wildfires – Invasive species	– Average annual temperature: Increase up to 23% (+10.8 degrees Fahrenheit) – Days/year with daily minimum temperatures below freezing: Decrease up to 42% (-62 days) – Winter temperatures: Increase at a greater rate than spring, summer, or fall – Long-term average minimum winter temperature: Increase up to 66% (+11.4 degrees Fahrenheit) – Days/year with daily maximum temperatures over 90 degrees Fahrenheit: Increase by up to 1,280% (+64 days) – Growing degree days: Increase by 23% to 52%
Extreme weather	– Hurricanes/tropical storms – Severe winter storms/nor'easters – Tornadoes – Other severe weather	– Frequency and magnitude: Increase

Note: This plan also assesses earthquakes, but there is no established correlation between climate change and earthquakes.
Source of Climate Change Projections: Northeast Climate Adaptation Science Center at the University of Massachusetts, Amherst.

Resilient MA Climate Change Clearinghouse for the Commonwealth

In 2017, the Commonwealth launched the Massachusetts Climate Change Clearinghouse (http://www.resilientma.org/), an online gateway for policymakers, local planners, and the public to identify and access climate data, maps, websites, tools, and documents on climate change adaptation and mitigation. The goal of ResilientMA is to support scientifically sound and cost-effective decision-making, and to enable users to plan and prepared for climate change impacts.

The ResilientMA site provides access to resources relevant to adaptation and building resiliency for climate change in Massachusetts. This includes information about GHG emission and atmospheric concentrations, projected temperature and precipitation changes, climate change impacts such as sea level rise and extreme weather events, and other changes. It also catalogs specific vulnerabilities, risks, and strategies for and across industry sectors, (including agriculture forestry local government, education, energy, recreation, and transportation) and for local governance priorities, including public health, public safety/emergency management, infrastructure, coastal zones, natural resources/habitats, and water resources.

The website's target audiences are local planners, decision maker, and state agency staff. It is intended to help decision makers identify vulnerable infrastructure, residential areas, and ecosystems; evaluate the risks posed by climate change; and develop strategies and implementation plans for the community. It is also a resource for policymakers, analysts, scientists, planners, businesses, and the public.

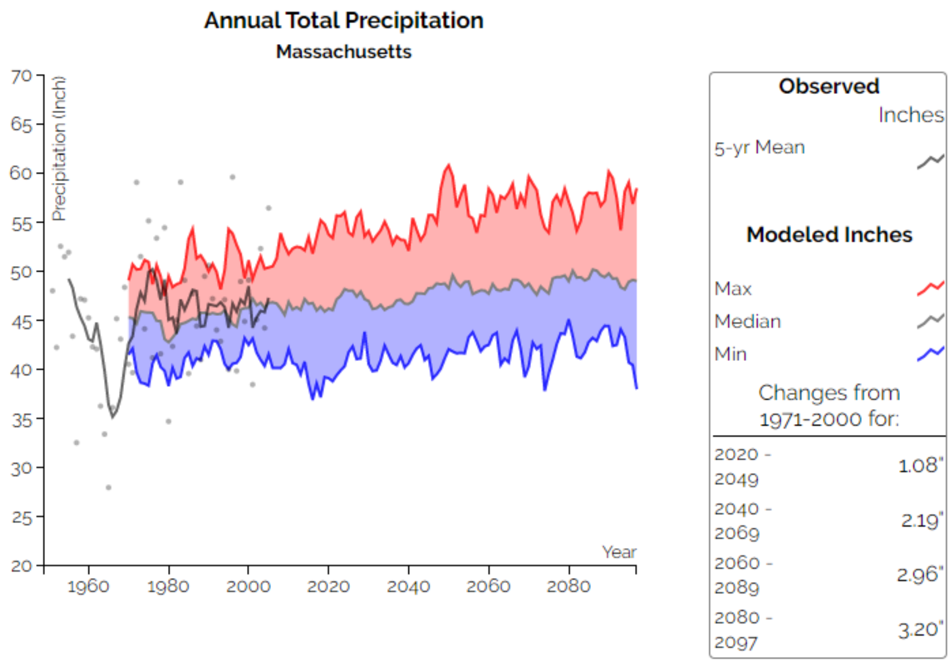
Precipitation

Precipitation is expected to increase over this century. Total annual precipitation is projected to increase by 1 to 6 inches by mid-century, and by 1.2 to 7.3 inches by the end of this century. This will result in up to 54.3 inches of rain per year, compared to the 1971-2001 average annual precipitation rate of 47 inches per year in Massachusetts. Precipitation during winter and spring is expected to increase, while precipitation during summer and fall is expected to decrease over this century.

By mid-century, the state can expect to receive greater than 1 inch of rain on an average of up to 10 days per year. The number of days with rainfall accumulation over 1 inch may reach 11 days by the end of this century, which represents an increase of 4 days from the observed average between 1971 and 2000.

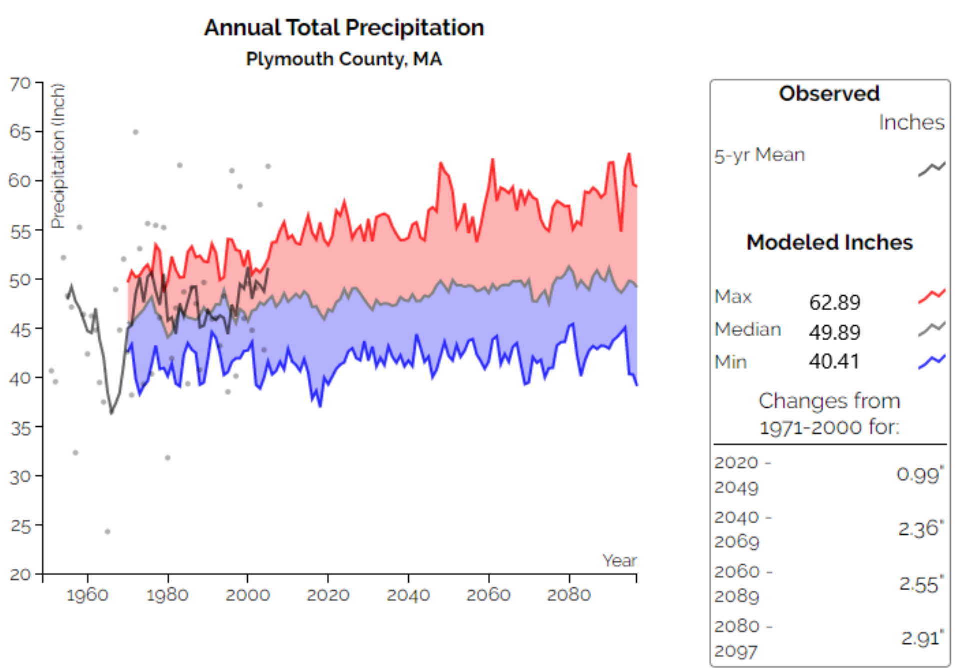
The number of continuous dry days is projected to increase to nearly 20 days per year at the end of this century, compared to the observed average of 16.64 days per year from 1971 to 2001. The eastern half of the state is expected to experience a greater number of consecutive dry days than the western side of the state.

Figure 1: Annual Total Precipitation, Massachusetts



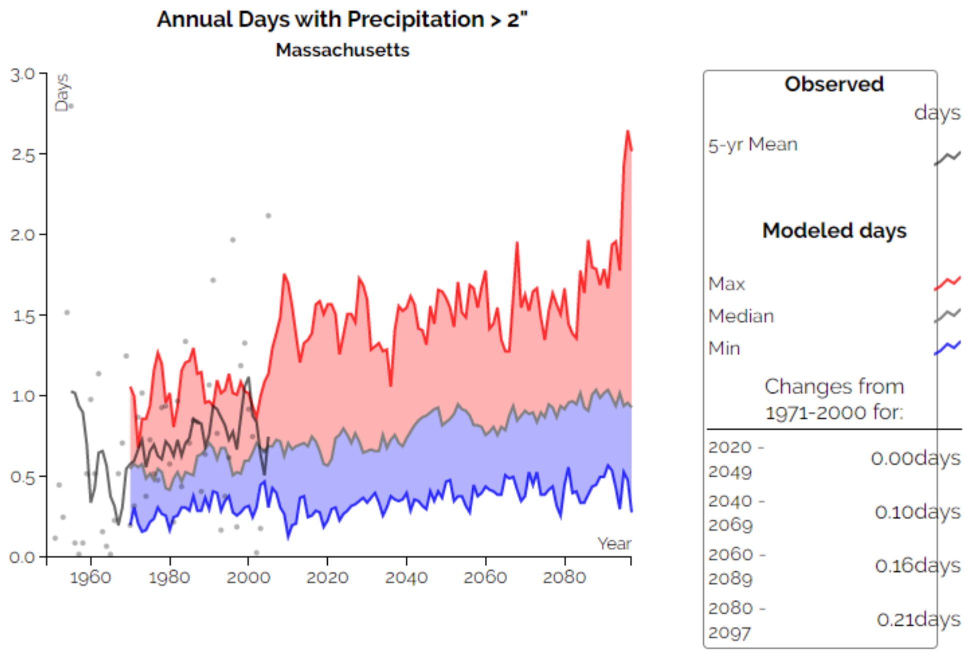
Source: ResilientMA.org, 2020

Figure 2: Annual Total Precipitation, Plymouth County



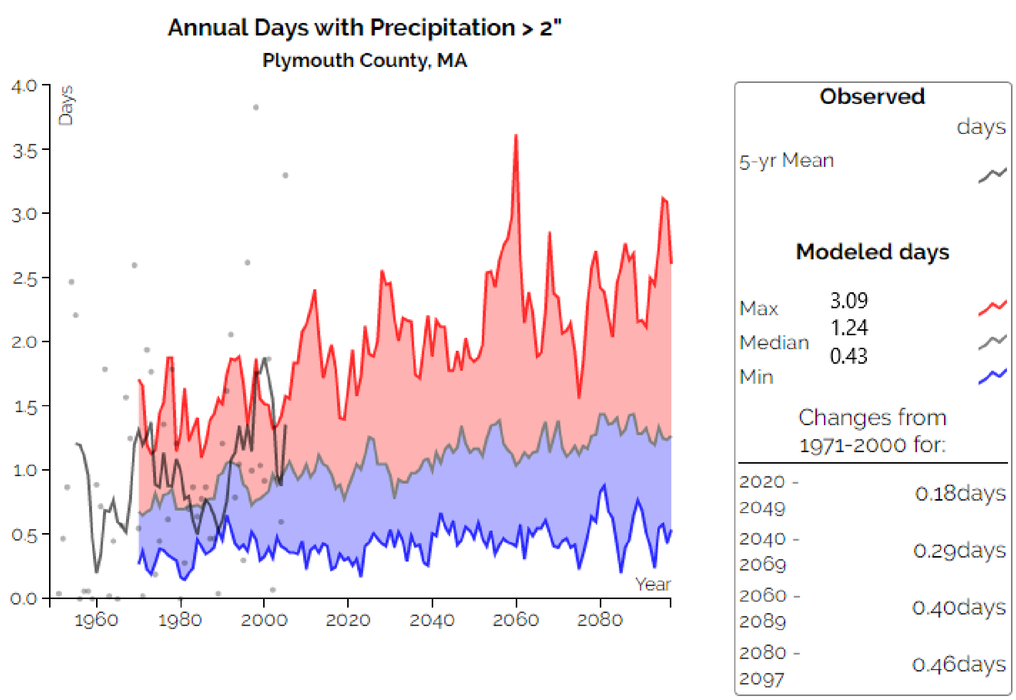
Source: ResilientMA.org, 2020

Figure 3: Annual Days with Precipitation > 2", Massachusetts



Source: ResilientMA.org, 2020

Figure 4: Annual Days with Precipitation > 2", Plymouth County



Temperature

The average, maximum, and minimum temperatures in Massachusetts are likely to increase significantly over the next century (resilient MA, 2018). The following Table displays the projected increase in annual and seasonal temperature by mid-century and the end of this century, compared to the baseline average temperature from 1971-2000. The average annual temperature is projected to increase from 47.6 degrees Fahrenheit (°F) to 50.4 to 53.8°F (2.8 to 6.2°F change) by mid-century, and to 51.4 to 58.4°F (3.8 to 10.8°F change) by the end of this century. This trend is shown on Figure 28 Annual Average Temperature.

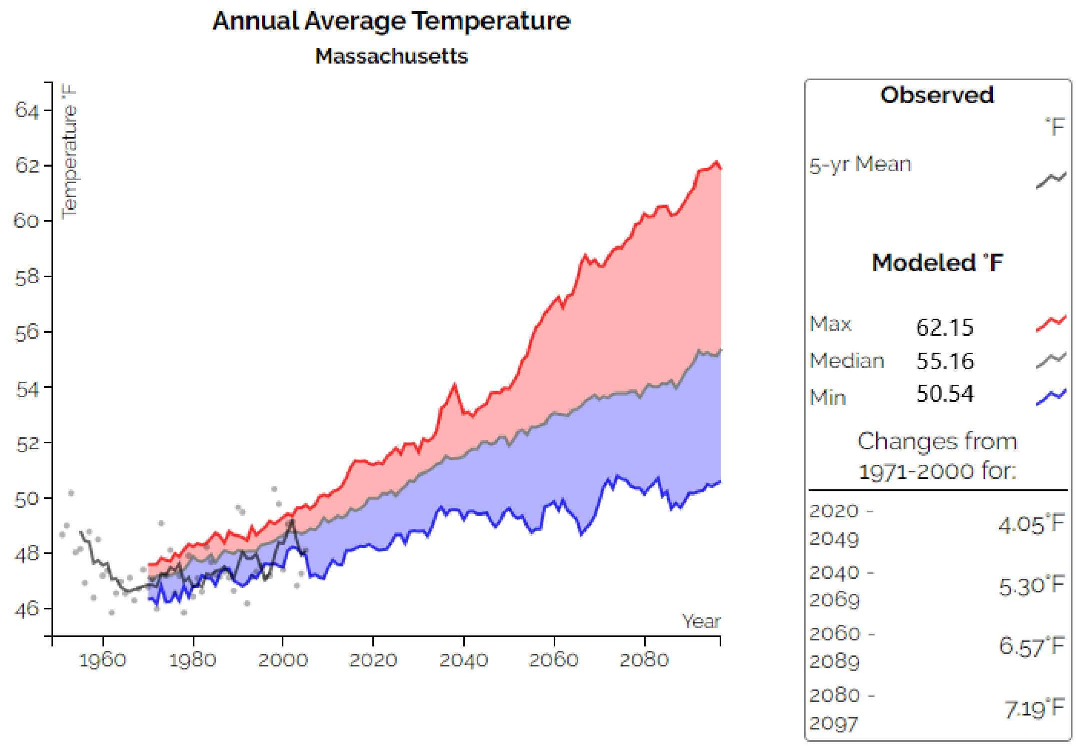
Table 17: Maximum Daily Projected Temperature Changes through 2100

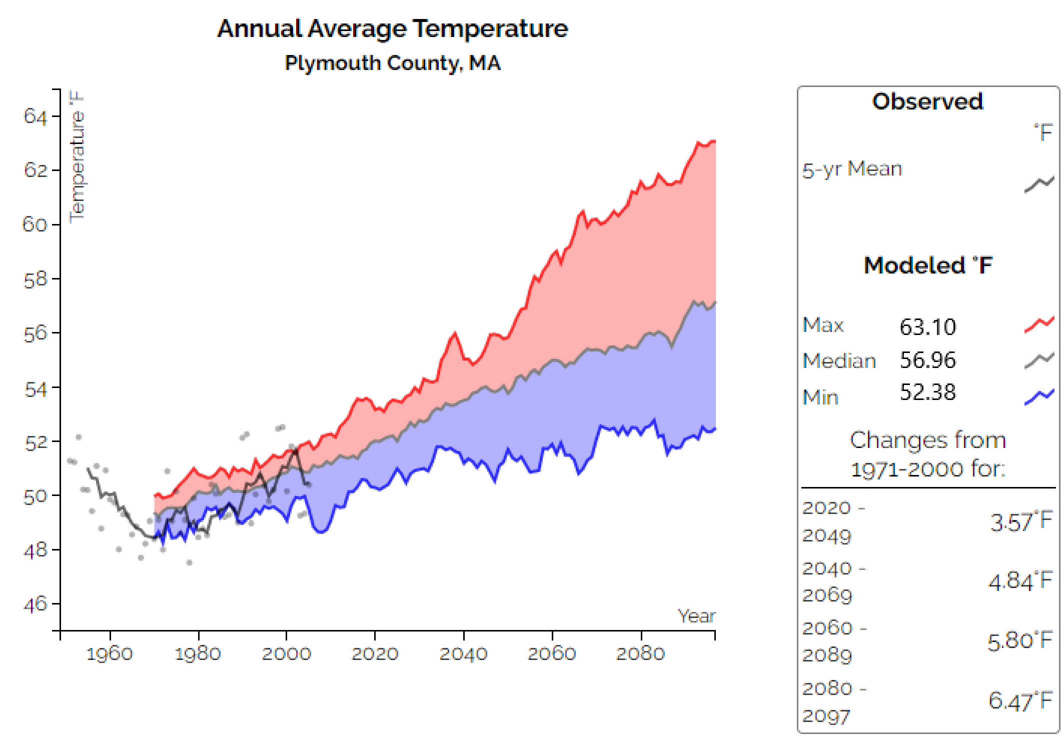
Climate Indicator		Observed Value 1971-2000 Average	Mid-Century Projected and Percent Change in 2050s (2040-2069)	End of Century Projected and Percent Change in 2090s (2080-2099)*
Average Temperature	Annual	47.6 °F	Increase by 2.8 to 6.2 °F Increase by 6 to 13 %	Increase by 3.8 to 10.8 °F Increase by 8 to 23 %
	Winter	26.6 °F	Increase by 2.9 to 7.4 °F Increase by 11 to 28 %	Increase by 4.1 to 10.6 °F Increase by 15 to 40 %
	Spring	45.4 °F	Increase by 2.5 to 5.5 °F Increase by 6 to 12 %	Increase by 3.2 to 9.3 °F Increase by 7 to 20 %
	Summer	67.9 °F	Increase by 2.8 to 6.7 °F Increase by 4 to 10 %	Increase by 3.7 to 12.2 °F Increase by 6 to 18 %
	Fall	50 °F	Increase by 3.6 to 6.6 °F Increase by 7 to 13 %	Increase by 3.9 to 11.5 °F Increase by 8 to 23 %
Maximum Temperature	Annual	58.0 °F	Increase by 2.6 to 6.1 °F Increase by 4 to 11 %	Increase by 3.4 to 10.7 °F Increase by 6 to 18 %
	Winter	36.2 °F	Increase by 2.5 to 6.8 °F Increase by 7 to 19 %	Increase by 3.5 to 9.6 °F Increase by 10 to 27 %
	Spring	56.1 °F	Increase by 2.3 to 5.4 °F Increase by 4 to 10 %	Increase by 3.1 to 9.4 °F Increase by 6 to 17 %
	Summer	78.9 °F	Increase by 2.6 to 6.7 °F Increase by 3 to 8 %	Increase by 3.6 to 12.5 °F Increase by 4 to 16 %
	Fall	60.6 °F	Increase by 3.4 to 6.8 °F Increase by 6 to 11 %	Increase by 3.8 to 11.9 °F Increase by 6 to 20 %
Minimum Temperature	Annual	37.1 °F	Increase 3.2 to 6.4 °F Increase by 9 to 17 %	Increase by 4.1 to 10.9°F Increase by 11 to 29 %
	Winter	17.1 °F	Increase by 3.3 to 8.0 °F Increase by 19 to 47 %	Increase by 4.6 to 11.4 °F Increase by 27 to 66 %
	Spring	34.6 °F	Increase by 2.6 to 5.9 °F Increase by 8 to 17 %	Increase by 3.3 to 9.2 °F Increase by 9 to 26 %
	Summer	56.8 °F	Increase by 3 to 6.9 °F Increase by 5 to 12 %	Increase by 3.9 to 12 °F Increase by 7 to 21 %
	Fall	39.4 °F	Increase by 3.5 to 6.5 °F Increase by 9 to 16 %	Increase by 4.0 to 11.4 °F Increase by 10 to 29 %

* A 20-yr mean is used for the 2090s because the climate models end at 2100.

Source: ResilientMA, 2018

Figure 5: Annual Average Temperature





Source: ResilientMA.org, 2020

Winter temperatures are projected to increase at a greater rate than spring, summer, or fall. By the end of this century, the long-term average minimum winter temperature of 17.1°F is projected to increase by 4.6 to 11.4°F (up to a 66 percent increase), resulting in a minimum winter temperature of between 21.7°F and 28.5°F. [15] The number of days per year with daily minimum temperatures below freezing (32°F) is projected to decrease by 19 to 40 days (down to 106 days total) by the 2050s, and 24 to 62 days (down to 84 days total) by the 2090s, from the average observed range from 1971 to 2000. [16] Figures 25 and 26 (Projected Annual Days with temperature below 32) displays this trend of fewer days below freezing.

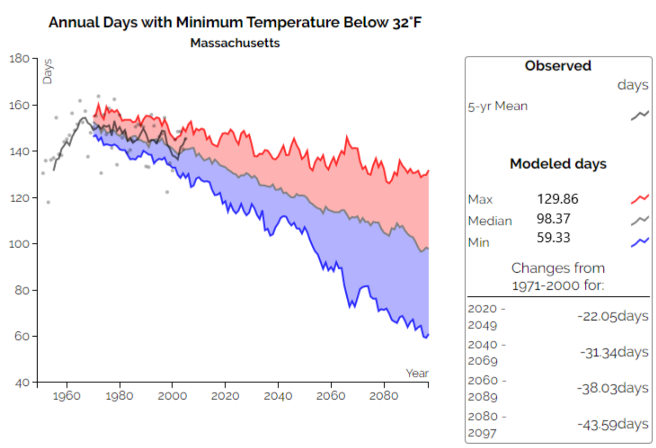
Although minimum temperatures are projected to increase at a greater rate than maximum temperatures in all seasons, significant increases in maximum temperatures are anticipated. Summer highs are projected to reach 85.6°F by mid-century, and 91.4°F by the end of this century, compared to the historical average of 78.9°F. [17]

Table 18: Consecutive Dry Days

Planning Year	2030s	2050s	2070s	2090s
Projected Range of Consecutive Dry Days	16.44-17.94	16.34-18.64	15.94-18.94	16.34-19.64

Source: resilient MA, 2018

Figure 6: Annual Days Minimum Temperature Below 32F, Massachusetts



Source: ResilientMA.org, 2020

[15] **SHMCAP, 2018**

[16] **SHMCAP, 2018**

[17] **SHMCAP,2018**

Figure 7: Annual Days with Minimum Temperature Below 32F, Plymouth County

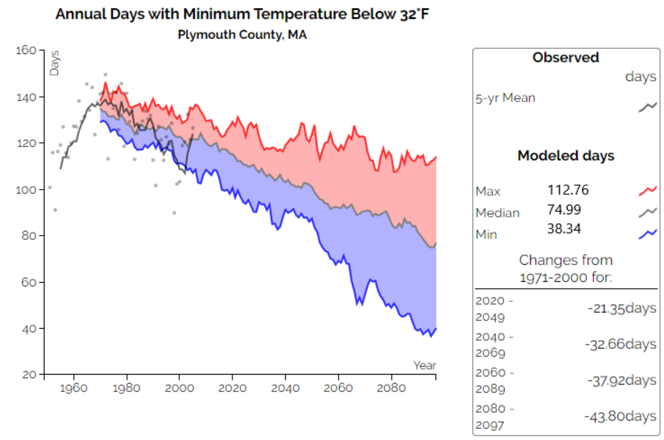


Figure 8: Annual Days with Minimum Temperature Below 0F, Massachusetts

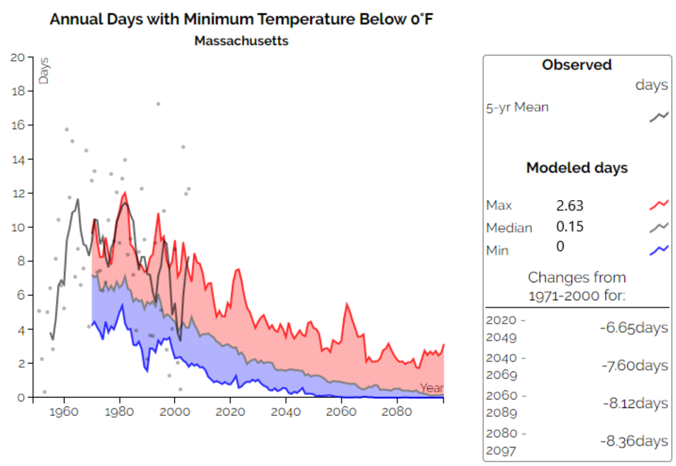
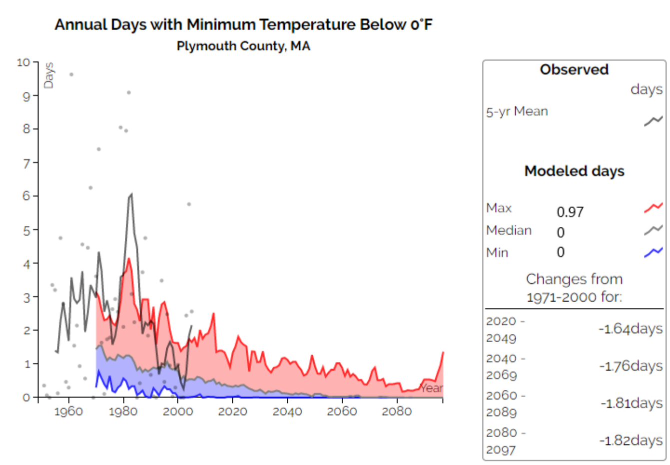


Figure 9: Annual Days with Minimum Temperature Below 0F, Plymouth County



Source: ResilientMA.org, 2020

Figure 10: Annual Minimum Temperature, Massachusetts

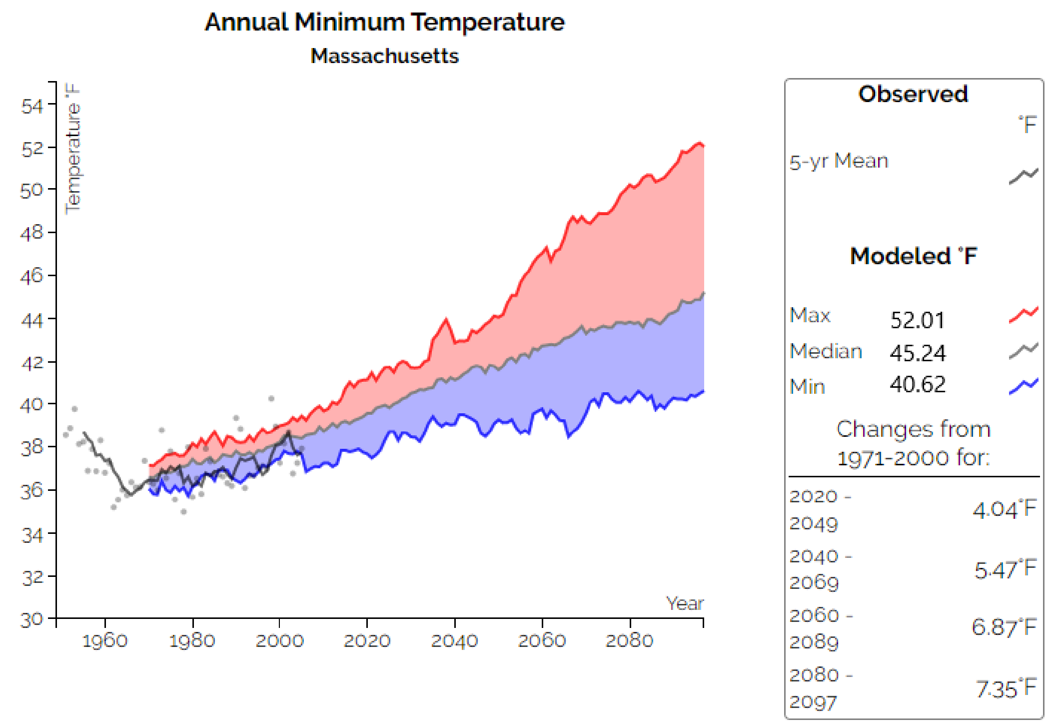
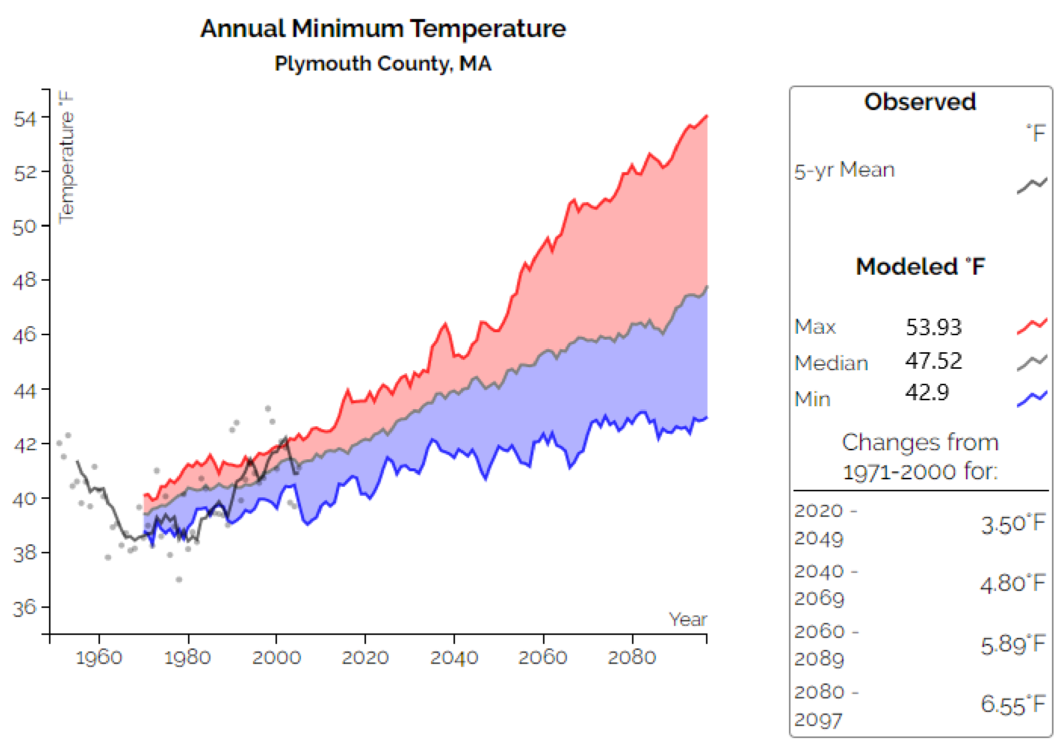


Figure 11: Annual Minimum Temperature, Plymouth County



Source: ResilientMA.org, 2020

Figure 12: Annual Maximum Temperature, Massachusetts

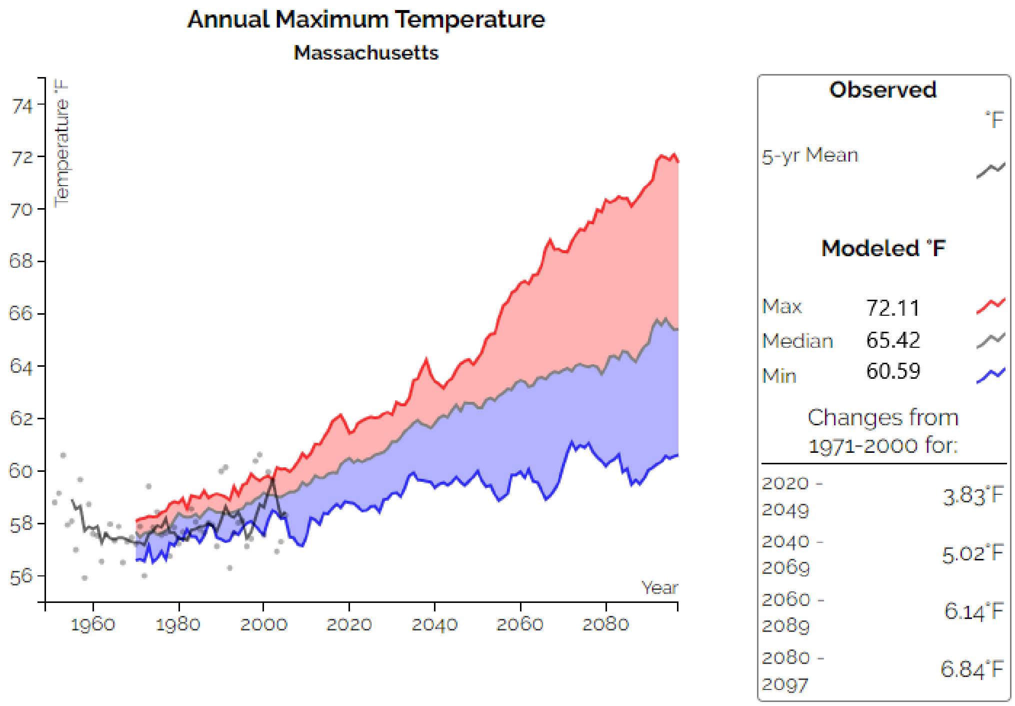
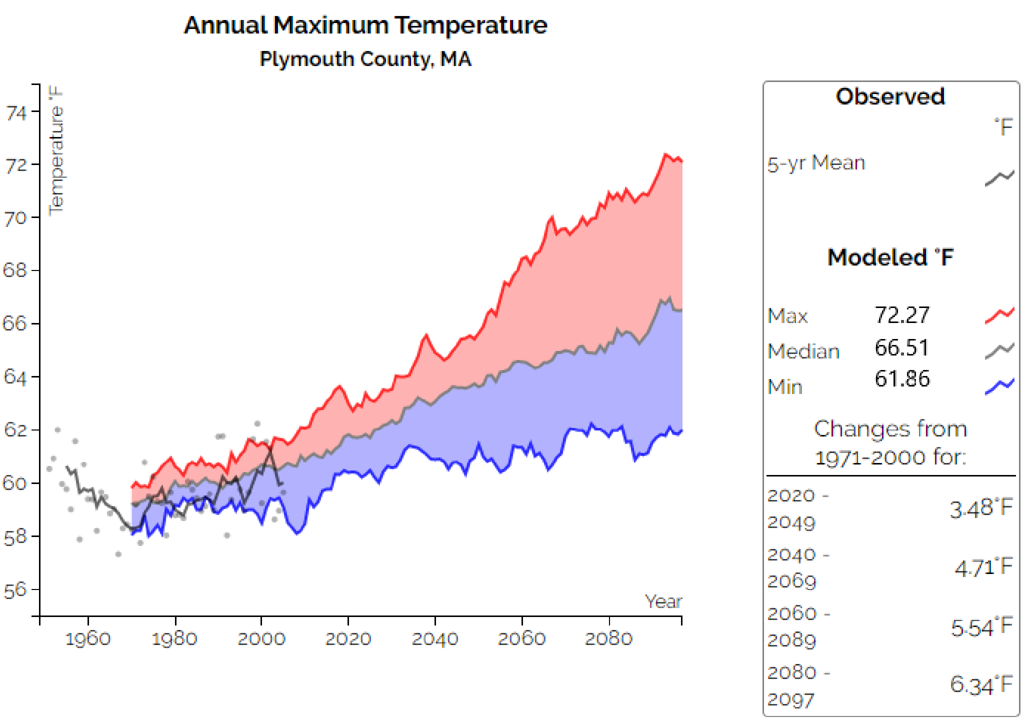


Figure 13: Annual Maximum Temperature, Plymouth County



Source: ResilientMA.org, 2020

Figure 14: Annual Days with Maximum Temperature Above 95F, Massachusetts

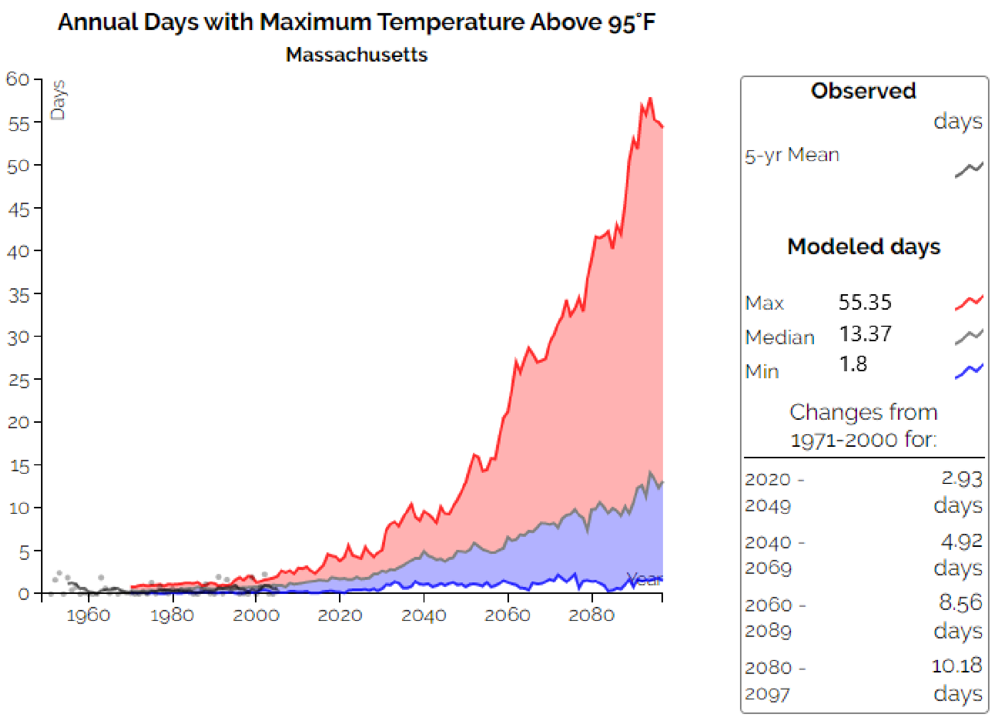
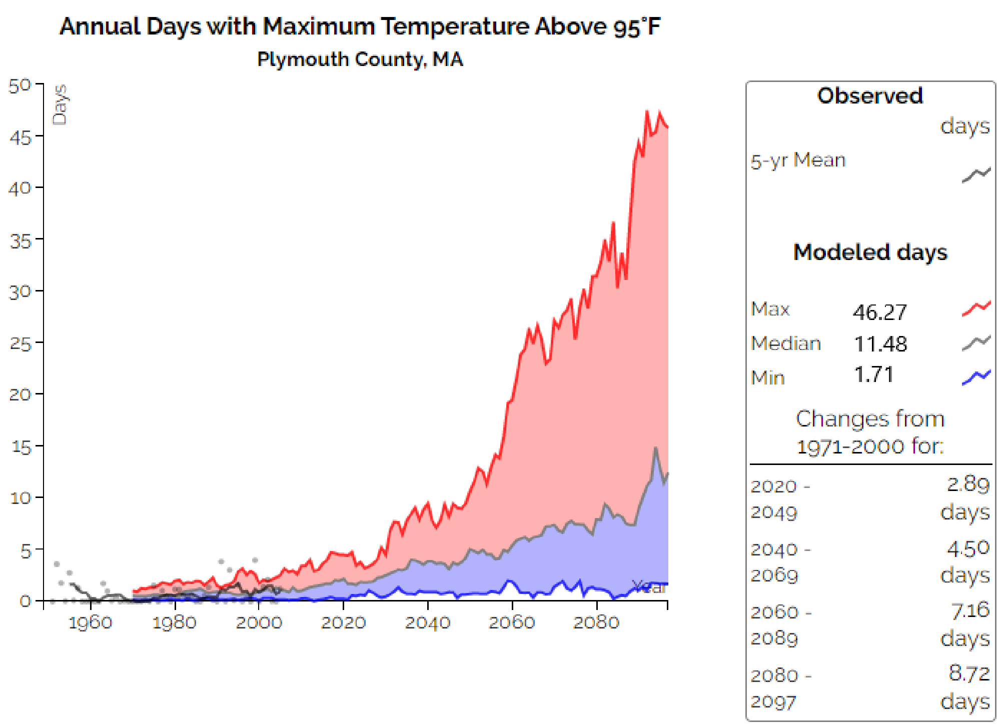


Figure 15: Annual Days with Maximum Temperature Above 95F, Plymouth County



Source: ResilientMA.org, 2020

Figure 16: Annual Days with Maximum Temperature Above 100F, Massachusetts

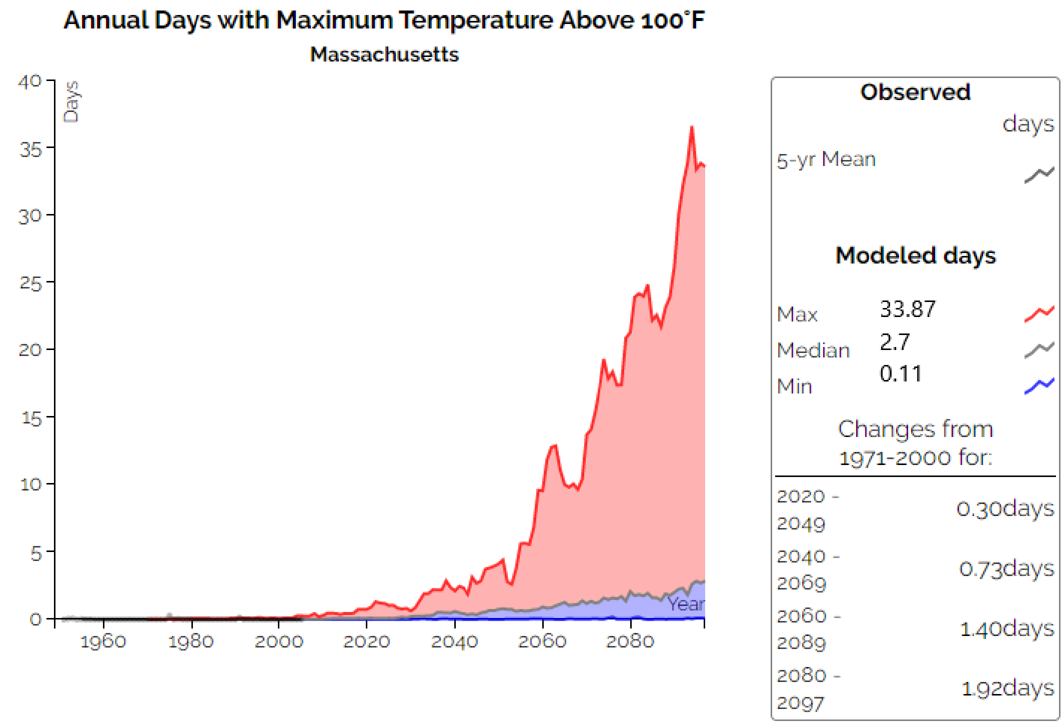
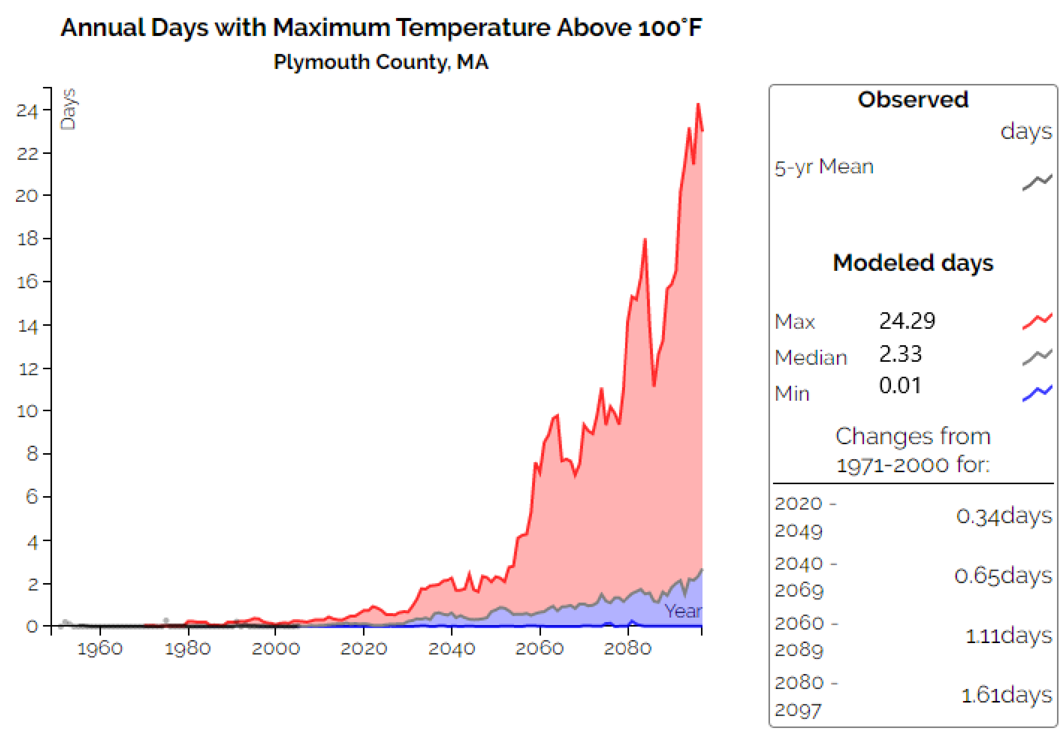


Figure 17: Annual Days with Maximum Temperature Above 100F, Plymouth County



Source: ResilientMA.org, 2020

The number of days per year with daily maximum temperatures over 90°F is projected to increase by 11.19 days by the 2050s, and by 29.21 days by the 2090s, compared to the average observed range from 1971 to 2000 of 5 days per year. Maximum temperatures in winter are projected to increase by 9.6°F by the end of this century. [18]

Growing Degree Days

As temperatures increase, the growing season will expand. The number of growing degree days is projected to be 23 to 52 percent higher at the end of this century relative to the 1971-2000 average, as shown on Figure 37. [19]

Figure 18: Annual Growing Degree-Day Accumulation (GDD), Massachusetts

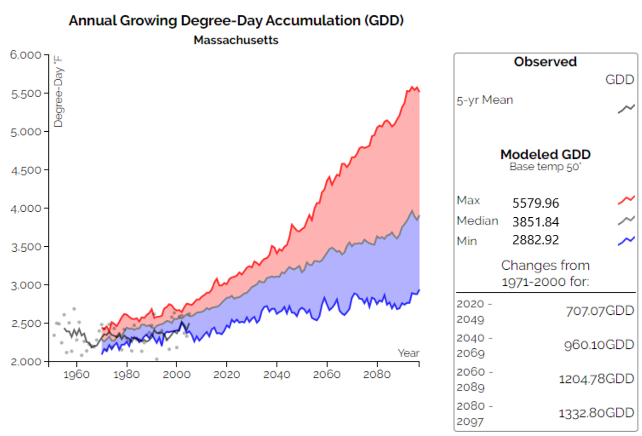
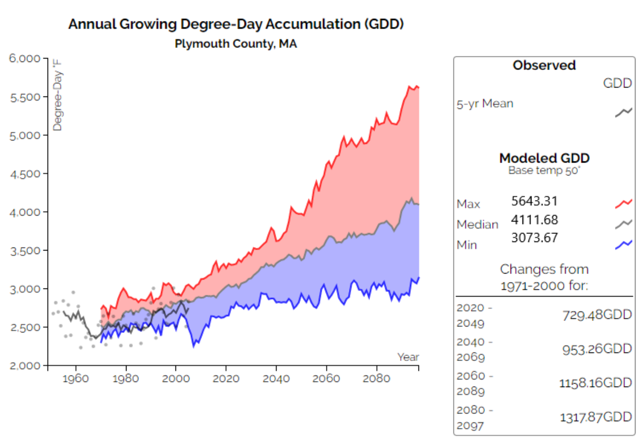


Figure 19: Annual Growing Degree-Day Accumulation (GDD), Plymouth County



Source: ResilientMA.org, 2020

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[18] resilientMA

[19] SHMCAP, 2018

Figure 20: Annual Cooling Degree-Day Accumulation (CDD), Massachusetts

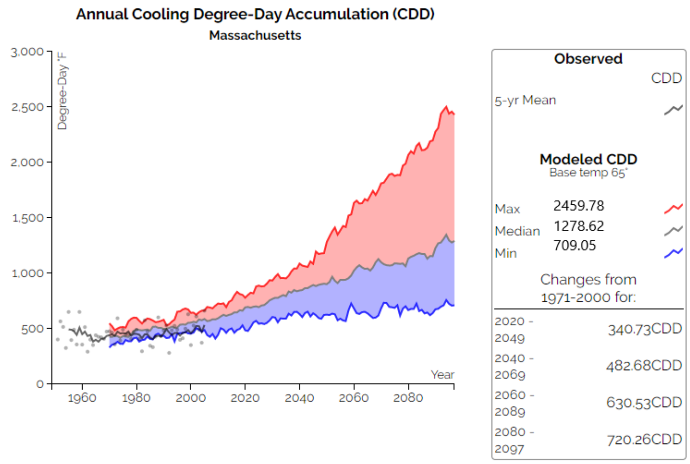


Figure 21: Annual Cooling Degree-Day Accumulation (CDD), Plymouth County, MA

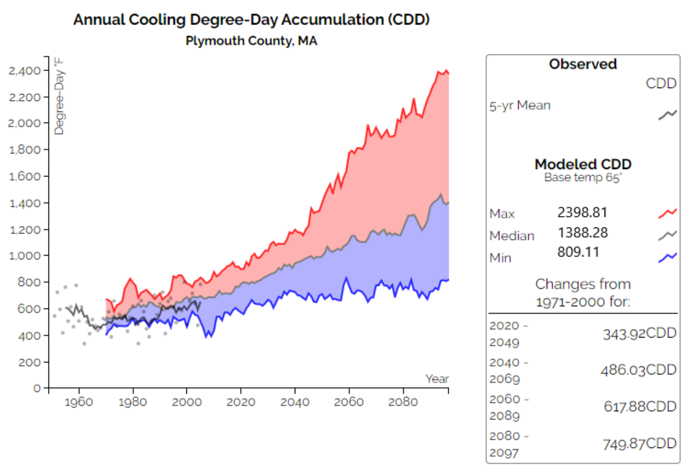
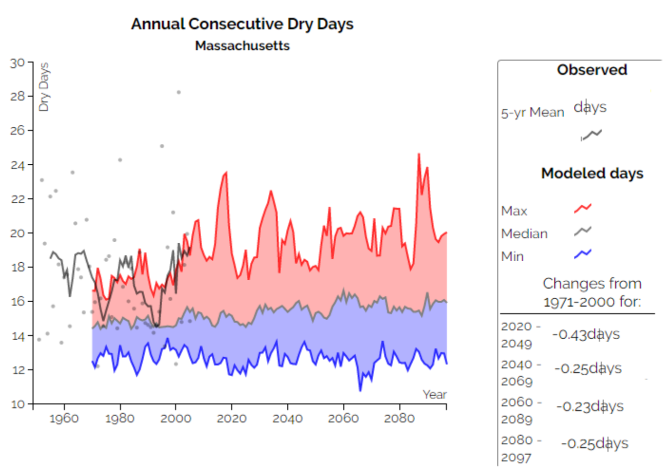


Figure 22: Annual Consecutive Dry Days, Massachusetts



Source: ResilientMA.org, 2020

Sea Level Rise

The rate of sea level rise is projected to increase with climate change. Along the Boston coast, sea level rise is expected to reach 2.4 feet by 2050 and 7.6 feet by 2100 under a high scenario (see Table 26). Figure 41 displays similar relative mean sea level and future scenarios at the tide station in Boston. [20]

Table 19: Northeast Climate Adaptation Science Center Relative Mean Sea Level Projections for Boston, MA Tide Station

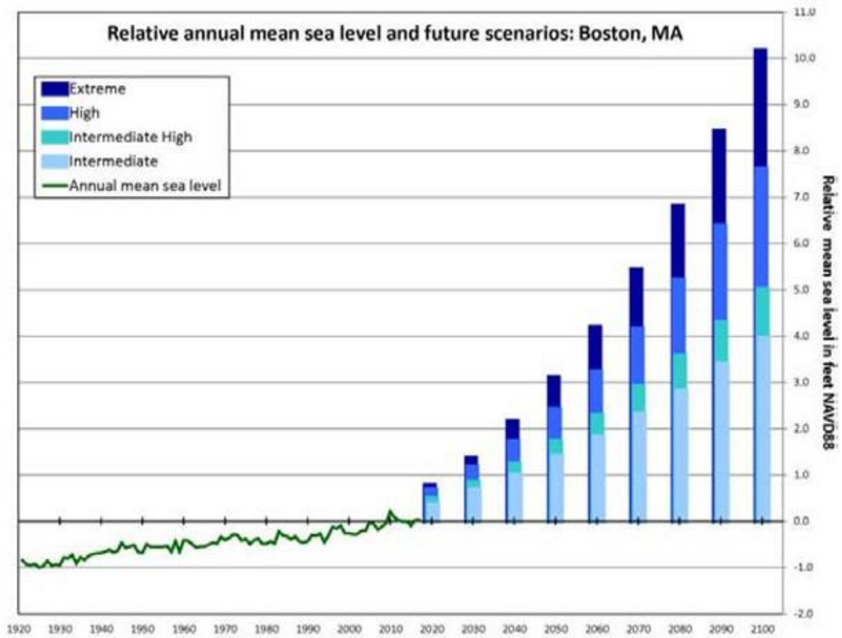
Boston Relative Mean Sea Level (feet NAVD88)									
Scenario	**Summary**	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**	**2090**	**2100**
Intermediate	Intermediate scenario primarily based on medium and high emissions scenarios and accounts for possible higher ice sheet contributions to sea level rise	0.7	1.0	1.4	1.8	2.3	2.8	3.4	4.0
Intermediate-High	Intermediate-high scenario primarily based on high emissions scenarios and accounts for possible higher ice sheet contributions to sea level rise	0.8	1.2	1.7	2.3	2.9	3.6	4.3	5.0
High	High scenario primarily based on high emissions scenarios and accounts for possible higher ice sheet contributions to sea level rise	1.2	1.7	2.4	3.2	4.2	5.2	6.4	7.6
Extreme (Maximum physically plausible)	Highest scenario primarily based on high emissions scenarios and accounts for possible higher ice sheet contributions to sea level rise and consistent with estimates of physically possible "worst case"	1.4	2.2	3.1	4.2	5.4	6.8	8.4	10.2

Source: resilient MA, 2018

Coastal flooding generally occurs along the coasts of oceans, bays, estuaries, coastal rivers, and large saltwater inlets. Coastal floods are defined by the submersion of land along the ocean coast and other inland waters caused by the movement of seawater over and above normal present-day tide action. Coastal flooding is often characterized as minor or major based on the magnitude (elevation), duration, and frequency of the flooding that is experienced. Sea level rise driven by climate change will exacerbate existing coastal flooding and coastal hazards.

[20] **SHMCAP, 2018**

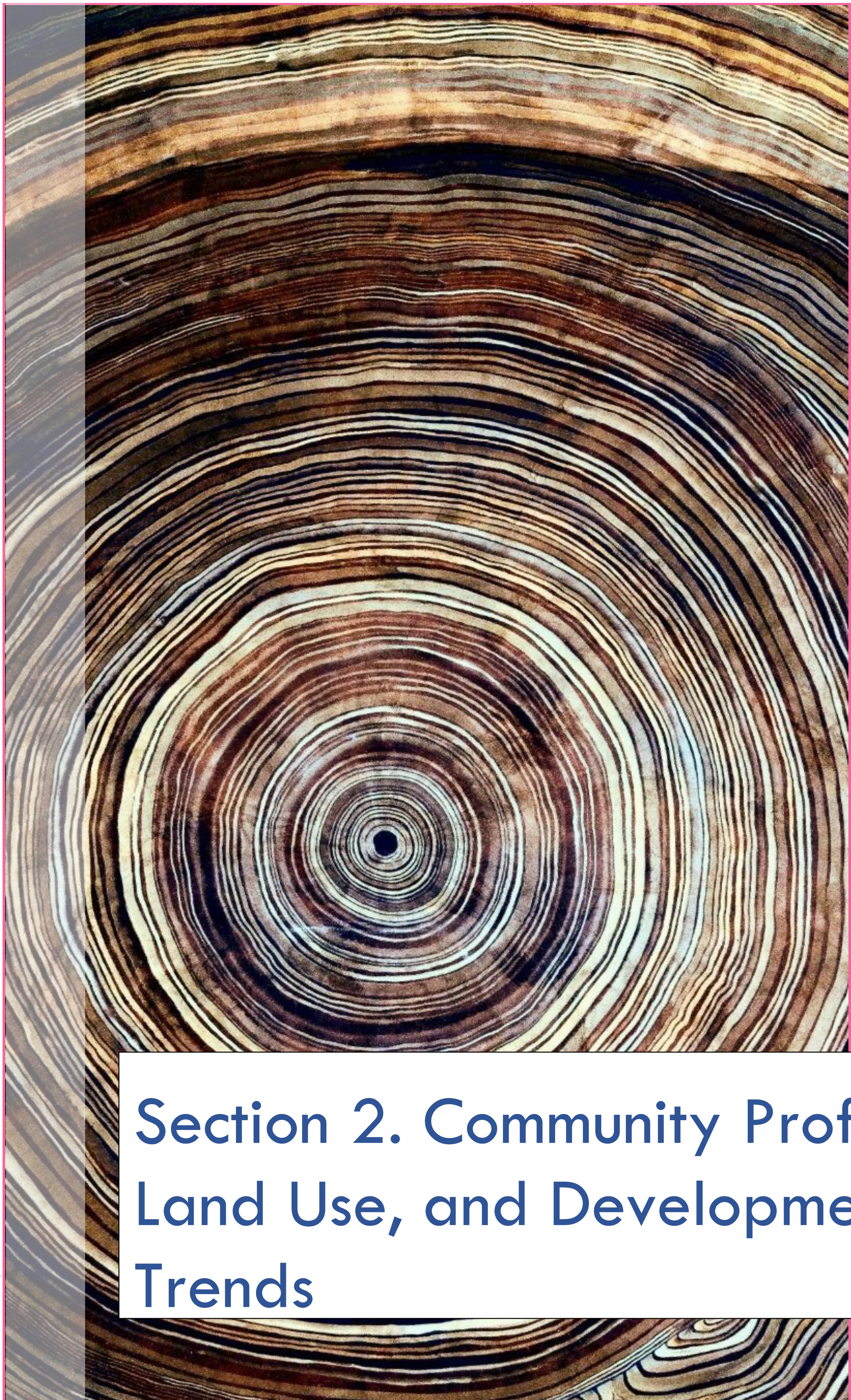
Figure 23: Relative Annual Sea Level and Future Scenarios; Boston, MA



Source: resilient MA, 2018

The rise in relative mean sea level is projected to range from approximately 1 to 3 feet in the near term (between 2000 and 2050), and from 4 to 10 feet by the end of this century (between 2000 and 2100) across the Commonwealth's coastline (EOEEA, 2018). As the sea level has continued to increase, there has been a corresponding increase in minor (or disruptive) coastal flooding associated with higher-than-normal monthly tides. Flooding impacts associated with these tides are becoming more noticeable and often result in the flooding of roads and parking lots with bimonthly spring tides. Greater flood levels (spatial and temporal) associated with more episodic, major, or event-based natural disturbances, such as hurricanes, nor'easters, and seismic waves, will impact built infrastructure directly, often with devastating effects. In addition to contributing to high-tide flooding, sea level rise will also exacerbate storm-related flooding due to the higher tidal elevation. Other impacts associated with more severe coastal flooding include beach erosion; loss or submergence of wetlands and other coastal ecosystems; saltwater intrusion into drinking water and wastewater infrastructure; high water tables; loss of coastal recreation areas, beaches, protective sand dunes, parks, and open space; and loss of coastal structures (sea walls, piers, bulkheads, and bridges) and buildings (SHMCAP, 2018).

Climate change is projected to exacerbate the severity of storms and severe rainfall events. Therefore, it is anticipated that all forms of flooding will increase in severity because of climate change.



Section 2. Community Profile, Land Use, and Development Trends

Section 2. Community Profile, Land Use, and Development Trends

Community Profile

Hanson is a pleasant community where the serenity, green appearance, open space, and aesthetic characteristics, which contribute to the quality of life, are maintained, and enhanced for future generations. Open space and recreation are a priority for Hanson residents. The resident's value its open space and understand the important role these features play in preserving the town's character and quality of life.

The Town is governed by a Board of Selectmen with a Town Administrator. The Town operates under the open Town meeting format.

Demographic Profile

According to the latest American Community Survey, (ACS), in 2018 Hanson had a population of 10,668 persons.[21] The 2017 ACS estimates the town's population density to be 671.33 persons per square mile, a decrease from 678.2 indicated in the 2010 Census but increased from Census 2000 data which indicates 632.5 people per square mile. Despite the increasing town-wide densities from 2000 to 2010, the density of typical neighborhoods has probably dropped with large lot development requirements.

The 2010 Census data shows a population count of 10,203, an increase of 8.43 percent from the 2000 US Census, the total population increase of 794 persons. The 2010 Census data indicates there were 3,468 households and 2,711 family households residing in town.[22] Of the total households in Hanson, 2,711 (78.2%) were family households. Of those family households 1,378 (50.8%) have children under the age of 18 living with them, and 1,271 of those total households (36.6%) live with their own children under 18 years of age. Of the total households in Hanson, 396 (11.4%) households were female households, and 333 of those female households had no husband present.[23]

[21] The U.S. Census Bureau's ACS is a nationwide survey that collects and produces information on social, economic, housing, and demographic characteristics about our nation's population every year.

[22] 2010 Census Summary File 1 QT-P11

[23] 2010 Census Summary File 1 DP-1

Table 20: Hanson Demographics

	2000 Census	2010 Census	2018 ACS
Population	9,495	10,209	10,668
Median Age	36.1	40.4	44.9
Under 5 Years	678	532	419
21 years and Over	6,498	7,184	
62 Years and Over	1,010	1,530	
85 Years and Over	59	110	130
Average Households Size	3.03	2.94	
Average Family Size	3.38	3.33	
Owner-Occupied Housing Units	3,123 [24]	88.6% [25]	3,495
Renter -Occupied Housing Units	11.0%	11.4%	311
Population Density per square mile	632.5	678.2	

Source: Census 2000, 2010 Summary File SF1 DP-1, 2018 ACS

Note: population burdened by housing costs is defined as housing costs above 35% of income

According to the 2010 US Census, of all households within town, 599 (17.3%) were made of individuals living alone and 861 (24.8%) households had someone living with them who was 65 years of age or older. The average household size was 2.94 and the average family size was 3.33.

Hanson is a relatively affluent community with high median annual income and a low poverty rate. According to the US Census, the median household income, in 2018 dollars, was $98,537 while 3.3 percent of the population was living below the poverty level.

Table 21: Demographics of Hanson and Plymouth County

People QuickFacts	Massachusetts	Plymouth County	Hanson
Population			
Population estimates July 1, 2019 (V2019)	6,892,503	521,202	10,914
Population estimates base, April 1, 2010	6,547,785	494,932	10,203
Population, percent change – April 1, 2010 (estimates base) to July 1, 2019 (V2019)	5.3%	5.3%	7.0%
Population, Census, April 1, 2010	6,547,629	494,919	10,209
Age and Sex			
Persons under 5 years, percent	5.2%	5.3%	3.9%
Persons under 18 years, percent	19.6%	21.2%	18.6%
Persons 65 years and over, percent	17.0%	18.6%	16.1%
Female persons, percent	51.5%	51.4%	49.1%

[24] Census 2000 Summary File 1 (SF 1) QT-H1 General Housing Characteristics: 2000.

[25] Census 2010 Summary File 1 QT-H1 General Housing Characteristics: 2010

People QuickFacts	Massachusetts	Plymouth County	Hanson
Race and Hispanic Origin			
White alone, percent	80.6%	84.2%	95.5%
Black or African American alone, percent	9.0%	11.7%	0.8%
American Indian or Alaska Native alone, percent	0.5%	0.3%	0.0%
Asian alone, percent	7.2%	1.6%	1.7%
Native Hawaiian and Other Pacific Islander alone, percent	0.1%	0.1%	0.0%
Two or More Races, percent	2.6%	2.0%	1.6%
Hispanic or Latino, percent	12.4%	4.2%	1.5%
White alone, not Hispanic or Latino, percent	71.1%	81.1%	94.0%

People QuickFacts	Massachusetts	Plymouth County	Hanson
Population Characteristics			
Veterans, 2014-2018	315,859	29,831	774
Foreign born persons, percent, 2014-2018	16.5%	9.35%	4.2%

People QuickFacts	Massachusetts	Plymouth County	Hanson
Housing			
Housing units, July 1, 2019 (V2019)	2,928,732	209,542	3,903
Owner-occupied housing unit rate, 2014-2018	62.3%	75.9%	91.8%
Median value of owner-occupied housing units, 2014-2018	$366,800	$356,700	$353,400
Median selected monthly owner costs – with a mortgage 2014-2018	$2,165	$2,205	$2,067
Median selected monthly owner costs – without a mortgage, 2014-2018	$786	$805	$729
Median gross rent, 2014-2018	$1,225	$1,227	$775
Building permits, 2019	17,365	1,114	

People QuickFacts	Massachusetts	Plymouth County	Hanson
Families & Living Arrangements			
Households, 2014-2018	2,601,914	186,306	3,806
Persons per household, 2014-2018	2.53	2.69	2.80
Living in same house 1 year ago, percent of persons age 1 year+, 2014-2018	87.1%	89.6%	93.4%
Language other than English spoken at home, percent of persons age 5 years+, 2014-2018	23.6%	13.2%	3.5%

People QuickFacts	Massachusetts	Plymouth County	Hanson
Computer and Internet Use			
Households with a computer, percent, 2014-2018	90.1%	92.0%	94.7%
Households with a broadband internet subscription, percent, 2014-2018	84.7%	86.9%	91.1%

People QuickFacts	Massachusetts	Plymouth County	Hanson
Education			
High school graduate or higher, percent of persons age 25 years+, 2014-2018	90.4%	92.9%	95.2%
Bachelor's degree or higher, percent of persons age 25 years+, 2014-2018	42.9%	36.7%	32.2%
Health			
With a disability, under age 65 years, percent, 2014-2018	7.9%	7.6%	7.9%
Persons without health insurance, under age 65 years, percent	3.2%	2.8%	1.5%

People QuickFacts	Massachusetts	Plymouth County	Hanson
Economy			
In civilian labor force, total, percent of population age 16 years+, 2014-2018	67.1%	67.6%	71.3%
In civilian labor force, female, percent of population age 16 years+, percent	63.4%	63.7%	70.0%
Total accommodation and food services sales, 2012 ($1,000)	17,508,975	909,430	9,569
Total retail sales, 2012 ($1,000)	63,583,090	6,889,614	73,168
Total retail sales per capita, 2012	81,927,799	$13,786	$7,109

People QuickFacts	Massachusetts	Plymouth County	Hanson
Transportation			
Mean travel time to work (minutes), workers age 16 years+, 2014-2018	29.7	33.3	36.9

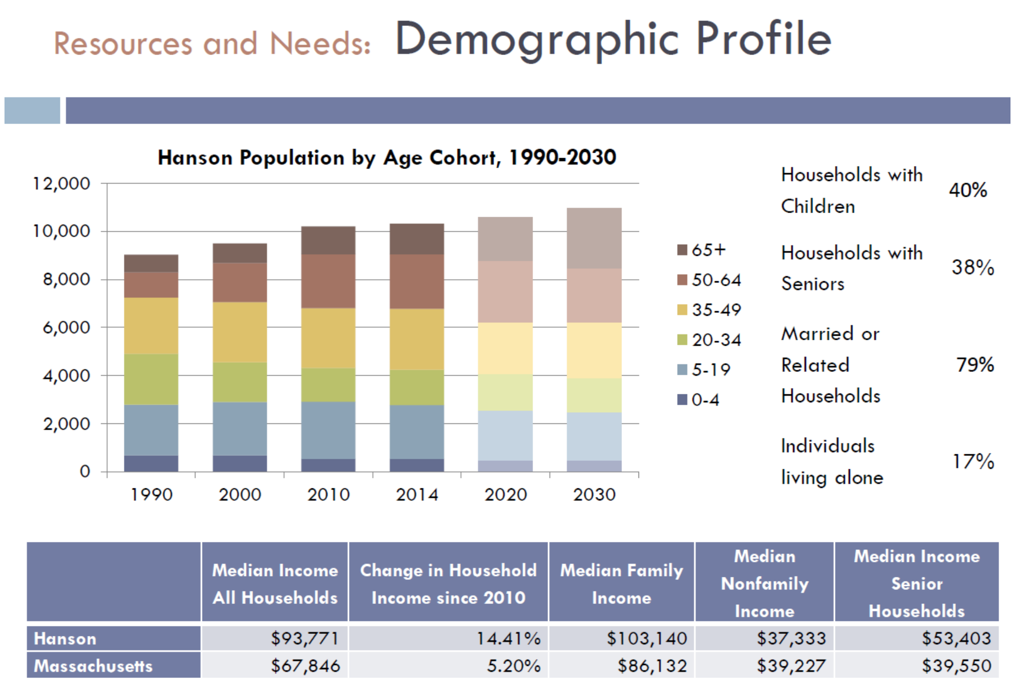
People QuickFacts	Massachusetts	Plymouth County	Hanson
Income & Poverty			
Median household income (in 2018 dollars), 2014-2018	$77,378	$85,654	$98,537

Per capita income in past 12 months (in 2018 dollars), 2014-2018	$41,794	$41,343	$40,618
Persons in poverty, percent	10.0%	6.2%	3.3%

Businesses QuickFacts	Massachusetts	Plymouth County	Hanson
Business			
Total employer establishments. 2018	180,307	12,737	
Total employment, 2018	3,323,852	175,318	
Total annual payroll, 2018 ($1,000)	227,920,705	8,387,017	
Total employment, percent change, 2017-2018	0.2%	1.4%	
Total non-employer establishments, 2018	573,754	41,058	
All firms, 2012	607,664	43,928	1,002
Men-owned firms, 2012	357,154	26,404	708
Women-owned firms, 2012	199,210	14,089	229
Minority-owned firms, 2012	89,967	3,987	25
Non-Minority-owned firms, 2012	499,959	38,762	962
Veteran-owned firms, 2012	58,339	4,843	188
Nonveteran-owned firms, 2012	525,667	37,423	792
Geography			
Population per square mile, 2010	839.4	750.9	678.2
Land area in square miles, 2010	7,800.06	659.08	15.05

Source: https://www.census.gov/quickfacts/hansontownplymouthcountymassachusetts, https://www.census.gov/quickfacts/fact/table/MA,plymouthcountymassachusetts,hansontownplymouthcountymassachusetts/PST045219

Figure 24: Hanson Demographic Profile



Source: Hanson Community Preservation Committee, 2016

Population Characteristics

Population Trends

Local, regional, and statewide populations in Massachusetts were prepared by the University of Massachusetts Donahue Institute in 2018. The projected population of Hanson and the Commonwealth is displayed in Table 2018.

Town	Census 2000	Census 2010	2020	2030	2040
Hanson	9,495	10,209	10,600	10,863	11,000
Massachusetts	6,349,097	6,547,629	6,933,887	7,225,472	7,380,399

According to these projections, the population of Hanson is projected to increase by 7.7 percent between 2010 and 2040. The population of the Commonwealth is projected to increase 12.7 percent between 2010 and 2040 exceeding 7.3 million in 2040. Factors that affect growth rates include natural increase associated with a greater number of births than deaths; and a net positive immigration, attributable to positive international immigrations into the state, despite the domestic out-migration to other areas of the US.

Figure 25: Percent Change in Population

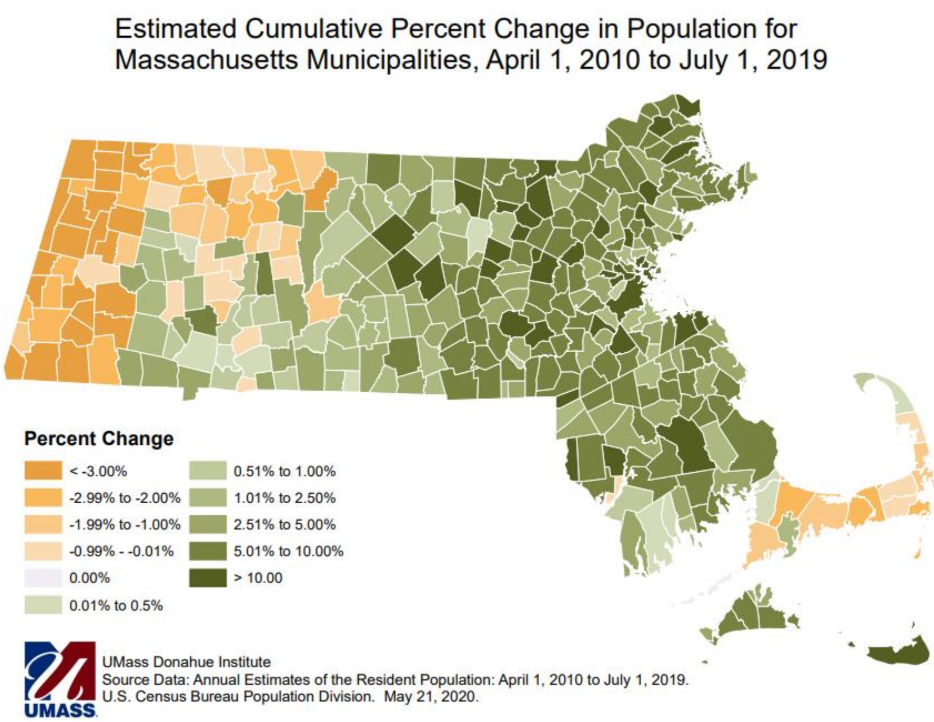
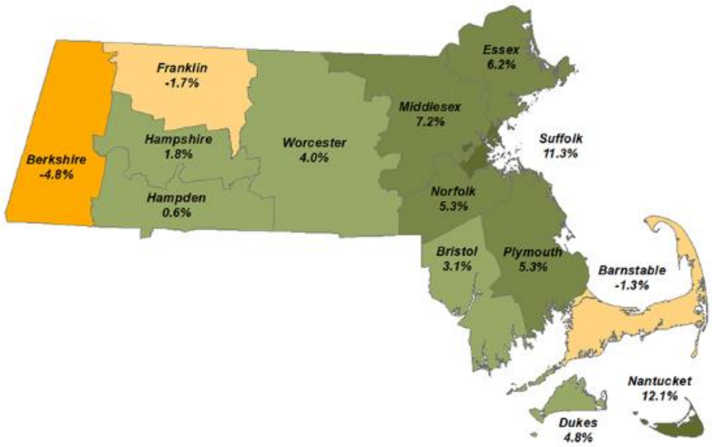


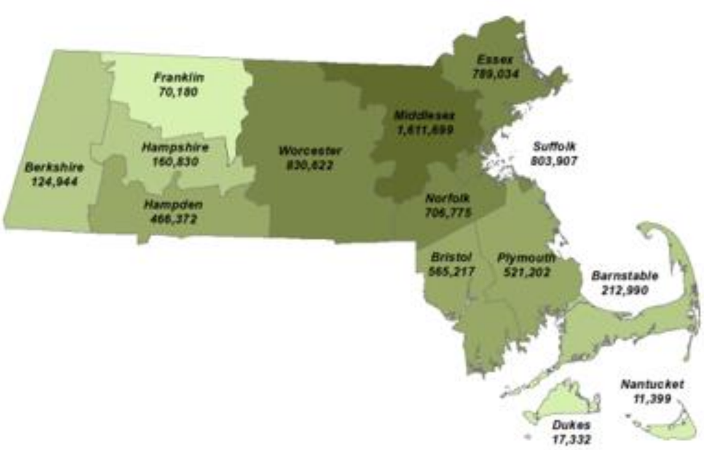
Figure 26: Massachusetts 2019 County Population Estimates: Cumulative Change, Census 2010 to July 1, 2019



Citation: Donahue Institute. Source data: Annual Estimates of the Resident Population April 1, 2010 to July 1, 2019.
U.S. Census Bureau, Population Division. March 26, 2020

On March 26, 2020, the US Census Bureau released population estimates for July 1, 2010 through July 1, 2019 for Massachusetts and US counties. These estimates are based on the demographic *components of change* since Census 2010, including births and deaths, domestic and international migration, and the group quarters population for reach county. [26]

Figure 27: Estimated Population by Massachusetts County, July 1, 2019



UMass Donahue Institute. Source data: Annual Estimates of the Resident Population April 1, 2010 to July 1, 2019.
U.S. Census Bureau, Population Division. March 26, 2020

[26] https://www.census.gov/programs-surveys/popest/data/data-sets.html

Table 22: Population Density

County	Population 2000[1]	2010[2]	2016[3]	Land Area (Square Miles)	Population Density in 2016 (People/Square Mile) [3,4]
Barnstable	222,230	215,888	214,703	394	545
Berkshire	134,953	131,219	128,563	927	139
Bristol	534,678	548,285	554,868	553	1,003
Dukes	14,987	16,535	17,137	103	166
Essex	723,419	743,159	769,362	492	1,562
Franklin	71,535	71,372	70,916	699	101
Hampden	456,228	463,490	468,072	617	759
Hampshire	152,251	158,080	161,035	527	305
Middlesex	1,465,396	1,503,085	1,567,610	818	1,917
Nantucket	9,520	10,172	10,694	46	232
Norfolk	650,308	670,850	691,218	396	1,745
Plymouth	472,822	494,919	506,657	659	769
Suffolk	689,807	722,023	767,719	58	13,180
Worcester	750,963	798,552	813,589	1,511	539
State	6,349,097	6,547,629	6,742,143	7,801	864

Source: [1]2000 Census; [2]2010 Census; [3]American Community Survey 2012-2016 5-Year Estimates; [4]U.S. Census TIGERweb

Age Distribution

In terms of the age of the population, the residents of Hanson are getting older. In the decade between 2000 and 2010, Hanson's elderly population continued to increase, from 818 residents (8.6%) over the age of 65 in Census year 2000 to 1,162 residents (11.3%) in 2010. At the same time, the percentage of the population under age 18 decreased by 2.1 percent from 30.6 percent in the 2000 Census to 28.5 percent in the 2010 Census. As the result of continuing changes in demographics, the needs of residents can be expected to change in relation to transportation, public facilities and services, economic development, and recreation as well as housing.

Compared to surrounding towns and the state, Hanson has a somewhat larger population of residents in the 35-54 and 55-64 age cohorts. The MAPC Population Projections predicts that the latter cohort will continue to grow significantly through 2030, as will the 65+ population for Hanson and all the surrounding towns.

Hanson and neighboring towns all have a notably small population in the 20-34 age range, a cohort generally associated with household formation. MAPC's reported figures and future projections indicate that this age group has decreased overall since 1990 and will likely continue to do so through 2030 in Hanson and the South Subregion as a whole. Fewer young families may be choosing or able to more into the area. The decrease is disproportionate to the anticipated total population growth, as is the relative stability of the school-age population.

Race and Ethnicity

The racial demographics of Hanson and the South Subregion towns are similar, but the area is far less diverse than Massachusetts as a whole. In Hanson, 94 percent of all residents are white, compared with 79 percent of Massachusetts residents. Additionally, Hanson's Latino population (2 percent) is like that of area towns but notably less than that of Massachusetts (11 percent). The lack of racial, ethnic, and cultural diversity in Hanson and so many suburbs on the South Shore is inextricably linked to the region's lack of housing diversity.

Economy

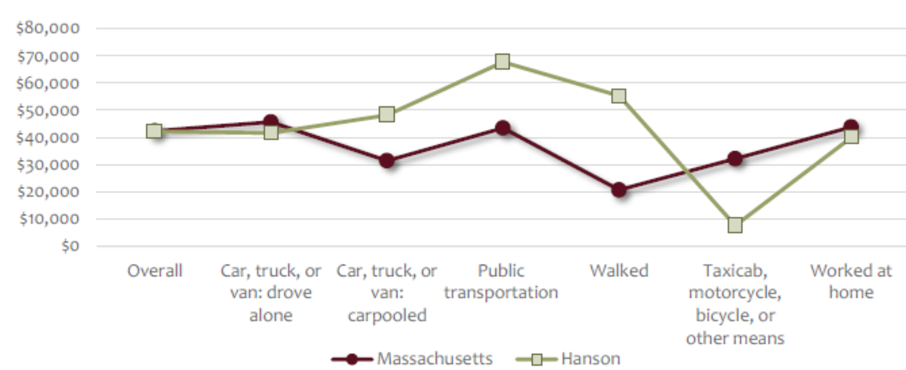
Income

According to the US Census Bureau, the income per capita for Hanson is $29,331 which is less than the Massachusetts average of $35,485 but greater than the National average of $28,051. The income per capita in Hanson is 5 percent higher than the national average.

The median household income for Hanson residents is $92,625 which is substantially more than the Massachusetts average of $66,658 and the National average of $53,046. The estimated median household income was $82,980 in 2007, up from $64,896 in the year 2000. The median household income in Hanson is 75 percent higher than the National average. The percentage of Hanson residents living below the poverty level is 4.1% percent according to the 2017 American Community Survey, 5-year profiles. One out of every 24.3 residents of Hanson live in poverty. Male median earnings in Hanson are 41 percent higher at $43,958 than female median earnings of $26,657. The poverty level in Hanson is 77 percent lower than the National average.

The median earnings for employed residents of Hanson and the surrounding towns is more dramatically linked to means of transportation to work than it is for Massachusetts. For example, the use of public transportation in Hanson is associated with a 60 percent increase in median earnings versus a 3 percent increase statewide.

Figure 28: Median Earnings in the Past 12 Months by Transportation to Work



Source: ACS

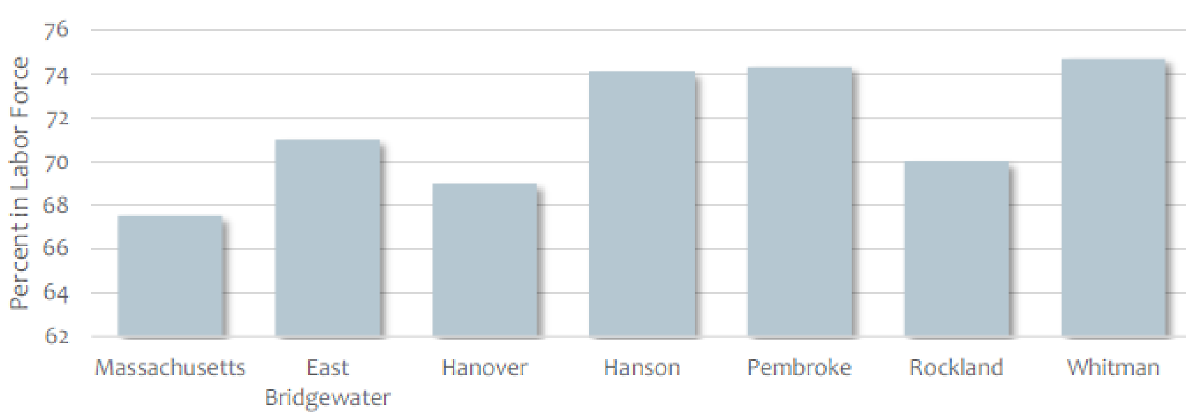
Hanson adopted the Community Preservation Act with a 1.5 percent property tax surcharge rate and a local bylaw establishing a Community Preservation Committee (CPC) at the May 2008 Annual Town Meeting. The CPA bylaw in Hanson exempts the first $100,000 of residential property value from the surcharge and offers an additional exemption for "low-income households", as defined by Section 2 of the Community Preservation Act. As of 2015, Hanson homeowners were paying an average of $47.69 per year for the CPA surcharge.

Employment

For any given city or town, the unemployment rate measures the number of residents in the labor force without a job and looking for work. Hanson's annual unemployment rate has been at or below the statewide rate although occasionally had a somewhat higher unemployment rate than the state, especially in the colder months.

Hanson's labor force participation rate (74 percent) is strong compared to Massachusetts (68 percent) and is just above the median rate for surrounding towns (73 percent). The labor force participation rate includes a community's employed residents and those without a job but actively looking for work. High labor force participation rates typically coincide with towns with high homeownership rates, so Hanson's experience is not surprising.

Figure 29: Labor Force Participation Rate Population 16 Years and Over



Source Hanson Housing Production Plan

Housing Needs Assessment

Hanson is a relatively affordable town – relative to most of the South Shore, but its 10-year rate of growth in single-family sale prices is higher than that of all the surrounding towns.

Hanson seems to attract young families, which is good for community development and the vibrancy of a small town, yet Hanson has fewer families with school-age children than other South Subregion communities.

Hanson's housing is overwhelming comprised of detached single-family homes, and this has had a noticeable impact on the make-up of Hanson households. The prevalence of single-family homes makes sense because Hanson is a small town with limited municipal infrastructure, and it seems that most people appreciate Hanson's quiet suburban ambience. The downside is that Hanson's lack of housing diversity means the Town has very few options for seniors, young people, and virtually anyone looking for small units or some type of managed housing.

Hanson has a small inventory of affordable housing – defined here as housing eligible for listing in the Chapter 40B Subsidized Housing Inventory (SHI). Today, the town has only 157 SHI- eligible units, many of which are owned by the Hanson Housing Authority. Moreover, 31 of the existing SHI units are subject to "expiring use restrictions," which means they can eventually become market rate units.

People leave to downsize or "move-up" to more valuable housing in communities like Hanover. The irony of housing in Hanson is that on one hand, the town has very few affordable units and on the other hand, it is not a high-end community. Overall, Hanson's housing supply is generally good quality and moderately priced, and this has some advantages and disadvantages for the Town. One reason Hanson has not attracted more interest from Chapter 40B developers is that its market-rate housing is not pricy enough to offset the loss of income to developers from the sale or rent of affordable units.

Figure 30: Estimated Number of Housing Cost Burdened Households in Hanson by Income Range

Income by Housing Problems	Housing Cost Burden	Total in Income Group	Percent Cost Burdened	Percent Owners
Extremely Low Income	200	250	80.0%	40.0%
Very Low Income	210	230	91.3%	63.0%
Low Income	185	305	60.7%	47.5%
Total	595	785	75.8%	50.3%

Source: HUD CHAS Data

Affordability Mismatch

Most towns have some modest, older single-family homes that are affordable and apartments with low monthly rents. However, housing that is affordable due to its age, condition, limited amenities, or location is not necessarily occupied by low- or moderate-income people. The US Department of Housing and Urban Development reports data for a n affordable housing barrier known as affordability mismatch, or housing units that are affordable but unavailable to lower income households because higher income households already live in the units.

According to a recent report from HUD:

> Even with the supply of more expensive units growing, higher income renter occupies a growing share – 43 percent- of the most affordable units. Only 62 affordable units are available per very low-income renters…only 66 affordable units exist for every 100 extremely low-income renters. The presence of higher income renters in units that are affordable to extremely low-income renters worsen this shortage. Only 38 affordable units are available for occupancy for every 100 extremely low-income renters. A final blow is that a significant portion of the affordable and available stock is physically inadequate and may post threats to occupants. Only one half of affordable units, or 33 units, are both physically adequate and available for occupancy for every 100 extremely low-income renters. [27]

Although Hanson does have some housing that is affordable to very-low, low- and moderate-income households, most of the "affordable" units are lower end market rate units without any type of income eligibility restrictions. In fact, about half of the renter occupied units and nearly 70 percent of the owner-occupied units that are technically "affordable" do not provide housing for low- or moderate-income people. As a result, Hanson's lower income households have an extremely high incidence of housing cost burden. This is because an affordability mismatch prevents them from accessing existing units they could otherwise afford to purchase or rent.

The problem of affordability mismatch is more complicated than may be apparent in a simple comparison of affordable units with low- or moderate-income households. When a very low-income tenant rents an apartment priced for moderate-income occupancy, the tenant will be housing cost burdened due to an affordability mismatch that occurs within the affordable housing inventory. This condition exists in Hanson and all the surrounding towns.

[27] HUD Office of Policy Research and Development (PDR), *Worst Case Housing Needs 2017: Report to Congress* (August 2017), 4-9

Vulnerable Populations

Accounting for the needs of socially vulnerable populations remains a distinct challenge in climate adaptation planning and implementation efforts. The interdependent nature of climate change adaptation requires technical solutions such as cost-benefit analysis, scenario planning, and vulnerability assessments. Robust community engagement is also a common feature of the adaptation process which helps to inform the planning process and educate the public about climate risks and opportunities.

Social Vulnerability is the disproportionate susceptibility of some social groups to the impacts of hazards. These impacts could include death, injury, loss or disruption of life or livelihood. Social vulnerability also affects a population's resilience; ability to adequately recover from or avoid impacts. Vulnerability is a function of demographic characteristics of the population, as well as environmental and community conditions such as healthcare provision, social capital, access to social networks, and social isolation.

Environmental Justice is defined as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.

Climate change is expected to increase the occurrence and intensity of weather-related events. Identifying and preparing for the hazards most prevalent in Hanson is the first step to reduce social vulnerability and increase the social resilience of the community.

Socially Vulnerable Populations

The impacts on human health, particularly vulnerable populations, were considered by the Committee and incorporated into the hazard profiles where possible. The risk analysis relied on US Census data and stakeholder information regarding vulnerable populations (including but not limited to disabled, low-income, elderly) that could potentially be more severe impacted by each hazard. Among other factors, these populations may require extra time or outside assistance during evacuations or during events that cause power outages or isolation and are more likely to seek or require emergency services.

Vulnerability is influenced by three factors: exposure or contact with the hazard; sensitivity or degree to which people or communities are affected by the exposure to the hazard; and capacity to adapt or the ability of communities, institutions, or people to adjust and respond to and recover from potential hazards.

The major health impacts from natural hazards and climate change are identified by the following classification:

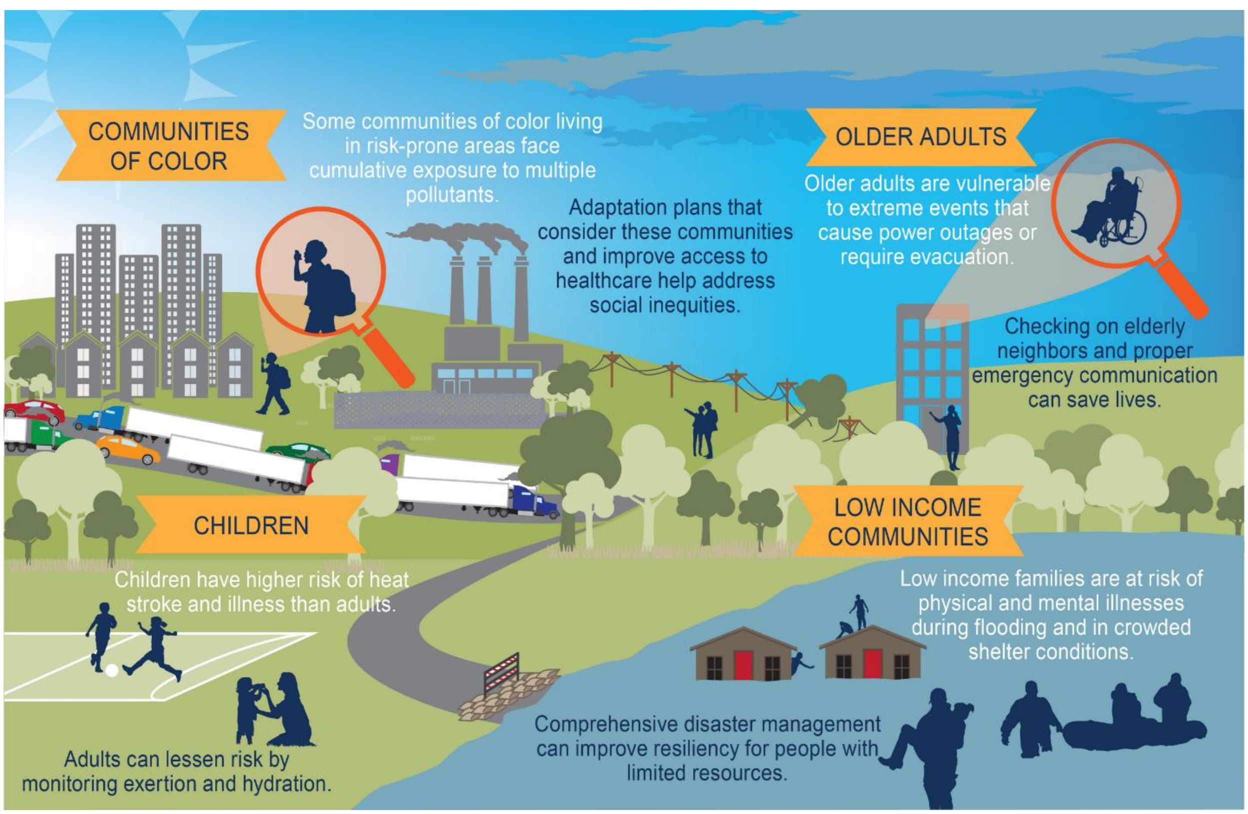
A. Heat-related illnesses and death from an increase in extreme temperatures and poor air quality (SHMCAP, 2018).

B. Increases in food and waterborne illnesses and other infectious diseases from altering geographic and seasonal distributions of existing vectors and vector-borne diseases) SHMCAP, 2018).

C. Injuries and accidental premature death associated with extreme weather events. Extreme weather events can result in acute health impacts, such as injuries and accidental premature death during an event (e.g., drowning during floods). In addition, health impacts can also occur during disaster preparation and post-event cleanup. Other impacts include damage to property, destruction of assets, loss of infrastructure and public services, social and economic impacts, environmental degradation, and other factors (SHMCAP, 2018).

D. Exacerbation of chronic diseases (SHMCAP,2018).

E. Mental health and stress-related disorders ranging from minimal stress and distress symptoms to clinical disorders such as anxiety, depression, post-traumatic stress, and suicidality. Specific groups of people who are at higher risk for distress and other adverse mental health consequences from exposure to climate-related or weather-related disasters include children, the elderly, women (especially pregnant and post-partum women), people with preexisting mental illness, people who are poor, the homeless, and first responders. Populations living in areas most susceptible to specific climate change events are at increased risk for adverse mental health outcomes (SHMCAP, 2018).



Source: www.groundworkusa.org

Vulnerability Category	Vulnerable Population	Heat-related illnesses	Changes in the prevalence and geographical distribution of food- and waterborne illnesses and other infectious diseases	Injuries and accidental premature death	Exacerbation of chronic diseases (respiratory and cardiovascular diseases, diabetes)	Mental health and stress-related disorders
Age	Individuals over 65	X	X	X	X	X
	Individuals over 65 and living alone	X		X	X	X
	Children under 5	X	X	X		
Socioeconomic Status	People living in poverty	X	X	X	X	X
	The homeless	X	X	X	X	X
	People with limited English proficiency	X	X	X	X	X
	People lacking access to air conditioning	X			X	X
Race	Communities of color	X	X	X	X	X
Place	People living in an urban area with limited green space	X			X	X
	People living near high-traffic roadways				X	X
Current Health Status	Adults with chronic diseases (e.g., respiratory, and cardiovascular diseases; compromised immune systems)	X	X	X	X	X
	Children with respiratory disease (e.g., asthma)	X			X	X
	Individuals using electricity-dependent medical equipment and/or medications that need refrigeration	X		X	X	X
	Individuals with disabilities or mobility problems	X	X	X	X	X
	Individuals with mental health challenges	X		X		X

Vulnerable Populations of Hanson

The following Table provides a snapshot of vulnerable populations in Hanson, Plymouth County, and the Commonwealth. This analysis reveals that Plymouth County has a greater percentage of vulnerable individuals 65 years of age or over compared to the overall state percentage.

	Percent < 5 Years	Percent > 65+ Years	Percent with disability	Percent non-white or another race	Percent of Occupied Housing Units/Renters	Percent of Households with a computer	Percent of Households with a broadband internet subscription
Hanson	4.1%	14.7%	10.7%	7.2%	8.0%	94.0%	89.3%
Plymouth County	5.3%	16.7%	11.0%	13.6%	24.1%	90.9%	85.6%
Massachusetts	5.3%	15.5%	11.6%	18.0%%	37.6%	88.9%	83.0%

Environmental Justice Populations

Vulnerable populations include Environmental Justice (EJ) populations. Since 2002, EOEEA has been implementing an Environmental Justice Policy to help ensure that all Massachusetts residents experience equal protection and meaningful involvement with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies and the equitable distribution of environmental benefits. This policy was instituted recognizing that communities across the Commonwealth, particularly those densely populated urban neighborhoods in and around the state's older industrial areas, are facing many environmental challenges associated with Massachusetts' industrial legacy. Residents in these predominantly low-income and minority communities – nearly 29 percent of the state population – lack open space and recreational resources and often live side-by-side numerous existing large and small sources of pollution and old abandoned, contaminated sites, which can pose risks to public health and the environment.

Environmental Justice Criteria

In Massachusetts, EJ populations are determined by identifying block groups from the 2010 Census.

The state considers a community to be an environmental justice community if it meets one or more of the following criteria:

1. 25% of the households earn 65% or less of the statewide household median income ($62,072 in 2010); or,
2. 25% or more of the residents are minority and identify as a race other than white; or,
3. 25% or more of the residents are foreign-born; or,
4. 25% or more of the residents are lacking English language proficiency or households have no one over the age of 14 who speaks English only, or very well (EOEEA, 2018).

EJ communities are vulnerable to hazards due to a range of factors, which may include lack of personal transportation or access to resources, preexisting health conditions, or difficulty translating and understanding emergency alerts or procedures.

Hanson does not meet the criteria to be designated an Environmental Justice population.

Environmental Justice Demographics

Race	2010 Census % of the Population	Percent
Total Population	10,218	100%
One Race	10,078	98.60%
White	9,859	96.50%
African American	104	1%
American Indian	4	0.00%
Asian	48	0.50%
Native Hawaiian	1	0.00%
Some other race	63	0.60%
Hispanic or Latino	95	0.90%
Mexican	15	0.10%
Puerto Rican	30	0.30%

Historical Overview

Early Industry

The industries that Hanson was known for early on was farming, iron forging, and quarrying, with the addition of sawmills being constructed along rivers in the nineteenth century. Since the end of the Industrial Revolution, the town is primarily residential with farming and cranberry bogs located throughout the community. Ocean Spray (originally named Ocean Spray Preserving Company, then changed to Cranberry Canners, Inc. in 1930 and the National Cranberry Association in 1946) was created by three cranberry farmers by the names of Marcus L. Urann, Elizabeth F. Lee and John C. Makepeace. Marcus Urann was proclaimed the “Cranberry King” and built his first cranberry packing house in 1912 in Hanson. Urann discovered that canning cranberries would let them last longer and was the original inventor of cranberry sauce. In 1930, Urann, Lee, and Makepeace joined forces to form the company that has expanded to create the company known today. Ocean Spray’s first headquarters were in Hanson until they moved to Plymouth in the 1970s. Ocean Spray was the original inventor of such cranberry juice beverages such as the cranberry juice cocktail and cranapple juice.

Figure 31: John C. Makepeace, Elizabeth F. Lee, and Marcus Urann

Source: Ocean Spray

Land Use and Development Trends

Hanson can be described as a semi-rural town with strong ties to its agricultural history. Prime agricultural soils in areas of Hanson have provided fertile ground for farmers for centuries. Hanson's long agricultural history defines much of the character of the community. Many of the prime agricultural soils have already been built on, however there are still areas of prime agricultural soil that remain underdeveloped and should be protected.

The large amounts of wetlands in Hanson encouraged a shift from poultry to cranberry cultivation in the late 19th century. All four key elements needed for cranberries can be found in Hanson: acidic peat soils, coarse sand, a constant water supply and a long frost-free growing season. Many cranberry bogs, especially smaller ones, are now retired from production. At least one upland bog has been filled and incorporated into a residential development (Donna Drive). Despite wetlands regulations, development often occurs right up to the gravelly edges of bogs. Cranberry bogs create some of the beautiful scenic views that many people associate with Hanson and should be protected for their aesthetic and environmental qualities.

Geographic Overview

The Town of Hanson is a Plymouth County community that was originally established in the western portion of Pembroke in 1632 and was later incorporated as a separate municipality in the 1820. It has a total size of 15.66 square miles, which breaks down into 15.0 square miles of land and 0.66 square miles of water. Hanson had a population of 10,668 persons based on the 2018 American Community Survey count. Hanson, which is approximately 18 miles southeast of Boston, is bordered by six communities: East Bridgewater (to the west), Halifax (to the south), Hanover (to the northeast), Pembroke (to the east), Rockland (to the north), and Whitman (to the west). The Town of Hanson was named after U.S. Senator Alexander Contee Hanson, who earlier in his life worked as a publisher of the Federal Republican Newspaper.

Hanson is primarily a residential community with the predominant land uses being forest (41.2%), wetlands and water (26.2%), and residential (21.4%). Hanson's natural features include numerous brooks, streams, rivers, and ponds. The main ponds in Hanson include the 121-acre Indian Head Pond, 62-acre Wampatuck Pond, and 48-acre Maquan Pond. Hanson is also home to part of the 1,625-acre Burrage Pond Wildlife Management Area and Great Cedar Swamp.

Hanson's current population density, 678.2 people per square mile (sq. mi.)[28], falls well below the state average (839.4/sq. mi.)[29] and that of Plymouth County (750.9/sq. mi.). The Table below depicts population data for Hanson and its neighbors. To underscore the impact of highway access and infrastructure on growth and investment in communities, in 1950 Hanson and Hanover had similar population counts, and Pembroke was smaller than both; today, Hanover is larger than Hanson and Pembroke are significantly larger.

Table 23: Population Trends - Annual Decennial Census Counts

Community	1950	1960	1970	1980	1990	2000	2010	2020	2030	2040
Brockton	62,860	72,813	89,040	95,172	92,788	94,304	93,810	96,000	96,700	97,100
East Bridgewater	4,412	6,139	8,347	9,945	11,104	12,974	13,794	14,400	14,616	14,800
Hanover	3,389	5,923	10,107	11,358	11,912	13,164	13,879	13,864	13,999	14,084
Hanson	3,264	4,370	7,148	8,617	9,028	9,495	10,209	10,600	10,863	11,000
Pembroke	2,579	4,919	11,193	13,487	14,544	16,927	17,837	18,300	18,695	18,931
Rockland	8,960	13,119	15,674	15,695	16,123	17,670	17,489	19,227	19,975	20,681
Whitman	8,413	10,485	13,059	13,534	13,240	13,882	14,489	15,169	15,389	15,583

Source: University of Massachusetts Donohue Institute, Massachusetts State Data Center

Geology and Topography

The geology of Hanson is dominated by glacial features, such as sand, gravel, glacial till soils, and low eskers and drumlins. Elevations range from 25 to just 160 feet above sea level, so the landscape is relatively flat and unremarkable, with few steep slopes or outcrops of stone or ledge. The most obvious features are water-related ponds, streams, and swamps, as described elsewhere in this document.

Interestingly, two surface water bodies (Maquan Pond and Indian Head Pond) exhibit sharply different qualities despite being near each other and connected by Indian Head Brook. Maquan Pond has "*remarkably soft water*" (quoting an 1830 surveyor's map notes), and recent studies by Professor William Hagar of UMass Boston confirm that typically acidic rain events are very poorly buffered due to the pond's relative purity, to such an extent that day-old sunfish fry are actually killed by brief but severe pH drops.[30] In contrast, Indian Head Pond, located downstream, has a higher mineral content,

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[28] https://www.census.gov/quickfacts/hansontownplymouthcountymassachusetts

[29] https://www.census.gov/quickfacts/fact/table/MA,plymouthcountymassachusetts,hansontownplymouthcountymassachusetts/PST045219

[30] **Hagar, W., Xu, Q. and Ebersole, J. (2017) Effect of Transient Acid Spikes on Developmental Stages of *Lepomis* Fishes. *Journal of Water Resource and Protection, 9, 1391-1402.***

such that the same 1830 surveyor notes "*[bog] iron ore of high quality was formerly taken from this pond.*" Indeed, in many locales the groundwater seeping to the surface is coated with reddish-brown iron oxide (rust) or a bluish-black metallic sheen of manganese oxide, or both; these discolorations are often mistaken for pollution by uninformed sources.

Another interesting aquatic geologic feature is the flow of cold, clean groundwater into Indian Head Brook from gravelly uplands, especially in the Gorwin Drive neighborhood. This results in the brook's ability to support a state-documented cold-water fishery (e.g., native brook trout, *Salvelinus fontinalis*), a condition that is increasingly rare, and thus valuable in southern New England.

Stone features are of basically three types. On is small, glacial boulders that have in many parts of town been built into classic "stone walls" during the long-past agricultural era. Secondly, several larger "glacial erratic" granite boulders have altered surfaces that bear the marks of having been "quarried", i.e., laboriously cut into rectangular pieces by hand tools during the 16-17 and 1800s; such stones were essential for the foundations of buildings before the invention if concrete. Collections of such altered boulders can be seen at Veterans Memorial Town Forest, near the Camp Kiwanee gatehouse, and at Rocky Run Conservation Area. A third type of interesting visual stone is the dramatic exposure of true bedrock – dark, igneous, and fine grained- at Rocky Run. This forms cliff-like features along Indian Head River, unlike the other landscape in Hanson, and represents the uplifted edge of the solid floor of the Narragansett Basin. This basin extends southwesterly from this area to Rhode Island and is roughly defined by the Taunton River watershed. Except for this small but striking feature, most of the basin's bedrock in Hanson is deeply buried by the previously mentioned sand, gravel, glacial till, and mucky swamp deposits or surface water.

Soils

Due to differences in substrate types, vegetation types, groundwater conditions, microclimate, and land-use history, Hanson has a rich mosaic of soils (see Hanson General Soil Map). Several named soil types are present and their characteristics further differ according to topographic slope.

Soils are an important physical characteristic to consider when determining the type and level of development a community can sustain. Soil type is a major determinant of characteristics such as drainage, degrees of flooding and frost action, susceptability to erosion and septic suitability. Proper interpretation of various soil types is an intergral part of land use planning.

Extensive areas of wet hydric soils characterize this Town. Hydric soils and soils with seasonally high water tables have been used for pastureland or conservation. Some of the latter soils also contain a restrictive hard layer that tends to prevent water from percolating downward. Most hydric soils in Hanson are mucks, especially Freetown and Swansea. Most soils with seasonally high water tables are loamy sand (e.g. Deerfield) or fine sandy loam (e.g. Merrimac). Seasonal high water table soils with a restrictive layer are overwhelmingly fine sandy loams, mostly of the Montauk and Paxton soil types.

Freetown, Swansea and Berryland soils are all mapped within low-lying depression areas and are associated with swamps and freshwater wetlands. All three soils have a seasonal high-water table at or near the surface for most of the year and are often ponded for long durations. Freetown soils consist of very deep organic material ranging from 51 inches to more than 20 feet in thickness. Swansea soils consist of organic material, 16 to 51 inches thick, underlain by fluvial material. Scarboro soils consist of organic material less than 16 inches thick, underlain by fluvial deposits.

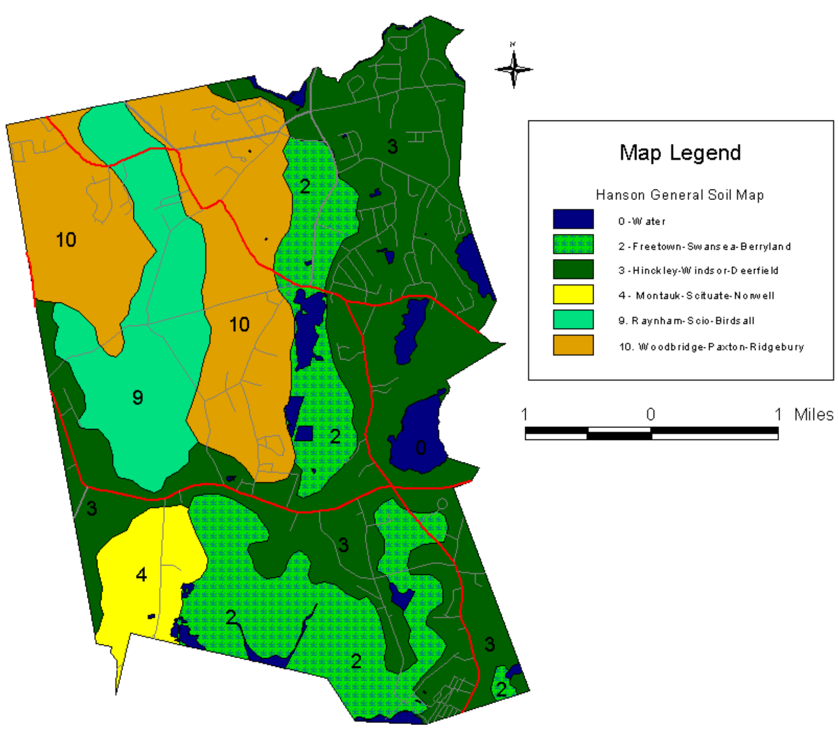
Minor soils in this map unit are excessively drained Carver and Hinckley soils, moderately well drained Birchwood and Deerfield soils, and poorly drained Mattapoisett and Pipestone soils. Very poorly drained Berryland and Brockton soils are also included in this map unit.

Hinckley- Windsor- Deerfield: Very deep, nearly level to steep, excessively to moderately well drained soils formed in glacial fluvial deposits on outwash plains, deltas, kames, and ice contact deposits. Hinckley soils are very gravelly, excessively drained, soils on kames, eskers, moraines, and heads of outwash plains.

Windsor soils are sandy, excessively drained, soils on deltas and along the southern end of outwash plains (distal part).

Deerfield soils are moderately well drained soils on lower elevations and in swales of outwash plains and deltas. Deerfield soils have an apparent seasonal high-water table between 1.5 and 4 feet and require mounded septic systems. These soils occur in areas of aquifer recharge and caution should be taken to protect the aquifer. These soils are well suited for woodland productivity, they are also well suited for cropland; irrigation is required for optimal growth.

Figure 32: Hanson General Soil Map



Montauk-Scituate-Norwell: Very deep, gently sloping to steep well drained to poorly drained soils formed in sandy loam material underlain by dense glacial till derived primarily from granitic materials on uplands, drumlins, and ground moraines.

Montauk soils are well drained soils convex top and side slopes of hills. Montauk soils have a perched, seasonal high-water table approximately 2.5 to 5 feet below the surface.

Scituate soils are moderately well drained soils on foot slopes and gently sloping hillsides. Scituate soils have a perched, seasonal high-water table about 1.5 to 4 feet below the surface. Norwell soils are poorly drained soils on concave slopes along drainage ways and depressions. Norwell soils have a perched, seasonal high-water table about 0.5 to 1.5 feet below the surface.

Most areas of this map unit are in woodland and mixed residential and industrial development. Some areas are used for cropland. Montauk and Scituate soils are well suited for woodland productivity and cropland; Norwell soils are poorly suited for woodland and cropland due to wetness. These soils are poorly suited to use as sites for septic tank absorption fields because the slowly permeable dense substratum which does not readily absorb the effluent. Subsurface drainage is also a problem with these soils; the firm substratum causes a perched seasonal high-water table.

The lacustrine (lake bottom) soils often coincide with modern wetlands and can range from sand to fine silt to muck, with significant limitations for septic systems. Thus the 1999 land use map shows these areas as still largely open.

The extensive areas of glacial till are quite varied, combining reasonably well-drained sandy loams with relatively impermeable underlying frangipanes, and occasional very tight clay lenses. At the same time tills are often found in north-south running drumlins rising above the less buildable wetlands, and are sites of early roads and development like that along Hanson's High Street (Bonney Hill). This pattern is shown on even the earliest land use maps.

Due to the large areas of wetlands and soils that drain poorly, most residential development in Hanson is taking place along existing major roads. At this time, all areas of Hanson have on-site sewage disposal.

Topography

Hanson's topography is relatively low and level and is part of the great glacial outwash plain of southeastern Massachusetts. Hanson's topography ranges in elevations from a high of 160 feet at Rye Hill on the Whitman Town Line and 153 feet for Bonney Hill, a glacial drumlin, in the center of town, down to 25 feet on the shores of Indian Head River at the northeast corner of Town. Most of the Town lies below 100 feet in elevation. There are similar hills in the northwest and southwest parts of Town, including a few eskers. Large, flat, low wetland areas provide varied wildlife habitat that supports biodiversity.

Land Use

Table 24: Number of Parcels in Each Land Use Classification

Land Use Type	Number of Parcels	Percent
Agricultural	12.966	0.300
Commercial	107.6178	.249
Forest	2.98218	.069
Industrial	33.97092	.786
Mixed-Use Commercial	1.42626	.033
Mixed-Use Residential	1.98812	.046
Open Space Conservation		
Open Space Recreation	1.64236	.038
Residential – Single Family Dwelling	3,542.743	81.97
Residential – Multi-family Dwelling	80.8214	1.87
Tax Exempt	242.8964	5.62
Res. Vac Land	293.0316	6.78
Total	4,322.086	100%

Source: Hanson Assessor's Office

Hanson has slowly changed from a two-center Town to a suburban community with residential areas scattered in new subdivisions town-wide. These generally are not directly connected to one another by local roads or sidewalks. The lack of interior connectors increases the dependency on the automobile. This is typical of suburban sprawl. Nevertheless, the two centers remain, as well as an older residential development in southeast Hanson. [31]

For the most part, commercial uses serve the residents of the Town. Industrial and distribution firms, who serve a larger area, have decreased in recent years. Considerable wetlands and waterways divide the town north to south, and much of the land east of Elm Street and south of the railroad track is wetlands.

[31] **Hanson Master Plan**

Subbasin ID	Entire Sub-Basin		Municipality	EPA Land Use Class Number	EPA Land Use Class Name	Unique ID	Total Area (Including Un-Regulated Areas)					Urbanized/Regulated Area Only				
							Total Area	Impervious Area (IA)		Directly Connected Impervious Area (DCIA)		All Urbanized/ Regulated Area	Impervious Area (IA)		Directly Connected Impervious Area (DCIA)	
	Acres	% Impervious Area					Area (acres)	Area (acres)	% of Total Area	% of Total Area	Area (acres)	Area (acres)	Area (acres)	% of Urbanized/ Regulated Area	% of Urbanized/ Regulated Area	Area (acres)
22016	3161.06	13.37	Hanson	3	Low Density Residential	Hanson_22016_LU3	42.10	12.57	29.87	12.88	5.42	42.10	12.64	30.02	12.99	5.47
22016	3161.06	13.37	Hanson	4	Medium Density Residential	Hanson_22016_LU4	34.18	10.52	30.78	17.08	5.84	34.18	10.50	30.72	17.02	5.82
22016	3161.06	13.37	Hanson	8	Forest	Hanson_22016_LU8	84.55	2.74	3.24	1.05	0.89	84.55	2.70	3.19	1.02	0.86
22016	3161.06	13.37	Hanson	10	Water	Hanson_22016_LU10	37.17	0.06	0.16	0.00	0.00	37.17	0.06	0.15	0.00	0.00
						Subbasin Subtotal:	**197.99**	**25.89**	**13.08**	**6.14**	**12.15**	**197.99**	**25.89**	**13.08**	**6.14**	**12.15**
22017	5720.84	19.09	Hanson	3	Low Density Residential	Hanson_22017_LU3	7.43	2.06	27.66	11.30	0.84	7.43	2.06	27.77	11.38	0.85
22017	5720.84	19.09	Hanson	4	Medium Density Residential	Hanson_22017_LU4	32.86	9.63	29.32	15.87	5.22	32.86	9.63	29.32	15.88	5.22
22017	5720.84	19.09	Hanson	8	Forest	Hanson_22017_LU8	65.95	1.51	2.29	0.53	0.35	65.95	1.50	2.28	0.52	0.34
22017	5720.84	19.09	Hanson	9	Open Land	Hanson_22017_LU9	1.56	1.27	81.55	73.65	1.15	1.56	1.28	81.88	74.10	1.16
22017	5720.84	19.09	Hanson	10	Water	Hanson_22017_LU10	39.29	0.01	0.01	0.00	0.00	39.29	0.00	0.01	0.00	0.00
						Subbasin Subtotal:	**147.09**	**14.48**	**9.84**	**5.13**	**7.55**	**147.09**	**14.48**	**9.85**	**5.14**	**7.56**
22020	1840.75	15.40	Hanson	1	Commercial	Hanson_22020_LU1	4.86	3.93	80.84	72.68	3.53	4.86	3.93	80.82	72.66	3.53
22020	1840.75	15.40	Hanson	3	Low Density Residential	Hanson_22020_LU3	177.87	46.19	25.97	10.16	18.06	177.87	46.15	25.95	10.14	18.04
22020	1840.75	15.40	Hanson	4	Medium Density Residential	Hanson_22020_LU4	9.38	2.89	30.85	17.13	1.61	9.38	2.88	30.69	17.00	1.60
22020	1840.75	15.40	Hanson	7	Agriculture	Hanson_22020_LU7	2.42	0.08	3.38	1.15	0.03	2.42	0.08	3.32	1.10	0.03
22020	1840.75	15.40	Hanson	8	Forest	Hanson_22020_LU8	238.82	8.19	3.43	1.17	2.81	238.82	8.27	3.46	1.20	2.86
22020	1840.75	15.40	Hanson	9	Open Land	Hanson_22020_LU9	3.79	0.57	15.04	5.83	0.22	3.79	0.55	14.45	5.49	0.21
22020	1840.75	15.40	Hanson	10	Water	Hanson_22020_LU10	77.52	0.28	0.37	0.00	0.00	77.52	0.29	0.37	0.00	0.00
						Subbasin Subtotal:	**514.66**	**62.14**	**12.07**	**5.10**	**26.26**	**514.66**	**62.14**	**12.07**	**5.10**	**26.26**
22021	2952.4	11.26	Hanson	1	Commercial	Hanson_22021_LU1	41.21	31.16	75.60	65.73	27.09	40.20	30.34	75.48	65.58	26.36
22021	2952.4	11.26	Hanson	2	Industrial	Hanson_22021_LU2	4.79	0.70	14.65	5.61	0.27	4.79	0.70	14.70	5.63	0.27
22021	2952.4	11.26	Hanson	3	Low Density Residential	Hanson_22021_LU3	566.06	147.12	25.99	10.17	57.56	557.66	144.26	25.87	10.09	56.26
22021	2952.4	11.26	Hanson	4	Medium Density Residential	Hanson_22021_LU4	105.59	28.67	27.15	14.15	14.94	105.59	28.69	27.17	14.17	14.96
22021	2952.4	11.26	Hanson	5	High Density Residential	Hanson_22021_LU5	11.91	5.74	48.19	41.84	4.98	11.91	5.71	47.93	41.57	4.95
22021	2952.4	11.26	Hanson	6	Urban Public/ Institutional	Hanson_22021_LU6	69.76	30.17	43.25	28.44	19.84	69.76	30.17	43.25	28.44	19.84
22021	2952.4	11.26	Hanson	7	Agriculture	Hanson_22021_LU7	9.07	0.34	3.80	1.45	0.13	9.07	0.34	3.73	1.39	0.13
22021	2952.4	11.26	Hanson	8	Forest	Hanson_22021_LU8	1039.11	28.75	2.77	0.77	7.95	1034.25	28.67	2.77	0.77	7.95
22021	2952.4	11.26	Hanson	9	Open Land	Hanson_22021_LU9	37.19	8.86	23.84	11.64	4.33	37.19	8.86	23.82	11.62	4.32
22021	2952.4	11.26	Hanson	10	Water	Hanson_22021_LU10	932.88	40.36	4.33	0.00	0.00	932.88	40.37	4.33	0.00	0.00
						Subbasin Subtotal:	**2817.56**	**321.87**	**11.42**	**4.87**	**137.09**	**2803.28**	**318.11**	**11.35**	**4.82**	**135.03**
22023	4825.87	11.99	Hanson	3	Low Density Residential	Hanson_22023_LU3	77.15	21.85	28.32	11.77	9.08	77.15	21.82	28.29	11.74	9.06
22023	4825.87	11.99	Hanson	4	Medium Density Residential	Hanson_22023_LU4	119.15	34.97	29.35	15.90	18.95	119.15	34.97	29.35	15.90	18.95
22023	4825.87	11.99	Hanson	8	Forest	Hanson_22023_LU8	185.27	8.51	4.59	2.11	3.91	185.27	8.54	4.61	2.13	3.94
22023	4825.87	11.99	Hanson	9	Open Land	Hanson_22023_LU9	7.44	1.39	18.65	8.06	0.60	7.44	1.39	18.63	8.04	0.60
22023	4825.87	11.99	Hanson	10	Water	Hanson_22023_LU10	138.26	2.12	1.54	0.00	0.00	138.26	2.13	1.54	0.00	0.00
						Subbasin Subtotal:	**527.27**	**68.85**	**13.06**	**6.17**	**32.54**	**527.27**	**68.85**	**13.06**	**6.17**	**32.54**
24019	5029.64	9.09	Hanson	1	Commercial	Hanson_24019_LU1	25.51	18.52	72.60	61.86	15.78	11.26	8.15	72.35	61.55	6.93
24019	5029.64	9.09	Hanson	2	Industrial	Hanson_24019_LU2	67.67	47.87	70.74	59.50	40.27	28.33	22.23	78.48	69.53	19.70
24019	5029.64	9.09	Hanson	3	Low Density Residential	Hanson_24019_LU3	463.43	113.26	24.44	9.16	42.44	309.66	76.26	24.63	9.28	28.73
24019	5029.64	9.09	Hanson	4	Medium Density Residential	Hanson_24019_LU4	25.06	8.44	33.68	19.54	4.90	20.42	7.45	36.46	22.01	4.50

24019	5029.64	9.09	Hanson	5	High Density Residential	Hanson_24019_LU5	5.97	2.83	47.37	40.99	2.45	5.97	2.82	47.18	40.79	2.44
24019	5029.64	9.09	Hanson	6	Urban Public/ Institutional	Hanson_24019_LU6	46.56	25.97	55.77	41.65	19.39	46.56	25.95	55.72	41.60	19.37
24019	5029.64	9.09	Hanson	7	Agriculture	Hanson_24019_LU7	94.20	11.10	11.78	13.87	13.07	58.77	8.50	14.46	20.91	12.29
24019	5029.64	9.09	Hanson	8	Forest	Hanson_24019_LU8	1772.18	28.06	1.58	0.25	4.44	853.51	14.83	1.74	0.30	2.58
24019	5029.64	9.09	Hanson	9	Open Land	Hanson_24019_LU9	75.36	26.43	35.07	20.77	15.65	22.55	6.40	28.38	15.12	3.41
24019	5029.64	9.09	Hanson	10	Water	Hanson_24019_LU10	747.63	1.75	0.23	0.00	0.00	243.92	0.90	0.37	0.00	0.00
						Subbasin Subtotal:	**3323.58**	**284.23**	**8.55**	**4.77**	**158.39**	**1600.96**	**173.49**	**10.84**	**6.24**	**99.94**
24021	1717.67	5.89	Hanson	1	Commercial	Hanson_24021_LU1	2.84	2.44	85.97	79.71	2.26	2.84	2.44	85.94	79.67	2.26
24021	1717.67	5.89	Hanson	2	Industrial	Hanson_24021_LU2	15.53	12.20	78.56	69.63	10.81	7.36	5.84	79.36	70.69	5.21
24021	1717.67	5.89	Hanson	3	Low Density Residential	Hanson_24021_LU3	102.66	29.14	28.38	11.81	12.12	68.05	17.33	25.47	9.83	6.69
24021	1717.67	5.89	Hanson	4	Medium Density Residential	Hanson_24021_LU4	15.41	4.90	31.80	17.94	2.76	15.41	4.90	31.77	17.91	2.76
24021	1717.67	5.89	Hanson	5	High Density Residential	Hanson_24021_LU5	2.57	0.78	30.50	24.17	0.62	2.57	0.78	30.32	23.99	0.62
24021	1717.67	5.89	Hanson	6	Urban Public/ Institutional	Hanson_24021_LU6	10.37	2.03	19.55	8.64	0.90	10.37	2.03	19.60	8.68	0.90
24021	1717.67	5.89	Hanson	7	Agriculture	Hanson_24021_LU7	24.04	5.63	23.42	54.86	13.19	5.80	3.31	57.14	326.44	18.94
24021	1717.67	5.89	Hanson	8	Forest	Hanson_24021_LU8	342.27	6.40	1.87	0.35	1.20	99.13	2.71	2.74	0.75	0.74
24021	1717.67	5.89	Hanson	10	Water	Hanson_24021_LU10	542.68	10.20	1.88	0.00	0.00	47.28	1.73	3.66	0.00	0.00
						Subbasin Subtotal:	**1058.37**	**73.72**	**6.97**	**4.14**	**43.87**	**258.82**	**41.09**	**15.88**	**14.72**	**38.11**
24022	4548.3	9.21	Hanson	1	Commercial	Hanson_24022_LU1	6.01	4.32	71.80	60.84	3.66	6.01	4.30	71.52	60.49	3.64
24022	4548.3	9.21	Hanson	2	Industrial	Hanson_24022_LU2	51.08	20.14	39.43	24.76	12.65	51.08	20.15	39.45	24.78	12.66
24022	4548.3	9.21	Hanson	3	Low Density Residential	Hanson_24022_LU3	222.37	56.26	25.30	9.71	21.60	212.76	54.32	25.53	9.86	20.99
24022	4548.3	9.21	Hanson	4	Medium Density Residential	Hanson_24022_LU4	110.10	31.16	28.30	15.05	16.57	107.42	30.57	28.46	15.18	16.31
24022	4548.3	9.21	Hanson	5	High Density Residential	Hanson_24022_LU5	0.90	0.59	65.82	60.83	0.55	0.90	0.59	65.74	60.74	0.55
24022	4548.3	9.21	Hanson	6	Urban Public/ Institutional	Hanson_24022_LU6	3.96	2.36	59.51	45.91	1.82	3.96	2.33	58.78	45.07	1.78
24022	4548.3	9.21	Hanson	7	Agriculture	Hanson_24022_LU7	0.04	0.03	78.59	617.58	0.24	0.04	0.03	86.69	751.59	0.30
24022	4548.3	9.21	Hanson	8	Forest	Hanson_24022_LU8	307.28	10.60	3.45	1.19	3.66	271.60	10.29	3.79	1.43	3.90
24022	4548.3	9.21	Hanson	9	Open Land	Hanson_24022_LU9	5.45	1.64	30.12	16.53	0.90	5.45	1.65	30.32	16.69	0.91
24022	4548.3	9.21	Hanson	10	Water	Hanson_24022_LU10	588.06	14.34	2.44	0.00	0.00	341.22	11.23	3.29	0.00	0.00
						Subbasin Subtotal:	**1295.26**	**141.44**	**10.92**	**4.76**	**61.65**	**1000.43**	**135.46**	**13.54**	**6.10**	**61.02**
24032	3763.38	8.03	Hanson	3	Low Density Residential	Hanson_24032_LU3	0.52	0.04	7.46	1.22	0.01	0.52	0.04	7.80	1.31	0.01
24032	3763.38	8.03	Hanson	8	Forest	Hanson_24032_LU8	1.14	0.03	2.38	0.57	0.01	1.05	0.02	2.33	0.54	0.01
24032	3763.38	8.03	Hanson	9	Open Land	Hanson_24032_LU9	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
						Subbasin Subtotal:	**1.67**	**0.07**	**3.94**	**0.77**	**0.01**	**1.58**	**0.06**	**4.10**	**0.79**	**0.01**
24091	5882.54	18.83	Hanson	3	Low Density Residential	Hanson_24091_LU3	12.74	2.85	22.35	7.86	1.00	12.74	2.87	22.51	7.96	1.01
24091	5882.54	18.83	Hanson	4	Medium Density Residential	Hanson_24091_LU4	33.92	8.48	25.01	12.51	4.24	33.92	8.47	24.99	12.49	4.24
24091	5882.54	18.83	Hanson	7	Agriculture	Hanson_24091_LU7	8.77	0.33	3.81	1.45	0.13	8.77	0.34	3.83	1.47	0.13
24091	5882.54	18.83	Hanson	8	Forest	Hanson_24091_LU8	111.71	3.54	3.17	1.01	1.12	111.71	3.54	3.16	1.00	1.12
24091	5882.54	18.83	Hanson	9	Open Land	Hanson_24091_LU9	0.36	0.27	75.34	65.39	0.23	0.36	0.27	74.72	64.58	0.23
24091	5882.54	18.83	Hanson	10	Water	Hanson_24091_LU10	12.09	0.01	0.05	0.00	0.00	12.09	0.01	0.07	0.00	0.00
						Subbasin Subtotal:	**179.58**	**15.48**	**8.62**	**3.75**	**6.73**	**179.58**	**15.49**	**8.63**	**3.75**	**6.73**

Natural Resources

Water Resources

There are five types of water features of importance: (1) watersheds; (2) surface water; (3) aquifer recharge areas; (4) flood hazard areas; and (5) wetlands.

Geographically, Hanson consists of three "bands" of woodlands crossing the Town separated by three "strips" of lowlands and lies within both the North and Taunton River Watersheds. Much of the town is low and wet, particularly in the Great Cedar Swamp area to the south and Little Cedar Swamp area in the north.

Hanson is located within the "Lakes Region" area of the Old Colony region ("Lake Communities" include Hanson, Halifax, Pembroke, and Plympton). This area has a range of tight wetlands soils and porous areas of sand and gravel, with many lakes and ponds and few major streams. The water coverage is 0.66 square miles or about 4.21 Percent of the land area is covered by water. Hanson is bordered by Hanover and Rockland to the north, Pembroke to the east, Halifax to the south, and East Bridgewater and Whitman to the west.

Watersheds

The Town of Hanson lies within two major surface watersheds: The North River and the Taunton River watersheds. There are approximately 4,600 acres in the northeast section of town which are contained in the North River watershed. Indian Head Brook serves as the only major surface drainage way in this area, flowing north from Indian Head Pond through Wampatuck Pond and Little Cedar Swamp into the Indian Head (or Drinkwater) River. Indian Head Brook has numerous intermittent and permanent tributary water courses which drain its watershed. The watershed contains many swampy areas with ridges of high ground. The Indian Head River flows in an east-west direction, ultimately tying into the North River. Most of the Indian Head River and all the North River can be canoed.

Hanson also contains approximately 5,700 acres of the Taunton River drainage area within its border, including the Great Cedar Swamp. The major surface drainage ways in this area are the Shumatuscacant River and Poor Meadow Brook. The Shumatuscacant River flows south from Whitman into Poor Meadow Brook, which is a tributary of the Satucket River.

The Taunton River Watershed in the coastal plain for southeastern Massachusetts is the second largest watershed in the Commonwealth. This watershed is vulnerable to the effects of climate change, including flooding, increased precipitation, and sea level rise due to its location and topography (RTI International, 2014).

Surface Water

Primary recreational uses of water resources include canoeing, boating, and fishing in ponds. Swimming is popular at Maquan Pond and canoeing and boating is popular on Indian Head, Maquan and Wampatuck ponds. Ice skating most often occurs on Wampatuck Pond. Essentially all areas adjoining surface water bodies provide recreational value for walking and enjoying nature, although not all these areas have public access. To maintain recreational opportunities and preserve water quality it is important to protect the land adjacent to surface water. Protecting and enhancing certain water bodies is a focus of the town.

Ponds are a critical part of Hanson's open space and recreational resources on a regional, town, and neighborhood level. On a regional level, Indian Head Pond, a "Great Pond" is a key shared resource for Hanson and Pembroke. Both towns must cooperate with the State in protecting and managing this high-value resource which draws visitors from the region.

Hanson contains 9 ponds totaling 371 acres in surface area that provide the Town with approximately 10 miles of shoreline. The larger ponds are used for fishing, boating, and other forms of recreation. None of the ponds are used exclusively for a public water supply, although since the 1960s the Monponsett Ponds (and Oldham and Furnace Ponds in Pembroke) have been seasonally diverted to Silver Lake and are major components of Brockton's water supply.

In addition to outright purchase of land, the Town should consider other tools, including conservation restrictions and shoreline zoning. Particularly where ponds can provide neighborhood outdoor recreation, private fundraising and Community Preservation Act funds for acquisition is possible, perhaps in conjunction with a land trust. Municipal land by ponds may contain some undeveloped land that should be managed for conservation values until needed for town services, thus maintaining both conservation value and long-term land-use flexibility.

To raise awareness about surface water resources among residents, an educational wetlands brochure, "*Living with Wetlands, A Guide to Wetland Protection Laws in Hanson,"* was created for distribution to all residents and provided to all real estate agents in 2017. It highlights the key regulatory provisions and the importance and values of buffers adjacent to wetlands.

Indian Head Pond (Great Pond)

Indian Head Pond is 119 acres in area and located on the Hanson-Pembroke town line at an elevation of 68 feet. The shoreline has an increasing number of residences and is accessible to the public through the Alton J. Smith Reserve "Smitty's Bog" Wetlands Restoration Project site. The maximum depth of Indian Head Pond is seven feet, and the mean depth is five feet. The pond gives rise to Indian Head Brook and serves as a reservoir for several cranberry bogs. Boating is the primary recreation activity on the pond. There is a narrow, unpaved public boat launch called the Marcus Urann Fisherman's Landing which was created in the 1960's. As boats and trailers have become larger, boaters have expanded the boat launch area to another piece of shoreline which is town Conservation land but prohibited by federal USDA deed from allowing vehicles. It is unclear if this access point is on town-owned land, and town boards are actively seeking resolution to this issue.

Indian Head Pond is listed in Category 2 of the 2002 Integrated List of Waters (MassDEP 2003a). This segment supported some uses (*Secondary Contact Recreation and Aesthetics)* and was not assessed for the others. This lake is in the North River watershed. The brook which flows from Maquan Pond is the only tributary besides some wetland drainage. Otherwise, the lake is precipitation and groundwater-fed. The outlet is Indian Head Brook, which flows through the Main Street bogs to Wampatuck Pond.

The lake is a Great Pond, and public access is required. Access from Hanson is via the Fisherman's Landing ramp, off Indian Head Street; there does not appear to be any other public access point in Hanson. The lake is used primarily for fishing and boating.

The eastern shore is the border between Hanson and Pembroke; residences on that shore are in Pembroke, but the entire lake is in Hanson. There is no public access from the Pembroke side. The lake is probably eutrophic; it is not tested or monitored to our knowledge. Potential conflict could arise over management of the lake, as Hanson Boards and Commissions have no jurisdiction in Pembroke.

Cranberry agriculture is still ongoing next to the pond on the Hanson side, and water is drawn from and returned to the lake. If this cranberry operation ceases, the bogs should be allowed to return to a natural state. If not, a tail-water recovery system should be installed and maintained. A ground water withdrawal permit exists for a company that trucks water away, e.g., for swimming pools.

Water rights belong to the Town via the Nathaniel Thomas Mill below Wampatuck Pond. Water was previously withdrawn and returned to the lake by Edgewood Bogs, now retired from cranberry production and being restored as wetlands under the USDA "Wetland Reserve Program," as the Alton J. Smith Reserve (Smitty's Bog Conservation Area).

Oldham Pond (Great Pond)

Oldham Pond is a 235-acre natural pond located in the towns of Pembroke and Hanson. Approximately 44 of Oldham Pond's 235 acres lie within the Town of Hanson. Oldham Pond receives water from Spring Brook, cranberry bogs and wetland areas and serves as the headwaters of Herring Brook; its outflow drains into Furnace Pond which is located immediately to the south. The Pond's 2.8 miles of shoreline is heavily developed with houses and a summer camp. The pond has three wooded islands, the largest of which is known as Monument Island, and numerous rocky shoals. Except for the islands and rocky shoal areas, much of the pond is uniform in depth with an average depth of ten feet and a maximum depth of 15 feet. The pond has a nominal elevation of 57 feet. The pond is used for boating, swimming, water-skiing, fishing, and skating activities. Boat access to Oldham Pond is provided by a town of Pembroke ramp located next to the town beach off Wampatuck Street, which is located to the north of Route 14 (Matakeesett Street) and Furnace Pond. Unofficial access is made in Hanson at the end of Arlene Street, through private property. This property has recently been sold and public access removed with the installation of a fence.

Oldham Pond is a natural Great Pond and under the Colonial Ordinances of 1641-1647 which allows anglers to pass over unimproved land on foot to gain access to the pond. This water body is a public water supply (tributary to Furnace Pond MA94043). Oldham Pond is listed in Category 4c of the 2002 Integrated List of Waters due to impairment from exotic species (MassDEP 2003a).

Maquan Pond (Great Pond)

Maquan Pond is a 45-acre natural pond located in Hanson just south of Route 14 and east of Route 58. The pond has an average depth of 12 feet and a maximum depth of 18 feet. The pond has a connection at the southern end to Indian Head Pond through a system comprising a corrugated pipe culvert inlet, natural stream bed system and an old cranberry bog enterprise now owned by the Town of Hanson. The pond has two youth camps, one of which is town-owned and operated, and a public swimming beach on the southeastern shore. The shoreline is generally high, wooded, and settled. The pond has 1.4 miles of shoreline which are somewhat developed with residences. The pond is generally clear with a sand and gravel bottom with silt in deeper areas and coves. The lake is used primarily for swimming, boating, and fishing during the summer months.

Maquan Pond is listed in Category 2 of the 2002 Integrated List of Waters (MassDEP 2003a). This segment supported some uses (*Secondary Contact Recreation and Aesthetics)* and was not assessed for the others. This pond is in the North River watershed. It has no tributaries, although small wetland areas drain to it. Indian Head Brook begins as a small outlet existing and flowing at the Hanson town beach (Cranberry Cove) and flowing to Indian Head Pond via the Alton J. Smith Reserve “Smitty’s Bog” Conservation Area (formerly Edgewood Bogs) when there is high water.

The lake is a Great Pond; access is provided adjacent to the Town beach (Cranberry Cove).

The lake is becoming impaired but is not yet eutrophic. It contains areas of nuisance plants during the growing season, however. E. coli testing is performed by the Board of Health at Cranberry Cove. Algae counts are made during the swimming season. There is no other testing or monitoring to our knowledge.

Complaints about the water level have been received from abutters in the past; an accurate water level gauge is in the process of being engineered and installed. Water level is largely controlled by groundwater and precipitation. Previously, high water level was supposedly caused by a filled outlet pipe, due to sand intrusion from the Town beach. A small outlet jetty was installed in 2015 to reduce sand intrusion. A more natural outlet should be constructed away from Cranberry Cove. The town should consider restoring the outlet to a more natural condition.

Monponsett Pond (Great Pond)

Located on the Hanson/Halifax town line at an elevation of 52 feet, Monponsett Pond is a 528-acre natural water body. It has a maximum depth of 13 feet and an average depth of 9 feet. The pond is also used for boating, swimming, water-skiing, fishing, and skating. Residences, cranberry bogs, woods, and swamp areas exist on the shoreline. A study of Monponsett Pond revealed an increasing count of bacteria caused mainly from overflow and, income cases, direct discharge of sewage from bordering residential properties.

This lake, on the border of Hanson and Halifax, is in the Taunton River watershed; major tributaries are White Oak Brook (in Hanson), and Stetson Brook (originating in Pembroke). It is a public water supply, because water is periodically diverted to Silver Lake for the City of Brockton water supply.

It is a Great Pond, and access is via Halifax, at the State boat ramp on Monponsett Street. However, there is a "beach" on Ocean Ave that is monitored by the Hanson BOH for E. coli. The Mass. Dept. of Public Health and/or DEP have made algae counts throughout the summers of 2014 and 15. The lake is used for fishing, boating, and swimming.

The Halifax Town beach is on both West and East Lake; in recent years, the beaches have been periodically closed to swimmers due to high algae counts (Cyanobacteria).

This lake is eutrophic, perhaps hyper-eutrophic. The Monponsett Watershed Association was formed in 2012 in Halifax to address concerns with the lake condition. To date, most of their discussion has centered on the Brockton Water Department's use and control of East and West Monponsett Pond via a dam at the Stump Brook outlet and diversions of water to Silver Lake in Kingston. The Town of Halifax has treated the lake with alum in 2013-15.

The Monponsett area in Hanson and Halifax is a great challenge to environmental protection of the water resources in that area, including the lake, due to the density and ages of septic systems. In addition, there is cranberry agriculture on Stetson Brook (see Chandler Mill Pond, below), and White Oak Brook, and in Halifax on the southwest of West Lake. The bogs in Halifax draw water from West Lake and return some of it to the lake.

Water Quality Based Requirements

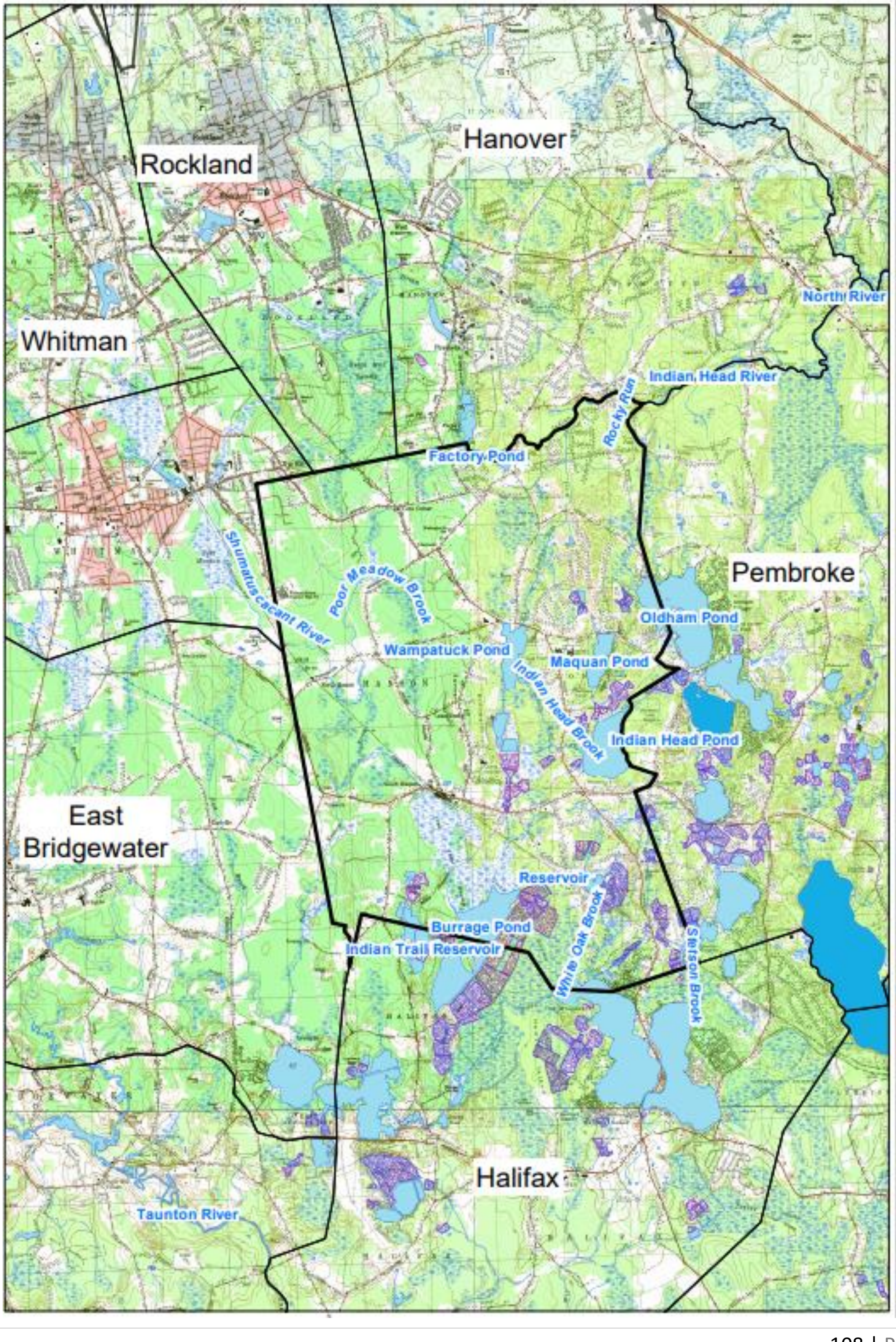
In compliance with the Clean Water Act (CWA), each state must administer a program to monitor and assess the quality of its surface water and ground water. Section 305(b) process of the CWA entails assessing each use for rivers, lakes, and coastal waters, and causes and sources of impairment are identified wherever possible. Section 303(d) of the CWA along with the regulations at 40 CFR 130.7 requires states to identify those water bodies that are not expected to meet surface water quality standards (SWQS) after the implementation of technology-based controls and prioritize them for the development of Total Maximum Daily Loads (TMDLs). A TMDL establishes the maximum amount of a pollutant that may be introduced into a water body and still ensure attainment and maintenance of water quality standards. The 303(d) *List of Impaired Waters* (303(D) List) lists each water body in one of the following five categories:

1) Unimpaired and not threatened for all designated uses.
2) Unimpaired for some uses and not assessed for others.
3) Insufficient information to make assessments for any uses.
4) Impaired or threatened for one or more uses, but not requiring the calculation of a TMDL; or
5) Impaired or threatened for one or more uses and requiring a TMDL.

Waters listed in Category 5 constitute the 303(d) List and are to be reviewed and approved by the EPA. An abbreviated version of *Table 1: Impaired Waters, TMDLs and Impairments* is shown in the following Table.

Table 25: Impaired Waters, TMDLs and Impairments

Category	Name	Segment ID	Watershed	Size	Impairment Cause
5 – "Water Requiring a TMDL"	Factory Pond	MA94175	South Coastal	51.395 acres	Mercury in Fish Tissue
	Indian Head River	MA94-04	South Coastal	2.914 miles	Mercury in Fish Tissue
					Oxygen, Dissolved
					Phosphorus (Total)
	Wampatuck Pond	MA94168	South Coastal	62.879 acres	Non-Native Aquatic Plants
					Chlorophyll-a
					Dissolved oxygen saturation
					Excess Algal growth
					Phosphorus (Total)
					Secchi disk transparency
	Monponsett Pond	MA62119	Taunton River	282.79 acres	Non-Native Aquatic Plants
					Excess Algal Growth
					Phosphorus (Total)
					Secchi disk transparency
	Shumatuscacant River	MA62-33	Taunton River	8.504 miles	Physical substrate habitat alterations
					Fecal Coliform
					Oxygen, Dissolved
					Sedimentation/Siltation


Hanover
Rockland
Whitman
North River
Indian Head River
Rocky Run
Factory Pond
Pembroke
Shumatuscacant River
Poor Meadow Brook
Oldham Pond
Wampatuck Pond
Maquan Pond
Indian Head Brook
Indian Head Pond
East Bridgewater
Reservoir
White Oak Brook
Burrage Pond
Indian Trail Reservoir
Stetson Brook
Halifax
Taunton River

Patterns of Development

Hanson today maintains a semi-rural character. Its varied landscape consists of forest, cranberry bogs, several small centers, large house lots in residential subdivisions, and small pond-side cottages, which were once seasonal residences, converted for year-round living. Hanson's growth was initiated first by Native Americans, then farmers, and more recently, residential development. But the town's topography, soils, and physiography (lakes, rivers, wetlands, and watershed areas) shape and constrain these land use patterns. Hanson's strong commitment and dedication to open space preservation also constrains growth as 19.18 percent (1,765 acres) of the total land area of Hanson (9,202 acres) is publicly owned open space.

The Town has little industry and few businesses. Despite this, the amount of developed land has increased steadily from 23 percent of the town's acreage in 1984 to 54 percent in 2005. Most of the town is served by a public water system that draws from local wells, but sewer service is not available.

Commercial and Industrial Development

Commercial and industrial development has always been limited in Hanson. In 1966, Shaw's Supermarket opened at the intersection of Rt. 58 and Rt. 14, allowing residents to stay in town for their grocery shopping, and attracting other retailers to set up business in Hanson. Today, Hanson is home to many retail shops, several small independent machine shops that make specialized products, and a few auto repair businesses.

By 1971 business was concentrated in the present shopping center and small scattered nearby sites along Liberty Street (Route 58) and along Main Street (Route 27) in South Hanson. This pattern continues through today with the greatest concentration in the Center, and increased amounts of retail and service activity along local roads with a small concentration at the junction of Route 27 and Union Street/Mattakeesett Street in Bryantville on the Pembroke line. Very few commercial uses are shown in the business-zoned strip of Monponsett Street in the Monponsett neighborhood on the Halifax line.

In recent years, there has been further industrial and heavy commercial activity in the Hanson Commerce Park off Route 27 near Route 14, along Route 27 itself, and in the smaller Hanson Industrial Park in South Hanson. Industrial space occupies 32.66 acres along Route 27. These are largely un-intensive uses including a large sand and gravel operation, and a fuel oil distribution center, along with two low-rise light industrial buildings in the industrial park, and the former Ocean Spray warehouse south of the railroad tracks. The former Ocean Spray facility located between Route 27 and the railroad tracks is South Hanson's most prominent feature and potentially one of its greatest assets. The wooden portion of the estimated 100,000 sf two-story building north of the track and fronting on Route 27 contains small businesses occupying much of the first floor and second floor. These are essentially commercial rather than industrial or distribution uses. Other parts of the complex may have potential for more intensive uses.

Zoning Districts

There are seven zoning districts in town: Agriculture-Recreation, Residence A, Residence AA, Residence B, Business, Commercial-Industrial and Flexible Zone – Overlay Districts. Residence A covers most of the eastern half of town and Residence AA is primarily the western part of town. The Business districts are along Route 58 and 27 and the Commercial-Industrial is along the railroad and western section of town. There are four Overlay Districts: Flexible, Adult Entertainment, Medical Marijuana Distribution Area Overlay District and the Aquifer Protection Districts. There are six sub-areas to the Aquifer Protection District.

Zoning District	Minimum Lot Size
Agricultural, Recreation, and Residence AA	40,000 square feet of land area per dwelling unit
Residence A, Residence B	30,000 square feet of land area per dwelling unit, except for units on special permit. (multi-family on special permit: 60,000 square feet for the first unit and 5,000 square feet for each additional until to a total of eight units)
Flexible Zone	35,000 square feet of land area per dwelling unit with exceptions for some uses on special permit (see above)
Commercial-Industrial	44,000 square feet of land area per dwelling unit

Until the town can get its affordable housing stock percentage up to 10 percent, Hanson is subject to subdivisions coming in under the state's Chapter 40B Comprehensive Permit Process. Hanson has one partially completed 40B project, "Dunham Farms" which is restricted to residents over the age of 55. A new Comprehensive Permit "Depot Village" was recently extended by the Zoning Board of Appeals to provide the applicant additional time for construction activities.

South Hanson is predominantly comprised of single-family housing along existing roads (since there are no major subdivisions) with industrial and commercials uses along Route 27. The most substantial concentration of single-family homes is to the northeast of the commuter rail station on Route 27. These are on lots ranging from 32,000 sf to 2.3 acres.

In addition to other factors, zoning and other land use regulations constitute Hanson's "blueprint" for its future. Land use patterns over time will continue to look more and more like the town's zoning map until the town is finally "built out" – there is no more developable land left. Therefore, in looking forward over time, it is critical that the town focus not on the current use and physical build-out today, but on the potential future uses and build-out that are allowed under the town's zoning map and zoning bylaws. Zoning is the primary land use tool that the town may use to manage development and direct growth to suitable and desired areas while also protecting critical resources and ensuring that development is in keeping with the town's character.

Long-Term Recommendations:

1. Update Subdivision Regulations – Should the Town decide to update Subdivision regulations to adopt a Low Impact Development standard, a review of Hanson's Subdivision Regulations should be undertaken as a review would provide recommendations of commonly accepted road and drainage construction standards.

2. Amend Site Plan Review Regulations – to incorporate LID standards and techniques to reduce overall impact from development.

Key areas for hazard mitigation-related zoning, land use and other regulatory strategies include revised site plan review regulations, low impact development standards (LID), revised subdivision regulations with a focus on green-infrastructure.

The proposed site plan review regulations as well as the adoption of low impact development (LID) standards could strengthen Hanson's Hazard Mitigation capability, especially for flood hazard mitigation. LID is accomplished as a two-step process: 1) thoughtful site planning, and 2) incorporation of best management practices (BMPs). Thoughtful site planning begins with an approach that identifies critical site features such as wetlands, poor soils, or drinking water protection areas that should be set aside as protected open space. After the critical open space areas are identified and set aside, sustainable development areas are then identified as building envelopes. Within the delineated building envelopes, a broad range of design techniques or BMPs, such as shared driveways, permeable pavers, and bioretention are used to reduce the level of impervious cover and improve the quantity and quality of stormwater drainage.

Other LID design techniques include green roofs, rain barrels, rain gardens, grassed swales, stormwater infiltration systems, and alternative landscaping. Through these techniques, natural drainage pathways are conserved, open space is preserved, and the overall impact from development significantly reduced.

Infrastructure

Hanson's infrastructure reflects its small population and rugged terrain. The transportation system, and its relationship to land use, plays a significant role in the settlement pattern and physical layout of a community and directly affects the quality of life and economic viability of a community. The changes in travel demand and in technology are important factors in shaping the community's transportation needs over time. The Town, in its regulation of land use, and through its decisions to expand infrastructure and roads, can strongly influence changes in the settlement pattern. It is important that public policies reflect the connections between land use and transportation.

The Town's transportation system consists of its local and state roads, sidewalks and bicycle paths and any off-road bicycle and pedestrian ways, along with its commuter rail station and related parking lots and service, and any supplementary demand-responsive para-transit services or local taxicab service.

Roads and Highways

Several state-numbered routes traverse Hanson, providing local and regional access to other communities and to and from the interstate highway system. Figure 8 shows the road system including state-numbered highways and local roads, and their functional classifications. The overall street system is less radial than that in many communities. While a group of major streets (County Road [Route 14], Liberty Street [Route 58], Winter Street, High Street, and Indian Head Street/Monponsett Street) converge at the center, there are also major east-west routes running to the north or south of the center such as Route 58/Whitman Street and East Washington Street to the north, and Route 27/Franklin Street/Main Street to the south. These allow some east-west traffic to go through the town without going through the center, and they provide a degree of circumferential movement not possible with more radial systems.

More specifically, Route 14 crosses Hanson from east to west from Route 27 (Franklin Street), just over the East Bridgewater town line to the Pembroke town line via a portion of West Washington Street, easterly from East Bridgewater to the intersection of Holmes Street, and via County Road east from Holmes to Liberty Street, where it merges with Route 58. Routes 14 and 58 continue Liberty St. to Maquan Street, where Route 58 turns south running along Indian Head Street. Route 14 then runs east along Maquan Street, from Indian Head Street to the Pembroke town line.

While the roads focus on the civic/commercial center at the junction of County Road, High Street (Route 14), Winter Street, and Liberty Street, (Route 58) the system also gives good access to the traditional industrial / heavy commercial center at South Hanson. This is on the major east-west road, Route 27/Main St., and is largely bounded by two north-south rural minor collectors, High Street and Elm Street.

Routes 27 and 14 provide access through East Bridgewater and Whitman to Brockton and to limited access Route 24 to the west. These roads also run east through Pembroke and Kingston or Duxbury to limited access Route 3 and on to Plymouth or Boston.

Route 58 runs north through Whitman and Abington, converging with Route 18 in Weymouth and running on to Route 3. It also runs south to Halifax, Plympton, and Carver to I-495 and to Wareham, Rochester, and Cape Cod.

In addition to state numbered routes, Hanson has several collector roads that are important for local circulation and transition to the regional network. These include: Spring Street (north of Route 58), Whitman Street, King Street, Winter Street, East Washington Street, Brook Street, State Street, West Washington Street, High Street, Elm Street and Union Street.

Table 26: Afternoon Peak Hour Intersection LOS

Intersection Location (Un-Signalized)	LOS
Route 58 at Whitman Street	C
Route 58 at West Washington Street and East Washington Street	E
Route 58 Liberty Street at East Washington Street	F
Winter Street at East Washington Street	C
Winter Street at Brook Street	C
State Street at Brook Street	B
Liberty Street at Maquan and Indian Head Street	D
West Washington at County Road and Holmes Street	C
Holmes Street at High Street	B
Franklin St at Oak and West Washington St (E. Bridgewater)	F
Main Street at Elm Street	D
Main Street at MBTA Lot	E
Main Street at Phillips Street	C
Main Street at High Street	C
Intersection Location (Signalized)	**LOS**
Route 27 Main Street at Indian Head Street Route 58	C
Liberty Street Routes 14/58 at Winter Street	B
High Street at Liberty Street	B

Sidewalks and Bicycle Routes

The Town of Hanson lacks sidewalks and bicycle ways, or even shoulders, along most of its major and minor roads due to its long-term automobile-oriented residential development. The major exception is Route 58, which has striped shoulders on both sides of the road for bicycles. It also has sidewalks along at least one side from East Washington Street to Main Street and along the east side of the stretch from the Halifax line to the Post Office.

Liberty Street provides sidewalks in the heart of town along the north side of the road from Winter Street to Maquan Street. Sidewalks then run along the south side of Maquan St. to School Street. In addition, School Street between Indian Head Street and Maquan Street has limited sidewalks serving the Indian Head School, but it lacks adequate sidewalks on both sides connecting the school through to Maquan Street. In all, the pedestrian route to and from the school from the north via School Street and Maquan Street contains gaps in the sidewalk system. Several the local streets also have sidewalks.

Several newer local streets also have sidewalks on at least one side as required by the Planning Board's Subdivision Rules and Regulations, but these often do not connect with sidewalks along the major streets as shown on Figure 9.

Figure 33: Local Street System & Functional Classification

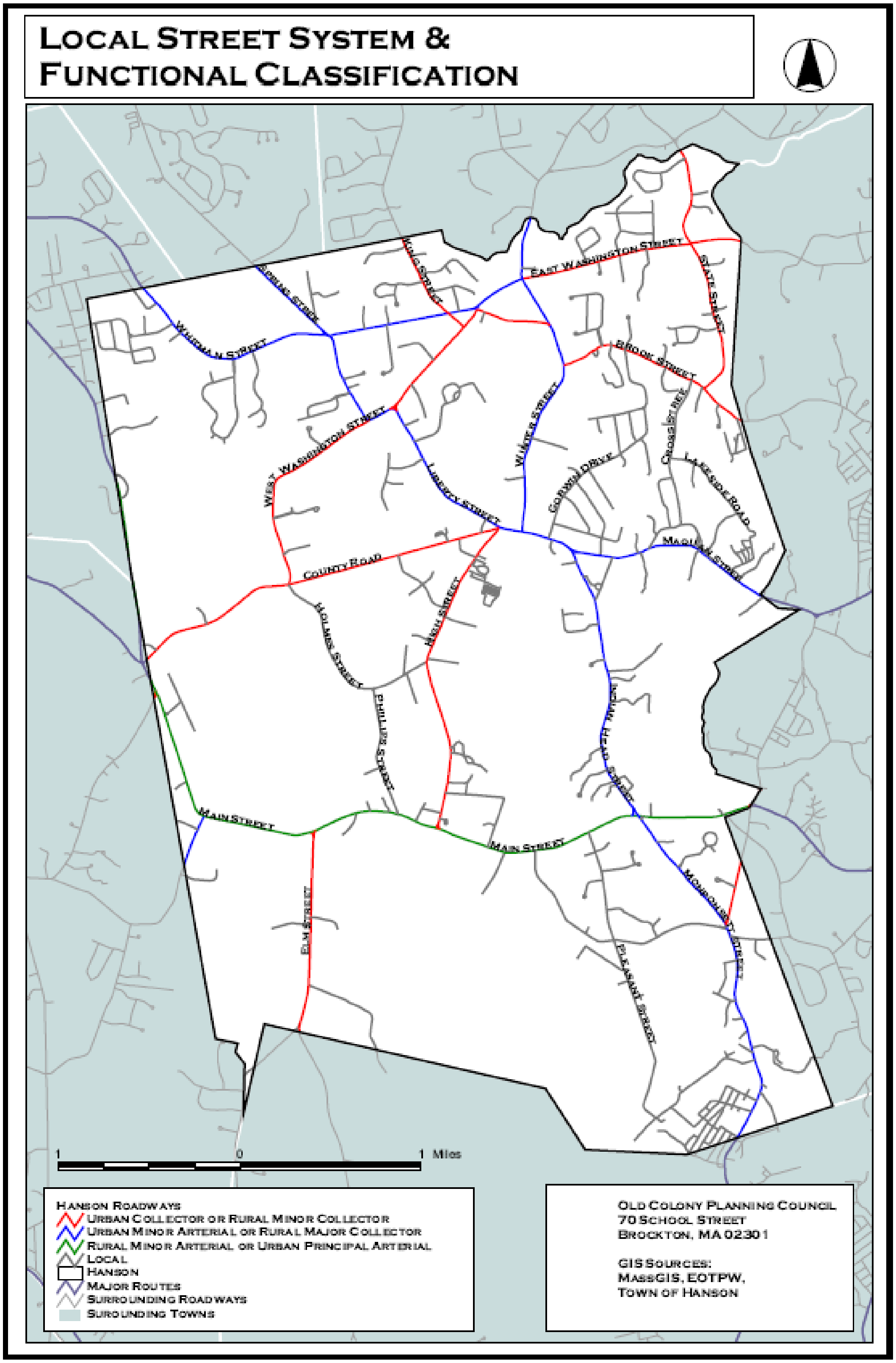


Figure 34: Existing Sidewalks

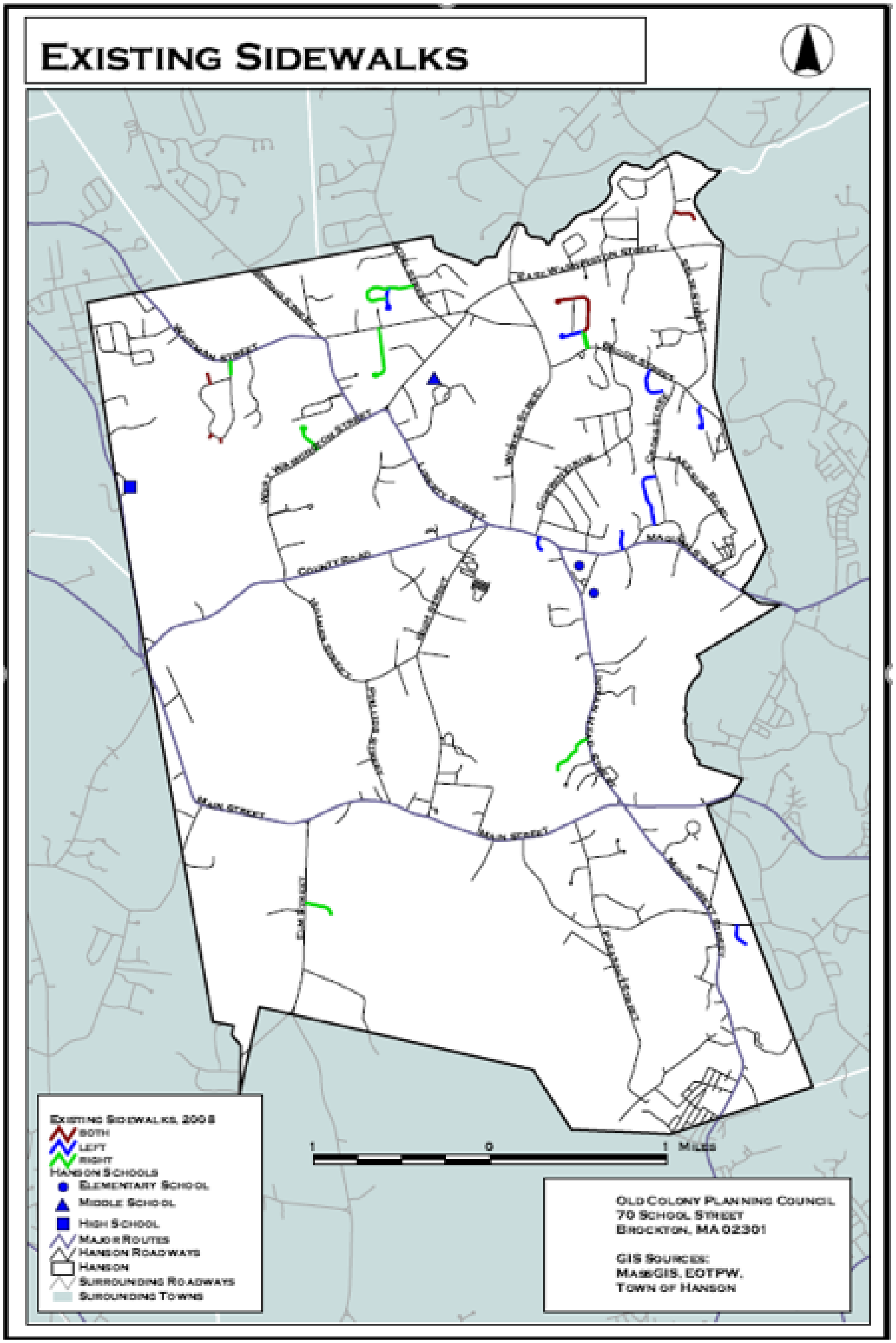
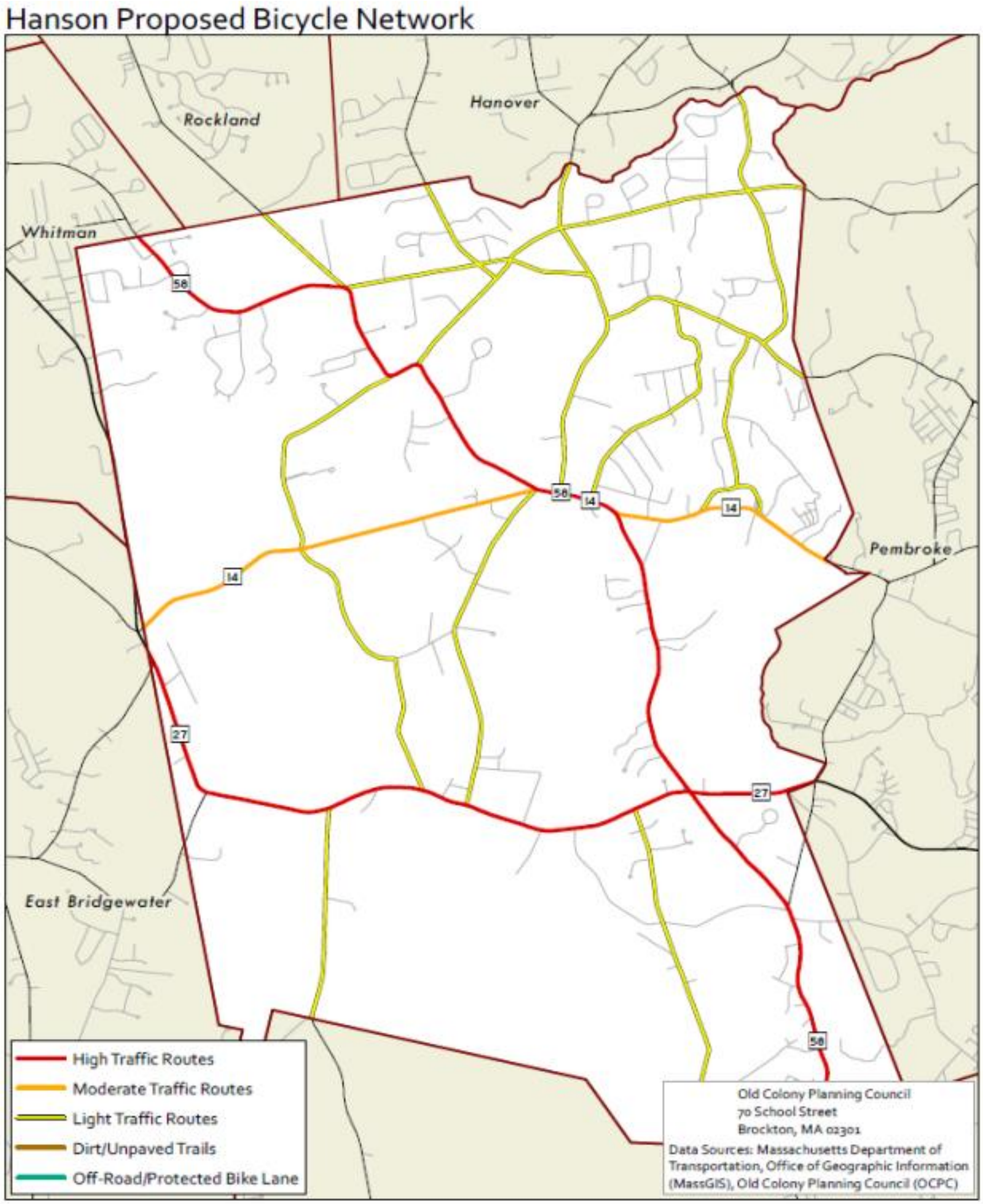


Figure 35: Hanson Proposed Bicycle Network



Public Water System

The Town of Hanson Water Department released a *Water System Master Plan and hydraulic Model Update* in February 2018. This assessment provided an evaluation of the current and future water demand with a summary of recommendations.

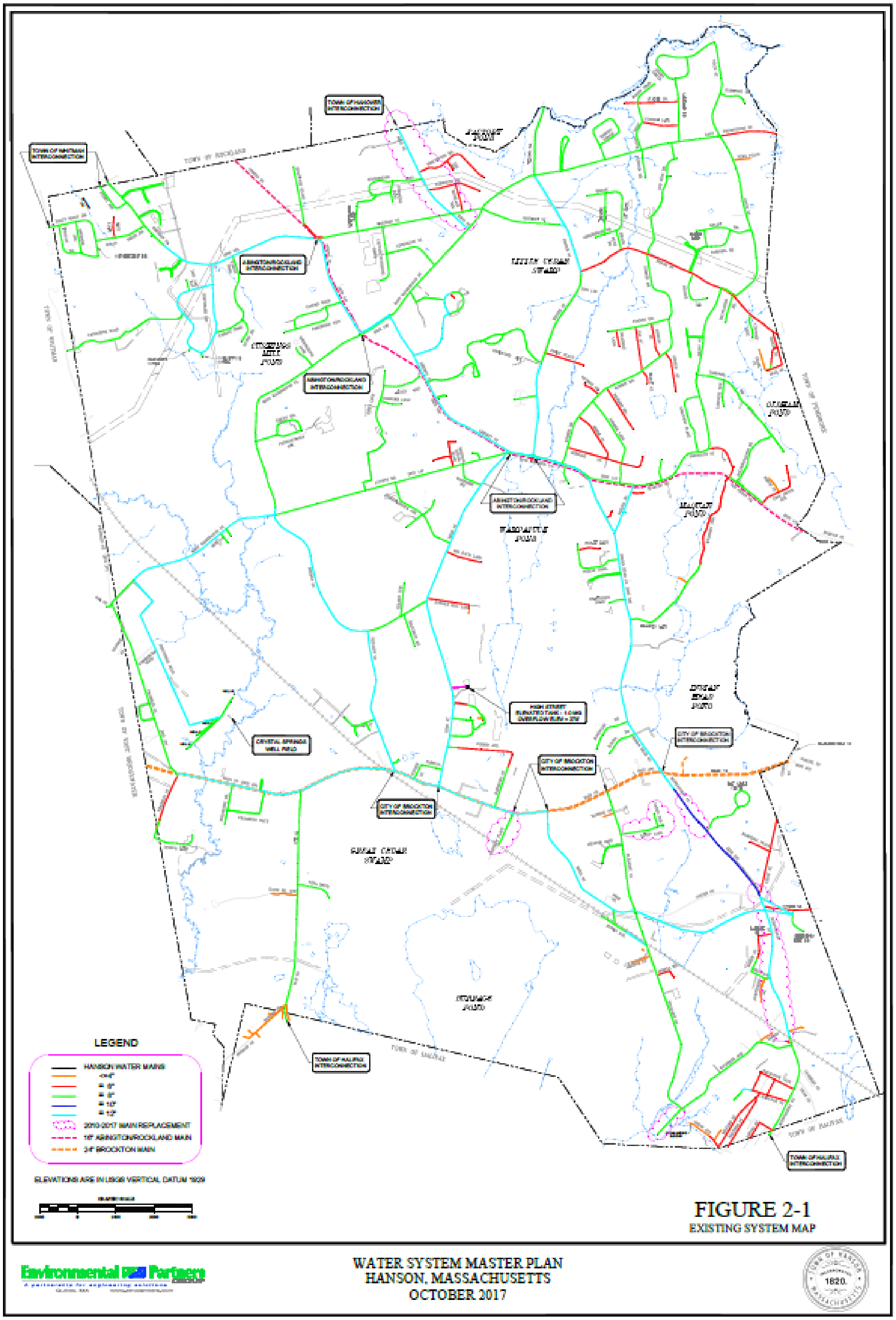
The only municipal infrastructure is the public water supply system. The existing water system currently serves approximately 94 percent of the town through 3,248 service connections, all of which are metered. The Town has 0.78 Million Gallons per Day (MGD) in registered and permitted withdrawals under their Water Management Act Permit (WMA). The current permit was originally set to expire February 28, 2010 but was extended during the development and promulgation of amendments to the WMA, which are known as the Sustainable Water Management Initiative (SWMI). Hanson's permit renewal is anticipated for December 31, 2021 and will include new requirements of SWMI.

The Town's water systems are supplied from four groundwater wells in the Crystal Springs Wellfield and supplemented by water purchased through an interconnection with the City of Brockton. Raw water from each well is treated before distribution. Treatment includes the addition of sodium hydroxide for corrosion control and sodium hypochlorite for disinfection. Water distribution storage is provided by one tank with a total capacity of 1.0 million gallons. Hanson's water distribution systems consist of approximately 71 miles of pipe, ranging in diameter from 1-inch through 16-inch.

Water Demand

The existing average-day demand is 0.61 MGD, and the maximum-day demand is 0.94 MGD. Historically approximately 1 percent or less of water is purchased from the City of Brockton. In 2016, 27 percent was purchased due to water storage tank maintenance that took the tank offline for an extended period. Water demand projections anticipate an average-day water demand of 0.71 MGD and a maximum-day water demand of 1.10 MGD by the year 2035. Residential water uses accounts for approximately 90.4 percent of metered sales, and the average residential water use is 50 residential gallons per capita per day. Prior to 2013, the system's average unaccounted for water was 15.5 percent, however since that time unaccounted for water has progressively decreased to 10.9 percent in 2016.

Figure 36: Hanson Water Dept. Master Plan



To prioritize improvements to the public water supply, the *Water System Master Plan and hydraulic Model Update* in February 2018 recommends 20-year capital improvements plan to be implemented in five phases.[32]

Figure 37: Hanson Water Department Master Plan Recommended Improvements

	Recommended Improvement Description
Phase 1 Improvements	Tank siting alternatives analysis (concurrent with new source feasibility study)
	Install 0.5-million-gallon elevated water storage tank
	Update Unidirectional Flushing Program
	Water quality study for manganese
	Install 1,550 feet of 12" main
	Install 15,100 feet of 8" main
	Install 1,160 feet of 6" main
Phase 2 Improvements	Install 14,850 feet of 12" main
Phase 3 Improvements	Install 4,900 feet of 12" main
	Install 13,900 feet of 8" main
Phase 4 Improvements	Replace 70,300 feet of vinyl lined asbestos cement (VLAC) pipes
Phase 5 Improvements	Replace 5,028 feet of pipe less than or equal to 2"

Source: Hanson Water Department Master Plan

Wastewater

Hanson does not have a public sewer system or any publicly owned wastewater treatment plant in the town. The Stonebridge Commons operate a minor sanitary wastewater treatment plant through the NPDES program. All other private residences and businesses are served by on-site septic systems.

However, to address pond degradation and eutrophication, it may be necessary to sewer densely populated areas around some of the ponds. All of Hanson's households have septic systems, most of which predate the rigorous standards required by the state's Title 5 regulations. Thus, wastewater from most households drains into septic tanks, underground pipes, and groundwater in yards across the Town. Surface waters such as streams and ponds are fed, indirectly, by groundwater. With proper operation and maintenance, organic matter associated pathogens (e.g., *E. coli*) in household wastewater is effectively treated by septic systems, before reaching surface waters. Also, with appropriate travel time through soil, mineral nutrients (especially phosphorus and nitrogen) in wastewater may also be diluted within the groundwater system, prior to being released into nearby surface water systems. Importantly, septic systems offer the only way to effectively recharge water locally.

With old or malfunctioning septic systems, the organic matter and mineral nutrients are more likely to reach and impair the town's streams and ponds. Furthermore, with increased development adding new septic systems across the town, increasing amounts of impurities may reach these surface waters. Septic organic matter reaching surface water can lead to a reduction of oxygen in ponds and streams that not only impart nuisance odors but could result in the loss of sensitive fish populations. Excess

[32] **Water Department released a *Water System Master Plan and hydraulic Model Update* in February 2018.**

mineral nutrients, especially phosphorus and nitrogen, from septic wastes can increase the rate of eutrophication and degrade associated aquatic ecosystems.

Commuter Rail

In 1845 the Old Colony Railroad first came through Hanson, followed in 1900 by the electrified Brockton and Plymouth Street Railway. However, the increasingly popular automobile spelled an early demise for the electric railway. Eventually, native trails became the region's highways. The primary east-west road developed into Bridgewater Path, now Main Street (Route 27), and Maquan-Liberty-County-West Washington Streets (Route 14). Passenger service on the Old Colony Line, discontinued in 1959, was restored by the MBTA in 1997. Passenger rail service started in 1845 but stopped in 1959 with the opening of the Southeast Expressway. The rails were rebuilt, and passenger service started up again in 1998, which spurred a surge in new home building for several years. The home building industry has continued to thrive over the last 100 years. The commuter rail station is in South Hanson next to the former station and has been studied as a prospective Transit Oriented Development (TOD) site.

Cranland Airport

Cranland Airport is a privately owned, publicly used airport that started construction in the late 1950s and was activated on March 1, 1961. Cranland Airport was originally built as a fueling location for the local cranberry crop dusters and was constructed with cranberry bogs on either side. The airport has a single runway, experiences around 100 flights per week, and houses just under 30 aircraft on site. In addition to people being able to store and fly their personal planes from here, Cranland Airport is also home to Boston Skydive Company. According to their website, if you skydive from there on a sunny, clear day, you will be able to see Boston and Cape Cod while skydiving. Figure 6 below shows the runway, parking lot, and plane storage.

The District and its Economy

County Population Change

Single-Year Change 2018 – 2019

According to the new county-level population estimates released by the US Census Bureau, the greatest numerical increases in Massachusetts counties from July 1, 2018 to July 1, 2019 were seen in Norfolk County at 3,545 net persons gained; Middlesex at 3,229; and Plymouth at 2,780. Worcester County was the fourth fastest grower again this year with 1,568 persons added net. In terms of percentage change, the largest net gains were in Nantucket at 1.8 percent followed by Plymouth and Norfolk – both rounding to 0.5 percent, and then Middlesex, Bristol, and Worcester – each rounding to a 0.2 percent increase from 2018 to 2019. [33]

Table 27: Population Change, OCPC Region

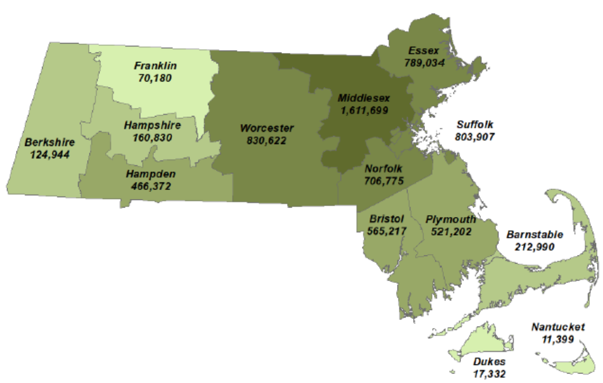
				Change 1990-2010		Change 2000-2010	
	1990	**2000**	**2010**	**Number**	**Percent**	**Number**	**Percent**
Avon	4,558	4,443	4,356	(202)	(4.6%)	(87)	(1.95%)
Abington	13,817	14,605	15,985	2,168	13.6%	1,380	9.49%
Bridgewater	21,249	25,185	26,563	5,314	20.0%	1,378	5.47%
Brockton	92,788	94,304	93,810	1,022	1.1%	(494)	(0.52%)
Duxbury	13,985	14,248	15,059	1,074	7.1%	811	5.69%
East Bridgewater	11,104	12,974	13,794	2,690	19.5%	820	3.67%
Easton	19,807	22,299	23,112	3,305	14.3%	813	3.64%
Halifax	6,526	7,500	7,518	992	13.2%	18	0.24%
Hanover	11,912	13,164	13,879	1,967	14.2%	715	5.43%
Hanson	**9,028**	**9,495**	**10,209**	**1,181**	**11.6%**	**714**	**7.51%**
Kingston	9,045	11,780	12,629	3,584	28.4%	849	7.20%
Pembroke	14,544	16,927	17,837	3,293	18.5%	910	5.37%
Plymouth	45,608	51,701	56,468	10,860	19.2%	4,767	9.22%
Plympton	2,384	2,637	2,820	436	15.5%	183	6.94%
Stoughton	26,777	27,149	26,962	185	0.7%	(187)	(0.69%)
West Bridgewater	6,389	6,634	6,916	527	7.6%	282	4.25%
Whitman	12,240	13,882	14,489	1,249	8.6%	607	4.37%
Plymouth County	435,276	472,822	494,919	59,643	13.7%	22,097	4.67%
Massachusetts	**6,016,425**	**6,349,097**	**6,547,629**	**531,204**	**8.8%**	**198,532**	**3.13%**

[33] Summary of the US Census Bureau's 2019 County-Level Population and Component Estimates for Massachusetts, UMass Donahue Institute March 2020

Table 28: Population Projections 2010 – 2040, OCPC Region

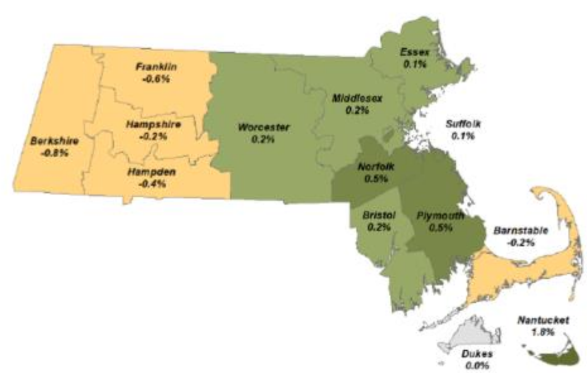
	Census 2010	Projection 2015	Projection 2020	Projection 2025	Projection 2030	Projection 2035	Projection 2040	Change 2010-2040	
								Number	Percent
Abington	15,985	17,066	17,386	18,522	18,764	18,903	19,000	3,015	18.86%
Avon	4,356	4,384	4,385	4,387	4,444	4,477	4,500	144	3.31%
Bridgewater	26,563	27,712	27,800	27,967	28,333	28,543	28,689	2,126	8.00%
Brockton	93,810	95,767	96,000	96,500	96,700	96,900	97,100	3,290	3.51%
Duxbury	15,059	15,025	15,030	15,110	15,307	15,421	15,500	441	2.93%
East Bridgewater	13,794	14,241	14,400	14,427	14,616	14,724	14,800	1,006	7.29%
Easton	23,112	23,391	23,830	24,371	24,689	24,872	25,000	1,888	8.17%
Halifax	7,518	7,552	7,600	7,610	7,620	7,630	7,640	122	1.62%
Hanover	13,879	13,965	13,864	13,882	13,999	14,105	14,084	205	1.48%
Hanson	**10,209**	**10,524**	**10,600**	**10,723**	**10,863**	**10,944**	**11,000**	**791**	**7.75%**
Kingston	12,629	13,123	13,369	14,622	14,814	14,923	15,000	2,371	18.77%
Pembroke	17,837	18,213	18,300	18,454	18,695	18,834	18,931	1,094	6.13%
Plymouth	56,468	59,985	64,166	66,533	68,559	69,629	70,312	13,844	24.52%
Plympton	2,820	2,907	2,910	2,924	2,963	2,985	3,000	180	6.38%
Stoughton	26,962	27,454	27,900	27,914	28,279	28,489	28,635	1,673	6.21%
West Bridgewater	6,916	7,094	7,227	7,452	7,549	7,605	7,644	728	10.53%
Whitman	14,489	14,890	15,169	15,191	15,389	15,503	15,583	1,094	7.55%
Massachusetts	6,547,629	6,784,235	6,933,887	7,094,087	7,225,472	7,313,149	7,380,399	832,770	12.72%

Estimated Population by Massachusetts County, July 1, 2019



UMass Donahue Institute. Source data: Annual Estimates of the Resident Population April 1, 2010 to July 1, 2019. U.S. Census Bureau, Population Division. March 26, 2020

Estimated Annual Percent Change in Population by Massachusetts County, July 1, 2018 to July 1, 2019



UMass Donahue Institute. Source data: Annual Estimates of the Resident Population April 1, 2010 to July 1, 2019. U.S. Census Bureau, Population Division. March 26, 2020

Population Projections 2010 through 2040

The Massachusetts Department of Transportation (MassDOT) Demographic and Socio-Economic Forecast prepared by the UMass Donahue Institute indicates that Hanson will grow from 10,209 residents in 2010 to 11,000 residents by 2040. Hanson's expected 7.75 percent increase in population during this period trails neighboring Abington (18.86 percent), Easton (8.17 percent) and Kingston (18.77 percent), as well as the Commonwealth (12.72 percent); but will surpass the growth expected to occur in Halifax (1.62 percent) and Hanover (1.48 percent).

The continued population growth, not only in Hanson, but across the region and the state, suggests a continued increase in housing demand, although changes in household size and type will have an impact on the type of housing that will be needed.

Educational Attainment

Table 29: Educational Attainment 25+, OCPC Region

	Less than High School Diploma	High School Graduate or GED	Some College	Associate degree	Bachelor's Degree	Graduate or Professional Degree	Bachelor's Degree or Higher
Avon	319	1,185	593	276	697	186	27.1%
Abington	381	3,076	2,465	1,363	2,840	1,018	37.7%
Bridgewater	868	4,960	3,177	1,770	3,700	1,886	35.1%
Brockton	6,045	20,964	13,282	5,076	7,664	3,211	18.4%
Duxbury	77	1,207	1,271	675	4,124	3,023	77.9%
East Bridgewater	301	3,113	2,405	944	1,691	1,082	29.2%
Easton	421	3,179	2,579	1,643	4,624	2,830	48.7%
Halifax	180	2,082	889	737	958	532	30.4%
Hanover	237	2,182	1,593	973	2,636	1,710	49.0%
Hanson	350	2,182	1,543	883	1,746	610	32.2%
Kingston	274	2,398	1,359	834	2,659	1,248	44.0%
Pembroke	364	3,721	2,260	1,311	3,411	1,372	38.5%
Plymouth	1,397	3,532	8,442	5,066	9,768	5,702	36.4%
Plympton	103	12,134	358	251	455	243	32.5%
Stoughton	918	5,182	3,860	2,041	4,888	2,637	37.2%
West Bridgewater	225	1,655	821	491	1,112	600	35.2%
Whitman	458	3,431	1,789	1,165	2,107	902	38.3%
Plymouth County	15,855	99,509	66,538	34,688	79,833	45,718	36.7%
Massachusetts	**241,431**	**1,162,683**	**741,582**	**363,330**	**1,101,605**	**879,256**	**45.0%**

Source: U.S. Census Bureau, 2013-2017 ACS, S1501

Households

More than population, the number and type of households and their spending power within a community correlate with housing demand. A ***household*** is a single person or two or more people who occupy the same housing unit, which can be a house, apartment, mobile home, group home or single room that is occupied as separate living quarters. According to the US Census Bureau, a household consists of all the people who occupy a housing unit (e.g., house, apartment, single room). A household includes the related family members and all the unrelated people, if any, such as lodgers, or foster children who share the housing unit. A person living alone in a housing unit, or a group of unrelated people sharing a housing unit, is also counted as a household. The household count excludes group quarters.

According to the U.S. Census Bureau, a household includes all people who occupy a housing unit, which can be a house, apartment, mobile home, group home or single room that is occupied as separate living quarters. The number of households in Hanson grew 22.2 percent from 2,838 in 2000 to 3,468 in 2010. This 22.2 percent increase in the number of households exceeded the County and the Commonwealth, but was less than Kingston, Plymouth, and Pembroke.

Table 30: Households OCPC Region 1990 - 2010

	1990	2000	2010	Change 1990-2010	
				Number	**Percent**
Abington	4,817	5,263	6,080	1,263	26.2%
Avon	1,591	1,705	1,709	118	7.4%
Bridgewater	5,947	7,526	7,995	2,048	34.4%
Brockton	32,850	33,675	33,303	453	13.8%
Duxbury	4,625	4,946	5,344	719	15.5%
East Bridgewater	3,593	4,344	4,750	1,157	32.2%
Easton	6,436	7,489	7,865	1,429	22.2%
Halifax	2,362	2,758	2,863	501	21.2%
Hanover	3,742	4,349	4,709	967	25.8%
Hanson	**2,838**	**3,123**	**3,468**	**630**	**22.2%**
Kingston	3,224	4,248	4,665	1,441	44.7%
Pembroke	4,666	5,750	6,298	1,632	35.0%
Plymouth	15,875	18,423	21,269	5,394	33.9%
Plympton	766	854	1,006	240	31.3%
Stoughton	9,394	10,254	10,295	901	9.6%
West Bridgewater	2,232	2,444	2,571	339	15.1%
Whitman	4,435	4,999	5,300	865	19.5%
Plymouth County	149,519	168,361	181,126	31,607	21.10%
Massachusetts	**2,247,110**	**2,443,580**	**2,547,075**	**299,965**	**13.30%**

Source: U.S. Census Bureau, 1990, 2000 & 2010 Census

Table 31: Household Projections 2000 – 2040, OCPC Region

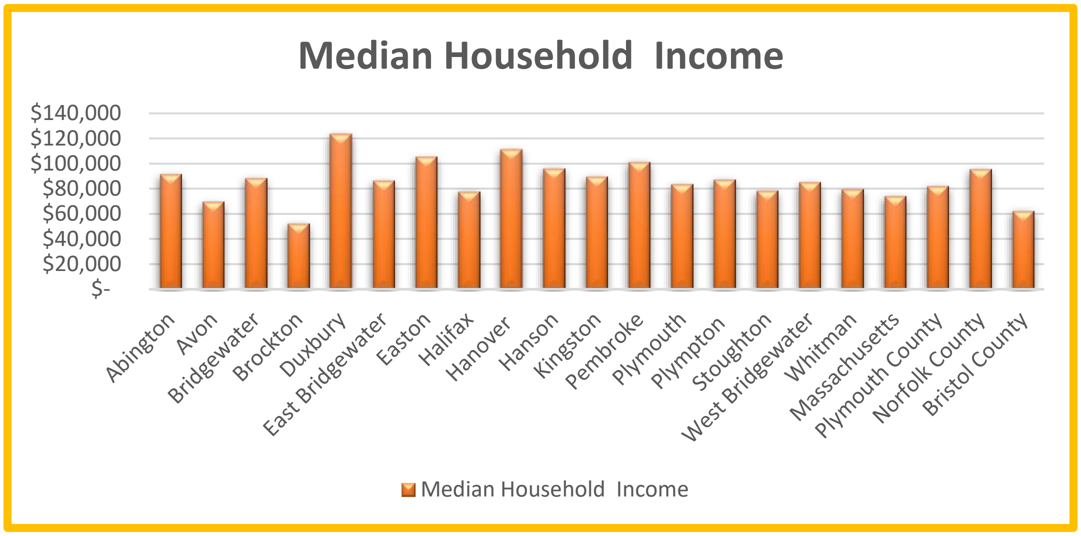
	Census 2000	Census 2010	2020	2030	2040	Change 2000 - 2040	
						Number	Percent
Abington	5,263	6,080	6,887	7,589	7,767	2,504	47.58%
Avon	1,705	1,709	1,793	1,902	2,008	303	17.79%
Bridgewater	7,526	7,995	8,946	9,553	9,626	2,100	27.91%
Brockton	33,675	33,303	34,967	35,465	35,668	1,993	5.92%
Duxbury	4,946	5,344	5,890	6,436	6,551	1,605	32.45%
East Bridgewater	4,344	4,750	5,327	5,613	5,737	1,393	32.07%
Easton	7,489	7,865	8,499	9,185	9,261	1,772	23.66%
Halifax	2,758	2,863	3,098	3,255	3,370	612	22.20%
Hanover	4,349	4,709	5,090	5,388	5,472	1,123	25.81%
Hanson	3,123	3,468	3,808	4,033	4,129	1,006	32.21%
Kingston	4,248	4,665	5,294	6,075	6,191	1,943	45.75%
Pembroke	5,750	6,298	6,904	7,263	7,384	1,634	28.42%
Plymouth	18,423	21,269	26,119	29,172	30,283	11,860	64.37%
Plympton	854	1,006	1,134	1,198	1,203	349	40.81%
Stoughton	10,254	10,295	11,178	11,754	12,217	1,963	19.15%
West Bridgewater	2,444	2,571	2,779	2,956	3,006	562	23.01%
Whitman	4,999	5,300	5,808	6,071	6,195	1,196	23.92%
Massachusetts	2,443,580	2,547,075	2,830,145	3,044,477	3,151,722	708,142	28.98%

Source: https://www.mass.gov/lists/socio-economic-projections-for-2020-regional-transportation-plans

Income

Household income is defined as the total income of all people 15 years of age and older living in a household. The median household income of a community is determined by dividing the income distribution into two equal groups, one having incomes above the median, and the other having incomes below the median. The median household income in Hanson in 2017 was $96,389. When compared to the surrounding communities, the Commonwealth and the County, Hanson's median household income trailed only Duxbury, Hanover, and Pembroke.

Figure 38: Median Household Income, OCPC Region



Source: U.S. Census Bureau, 2013-2017 American Community Survey, Selected Economic Characteristics, DP03

Table 32: Median Household Income, Percent Change 1999-2017, OCPC Region

Old Colony Municipalities	**1999 Median Household Income (Dollars)**	**2013 - 2017 Median Household Income (Dollars)**	**% change 1999 to 2017**
Abington	$ 57,100	$ 91,643	60.50%
Avon	$ 50,305	$ 69,709	38.57%
Bridgewater	$ 65,318	$ 88,640	35.71%
Brockton	$ 39,507	$ 52,393	32.62%
Duxbury	$ 97,124	$ 123,613	27.27%
East Bridgewater	$ 60,311	$ 86,568	43.54%
Easton	$ 69,144	$ 105,380	52.41%
Halifax	$ 57,015	$ 77,993	36.79%
Hanover	$ 73,838	$ 111,311	50.75%
Hanson	$ 62,687	$ 96,389	53.76%
Kingston	$ 53,780	$ 89,796	66.97%
Marshfield	$ 66,508	$ 94,737	42.44%
Pembroke	$ 65,050	$ 101,447	55.95%
Plymouth	$ 54,677	$ 83,746	53.16%
Plympton	$ 70,045	$ 87,438	24.83%
Stoughton	$ 57,838	$ 78,343	35.45%
West Bridgewater	$ 55,958	$ 85,368	52.56%
Whitman	$ 55,303	$ 79,705	44.12%

Source: 2013-2017 American Community Survey, Selected Economic Characteristics, DP03, Census 2000 Summary File 3 Selected Economic Characteristics

Table 33: Income and Poverty, OCPC Region

	2018 ACS Median Household Income	Female Median Income	Male Median Income	Poverty Rate	Median Age
Abington	$90,873	$47,317	$63,594	3.7%	41.0
Avon	$69,709	$40,027	$60,345	10.2%	42.2
Bridgewater	$27,397	$51,815	$71,250	9.3%	34.2
Brockton	$60,250	$41,786	$48,828	15.6%	35.6
Duxbury	$160,893	$51,429	$136,250	0.0%	52.9
East Bridgewater	$86,922	$49,572	$63,962	6.7%	38.8
Easton	$109,719	$60,590	$80,724	4.0%	40.5
Halifax	$92,111	$54,583	$64,952	4.3%	42.1
Hanover	$120,000	$75,445	$87,574	2.8%	41.4
Hanson	$98,537	$57,934	$64,962	3.3%	44.9
Kingston	$106,654	$58,629	$76,979	6.1%	44.1
Pembroke	$103,920	$62,979	$71,591	3.0%	42.7
Plymouth	$87,595	$51,870	$72,477	6.6%	47.0
Plympton	$98,359	$53,250	$63,750	4.3%	45.9
Stoughton	$79,421	$53,744	$63,336	7.3%	43.9
West Bridgewater	$86,806	$53,408	$63,569	5.0%	44.1
Whitman	$83,066	$55,432	$62,850	6.0%	38.3

Source: ACS 2018, DP05

Housing Units

From 2000 to 2017, the number of housing units in Hanson increased by 19.92 percent. The towns of Plymouth and Plympton were the only communities to receive a higher percent change in housing units.

Table 34: Housing Units, 2000 – 201, OCPC Region

	2000	2010	2017	Change 2000-2017	
				Number	Percent
Avon	1,740	1,769	1,766	26	1.5%
Abington	5,348	6,377	6,538	1,190	22.25%
Bridgewater	7,652	8,336	8,435	783	10.23%
Brockton	34,837	35,552	34,873	36	0.1%
Duxbury	5,345	5,875	5,957	612	11.45%
East Bridgewater	4,427	4,906	5,018	591	13.35%
Easton	7,631	8,155	8,308	677	8.88%
Halifax	2,841	3,014	2,941	100	3.52%
Hanover	4,445	4,852	5,026	581	13.08%
Hanson	3,178	3,589	3,811	633	19.92%
Kingston	4,525	5,010	5,070	545	12.04%
Marshfield	9,954	10,940	10,660	706	7.09%
Pembroke	5,897	6,552	6,731	834	14.14%
Plymouth	21,250	24,800	26,710	5,460	25.69%
Plympton	872	1,043	1,067	195	22.36%

Stoughton	10,488	10,787	11,636	1,148	10.94%
West Bridgewater	2,510	2,669	2,690	180	7.17%
Whitman	5,104	5,522	5,548	444	8.69%
Plymouth County	181,524	200,161	201,930	20,406	11.20%
Massachusetts	**2,621,989**	**2,808,254**	**2,827,820**	**205,831**	**7.90%**

Source: U.S. Census Bureau, 2000 Census & 2013-2017 American Community Survey DP04

Table 35: Occupied Housing Units, OCPC Region

	2018 ACS Housing Units	Occupied Housing Units	Owner-Occupied Housing Units	Renter-Occupied Housing Units
Avon	1,799	1,582	1,158	424
Abington	6,762	6,413	4,491	1,922
Bridgewater	8,519	8,050	5,705	2,345
Brockton	33,880	31,440	16,908	14,532
Duxbury	775	673	572	101
East Bridgewater	5,033	4,907	3,985	922
Easton	8,500	8,183	6,491	1,692
Halifax	2,881	2,798	2,482	316
Hanover	4,978	4,882	4,281	601
Hanson	3,903	3,806	3,495	311
Kingston	5,188	4,859	3,992	867
Pembroke	6,730	6,489	5,606	883
Plymouth	27,418	23,101	18,260	4,841
Plympton	1,067	1,019	879	140
Stoughton	11,493	10,784	7,618	3,166
West Bridgewater	2,712	2,515	2,153	362
Whitman	5,536	5,379	3,770	1,609

Source: ACS 2018, S2501

Rental Housing

Rental housing is increasingly considered an important asset to economic development, particularly as it enables a community to attract and/or retain its younger labor force, empty nesters and early retirees who may want to sell an existing single-family residence but remain in the community, and others not interested in or able to afford homeownership. Rental housing development can complement office, retail, and recreational uses and lend scale to achieve feasible development. In the case of a potential mixed-use development in the vicinity of the South Hanson MBTA rail station, it also represents an opportunity to upgrade underutilized commercial properties.

Table 36: Multifamily Rental Units in Hanson & Surrounding Towns

Multifamily Rental Units in Hanson & Surrounding Towns							
	Units in 2019	% of Units	Ave Unit Size (SF)	Ave Annual Increase in Units: 2010-2019	Monthly Rent in 2019	Ave Annual Increase in Rent: 2010-2019	Ave Rent per sf
Studio	46	2%	368	0	$785	2.2%	$2.13
1 BR	711	38%	704	7	$1,456	3.2%	$2.07
2 BR	841	45%	1,007	10	$1,815	4.2%	$1.80
3 BR	115	6%	1,158	3	$1,875	3.6%	$1.62
ALL BRs	1,850	93%	877	20	$1,652	3.8%	$1.88

Source: CoStar *Property Information System*, April 2019, and FXM Associates

The picture that emerges from the assessment of demand for and supply of multi-family rental housing in Hanson and the local market area is one in which expected demand – driven by household mobility as well as net new growth – dramatically exceeds the current supply which has grown very modestly over the past ten years. There are virtually no vacancies within the current supply. Even in this context of limited supply, Hanson is especially underrepresented in its expected share of rental housing.[34] On the higher end, the rentals that are available in conventional listings are priced above thresholds needed to support rehabilitation and new construction costs for market rate (unsubsidized) housing. Multi-family rental housing that includes opportunities for below-market rentals can also aid Hanson in achieving its housing production goals.[35]

Prices and Sizes of Recently Available Rentals

To get a sense of the sizes and prices of units on the market, FXM sampled listings of rental units in apartment complexes in towns approximately within the 20-minute drive time of central Hanson. The listings were gathered in April 2019. Available rental units were one- to three-bedroom units, and rents averaged around $1,600 for one-bedroom units and $1,900 for three-bedrooms. Studios and larger units were very scarce.

Table 37: Average Rental Listings, Hanson 20-Minute Area

# of Bedrooms	Rent	# of Units	High	Low
Studio	$1,436	3	$2,400	$650
1 BR	$1,876	27	$2,317	$925
2 BR	$1,876	24	$2,550	$1,195
3 BR	$2,154	21	$2,500	$1,700

[34] Based on estimated 2019 population and households, Hanson currently has about half as many multi-family rental units as the average of other communities within the 20-minute drive time market area.

[35] Town of Hanson *Housing Production Plan*, March 2019, Barrett Planning Group for the Town of Hanson, and Hanson Housing Authority,

Table 38: Average Sizes of Rental Listings, Hanson 20-Minute Area

# BRs	SF	# Units	High	Low
Studio	1,200	2	1,800	600
1 BR	829	12	1,352	526
2 BR	1,095	18	1,886	600
3 BR	1,297	13	1,800	900

Employment Trends and Occupations

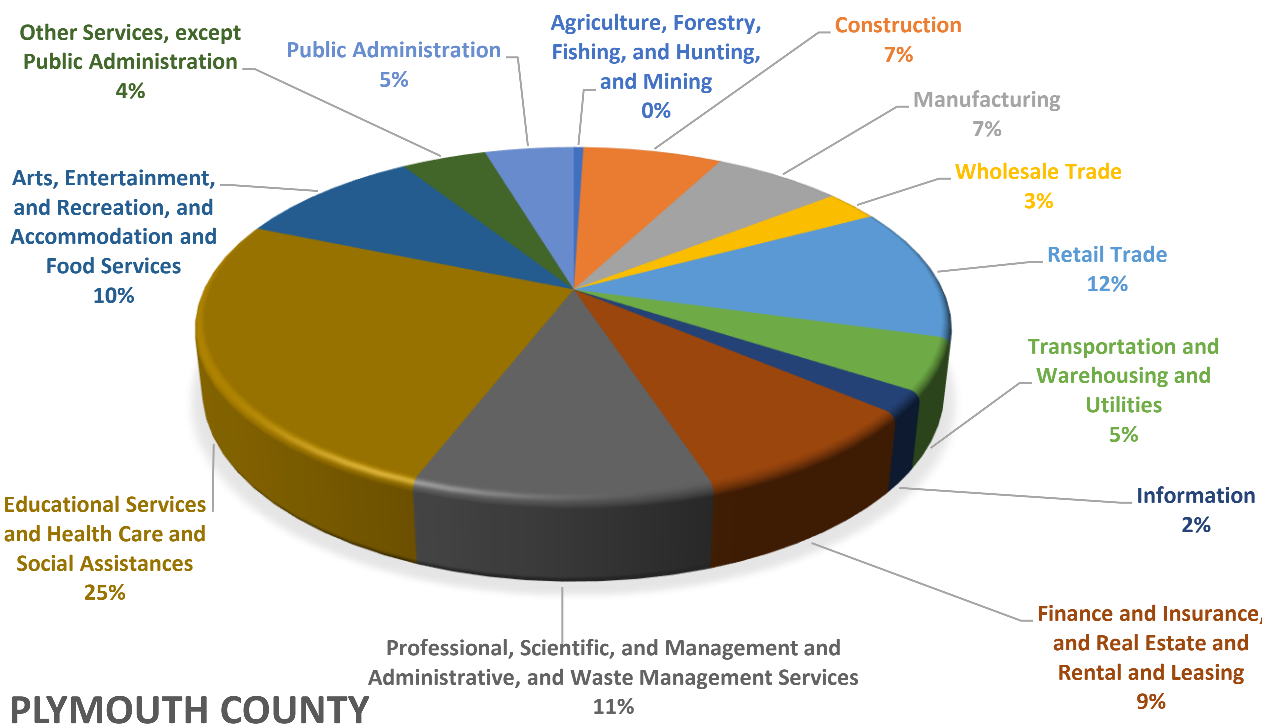
The largest numbers of jobs in the region are in Health Care and Social Assistance. Other large employment areas include Retail Trade, Construction, Professional, and Technical Services.

Table 39: Employment Projections for the OCPC Region, 2020 - 2040

TOWN	COUNTY	DET 2000	DET 2010	2020	2030	2040
Abington	Plymouth	4,205	4,032	4,503	4,505	4,520
Avon	Norfolk	6,859	5,178	5,170	5,155	5,177
Bridgewater	Plymouth	7,211	8,025	8,733	8,720	8,758
Brockton	Plymouth	37,754	37,160	36,707	36,602	36,763
Duxbury	Plymouth	2,562	3,563	3,665	3,607	3,625
East Bridgewater	Plymouth	3,422	2,975	3,351	3,360	3,366
Easton	Bristol	9,347	10,440	10,287	10,271	10,314
Halifax	Plymouth	1,099	1,431	,1.401	1,400	1,405
Hanover	Plymouth	7,011	7,299	7,436	7,322	7,349
Hanson	Plymouth	1,839	2,158	2,060	2,063	2,066
Kingston	Plymouth	5,318	5,570	7,473	7,488	7,499
Pembroke	Plymouth	6,053	4,987	5,144	5,072	5,083
Plymouth	Plymouth	19,100	23,807	27,145	27,180	27,247
Plympton	Plymouth	267	393	1,082	1,082	1,086
Stoughton	Norfolk	14,280	13,777	15,365	15,365	15,642
West Bridgewater	Plymouth	6,906	7,096	7,843	7,845	7,873
Whitman	Plymouth	2,953	2,681	2,622	2,613	2,632
TOTAL		136,186	140,572	149,986	149,870	150,406

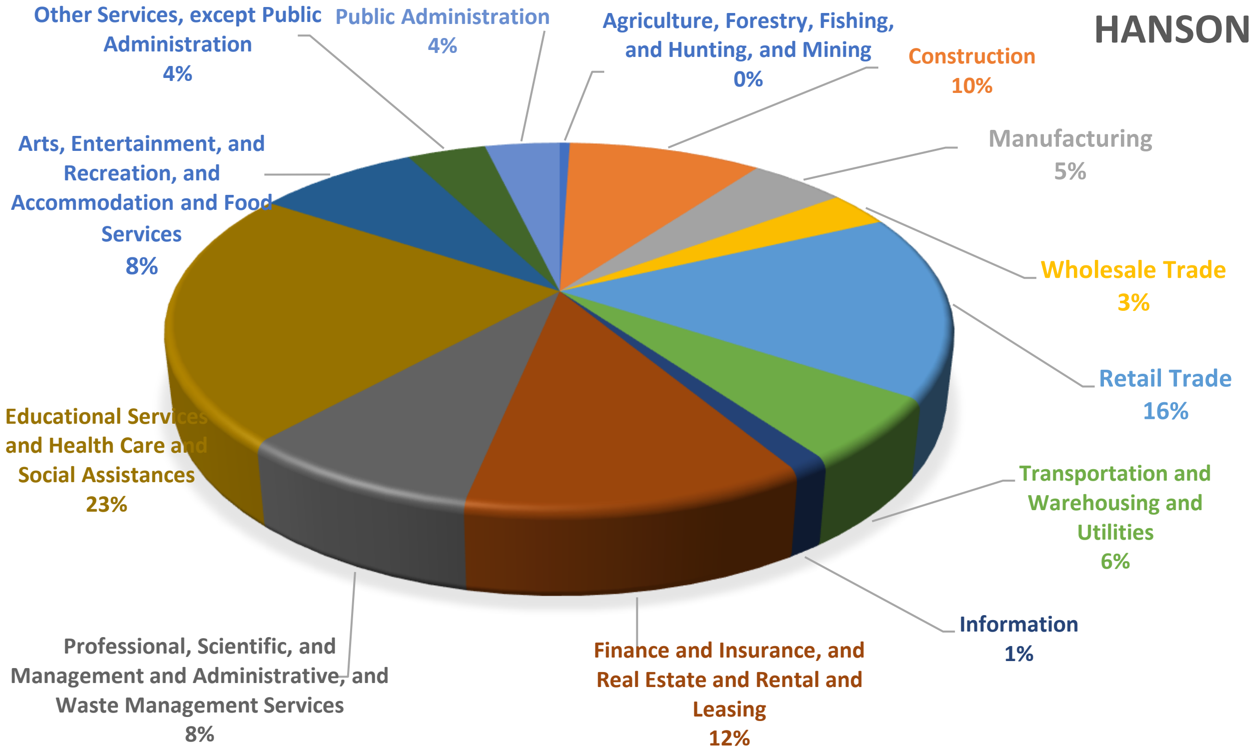
Industry

Based on US Census data, the County's economy today is strongly based in the education/healthcare/social assistance industry – providing about 25 percent of all employment – followed by the Professional, scientific, and management and administrative and waste management services. Agriculture, forestry, fishing, hunting, and mining industries make up the smallest source of the local economy. The economy of Hanson is reflective of the region, with educational services, health care and social assistances industry providing 22.6 percent of all employment, followed by retail trade at 16.3 percent.



Occupations

The following Figure shows the occupations of employed residents in Hanson compared to those in Plymouth County and Massachusetts overall. A measurably higher proportion of Hanson residents are employed in construction, installation/maintenance/repair, office/administrative support, and sales/related occupations compared to residents of Plymouth County and Massachusetts overall. A relatively lower proportion of Hanson residents hold occupations in building/grounds cleaning/maintenance, community/social services, healthcare practitioner/technician, and management fields than the overall residents of Plymouth County and the Commonwealth.



The characteristics of Hanson's workforce differ slightly compared to the county and state averages – the proportion of residents aged 25+ with a bachelor's degree or higher for the Town of Hanson is 4 percentage points less (32%) than for Plymouth County (36%) and 10 percentage points less (32%) than for the Commonwealth over (42%). The Town of Hanson has a slightly higher percentage of service and blue-collar workers when compared to both the County and the Commonwealth. Hanson has a higher number of employed persons per household on average (1.58) that the average for Plymouth County (1.34) and Massachusetts overall (1.28) and this may account in part for the relatively high average and median incomes of Hanson residents. [36]

Between 2007 and 2017, jobs in Hanson decreased by 1 percent compared to 14 percent growth for Plymouth County and 15 percent growth statewide. During this period job losses were greatest in manufacturing, retail trade, health care and social assistance, and finance and insurance. Employment in accommodation & food services showed a significant gain, as did jobs in construction, wholesale trade, professional and &technical services, and administrative services. Noteworthy in the comparison of historical employment trends is that overall jobs in Hanson bottomed out in 2011, at 1,474 jobs.

Between 2011 and 2017 Hanson gained approximately 300 jobs, a 21 percent increase, showing jobs growth in all sectors except manufacturing and health care. The greatest gains were in professional &

[36] **Town of Hanson Economic Development Plan, July 2019, FXM Associates**

technical services, which continues to trend upward and is an important potential generator of demand for office space.

At $39,000 on average for all jobs, average annual wages paid in Hanson are 77 percent of those for Plymouth County overall and 58 percent of the statewide average. This difference may in part be attributable to the relatively large number of jobs in Hanson in Retail Trade and Accommodations & Food Services, which are relatively low-wage occupations.

Table 40: Major Employers by Community, 2020

Community	Employer	Address	Est. Employees
Abington	Walmart Super Center	Brockton Ave	250-499
Avon	Costco Wholesale	Stockwell Drive	1000-4999
Bridgewater	Bridgewater State University	Summer St	500-999
	Bridgewater State Hospital	Administration Rd.	500-999
Brockton	Signature Healthcare	Centre Street	1000-4999
	Stewart Good Samaritan	N. Pearl St.	1000-4999
	NiSource	Belmont St.	1000-4999
	VA Brockton Healthcare	Belmont St.	1000-4999
	Brockton Area Multi Services	Pleasant St	1000-4999
	Massasoit Community College	Massasoit Dr.	1000-4999
Duxbury	Allerton House	Kingston Way	100-249
East Bridgewater	Harte Hanks Dir. Marketing	N. Bedford St.	100-249
	Compass Medical	N. Bedford St.	100-249
	Mueller Corp.	Spring St.	100-249
Easton	Stonehill College	Washington St.	500-999
	Roache Brothers Supermarket	Washington St.	250-499
	SE Regional Vo-Tech School	Pond St.	250-499
Halifax	Walmart Super Center	Plymouth St.	250-499
Hanover	Hanover YMCA	Mill St.	250-499
Hanson	New England Villages Inc.	Commercial Waye	100-249
	Shaw's Supermarket	Liberty St.	100-249
Kingston	Wingate Inn at Silver Lake	Chipman Way	1000-4999
Pembroke	Pembroke Hospital	Oak St.	250-499
Plymouth	Beth Israel Deaconess Hospital	Sandwich St.	250-499
Plympton	Sysco Boston LLC	Spring St	500-999
Stoughton	Steward NE Sinai Hospital	York St	500-999
	Kindred Hospital	Summer St	250-499
West Bridgewater	Shaw's Supermarket	West Center St	500-999
Whitman	Stop and Shop Supermarket	Bedford St	100-249

Hanson's commercial development is dispersed through town, but the major retail center is located along Liberty Street (Route 58) near Town Hall. Some limited commercial development is also located in the area around the commuter rail station in South Hanson as well as along the Pembroke town line in the Bryantville section of Hanson.

Industrial development in Hanson is limited to two small industrial parks-the 34-acre Hanson Commerce Center off Route 27 on the East Bridgewater Town Line and the Station Street Industrial Park near the commuter rail station in South Hanson.

Hanson's municipal drinking water supply is drawn from four wells in Hanson as well as from the City of Brockton on an as needed basis. The wells are protected by Zone II wellhead protection areas and by Hanson's Aquifer and Well Protection District. Halifax does not have municipal wastewater service, therefore requiring wastewater be disposed of via on-site septic systems.

A list of critical facilities is shown in the upcoming section. It shows the relationship of these facilities to several hazards: flooding, hurricanes, snowfall, wildfire, landslide, and earthquakes.

The town maintains a website at https://www.hanson-ma.gov

The Town of Hanson has several unique characteristics to keep in mind while planning for natural hazards:

- Hanson has been proactive in addressing the impact of climate on natural hazards. Hanson is in the process of becoming certified by the Commonwealth as a Municipal Vulnerability Preparedness community.
- Hanson has the benefits of significant forest and tree cover. However, power outages and damage from falling trees, as well as the potential for forest fire are important concerns.
- Water quality and quantity are important concerns for both maintaining drinking water supply and the health of the many brooks and wetlands within the town.

Market Conditions and Trends

In the Hanson Economic Development Plan, FXM Associates assessed potential market demand for commercial development using two complementary approaches. The first considers historical trends in jobs by industry sector, projects these trends forward, and then converts projected numbers of jobs into potential demand for space using space per employee norms. The second approach examines historical trends in the inventory, occupancies, vacancies, net absorption, and lease rates for each of the major types of space – office, industrial/warehouse, and retail. The Table below summarizes the results of these two approaches.

The differences in forecasts reflect the typical range found when using two distinctly different data sources and projection methods but provides greater confidence in whether the overarching trends are positive or negative for each type of space as well as in the range of likely outcomes.

Plymouth County is a broader geographic area than the submarket use for the supply analysis but because of data limitations is more reliable for employment projects. In the case of both projection methods, and notwithstanding land and development costs, zoning, and other factors affecting potential development at specific sites, the results of the commercial market analysis clearly suggest that there is market support for additional development in Hanson.

With success overcoming development constraints in the vicinity of the MBTA commuter rail station in South Hanson, an aggressive outreach by local property owners, brokers, and developers, Hanson could capture a greater share of projected regional and submarket growth in each of the space types analyzed. The absorption trends are specially promising. The defined "submarket" includes only Hanson and surrounding communities.[37] Occupancies have been increasing, vacancies are extremely low, and rents have been steadily rising.

Table 41: Average Annual Projected Demand through 2022

Average Annual Projected Demand through 2022				
Type of Space	**Based on Projected Jobs**		**Based on Absorption Trends**	
	Hanson SF	Plymouth Cty SF	Hanson SF	Submarket SF
Office	5,000	120,000	500	24,000
Industrial/Warehouse	2,000	40,000	3,000	93,000
Retail/Restaurant	3,000	38,000	1,500	55,000
Sources: MDOL ES202; BEA REIS; CoStar *Property Information System*; and FXM Associates, 2019				

In addition to the trend's projections for potential retail space demand community-wide, a Retail Opportunity Gap/Surplus analysis was done to estimate the types and numbers of stores and potential square footage of space that might be captured in the South Hanson MBTA commuter rail station area. The Gap analysis measures sales "leakage" within given drive-time markets, wherein consumer expenditures are not now being captured by stores within those market areas. The result is a snapshot of current sales leakage rather than projection of future demand. The technique is commonly used by major retail developers to aid their recruitment of tenants. In the case of the South Hanson MBTA rail station area, current sales leakages suggest a potential to capture about 98,000 additional square feet of retail and restaurant uses.

Fiscal Comparisons

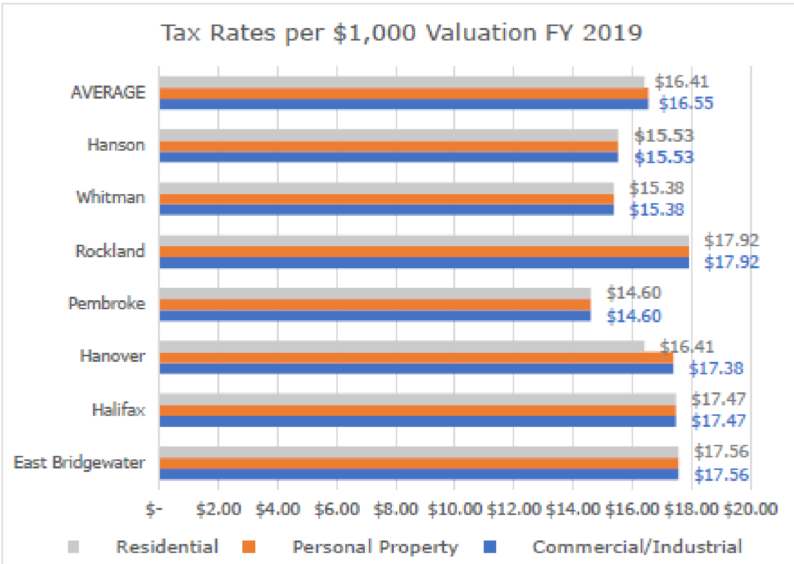
Hanson's residential and commercial tax rates are slightly below the average of surrounding communities, as shown in the following graph. Only Pembroke has a commercial tax rate that might be considered a competitive advantage over Hanson. Hanson derives the lowest percentage of its property tax revenues from commercial uses – 8 percent -- compared to an average 12 percent commercial for the surrounding communities.

[37] **Defined by local real estate brokers as the area directly competitive with Hanson for development, the "submarket" includes Hanson, Rockland, Hanover, Whitman, East Bridgewater, Pembroke, and Halifax.**

Tax Rates

Hanson's 2019 commercial/industrial tax rate and residential tax rate are the third lowest of the seven communities. Only Whitman and Pembroke have lower rates.

Figure 39: Tax Rates per $1,000 Valuation FY 2019

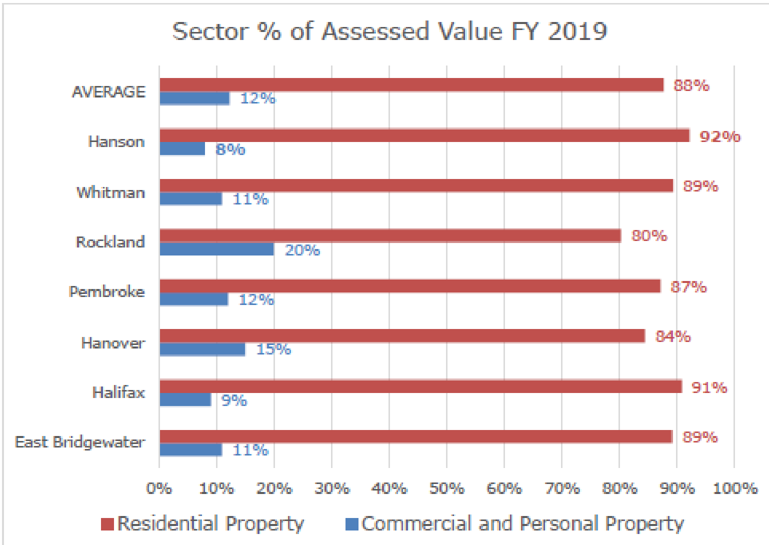


Source: Mass Department of Revenue, Divison of Local Services, Municpal Data Bank, 2019, and FXM Associates

Residential and Commercial Property as Percent of Total Assessed Valuation and Tax Levy

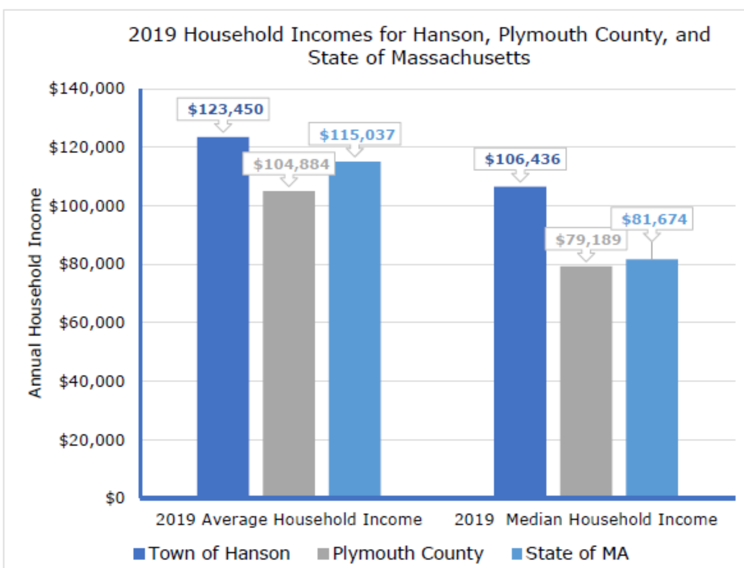
Of all property in Hanson, 8 percent is assessed as commercial. Halifax is close at 9 percent commercial assessment, both towns having the lowest proportion of commercial/industrial/personal property assessed values. Rockland has the highest proportion of its assessed value classified as commercial.

Figure 40: Sector Percent of Assessed Value FY2019



Source: Mass Department of Revenue, Divison of Local Services, Municpal Data Bank, 2019, and FXM Associates

Figure 41: Illustrates the Relative Annual Incomes among Hanson, Plymouth County, and State of Massachusetts Households



Source: EnvironicsAnalytics, 2019 and FXM Associates

In terms of elements of key to economic growth, i.e., population growth and income, Hanson compares favorably to both Plymouth County and the Commonwealth of Massachusetts. As shown in the Table below, the average annual income in Hanson ($23,450) is 18 percent higher than average incomes for Plymouth County (2% vs. 6%) and of the state (2% versus 8%). There is a low proportion of Families Below Poverty with Children (1%) versus that of the county (5%) and the Commonwealth (6%).

Table 42: Hanson Households Compared to Plymouth County and Commonwealth

Population & Households Compared								
		Town of Hanson			Plymouth County		State of MA	
Population								
2024 Projection		11,251			535,770		7,131,739	
2019 Estimate		10,836			519,639		6,916,527	
2010 Census		10,188			494,919		6,547,629	
2000 Census		9,564			472,497		6,349,100	
Projected Growth 2019 - 2024			4%			3%		3%
Estimated Growth 2010 - 2019			6%			5%		6%
Growth 2000 - 2010			7%			5%		3%
2019 Estimated Average Age		43.3			41.1		40.6	
Households								
2024 Projection		3,920			200,709		2,804,920	
2019 Estimate		3,750			193,463		2,710,577	
2010 Census		3,464			181,126		2,547,075	
2000 Census		3,150			168,231		2,443,572	
Projected Growth 2019 - 2024			5%			4%		3%
Estimated Growth 2010 - 2019			8%			5%		6%
Growth 2000 - 2010			10%			8%		4%
2019 Average Household Size		2.4			2.6		2.5	
2019 Estimated Household Income		**3,750**			**193,473**		**2,682,402**	
Income Less than $15,000		132	4%		12,834	7%	249,280	9%
Income $15,000 - $24,999		139	4%		11,843	6%	197,422	7%
Income $25,000 - $34,999		182	5%		11,449	6%	177,436	7%
Income $35,000 - $49,999		282	8%		19,069	10%	263,460	10%
Income $50,000 - $74,999		482	13%		28,495	15%	376,903	14%
Income $75,000 - $99,999		531	14%		23,037	12%	320,387	12%
Income $100,000 - $124,999		472	13%		21,097	11%	271,919	10%
Income $125,000 - $149,000		418	11%		17,873	9%	216,612	8%
Income $150,000 - $199,999		603	16%		20,712	11%	262,249	10%
Income $200,000 - $249,999		294	8%		10,461	5%	137,018	5%
Income $250,000 - $499,999		176	5%		11,053	5%	151,232	6%
Income $500,000 and over		39	1%		5,550	3%	86,659	3%
Household Income Less than $25,000		271	7%		24,677	13%	446,702	19%
Household income more than $150,000		1,112	30%		47,776	25%	637,099	19%
2019 Families by Poverty Status								
2019 Families Below Poverty		***62***	***2%***		7,777	6%	140,682	8%
2019 Families Below Poverty with Children		***31***	***1%***		6,171	5%	106,439	6%
2019 Estimated Average Household Income	**$**	**123,450**		**$**	**104,884**	**$**	**115,037**	
2019 Estimated Median Household Income	**$**	**106,436**		**$**	**79,189**	**$**	**81,674**	

Source: EnvironicsAnalytics, 2019 and FXM Associates

Workforce Characteristics

The data in the following tables show that the proportion of residents aged 25+ with a bachelor's degree or higher for the Town of Hanson is 4 percentage points less than for Plymouth County and 10 percentage points less than for the Commonwealth. The Town of Hanson has a higher percentage of service, farm, and blue-collar workers when compared to both the County and the Commonwealth. Travel time to work for those in Hanson are shorter than for the county and state: 30 minutes, compared to 36 and 33 minutes at the county and state levels, respectively.

Table 43: Workforce Characteristics, 2019

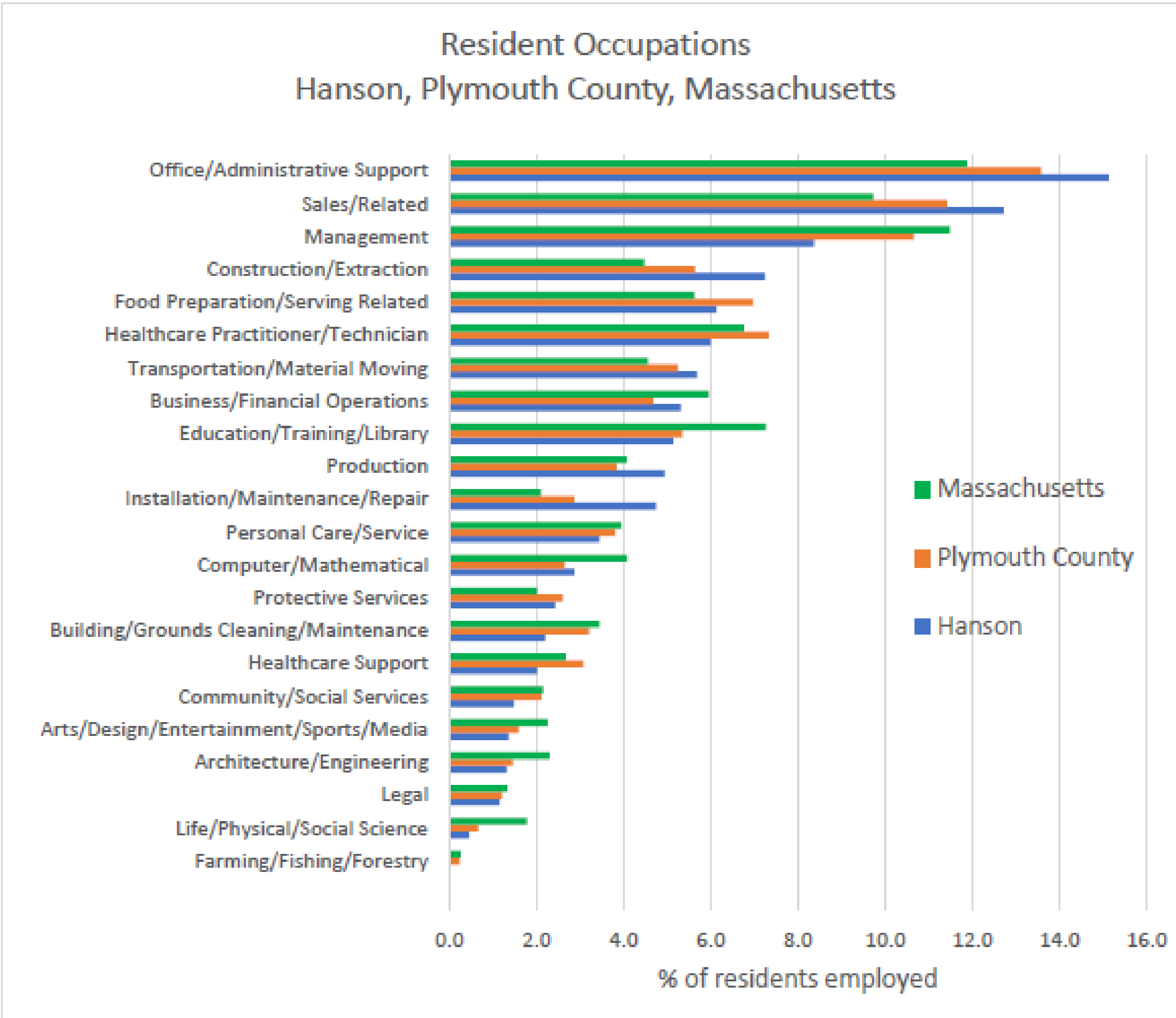
Workforce Characteristics for Hanson, Plymouth County, and State of MA

	Town of Hanson		Plymouth County		State of MA	
Education (Pop. Age 25+)	**7,542**		**356,216**		**4,766,815**	
Less than 9th grade	78	1%	10,237	3%	220,451	5%
Some High School, no diploma	315	4%	17,035	5%	248,368	5%
High School Graduate (or GED)	2,376	32%	106,062	29%	1,188,929	25%
Some College, no degree	1,510	20%	65,930	18%	753,381	16%
Associate Degree	826	11%	33,500	9%	372,047	8%
Bachelor's Degree	1,631	22%	83,006	23%	1,135,958	24%
Master's Degree	668	9%	35,225	10%	633,236	13%
Professional School Degree	123	2%	7,583	2%	141,317	3%
Doctorate Degree	15	0%	3,687	1%	127,174	3%
Less than high school diploma	393	5%	27,272	8%	468,819	10%
Bachelor's Degree or higher	2,437	32%	129,501	36%	2,037,685	42%
Occupation Classfication (Pop. Age 16+)	**6,198**		**268,280**		**3,584,409**	
Blue Collar	1,401	20%	47,090	18%	544,368	15%
White Collar	3,795	55%	167,912	63%	2,398,182	67%
Service and Farm	1,002	25%	53,278	20%	641,859	18%
Type of Worker (Civ. Employed Pop. 16+)	**6,198**		**268,280**		**3,584,409**	
For-Profit Private Workers	4,550	73%	182,870	68%	2,382,663	66%
Non-Profit Private Workers	591	10%	27,601	10%	451,630	13%
Local Government Workers	444	7%	19,897	7%	245,505	7%
State Government Workers	180	3%	10,085	4%	128,385	4%
Federal Government Workers	47	1%	3,872	1%	57,543	2%
Self-Emp Workers	381	6%	23,537	9%	314,176	9%
Unpaid Family Workers	5	0%	418	0%	4,507	0%
2019 Est. Households by Number of Vehicles	**3,750**		**190,870**		**2,710,577**	
No Vehicles	121	3%	11,854	6%	339,251	13%
1 Vehicle	832	22%	59,531	31%	964,924	36%
2 Vehicles	1,659	44%	80,519	42%	982,077	36%
3 Vehicles	780	21%	27,964	15%	305,986	11%
4 Vehicles	268	7%	8,657	5%	88,841	3%
5 or more Vehicles	90	2%	2,345	1%	29,498	1%
Average Travel Time to Work (minutes)	**30**		**36**		**33**	

Source: EnvironicsAnalytics, 2019 and FXM Associates

The following Figure shows the occupations of employed residents in Hanson compared to those in Plymouth County and Massachusetts overall. A measurably higher proportion of Hanson residents are employed in construction, installation/maintenance/repair, office/administrative support, and sales/related occupations compared to residents of Plymouth County and Massachusetts overall. A relatively lower proportion of Hanson residents hold occupations in building/grounds cleaning/maintenance, community/social services, healthcare practitioner/technician, and management fields than the overall residents of Plymouth County and the Commonwealth of Massachusetts.

Figure 42: Occupations Compared.



Source: FXM Associates, July 2019

The following Figures show the commuting origin and destination patterns for work trips out of (Figure A) and into Hanson (Figure B). The blue columns represent numbers of commuters by town, and the orange line is the cumulative percentage. The principal destinations for Hanson workers are Hanson (14%), Boston (11%), Hanover (7%), Brockton (5%), and Pembroke (5%). The major origins for work trips into Hanson are Hanson (39%), Pembroke (7%), Halifax (7%), Whitman (6%), and (6%).

Figure 43: Average Annual Wages by Industry Hanson, Plymouth County, Commonwealth of Massachusetts, 2018

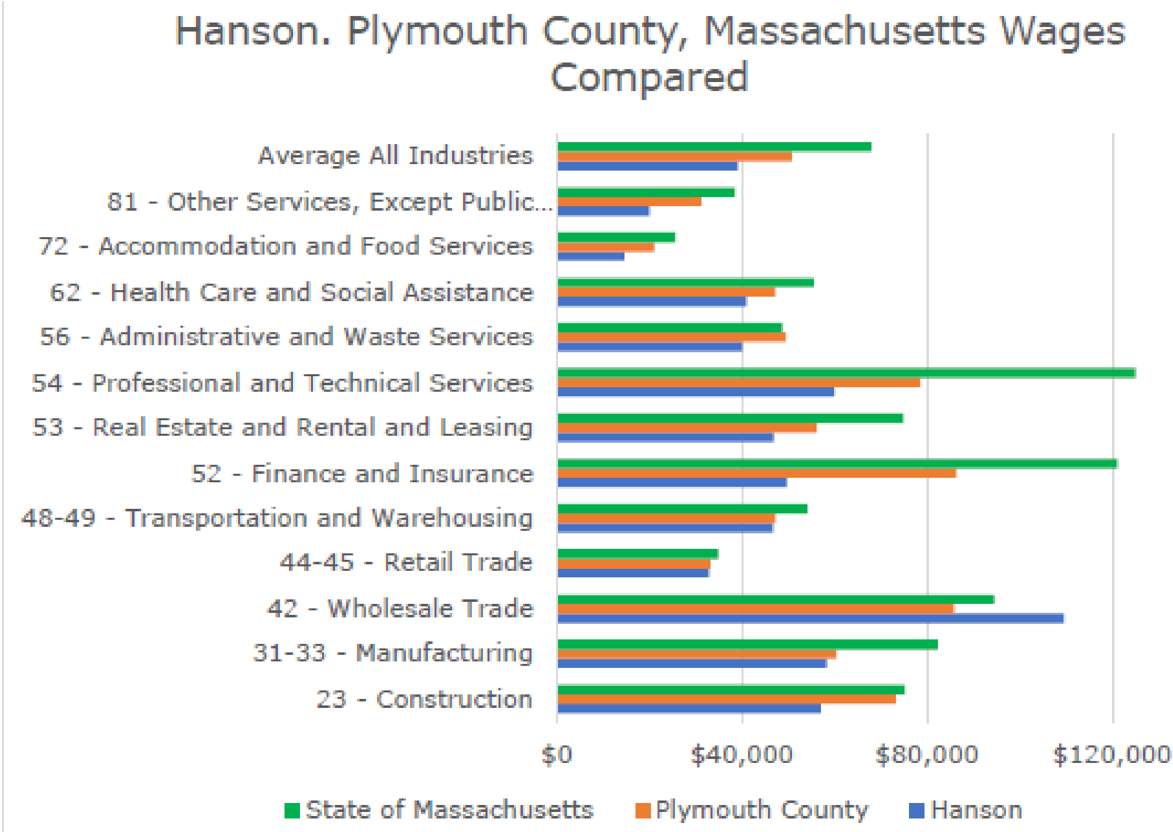


Figure 44: Hanson Commuters Destinations

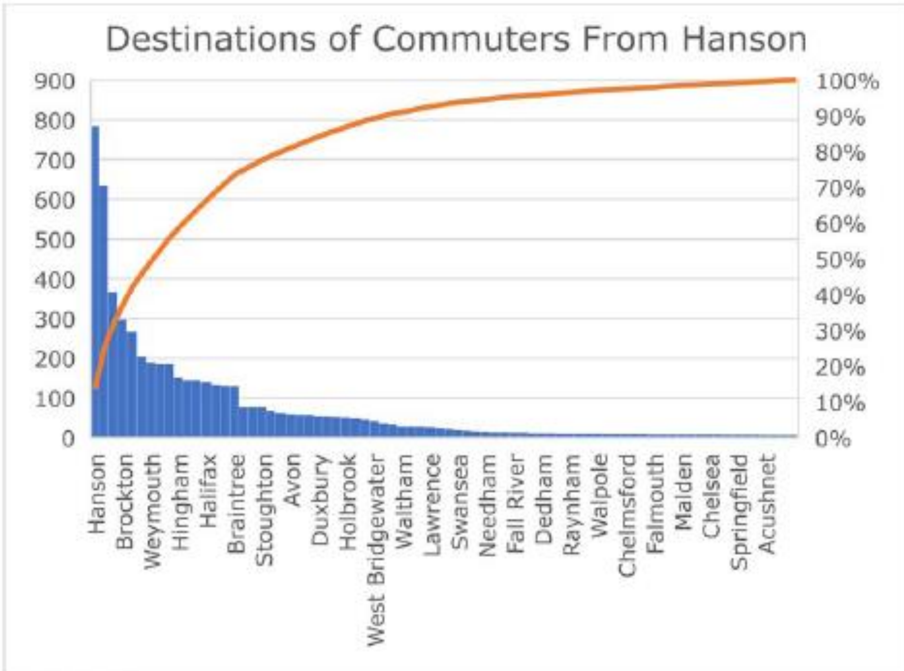
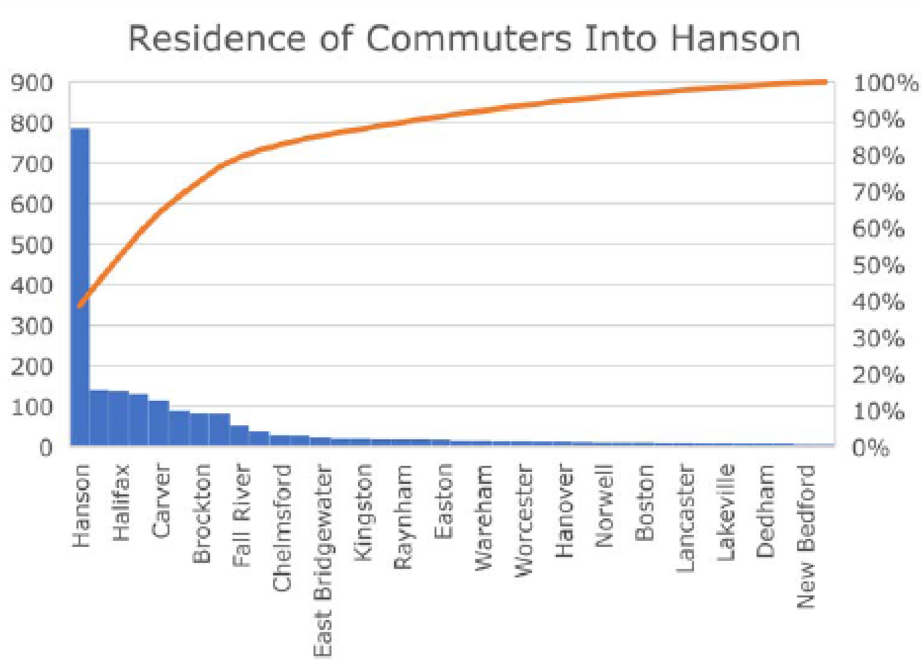


Figure 45: Origin of Commuters to Hanson



SECTION 3. Introduction to Risk Assessment

Section 3. Introduction to Risk Assessment

Identifies the natural hazards included in this HMP/MVP Plan and describes the three major climate change interactions included in the plan:

1. Heavy Precipitation and Flooding, Snowstorms, Ice storms and Extreme Cold Temperatures.
2. Extreme Heat, Droughts, and Wildfires
3. Strong Winds, Nor'easters, and Tornado

Profiling the Natural Hazards

To identify natural hazards of concern for the Hazard Identification and Risk Assessment, the Core Team reviewed the 2015 OCPC Regional HMP, the 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan (SHMCAP, 2018), available hazard mapping, and other weather-related databases. Historical research and conversations with local officials and emergency management personnel were also used to identify and profile the natural hazards which are most likely to have an impact on Hanson.

Natural hazards are natural events that threaten lives, property, and other assets. Often, natural hazards can be predicted. They tend to occur repeatedly in the same geographical locations because they are related to weather patterns or physical characteristics of an area. The assessment conducted for the *May 2015 Natural Hazard Mitigation Plan for the Old Colony Region* recognized the following 7 natural hazards and one man-made hazard that could potentially impact Hanson.

- Flood Related Hazards – (100-Year and Localized)
- Wind-Related Hazards – Hurricanes & Tropical Storms, Tornados
- Winter-Related Hazards – Winter Storms and Nor'easters
- Coastal Related Hazards – Coastal Erosion & Shoreline Change
- Fire-Related Hazards – Wildfires, Major Urban Fires
- Geologic Hazards – Earthquakes, Landslides and Tsunamis
- Other Natural Hazards – Extreme Temperatures
- Hazardous Materials

Each of these hazards were assessed by the Committee for location of occurrence, extent, previous occurrences, and probability of future events. Of the hazards identified in the 2015 HMP, coastal-related hazards and tsunamis were identified as not threatening Hanson due to the Town's location and therefore not considered within this update.

Some of these hazards were reclassified and/or regrouped to align with the 2018 SHMCAP and three hazards average/extreme temperatures, drought and invasive species were added.

In addition to the hazards discussed above, the Hazard Mitigation committee reviewed the other hazards listed in the Massachusetts Hazard Mitigation Plan, coastal hazards, atmospheric hazards, ice jams, coastal erosion, sea level rise, and tsunamis. It was determined that these hazards are not threatening Hanson due to the Town's location.

Natural Hazards Assessed

The following Table summarizes the 2020 natural hazard risks for Hanson. This evaluation considers the frequency of the hazard, historical records, and variations in land use.

The following Table provides the outcome for the full range of natural hazards considered. The Table documents the evaluation process used for determining the significance of each hazard. Only hazards identified as significant were included. Hazards not identified for inclusion at this time may be addressed during future evaluations and updates.

Hazard	Significant	Justification
Inland Flooding 	YES	The impact of flooding on life, health, and safety is dependent on several factors, including the severity of the event and whether adequate warning time is provided to residents. Exposure includes the population living in or near floodplain areas that could be impacted should a flood event occur and those affected by a hazard event. Scattered major property damage, some minor infrastructure damage, essential services are briefly interrupted, some injuries or fatalities. • Areas that are highly developed or within the floodplain are most vulnerable. • More intense and frequent downpours will result in more frequent flooding and greater area exposed.
Drought 	YES	Drought was not identified as a hazard in the 2015 HMP for OCPC. Current frequency for Hanson is 1% any given month. Long-term drought can have moderate to high-risk effects on both the environment and the economy. Reduced water levels also cause loss of landscape due to restrictions on outdoor watering, and therefore less crop production and loss of business revenues. Limited and scattered property damage, limited damage to public infrastructure and essential services not interrupted. • Entire Commonwealth is vulnerable and impacts on all sectors are widespread. • Chance of Watch level drought occurring in any given month: 8% • Frequency and intensity projected to increase during the summer and fall.
Extreme Temperatures 	YES	Included in the State Plan, high frequency of occurrence. In Plymouth County in the past ten years there has been one excessive heat day and no deaths. The town has not struggled with issues pertaining to extreme heat, but certainly experiences extreme cold. No improvements recommended at this time. • An average of two extreme heat and 1.5 extreme cold weather event/year have occurred over the last two decades. • Young and elderly populations and people with pre-existing health conditions are especially vulnerable to heat and cold. • By the end of the century there could be 13-56 extreme heat days during summer • The 9 warmest years on record all occurred in the last 20 years (2017, 2015, 2014, 2013, 2010, 2009, 2005, and 1998)
Tornados 	YES	High winds can launch debris, which can lead to loss of life if proper shelter is not taken. Can impede emergency response agencies from responding to those affected by the natural disaster. • Massachusetts experiences an average of 1.7 tornados/year. • Most tornado-prone areas of the state are the central countries. • Over 200 critical facilities and 1,500 government facilities are in identified tornado hazard zones.

Extreme Wind Thunderstorms 	YES	Included in the State Plan, the area has a potential risk for extreme winds. 20-30 thunderstorms annually, 43.5 high wind events annual in MA. Limited and scattered property damage, limited damage to public infrastructure and essential services not interrupted, limited injuries or fatalities. • Increase in frequency and intensity of severe thunderstorms may increase risk of tornados. • The coastal zone is most frequently impacted by high wind events. • Massachusetts experiences 20-30 thunderstorm days/year, high winds occur more frequently. • Road closures and power outages are common impacts. • Expected increases in the intensity and frequency of severe weather events
Wildfires 	YES	One notable event per year in MA. Increased risk and rates of wildfires combined with the reduced water levels can cause heightened mortality of both wildlife and livestock. Limited and scattered property damage, limited damage to public infrastructure and essential services not interrupted, limited injuries. • Massachusetts is likely to experience at least one event/year with noteworthy damages. • Barnstable and Plymouth Counties are most vulnerable due to their vegetation, sandy soils, and wind conditions. • There are over 1,200 state owned buildings in identified wildfire hazard areas in the Commonwealth. • Projected increase in seasonal drought and warmer temperatures will increase the risk of wildfire
Hurricane Tropical Storm 	YES	One every two years in MA. Scattered major property damage, some minor infrastructure damage, essential services are briefly interrupted, some injuries and/or fatalities. Impact of a hurricane or tropical storm on life, health, and safety is dependent on several factors, including the severity of the event and whether residents received adequate warning time. Have the capacity to displace citizens in direct impact zones to long-term sheltering facilities and can cause severe injuries and death due to infrastructure damage, debris, and downed trees. • Average occurrence of once event every two years • Coastal areas are more susceptible to damage due to high winds and tidal surge, but all locations are vulnerable. • Vulnerable populations include those who may have difficulty evacuating. • Warmer oceans will likely result in increased intensity of storms
Severe Winter Storm Nor'easter 	YES	One notable event per year in MA. The Commonwealth is vulnerable to both the wind and precipitation that accompany these storms. Winter storms are often accompanied by strong winds, creating blizzard conditions with blinding wind-driven snow, drifting snow, and extreme cold temperatures with dangerous wind chills. These storms are considered deceptive killers, because most deaths and other impacts or losses are indirectly related to the storm. Heavy snow can immobilize a region and paralyze Hanson, shutting down its transportation network, stopping the flow of supplies, and disrupting medical and emergency services. The conditions created by freezing rain can make driving particularly dangerous, and emergency response more difficult. The weight of ice on tree branches can also lead to falling branches damaging electric lines. • Currently the most frequently occurring natural hazard in the state. • High snowfall and ice storms are greater in high elevations of Western and Central Massachusetts, while coastal areas are more vulnerable to nor'easters. • Increase in the intensity and frequency of extreme weather events as the climate changes may include more nor'easters and higher precipitation amounts during winter storms.

Invasive Species  	YES	This is a new hazard identified over the course of the MVP CRB workshop process. The team recommends the Town stay abreast of regional and state-wide efforts to understand and mitigate the spread of invasive species. • Risk to native or minimally managed ecosystems has increase as dispersion of exotic species has increased. • Changes in temperature and precipitation may increase changes of a successful invasion of non-native species
Landslide 	NO	The effects of landslide are localized, and it is difficult to determine Hanson populations vulnerable to landslides. Frequency every other year in MA. • Areas with unstable slopes are most vulnerable. • Secondary impacts such as road closures can have a significant impact on communities. • More frequent and intense storms will result in more frequent soil saturation conditions that are conducive to landslides
Earthquake 	NO	10-15% chance of a Mag 5 event in 10-year period. Earthquakes represent a very low-frequency, serious severity hazard for Hanson. Based on historical events, earthquakes in the region will likely be in the 2-3 magnitude range. According to the USGS, earthquake damage usually occurs with earthquakes in the 4-5 magnitude range. Widespread major property damage, major infrastructure damage, essential services are interrupted from several hours to several days, many injuries and/or fatalities. • Cannot be predicted. • Probability of a magnitude 5.0 or greater earthquake centered in New England is about 10-15% in a 10-year period. • Tall buildings, high population, and soil characteristics contribute to vulnerability
Emerging Hazards, Pandemics 	YES	Living Document – COVID-19 Recovery

Climate Change Risk Assessment

Climate, consisting of patterns of temperature, precipitation, humidity, wind and seasons, plays a fundamental role in shaping natural ecosystems and the human economies and cultures that depend on them. “Climate change” refers to changes over a long period of time.

When scientists talked about global warming in the 1990s, they focused on the average annual global temperature and sea level rise. Scientists now have more data, better computational models, and better observations to record and analyze the most significant effects of climate change. Wildfires, hurricanes, and associated extreme rainfalls, flooding, drought, and heat waves have all worsened due to climate change, in addition to the increase in global temperatures and sea level rise.

Climate change observations come from a variety of data sources that have measured and recorded changes in recent decades and centuries. Climate change projections, however, predict future climate impacts and, by their nature, cannot be observed or measured. As a result of the inherent uncertainty in predicting future conditions, climate projections are generally expressed as a range of possible impacts.

Public health is also being affected: The Centers for Disease Control and Prevention (CDC) has found that illness from mosquito, tick, and flea bites more than tripled in the United States from 2004-2016. New disease vectors are possible from newly invasive species, such as the Asian long-horned tick – the first invasive tick in the United States in approximately 80 years.

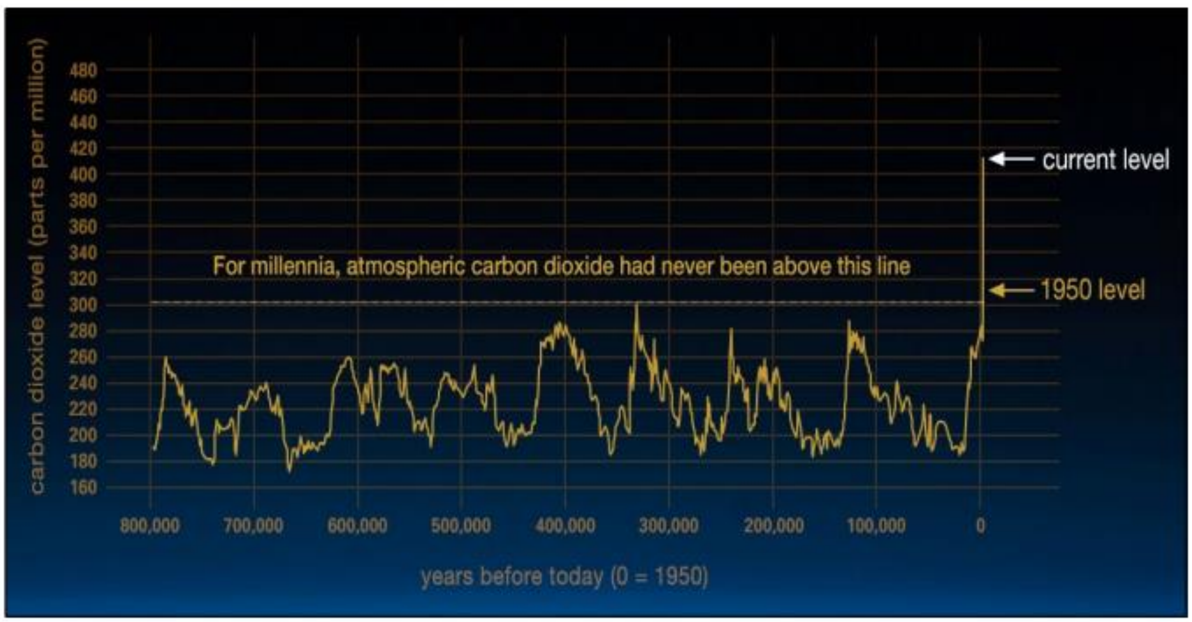
The Town of Hanson, like many communities in Massachusetts, has already been impacted by and is expected to face further impacts from two major changes: the shift from more heating days to more cooling days and the increase in the intensity of precipitation events. Some of the impacts include the following:

- Services the Town needs to provide to its residents, such as cooling shelters for those who cannot cool their homes, increased public health awareness and prevention, and emergency services during and after storm events.
- The viability of agriculture, part of the Town’s economic and historical base evolves from cranberry production, which faces threats from drought, variable temperatures during a single season, and pest activity.
- The future of significant natural resources such as ponds, wetlands, and forests that are threatened by storm damage, drought, invasive pests and plants, and diseases.

The presentation during the CRB workshop reviewed recent climate events and impacts within Massachusetts and climate projections and potential impacts on Hanson. For example, data for Massachusetts from *NOAA Technical Report NESDIS 149-MA* (2017) show average annual temperatures increased almost 3°F between 1900-2014 and the number of days when the maximum temperature was above 90°F has been consistently above average since the 1990s. The report also noted that all precipitation metrics (e.g., observed extreme precipitation events) have been highest during the most recent decade of data (2005-2014).

The well-established worldwide warming trend of recent decades and its related impacts are caused by increasing concentrations of carbon dioxide and other greenhouse gases in the earth's atmosphere. Greenhouse gases are gases that trap heat in the atmosphere, resulting in a warming effect. Carbon dioxide is the most known greenhouse gas; however, methane, nitrous oxide and fluorinated gases also contribute to warming. Emissions of these gases come from a variety of sources, such as the combustion of fossil fuels, agricultural production, and changes in land use. According to the National Aeronautics and Space Administration (NASA), carbon dioxide concentrations measured about 280 parts per million (ppm) before the industrial era began in the late 1700s and have risen dramatically since then, surpassing 400 ppm in 2013 for the first time in recorded history (see Figure 46).

Figure 46: Global Dioxide Concentrations Over Time



Source: NASA, 2020

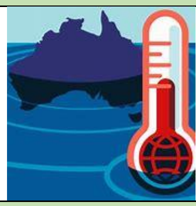
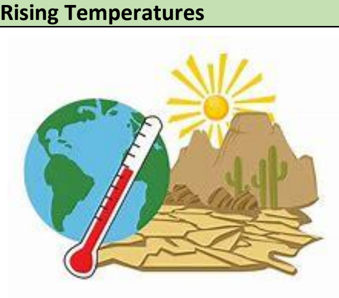
How Climate Change Affects Hazard Mitigation

Climate change will affect the people, property, economy, and ecosystems of Plymouth County in a variety of ways. Consequences of climate change include increased flood vulnerability and increased heat-related illnesses. The most important effect for the development of this plan is that climate change will have a measurable impact on the occurrence and severity of natural hazards.

An essential aspect of hazard mitigation is predicting the likelihood of hazard events in a planning area. Typically, predictions are based on statistical projections from records of past events. This approach assumes that the likelihood of hazard events remains essentially unchanged over time. Thus, averages based on the past frequencies of, for example, flood are used to estimate future frequencies: if a river has flooded an average of once every 5 years for the past 100 years, then it can be expected to continue to flood an average of once every 5 years.

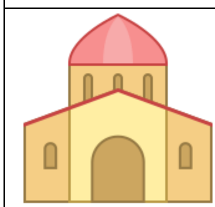
For hazards that are affected by climate conditions, the assumption that future behavior will be equivalent to past behavior is not valid if climate conditions are changing. As flooding is generally associated with precipitation frequency and quantity, for example, the frequency of flooding will not remain constant if broad precipitation patterns change over time. Specifically, as hydrology changes, storms currently considered to be the 100-year flood might strike more often, leaving many communities at greater risk. The risk of severe storms and wildfires are all affected by climate patterns as well. For this reason, an understanding of climate change is pertinent to efforts to mitigate natural hazards. Information about how climate patterns are changing provides insight on the reliability of future hazard projections used in mitigation analysis.

Primary Climate Change Interaction – Change in Precipitation

Primary Climate Change Interaction	Natural Hazard	Other Climate Change Interactions	Representative Climate Change Impacts
Change in Precipitation			
	Inland Flooding	Extreme Weather	Flash flooding, urban flooding, drainage system impacts (natural and human-made), lack of groundwater recharge, impacts to drinking water supply, public health impacts from mold and worsened indoor air quality, vector-borne diseases from stagnant water, episodic drought, changes in snow-rain ratios, changes in extent and duration of snow cover, degradation of stream channels and wetland.
	Drought	Rising Temperatures, Extreme Weather	
	Landslide	Rising Temperatures, Extreme Weather	
Sea Level Rise			
	Coastal Flooding	Extreme Weather	Increase in tidal and coastal floods, storm surge, coastal erosion, marsh migration, inundation of coastal and marine ecosystems, loss, and subsidence of wetlands.
	Coastal Erosion	Changes in Precipitation, Extreme Precipitation	
	Tsunami	Rising Temperatures	
Rising Temperatures			
	Average. Extreme Temperatures	N/A	Shifting in seasons (longer summer, early spring, including earlier timing of spring peak flow), increase in length of growing season, increase of invasive species, ecosystem stress, energy brownouts from higher energy demands, more intense heat waves, public health impacts from high heat exposure and poor outdoor air quality, drying of streams and wetlands, eutrophication of lakes and ponds.
	Wildfires	Changes in Precipitation	
	Invasive Species	Changes in Precipitation, Extreme Weather	
Extreme Weather			
	Hurricanes/Tropical Storms	Rising Temperatures, Changes in Precipitation	Increase in frequency and intensity of extreme weather events, resulting in greater damage to natural resources, property, and infrastructure, as well as increased potential for loss of life
	Severe Winter Storm/Nor'easter	Rising Temperatures, Changes in Precipitation	
	Tornados	Rising Temperatures, Changes in Precipitation	
	Other Severe Weather (including Strong Wind and Extreme Precipitation)	Rising Temperatures, Changes in Precipitation	
Non-Climate Influenced Hazards			
	Earthquake	N/A	There is no established correlation between climate change and this hazard

Sectors Assessed

Several key sectors were evaluated as part of the risk assessment for each of the hazards profiled in the sections below. These sectors are introduced here and are included in the hazard profiles where appropriate and where sufficient data allowed.

	Populations	The major health impacts from natural hazards and climate change include: • **Heat-related illness and death** from an increase in extreme temperatures and poor air quality (USGCRP, 2016; DPH, 2017). • **Increases in food-and waterborne illness and other infectious diseases** from altering geographic and seasonal distributions of existing vectors and vector-borne diseases (USGCRP, 2016). • **Injuries and accidental premature death** associated with extreme weather events. • **Exacerbation of chronic diseases (**USGCRP, 2016; DPH, 2017). • **Mental health and stress-related disorders** ranging from minimal stress and distress symptoms to clinical disorders such as anxiety, depression, post-traumatic stress, and suicidality.
	Government	All municipal sites including the Police Station, Fire Station and the Highway Department, schools (Indian Head and Hanson Middle School), the Hanson Library and Town Hall. Municipal assets such as transportation (e.g., roads, bridges), buildings, landholdings, and other infrastructure such as dams.
	Built Environment	The Critical Facilities list identifies 50 Critical facilities provide indispensable service that enables the continuous operation of critical business and government functions, and is critical to human health and safety, or economic security. Facilities were identified in the following categories: • Safety and Security • Food Water and Sheltering • Health and Medical Facilities • Energy • Communications • Transportation • Hazardous Materials
	Natural Resources and Environment	The Natural Resources and Environment sector includes land-based assets owned by the Town of Hanson and the Commonwealth.
	Economy	The components in the economy sector include economic loss resulting from damage to critical assets, the built environment, municipal resources, natural resources, and other sectors. Many sectors of the economy are dependent on the integrity of natural resources.

Populations

For each hazard, the impacts on human health, particularly vulnerable populations were evaluated and incorporated into each hazard profile. Vulnerability is influenced by three factors: exposure or contact with the hazard; sensitivity or degree to which people or communities are affected by the exposure to the hazard; and capacity to adapt or the ability of communities, institutions, or people to adjust and respond to and recover from potential hazards.

Humans are vulnerable to environmental extremes of temperature, pressure, and chemical exposures that can cause death, injury, and illness. For any hazard agent – water, wind, ionizing radiation, toxic chemicals, infectious agents – there often is variability in the physiological response of the affected population. That is, given the same level of exposure, some people will die, others will be severely injured, still others slightly injured, and the rest will survive unscathed. Typically, the most susceptible to any environmental stressor will be the very young, the very old, and those with weakened immune systems.

Vulnerable Populations

The disproportionate susceptibility of some social groups to the impacts of hazards. These impacts could include death, injury, loss, or disruption of life or livelihood. Social vulnerability also affects a population's resilience: ability to adequately recover from or avoid impacts. Vulnerability is a function of demographic characteristics of the population, as well as environmental and community conditions such as healthcare provision, social capital, access to social networks, and social isolation.

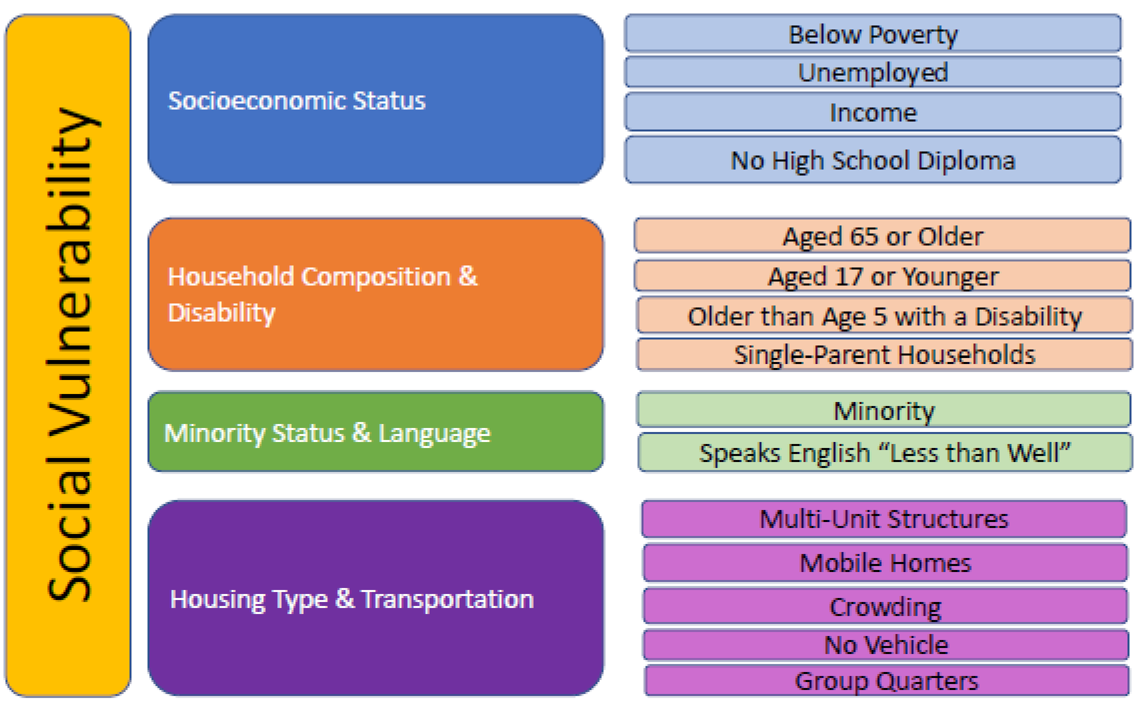
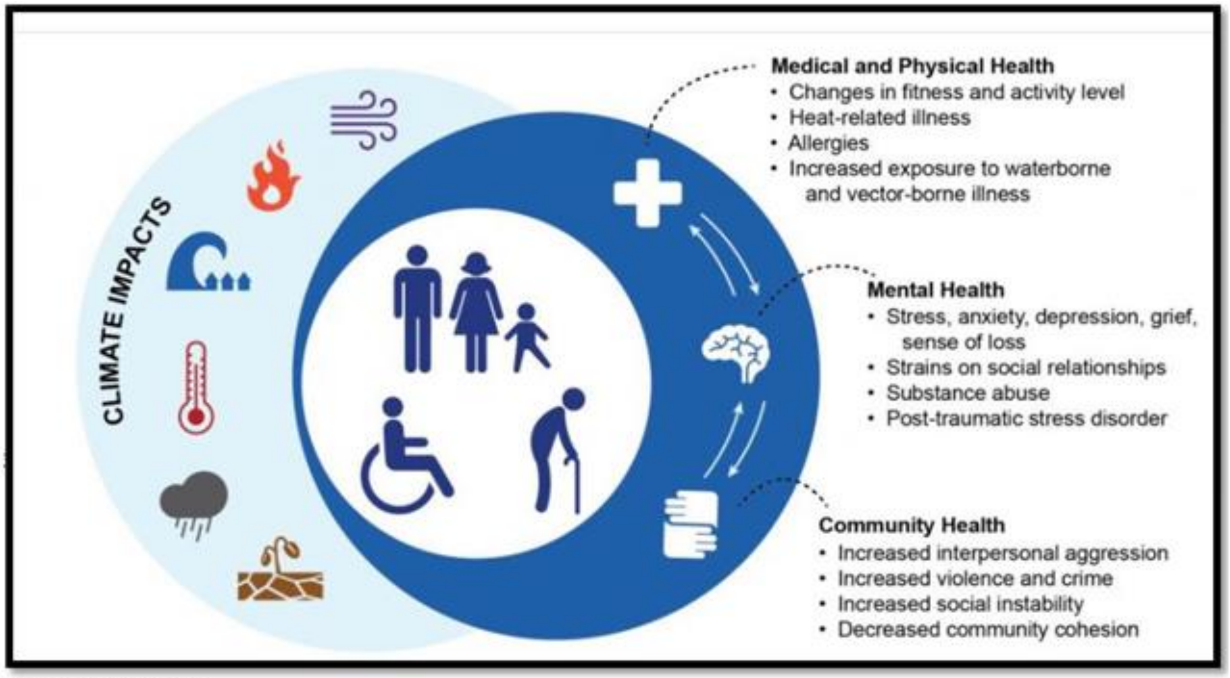


Figure 47: Potential Impacts of Climate Change on Physical, Mental, and Community Health



Source: USGCRP, 2016

Accounting for the needs of socially vulnerable populations remains a distinct challenge in climate adaptation planning and implementation efforts. The central point of the social vulnerability perspective is that, just as people's occupancy of hazard prone areas and the physical vulnerability of the structures in which they live and work are not randomly distributed, neither is social vulnerability randomly distributed – either geographically or demographically. Thus, just as variations in structural vulnerability can increase or decrease the effect of hazard exposure on physical impacts (property damage and casualties), so too can variations in social vulnerability. Social vulnerability varies across communities and across households within communities. It is the variability in vulnerability that is likely to be of greatest concern to local emergency managers because it requires that they identify the areas within their communities having population segments with the highest levels of social vulnerability.

Government

The government sector includes such municipal or state-owned assets such as transportation (e.g., roads, bridges, and rail), buildings, landholdings, and other infrastructure, such as pump stations and dams.

It is also important to recognize the financial impacts of recovery (in addition to the financial impacts of emergency response) on local government. Costs must be incurred for tasks such as damage assessment, emergency demolition, debris removal, infrastructure restoration, and re-planning-stricken areas. In addition to these costs, there are decreased revenues due to loss or deferral of sales taxes, business taxes, property taxes, personal income taxes, and user fees.

Political Impacts. There is substantial evidence that disaster impacts can cause social activism resulting in political disruption, especially during the seemingly interminable period of disaster recovery. The disaster recovery period is a source of many victim grievances and this creates many opportunities for community conflict. Victims usually attempt to recreate preimpact housing patterns, but it can be problematic for their neighbors if victims attempt to site mobile homes on their own lots while awaiting the reconstruction of permanent housing. Conflicts arise because such housing usually is considered blight on the neighborhood and neighbors are afraid the "temporary" housing will become permanent. Neighbors also are pitted against each other when developers attempt to buy up damaged or destroyed properties and built multi-family units on lots previously zoned for single family dwellings. Such rezoning attempts are a major threat to the market value of owner-occupied homes but tend to have less impact on renters because they have less incentive to remain in the neighborhood.

Attempts to change prevailing patterns of civil governance can arise when individuals sharing a grievance about the handling of the recovery process seek to redress that grievance through collective action. Existing community groups with an explicit political agenda can expand their membership to increase their strength, whereas community groups without an explicit political agenda can extend their domains to include disaster-related grievances. Alternatively, new groups can emerge to influence local, state, or federal government agencies and legislators to take actions that they support and to terminate actions that they disapprove. Usually, community action groups pressure government to provide additional resources for recovering from disaster impact but may oppose candidates' re-elections or even seek to recall some politicians from office.

Built Environment

Structural vulnerability arises when buildings are constructed using designs and materials that are incapable of resisting extreme stresses (e.g., high wind, hydraulic pressures of water, seismic shaking) or that allow hazardous materials to infiltrate into the building. The construction of most buildings is governed by building codes intended to protect the life safety of building occupants from structural collapse – primarily from the deal load of the building material themselves and the live load of the occupants and furnishings – but do not necessarily provide protection from extreme wind, seismic, or hydraulic loads. Nor do they provide an impermeable barrier to the infiltration of toxic air pollutants.

The built environment section includes all municipal structures in Hanson, including critical facilities owned by the municipality and critical infrastructure sectors that provide or link to key lifeline services, social welfare, and economic development. Assessments were based on an assessor's data on the total value of all structures in Hanson $1,396,121,110 in 2019 according to MassGIS L3 data, along with the median value of a home in Hanson $355,000. The critical facilities assessed were derived from a combination of a Critical Facilities List. Critical infrastructure sectors that were qualitatively assessed and where information was available include:

- Agriculture (farms, land, crops, livestock, and operations)
- Energy (production, transmission, storage, and distribution, including power plants, substations, electric lines, natural gas systems, and fuel systems)
- Public safety (including public safety facilities and communications)

- Public health (including public health facilities and services provided)
- Transportation (including roads, highways, bridges, tunnels, subways, commuter and commercial rail, ferries, buses, airports, and ports)
- Water infrastructure (including water sources, pump stations, storage tanks, or reservoirs, distribution systems, and drinking water)

Perhaps the most significant structural impact of a disaster on a stricken community is the destruction of households' dwellings. Such an event initiates what can be a very long process of disaster recovery for some population segments. People typically pass through four stages of housing recovery following a disaster[38] The first stage is *emergency shelter*, which consists of unplanned and spontaneously sought locations that are intended only to provide protection from the elements, typically open yards, and cars after earthquakes (Bolin & Stanford, 1991, 1998). The next step is *temporary shelter,* which includes food preparation, and sleeping facilities that usually are sought from friends and relatives or are found in commercial lodging, although "mass care" facilities in school gymnasiums or church auditoriums are acceptable as a last resort. The third step is *temporary housing,* which allows victims to re-establish household routines in nonpreferred locations or structures. The last step is *permanent housing*, which re-establishes household routines in preferred locations and structures.

Particularly significant are the problems faced by lower income households, which tend to be headed disproportionately by females and racial/ethnic minorities. Such households are more likely to experience destruction of their homes because of preimpact locational vulnerability. The homes of these households are more likely to be destroyed because the structures were built according to older, less stringent building codes, used lower quality construction materials and methods, and were less well-maintained (Bolin & Bolton, 1986). Because lower income households have fewer resources on which to draw for recovery, they also take longer to transition through the stages of housing, sometimes remaining for extended periods of time in severely damaged homes (Girard & Peacock, 1997).

Estimates of losses to the built environment are prone to error. Damage estimates are most accurate when trained damage assessors enter each building to assess the percent of damage to each of the major structural systems (e.g., roof, walls, floors) and the percentage reduction in market valuation due to the damage. Early approximate estimates are obtained by conducting "windshield surveys" in which trained damage assessors drive through the impact area and estimate the extent of damage that is visible from the street, or by conducting computer analyses using HAZUS (National Institute of Building Sciences, 1998). These early approximate estimates are especially important in major disasters because detailed assessments are not needed in the early stages of disaster recovery and the time required to conduct them on many damaged structures using a limited number of qualified inspectors would unnecessarily delay the community recovery process.

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[38] Quarantelli, 1982

Table 44: Building Department Info

Year	Building Permits	Building Permit Fees	Plumbing Permits	Plumbing Permit Fees	Gas Permits	Gas Permit Fees	Electric Permits	Electric Permit Fees
2014	321	$165,750	173	$17,150	201	$13,630	279	$23,172
2015	425	$165,934	173	$18,654	203	$17,602	298	$28,650
2016	363	$112,976	146	$14,660	183	$13,920	275	$24,323
2017	301	$149,712	149	$15,220	168	$13,775	241	$21,000
2018	313	$101,264	123	$12,480	173	$11,760	278	$22,710
2019	320	$99,651	138	$13,760	171	$12,595	243	$23,217

Table 45: Hanson Housing Construction

Year	Single Family	Townhomes	Condos	2-Family Rental
2014	26	22	15	3
2015	27	19	7	0
2016	12	2	10	0
2017	15	22	15	0
2018	8	6	3 Commercial	0
2019	8	6	2 Commercial	0

Pending Development Projects

- Affordable housing developments on Main Street and Phillips Street with a total of 105 units of which will be age restricted to residents 55+.
- Station Landing at 965 Main Street has been approved for three (3) four-unit and one (1) two-unit condominiums.
- The ZBA approved three duplexes on Main Street.
- Occupancy permits for 6 additional units at Dunham Farms have been issued.
- Cushing Trail located on Spring Street approved for 8 single family homes.

Natural Resources and Environment

The natural resources and environment sector include key habitats and natural landscapes documented in Hanson's BioMap 2 (Conserving the Biodiversity of Massachusetts in a Changing World) and Areas of Critical Environmental Concern, as well as species identified in the *Hanson Open Space and Recreation Plan* approved by DCR in 2020.

Agricultural vulnerability. Like humans, agricultural plants and animals are also vulnerable to environmental extremes of temperature, pressure, chemicals, radiation, and infectious agents. Like humans, there are differences among individuals within each plant and animal population. However, agricultural vulnerability is more complex than human vulnerability because there is a greater number of species to be assessed, each of which has its own characteristic response to each environmental stressor.

Other important physical impacts from disasters include damage or contamination to cropland, rangeland, and woodlands. Such impacts may be well understood for some hazard agents but not others. There also is concern about damage or contamination to the natural environment (wild lands0 because these areas serve valuable functions such as damping the extremes of river discharge and providing habitat for wildlife. In part, concern arises from the potential for indirect consequences such as increased runoff and silting of downstream riverbeds, but many people are concerned about the natural environment simply because they value it for its own sake.

Economy

Economic impacts include economic loss resulting from damage to critical facilities, the built environment, municipal resources, natural resources, and other sectors. Many sectors of the economy are dependent on the integrity of natural resources. For example, if a major recreation area is damaged beyond repair by a storm, that property will no longer attract tourists and the local economy may experience a loss of revenue from tourism and recreation.

The property damage caused by disaster impact creates losses in asset values that can be measured by the cost of repair or replacement. Disaster losses in United States are initially borne by the affected households, businesses, and local government agencies whose property is damaged or destroyed. However, some of these losses are redistributed during the disaster recovery process. For insured property, the insurers record the amount of the deductible and the reimbursed loss, but uninsured losses are not recorded so they must be estimated, sometimes with questionable accuracy.

The ultimate economic impact of a disaster depends upon the disposition of the damaged assets. Some of these assets are not replaced, so their loss causes a reduction in consumption (and, thus, a decreased in the quality of life) or a reduction in investment (and, thus, a decrease in economic productivity). Other assets are replaced, either through in-kind donations (e.g., food and clothing) or commercial purchases. In the latter, the cost of replacement must come from some source of recovery funding, which generally can be characterized as either intertemporal transfers (to the present time from past savings) or future loan payments or interpersonal transfers (from one group to another at a given time). Some of the specific mechanisms for financing recovery include obtaining tax deductions or deferrals, unemployment benefits, loans (paying back the principal at low- or no-interest), grants (requiring no return of principal), insurance payoffs, or additional employment. Other sources include depleting cash financial assets (e.g., savings accounts), selling tangible assets, or migrating to an area with available housing, employment, or less risk (in some cases this is done by the principal wage earner only).

Techniques and Approaches

This document is considered a "living" document throughout much of the plan update process, because the methodologies required refinement on receipt and application of referenced data sets. For hazards whose underlying data has not changed, updates were primarily limited to data interpretation, inclusion of climate change analysis, and the addition of any recent hazard occurrences, as appropriate. Asset data required for exposure and vulnerability analysis were provided by state agencies, as well as the resilientma.org resources.

Hazard Profile Key Terms

The following definitions apply for terms used in the risk assessment:

- ***Climate Adaptation*** - Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.
- ***Climate Change*** - A change in the state of the climate that can be identified by statistical changes of its properties that persist for an extended period, whether due to natural variability or human activity.
- ***Climate Change Impact*** - Consequences of climate change on natural and human systems.
- ***Consequence*** - The effect of hazard occurrence. Consequence is demonstrated by the impact on population, physical property (e.g., state facilities, local jurisdiction assets and general building stock, and critical facilities), responders, operations, the environment, the economy, and public confidence in state governance.
- ***Critical Facilities –*** Locations that possess resources that will be needed in a disaster or hazard, such as police/fire stations, or have high concentrations of vulnerable people, such as hospitals, nursing homes, and daycare.
- ***Exposure*** - The extent to which something is in direct contact with natural hazards or their related climate change impacts. Exposure is often determined by examining the number of people or assets that lie within a geographic area affected by a natural hazard, or by determining the magnitude of the climate change impact. For example, measurements of flood depth outside a building or number of heat waves experienced by a county are measurements of exposure.
- ***Flood Insurance Rate Map (FIRM) –*** An official map created by FEMA that graphically represents the extent of the floodplain for a geographic area and is used for the purpose of rating the relative risk and subsequent rate of flood insurance policies sold through the National Flood Insurance Program.
- ***Hazards –*** Any natural or manmade event that could harm or otherwise adversely affect members of the community.
- ***Local Emergency Planning Committees (LEPCs) –*** work to understand chemical hazards in the community, develop emergency plans in case of an accidental release, and look for ways to prevent chemical accidents.
- ***Location*** - The area of potential or demonstrated impact within the region in which the analysis is being conducted. In some instances, the area of impact is in a geographically defined area,

such as a floodplain. In other instances, such as for severe weather, there is no established geographic boundary associated with the hazard, because it can impact the entire Commonwealth.

- ***Manmade Hazards –*** Those hazards that are due to human actions (or inaction), such as a chemical spill, fire, or explosion.
- ***Natural Hazard*** - Natural hazards are natural events that threaten lives, property, and other assets. Often, natural hazards can be predicted. They tend to occur repeatedly in the same geographic locations because they are related to weather patterns or physical characteristics of an area.
- ***Natural Resources*** - These are components of natural systems that exist without human involvement. Key natural resource categories include forested ecosystems, aquatic ecosystems, coastal ecosystems, wetland ecosystems, and old field ecosystems.
- ***Probability*** - Probability is used as a synonym for likelihood, or the estimated potential for an incident to occur.
- ***Risk*** - The potential for an unwanted outcome resulting from a hazard event, as determined by its likelihood and associated consequences; and expressed, when possible, in dollar losses. Risk represents potential future losses, based on assessments of probability, severity, and vulnerability.
- ***Sensitivity*** - Sensitivity refers to the impact on a system, service, or asset when exposed to natural hazards. The level of sensitivity indicates how much or to what extent the occurrence of a hazard would exceed a critical threshold (if known) for something such that it would disrupt the ability of the system, service, or asset to continue normal operation. If the critical threshold is not exceeded, then the sensitivity to a certain hazard is low, even if it is exposed.
- ***Severity/Extent*** - The extent or magnitude of a hazard, as measured against an established indicator (e.g., Richter Scale, Saffir-Simpson Hurricane Scale, or Regional Snowfall Index).
- ***Tier II Report –*** A report required annually by FEMA for every facility that stores an extremely toxic subset hazardous material. The report is an inventory of every hazardous material on site along with the amount and specific location of it.
- ***Vulnerability*** - The propensity of predisposition to be adversely affected; for example, as applied to building performance (functionality), damage, or the number of people injured. Vulnerability is a function of exposure, sensitivity, and adaptive capacity.

State Climate Extremes

Element	Value	Date	Location
Maximum Temperature	107°F	08/02/1975	Chester
Minimum Temperature	-35°F	02/15/1943	Coldbrook
		01/12/1981	Chester
		01/05/1904	Taunton
24-Hour Precipitation	18.15 in.	08/18-19/1955	Westfield
24-Hour Snowfall	29 in.	04/01/1997	Natick
Snow Depth	62 in.	01/13/1996	Great Barrington

Source: NOAA State Climate Extremes Committee

Mitigation Goals from the 2015 Old Colony Planning Council Regional Hazard Mitigation Plan

OCPC collected and analyzed natural hazard data throughout the 2014 year. During that time, OCPC staff visited and spoke with a variety of local officials in each of the 15 communities. Personnel interviewed included but was not limited to emergency managers, police officers, fire fighters, planners, public works personnel, building inspectors, and health agents. The Goals and Actions within the 2015 plan were developed as local vulnerabilities were identified and concerns were being raised by emergency responders and local officials. The following mitigation actions developed from those meetings.

Regional Goal: Reduce the loss of life, property, infrastructure, and environmental and cultural resources from natural disaster.

In support of the regional goal, there are five additional goals:

Goal: Investigate, design, and implement structural projects that will reduce and minimize the risks and impacts from riverine and coastal flooding.

Goal: Investigate, design, and implement projects that will reduce and minimize the risks and impacts from non-flooding hazards, such as wildfires, earthquakes, tornadoes, etc.

Goal: Increase the awareness of the public and communities to the risks presented by the multiple natural hazards that affect the region as well as to the mitigation activities and grant opportunities available to minimize the impacts of these hazards.

Goal: Improve existing policies and programs to further reduce or eliminate the impacts of natural hazards.

Cost Benefit Review from 2015 OCPC Regional HMP

The benefit/cost review was qualitative; that is, it did not include the level of detail required by FEMA for project grant eligibility under the HMGP and PDM grant program. This was done because some projects may not be implemented for up to 10 years, and the costs and benefits associated with them could change dramatically during that time. Each action was assessed and assigned subjective ratings (high, medium, and low) to its costs and benefits, as stated in the following Table below:

Costs	
High	Existing funding levels are not adequate to cover the costs of the proposed project and implementation would require an increase in revenue through an alternative source, such as bonds, grants, fee increases, etc.
Medium	Action could be implemented with existing funding but would require a reapportionment of the budget or a budget amendment, or the cost of the action would have to be spread over multiple years.
Low	Action could be funded under the existing budget. The project is part of or can be part of an existing, ongoing program.
Benefits	
High	Action will have an immediate impact on the reduction of risk exposure to life and property.
Medium	Action will have a long-term impact on the reduction of risk exposure to life and property or will provide an immediate reduction in the risk exposure to property.
Low	Long-term benefits of the action are difficult to quantify in the short-term.

Mitigation Measures from 2015 Old Colony Regional Hazard Mitigation Plan

Category of Action & Hazard Addressed	Description of Action	Responsible Party	Timeframe/Priority	Benefit/Cost	Potential Funding Sources	Status from 2015
Prevention of All Hazards	Provide technical assistance to local communities in the development, adoption, and maintenance of local multi-jurisdictional hazard mitigation plans	OCPC	5 Years/High	Medium/Medium	OCPC, FEMA, HMA Program	OCPC continues to work with the region to participate with Hazard Mitigation Planning.
Public Education & Awareness- All Hazards	Notify eligible applicants of available hazard mitigation project grant funding through the FMA, PDM, HMGP, and SRL programs	OCPC	Annually/High	Low/Low	OCPC	Of the 17 communities in the region 15 have received an MVP Planning Grant. There are 4 communities participating in a regional BRIC application for HMP. One Community will apply for funding under the DLTA program.
Emergency Services Protection All Hazards	Conduct local disaster response drills	Community Emergency Management Agencies (CEMA)	1-3 years/Medium	Low/Low	CEMA Budget, Department of Homeland Security (DHS), Mass Dept. of Public Health (DPH)	Region has participated in local disaster response drills
Public Education & Awareness – All Hazards	Conduct workshop to assist local businesses and cultural institutions to develop disaster mitigation plans for their facilities	MEMA, CEMA, Private Businesses & Cultural Institutions	1-5 Years/Medium	Low/Low	Local Community, Private Businesses & Cultural Institutions	
Emergency Services Protection – All Hazards	Develop and publicize local and regional evacuation routes.	MEMA, MADOT, CEMA	1-3 Years/Medium	Medium/Medium	Local Community, MEMA, DHS, DPH	Multiple agencies undertook this project
Emergency Services Protection – All Hazards	Expand and formalize local agreements for use of shared mass care shelters in the event of a disaster	CEMA, Red Cross, Regional Emergency Planning Committee (REPA)	1-5 Years/Low	Low/Low	Local Community	

Emergency Services Protection – All Hazards	Install generators and/or back-up generators at the most critical of facilities, ex. Police, Fire, EOC, Mass Care Shelters, and Elderly Housing	CEMA, Local Department of Public Works (DPW)	1-5 Years/Medium	Medium/Medium	Local Community, FEMA, HMA Programs	Ongoing
Emergency Services Protection – All Hazards	Add additional airwave capacity for emergencies, if needed	MEMA, CEMA	1-3 Years/Medium	Low/Medium	Local Community	
Emergency Services Protection – All Hazards	Develop formal Mutual Aid Agreements for DPWs and Emergency Response Teams, if not done so already	CEMA, DPW, REPC, Southeast Regional Advisory Council Homeland Security (SRACHS)	1-3 Years/High	Low/Low	Local Community/SRACH	Region has not been receptive
Emergency Services Protection – All Hazards	Develop a coordinated resource list of equipment to be shared among communities during an emergency	CEMA, DPW, SRACHS	1-5 Years/Medium	Low/Low	Local Community	This action has been adopted by some abutting communities within the region
Public Education – All Hazards	Provide brochures or leaflets to landowners in hazard prone areas that discuss hazard mitigation	MEMA, CEMA	1-3 Years/Low	Low/Low	Local Community	This action was recently utilized by the town of Plymouth with MVP funding resources
Emergency Services Protection – All Hazards	Educate local officials to help them develop plans to protect critical documents and materials	MEMA, CEMA	1-5 Years/Medium	Low/Low	Local Community	Some communities have considered as an action item during the MVP process
Prevention – Flooding	Incorporate updated FEMA floodplain data and maps into existing and future planning efforts	MEMA, Local Community Planning Departments	Ongoing/High	Medium/Low	Local Community	Due to COVID-19 Pandemic, many communities were unable to hold Annual Town Meetings in a timely fashion to meet the guidelines of FEMA. Maps were removed from consideration and preliminary maps are current in effect until the revised maps can be adopted by ATM vote.

2015 Hanson Mitigation Action Plan

Category of Action & Hazard Addressed	Description of Action	Responsible Party	Timeframe/Priority	Benefit/Cost	Potential Funding Sources	Status from 2015
Emergency Services Protection – All Hazards	Purchase a generator for Town Hall. This is needed as Town Hall houses the email communication infrastructure for the town as well as several vital records in the Town Clerk's office	Town Administrator, Board of Selectmen	1-5 Years/Medium	Medium/Medium	General Fund, PDM Grant Program	Town acquired the generator
Property Protection Flooding	Work with DCR to upgrade the current Wampatuck Pond Dam control structure from manual management to a more mechanized control structure. Also create a Dam Management Plan for the Wampatuck Pond Dam	Highway Department, Town Administrator	1-5 Years	Medium/High	General Fund, DCR	Dam was determined to be town owned through transfer of the Nathanial Thomas Mill. This mitigation action was not completed and is currently listed on this update
Structural Project – Flooding	Replace and enlarge culvert on King Street to eliminate flooding	Highway Department	1-10 Years/Medium	Medium/Medium	General Fund, Bond, PDM Grant Program	This action was not completed and is included in this update
Structural Project – Flooding	Replace and enlarge culvert on Winter Street to eliminate flooding	Highway Department	1-10 Years/Medium	Medium/Medium	General Fund, Bond, PDM Grant Program	This action was not completed and is included in this update
Structural Project – Flooding	Upgrade drainage infrastructure along Route 58 to alleviate flooding during heavy rain	Highway Department	1-10 Years/Medium	Medium/Medium	General Fund, Bond, PDM Grant Program	This action was not completed and is included in this update
Structural Project – Flooding	Upgrade drainage infrastructure on Gorwin Drive to alleviate flooding during heavy rain	Highway Department	1-10 Years/Medium	Medium/Medium	General Fund, Bond, PDM Grant Program	This action was not completed and is included in this update
Natural Resource Protection – Flooding	Dredge trenches located alongside roadways throughout town. These trenches buildup with sediment over time and flood the nearby road.	Highway Department	1-10 Years/Medium	Medium/Medium	General Fund, Bond, PDM Grant Program	This action was not completed and is included in this update

Section 4. Risk Assessment

The risk assessment for the Town of Hanson Hazard Mitigation and Municipal Vulnerability Preparedness Plan examines the natural hazards that have the potential to impact the Town, and specific populations that are most vulnerable to climate impacts and estimates the associated economic losses.

Primary Climate Change Interaction: Changes in Precipitation

Flooding

Floods are one of the most common natural hazards in the United States, they can develop slowly over a period of days or develop quickly, with disastrous effects that can be local (impacting a neighborhood or community) or regional (affecting entire river basins, coastlines, and multiple counties or states). A floodplain is defined as the land adjoining the channel of a river, stream, ocean, lake, or other watercourse or water body that becomes inundated with water during a flood.

Inland flooding is the result of moderate precipitation over several days, intense precipitation over a short period, or melting snowpack. In addition, developed areas that have impervious areas can contribute to inland flooding. [39]

Common types of inland flooding include:

- ***Riverine Flooding*** - Riverine flooding often occurs after heavy rain. Areas of the state with high slopes and minimal soil cover (such as found in western Massachusetts) are particularly susceptible to flash flooding caused by rapid runoff that occurs in heavy precipitation events and in combination with spring snowmelt, which can contribute to riverine flooding. Frozen ground conditions can also contribute to low rainfall infiltration and high runoff events that may result in riverine flooding. Some of the worst riverine flooding in Massachusetts' history occurred because of strong nor'easters and tropical storms in which snowmelt was not a factor. Tropical storms can produce extremely high rainfall rates and volumes of rain that can generate high runoff when soil infiltration rates are exceeded. Inland flooding in Massachusetts is forecast and classified by the National Weather Service's (NWS) Northeast River Forecast Center as minor, moderate, or severe based upon the types of impacts that occur.

- ***Urban Drainage Flooding*** - Urban drainage flooding entails floods caused by increased water runoff due to urban development and drainage systems that are not capable of conveying high flows. In urban areas, basement, roadway, and infrastructure flooding can result in significant damage due to poor or insufficient stormwater drainage. Overbank flooding occurs when water in rivers and streams flows into the surrounding floodplain or into any area of land susceptible to being inundated by floodwaters from any source, according to FEMA. Flash floods are characterized by rapid and extreme flow of high water into a normally dry area, or a rapid rise in a stream or creek above a predetermined flood level, based on FEMA definitions.

- ***Overland Sheet Flow*** – Poorly drained low-lying areas are a problem when flooding occurs even when rainfall is not heavy. Overland sheet flow occurs primarily in areas with undefined drainage ways.

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[39] Massachusetts State Hazard Mitigation and Climate Adaptation Plan, Chapter 4: Risk Assessment, September 2018, Page 4-1.

- ***Dam Overtopping*** - A dam is an artificial barrier that can impound water, wastewater, or any liquid borne material for the purpose of storage or control of water. There are two primary types of dam failure: catastrophic failure, characterized by the sudden, rapid, and uncontrolled release of impounded water, or design failure, which occurs because of minor overflow events. Dam overtopping is caused by floods that exceed the capacity of the dam, and it can occur because of inadequate spillway design, settlement of the dam crest, blockage of spillways, and other factors.

- ***Beaver Dams or Levee Failure*** - Beaver dams obstruct the flow of water and cause water levels to rise. Significant downstream flooding can occur if beaver dams break.

- ***Floodplains*** - Floodplains by nature are vulnerable to inland flooding. Floodplains are the low, flat, and periodically flooded lands adjacent to rivers, lakes, and oceans. These areas are subject to geomorphic (land-shaping) and hydrologic (water flow) processes. Floodplains may be broad, as when a river crosses an extensive flat landscape, or narrow, as when a river is confined in a canyon.

- ***Flooding and Flood-Related Erosion*** can result from various types of ground failures, which include mud floods and mudflows, and to a much lesser degree, subsidence, liquefaction, and fluvial erosion.

Floods can be classified as either ***flash floods,*** which are the product of heavy, localized precipitation in a short time over a given location or ***general floods,*** which are caused by precipitation over a longer time in a river basin.

Intense rainfall may trigger "flash-floods" which provide little warning (less than 6 hours) before the affected area experiences flood conditions. Flash floods are "a rapid and extreme flow of high water into a normally dry area, or a rapid water level rise in a stream or creek above a predetermined flood level, beginning within 6 hours of the causative event (e.g., intense rainfall, dam failure). However, the actual time threshold may vary in different parts of the country. Ongoing flooding can intensify to flash flooding in cases where intense rainfall results in a rapid surge of rising flood waters. [40]

There are several local factors that determine the severity of a flooding event, including: stream and river basin topography, precipitation and weather patterns, recent soil moisture conditions, amount of impervious surface area, and the degree of vegetative clearing. Flooding can also be influenced by larger, global climate events. Global warming and climate change are shifting rainfall and storm patterns, resulting in increased precipitation and the frequency of flooding in the region.

Flash flooding events typically occur within minutes or hours after a period of heavy precipitation, after a dam or levee failure, or from a sudden release of water from an ice jam. Most often, flash flooding is the result of a slow-moving thunderstorm or the heavy rains from a hurricane. In rural areas, flash flooding often occurs when small streams spill over their banks. However, in urbanized areas, flash

[40] **https://w1.weather.gov/glossary/index.php?word=flash+flood**

flooding is often the result of clogged storm drains (leaves and other debris) and the higher amount of impervious surface areas (roadways, parking lots, roof tops).

General flooding events may last for several days. Excessive precipitation within a watershed of a stream or river can result in flooding particularly when development in the floodplain has obstructed the natural flow of the water and/or decreased the natural ability of the groundcover to absorb and retain surface water runoff (e.g., the loss of wetlands and the higher amounts of impervious surface area in urban areas).

Floodplain Ecosystems

As the name implies, flooding is a natural and important part of wetland ecosystems that form along rivers and streams. Floodplains can support ecosystems that are rich in plant and animal species. Wetting the floodplain soil releases an immediate surge of nutrients from the rapid decomposition of organic matter that has accumulated over time. When this occurs, microscopic organisms thrive, and larger species enter a rapid breeding cycle. Opportunistic feeders (particularly fish or birds) often utilize the increased food supply. The production of nutrients peaks and falls away quickly, but the surge of new growth that results endures for some time.
Species growing in floodplains are markedly different from those that grow outside floodplains. For instance, riparian trees (trees that grow in floodplains) tend to be very tolerant of root disturbance and grow quickly in comparison to non-riparian trees.

A floodplain is the relatively flat, lowland area adjacent to a river, lake, or stream. Floodplains serve an important function, acting like a large sponge to absorb and slowly release floodwaters back to surface water and groundwater. Over time, sediments that are deposited in floodplains develop into fertile, productive farmland like that found in Hanson. In the past, floodplain areas were also often seen as prime locations for development. Industries were located on the banks of rivers for access to hydropower (e.g., Nathanial Thomas Mill and Ocean Spray). Residential and commercial development occurred in floodplains because of their scenic qualities and proximity to the water. Although periodic flooding of a floodplain area is a natural occurrence, past and current development and alteration of these areas will result in flooding that is a costly and frequent hazard. In addition to damage of buildings directly in the floodplain, development can result in a loss of natural flood storage capacity and can increase the water levels in water bodies. Flood levels may then increase, causing damage to structure not normally in the floodplain.

Inland Flooding (Including Dam Overtopping)

Potential Effects of Climate Change – Inland Flooding		
	Changes in Precipitation – More Intense and Frequent Downpours	More intense downpours often lead to inland flooding as soils become saturated and stop absorbing more water, river flows rise, and urban stormwater systems become overwhelmed. Flooding may occur because of heavy rainfall, snowmelt or coastal flooding associated with high wind and storm surge.
	Extreme Weather – More Frequent Severe Storms	Climate change is expected to result in an increased frequency of severe storm events. This would directly increase the frequency of flooding events and could increase the chance that subsequent precipitation will cause flooding if water stages are still elevated.
	Changes in Precipitation – Episodic droughts	Vegetated ground cover has been shown to significantly reduce runoff. If drought causes vegetation to die off, this flood-mitigating capacity is diminished.

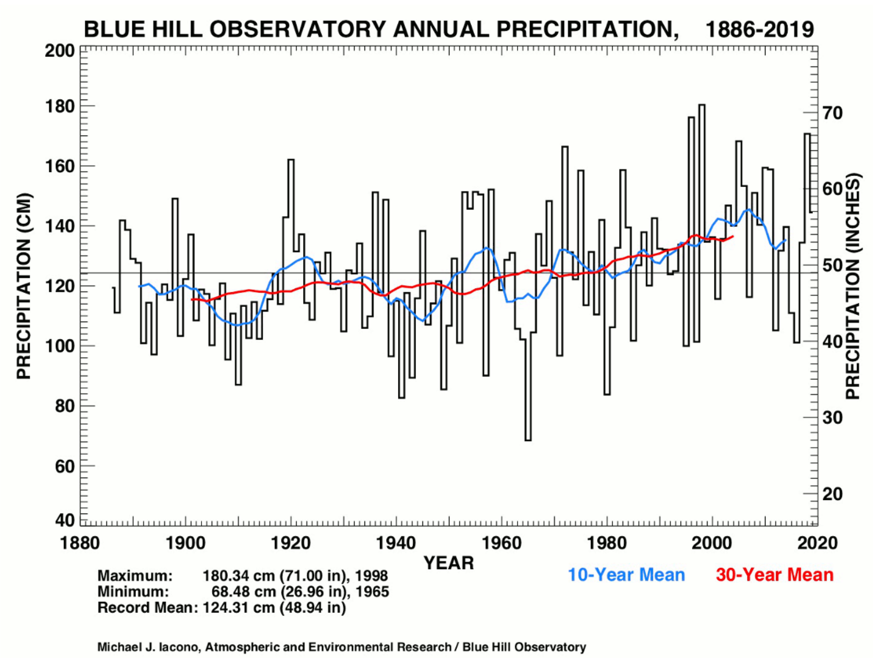
Use of historical hydrologic data has long been the standard of practice for designing and operating water supply and flood protection projects. However, the hydrologic record cannot be used to predict changes in frequency and severity of extreme climate events such as floods. Climate change is already impacting water resources, and resource managers have observed the following:

- Historical hydrologic patterns can no longer be solely relied upon to forecast the water future.
- Precipitation and runoff patterns are changing, increasing the uncertainty for water supply and quality, flood management and ecosystem functions.
- Extreme climatic events will become more frequent, necessitating improvement in flood protection, drought preparedness and emergency response.

High frequency flood events (e.g., 10-year floods) will likely increase with a changing climate. Scientists project greater storm intensity, resulting in more direct runoff and flooding. Changes in watershed vegetation and soil moisture conditions will likewise change runoff and recharge patterns. As stream flows and velocities change, erosion patterns will also change, altering channel shapes and depths, possibly increasing sedimentation behind dams, and affecting habitat and water quality. With potential increases in the frequency and intensity of wildfires due to climate change, there is potential for more floods following fire, which increase sediment loads and water quality impacts.

As hydrology changes, what is currently considered a 100-year flood may strike more often, leaving many communities at greater risk.

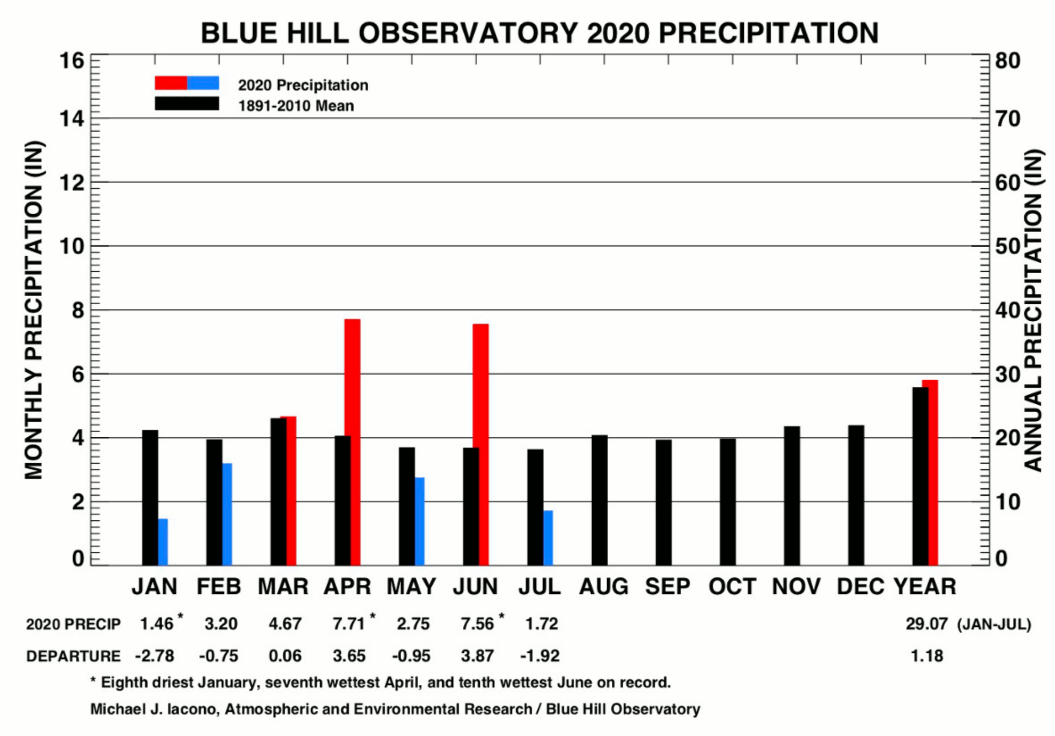
Figure 48: Annual Precipitation



- 30-year mean rising since mid-20th century.
- More rain expected in warmer climate.
- Total Precipitation (rain plus melted snow) is increasing +0.60 inch/decade.
- High variability from year to year, upward trend is statistically significant.
- Highest: 71.00" in 1998
- Lowest: 26.96" in 1965

Inland Flooding (Including Dam Overtopping)		
Hazard	**Significant**	**Justification**
Inland Flooding 	YES	The impact of flooding on life, health, and safety is dependent on several factors, including the severity of the event and whether adequate warning time is provided to residents. Exposure includes the population living in or near floodplain areas that could be impacted should a flood event occur and those affected by a hazard event. Scattered major property damage, some minor infrastructure damage, essential services are briefly interrupted, some injuries or fatalities. • Areas that are highly developed or within the floodplain are most vulnerable. • More intense and frequent downpours will result in more frequent flooding and greater area exposed.
Exposure and Vulnerability by Key Sector		
	Populations	**General At-Risk Populations:** Populations living in or near floodplain areas; people traveling in flooded areas or living in urban areas with poor stormwater drainage. **Vulnerable Populations:** Populations with low socioeconomic status who may consider the economic impacts of evacuating; people over age 65 who may require medical attention; households with young children who have difficulty evacuating; populations with low English language fluency who may not receive or understand warnings to evacuate.
	Government	Flooding can cause direct damage to municipally owned facilities and result in road closures which increase emergency response times. The Town Hall was identified as being vulnerable to flooding, especially if the nearby dam (Wampatuck Pond Dam) failed.
	Built Environment	Several critical facilities, including the fire station are subject to flooding should the Wampatuck Pond Dam fail. A high priority short-term action that was identified was an inventory of culverts and catch basins to prioritize for repair and/or replacement. Several culverts were identified for immediate consideration.
	Natural Resources and Environment	While participants noted that existing town wells are well-protected, there was some concern that the uncapped landfill/transfer station could possibly leach into water sources. A risk assessment was identified to better understand this vulnerability. Flooding can also affect the health and well-being of wildlife. Animals can be directly swept away or lose their habitats to flooding. Floodwaters can also impact habitats downstream of agricultural operations by dispersing waste and pollutants from fertilizers. These substances, particularly organic matter and nutrients can result in severe impacts to aquatic habitats, such as eutrophication.
	Economy	Economic losses due to a flood include but are not limited to damages to buildings (and their contents) and infrastructure, agricultural losses, business interruption (including loss of wages), impacts on tourism, and tax base.

Figure 49: 2020 Precipitation, Bill Hill Observatory



Source: https://bluehill.org/observatory/2014/02/blue-hill-observatory-climate-research-reports/

Table 46: Natural Resource Exposures - Areas of Critical Concern, Plymouth County

Name	County	Total Acreage	1 percent Annual Chance Flood Event A Zone		0.2 Percent Annual Chance Flood Event X500 Zone	
			Acres	% of Total	Acres	% of Total
Ellisville Harbor	Plymouth	573.0	-	-	1.0	0.2
Herring River Watershed	Plymouth	3,211.7	537.1	16.7	200.6	6.2
Hocomock Swamp	Plymouth	6,231.5	4,022.1	64.5	-	-
Weir River	Plymouth	400.7	5.5	1.4	-	-
Weymouth Back River	Plymouth	576.9	44.2	7.7	-	-

Table 47: Natural Resource Exposure - BioMap 2 Core Habitat

Name	County	Total Acreage	1 percent Annual Chance Flood Event A Zone		0.2 Percent Annual Chance Flood Event X500 Zone	
			Acres	% of Total	Acres	% of Total
Aquatic Core	Plymouth	27,564.3	15,240.8	55.3	1,316.3	4.8
Forest Core	Plymouth	20,647.7	5,788.1	28.0	274.8	1.3
Priority Natural Communities	Plymouth	23,473.0	3,885.8	16.6	272.4	1.2
Species of Conservation Concern	Plymouth	98,328.1	24,404.3	24.8	2,832.5	2.9
Vernal Pool	Plymouth	2,306.3	51.0	2.2	55.5	2.4
Wetlands	Plymouth	23,776.4	14,033.2	59.0	734.8	3.1

Table 48: Natural Resources Exposure - BioMap2 Critical Natural Landscape

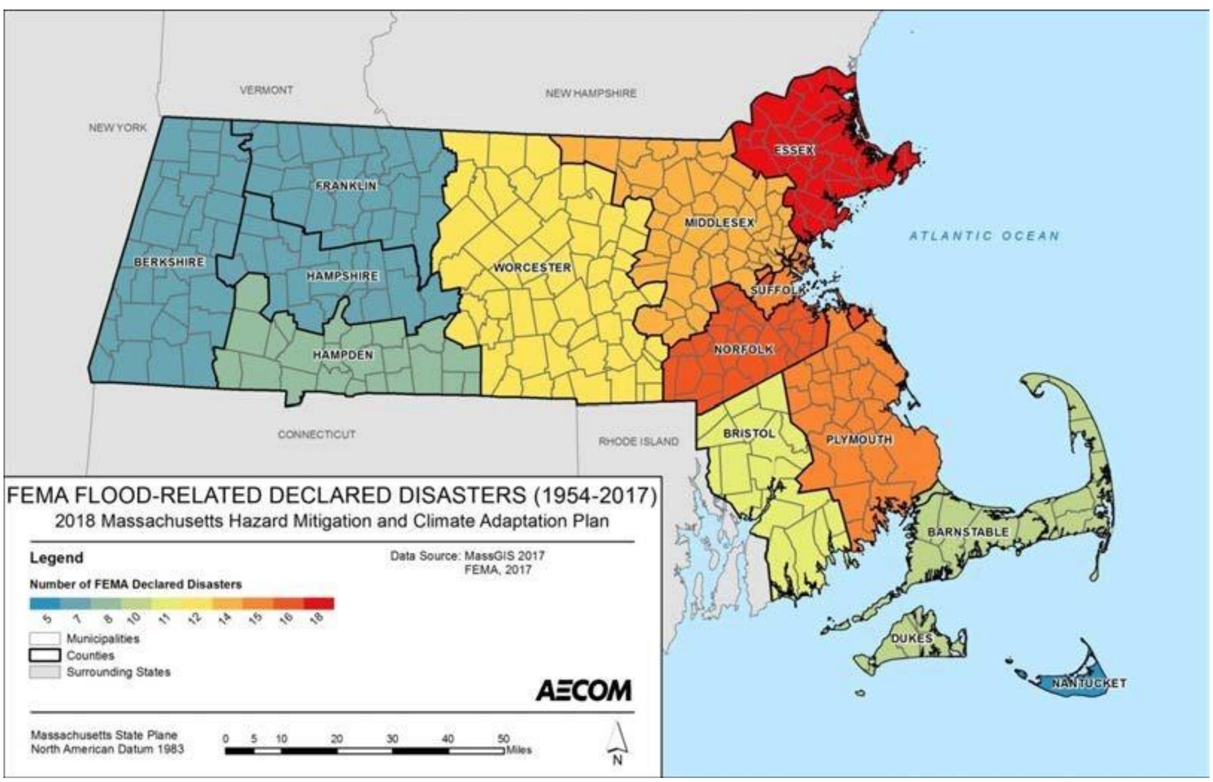
Name	County	Total Acreage	1 percent Annual Chance Flood Event A Zone		0.2 Percent Annual Chance Flood Event X500 Zone	
			Acres	% of Total	Acres	% of Total
Aquatic Buffer	Plymouth	41,381.2	18,680.9	45.1	1,745.0	4.2
Coastal Adaptation Analysis	Plymouth	12,732.9	89.6	0.7	6.5	0.1
Landscape Blocks	Plymouth	124,678.0	28,414.8	22.8	2,356.9	1.9
Tern Forging	Plymouth	5,482.2	7.1	0.1	-	-
Wetland Buffer	Plymouth	45,543.6	19,166.2	42.1	1585.5	3.5

Table 49: Flash Flood Events, 2000 - 2020

COUNTY	DATE	PROPERTY DAMAGE (Numbers)	HAZARD	FLASH FLOOD CAUSE
PLYMOUTH	8/13/2003	25,000	Flash Flood	
PLYMOUTH	8/16/2003	10,000	Flash Flood	
BROCKTON	8/14/2005	20,000	Flash Flood	
WAREHAM	8/30/2005	5,000	Flash Flood	
MIDDLEBORO	9/15/2005	7,000	Flash Flood	
HINGHAM	6/23/2006	5,000	Flash Flood	
HARBOR BEACH	10/30/2012	0	Flash Flood	Heavy Rain Tropical System
ISLAND CREEK	10/30/2012	0	Flash Flood	Heavy Rain Tropical System
EAST WAREHAM	7/4/2014	25,000	Flash Flood	Heavy Rain
LONG POND	9/18/2018	0	Flash Flood	Heavy Rain
MANOMET	7/12/2019	70,000	Flash Flood	Heavy Rain

Source: https://www.ncdc.noaa.gov/stormevents/

Figure 50: FEMA Flood Declaration



Source: SHMCAP, 2018

Table 50: Flooding Events 2000 - 2020

COUNTY	DATE	PROPERTY DAMAGE (NUMBERS)	HAZARD	FLOOD CAUSE
Eastern Plymouth	3/5/2001		Flood	
Eastern Plymouth	3/28/2005		Flood	
Western Plymouth	10/15/2005	350,000	Flood	
Eastern Plymouth	10/15/2005	200,000	Flood	
Western Plymouth	10/15/2005	50,000	Flood	
Western Plymouth	10/15/2005	100,000	Flood	
Eastern Plymouth	10/15/2005	140,000	Flood	
Eastern Plymouth	10/25/2005	35,000	Flood	
Southern Plymouth	12/9/2005	40,000	Flood	
Plymouth County	5/13/2006	500,000	Flood	
Plymouth County	5/13/2006		Flood	
Plymouth County	6/7/2006	30,000	Flood	
Plymouth County	6/23/2006	2,000	Flood	
Plymouth County	8/20/2006	5,000	Flood	
Plymouth County	10/28/2006	10,000	Flood	Heavy Rain
Plymouth County	3/2/2007	10,000	Flood	Heavy Rain
Plymouth County	3/17/2007	8,000	Flood	Heavy Rain
Plymouth County	4/15/2007	25,000	Flood	Heavy Rain
Plymouth County	2/13/2008		Flood	Heavy Rain
Plymouth County	3/8/2008	5,000	Flood	Heavy Rain
Plymouth County	3/8/2008		Flood	Heavy Rain
Plymouth County	9/27/2008	50,000	Flood	Heavy Rain
Plymouth County	5/24/2009		Flood	Heavy Rain
Plymouth County	8/29/2009		Flood	Heavy Rain
Plymouth County	3/14/2010	16,150,000	Flood	Heavy Rain
Plymouth County	3/29/2010	8,070,000	Flood	Heavy Rain
Plymouth County	4/1/2010		Flood	Heavy Rain
Plymouth County	7/13/2011	5,000	Flood	Heavy Rain
Plymouth County	8/10/2012	30,000	Flood	Heavy Rain
Plymouth County	5/11/2013		Flood	Heavy Rain
Plymouth County	5/11/2013		Flood	Heavy Rain
Plymouth County	6/7/2013		Flood	Heavy Rain Tropical System
Plymouth County	9/3/2013		Flood	Heavy Rain
Plymouth County	3/30/2014		Flood	Heavy Rain
Plymouth County	3/30/2014		Flood	Heavy Rain
Plymouth County	10/22/2014		Flood	Heavy Rain
Plymouth County	11/17/2014		Flood	Heavy Rain

Plymouth County	5/31/2015		Flood	Heavy Rain
Plymouth County	7/28/2015	15,000	Flood	Heavy Rain
Plymouth County	9/10/2015		Flood	Heavy Rain
Plymouth County	10/29/2015		Flood	Heavy Rain
Plymouth County	5/30/2016		Flood	Heavy Rain
Plymouth County	4/1/2017	5,000	Flood	Heavy Rain
Plymouth County	4/6/2017	5,000	Flood	Heavy Rain
Plymouth County	6/24/2017	1,000	Flood	Heavy Rain
Plymouth County	10/25/2017		Flood	Heavy Rain
Plymouth County	10/25/2017		Flood	Heavy Rain
Plymouth County	10/29/2017		Flood	Heavy Rain
Plymouth County	1/12/2018		Flood	Heavy Rain
Plymouth County	11/3/2018	1,000	Flood	Heavy Rain
Plymouth County	4/15/2019		Flood	Heavy Rain
Plymouth County	7/12/2019		Flood	Heavy Rain
Plymouth County	7/22/2019		Flood	Heavy Rain
Plymouth County	9/2/2019	1,000	Flood	Heavy Rain
Plymouth County	9/2/2019	1,000	Flood	Heavy Rain

Significant Massachusetts Floods:

The Great Flood of 1936

The Great Flood of 1936 brought devastating floods to much of the Bay State, particularly across the Merrimack and Connecticut valleys. This event was created by several key elements. The first was consistently well below normal temperatures from mid-January through early March. This prolonged cold spell contributed to a buildup of thick ice on many area rivers. The next key element, also helped by the cold temperatures, was the buildup of a sizeable snowpack across much of the region. Finally, mid through late March brought a substantial warm-up accompanied by periods of significant rainfall. The result was a devastating combination of runoff from rain and snowmelt, as well as the breakup of river ice that was destructive in its size and the subsequent creation of ice jams in many rivers.

Across central and western Massachusetts, the combination of rainfall and liquid equivalent of melted snow during mid to late March ranged from 7 to 13 inches. Rainfall and snowmelt were even more substantial in the headwaters of the Connecticut and Merrimack Rivers (New Hampshire and Vermont). Major to record flooding occurred on many rivers in Massachusetts, largely in portions of the Connecticut and Merrimack River Valleys. The March 1936 flood records for the Connecticut and Merrimack rivers remain the worst on record today. Numerous bridges were destroyed between the freshwater floods and the ice jam damage. Along the Merrimack River from southern New Hampshire into Massachusetts, there was widespread damage and destruction of mills and manufacturing plants. In Springfield, which was not yet protected by a levee, a large percentage of the residents were affected by the floodwaters. In Massachusetts and New Hampshire combined, there were 8 deaths attributed to the floods.[41]

Record flood crests during March of 1936 occurred over several river locations, and these record flood crests stand today:

- Connecticut River at Montague, Northampton, Holyoke, and Springfield
- Merrimack River at Lowell, Lawrence, and Haverhill
- Nashua River at East Pepperell

The Great New England Hurricane of 1938

The Great New England Hurricane of 1938 came ashore on September 21 as a Category 3 Hurricane at Suffolk County Long Island, then into Milford, CT. The center made landfall at the time of astronomical high tide, moving north at 60 mph. The hurricane produced destructive storm surge over south coastal Massachusetts and Cape Cod. Sections of Falmouth and New Bedford were submerged under as much as 8 feet of water, in concert with sustained winds of 121 mph and a peak gust of 186 mph.

[41] **NOAA, National Weather Service.**

Rainfall from this hurricane resulted in severe river flooding, especially across portions of western Massachusetts, where 3 to 6 inches of rain fell. The rainfall from the hurricane added to the amounts that had occurred with a frontal system several days before the hurricane struck. The combined effects from the frontal system and the hurricane produced rainfall of 10 to 17 inches across most of the Connecticut River Valley. This resulted in some of the worst flooding ever recorded in this area. Along the Connecticut River in the vicinity of Springfield, the river rose to 6 to 10 feet above flood stage, causing extensive damage. While less rains fell across eastern Massachusetts, substantial freshwater flooding still occurred at some locations. This included the lower Merrimack River, which from Lowell to Haverhill achieved one of its top 3 flood crests on record.

Throughout southern New England, a total of 8,900 homes, cottages and buildings were destroyed, and over 15,000 were damaged by the hurricane. The marine community was devastated. Across all southern New England, over 2,600 boats were destroyed, and over 3,300 damaged. The hurricane was responsible for 564 deaths and at least 1,700 injuries in Southern New England. Damage to the fishing fleets in Southern New England was catastrophic. A total of 2,605 vessels were destroyed, with 3,369 damaged. [42]

1955 Floods from Connie and Diane

Two named tropical systems in August 1955, producing significant flooding over much of Massachusetts. Connie produced generally 4 to 6 inches of rainfall over Massachusetts on August 11 and 12. The result of this was to saturate the ground and bring river and reservoir levels to above normal levels. Diane came a week later with rainfall totals ranging up to nearly 20 inches over a 2-day period. This exceeded records for New England.

With the strong intensity rainfall on saturated soil, the rise of the rivers was rapid. Even rivers along the coastal region of eastern Massachusetts, including the Charles, Taunton, and Neponset, experienced dramatic and rapid rises. On the Blackstone and Thames River headwaters south of Worcester, many dam breaks occurred, producing significant flooding and destruction downstream. In the Connecticut River Valley, the most significant floods were experienced on the Chicopee and Westfield Rivers; however, since the heaviest rains did not reach into northern New England, the mainstem Connecticut River did not flood to the degree seen on the Chicopee and Westfield Rivers.

Floods of May 8-10, 1995

Widespread flooding occurred in central and eastern Massachusetts during mid to late March 2010 caused by a series of moderate to heavy rainfall events over a 5-week period starting in late February. The successive and unrelenting nature of these moderate to heavy rainfall events saturated soils and limited opportunities for rivers and streams to recede, making the state vulnerable to flooding. Widespread flooding occurred along the eastern half of Massachusetts in mid-March. An exceptional number of homes, businesses and streets were impacted. Several gages indicated floods of record.

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[42] ***Southern New England Tropical Storms and Hurricanes, A 98-year summary 1909-1997,"*** **D.R. Vallee, M.R. Dion, National Weather Service**

These sites included the Concord River at Lowell, the Taunton River at Bridgewater, the Shawsheen River at Wilmington, and the Charles River at Waltham.

Blizzard of '78

Although the Blizzard of ’78 (February 6-8) is known for the incapacitating snowfall, snow drifts and wind gusts it brought to Massachusetts, it is also known for the devastating coastal flooding that it brought to Massachusetts. Astronomical high tides occurred during the timeframe of the blizzard. Major coastal flooding severely damaged over 2,000 homes, displacing some of the 10,000 people who required shelter. Damage from the storm is estimated at more than $2.3 billion (in 1998 dollars). The storm resulted in 73 deaths in Massachusetts.

Flooding Vulnerability Assessment

An analysis of FEMA flood hazard maps indicates that approximately 453 acres, or 4.5 percent, of Hanson is within a 100-year floodplain. Based on additional analysis, 14 acres, or 3.2 percent, of the floodplain is developed. To limit additional development from occurring within floodplains, Hanson adopted a Floodplain District. The district is intended to ensure public safety through reducing the threats to life and personal injury; eliminate new hazards to emergency response officials; prevent the occurrence of public emergencies resulting from water quality, contamination, and pollution due to flooding; avoiding the loss of utility services which if damaged by flooding would disrupt for shut down the utility network and impact regions of the community beyond the site of flooding; eliminate costs associated with the response and cleanup of flooding conditions; reduce damage to public private property resulting from flooding waters.

The Town of Hanson also adopted a Wetlands Protection By-law, Article 3-13 and regulations promulgated pursuant to the By-law of the Town of Hanson and the Hanson Conservation Commission which are intended to establish criteria and standards for the uniform and coordinated administration of the provisions of the By-law. These regulations create a uniformity of process and clarify and define the provisions of the Town By-laws. Any activity proposed or undertaken which constitutes removing, filling, dredging, altering, draining into, or building upon any area specified as defined in Section 1.02 or within 100 feet of any area of those area requires the filing of a Notice of Intent. The Conservation Commission may deny permission for any work if, in its judgment, such denial is necessary to preserve environmental quality of either or both the subject and contiguous lands.

Of the 50 critical facilities identified in Hanson, only five are located within a 100-year floodplain and consist of three dams and two bridges. While there are no critical facilities located within any of the locally identified flood areas, only one facility - Kid’s Country is within 200 feet of a locally identified flood area.

The 100-Year Flood

The 100-year flood is the flood that has a 1 percent chance of being equaled or exceeded each year. The 100-year flood is the standard used by most federal and state agencies. For example, it is used by the National Flood Insurance Program (NFIP) to guide floodplain management and determine the need for flood insurance. The extent of flooding associated with a 1 percent annual probability of occurrence (the base flood or 100-year flood) is called the 100-year floodplain, which is used as the regulatory boundary by many agencies. Also referred to as the Special Flood Hazard Area (SFHA), this boundary is a convenient tool for assessing vulnerability and risk in flood-prone communities.

The 500-Year Flood

A 500-year flood is an event that has a 1 in 500 chance of occurring in any given year. "For a 500-year flood, there is a 0.2 percent chance of having a flood of that magnitude occurring" in any given year, according to the National Weather Service.

Warning Time

Due to the sequential pattern of weather conditions needed to cause serious flooding, it is unusual for a flood to occur without warning. Advance weather forecasting, blockades, and emergency alerts and warnings help to minimize the total number of injuries and casualties that typically result from riverine flooding. Warning times for floods can be between 24 and 48 hours. Flash flooding can be less predictable, but potential hazard areas can be warned in advanced of potential flash flood danger.

However, even a relatively low-level flood can be hazardous and can result in direct mortality to individuals interacting with the flood zone. Downed powerlines, sharp objects in the water, or fast-moving debris that may be in or near the water all present an immediate danger to individuals in the flood zone. Floodwater can also carry a wide range of infectious organisms from raw sewage and/or chemicals and hazardous materials swept away from containment areas.

The duration of a flood event means the time between the start and end of the flood or the event that caused it. This can be difficult to define for floods, particularly inland floods, as they recede slowly and do not vanish completely; flood water moved from one area to another. Flash flooding occurs within six hours of a rain event, while other types of flooding are longer-term events and may last a week or more.

Flood warning and watches are issued by the local NWS office. The NWS updates watches and warnings and notifies the public when they are no longer in effect. Watches and warnings for flooding in the Commonwealth of Massachusetts are as follows:

- ***Coastal Flooding:***
    - **Coastal Flood Advisory –** Issued when minor or nuisance coastal flooding is occurring or imminent.
    - **Coastal Flood Watch –** Issued when moderate to major coastal flooding is possible. Such flooding could post a serious risk to life and property.

- **Coastal Flood Warning –** Issued when moderate to major coastal flooding is occurring or imminent. This flooding will post a serious risk to life and property.

- ***Inland Flooding***
  - **Flood Advisory –** Issued when nuisance flooding is occurring or imminent. A flood advisory may be upgraded to a flash flood warning if flooding worsens and posts a threat to life and property.
  - **Flash Flood Watch –** Issued when heavy rain leading to flash flooding is possible. People in a flash flood watch should be prepared for heavy rains and potential flooding. Flash flood watches may be issued up to 12 hours before flash flooding is expected.
  - **Flash Flood Warning –** Issued when flooding is occurring or will develop quickly. If a flash flood warning is issued for an area, the population needs to take shelter and/or move to high ground, as necessary.

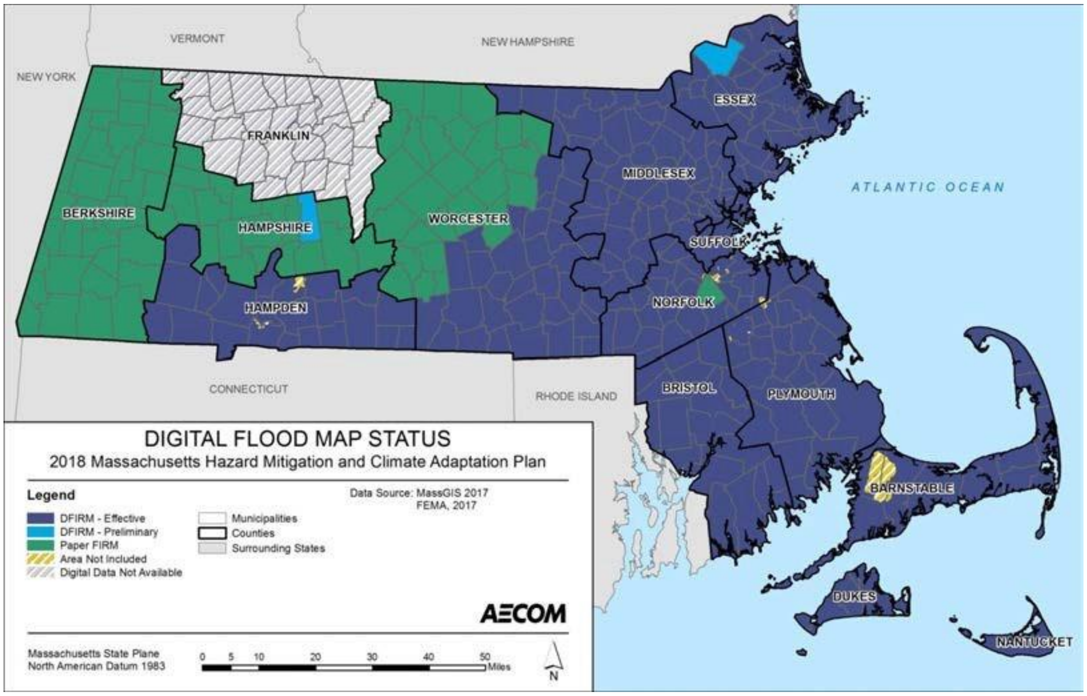
The National Flood Insurance Program (NFIP)

According to FEMA, the National Flood Insurance Program (NFIP) is a federal program that aims to reduce the impact of flooding on private and public structures. It provides affordable insurance to property owners, renters and businesses and encourages communities to adopt and enforce floodplain management regulations. The program is intended to reduce the socio-economic impacts of disasters by promoting the purchase and retention of general risk insurance, and specifically, flood insurance.

Flood zones are geographic areas that FEMA has defined according to varying levels of flood risk. These zones are shown on a community's official Flood Insurance Rate Map (FIRM) or Flood Hazard Boundary Map. Each zone reflects the severity or type of flooding in the area. According to FEMA, The Flood Insurance Rate Map (FIRM) is the official map of a community on which FEMA has delineated Special Flood Hazard Areas (SFHA) for floods and the risk premium zones applicable to parcels in a specific community.

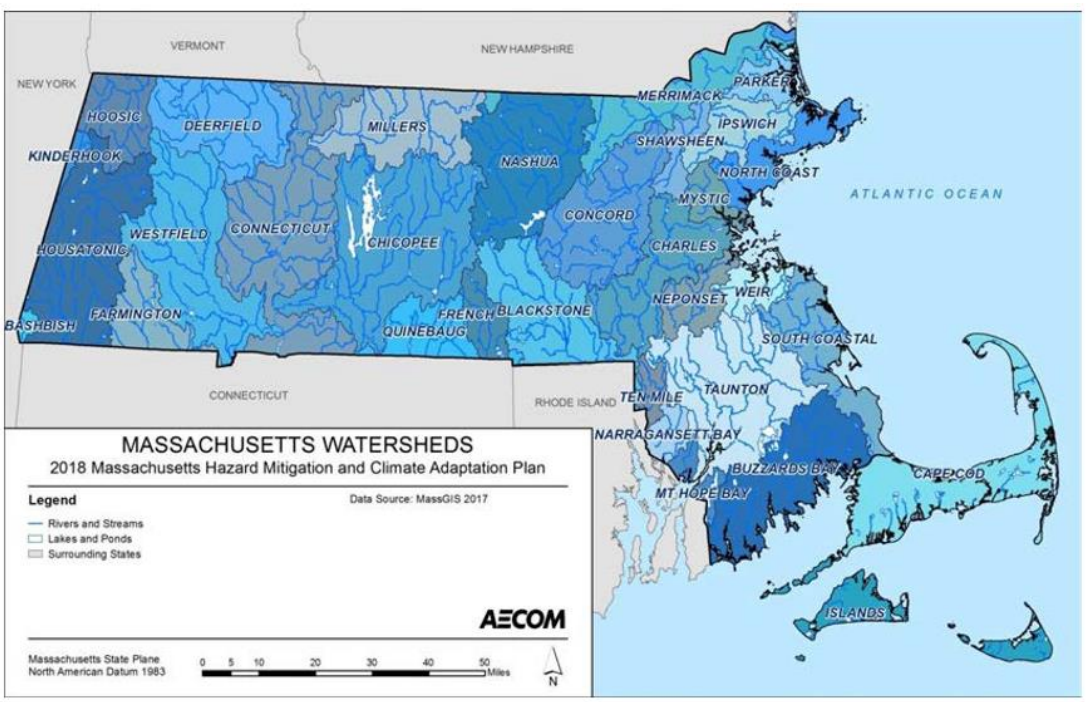
Special Flood Hazard Areas (SFHA) identified on the Flood Insurance Rate Map are defined as the area that will be inundated by the flood event having a one percent chance of being equaled or exceeded in any given year. The one percent annual chance flood is also referred to as the base flood or 100-year flood.

Figure 51: Digital Flood Map Status



Source: SHMCAP, 2018

Figure 52: Massachusetts Watersheds



Source: SHMCAP, 2018

Figure 53: FIRM Panel 25023C0183J

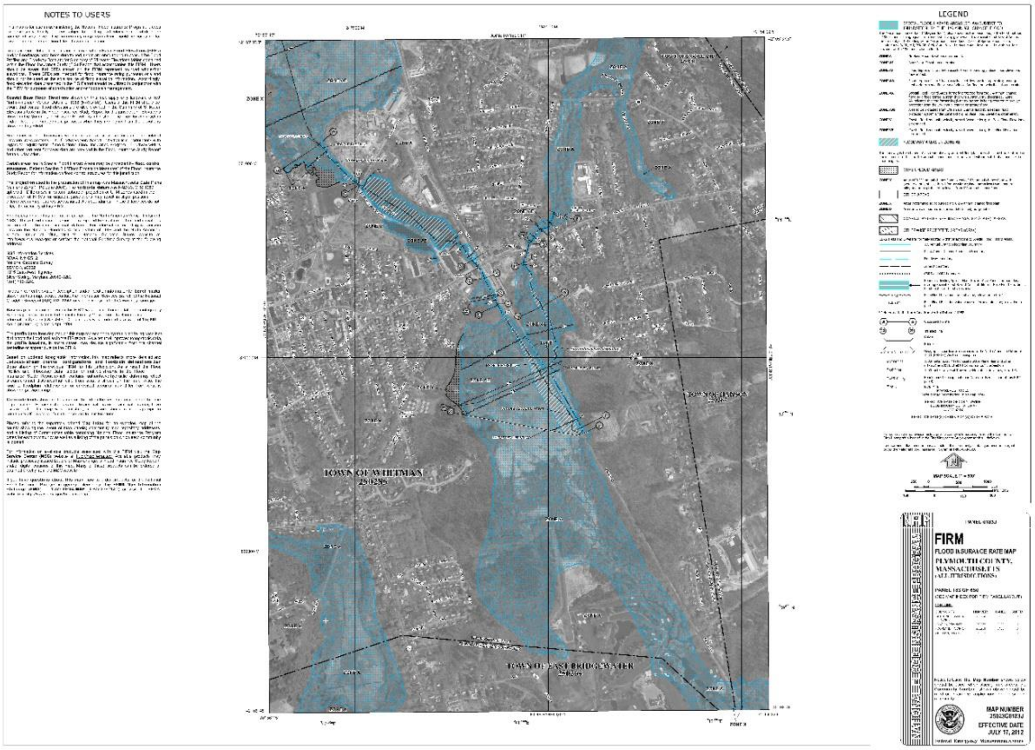


Figure 54: FIRM Panel 25023C0184J

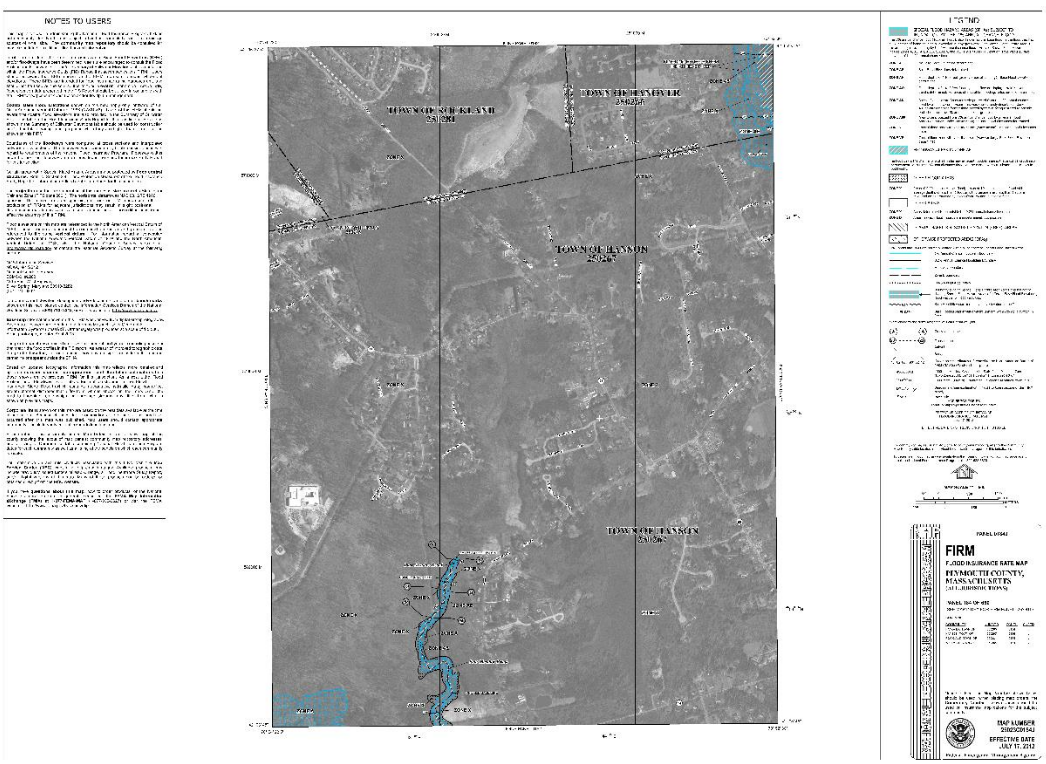


Figure 55: FIRM Panel 25023C0192J

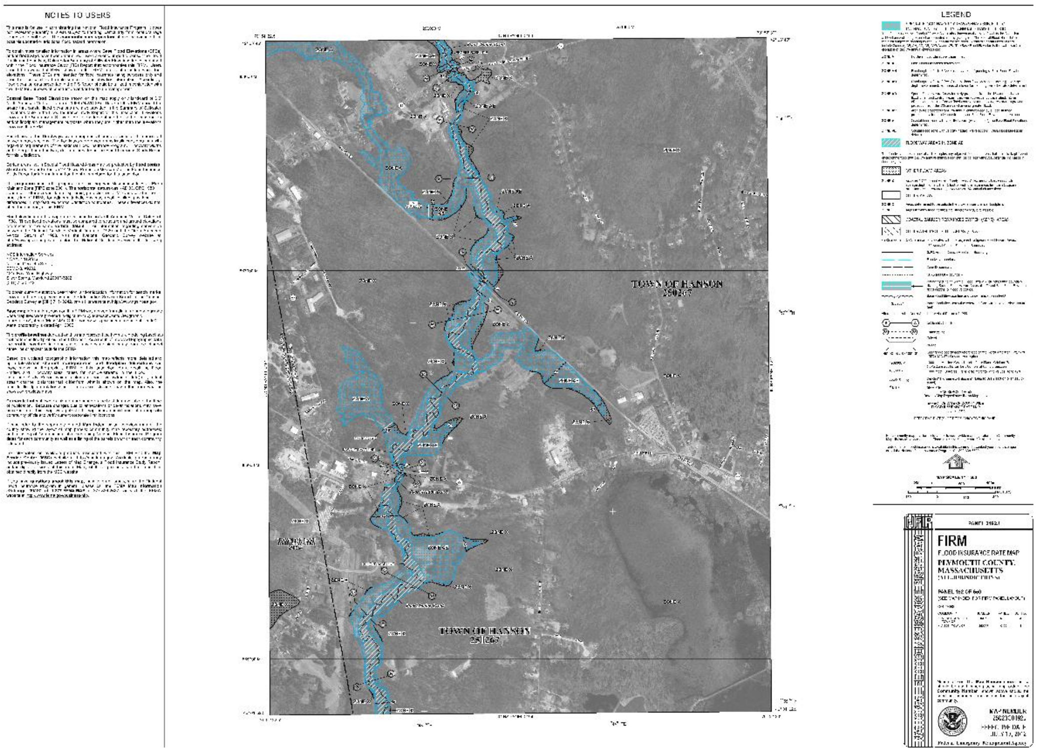


Figure 56: FIRM Panel 25023C0194J

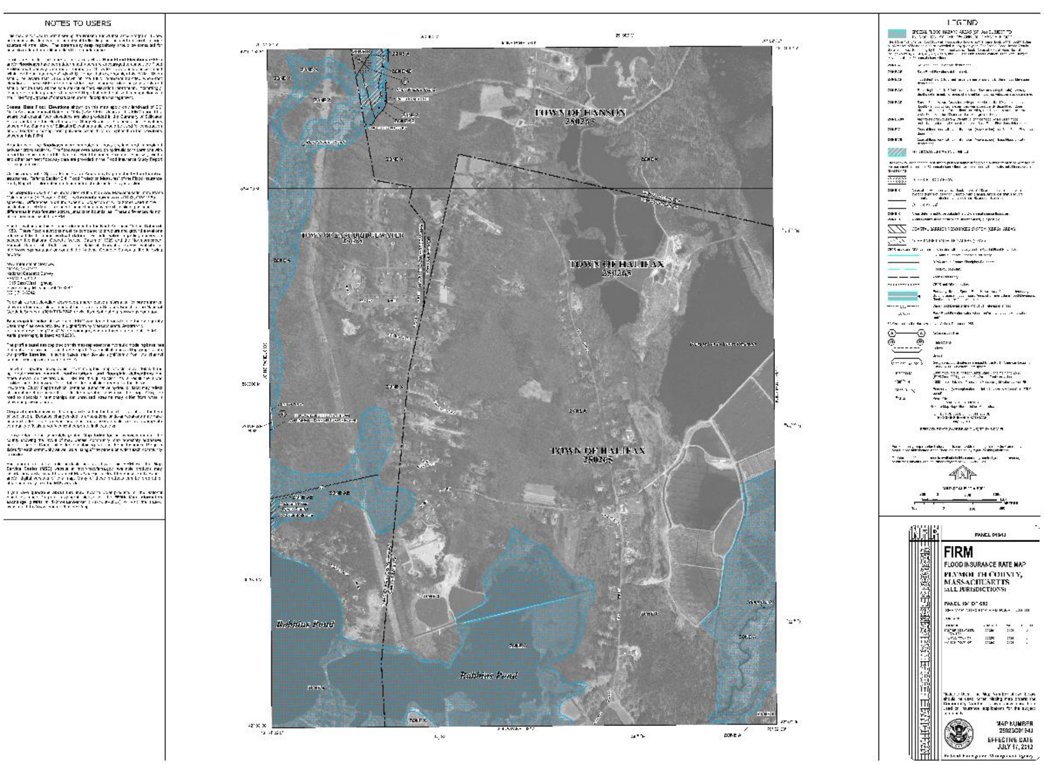


Figure 57: FIRM Panel 25023C0201J

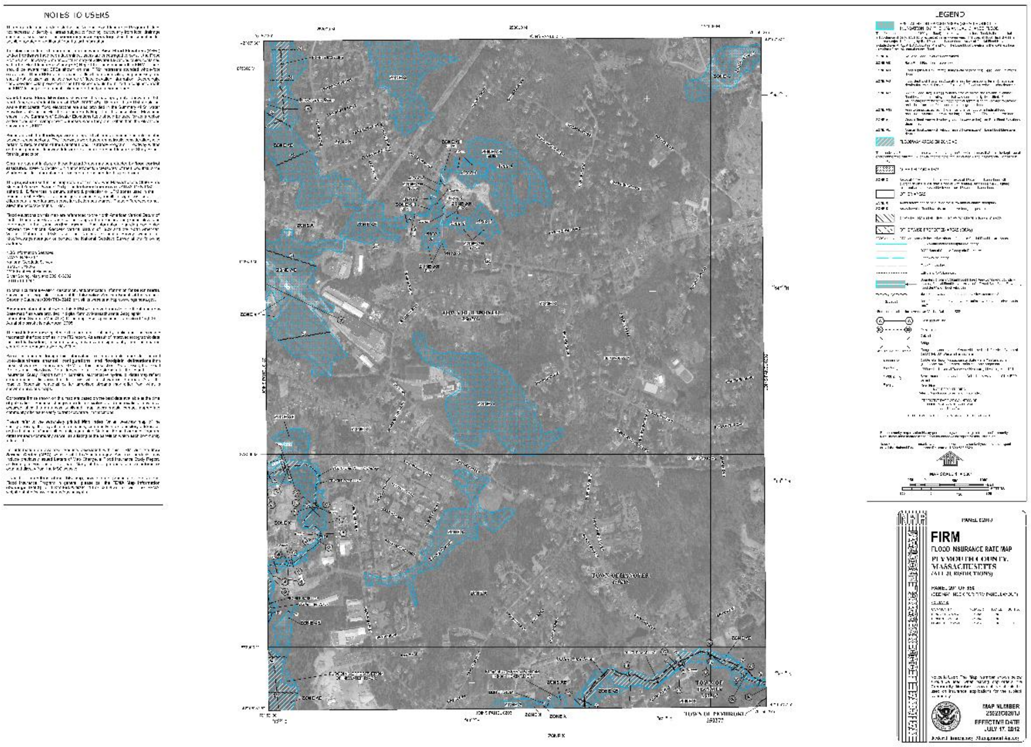


Figure 58: FIRM Panel 25023C0202J

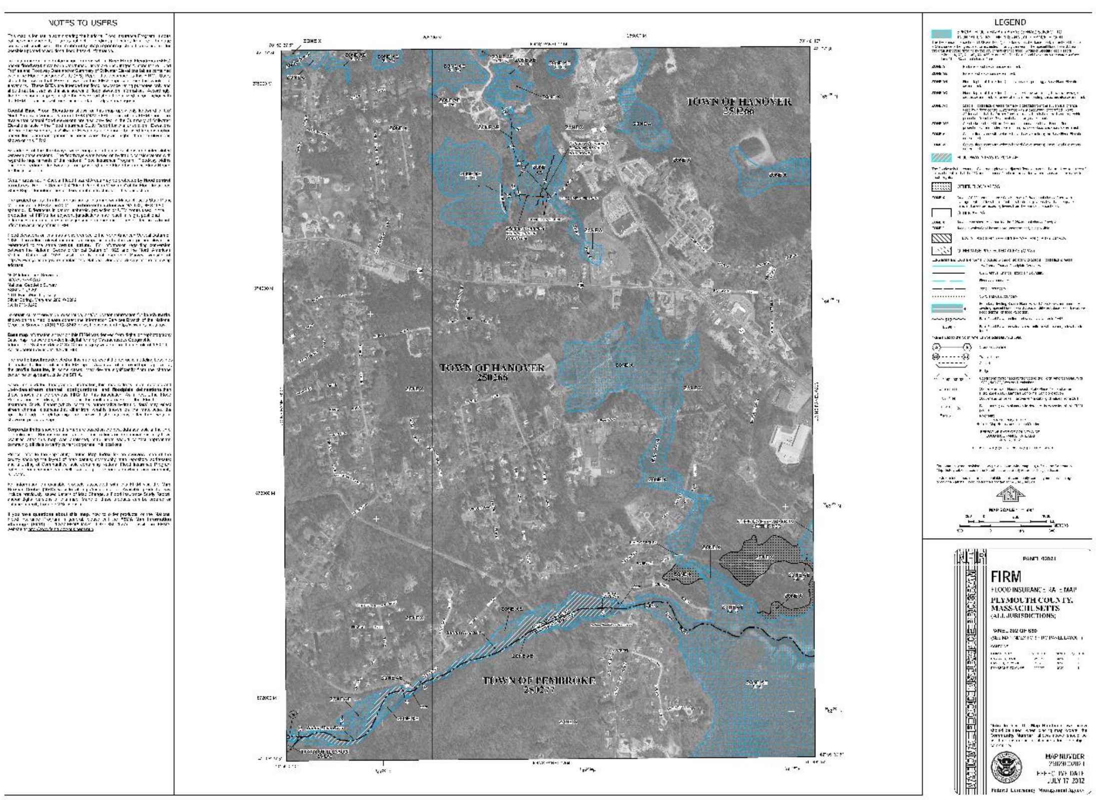


Figure 59: FIRM Panel 25023C0203J

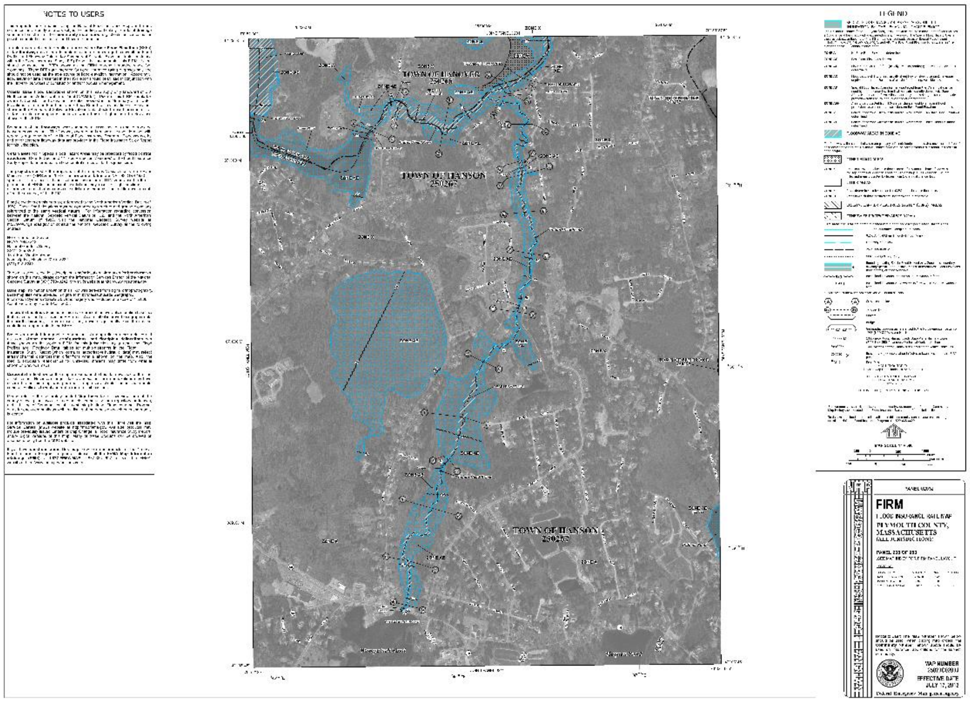


Figure 60: FIRM Panel 25023C0212J

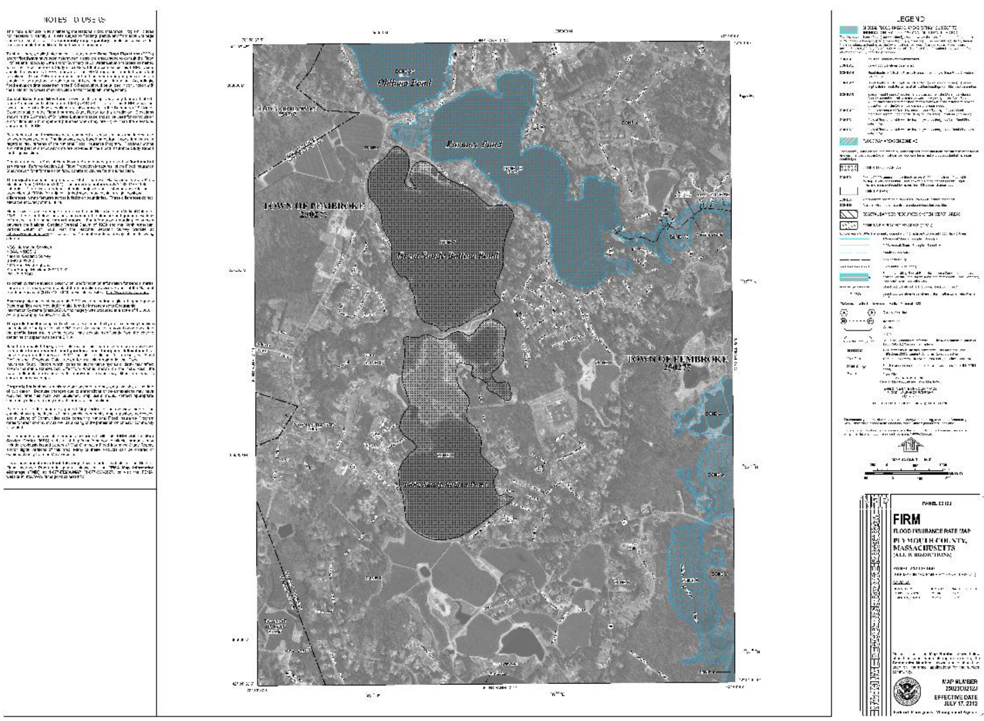


Figure 61: FIRM Panel 25023C0213J

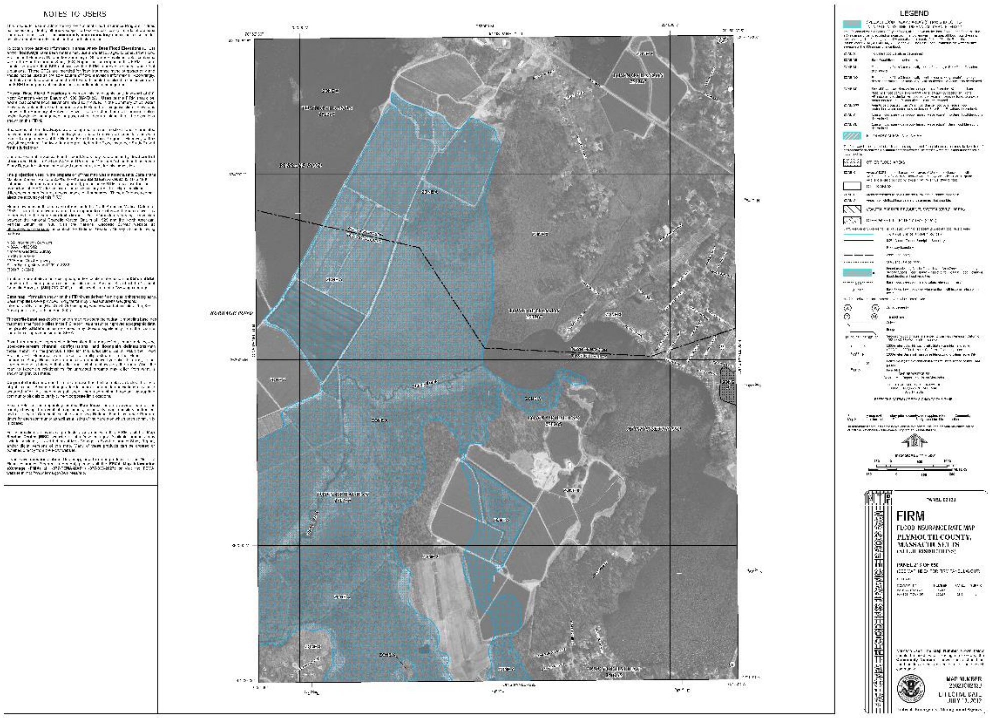


Figure 62: FIRM Panel 25023C0214J

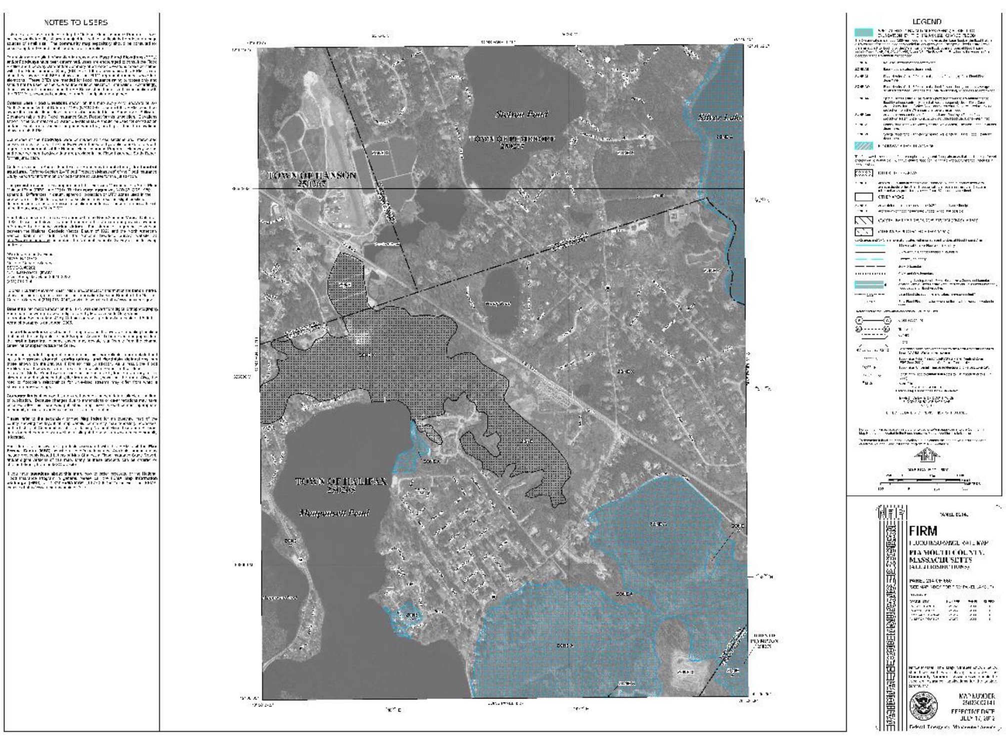
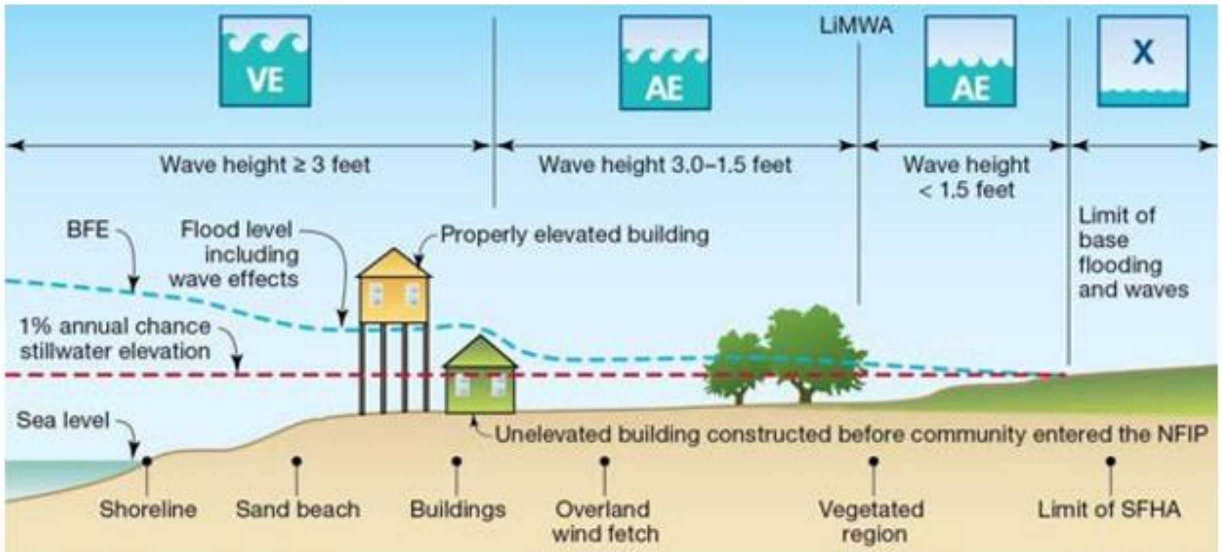


Figure 63: FEMA Flood Zones along the Coast



Source: FEMA, n.d.

In addition to providing the basis for flood insurance premiums, these flood zones are referenced in the Massachusetts State Building Code and used to ensure, among other things, that new and substantially improved structures are elevated based on the magnitude of the hazard. Under the Massachusetts State Building Code, the top of the first floor in residential structures must be located 1 foot above the base flood elevation (BFE) in A and AE Zones and the lowest horizontal structural member must be 2 feet above the BFE in V Zones. [43]

Managing Concurrent Disaster Assistance Financial Resources

A catastrophic flood, like the scenario in the introduction, requires assistance from various agencies and programs to cover a jurisdiction's needs.

- ***FEMA Public Assistance*** funding may be available for debris management and repairs to damaged roads and bridges, public facilities, critical infrastructure, and parks.
- ***USDA's Natural Resources Conservation Service (NRCS) Emergency Watershed Protection Program*** may help stabilize eroding stream banks and prevent further impacts to life and property.
- ***FEMA's Hazard Mitigation Grant Program*** may support priority projects to protect the community from future floods.
- ***HUD CDBG-DR Funds*** may provide additional resources to repair damaged homes, develop replacement housing, support impacted local businesses and supplement gaps in needed infrastructure funding.
- ***FEMA Individual Assistance*** may be provided directly to individuals and households with disaster-related needs or may be provided to jurisdictions to support individual survivors.

[43] **SHMCAP, 2018**

Different agencies or offices manage these programs, and they have different rules and timelines. Many of the programs listed can be concurrently implemented, but jurisdictions need successful disaster financial and portfolio management to realize the maximum benefit and avoid ineligible expenses.

Dam Overtopping

A dam is an artificial barrier that can impound water, wastewater, or any liquid-borne materials for the purpose of storage or control of water. There are two primary types of dam failure: catastrophic failure, characterized by the sudden, rapid, and uncontrolled release of impounded water, or design failure, which occurs because of minor overflow events. Dam overtopping is caused by floods that exceed the capacity of the dam, and it can occur because of inadequate spillway design, settlement of the dam crest, blockage of spillways, and other factors. Overtopping accounts for 34 percent of all dam failures in the U.S.

Dams are designed partly based on assumptions about a stream's flow behavior, expressed as hydrographs. Changes in weather patterns can have significant effects on the hydrograph used for the design of the dam. If the hydrograph changes, it is conceivable that the dam can lose some of its designed margin of safety, also known as freeboard. If freeboard is reduced, dam operators may be forced to release increased volumes earlier in a storm cycle to maintain the required margins of safety. Such early releases of increased volumes can increase flood potential downstream.

Dams are constructed with safety features known as "spillways," which provide as safety measure in the event of the reservoir filing too quickly. Spillway overflow events, often referred to as "design failures," result in increased discharges downstream and increased flooding potential. Although climate change will not increase the probability of catastrophic dam failure, it may increase the probability of design failures.

There are several ways in which climate change could alter the flow behavior of a river, causing conditions to deviate from what the dam was designed to handle. For example, more extreme precipitation events could increase the frequency of intentional discharges. Many other climate impacts—including shifts in seasonal and geographic rainfall patterns—could also cause the flow behavior of rivers to deviate from previous hydrographs. When flows are greater than expected, spillway overflow events (often referred to as "design failures") can occur. These overflows result in increased discharges downstream and increased flooding potential. Therefore, although climate change will not increase the probability of catastrophic dam failure, it may increase the probability of design failures.

CRB Workshop participants agreed that addressing the vulnerability of the Town Center and making dam improvements to the Wampatuck Pond Dam were high priority actions that could be tackled in the short-term. It was noted that the dam was structurally in good condition, but that automated controls are needed to manage flows efficiently and effectively.

There are six dams in Hanson according to the Massachusetts Department of Conservation and Recreation Office of Dam Safety. The Burrage Pond Dam is considered non-jurisdictional and does not fall under the Massachusetts Office of Dam Safety regulatory authority and therefore the information provided is limited.

Table 51: Hanson Dams

Name	Impoundment	Waterway	Hazard Code	Owner
Burrage Upper Reservoir Dam	Burrage Pond	Tri-Stump Brook	Significant	State
Chandler Mill Pond Dam	Chandler Mill Pond	N/A	Low	Private
Factory Pond Dam	Factory Pond	Drinkwater River	Significant	Towns of Hanson and Hanover
Indian Head Dam	Indian Head River	Indian Head River	Low	Town of Hanover
Wampatuck Pond Dam	Wampatuck Pond	Indian Head Brook	Significant	Town
Burrage Pond Dam	Burrage Pond	Great Cedar Swamp	Not Available	Unknown

Secondary Hazards

The most problematic secondary hazard for riverine flooding is bank erosion, which in some cases can be more harmful than actual flooding. This is especially true in the upper courses of rivers with steep gradients, where floodwaters may pass quickly and without much damage, but scour the banks, edging properties closer to the floodplain or causing them to fall in. Flooding is also responsible for hazards such as landslides when high flows over-saturate soils on steep slopes, causing them to fail. Hazardous materials spills are also a secondary hazard of flooding if storage tanks rupture and spill into streams, rivers, or storm sewers.

Factory Pond Dam

Factory Pond is a 51-acre impoundment located on the Indian Head River at Winter Street at an elevation of 48-feet. The Factory Pond is in the North River watershed, on the border between Hanson and Hanover. It is an impoundment of the Drinkwater River formed by a dam near Winter Street behind the Country Ski shop (a former mill site).

Additional Causes of Flooding

Additional causes of flooding include beaver dams or levee failure. Beaver dams obstruct the flow of water and cause water levels to rise. Significant downstream flooding can occur if beaver dams break.

Floodplains

Floodplains by nature are vulnerable to inland flooding. Floodplains are the low, flat, and periodically flooded lands adjacent to rivers, lakes, and oceans. These areas are subject to geomorphic (land-shaping) and hydrologic (water flow) processes. Floodplains may be broad, as when a river crosses an extensive flat landscape, or narrow, as when a river is confined in a canyon. These areas form a complex physical and biological system that not only supports a variety of natural resources, but also provides natural flood storage and erosion control. When a river is separated from its floodplain by levees and other flood control facilities, these natural benefits are lost, altered, or significantly reduced. When floodwaters recede after a flood event, they leave behind layers of rock and mud. These gradually build up to create a new floor of the floodplain. Floodplains generally contain unconsolidated sediments known as alluvium (accumulations of sand, gravel, loam, silt, and/or clay), often extending below the bed of the stream. These sediments provide a natural filtering system, with water percolating back into the ground and replenishing groundwater supplies.

Floodplain Ecosystems

As the name implies, flooding is a natural and important part of wetland ecosystems that form along rivers and streams. Floodplains can support ecosystems that are rich in plant and animal species. Wetting the floodplain soil releases an immediate surge of nutrients from the rapid decomposition of organic matter that has accumulated over time. When this occurs, microscopic organisms thrive, and larger species enter a rapid breeding cycle. Opportunistic feeders (particularly fish or birds) often utilize the increased food supply. The production of nutrients peaks and falls away quickly, but the surge of new growth that results endures for some time.
Species growing in floodplains are markedly different from those that grow outside floodplains. For instance, riparian trees (trees that grow in floodplains) tend to be very tolerant of root disturbance and grow quickly in comparison to non-riparian trees.

Location

Human development within historic floodplains has resulted in increased potential risks to public safety and infrastructure. Such development has occurred for centuries along rivers in Massachusetts, resulting in reduced natural flood storage capacity and increased exposure to flood risks. Inland flooding affects most communities in the Commonwealth. Massachusetts has 27 regionally significant watershed areas.

Flood Prone Areas

The areas identified as being most vulnerable to flooding are areas located within 100-year floodplains. According to FEMA Flood Insurance Rate Maps (FIRM), areas most vulnerable to flooding in Hanson are areas along the Indian Head Brook, Indian Head River, Poor Meadow Brook, and the Shumatuscacant River. In addition to these areas, town officials also noted the following locations where flooding has historically occurred:

- Maquan Street (Route 14) from Rollercoaster Road to the Pembroke Town Line

- East Washington Street at the Pembroke town line (Rocky Run Brook)
- West Washington Street near Pennsylvania Avenue
- Brett's Brook near the Blueberry Farm

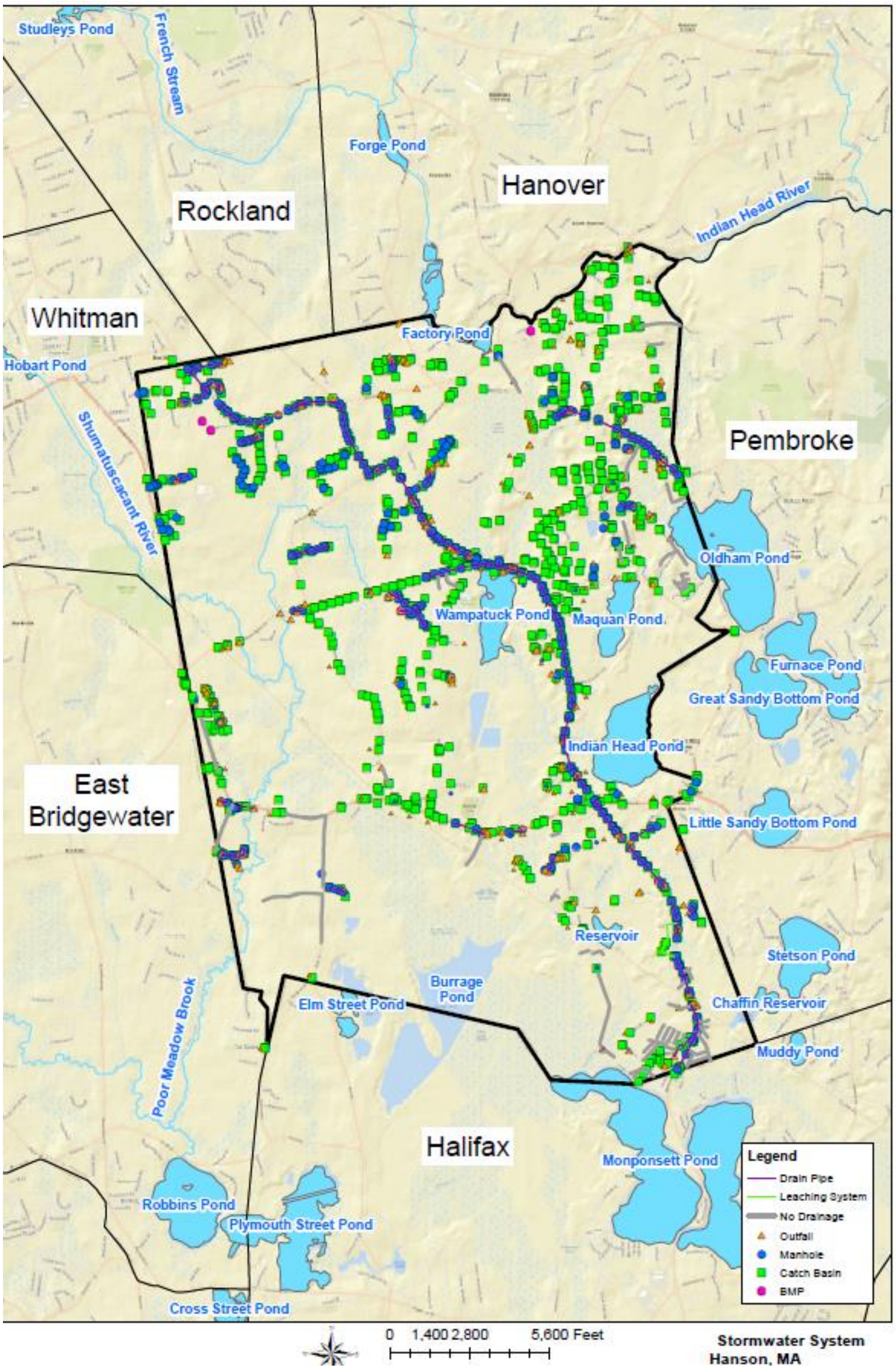
Stormwater Infrastructure

Stormwater drainage systems and culverts that are not sized to accommodate larger storms are likely to experience flood damage as extreme precipitation events increase (ResilientMA, 2018). Both culverts that are currently undersized and culverts that are appropriately sized may be overwhelmed by larger storms. Gravity-fed water and wastewater infrastructure located in low-lying areas near rivers and reservoirs may experience increased risks.

Catch Basins and Culverts:

1) Catch Basin at Indian Trail
2) Catch Basin at Hanson/Halifax town line.
3) Woodbine Avenue Catch Basin collapsed
4) Holly Ridge Catch Basin
5) Crocker Place Basin
6) Culvert at Indian Head
7) Maquan St/Pine Grove Avenue
8) Crescent Street
9) South Street
10) West Washington Street (low spot) Winter Street
11) White Oak Brook Pleasant Street
12) Pratt Place at bridge
13) Woodman Terrace

Figure 64: Stormwater Management System



Debris Management

Flooding causes damage to property due to inundation and erosion. Flooding is often confined to discernible floodplain areas but may also occur because of a dam failure or flash flood in areas downstream of higher elevation streams, ponds, and rivers. Debris consists of sediments deposited on public and private property, and water damaged materials. Soil, gravel, rock, and construction materials may also be eroded by floodwaters.

Sectors Assessed

Populations

The impact of flooding on life, health, and safety is dependent upon several factors, including the severity of the event and whether adequate warning time is provided to residents. Populations living in or near floodplain areas may be impacted during a flood event. People traveling in flooded areas or those living in urban areas with poor stormwater drainage may be exposed to floodwater. People may also be impacted when transportation infrastructure is compromised from flooding.

To estimate the population exposed to the 1 percent and 0.2 percent annual chance flood events, the flood hazard boundaries were overlaid upon the 2010 US Census block population data in GIS (US Census, 2010). Census blocks do not follow the boundaries of the floodplain. The portion of the Census block within the floodplain was used to approximate the population contained therein. For example, if 50 percent of a census block of 1,000 people was located within a floodplain, the estimated population exposed to the hazard would be 500. The following Table lists the estimated population located within the 1 percent and 0.2 percent flood zones by county.

Vulnerable Populations

Of the population exposed, the most vulnerable include people with low socioeconomic status, people over the age of 65, young children, people with medical needs, and those with low English fluency. For example, people with low socioeconomic status are more vulnerable because they are likely to consider the economic impacts of evacuation when deciding whether to evacuate.

The population over the age of 65 is also more vulnerable because some of these individuals are more likely to seek or need medical attention because they may have more difficultly evacuating, or the medical facility may be flooded. Those who have low English language fluency may not receive or understand the warnings to evacuate. Vulnerable populations may also be less likely to have adequate resources to recover from the loss of their homes and jobs. Populations that live or work in proximity to facilities that use, or store toxic substances are at greater risk of exposure to these substances during a flood event.

Table 52: Estimated Population Exposed to the 1 Percent and 0.3 Percent Annual Chance Inland Flood

County	Total 2010 Population	1 Percent Annual Chance Flood Event A Zone		0.2 Percent Annual Chance Flood Event X500 Zone	
		Population	% of Total	Population (1)	% of Total
Barnstable	215,888	149	0.1	1,141	0.5
Berkshire	131,219	7,985	6.1	2,311	1.8
Bristol	548,285	12,580	2.3	3,472	0.6
Dukes	16,535	—	N/A	11	0.1
Essex	743,159	18,667	2.5	15,385	2.1
Franklin	71,372	N/A	N/A	N/A	N/A
Hampden	463,490	8,178	1.8	14,622	3.2
Hampshire	158,080	5,315	3.4	2,604	1.6
Middlesex	1,503,085	38,798	2.6	34,182	2.3
Nantucket	10,172	11	0.1	129	1.3
Norfolk	670,850	17,409	2.6	9,845	1.5
Plymouth	494,919	15,954	3.2	4,231	0.9
Suffolk	722,023	1,875	0.3	603	0.1
Worcester	798,552	18,020	2.3	9,107	1.1
Total	**6,547,629**	**144,941**	2.2	**97,644**	1.5

[1]Represents population within the X500 Zone. Population in the A Zone would also be exposed to a 0.2 percent annual chance flood event.

Sources: 2010 U.S. Census, MassGIS

Food Insecurity

Globally, climate change is expected to threaten food production and certain aspects of food quality, as well as food prices and distribution systems. Many crop yields are predicted to decline because of the combined effects of changes in precipitation, severe weather events, and increasing competition from weeds and pests on crop plants. Livestock and fish production are also projected to decline. Prices are expected to rise in response to declining food production and associated trends such as increasingly expensive petroleum (used for agricultural inputs such as pesticides and fertilizers). [44]

Health can be affected in several ways. Populations with dietary patterns will confront shortage of key foods. Food insecurity increases with rising food prices. In those situations, people cope by turning to nutrient-poor but calorie-rich foods and/or they endure hunger, with consequences ranging from micronutrient malnutrition to obesity. The nutritional value of some foods is projected to decline due to decreased plant nitrogen concentration, and therefore decreased protein, in many crops, such as barley and soy. Farmers are expected to need to use more herbicides and pesticides because of increased

[44] https://www.cdc.gov/climateandhealth/effects/food_security.htm

growth of pests and weeds, as well as decreased effectiveness and duration of some chemicals. Farmers, farmworkers, and consumers will be increasingly exposed to these substances and their residues, which can be toxic.

Health Impacts

The total number of injuries and casualties resulting from typical riverine flooding is generally limited due to advance weather forecasting, blockades, and warnings. The historical record from 1993 to 2017 indicates that there have been two fatalities associated with flooding (occurring in May 2006) and five injuries associated with two flood events (occurring within 2 weeks of each other in March 2010).

Flooding can result in direct mortality to individuals in the flood zone. This hazard is particularly dangerous because even a relatively low-level flood can be more hazardous than many residents realize. Downed powerlines, sharp objects in the water, or fast-moving debris that may be moving in or near the water all present an immediate danger to individuals in the flood zone.

Events that cause loss of electricity and flooding in basements, which are where heating systems are generally located in Massachusetts homes, increase the risk of carbon monoxide poisoning. Carbon monoxide results from improper location and operation of cooking and heating devices (grills, and stoves), damaged chimneys, or generators.

According to the US Environmental Protection Agency (EPA), floodwater often contains a wide range of infectious organisms from raw sewage. These organisms include intestinal bacteria, MRSA, strains of hepatitis, and agents of typhoid, paratyphoid, and tetanus (OSHA, 2005). Floodwaters may also contain agricultural or industrial chemicals and hazardous materials swept away from containment areas. Individuals who evacuate and move to crowded shelters to escape the storm may face the additional risk of contagious disease; however, seeking shelter from storm events when advised is considered far safer than remaining in threatened areas. Individuals who evacuate and move to crowed shelters to escape the storm may face the additional risk of contagious disease; however, seeking shelter from storm events when advised is considered far safer than remaining in threatened areas. Individuals with pre-existing health conditions are also at risk of contagious disease; however, seeking shelter from storm events when advised is considered far safer than remaining in threatened areas. Individuals with pre-existing health conditions are also at risk if flood events (or related evacuations) render them unable to access medical support. Flooded streets and roadblocks can also make it difficult for emergency vehicles to respond to calls for service, in particularly in rural areas.

Flood events can also have significant impacts after the initial event has passed. Flooded areas that do not drain properly can become breeding grounds for mosquitos, which can transmit vector-borne diseases. Exposure to mosquitos may also increase if individuals are outside of their homes for longer than usual due to power outages or other flood-related conditions. The growth of mold inside buildings is often widespread after a flood. Mold can result in allergic reactions and can exacerbate existing respiratory diseases, including asthma (CDC, 2004). Property damage and displacement of homes and businesses can lead to loss of livelihood and long-term mental stress for those facing relocation. Individuals may develop post-traumatic stress, anxiety, and depression following major flooding events (Neria et al., 2008).

Massachusetts Arbovirus

Since 2000, there have been 208 cases of West Nile Virus among Massachusetts residents resulting in at least 12 deaths and 38 cases of EEE resulting in at least 20 deaths. [45]

Massachusetts Eastern Equine Encephalitis Experience		
Year(s)	Human EEE Cases	Human EEE Deaths
1938-39	35	25
1955-56	16	9
1973-74	6	4
1982-84	10	3
1990-92	4	1
2000-01	2	0
2004-06	13	8
2008	1	1
2010-11	2 (plus 2 non-residents)	1
2012	7	3
2013	1	1
2014-2018	0	0
2019	12	6

Source: Mass Dept of Public Health Arbovirus Surveillance and Response Plan, 2020

Vector-borne Diseases

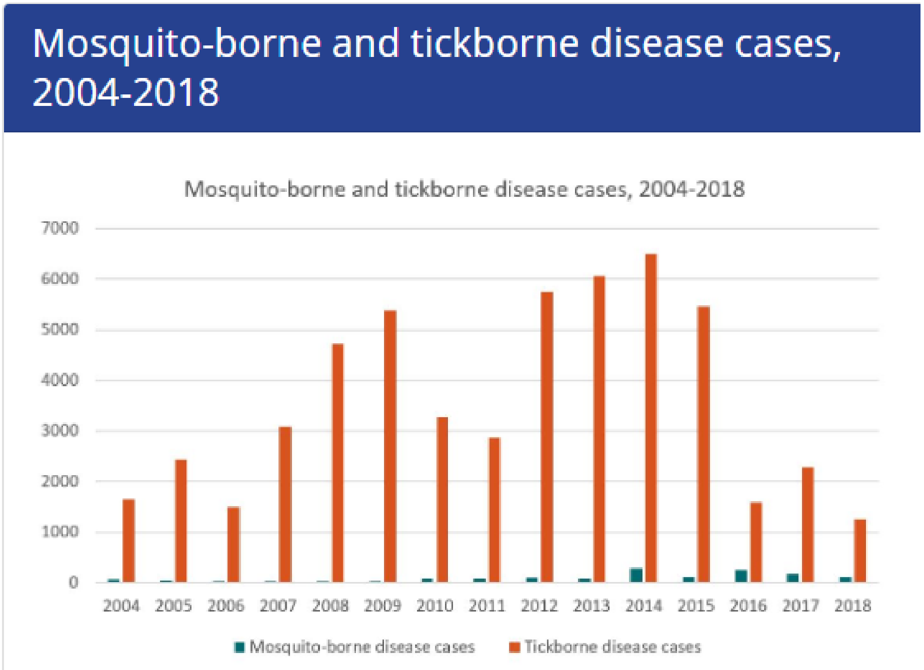
Climate is one of the factors that influence the distribution of diseases borne by vectors (such as fleas, ticks, and mosquitos, which spread pathogens that cause illness. The geographic and seasonal distribution of vector populations, and the diseases they can carry, depends not only on climate but also on land use, socioeconomic and cultural factors, pest control, access to health care, and human responses to disease risk, among other factors. Daily, seasonal, and year-to-year climate variability can sometimes result in vector/pathogen adaptation and shifts or expansions in their geographic ranges. Such shifts can alter disease incidence depending on vector-hose interaction, host immunity, and pathogen evolution. Plymouth County and Hanson are currently at risk from numerous vector-borne diseases, including Lyme, dengue fever, West Nile Virus, Rock Mountain spotted fever, plague, and eastern equine encephalitis. [46]

A changing climate's impact on the geographical distribution and incidence of vector-borne diseases in other countries where these diseases are already found can also impact North Americans, especially because of increasing trade with, and travel to tropical and subtropical areas. Whether a changing climate in the US will increase the chances of domestically acquiring diseases such as dengue fever is uncertain due to vector-control efforts and lifestyle factors, such as time spent indoors, that reduce human-insect contact.

[45] **Massachusetts Department of Public Health Massachusetts Arbovirus Surveillance and Response Plan, 2020**

[46] https://www.cdc.gov/climateandhealth/effects/vectors.htm

Figure 65: Mosquito-borne and Tick-borne Disease Cases, 2004 - 2018

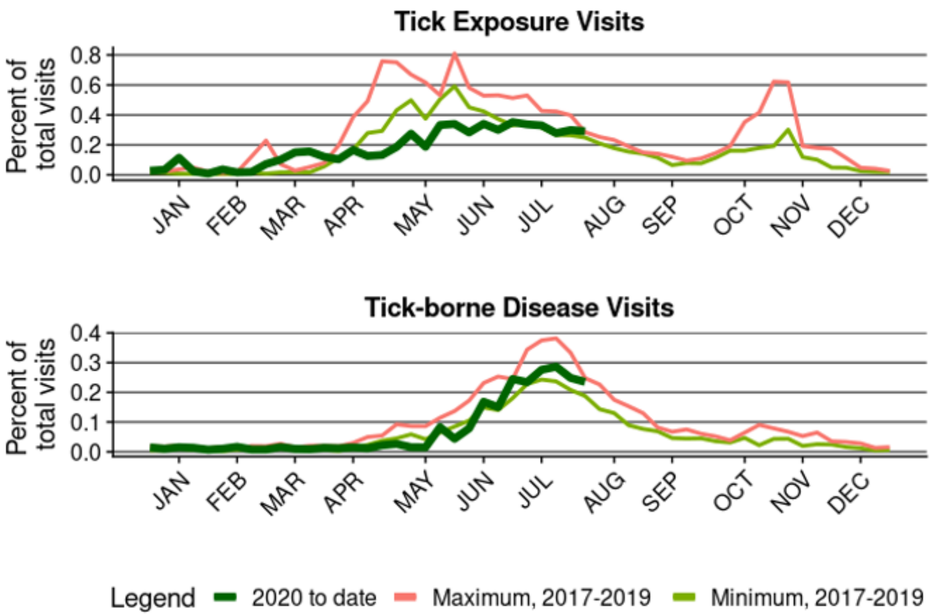


Source: https://www.cdc.gov/ncezid/dvbd/vital-signs/massachusetts.html

The graphs below show that in July of 2020, less than 0.4 percent of visits to Eds were related to exposure to ticks and less than 0.3 percent were related to diagnosis of a tick-borne disease. The 2020 data are shown compared to both the minimum and the maximum number of visits recorded over the last three years. Tick activity usually increases sometime in March or April depending on weather. [47]

[47] **Massachusetts Department of Public Health, Bureau of Infectious Disease and Laboratory Sciences. *Tick Exposure and Tick-borne Disease Syndromic Surveillance Report, July 2020.***

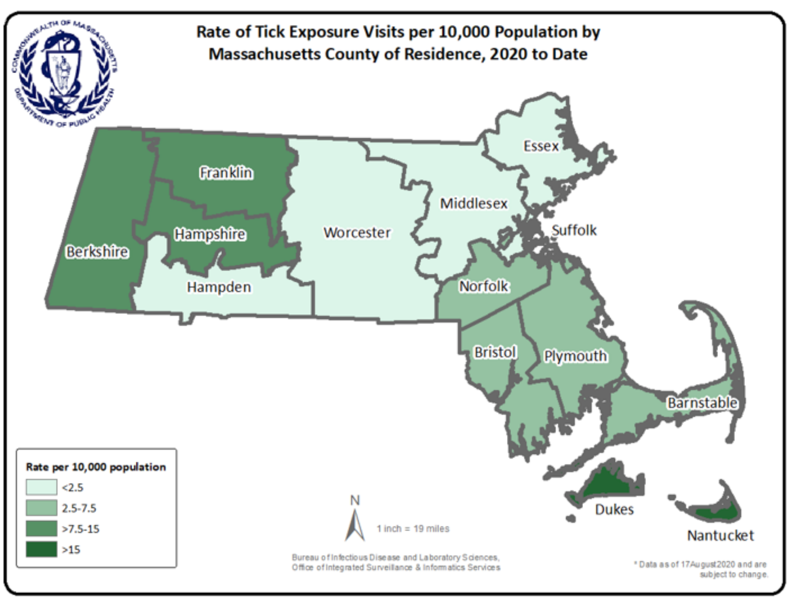
Figure 66: Tick Exposure Visits



Source: Bureau of Infectious Disease and Laboratory Science

The following map shows the rate, per 10,000 total population of ER visits by patients who had a visit related to a tick exposure, by Massachusetts county of residence, 2020 to date. Although there are differences in the rate of patient visits, this shows that people are exposed to ticks throughout all of Massachusetts and should take recommended steps to reduce the chance of being bitten.

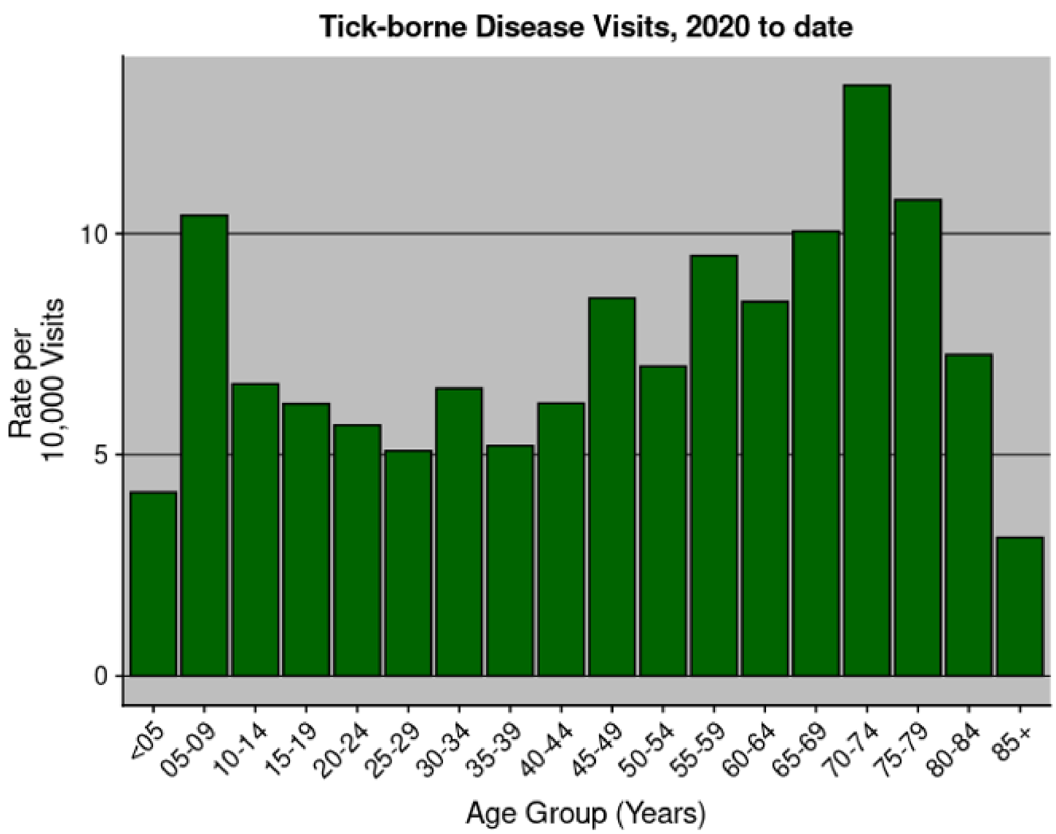
Figure 67: Rate of Tick Exposure Visits per 10,000 Population by Massachusetts County of Residence, 2020 to Date



Source: http://www.mass.gov/eohhs/gov/departments/dph/programs/id/

This graph shows the rate of emergency department visits made by patients who were diagnosed with a tick-borne disease, by age group, 2020 to date. This trend is expected and demonstrates that children ages 5-15 and older adults are more frequently diagnosed with tick-borne diseases. Children are most diagnosed with Lyme disease while older adults are more commonly diagnosed with Lyme disease, anaplasmosis, or babesiosis.

Figure 68: Tick-borne Disease Visits, 2020 to Date



Source: http://www.mass.gov/eohhs/gov/departments/dph/programs/id/

This Table shows the number and rate of emergency department visits by patients who were diagnosed with a tick-borne disease, by county 2020 to date. Although there are differences in the numbers and rates of patient visits, this table shows that people are exposed to ticks and are diagnosed with tick-borne diseases throughout all of Massachusetts. Both patients and providers should be aware of what tick-borne occur in Massachusetts.

Table 53: Emergency Department Visits

County	*Total Visits*	*Number of Tick-borne Disease Visits*	*Rate (per 10,000) of Tick-borne Disease Visits*
Barnstable	*52,155*	*56*	*10.74*
Berkshire	*36,437*	*41*	*11.25*
Bristol	*145,095*	*130*	*8.96*
Dukes/Nantucket	*8,218*	*101*	*122.9*
Essex	*177,821*	*47*	*2.64*
Franklin	*15,469*	*21*	*13.58*
Hampden	*129,922*	*40*	*3.08*
Hampshire	*28,768*	*32*	*11.12*
Middlesex	*235,378*	*127*	*5.4*
Norfolk	*124,998*	*109*	*8.72*
Plymouth	*122,121*	*148*	*12.12*
Suffolk	*194,355*	*30*	*1.54*
Worcester	*179,097*	*101*	*5.64*

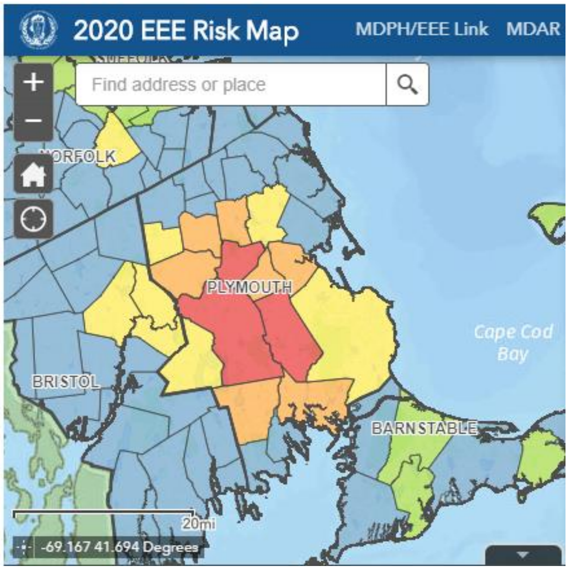
Source: http://www.mass.gov/eohhs/gov/departments/dph/programs/id/

The virus that causes EEE is spread through the bite of an infected mosquito. In Massachusetts, the virus is most often identified in mosquitos found in and around freshwater, hardwood swamps, environments prevalent in the Town of Hanson. EEE virus particularly infects birds, often with no evidence of illness in the bird. Mosquitoes become infected when they bite infected birds. Although humans and several other types of mammals, particularly horses and llamas, can become infected, they do not spread disease.

EEE is a rare disease. Since the virus was first identified in Massachusetts in 1938, just over 110 cases have occurred. Most cases typically have been from Bristol, Plymouth, and Norfolk counties. However, in an active year human cases can occur throughout the Commonwealth. [48] Outbreaks of EEE usually occur in Massachusetts every 10-20 years. These outbreaks will typically last two to three years. The most recent outbreak of EEE in Massachusetts began in 2019 and included 12 cases with 6 fatalities.

[48] **https://www.mass.gov/service-details/eee-eastern-equine-encephalitis**

Figure 69: EEE Risk Map



Lyme disease is a multistage bacterial infection, caused by a spiral-shaped bacterium transmitted by a tick bite. The condition has a wide range of signs and symptoms that can affect many different body parts, particularly the skin, joints, nervous system, or heart. Tests are required to diagnosis Lyme disease by detecting the presence of a specific antibody or in some cases, the organism itself. [49]

Source: https://www.mass.gov/info-details/massachusetts-arbovirus-update

Government

Flooding can cause direct damage to municipally owned facilities and result in road closures and inaccessible streets that impact the ability of public safety and emergency vehicles to respond to calls for service.

Floodplain Considerations for Temporary Critical Facilities

Even a slight chance of flooding can pose too great a threat to the delivery of services provided by a critical facility (such as those that provide temporary medical services, including but not limited to hospitals, medical sheltering, and mortuary facilities). Further, these critical facilities are likely to have occupants who may not be sufficiently mobile to evacuate to avoid injury or death during a flood. Site considerations for such facilities must include an evaluation of flood risk.

All critical facilities – including those of a temporary nature – should be located outside of all high-risk flood hazard areas, including Zones V and A and Shaded X. Specifically, these facilities or uses should not be in the Coastal High Hazard Area (including Zone V), the entire Special Flood Hazard Area (SFHA, or 1-percent-annual-chance flood hazard area), or the 0.2 percent-annual-chance-flood hazard area (including Shaded X zones).

[49] **https://www.massgeneral.org/medicine/rheumatology/treatments-and-services/lyme-disease**

To minimize the impacts of floods on human health, safety, and welfare, if a critical facility must be in a high-risk flood hazard area, it should be designed to higher protection standards (if possible, for a temporary facility) and have flood evacuation plans.

The following steps should be taken when considering the placement of a temporary facility providing medical services or other critical facility to determine if the function, building systems, and equipment can remain operational in the event of a flood:

- Determine if the site, as well as ingress and egress to the site, is in a Coastal High Hazard Area (Zone V), the Special Flood Hazard Area (SFHA, or 1-percent-annual-chance flood hazard area), or the 500-year floodplain (0.2 percent-annual-chance-flood hazard).
- If the site is in any of these high-risk flood hazard areas, the facility should not be located at that site.
- If no practicable alternative sites exist, and the site must be used, and assessment of the type of flood hazards at the site should be conducted (e.g., flood, velocity, flood depth, wave action, etc.), practicable opportunities for flood mitigation assessed, and a flood evacuation plan/emergency plan developed.
- The emergency plan should include a plan for site evacuation and contingency of loss of facility's function in the event the facility is damaged and can no longer serve its intended purpose.

The Built Environment

Buildings, infrastructure, and other elements of the built environment are vulnerable to inland flooding. At the site scale, buildings that are not elevated or flood-proofed and those located within the floodplain are highly vulnerable to inland flooding. These buildings are likely to become increasingly vulnerable as riverine flooding increases due to climate change (ResilientMA, 2018). At a neighborhood to regional scale, highly developed areas and areas with high impervious surface coverage may be most vulnerable to flooding. Even moderate development that results in as little as 3 percent impervious cover can lead to flashier flows and river degradation, including channel deepening, widening, and instability (Vietz and Hawley, 2016). Additionally, changes in precipitation will threaten key infrastructure assets with flood and water damage. Climate change has the potential to impact public and private services and business operations. Damage associated with flooding to business facilities, large manufacturing areas in river valleys, energy delivery and transmission, and transportation systems has economic implications for business owners as well as the state's economy in general (ResilientMA, 2018).

Climate change impacts, including increased frequency of extreme weather events, are expected to raise the risk of damage to transportation systems, energy-related facilities, communications systems, a wide-range of structures and buildings, solid and hazardous wastes facilities, and water supply and wastewater management systems. The infrastructure of Hanson has been sited and designed based on historic weather and flooding patterns and may lack the capacity to handle greater volumes of water or the require elevation to reduce vulnerability to flooding.

Agriculture: Inland flooding is likely to impact the agricultural sector. Increased river flooding is likely to cause soil erosion, soil loss, and crop damage (ResilientMA, 2018). In addition, wetter springs may delay planting of crops, resulting in reduced yields.

Energy: Flooding can increase bank erosion and undermine buried energy infrastructure, such as underground power, gas, and cable infrastructure. Basement flooding can destroy electrical panels and furnaces. This can result in releases of oil and hazardous wastes to floodwaters. Inland flooding can also disrupt delivery of liquid fuels.

Transportation: Heavy precipitation events may damage roads, bridges, and energy facilities, leading to disruptions in transportation and utility services (ResilientMA, 2018). Roads may experience greater ponding, which will further impact transportation. If alternative routes are not available, damage to roads and bridges may dramatically affect commerce and public health and safety. Bridges are inherently vulnerable to flooding.

Table 54:: Hanson Bridges Spanning Waterways

Bridge Name	Facility Carried	Waterway Spanned	Year Built	Length	Deck Area	Inspection Date	Owner	Bridge Dept. #
PFC Robert S. Hammond	HWY State Street	Indian Head River	1995	18.30	1,930.40	06/03/2018	MUN	H07004
N/A	Rt. 27 Main St	Poor Meadow Brook	1850	7.90	986.40	08/09/2018	DOT	H07001
N/A	Rt. 14 Washington St	Shumatuscacant River	1951	4.90	617.09	04/24/2019	MUN	H07002

Natural Resources and Environment

Flooding is part of the natural cycle of a balanced environment. However, severe flood events can also result in substantial damage to the environment and natural resources, particularly in areas where human development has interfered with natural flood-related processes. One common environmental effect of flooding is riverbank and soil erosion. Riverbank erosion occurs when high, fast water flows scour the edges of the river, transporting sediment downstream and reshaping the ecosystem. In addition to changing the habitat around the riverbank, this process also results in the deposition of sediment once water velocities slow. This deposition can clog riverbeds and streams, disrupting the water supply to downstream habitats. Soil erosion occurs whenever floodwaters loosen particles of topsoil and then transport them downstream, where they may be redeposited somewhere else or flushed into the ocean. Flooding can also influence soil conditions in areas where floodwater pool for long periods of time, as continued soil submersion can cause oxygen depletion in the soil, reducing the soil quality and potentially limiting future crop production.

Flooding can also affect the health and well-being of wildlife. Animals can be directly swept away by flooding or lose their habitats to prolonged inundation. Floodwaters can also impact habitats nearby or downstream of agricultural operations by dispersing waste, pollutants, and nutrients from fertilizers. While some of these substances, particularly organic matter, and nutrients, can increase the fertility of downstream soils, they can also result in severe impacts to aquatic habitats, such as eutrophication.

Figure 70: Wampatuck Pond Cyanobacteria Bloom

Economy

Economic losses due to a flood include damages to buildings and infrastructure, agricultural losses, business interruptions (including loss of wages), impacts on tourism, and impacts on the tax base. Flooding can also cause extensive damage to public utilities and disruptions to the delivery of services. Loss of power and communications may occur. Flooding can shut down major roadways making it difficult for people to get to work. Floodwaters can wash out sections of roadway and bridges, and the removal and disposal of debris can also be an enormous cost during the recovery phase of a flood event. Agricultural impacts range from crop and infrastructure damage to loss of livestock. Extreme precipitation events may result in crop failure, inability to harvest, rot, and increases in crop pests and disease. In addition to having a detrimental effect on water quality and soil health and stability, these impacts can result in increased reliance on crop insurance claims.

Drought

As parts of the world get drier, the amount and quality of water available will decrease, impacting people's health and food supplies. With a warmer climate, droughts could become more frequent, more severe, and longer lasting. More frequent extreme droughts could result in decreased stream flows in local rivers, affecting water supplies for domestic and agricultural uses.

Between 2000 and 2009, approximately 30 to 60 percent of the United States experienced drought conditions at any one time (NRDC, n.d.).

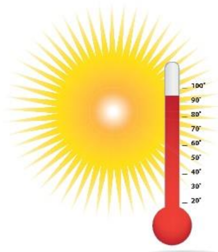
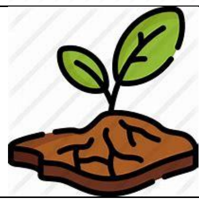
Drought is a period characterized by long durations of below normal precipitation. Drought diminishes natural stream flow and depletes soil moisture, which can cause social, environmental, and economic impacts. In general, the term "drought" is reserved for periods of moisture deficiency that are relatively extensive in both space and time. Drought conditions occur in virtually all climatic zones yet its characteristics very significantly from one region to another, since it is relative to the normal precipitation in that region.

Droughts originate from a deficiency of precipitation resulting from an unusual weather pattern. If the weather pattern lasts a short time (a few weeks or a couple of months), the drought is considered short-term. If the weather pattern becomes entrenched and the precipitation deficits last for several months or years, the drought is long-term. If tis possible for a region to experience a long-term circulation pattern that produces drought, and to have short-term changes in this long-term pattern that result in short-term weather spells that result in short-term drought.

Although New England is generally considered to be a moist region with ample precipitation, droughts are not uncommon. Widespread drought has occurred across New England several times since climate records have been kept. More frequent and severe droughts are expected as climate change continues to increase temperatures, raise evaporation rates, and soils dry out, despite heavier rainfall events. Seasonal or short-term droughts that last less than six months are most common in New England. The greatest risk for seasonal drought may be in summer and early fall because of higher temperatures that lead to greater evaporation and earlier snowmelt.[50] The most common index used to define and monitor drought is the Palmer Drought Severity Index (PDSI), which attempts to measure the duration and intensity of long-term, spatially extensive drought, based on precipitation, temperature, and available water content data.

[50] **Massachusetts Wildlife Climate Action Tools.**

Drought		
Hazard	**Significant**	**Justification**
Drought 	YES	Drought was not identified as a hazard in the 2015 HMP for OCPC. Current frequency for Hanson is 1% any given month. Long-term drought can have moderate to high-risk effects on both the environment and the economy. Reduced water levels also cause loss of landscape due to restrictions on outdoor watering, and therefore less crop production and loss of business revenues. Limited and scattered property damage, limited damage to public infrastructure and essential services not interrupted. • Entire Commonwealth is vulnerable and impacts on all sectors are widespread. • Chance of Watch level drought occurring in any given month: 8% • Frequency and intensity projected to increase during the summer and fall.
Exposure and Vulnerability by Key Sector		
	Populations	**General At-Risk Populations:** Statewide exposure. **Vulnerable Populations:** Residents with a private water supply, persons who receive water through a public provider; populations with respiratory health conditions.
	Government	Drought impacts on government facilities are limited, except for facilities like parks that rely on specific environmental conditions. However, droughts contribute to conditions that can be conducive to wildfire and firefighting can be hampered by water shortage.
	Built Environment	Some infrastructures may not be built to operate during drought conditions. For groundwater supply deeper wells may be needed or alternate supplies found for emergency backup during severe droughts. Drier summers and intermittent droughts may strain irrigation water supplies, stress crops, and delay harvests.
	Natural Resources and Environment	Prolonged droughts can have severe impacts on groundwater and surface water dependent ecosystems and natural resources, as most organisms require water throughout their life cycle. Forests managed for timber or other economic uses could experience reduced growth rates or mortality during periods of drought.
	Economy	The economic impacts of drought can be significant in the agriculture, recreation, forestry, and energy sectors. Economic impacts might also include purchasing water during drought emergencies. Crop failure can also result in an increase in food prices, placing economic stress on a broader portion of the economy.

Potential Effects of Climate Change		
	Drought - Rising Temperatures and Changes in Precipitation – Prolonged Drought	The frequency and intensity of drought are projected to increase during summer and fall in the Northeast as higher temperatures lead to greater evaporation and earlier winter and spring snowmelt, and precipitation patterns become more variable and extreme.
	Rising Temperatures and Changes in Precipitation – Reduced Snowpack	Due to climate change, the proportion of precipitation falling as snow and the extent of time snowpack remains are both expected to decrease. This reduces the period during which snowmelt can recharge groundwater supplies, bolster streamflow, and provide water for the growing period.
	Changes in Precipitation – Episodic droughts	Vegetated ground cover has been shown to significantly reduce runoff. If drought causes vegetation to die off, this flood-mitigating capacity is diminished.

Drought Assessment and Determination

Drought Levels

For the purposes of this Plan, conditions are classified into five levels: a normal condition and four drought severity levels. These levels are based on five drought indices, observed impacts to various resources and forecasts.

Level 0 - Normal
Level 1 - Mild Drought (formerly Advisory)
Level 2 - Significant Drought (formerly Watch)
Level 3 - Critical Drought (formerly Warning)
Level 4 - Emergency Drought

These levels are based on the regional conditions and are designed to provide information about the status of water resources. A Mild Drought calls for a heightened level of vigilance and increased data collection as conditions begin to deviate from normal. During a Significant Drought, increased assessment would continue, in addition to proactive public education about water conservation. Water restrictions might become necessary during the watch or warning stage, depending on the capacity and condition of each water supply system. A Critical Drought is issued during a severe situation and the possibility of a drought emergency may be issued. Finally, an Emergency Drought often requires mandatory water restrictions and/or the use of emergency water supplies (EOEEA, 2013). These categories and their associated characteristics are summarized in the following Table.

Drought Indices from the Massachusetts Drought Management Plan 2019

The Massachusetts Drought Management Plan (DMP) was created in 2001 and updated in 2013. The 2016-2017 [51] drought was the most significant drought in recent history, and it was the first time a Warning level drought was reached since the creation of the Massachusetts DMP in 2001. During this drought, the Drought Management Task Force (DMTF), staff, and stakeholders identified several aspects of the 2013 DMP that needed further updates. This appendix outlines the 2017-2019 process of reexamining and revising the drought indices as part of the DMP update, and the resulting changes to the indices.

Based on the categories outlined in the previous Table, the Massachusetts Executive Office of Energy and Environmental Affairs has compiled information about past drought declarations at a regional level. There was a relatively long drought from July 2016 to May 2017, ranging in severity from an Advisory to a Warning.

The National Drought Mitigation Center references five common, conceptual definitions of drought categorized by Wilhite and Glantz in 1985:

Meteorological Drought is a measure of departure of precipitation from normal. It is defined solely on the degree of dryness. Due to climatic differences, what might be considered a drought in one location of the country may not be a drought in another location.

Hydrological Drought is associated with the effects of periods of precipitation (including snowfall) shortfalls on the surface or subsurface water supply and occurs when these water supplies are below normal. This type of drought is related to the effects of precipitation shortfalls on stream flows and on reservoir and groundwater levels.

Agricultural Drought links various characteristics of meteorological (or hydrological) drought to agricultural impacts, such as precipitation shortages, differences between actual and potential evapotranspiration, soil water deficits, and reduced ground water or reservoir levels. It occurs when there is not enough water available for a crop to grow at a time. Agricultural drought is defined in terms of soil moisture deficiencies relative to the water demands of plant life, primarily crops.

Socioeconomic Drought is associated with the supply and demand of some economic good with elements of meteorological, hydrological, and agricultural drought. This differs from the types of

[51] The 2016-2017 timeframe designation for this drought is based on when there were official drought declarations by the Secretary of Energy and Environmental Affairs. There were, however, portions of the state that experienced dry conditions in 2015, and the U.S. Drought Monitor placed part or all the state in level 1 drought status during different portions of 2015.

drought because its occurrence depends on the time and space processes of supply and demand to identify or classify droughts. The supply of many economic goods depends on the weather (e.g., water, forage, food grains, fish, and hydroelectric power). Socioeconomic drought occurs when the demand for an economic good exceeds the supply because of a weather-related shortfall in the water supply.

Ecological Drought is an episodic deficit in water availability that drives ecosystems beyond thresholds of vulnerability, impacts ecosystem services, and triggers feedbacks in natural and/or human systems (Crausbay et al., 2017).

There are also multiple operational definitions of drought. An operational definition attempts to quantitatively characterize the onset and end of droughts as well as the severity or levels during the drought.

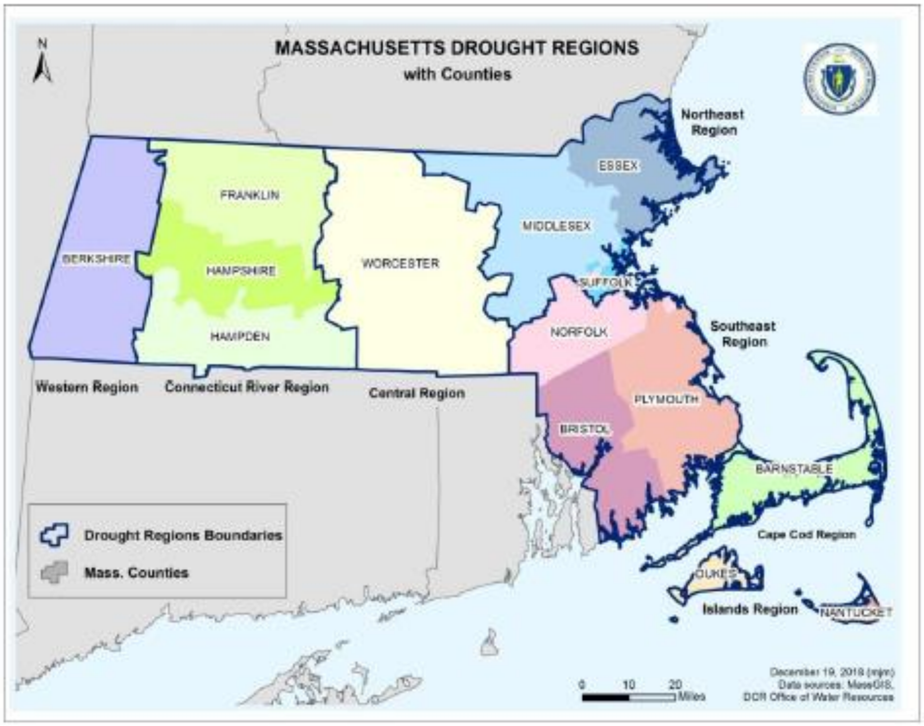
Drought Regions

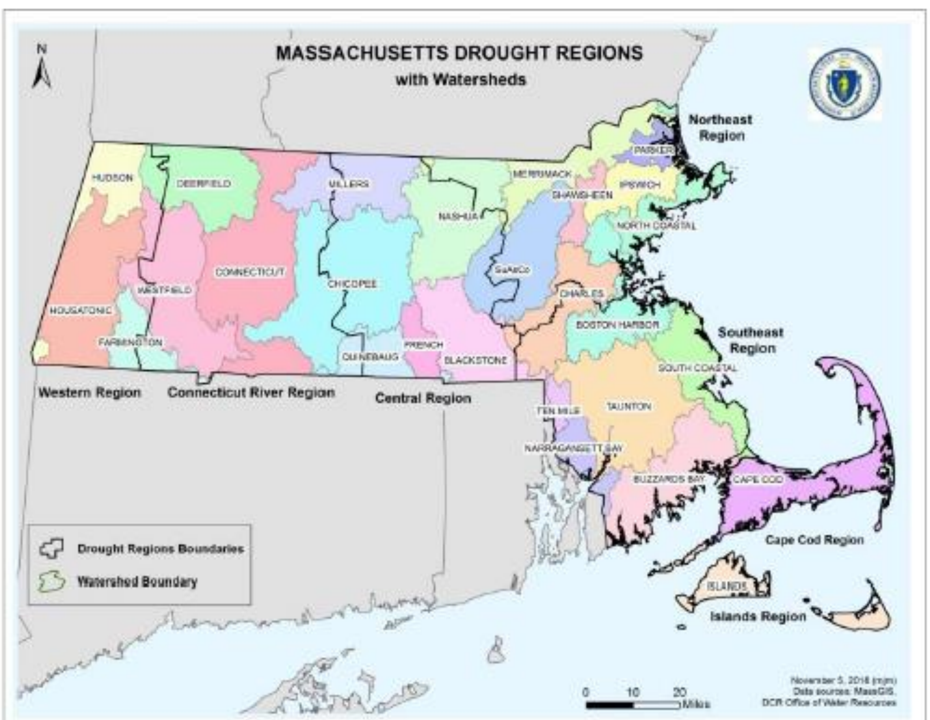
Regions across the Commonwealth differ in precipitation patterns, topography, land use, population density, and other factors that affect drought propensity and intensity. This Plan delineates seven Drought Regions to allow flexibility and customization of drought declarations and response actions for different areas within the Commonwealth. The Drought Regions represent broad geographic areas, originally based on precipitation patterns, which have been refined along their boundaries to align with county boundaries. County alignment facilitates more streamlined communication and response when droughts occur.

Table 55: Counties within Each Drought Region

Drought Region	Counties
Western	Berkshire
Connecticut River Valley	Franklin, Hampshire, and Hampden
Central	Worcester
Northeast	Essex, Middlesex, and Suffolk (plus town of Brookline)
Southeast	Bristol, Plymouth, and Norfolk (minus town of Brookline)
Cape Cod	Barnstable
Islands	Nantucket and Dukes

Figure 71: Massachusetts Drought Regions with Counties and Watersheds





During a drought, these regions may be adjusted based on the conditions of the drought.

Previous Occurrences

The following Table reflects only the time of recorded history going back to the late 1800s. Newby et. Al. (2014) reconstructed centennial and longer paleohydrologic changes in the Northeastern United States.[52] They concluded that the condition of water resources historically experienced are at high water levels relative to pre-recorded history and there is a low probability of these "wet" conditions remaining at current levels in coming decades and centuries. The Commonwealth of Massachusetts has never received a Presidential Disaster Declaration for a drought-related disaster; however, the Commonwealth has experienced several substantial droughts over the past 100 years and has recorded events dating back to 1879.

Beginning in 1960 in western Massachusetts and in 1962 in eastern Massachusetts through 1969, Massachusetts experienced the most significant drought on record (USGS, 2004). The severity and duration of the drought caused significant impacts on both water supplies and agriculture.

Although short or relatively minor droughts occurred over the next 50 years, the next long-term event began in March 2015, when Massachusetts began experiencing widespread abnormally dry conditions. In July 2016, based on a recommendation from the Drought Management Task Force (DMTF), the Secretary of EOEEA declared a Drought Watch for Central and Northeast Massachusetts and a Drought Advisory for Southeast Massachusetts and the Connecticut River Valley. Drought warnings were issued in five out of six drought regions of the state. Many experts stated that this drought was the worst in more than 50 years. However, the DMTF was able to declare an end to the drought in May 2017, since the entire Commonwealth had returned to "normal" conditions due to wetter-than-normal conditions in the spring of 2017 (SHMCAP, 2018).

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[52] **Newby, P.E.; Shuman, B.N.; Donnelly, J.P.; Karnauskas, K.B.; Marsicek, J. 2014. Centennial-to-millennial hydrologic trends and variability along the North Atlantic Coast, USA, during the Holocene. *Geophysical Research Letters:* 4300-4307 https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2014GL060183**

Table 56:Droughts in Massachusetts Based on Instrumental Records

Date	Area Affected	Recurrence Interval (years)	Remarks	Reference
1879-83			Kinnison 1931 referenced these periods as two of three worst droughts on record in 1931, the third being the then current drought of 1929-32	Kinnison 1931 [53]
1908-12				
1929-32	Statewide	10 to > 50	Water-supply sources altered in 13 communities. Multistate	USGS 1989 [54]
1939-44	Statewide	15 to > 50	More severe in eastern and extreme western Massachusetts. Multistate	USGS 1989
1957-59	Statewide	5 to 25	Record low water levels in observation wells, northeastern Massachusetts.	USGS 1989
1961-69	Statewide	35 to > 50	Water-supply shortages common. Record drought. Multistate	USGS 1989
1980-83	Statewide	10 to 30	Most severe in Ipswich and Taunton River basins; minimal effect in Nashua River basin. Multistate	USGS 1989
1985-88	Housatonic River Basin	25	Duration and severity yet unknown. Streamflow showed mixed trends elsewhere	USGS 1989
1995	-	-	Based on statewide average precipitation	DMP 2013 [55]
1998-1999	-	-	Based on statewide average precipitation	DMP 2013
Dec 2001 – Jan 2003	Statewide	-	Level 2 Drought (out of 4 levels) was reached statewide for several months	DCR 2017 [56]
Oct 2007 – Mar 2008	Statewide except West and Cape & Islands Region	-	Level 1 drought (out of 4 levels)	DCR 2017

[53] Kinnison, HB 1931. The 1929-1930 Drought in New England. Journal of the New England Water Works Association, v. 45, no. 2, p. 145-163. Kinnison compared runoff for the three periods from two regulated lake basins; runoff during the 1908-12 and 1929-30 droughts was about equal to and less than the runoff during the 1879-83 drought. Later analysis indicated that the 1929-30 drought extended for two more years and thus became the 1929-32 drought.

[54] USGS (US Geological Survey). 1989. Water-Supply Paper 2375: National Water Summary 1988-89—Floods and Droughts: Massachusetts (https://md.water.usgs.gov/publications/wsp-2375/ma/ USGS 1989 determined dry periods from streamflow and precipitation records. Dry periods that exceed a recurrence interval of 10 years were deemed droughts.

[55] DMP 2013: Massachusetts Executive Office of Energy and Environmental Affairs and Massachusetts Emergency Management Agency. 2013. Massachusetts Drought Management Plan. This plan analyzed precipitation data as a statewide average of stations.

[56] DCR 2017: The Department of Conservation and Recreation (DCR) compiled data based on historical drought declarations by the state using the methods in the 2013 Massachusetts Drought Management Plan.

Aug 2010 – Nov 2010	Connecticut River Valley, Central and Northeast Regions	-	Level 1 drought (out of 4 levels)	DCR 2017
Oct 2014- Nov 2014	Southeast and Cape & Islands Region	-	Level 1 drought (out of 4 levels)	DCR 2017
Jul 2016 – Apr 2017	Statewide	-	Level 3 drought (out of 4 levels)	DCR 2017

Source: Massachusetts Drought Management Plan, 2019

Significant periods of drought have occurred in Plymouth County in the past. The Massachusetts Department of Conservation and Recreation (DCR) compiles monthly water conditions reports, summarizing the rainfall and its diversion from average conditions for each of the 6 regions in the Commonwealth (Cape Cod and Islands, Central, Connecticut River, Northeast, Southeast and Western). Data for the Southeast region from a recent twelve (12) month period (DCR 2018) is summarized in the Table below.

Table 57: Summary of the Southeast Region Rainfall from DCR Hydrologic Conditions Reports (2019)

Month-Year	Total Rainfall (inches)	Departure from normal (inches)
Jan 2019	6.04	2.12
Feb 2019	3.56	0.02
Mar 2019	3.34	-0.90
Apr 2019	6.98	3.05
May 2019	3.85	0.47
June 2019	4.50	1.13
July 2019	5.87	2.54
Aug 2019	3.19	-0.07
Sept 2019	1.92	-1.84
Oct 2019	6.01	1.62
Nov 2019	3.88	-0.47
Dec 2019	7.70	4.70
Total	56.84	+12.37

The evolution of this drought can be seen in the yearly statistics shown in the following Table. For example, in September 2016, 100 percent of the Commonwealth was categorized above “abnormally dry” and 90 percent was categorized as “severe drought” or higher. In summer 2017, these metrics indicate that the Commonwealth experienced no drought conditions (SHMCAP, 2018).

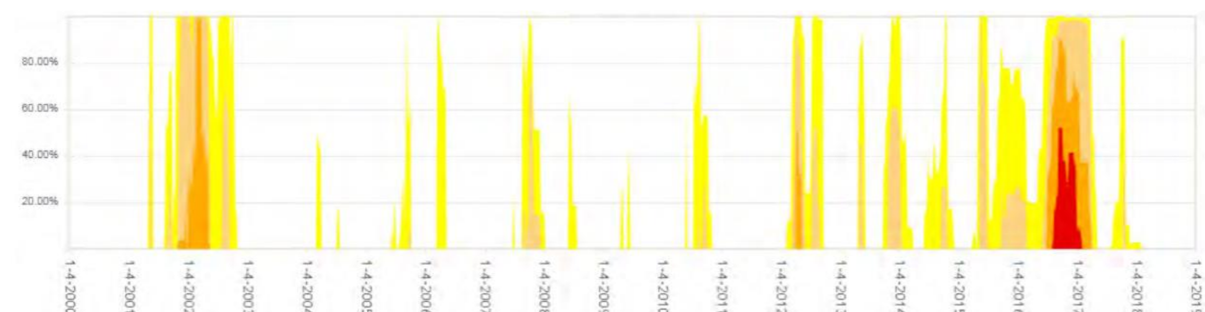
Table 58: Evolution of 2016 - 2017 Drought

Time	Percent of Commonwealth at a Given Drought Level					
	None	D0 (Abnormally Dry) or above	D1 (Moderate Drought) or above	D2 (Severe Drought) or above	D3 (Extreme Drought) or above	D4 (Exceptional Drought)
September 2016	0%	100%	98%	90%	52%	0%
December 2016	1%	99%	98%	69%	36%	0%
May 2017	100%	0%	0%	0%	0%	0%

Source: U.S. Drought Monitor, 2017

The following Figure depicts the incidents and percent area of drought levels' occurrence in Massachusetts from 1850 to 2018 using the Standardized Precipitation Index (SPI) parameter alone. On a monthly basis, the Commonwealth would have been in a Drought Watch to Emergency condition 11 percent of the time between 1850 and 2012.

Figure 72: Percent Area in Massachusetts with Drought Conditions 2000 - 2018

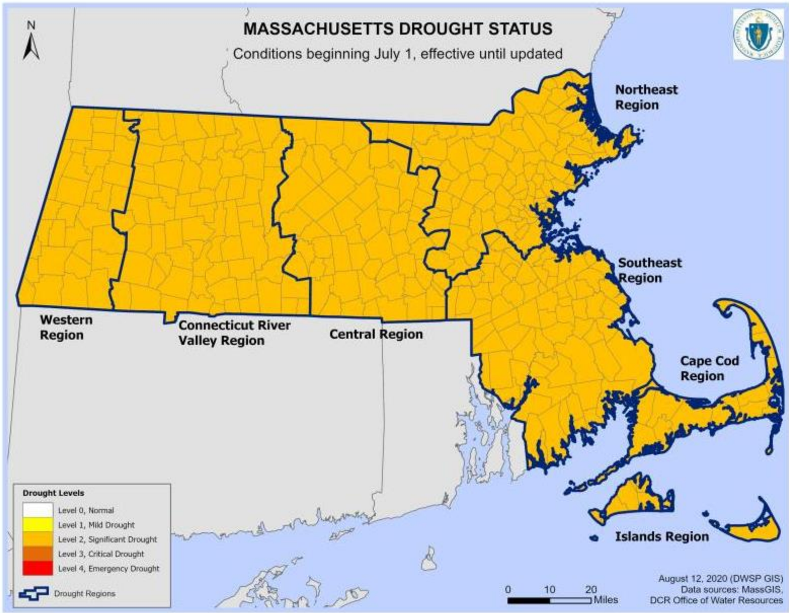


Source: US Drought Monitor

Current Drought Conditions 2020

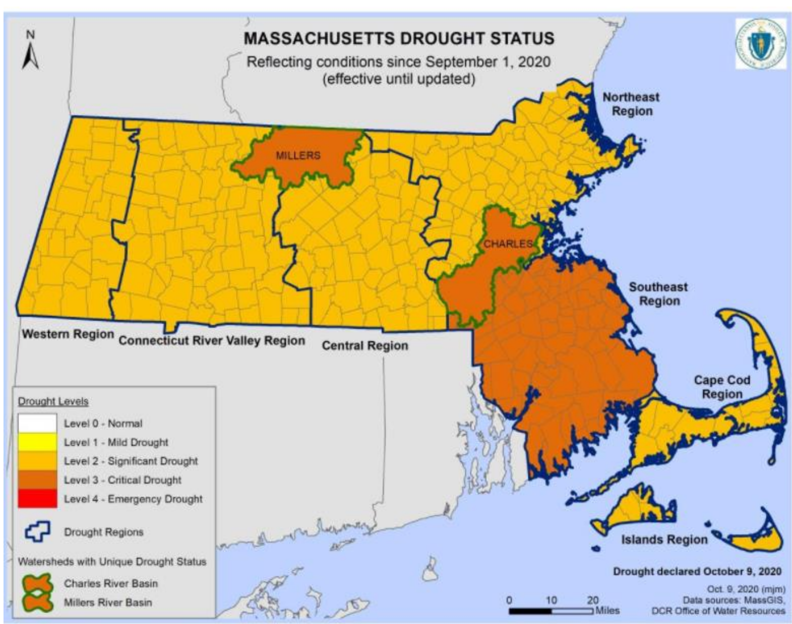
Due to above normal temperatures throughout July and early August and more than four months of below normal rainfall, Energy and Environmental Affairs (EEA) declared a Level 2 – Significant Drought in all seven regions of the Commonwealth. At a Level 2 – Significant Drought conditions are becoming significantly dry and warrant detailed monitoring of drought conditions, close coordination among state and federal agencies, emphasis on water conservation, more stringent watering restrictions and technical outreach and assistance. Dry conditions increase the threat of brush and wildland fires, so residents are advised to exercise caution when using charcoal grills, matches and other open flames during outdoor activities.

Figure 73: Massachusetts Drought Status Summer 2020



Extended drought conditions have rendered grasses, shrubs, and forest fuels very dry across most of the state, and extremely dry in areas of the Southeast, resulting in increased wildfire risk and added challenges for firefighting agencies. Long term precipitation deficits have also led to extremely dry soil conditions, which results in fires burning deep into the ground, and taking multiple days to extinguish. These conditions exhaust local resources and increase risk to firefighter safety. Fire officials remind the public to be very aware of this situation, and to be careful with all open burning and disposal of combustible materials.

Figure 74: Massachusetts Drought Status Fall 2020



Source: https://www.mass.gov/info-details/drought-status

On October 9, 2020 due to five months of below normal rainfall, Energy and Environmental Affairs (EEA) Secretary Kathleen Theoharides declared a Level 3 – Critical Drought in the Southeast Region of the Commonwealth. At a Level 3 Critical Drought there is an increased reliance on mandatory conservation measures to augment voluntary measures.

Community Drought Response Actions

During a drought, the general roles and responsibilities of local authorities may include the following:

- Gathering available drought information for the community and identifying information gaps
- Identifying vulnerable aquatic ecosystems
- Implementing a local drought plan and a water conservation program
- Managing community water supplies

*Table 59: Example of Staged Drought Response Matrix**

		STATE DROUGHT LEVEL and DESCRIPTION			
	ACTIONS	**Level 1: MILD DROUGHT**	**Level 2: SIGNIFICANT DROUGHT**	**Level 3: CRITICAL DROUGHT**	**Level 4: EMERGENCY DROUGHT**
	Reservoir Trigger(s)	Fill in if using local reservoir triggers for staged drought response			
ACTION CATEGORY	Groundwater Trigger(s)	Fill in if using local groundwater triggers for staged drought response			
Coordination	Drought Management Team (DMT)	Convene Monthly DMT Meetings	Biweekly or weekly DMT Meetings	Weekly or Daily DMT Meetings	Daily DMT Meetings
Demand Management	Nonessential Outdoor Watering	1 day per week watering, before 9 am and after 5 pm.	Hand-held watering only, before 9 am and after 5pm	No nonessential outdoor water use	No nonessential outdoor water use
	New sod, seeding, and landscaping	Follow best management practices for efficient watering.	Installation of new sod, seeding, and landscaping is discouraged	Installation of new sod, seeding, and landscaping is strongly discouraged.	Installation of new sod, seeding, and landscaping is prohibited.
	Water Savings Goal	reduce use by __%	reduce use by __%	reduce use by __%	reduce use by __%
Water Supply Augmentation	Interconnections/Backup and Emergency Supplies	Review/test backup supplies	Prepare for/ possible activation of backup supplies	Possible activation of backup supplies	Activate backup supplies
Communication	Website/Press/Social Media	Update website and social media with latest information on drought status and restrictions/tips	Weekly Tweets on Water Conservation	Press Events and Weekly or Daily Social Media Updates	Daily Communication using all tools

**A complete drought response matrix would include additional actions for each category*

- Providing timely information to the public about water supplies, low stream flows, projected flow levels without water conservation efforts, public health risks, and drought conditions.
- Communicating with the appropriate state agencies in the coordination of drought response.
- Coordinating with local water agencies/suppliers to ensure local systems can provide water sufficiently to meet public health and safety needs.
- Establishing MOUs or emergency contracts for portable drinking water, as needed.
- Imposing water restrictions and other measures early so that serious deficits, pressure problems, environmental impacts, or water quality issues are avoided to the greatest extent possible.

Local or Regional Water Agencies/Suppliers

- In conjunction with MassDEP and DPU, manage systems to ensure that they can provide water sufficiently to meet public health and safety needs.
- Systems like the Massachusetts Water Resources Authority (MWRA) water supply system, which serve areas outside their watersheds, may assess their water supply conditions, and initiate their own plan based on the capacities of their system, in addition to the regional indices.
- Implement up-to-date emergency response plans.
- Educate the public and elected officials on the need to impose water restrictions and other measures early so that serious deficits, pressure problems, environmental damage, or water quality issues are avoided to the greatest extent possible
- During dry conditions, coordinate with local governments to request mandatory or voluntary reductions in water use and/or declare a local water emergency (either under local bylaw or through petition to the MassDEP) based on the status of local water supplies.

Local Public Health and Safety Agencies

- Coordinate with other members of local government to provide timely information to the public about water supplies, public health risks, water conservation efforts, and drought.
- Communicate with self-supplied households on the status of their water systems and provide technical assistance as needed.
- Communicate with the appropriate state agencies in the coordination of drought response.
- Provide technical assistance as needed.
- Coordinate with local water agencies/suppliers to ensure local systems can provide water sufficiently to meet public health and safety needs.
- Establish MOUs or emergency contracts for portable water, as needed.

Possibility of Future Occurrences

According to the 2018 State Hazard Mitigation Plan, the last emergency level drought was in the 1960s, but since then multiple severe droughts have occurred, including two at the Warning level and four at the watch level. Although shorter in duration, the severity of the 2016 drought was equivalent to that of the 1960s. However less severe droughts occur more often. Based on historical precipitation data analyzed in the Drought Management Plan, there is approximately an 8% change of a Watch level drought occurring in any given month.

Temperatures remain well above normal, as the Commonwealth recorded the seconded hottest July on record last month.[57] Rainfall was scattered across the state with only a few areas receiving above normal precipitation; most areas were in a deficit by 1 to 3 inches. Temperatures throughout the first two weeks of August 2020 are 2 to 4 degrees above normal throughout Massachusetts, with warmer than normal temperatures predicted in the coming weeks and months. While most regions of the Commonwealth are experiencing a classic long-term drought, the Southeast, Cape Cod, and Islands regions are experiencing conditions akin to a "flash drought" which is a rapid onset drought with decreased precipitation, above normal temperatures, and incoming radiation resulting in abnormally high evapotranspiration all combining to increase fire danger and decrease crop moisture levels.

Responsibility of State and Federal Agencies for Drought Situations

Table 60: Responsibilities of State and Federal Agencies

Agency	Responsibilities
Department of Agricultural Resources	• Monitor and report on crop moisture status and agricultural impacts from drought in coordination with UMass Extension. • Communicate with USDA for federal assistance, as appropriate. • Communicate with agricultural community about available aid and provide technical assistance
Department of Conservation and Recreation	Office of Water Resources • Manage the state's network of precipitation observation stations and a precipitation database. • Coordinate, collect, and analyze data to deliver monthly reports on six drought indices. • Assist in DMTF meeting preparation and follow up. Forestry • Monitor and report on level of fire danger in each drought region. • Mange state fire suppression resources • Coordinate with local, state, federal agencies, and other states to mobilize resources, as needed. Engineering and Dam Safety • Assess conditions and report on flood control dams. • Report on other critical DCR infrastructure
Department of Environmental Protection	► Provide list of communities with voluntary and mandatory water bans (as reported) and declared water emergencies.

[57] https://www.mass.gov/news/significant-drought-conditions-declared-across-massachusetts

	▶ Review petitions from public water systems to declare a state of water emergency and declare such emergencies with applicable requirements for communities facing public health or safety threats due to drought impacts to their water supply systems. ▶ Provide information on public water supplies, drinking water quality, water pressure or public health concerns associated with drinking water supplies. ▶ Ensure that any public water supply with a public heath order notify its customers and its local Board of Health
Department of Fire Services	▶ Provide guidance and support on pre-planning, risk assessment and Fire Code requirements relating to water supplies for fire-fighting purposes.
Department of Fish and Game	▶ Monitor and report on impacts to coastal and inland ecosystems, flora, and fauna
Department of Public Health	▶ Summarize any public health issues related to drought such as impacts to private wells, beaches, lakes, and ponds, etc.
National Weather Service	▶ Provide summary of precipitation data, historical comparisons, and forecasts of weather and riverine conditions
United States Geological Survey	▶ Provide summary of groundwater, streamflow, and surface water conditions

Table 61: Critical Information and Agencies or Organizations Responsible for Reporting

Information	Agency or Organization
Groundwater levels, streamflow, and levels of lakes and impoundments	Department of Conservation and Recreation (DCR): Office of Water Resources (OWR) United States Geological Survey (USGS) United States Army Corps of Engineers (USACE)
Precipitation and temperature	DCR OWR National Weather Service (NWS)
Forecast and weather information.	NWS USGS
List of communities with reported voluntary and mandatory water bans and declared water emergencies.	Department of Environmental Protection (MassDEP)
Other drinking water quality, water pressure or public health concerns associated with drinking water supplies.	MassDEP Department of Public Health (DPH) Massachusetts Water Works Association (MWWA)
Quabbin and Wachusett reservoir levels and status of MWRA communities' water supplies	DCR Massachusetts Water Resources Authority (MWRA)
Fire danger levels, forest fire conditions	DCR Bureau of Forest Fire Control and Forestry Department of Fire Services State Fire Marshal
Soil, crop, livestock and other agricultural conditions and impacts	Department of Agricultural Resources (DAR) United States Department of Agriculture (USDA) Farm Services Agency (FSA)
Public utility impacts	Department of Public Utilities (DPU)
Public health impacts	Department of Public Health (DPH) Massachusetts Association of Health Boards (MAHB)
Ecosystems, forests, flora, and fauna impacts	Department of Fish and Game (DFG), DCR (as applicable)
Other	As reported through the Drought Impact Reporter or other sources.

Drought Warning

Drought Warning levels not associated with drought Emergencies have occurred five times, in 1894, 1915, 1930, 1985, and 2016. On a monthly basis over the 162-year period of record, there is a two percent chance of being in a drought Warning level. From July – December 2016, a Drought Warning was declared for the Northeast region, which includes the Town of Hanson. December 2015 marked the ninth consecutive month of below average rainfall. In response to the drought, surface drinking water supply was severely impacted, and the Hanson Water Department imposed a Level V Watering Restriction.

Drought Watch

Drought Watches not associated with higher levels of drought generally have occurred in three to four years per decade between 1850 and 1950. In the 1980s, there was a lengthy drought Watch level of precipitation between 1980 and 1981, followed by a drought Warning in 1985. A frequency of drought Watches at a rate of three years per decade resumed in the 1990s (1995, 1998, 1999). In the 2000s, drought Watches occurred in 2001 and 2002. The overall frequency of being in a drought Watch is 8 percent monthly over the 162-year period of record.

Warning Time

Typically, droughts develop over long periods of time relative to other hazards. For example, drought development can be tracked over months and levels of drought may be increased to warn of growing or impending negative impacts that may require more intensive interventions. However, more recently, "flash droughts" are changing these norms (AMS, 2017). Flash droughts may develop quickly or quickly intensify a developing or existing drought. The most recent example is that of the 2016-2017 drought. Dry conditions from late 2015 lingered through the winter, with scattered groundwater levels reporting below normal and less than normal snowpack heading into spring 2016. Impacts were first seen in March 2016 in stream flows, groundwater levels, and reservoirs showing the long-term deficit from 2015 (lack of recharge resulting in low groundwater and base flow and lack of spring melt). Then, as precipitation dramatically dropped below normal from June through September 2016, the entire state experienced record low stream flows and groundwater levels. The combination of dry conditions and sudden loss of precipitation resulted in relatively quick impacts. NOAA and others are now advancing the science of early warning for droughts like the early warnings for floods and earthquakes to better project flash droughts. Based on projected climate change, the distributions of precipitation events will continue to become more extreme, with periods of minimal rain alternating with extreme rain events. Therefore, developing ways to project and adapt to flash droughts may be critical for sectors such as agriculture and water supply. The Massachusetts Water Resources Commission publishes the hydrologic conditions report monthly, which includes the seven drought indices and the National Climate Prediction Center's U.S. Monthly and Seasonal Drought Outlooks. The National Drought Mitigation Center produces a weekly Drought Monitor map. Although this resource does not include groundwater and reservoir levels, it can be used to monitor general changes in conditions during droughts between the monthly hydrologic condition's reports. In accordance with the DMP, drought declarations are made monthly.

Secondary Hazards

The secondary hazard most associated with drought is wildfire. A prolonged lack of precipitation dries out vegetation, which becomes increasingly susceptible to ignition as the duration of the drought extends.

Sectors Assessed

Populations

Under a severe long-term drought, the Town of Hanson could be vulnerable to restrictions on water supply. Potential damages of a severe drought could include losses of landscaped areas if outdoor watering is restricted and potential loss of business revenues if water supplies were severely restricted for a prolonged period. As this hazard has never occurred to such a degree in Hanson, there are no data or estimates of potential damages, but under a severe long-term drought scenario it would be reasonable to expect a range of potential damages.

The number and type of impacts increase with the persistence of a drought as the effect of the precipitation deficit cascades down parts of the watershed and associated natural and socioeconomic assets. For example, a precipitation deficiency may result in a rapid depletion of soil moisture that may be discernible relatively quickly to agriculture. The impact of this same deficiency on reservoir levels may not affect hydroelectric power production, drinking water supply availability, or recreational uses for many months.
The Town of Hanson can minimize the impacts on residents and water consumers should several consecutive dry years occur. No significant life or health impacts are anticipated because of drought within the planning area.

Because droughts can be widespread and long-term events without discrete boundaries, individual populations that are likely to be exposed cannot be isolated. Thus, the entire population of Massachusetts can be exposed to drought events. The vulnerability of populations to this hazard can vary significantly based on water supply sources and municipal water use policies.

Vulnerable Populations

Drought conditions can cause a shortage of water for human consumption and reduce local firefighting capabilities. Public water suppliers (PWSs) provide water for both services and may struggle to meet system demands while maintaining adequate pressure for fire suppression and meeting water quality standards. The populations on public water supplies are as vulnerable as the emergency response plans of their PWS. The Massachusetts Department of Environmental Protection (DEP) requires all PWSs to maintain an emergency preparedness plan. Residential well owners are as vulnerable as their ability to re-drill or temporarily relocate.

Health Impacts

According to the Centers for Disease Control and Prevention (CDC), droughts can have a wide range of health impacts (CDC, 2017). The impacts of reduced water levels are complex and depend on the water source. Supplies generated from direct riverine withdrawals may experience increased pollutant concentrations because of a reduction in water available for the dilution of authorized discharges under the National Pollutant Discharge Elimination System or naturally occurring constituents. These increased concentrations may affect water supply treatment and exposure via recreational swimming and fishing. Cyanobacteria blooms can render surface water drinking supplies unusable and necessitate the purchase of emergency water supplies, as occurred in the Midwest in 2014 (EcoWatch, 2014). Water levels may also drop below supply intakes. In addition, stagnant water bodies may develop and increase the prevalence of mosquito breeding, thus increasing the risk for vector-borne illnesses. Finally, unexpectedly low water levels may result in injuries for recreational users engaged in activities like boating, swimming, or jumping in water.

With declining groundwater levels, residential well owners may experience dry wells or sediment in their water due to the more intense pumping required to pull water from the formation and to raise water from a deeper depth. Wells may also develop a concentration of pollutants, which may include nitrates and heavy metals (including uranium) depending on local geology.

The loss of clean water for consumption and for sanitation may be a significant impact depending on the affected population's ability to quickly drill a deeper or a new well or to relocate to unaffected areas.

During a drought, dry soil and the increased prevalence of wildfires can increase the number of irritants (such as pollen or smoke) in the air. Reduced air quality can have widespread deleterious health impacts but is particularly significant to the health of individuals with pre-existing respiratory health conditions like asthma (CDC, n.d.). Lowered water levels can also result in direct environmental health impacts, as the concentration of contaminants in swimmable bodies of water will increase when less water is present.

Government - Critical Facilities

Critical facilities as defined for this plan will continue to be operational during a drought. Critical facility elements such as landscaping may not be maintained due to limited resources, but the risk to the planning area's critical facilities inventory will be largely aesthetic. These aesthetic impacts are not considered significant.

Additionally, droughts contribute to conditions conducive to wildfires. All critical facilities in and adjacent to the wildland-urban interface are considered vulnerable to wildfire. Governmental facilities that rely on water to perform their core function, such as public swimming pools or grass athletic fields, may face additional challenges during times of water restriction.

Built Environment

No structure will be directly affected by drought conditions, though some structures may become vulnerable to wildfires, which are more likely following years of drought. Droughts can also have significant impacts on landscapes, which could cause a financial burden to property owners. However, these impacts are not considered critical in planning for impacts from the drought hazard.

Agriculture

Drier summers and intermittent droughts may strain irrigation water supplies, stress crops, and delay harvests (resilient MA, 2018). Droughts affect the ability of farmers to provide fresh produce to neighboring communities. Insufficient irrigation will impact the availability of produce, which may result in higher demand than supply. This can drive up the price of food, leading to economic stress on a broader portion of the economy. Food banks may also experience a shortage in produce and a diminished capacity to provide food to pantries and other charities. Farmers with wells that are dry are advised to contact the Massachusetts Department of Agricultural Resources to explore microloans through the Massachusetts Drought Emergency Loan Fund or to seek federal Economic Injury Disaster Loans.

Energy

Public water supply systems and other systems that rely on water for cooling power plants may be compromised during a drought if water intakes drop below waterlines.

Public Health

More frequent intermittent droughts may create local water supply shortages, and such shortages could have major public health impacts (resilient MA, 2018).

Public Safety

Public water supply systems and other systems that rely on water availability for fire suppression may be compromised during a drought if water intakes drop below waterlines.

Water Infrastructure

Drought affects both groundwater sources and smaller surface water reservoir supplies. Water supplies for drinking, agriculture, and water-dependent industries may be depleted by smaller winter snowpack and drier summers (resilient MA, 2018). Reduced precipitation during a drought means that water supplies are not replenished at a normal rate. This can lead to a reduction in groundwater levels and problems such as reduced pumping capacity or wells going dry. Shallow wells are more susceptible than deep wells. Suppliers may struggle to meet system demands while maintaining adequate water supply pressure for fire suppression requirements. Private well supplies may dry up and need to either be deepened or supplemented with water from outside sources. In extreme cases, potable water could be supplied by other suppliers through emergency intermunicipal connections or by bulk-trucked water suppliers via distribution centers for residents. The Massachusetts Water Resources Authority has a DMP that sets mandatory water use reduction rates for three drought emergency stages. In addition, municipalities may need to raise water rates due to strained water supplies and the costs of developing new supplies (resilient MA, 2018).

Populations on a private water supply are likely more vulnerable to droughts than those on a public supply. During a drought, water sources such as small reservoirs that are replenished by surface flows and wells that draw from underground aquifers can be slow to recharge, causing water levels to become quite low. As a result, individuals and farmers with private wells are particularly vulnerable to the drought hazard. Private water supply wells are not as reliable as public wells, and public water supply wells are not as reliable as public reservoirs. Private wells and the groundwater levels of private wells are not monitored by any state or local entity, which leaves consumers vulnerable to drought impacts without any oversight. In 2017, DCR's Office of Water Resources surveyed municipal Boards of Health to gauge the impact of the 2016-2017 drought on private wells. Approximately half of the 91 respondents indicated that one or more private wells in the municipalities were compromised due to quantity and/or quality issues. Eight municipalities had 10 or more wells affected, and 20 wells were affected in one municipality.

EOEEA's drought website provides resources for residents whose wells have gone dry during a drought, including the suggestion to hook up to a water connection at a local fire department or school, or to purchase water. These are costly solutions that take time to implement and may not be financially feasible. Moreover, these situations may most heavily impact people with little means (e.g., rural, elderly, and disabled individuals) who have no means of paying for a drilled well to reach remaining water supplies when their shallower wells have failed.

Natural Resources and Environment

Environmental losses from drought are associated with damage to plants, animals, wildlife habitat, and air and water quality; forest and range fires; degradation of landscape quality; loss of biodiversity; and soil erosion. Some of the effects are short-term and conditions quickly return to normal following the end of the drought. Other environmental effects linger for some time or may even become permanent. Wildlife habitat, for example, may become degraded through the loss of wetlands, lakes, and vegetation. However, many species will eventually recover from this temporary aberration. The degradation of landscape quality, including increased soil erosion, may lead to more permanent loss of biological productivity. Although environmental losses are difficult to quantify, growing public awareness and concern for environmental quality has forced public officials to focus greater attention and resources on these effects.

Drought has a wide-ranging impact on a variety of natural systems. Some of those impacts can include the following (Clark et al, 2016).

- Reduced water availability, specifically, but not limited to, habitat for aquatic species.
- Decreased plant growth and productivity.
- Increased wildfires
- Greater insect outbreaks
- Increased local species extinctions.
- Lower stream flows and freshwater delivery to downstream estuarine habitats
- Changes in the timing, magnitude, and strength of mixing (stratification) in coastal waters
- Increase potential for hypoxia (low oxygen) events.
- Reduced forest productivity
- Direct and indirect effects on goods and services provided by habitats (such as timber, carbon sequestration, recreation, and water quality from forests)
- Limited fish migration or breeding due to dry streambeds or fish mortality caused by dry streambeds.

In addition to these direct natural resource impacts, a wildfire exacerbated by drought conditions could cause significant damage to the Commonwealth's environment as well as economic damage related to the loss of valuable natural resources.

Climate change is also likely to result in a shift in the timing and durations of various seasons. This change will likely have repercussions on the life cycles of both flora and fauna within the Commonwealth. While there could be economic benefits from a lengthened growing season, a lengthened season also carries risks. The probability of frost damage will increase, as the earlier arrival of warm temperatures may cause many trees and flowers to blossom prematurely only to experience a subsequent frost. Additionally, pests and diseases may also have a greater impact on a drier world, as they will begin feeding and breeding earlier in the year (Land Trust Alliance, n.d.).

Economy

Drought can affect agriculture, water supply, aquatic ecology, wildlife, and plant life. Economic impact will be largely associated with industries that use water or depend on water for their business. For example, landscaping businesses were affected in the droughts of the past, as the demand for service significantly declined because landscaping was not watered. Agricultural industries will be impacted if water usage is restricted for irrigation.

The economic impacts on drought can be substantial, and would primarily affect the agriculture, recreation and tourism, forestry, and energy sectors. For example, drought can result in farmers not being able to plant crops or in the failure of planted crops. This results in loss of work for farmworkers and those in related food-processing jobs. Crop failure is also likely to result in an increase in produce prices, which may render these items unaffordable for certain members of the population. Increasing globalization of the food system reduces the impact of isolated drought events on food prices, but the financial impact on farmers may be greater as a result. Reduced water quality or habitat loss may also impact Massachusetts fisheries.

Landslide

Landslides represent an extremely low frequency, minor hazard for Hanson. The Town of Hanson has not experienced a recorded landslide and is not especially vulnerable to landslides due to its lack of hills and generally flat topography.

The term landslide includes a wide range of ground movements, such as rock falls, deep failure of slopes, and shallow debris flows. The most common types of landslides in Massachusetts include translational debris slides, rotational slides, and debris flows. Most of these events are caused by a combination of unfavorable geologic conditions (silty clay or clay layers contained in glaciomarine, glaciolacustrine, or thick till deposits), steep slopes, and/or excessive wetness leading to excess pore pressures in the subsurface.

Landslides associated with slope saturation occur predominately in areas with steep slopes underlain by glacial till or bedrock. Bedrock is relatively impermeable relative to the unconsolidated material that overlies it. Similarly, glacial till is less permeable that the soil that forms above it. Thus, there is a permeability contract between the overlying soil and the underlying, and less permeable, un-weathered till, and/or bedrock. Water accumulates on this less permeable layer, increasing the pore pressure at the interface. This interface becomes a plane of weakness. If conditions are favorable, failure will occur (Mabee, 2010).

Construction-related failures occur predominantly in road cuts excavated into glacial till where topsoil has been placed on top of the till. Examples can be found along the Massachusetts Turnpike. Other construction-related failures occur in utility trenches excavated in materials that have low cohesive strength and an associated high-water table (usually within a few feet of the surface). This situation occurs in sandy deposits with very few fine sediments and can occur in any part of the Commonwealth.

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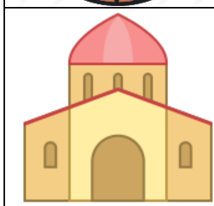
Commonwealth.

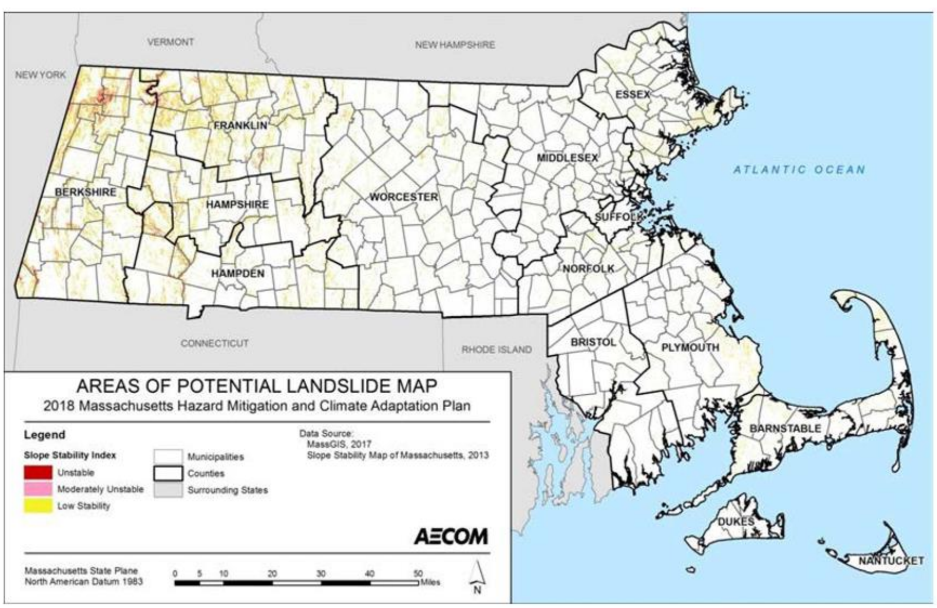
Landslide		
Hazard	**Significant**	**Justification**
Landslide 	NO	The effects of landslide are localized, and it is difficult to determine Hanson populations vulnerable to landslides. Frequency every other year in MA. • Areas with unstable slopes are most vulnerable. • Secondary impacts such as road closures can have a significant impact on communities. More frequent and intense storms will result in more frequent soil saturation conditions that are conducive to landslides
Exposure and Vulnerability by Key Sector		
	Populations	**General At-Risk Populations:** Population who reside or travel near steep slopes. **Vulnerable Populations:** Residents with rely on potentially impacted roads for vital transportation needs.
	Government	There are no identified municipal or state-owned facilities with unstable slopes that would be considered a risk in Hanson.
	Built Environment	Landslides can cause direct losses to roads, buildings, and other elements of the built environment as well as indirect socio-economic losses related to road closures that interfere with travel or downed power lines. Landslides can impact agriculture and forestry as well as water infrastructure.
	Natural Resources and Environment	Landslides can affect many facets of the environment, including the landscape itself, water quality, and habitat health. Transported soil may harm aquatic habitats, and mass movement of sediment may result in stripping of forests and other vegetated systems.
	Economy	Direct costs include actual damage sustained by buildings, property, and infrastructure. Indirect costs from a large landslide event could include clean-up costs, business interruption, loss of tax revenues, reduced property values, and loss of productivity.

Potential Effects of Climate Change - Landslide		
	Changes in Precipitation and Extreme Weather – Slope Saturation	Regional climate change models suggest that Massachusetts will likely experience more frequent and intense storms throughout the year. This change could result in more frequent soil saturation conditions, which are conducive to an increased frequency of landslides.
	Rising Temperatures – Reduced vegetation extent	An increased frequency of drought events is likely to reduce the extent of vegetation throughout the Commonwealth. The loss of the soil stability provided by vegetation could also increase the probability of landslides wherever these events occur.

Hazard Profile

In 2013, the Massachusetts Geological Survey prepared an updated map of potential landslide hazards for the Commonwealth (funded by FEMA's Hazard Mitigation Grant Program) to provide the public, local governments, and emergency management agencies with the location of areas where slope movements have occurred or may possibly occur in the future under conditions of prolonged moisture and high-intensity rainfall. Historical landslide data for the Commonwealth suggests that most landslides are preceded by 2 or more months of higher-than-normal precipitation, followed by a single, high-intensity rainfall of several inches or more (Mabee and Duncan, 2013). This precipitation can cause slopes to become saturated.

Figure 75: Areas of Potential Landslide Map



Source: SHMCAP, 2018

Previous Occurrences

In Massachusetts, landslides tend to be more isolated in size and pose threats to highways and structures that support fisheries, tourism, and general transportation. Landslides commonly occur shortly after other major natural disasters, such as earthquakes and floods, which can exacerbate relief and reconstruction efforts. Many landslide events may have occurred in remote areas, causing their existence or impact to go unnoticed. Therefore, this hazard profile may not identify all ground failure events that have impacted the Commonwealth. Expanded development and other land uses may contribute to the increased number of landslide incidences and/or the increased number of reported events in the recent record.

Frequency of Occurrences

Landslides are often triggered by other natural hazards such as earthquakes, heavy rain, floods, or wildfires, so landslide frequency is often related to the frequency of these other hazards. In general, landslides are most likely during periods of higher-than-average rainfall. The ground must be saturated prior to the onset of a major storm for a significant landslide to occur.

From 1996 to 2012, there were eight noteworthy events that triggered one or more slides in the Commonwealth. However, because many landslides are minor and occur unobserved in remote areas, the true number of landslide events is probably higher. Based on MassDOT, it is estimated that about 30 or more landslide events have occurred in the period between 1986 and 2006 (Hourani, 2006). This roughly equates to one to three landslide events each year.

Warning Time

Mass movements can occur suddenly or slowly. The velocity of movement may range from a slow creep of inches per year to many feet per second, depending on slope angle, material, and water content. Some methods used to monitor mass movements can provide an idea of the type of movement and the amount of time prior to failure. It is also possible to determine the areas that are at risk during general time periods. Assessing the geology, vegetation, and amount of predicted precipitation for an area can help in these predictions. However, there is no practical warning system for individual landslides. The current standard operating procedure is to monitor situations on a case-by-case basis and respond after the event as occurred. Generally accepted warning signs for landslide activity include the following:

- Springs, seeps, or saturated ground in areas that have not typically been wet before
- New cracks or unusual bulges in the ground, street pavements, or sidewalks
- Soil moving away from foundations.
- Ancillary structures, such as decks and patios, tilting and/or moving relative to the main house.
- Tilting or cracking of concrete floors or foundations
- Broken waterlines and other underground utilities
- Leaning telephone poles, trees, retaining walls, or fences

- Offset fence lines.
- Rapid increase in creek water levels, possibly accompanied by increased turbidity (soil content)
- Sudden decrease in creek water levels even though rain is still falling or has just recently stopped.
- A faint rumbling sound that increases in volume as the landslide nears
- Unusual sounds, such as trees cracking or boulders knocking together.

Secondary Hazards

Landslides do not typically trigger other natural hazards. However, they can cause several types of secondary effects, such as blocking access to roads, which can isolate residents and businesses and delay commercial, public, and private transportation. This could result in economic losses for businesses. Other potential problems resulting from landslides are power and communication failures. Vegetation or poles on slopes can be knocked over, resulting in possible losses to power and communication lines. Power outages may also result in an inappropriate use of combustion heaters, cooking appliances, and generators in indoor or poorly ventilated areas, leading to increased risks of carbon monoxide poisoning. Landslides also have the potential of destabilizing the foundation of structures, which may result in monetary losses for residents.

Sectors Assessed

Populations

The Commonwealth's exposure to landslides was determined by overlaying the slope stability map on layers indicative of area populations (2010 US Census) and government facilities (DCAMM, 2017 [facility inventory]). The following Table summarizes the Commonwealth's estimated population in unstable slope areas that may be more prone to landslides. [58]

[58] **SHMCAP, 2018**

Table 62: Populations Impacted by Slope Stability

County	Population	Unstable Areas		Moderately Unstable		Low Instability	
		Number	% Total	Number	% Total	Number	% Total
Barnstable	215,888	4	0.0	628	0.3	1,883	0.9
Berkshire	131,219	100	0.1	1,710	1.3	2,285	1.7
Bristol	548,285	86	0.0	1,136	0.2	2,373	0.4
Dukes	16,535	0	0.0	13	0.1	14	0.1
Essex	743,159	290	0.0	7,708	1.0	13,739	1.8
Franklin	71,372	69	0.1	984	1.4	1,466	2.1
Hampden	463,490	223	0.0	2,200	0.5	3,097	0.7
Hampshire	158,080	44	0.0	591	0.4	1,075	0.7
Middlesex	1,503,085	112	0.0	3,490	0.2	7,498	0.5
Nantucket	10,172	0	0.0	1	0.0	3	0.0
Norfolk	670,850	113	0.0	1,800	0.3	4,766	0.7
Plymouth	494,919	40	0.0	1,678	0.3	3,791	0.8
Suffolk	722,023	99	0.0	869	0.1	2,329	0.3
Worcester	798,552	90	0.0	2,626	0.3	5,460	0.7
Total	**6,547,629**	**1,270**	0.0	**25,434**	0.4	**49,779**	0.8

Source: 2010 U.S. Census, Slope Stability Map, 2017

Vulnerable Populations

Populations who rely on potentially impacted roads for vital transportation needs are particularly vulnerable to this hazard. The number of lives endangered by the landslide hazard in the Town of Hanson is negligible.

Health Impacts

People in landslide hazard zones are exposed to the risk of dying during a large-scale landslide; however, damage to infrastructure that impedes emergency access and access to health care is the largest health impact associated with this hazard. Mass movement events in the vicinity of major roads could deposit many tons of sediment and debris on top of the road. Restoring vehicular access if often a lengthy and expensive process.[59]

[59] **SHMCAP, 2018**

Government
There are no government facilities vulnerable to landslides in the Town of Hanson.

The Built Environment
Landslides can result in direct losses as well as indirect socioeconomic losses related to damaged infrastructure. Highly vulnerable areas of the Commonwealth include mountain roads, coastal roads, and transportation infrastructure, both because of their exposure to this hazard and the fact that there may be limited transportation alternatives if this infrastructure becomes unstable.

Agriculture
Landslides that affect farmland can result in significant loss of livelihood and long-term loss of productivity. Forests can also be significantly impacted by landslides.

Energy
The energy sector is vulnerable to damaged infrastructure associated with landslides. Transmission lines are generally elevated above steep slopes, but the towers supporting them can be subject to landslides. A landslide may cause a tower to collapse, bringing down the lines and causing transmission fault. Transmission faults can cause extended and broad area outages.

Public Health
Landslides can result in injury and loss of life. Landslides can impact access to power and clean water and increase exposure to vector-borne diseases.

Public Safety
Access to major roads is crucial to life safety after a disaster event and to response and recovery operations. The ability of emergency responders to reach people and property impacted by landslides can be impaired by roads that have been buried or washed out by landslides. The instability of areas where landslides have occurred can also limit the ability of emergency responders to reach survivors.

Transportation
Landslides can significantly impact roads and bridges. Landslides can block egress and ingress on roads, isolating neighborhoods and causing traffic problems and delays for public and private transportation. These impacts can result in economic losses for businesses. Mass movements can knock out bridge abutments or significantly weaken the soil supporting them, making them hazardous for use.

Water Infrastructure
Surface water bodies may become directly or indirectly contaminated by landslides. Landslides can reduce the flow of streams and rivers, which can result in upstream flooding and reduced downstream flow. This may impact the availability of drinking water. Water and wastewater infrastructure may be physically damaged by mass movements.

Natural Resources and Environment

Landslides can affect difference facets of the environment, including the landscape itself, water quality, and habitat health. Following a landslide, soil and organic materials may enter streams, reducing the potability of the water and the quality of the aquatic habitat. Mass movements of sediment may result in the stripping of forests, which in turn impacts the habitat quality of the animals that live in those forests (Geertsema and Vaugeousi, 2008). Flora in the area may struggle to re-establish following a significant landslide because of a lack of topsoil.

Economy

A landslide's impact on the economy and estimated dollar losses are difficult to measure. Direct costs include the actual damage sustained by buildings, property, and infrastructure. Indirect costs, such as clean-up costs, business interruption, loss of tax revenues, reduced property values, and loss of productivity are difficult to measure. Additionally, ground failure threatens transportation corridors, fuel and energy conduits, and communication lines (USGS, 2003).

The SHMCAP, utilizing data from the MassDOT from 1986 to 2006 estimates that, on average, roughly one to three known landslides have occurred each year. Hanson is classified as having a low susceptibility and a low incidence of landslides. Should a landslide occur in the future, the type and degree of impacts would be highly localized. The Town's vulnerabilities could include damage to structures, damage to transportation, and other infrastructure, and localized road closures. Injuries and causalities, while possible, would be unlikely given the low extent and impact of landslides in Hanson. There are no recorded instances of landslides having occurred in the Town of Hanson.

Primary Climate Change Interaction: Sea Level Rise

Sea level rise will impact coastal areas across the Commonwealth. Many local variables influence the extent of damages from coastal flooding associated with sea level rise. Elevated coastal landforms, such as coastal banks and salt marshes, can buffer increased tidal levels as well as storm surges. As tidal ranges expand, water levels downstream of dams, bridges, and culverts may increase, reducing the drainage capacity of these structures and the upstream storage capacity. As a result, flooding over riverbanks may increase during heavy precipitation or snowmelt events. Where tidal restrictions do not exist, sea level rise may extend the reach of salt water up rivers.

A recent analysis for Massachusetts conducted by the NE CASC produced a probabilistic assessment of future relative sea level rise at several tide gauge locations within the Commonwealth. The Table below shows relative (or local) mean sea level projections for the Boston, MA, tide station based on four National Climate Assessment global scenarios with associated probabilistic model outputs from the NE CASC. Each of the scenarios—Intermediate, Intermediate-High, High, and Extreme—is cross-walked with two to three probabilistic model outputs. Modeling considered two future concentrations of greenhouse gas (GHG) emissions (referred to as representative concentration pathways [RCP]) and two methods of accounting for Antarctic ice sheet contributions to sea level rise.

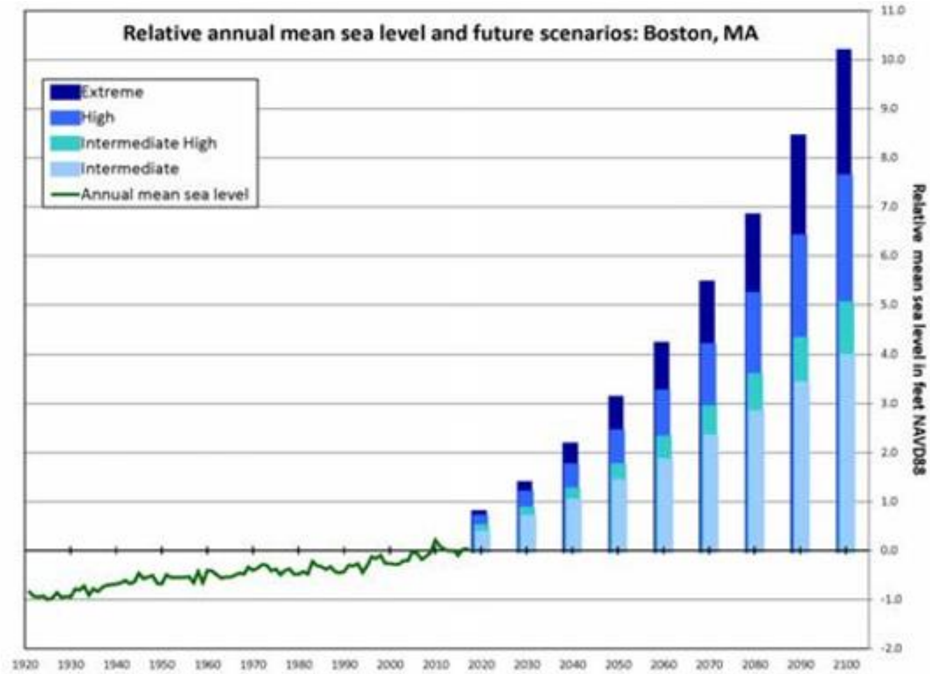
The values presented in the Table reflect a high emissions pathway (RCP 8.5). A 19-year reference time for sea level (tidal epoch) centered on the year 2000 was used to reduce biases caused by tidal, seasonal, and interannual climate variability. Sea level projections for the Boston tide station are referenced to the North American Vertical Datum of 1988 (NAVD88). The decadal distribution of these projections by scenario is shown in the Figure below.

Table 63: Boston Relative Mean Sea Level

Boston Relative Mean Sea Level (feet NAVD88)									
Scenario	**Summary**	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**	**2090**	**2100**
Intermediate	Intermediate scenario primarily based on medium and high emissions scenarios and accounts for possible higher ice sheet contributions to sea level rise (Unlikely to exceed 83% probability given a high emissions pathways)	0.7	1.0	1.4	1.8	2.3	2.8	3.4	4.0
Intermediate-High	Intermediate-high scenario primarily based on high emissions scenarios and accounts for possible higher ice sheet contributions to sea level rise (Extremely unlikely to exceed 95% probability given a high emissions pathway)	0.8	1.2	1.7	2.3	2.9	3.6	4.3	5.0
High	High scenario primarily based on high emissions scenarios and accounts for possible higher ice sheet contributions to sea level rise (Extremely unlikely to exceed 99.5% probability given a high emissions pathway)	1.2	1.7	2.4	3.2	4.2	5.2	6.4	7.6
Extreme (Maximum physically plausible)	Highest scenario primarily based on high emissions scenarios and accounts for possible higher ice sheet contributions to sea level rise and consistent with estimates of physically possible "worst case" (Exceptionally unlikely to exceed 99.9% probability given a high emissions pathway)	1.4	2.2	3.1	4.2	5.4	6.8	8.4	10.2

Source: resilient MA, 2018

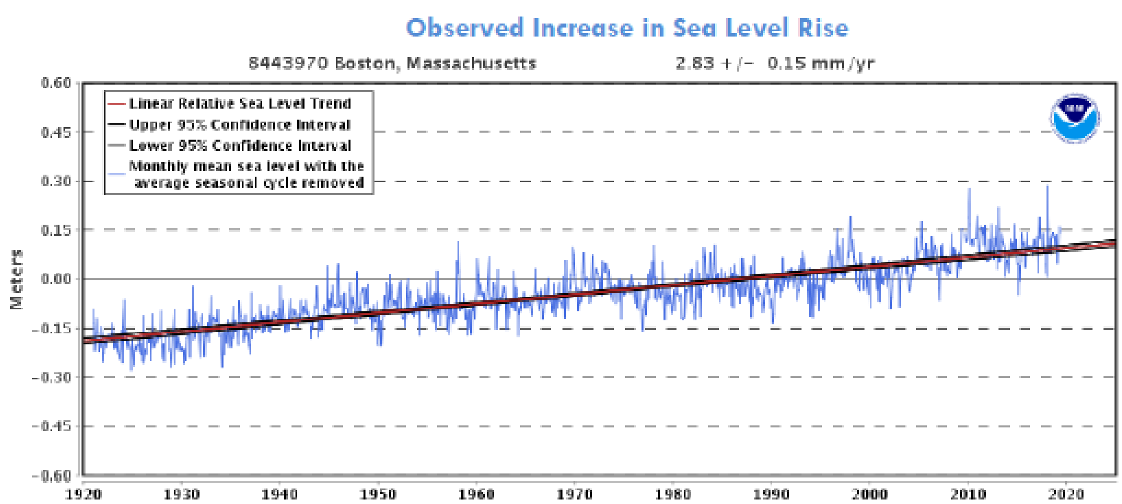
Figure 76: Relative Annual Mean Sea Level and Future Scenarios: Boston, MA



Source: resilient MA, 2018

Records from the Boston Tide Station show nearly one foot of sea level risk in the past century (see Figure 76: Observed Increase in Sea Level Rise). Warming temperatures contribute to sea level rise in two ways. First, warm water expands to take up more space. Second, rising temperatures are melting land-based ice which enters the oceans as melt water. A third, quite minor, contributor to sea level rise in New England is not related to climate change. New England is still experiencing a small amount of land subsidence in response to the last glacial period.

Figure 77: Observed Increase in Sea Level Rise



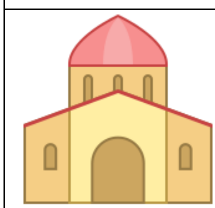
Projections of sea level rise through 2100 vary significantly depending on future greenhouse gas emissions and melting of land-based glaciers. Currently sea level is rising at an increasing rate. The following Figure depicts the recent rate of sea level rise, and a range of sea level rise scenarios. Projections for 2100 range from 4 feet to 10 feet. With ten feet representing the most extreme scenario. For 2050, the projections range approximately 1.5 to 3 feet.

Coastal Flooding

Coastal flooding generally occurs along the coasts of oceans, bays, estuaries, coastal rivers, and large saltwater inlets. Coastal floods are defined by the submersion of land along the ocean coast and other inland waters caused by the movement of seawater over and above normal present-day tide action. Coastal flooding is often characterized as minor or major based on the magnitude (elevation), duration, and frequency of the flooding that is experienced. Sea level rise driven by climate change will exacerbate existing coastal flooding and coastal hazards.

The rise in relative mean sea level is projected to range from approximately 1 to 3 feet in the new term (between 2000 and 2050), and from 4 to 10 feet by the end of this century (between 2000 and 2100) across the Commonwealth's coastline (EOEEA, 2018). As the sea level has continued to increase, there has been a corresponding increase in minor (or disruptive) coastal flooding associated with higher-than-normal monthly tides. Flooding impacts associated with these tides are becoming more noticeable and often result in the flooding of roads and parking lots with bimonthly spring tides. Greater flood levels (spatial and temporal) associated with more episodic, major, or event-based natural disturbances, such as hurricanes, nor'easters, and seismic waves, will impact built infrastructure directly, often with devastating effects. In addition to contributing to high-tide flooding, sea level rise will also exacerbate storm-related flooding due to the higher tidal elevation. Other impacts associated with more severe coastal flooding include beach erosion; loss or submergence of wetlands and other coastal ecosystems; saltwater intrusion into drinking water and wastewater infrastructure; high water tables; loss of coastal recreation areas, beaches, protective sand dunes, parks, and open space; and loss of coastal structures (sea walls, piers, bulkheads, and bridges) and buildings.

Climate change is projected to exacerbate the severity of storms and severe rainfall events. Therefore, it is anticipated that all forms of flooding will increase in severity because of climate change. Many of these hazards have historically impacted the coastline more severely than inland areas. In addition, flooding generated by these events will be compounded by higher sea levels, as described elsewhere in this section.

Sea Level Rise - Coastal Flooding		
Hazard	**Significant**	**Justification**
	No	There are two primary types of coastal flooding: routing tidal flood and flooding caused by storm events. The former is caused by regular tidal cycles, while the latter can result from precipitation, storm surge, or a combination of the two. The entire Massachusetts coastline is exposed to this hazard. Historically, the highest concentration of coastal flooding events has occurred in Eastern Plymouth County. According to the National Climatic Data Center, the Commonwealth has experienced an average of 6 flooding events per year over the past decade.
Exposure and Vulnerability by Key Sector		
	Populations	**General At-Risk Populations:** Populations living in coastal communities, especially those in coastal flood hazard areas. **Vulnerable Populations:** Populations who lack reliable access to emergency information, such as populations with lo English language fluency or low internet service; populations who face challenges in evacuating, such as people over age 65, those with young children, or households without a vehicle; populations who will have difficulty recovering from displacement, including renters, the elderly, people with disabilities, and low-income families.
	Government	Flooding can cause direct damage to municipally owned facilities and result in road closures which increase emergency response times. The Town of Hanson is not located in a coastal area and this hazard does not impact the community.
	Built Environment	This hazard does not impact the Town of Hanson.
	Natural Resources and Environment	Coastal flooding is a natural element of the coastal environment. However, both increased storm-related flooding and sea level rise represent threats to coastal natural resources, as many coastal habitats are dependent on specific inundation frequencies. These habitats, and the species that rely on them, will be threatened by sea level rise.
	Economy	The Town of Hanson's economy is not impacted by coastal flooding.

Potential Effects of Climate Change – Sea Level Rise Coastal Flooding		
	Sea level rise – Increase in frequency and severity of coastal flooding.	Sea level rise will increase the frequency and severity of both routine tidal flooding and storm-related flooding. Downscaled climate projections suggest that Boston may experience between 4.0 and 10.2 feet of sea level rise by 2100.
	Extreme Weather – Storm Surge	Climate change is likely to increase the frequency of severe storm events, including hurricane's and Nor'easters. As a result, storm surge sufficient to cause coastal flooding is likely to occur more often.

Previous Occurrences

Hanson is not located directly on the coast. Local data for previous coastal flooding occurrences are not collected by the Town of Hanson. The best available local data is for Plymouth County through the National Climatic Data Center. Plymouth County, which includes the Town of Hanson, experienced 48 coastal flood events from 2006 through 2020 [60].

Table 64: Plymouth County Coastal Flood Events, 2006 - 2020

Date	County	Event	Property Damage	Injuries
1/31/2006	EASTERN PLYMOUTH	Coastal Flood	60,000	0
4/15/2007	SOUTHERN PLYMOUTH	Coastal Flood	5,000	0
4/15/2007	EASTERN PLYMOUTH	Coastal Flood	5,000	0
4/16/2007	SOUTHERN PLYMOUTH	Coastal Flood	5,000	0
4/16/2007	EASTERN PLYMOUTH	Coastal Flood	5,000	0
4/17/2007	EASTERN PLYMOUTH	Coastal Flood	15,000	1
3/8/2008	SOUTHERN PLYMOUTH	Coastal Flood	5,000	0
10/18/2009	EASTERN PLYMOUTH	Coastal Flood	-	0
1/2/2010	EASTERN PLYMOUTH	Coastal Flood	-	0
2/25/2010	EASTERN PLYMOUTH	Coastal Flood	-	0
3/4/2010	EASTERN PLYMOUTH	Coastal Flood	-	0
3/15/2010	EASTERN PLYMOUTH	Coastal Flood	-	0
10/6/2010	EASTERN PLYMOUTH	Coastal Flood	-	0
11/8/2010	EASTERN PLYMOUTH	Coastal Flood	1,000	0
12/27/2010	EASTERN PLYMOUTH	Coastal Flood	2,200,000	0

60 https://www.ncdc.noaa.gov/stormevents/listevents.jsp?eventType=%28Z%29+Coastal+Flood&beginDate_mm=01&beginDate_dd=01&beginDate_yyyy=2000&endDate_mm=05&endDate_dd=31&endDate_yyyy=2020&county=PLYMOUTH%3A23&hailfilter=0.00&tornfilter=0&windfilter=000&sort=DT&submitbutton=Search&statefips=25%2CMASSACHUSETTS

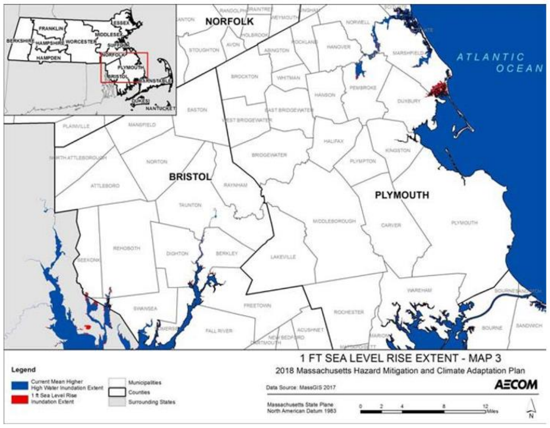
10/30/2011	EASTERN PLYMOUTH	Coastal Flood	10,000	0
11/23/2011	EASTERN PLYMOUTH	Coastal Flood	-	0
6/3/2012	EASTERN PLYMOUTH	Coastal Flood	35,000	1
6/4/2012	EASTERN PLYMOUTH	Coastal Flood	-	0
6/4/2012	EASTERN PLYMOUTH	Coastal Flood	40,000	0
10/29/2012	EASTERN PLYMOUTH	Coastal Flood	645,000	0
10/29/2012	SOUTHERN PLYMOUTH	Coastal Flood	322,000	0
12/27/2012	SOUTHERN PLYMOUTH	Coastal Flood	-	0
12/27/2012	EASTERN PLYMOUTH	Coastal Flood	-	0
2/9/2013	EASTERN PLYMOUTH	Coastal Flood	9,200,000	0
3/7/2013	EASTERN PLYMOUTH	Coastal Flood	500,000	0
12/15/2013	EASTERN PLYMOUTH	Coastal Flood	-	0
1/2/2014	EASTERN PLYMOUTH	Coastal Flood	-	0
1/2/2014	EASTERN PLYMOUTH	Coastal Flood	-	0
1/3/2014	EASTERN PLYMOUTH	Coastal Flood	-	0
3/26/2014	EASTERN PLYMOUTH	Coastal Flood	-	0
10/22/2014	EASTERN PLYMOUTH	Coastal Flood	75,000	0
10/23/2014	EASTERN PLYMOUTH	Coastal Flood	-	0
11/2/2014	EASTERN PLYMOUTH	Coastal Flood	-	0
1/27/2015	EASTERN PLYMOUTH	Coastal Flood	1,500,000	1
2/15/2015	EASTERN PLYMOUTH	Coastal Flood	-	0
10/2/2015	EASTERN PLYMOUTH	Coastal Flood	-	0
1/23/2016	EASTERN PLYMOUTH	Coastal Flood	-	0
1/24/2016	EASTERN PLYMOUTH	Coastal Flood	3,000	0
Date	**County**	**Event**	**Property Damage**	**Injuries**
2/8/2016	EASTERN PLYMOUTH	Coastal Flood	-	0
1/4/2018	EASTERN PLYMOUTH	Coastal Flood	500,000	0
1/30/2018	EASTERN PLYMOUTH	Coastal Flood	-	0
3/2/2018	EASTERN PLYMOUTH	Coastal Flood	-	0
3/8/2018	EASTERN PLYMOUTH	Coastal Flood	-	0
10/27/2018	EASTERN PLYMOUTH	Coastal Flood	-	0
11/25/2018	EASTERN PLYMOUTH	Coastal Flood	-	0
1/20/2019	EASTERN PLYMOUTH	Coastal Flood	-	0
4/3/2020	EASTERN PLYMOUTH	Coastal Flood	2,000	0

Source: NOAA

Warning Time

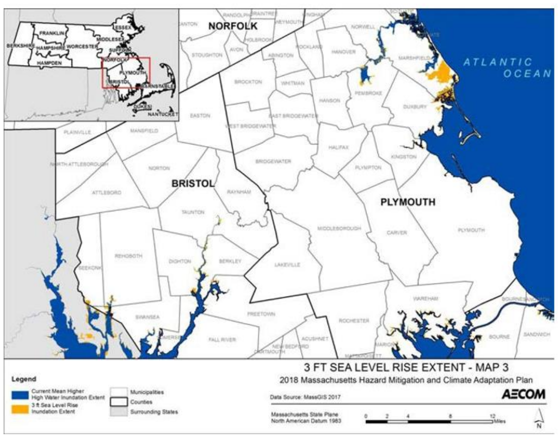
Although coastal flooding and inland flooding mechanisms are different, the warning times available for coastal floods are generally like those for inland flood events. Most warning times for coastal flooding could be described as more than 24 hours due to awareness of incoming storms and how they correlate with the tides and whether King Tides are possible. Inland flooding is the same except for flash flooding, which can have a warning time of less than 6 hours.

Figure 78: Plymouth County Inundation Extent of 1-Foot Sea Level Rise to MHHW



Source: 2018 SHMCAP

Figure 79: Plymouth County Inundation Extent of 3-Foot Sea Level Rise Relative to MHHW



Source: 2018 SHMCAP

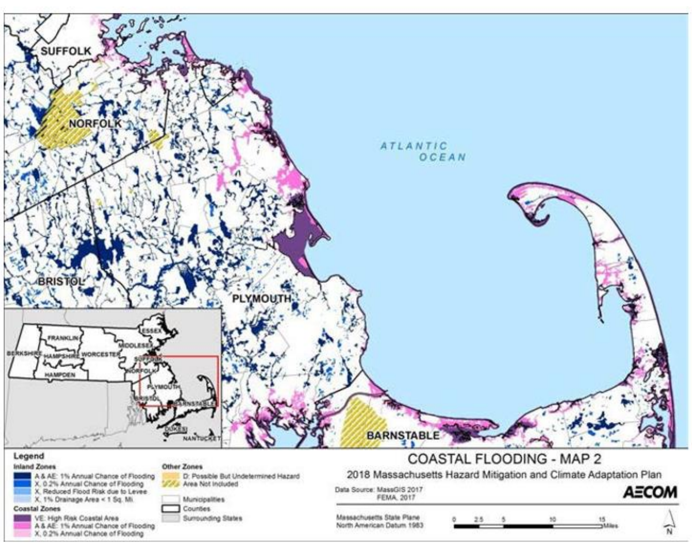


Figure 80: Coastal Flooding

Secondary Hazards

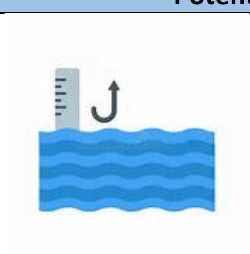
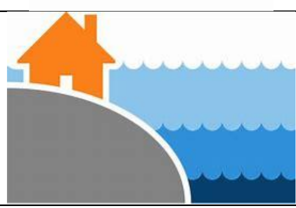
Many of the secondary hazards described for inland flooding can also occur due to coastal flooding if the necessary physical elements (rivers and slopes) are present within the impacted portion of the coastal zone. Although sea level rise does not result directly in coastal erosion, by increasing tidal datum heights, sea level rise can increase the impacts associated with storm surge and high tides and other erosive processes (e.g., currents and waves).

An additional secondary hazard associated with sea level rise is the possibility of saltwater intrusion into groundwater supplies, which provide potable water nor only for residential uses but also for agriculture and industry. Sea level rise is also decreasing the separation distance between septic fields and groundwater table, which compromises the septic systems' ability to treat bacteria and pathogens (CLF, 2017). Projected increased precipitation will exacerbate the effect of saltwater intrusion on groundwater, as groundwater levels are further elevated and the oxygen needed for microbial wastewater treatment is depleted (CLF, 2017).

Coastal Erosion

Coastal shorelines change constantly in response to storms, seasons, sea level, and human alterations. Coastal erosion is measured as a rate of change over times. According to the SHMCAP frequency of erosion cannot be measured. Rising seas and more frequent and intense storms will tend to increase erosion, although some areas may accrete material. Erosion may be exacerbated by efforts to protect shoreline as engineered structures can reduce sediment sources to downdrift areas or, increase erosion seaward of structures due to interaction with waves.

Massachusetts Coastal Zone Management (CZM) in cooperation with the US Geological Survey (USGS) provides shoreline change data for the Massachusetts coast. Erosion has not been identified as a concern in Hanson.

Potential Effects of Climate Change – Sea Level Rise Coastal Erosion		
	Sea Level Rise – Rising Wave Action	As the sea level rises, wave action moves higher onto the beach. The surf washes sand and dunes out to sea or makes the sand migrate parallel to the shoreline. As a rule of thumb, a sandy shoreline retreats landward about 100 feet for every 1-foot rise in sea level.
	Sea Level Rise – Loss of Buffer Systems	Rising waves, tides, and current erode beaches, dunes, and banks, resulting in landward retreat of these landforms and reducing the buffer they provide to existing development. More sediment is washed out to sea, rather than settling on the shore.

Sections Assessed

Populations

There are no coastal areas within the Town of Hanson. There are no populations within the Town of Hanson vulnerable to coastal flooding or coastal erosion.

Vulnerable Populations

As there are no coastal areas within the Town of Hanson, there are no populations vulnerable to affects caused by coastal flooding or coastal erosion. Of the populations within the Commonwealth coastal areas exposed, the most vulnerable include the people with low socioeconomic status, people over the age of 65, renters, people with compromised immune systems, children under the age of 5, and people with low English language fluency. The population over the age of 65 is vulnerable because these individuals are more likely to see or need medical attention, which may not be available due to isolation during a flood event, and they may have more difficulty evacuating. People with mobility limitations are similarly vulnerable. Young children are vulnerable due to their dependence on adults to make decisions about their safety. People with low socioeconomic status are vulnerable because they are likely less able to bear the additional expense of evacuating and/or may lack transportation to evacuate. They are also less likely to have the resources needed to recover from damage to homes and businesses.

Health Impacts

Flood waters from coastal flooding events may contain infectious organisms, such as bacteria, and viruses from untreated wastewater that is released to surface waters (OSHA, 2005). For example, coastal flooding may directly damage or flood wastewater treatment facilities, causing the floodwater to carry untreated wastewater to other locations. Flooding that causes power outages at wastewater treatment facilities could impact treatment prior to discharge if the facility lacks sufficient backup power. To a lesser degree, coastal floodwaters could inundate streets that drain to combined sewers, causing activation of the combined sewage overflows, which normally discharge a combination of stormwater and untreated wastewater to the harbor or nearby rivers during periods of heavy rainfall.

Coastal storm flooding can also result in direct mortality in the flood zone. Even a relatively low-level flood can be more hazardous than many residents realize. For example, only 6 inches of moving water can cause adults to fall, and 1 foot to 2 feet of water can sweep cars away. Immediate danger is also presented by downed powerlines, sharp objects in the water, or fast-moving debris that may be moving in or near the water.

Coastal floodwaters may also contain agricultural or industrial chemicals, hazardous materials swept away from containment areas, or electrical hazards if downed power lines are present.

Individuals with pre-existing health conditions may also experience medical emergencies, and they are at risk if flood events (or related evacuations) render them unable to access medical support. Flooded streets and roadblocks may make it difficult for emergency vehicles to respond to calls for service, particularly in rural areas.

Government

Hanson is not located directly on the coast. There are no government facilities in the Town of Hanson subject to the impacts of coastal flooding.

The Built Environment

Hanson is not located directly on the coast therefore there are no critical facilities subject to the effects of coastal flooding. Coastal flooding could hamper or disable operations for a wide range of facilities, including commercial establishments such as ports, natural gas terminals, and chemical storage facilities, as well as services such as the Coast Guard. There are no critical facilities in flood zones in the Plymouth County.

Table 65: Critical Facilities in Flood Zones by County

County	1 Percent Annual Chance Flood Event		0.2 Percent Annual Chance Flood Event
	In A Zone	In V Zone	In X500 Zone
Barnstable	1	1	—
Bristol	1	1	—
Dukes	—	—	—
Essex	2	1	—
Middlesex	—	—	—
Nantucket	—	—	—
Norfolk	—	—	—
Plymouth	—	—	—
Suffolk	3	2	1
Total	**7**	**5**	**1**

Sources: MassGIS 2017; DCAMM, 2017 (facility inventory)

Natural Resources and Environment

Coastal flooding is a natural component of the environmental process. However, populations that become established in coastal areas, and the development that occurs as a result, can often exacerbate both the severity of flooding and its impacts due to the loss of flood buffering from the environment.

Economy

Economic losses due to coastal flooding will include damage to buildings and infrastructure, agricultural losses, interruption of business activity with minor flooding of roads and parking areas, impacts on tourism, and tax base impacts. The extent of economic impacts from coastal flooding and sea level rise may be greater than inland flooding because of the concentration of populations, infrastructure, and economic activity in Massachusetts coastal zone. The US National Assessment's coastal sector assessment (Boesch et al., 2000) estimated the total cost of 18 inches of sea level rise by 2100 at between $20 billion and $200 billion, and the economic cost of 36 inches of sea level rise at approximately double that value. Those costs could be incurred even as the result of one storm. Some research has found that under sea level rise conditions in the future, evacuation costs alone for a storm in the Northeast region of the US could range between $2 billion and $6.5 billion (Ruth et al., 2007). These costs may now be underestimates, considering newly projected sea level rise rates (SHMCAP, 2018).

Primary Climate Change Interaction: Extreme Temperature

There is no universal definition for extreme temperatures. What constitutes “extreme cold” or “extreme heat” can vary across different geographies, based on what the population of a place is accustomed to. The term is relative to the usual weather in the region based on climatic averages. According to the Massachusetts State Hazard and Climate Adaptation Plan, extreme heat for Massachusetts is usually defined as a period of 3 or more consecutive days above 90 degrees Fahrenheit (°F), but more generally as a prolonged period of excessively hot weather, which may be accompanied by high humidity. Extreme cold is also considered relative to the normal climatic lows in a region.

More broadly, extreme temperatures can be defined as those that are far outside the normal ranges.

The following are the climate extremes recorded in parts of Massachusetts for the period from 1895 to present according to NOAA’s State Climate Extremes Committee (SCEC): [61]

Table 66: Massachusetts Climate Extremes

STATE	ELEMENT	VALUE	DATE	LOCATION	STATION ID	STATUS
Massachusetts	Maximum Temperature	107°F	Aug 2, 1975	CHESTER 2	191430	E2
Massachusetts	Minimum Temperature	-35°F	Feb 15, 1943	COLDBROOK	191589	E1
			Jan 12, 1981	CHESTER 2	191430	E1
			Jan 5, 1904	TAUNTON	198367	E1
Massachusetts	24-Hour Precipitation	18.15 in.	Aug 18 - 19, 1955	WESTFIELD	199191	E
Massachusetts	24-Hour Snowfall	29 in.	April 1, 1997	NATICK	195175	E
Massachusetts	Snow Depth	62 in.	Jan 13, 1996	GREAT BARRINGTON	193208	E

These values have been evaluated by the NOAA National Centers for Environmental Information and/or by the State Climate Extremes Committee and determined to be valid. The data may come from sources other than official NOAA-supervised weather stations, but are archived, officially recognized observations.

[61] https://www.ncdc.noaa.gov/extremes/scec/records/ma

Massachusetts has a humid continental climate type with warm, humid summers and cold, snowy winters. This type of climate is found over large areas of land masses in the temperate regions of the mid-latitudes where there is a zone of conflict between polar and tropical air masses. The state is prone to extreme weather, with influences from the polar region as well as tropical weather from the south. In addition, the state's proximity to the ocean makes susceptible to winds and weather from the Atlantic. The hottest month is July, with an average high of 82 °F (28 °C) and average low of 66 °F (18 °C), with conditions usually humid. Periods exceeding 90 °F (32 °C) in summer and below 10 °F (−12 °C) in winter are not uncommon.

Since 1994, there have been 33 cold weather events within the Commonwealth, ranging from Cold/Wind Chill to Extreme Cold/Wind Chill events. In February 2015, a series of snowstorms piled up to 60 inches in some areas in 3 weeks and caused recurrent blizzards across eastern Massachusetts. Temperature gauges across the Commonwealth measured extreme cold, with wind chills as low as -31°F. Four indirect fatalities occurred because of this event: two adults died shoveling snow and two adults were hit by snowplows. In February 2016, one cold weather event broke records throughout the state. Extreme cold/wind chill events were declared in 16 climate zones across the Commonwealth (SHMCAP, 2018).

According to the NOAA's Storm Events Database, there were 43 warm weather events (ranging from Record Warmth/Heat to Excessive Heat events) in Massachusetts between 1995 and 2018, the most recent of which occurred in July 2013. Whenever the heat index values meet or exceed locally or regionally established here or excessive heat warning thresholds, an event is reported in the database. In 2012, Massachusetts temperatures broke 27 heat records. Most of these records were broken between June 20 and June 22, 2012, during the first major heat wave of the summer to hit Massachusetts and the East Coast. One fatality occurred on July 6, when a postal worker collapsed as the Heat Index reached 100°F (MASHMCAAP, 2018). None of these events was known to impact individuals in Hanson.

The NE CASC data support the trends of an increased frequency of extreme hot weather events and a decreased frequency of extreme cold weather events.

According to the 2018 SHMCAMP, the most significant secondary hazard associated with extreme temperatures is a severe weather event. Severe heat events are often associated with drought, as evaporation increases with temperature, and with wildfire, as high temperatures can cause vegetation to dry out and become more flammable. Warmer weather will also have an impact on invasive species. More commonly, heat events contribute to poor air quality that can exacerbate asthma and result in an increase in emergency department visits.

Average, maximum, and minimum temperatures are expected to increase.

Days with daily maximum temperatures over 90°F are expected to increase.

Days with daily minimum temperatures below 32°F are expected to decrease.

Figure 81: Heat Index Chart

Relative Humidity (%)	Temperature (°F)															
	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Category	Heat Index	Health Hazards
Extreme Danger	130 °F – Higher	Heat Stroke or Sunstroke is likely with continued exposure.
Danger	105 °F – 129 °F	Sunstroke, muscle cramps, and/or heat exhaustion possible with prolonged exposure and/or physical activity.
Extreme Caution	90 °F – 105 °F	Sunstroke, muscle cramps, and/or heat exhaustions possible with prolonged exposure and/or physical activity.
Caution	80 °F – 90 °F	Fatigue possible with prolonged exposure and/or physical activity.

Source: National Weather Service, Heat Index, 2020

Conversely, extreme cold events are primarily associated with severe winter storms. The combination of cold weather with severe winter storm events is especially dangerous because winter weather can knock out heat and power, increasing exposure to extreme cold temperatures. Loss of heat and power may also lead to carbon monoxide poisoning from inappropriate use of combustion-powered generators, heather, and cooking appliances, and heavy snowfall may block vents for gas dryers and heaters. Similarly, prolonged exposure to extreme heat can compromise power infrastructure, leaving customers without power or the ability to operate air conditioning. Power failure leads to increased use of diesel generators for power and more wood stoves are used in extreme cold; both situations lead to increasing air pollution and health impacts.

Table 67: Average, Maximum, and Minimum Temperatures.

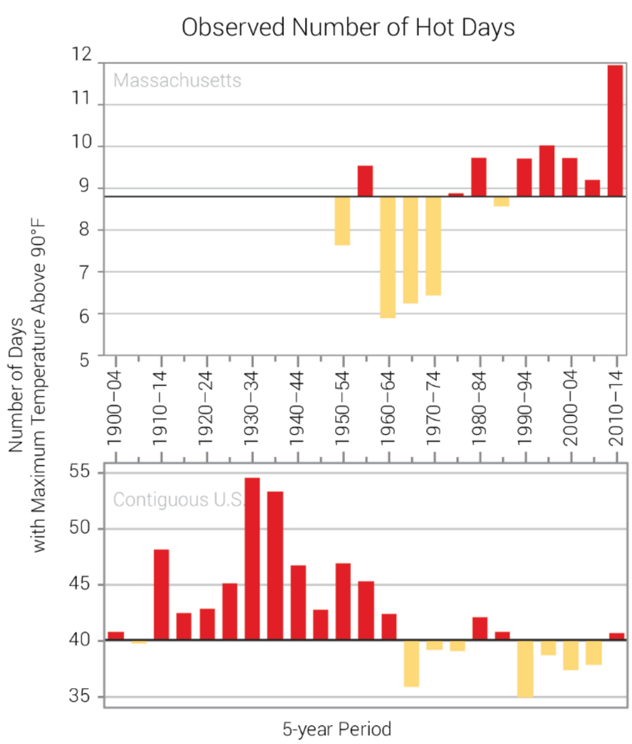
	Baseline (1971-2000)	Mid-Century (2050s)	End of Century (2090s)
Average annual temperature (°F)	46.8°F	+ 3.0 to 6.4°F	+ 3.9 to 11.0°F
Average days max temperature >90°F	4 days	9 to 30 more days	13 to 70 more days
Annual days min temperature <32°F	156 days	19 to 38 fewer days	23 to 64 fewer days

Source: resilientMA.org

Temperatures in Massachusetts have increased almost 3°F since the beginning of the 20th century.[62] The number of hot days (maximum temperature above 90°F) in Massachusetts has been consistently above average since the early 1990s (see the following Figures) with the highest number since 1950 (11.5 days per year) occurring during the most recent 5-year period of 2010 to 2014. The number of warm nights (minimum temperature above 70°F in Massachusetts has been steadily increasing since 1995, with the highest number occurring from 2005 to 2014.

In 2012, Boston experienced the warmest January to July in 77 years. During that time, Boston's average temperature was 53.5°F – almost 4°F warmer than historical average temperatures. Trends in extreme low temperatures also reflect this warming trend. The number of very cold nights (minimum temperature below 0°F) has been below-average since the early 1990s. Despite this overall trend, the recent winter of 2014-2015 was rather severe as the eastern US was one of the few places globally with colder than normal temperatures. Heavy snowfall was the most prominent feature in Massachusetts as Boston set a record for snowfall in 2014-2015 with 108 inches. Massachusetts' winter temperature for 2014-2015 was the 24th coldest.

Figure 82: Observed Number of Hot Days

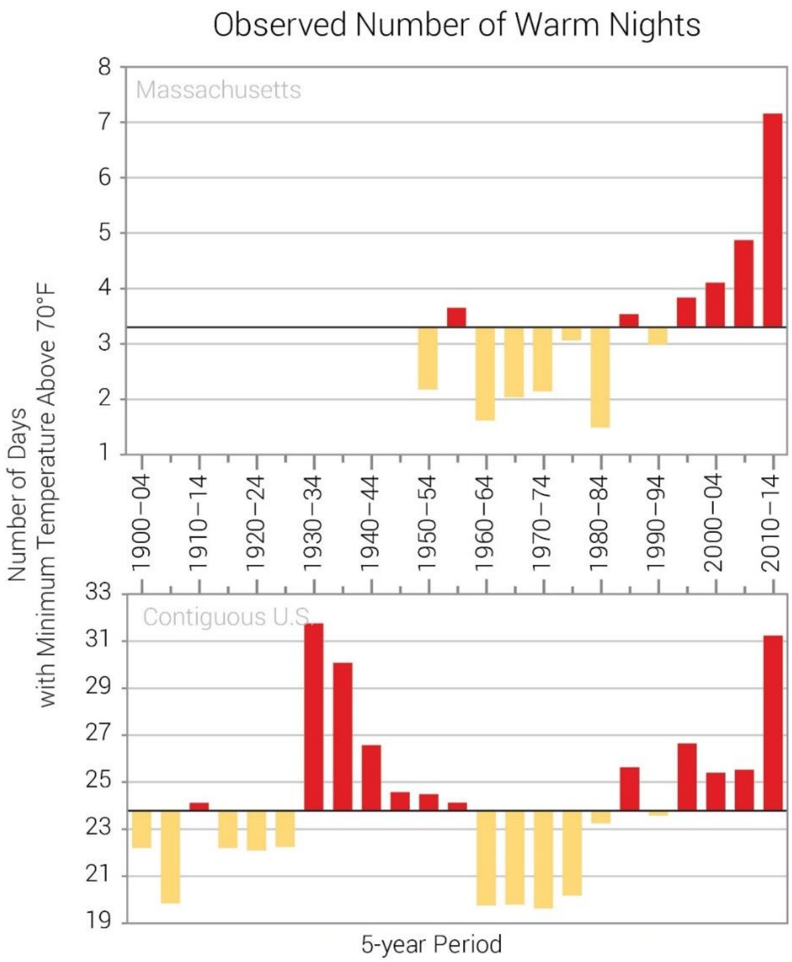


Source: https://statesummaries.ncics.org/chapter/ma/

The observed number of hot days (maximum temperature above 90°F) averaged over 5-year periods. The dark horizontal lines represent the long-term average. The values in Figures 2a are averages from long-term reporting stations, 15 for temperature and 24 for precipitation. Source: CICS-NC and NOAA NCEI.

[62] NOAA National Centers for Environmental Information, State Summaries, 2017

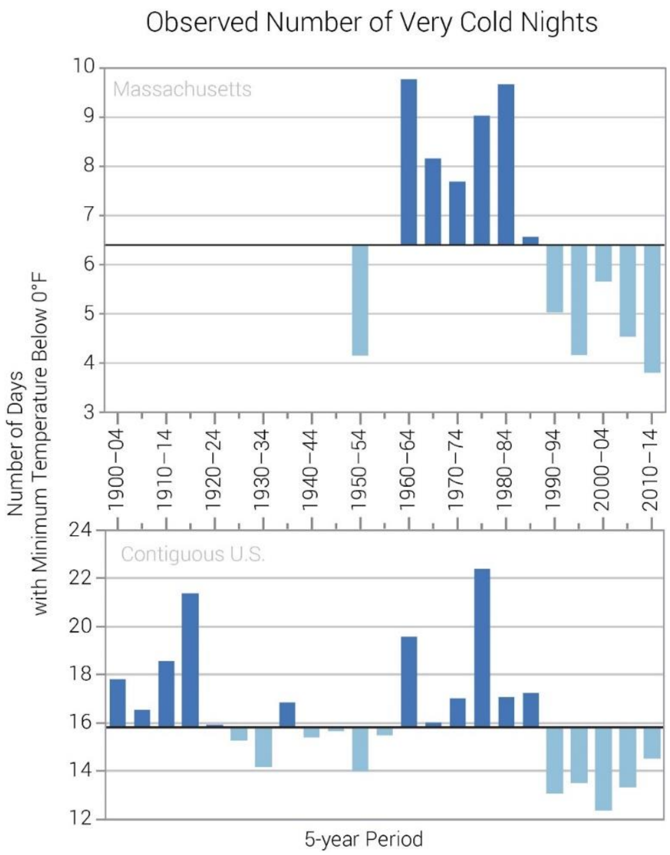
Figure 83: Observed Number of Warm Nights



Source: https://statesummaries.ncics.org/chapter/ma/

The observed number of warm nights (minimum temperature above 70°F) for 1950–2014, averaged over 5-year periods; these values are averages from 15 long-term reporting stations. The number of warm nights in Massachusetts has steadily increased since the mid-1990s with the highest number (since 1950) occurring between 2010 and 2014. The dark horizontal lines represent the long-term average. The number of warm nights for the contiguous United States (bottom panel) is also shown to provide a longer and larger context. Long-term stations back to 1900 were not available for Massachusetts. Source: CICS-NC and NOAA NCEI.

Figure 84: Observed Number of Very Cold Nights



Source: https://statesummaries.ncics.org/chapter/ma/

The observed number of very cold nights (minimum temperature below 0°F) for 1950–2014, averaged over 5-year periods; these values are averages from 15 long-term reporting stations. The dark horizontal lines represent the long-term average. The number of very cold nights has been consistently below average since the early- 1990s. The lowest number of cold nights occurred during 2010–2014. The number of very cold nights for the contiguous United States (bottom panel) is also shown to provide a longer and larger context. Long-term stations back to 1900 were not available for Massachusetts. Source: CICS-NC and NOAA NCEI.

Rising Temperatures/Extreme Heat

A heat wave is a period of abnormally and uncomfortably hot and usually humid weather. The World Meteorological Organization is specific in its definition by stating that a heat wave is when the daily maximum temperature for more than five consecutive days exceeds the average maximum temperature by 9 degrees. The National Weather Service said the longest heat wave in Greater Boston lasted 9 days and took place between July 3 and July 11, 1912, a span during which temperatures ranged from daytime lows of 90 degrees to a high of 98 degrees.

The Heat Index is a measure of how hot it really feels when relative humidity is factored in with the actual air temperature. To find the Heat Index temperature, look at the Heat Index Chart below. As an example, if the air temperature is 96°F and the relative humidity is 65 percent, the heat index (how hot it feels) is 121°F. The red area without numbers indicates extreme danger. The National Weather Service will initiate alert procedures when the Heat Index is expected to exceed 105° - 110°F (depending on local climate) for at least 2 consecutive days.[63]

The highest temperature recorded in the Commonwealth for the period 1895 to present was 107°F[64] on August 2, 1975 in Chester (NOAA's State Climate Extremes Committee (SCEC). Projected temperature extremes will shift with climate change, according to research conducted by the Massachusetts Executive Office for Energy and Environmental Affairs and the University of Massachusetts, Amherst.

Figure 85: Projected Change in Average Temperature (°F)

Average Temperatures (Projected)

Table shows estimated 50th percentile values for projected change in Average Temperature. The value highlighted in dark green is the value corresponding to the season, decade and emissions scenario currently selected on the map. Hover over values to see the likely range (10th to 90th percentile) for any given value. Projected decreases are denoted by a minus (-) sign .

South Coastal Basin

		Projected change in Average Temperature (°F)				
Season	**Baseline (°F)**	**Emissions Scenario**	**2030s**	**2050s**	**2070s**	**2090s**
Annual	49.72	High RCP8.5	+3.27	+4.97	+6.99	+8.71
		Medium RCP4.5	+2.48	+3.56	+4.26	+4.68
Fall	52.39	High RCP8.5	+3.49	+5.15	+7.62	+9.15
		Medium RCP4.5	+3	+3.96	+4.57	+4.89
Spring	46.72	High RCP8.5	+2.74	+4.51	+6.15	+7.81
		Medium RCP4.5	+2.54	+3.18	+4.05	+5.09
Summer	69.12	High RCP8.5	+2.74	+4.89	+7.25	+9.17
		Medium RCP4.5	+2.41	+3.35	+3.82	+4.61
Winter	30.29	High RCP8.5	+3.29	+4.91	+6.88	+8.82
		Medium RCP4.5	+2.78	+3.98	+4.61	+4.93

Source: ResilientMA.org

[63] https://www.weather.gov/safety/heat-index

[64] **https://www.ncdc.noaa.gov/extremes/scec/records**

Figure 86: Projected Change in Maximum Temperature (°F)

Maximum Temperatures (Projected)

Table shows estimated 50th percentile values for projected change in Maximum Temperature. The value highlighted in dark green is the value corresponding to the season, decade and emissions scenario currently selected on the map. Hover over values to see the likely range (10th to 90th percentile) for any given value. Projected decreases are denoted by a minus (-) sign .

South Coastal Basin

		Projected change in maximum temperature (°F)				
Season	**Baseline (°F)**	**Emissions Scenario**	**2030s**	**2050s**	**2070s**	**2090s**
Annual	59.47	High RCP8.5	+3.11	+4.79	+6.69	+8.54
		Medium RCP4.5	+2.42	+3.41	+4.08	+4.6
Fall	62.22	High RCP8.5	+3.46	+4.93	+7.35	+8.94
		Medium RCP4.5	+3	+3.89	+4.41	+4.84
Spring	56.69	High RCP8.5	+2.65	+4.37	+6	+7.55
		Medium RCP4.5	+2.44	+3.07	+3.86	+5
Summer	79.10	High RCP8.5	+2.63	+4.83	+7.21	+9.22
		Medium RCP4.5	+2.43	+3.31	+3.81	+4.48
Winter	39.52	High RCP8.5	+2.98	+4.36	+6.14	+8.09
		Medium RCP4.5	+2.48	+3.53	+4.02	+4.55

Source: ResilientMA.org

Massachusetts has four seasons with several defining factors, and temperature is one of the most significant. Extreme temperatures can be defined as those that are far outside the normal ranges. The average highs and lows of the hottest and coolest months in Massachusetts are provided in the following Table.

Table 68: Average High and Average Low

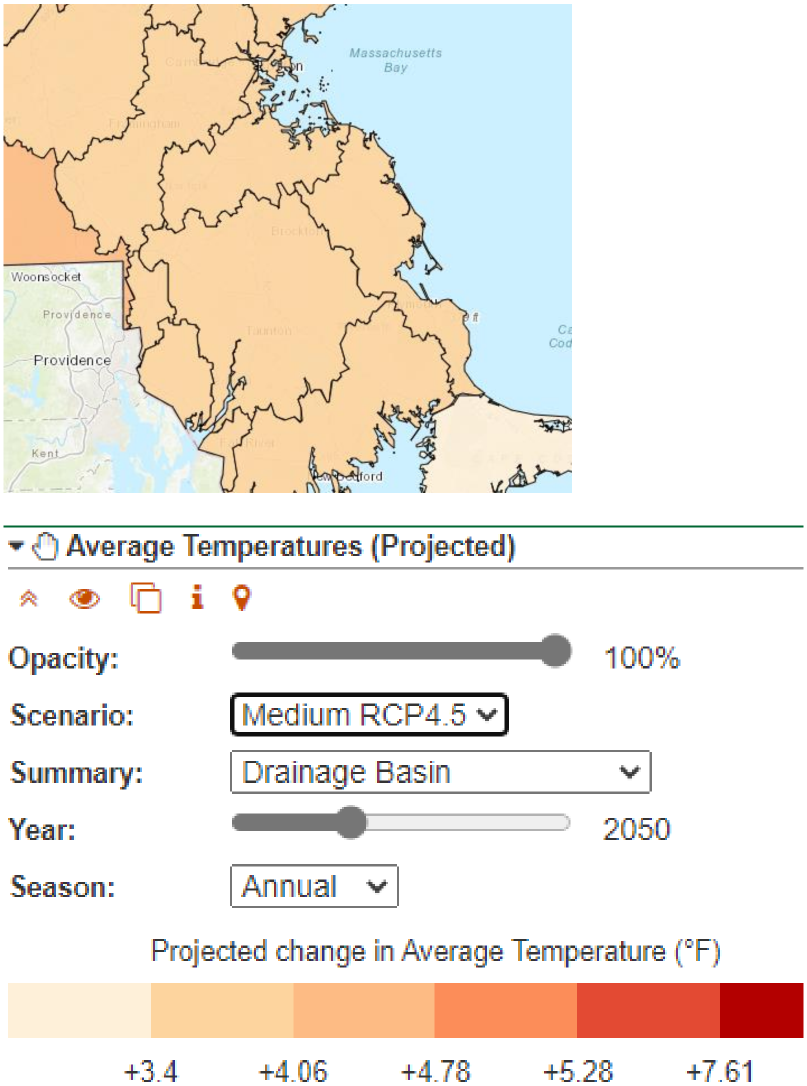
	July (Hottest Month)	January (Coldest Month)
Average High (°F)	81°	36°
Average Low (°F)	65°	22°

Source: US Climate Data, 2017

Projected temperature extremes will shift with climate change, according to research conducted by the Massachusetts Executive Office for Energy and Environmental Affairs and the University of Massachusetts, Amherst. Projected changes in annual or seasonal average temperature for two different Representative Concentration Pathways (RCPs) summarized by drainage basin. The two emission scenarios are RCP 4.5, a "medium stabilization scenario" in which emissions are expected to peak in the mid-21st century and decline thereafter, and RCP 8.5, a high emissions scenario without any reduction in emissions over time.

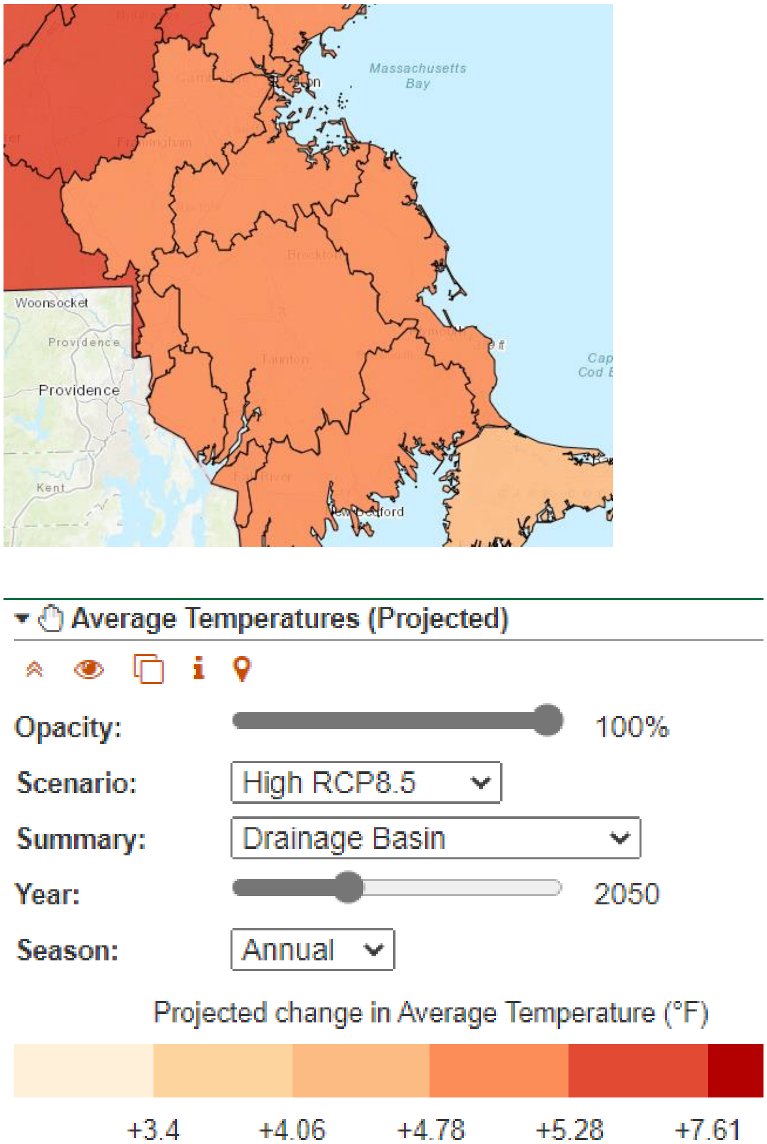
Heat waves cause more fatalities in the US than the total of all other meteorological events combined. Since 1979, more than 9,000 Americans have died from heat-related ailments (EPA, 2016).

Figure 87: Average Temperature Projected 2050, Medium RCP 4.5

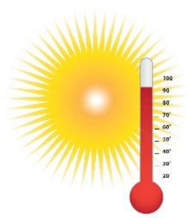


Source: ResilientMA

Figure 88: Average Temperature Projected 2050, High RCP 8.5



Source: ResilientMA

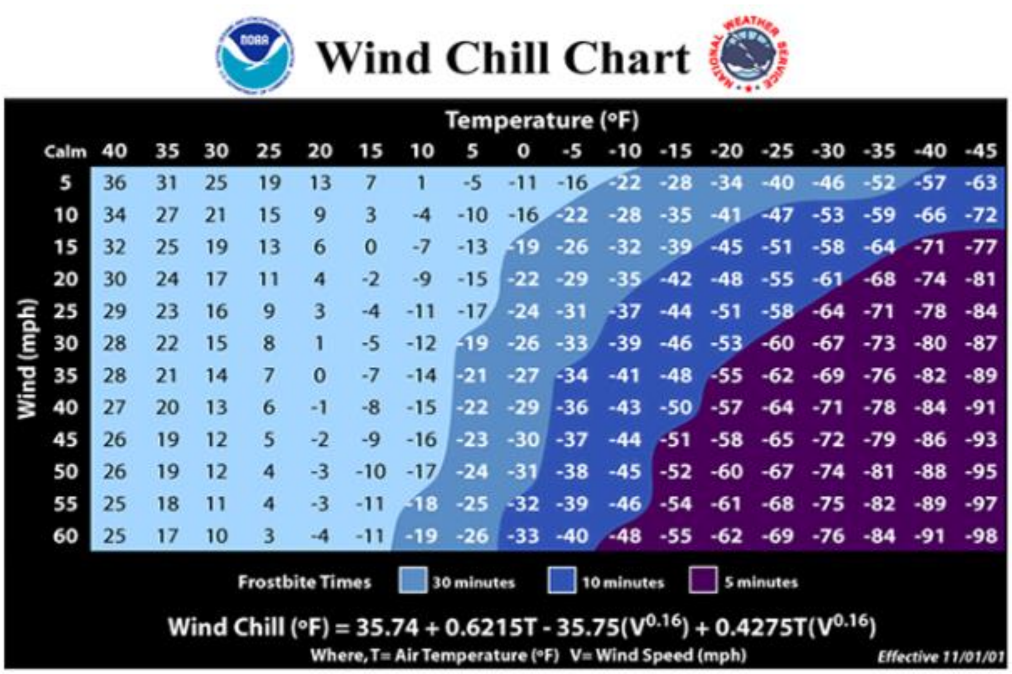
Rising Temperatures Extreme Heat		
Hazard	**Significant**	**Justification**
Extreme Heat 	YES	Included in the State Plan, high frequency of occurrence. In Plymouth County in the past ten years there has been one excessive heat day and no deaths. The town has not struggled with issues pertaining to extreme heat, but certainly experiences extreme cold. No improvements recommended at this time. • An average of two extreme heat and 1.5 extreme cold weather event/year have occurred over the last two decades. • Young and elderly populations and people with pre-existing health conditions are especially vulnerable to heat and cold. By the end of the century there could be 13-56 extreme heat days during summer
Exposure and Vulnerability by Key Sector		
	Populations	**General At-Risk Populations:** State-wide exposure; population in urban areas may face greater risk. **Vulnerable Populations:** Populations over age 65; infants and young children; individuals who are physically ill; low-income individuals who cannot afford proper cooling; populations whose jobs involve exposure to extreme temperatures.
	Government	Extreme heat generally does not impact buildings, although losses may occur as the result of overheated HVAC systems. Extreme cold temperature events can damage buildings through freezing /bursting pipes and freeze/thaw cycles.
	Built Environment	Extreme heat events can sometimes cause short periods of utility failure due to increased usage from air conditioners and other appliances. Heavy snowfall and ice storms, associated with extreme cold temperature events, can also cause power interruption. Periods of both hot and cold weather can stress energy infrastructure. Above extreme, below average, and extreme temperatures are likely to impact crops – such as apples, cranberries, and maple syrup – that rely on specific temperatures.
	Natural Resources and Environment	Because the species that exist in each area are designed to survive within a specific temperature range, extreme temperature events can place significant stress both on individual species and ecosystem. Warming temperature across the globe force species poleward, or upward in elevation, while species that cannot relocate fast enough or find suitable habitat face local extinction.
	Economy	Extreme temperature events can have significant economic impacts including loss of business function and damage/loss of inventory. The agricultural industry is the industry most at risk in terms of economic impact and damage due to extreme temperature and drought events.

Potential Effects of Climate Change – Rising Temperature		
	Rising Temperatures – Higher Extreme Temperatures	The average summer across the Massachusetts during the years between 1971 and 2000 included 4 days over 90°F (i.e., extreme heat days).
	Rising Temperatures – Higher Average Temperatures	Compared to an annual 1971-2000 average temperature baseline of 47.6°F, annual average temperatures in Massachusetts are projected to increase by 3.8 to 10.8 degrees by the end of the 21st century: slightly higher in western MA

Extreme Cold

The extent (severity or magnitude) of extreme cold temperatures is generally measured through the Wind Chill Temperature Index. Wind Chill Temperature is the temperature that people and animals feel when they are outside, and it is based on the rate of heat loss from exposed skin by the effects of wind and cold. As the wind increases, the body loses heat at a faster rate, causing the skin's temperature to drop.

Figure 89: Wind Chill Chart



Wind Chill Chart

Wind (mph) \ Temperature (°F)	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes; 10 minutes; 5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

Source: National Weather Service

Extreme cold events are when temperatures drop well below normal in an area. Generally, extreme cold temperatures are characterized by the ambient air temperature dropping to or below 0 degrees Fahrenheit (°F) (NWS, 2015). When winter temperatures drop significantly below normal, staying warm and safe can become a challenge. Extremely cold temperatures may accompany or follow a winter storm, which may also cause power failures and icy roads. Many homes will be too cold, either due to a power failure or because the heating system is not adequate for the weather. Extensive exposure to extreme cold temperatures can cause frostbite or hypothermia and can become life-threatening.

The Town of Hanson does not collect data for previous occurrences of extreme cold. The best available local data are for Plymouth County, through the National Climatic Data Center (NCDC). There have been two extreme cold events in the past ten years, which caused no deaths, no injuries, or property damage. This is an average of one event every 5 years.

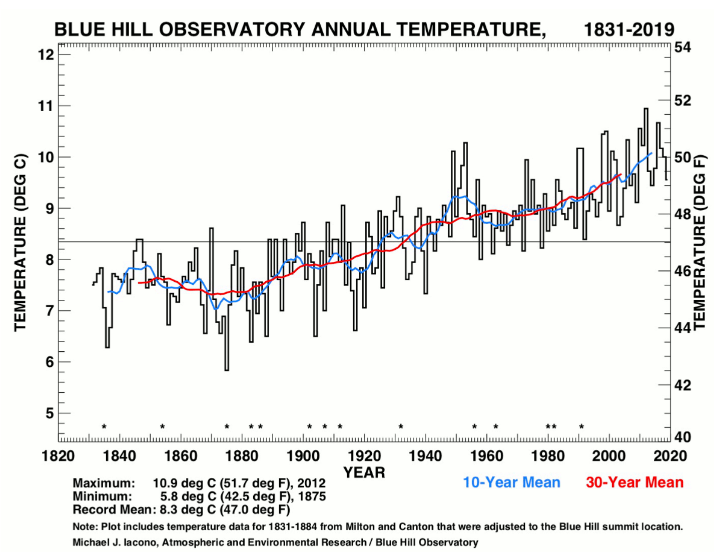
Table 69: Plymouth County Extreme Cold and Wind Chill Occurrences, 2010 through 2020

Date	Deaths	Injuries	Damage
02/16/2015	0	0	0
02/14/2016	0	0	0

Source: NOAA, National Climatic Data Center

Records from the Blue Hill Observatory in Milton, MA show that average temperatures have risen approximately 3°F since record keeping began in 1831. [65]

Figure 90: Blue Hill Observatory Annual Temperature, 1831 - 2019



- Upward Trend: +0.31-degree F/decade, +4.0-degree F since 1885
    - 30-year mean now warmer than 1870s by 4°F (2.2°C)

[65] https://bluehill.org/climate/anntemp.gif

- Trend statistically significant to 99.9% due to:
    - Long duration
    - Size of trend relative to annual variations
- Warmest: 51.7°F in 2012
- Coldest: 42.5°F in 1875
- Number of daily record high temperatures has increased.
- Number of daily record low temperatures has decreased.

Figure 91: Blue Hill Observatory 2020 Mean Temperatures 2020 [66]

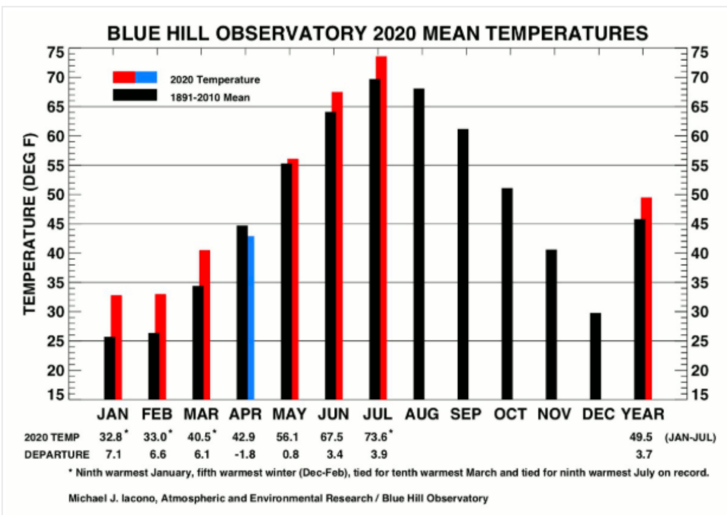
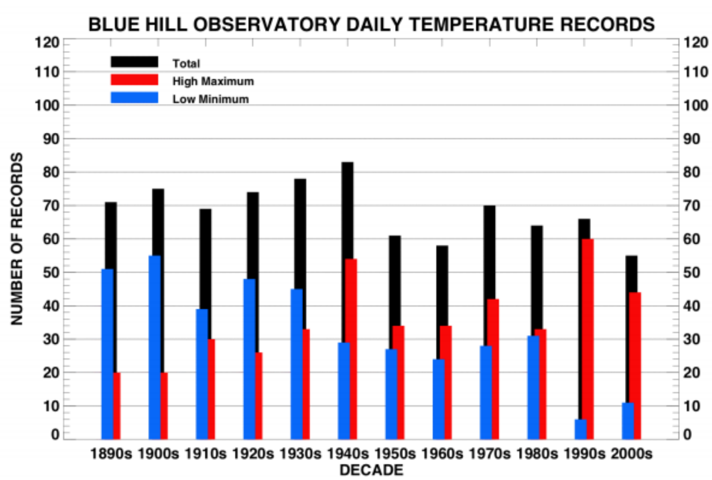
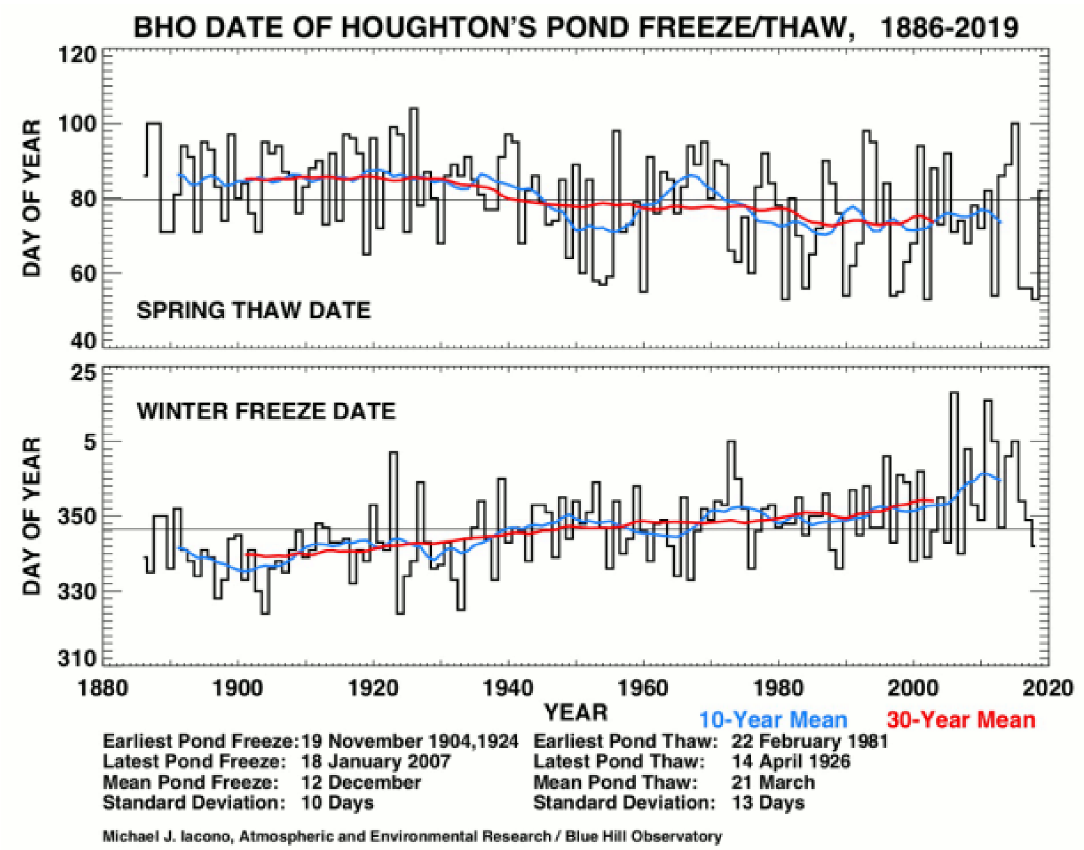


Figure 92: Blue Hill Observatory Daily Temperature Records



66 https://bluehill.org/observatory/2018/02/2018-mean-temperatures/

Figure 93: Pond Freeze/Thaw Dates



- Length of time local pond remains frozen in winter has decreased by two weeks since 1880s.
- Represents a natural indicator of climate change.

These climate projections include an increase in average and in the number of extreme heat days. Extreme cold day are projected to increase in number. The Northeast Climate Adaptation Science Center (NECASC) projects average temperatures in Massachusetts will increase by 5°F by mid-century and nearly 7°F by the end of the century.

Data from the Massachusetts Executive Office of Energy and Environmental Affairs' clearinghouse of climate science maps, data, documents, (www.resilientma.org) was also presented. ResilientMA provides climate projections from the Northeast Climate Adaptation Science Center. Downscaled to the level of major watershed basins, these projections provide a more focused look at what specific municipalities may experience in the future.

Precipitation will be more variable.

- “Extreme” precipitation events are likely to occur more frequently. Extreme weather includes blizzards, nor’easters, and hurricanes. According to resilientma.org the Commonwealth’s clearinghouse of climate data, the trend of more intense thunderstorms and downpours in the Northeast is likely to continue.
- Winter is expected to see the greatest change in precipitation (increase 2-225 by 2050s, increase 6-39% by 2090s).
- Given projected increase in average temperatures, this precipitation is more likely to be rain.
- Snow is likely to be wetter and heavier.
- Fall and summer are expected to continue to have the most consecutive dry days.

Extreme heat for Massachusetts is usually defined as a period of 3 or more consecutive days above 90 degrees Fahrenheit (°F), but more generally as a prolonged period of excessively hot weather, which may be accomplished by high humidity. Extreme cold is also considered relative to the normal climatic lows in a region.

Location

NOAA divides Massachusetts up into three climate divisions – Western, Central, and Coastal – and average annual temperatures vary slightly over the divisions. Another distinction between the divisions is that extreme temperature events occur more frequently and vary more in the inland regions where temperatures are not moderated by the Atlantic Ocean. Hanson sits within the Coastal Division.

Figure 94: Climate Divisions of Massachusetts

Source: NOAA, n.d.

Previous Occurrences

Extreme Cold

The following are the lowest temperatures recorded in parts of Massachusetts for the period from 1895 to present according to NOAA's Climate Extremes Committee (SCEC) [67].

- Taunton (-35°F), January 5, 1904
- Coldbrook (-35°F), February 15, 1943
- Chester (-35°F), January 12, 1981

Since 1994, there have been 33 cold weather events within the Commonwealth, ranging from Cold/Wind Chill to Extreme Cold/Wind Chill events. Detailed information regarding most of these extreme temperature events was not available; however, additional detail on recent extreme events is provided below (SHMCAP, 2018).

In February 2015, a series of snowstorms piled nearly 60 inches on the city of Boston in 3 weeks and caused recurrent blizzards across eastern Massachusetts. Temperature gauges across the Commonwealth measured extreme cold, with wind chills as low as -31°F. Four indirect fatalities occurred because of this event: two adults died shoveling snow and two adults were hit by snowplows.

In February 2016, one cold weather event broke records throughout the state. Wind chill in Worcester was measured at (-44°F), and the measured temperature in Boston (-9°F) broke a record previously set in 1957. Extreme cold/wind chill events were declared in 16 climate zones across the Commonwealth.

Extreme Heat

According to the NOAA's Storm Events Database, accessed in March 2018, there have been 43 warm weather events (ranging from Record Warmth/Heat to Excessive Heat events) since 1995. The most current event in the database occurred in July 2013. Excessive heat results from a combination of temperatures well above normal and high humidity. Whenever the heat index values meet or exceed locally or regionally established heat or excessive heat warning thresholds, an event is reported in the database.

In 2012, Massachusetts temperatures broke 27 heat records. Most of these records were broken between June 20 and June 22, 2012, during the first major heat wave of the summer to hit

[67] https://www.ncdc.noaa.gov/extremes/scec/records

Massachusetts and the East Coast. In July 2013, a long period of hot and humid weather occurred throughout New England. One fatality occurred on July 6, when a postal worker collapsed as the Heat Index reached 100°F.

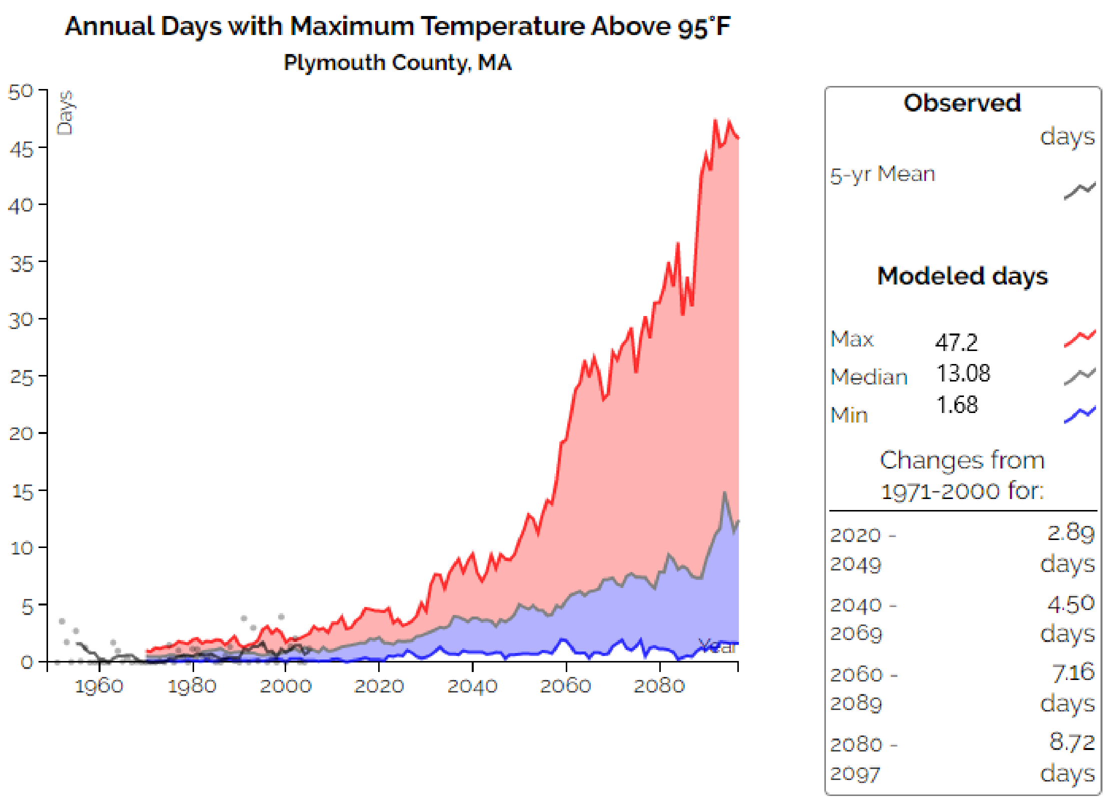
Frequency of Occurrences

Massachusetts has averaged 2.4 declared cold weather events and 0.8 extreme cold weather events annually between January 2013 and October 2017. The year 2015 was a particularly notable one, with seven cold weather events, including three extreme cold/wind chill events, as compared to no cold weather events in 2012 and one in 2013.

Probability of Future Occurrences

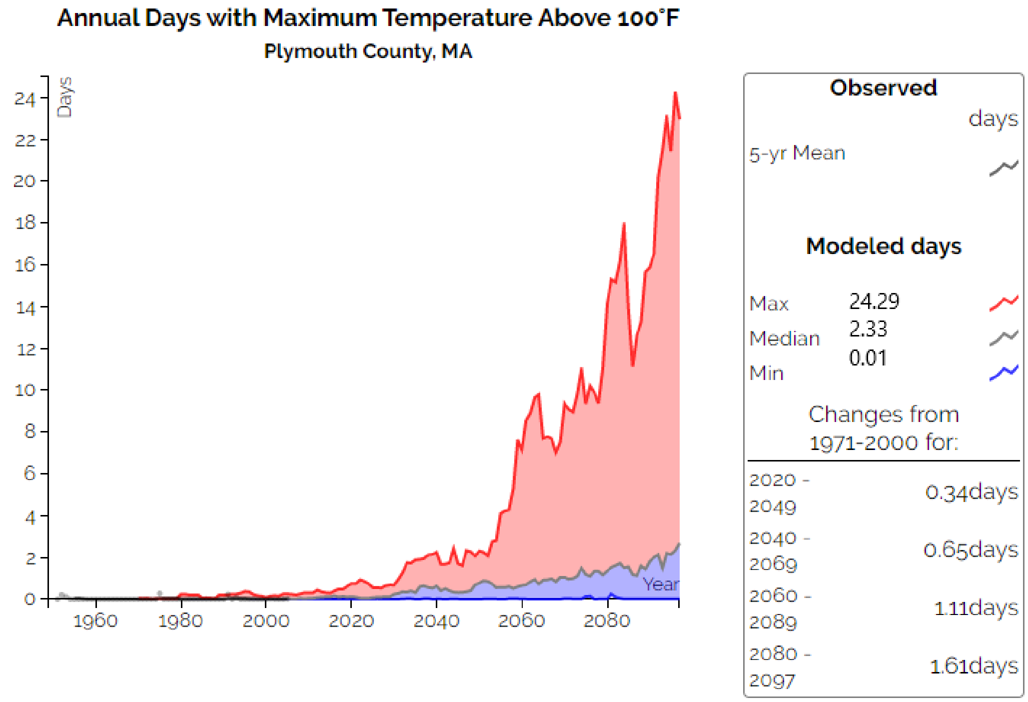
The NE CASC data support the trends of an increased frequency of extreme hot weather events and a decreased frequency of extreme cold weather events. The following figure shows the projected changes in these variables between 2020 and the end of this century.

Figure 95: Projected Annual Days with Temperature Above 95°F, Plymouth County



Source: ResilientMA

Figure 96: Annual Days with Maximum Temperature Above 100°F, Plymouth County



Source: ResilientMA

Figure 97: Projected Annual Days with Temperature Below 32°F, Plymouth County

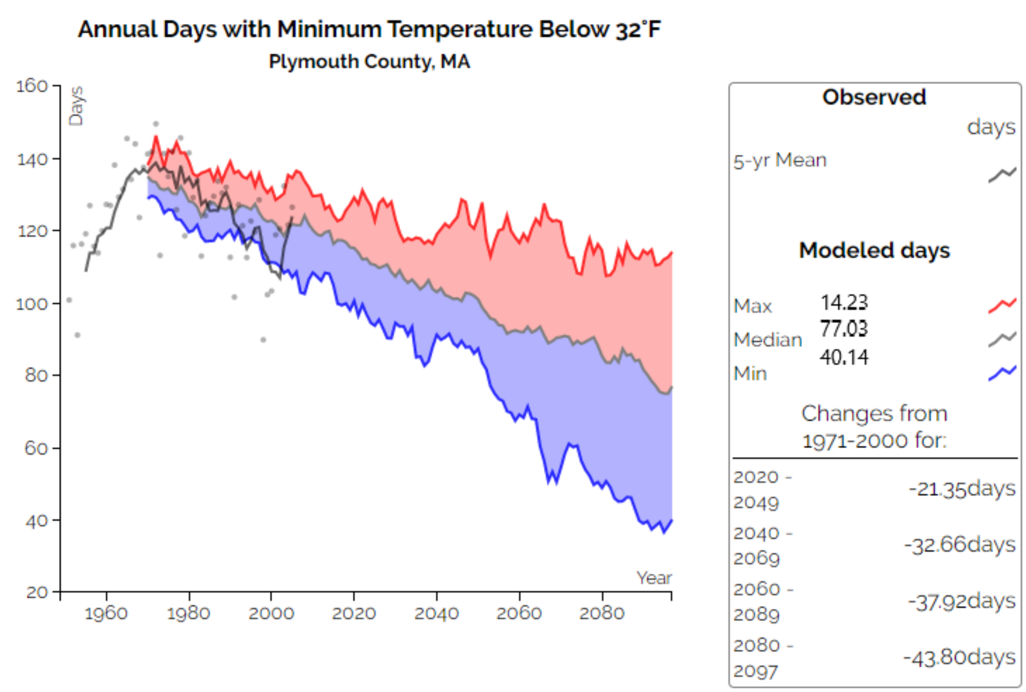
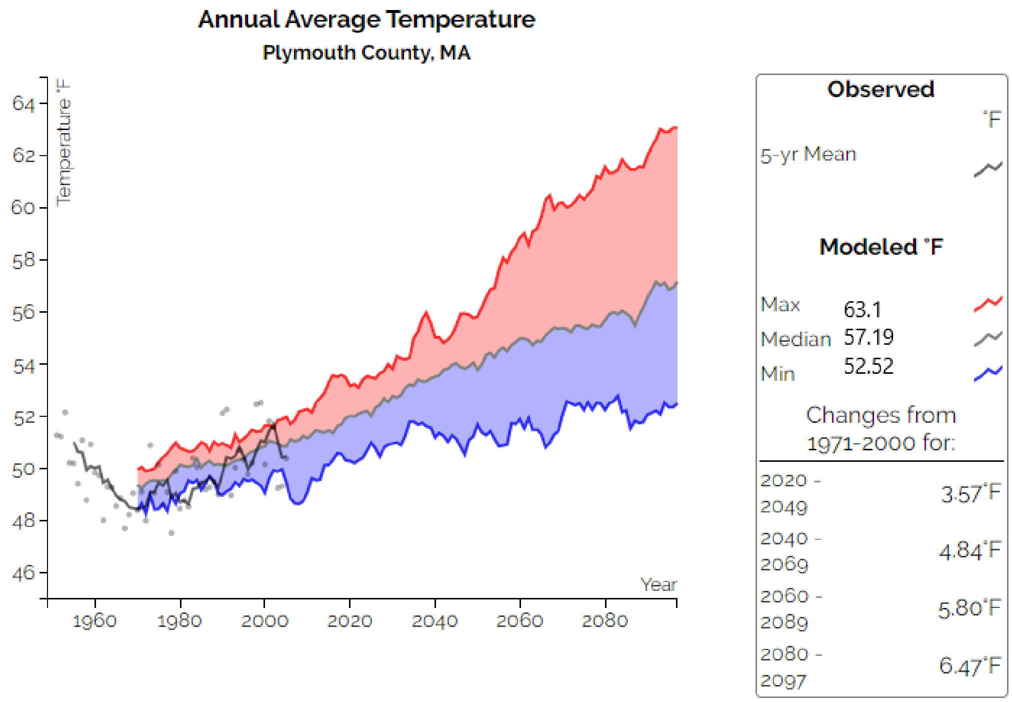


Figure 98: Annual Average Temperature, Plymouth County



The probability of future extreme heat and extreme cold is “high”, or between 40 and 70 percent in any given year.

Warning Time

Temperature changes will be gradual over the years. However, for the extremes, meteorologists can accurately forecast event development and the severity of the associated conditions with several days lead time. These forecasts provide an opportunity for public health and other officials to notify vulnerable populations. For heat events, the NWS issues excessive heat outlooks when the potential exists for an excessive heat event in the next 3 to 7 days.

Notifications such as “watches” are issued when conditions are favorable for an excessive heat event in the next 24 to 72 hours. Excessive heat warning/advisories are issued when an excessive heat event is expected in the next 36 hours. Winter temperatures may fall to extreme cold readings with no wind occurring. Currently, the only way to headline very cold temperatures is either through the issuance of a Wind Chill Advisory or Warning, or the issuance of a winter weather-related Warning, Watch, or Advisory if the cold temperatures are occurring in conjunction with a winter storm event (SHMCAP, 2018).

Secondary Hazard

According to the 2018 SHMCAP, the most significant secondary hazard associated with extreme temperatures is a severe weather event. Severe heat events are often associated with drought, as evaporation increases with temperature, and with wildfire, as high temperatures can cause vegetation to dry out and become more flammable. Warmer weather will also have an impact on invasive species. More commonly, heat events contribute to poor air quality that can exacerbate asthma and result in emergency department visits.

Conversely, extreme cold events are primarily associated with severe winter storms. The combination of cold weather with severe winter storm events is especially dangerous because winter weather can knock out heat and power, increasing exposure to extreme cold temperatures. Loss of heat and power may also lead to carbon monoxide poisoning from inappropriate use of combustion-powered generators, heaters, and cooking appliances, and heavy snowfall may block vents for gas dryers and heaters. Similarly, prolonged exposure to extreme heat can compromise power infrastructure, leaving customers without power or the ability to operate air conditioning. Power failure leads to increased use of diesel generators for power and more wood stoves are used in extreme cold; both situations lead to increasing air pollution and health impacts.

Sectors Assessed

Populations

The entire population of the Commonwealth of Massachusetts is exposed to extreme temperatures. While extreme temperatures are historically more common in the inland portions of the Commonwealth, the impacts to people may be more severe in densely developed urban areas around the state.

Extensive exposure to extreme cold temperatures can cause frostbite or hypothermia and can become life-threatening. Extreme cold and extreme heat are dangerous situations that can result in health emergencies for individuals without shelter or some other way to stay cool, or who live in homes that are poorly insulated, or without heat or air conditioning. Power outages may also result in inappropriate use of combustion heaters and other appliances. Extreme heat events can also contribute to a worsening of air quality, as high temperatures increase the production of ozone from aerosols such as volatile organic compounds. Weather patterns that bring high temperatures can also transport air pollutants from other areas of the continent. Additionally, atmospheric inversions and low wind speeds associated with heat waves allow polluted air to remain in one location for a prolonged period (UCI, 2017).

According to the 2018 SHMCAP, the interaction of heat and cardiovascular disease caused approximately 25 percent of the heat related deaths since 1999. The Town of Hanson does not collect data on excessive heat occurrences. The best available local data are for Plymouth County, through the

National Climatic Data Center. In the past ten years there has been one excessive heat day and no deaths, injuries, or property damage.

Table 70: General Vulnerability Indicators

Location	Estimated Increase in Average Temperature by 2100 (°F)	Proportion of Population Aged 65 or Older	Proportion of Population Aged <5 Years	Proportion of the Population Living Below Poverty Level
Massachusetts	4° - 12°	17.0%	5.2%	10.0%
Plymouth County	6.47°	18.6%	5.3%	6.2%
Hanson		16.1%	3.9%	3.3%

https://www.census.gov/quickfacts/fact/table/hansontownplymouthcountymassachusetts,plymouthcountymassachusetts,MA/PST045219

Vulnerable Populations

Extreme temperature can have a significant impact on human health, commercial/agricultural businesses, and primary and secondary effects on infrastructure (e.g., burst pipes and power failure). According to the Centers for Disease Control and Prevention, populations most at risk to extreme cold and heat events include people over the age of 65, who are less able to withstand temperature extremes due to their age, health conditions, and limited mobility to access shelters; infants and children under 5 years of age; individuals with pre-existing medical conditions that impair heat tolerance; low-income individuals who cannot afford proper heating and cooling; people with respiratory conditions, such as asthma or chronic obstructive pulmonary disease; and the public who may overexert themselves when working or exercising during extreme heat events or who may experience hypothermia during extreme cold events. Additionally, people who live along- particularly the elderly and individuals with disabilities are at higher risk of heat-related illness due to their isolation and reluctance to relocate to cooler environments.

The urban heat island effect can exacerbate vulnerability to extreme heat in urban areas. Other research, including a study of the spatial variability of heat-related mortality in Massachusetts, found that sociodemographic variables, including percent African American and percent elderly, may be more important to heat-related mortality than the level of urbanization (Hattis et al., 2012).

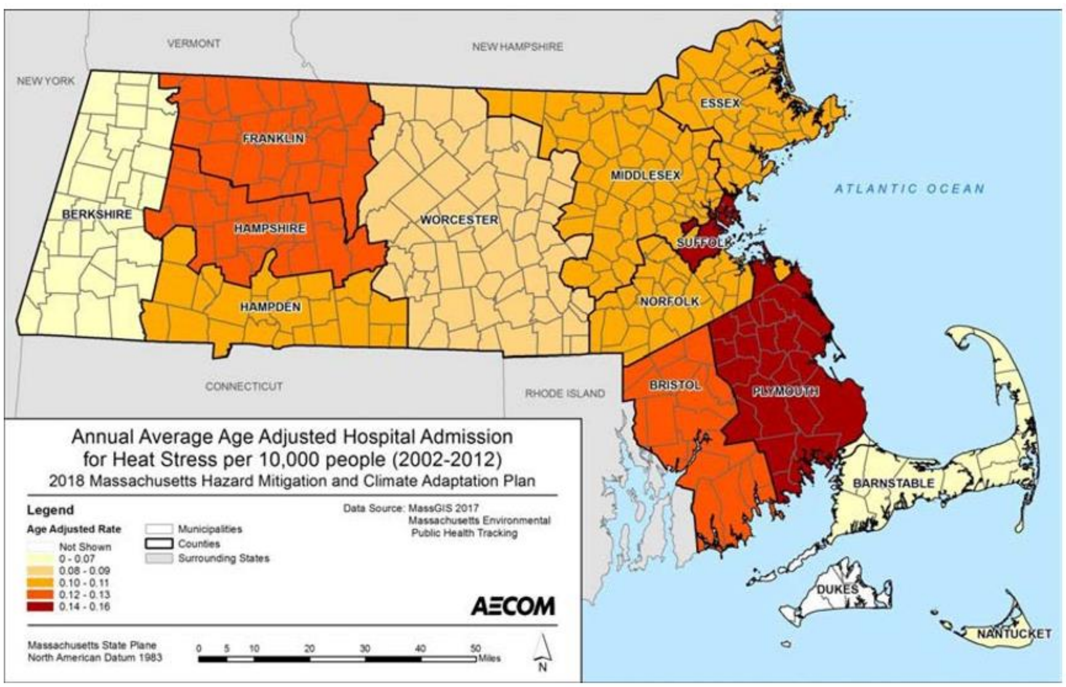
Health Impacts

When people are exposed to extreme heat, they can suffer from potentially deadly illnesses, such as heat exhaustion and heat stroke. Heat is the leading weather-related killer in the U.S., even though most heat-related deaths are preventable through outreach and intervention (EPA, 2016). A study of heat-related deaths across Massachusetts estimated that when the temperature rises above the 85th percentile (hot: 85-86°F), 90th percentile (very hot: 87-89°F) and 95th percentile (extremely hot: 89-

92°F) there are between five and seven excess deaths per day in Massachusetts. These estimates were higher for communities with high percentages of African American residents and elderly residents on days exceeding the 85th percentile (Hattis et al., 2011). A 2013 study of heart disease patients in Worcester, MA, found that extreme heat (high temperature greater than the 95th percentile) in the 2 days before a heart attack resulted in an estimated 44 percent increase in mortality. Living in poverty appeared to increase this effect (Madrigano et al., 2013). In 2015, researchers analyzed Medicare records for adults over the age of 65 who were living in New England from 2000 to 2008. They found that a rise in summer mean temperatures of 1°C resulted in a 1 percent rise in the mortality rate due to an increase in the number and intensity of heat events (Shi et al., 2015).

Hot temperatures can also contribute to deaths from respiratory conditions (including asthma), heart attacks, strokes, other forms of cardiovascular disease, renal disease, and respiratory diseases such as asthma and chronic obstructive pulmonary disorder. Human bodies cool themselves primarily through sweating and through increasing blood flow to body surfaces. Heat events thus increase stress on cardiovascular, renal, and respiratory systems, and may lead to hospitalization or death in the elderly and those with pre-existing diseases.

Figure 99: Rates of Heat Stress-Related Hospitalization by County

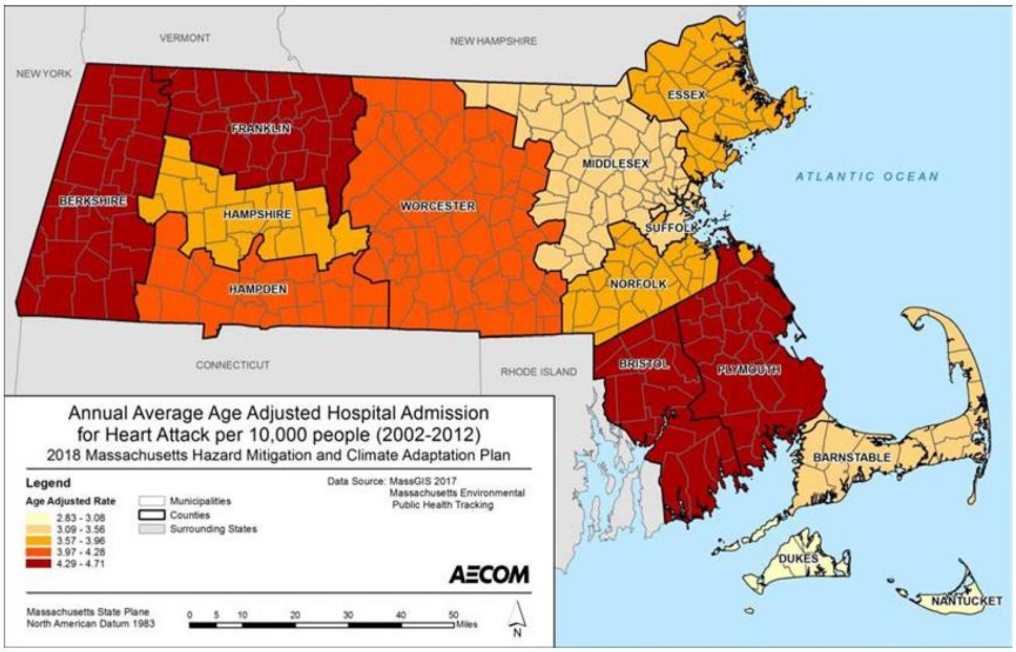


Source: SHMCAP, 2018

The interaction of heat and cardiovascular disease caused approximately 25 percent of the heat- related deaths since 1999 (EPA, 2016). The rate of hospital admissions for heat stress under existing conditions is shown in Figure 102. Between 2002 and 2012, the annual average age-adjusted rate of hospital admission for heat stress was highest in Plymouth and Suffolk Counties (0.14 to 0.16 admissions per 10,000 people).

As displayed in Figure 103, Plymouth, Bristol, Franklin, and Berkshire Counties experienced the highest annual average age-adjusted hospital admissions for heart attacks (4.29 to 4.17 per 10,000 people) during this period (SHMCAP, 2018).

Figure 100: Rates of Hospital Admissions for Heart Attacks by County



Source: SHMCAP, 2018

Government

All municipal buildings are exposed to the extreme temperature hazard. Extreme heat will result in an increased demand for cooling centers and air conditioning. Extreme heat events can sometimes cause short periods of utility failure, commonly referred to as brownouts, due to increased usage of air conditioners, appliances, and other items requiring power.

Extreme cold temperature events can damage buildings through freezing or bursting pipes and freeze and thaw cycles. Additionally, manufactured buildings (trailers and mobile homes) and antiquated or poorly constructed facilities may not be able to withstand extreme temperatures. The heavy snowfall and ice storms associated with extreme cold temperature events can also cause power interruptions. Backup power is recommended for critical facilities and infrastructure.

Built Environment

Except for power infrastructure, most structures and infrastructure within the town are not at risk for damage due to extreme temperatures, but populations that are not prepared to contend with these temperature extremes could be most vulnerable. However, extreme cold temperature events can damage buildings through freezing or bursting pipes and freeze and thaw cycles. Furthermore, secondary impacts of this hazard include extreme temperature fluctuations, which have serious implications for transportation infrastructure lifespan and maintenance needs.

Natural Resources and Environment

Individual extreme temperature events usually have a limited long-term impact on natural systems, although unusual frost events occurring after plants begin to bloom in the spring can cause significant damage. However, changing average temperatures and the changing frequency of extreme climate events will likely have a major impact on natural resources throughout the Commonwealth and worldwide (SHMCAP, 2018).

Changing temperatures will impact the natural environment in many ways. Because the species that exist in each area have adapted to survive within a specific temperature range, extreme temperature events can place significant stress both on individual species and the ecosystems in which they function.

Massachusetts ecosystems that are expected to be particularly vulnerable to warming temperatures include:

- Coldwater streams and fisheries
- Vernal pools
- Spruce-fir forests
- Northern hardwood (Maple-Beech-Birch) forests, which are economically important due to their role in sugar production.
- Hemlock forests, particularly those with the hemlock wooly adelgid
- Urban forests, which will experience extra impacts due to the urban heat island effect (SHMCAP, 2018).

Economy

Extreme temperatures can impact a municipal and regional economy in various ways. Hanson business owners may be faced with increased financial burdens due to unexpected building repairs (e.g., repairs for burst pipes), higher than normal utility bills, or business interruptions due to power failure (i.e., loss of electricity and telecommunications). There is a loss of productivity and income when the transportation sector is impacted, and people and commodities cannot get to their intended destination. Employers with outdoor workers (such as agricultural and construction companies) may have to reduce employees' exposure to the elements by reducing or shifting their hours to cooler or warmer periods of the day – these shifts can impact the earnings of both the company and the individual employee. The agricultural industry is most directly at risk in terms of economic impact and damage due to extreme temperature and drought events. Extreme heat can result in drought and dry conditions, which directly impact livestock and crop production (SHMCAP, 2018).

Fire

A wildfire is any uncontrolled fire occurring on undeveloped land that requires fire suppression. Wildfires can be ignited by lightning or by human activity such as smoking, campfires, equipment use and arson.

Although somewhat common, most brushfires in Hanson are small and quickly contained. However, as with any illegal fire or brushfire, there is always the risk that a small brushfire could grow into a larger, more dangerous wildfire, especially if conditions are right. Therefore, it is important to take steps to prevent wildfires and brushfires from turning into natural disasters.

While wildfires or brushfires have not been a significant problem in Hanson, there is always a possibility that changing land use patterns and weather conditions will increase a community's vulnerability. For example, drought conditions can make forests and other open, vegetated areas more vulnerable to ignition. Once the fire starts, it will burn hotter and be harder to extinguish. Soils and root systems starved for moisture are also vulnerable to fire. Residential growth in rural, forested areas increases the total area that is vulnerable to fire and places homes and neighborhoods closer to areas where wildfires are more likely to occur. Global climate changes may also influence precipitation patterns, making the region more susceptible to drought and therefore, wildfires.

Low risk exists for potential wildfire incidents, especially near some of the town's forested, agricultural, and recreational lands.

Location

In Massachusetts, the DCR Bureau of Forest Fire Control has been the state agency responsible for providing aid, assistance, and advice to the Commonwealth's cities and towns since 1911. The Bureau aids and cooperation with fire departments, local law enforcement agencies, the Commonwealth's county and statewide civil defense agencies, and mutual aid assistance organizations.

Extent

The National Wildfire Coordinating Group defines seven classes of wildfires:

- Class A: 0.25 acre or less
- Class B: more than 0.25 acre, but less than 10 acres
- Class C: 10 acres or more, but less than 100 acres
- Class D: 100 acres or more, but less than 300 acres
- Class E: 300 acres or more, but less than 1,000 acres
- Class F: 1,000 acres or more, but less than 5,000 acres
- Class G: 5,000 acres or more

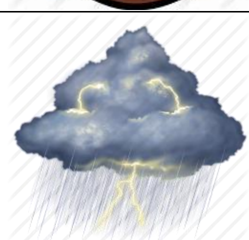
Wildfire

Wildfires		
Hazard	**Significant**	**Justification**
Wildfires 	YES	One notable event per year in MA. Increased risk and rates of wildfires combined with the reduced water levels can cause heightened mortality of both wildlife and livestock. Limited and scattered property damage, limited damage to public infrastructure and essential services not interrupted, limited injuries. • Massachusetts is likely to experience at least one event/year with noteworthy damages. • Barnstable and Plymouth Counties are most vulnerable due to their vegetation, sandy soils, and wind conditions. • There are over 1,200 state owned buildings in identified wildfire hazard areas in the Commonwealth. Projected increase in seasonal drought and warmer temperatures will increase the risk of wildfire.
Exposure and Vulnerability by Key Sector		
	Populations	**General At-Risk Populations:** Populations whose homes located in wildfire hazard areas. **Vulnerable Populations:** Populations who are sensitive to smoke and poor air quality, including children, the elderly, and those with respiratory and cardiovascular diseases.
	Government	
	Built Environment	Fires can create conditions that block or prevent access and can isolate residents and emergency service providers. Power lines are the most at risk to wildfire because most poles are made of wood and susceptible to burning. In addition to potential direct losses to water infrastructure, wildfires may result in significant withdrawal of water supplies. They can also damage infrastructure elements such as power and communication lines.
	Natural Resources and Environment	Wildfires and the ash they generate can distort the flow of nutrients through an ecosystem, reducing the biodiversity that can be supported.
	Economy	Wildfire events can have major economic impacts on a community both from the initial loss of structures and the subsequent loss of revenue from destroyed businesses and decrease in tourism. Additionally, wildfires can require thousands of taxpayer dollars in fire response efforts.

Unfragmented and heavily forested areas are vulnerable to wildfires, particularly during droughts. Forested and agricultural areas with high fuel content have more potential to burn. In addition, it is often exceedingly difficult to access some of the locations to extinguish brush fires. However, the greatest potential for significant damage to life and property from fire exists in areas designated as wildland-urban interface areas. Again, the wildland-urban interface area defines the conditions where highly flammable vegetation is adjacent to developed areas. Based on the total area of this type of condition within town, the extent of a significant wildfire or brushfire in Hanson is deemed Limited.

- Surface fires are the most common type and burn along the floor of a forest, moving slowly and killing or damaging trees.
- Ground Fires are usually started by lightning and burn on or below the forest floor.
- Crown fires spread rapidly by wind, jumping along the tops of trees.

A wildfire differs greatly from other fires by its extensive size, the speed at which it can spread out from its original source, its potential to unexpectedly change direction, and its ability to jump gaps such as roads, rivers, and fire breaks. Wildfire season begins in March and usually ends in late November. Most wildfires typically occur in April and May, when most vegetation is void of any appreciable moisture, making them highly flammable. Once "green-up" takes place in late May to early June, the fire danger usually is reduced somewhat. As the climate warms, drought and warmer temperatures may increase the risk of wildfire as vegetation dries out and becomes more flammable.

Potential Effects of Climate Change - Wildfire		
	Rising Temperatures and Changes in Precipitation – Prolonged Drought	Seasonal drought risk is projected to increase during summer and fall in the Northeast as higher temperatures lead to greater evaporation and earlier winter and spring snowmelt, coupled with more variable precipitation patterns. Drought and warmer temperatures may also heighten the risk of wildfire, by causing forested areas to dry out and become more flammable.
	Rising Temperatures – More Frequent lightning	Research has found that the frequency of lightning strikes – an occasional cause of wildfires – could increase by approximately 12 percent for every degree Celsius of warming.

Wildfire is determined by climate variability, local topography, and human intervention. Climate change has the potential to affect multiple elements of the wildfire system, fire behavior, ignitions, fire management, and vegetation fuels. AN increase in temperature coupled with a noticeable decrease in precipitation exacerbated droughts and has the potential to contribute to an increased frequency of wildfire. Hot dry spells create the highest fire risk. Increased temperatures may intensify wildfire danger by warming and drying out vegetation. When climate alters fuel loads and fuel moisture, forest susceptibility to wildfires changes. Climate changes also may increase winds that spread fires. Faster fires are harder to contain, and thus are more likely to expand into residential neighborhoods.

Wildfire Types

Once a fire starts, location of the fire and the type of fuel consumed determines how severe the fire will be. There are four types of wildfires (Table 52). These fire types range from ground fires, which tend to travel relatively slow and are easier to control, to canopy fires, in which flames can jump from tree to tree through the canopy relatively quickly. These are the most difficult to control and extinguish.

Table 71: Wildfire Types

Type	Location	Typical Fuel
Ground	At or below ground surface	Underground roots buried leaves and other organic matter
Surface	Ground Surface	Surface leaves, grass, low lying vegetation, underbrush
Ladder	Between the surface and canopy	Underbrush, downed logs, vines, and small trees
Canopy	In the tree canopy	Tall trees, vines, and branches

Secondary Hazards

Wildfires can generate a range of secondary effects, which in some cases may cause more widespread and prolonged damage than the fire itself. Wildfires cause the contamination of reservoirs; destroy power, gas, water, broadband, and oil transmission lines; and contribute to flooding. They strip slopes of vegetation, exposing them to greater amounts of runoff. This in turn can weaken soils and cause failures on slopes as well as water quality impacts in downstream water bodies. Major landslides can occur several years after a wildfire. Most wildfires burn hot, and they can bake soils for long periods of time, thus increasing the imperviousness of the ground. This increases the runoff generated by storm events and, as a result, the chance of flooding.

Warning Time

Humans often cause wildfires, intentionally or accidentally. There is no way to predict when one might break out. Since fireworks often cause brush fires, extra diligence is warranted around the Fourth of July when the use of fireworks is highest. Dry seasons and droughts are factors that greatly increase fire likelihood. Dry lightning may trigger wildfires. Severe weather can be predicted, so special attention can be paid during weather events that may include lightning. Reliable National Weather Service lightning warnings are available on average 24 to 48 hours prior to a significant electrical storm.

Sectors Assessed

Populations

Potential losses from wildfires include human life, structures and other improvements, and natural resources. Given the immediate response times to reported fires, the likelihood of injuries and casualties is minimal. Smoke and air pollution from wildfires can be a health hazard, especially for sensitive populations including children, the elderly and those with respiratory and cardiovascular diseases. Wildfires may also threaten the health and safety of those fighting the fires. First responders are exposed to the dangers from the initial incident and after-effects from smoke inhalation and heat stroke. In addition, wildfire can lead to ancillary impacts such as landslides in steep ravine areas and flooding due to the impacts of silt in local watersheds.

Vulnerable Populations

All individuals whose homes or workplaces located in wildfire hazard zones are exposed to this hazard, as wildfire behavior can be unpredictable and dynamic. However, the most vulnerable members of this population are those who would be unable to evacuate quickly, including those over the age of 65, households with young children under the age of 5, people with mobility limitations, and people with low socioeconomic status. Landowners with pets or livestock may face additional challenges in evacuating if they cannot easily transport their animals. Outside of the area of immediate impact, sensitive populations, such as those with compromised immune systems or cardiovascular or respiratory diseases, can suffer health impacts from smoke inhalation. Individuals with asthma are more vulnerable to the poor air quality associated with wildfire. Finally, firefighters and first responders are vulnerable to this hazard if they are deployed to fight a fire in an area that would not otherwise be in.

Health Impacts

Smoke and air pollution from wildfires can be a severe health hazard. Smoke generated by wildfire consists of visible and invisible emissions containing particulate matter (soot, tar, and minerals), gases (water vapor, carbon monoxide, carbon dioxide, and nitrogen oxides), and toxics (formaldehyde and benzene). Emissions from wildfires depend on the type of fuel, the moisture content of the fuel, the efficiency (or temperature) of combustion, and the weather. Other public health impacts associated with wildfire include difficulty in breathing, reactions to odor, and reduction in visibility. Due to the high prevalence of asthma in Massachusetts, there is a high incidence of emergency department visits when respiratory irritants like smoke envelop an area. Wildfires may also threaten the health and safety of those fighting the fires. First responders are exposed to dangers from the initial incident and the aftereffects of smoke inhalation and heat-related illness.

Government

There are likely to be several facilities containing hazardous materials exposed to the wildfire hazard. During a wildfire event, these materials could rupture due to excessive heat and act as fuel for the fire, causing rapid spreading and escalating the fire to unmanageable levels. In addition, they could lead into surrounding areas, saturating soils, and seeping into surface waters, and have disastrous effect on the environment.

In the event of wildfire, there would likely be little damage to the majority of infrastructure. Most road and railroads would be without damage except in the worst scenarios. Power lines are the most at risk to wildfire because most are made of wood and susceptible to burning. In the event of a wildfire, pipelines could provide a source of fuel and lead to a catastrophic explosion.

Built Environment

Property damage from wildfires can be severe and can significantly alter entire communities. Structures that were not designed with fire smart principles in mind vulnerable. Fires can create conditions that block or prevent access, and they can isolate residents and emergency service providers. Wildfires can create conditions in which bridges are obstructed. Transmission lines are at risk to faulting during wildfires, which can result in a broad area outage. In the event of a wildfire, pipelines could provide a source of fuel and lead to a catastrophic explosion. Wildfires may result in significant withdrawal of water supplies. Coupled with the increased likelihood that drought and wildfire will coincide under the future warmer temperatures associated with climate change, this withdrawal may result in regional water shortages and the need to identify new water sources.

Natural Resources and Environment

Fire is a natural and critical ecosystem process in most terrestrial ecosystems, dictating in part the types, structure, and spatial extent of native vegetation. However, wildfires can cause severe environmental impacts:

- ***Damaged Fisheries –*** Critical fisheries can suffer from increased water temperatures, sedimentation, and changes in water quality.
- ***Soil Erosion –*** The protective covering provided by foliage and dead organic matter is removed, leaving the soil fully exposed to wind and water erosion. Accelerated soil erosion occurs, causing landslides and threatening aquatic habitats.
- ***Spread of Invasive Plant Species –*** Non-native woody plant species frequently invade burned areas. When weeds become established, they can dominate the plant cover over broad landscapes, and become difficult and costly to control.

Economy

Currently there is no measure in place to quantify the potential economic impacts due to wildfires besides historical data. The risk of wildfires is measured in terms of the hazard's economic, environment, or social impacts. Economic impacts due to wildfires include costs and losses due to burned agricultural crops, damaged public infrastructure, and private property, interrupted transportation corridors, and disrupted communication lines. Economic impacts also include diminished real property values and thus tax revenues, loss of retail sales, and relocation expenses of temporarily or permanently displaced residents.

Invasive Species

Invasive species are defined as non-native species that cause or are likely to cause harm to ecosystems, economies, and/or public health (NISC, 2006). Although invasive species can be any type of organism, including marine organisms, insects and birds, the 2018 Massachusetts State Hazard and Climate Adaptation Plan focuses specifically on invasive terrestrial plants, as these are the most studied and managed type of invasive species.

Invasive Species		
Hazard	**Significant**	**Justification**
	YES	This is a new hazard identified over the course of the MVP CRB workshop process. The team recommends the Town stay abreast of regional and state-wide efforts to understand and mitigate the spread of invasive species. • Risk to native or minimally managed ecosystems has increase as dispersion of exotic species has increased. Changes in temperature and precipitation may increase changes of a successful invasion of non-native species.
Exposure and Vulnerability by Key Sector		
	Populations	**General At-Risk Populations:** Statewide exposure **Vulnerable Populations:** Populations who depend on the Commonwealth's existing ecosystems for their economic success.
	Government	State=managed and publicly owned water bodies and reservoirs could be unknowingly exposed to invasive species introduced from other areas. Invasive species can clog water infrastructure and cause extensive ecological, economic, and social impacts. Invasive species also impact state wildlife management areas.
	Built Environment	Invasive species can impose a threat along roadways by impeding sight lines if left unchecked. More pest pressure from insect, diseases, and weeds may harm crops and cause farms to increase pesticide use. Invasive species may cause impacts to water quality, which would have implications for the drinking water supplies and the cost of treatment.
	Natural Resources and Environment	Invasive species present a significant threat to the environment and natural resources present in the Commonwealth. Research has found that competition or predation by alien species is the second most significant threat to biodiversity, only surpassed by direct habitat destruction or degradation.
	Economy	Invasive species are widely considered to be one of the costliest natural hazards in the US, as invasive control efforts can be quite extensive, and these species can damage crops, recreational amenities, and public goods such as water quality.

Species that may have negative impacts in Hanson include purple loosestrife, phragmites, which are susceptible to wildfire.

Exotic non-native invasive plant and insect species have become a great concern for the Town of Hanson. These species threaten the overall and long-term health of many of Hanson's rich natural habitats because they outcompete native species for precious resources and, in extreme cases, eliminate native species from those habitat areas. On a priority basis, site by site, the Town is attempting to eliminate the invasive species. Of greatest concern are those invasive species that reside in some of the town's water bodies. These species degrade the ecological health of these systems and limit recreational use. Hobomock Pond is occasionally closed for recreation to an abundance of the aquatic plant hydrilla (*Hydrilla ssp.)*. Efforts to eradicate the persistent weed have lasted for years with varying degrees of success. Other problematic aquatic and riparian species include common reed (*Phragmites australis),* purple loosestrife (*Lythrum salicaria)*, fanwort (*Cambomba spp.)* and veriable milifoil (*Myriophyllum heterophyllum) (*Glover, 2012).

Potential Effects of Climate Change – Invasive Species		
	Rising Temperatures and Warming Climate	A warming climate may place stress on colder-weather species while allowing non-native species accustomed to warmer climates to spread northward.
	Rising Temperatures and Changes in Precipitation – Ecosystem Stress	Changes in precipitation and temperature combine to create new stresses for Massachusetts unique ecosystems. For example, intense rainfall in urbanized areas can cause pollutants on roads and parking lots to get washed into nearby rivers and lakes, reducing habitat quality. As rainfall and snowfall patterns change, certain habitats and species that have specific physiological requirements may be affected. The stresses experienced by native ecosystems because of these changes may increase the changes of a successful invasion of non-native species.

Invasive species are one of the greatest threats to the integrity of natural communities and a direct threat to the survival of many indigenous species.

Massachusetts has also implemented biological control programs aimed at controlling these invasive species: purple loosestrife (*Lythrum salicaria*), mile-a-minute vine (*Persicaria perfoliata*), hemlock woolly adelgid (*Adelges tsugae*), and winter moth (*Operophtera brumata*).

Although there are fewer clear-cut criteria for invasive fauna, there are several animals that have disrupted natural systems and inflicted economic damage on the Commonwealth, as summarized in the Table below. Invasive fungi are also included in this table. In marine systems, management of invasive is extremely difficult once a species has become established; therefore, the focus is on monitoring established populations and surveying marine habitats for early detection and rapid response. Because of the rapidly evolving nature of the invasive species hazard, this list is not considered exhaustive.

Species	Common name	Notes
Terrestrial/Freshwater		
Acer platanoides	Norway maple	A tree occurring in all regions of the state in upland and wetland habitats, and especially common in woodlands with colluvial soils. It grows in full sun to full shade. Escapes from cultivation; can form dense stands; outcompetes native vegetation, including sugar maples; dispersed by wind, water, and vehicles.
Acer pseudoplatanus	Sycamore maple	A tree occurring mostly in southeastern counties of Massachusetts, primarily in woodlands and especially near the coast. It grows in full sun to partial shade. Escapes from cultivation inland as well as along the coast; salt-spray tolerant; dispersed by wind, water, and vehicles.
Aegopodium podagraria	Bishop’s goutweed, bishop’s weed; goutweed	A perennial herb occurring in all regions of the state in uplands and wetlands. Grows in full sun to full shade. Escapes from cultivation; spreads aggressively by roots; forms dense colonies in floodplains.
Ailanthus altissima	Tree of Heaven	This tree occurs in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade. Spreads aggressively from root suckers, especially in disturbed areas.
Alliaria petiolata	Garlic mustard	A biennial herb occurring in all regions of the state in uplands. Grows in full sun to full shade. Spreads aggressively by seed, especially in wooded areas.
Berberis thunbergii	Japanese barberry	A shrub occurring in all regions of the state in open and wooded uplands and wetlands. Grows in full sun to full shade. Escapes from cultivation; spread by birds; forms dense stands.
Cabomba caroliniana	Carolina fanwort; fanwort	A perennial herb occurring in all regions of the state in aquatic habitats. Common in the aquarium trade; chokes waterways.
Celastrus orbiculatus	Oriental bittersweet; Asian or Asiatic bittersweet	A perennial vine occurring in all regions of the state in uplands. Grows in full sun to partial shade. Escapes from cultivation; berries spread by birds and humans; overwhelms and kills vegetation.
Cynanchum louiseae	Black swallowwort; Louise’s swallowwort	A perennial vine occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to partial shade. Forms dense stands, outcompeting native species: deadly to Monarch butterflies.
Elaeagnus umbellata	Autumn olive	A shrub occurring in uplands in all regions of the state. Grows in full sun. Escapes from cultivation; berries spread by birds; aggressive in open areas; can change soil.
Euonymus alatus	Winged euonymus, burning bush	A shrub occurring in all regions of the state and capable of germinating prolifically in many different habitats. It grows in full sun to full shade. Escapes from cultivation and can form dense thickets and dominate the understory; seeds are dispersed by birds.
Euphorbia esula	Leafy spurge; wolf's milk	A perennial herb occurring in all regions of the state in grasslands and coastal habitats. Grows in full sun. An aggressive herbaceous perennial and a notable problem in the western U.S..

Species	Common name	Notes
Frangula alnus	European buckthorn, glossy buckthorn	Shrub or tree occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade. Produces fruit throughout the growing season; grows in multiple habitats; forms thickets.
Glaucium flavum	Sea or horned poppy, yellow hornpoppy	A biennial and perennial herb occurring in southeastern MA in coastal habitats. Grows in full sun. Seeds float; spreads along rocky beaches; primarily Cape Cod and Islands.
Hesperis matronalis	Dame's rocket	A biennial and perennial herb occurring in all regions of the state in upland and wetland habitats. Grows in full sun to full shade. Spreads by seed; can form dense stands, particularly in floodplains.
Iris pseudacorus	Yellow iris	A perennial herb occurring in all regions of the state in wetland habitats, primarily in floodplains. Grows in full sun to partial shade. Outcompetes native plant communities.
Lepidium latifolium	Broad-leaved pepperweed, tall pepperweed	A perennial herb occurring in eastern and southeastern regions of the state in coastal habitats. Grows in full sun. Primarily coastal at upper edge of wetlands; also found in disturbed areas; salt tolerant.
Lonicera japonica	Japanese honeysuckle	A perennial vine occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade. The rapidly growing, dense stands climb and overwhelm native vegetation; produces many seeds that are dispersed by birds; more common in southeastern Massachusetts.
Lonicera morrowii	Morrow's honeysuckle	A shrub occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade. Part of a confusing hybrid complex of non-native honeysuckles commonly planted and escaping from cultivation via bird dispersal.
Lonicera x bella [morrowii x tatarica]	Bell's honeysuckle	This shrub occurs in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade. Part of a confusing hybrid complex of non-native honeysuckles commonly planted and escaping from cultivation via bird dispersal.
Lysimachia nummularia	Creeping jenny, moneywort	A perennial herb occurring in all regions of the state in upland and wetland habitats. Grows in full sun to full shade. Escaping from cultivation; problematic in floodplains, forests, and wetlands; forms dense mats.
Lythrum salicaria	Purple loosestrife	A perennial herb or subshrub occurring in all regions of the state in upland and wetland habitats. Grows in full sun to partial shade. Escaping from cultivation; overtakes wetlands; high seed production and longevity.
Myriophyllum heterophyllum	Variable watermilfoil; two-leaved watermilfoil	A perennial herb occurring in all regions of the state in aquatic habitats. Chokes waterways, spread by humans and possibly birds.
Myriophyllum spicatum	Eurasian or European water-milfoil; spike water- milfoil	A perennial herb found in all regions of the state in aquatic habitats. Chokes waterways, spread by humans and possibly birds.
Phalaris arundinacea	Reed canary-grass	This perennial grass occurs in all regions of the state in wetlands and open uplands. Grows in full sun to partial shade. Can form huge colonies and overwhelm wetlands; flourishes in disturbed areas; native and introduced strains; common in agricultural settings and in forage crops.

Species	Common name	Notes
Phragmites australis	Common reed	A perennial grass (USDA lists as subshrub, shrub) found in all regions of the state. Grows in upland and wetland habitats in full sun to full shade. Overwhelms wetlands forming huge, dense stands; flourishes in disturbed areas; native and introduced strains.
Polygonum cuspidatum / Fallopia japonica	Japanese knotweed; Japanese or Mexican bamboo	A perennial herbaceous subshrub or shrub occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade, but hardier in full sun. Spreads vegetatively and by seed; forms dense thickets.
Polygonum perfoliatum	Mile-a-minute vine or weed; Asiatic tearthumb	This annual herbaceous vine is currently known to exist in several counties in MA and has also been found in RI and CT. Habitats include stream sides, fields, and road edges in full sun to partial shade. Overly aggressive; bird and human dispersed.
Potamogeton crispus	Crisped pondweed, curly pondweed	A perennial herb occurring in all regions of the state in aquatic habitats. Forms dense mats in the spring and persists vegetatively.
Ranunculus ficaria	Lesser celandine; fig buttercup	A perennial herb occurring on stream banks, and in lowland and uplands woods in all regions of the state. Grows in full sun to full shade. Propagates vegetatively and by seed; forms dense stands, especially in riparian woodlands; an ephemeral that outcompetes native spring wildflowers.
Rhamnus cathartica	Common buckthorn	A shrub or tree occurring in all regions of the state in upland and wetland habitats. Grows in full sun to full shade. Produces fruit in fall; grows in multiple habitats; forms dense thickets.
Robinia pseudoacacia	Black locust	A tree that occurs in all regions of the state in upland habitats. Grows in full sun to full shade. While the species is native to central portions of Eastern North America, it is not indigenous to MA. It has been planted throughout the state since the 1700s and is now widely naturalized. It behaves as an invasive species in areas with sandy soils.
Rosa multiflora	Multiflora rose	A perennial vine or shrub occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade. Forms impenetrable thorny thickets that can overwhelm other vegetation; bird dispersed.
Salix atrocinerea/Salix cinerea	Rusty Willow/Large Gray Willow complex	A large shrub or small tree most found in the eastern and southeastern areas of the state, with new occurrences being reported further west. Primarily found on pond shores but is also known from other wetland types and rarely uplands. Forms dense stands and can outcompete native species along the shores of coastal plain ponds.
Trapa natans	Water chestnut	An annual herb occurring in the western, central, and eastern regions of the state in aquatic habitats. Forms dense floating mats on water.

Species	Common name	Notes
Marine		
Codium fragile ssp. fragile	Codium	This alga is distributed along nearly the entire coastline of the eastern United States. It was most likely introduced to Massachusetts waters with oysters transplanted from Long Island Sound in the mid-20th century. It now covers a region from the Gulf of St. Lawrence, Canada, to North Carolina. It attaches to nearly any hard surface, increasing maintenance labor for aquaculturists and reducing the productivity of cultured species. It can also cause its host shellfish to detach. This species outcompetes many native species, such as kelp, that serve as shelters for fish and invertebrate species.
Colpomenia peregrina	Sea potato (brown seaweed)	C. peregrina was first reported in Massachusetts waters in 2011. It looks like the native Leathesia marina and forms a bubble as it grows, often attaching to other seaweeds. First observed in Nova Scotia in 1960, it has made its way south into Maine, New Hampshire, and Massachusetts. The impacts to Massachusetts waters are unclear at this time, but its tendency to grow on native seaweeds, shellfish, and other species could lead to shading and other competitive impacts.
Grateloupia turuturu	Red algae	This red alga, native to Asia, was first observed in Rhode Island in 1994. Since then, it has expanded northward and was first recorded in Massachusetts in 2007; is continuing to spread northward at this time. This species can grow rapidly, producing large blades capable of covering other seaweed species in the intertidal and subtidal environments.
Dasysiphonia japonica	Red filamentous algae	This red filamentous alga, native to Asia, is widespread across Europe, likely introduced there as a hitchhiker on oysters for aquaculture. It was first observed on the coast of Rhode Island in 2009, then found in Massachusetts in 2010. In the spring and summer of 2012, this species received much attention and press reports of masses washing up on beaches. As it is difficult to identify, these reports have not been substantiated. This species is likely expanding its distribution along the coast of Massachusetts, and research on the impacts to native species is ongoing.
Neosiphonia harveyi	Red filamentous algae	This invasive red filamentous alga was misidentified as a native species for nearly 150 years, highlighting the difficulty in identifying many non-native seaweed species. The increase in the invasive green algae Codium has helped pave the way for this red filamentous alga, which grows attached to other seaweeds. It has increased six-fold since 1966 and is now one of the most widely distributed seaweed species in the Gulf of Maine and the Northeast. It was documented at 100% of monitored sites during CZM’s 2013 Rapid Assessment Survey.

Source: Massachusetts DNR, CZM 2013, CZM 2015

Table 72: Invasive Species (Fauna and Fungi) in Massachusetts

Species	Common name	Notes
Terrestrial Species		
Lymantria dispar	Gypsy moth (insect)	This species was imported to Massachusetts for silk production but escaped captivity in the 1860s. It is now found throughout the Commonwealth and has spread to parts of the Midwest. This species is considered a serious defoliator of oaks and other forest and urban trees; however, biological controls have been successful against it.
Ophiostoma ulmi, Ophiostoma himal-ulmi, Ophiostoma novo-ulmi	Dutch elm disease (fungus)	In the 1930s, this disease arrived in Cleveland, Ohio, on infected elm logs imported from Europe. A more virulent strain arrived in the 1940s. The American elm originally ranged in all states east of Rockies, and elms were once the nation's most popular urban street tree. However, the trees have now largely disappeared from both urban and forested landscapes. It is estimated that "Dutch" elm disease has killed more than 100 million trees.
Adelges tsugae	Hemlock woolly adelgid (insect)	This species was introduced accidentally around 1924 and is now found from Maine to Georgia, including all of Massachusetts. It has caused up to 90% mortality in eastern hemlock species, which are important for shading trout streams and provide habitat for about 90 species of birds and mammals. It has been documented in about one-third of Massachusetts cities and towns and threatens the state's extensive Eastern Hemlock groves.
Cryphonectria parasitica	Chestnut blight (fungus)	This fungus was first detected in New York City in 1904. By 1926, the disease had devastated chestnuts from Maine to Alabama. Chestnuts once made up one-fourth to one-half of eastern U.S. forests, and the tree was prized for its durable wood and as a food for humans, livestock, and wildlife. Today, only stump sprouts from killed trees remain.
Anoplophora glabripennis	Asian long-horned beetle	This species was discovered in Worcester in 2008. The beetle rapidly infested trees in the area, resulting in the removal of nearly 30,000 infected or high-risk trees in just 3 years.
Cronartium ribicola	White pine blister rust (fungus)	This fungus is an aggressive and non-native pathogen that was introduced into eastern North America in 1909. Both the pine and plants in the Ribes genus (gooseberries ad currants) must be present for the disease to complete its life cycle. The rust threatens any pines within a quarter-mile radius from infected Ribes.
Aquatic Species		
Carcinus maenus	European green crab (crab)	This crab was probably introduced accidentally via ballast water in the 1800s. It is now the most prolific crab in Massachusetts. It is a voracious predator on native shore organisms; some blame the crab for the collapse of the New England soft-shell clam fishery. A 1999 study estimated that predation of shellfish by the European green crab has resulted in a loss of $44 million per year in New England and the Canadian Maritimes.

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Didemnum vexillum	Tunicate	The tunicate *Didemnum vexillum* was first observed in Damariscotta River area in Maine in the 1970s and has recently expanded its range. Unlike other invasive tunicates, *D. vexillum* can utilize open coast and deep-water habitats, including Georges Bank. It can overgrow and displace most species and established communities, forming a barrier to prey, modifying habitat, and leading to the death of bivalves by overgrowing their siphons.
Hemigrapsis sanguineus	Asian shore crab	The Asian shore crab was likely introduced to the Massachusetts area in the late 1990s or early 2000s. It competes with the European green crab; as a result, it is anticipated that the arrival of this species may reduce the long-existing predominance of the green crab in the Commonwealth in some habitats where they overlap.
Membranipora mambranacea	Lace Bryozoan	This species encrusts seaweed fronds, including kelp, leading to breakage and losses that can disrupt the function of the surrounding ecosystem.
Dreissena polymorpha	Zebra mussel	The first documented occurrence of zebra mussels in a Massachusetts water body occurred in Laurel Lake in July 2009. Zebra mussels can significantly alter the ecology of a water body and attach themselves to boats hulls and propellers, dock pilings, water intake pipes and aquatic animals. They are voracious eaters that can filter up to a liter of water a day per individual. This consumption can deprive young fish of crucial nutrients.
Ostrea edulis	European Oyster	The European oyster was first imported to Maine in the 1950s for aquaculture. A 1997 Salem Sound survey revealed dense concentrations of *O. edulis* in Salem Harbor, Danvers River, and Manchester Bay, Massachusetts. Lower densities were observed north to Cape Ann and south to Boston Harbor. It has continued to expand its range and is now found throughout Massachusetts.
Palaemon elegans	European Shrimp	*Palaemon elegans* was first documented in New England during the 2010 Rapid Assessment Survey and has since rapidly expanded it range from Maine to Connecticut. *P. elegans* can grow to more than 2 inches in length and is able to consume several smaller marine organisms.

Species	Common name	Notes
Styela clava	Club tunicate	Abundant in sheltered, subtidal waters attached to hard surfaces, this solitary tunicate first appeared in Long Island Sound, Connecticut, in 1973 and rapidly spread north to Prince Edward Island and south to New Jersey. This species is a strong competitor for space and is a fouling organism on ship hulls, mussels, and oyster beds, impacting native species and the aquaculture industry.

Sources: Chase et al., 1997; Pederson et al., 2005, CZM, 2013, 2014; Defenders of Wildlife; Gulf of Maine; EOEEA, 2013a, 2013b

Hazard Location

Although the entire Town of Hanson is potentially vulnerable to the introduction and establishment of invasive species, they pose the biggest threat to native or minimally managed ecosystems. In addition, the ability of invasive species to travel far distances (either via natural means or accidental human interference) allows these species to propagate rapidly over large geographic areas.

Previous Occurrences

The Massachusetts Invasive Plant Advisory Group (MIPAG) recognizes 69 plant species as “Invasive”, “Likely Invasive”, or “Potentially Invasive”. The Massachusetts Invasive Plant Advisory Group (MIPAG) was charged by the Massachusetts Executive Office of Environmental Affairs to provide recommendations to the Commonwealth regarding which plants are invasive and what steps should be taken to manage these species. [68]

Because the presence of invasive species is ongoing rather than a series of discrete events, it is difficult to quantify the frequency of these occurrences. However, increased rates of global trade and travel have created many new pathways for the dispersion of exotic species. As a result, the frequency with which these threats have been introduced has increased significantly. Increased international trade in ornamental plants is particularly concerning because many of the invasive plant species in the US were originally imported as ornamentals (SHMCAP, 2018).

During holiday seasons, many people use plants to decorate their homes or businesses. It is recommended to avoid using certain exotic, invasive plants such as Oriental bittersweet (*Celastrus orbiculatus)* and Multiflora rose (*Rosa multiflora)* in holiday decorations. Though these plants are attractive, it is best to refrain from using them. Birds eat and carry away the fruits from wreaths and garlands and the digested but still-viable seeds sprout where deposited.

Exotic, invasive plants create severe environmental damage, invading open fields, forest, wetlands, meadows, and backyards, and crowding out native plants. Bittersweet can even kill mature trees through strangling. Both plants are extremely difficult to control when cut off, the remaining plant

[68] **https://www.massnrc.org/mipag/**

segment in the ground will re-sprout. It is illegal to import or sell bittersweet or multiflora rose in any form (plants or cuttings) in Massachusetts. [69]

Probability

There are known invasive species within the Town of Hanson, so it is 100 percent likely that invasive species occur in Town. However, the likelihood that a significant negative impact would occur due to the presence of these species is possible, but not as high. Because plant and animal life are abundant throughout the Commonwealth, the entire area is exposed to the invasive species hazard. Areas like the Town of Hanson, with high amounts of plant or animal life may be at higher risk of exposure to invasive species than less vegetated urban areas; however, invasive species can disrupt ecosystems of all kinds.

Invasive species are a widespread problem in Massachusetts and throughout the country. The geographic extent of invasive species varies greatly depending on the species in question and other factors, including habitat and the range of the species. In marine environments, for example, most invasive species are found on artificial substrates such as docks, oceanic platforms, boats, and ships (Mineur et al., 2012).

Some (such as the gypsy moth) are nearly controlled, whereas others, such as the zebra mussel, are currently adversely impacting ecosystems throughout the Commonwealth. Invasive species can be measured through monitoring and recording observances.

Secondary Hazards

Invasive species can trigger a wide-ranging cascade of lost ecosystem services. Additionally, they can reduce the resilience of ecosystems to future hazards by placing a constant stress on the system.

Sectors Assessed

Populations

Those who rely on natural systems for their livelihood or well-being are more likely to experience negative repercussions from the expansion of invasive species. Because this hazard is present throughout the Commonwealth, the entire population is considered exposed. Most invasive species do not have direct impacts on human well-being; however, as described in the following subsections, there are some health impacts associated with invasive species.

[69] **https://www.mass.gov/service-details/invasive-plants**

Vulnerable Populations

Invasive species rarely result in direct impacts on humans, but sensitive people may be vulnerable to specific species that may be present in the state in the future. These include people with compromised immune systems, children under the age of 5, people over the age of 65, and pregnant women. Those who rely on natural systems for their livelihood or mental and emotional well-being are more likely to experience negative repercussions from the expansion of invasive species.

Health Impacts

Some research suggests that "unnatural" green space that appears to fall outside the expected appearance of a natural area can cause psychological stress in visitors to that area (Fuller et al., 2007). When an invasive species causes an area to appear overrun and unmanaged, the area is also more likely to be perceived as unsafe, reducing the likelihood that residents and visitors will reap the health benefits associated with outdoor recreation.

Additionally, specific species have been found to have negative impacts on human health. The Tree of Heaven (*Ailanthus altissima*)) produces powerful allelochemicals that prevent the reproduction of other species and can cause allergic reactions in humans (Bardsley and Edward- Jones, 2007). Similarly, due to its voracious consumption, the zebra mussel accumulates aquatic toxins, such as polychlorinated biphenyls or polyaromatic hydrocarbons, in their tissues at a rapid rate. When other organisms consume these mussels, the toxins can accumulate, resulting in potential human health impacts if any of these animals are ever eaten by humans.

An increase in species not typically found in Massachusetts could expose populations to vector-borne disease. A major outbreak could exceed the capacity of hospitals and medical providers to care for patients.

Government

No structures in the Town of Hanson are anticipated to be directly affected by invasive species, although water storage facilities, reservoirs and other town or state-managed water bodies are vulnerable to invasive species such as zebra mussels. Because these species are present throughout the Commonwealth, all state facilities are considered exposed to this hazard.

The Built Environment

Because invasive species are present throughout the Commonwealth, all elements are considered exposed to this hazard; however, the built environment is not expected to be impacted by invasive species to the degree that the natural environment is. Buildings are not likely to be directly impacted by invasive species. Amenities such as outdoor recreational areas that depend on biodiversity or the health of surrounding ecosystems, such as outdoor recreation areas or agricultural/forestry operations, could be more vulnerable to impacts from invasive species.

Transportation

Water transportation may be subject to increased inspections, cleanings, and costs that result from the threat and spread of invasive species. Species such as zebra mussels can damage aquatic infrastructure and vessels.

Natural Resources and Environment

Biodiversity and ecosystem health may be impacted by invasive species. Aquatic invasive species pose a threat to water bodies. Impacts of aquatic invasive species include impairment of recreational uses, such as swimming, boating, and fishing, degradation of water quality and wildlife habitat, declines in finfish and shellfish habitat, and diminished property values.

An analysis of threats to endangered and threatened species in the US indicates that invasive species are implicated in the decline of 42 percent of the endangered and threatened species. In 18 percent of the cases, invasive species were listed as the primary cause of the species being threatened, whereas in 24 percent of the cases they were identified as a contributing factor (Somers, 2016). A 1998 study found that competition or predation by alien species is the second most significant threat to biodiversity, only surpassed by direct habitat destruction or degradation (Wilcove et al., 1998). This indicates that invasive species present a significant threat to the environment and natural resources in the Commonwealth.

Aquatic invasive species pose a threat to water bodies. In addition to threatening native species, they can degrade water quality and wildlife habitat. Impacts of aquatic invasive species include:

- Reduced diversity of native plants and animals
- Impairment of recreational uses, such as swimming, boating, and fishing
- Degradation of water quality
- Degradation of wildlife habitat
- Increased threats to public health and safety
- Diminished property values
- Declines in fin and shellfish populations.
- Loss of coastal infrastructure due to the habits of fouling and boring organisms
- Local and complete extinction of rare and endangered species (EOEEA, 2002)

Economy

The agricultural sector is vulnerable to increased invasive species associated with increased temperatures. More pest pressure from insects, diseases, and weeds may harm crops and cause farms to increase pesticide use.

A widely cited paper (Pimental et al., 2005) found that invasive species cost the U.S. more than $120 billion in damages every year. One study found that in 1 year alone, Massachusetts agencies spent more than $500,000 on the control of invasive aquatic species through direct efforts and cost-share assistance. This figure does not include the extensive control efforts undertaken by municipalities and private landowners, lost revenue due to decreased recreational opportunities, or decreases in property value due to infestations (Hsu, 2000).

Individuals who are particularly vulnerable to the economic impacts of this hazard would include all groups who depend on existing ecosystems in the Commonwealth for their economic success. This includes all individuals working in agriculture-related fields, as well as those whose livelihoods depend on outdoor recreation activities such as hunting, hiking, or aquatic sports.

Primary Climate Change Interaction: Extreme Weather

Severe Winds

Historical data shows that the probability for severe weather events such as high windstorms increase in a warmer climate.

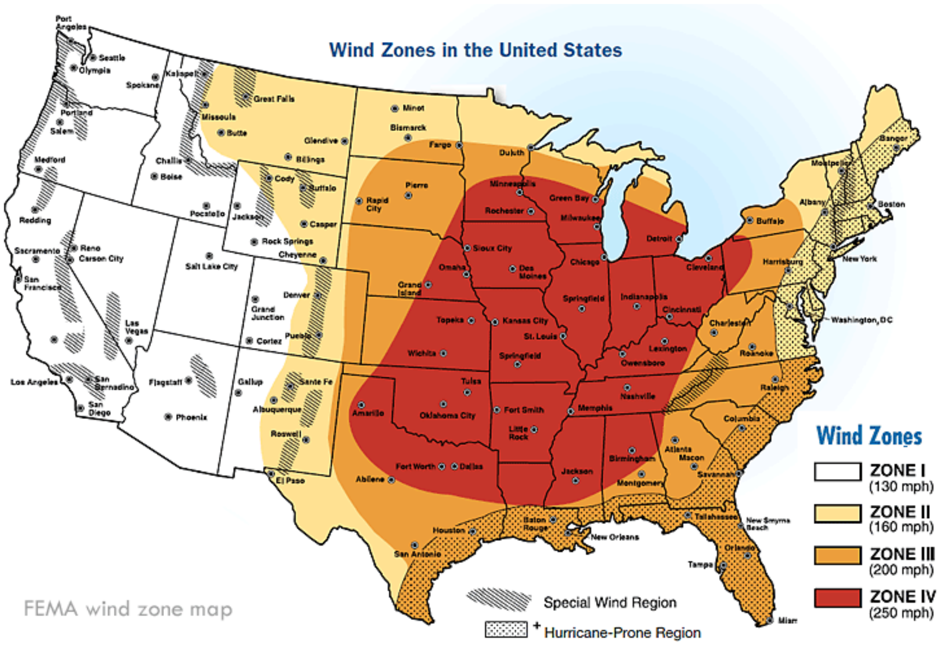
There is no wind damage scale developed specifically for thunderstorm high winds or straight-line winds. Two scales that provide damage descriptions consider the extent and type of damage that may result from extreme winds. These scales are the Beaufort Wind Scale and the Saffir-Simpson Hurricane Wind Scale.

Though used primarily to describe maritime wind conditions, the Beaufort Scale is also useful for providing a frame of reference for wind conditions on land that fall below the measurements of the Saffir-Simpson Hurricane Wind Scale.

Table 73: Beaufort Wind Force Scale

Beaufort Number	Wind Speed in MPH	Seaman's Term	Visible Effects of Land
0	>1	Calm	*Calm, smoke rises vertically*
1	1-3	Light Air	*Smoke drift indicates wind direction; vanes do not move*
2	4-7	Light Breeze	*Wind felt on face; leaves rustle, vanes begin to move*
3	8-12	Gentle Breeze	*Leaves, small twigs in constant motion; light flags extended*
4	13-18	Moderate Breeze	*Dust, leaves, and loose paper raised up; small branches move*
5	19-24	Fresh Breeze	*Small trees begin to sway*
6	25-31	Strong Breeze	*Large branches of trees in motion; whistling heard in wires*
7	32-38	Near Gale	*Whole trees in motion; resistance felt in walking against the wind*
8	39-46	Gale	*Twigs and small branches broken off trees, generally impedes progress*
9	47-54	Severe Gale	*Slight structural damage occurs; shingles blown from roofs*
10	55-63	Storm	*Seldom experienced inland; trees broken; structural damage occurs*
11	64-72	Violent Storm	*Very rarely experienced; accompanied by wide-spread damage*
12	73+	Hurricane	*Violence and destruction*

Figure 101: Wind Zones in the United States



Wind Related Hazards in Hanson

Wind is one of the costliest hazards to insured property, causing more damage than earthquakes or other natural hazards. Wind pressure, not wind speed, causes damage. There are three types of wind pressure:

- ***Positive Wind Pressure*** is the direct pressure from the force of the wind pushing inward against walls, doors, and windows.
- ***Negative Wind Pressure*** occurs on the sides and roof of buildings as wind blows past. Air moving parallel to a surface reduces the air pressure on the surface, resulting in a force pulling the surface outward toward the moving air. Negative pressure causes buildings to lose all or a portion of their roofs and side walls and pulls storm shutters off the leeward (side sheltered from wind) side of a building.
- ***Interior Pressure*** increases dramatically when a building loses a door or window on its windward side. The roof is placed under tremendous internal pressures pushing up from inside of the building together with the negative wind pressure lifting the roof from the outside.

Besides the high wind pressure exerted on structures during windstorms, and especially during hurricanes or tropical storms, windborne debris can be a major factor in causing damage. Such debris includes flying objects, such as tree limbs, outdoor furniture, signs roofs, gravel, and loose building components.

Wind-related hazards include hurricanes, tropical storms, and tornados, as well as high winds during nor'easters and thunderstorms. Downed trees and limbs can be a problem due to weather conditions such as strong wind or heavy snow and ice. Tree limbs can down power and communication lines and impact major roadways. The combination of wind and snow caused significant power line damage during several weather-related events including a nor'easter in 1918.

Previous Occurrences

The following Table summarizes high wind events in the planning areas since January 2000, as recorded by the National Oceanic and Atmospheric Administration (NOAA). According to this data, there have been 1 recorded fatality and 2 severe injuries attributable to high wind events in Plymouth County.[70] Many of the events caused power outages, downed trees, and some property damage, but the costs of property damage are not available.

Table 74: High Wind Events 2000 - 2020

DATE	PROPERTY DAMAGE (Numbers)	HAZARD	MAG	DEATHS	INJURIES	DATE	PROP DAMAGE (Numbers)	MAG	DEATHS	INJURIES
4/8/2000		High Wind	50	0	0	5/7/2005	15,000	50	0	0
4/8/2000		High Wind	50	0	0	5/7/2005	25,000	50	0	0
12/12/2000		High Wind	50	0	0	5/7/2005	20,000	50	0	0
12/12/2000		High Wind	50	0	0	5/24/2005	20,000	50	0	0
12/17/2000		High Wind	50	0	0	5/24/2005	10,000	50	0	0
12/17/2000		High Wind	55	0	0	5/25/2005	15,000	50	0	0
12/17/2000		High Wind	50	0	0	5/25/2005	10,000	50	0	0
3/5/2001		High Wind	50	0	0	9/29/2005	20,000	58	0	0
11/13/2003	50,000	High Wind	50	0	0	9/29/2005	15,000	58	0	0
11/13/2003	50,000	High Wind	50	0	0	10/16/2005	10,000	58	0	0
11/13/2003	50,000	High Wind	50	0	0	10/16/2005	5,000	58	0	0
11/5/2004	25,000	High Wind	50	0	1	10/16/2005	5,000	58	0	0
11/5/2004	25,000	High Wind	50	0	0	10/16/2005	10,000	58	0	0
12/1/2004	25,000	High Wind	58	0	0	10/25/2005	10,000	58	0	0
12/1/2004	20,000	High Wind	58	0	0	10/25/2005	5,000	58	0	0
3/8/2005	200,000	High Wind	50	0	0	10/25/2005	45,000	58	0	0
3/8/2005	100,000	High Wind	50	0	1	10/25/2005	20,000	58	0	0
1/18/2006	10,000	High Wind	58	0	0	9/18/2012	10,000	50	0	0
2/17/2006	15,000	High Wind	58	0	0	10/29/2012	80,000	50	0	0
2/17/2006	40,000	High Wind	68	0	0	10/29/2012	100,000	50	0	0

[70] **NOAA Storm Events Database** https://www.ncdc.noaa.gov/stormevents/details.jsp

10/28/2006	8,000	High Wind	50	0	0	10/29/2012	50,000	66	0	0
10/28/2006	5,000	High Wind	50	0	0	11/7/2012	80,000	53	0	0
10/28/2006	4,000	High Wind	50	0	0	11/7/2012	15,000	53	0	0
12/1/2006	-	High Wind	51	0	0	11/7/2012	15,000	50	0	0
12/1/2006	7,000	High Wind	50	0	0	12/21/2012	5,000	40	0	0
12/1/2006	10,000	High Wind	50	0	0	12/27/2012	8,000	53	0	0
4/15/2007	30,000	High Wind	55	0	0	1/31/2013	25,000	56	0	0
4/16/2007	20,000	High Wind	52	0	0	1/31/2013	40,000	56	0	0
11/3/2007	6,000	High Wind	60	0	0	1/31/2013	10,000	50	0	0
11/3/2007	10,000	High Wind	50	0	0	3/7/2013	75,000	50	0	0
11/3/2007	6,000	High Wind	50	0	0	11/1/2013	55,000	50	0	0
12/23/2007	2,000	High Wind	50	0	0	11/27/2013	30,000	50	0	0
3/8/2008	5,000	High Wind	52	0	0	11/27/2013	55,000	50	0	0
11/15/2008	7,500	High Wind	50	0	0	3/26/2014	5,000	52	0	0
12/25/2008	-	High Wind	35	0	0	10/22/2014	75,000	50	0	0
10/18/2009	45,000	High Wind	35	0	0	10/22/2014	100,000	52	0	0
10/24/2009	10,000	High Wind	50	0	0	11/2/2014	100,000	50	0	0
12/3/2009	30,000	High Wind	50	0	0	1/27/2015	30,000	64	0	0
1/25/2010	30,000	High Wind	50	0	0	3/17/2015	40,000	50	0	0
1/25/2010	25,000	High Wind	50	0	0	6/28/2015	35,000	50	0	0
1/25/2010	45,000	High Wind	50	0	0	2/24/2016	15,000	50	0	0
3/14/2010	25,000	High Wind	50	0	0	2/25/2016	55,000	50	0	0
3/14/2010	25,000	High Wind	50	0	0	2/25/2016	20,000	50	0	0
2/19/2011	10,000	High Wind	51	0	0	3/31/2016	85,000	40	0	0
1/13/2012	20,000	High Wind	50	0	0	3/31/2016	30,000	50	0	0
10/9/2016	-	High Wind	38	0	0	1/24/2019	15,500	63	0	0
12/15/2016	2,200	High Wind	50	0	0	1/24/2019	-	56	0	0
1/23/2017	2,000	High Wind	50	0	0	1/24/2019	15,000	56	0	0
1/23/2017	5,000	High Wind	50	0	0	2/25/2019	46,000	58	0	0
3/2/2017	2,000	High Wind	50	0	0	10/17/2019	800	50	0	0
3/14/2017	18,000	High Wind	50	0	0	10/17/2019	-	53	0	0
3/14/2017	-	High Wind	50	0	0	10/17/2019	-	39	0	0
10/24/2017	10,000	High Wind	50	0	0	10/17/2019	-	53	0	0
10/29/2017	4,000	High Wind	54	0	0	10/17/2019	800	50	0	0
10/29/2017	10,000	High Wind	70	0	0	10/17/2019	800	50	0	0
12/25/2017	-	High Wind	59	0	0	10/17/2019	500	50	0	0
3/2/2018	40,000	High Wind	76	1	0	10/17/2019	800	50	0	0
3/2/2018	45,000	High Wind	54	0	0	11/1/2019	1,000	50	0	0
3/2/2018	5,000	High Wind	56	0	0	11/1/2019	1,000	56	0	0
3/2/2018	5,000	High Wind	56	0	0	1/12/2020	-	50	0	0
10/27/2018	30,000	High Wind	36	0	0	2/7/2020	15,000	56	0	0

11/3/2018	-	High Wind	52	0	0	2/7/2020	2,000	54	0	0
11/3/2018	500	High Wind	50	0	0	2/7/2020	3,000	50	0	0
11/16/2018	-	High Wind	36	0	0	4/9/2020	8,000	54	0	0
12/21/2018	7,000	High Wind	50	0	0	4/13/2020	700	68	0	0
4/13/2020	-	High Wind	53	0	0					
4/13/2020	1,000	High Wind	51	0	0					

Warning Time

Meteorologists can often predict the likelihood of a severe storm. This can give several days of warning time. However, meteorologists cannot predict the exact time of onset or severity of the storm. Some storms may come on more quickly and have only a few hours of warning time. The predicted wind speed given in wind warnings issued by the National Weather Service is for a one-minute average; gusts may be 25 to 30 percent higher.

Sectors Assessed

Population

Populations living in areas with large stands of trees or power lines may be more susceptible to wind damage and black out. Loss of electricity and phone connection would leave certain populations isolated because residents would be unable to call for assistance. Vulnerable populations are the elderly, low-income, or linguistically isolated populations, and people with life-threatening illnesses. These populations face isolation and exposure during high windstorms and could suffer more secondary effects of the hazard. Power outages can be life threatening to those dependent of electricity for life support.

Vulnerable Populations

A worst-case event would involve prolonged high winds. Initially, schools and roads would be closed due to power outages caused by high winds and downed debris. Some isolated communities throughout the planning area could experience limited or no ingress and egress. Additionally, temporary structure and structures unable to resist sustained wind speeds may collapse, posing an immediate threat to those within or around the structure. Long-term effects may include the removal of collapsed buildings and removal of debris from waterways.

Built Environment

All property is vulnerable during high windstorms, but properties in poor condition or in particularly vulnerable locations may risk the most damage. Structures that were built before the building code incorporated provisions for wind load are particularly vulnerable. Buildings under or near overhead power lines or near large trees may be vulnerable to falling lines or trees.

Government - Critical Facilities

The most common problems associated with high windstorms are loss of utilities. Downed power lines can cause blackouts, leaving large areas isolated. Phone, water, and septic systems may not function. High wind can block roads with debris, incapacitating transportation, isolating population, and disrupting ingress and egress. Of concern are roads providing access to isolated areas and to the elderly.

High wind events post a problem for facilities that house hazardous materials. Such facilities often depend on electricity and other utilities to maintain safe operations. During a severe high wind event, downed trees may cut off power. While most of these facilities have back-up power source to ensure continued operations, backup power can only be used for a finite time; prolonged utility disruption could have dire consequences.

Natural Resources and Environment

Natural habitats such as streams and trees are exposed to the elements during a severe storm and risk major damage and destruction including downed debris, uprooted trees, and debris-blocked rivers and streams.

Economy

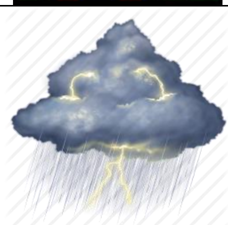
Although it is difficult to forecast the economic impact of any specific event, potential damage to buildings serves as a valuable proxy because damage to buildings can impact a community's economy and tax base.

Future Trends in Development

All future development in Plymouth County will be affected by high windstorms. The ability to withstand lies in sound land use practices and consistent enforcement of codes and regulations for new construction. Massachusetts Building Code has developed county-specific wind load requirements. These codes are equipped to deal with the impacts of high windstorms. Land use policies identified in Master Plans within the planning area also address many of the secondary impacts of high windstorms. With these tools, Hanson is well equipped to deal with future growth and the associated impacts of high windstorms.

Hurricanes and Tropical Storms

Hurricanes and Tropical Storms		
Hazard	**Significant**	**Justification**
Hurricanes and Tropical Storms 	YES	The entire Commonwealth is vulnerable to hurricanes and tropical storms, dependent on the storm's track. The coastal areas are more susceptible to damage due to the combination of both high winds and tidal surge. The average number of hurricane or tropical storm events is 1 every 2 years. Storms severe enough to receive FEMA disaster declarations, however, only occur every 9 years on average.
Exposure and Vulnerability by Key Sector		
	Populations	**General At-Risk Populations:** State-wide exposure. **Vulnerable Populations:** Poor population, which is more likely to evaluate the economic impact of evacuating; individuals over age 65, who are more likely to face physical challenges or to require medical care while evacuating; individuals with low English language fluency who may not receive or understand warnings to evacuate.
	Government	All municipal sites including the Police Station, Fire Station and the Highway Department, schools (Indian Head and Hanson Middle School), the Hanson Library and Town Hall. Natural Hazard threats are the same as those listed under Flooding.
	Built Environment	Hurricanes and Tropical Storms can result in power outages and road closures that impact emergency response. Heavy rains can lead to contamination of well water, septic system failure, and overburden stormwater systems.
	Natural Resources and Environment	As the storm is occurring, flooding or wind/water-borne detritus can cause mortality to animals if it strikes them or transports them to a non-suitable habitat. In the longer term, environmental impacts can occur because of riverbed scour, fallen trees, storm surge or contamination of ecosystems by transported pollutants.
	Economy	Hurricanes are among the costliest natural disasters in terms of damage inflicted and recovery costs required. This damage will likely include loss of building function, relocation costs, wage loss, road repair and rental loss.

Potential Effects of Climate Change – Hurricanes and Tropical Storms		
	Extreme weather and rising temperatures – larger, stronger storms	As warmer oceans provide more energy for storms, both past events and models of future conditions suggest that the intensity of tropical storms and hurricanes will increase.
	Changes in Precipitation – Increased rainfall rates	Warmer air can hold more water vapor, which means the rate of rainfall will increase. Once study found that hurricane rainfall rates were projected to rise 7 percent for every degree Celsius increase in tropical sea surface temperature.

Of all the natural disasters that could potentially impact Hanson, hurricanes provide the most lead warning time because of the relative ease in predicting the storm's track and potential landfall. MEMA assumes "standby status" when a hurricane's location is 35 degrees North Latitude (Cape Hatteras) and "alter status" when the storm reaches 40 degrees North Latitude (Long Island). Even with significant warning, hurricanes can do significant damage – both due to flooding and severe wind.

A hurricane is a violent wind and rainstorm with wind speeds of 74 to 200 miles per hour. A hurricane is strongest as it travels over the ocean and is particularly destructive to coastal property as the storm hits land. Given its location, Hanson is not as vulnerable to coastal storms and hurricanes as other communities in the OCPC region, but hurricanes and tropical storms should be considered. A tropical storm has similar characteristics but with reduced wind speeds below 74 miles per hour.

Severity Ratings

In the United States, forecast centers classify tropical cyclones in the following categories according to their maximum sustained winds:

- ***Tropical Depression –*** A weak tropical cyclone with a surface circulation include one or more closed isobars (lines or curves of constant pressure) and highest sustained winds (measured over one minute or more) of less than 38 miles per hour. Tropical depressions are assigned a number denoting their chronological order of formation each year.
- ***Tropical Storm –*** A typical cyclone with highest sustained winds between 39 and 73 miles per hour.
- ***Hurricane –*** A tropical cyclone with highest sustained winds greater than 74 miles per hour. Intensity is qualified by the Saffir-Simpson Hurricane Scale based on a hurricane's sustained wind speed.

The flooding associated with hurricanes can be a major source of damage to buildings, infrastructure, and a potential threat to human lives. Therefore**, all the flood protection mitigation measures** described can also be considered hurricane measures.

The high winds that oftentimes accompany hurricanes can also damage buildings and infrastructure. But regulations can be put into place to help minimize the extent of wind damages. The Town's current mitigation strategies to deal with severe wind are equally applicable to wind events such as tornados and microbursts. Therefore, the analysis of severe wind strategies is coupled with this hazard.

Hurricane intensity is measured according to the ***Saffir/Simpson Hurricane Scale***, based on a hurricane's sustained wind speed. This scale is used to estimate the potential property damage and flooding expected when a hurricane makes landfall; it categorizes hurricane intensity linearly based upon maximum sustained winds, barometric pressure, and storm surge potential. These are combined to estimate potential damage.

It is important to note that lower category storms can inflict greater damage than higher category storms, depending on where they strike, other weather they interact with, and how slow their forward speed is. The Saffir-Simpson Hurricane Wind Scale does not address the potential for other hurricane-related impacts, such as storm surge, rainfall-induced floods, and tornados. It should also be noted that these wind-caused damage general descriptions are to some degree dependent upon the building's condition (e.g., age, construction, maintenance). All these issues factor into a building's ability to withstand wind loads. Hurricane wind damage is also very dependent upon other factors, such as duration of high winds, change of wind direction, and age of structures. Hurricane's reaching Category 3 and higher are considered major hurricanes because of their potential for significant loss of life and damage. Category 1 and 2 storms are still dangerous and require preventative measures. [71]

The National Weather Service has developed an extreme wind warning system like other events. ***Watches*** are issued when conditions are favorable for high winds to develop 12 to 24 hours in advance. ***Advisories*** are issued when existing or imminent high winds cover part of or all the area and pose a mere inconvenience. High wind warnings are issued when existing or imminent high winds cover part of all the forecast area and post a threat to life and property.

Hurricanes typically have regional impacts beyond their immediate tracks. Falling trees and branches are a significant problem because they can result in power outages when they fall on power lines or block traffic and emergency routes. Hurricanes are a town-wide hazard. Potential hurricane damages also include debris generation and sheltering needs.

The Saffir-Simpson Hurricane Scale gives an overview of the wind speeds, surges, and range of damage caused by different hurricane categories:

[71] **NOAA**

Table 75: Saffir-Simpson Hurricane Scale

Scale No. Category	Winds mph	Surge (ft)	Potential Damage	Storm Example and Year
1	74-95	4-5	***Minimal:*** *Damage to building structures possible, primarily to unanchored older model mobile homes. Damage to poorly constructed signs, shrubbery, and trees. Loose outdoor items become projectiles. Numerous power outages.*	Humberto 2007
2	96-110	6-8	***Widespread from strong winds:*** *Some roofing materials, door, and window damage to buildings. Considerable damage to trees, vegetation, mobile homes, and piers. Several high-rise building glass windows dislodged to become projectiles. Widespread power outages up to several days.*	Ike 2008
3	111-130	9-12	***Extensive from dangerous winds:*** *Some structural damage to small residences and utility buildings with minor amount of wall failures. Mobile homes destroyed. Many trees uprooted and snapped. Power outages lasting several days or weeks.*	Alicia 1983
4	131-155	13-18	***Devastating from extremely dangerous winds****: Some wall failures with complete house roof structure failures. Extensive damage to doors, windows, and trees. Electricity unavailable for weeks.*	Harvey 2017
5	>155	>18	***Catastrophic:*** *Complete roof failure on many residences and industrial buildings. Some complete building failures with small buildings blown over or away. Power outages for weeks or months.*	Andrew 1992

Source: NOAA, National Weather Service

Tropical storms and tropical depressions, while generally less dangerous than hurricanes, can be deadly. The winds of tropical depressions and tropical storms are usually not the greatest threat; rather, the rains, flooding and severe weather associated with the tropical storms are what customarily cause more significant problems. Serious power outages can also be associated with these types of events. After Hurricane Irene passed through the region as a tropical storm in late August 2011, many areas of the Commonwealth were without power for more than 5 days.

While tropical storms can produce extremely powerful winds and torrential rain, they area lao able to produce high waves, damaging storm surge, and tornados. They develop over large bodies of water and lose their strength if they move over land due to increased surface friction and loss of the warm ocean as an energy source. Heavy rains associated with a tropical storm, however, can produce significant flooding inland, and storm surges can produce extensive coastal flooding up to 25 miles from the coastline.

One measure of the size of a tropical cyclone is determined by measuring the distance from its center of circulation to its outermost closed isobar. If the radius is less than 2 degrees of latitude, or 138 miles, then the cyclone is “very small.” A radius between 3 and 6 degrees of latitude, or 207 to 420 miles, is considered “average-sized.” “Very large” tropical cyclones have a radius of greater than 8 degrees, or 552 miles.

The location and path of a system can also be a major factor in the severity of storm impacts, especially when it comes to storm surge. Most storm surge happens when the force of the wind (called wind stress) pushes water toward the shore. For hurricanes in the northern hemisphere, this occurs most intensely in the right-front quadrant of the storm. For Massachusetts, a particularly serious scenario would be if the eye of a major hurricane tracked west of Buzzards Bay. This would produce a potential storm surge of 25 feet or more at the upper part of Buzzards Bay. According to the NWS, this was most likely the scenario that occurred in the Colonial Hurricane of 1635, which produced a storm surge of 20 feet at the upper part of Buzzards Bay.

Past Occurrences

Since 1900, 39 tropical storms have impacted New England (NESEC).[72] The following Table shows the hurricanes and storms that affected Massachusetts since 1938.

Table 76: Hurricanes and Tropical Storms Affecting New England and Massachusetts

Storm Name	Peak Intensity	Intensity at Landfall	Year
Great NE Hurricane	Category 5	Category 3	1938
Great Atlantic	Category 4	Category 1	1944
Carol	Category 3	Category 3	1954
Edna	Category 3	Category 2	1954
Donna	Category 4	Category 1	1960
Esther	Category 5	Tropical Storm	1961
Gerda	Category 3	Category 2	1969
Heidi	Tropical Storm	Tropical Storm	1971
Belle	Category 3	Tropical Storm	1976
Gloria	Category 4	Category 1	1985
Bob	Category 3	Category 2	1991
Bertha	Category 3	Tropical Storm	1996
Floyd	Category 4	Tropical Storm	1999
Hermine	Tropical Storm	Tropical Storm	2004
Beryl	Tropical Storm	Tropical Storm	2006
Hanna	Category 1	Tropical Storm	2008

[72] **NESEC** http://nesec.org/hurricanes/

Table 77: FEMA Declaration Hurricane Irene

Dates of Event	**Event Type**	**FEMA Declaration #**	**Losses/Impacts**
08/27-29/2011	Tropical Storm Hurricane Irene	EM-3330 DR – 4028	*Tropical Storm Irene produced significant amounts of rain, storm surge, inland and coastal flooding, and wind damage across southern New England and much of the east coast of MA. Rainfall totals ranged between 0.03 inches on Nantucket to 9.92 inches (Conway, MA). These heavy rains caused flooding throughout the Commonwealth and a presidential disaster was declared (DR-4028).* *Tropical Storm Irene was closely followed by the remnants of Tropical Storm Lee, which brought additional heavy rain to Massachusetts and extended flooding.*

Source: NOAA Storm Events Database, FEMA 2019

Frequency of Occurrences

According to NOAA's Historical Hurricane Tracker tool, 63 hurricane or tropical storm events have occurred in the vicinity of Massachusetts between 1842 and 2016. The Commonwealth was impacted by tropical storms Jose and Phillipe in 2017. Therefore, there is an average of one storm every other year or 0.5 storms per year. Storms severe enough to receive FEMA disaster declarations, however, are far rarer, occurring every 9 years on average.

Warning Time

Tropical cyclones can be closely monitored and tracked. As a result, accurate warnings up to days in advance of the event are possible, with the modeling offering possible storm movement up to a week prior. Track forecasts have improved due in part to the increased numbers of satellites, outfitted with more sophisticated weather-monitoring devices. At the same time, supercomputing power has increased exponentially, and computer models used to forecast a hurricane's direction keep improving (Main, 2014). The National Oceanic and Atmospheric Administration (NOAA) offers multiple watch, warnings, and resource tools through the National Hurricane Center including but not limited to those described in the sections below (NWS, 2020).

The NWS issues a hurricane warning when sustained winds of 74 mph or higher are *expected* in a specified area in association with a tropical, subtropical, or post-tropical cyclone. A warning is issued 36 hours in advance of the anticipated onset of tropical-storm-force winds. A hurricane watch is announced when sustained winds of 74 mph or higher are *possible* within the specified area in association with a tropical, subtropical, or post-tropical cyclone. A watch is issued 48 hours in advance of the anticipated onset of tropical-storm-force winds (NWS, 2013).

Preparations should be complete by the time the storm is at the latitude of North Carolina. Outer bands containing squalls with heavy showers and wind gusts to tropical storm force can occur as much as 12 to 14 hours in advance of the eye, which can cause coastal flooding and may cut off exposed coastal roadways. The 1938 hurricane raced from Cape Hatteras to the Connecticut coast in 8 hours. [73]

Secondary Hazards

The main secondary effects of tropical cyclones are storm surge and high winds. Other secondary hazards include landslides, flooding, coastal erosion, storms, and high surf. Precursor events or hazards that may exacerbate hurricane damage include heavy rains, winds, tornadoes, storm surge, insufficient flood preparedness, subsea infrastructure, and levee or dam breach or failure. Potential cascading events include health issues (mold and mildew); increased risk of fire hazards; hazardous materials, including waste byproducts; coastal erosion; compromise of levees or dams; isolated islands of humanity; increased risk of landslides or other types of land movement; disruptions to transportation; disruption of power transmission and infrastructure; structural and property damage; debris distribution; and environmental impacts.

Debris Management

The damaging forces of hurricanes and tropical storms include high velocity winds (up to 150 miles per hour or higher in gusts), storm surge, and wave action. The most severe damage frequently occurs along the coast. Hurricane debris consists primarily of vegetation, sediments, trees, personal property and building materials. The effects of a hurricane often extend far inland, with significant tree and structural damage. Hurricanes are rated from categories 1 through 5. Tornadoes may be spawned from hurricanes causing severe localized damage. [74]

Using the United States Army Corps of Engineers (USACE) model, the estimated cubic yards of debris that might be generated, and space needed to manage that debris for a worst-case (category 3 hurricane) for each county in Massachusetts is presented in the following Table.

[73] SHMCAP, 2018

[74] Commonwealth of Massachusetts All Hazards Disaster Debris Management Plan, Rev. #6

Table 78: Debris Estimates for the Counties in Massachusetts

Corps of Engineers Debris Model				
County	Population	Housing Units	Debris Estimate (cy)	DMS Acres
Barnstable County	215,888	160,281	8,451,296	870
Berkshire County	131,219	68,449	3,609,178	372
Bristol County	548,285	230,535	12,155,649	1,252
Dukes County	16,535	17,188	906,288	93
Essex County	743,159	306,754	16,174,524	1,666
Franklin County	71,372	33,758	1,779,991	183
Hampden County	463,490	192,175	10,133,003	104
Hampshire County	158,080	62,603	3,300,930	340
Middlesex County	1,503,085	612,004	32,269,746	3,324
Nantucket County	10,172	11,571	610,115	63
Norfolk County	670,850	270,235	14,248,950	1,468
Plymouth County	494,919	199,885	10,539,536	1,086
Suffolk County	722,023	314,385	16,576,891	1,707
Suffolk County	722,023	314,385	16,576,891	1,707
Worcester County	798,552	326,345	17,207,518	1,772
Total Massachusetts	6,277,629	2,806,168	147,963,626	15,240

Source: US Census Bureau 2010, Corps of Engineers Debris Model, Mass Debris Plan

Sectors Assessed

Populations

Populations that live or work in proximity to facilities that use, or store toxic substances are at greater risk of exposure to these substances during a flood event.

Vulnerable Populations

Among the exposed populations, the most vulnerable include people with low socioeconomic status, people over the age of 65, people with medical needs, and those with low English language fluency. Individuals with medical needs may have trouble evacuating and accessing needed medical care while displaced. Those who have low English language fluency may not receive or understand the warnings to evacuate. Findings reveal that human behavior contributes to flood fatality occurrences. For example, people between the ages of 10 and 29 and over 60 years of age are found to be more vulnerable to floods. During and after an event, rescue workers and utility workers are vulnerable to impacts from high water, swift currents, rescues, and submerged debris. Vulnerable populations may also be less likely to have adequate resources to recover from the loss of their homes and jobs or to relocate from a damaged neighborhood (SHMCAP, 2018).

Due to the impacts of the COVID-19 pandemic, communities should be prepared to shelter vulnerable populations with social distancing requirements to prevent the spread of the virus. College dormitories, motels, and other suitable locations should be determined prior to a storm event.

Health Impacts

The health impacts from hurricanes and tropical storms can generally be separated into impacts from flooding and impacts from wind. The potential health impacts of flooding are extensive and are discussed in the flooding section of this plan. In general, some of the most serious flooding-related health threats include floodwaters sweeping away individuals or cars, downed power lines, and exposure to hazards in the water, including dangerous animals or infectious organisms. Contact with contaminated floodwaters can cause gastrointestinal illness. Individuals who are housed in public shelters during or after hurricane events also have an increased risk of becoming infected by contagious diseases (CDC, 2017).

Wind-related health threats associated with hurricanes are often caused by projectiles propelled by the storm's winds. Wind- and water-caused damage to residential structures can also increase the risk of threat impacts by leaving residents more exposed to the elements. Hurricanes that occur later in the year also increase the risk of hypothermia.

After a hurricane or tropical storm subsides, substantial health risks remain. For example, flooded areas that do not drain properly can become breeding grounds for mosquitos, which can transmit vector-borne diseases. Exposure to mosquitos may also increase if individuals are outside of their homes for longer than usual because of power outages or other flood-related conditions.

The growth of mold inside buildings is often widespread after a flood. Investigations following Hurricane Katrina and Superstorm Sandy found mold in the walls of many water- damaged homes and buildings. Mold can result in allergic reactions and can exacerbate existing respiratory diseases, including asthma (CDC, 2014). Extended loss of electricity and heating systems increases the risk of carbon monoxide poisoning. Carbon monoxide is present in emissions from combustion appliances such as cooking and heating devices (grills, stoves, etc.), damaged chimneys, or generators, and improper location and operation of combustion appliances in indoor or poorly ventilated areas leads to increased risks (Chen et al., 2015). Severe flooding that can occur because of hurricanes and tropical storms may damage transportation networks and prevent individuals in need from reaching health services for long periods of time after the storm has passed. Finally, property damage and displacement of homes and businesses can lead to loss of livelihood and long-term mental stress for those facing relocation. Individuals may develop post-traumatic stress, anxiety, and depression following major flooding events.

New research by scientists from Columbia University and the Union of Concerned Scientists found that fierce storms ranked as Category 3 or higher could result in thousands of new COVID-19 infections. The scientists modeled an infection scenario by retracing the evacuation routes of the 2.3 million southeastern Floridians who fled Hurricane Irma in 2017. That same number of evacuees on the move today could prompt as many as 61,000 new cases of COVID-19, the study found. [75]

Government

Critical infrastructure, including local police and fire stations, and other public safety facilities that serve as emergency operation centers may experience direct loss (damage) during a hurricane or tropical storm. Emergency responders may also be exposed to hazardous situations when responding to calls. Flooding and debris can cause direct damage to municipally owned facilities and result in road closures and inaccessible streets that impact the ability of public safety and emergency vehicles to respond to calls for service.

The Built Environment

Hurricanes and tropical storms often result in power outages and contact with damaged power lines during and after a storm, which may result in electrocution. Hurricanes and tropical storms resulted in 80,000 electric customers disrupted by NERC-reported electrical transmission between 1992 and 2009 (DOE, n.d.). Road blockages caused by downed trees may impair movement for evacuations and emergency response vehicles.

Water Infrastructure

Heavy rains can lead to contamination of well water and can release contaminants from septic systems (DPH, 2014). Heavy rainfall can also overburden stormwater systems, drinking water supplies, and sewage systems. Combined septic overflows associated with heavy rainfall can

[75] **https://www.nationalgeographic.com/science/2020/08/how-hurricane-evacuations-shelters-change-with-coronavirus/**

release contaminants, chemicals, and pathogens directly into the environment and into water systems. If a mass outbreak of waterborne illness were to occur, hospitals and medical providers may lack the capacity to treat patients.

Some roads and bridges are also considered critical infrastructure, particularly those providing ingress and egress and allowing emergency vehicles access to those in need. Costly damage to roads, bridges, and rail networks may occur because of hurricanes (resilient MA, 2018).

Natural Resources and Environments

The environmental impacts of hurricanes and tropical storms are like those described for other hazards, including inland flooding, severe winter storms and other severe weather events. Environmental impacts can generally be divided into short-term direct impacts and long-term impacts. As the storm is occurring, flooding may disrupt normal ecosystem function and wind may fell trees and other vegetation. Wind-borne and waterborne detritus can cause mortality to animals if they are stuck or transported to a non-sustainable habitat. Estuarine habitats are particularly susceptible to hurricanes and tropical storms, both because they also experience coastal storm surge and because altering the salinity of these systems can cause widespread effects to the many inhabitant species.

In the longer term, impacts to natural resources and the environment because of hurricanes and tropical storms are generally related to changes in the physical structure of ecosystems. For example, flooding may cause scour in riverbeds, modifying the river ecosystem and depositing the scoured sediment in another location. Similarly, trees that fall during the storm may represent lost habitat for local species, or they may decompose and provide nutrients for the growth of new vegetation. If the storm spreads pollutants into natural ecosystems, contamination can disrupt food and water supplies, causing widespread and long-term population impacts on species in the area.

Economy

Hurricanes are among the costliest natural disasters in terms of damage inflicted and recovery costs required. Although it is difficult to forecast the economic impact of any specific event, potential damage to buildings serves as a valuable proxy because damage to buildings can impact a community’s economy and tax base.

Town Overview

Hanson lies within the Bristol Lowland/Narragansett Lowland Ecoregion, an area of flat, gently rolling plains. Forests are mostly central hardwoods and some elm-ash-red maple and red and white pine. There are numerous wetlands, some cropland/pasture, and many cranberry bogs. Many rivers drain this area.

Hanson at a Glance

- Total Area: 10,069 acres (15.7 square miles)
- Human Population in 2010: 10,209
- Open space protected in perpetuity: 1,562 acres, or 15.5% percent of total area*
- *BioMap2* Core Habitat: 981 acres
- *BioMap2* Core Habitat Protected: 606 acres or 61.7%
- *BioMap2* Critical Natural Landscape: 1,413 acres
- *BioMap2* Critical Natural Landscape Protected: 958 acres or 67.8%.

BioMap2 Components

Core Habitat

- 4 Wetland Cores
- 3Aquatic Cores
- 5 Species of Conservation Concern Cores**
  - 1 fish, 3 insects, 2 mussels,

Critical Natural Landscape

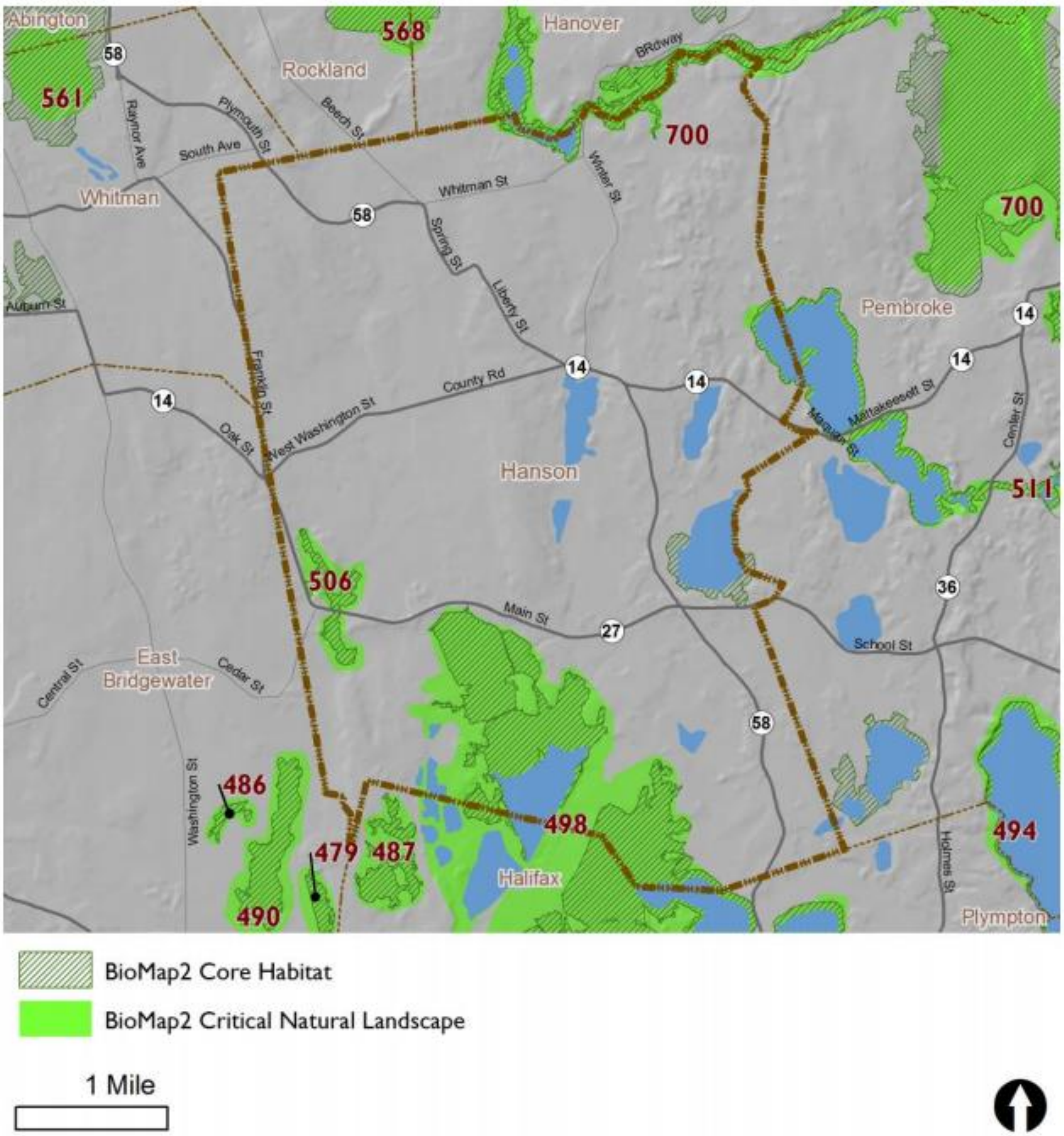
- 1 Landscape Block
- 1 Wetland Core Buffer
- 3 Aquatic Core Buffers

* Calculated using MassGIS data layer "Protected and Recreational Open Space—March, 2012".

** See next pages for complete list of species, natural communities and other biodiversity elements.

BioMap2 Critical Natural Landscape in Hanson

Critical Natural Landscape IDs correspond with the following element lists and summaries.



Critical Natural Landscape Summaries

CNL 498

A 3,128-acre Critical Natural Landscape featuring Aquatic Core Buffer, Wetland Core Buffer and Landscape Block.

A variety of analyses were used to identify protective upland buffers around wetlands and rivers. One, the variable width buffers methodology, included the most intact areas around each wetland and river, by extending deeper into surrounding unfragmented habitats than into developed areas adjacent to each wetland. Other upland buffers were identified through the rare species habitat analysis. In this way, the conservation of wetland buffers will support the habitats and functionality of each wetland and include adjacent uplands that are important for many species that move between habitat types.

Landscape Blocks, the primary component of Critical Natural Landscapes, are large areas of intact predominately natural vegetation, consisting of contiguous forests, wetlands, rivers, lakes, and ponds, as well as coastal habitats such as barrier beaches and salt marshes. Pastures and power-line rights-of-way, which are less intensively altered than most developed areas, were also included since they provide habitat and connectivity for many species. Collectively, these natural cover types total 3.6 million acres across the state. An Ecological Integrity assessment was used to identify the most intact and least fragmented areas. These large Landscape Blocks are most likely to maintain dynamic ecological processes such as buffering, connectivity, natural disturbance, and hydrological regimes, all of which help to support wide-ranging wildlife species and many other elements of biodiversity.

To identify critical Landscape Blocks in each ecoregion, different Ecological Integrity thresholds were used to select the largest intact landscape patches in each ecoregion while avoiding altered habitat as much as possible. This ecoregional representation accomplishes a key goal of BioMap2 to protect the ecological stages that support a broad suite of biodiversity in the context of climate change. Blocks were defined by major roads, and minimum size thresholds differed among ecoregions to ensure that BioMap2 includes the best of the best in each ecoregion.

CNL 506

A 138-acre Critical Natural Landscape featuring Aquatic Core Buffer.

A variety of analyses were used to identify protective upland buffers around wetlands and rivers. One, the variable width buffers methodology, included the most intact areas around each wetland and river, by extending deeper into surrounding unfragmented habitats than into developed areas adjacent to each wetland. Other upland buffers were identified through the rare species habitat analysis. In this way, the conservation of wetland buffers will support the habitats and functionality of each wetland and include adjacent uplands that are important for many species that move between habitat types.

CNL 700

A 14,690-acre Critical Natural Landscape featuring Aquatic Core Buffer, Landscape Block, Coastal Adaptation Area, and Tern Foraging Area.

A variety of analyses were used to identify protective upland buffers around wetlands and rivers. One, the variable width buffers methodology, included the most intact areas around each wetland and river, by extending deeper into surrounding unfragmented habitats than into developed areas adjacent to each wetland. Other upland buffers were identified through the rare species habitat analysis. In this way, the conservation of wetland buffers will support the habitats and functionality of each wetland and include adjacent uplands that are important for many species that move between habitat types.

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The coastal habitats of Massachusetts are particularly vulnerable to potential sea-level rise in the next century, which many estimates suggest is likely to exceed one meter. Therefore, in addition to prioritizing current coastal habitats, the creators of BioMap2 examined the landward side of salt marshes to determine where these habitats might move to as sea levels rise. Undeveloped lands adjacent to and up to one and a half meters above existing salt marshes were identified and included as Critical Natural Landscapes with high potential to support inland migration of salt marsh and other coastal habitats over the coming century. [76]

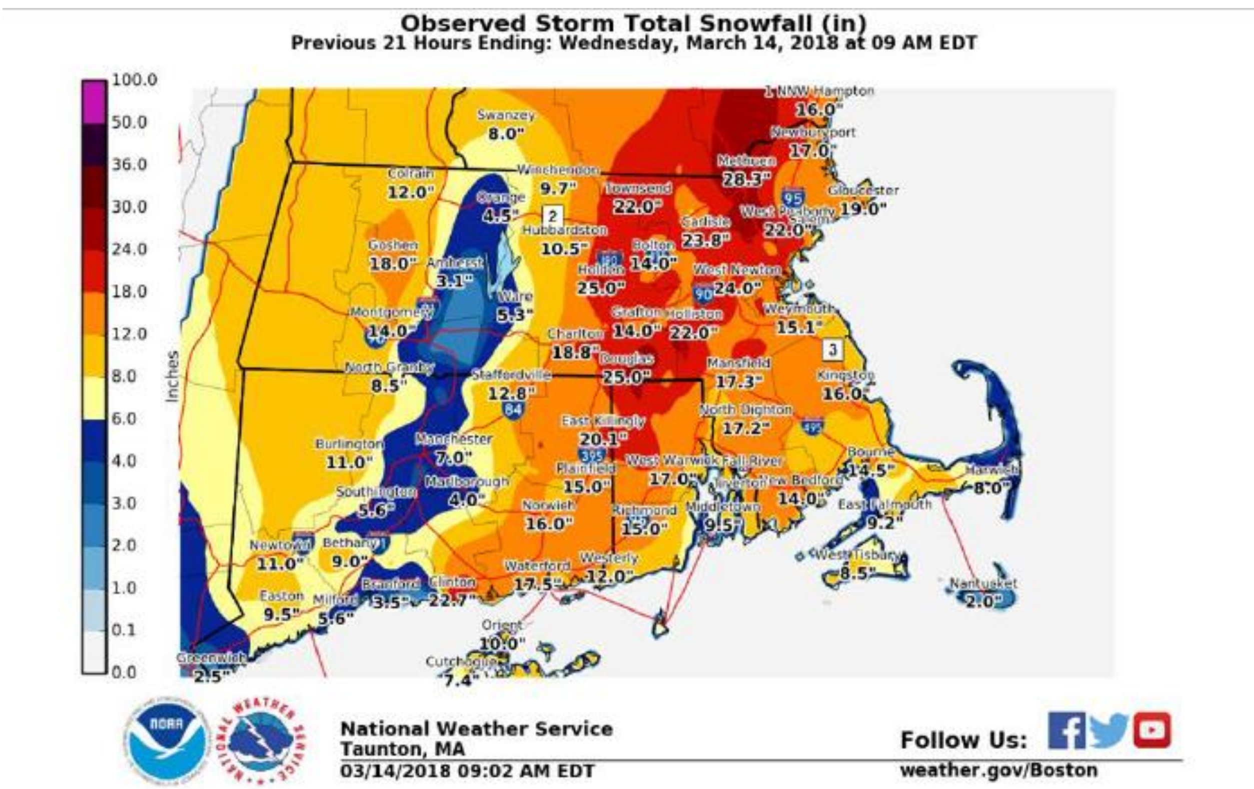
[76] BioMap2 Hanson, 2012

Nor’easter – Severe Winter Storm

Severe winter storms include ice storms, nor’easters, heavy snow, blowing snow, and other extreme forms of winter precipitation.

Snow is characterized as frozen precipitation in the form of six-sided ice crystal. For snow to occur, temperatures in the atmosphere (from ground level to cloud level) must be at or below freezing. The strongest form of a severe snowstorm is a blizzard. Blizzards are characterized by frequent wind gusts above 35 miles per hour, limited to no visibility due to falling snow and extreme cold that lasts longer than three hours. Ice storms are liquid rain that falls and freezes upon contact with cold objects. There must be an ice buildup of greater than ¼ inch for it to be considered an ice storm. When more than a ½ inch build-up is forecasted a winter storm warning can be triggered.

Figure 102: Observed Storm Total Snowfall (in)



A nor'easter is an extratropical cyclone in the western North Atlantic Ocean. The name derives from the direction of the winds that blow from the northeast. The original use of the term in North America is associated with storms that impact the upper north Atlantic coast of the United States and the Atlantic Provinces of Canada.

Nor’easter – Severe Winter Storms		
Hazard	**Significant**	**Justification**
Nor’easter 	YES	Nor’easters are macro-scale cyclones that begin as strong areas of low pressure in the Gulf of Mexico or off the east coast of the Atlantic Ocean. Higher snow accumulations are prevalent at higher elevations and along the coast where snowfall can be enhanced by additional ocean moisture. Although there is significant interannual variability in the frequency and severity of winter storms, a notable winter storm generally occurs at least once every winter. Nor’easters generally occur on at least an annual basis, with some years bringing up to four Nor’easter events. This is currently the most frequently occurring natural hazard in the state.
Exposure and Vulnerability by Key Sector		
	Populations	**General At-Risk Populations:** State-wide exposure. **Vulnerable Populations:** Elderly populations, who are susceptible due to their increased risk of injury and death from falls, overexertion, or hypothermia related to clearing snow or power failures; residents with low incomes who may lack access to housing or housing with sufficient insulation or heating supply; individuals who have difficulty evacuating for economic or physical reasons.
	Government	All municipal sites including the Police Station, Fire Station and the Highway Department, schools (Indian Head and Hanson Middle School), the Hanson Library and Town Hall.
	Built Environment	All elements of the built environment in the Commonwealth are exposed to severe winter weather. Severe winter weather can result in downed power lines, extended power failures, and road blockages. It can also overwhelm the capacity of public safety providers.
	Natural Resources and Environment	Winter storms are a natural part of the Massachusetts climate, and native ecosystems and species are well-adapted to these events. However, more extreme winter storms can result in direct mortality, habitat modification, and flooding when snow and ice melt.
	Economy	Potential impacts from winter storms and nor’easters include loss of utilities, interruption of transportation corridors, loss of business function and loss of income during business closures. The cost of snow and ice removal and repair of roads from the freeze/thaw process can also strain local financial resources.

Potential Effects of Climate Change – Nor'easter – Severe Winter Storm		
	Extreme weather and rising temperatures – increased snowfall.	Increased sea surface temperature in the Atlantic Ocean will cause air moving north over the ocean to hold more moisture. As a result, when these fronts meet cold air systems moving from the north, an even greater amount of snow than normal can be anticipated to fall on Massachusetts.
	Rising temperatures – Changing circulation patterns and warming oceans.	Research has found that increasing water temperatures and reduced sea ice extent in the Artic are producing atmospheric circulation patterns that favor the development of winter storms in the eastern US. Global warming is increasing the severity of winter storms because warming ocean water allows additional moisture to flow into the storm, which fuels the storm to greater intensity.
	Extreme Weather – Increase in Frequency and Intensity	There is evidence suggesting that nor'easters along the Atlantic coast are increasing in frequency and intensity. Future nor'easters may become more concentrated in the coldest winter months when atmospheric temperatures are still low enough to result in snowfall rather than rain.

Nor'easters are among winter's most ferocious storms. They are characterized by a large counterclockwise wind circulation around a low-pressure area that forms within 100 miles from the shore between North Carolina and Massachusetts. The precipitation pattern is like that of other extratropical storms. Nor'easters are usually accompanied by very heavy rain or snow, and can cause severe coastal flooding, coastal erosion, hurricane-force winds, (more than 74 miles per hour) or blizzard conditions. Nor'easters are usually most intense during winter in New England and Atlantic Canada. They are fueled by converging air masses that include the cold polar air mass and the warmer air over the water. They can be more severe in the winter when the difference in temperature between air masses is greater.

Nor'easters tend to develop most often and most powerfully between the months of October and April, although they can (much less commonly) develop during other parts of the year as well.

Past Occurrences

Date of Event	Event Type	Losses/Impacts
01/02/1996	Heavy Snow Snowfall totals ranged from 8 to 12 inches.	Most schools closed on the 3rd. Final snow totals fell early morning hours of the 4th Snowfall totals ranged from 8 to 12 inches with 12 to 16 inches in the Milton-Randolph area. A strong low-pressure system moved from Tennessee to the Virginia coast and then northeast off the New Jersey coast passing southeast of Cape Cod. This system produced heavy snow across the state, except along the south coast in extreme southern Plymouth and Bristol Counties and over Cape Cod and the Islands. A small area of from 12 to 16 inches was reported in the southwest suburbs of Boston in the Milton-Randolph area. The heaviest snow occurred during the early morning hours of the 3rd and made for a difficult commute, especially in the Boston area. The two busiest highways in the state were left poorly plowed at peak travel time. Most schools and some businesses were closed on the 3rd. Some final storm totals, which include light snow that fell late on the 3rd and during the early morning hours of the 4th are as follows: Boston, 13.1 inches; North Amherst, 11.9 inches; Westborough, 11 inches; Springfield, 8 inches; Fall River, 4 inches; New Bedford, 6 inches; Plymouth, 7 inches; and Provincetown, 1 inch.
01/07/1996	Blizzard, Heavy Snow Totals ranged from 15 to 25 inches with many totals of 20 to 25 inches in parts of Plymouth and Bristol Counties.	This storm was one of the most significant winter storms to hit southern New England in the past 20 years and was named ***"The Blizzard of '96"*** as it dumped record snowfalls from the mid-Atlantic states to southern New England but only met true blizzard criteria for a few hours in a small section of eastern MA. Very heavy snowfall that was measured in feet. Boston snow depths totals 30 inches breaking the record of 29 inches at the end of the Blizzard of 78.
1/10/1996	Heavy Snow More than one foot of snow fell on parts of the Cape.	A coastal low-pressure system brought a heavy snowfall to eastern Massachusetts, Cape Cod, and the Islands Some snowfall totals included: Chatham, 15 inches; Hyannisport, 14 inches; Yarmouthport, 13 inches; Sandwich, 12 inches; Martha's Vineyard, 8 inches; Marshfield, 12 inches; Carver, 11 inches; Pembroke, 10 inches; Shrewsbury, 6.2 inches; and Rockport, 6 inches. Travel conditions were difficult during the heavy snowfall but since the storm occurred late Friday evening into Saturday morning, there were fewer cancellations that usual.
2/2/1996	Heavy Snow More than one foot of snow fell on parts of the Cape.	A coastal low-pressure system brought a heavy snowfall to eastern Massachusetts, Cape Cod, and the Islands. Some snowfall totals included: Chatham, 15 inches; Hyannisport, 14 inches; Yarmouthport, 13 inches; Sandwich, 12 inches; Martha's Vineyard, 8 inches; Marshfield, 12 inches; Carver, 11 inches; Pembroke, 10 inches; Shrewsbury, 6.2 inches; and Rockport, 6 inches. Travel conditions were difficult during the heavy snowfall but since the storm occurred late Friday evening into Saturday morning, there were fewer cancellations that usual.

2/16/1996	Heavy Snow Snowfall totals ranged from only 3 to 5 inches away from the coast in Essex County and the south portion of Worcester County to 7 to 9 inches in the Boston area.	A rapidly intensifying storm system moved northeast from off the Virginia Capes passing southeast of Cape Cod and brought still another in a long series of major snowstorms this winter season. The maximum amount of snowfall was 14 inches reported from Ashburnham in the extreme northern portion of Worcester County. On Cape Cod there were totals of 5 to 10 inches and Nantucket and Martha's Vineyard had 5 to 7 inches. This storm brought the total seasonal snowfall at Boston to 83.5 inches.
3/2/1996	Heavy Snow When the precipitation ended, many parts of the state had received 6 to 12 inches of snow.	A low-pressure system located about 100 miles off the North Carolina coast at 7 AM moved northeast and spread snow across the entire state during the forenoon. The snow became moderate to heavy by noon and continued into the late afternoon and early evening. While Boston's Logan Int'l. Airport received only 3.9 inches from this storm, locations to the north, west, and south had much more snow. The heaviest amounts of up to one foot were reported along the south coast where Bourne had 12 inches and Acushnet, North Dartmouth, and Westport received 11 inches. The cities of Fall River and New Bedford had 8 to 9 inches of snow. On Cape Cod, Marstons Mills had 10 inches; Sandwich 9.5 inches; Yarmouthport 8.5 inches; and Chatham 6 inches. Numerous skidding accidents were reported on highways across the state. There was a 30-car pile-up on Route 495 in Littleton. In Weymouth, 17 accidents were reported between noon and about 3 PM. Seventeen people received minor injuries.
3/7/1996	Heavy Snow Snowfall totals ranged from less than 6 inches over southern Plymouth and Bristol Counties and Cape Cod and the Islands to 7 to 18 inches across the rest of the state.	A low-pressure system moved northeastward from North Carolina and passed just to the southeast of New England, bringing yet another heavy snowstorm to most of the state. A total of 18 inches was reported from Rowley in Essex County. There was some light freezing rain and drizzle in the eastern part of the state on March 6th and early March 7th preceding this storm. Significant snowfall began during the afternoon on March 7th. Snowfall totals for the season beginning in November 1995 soared to new all-time records more than 100 inches. Some storm totals and seasonal totals included: Methuen 14.5 inches/120.8 inches, Greenfield 10.5 inches; in Norfolk County, Randolph 14.5 inches, Cohasset 10 inches***; in Plymouth County, Hingham 12.2 inches/105.8 inches, Brockton, and Duxbury 9 inches.*** Boston's official snowfall was 10.4 inches for this storm and the seasonal total reached a record of 100.3 inches, which exceeded the previous record of 96.3 inches set just two years ago. There were many cancellations and hundreds of minor skidding accidents, as well as slow and difficult commuting.
4/9/1996	Winter Storm, Heavy Snow A general snowfall of 4 to 8 inches was observed near sea level, except within several miles of the coast, where less than 4 inches fell.	A low-pressure system developed along the middle Atlantic coast and ***intensified to 984 mb (29.06 in.)*** as its center passed right over Nantucket Island at 10 AM on April 10. This storm brought a record late-season snowfall to most of the state, except right along the immediate coast. New snowfall records were established, especially at inland locations and even at those locations along the coast which had some elevation. Some of the records set included the greatest April snowfall in a single storm, for a 24-hour period in April, and for a late-season storm. Seasonal snowfall totals reached all-time new record maxima of well over 100 inches.

		The greatest totals for this storm of 15 to 21 inches occurred across central Massachusetts from the Rhode Island/Connecticut border to the New Hampshire border. Blue Hill Observatory-Milton received 15.0 inches. Also, at Blue Hill, the maximum snow depth on the ground reached 18 inches, setting a record for April and for so late in the season. However, Boston's Logan International Airport had 6 inches, pushing the seasonal total to 107.6 inches, beating the old record of 101.6 inches set just a few days earlier. All slightly higher terrain locations, especially above 500 feet had totals of 12 to 20 inches. Since this was a late-season event, snowfall on pavements was much less. Accumulation of heavy, wet snow on trees and power lines and gusty winds up to 30 to 40 mph resulted in many power outages. There were numerous reports of lightning in the eastern part of the state. A peak wind gust of 50 mph was recorded at Gloucester at 955 AM on the 10th. The Blue Hill Observatory in Milton reported a peak gust to 53 mph. Some final seasonal snowfall totals after this storm included: Blue Hill Observatory-Milton, 144.4 inches (old record 136.0 inches in 1947-1948); Easton, 124.0 inches; Taunton, 112.3 inches; Hingham, 112.3 inches (old record 95.1 inches in 1993-1994); Acushnet, 112.2 inches; and Boston 107.6 inches (old record 96.3 inches in 1993-1994).
1/11/1997	Heavy Snow Six to nine inches of snow fell from just south of Boston to northern Rhode Island and southeastward to Cape Cod.	A developing low-pressure system south of Long Island spread bands of heavy snow across southeastern Massachusetts, Cape Cod, and the Islands. This was a quick-hitting storm with snow accumulation rates up to 2 inches per hour. Most of the snowfall occurred during a 6-hour period. Some snowfall amounts included: Norwell, 9 inches; Taunton, 8.6 inches; Hingham and Blue Hill in Milton, both 8.0 inches; Norwood, and Stoughton, 7 inches; and New Bedford, 6 inches.
2/16/1997	Heavy Snow Snowfalls of 6 to 7 inches	A “clipper-like" low pressure system moved rapidly eastward from south of the Great Lakes passing south of Long Island and Cape Cod. It spread a band of moderate snow across the area. The maximum snowfall reported was 7.5 inches at Orleans. Nearby Carver in southern Plymouth County reported 6.3 inches.
3/31/1997	Blizzard of ‘97, Heavy Snow	A low-pressure system formed off the New Jersey coast during the early morning hours and intensified rapidly as it moved to a position 60 miles south of Newport, Rhode Island by early evening**.** ***Pressure falls of 14 millibars occurred during a 12-hour period.*** The system then retreated to the south during the evening. ***This storm went on to produce one of the greatest snowfalls ever recorded in central and eastern Massachusetts and was termed the Blizzard of '97."*** The storm was made even more unusual by its late-season occurrence. The final snowfall totals will be included in April 1997 Storm Data
04/01/1997	Snowfall totals of 20 to 30 inches were common from a Plymouth to Taunton line northwestward to the Berkshires.	A low-pressure system which formed off the New Jersey coast during the early morning hours of March 31st intensified rapidly as it moved to a position 60 miles south of Newport, Rhode Island. This system retreated to the south during the early morning hours of April 1st, pulling in cold air from the north. The center then moved slowly eastward. ***Heavy snow and strong winds produced blizzard or near-blizzard conditions*** across most of Massachusetts, except for the Islands of Nantucket and

	Maximum totals of more than 30 inches were reported in southeast Worcester County, where Milford had a phenomenal total of 36 inches.	Martha's Vineyard. Northeast winds gusting to 30 to 50 mph were reported. The storm produced the greatest snowfall on record for any storm at Worcester Municipal Airport, with a total of 33 inches. It was the third greatest snowfall on record at Boston with an accumulation of 25.4 inches. The Blue Hill Observatory in Milton recorded 29 inches in 24 hours, establishing a record and the storm total there of 30 inches made it the third greatest snowstorm on record. Two to five inches of liquid equivalent precipitation made this snowfall extremely heavy and difficult to remove. The weight of the snow resulted in severe damage to trees and power lines and up to 750,000 electric customers lost power statewide during the height of the storm in the early morning hours of April 1st. Whole towns were without power for up to three days after the storm. More than 100 power crews were brought in from states outside of New England to help restore power. The governor of the Commonwealth of Massachusetts declared a state of emergency, The City of Boston, which recorded 25.4 inches of snow, was paralyzed for two days and the National Guard was called in to help with snow removal. Boston's Logan International Airport was closed for one day. A roof collapse was reported at an automobile dealership in Norwell. Hundreds of cars and trailer trucks were abandoned on state highways, making plowing operations difficult. More than 40 trailer trucks were stuck on Route 128 between Newton and Canton. The cost of snow removal was estimated to cost the state highway department between $6,000,000 and $7,000,000.
12/24/1998	Heavy Snow The greatest snowfall reported was over 9 inches over the south part of the town of Plymouth.	A low-pressure system intensified as it moved across the offshore waters during the early morning hours. This storm system brought the heaviest snowfall to southeast coastal Massachusetts, where the snow lasted nearly 10 hours. The northern fringe of the snow reached the northern and northwest suburbs of Boston. Other totals of 6 inches or more included 8 inches in downtown Plymouth, and Truro; 7 inches in Whitehorse Beach in Plymouth, and in Somerset; 6.2 inches in Carver and Fairhaven; and 6.0 inches in Bridgewater, New Bedford, and West Wareham.
1/14/1999	Heavy Snow Total snowfall in these areas ranged from 10 to 16 inches. with as much as 16.5 inches in South Weymouth.	A strong high-pressure system centered over southeast Canada brought an Arctic airmass into Massachusetts. Northeast winds off the warmer waters of the Atlantic Ocean produced “ocean effect" snow squalls along the eastern coast from Essex County to Plymouth County. During the same time an intensifying low-pressure system over the mid-Atlantic states brought a more general snowfall across the state. The highest snowfall totals were found in two areas - in coastal northeast Massachusetts and in Boston's southern suburbs which both received enhancement from the "ocean effect" snow. The heavy snow in the Boston area created havoc with the afternoon and evening rush hour. Many drivers abandoned their vehicles on a section of the Southeast Expressway in Quincy and, along most of Route 128. Portions of both roadways had to be closed until snowplows could keep up with the snow which was falling at the rate of around 2 inches per hour. It took evening commuters as long as 3 to 4 hours just to drive 10

		to 15 miles. Schools were closed in Greater Boston for one to two days because of this storm.
2/25/1999	Nor'easter, Heavy Snow The hardest hit areas were in southeast Massachusetts, including Cape Cod, where as much as two feet of snow was reported.	***A powerful nor'easter***, which passed about 200 miles southeast of Cape Cod, brought heavy snow and strong winds to the eastern third of the state. A peak wind gust of 67 mph was reported from Nantucket. The heavy snow and strong winds toppled trees and utility poles on the Cape and Islands, where more than 16,000 electric customers lost power by early morning on the 26th. The storm forced the cancellation of half of the scheduled 700 flights from Logan International Airport in Boston. Rush hour traffic was snarled on the main routes out of the Boston area as well. The National Weather Service Office in Taunton reported 10.9 inches, Worcester reported 10.5 inches, and Logan International Airport reported 6.5 inches of snow
3/15/1999	Heavy Snow The highest totals reported were in southern Bristol County, where amounts approached one foot of snow.	A strong low-pressure system, centered off the coast of Virginia during the early morning hours, moved northeast to a position southeast of Nantucket by early afternoon. This system brought a significant late season snowstorm to much of the state, with the highest snowfall totals reported in eastern and southeastern Massachusetts. Most of the snow fell within a 12-hour period, when snowfall rates exceeded one inch per hour. Some of the higher totals reported include 11 inches in Fairhaven and at the Blue Hill Observatory in Milton, 10 inches in Westport, 9 inches in South Plymouth, Brockton, Sagamore Beach, and Falmouth, and 6 inches on Nantucket. The heavy snow made travel difficult for the Monday morning commute, and many schools were closed as a result.
1/13/2000	Heavy Snow Accumulations ranged from 1 to 3 inches on the south coast to 3 to 6 inches as far north as the Mass Pike.	Low-pressure passing just south of the Cape and Islands brought the first widespread snowfall of the winter season to the Bay State and brought heavy snow to much of central Massachusetts. Accumulating snow was reported down to the south coast. ***The snow ended the stretch of more than 300 days without measurable snowfall in Boston.*** The last time snow had fallen at Logan International Airport was on March 15, 1999. It began snowing during the morning rush hour, causing roadways to quickly become iced over. State Police handled more than 100 car accidents in Greater Boston alone between 7 and 9 am. Greater Boston received 4 to 6 inches of snow, with as much as 7 to 9 inches in northern Worcester County. The storm was followed by a bitterly cold airmass, which brought subzero wind chills to the region.
1/20/2000	Heavy Snow Snowfall amounts ranged from 5 to 7 inches across interior Plymouth County.	Low pressure moving from the Carolina coast to south of Nantucket brought heavy snow to parts of southeast Massachusetts. Strong winds during the height of the storm downed several large limbs in Eastham and produced drifts as high as 2 to 3 feet. Snowfall amounts ranged from 5 to 7 inches across interior Plymouth County, to as much as 6 to 10 inches on the outer Cape and Nantucket Minor splash over was also reported on the outer Cape during high tide, but no major damage or flooding resulted.
2/18/2000	Heavy Snow	Low pressure tracking from the Ohio Valley to the coast of southern New England brought heavy snow to much of the Bay State, except for the

	Most places ended up with 6 to 8 inches of snow	south coast, Cape Cod, and the Islands where only 2 to 5 inches of snow fell. Most places ended up with 6 to 8 inches of snow from the storm, but as much as 10 inches fell across northern Massachusetts. The storm, which coincided with the beginning of the Presidents' Day holiday weekend and school vacation week, snarled traffic on major highways and created treacherous driving conditions. Dozens of accidents were reported, many of which were due to excessive speed. Some snowfall totals include 7 inches in Springfield, and Stoughton; and 6 inches in Foxboro, and Easton. Most places ended up with 6 to 8 inches of snow from the storm, but as much as 10 inches fell across northern Massachusetts.
1/20/2001	Heavy Snow The highest snowfall totals were in Norfolk, Bristol, and Plymouth Counties where many reports of 10-inch storm totals were received.	Heavy snow fell over much of central and eastern Massachusetts. Since the snowstorm occurred over the weekend there was little significant impact on travel, though Logan International Airport in Boston closed for 40 minutes for snow removal. In Dartmouth, the 70-foot-high Dartmouth Sports Dome collapsed under the weight of the heavy, wet snow. No one was inside the complex at the time and there were no injuries. Some snowfall totals from the storm include 11 inches in Mansfield and South Easton; 10 inches in Stoughton, South Weymouth, Plymouth, and at the National Weather Service in Taunton; 8 to 9 inches in Middleboro and Bridgewater; and 6 to 7 inches in Franklin, and Pembroke. Official storm totals were 6.5 inches at Worcester Regional Airport and 6 inches at Logan International Airport in Boston.
3/5/2001	Heavy Snow Amounts in southeast Massachusetts ranged from 2 to 4 inches along the immediate coast to as much as a foot farther inland.	A major winter storm impacted the Bay State with ***near blizzard conditions***, high winds, and coastal flooding. The slow-moving storm, which tracked south of New England, dumped over two feet of snow across the interior, knocked out power to about 80,000 customers, and shut down businesses and schools for several days. There were also many reports of downed trees and wires during the height of the storm, along with reports of lightning and thunder. In magnitude, it was the worst storm to affect the state since 1992, and a state of emergency was in effect for three days. After the storm, the weight of the heavy wet snow caused several roof collapses throughout the state, most notably at a church in Westford. No injuries were reported. Damage from this storm was estimated to be in the tens of millions of dollars. The highest snowfall totals were reported from the east slopes of the Berkshires across Worcester County and into northeast Massachusetts, where amounts of 15 to 30 inches were common. Greater Boston received between 12 and 22 inches of snow, but Logan International Airport received 9.8 inches from this storm. Amounts in southeast Massachusetts ranged from 2 to 4 inches along the immediate coast to as much as a foot farther inland. Other official totals include 23 inches at the Blue Hills Observatory in Milton, 22 inches at Worcester Airport, and 9.5 inches at the National Weather Service in Taunton. Powerful northeast winds affected much of east coastal and southeast Massachusetts. Speeds of 50 to 60 mph were widely observed and caused damage to trees and power lines, especially on Cape Cod and the

		islands. Some unofficial gusts reported by spotters include 64 mph in Wareham, 61 mph in Fairhaven, and 60 mph at Nauset Beach in Orleans. High tides during the storm ran 2 to 3 feet above normal, resulting in widespread coastal flooding along the entire east facing coastline, including Cape Cod and the islands.
3/26/2001	Heavy Snow Snowfall totals of 5 to 10 inches	A small but fast-moving storm brought heavy snow to southeast Massachusetts, as it moved off the coast south of Long Island. As much as 10.6 inches of snow fell in Fairhaven. Snowfall totals of 5 to 10 inches were widely reported from the southern suburbs of Boston to Cape Cod.
12/5/2002	Winter Storm Heavy Snow Snowfall totals of 6.0 – 8.0 inches	***A winter storm*** passing about 200 miles southeast of Nantucket brought heavy snow to southeast Massachusetts, including Cape Cod and the Islands. No storm damage or injuries were reported. Officially, a storm total of 6.0 inches was reported at the National Weather Service office in Taunton. Other snowfall totals included 6 inches in Mansfield, Brockton, and Fairhaven. Snowfall amounts averaged around 6 inches in these areas, while farther north and west, amounts of 2 to 5 inches were common throughout the rest of the Bay State.
3/16/2004	Winter Storm Heavy Snow Official snowfall totals included 11.2 inches at Blue Hill Observatory in Milton.	A late season ***winter storm*** passing southeast of New England brought heavy snow to most of Massachusetts. Snowfall totals of 5 to 10 inches were common from the east slopes of the Berkshires across central and eastern Massachusetts, down to parts of the south coast. Amounts were somewhat lower in the Connecticut River Valley due to a shadowing effect, and on Cape Cod and the Islands where surface temperatures were warm enough to allow for some melting. Official snowfall totals included 11.2 inches at Blue Hill Observatory in Milton, 9.6 inches at Logan International Airport in Boston, 9.0 inches at the National Weather Service Office in Taunton. Other snowfall totals, as reported by trained spotters, included 10 inches in North Andover, Salem, and Brockton.
2/24/2005	Heavy Snow Snowfall totals averaged 4 to 8 inches, with locally as much as 11 inches in southern Plymouth County.	Low-pressure over the Mid-Atlantic states strengthened rapidly as it passed southeast of Nantucket and brought heavy snow to much of southeast New England, including Massachusetts from greater Boston to the south coast, Cape Cod, and the islands. Official snowfall totals included 8.0 inches at Logan International Airport in Boston, 6.7 inches at the National Weather Service office in Taunton and at Blue Hill Observatory in Milton. Other snowfall totals, 6 inches in Norton, Bridgewater, Duxbury, Quincy, Randolph, Norwood, and Foxboro.
12/13/2007	Heavy Snow Snow fell nearly a foot of snow in most locations.	High pressure across the St. Lawrence Valley locked in cold air across southern New England and combined with low pressure south of the coast to produce a significant snowfall. Many motorists were affected as early dismissals from work and school just before snow began created rush hour like conditions which limited the snowplows' ability to plow. Snow fell at rates of up to two inches per hour for an eight to ten-hour period resulting in nearly a foot of snow in most locations.
1/27/2008	Heavy Snow	A low-pressure center gathered strength off the mid-Atlantic coast and became a powerful ocean storm. This storm spread snow and winds

		across Cape Cod, Nantucket, Martha's Vineyard, and portions of southeast Massachusetts. In addition, some minor coastal flooding occurred along Cape Cod. Dozens of minor accidents occurred on the Cape, resulting in a brief closure of the Sagamore Bridge over Cape Cod Canal. Ferry service to Nantucket was discontinued for roughly 24 hours and high winds kept planes grounded at Barnstable Municipal Airport, cutting off access to Nantucket. Most schools on the Cape were cancelled during the storm, as well as schools along the south coast of Massachusetts
12/19/2008	Heavy Snow Eleven inches of snow fell across south coastal Plymouth County.	Large trees and wires in Wareham and Mattapoisett were downed by heavy snow and 30 mph winds. One of these trees fell on a house in the Onset section of Wareham. An intensifying coastal low spread heavy snow across southern New England. Snow began in the early afternoon across Connecticut and southwestern Massachusetts, spreading quickly across Massachusetts, Rhode Island, and southern New Hampshire. Eight to twelve inches of snow fell across much of southern New England with higher amounts falling in Plymouth County. The heavy snow combined with 30 to 40 mph winds, resulting in one fatality and some tree and structural damage. The fatality occurred in Acushnet where a tree fell on a 44-year-old man, killing him.
12/31/2008	Heavy Snow Numerous reports of six to eleven inches of snow were received.	A fast-moving low-pressure system moved through Southern New England bringing 4-10 inches of snow to the region. In addition, strong cold advection and pressure rises resulted in very cold temperatures, strong winds, and bitterly cold wind chills.
1/18/2009	Heavy Snow Five and a half inches of snow fell in eastern Plymouth County.	A low-pressure system in the Great Lakes redeveloped south of New England, spreading snow across the area.
1/19/2009	Heavy Snow Five and a half inches of snow fell in eastern Plymouth County.	An upper-level disturbance followed the previous days clipper low providing enough energy for an isolated heavy snow event along the east coast of Massachusetts.
2/3/2009	Heavy Snow Six inches of snow fell across eastern Plymouth County on average.	A coastal low-pressure system moved just southeast of the 40 N/70 W benchmark, spreading snow across much of southern New England. Snowfall largely fell into the advisory criteria - three to six inches.
3/2/2009	Heavy Snow Six to eight inches of snow fell across eastern Plymouth County.	A coastal low-pressure system moved southeast of Nantucket, spreading snow across Southern New England. Snowfall amounts ranged from three inches on Cape Cod to almost twelve inches in southern New Hampshire. This late season storm affected most of the east coast and resulted in hundreds of flight cancellations at Boston's Logan Airport and many car accidents. In Massachusetts, snowfall amounts ranged from three to ten inches.

12/19/2009	Blizzard Heavy Snow Thirteen to twenty-one inches of snow fell across eastern Plymouth County.	***Blizzard conditions*** were also observed. Low pressure off the mid-Atlantic coast intensified dramatically resulting in widespread snowfall along the northeast corridor of the U.S. While the mid-Atlantic received much of the snow and wind from this storm, snow spread across much of Southern New England and blizzard conditions occurred in Newport, Rhode Island and Marshfield, Massachusetts. Snowfall totals ranged from 1 to 3 inches in northwestern Massachusetts and southern New Hampshire to 18 to 20 inches across Rhode Island and southeastern Massachusetts.
12/20/2010	Heavy Snow Anywhere from 7 to 12 inches of snow fell in eastern Plymouth County.	An ocean storm brought significant amounts of snow to Plymouth County, the Cape, and Islands. A deep layer of moisture over this region aided in producing the highest snowfall Southern New England had seen to date this winter. Average accumulations ran from 2 to 4 inches in southern Bristol County and Boston to 8 to 10 inches in eastern Plymouth County and Cape Cod.
1/12/2011	Nor'easter Heavy Snow Eight to nine inches of snow fell across southern Plymouth County	A developing ***nor'easter coastal storm*** dumped up to two feet of snow across Massachusetts in a 24-hour period. Strong winds combined with the heavy snow along the coast producing numerous downed trees and wires, resulting in 100,000 homes without power statewide, though most were in southeastern Massachusetts. Logan International Airport closed for several hours during the storm. This was the second major storm of an above average winter of snowfall. The first occurred December 26 and 27, with several other relatively minor snowfalls in the month of January, and a third major storm February 1 and 2. With only a brief thaw in between the December storm and the January storm, snow piled up across southern New England resulting in numerous roof collapses, towns seeking permission to dump excess snow in area rivers and bays, and numerous disruptions to transportation. Federal assistance was sought by Governor Patrick for costs associated with the January 12 winter storm and its cleanup. It was granted by President Obama for Hampshire, Essex, Middlesex, Norfolk, and Suffolk counties.
1/26/2011	Heavy Snow Six to eight inches of snow fell across southern Plymouth County.	A strong low-pressure system moved up the coast and southeast of Nantucket producing up to a foot of snow across Massachusetts.
1/21/2012	Heavy Snow Amateur Radio operator reported 5 to 8 inches of snow on the ground.	A weak low-pressure system moved southeast of southern New England, bringing snow to much of southern New England. While most of the area received at least an inch of snow, a mesoscale band set up along the south coast of Massachusetts and Rhode Island resulting in incredible snowfall rates. Eight to twelve inches of snow fell along the coast with five to eight inches falling on Martha's Vineyard and Nantucket.
2/8/2013	Blizzard Heavy Snow Twelve to eighteen inches of snow fell across southern Plymouth County.	***An historic winter storm*** deposited tremendous amounts of snow over all southern New England, mainly from the mid-afternoon on Friday, February 8 and lasting into the daylight hours of Saturday, February 9. What made this an amazing storm was the widespread coverage of heavy snowfall. Most locations received 2 to 2.5 feet of snow! A stationary band of even heavier snowfall persisted from southwest NH through central MA and on to the southwest across central and western CT. In those areas, reports averaged closer to 2.5 to 3 feet!

		Along the southeast MA coast, average amounts ranged from 1 to 2 feet. Isolated thunderstorms were common across the entire region during the height of the storm. A low-pressure system advancing from the Great Lakes region combined forces with a very moist low-pressure system moving northeast from the Gulf Coast states. Explosive deepening took place Friday evening, February 8, as a low center moved from the North Carolina coast to south of Nantucket. Strong high pressure to the north of New England helped ensure that cold air remained in place over the area. Snowfall gained intensity during the afternoon, but during the night, 2 to 3 inch per hour amounts were common throughout the region. The band of heaviest snowfall, with 3 to 5 inches per hour for several hours, extended from southwest NH to central and western CT. The precipitation started as mainly snow, although a brief period of rain at the onset was common on the Islands. Snow ended in the morning in western and central MA, southwest NH, most of CT and RI, and in the early afternoon across eastern MA. It lingered during the whole afternoon over Cape Cod and Nantucket, aided by some ocean-effect bands of snowfall. ***The Blizzard of 2013*** also produced a prolonged period of strong winds Friday night along the MA and RI coasts. Gusts exceeded hurricane force (74 mph) at a few locations. Gale force gusts (to 50 mph) continued the MA coast through Saturday afternoon. The strong winds, combined with a wet snow, led to extensive power outages from downed trees and wires in southeast coastal MA and in southern RI. Elsewhere, farther inland, the snow became drier and did not cling to trees like it did along the south and southeast coast of New England. Some wind gusts included: 76 mph at Logan international Airport (Boston, MA), 77 mph at Hyannis, MA and 68 mph in Jamestown, RI. Damaging gusts to 60 mph were recorded as far west as Worcester County, MA. Wind gusts of 35 to 50 mph were common elsewhere in southern New England. In addition, ***moderate to major coastal flooding occurred***, most notably during the time of the high tide Saturday morning along the Massachusetts east coast. At the storm's height near the early morning low tide, the ***storm surge reached 3 to 4 feet along much of the MA east coast*** from Boston south. At the time of the mid-morning high tide, the winds had shifted from northeast to north and the surge had dropped to 1.5 to 2.5 feet for most MA east coast locations. However, this was an astronomically high tide given the nearness to the time of the new moon, and waves to 30 feet had built just 15 miles off the coast. Consequently, many coastal roadways were impassable from Gloucester to Marshfield and Scituate on the south shore and on parts of Cape Cod. Water several feet deep was seen flowing into some vulnerable homes in Scituate. Although there was some structural damage, it did not come close to what was experienced during the Blizzard of 1978. Minor tidal flooding occurred along the south coasts of Connecticut, Massachusetts, and Rhode Island during times of high tide Friday night and Saturday morning.
3/7/2013	Heavy Snow Five to twelve inches of snow fell	This storm brought ***heavy snow and significant coastal flooding*** to the forecast area. This was an unusual synoptic set-up, with low pressure lingering off the coast of southern New England for several days. Snowfall was difficult to forecast due to concerns about precipitation

	across southern Plymouth County.	type and boundary layer temperature. In the end, precipitation type turned out to be all snow for much of the area, with most locations receiving 1 to 2 feet of snow. In addition, the Massachusetts east coast was hit by widespread moderate and pockets of major coastal flooding for two high tide cycles and beach erosion for at least 5 high tide cycles.
1/2/2014	Heavy Snow Nine to eleven inches of snow fell across southern Plymouth County.	A ***significant, rapidly developing coastal storm*** moved southeast of Southern New England bringing heavy snow, bitter cold temperatures, coastal flooding, and strong winds to Massachusetts. Snow amounts varied widely, from roughly six inches across the east slopes of the Berkshires to nearly two feet in coastal Essex County.
1/21/2014	Heavy Snow Ten to eleven inches of snow fell across southern Plymouth County.	Low-pressure tracked along an arctic front bringing heavy snow and strong winds to much of southern New England. A snow band set up along the east coast, through portions of eastern Plymouth and Norfolk counties. Snow fell at a rate of 1-3 inches per hour within this band.
2/5/2014	Heavy Snow Four to nine inches of snow fell across eastern Plymouth County.	Low-pressure moving off the mid-Atlantic coast intensified as it moved northeastward over Nantucket. This spread heavy snow across all southern New England.
2/15/2014	Heavy Snow Seven to ten inches of snow fell across eastern Plymouth County.	A tree, branches, and a few wires were downed due to the weight of the snow and winds gusting to around 40 mph. Low-pressure moved off the Delmarva peninsula and moved northeastward passing southeast of southern New England. This brought strong winds and heavy snow to the southern portions of the region.
1/26/2015	Blizzard Heavy Snow Eighteen to twenty-two inches of snow fell across southern Plymouth County.	An historic winter storm brought heavy snow to southern New England with ***blizzard conditions*** to much of Rhode Island and eastern Massachusetts, beginning during the day on Monday, January 26 and lasting into the early morning hours of Tuesday, January 27. Some of the highest totals reported include Hudson, MA (36 inches), Acton, MA (34 inches), Thompson, CT (33.5 inches), and Methuen, MA (31.5 inches). Much of southeast Massachusetts and the rest of Rhode Island received one to two feet of snow. Totals dropped off dramatically west of the Connecticut River Valley where totals of 4 to 8 inches were observed. ***The storm was well-forecast, with Blizzard Watches and Winter Storm Watches issued 2 days before the snow began***. Low pressure tracked northeast from the Carolinas and strengthened rapidly as it slowly passed southeast of Nantucket on Monday evening, January 26. All the precipitation fell as snow with this storm. At its peak, snowfall rates of 2 to 3 inches per hour were common. In Massachusetts, blizzard conditions were officially reported in Marshfield (14 hours), Hyannis (13 hours), Nantucket (11 hours), Boston (9 hours), Chatham (9 hours), Worcester (7 hours), and Beverly (3 hours). Daily snowfall records were set for January 27 in Boston (22.1 inches, previous record 8.8 inches in 2011), Worcester (31.9 inches, previous record 11.0 in 2011), and Providence (16.0 inches, previous record 6.7 inches in 2011).

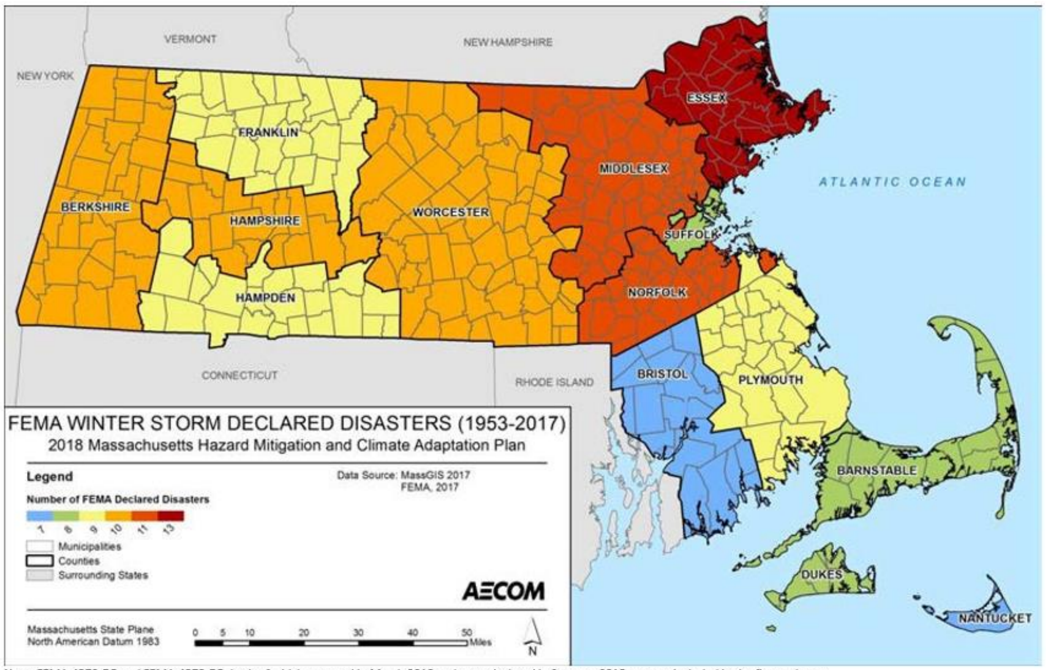
		The Blizzard of January 2015 produced extraordinarily strong winds late Monday into Tuesday near the Massachusetts and Rhode Island coasts where gusts of 50 to 65 mph were common. Gusts reached hurricane force at a few locations in Massachusetts including Nantucket (78 mph), Chatham (75 mph), and Aquinnah (74 mph). ***Significant coastal flooding*** occurred along the Massachusetts east coast, mainly south of Boston. Due to a north-northeast wind around the time of the early morning high tide, Boston's north shore was spared to some degree with mostly minor impacts. North and east facing coastlines from Hull to Chatham as well as Nantucket experienced moderate to major coastal flooding with ***some areas experiencing inundation more than 3 feet and pockets of structural damage***, especially where sea walls and other protective devices were compromised***. Severe erosion was reported along portions of the coastline*** south of Boston. The Sandwich area was especially hard hit with erosion because of strong onshore winds by the time of the early morning high tide. Very preliminary estimates indicate that the coastal impact along the eastern Massachusetts coast south of Boston was generally comparable to but in a few locations a little greater than the February 2013 Blizzard. Residents had to be evacuated from neighborhoods in Hull and Scituate. ***The governor of Massachusetts declared a travel ban that began on January 27th*** at midnight and was lifted county-by-county as conditions allowed. Power outages were few (limited mainly to Cape Cod and the Islands) but had a high impact as all power was out on the island of Nantucket. Logan International Airport was closed through 6 am January 28th. A total of 116 cities and towns declared local states of emergency during this storm, activating their Emergency Operations Centers. Most Amtrak, ferry, train, and bus service were suspended for January 27th, prior to the storm. Over 40 shelters opened, serving a total of 450 individuals. Two fatalities were reported because of this storm: a 97-year-old man who died while trying to clear a carbon dioxide vent at his home in Yarmouth and a 53-year-old man in New Bedford who died while snow blowing his neighbor's driveway. ***President Obama issued a federal disaster declaration for the eastern parts of Massachusetts for this storm, allowing federal assistance for emergency work and repairs to facilities damaged by the storm***.
2/2/2015	Heavy Snow Five to fourteen inches of snow fell across east coastal Plymouth County.	Low-pressure passed south of New England bringing snow and gusty winds to much of Southern New England. Up to a foot and a half of snow fell on much of eastern Massachusetts. This came just one week after a blizzard (January 27) brought over two feet of snow to the same area. This set a 7-day record snowfall (40.2 inches) in the city of Boston.
2/8/2015	Nor'easter Heavy Snow Eight to ten inches of snow fell across south coastal Plymouth County.	A clipper low moved across southern Quebec on February 7. This was followed by low pressure moving east from the Great Lakes on February 8. On February 9 & 10, low pressure moved off the mid-Atlantic coast becoming a ***nor'easter*** as it approached southern New England. This all resulted in a long duration snowstorm that dumped up to a foot and a half of snow across southern New England. The weight of this snowfall, on top of the two feet of snow many locations received two weeks prior resulted in several roofs collapsing.
2/14/2015	Near blizzard conditions occurred	Low pressure off the Delmarva peninsula intensified rapidly as it moved northeastward. Its path just southeast of Nantucket brought heavy snow

	across much of eastern Massachusetts Heavy Snow Eleven to eighteen inches of snow fell across southern Plymouth County.	to all southern New England and blizzard conditions and coastal flooding to coastal areas. ***Near blizzard conditions occurred across much of eastern Massachusetts***. This was the latest in a series of snowstorms that piled nearly 60 inches of snow on the city of Boston in barely three weeks. This amount of snow in such a short amount of time wreaked havoc on much of eastern Massachusetts. School and work for some employees were delayed or even cancelled, plowing, and shoveling became nearly impossible, and the Massachusetts Bay Transit Authority reduced or even cancelled services more than once during the winter snow blitz. The MBTA commuter rail and subway lines were plagued with delays and cancellations that lasted until the end of March. The large amount of snow combined with wintry, frigid temperatures resulted in snow piling up on roofs and numerous (250) roof collapses were reported to emergency management and to the National Weather Service in the days after this snowstorm. Fortunately, no injuries to humans were reported. In barn collapses in Stoughton and Andover, a total of 40 horses were trapped and rescued. In another who would have guessed scenario, a falling icicle ruptured a gas line causing an explosion at the Duxbury House, an Alzheimer's care facility in Duxbury. No one was injured. There were several indirect fatalities related to the snow. These include: a 57-year-old man who died shoveling snow, a 57-year-old woman hit by a snowplow, and a 60-year-old man hit by a snowplow.
3/5/2015	Heavy Snow About nine inches of snow fell across southern Plymouth County.	Low-pressure moved along a cold front stalled south of southern New England, bringing accumulating snow to much of the region. Snow was focused along the south coasts of Massachusetts and Rhode Island, including Cape Cod and the islands. This snow, in addition to record snow received during the month of February resulted in a roof collapse at a Dollar Tree store in Holden. No estimate of damage was able to be found.
1/23/2016	Heavy Snow Seven to thirteen inches of snow fell across south coastal Plymouth County.	Strong, gusty winds occurring simultaneously made snow difficult to measure. Low pressure intensified as it moved off the coast of North Carolina and tracked northeastward, passing south of southern New England. This brought accumulating snow to areas south of Interstate 90 in Massachusetts, including Connecticut and Rhode Island. In addition, strong, damaging winds accompanied the snow. With bare trees, there was remarkably little damage associated with winds that gusted near hurricane force at times.
2/5/2016	Wet, Heavy Snow One to ten inches of snow fell across eastern Plymouth County.	In addition, a tree was downed on Route 3 north just north of exit 11 in Duxbury. In Marshfield, trees and wires were downed on Union Street, Moraine Street, Summer Street, Ferry Street, Flagger Drive, Pleasant Street, South River Street, and Highland Street. A tree and wires were downed on King Road in Kingston. Trees and wires were downed on Tremont Street, Chandler Street, and Summer Street in Duxbury. In Norwell, trees and wires were downed throughout town, including on Stetson Road. Trees were downed on Patriot Circle, Janet Street, and Summer Street in Plymouth. Low pressure traveling along a cold front stalled south of southern New England brought heavy rain, which changed over to heavy snow as temperatures dropped. This snow was extraordinarily wet and heavy,

		bringing down trees and wires across portions of southern New England. Power outages reached a peak of approximately 107,000 customers without power in Massachusetts during the peak of the storm, mainly across eastern Massachusetts.
2/8/2016	Blizzard Heavy Snow Seven to nine inches of snow fell across southern Plymouth County.	A powerful low-pressure system tracked up the east coast, passing southeast of Southern New England. This storm brought heavy snow and gusty winds, resulting in blizzard conditions along the Massachusetts east coast.
4/4/2016	Heavy Snow Six to seven inches of snow fell across southern Plymouth County.	Low-pressure approaching from the west brought warm air advection over an anomalously cold air mass at the surface. This resulted in another round of early April snow across much of southern New England.
03/13/2018	Blizzard From ten to fifteen inches of snow fell on Southern Plymouth County.	From 6:32 AM EST to at least 9:30 AM EST, frequent wind gusts above 35 mph were measured by the Automated Surface Observing System at Plymouth Municipal Airport, leading to blizzard conditions through this period. At 6:01 AM EST a tree was down on Burgess Avenue in Rochester. At 7:10 AM EST a tree was blocking Crystal Spring Road in Mattapoisett. At 7:30 AM EST a tree fell through a house on Mattapoisett Neck Road in Mattapoisett. At 7:53 AM EST a tree was across Brant Island Road in Mattapoisett. At 8:14 AM EST multiple trees were down on Point Road in Marion, near the Little Marion Golf Course. At 8:57 AM EST multiple trees and wires were down on Kings Highway in Rochester. At 10:43 AM EST a tree was down on Front Street at Washburn Park in Marion, and multiple trees were down on Wareham Road.

Winter storms can be especially challenging for emergency management personnel. The Massachusetts Emergency Management Agency (MEMA) serves as the primary coordinating entity in the statewide management of all types of winter storms and monitors the National Weather Service (NWS) alerting systems during periods when winter storms are expected. Even though the storm has usually been forecast, there is no certain way for predicting its length, size, or severity. Therefore, mitigation strategies must focus on preparedness prior to a severe snow/ice storm.

Figure 103: FEMA Winter Storm-Related Declared Disasters by County (1953 to 2017)



Note: FEMA-4372-DR and FEMA-4379-DR, both of which occurred in March 2018 and were declared in Summer 2018, are not included in the figure above.

Source: SHMCAP, 2018

Warning Time

Meteorologists can often predict the likelihood of a severe storm or nor'easter. This can give several days of warning time. The NOAA's NWS monitors potential events and provides extensive forecasts and information several days in advance of the storm to help the state to prepare for the incident. However, meteorologists cannot predict the exact time of onset or severity of the storm. Some storms may come on more quickly and have only a few hours of warning time.

Ice Storms

From 1998 to 2017, NCDC reported 28 ice storm events. All the storms within that period occurred between November and February, most frequently occurring in late December and early January. Ice storms of lesser magnitudes impact the Commonwealth on at least an annual basis.

Secondary Hazards

The phrase "severe winter storm" encapsulates several types of natural hazards, including snowfall, wind, ice, sleet, and freezing rain hazards. Additional natural hazards that can occur because of winter storms include sudden and severe drops in temperature. Winter storms can also result in flooding and the destabilization of hillsides as snow or ice melts and begins to run off. The storms can also result in significant structural damage from wind and snow load as well as human injuries and economic and infrastructure impacts (described later in this section).

The secondary hazards associated with nor'easters are like those associated with hurricanes and severe winter storms. Natural hazards that could occur because of a nor'easter include coastal erosion, flooding, levee or dam failure, increased risk of landslides or other land movement, the release of hazardous materials, and environmental damage. Secondary social hazards could include health issues such as the growth of mold or mildew, isolation due to impacts on transportation, power loss, and structural and property damage. Power outages may also result in inappropriate use of combustion heaters, cooking appliances, and generators in indoor or poorly ventilated areas, which can lead to increased risks of carbon monoxide poisoning. Loss of power and refrigeration can also cause food contamination.

Debris Management

Ice and winter storms cause damage to trees, utility lines/infrastructure, and wide span roofs. Coastal storms may flood developed areas and erode near shore areas. Debris consists of trees, utility lines, wires, poles/towers, and building debris from damaged roofs and structures. Disposal of possibly contaminated snow and ice from roadways is also a consideration. [77]

Sectors Assessed

Populations

Nor'easters share many characteristics with hurricane events. Both types of events can bring high winds and surge inundation that results in similar impacts on the population, structures, and the economy. According to the NOAA National Severe Storms Laboratory, every year, winter weather indirectly and deceptively kills hundreds of people in the US, primarily from automobile accidents, overexertion, and exposure. Winter storms are often accompanied by strong winds creating blizzard conditions with blinding wind-driven snow, drifting snow, and extreme cold temperatures with dangerous wind chill. They are considered deceptive killers because most deaths and other impacts or losses are indirectly related to the storm. Injuries and deaths may occur due to traffic accidents on icy roads, heart attacks while shoveling snow, or hypothermia from prolonged exposure to cold.

Heavy snow can immobilize a region and paralyze a city, shutting down air and rail transportation, stopping the flow of supplies, and disrupting medical and emergency services. Accumulations of snow can cause buildings to collapse and knock down trees and power lines.

In rural areas, homes and farms may be isolated for days, and unprotected livestock may be lost. In the mountains, heavy snow can lead to avalanches. Storms near the coast can cause coastal flooding and beach erosion as well as sink ships at sea.

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[77] Commonwealth of Massachusetts All Hazards Disaster Debris Management Plan, Rev. #6

The impact of a nor'easter on life, health, and safety is dependent upon several factors, including the severity of the event and whether adequate warning time was provided to residents. Residents may be displaced or require temporary to long-term sheltering. In addition, downed trees, damaged buildings, and debris carried by high winds can lead to injury or loss of life.

Vulnerable Populations

Vulnerable populations include the elderly living alone, who are susceptible to winter hazards due to their increased risk of injury and death from falls, overexertion, and/or hypothermia from attempts to clear snow and ice, or injury and death related to power failures. In addition, severe winter weather events can reduce the ability of these populations to access emergency services. People with low socioeconomic status are more vulnerable because they are likely to evaluate their risk and make decision to evacuate based on the net economic impact on their families. Residents with low incomes may not have access to housing or their housing may be less able to withstand cold temperatures (e.g., homes with poor insulation and heating supply). The population over the age of 65, individuals with disabilities, and people with mobility limitations or who lack transportation are also more vulnerable because they are more likely to seek or need medical attention, which may not be available due to isolation during a flood event. These individuals are also more vulnerable because they may have more difficulty if evacuation becomes necessary. People with limited mobility risk becoming isolated or "snowbound" if they are unable to remove snow from their homes. Rural populations may become isolated by downed trees, blocked roadways, and power outages.

Health Impacts

Health impacts from severe winter storms are like those described for other hazards, particularly the extreme temperatures. Cold weather, which is a component of a severe winter storm, increases the risk of hypothermia and frostbite. Exposure to cold conditions can also exacerbate pre-existing respiratory and cardiovascular conditions. In addition to temperature-related dangers, however, severe winter storms also present other potential health impacts. For example, individuals may use generators in their homes if the power goes out or may use the heat system in their cars if they become trapped by snow. Without proper ventilation, both activities can result in carbon monoxide buildup that can be fatal. Loss of power can also lead to hypothermia. After Hurricane Sandy, the number of cases of cold exposure in New York City was three times greater than the same period in previous years (Fink, 2012). Driving during severe snow and ice conditions can also be dangerous, as roads become slick and cars can lose control. During and after winter storms, roads may be littered with debris, presenting a danger to drivers. Health impacts on people include the inability to travel to receive needed medical services and isolation in their homes. Additionally, natural gas-fueled furnaces, water heaters, and clothes driers, and even automobile exhaust pipes, may become blocked by snow and ice, which can lead to carbon monoxide poisoning.

Government

Public safety buildings may experience direct loss (damage) from downed trees, heavy snowfall, and high winds. Full functionality of critical facilities, such as police, fire, and medical facilities, is essential for response during and after a winter storm event. Because power interruptions can occur, backup power is recommended for critical facilities and infrastructure. The ability of emergency responders to respond to calls may be impaired by heavy snowfall, icy roads, and downed trees.

The Built Environment

Other infrastructure elements at risk for this hazard include roadways, which can be obstructed by snow and ice accumulation or by windblown debris. Additionally, over time, roadways can be damaged from the application of salt and the thermal expansion and contraction from alternating freezing and warming conditions. Other types of infrastructure, including rail, aviation, port, and waterway infrastructure (if temperatures are cold enough to cause widespread freezing), can be impacted by winter storm conditions.

Water Infrastructure

Water infrastructure that is exposed to winter conditions may freeze or be damaged by ice.

Natural Resources and Environment

Although winter storms are a natural part of the Massachusetts climate, and native ecosystems and species are adapted to these events. However, changes in the frequency or severity of winter storms could increase their environmental impacts. Environmental impacts of severe winter storms can include direct mortality of individuals and felling of trees, which can damage the physical structure of the ecosystem. Similarly, if large numbers of plants or animals die as the result of a storm, their lack of availability can impact the food supply for animals in the same food web. If many trees fall within a small area, they can release large amounts of carbon as they decay. This unexpected release can cause further imbalance in the local ecosystem. The flooding that results when snow and ice melt can also cause extensive environmental impacts. Nor'easters can cause impacts that are like those of hurricanes and tropical storms, coastal flooding, and inland flooding. These impacts can include direct damage to species and ecosystems, habitat destruction, and the distribution of contaminants and hazardous materials throughout the environment.

Economy

The entire general building stock inventory in the Commonwealth is exposed to the severe winter weather hazard. In general, structural impacts include damage to roofs and building frames rather than building content. Heavy accumulations of ice can bring down trees, electrical wires, telephone poles, and lines, and communication towers. Communications and power can be disrupted for days while utility companies work to repair the extensive damage. Even small accumulations of ice may cause extreme hazards to motorists and pedestrians.

Bridges and overpasses are particularly dangerous because they freeze before other surfaces. A specific area that is vulnerable to the winter storm hazard is the floodplain. Snow and ice melt can cause both riverine and urban flooding. The cost of snow and ice removal and repair of roads from the freeze/thaw process can drain local financial resources. The potential secondary impacts from winter storms, including loss of utilities, interruption of transportation corridors, loss of business functions, and loss of income for many individuals during business closures, also impact the local economy.

Like hurricanes and tropical storms, nor'easter events can greatly impact the economy, with impacts that include the loss of business functions (e.g., tourism and recreation), damage to inventories or infrastructure (the supply of fuel), relocation costs, wage losses, and rental losses due to the repair or replacement of buildings.

Tornados

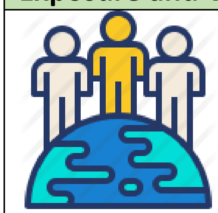
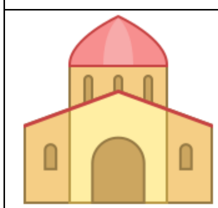
The location and extent of potential damaging impacts of a tornado are completely unpredictable. Most damage from tornadoes or microbursts comes from high winds that can fell trees and electrical wires, generate hurling debris and possibly, hail. According to the Institute for Business and Home Safety, the wind speeds in most tornados are at or below design speeds that are used in current building codes. In addition, current land development regulations can also help prevent wind damages.

A tornado is a violent windstorm characterized by a twisting, funnel-shaped cloud. These events are spawned by thunderstorms and occasionally by hurricanes and may occur singularly or in multiples. They develop when cool air overrides a layer of warm air, causing the warm air to rise rapidly. Most vortices remain suspended in the atmosphere. Should they touch down, they become a force of destruction.

Some ingredients for tornado formation include:

- Strong winds in the mid and upper levels of the atmosphere.
- Clockwise turning of the wind with height (from southeast at the surface to west aloft).

- Increasing wind speed with altitude in the lowest 10,000 feet of the atmosphere (i.e., 20 mph at the surface and 50 mph at 7,000 feet).
- Very warm, moist air near the ground with unusually cooler air aloft.
- A forcing mechanism such as a cold front or leftover weather boundary from previous shower or thunderstorm activity.

Tornadoes		
Hazard	**Significant**	**Justification**
	YES	Tornadoes require several elements to form strong atmospheric winds, clockwise turning of the winds with height, increasing wind speed in the low atmosphere, a gradient of cooler, direr air at elevation and a forcing mechanism. Massachusetts experiences an average of 1.7 tornadoes per year.
Exposure and Vulnerability by Key Sector		
	Populations	**General At-Risk Populations:** State-wide exposure; population in area having higher-than-average tornado frequency are at greater risk. **Vulnerable Populations:** Populations who may have difficulty evacuating, including car-free households, individuals over age 65, and households with young children; individuals with limited internet or phone access or low English language fluency may not be aware of impending warning; people who reside in older or less stable housing.
	Government	The entire town would be vulnerable to the destruction caused by microbursts or tornadoes. Most buildings in town have not been built to Zone 1, Design Wind Speed Codes. All municipal sites including the Police Station, Fire Station and the Highway Department, schools (Indian Head and Hanson Middle School), the Hanson Library and Town Hall.
	Built Environment	Tornadoes down power lines and damage transmission infrastructure. Shelters and other public safety facilities that provide services for people whose homes are damaged may be overburdened. Hail, wind, debris, and flash flooding associated with tornadoes can damage water infrastructure.
	Natural Resources and Environment	Direct impacts may occur to flora and fauna small enough to be transported by the tornado. Even if the winds are not sufficient to transport trees and other large plants, they may still uproot them. Material transported by tornadoes can also cause environmental havoc in surrounding areas, particularly if contaminating materials are introduced into the atmosphere or local water supplies.
	Economy	Tornado events are typically localized; however, in those areas, economic impacts can be significant. Types of impacts may include loss of business function, water supply system damage, damage to inventory, relocation costs, wage loss, and rental loss due to the repair/replacement of buildings. Recover and clean-up costs can also be costly.

Potential Effects of Climate Change – Tornado		
	Extreme weather – Increase in frequency and intensity of severe thunderstorms	Future environmental changes may result in an increase in the frequency and intensity of severe thunderstorms, which can include tornadoes. However, the resolution of current climate models is too coarse to accurately simulate tornado formation and the confidence on model details associated with the potential increase is low.

Tornado damage severity is measured by the Fujita Tornado Scale, is which wind speed is not measured directly but rather estimated from the amount of damage. As of February 1, 2007, the National Weather Service began rating tornados using the Enhanced Fujita-scale, which allows surveyors to create more precise assessment of tornado severity.

Microbursts often cause tornado-like damage and can be mistaken for tornadoes. In contrast to the upward rush of air in a tornado, air blasts rapidly downward from thunderstorms to create microbursts. Microbursts and tornadoes are expected to become more frequent and more violent as the earth's atmosphere warms, due to predictions of climate change from global warming.

Microbursts are typically less than three miles across. They can last anywhere from a few seconds to several minutes. Microbursts bring damaging winds up t o170 miles per hour in strength and can be accompanied by precipitation.

Table 79: Enhanced Fujita Scale

Scale	3 Second Wind Gust	Light damage
EFO	65-85 mph	Light Damage
EF 1	86-110 mph	Moderate damage
EF 2	111-135 mph	Considerable damage
EF 3	136-165 mph	Severe damage
EF 4	166-200 mph	Devastating damage
EF 5	>200 mph	Incredible damage

Table 80: Enhanced Fujita Tornado Damage Scale

Scale	Intensity Phrase	Wind Estimate (mph)	Typical Damage
F0	Gale	65-85	*Light damage: some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged*
F1	Moderate	86-110	*The lower limit is the beginning of hurricane wind speed. Moderate damage: peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos blown off roads*
F2	Significant	111-135	*Considerable damage: roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground*
F3	Severe	136-165	*Severe damage: roof and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown*
F4	Devastating	166-200	*Devastating damage: well-constructed houses level; structures with weak foundations moved; cars thrown; large missiles generated*
F5	Incredible	201-318	*Incredible damage: strong frame houses leveled off foundations and swept away; automobile-sized missiles fly more than 100-meters; trees debarked; incredible phenomena will occur*

Probability

Although tornadoes have not been recorded in Hanson since NOAA's records began in 1951, relatively small-scale tornadoes do occur throughout Massachusetts on a regular basis. As such, it is possible (between 1 and 10% probability in the next year) that a tornado will occur in Hanson.

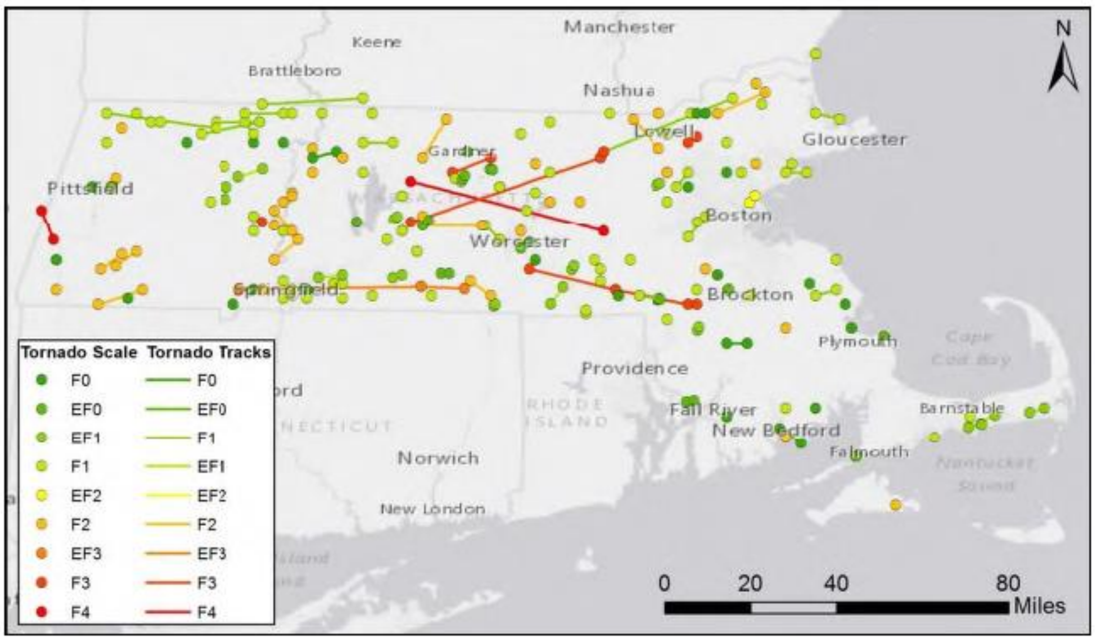
On average there are six tornados that touchdown somewhere in the Northeast region every year. On average, (between 1950 and 2008), more than two tornadoes per year strike the Commonwealth of Massachusetts alone, with New England as a whole recording more than 8. Most tornadoes reported in the region are "weak", rated EF0 or EF1 on the Enhanced Fujita Scale. Around 30 percent are "significant" tornadoes (rated EF2 or greater), and only one percent are violent (rated EF4 or EF5, the highest damage rating).

Hazard Location

As per the Massachusetts Hazard Mitigation Plan, the entire Town of Hanson is at risk of tornadoes and microbursts. However, the actual area that would be affected by these hazards is "medium", or between 10 and 50 percent of total land area.

NOAA's National Weather Service maintains a database of tornado information in the US. The data include information on date, start and end location, number of injuries and fatalities, and categories of property loss values from each storm. There have been 181 tornados documented in Massachusetts since 1950; of these, none have occurred in Hanson, and only ten have occurred within all of Plymouth County.

Figure 104: Massachusetts Tornadoes Between 1950 and 2019



Source: NOAA

Previous Occurrences

There have been ten tornados between September 7, 1958[78] with Fujita scales between 0 and 2. Only two tornadoes in Massachusetts have ever received FEMA disaster declarations. The most destructive tornado in New England history was the Worcester tornado of June 9, 1953. The F4 tornado hit at about 3:30 pm. The funnel quickly intensified, carving a 46-mile path of death and destruction as it moved through seven towns. It killed 90 people and left approximately 1,200 people injured. The National Storm Prediction Center has ranked this as one of the deadliest tornadoes in the nation's history. With winds speeds between 200 and 260 mph, the force of the tornado carried debris miles away and into the Atlantic Ocean.

From 1950 to 2019, the Commonwealth experienced 181 tornadoes, or an average annual occurrence of 2.6 tornado events per year. In the last 20 years, the average frequency of these events has been 1.7 events per year (NOAA, 2018). Massachusetts experienced an average of 1.4 tornadoes per 10,000

[78] https://www.ncdc.noaa.gov/data-access/severe-weather

square feet annually between 1991 and 2010, less than half of the national average of 3.5 tornadoes per 10,000 square feet per year (NOAA, n.d.). As highlighted in the National Climate Assessment, tornado activity in the U.S. has become more variable, and increasingly so in the last 2 decades. While the number of days per year that tornadoes occur has decreased, the number of tornadoes on these days has increased. Climate models show projections that the frequency and intensity of severe thunderstorms (which include tornadoes, hail, and winds) will increase (USGCRP, 2017).

Table 81: Tornadoes in Plymouth County, 1958 to 2012

Date	Affected Counties	Fujita	Fatalities	Injuries	Width	Length	Damage
09/07/1958	Plymouth	0	1	1	10	0.1	$500-$5000
07/04/1964	Plymouth	1	0	0	10	2.3	$50K - $500K
06/09/1965	Plymouth	0	0	0	10	0.1	<$50
11/18/1967	Plymouth	2	0	0	17	0.1	$50 - $500
08/09/1968	Bristol, Plymouth	1	0	0	100	1	$500 - $5000
09/16/1986	Plymouth	1	0	0	50	0.1	$50K - $500K
07/10/1989	Plymouth	1	0	1	23	0.1	$5K - $50K
07/10/1989	Plymouth	0	0	0	23	0.1	$5K - $50K
08/20/1997	Plymouth	0	0	0	10	0.1	-
07/24/2012	Plymouth	0	0	0	15	0.03	-

Source: NOAA

The following table outlines the Town's existing mitigation strategies that help prevent wind damages, whether from hurricanes, tornadoes, microbursts, or any other event.

Table 82: Existing Severe Wind Hazard Mitigation Measures (Including Hurricane, Tornado, Microburst Hazards)

Existing Strategy	Description	Effectiveness
Zoning Bylaws – Wireless Communications Structures and Facilities	Structures are required to be as minimally invasive as possible to the environment, have height restrictions, and must be setback 1.5 times the structures height.	Effective for preventing damage in the case of a severe storm.
Subdivision Regulations – Design Standards	Utilities must be placed underground	Effective for preventing power loss.
State Building Code	The Town has adopted the MA State Building Code	Effective
Tree Management	Tree Warden on staff	Effective preventative collaboration.

Debris Management

Damage from tornadoes is caused by high velocity rotating winds. Like hurricanes, tornadoes are rated on a numerical scale based on the severity and other characteristics. The amount of damage depends on the size, velocity of winds, and duration of funnel contact with the earth. Contact paths may range from a mile or less in width and from 100 yards to several miles in length. Tornadoes may skip across a wide area with several touchdowns. Damage consists of trees, structures, and personal property.

Sectors Assessed

Populations

The entire Commonwealth has the potential for tornado formation, although residents of areas described above as having higher-than-average tornado frequency face additional risk. Residents of impacted areas may be displaced or require temporary to long-term shelter due to severe weather events. In addition, downed trees, damaged buildings, and debris carried by high winds can lead to injury or loss of life.

Vulnerable Populations

In general, vulnerable populations include people over the age of 65, people with low socioeconomic status, people with low English language fluency, people with compromised immune systems, and residents living in areas that are isolated from major roads. Power outages can be life-threatening to those who are dependent on electricity for life support and can result in increased risk of carbon monoxide poisoning. Individuals with limited communication capacity, such as those with limited internet or phone access, may not be aware of impending tornado warnings. The isolation of these populations is also a significant concern, as is the potential insufficiency of older or less stable housing to offer adequate shelter from tornadoes.

Health Impacts

The primary health hazard associated with tornadoes is the threat of direct injury from flying debris or structural collapse as well as the potential for an individual to be lifted and dropped by the tornado's winds. After the storm has subsided, tornadoes can present unique challenges to search and rescue efforts because of the extensive and widespread distribution of debris. The distribution of hazardous materials, including asbestos-containing building materials, can present an acute health risk for personnel cleaning up after a tornado disaster and for residents in the area. The duration of exposure to contaminated material may be far longer if drinking water reservoir or groundwater aquifers are contaminated. According to the EPA, professionally designed storage facilities for hazardous materials can reduce the risk of those materials being spread during a tornado (EPA, n.d.). Many of the health impacts described for other types of storms, including lack of access to a hospital, carbon monoxide poisoning from generators, and mental health impacts from storm-related trauma, could also occur because of tornado activity.

Government

Public safety facilities and equipment may experience direct loss (damage) from tornadoes. Shelters and other critical facilities that provide services for people whose property is uninhabitable following a tornado may experience overcrowding and inadequate capacity to provide shelter space and services. Hazardous driving conditions could result from blocked roadways.

Built Environment

All critical facilities and infrastructure are exposed to tornado events. High winds could down power lines and poles adjacent to roads (ResilientMA, 2018). Damage to aboveground transmission infrastructure can result in extended power outages. Tornadoes can pass through highly developed areas can cause significant property damage, blowing off roofs, and in severe cases, leveling structures.

Transportation

Incapacity and loss of roads and bridges are the primary transportation failures resulting from tornadoes, and these failures are primarily associated with secondary hazards, such as landslide events. Tornadoes can cause significant damage to trees and power lines, blocking roads with debris, incapacitating transportation, isolating populations, and disrupting ingress and egress. Of concern are bridges and roads providing access to isolated areas and to the elderly.

Prolonged obstruction of major routes due to secondary hazards, such as landslides, debris, or floodwaters, can disrupt the shipment of goods and other commerce. If the tornado is strong enough to transport large debris or knock out infrastructure, it can create serious impacts on power and aboveground communication lines.

Water Infrastructure

The hail, wind, debris, and flash flooding associated with tornadoes can cause damage to infrastructure, such as storage tanks, hydrants, residential pumping fixtures, and distribution systems. This can result in loss of service or reduced pressure throughout the system (EPA, 2015). Water and wastewater utilities are also vulnerable to potential contamination due to chemical leaks from ruptured containers. Ruptured service lines in damaged buildings and broken hydrants can lead to loss of water and pressure (EPA, 2015).

Natural Resources and Environment

Downed trees and the transportation of small flora and fauna by high winds can cause damage to the natural environment.

Economy

To approximate the potential impact to property that could be affected by a tornado or microburst, the total value of all property in town, $1,296,121,110 is used. An estimated 100 percent of damage would occur to 1 percent of structures, resulting in a total of $12,961,211 worth of damage. The cost of repairing or replacing the roads, bridges, utilities, and contents of structures is not included in this estimate.

- Tornadoes/microburst hazard estimates 20 percent damage to 10 percent of structures in Town.
- Vulnerability assessment estimates in damages: $25,922,422.
- Estimates cost does not include building contents, land values or damages to utilities.

The most common problem associated with severe weather is loss of utilities. Downed trees from severe windstorms can create serious impacts on power and aboveground communication lines. Water and sewer systems may not function if power is lost. The vulnerabilities associated with flooding could be present if substantial rain accompanies severe thunderstorms. Additionally, severe wind may damage older buildings.

Non-Climate-Influenced Hazards

Earthquake

An earthquake is a sudden, rapid shaking of the ground that is caused by the breaking and shifting of rock beneath the Earth's surface. Ground shaking from earthquakes can rupture gas mains and disrupt other utility service, damage buildings, bridges, and roads, and trigger other hazardous events such as avalanches, flash floods (dam failure) and fire. Un-reinforced masonry buildings, buildings with foundations that rest on filled land or unconsolidated, unstable soil, and mobile homes not tied to their foundations are at risk during an earthquake. Earthquakes can occur suddenly, without warning, at any time of the year. New England experiences an average of 30 to 40 earthquakes each year although most are not noticed by people. [79]

Although there are five mapped seismological faults in Massachusetts, there is no discernable pattern of previous earthquakes along these faults nor is there a reliable way to predict future earthquakes along

[79] **Northeast States Emergency Consortium http://nesec.org/earthquakes-hazards/.**

these faults or in any other areas of the state. Consequently, earthquakes are arguably the most difficult natural hazard to plan for.

Earthquakes		
Hazard	**Significant**	**Justification**
	YES	Earthquakes can occur throughout Massachusetts. Large earthquakes in Canada, which is more seismically active than New England, can affect tall buildings in Boston and elsewhere in eastern Massachusetts. Earthquakes cannot be predicted and may occur at any time. Research has found that the probability of a magnitude 5.0 or greater earthquake centered somewhere in New England in a 10-year period is about 10% to 15%.
Exposure and Vulnerability by Key Sector		
	Populations	**General At-Risk Populations:** State-wide exposure. **Vulnerable Populations:** Socially vulnerable populations due to factors including their physical and financial ability to react or respond during a hazard event; the location and construction quality of housing; and the ability to be self-sustainable after an event due to limited ability to stockpile supplies.
	Government	The entire town would be vulnerable to the destruction caused by an earthquake. Generally, there is no way to determine which Town owned facilities will be impacted. All municipal sites including the Police Station, Fire Station and the Highway Department, schools (Indian Head and Hanson Middle School), the Hanson Library and Town Hall.
	Built Environment	In addition to direct impacts to roads, bridges, agriculture, infrastructure, public health and safety facilities, and water infrastructure networks, earthquakes also present a risk associated with hazardous materials releases, which have the potential to be released at a production or storage facility or because of pipeline damage. These events could cause widespread interruption of services as well as air and water contamination.
	Natural Resources and Environment	If strong shaking occurs in a forest, trees may fall – resulting not only in environmental impacts but also potential economic impacts to any industries relying on that forest. Disrupting the physical foundation of the ecosystem can modify the species balance in that ecosystem and leave the area more vulnerable to the spread of invasive species.
	Economy	Earthquakes losses can include structural and non-structural damage to buildings (which could include damage to architectural components like ceilings and lights, or power systems0, loss of business function, damage to inventory, relocation costs, wage loss, and rental loss due to the repair/replacement of buildings.

Most buildings and structures in the Commonwealth were constructed without specific earthquake resistant design features. In addition, earthquakes precipitate several potential devastating secondary effects such as building collapse, utility pipeline rupture, water contamination, and extended power outages. Therefore, many of the mitigation efforts for other natural hazards identified in this plan may be applicable during the Town's recovery from an earthquake.

Location

In the event of an earthquake, all of Hanson would be affected with some portions more impacted than others, depending on the magnitude of the earthquake, population density, predominant building type, and underlying soil types. Although the zone of greatest seismic activity in the US is along the Pacific Coast in Alaska and California, several damaging earthquakes have occurred in New England. In fact, New Englanders feel an average of six earthquakes each year. Due to differing geology, earthquakes in New England have different characteristics than those on the West Coast.

New England is situated in the middle of the North American Plate and earthquakes in the region are the result of the compression of this plate as it is slowly squeezed by its neighboring plates. One edge of the North American Plate is along the West Coast where the plate is pushing against the Pacific Ocean Plate. The eastern edge of the North American Plate is located at the middle of the Atlantic Ocean, where the plate is spreading away from the European and African Plates. New England's earthquakes appear to be the result of the cracking of the crustal rocks due to compression as the North American Plate is being very slowly squeezed by the global plate movements. As a result, New England epicenters do not follow the major mapped faults of the region, nor are they confined to geologic structures or terrains. Because earthquakes have been detected all over New England, seismologists suspect that a strong earthquake could be centered anywhere in the region. Furthermore, the mapped geologic faults of New England currently do not provide any indications detailing specific locations where strong earthquakes are most likely to be centered. Because of this, earthquakes can occur throughout New England independent of fault lines and geology. Additionally, due to geological differences, earthquakes in New England tend to have a significantly wider impact area then those on the West Coast.

Extent

The magnitude of an earthquake is measured using the Richter Scale, which measures the energy of an earthquake by determining the size of the greatest vibrations recorded on the seismogram. On this scale, one step up in magnitude (from 5.0 to 6.0, for example) increases the energy more than 30 times.

Table 83: Richter Scale Magnitudes and Effects

Richter Scale Magnitudes and Effects	
Magnitude	**Effects**
<3.5	Generally, not felt, but recorded.
3.5 – 5.4	Often felt, but rarely causes damage.
5.4 – 6.0	At most slight damage to well-designed buildings. Can cause major damage to poorly constructed buildings over small regions.
6.1 – 6.9	Can be destructive in areas up to about 100 kilometers across where people live.
7.0 – 7.9	Major earthquake. Can cause serious damage over larger areas.
8 or >	Great earthquake. Can cause serious damage in areas several hundred kilometers across.

The intensity of an earthquake is measured using the Modified Mercalli Scale. This scale quantifies the effects of an earthquake on the Earth's surface, humans, objects of nature, and man-made structures on a scale of I through XII, with 1 depicting a weak earthquake and XII denoting an earthquake that causes almost complete destruction.

Table 84: Modified Mercalli Intensity Scale for and Effects

Modified Mercalli Intensity Scale for and Effects			
Scale	**Intensity**	**Description of Effects**	**Corresponding Richter Scale Magnitude**
I	Instrumental	Detected only on seismographs	
II	Feeble	Some people feel it	< 4.2
III	Slight	Felt by people resting; like a truck rumbling by	
IV	Moderate	Felt by people walking	
V	Slightly Strong	Sleepers awake, church bells ring	< 4.8
VI	Strong	Trees sway: suspended objects swing, objects fall off shelves	< 5.4
VII	Very Strong	Mild alarm; walls crack, plaster falls	< 6.1
VIII	Destructive	Moving cars uncontrollable; masonry fractures, poorly constructed buildings damaged	
IX	Ruinous	Some houses collapse: ground cracks, pipes break open	< 6.9
X	Disastrous	Ground cracks profusely, many buildings destroyed, liquefaction and landslides widespread	< 7.3
XI	Very Disastrous	Most buildings and bridges collapse, roads, railways, pipes, and cables destroyed, general triggering of other hazards.	< 8.1
XII	Catastrophic	Complete destruction: trees fall; ground rises and falls in waves	>8.1

Warning Time

There is currently no reliable way to predict the day or month that an earthquake will occur at any given location. Research is being done with early-warning systems that use the low-energy waves preceding major earthquakes to issue an alert of the impending event. This applies to the West Coast and to other countries. It is not currently relevant in Massachusetts and this should be clearly stated. These potential early-warning systems can give up to approximately 40 to 60 seconds notice that earthquake shaking is about to occur, with shorter warning times for places closer to the earthquake epicenter. Although the warning time is short, it could allow immediate safety measures to be taken, such as getting under a desk, stepping away from a hazardous material, or shutting down a computer system to prevent damage. [80]

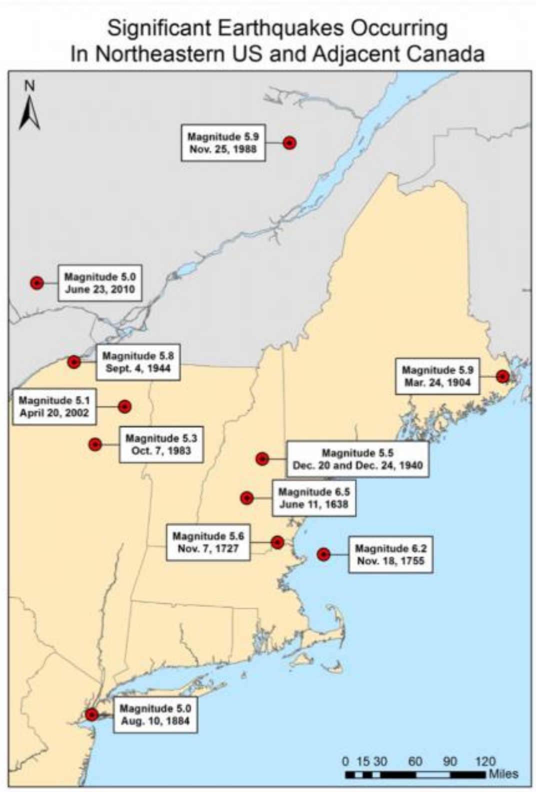
Secondary Hazards

Secondary hazards can occur to all forms of critical infrastructure and key resources because of an earthquake. They can also impact structures not typically identified as critical, such as fires in residential buildings that can cause injury, loss of life, and significant damage. Earthquakes can also cause large and sometimes disastrous landslides as well as tsunamis and wildfires.

Soil liquefaction is a secondary hazard unique to earthquakes that occurs when water-saturated sands, silts, or gravelly soils are shaken so violently that the individual grains lose contact with one another and float freely in the water, turning the ground into a pudding-like liquid. Building and road foundations lose load- bearing strength and may sink into what was previously solid ground. Unless properly secured, hazardous materials can be released, causing significant damage to the environment and people. Liquefaction may occur along the shorelines of the ocean, rivers, and lakes, and can also happen in low-lying areas away from water bodies but where the underlying groundwater is near the Earth's surface. Earthen dams and levees are highly susceptible to seismic events, and the impacts of their eventual failures can be considered secondary risks for earthquakes.

[80] **SHMCAP, 2018**

Figure 105: Significant Earthquakes Occurring in Northeastern US and Canada



Source: http://nesec.org/earthquakes-hazards/

Previous Occurrences

Nineteen earthquakes, intensity V (Modified Mercalli scale) or greater, have centered in Massachusetts since it was colonized by Europeans. A shock in 1755 reached intensity VIII at Boston and was felt across the State. In addition, Massachusetts was affected by some of the more severe Canadian shocks plus the earthquake of 1929 that centered on Grand Banks of Newfoundland.

In addition to the earthquakes from within the region, Massachusetts also has been strongly affected by several earthquakes that were centered outside of New England. Most recently, the magnitude 5.8 earthquake on August 23, 2011 centered at Mineral, VA was felt throughout Massachusetts, but no damage was reported.

Between 1954 and 2019, Hampshire County was not included in any FEMA earthquake -related disasters (DR) or emergencies (EM). No known seismic events have impacted Worthington between 1950 and 2019. Please note that not all events that have occurred in the town are included due to the extent of documentation and the fact that not all sources may have been identified or researched.

According to the Northeast States Emergency Consortium, only one magnitude 4 or higher earthquake has occurred in New England since 2010. This was a 4.6 magnitude earthquake centered at Hollis Center

Maine, on October 16, 2012. This earthquake was not noted to cause any damage in Worthington or the surrounding area.

Figure 106: Historic Wood Cut Print of 1744 Newburyport, MA 5.6 Earthquake

Colonial New England experienced some earthquakes that were strong enough to cause damage. On October 29, 1727, an earthquake rattled the east coast from Maine to Pennsylvania. This was about a magnitude 5.6 shock that was centered in Newburyport, MA. In northeastern Massachusetts and coastal New Hampshire, many chimneys were damaged, some cellar walls caved in, and stone fences in the fields were thrown down by the earthquake shaking.

The following Tables list the number of felt earthquakes in the Northeast States and the years in which damaging earthquakes have taken place in Massachusetts.

Table 85: Massachusetts Earthquakes

Location	Date	Magnitude
MA – Cape Ann	11/10/1727	5
MA – Cape Ann	12/29/1727	
MA – Cape Ann	02/10/1728	
MA – Cape Ann	03/30/1729	
MA – Cape Ann	12/09/1729	
MA – Cape Ann	2/20/1730	
MA – Cape Ann	03/09/1730	
MA - Boston	06/24/1741	
MA – Cape Ann	06/14/1744	4.7
MA – Salem	07/01/1744	
MA – Off Cape Ann	11/18/1755	6
MA – Off Cape Cod	11/23/1755	
MA – Boston	03/12/1761	4.6
MA – Off Cape Cod	02/02/1766	

MA – Offshore	01/02/1785	5.4
MA – Wareham Taunton	12/25/1800	
MA – Woburn	10/05/1817	4.3
MA – Marblehead	08/25/1846	4.3
MA – Brewster	08/08/1847	4.2
MA – Boxford	05/12/1880	
MA – Newbury	11/07/1907	
MA – Wareham	04/25/1924	
MA Cape Ann	01/07/1925	4
MA – Nantucket	10/25/1965	
MA – Boston	12/27/1974	2.3
MA – Nantucket	04/12/2012	4.5
MA – Hollis	10/17/2012	4.0

Source: Boston HIRA

Table 86: Number of Felt Earthquakes in the Northeast States

Number of Felt Earthquakes in the Northeast States

State	Years of Earthquake Record	Number of Felt Earthquakes	Years with Damaging Earthquakes
Connecticut	1678-2016	115	1791
Maine	1766-2016	454	1973, 1904
Massachusetts	1668-2016	408	1727, 1755
New Hampshire	1638-2016	320	1638, 1940
New Jersey	1738-2016	98	1884
New York	1737-2016	551	1737, 1929, 1944, 1983, 2002
Rhode Island	1766-2016	34	
Vermont	1843-2016	50	
Total Number of Felt Earthquakes		2030	

Note: Earthquakes from other proximate U.S. states and Canadian provinces are not included in this table. All data are from Weston Observatory of Boston College.

Source: Northeast States Emergency Consortium

Debris Management

Earthquakes cause damage by shock waves and earth movement along fault lines and over some distance from the center of the quake. Secondary damage from fires can be substantial. Debris consists of building materials, personal property, and a host of utility and transportation infrastructures.

Sectors Assessed

Populations

The entire population of Massachusetts is potentially exposed to direct and indirect impacts from earthquakes. The degree of exposure depends on many factors, including the age and construction type of the structures where people live, work, and go to school. The soil types these buildings are constructed on, and the proximity of these buildings to the fault location. In addition, the time of day also exposes different sectors of the community to the hazard. There are many ways in which earthquakes could impact the lives of individuals across the Commonwealth. Business interruptions could keep people from working, road closures could isolate populations, and loss of utilities could impact populations that suffered no direct damage from an event itself.

Vulnerable Populations

Socially vulnerable populations are at the highest risk from earthquakes. These populations may lack the means physically or financially to respond to an earthquake. They may not be able to prepare and live self-sufficiently in the aftermath of an earthquake. Low-income populations are more likely to live in structurally compromised buildings. Residents may be displaced or require temporary to long-term sheltering due to the event. The number of people requiring shelter is generally less than the number displaced, as some who are displaced use hotels or stay with family or friends following a disaster event.

Health Impacts

The most immediate health risk presented by the earthquake hazard is trauma-related injuries and fatalities, either from structural collapse, impacts from nonstructural items such as furniture, or the secondary effects of earthquakes, such as tsunamis, landslides, and fires. Following a severe earthquake, health impacts related to transportation impediments and lack of access to hospitals may occur, as described for other hazards.

Government

There are many ways in which Hanson's structures, infrastructure, and individuals would be vulnerable to earthquakes. Road closures could isolate populations and keep people from getting to work, and loss of utilities could impact populations that suffered no direct damage from the earthquake itself.

Police stations, fire stations, and other public safety infrastructure can experience direct losses (damage) from earthquakes. The capability of the public safety sector is also vulnerable to damage caused by earthquakes to roads and the transportation sector. Following a severe earthquake, damage to roadways, bridges or underpasses that serve as evacuation routes would limit access to emergency services and medical facilities.

Built Environment

All elements of the built environment in the Town of Hanson are exposed to the earthquake hazard. Older buildings are particularly vulnerable to earthquakes because their construction pre-dates building codes that included strong seismic consideration. The town has several historical buildings that could be damaged or destroyed if a large enough earthquake were to happen. A loss of these historic buildings could represent a loss of Hanson's history and culture. In addition to these direct impacts, there is increased risk associated with hazardous materials releases, which have the potential to occur during an earthquake from fixed facilities, transportation- related incidents (vehicle transportation), and pipeline distribution. These failures can lead to the release of materials to the surrounding environment, including potentially catastrophic discharges into the atmosphere or nearby waterways, and can disrupt services well beyond the primary area of impact.

Agriculture

Earthquakes can result in loss of crop yields, loss of livestock, and damage to barns, processing facilities, greenhouses, equipment, and other agricultural infrastructure. Earthquakes can be damaging to farms and forestry if they trigger a landslide.

Energy

Earthquakes can damage power plants, gas lines, liquid fuel storage infrastructure, transmission lines, utilities poles, solar and wind infrastructure, and other elements of the energy sector. Damage to any components of the grid can result in power outages.

Transportation

Earthquakes can impact many aspects of the transportation sector, including causing damage to roads, bridges, airports, vehicles, and storage facilities and sheds. Damage to road networks and bridges can cause widespread disruption of services and impede disaster recovery and response.

Water Infrastructure

Due to their extensive networks of aboveground and belowground infrastructure—including pipelines, pump stations, tanks, administrative and laboratory buildings, reservoirs, chemical storage facilities, and treatment facilities—water and wastewater utilities are vulnerable to earthquakes (EPA, 2018). Additionally, sewer and water treatment facilities are often built on ground that is subject to liquefaction, increasing their vulnerability. Earthquakes can cause ruptures in storage and process tanks, breaks in pipelines, and building collapse, resulting in loss of water and loss of pressure, and contamination and disruption of drinking water services. Damage to wastewater infrastructure can lead to sewage backups and releases of untreated sewage into the environment (EPA, 2018).

Natural Resources and Environment

A strong earthquake can cause trees to fall and cliffs to collapse. Such environmental damage can impact the balance within a habitat or ecosystem leading to increased vulnerability to invasive species.

Economy

To approximate the potential impact to property and people that could be affected by this hazard, the total value of all property in town, $1,296,121,110 is used. An estimated 25 percent of damage would occur to 25 percent of structures, resulting in a total of $181,007,569 worth of damage. The cost of repairing or replacing the roads, bridges, utilities, and contents of structures is not included in this estimate.

- Moderate potential for serious damage in downtown Hanson.
- Structures are mostly wood frame construction, so loss estimates predict 25 percent damage to 25 percent of town assessed value, not including costs of repairing or replacing roads, bridges, power lines, telephone lines, or the contents of the structures.

Table 87: Existing Earthquake Hazard Mitigation Measures

Existing Earthquake Hazard Mitigation Measures		
Existing Strategy	Description	Effectiveness
Zoning By-law Wireless Communications Structures and Facilities	Structures are required to be as minimally invasive as possible to the environment, have height restrictions and must have a setback of 1.5 times the structures height	Highly effective for preventing damage in the case of an earthquake.
State Building Code	The Town of Hanson has adopted the state building Code	Effective for new buildings.

Future Mitigation Measures

None proposed but the Town is committed to keeping their local policies up to date of state and federal policies and practices.

Technological and Human-Caused Hazards

Technological hazards include hazardous materials incidents and nuclear power plant failures. Usually, little or no warning precedes incidents involving technological hazards. In many cases, victims may not know they have been affected until many years later. For example, health problems caused by hidden toxic waste sites—like that at Love Canal, near Niagara Falls, New York—surfaced years after initial exposure.

The number of technological incidents is escalating, mainly because of the increased number of new substances and the opportunities for human error inherent in the use of these materials.

Chemicals are found everywhere. They purify drinking water, increase crop production, and simplify household chores. But chemicals also can be hazardous to humans or the environment if used or released improperly. Hazards can occur during production, storage, transportation, use, or disposal. You and your community are at risk if a chemical is used unsafely or released in harmful amounts into the environment where you live, work, or play.

Chemical manufacturers are one source of hazardous materials, but there are many others, including service stations, hospitals, and hazardous materials waste sites.

As discussed in the *Introduction to Risk Assessment* section*,* the Hazard Identification and Risk Assessment (HIRA) portion of the Town of Hanson Hazard Mitigation and Climate Adaptation Plan meets the requirements of the Federal Emergency Management Agency (FEMA) State Mitigation Plan requirements for the natural hazards that were assessed.

Man-Made Hazardous Materials

A hazardous material may cause damage to people, property, or the environment when released to soil, water, or air. Hazardous materials are substances or materials that pose and unreasonable risk to health, safety, and property, and include hazardous substances, hazardous wastes, marine pollutants, elevated temperature materials, and others. Hazardous materials are used and stored in homes and businesses. Pro-ducts are shipped daily on highways, railroads, waterways, and pipelines.

Damage from HAZMAT can occur from the material's flammability, toxicity, corrosiveness, chemical instability, and/or combustibility. Material releases seep through the soil and eventually into the groundwater, making water supplies unsafe to drink. Vapors from spilled materials can collect in houses and businesses, sometimes in low-lying areas, creating fire, explosion, and toxic inhalation hazards. Public health impacts of a release can vary from temporary skin irritation to death. Exposure can pose short- and long-term toxicological threats to humans, terrestrial and aquatic plants, and to land and marine wildlife.

Hazardous materials are chemical substances, which if released or misused can pose a threat to the environment or health. These chemicals come in the form of explosives, flammable and combustible substances, poisons, and radioactive materials. Hazardous materials in various forms can cause death, serious injury, long-lasting health effects, and damage to buildings, homes, and other property. Many products containing hazardous chemicals are used and stored in homes and businesses routinely. Hazardous materials are in existence throughout Town and are constantly being moved on Hanson's roads. However, there is no way to anticipate where and when a hazards materials spill or explosion could take place. Therefore, it is somewhat difficult to determine mitigation strategies, but Hanson has some regulations in place to mitigate the impacts of a hazardous materials disaster.

Location

The following locations in Town are identified as storage facilities for hazards materials (fuel storage).

Table 88: Hazardous Materials Site Locations

ID	Facility	Name	Addre	FEMA	Locally	100 Year	Wildfire	Landslide
Fuel	Cumberland	2 Main St.	N/A	No	120	36"-48"	Low	Zone 4
Fuel	Hess	318 Main St.	N/A	No	120	36"-48"	Low	Zone 4
Fuel	Main Street Auto	1158 Main St.	N/A	No	120	36"-48"	Low	Zone 4
Fuel	Sunoco	527 Liberty St.	N/A	No	120	36"-48"	Low	Zone 4
Fuel	Super Petroleum	507 Monponsett St.	N/A	No	120	36"-48"	Low	Zone 4
Fuel	Hanson Fuel	1158 Main St.	N/A	No	120	36"-48"	Low	Zone 4
Public	Highway	797 Indian Head	N/A	No	120	36"-48"	Low	Zone 4
Fire	Fire Station	505 Liberty St	N/A	No	120	36" –	Low	Zone 4
Transfer	Transfer Station	201 Franklin	N/A	No	120	36"-48"	Low	Zone 4
Airport	Cranland Airport	777 Monponsett	N/A	No	120	36"-48"	Low	Zone 4

Table 89: Existing Hazardous Materials Hazard Mitigation Measures

Existing Hazardous Materials Hazard Mitigation Measures		
Existing Strategy	Description	Effectiveness
Zoning By-law Water Supply Protection District	No hazardous materials permitted within areas delineated as recharge areas.	Highly effective for preventing groundwater contamination.
	All hazardous materials usage or storage must be registered with the Fire Chief.	Effective

Extent

The extent of hazardous chemical release is not predictable as it is dependent on the location including whether it is from a stationary or moving source, amount and type of chemical released, and weather conditions at the time of the release, but given the relative lack of chemicals present in Hanson the extent is likely to be limited.

Previous Occurrences

Available data from the National Response Center shows zero releases of hazardous materials in the Town of Hanson. There is no history of any major accidents involving some sort of oil or chemical spill, but transportation of chemicals and bio-hazardous materials storage increase the potential for future incidents.

Possibility of Future Events

Based on the past events, it is reasonable to say that there is a low likelihood of hazardous chemical releases in Hanson.

Warning Time

HAZMAT incidents usually offer little to no warning time before the incident occurs. People in the immediate vicinity have the least amount of warning and response time. Surrounding community members will usually have more time to shelter-in-place or evacuate the area. The initial identification of specific HAZMAT types can increase response capabilities and timeliness.

During a Hazardous Materials Incident: Listen to local radio or television stations for detailed information and instructions. Follow the instructions carefully. You should stay away from the area to minimize the risk of contamination. Remember some toxic chemicals are odorless.

Secondary Hazards

HAZMAT incidents can result in the contamination of air, water, including reservoirs and groundwater aquifers, and soils, leaving lasting long-term exposure and negative impacts on plants, animals, and even humans. Large-scale incidents can require long-term health and environmental monitoring costs to monitor impacts on humans and the environment. With certain materials, there is a chance for fire, which can result in an urban fire or wildfire. Long-term environmental impacts can in turn cause negative economic impacts to tourism, through activities such as camping, hiking, hunting, and fishing. Because water, soil, and vegetation can be affected by HAZMAT incidents, toxins may be carried out of the area by wildlife and fish that meet the contaminated water, soil, and/or vegetation.

Climate Change Impacts

Non-natural incidents such as hazardous substance incidents are not typically considered to be vulnerable to climate change. Climate change and its impacts on HAZMAT sites, particularly waste sites, is a growing concern. Hazardous waste sites near rivers and other waters are tentatively at highest risk because extreme storms and higher water levels could release pollution into the environment. Many of these sites were built in locations believed to be removed from potential contamination or exposure to increasing factors. However, development, floodplain boundary change, and an increase in extreme events from climate change are increasing the possibility that water may reach hazardous material and waste sites. Increased severe weather events can increase the chances of a hazardous materials incident as a secondary hazard.

Sectors Assessed

Populations

The entire population of Hanson is exposed and vulnerable to a HAZMAT incident due to widespread use and storage throughout communities. Although the vulnerability is low, populations are more at risk because of higher utilization and transportation of HAZMAT. Communities along major transportation highway and rail transportation routes are at a higher risk for an incident. The general population may be exposed to a hazardous material release through inhalation, ingestion, or dermal exposure.

Vulnerable Populations

Vulnerable populations are all populations that may be exposed to an incident and are incapable of escaping the area within the allowable timeframe. This population includes those who may not have adequate warning, such as linguistically isolated people. Vulnerable populations would include low-income residents who are more likely to live in proximity to industrial and potentially hazardous sites.

Government

Multiple critical facilities in Hanson are vulnerable to a HAZMAT incident. It is difficult to quantify losses of critical facilities due to an incident. Potential losses may include inaccessibility, loss of service, contamination, and/or potential structural and content loss if an explosion occurs. Cost of clean-up and potential future monitoring can put extra strain on the facility and may contribute to bankruptcy.

Most critical facilities store HAZMAT, increasing vulnerability and likelihood of an incident. Transportation infrastructure are used to transport HAZMAT and thus are vulnerable to potential disruption in the event of a materials release.

The Built Environment

Some HAZMAT poses a reactivity, fire, or explosion risk. Materials improperly stored in buildings have the potential to mix with incompatible substances which can result in polymerization, the production of heat, combustion, or fire, and even an explosion.

It is difficult to determine potential losses and vulnerabilities to properties due to the variable nature and amount of hazmat being stored. HAZMAT incidents can pose a serious long-term threat to property.

Transportation

The Fire Department are the second line of defense in HAZMAT response situations. Data relating to the number of vehicles transporting hazardous materials or the types of materials that they transport is limited.

Natural Resources and Environment

Environmental damage resulting from a HAZMAT incident can be on a scale from limited to disastrous. Released materials can end up in the air, soil, and water. Some materials contribute to the destruction of the ozone. As materials soak into the soil, they can kill microorganisms and nutrients that contribute to the livelihood of plants and animals. HAZMAT can eventually reach the groundwater, potentially toxifying community drinking water systems. Materials that end up in bodies of water can kill off aquatic plants and animals and strain an ecosystem.

Economy

Impacts to the built environment would likely be limited due to the limited impact area of such an event. Such an incident could lead to closure along transportation lines or in hazardous material facilities. Such closures could have a limited impact on the Town’s economy.

Future Trends in Development

The number and types of hazardous chemicals stored in and transported through the county will likely continue to increase. As population grows, the number of people vulnerable to the impacts of hazardous materials incidents will increase. Population and business growth along major transportation corridors increases the vulnerability to transportation HAZMAT spills.

Epidemic – Pandemic

The epidemic/pandemic hazard was not ranked for the update process. Due to the emerging pandemic of Coronavirus Disease 2019 (COVID-19), the OCPC determined later in the planning process that epidemic/pandemic should be addressed as a hazard in this plan update.

Epidemics of infectious diseases are occurring more often, spreading faster and further all over the world. Diseases that are occurring are both newly discovered and re-emerging (WHO 2018). For example, Severe Acute Respiratory Syndrome (SARS) was unheard of before 2003, and on outbreak of the plague occurred in Madagascar in 2017 (WHO 2018). Diseases very rarely disappear, and new ones are constantly being discovered (WHO 2018). Magnifying vulnerability to both newly discovered and re-emerging diseases are new strains of pathogens and anti-vaccination movements.

Outbreaks may occur on a periodic basis (e.g., influenza), may be rare but result in a severe disease (e.g., meningococcal meningitis), occur after a disaster (e.g., cholera), or occur due to an intentional release of an agent (e.g., bioterrorism). Agents causing outbreaks can be viruses, bacteria, parasites, fungi, or toxins, and can be spread by people, contaminated food or water, healthcare procedures, animals, insects, and other arthropods, or directly from the environment. An individual may be exposed by breathing, eating, drinking, or having direct contact. Some agents have multiple means of spreading, while others are only spread person-to-person.

Epidemics can spread more quickly and widely than before, potentially affecting ever-greater numbers of people, having a significant impact of the economy of the affected community, and spilling over into the global economy, disrupting travel, trade, and livelihoods (WHO 2018). Local outbreaks can overwhelm medical facilities, and a pandemic could jeopardize essential community services by causing critical positions to go unfilled.

Basic public services such as health care, law enforcement, fire and emergency response, communications, transportation, and utilities could be disrupted or severely reduced. The length of the epidemic or pandemic would stress societal systems and local and outside resources.

Location

All the Town of Hanson and the Commonwealth is susceptible to human health hazards and epidemics. Communicable disease can cause exposure to the county from outside the local region. Residents who travel or commute can become exposed and bring diseases back into the community. It is difficult to map the extent of an outbreak or epidemic.

Frequency

Due to an increased air travel, commuters and population growth, the probability of an epidemic or outbreak occurring is growing. The frequency of epidemics is difficult to establish, depending largely on unique circumstances surrounding the outbreak and expansion into epidemics and eventually pandemics.

Warning Time

Warning time for public health risks varies from a few hours or days to a few months, depending on the illness and outbreak.

Disaster Financial Management

Effective disaster financial management is critical for successful response and recovery. It helps jurisdictions obtain the resources needed to support their communities, increases the efficiency of recovery efforts, and reduces the likelihood of audits and financial penalties for the jurisdiction. Fiscal and grant regulations are strict and apply to all jurisdictions, regardless of size, so it is imperative that all jurisdictions have robust, scalable, flexible, and adaptable disaster financial management plans and processes in place pre-disaster for all types of incidents.

Although many government and private sector/nonprofit resources and programs are available to help jurisdictions respond and recover, navigating the various eligibility requirements and application processes – many of which change frequently – poses administrative challenges. Disaster funding or cost reimbursements are often delayed or not approved because of incomplete paperwork, missed steps in the process or a lack of understanding of the eligibility criteria. Furthermore, audits are routinely performed by authorizing agencies to identify any problems with recipient financial management and program operations, and such audits become costly if a jurisdiction has not properly followed all program requirements. These issues have the potential to upend key priorities during a jurisdiction's cost reimbursement and long-term recovery and may result in a re-prioritization of the jurisdiction's budget for several years to pay back ineligible expenses. One misstep has the potential to impact the entire recovery process.

Communities that develop and coordinate disaster financial management practices pre-disaster can better manage a disaster, expedite response cost, and prepare for long-term recovery actions. These practices include knowing where and how to access financial resources and technical support, as well as having mechanisms in place to meet the varying requirements. Emergency and recovery managers who effectively identify and manage multiple streams of disaster funding provide the most resilient financial support to their communities.

Funding a Recovery Manager

Local governments are expected to manage their own recover after a disaster even if they do not have the expertise, staff, or resources to do so. The newness and volume of paperwork and decisions can overwhelm senior or elected officials, particularly those serving in a part-time or volunteer capacity. A recovery manager can help the Town handle the diversity and volume.

The Town of Hanson can take multiple approaches to fill recovery manager positions [81] for example:
Pre-Disaster

- **Look for Employees** who do work like a recovery manager, such as in public works, and reallocate those employees to new recovery manager duties.
- **Combine Administrative Line Items** of several grants and hire a single recovery manager to manage all the grants as well as other recovery manager duties.
- **Leverage Emergency Preparedness Grant Funding** to fund a recovery manager to accomplish recovery planning and resilience building tasks.
- **Solicit Volunteers** from the community (such as a retire Town Administrator, community planner, or county executive) to perform recovery manager duties and functions in a nonpaid status based on the jurisdiction's law.

Post-Disaster

- **Use State Funding** to hire a recover manager.
- **Use Economic Development Administration (EDA) Funding** to fund some recovery manager duties. Historically, EDA grants can fund disaster economic recovery duties, to include specific cross-cutting support areas such as natural resources, infrastructure, and housing.

Debris Management

Infectious diseases may be either animal diseases or human pandemic diseases, each of which results in different infectious and/or medical wastes that require specific management approaches.

Infectious animal diseases pose unique debris management challenges, with the key issue being the need to reduce the potential for disease transmission while safely managing diseased carcasses and associated materials. Disposal of animal carcasses may also be an issue in other disasters, especially floods. [82]

A human pandemic disease also would create challenging debris management problems, particularly in terms of managing medical waste and other infectious debris. In such an event, it would be critical to manage infectious wastes separately from regular trash to limit the amount of material that needs to be managed as infectious waste.

[81] The examples shown are situationally dependent and may require waivers, supplemental or reallocation of non-expended Federal funds.

[82] Commonwealth of Massachusetts All Hazards Disaster Debris Management Plan, Rev. #6

Figure 107: Disaster Management Planning

Source: FEMA Disaster Financial Management

Coronavirus COVID-19 Federal Disaster Declaration

On March 27, 2020, the President declared a Major Disaster Declaration for the Commonwealth of Massachusetts, DR-4496, related to the COVID-19 pandemic response. This declaration supersedes the previous Emergency Declaration, EM-3438, granted to the Commonwealth of Massachusetts by the President on March 13, 2020. The Major Disaster Declaration, like the Emergency Declaration, authorizes only Category B, Emergency Protective Measures, making federal funding available to local governments, state agencies, and eligible private non-profit organizations in all counties. The incident period is from January 20, 2020 and counting.

As this planning process was being completed, the Commonwealth was just beginning to deal with the impacts from the COVID-19 Global Pandemic. The impacts from this event will be long term and change the way society as a whole view, prepare for and respond to Pandemics. Data on the impacts from this event and the development policies to respond were in their infancy as of this writing and were not fully vetted enough to inform this plan update. It is anticipated that future updates of this plan will have well informed, expanded dialogue on this subject matter.

Pandemic Severity Index

The CDC has proposed a classification scale to determine the severity of pandemics and communicable disease outbreaks. This scale is known as the Pandemic Severity Index (PSI). The index focuses less on the likelihood of the disease spreading worldwide, and more upon severity of the epidemic. The main criteria used to measure pandemic severity will be case-fatality ratio (CFR), the percentage of deaths out of the total reported cases of the disease.

Like the Saffir-Simpson Hurricane Scale, the PSI ranges from 1 to 5, with Category 1 pandemics being most mild (equivalent to seasonal flu) and level 5 being reserved for the most severe worst-case scenario pandemics, such as the 1918 Spanish Flu pandemic.

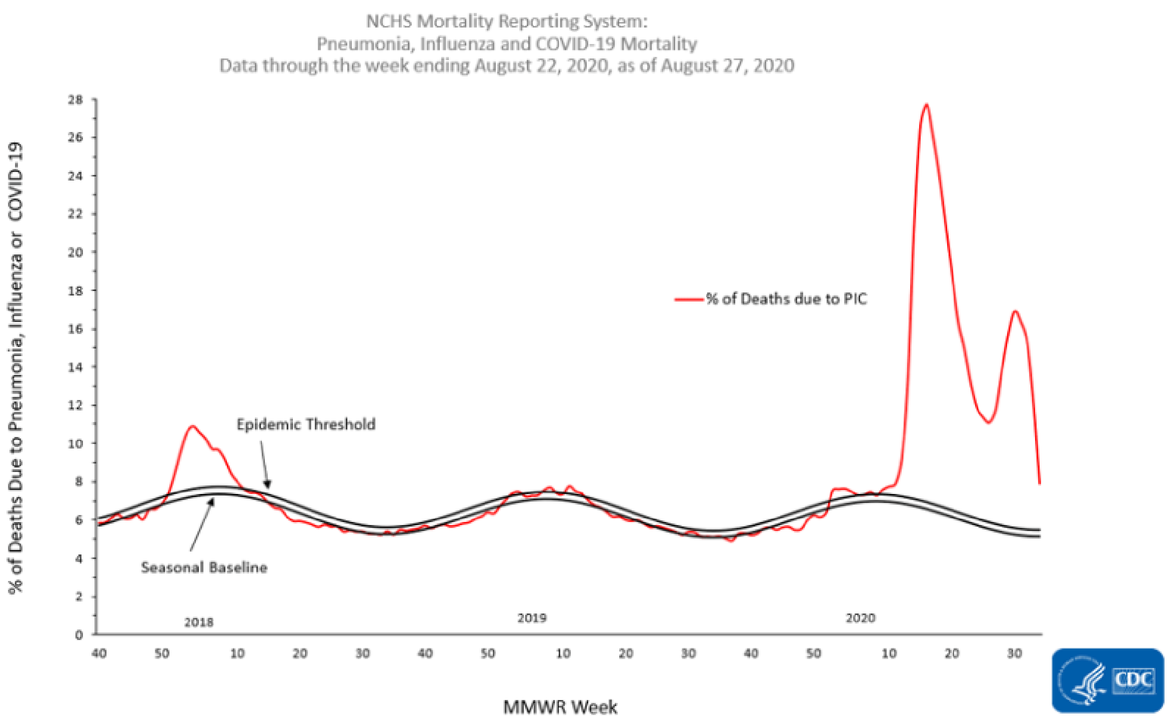
Table 90: Pandemic Severity Index

Category	Case-Fatality Ratio	Example Illness
1	Less than 0.1%	Seasonal flu, Swine flu (H1N1)
2	0.1% to 0.5%	Asian flu, Hong Kong Flu
3	0.5% to 1%	No example illness provided
4	1% to 2%	No example illness provided
5	2% or Higher	Spanish Flu

Source: CDC

The National Center for Health Statistics (NCHS) collects death certificate data from vital statistics offices for all deaths occurring in the US. Based on death certificate data available on August 27, 2020, the percentage of deaths attributed to pneumonia, influenza, or COVID-19 for week 34 is 7.9%. ***This is currently lower than the percentage during week 33 (12.3%); however, the percentage remains above the epidemic threshold and will likely increase as more death certificates are processed***.[83]

Figure 108: Pneumonia, Influenza, and COVID-19 Mortality



Source: https://www.cdc.gov/coronavirus/2019-ncov/covid-data/covidview/index.html

Hospitalization Rates

The overall cumulative COVID-19 associated hospitalization rate was 156.8 per 100,000; rates were highest in people 65 years of age and older (425.7 per 100,000) followed by people 50-64 years (235.7 per 100,000).

Non-Hispanic American Indian or Alaska Native Persons and Non-Hispanic Black persons had age-adjusted hospitalization rates approximately 4.7 times that of non-Hispanic White persons. The rate for Hispanic or Latino persons was approximately 4.6 times the rate among non-Hispanic White persons.

[83] **https://www.cdc.gov/coronavirus/2019-ncov/covid-data/covidview/index.html**

Table 91: COVID-19 Testing Results

Summary of Laboratory Testing Results Reported to CDC*	Week 34 (August 16-22, 2020)	Cumulative Since March 1, 2020
Number of Specimens Tested	2,021,409	43,204,184
Number of Positive Specimens	114, 199	3,836,639
Percent Positive	5.6%	8.9%

*Commercial and clinical laboratory data represent select laboratories and do not capture all tests performed in the US.

Open-Access Data and Computational Resources to Address COVID-19

COVID-19 open-access data and computational resources are being provided by federal agencies, including NIH, public consortia, and private entities. These resources are freely available to researchers and will be updated as more information becomes available.

Sectors Assessed

Populations

The asset that is most vulnerable to the impacts from pandemic or communicable disease is the human population. As more and more people fall ill, they will transmit the illness to others many times before they even realize they have been exposed, let alone contracted the illness. This will result in increased absenteeism and could place a strain on the community's medical centers. The elderly, infants, and infirm often are more vulnerable to biological hazards than other individuals, although in some influenza outbreaks, including the 2009 pandemic, young adults were highly vulnerable as well.

All residents of Hanson could be susceptible to the effects and exposed to infectious disease. A large outbreak or epidemic could have devastating effects on the population. Those with compromised immune systems, children, individuals that are socioeconomic or health disadvantaged, and individuals with access and functional needs are considered some of the most vulnerable to diseases.

Vulnerable Populations

The severity of a disease or epidemic varies from individual to individual. Typically, vulnerable populations (specifically young children and elderly adults) are more susceptible to acquiring communicable diseases due to immune system challenges and capabilities. In general, severity depends on the pathology of the disease, the health of the individual, vaccinations, and availability of treatments for symptoms or curing the disease.

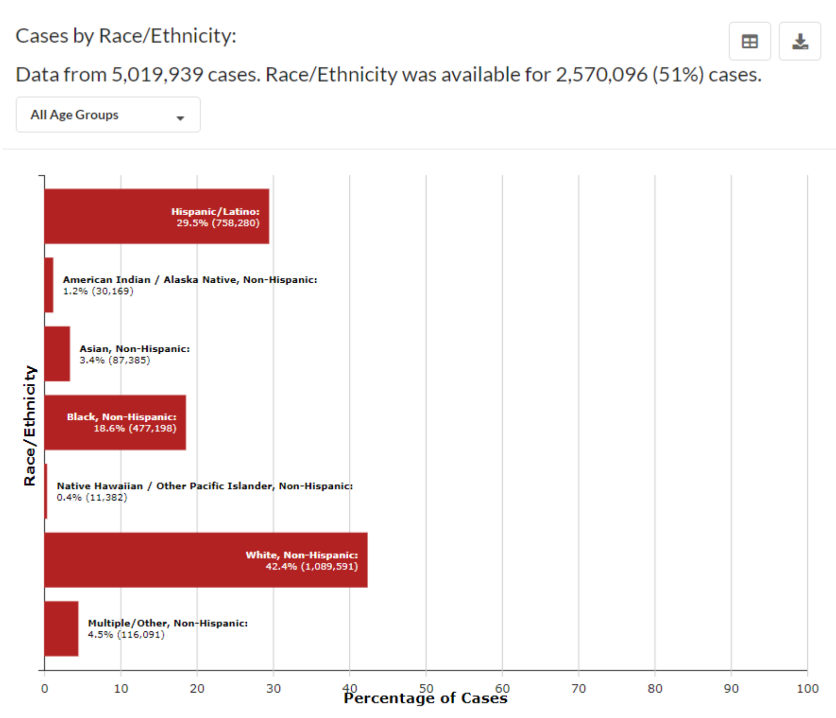
Non-Hispanic Black persons and non-Hispanic White persons represented the highest proportions of hospitalized cases, followed by Hispanic or Latino, non-Hispanic Asian or Pacific Islander, and non-

Hispanic American Indian or Alaska Native persons. However, some racial and ethnic groups are disproportionately represented among hospitalized cases as compared to the overall population of the catchment area. Prevalence ratios showed a similar pattern to that of the age-adjusted hospitalization rates: non-Hispanic American Indian or Alaska Native persons and non-Hispanic Black persons had the highest prevalence rations, followed by Hispanic or Latino persons.

A pandemic event can be expected to result in stress for responders, health care providers, and communities. Hospitals will need to provide psychological and stress management support to those who are symptomatic, those who believe they are ill, and to staff who are dealing with the increased workloads and personal concerns.

The public will require information on how to recognize and cope with the short-and long-term risks of sustained stress during mass vaccinations, for those debilitated by influenza, and their caregivers. Special attention and resources will be needed to ensure that special populations are identified prior to the event, and that unique service and transportation needs are incorporated into the local pandemic influenza emergency management plan. A vital part of pandemic planning is the development of strategies and tactics to address these potential problems.[84]

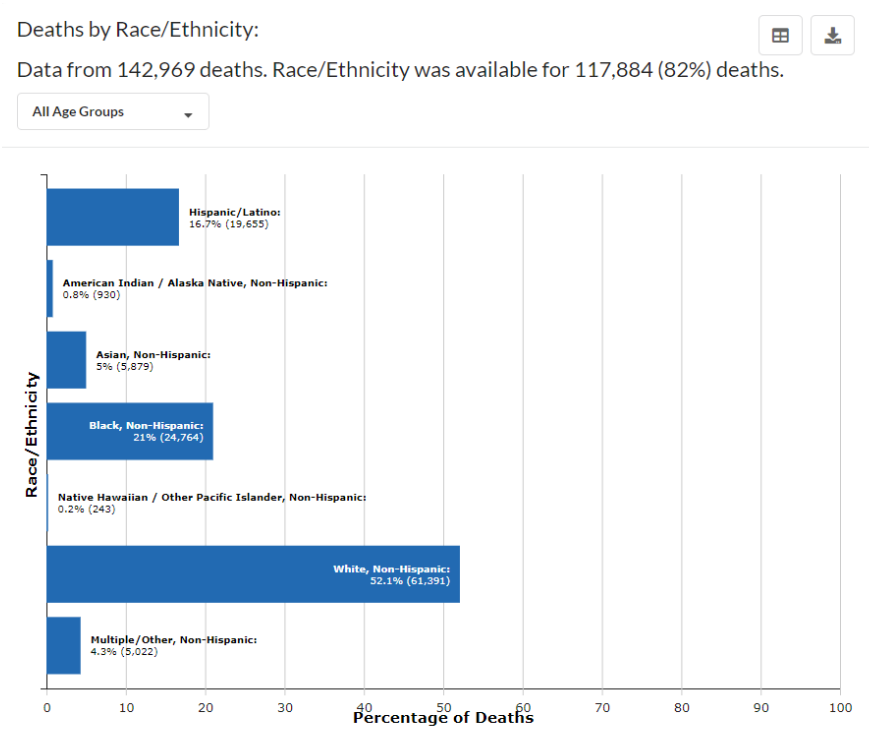
Figure 109: COVID-19 Cases by Race/Ethnicity



Source: https://covid.cdc.gov/covid-data-tracker

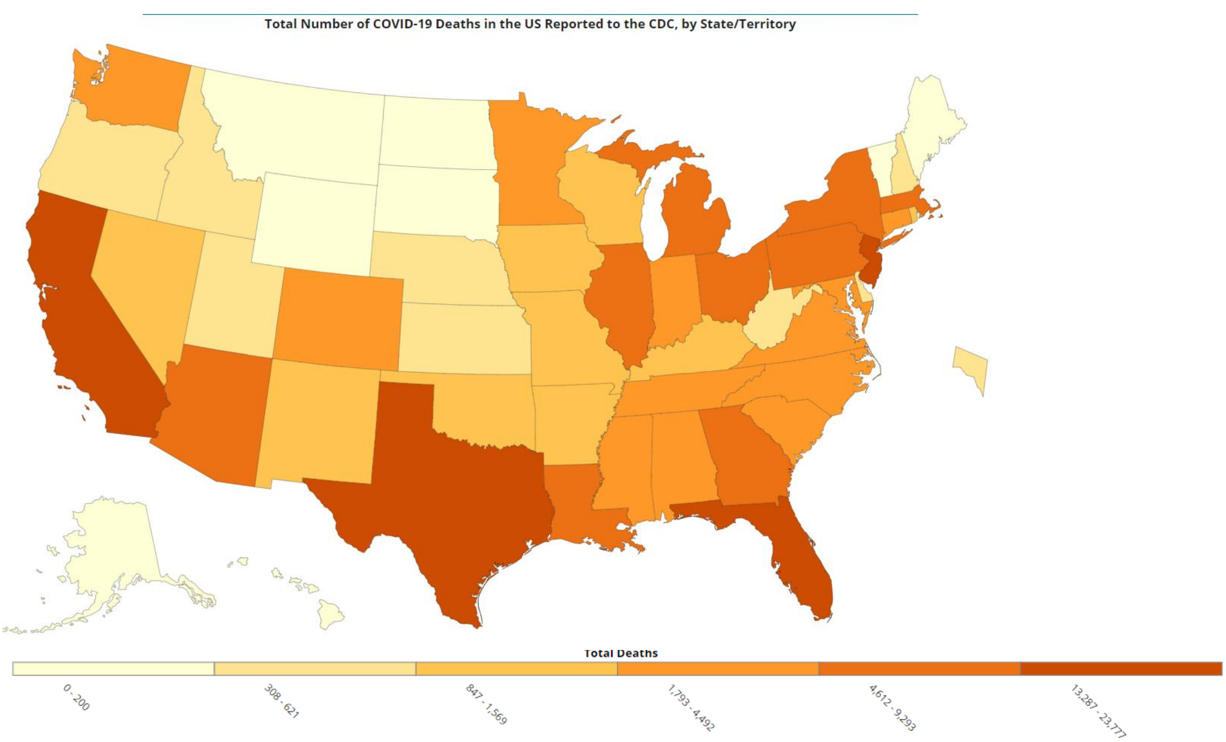
[84] **San Antonio Metropolitan Health District**

Figure 110: Deaths by Race/Ethnicity



Source: https://covid.cdc.gov/covid-data-tracker

Figure 111: Total Number of Deaths



Government

Health care facilities may reach capacity and become inundated with people. Early identification of shelters, alternate treatment facilities, isolation capacity, and methods to expand resources can help health care facilities and governments cope with an epidemic. However, epidemics and diseases would have significant measurable impact on the physical conditions of critical facilities or infrastructure with the installation of PPE and social distancing measures, and reduced access to municipal facilities.

Town operations are vulnerable to this hazard because of their dependence on human population. If a significant portion of the workforce is affected, delivery of services and general continuity of operations may suffer as a result. Interruptions would likely occur both within individual departments and within Town operations.

The Built Environment

Epidemics and diseases would not have a significant measurable impact on the property in the Town of Hanson.

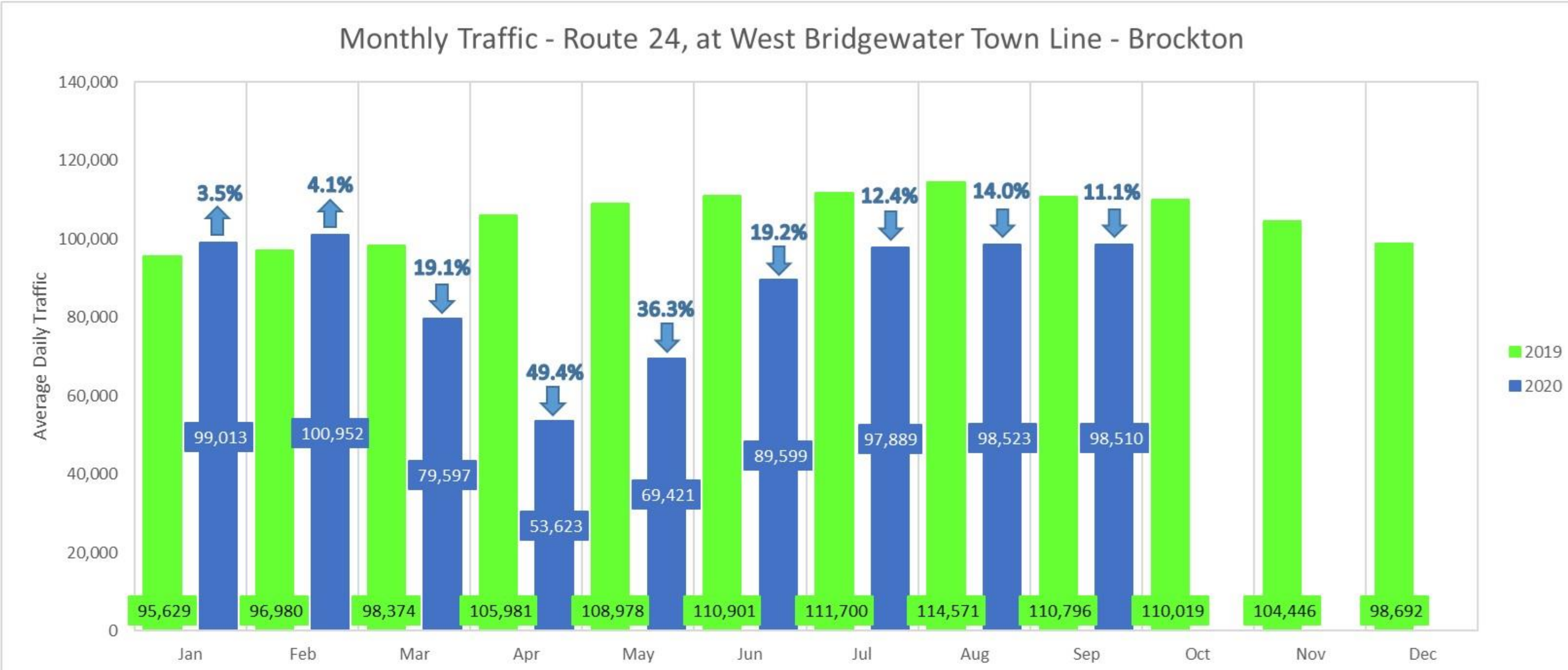
Transportation

Transportation systems plan an important role in responding to a range of disasters, from aiding evacuation from hurricanes and wildfires to helping to deliver resources after earthquakes. COVID-19 demonstrates the critical role these systems can play in a pandemic to ensure that essential workers can reach their jobs, freight mobility can be maintained to deliver critical resources, and transit-dependent populations are able to carry out necessary everyday activities. Planning for increased built-in flexibility of these systems could now enable communities to prioritize the modes and services needed to adapt to dynamic situations in the future.

In the months following the initial outbreak of COVID-19 in the US transportation departments, transit agencies, and other organizations have been implementing a variety of ***rapid response initiatives*** to help adapt transportation systems to the conditions caused by the pandemic. These adaptations include ***pop-up bus*** and ***bicycle lanes, automobile-restricted streets,*** and ***suspension of parking fees*** in addition to the development of ***street design guidelines*** for pandemic response and recovery. While these actions have re-shaped a range of public spaces and services to address some short-term problems stemming from COVID-19, they could also be considered as part of a broader, long-term approach to addressing a variety of potential hazards, both acute and chronic.

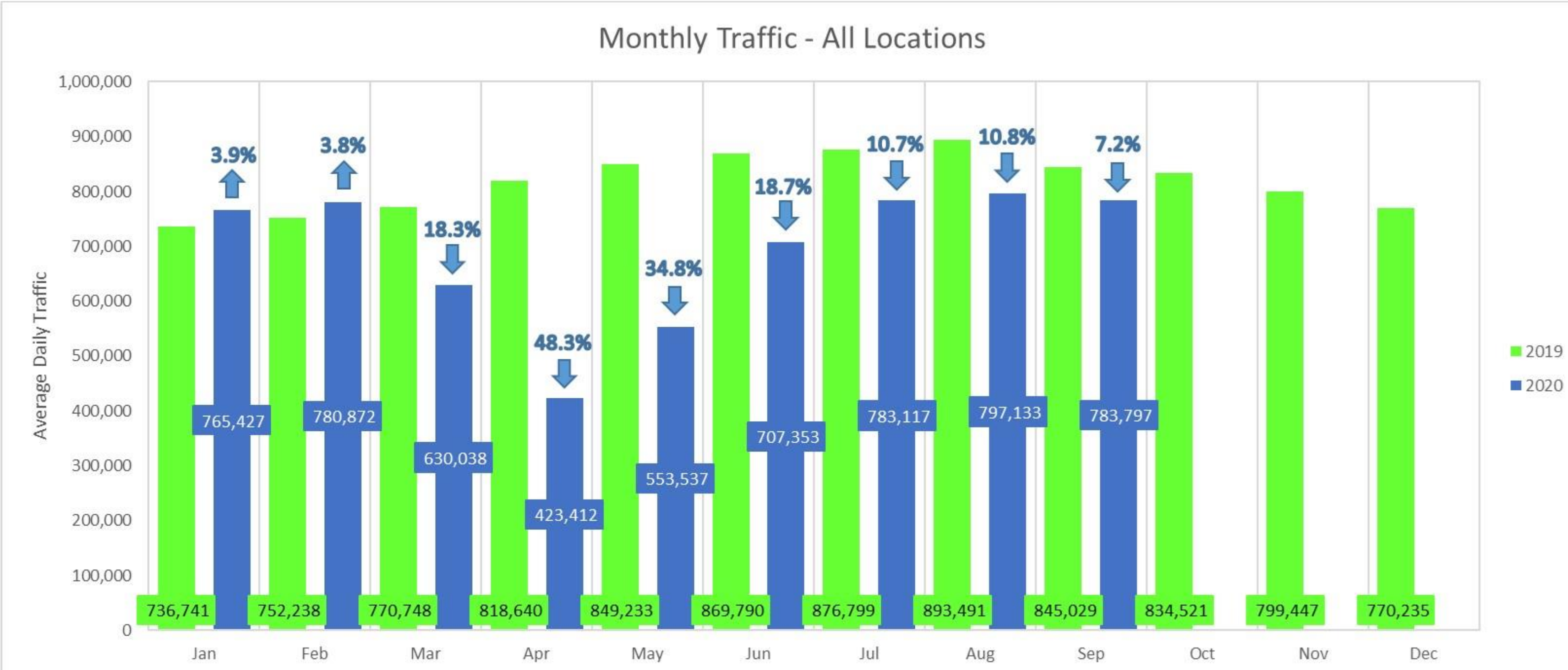
Resources for disaster mitigation are sparse, and it is particularly difficult to prioritize funding preparedness for uncertain events, but the consequences of such events can result in loss of lives and widespread damage. Responding to COVID-19 and preparing for future pandemics is likely to increase the strain on available resources for hazard mitigation, which heightens the appeal of developing robust strategies that can be sued to address multiple types of disasters.

Figure 112: Monthly Traffic – Route 24, at West Bridgewater Town Line - Brockton



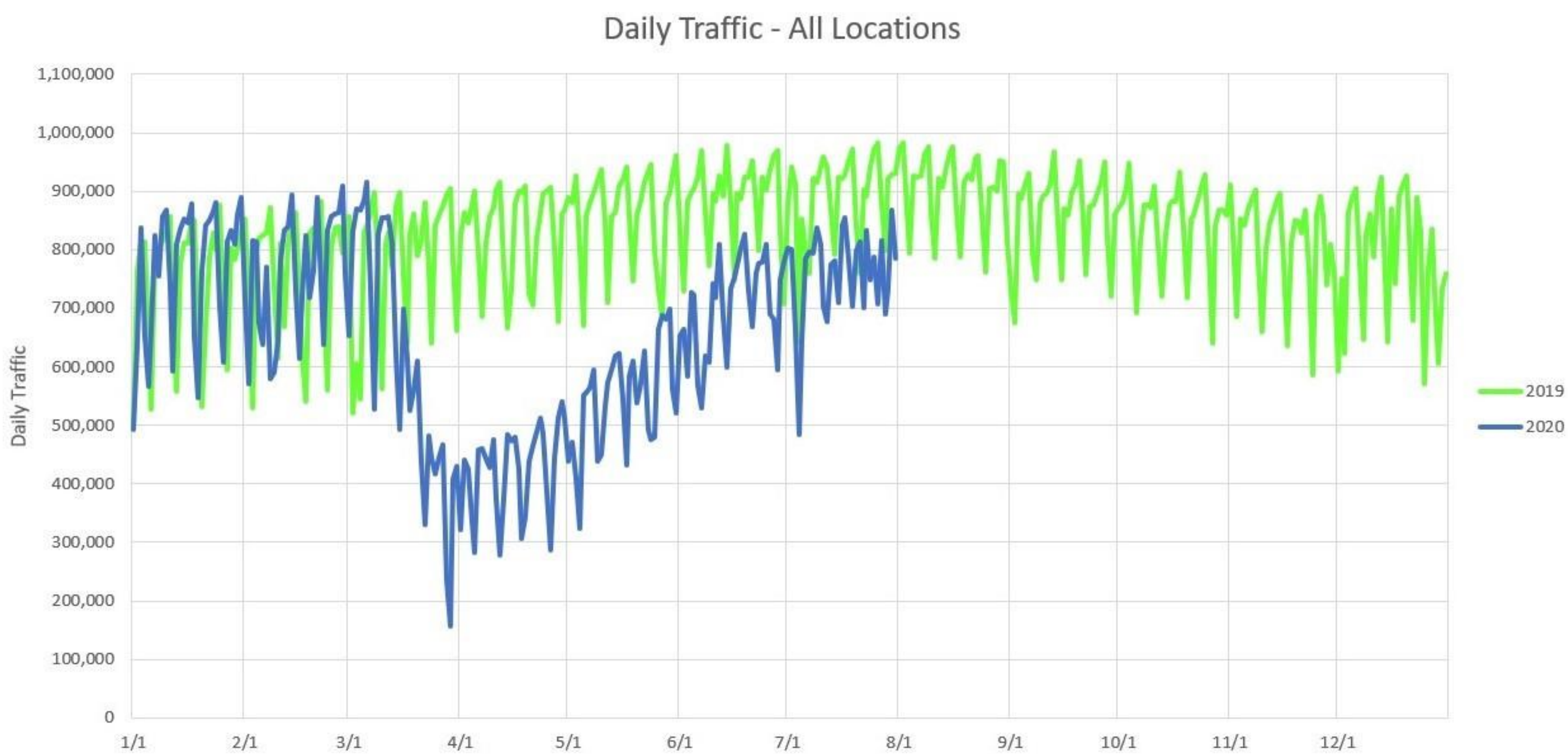
Source: OCPC Traffic Counts

Figure 113: Monthly Traffic All Locations



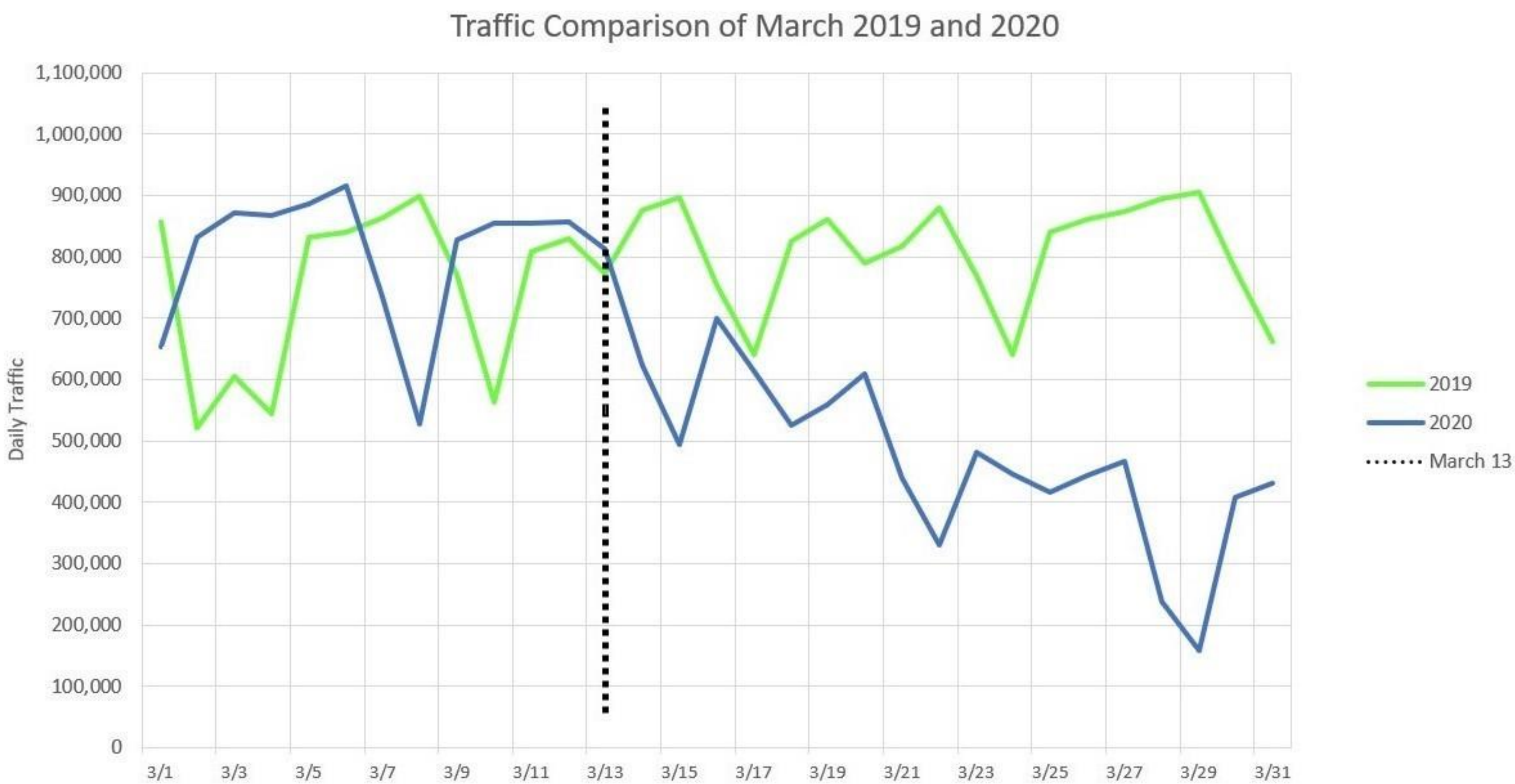
Source: OCPC Traffic Counts

Figure 114: Daily Traffic - All Locations



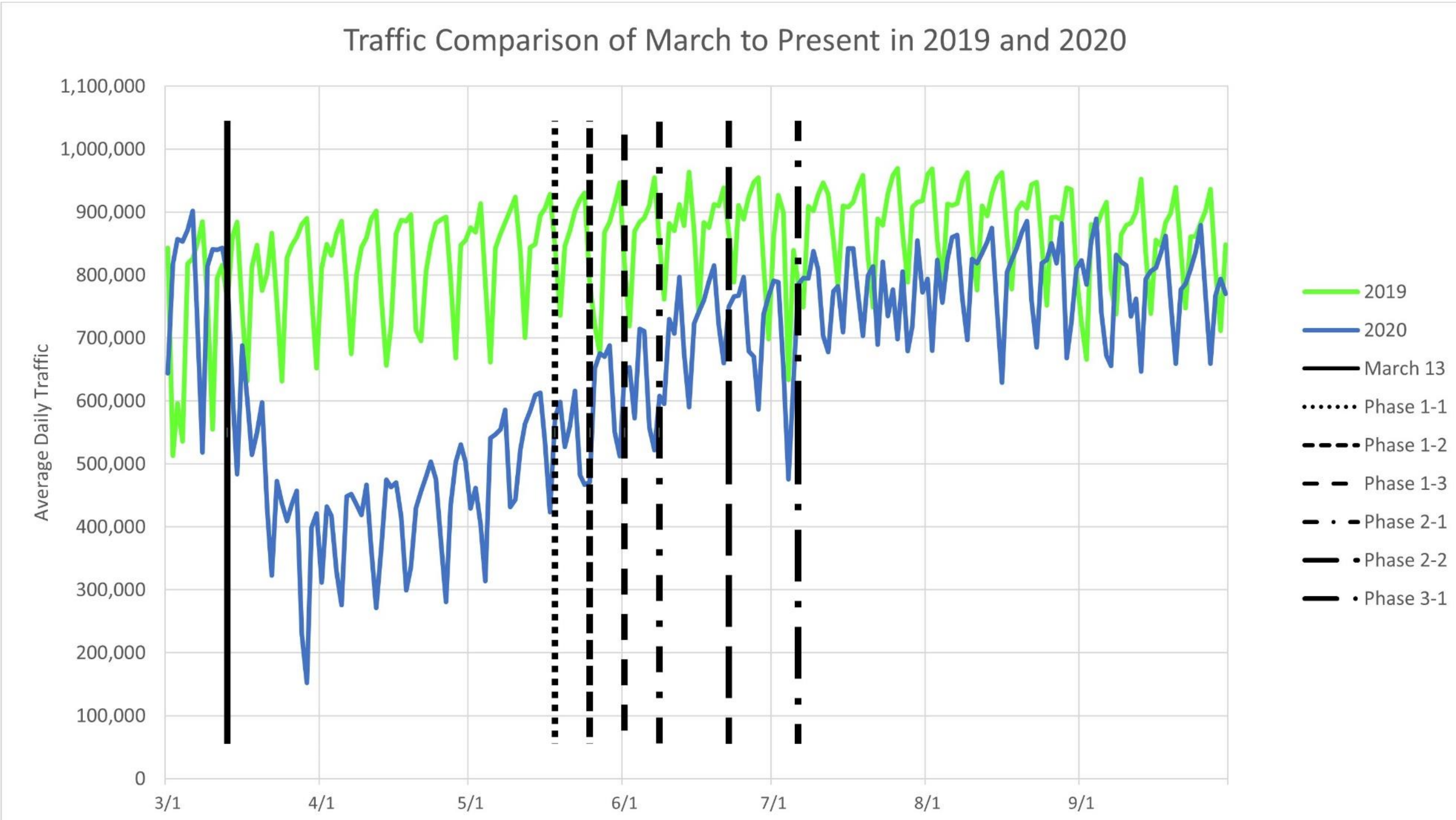
Source: OCPC Traffic Counts

Figure 115: Traffic Comparison of March 2019 and 2020



Source: OCPC Traffic Counts

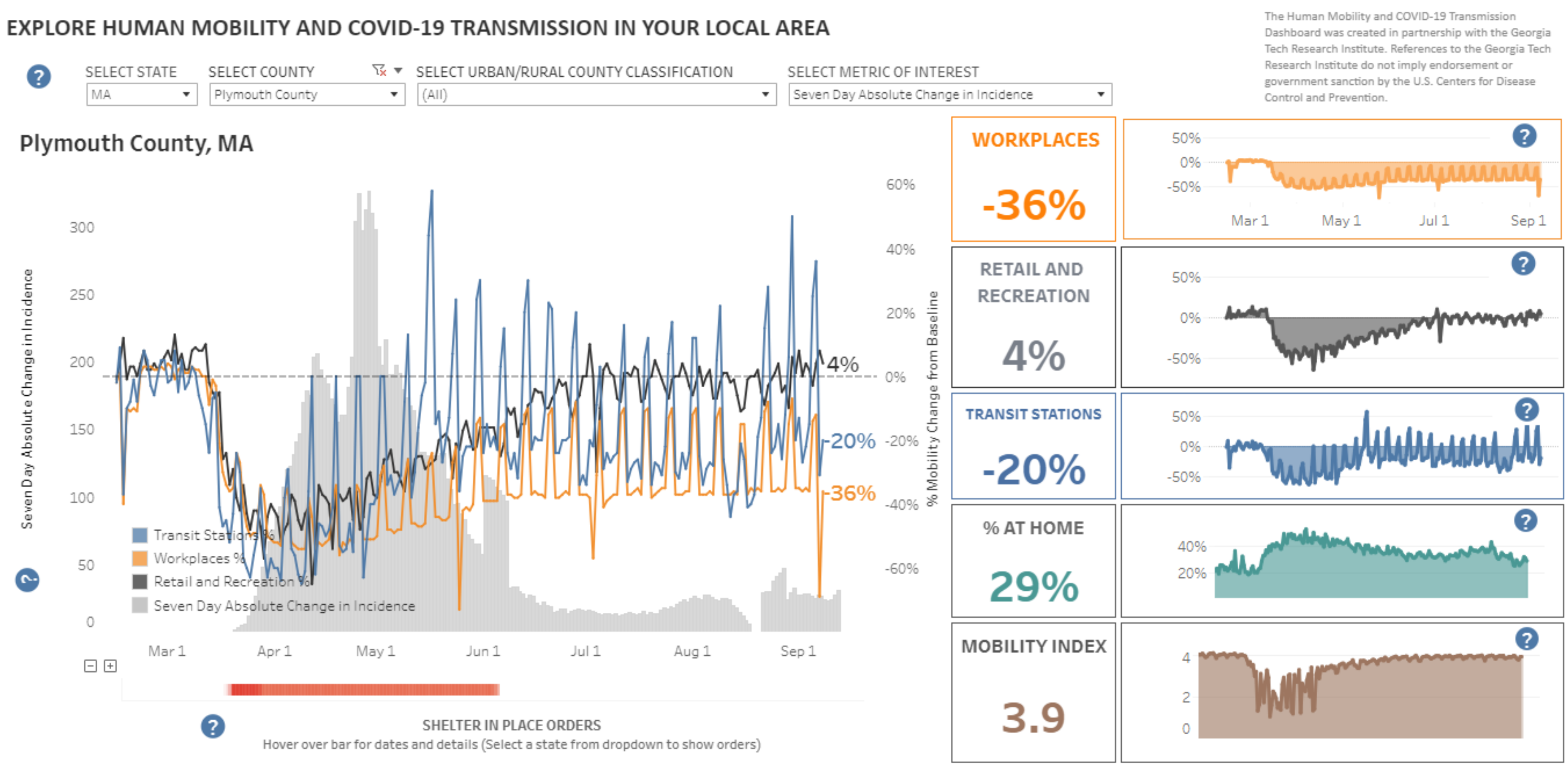
Figure 116: Traffic Comparison of March to Present 2019 and 2020



Source: OCPC Traffic Counts

Human Mobility and COVID-19 Transmission

Figure 117: Human Mobility and COVID-19 Transmission 7-Day Absolute Change



Source: https://covid.cdc.gov/covid-data-tracker/#mobility

Natural Resources and Environment

Epidemics and diseases would not have a significant measurable impact on the environment of the Town of Hanson.

NOAA exploring impact of COVID-19 response on the environment.

The coronavirus pandemic response has reduced pollution from many sources across many geographic regions. NOAA has launched a wide-ranging research effort to investigate the impact of reduced vehicle traffic, air travel, shipping, manufacturing and other activities on Earth's atmosphere and oceans. [85] NOAA scientists are using the most advanced atmosphere-ocean models to look for changes in atmospheric composition, weather, climate, and precipitation over weeks to months. This research will provide important evaluations to improve weather forecasting and climate projections going forward. "This unique view into the relative stillness we find ourselves in is only possible because of the existing baseline knowledge that NOAA has built over decades of monitoring, modeling, and research." [86] This research is anticipated to provide new insight into the drivers of change to oceans, atmosphere, air quality, and weather. NOAA scientists are investigating the impact of decreased pollution in specific areas over the short term and will analyze measurements collected from its global sampling network of contract airplanes, towers, and ground sites at laboratories in Colorado and Maryland.

- Several NOAA research laboratories, including those focused on satellite data, are evaluating how changes in activity impact emissions like carbon dioxide, methane, aerosols, and common air pollutants. In College Park, atmospheric researchers have found slight decreases in fine particulate pollution in the eastern and western United States, and a stronger signal of declines in ground-level ozone, or smog. In Boulder, scientists are observing changes in the composition and timing of emissions, in addition to volume - due to a smaller, later "rush-hour" – that could have local air quality impacts.
- NOAA's global greenhouse gas monitoring network, which continues to capture almost all its normal long-term observations, has begun aerial sampling over several large East Coast cities that have been previously studied.
- Scientists are also watching the sky, to see if reduced airline traffic is reducing the amount of high cirrus clouds, and whether that is affecting the formation of lower-altitude clouds or the amount of solar energy reaching the surface.

[85] **https://research.noaa.gov/article/ArtMID/587/ArticleID/2617/NOAA-exploring-impact-of-coronavirus-response-on-the-environment**

[86] **NOAA**

Economy

The largest secondary impact caused by an epidemic or outbreak would be economic. The reduction in workforce and labor hours would cause businesses and agencies to be greatly impacted. With a reduced workforce, there may be transportation route closures or supply chain disruptions, resulting in a lack of food, water, or medical resources. Another large and costly secondary impact would be fear or stigmatization, which may result in isolation or social unrest.

Hospitals and public health facilities may be inundated with individuals, including those with the disease and concerned about having contracted it. Additionally, medical workers will become sick and staffing shortages of professional medical personnel can occur. There is a potential for shortages and increased competition for medical supplies; this may lead to a controlled system where all supplies are monitored closely and prioritized. Finally, the disease may mutate, rendering cures and research unusable and contributing to the previously identified secondary impacts.

The municipality should determine methods to reduce economic household insecurity during a pandemic. Policies that may create deficits to promote long-term economic growth normally not considered in economic development plans, might be considered in pandemic recovery efforts. Growth in an inclusive and sustainable manner, the focus is on inclusive growth, to support recovery of the community in its entirety.

Future Trends in Development

The potential for an epidemic or outbreak is likely to slow expected growth in the county. The possibility of restricting travel and access to and within the county can strain or temporarily negatively affect the tourism industry, which can lead to small business closing. Travel restrictions related to epidemics or pandemics had significant economic consequences that last longer than the restrictions, slowing growth until the pandemic is over.

Important issues associated with epidemics and outbreaks include:

- Providing culturally appropriate preventative health care to changing demographic and aging population, including vaccination and education to help reduce the impacts.
- Integrating response efforts by medical and emergency response personnel to provide care when needed.
- Training and supplying medical and response personnel.
- Communicating a clear message to the public with facts about the disease, actions to reduce personal risk, and care options.
- Managing surge capacity for health agencies and to adapt to the rising number and needs of the area.

Climate Change Impacts

Future climate conditions and continued improvement of the ability to travel will contribute to the development and spread of diseases. Overall warmer temperatures and changes (typically increase) in rainfall can contribute to the spread of some diseases. In warmer temperatures, disease-carrying mosquitos survive longer, transmitting viruses more efficiently. The Zika virus happened during the warmest year on record at the time. Waterborne diseases, such as cholera and baritosis, are becoming more common as the world's waters get warmer. Blooms of toxic algae are occurring more often.

Infectious Disease

Infectious pathologies are also called communicable diseases or transmissible diseases due to the potential of transmission from one person or species to another by a replicating agent (as opposed to a toxin). An infectious disease is a clinically evident illness resulting from the presence of pathogenic, microbial agents, including pathogenic viruses, pathogenic bacteria, fungi, protozoa, multi-cellular parasites, or aberrant proteins known as prions. Transmission of an infectious disease may occur through one or more pathways, including physical contact with infected individuals. These infecting agents may also be transmitted through liquids, food, body fluids, contaminated objects, airborne inhalation, or through vector-borne spread.

Transmissible diseases that occur through contact with an ill person or their secretions, or objects touched by them, are especially infective and are sometimes referred to as contagious diseases. Infectious (communicable) diseases that usually require a more specialized route of infection, such as vector transmission, or blood or needle transmission, are usually not regarded as contagious.

The term "infectivity" describes the ability of an organism to enter, survive, and multiply in a host, while the infectiousness of a disease indicates the comparative ease with which the disease is transmitted to other hosts. An infection, however, is not synonymous with an infectious disease, as an infection may not cause important clinical symptoms or impair host function.

Examples of communicable or infectious diseases include plague, malaria, tuberculosis (TB), syphilis, hepatitis B, influenza, and measles.

DEFINITIONS

Cluster – An aggregation of cases grouped in place and time that are suspected to be greater than the number expected.

Endemic – Refers to the constant presence and/or unusual prevalence of a disease or infectious agent in a population within a geographic area.

Epidemic – An increase, often sudden, in the number of cases of a disease above what is normally expected in that population in that area.

Hyperendemic – Persistent, high levels of disease occurrence.

Medical Countermeasures – Life-saving medicines and medical supplies that can be used to diagnose, prevent, protect from, or treat conditions associated with chemical, biological, radiological, or nuclear threats, emerging infectious disease, or natural disaster.

Outbreak – The same definition of epidemic, but it is often used for a more limited geographic area, jurisdiction, or group of people.

Pandemic – An epidemic that has spread over several countries or continents, usually affecting many people.

Sporadic – Refers to a disease that occurs infrequently or irregularly.

Infectious disease is usually classified as endemic, epidemic, or pandemic. An endemic is always present, at a low frequency (e.g., chicken pox in the United States (US)). An epidemic is a sudden severe outbreak of disease (e.g., the bubonic plague during the Late Middle Ages) and a pandemic is an epidemic that becomes very widespread and affects a whole region, a continent, or the entire world (for example, the 1957 flu pandemic caused at least 70,000 deaths in the US and 1-2 million deaths worldwide). The term "pandemic" refers to geographic scope rather than intensity. A flu virus can become a pandemic depending on the geographic spread of the virus and can occur when a new flu virus emerges.

General Characteristics

The following graphic illustrates the characteristics and differences between seasonal and pandemic flu.

Table 92: Pandemic or Seasonal Flu?

Pandemic or Seasonal Flu?	
Seasonal Flu	**Pandemic Flu**
Occurs yearly, October – March	Occurs in cycles of 10-40 years, any time of the year
Affects 5-20% of the population, particularly the elderly, infants, and people with existing medical conditions	Affects 25-50% of the population, particularly healthy, young adults
In the US, kills 36,000 – 40,000 with most deaths in the high-risk groups	In the US, 70,000 deaths (1957-58) to 500,000 Deaths (1918)
Vaccine available based upon currently circulating virus strains	Caused by a new virus strain, no vaccine would be immediately available. New vaccine production requires at least six months.

Source: San Antonio Office of Emergency Management

The influenza outbreaks that happen nearly every year are important events. Influenza and similar respiratory illnesses affect hundreds of thousands of people each year and kills tens of thousands. One of the most important features about influenza viruses is that their structure changes slightly but frequently over time, a process known as "genetic drift." This process results in the appearance of different strains that circulate each year. The composition of the influenza vaccine is changed annually to help protect people from the strains of influenza virus that are expected to be the most common ones circulating during the coming influenza season. Currently, only three influenza virus strains are in general circulation in humans (H1N1, H1N2, and H3N2); H2N2 circulated in 1957 and 1968, causing the Hong Kong influenza pandemic but has not been seen since. (Source: *Texas Department of State Health Services*).

A key difference between seasonal influenza and a strain that continues to spread among the human population is the potential for far fewer people to have any immunity to the new strain, creating more severe illness and potentially more rapid spread. (Source: *Centers for Disease Control and Prevention*).

National experts have not come to a consensus for the anticipated severity or duration of the next influenza pandemic. Some scientists and public health officials estimate a lower attack rate than others. In general, experts estimate that an international outbreak (pandemic) due to a new variation of influenza may have a 25 percent to 50 percent attack rate. The estimates of case fatality rates range from 1.5 percent to 5 percent.

Table 93: Estimated Pandemic Attack Rate

People QuickFacts	Massachusetts	Plymouth County	Hanson
Population			
Population estimates July 1, 2019 (V2019)	6,892,503	521,202	10,914
Attack Rate 25%	1,723,125	130,300	2,728
Attack Rate 50%	3,446,251	260,601	5,457
Fatality Rate 1.7%	29,293	2,215	27
Fatality Rate 5%	86,156	6,515	546
Require Hospitalization 4% of 25% Attack Rate	68,925	5,212	109
Require Hospitalization 4% of 50% Attack Rate	137,850	10,424	218

Secondary Impacts

The largest secondary impact caused by an epidemic or outbreak would be economic. The reduction in workforce and labor hours would cause businesses and agencies to be greatly impacted. With a reduced workforce, there may be transportation route closures or supply chain disruptions, resulting in a lack of food, water, or medical resources. Another large and costly secondary impact would be fear or stigmatization, which may result in isolation or social unrest. Hospitals and public health facilities may be inundated with individuals, including those with the disease and concerned about having contracted it. Finally, the disease may mutate, rendering cures and research unusable and contributing to the previously identified secondary impacts.

Exposure

All residents and visitors in the region could be susceptible to the effects and exposed to infectious disease. A large outbreak or epidemic could have devastating effects of the population. Those with compromised immune systems, children, individuals who are socioeconomic or health disadvantaged, and individuals with access and functional needs are considered some of the most vulnerable to diseases.

Health care facilities may reach capacity and become inundated with people. Early identification of shelters, alternate treatment facilities, isolation capacity, and methods to expand resources can help health care facilities and governments cope with an epidemic. However, epidemics and diseases would not have significant measurable impact on the critical facilities or infrastructure of the region.

Compound Disasters

Adopting a multi-hazard perspective, which considers multiple hazards affecting a place as well as their potential interrelations and interactions, would help to support the development of more robust preparedness strategies. Although multi-hazard approaches are admittedly more complex, they provide a more resourceful and effective approach to reducing risk. The effects of disasters cannot be fixed with physical infrastructure alone, but where changes in physical infrastructure are made, they should be done with an eye toward multiple hazards and long-term resilience. These changes should be viewed as a long-term investment strategy in both transit-dependent populations and in future transportation system resilience.

The combination of the COVID-19 pandemic, existing racial and socioeconomic inequalities, and environmental stressors exacerbated by climate change is exposing the many ways in which "compound risks" threaten human lives and wellbeing while straining the ability of governments at all scales to limit the damage from any one threat on its own. [87] Intersections of climate extremes with the pandemic have made clear that the consequences of such compound risk events can be lethal, though the underreporting of cases around the world [88] and widely varying testing capabilities [89] make it difficult to accurately quantify their magnitude.

Compound disasters have complex ramifications. At the intersection of a natural hazard and a pandemic is a decision process fraught with contradictions. Current projections and unprecedented storm activity to date suggest the 2020 Atlantic hurricane season will be extremely active and that a major hurricane could make landfall during the global COVID-19 pandemic. Such an event would necessitate a large-scale evacuation, with implications for the trajectory of the pandemic.

With hurricane Laura hitting Louisiana and Texas as an "extremely dangerous" Category 4 storm and wildfires menacing the western US, millions of Americans faced the complex risks of a natural disaster striking in the middle of a pandemic. The steps people normally take to prepare for a severe storm or to evacuate can contradict the public health recommendations for protecting themselves and others from COVID-19.

Texas A&M University has been examining interactions between urban infrastructure, systems, and people in disasters to study the effect of the pandemic on urban systems during a natural disaster.

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[87] Phillips, C.A.*et al.* Compound climate risks in the COVID-19 pandemic. *Nat. Clim. Change* 10, 586-588 (2020)

[88] Lau, H. *et al.* Evaluating the massive underreporting and undertesting of COVID-10 cases in multiple global epicenters. *Pulmonology (2020)* doi: 10.1016/j.pulmoe.2020.05.015.

[89] Kavanagh, M.M. *et al.* Access to lifesaving medical resources for African countries: COVID-19 testing and response, ethics, and politics. *The Lancet* 395, 1835-1738 (2020).

The decision to evacuate in the face of even a single hazard, whether a wildfire or a hurricane, is difficult. Sheltering in place can mean life threatening conditions, prolonged power outages and disrupted access to critical facilities. Evacuating means leaving behind one's house and possibly animals to an uncertain fate. When an emergency shelter is the best choice it can mean a higher risk of being exposed to someone infected with the coronavirus.

In the face of a pandemic, authorities now must think about disease transmission, and not just in individual emergency shelters but also on a larger scale. When a large population moves from one area with a high rate of disease spread to a less affected area, it can put the local population at a higher risk.

Section 5. Hazard Mitigation and Climate Adaptation Strategies

Section 5. Hazard Mitigation and Climate Adaptation Strategies

Global/Cross-Cutting Hazards Mitigation Actions

Proposed Strategy	Type of Action	Effectiveness	Lead & Supporting Departments	FEMA Lifeline Supported	Hazards Addressed	Time Frame	Funding Source	Benefit to Community
Comprehensive Emergency Management Plan (CEMP)	Develop internal protocol, policies, and procedures for logistics management and resource support during disasters, and develop agreement with state, federal and private partners to implement the plan.	Emphasis is on emergency response, mitigation, preparedness, response, and recovery from a variety of natural and man-made emergencies. It organizes information, includes supply and inventories.	Board of Selectmen, Fire Chief, Police Chief	Safety and Security, Communications, Food, Water, Shelter, Health and Medical, Preparedness & Response	Flood, Severe Storms, Extreme Temperatures , Hurricane & Tropical Storm, Nor'easters	3-5 Years	General Fund, Grant Funding, Staff Time, Volunteers	High
Infrastructure/ Capital Project & Preparedness and Response	Obtain funding to supply shelters with food, water, and supplies; recruit volunteers to fun the shelters	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact	Town Administrator, Board of Selectmen, Emergency Management	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials	Flood, Severe Storms, Extreme Temperatures , Hurricane & Tropical Storm, Nor'easters	3-5 Years	General Fund, Grant Funding	High
Local Emergency Planning Committee (LEPC) Create an emergency response network and a medical professional network to coordinate professional and volunteer-based emergency and medical response teams.	Coordinate emergency management planning with climate change vulnerabilities that include vulnerable populations and road system interconnectivity.	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact	This combined network should include Town public safety departments (police, fire, Board of Health, COA, DPW), existing or new CERTs (Civilian Emergency Response Teams), and existing volunteer organizations.	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials	Flood, Severe Storms, Extreme Temperatures , Hurricane & Tropical Storm, Nor'easters	1-3 Years	General Fund, Grant Funding, Staff Time	High

Multi-Department Review of Developments	Multiple departments within town review and comment on site plans before development.	Most effective for new construction.	Planning Board, Zoning Board of Appeals, Conservation Commission, Board of Health, Highway Dept	Transportation, Food, Water, Shelter, Health and Medical,	Flood, Severe Storms, Extreme Temperatures, Hurricane & Tropical Storm, Nor'easters	1-3 Years	General Fund, Staff Time	High
Conduct one exercise annually, involving members of the public, regarding the four phases of emergency management to increase understanding of each person's role during a disaster, including public health issues such as pandemic.	Economic Benefit-Cost, Social equity	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact	Town Administrator, Fire Department, Police Department, Emergency Management	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials	Flood, Severe Storms, Extreme Temperatures, Hurricane & Tropical Storm, Nor'easters	1-3 Years	General Fund, Staff Time	High
Mass Gathering Plan	Develop a plan that includes policies, procedures, and protocols for conducting mass gathering events with an emphasis on pandemic.	Co-benefits social-equity, long-term and lasting impact	Town Administrator, Board of Selectmen, Emergency Management	Effective for emergency preparedness response and recovery	Pandemic, Flood, Severe Storms, Extreme Temperatures, Hurricane & Tropical Storm, Nor'easters	1-3 Years	General Fund	High
Obtain funding to supply shelters with food, water, and supplies; recruit volunteers to run the shelters.	Infrastructure – capital project Preparedness and Response	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity	Town Administrator, Board of Selectmen, Emergency Management	Safety and Security, Education and Awareness, Preparedness and Response	Pandemic, Flood, Severe Storms, Extreme Temperatures, Hurricane & Tropical Storm, Nor'easters	1-3 Years	General Fund, Staff Time, Grant	Medium

		Long-term and Lasting Impact						
Emerging Hazards	Review and adopt plan to emerging hazards that fall outside of traditional natural hazards	Co-benefits social-equity, long-term and lasting impact	Town Administrator, Board of Selectmen, Emergency Management	Safety and Security, Education and Awareness, Preparedness and Response	Emerging	3-5 Years	General Fund	Medium
Master Plan Updates	Include a new section on Climate Change in the next Master Plan update.	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact	Town Administrator, Board of Selectmen, Planning Board	Improves access to critical data and information after a disaster. Planning and Regulation.	Climate Change Adaptation	1-3 Years	General Fund, Staff Time, Grant	High
Master Plan Updates	Provide training, webinars, workshops on integration of local mitigation plans into local Comprehensive Plans	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials	OCPC	Improves integration of local mitigation plans, improves understanding of vulnerability. Planning and Regulation	Ongoing as plans are created or updated	1-3 Years	DLTA Grant	High
Create a Climate Action Plan	Create an implementation committee to manage the process of creating and monitor implementation of a comprehensive Climate Action Plan.	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact	Emergency Management, Planning Board, Conservation Commission, Board of Health, Building Department, Highway Department	Safety and Security, Education and Awareness, Preparedness and Response, Climate Adaptation	Pandemic, Flood, Severe Storms, Extreme Temperatures, Hurricane & Tropical Storm, Nor'easters	1-3 Years	General Fund, Grant Funding	High

Budgeting, coordinating administrative functions, and planning	Incorporate climate change vulnerability, resiliency, and adaptation standards into budgeting, coordination, and capital planning.	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact	Town Administrator, Board of Selectmen, Finance Committee	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials	Pandemic, Flood, Severe Storms, Extreme Temperatures, Hurricane & Tropical Storm, Nor'easters	3-5 Years	Staff Time, General Fund, Grant	High
Incorporate hazard and climate change vulnerability into personnel and workplace policies training and guidance as appropriate	Evaluate current policies and guidance to consider updates and other training opportunities related to personnel readiness, workplace climate change vulnerabilities, hazard mitigation, and climate adaptation techniques.	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact	Town Administrator, Board of Selectmen,	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials	Pandemic, Flood, Severe Storms, Extreme Temperatures, Hurricane & Tropical Storm, Nor'easters	3-5 Years	Staff Time, General Fund, Grant	High
Incorporate hazard and climate change vulnerability into capital planning, master planning and facilities management functions	Incorporate climate change vulnerability, resilience, and adaptation standards into capital planning for new projects.	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact	Town Administrator, Board of Selectmen, Planning Board	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials	Pandemic, Flood, Severe Storms, Extreme Temperatures, Hurricane & Tropical Storm, Nor'easters	3-5 Years	Staff Time, General Fund, Grant	High
Review, evaluate, and implement revisions as needed to environmental	Conduct outreach with stakeholders to review, evaluate, and implement revisions	Co-Benefits High Risk and Vulnerability Economic Benefit-cost	Planning Board, Conservation Commission	Safety and Security, Food, Water, Shelter, Health and	Pandemic, Flood, Severe Storms, Extreme	3-5 Years	Staff Time, General Fund, Grant	High

and energy policies, regulations, and plans	needed to key state environmental and energy policies, regulations, and plans maintained by EOEEA and its agencies	Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact		Medical, Energy, Communications, Transportation, Hazardous Materials	Temperatures, Hurricane & Tropical Storm, Nor'easters			
Open Space Residential Design and Low Impact Development Standards	Consider zoning amendments that promote the use of LID standards using nature-based solutions to manage stormwater in new subdivision development	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact	Planning Board	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation	Preparedness and Response, Climate Adaptation	1-3 Years	Staff Time	High

Inland Flooding Hazards Mitigation Actions

Proposed Strategy	Type of Action	Effectiveness	Lead & Supporting Departments	FEMA Lifeline Supported	Hazards Addressed	Time Frame	Funding Source	Benefit to Community
Continue to identify those areas most in need of flood hazard reduction plans with detailed engineering analysis to identify specific drainage "hot spots" to develop engineering plans to improve bridges, culverts, channels, and other infrastructure, fund the projects and complete them to lessen the likelihood that future floods will cause harm to existing and future buildings.	Infrastructure - Capital Project. **CRB Workshop identified the former Ocean Spray property on Main Street as a "hot spot" for flooding events which prohibit past and future commercial structures and high priority.**	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact	Board of Selectmen, Conservation Commission, Planning Board, Board of Health, Building Dept	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials	Flood	3-5 Years	Staff time, general fund, and grants	High
Culvert Maintenance and Repair Plan with long-term implementation. **Inventory and Prioritize culverts for repairs and replacement.**	Infrastructure – Capital Project **CRB Workshop identified the following culverts at the following locations: Maquan Street, King Street, Winter Street, Pratt Place, Indian Head Street.**	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact	Board of Selectmen, Highway Department	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials	Flood	1-3 Years	General Fund, Grant Funding	High
Identify key road networks and develop safe evacuation routes; Install evacuation route signage;		Co-Benefits High Risk and Vulnerability	Board of Selectmen, Highway Surveyor,	Safety and Security, Food, Water, Shelter, Health and	Multi-hazard,	1-3 years	General Fund, staff time	High

Develop alternative methods of evacuation		Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact	Planning Board, Police Chief, Fire Chief	Medical, Energy, Communications, Transportation, Hazardous Materials				
Acquisition of vacant flood prone lands	Identify lands subject to flooding and rank by priority	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact	Conservation Agent, Town Planner, Assessors	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials	Inland Flooding	3 – 5 years	General fund, Staff time, Capital Improvement Plan, FEMA, MVP, CPA	Medium

Inland Flooding Hazards Mitigation Actions – Dam Failure

Proposed Strategy	Type of Action	Effectiveness	Lead & Supporting Departments	FEMA Lifeline Supported	Hazards Addressed	Time Frame	Funding Source	Benefit to Community
Wampatuck Pond Dam Improvements	Dam is in structurally good condition, but automated controls would more efficiently and effectively manage flows.	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact	Town Administrator, Board of Selectmen	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials	Flood	>5 Years	General Fund, Grant	Medium
Map dam failures areas. Enhance emergency operations plan to include a dam failure component.	Consider residual risk associated with protection provided by dams in future land use decisions	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact	Planning Board, Conservation Commission	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials	Flood	3-5 Years	General Fund, Staff time	Medium

Drought Hazards Mitigation Actions

Proposed Strategy	Type of Action	Effectiveness	Lead & Supporting Departments	FEMA Lifeline Supported	Hazards Addressed	Time Frame	Funding Source	Benefit to Community
As climate change continues to affect the region, it will be important to identify alternative water supplies for time of drought. Consider the development of an alternative groundwater wellhead source.	Infrastructure – Capital Project **CRB Workshop identified funding for the development of a new wellhead on town owned property a high priority.**	Economic Benefit-cost, Social Equity, Adaptive Capacity, Harmonize with existing activity, long-term and lasting impact.	Water Commission, Board of Selectmen	Safety and Security, Food, Water, Shelter	Drought	3-5 Years	General Fund, MVP Action Grant, Staff Time	High
Research options, cost, funding, and acquisition of back up water resources including increasing storage capacity through the acquisition of a new water tower to avoid water shortages.	Infrastructure – Capital Project **CRB Workshop identified funding for the construction of a new water storage tower to increase the storage capacity during drought events.**	Co-Benefits, Economic Benefit-cost, Adaptive Capacity, Long-term and lasting impact	Water Commission, Board of Selectmen	Food, Water, Shelter, Safety and Security	Drought	>5 years	General Fund, MVP Action Grant	High
Educate the public about ways to lessen the effects of drought and the need to be water wise.	Education and Awareness	Economic Benefit-cost, Social Equity, Adaptive Capacity,	Water, Conservation Commission, BOH, Building Department	Safety and Security	Economic Benefit-Cost, Social Equity, Adaptive Capacity	1 – 3 Years	Staff Time, General Fund	High
Encourage drought resistance landscapes and rainwater	Regulatory	Economic Benefit-cost, Social Equity,	Planning Board, Zoning Board of Appeals	Safety and Security, Food, Water,	Drought Extreme Temperatures	1-3 Years	Staff Time	High

catchments in subdivision and site plan review regulations		Adaptive Capacity, Harmonize with existing activity, long-term and lasting impact.		Shelter, Preparedness				
Reduce Water System Losses		Economic Benefit-cost, Social Equity, Adaptive Capacity, Harmonize with existing activity, long-term and lasting impact.	Water Commission	Safety and Security, Food, Water, Shelter, Preparedness	Drought Extreme Temperatures	3 – 5 Years		High
Modify Rate Structure to influence active water conservation		Economic Benefit-cost, Social Equity, Adaptive Capacity, Harmonize with existing activity, long-term and lasting impact.	Water Commission	Safety and Security, Food, Water, Shelter, Preparedness	Drought Extreme Temperatures	1-3 Years		Medium

Wildfire Hazard Mitigation Actions

Proposed Strategy	Type of Action	Effectiveness	Lead & Supporting Departments	FEMA Lifeline Supported	Hazards Addressed	Time Frame	Funding Source	Benefit to Community
Support programs such as a “tree watch” program that encourages residents to proactively manage vegetative problem areas.	Education and Awareness Preparedness and Response	Co-benefits, Economic Benefit-cost, Social Equity, Harmonize with existing activity	Conservation Commission	Safety and Security	Wildfire Invasive Species	1-3 Years	General Fund, Volunteer	Medium
Review current town bylaws and regulations and update as necessary to encourage residents and businesses to create and maintain defensible space around structures and infrastructure.	Plans and Regulations, Education and Awareness	Economic Benefit-cost, technical soundness, harmonize with existing activity	Town Administrator, Planning Board, Tree Warden, Conservation Commission	Safety and Security, Food, Water, Shelter	Wildfire	1-3 Years	General Fund	Low

Extreme Temperatures, Snowstorms, Ice Storms Hazard Mitigation Actions

Proposed Strategy	Type of Action	Effectiveness	Lead & Supporting Departments	FEMA Lifeline Supported	Hazards Addressed	Time Frame	Funding Source	Benefit to Community
Public Education on snow operations and winter maintenance on town website	Create an education program regarding winter weather preparedness for citizens. Ensure that pet owners are included in the process and specific strategies for protecting livestock and pets from severe winter weather events are addressed.	Co-benefits, Economic Benefit-cost, Social Equity, Harmonize with existing activity	Board of Health	Safety and Security, Food, Water, Shelter, Social Equity	Severe Snowstorms, Nor'easters	1 – 3 Years	Staff Time	Medium
Review of Building Stock	Older building stock is built to low code standards or none. These structures could be highly vulnerable to windstorms. The town could conduct a study within the planning area to identify as-risk buildings and investigate options for bringing them up to code.				Wind, Hurricane and Tornadoes, Nor'easters	3 – 5 Years	Staff Time	Medium
Alternate Power Supply		Redundancy of power supply must be evaluated to ensure continuity of	Emergency Management	Safety and Security, Food, Water, Shelter, Social Equity	Wind, Hurricane and Tornadoes, Nor'easters	3 – 5 Years	Staff Time	Medium

		power at critical facilities throughout Hanson.						
Public Outreach for Isolated Population Centers	Depending on the severity of the storm event, isolated population centers could potentially become stranded from the rest of the Town. As such, the Town should take steps to inform such isolated population centers about what to do if they become stranded.	This could include public information on sheltering in place, tips on developing a personal go-kit, and instructions on developing a personal emergency plan. Co-benefits, Economic Benefit-Cost, Social Equity	Emergency Management	Safety and Security, Food, Water, Shelter, Social Equity, Preparedness	Wind, Hurricane and Tornadoes, Nor'easters	3 – 5 Years	Staff Time	Medium
Green Site Design to increase tree plantings near buildings, increase the percentage of trees used in parking areas, and along public ways. Promote Green Infrastructure, adopt Net Zero Water Use policies and regulations.	Green Site design to control stormwater.	Co-benefits, Economic Benefit-Cost, Social Equity	Town Planner, Conservation Agent, Building Dept.	Stormwater management, Safety and Security, Emergency Preparedness	Extreme temperature mitigation, increased precipitation	5+ years	General Fund, staff time, Conservation Agent, Highway Surveyor, Town Planner	Low

Extreme Wind, Thunderstorms Hazards Mitigation Actions

Proposed Strategy	Type of Action	Effectiveness	Lead & Supporting Departments	FEMA Lifeline Supported	Hazards Addressed	Time Frame	Funding Source	Benefit to Community
Require underground electrical for all new construction	Reduce expose to hazards	Co-benefits, Economic Benefit-cost, Social Equity, Harmonize with existing activity, Preparedness and Adaptation	Planning Board, Building Dept., Zoning Board of Appeals	Safety and Security, Food, Water, Shelter, Social Equity, Preparedness, Transportation, Hazardous Materials	Wind, Hurricane and Tornadoes, Nor'easters	>5 Years	Staff Time	High
Retrofit public buildings and critical facilities to reduce future wind damage	Reduce exposure to hazards	Co-benefits, Economic Benefit-cost, Social Equity, Harmonize with existing activity, Preparedness and Adaptation	Building Dept., Town Administrator, Board of Selectmen	Safety and Security, Food, Water, Shelter, Social Equity, Preparedness, Climate Adaptation	Wind, Hurricane and Tornadoes, Nor'easters	>5 Years	Staff Time, General Fund	Medium
Adopt a tree ordinance that creates a town-wide database of all town-owned trees and creates a schedule for new plantings and removal of diseased and dead trees from high hazard areas.	Reduce exposure to tree limb damage from extreme wind events	Co-benefits, Economic Benefit-cost, Social Equity, Harmonize with existing activity, Preparedness and Adaptation	Town Planner, Highway Surveyor, Tree Warden, Conservation Agent, Assessors Office, GIS	Safety and Security, Food, Water, Shelter, Social Equity, Preparedness, Transportation, Hazardous Materials, Climate Adaptation	Wind, Hurricane, Tornadoes, Nor'easters, Extreme Weather, Snow	>5 Years	Staff Time, General Fund	High

Hurricane and Tropical Storm Hazards Mitigation Actions

Proposed Strategy	Type of Action	Effectiveness	Lead & Supporting Departments	FEMA Lifeline Supported	Hazards Addressed	Time Frame	Funding Source	Benefit to Community
Emergency Shelter Wind Speed Capability Assessment	Because of the secondary hazards associated with tropical storms, emergency shelters are often needed to house residents displaced by collapsing houses or rising flood waters. The town should begin making efforts to test its emergency shelters to ensure that they can withstand sustained wind speeds comparable to a Category 2 hurricane.	Co-benefits, Economic Benefit-cost, Social Equity, Harmonize with existing activity, Preparedness and Adaptation, Health and Medical	Emergency Management, Town Administrator	Safety and Security, Food, Water, Shelter, Social Equity, Preparedness, Climate Adaptation	Hurricane, Tropical Storm, Severe Winds	3-5 Years	General Fund, Grant	High
Vulnerable Trees – Inventory and Maintain Street tree canopy, Camp Kiwanee entrance and parking	There is a significant tree exposure to hurricane wind forces in Hanson. The vulnerability of these trees to wind forces should be monitored by the town to pre-identify potential problem areas prior to pending storms.	Co-benefits, Economic Benefit-cost, Social Equity, Harmonize with existing activity, Preparedness and Adaptation, Health and Medical, Transportation	Tree Warden	Safety and Security, Food, Water, Shelter, Social Equity, Preparedness, Climate Adaptation, Health and Medical, Transportation, Hazardous Materials	Hurricane, Tropical Storm, Severe Winds	1-3 Years	Staff Time	High
Debris Management Plan	Pre-incident planning can encompass community resilience, source reduction, and hazard mitigation activities aimed at reducing the amount of time it takes a community to recover, the total amount of debris generated, and the release and exposure to potentially harmful components in the debris.	Co-benefits, Economic Benefit-cost, Social Equity, Harmonize with existing activity, Preparedness and Adaptation, Health and Medical, Transportation	Emergency Management, Town Administrator, Board of Health	Safety and Security, Food, Water, Shelter, Social Equity, Preparedness, Climate Adaptation, Health and Medical, Transportation, Hazardous Materials	All identified hazards	1-3 Years	Staff Time, General Fund, Grant	High

Vector-borne Disease and Pandemics Hazards Mitigation Actions

Proposed Strategy	Type of Action	Effectiveness	Lead & Supporting Departments	FEMA Lifeline Supported	Hazards Addressed	Time Frame	Funding Source	Benefit to Community
Mass Gathering Plan	Develop a plan that includes policies, procedures, and protocols for conducting mass gathering events with an emphasis on pandemic.	Co-benefits social-equity, long-term and lasting impact	Town Administrator, Board of Selectmen, Emergency Management	Effective for emergency preparedness response and recovery	Pandemic, Flood, Severe Storms, Extreme Temperatures, Hurricane & Tropical Storm, Nor'easters	1-3 Years	General Fund	High
Disaster Financial Management Team	Establish a multidisciplinary team of planning, grants management, and financial management subject matter experts to develop a disaster financial management plan before an incident occurs and help execute it following a disaster.	A critical step post-disaster even if the Town does not take this approach pre-disaster.	Town Administrator, Financial Management, Emergency Management	Effective for emergency preparedness response and recovery, Food, Shelter, Water, Health and Medical, Transportation, Hazardous Materials	Pandemic, Flood, Severe Storms, Extreme Temperatures, Hurricane & Tropical Storm, Nor'easters	1-3 Years	General Fund	High
Creation of an Economic Recovery Task Force	Goal of developing both short-term and long-term policy recommendations for consideration by the Board of Selectmen. Immediate focus: parking, signage, vacant storefront, outdoor dining and permitting processes.	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity	Town Administrator, Planning Board, Board of Health, Board of Selectmen, Building Dept., Zoning Board of Appeals, Conservation Commission,	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials	Pandemic, Flood, Severe Storms, Extreme Temperatures, Hurricane & Tropical Storm, Nor'easters, Extreme Temperatures	1-3 Years	General Fund, Staff Time, Grant	High

		Long-term and Lasting Impact	Emergency Management					
Fund an Economic Recovery Manager Position and Economic Recovery Task Force	A recovery manager experienced in where and how to access financial resources and technical support and having mechanisms in place to meet the varying requirements.	Effectively identify and manage multiple streams of disaster funding to increase the efficiency of recovery efforts and reduce the likelihood of audits and financial penalties. Co-Benefits High Risk and Vulnerability, Economic Benefit-Cost, Technical Soundness, Adaptative Capacity, Long-Term and Lasting Impact	Town Administrator, Board of Selectmen, Board Membership includes the Chamber of Commerce, Business Owners, Property Owners, Arts Community, Non-profits, and Town Departments	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials	Pandemic, Flood, Severe Storms, Extreme Temperatures, Hurricane & Tropical Storm, Nor'easters, Extreme Temperatures	1 – 3 Years	General Fund, Staff Time, Grant	High
Future Infrastructure Improvements.	Public spaces, such as the right-of-way should be flexible enough to equitably serve the public both on an everyday basis and during times of disaster.	These include spaces for social distance requirements. Prioritize actions that benefit the most vulnerable communities.	Town Administrator, Board of Selectmen, Finance Committee, Planning Board, Zoning Board of Appeals,	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials	Pandemic, Flood, Severe Storms, Extreme Temperatures, Hurricane & Tropical Storm, Nor'easters, Extreme Temperatures	1 – 3 Years	General Fund, Staff Time, Grant	High
Remote Technology to support elections, municipal government, and	Develop policies and procedures for remote work and educational needs.	Stagger log-in for students participating in remote learning to avoid overwhelming the computer network.	Emergency Management, Capital projects, IT, Town Administrator	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials	Pandemic, Flood, Severe Storms, Extreme Temperatures, Hurricane & Tropical Storm, Nor'easters,	1 – 3 Years	General Fund, Staff Time, Grant	High

educational needs					Extreme Temperatures			
Increase mosquito surveillance and control capacity	Providing quality and ongoing staff training in standard mosquito surveillance and control techniques.	Ensuring sustainable funding and resources are dedicated to local vector control programs to maintain trained staff and adequate supplies to perform chemical and non-chemical abatement activities.	Board of Health, Parks and Recreation, School Department, Conservation Commission	Safety and Security, Food, Water, Shelter, Health and Medical	Vector-Borne disease, extreme temperatures, increased precipitation	1 – 3 Years	General Fund, Staff Time, Grant	High
Decrease barriers to mosquito surveillance and control competency	Identify barriers to routine mosquito surveillance and pesticide resistance testing. Bolster public communication strategies to educate property and homeowners on eliminating mosquito breeding grounds.	Support data collection and sharing across jurisdictions to monitor mosquito activities	Board of Health, Parks and Recreation, School Department, Conservation Commission	Safety and Security, Food, Water, Shelter, Health and Medical	Vector-Borne disease, extreme temperatures, increased precipitation	1 – 3 Years	General Fund, Staff Time, Grant	High
Flu Vaccine Protocol	Protocol can serve as a template for when a vaccine becomes available	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact	Board of Health, Board of Selectmen, Town Administrator	Safety and Security, Food, Water, Shelter, Health and Medical	Pandemic, Infectious Disease	1 – 3 Years	General Fund, Staff Time, Grant	High

Zoning and Regulatory Hazard Mitigation and Climate Adaptation Actions

Proposed Strategy	Type of Action	Effectiveness	Lead & Supporting Departments	FEMA Lifeline Supported	Hazards Addressed	Time Frame	Funding Source	Benefit to Community
Stormwater Management in New Development and Redevelopment	Include a requirement that new development and redevelopment stormwater management BMPs be optimized for phosphorus removal with nature-based solutions	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact	Planning Board, Zoning Board of Appeals, Highway Dept.	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials	Flood, Severe Storms, Extreme Temperatures, Hurricane & Tropical Storm, Nor'easters, Extreme Temperatures	1 – 3 Years	Staff Time, General Fund	High
	Retrofit inventory and priority ranking shall include consideration of BMPs that infiltrate stormwater where feasible.	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact	Planning Board, Zoning Board of Appeals, Highway Dept.	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials	Flood, Severe Storms, Extreme Temperatures, Hurricane & Tropical Storm, Nor'easters, Extreme Temperatures	1 – 3 Years	Staff Time, General Fund	High
Design Standards	Incorporate designs that allow for shutdown and containment where appropriate to isolate the system in the event of an emergency spill or unexpected event.	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity	Planning Board, Zoning Board of Appeals, Highway Dept.	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation,	Flood, Severe Storms, Extreme Temperatures, Hurricane & Tropical Storm, Nor'easters, Extreme Temperatures	1 – 3 Years	Staff Time, General Fund	High

		Harmonize with Existing Activity Long-term and Lasting Impact		Hazardous Materials				
	Require any stormwater management system designed to infiltrate stormwater on commercial or industrial sites to provide the level of pollutant removal equal to or greater than the level of pollutant removal provided using biofiltration of the same volume of runoff to be infiltrated, prior to infiltration.	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact	Planning Board, Zoning Board of Appeals, Highway Dept.	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials	Flood, Severe Storms, Extreme Temperatures, Hurricane & Tropical Storm, Nor'easters, Extreme Temperatures	1 – 3 Years	Staff Time, General Fund	High
Design Standards	Excavation and Grading – regulates how earth removal must be conducted. Effective for minimizing earth removal and preventing sedimentation	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact	Planning Board, Zoning Board of Appeals, Highway Dept. Town Administrator, Board of Selectmen, Board of Health, Conservation Commission	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials	Flood, Severe Storms, Extreme Temperatures, Hurricane & Tropical Storm, Nor'easters, Extreme Temperatures	1 – 3 Years	Staff Time, General Fund	High

Hazardous Materials Hazards Mitigation Actions

Proposed Strategy	Type of Action	Effectiveness	Lead & Supporting Departments	FEMA Lifeline Supported	Hazards Addressed	Time Frame	Funding Source	Benefit to Community
Continue all facets of emergency preparedness training	Police, Fire, Public Works, and public information staff training in responding to HAZMAT incidents.	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact Preparedness and Adaptation	Emergency Management	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials	Flood, Severe Storms, Extreme Temperatures, Hurricane & Tropical Storm, Nor'easters, Extreme Temperatures, Pandemic and Infectious Disease	1 – 3 Years	Staff Time, General Fund, Grant	High
Work proactively with hazardous materials facilities to follow best management practices	• Placards and labeling of containers. • Emergency plans and coordination • Standardized response procedures Notification of the types of materials being transported through the Town of Hanson	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact Preparedness and Adaptation	Emergency Management	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials, Preparedness	Flood, Severe Storms, Extreme Temperatures, Hurricane & Tropical Storm, Nor'easters, Extreme Temperatures, Pandemic and Infectious Disease	1 – 3 Years	Staff Time, General Fund, Grant	High
	Work with the private sector to enhance and create Business Continuity Plans	Co-Benefits High Risk and Vulnerability	Emergency Management, Chamber of Commerce,	Safety and Security, Food, Water, Shelter, Health and	Flood, Severe Storms, Extreme Temperatures, Hurricane & Tropical	1 – 3 Years	Staff Time, General Fund, Grant	High

		Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact Preparedness and Adaptation	Small Business Association	Medical, Energy, Communications, Transportation, Hazardous Materials, Preparedness and Resiliency	Storm, Nor'easters, Extreme Temperatures, Pandemic and Infectious Disease			
	Coordinate with school district to ensure that their emergency preparedness plan includes preparation for hazardous material releases	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact Preparedness and Adaptation	Emergency Management	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials, Preparedness and Resiliency	Flood, Severe Storms, Extreme Temperatures, Hurricane & Tropical Storm, Nor'easters, Extreme Temperatures, Pandemic and Infectious Disease	1 – 3 Years	Staff Time, General Fund, Grant	High

Environmental Hazards Mitigation Actions

Proposed Strategy	Type of Action	Effectiveness	Lead & Supporting Departments	FEMA Lifeline Supported	Hazards Addressed	Time Frame	Funding Source	Benefit to Community
North River Watershed Plan	To improve quality, maintain adequate flows, and prevent future issues, especially flooding and deteriorating water quality.	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact Preparedness and Adaptation	Conservation Agent, Conservation Commission, Planning Board	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials, Preparedness and Resiliency	Flood, Severe Storms, Extreme Temperatures, Hurricane & Tropical Storm, Nor'easters, Extreme Temperatures,	3 – 5 Years	Staff Time, Volunteers	Medium
Risk Assessment	Consider a risk assessment to determine vulnerability of town well source from contamination from former landfill, current transfer station.	Co-Benefits High Risk and Vulnerability Economic Benefit-cost Social Equity Technical Soundness Adaptive Capacity Harmonize with Existing Activity Long-term and Lasting Impact Preparedness and Adaptation	Town Administrator, Board of Selectmen, Board of Health	Safety and Security, Food, Water, Shelter, Health and Medical, Energy, Communications, Transportation, Hazardous Materials, Preparedness and Resiliency	Hazardous Materials	>5 Year	Grant, General Fund	Medium
Public Education and Outreach	Distribute an annual message in the spring that encourages the proper use and disposal of grass clippings and encourages the proper use of slow-	Co-benefits, Economic Benefit-cost, Social Equity, Harmonize with existing activity	Board of Health, Conservation Commission, Building Dept	Safety and Security, Food, Water, Shelter, Social Equity	Flood, Hurricane and Tropical Storm	1 – 3 Years	Staff Time	Medium

	release and phosphorus-free fertilizers.							
Public Education and Outreach	Distribute an annual message in the summer months encouraging the proper management of pet waste, including noting any existing ordinances where appropriate. Disseminate educational materials to dog owners at the time of issuance or renewal of dog license, or other appropriate time.	Co-benefits, Economic Benefit-cost, Social Equity, Harmonize with existing activity	Board of Health, Conservation Commission, Building Dept	Safety and Security, Food, Water, Shelter, Social Equity	Flood, Hurricane and Tropical Storm	1 – 3 Years	Staff Time	Medium
Public Education and Outreach	Distribute information to owners of septic systems about proper maintenance in any catchment that discharges to a water body impaired for bacteria or pathogens.	Co-benefits, Economic Benefit-cost, Social Equity, Harmonize with existing activity	Board of Health, Conservation Commission, Building Dept	Safety and Security, Food, Water, Shelter, Social Equity	Flood, Hurricane and Tropical Storm	1 – 3 Years	Staff Time	Medium
Water Quality Assessment	To assess the impact of climate change on groundwater quality Measure road salt impacts on drinking water quality	Co-benefits, Economic Benefit-cost, Social Equity, Harmonize with existing activity	Board of Health, Conservation Commission, Highway Dept	Safety and Security, Food, Water, Shelter, Social Equity	Flood, Hurricane and Tropical Storm	1 – 3 Years	Staff Time	Medium

Earthquake Hazards Mitigation Actions

Proposed Strategy	Type of Action	Effectiveness	Lead & Supporting Departments	FEMA Lifeline Supported	Hazards Addressed	Time Frame	Funding Source	Benefit to Community
Build local capacity to respond to or prepare for the hazard	Include retrofitting and replacement of critical system elements in capital improvement plan. Develop strategy to take advantage of post disaster opportunities. Develop a post-disaster action plan that includes grant funding and debris removal components	Emphasis is on emergency response, mitigation, preparedness, response, and recovery from a variety of natural and man-made emergencies. It organizes information, includes supply and inventories.	Board of Selectmen, Fire Chief, Police Chief, Emergency Management, Highway Department, Building Department	Safety and Security, Communications, Food, Water, Shelter, Health and Medical, Preparedness & Response	Earthquake	3-5 Years	General Fund, Grant Funding, Staff Time, Volunteers	High
Assess the earthquake vulnerability of all public buildings. Investigate options to make buildings earthquake resistant.	Town-wide assessment of earthquake vulnerability. Develop and adopt a continuity of operations plan. Initiate triggers guiding improvements (such as <50% substantial damage or improvements).	Provide inventory of improvements.	Building Department, Conservation Agent, Town Planner, Assessors Office	Safety and Security, Communications, Food, Water, Shelter, Health and Medical, Preparedness & Response	Earthquake	5+ years	General Fund, Grant Funding, Staff Time, Volunteers	Medium

Landslide Hazards Mitigation Actions

Proposed Strategy	Type of Action	Effectiveness	Lead & Supporting Departments	FEMA Lifeline Supported	Hazards Addressed	Time Frame	Funding Source	Benefit to Community
Adopt regulatory standards for new development in unstable slope areas	Regulatory							

Technological and Human Caused Hazards Mitigation Actions

If you are	Then
Asked to evacuate	Do so immediately
Caught Outside	Stay upstream, uphill, and upwind. In general, try to go at least one-half mile from the danger area. Do not walk into or touch any spilled liquids, airborne mists, or condensed solid chemical deposits
In a motor vehicle	Stop and seek shelter in a permanent building. If you must remain in your car, keep car windows and vents closed and shut off the air conditioner and heater.
Requested to stay indoors	• Close and lock all exterior doors and windows. Close vents, fireplace dampers, and as many interior doors as possible. • Turn off air conditioners and ventilation systems. In large buildings, set ventilation systems to 100 percent recirculation so that no outside air is drawn into the building. If this is not possible, ventilation systems should be turned off. • Go into the pre-selected shelter room. This room should be outside above-ground and have the fewest openings to the outside. • Seal the room by covering each window, door, and vent using plastic sheeting and duct tape. • Use material to fill cracks and holes in the room, such as those around pipes.
Shelter Safety for Sealed Rooms	Ten square feet of floor space per person will provide sufficient air to prevent carbon dioxide build-up for up to five hours, assuming a normal breathing rate while resting. Local officials are unlikely to recommend the public shelter in a sealed room for more than 2-3 hours because the effectiveness of such sheltering diminishes with time as the contaminated outside air gradually seeps into the shelter. At this point, evacuation from the area is the better protective action to take. You should ventilate the shelter when the emergency has passed to avoid breathing contaminated air still inside the shelter.

Mitigation for Vulnerable Populations

Disasters, by definition, are the result of a combination of hazard and vulnerability. With natural hazards increasing in frequency and severity, and vulnerability intensifying due to changes in land use and demographics, the most vulnerable residents will face increased food insecurity, be more susceptible to environmental risk, and could experience residential and occupational displacement. If hazard mitigation planning dynamics do not shift in response to community changes such as aging, increased racial and ethnic diversity, and income inequality, they will not reflect the needs of at-risk populations or provide them with timely and adequate support.

Several key issues impede efforts to engage vulnerable populations in the mitigation planning process. These include access to information (specifically the digital divide), social barriers such as racism, lack of trust, and language and cultural barriers. Mismatches between engagement opportunities and the lived experiences of vulnerable populations are also a problem.

Equitable Engagement Blueprint

One approach some communities are using to meet the challenges is an equitable engagement blueprint – a guide that identifies best practices, like holding meeting at times and in locations that are accessible to all, for all municipal planning to expand engagement opportunities.

- Details barriers that obstruct robust community engagement
    - Lack of childcare or transportation
    - Lack of transparency, inauthentic engagement, inequitable development
- Engages community and involves partners such as public health and mental health agencies.

Pre-recovery planning enhances resilience by mitigating population displacement, maintaining social networks, speeding recovery, and rebuilding, and providing cost-effective solutions. Importantly, it also engages community stakeholders in developing a vision for the future of the community.

Social Vulnerability

Vulnerability	Mitigation Opportunity
Low Income Communities: Low Income communities living in risk-prone environments are disproportionately exposed to pollutants and natural hazards.	Adaptations plans that explicitly acknowledge the causes of social inequity can improve the capacity of vulnerable populations to cope and recover from climate impacts.
Older Adults/Seniors: Older adults with limited mobility are vulnerable to conditions that require people to evacuate or shelter-in-place.	Checking on elderly neighbors and proper emergency communication can save lives.
Children: Extreme heat and poor air quality puts children at a greater risk than adults to illness such as heat stroke or asthma.	Adults can lessen risk by monitoring exertion and hydration. Finding shaded areas at a park or community center is a great way to stay cool.
Minority Populations: Low-income families are at risk of physical and mental illnesses when natural hazards disrupt school and work schedules.	Emergency preparedness and response can improve outcomes for people with limited resources.

Social Vulnerability – Food Insecurity

Food Insecurity	
Access to food during and immediately after storm event by persons with limited mobility.	School meal programs are critical to student health and well-being especially for low income socially vulnerable populations.
Getting to school can be a challenge for vulnerable populations with limited resources.	Extreme weather events can close schools which provide important resources to low-income populations.
School Meal Programs are critical to student health and well-being especially for low-income, socially vulnerable populations.	In a weather-related emergency where schools are forced to shut down or serve as a community shelter, access to health meals for children and young adults are diminished.
Social Support	
Socially vulnerable populations such as the elderly, disabled, or children are particularly susceptible to environmental risk factors such as flooding and heat.	Social support systems that help prepare communities for future climate events through climate health education and community preparedness helps the most at-risk populations in the community.

Prioritize marginalized populations when it comes to flood mitigation activities. Funding for flood control infrastructure should prioritize flood mitigation work in vulnerable communities.

Social Vulnerability – Power Outages

Power Outage	
Dangerous heat waves can cause large scale power outages where intense heat spikes electricity demand and aging infrastructure, leaving people without air conditioning or ways to communicate with others. Extreme snow and ice events, blizzards, Nor'easters, and Hurricanes also cause power outages	People who lack mobility or may be sick such as elderly or disabled population are at risk during heat waves when they remain isolated in their homes rather than finding a cooling center or public shelter. Heat loss during extreme snow events puts the vulnerable at risk.
Dangerous wildfires can cause power outages leaving vulnerable populations without heat or air conditioning. Individuals using electricity-dependent medical equipment or medications that need refrigeration.	People who lack mobility or may be sick such as elderly or disabled population are at risk during power outages and may remain isolated in their homes rather than finding a public shelter.
Senior adults are at particularly high risk to heat. They may not adjust to sudden changes in temperature and are more likely to have a chronic medical condition whose symptoms may be exacerbated by heat. They are more likely to be taking prescription medications that affect their ability to control body temperature.	Extreme weather conditions may require seniors to seek shelter where a generator can ensure heating and cooling during power outages due to extreme weather conditions. They should have a list of current medications available should sudden transportation to a shelter be necessary.
Schools that lack air conditioning or backup power shortage are a source of vulnerability for a community during heat waves.	In a weather-related emergency where schools are forced to shut down or serve as a community shelter, access to healthy meals for children and young adults is diminished.
Getting to school can be a challenge for vulnerable populations with limited resources.	Extreme weather events can close schools which provide important resources to low-income populations.
Oxygen dependent populations, vulnerable populations with medication requiring refrigeration, populations dependent upon electricity for heat and cooking	Database with vulnerable populations identified by limitation and level of assistance necessary.
Education and Social Support	
Socially vulnerable populations such as the elderly, disabled, or children are particularly susceptible to environmental risk factors such as flooding and heat.	Shared spaces such as public parks, shelters or cooling centers provide important social support systems during climate related emergencies.

Social Vulnerability – Flooding

Transportation	
A lack of transportation for low income and elderly populations limits access to critical infrastructure and services such as school, grocery, hospitals, emergency care, community centers, and public parks.	Natural disasters such as floods or extreme heat increases the need for reliable transportation services for people in need.
Power Outage	
Access to public transportation, critical roadway infrastructure, and public services can be impacted during an emergency event. Debris or other hazards can impact escape routes and alternatives for vulnerable populations.	Power outages due to flooding can impact access for emergency vehicles and communication of additional hazards or sheltering needs. Elderly and disabled persons are particularly vulnerable to isolation and inability to seek shelter unassisted.
Food Insecurity	
Transportation is an important community resource for socially vulnerable populations to provide access to critical infrastructure and services such as school, grocery, hospitals, emergency care, community centers, and public parks.	Power-outages can impact transportation. Flexible, coordinated transportation systems must account for the diverse needs of vulnerable populations. Access to medical appointments or social events and access to food are different for elderly and transitional youth populations.
Social Support	
Socially vulnerable individuals may not have access to transportation during emergency events.	Community preparedness and a strong social support system to safely identify and accommodate persons who need transportation. Community groups should prepare a plan to meet the needs of this group.

Social Vulnerability – Wildfires

Food Insecurity	
Getting access to food during a wildfire is a source of vulnerability	In a brushfire event where schools are forced to shut down, access to healthy meals for children and young adults is diminished.
Power Outage	
Dangerous wildfires can cause power outages leaving vulnerable populations without heat or air conditioning. Individuals using electricity-dependent medical equipment or medications that need refrigeration.	People who lack mobility or may be sick such as elderly or disabled population are at risk during power outages and may remain isolated in their homes rather than finding a public shelter.
Transportation	

Fires can impact access to public transportation, critical roadway infrastructure, and public services. It can impact escape routes and alternatives for vulnerable populations.	Transportation is an important community resource for socially vulnerable populations to provide access to critical infrastructure and services such as school, grocery, hospitals, emergency care, community centers, and public parks.
Social Support	
Socially vulnerable populations such as the elderly, disabled, or children are particularly susceptible to environmental risk factors from wildfires and brush fires such as exasperation of pre-existing medical conditions, asthma, respiratory and cardiovascular diseases.	Social support systems that help prepare communities for future climate events through climate health education and community preparedness helps the most at-risk populations in the community.

Prior to a hazard event, identify lead contacts serving vulnerable populations and coordinate actions to maximize safety and information sharing.

- To guarantee the proper dissemination of emergency and early warning information, the Town should identify key points of contact who can convey safety information prior to, during, and after a hazard event.

Create an educational program centered on flood hazards, coastal construction practices, and evacuation procedures.

- It is critically important that owners of properties within the floodplain understand their obligations. The Town will launch a consumer education campaign to convey this information. Communication channels may include advertisements, radio spots, news blasts, and social media, among other options.

Drafting a voluntary emergency assistance registry that includes people who are elderly, disabled, or have a medical condition that may require special assistance evacuating their housing during a vulnerability.

Debris Management Hazard Mitigation Actions

Large-scale natural disasters may generate debris in quantities greater than the amount of waste many communities handle each year. While this section does not provide all the information a community may need to plan for natural disaster debris, this document draws from communities' experiences and provides planning recommendations for managing natural disaster debris.

The primary goal of pre-incident debris management planning should be to prepare the community to manage natural disaster debris effectively in coordination with the whole community (i.e., all governmental, private, nonprofit, community, and other stakeholders). In addition to helping the community prepare for managing debris generated by natural disasters, pre-incident planning can encompass community resilience, source reduction, and hazard mitigation activities aimed at reducing the amount of time it takes a community to recover, the total amount of debris generated, and the release and exposure to potentially harmful components in the debris.

Pre-incident debris management planning can provide many benefits, such as:

- Saves valuable time and resources during a response to a disaster.
- Allows more efficient, effective, and environmentally responsible waste management decision-making during a disaster.
- Encourages stakeholders (e.g., state, local, tribal, and territorial governments, owners of private storage, treatment, and disposal facilities, residents) to work together before a disaster occurs.
- Boosts the community's resiliency in the wake of a disaster and positions it for a quicker and less costly recovery to its pre-incident state.
- Enhances the community's adaptation to the debris-related impacts of climate change; and
- Minimally detracts from, or otherwise impacts, the broader response and recovery efforts due to the efficient implementation of debris management activities.

Debris management planning activities that may provide the greatest benefit for a community that has limited resources and time to devote to planning include the following:

- ***Consult with key stakeholders and sectors***, including transportation, sanitation, emergency response, environmental, agricultural, public health, public works, zoning, and other industry and business leaders.
- ***Identify potential debris streams***, including harmful constituents, and possible quantities that may be generated by a disaster considering the industrial, agricultural, residential, and commercial zones in the community.
- ***Evaluate existing reuse and recycling programs*** to determine if they can be scaled up to handle disaster-related wastes.
- ***Consider waste collection strategies***, such as separating the debris into different waste streams before transporting it off-site.

- ***Determine locations (or criteria) and capacities for debris management sites*** that are suitable for debris staging, temporary storage, and decontamination activities.
- ***Select potential reuse, composting, recycling, treatment, and disposal facilities***, including mobile treatment units, that are currently available to the community, state, and region and assess their daily and long-term capacities.
- ***Create a debris management-focused community outreach plan***.
- ***Address health and safety considerations for debris management operations*** (e.g., handling orphaned tanks, animal carcasses, asbestos-containing materials, quarantined materials like pest-infested vegetative debris, and hazardous chemicals from school chemistry labs, medical offices, and hospitals).

Enhancing Residential Resiliency

Residents can take certain actions to limit the damage to their homes during natural disasters, decreasing the amount of debris generated, such as:

- Brace hot water heaters to keep them from toppling and rupturing gas lines to prevent fire outbreaks.
- Strengthen walls, foundations, and chimneys to limit damage.
- Bring inside or secure (e.g., with ground anchors or straps) all outdoor objects, such as trash cans and recycling bins, patio furniture, grills, and lawn ornaments (e.g., garden gnomes), to reduce potential projectiles and debris. If trash cans and recycling bins are left outside, strap down their lids (e.g., secure the lid with duct tape).
- Secure propane and other tanks and containers to limit spills and releases.
- Place barriers (e.g., sandbags) around structures to help divert debris and water.
- Remove dead or diseased trees and trim limbs away from buildings and water pipes to help prevent dislodged trees and branches and damage from flying vegetative debris.
- Cover and secure windows and doors (e.g., with protective shutters) to prevent damage from flying debris and reduce the risk of water damage.
- Use fire-safe landscaping and fire-resistant building materials (e.g., metal roofs and stucco) to reduce damage from fire.

Source: Planning for Natural Disaster Debris, EPA, April 2019

The disaster debris-related consequences of major natural disasters may include:

- Larger quantities of debris resulting from the disaster.
- Wider variety of generated debris at one time, including atypical wastes in greater quantities.
- Wider area of impact, possibly affecting more than one jurisdiction.

- Insufficient debris management capacity to handle surges in necessary recycling, treatment, and disposal of debris.
- Greater chances of debris management facilities being impacted by the disaster, resulting in a possible decrease in existing capacity for generated debris and reduction of available debris management options.
- Greater risk of releases from facilities and sites that store chemicals (e.g., industrial facilities, underground storage tank sites) and contaminated sites (e.g., Superfund sites, brownfields); and
- Increased greenhouse gas emissions from debris management activities, such as the transportation, treatment, and disposal of large amounts of debris.

Generally, natural disaster debris can include:

- ACM (e.g., asbestos pipe wrap, siding, and ceiling and floor tiles)
- Ammunition and explosives
- Animal carcasses
- Ash
- Asphalt
- Building contents (e.g., furniture, personal property)
- Commingled debris (i.e., a mixture of many debris types, such as C&D debris, vegetative debris, HHW, and building contents)
- C&D debris (e.g., mixed metals, masonry materials, concrete, lumber, asphalt shingles).
- Cylinders and tanks
- Electronics waste (e-waste) (e.g., televisions, computers, cell phones)
- Food waste (e.g., rotten food from grocery stores, restaurants, and residences)
- Hazardous waste (e.g., batteries, pesticides, solvents, paint thinners, mercury-containing devices)
- HHW (e.g., household cleaners, freezer, and refrigerator coolant).
- Lead-based paint
- Marine or waterway debris
- Medical waste
- Metals
- Mixed waste (i.e., waste containing both radioactive and hazardous waste components)
- Municipal solid waste (MSW)
- PCB-containing waste (e.g., transformers, capacitors, other electrical equipment)
- Pharmaceuticals
- Radiological-contaminated waste (e.g., hospital equipment)
- Scrap tires
- Soils, sediments, and sandbags
- Treated wood (e.g., utility poles, fencing, decks)
- Used oil and oil-contaminated waste.
- Vegetative debris (or green waste) (e.g., uprooted trees, branches, stumps, leaves)
- Vehicles and vessels; and
- White goods (i.e., household appliances, such as stoves, refrigerators, washers/dryers, air conditioner units)