Town of Whitman, Massachusetts

Integrated Municipal Vulnerability Preparedness and Hazard Mitigation Plan (MVP-HMP)

Community Resilience Building Workshop Summary of Findings

Prepared by

Old Colony Planning Council

June 2021

OLD COLONY
PLANNING COUNCIL

Acknowledgements

This plan was prepared for the Town of Whitman 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.

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Community Resilience Building Workshop

Summary of Findings

To prepare for the development of this MVP-HMP Plan, the Town of Whitman 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 values and priorities for Whitman 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 Whitman 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

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

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.

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 Whitman.
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.

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

Whitman CRB Planning Activities

A1. Does the Plan document the planning process, including how it was prepared and who was involved in the process for each jurisdiction? (Requirement §201.6(c)(1))

The planning process was developed in full compliance with the current planning requirements of the Federal Emergency Management Agency (FEMA) per the following rules and regulations:

- Robert T. Stafford Disaster Relief and Emergency Assistance Act (Public Law 93-288), as amended by the Disaster Mitigation Act of 2000
- Code of Federal Regulations – Title 44, Chapter 1, Part 201 (§201.6: Local Mitigation Plans)
- Federal Emergency Management Agency *Local Mitigation Plan Review Guide* (dated October 1, 2011)

The purpose of this hazard mitigation planning process is to create a Town of Whitman Hazard Mitigation Plan Update that meets all the requirements of both the Massachusetts Department of Emergency Management and FEMA.

The planning process to develop this updated mitigation plan took place in conjunction with the Town's Massachusetts Municipal Vulnerability Preparedness Program (MVP). Throughout the mitigation planning process, efforts were made to align the mitigation plan update with the MVP efforts.

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 Whitman, 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.

Federal regulations for HMP approval also guided the process. Most importantly, FEMA requires that stakeholders and the public have opportunities to be involved in the planning process and its maintenance and implementation. Community members can therefore provide input that can alter 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 of the Town, 2) Stakeholders who could be vulnerable to, or provide strength against natural hazards and/or climate change from Hanson and abutting communities. And 3) the public, who live and work in the Town and those entities from abutting communities.

Core Team

CORE TEAM MEMBER	DEPARTMENT
Lincoln Heineman	Town Administrator/ Capital Planning Committee
Bruce Martin	Highway Surveyor/Tree Warden
George Porter	Conservation Commission Chair
Robert Curran	Building Commissioner
Alexis Andrews	Board of Health Agent
Barbara Garvey	
Dennis Smith	Water Dept
Timothy Grenno	Fire Chief – Traffic Safety Committee
Timothy Hanlon	Police Chief
North and South River Watershed	
Eric Pretorius	Planning Board Chair
John Goldrosen	Zoning Board of Appeals Chair
Marie Lailer	Historical Commission
Kathleen Woodward	Recreation Director
Sara Lansing	Veterans Services Director

Stakeholder Engagement and Public Participation

A2. Does the Plan document an opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, agencies that have the authority to regulate development as well as other interests to be involved in the planning process? (Requirement §201.6(b)(2))

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 the Hazard Mitigation Plan 2021 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) process to complete this plan
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 2021 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.

Stakeholder Engagement

The Town of Whitman Planning Board is the primary town agency responsible for regulating development in the town. Their responsibilities include oversight of the Town's Master Plan, Studies and Reports, Public ways, Capital Improvement Program, Zoning and Subdivisions. Feedback to the Planning Board was ensured through the participation of the Town Administrator on the local hazard planning team. The Building Commissioner Robert Curran is the primary town agency responsible for administration of the Zoning Bylaws in the Town of Whitman. In addition, the Old Colony Planning Council, the state-designated regional planning agency for Whitman, works with all agencies that regulate development in its region, including the municipal entities listed and state agencies, such as Department of Conservation and Recreation and MassDOT. This regular involvement ensured that during the development of the Town of Whitman Integrated MVP HMP Plan, the operational policies and any mitigation strategies or identified hazards from these entities were incorporated.

The Community Resilience Building (CRB) Workshop was held over three separate dates, April 28th, April 30^{th,} and May 5th through Zoom video conferencing. The first workshop focused on the strengths and vulnerabilities to Infrastructure from natural hazards and impacts of climate change. The second workshop focused on Environmental strengths and vulnerabilities in relation to those same impacts and the third focused on Societal impacts.

Invitees to the Workshop 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.

Neighboring communities and regional stakeholders were notified of the Workshop invited to participate through email invitations, flyers, press releases. Delegates of Old Colony Planning Council were provided electronic links to the draft Plan and survey and were requested to review the material with their community and provide comment through several methods including email, survey response, written response or telephone. The draft plan was presented to regional delegates of Old Colony Planning Council for their review and comment at two subsequent monthly meetings of the Council. The draft Plan was also placed on the OCPC website and advertised in the e-newsletter requesting public review and comment.

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 Whitman is contingent upon ongoing participation of community stakeholders.

The following list represents the people and organizations invited to participate in the CRB Workshop. All Workshop invitees are listed below; attendees are indicated with an asterisk.

Core Team Members and Invitees	Department or Agency
Lincoln Heineman*	Town Administrator/ Capital Planning Committee
Bruce Martin*	Highway Surveyor/Tree Warden
George Porter*	Conservation Commission Chair
Sandra Cortez	Conservation Commission Vice-Chair
Robert Curran*	Building Commissioner
Daniel Kelly*	Board of Health Agent
Alexis Andrews*	Health Inspector, Town of Whitman
Mary Holland*	Council on Aging Director
Alfred Cunningham*	Deputy Fire Chief
Lisa Riley*	Asst. to the Fire Chief, Deputy Director of Administration
Dennis Smith	Water Dept
David Cook	Public Works Board of Commissioners
Timothy Grenno*	Fire Chief – Traffic Safety Committee

Timothy Hanlon*	Police Chief
Eric Pretorius*	Planning Board Chair
John Goldrosen*	Zoning Board of Appeals Chair
Kathleen Woodward*	Recreation Director
Marie Lailer*	Historic Commission Chair
Sara Lansing *	Veterans Services Director
Jamison Shave	Town of Hanson, Highway Dept.
Deborah Pettey	Town of Hanson, Town Planner
John Stanbrook	Town of Hanson, Town Administrator
Shane O'Brien	Town of Kingston, Town Planner
Michelle Grenier	Town of Hanover, Town Planner
Raymond Guarino*	Senior Transportation Planner, OCPC
Joanne Zygmunt*	Senior Economic Development & Environmental Planner
Dottie Fuginiti*	Economic Recovery Planner, OCPC
Laurie Muncy, AICP*	Director, Community Planning & Economic Development, OCPC
Mary Waldron*	OCPC, Executive Director
Carl Kowalsko	Chairman BOS
Dan Salvucci	Vice-Chairman BOS
Noreen O'Toole	Business Owner, Delegate OCPC
Kathleen Keefe	Assessor, Town of Whitman

Public Outreach

A3. Does the Plan document how the public was involved in the planning process during the drafting stage? (Requirement §201.6(b)(1)

The Public Outreach Strategy was designed to involve the public in the mitigation planning process. The purpose of public outreach and stakeholder involvement was to:

- Generate public interest in mitigation planning.
- Accommodate special populations identified in the Town.
- Solicit public input.
- Engage local stakeholders.
- Create opportunites for the public and local stakeholders to be actively involved in the mitigation planning process.

The public outreach strategy included a Public Survey, Public Meetings/Listening Sessions and a YouTube video presentation to provide opportunity for those who were unable to attend the Workshop to review the information and information of where to review the draft plan. The initial Core Team Meeting and all three Workshops were recorded for distribution on YouTube.

The Public Survey was an integral part of the Public Outreach Strategy. It provided the public with an opportunity to comment on their level of interest, knowledge, and readiness toward hazards in the Town. The survey was developed on SurveyMonkey in English. A copy of the survey and results is located in Appendix C.

The draft Plan was provided to delegates of Old Colony Planning Council through 2 monthly council meetings. These delegates were requested to provide the materials to the communities they represent for review and comment.

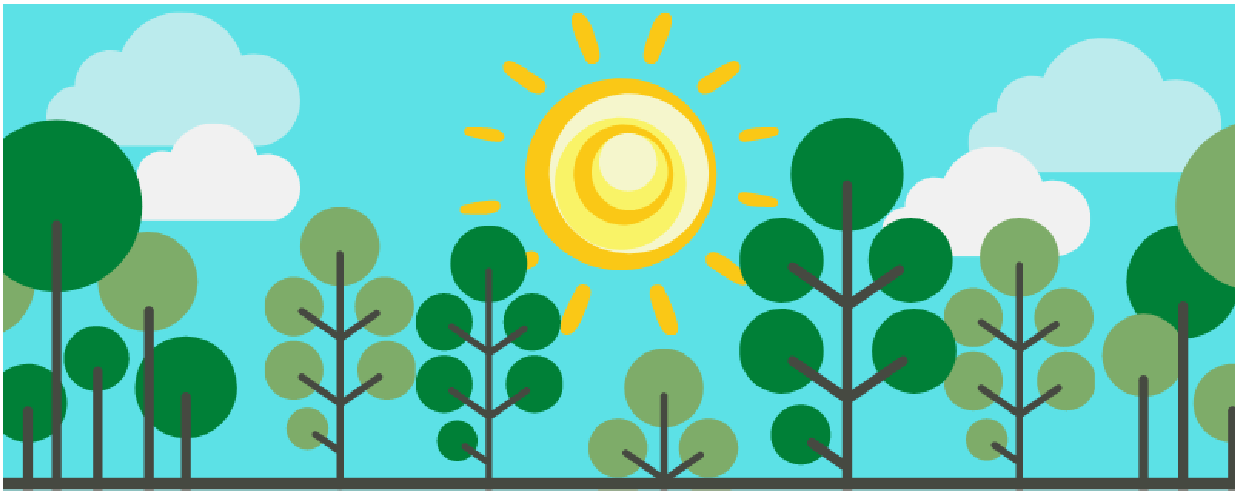
Public Meetings/MVP Listening Sessions

The Planning Grant Kickoff Meeting was held on March 9, 2021, with Town Administrator Lincoln Heineman through a Zoom video conference. The first Core Team Meeting was held on April 9, 2021, as a working Kickoff Meeting with a project introduction and climate change vulnerability assessment presentation. A public listening session was held on April 15, 2021, on Zoom video conference to provide the public with information on the HMP Update and MVP Workshop CRB process. A copy of this presentation is included in Appendix A.

The first public meeting was held during the planning process: April 9, 2021, on a Zoom video conference. Outreach for these meetings included press releases, flyers, email announcements and personal invitations. A presentation was made for each meeting and these presentations were made available on the OCPC website for public review and comment. Anyone who reviewed the presentations online was encouraged to comment. A copy of the slides from the listening session is included for review in Appendix A. Copies of the Workshop presentations are included in Appendix B.

CORE TEAM MEETING AND LISTENING SESSION DATES	TOPICS
Planning Grant Kickoff Meeting 03/09/2021	MVP Kickoff with Town Administrator
Core Team Meeting 04/09/2021	MVP Kickoff Meeting – Project Introduction, Climate Vulnerability Assessment, Municipal Vulnerability Preparedness, Community Engagement Plan, Task Force Role. Identification of Climate Concerns.
Public Listening Session #1 April 15, 2021	The updated HMP includes additional sections including Climate Change Projections and Resiliency, Epidemic-Pandemic, Vector-Borne Disease, Debris Management and Disaster Financial Management. Section 6 Plan Maintenance Procedures for Monitoring,

	Evaluating, and Updating the Plan. Critical Infrastructure List provided for review and update. Public Outreach for Workshop participation.
CRB Workshop April 28, 2021, Part 1 Infrastructure	Intro to Climate Change and MVP, Whitman Climate Change Vulnerability, Identification of Risk Areas and Community Strengths
CRB Workshop April 30, 2021, Part 2 Environmental	Create Climate Actions, Prioritize Climate Actions, Large Group Report Out, Community Resilience Building, Prioritize Top Resilience Actions – Engagement Exercise
CRB Workshop May 5, 2021, Part 3 Societal	Review Social Vulnerability, identify immediate opportunities to collaboratively advance action to increase resilience, Large Group Report Out.
Public Listening Session #2 May 18, 2021	Public Listening Session #1 – Integrated MVP/HMP Planning On-line Zoom video conferencing webinar recorded for upload to YouTube for additional public review and comment. Public Comment period opened through the end of May. Comments after May 30th will be recorded for future updates.



TOWN OF WHITMAN
MVP-HMP WORKSHOPS

These **M**unicipal **V**ulnerability **P**reparedness & **H**azard **M**itigation **P**lan Workshops take your concerns for the environment and put them into a plan of action!

Workshops start @ 10 am #ResilientWhitman

1. **Wed. April 28, 2021 ZOOM ID: 842 0534 3579**
2. **Fri. April 30, 2021 ZOOM ID: 860 1848 5500**
3. **Wed. May, 5, 2021 ZOOM ID: 818 9677 3099**

Scan to Take Our Survey!

For more info contact Elijah Romulus at eromulus@ocpcrpa.org or 508-583-1833 Ext: 210

HOSTED BY OLD COLONY PLANNING COUNCIL

Town of Whitman Seeks Public Input for
Municipal Vulnerability Preparedness & Hazard Mitigation Plan

The Town of Whitman has embarked on a planning process to identify projects to reduce the potential impacts from natural hazards like severe storms, flooding, and extreme heat. The Town will also consider the likelihood of experiencing more severe natural hazards more frequently due to projected climate change. The planning process will broadly focus on three topic areas: infrastructure assets, societal and economic resilience, and environmental resources.

The Town of Whitman's resilience is evident through the community's response to the current public health concerns and historic responses to weather-related events. The Municipal Vulnerability Preparedness (MVP) and Hazard Mitigation Plan (HMP) Project aims to document historic successes and challenges in order to better develop solutions for tomorrow. The Town is seeking input from the public in this process. Feedback from the community is vital to ensure the planning process is comprehensive and relevant to its constituents.

Given the current COVID-19 crisis, in person public meetings will not be possible. However, the Town is making available resources to connect as a community online. The latest information will be available on a dedicated project webpage. Posts will also be found on the Town's social media platforms. The Town plans to release videos, surveys, and more in the coming days to hear about experiences, concerns, ideas, and solutions for the challenges associated with natural hazards and climate change. A copy of the draft report can be found here (https://documentcloud.adobe.com/link/review?uri=urn%3Aaaid%3Ascds%3AUS%3Ad6d362a7-0a70-4a61-a4dc-3e1dc545ada3) A recording of the first public listening session can be viewed here (Whitman MVP/HMP Public Listening Session I - Zoom). **For those attending the workshops and for those who cannot, a survey for your input can be found here:** (https://www.surveymonkey.com/r/33RGRVT)

As part of integrated the process, the Town of Whitman will also fulfill the Federal Emergency Management Agency's (FEMA) requirements to update the Town's Hazard Mitigation Plan (HMP) from 2015. The HMP update will maintain the Town's eligibility for FEMA grant funding.

Virtual Workshops will be held at 10 am on:

- **Wednesday April 28 (Zoom ID 842 0534 3579),**
- **Friday April 30 (Zoom ID 860 1848 5500), and**
- **Wednesday May 5, 2021 (Zoom ID 818 9677 3099).**

If you would like to receive updates on this project, please forward your contact information to Elijah Romulus, Senior Comprehensive Planner at Old Colony Planning Council (eromulus@ocpcrpa.org) or 508-583-1833 Ext: 210.

#ResilientWhitman

TOWN OF WHITMAN MVP-HMP PUBLIC LISTENING SESSION TUESDAY MAY 18, 2021 @ 6PM ON ZOOM

The Town of Whitman will host a public listening session to provide an overview of the planning process, climate impacts in Whitman and the results of the CRB Workshops. Three Workshops were held in April & May during which participants helped to define the top local natural and climate-related hazards of concern, identified existing and future strengths and vulnerabilities, and identified and prioritized actions and projects the Town can implement to increase resilience to climate change. Communities that complete the MVP certification program are eligible for Action Grant funding and other opportunities.

This is an opportunity for Whitman residents and other community members to review and comment on the Action Priority Outcomes of the MVP Planning Process as well as the Draft Integrated MVP HMP, as prepared by OCPC.

Provide public comment between **May 19 – June 3, 2021**

- **Please register in advance of the meeting:**
  https://us02web.zoom.us/webinar/register/WN_3uRYDxF0SsOPtOYgwKIB1Q
  Once registered you will receive the link to join the session.

- MVP HMP Plan is posted:
  https://documentcloud.adobe.com/link/review?uri=urn%3Aaaid%3Ascds%3AUS%3Ad6d362a7-0a70-4a61-a4dc-3e1dc545ada3#pageNum=1
- Comment via email to: **eromulus@ocpcrpa.org** or phone: **508-583-1833 Ext: 210**
- **Complete our survey here: https://www.surveymonkey.com/r/33RGRVT**

OLD COLONY PLANNING COUNCIL

THE COMMONWEALTH OF MASSACHUSETTS
TOWN OF WHITMAN
PUBLIC LISTENING SESSION TO REVIEW THE
MUNICIPAL VULNERABILITY PREPAREDNESS (MVP) AND HAZARD MITIGATION PLAN (HMP)

*ATTENTION: THIS MEETING WILL BE CONDUCTED VIRTUALLY VIA ZOOM. A RECORDING OF THE MEETING WILL BE AVAILABLE DURING OR AS SOON AS POSSIBLE AFTER THE MEETING BY LOGGING ON TO THE WHITMANHANSON CABLE ACCESS TV'S YOUTUBE SITE:

HTTPS://WWW.YOUTUBE.COM/USER/WHCA9TV

The Town of Whitman, acting through the office of the Town Administrator, will call to order a Zoom webinar on **April 15, 2021, at 10AM**. This virtual meeting will serve as a Listening Session to review the Town of Whitman's Municipal Vulnerability Preparedness (MVP) and Hazard Mitigation Plan (HMP) Plan.

The objectives of this summary:

- 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.

The key product of this integrated process is the development of a combined Municipal Vulnerability Preparedness (MVP) and Hazard Mitigation Plan (HMP) Plan with a Prioritized Implementation Schedule.

A copy of the draft plan for review can be downloaded at

https://www.hanson-ma.gov/sites/g/files/vyhlif3231/f/uploads/hanson_summy_of_findings.pdf

Please direct questions and comments to Laurie Muncy at lmuncy@ocpcrpa.org or (508) 583-1833 extension 210. You may also mail comments to Old Colony Planning Council, 70 School Street, Brockton, MA 02302. **Comments must be received by 4 p.m. on March 5, 2021.**

You are invited to stream live at
HTTPS://WWW.YOUTUBE.COM/USER/WHCA9TV

Review of the Draft Plan

After the Core Team reviewed the Draft Plan, the Town made the Plan available to the public for a two-week period. The OCPC distributed a press release announcing the availability of the Plan for public review. The Core Team informed their departments/agencies about the draft Plan. The Town posted information regarding the draft plan on their website. The plan was also posted on the OCPC website for public review and comment [Town of Whitman Integrated MVP HMP Plan (ocpcrpa.org)]

Review and Incorporation of Existing Studies

A4. Does the Plan describe the review and incorporation of existing plans, studies, reports, and technical information? (Requirement §201.6(b)(3))

Many sources were used to develop this plan, including web-based resources, reports, and stakeholder engagement. Throughout the plan, these sources are cited within the text, and included as footnotes.

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 Whitman. This section reviews details of several key plans and studies, and how their content influenced the development of this plan.

Massachusetts Hazard Mitigation and Climate Adaptation Plan, 2018

Consistency with the State Plan is required. The State Plan was used as a starting point for hazard identification and then for hazard analysis. Details are included in the Risk Assessment. Of significance is the classification of natural hazards in terms of climate change interactions, changes in precipitation, rising temperatures, extreme weather, and non-climate influenced hazards.

Natural Hazard Mitigation Plan for the Old Colony Region, May 2015

The Town of Whitman Integrated Municipal Vulnerability Preparedness and Hazard Mitigation Plan reflects a complete update of the previous regional Hazard Mitigation Plan prepared in 2015 for the OCPC region in its entirety.

Town of Whitman Capital Improvement Plan FY2021 – FY2025

The FY2021 – FY2025 Capital Improvement Plan (CIP) for the Town of Whitman invests more than $26.7 million into the community for a variety of goals, for example: maintaining and upgrading roadways to ensure safe and comfortable travel, replacing old and failing vehicles used to accomplish the day-to-day operations of Police, Fire, and Public Works and investing in the Town's properties, including the construction of a new DPW Facility.

Town of Whitman Community Development Strategy, 2012

The Town's Community Development Strategy should reference or incorporate findings of relevant plans and analyses that have been completed and used for decision-making purposes by municipal boards, agencies, and departments. Such plans may include but are not limited to EO 418 Community Development Plans, EO 418 housing strategies, Capital Improvement Plans, Master Plans, Downtown Plans, Open Space and Recreation Plans, Area Revitalization Strategies, Urban Renewal Plans, the regional Comprehensive Economic Development Strategy, and a Community Action Statement (CAS).

Town of Whiman Stormwater Management Plan EPA NPDES Permit Number: MA04071, June 2019.

Town of Whitman Proposed Floodplain District and Watershed Protection District Bylaw, April 2021.

Old Colony Bicycle and Pedestrian Connectivity and Livability Study, March 2018

This study contains information on the current bicycle and pedestrian transportation network, the types of bicycle and pedestrian infrastructure treatments, best practices, and future proposals for the bicycle and pedestrian network for the OCPC region.

Plan Maintenance Procedures

A5. Is there discussion on how the community will continue public participation in the plan maintenance process? 44 CFR 201.6(c)(4)(iii)

This section details the formal process that will ensure that the Hazard Mitigation Plan (HMP) remains an active and relevant document and the Town maintains their eligibility for applicable funding sources and reflects their continuing commitment to reducing risks from natural hazards and climate change.

Plan Adoption and Maintenance

The Town of Whitman 2021 Integrated Municipal Vulnerability Preparedness and Hazard Mitigation Plan was adopted by the Board of Selectmen on [ADD DATE]. See page 72 for documentation. The plan was approved by FEMA on [ADD DATE] for a five-year period that will expire on [ADD DATE].

The plan maintenance process includes a schedule for monitoring and evaluating the plan annually and producing an updated plan every 5 years. In addition, this section describes how public participation will be integrated throughout the plan maintenance and implementation process. It explains how the mitigations strategies outlined in this plan update will be incorporated into existing planning mechanisms and programs, such as comprehensive land use planning processes, capital improvement planning, and building code enforcement and implementation. The plan's format allows sections to be reviewed and updated when new data becomes available, resulting in a plan that will remain current and relevant.

After approval of the Plan by FEMA, the Hazard Mitigation Planning Core Team will meet to function as the Hazard Mitigation Implementation Team with the Town Planner and Zoning Enforcement Officer designated as HMP Coordinators. Additional members could be added to the local implementation team from businesses, non-profits, and institutions. The Town will encourage public participation during the next 5-year planning cycle. As annual updates and a review of the plan are conducted by the Hazard Mitigation Implementation Team, these will be placed on the Town's web site, and any meetings of the Hazard Mitigation Implementation Team will be publicly noticed in accordance with town and state open meeting laws.

The overall responsibility to implement, monitor, evaluate, enhance, and provide strategic policy over time are the Hazard Mitigation Implementation Team and HMP Coordinators, and together with the lead agencies will oversee plan maintenance. This team will also lead the following ongoing activities.

- Help ensure the current version of the HMP is made readily accessible to municipal agencies and the public, including an online version on the Town website.
- Provide clear methods for stakeholders to review and provide comments on the plan and/or its effectiveness, especially during any scheduled plan reviews or updates.
- Support incorporation into other municipal plans, policies, programs, or activities.

The annual review process shall include an evaluation of the plan's effectiveness for the area. Criteria used to evaluate the plan includes:

- The goals and objectives address current and expected conditions.
- The nature, magnitude and/or types of risk have changed.
- The current resources are appropriate for implementing the plan.
- The outcomes have occurred as expected.
- The agency and partners participated as originally proposed.

The plan maintenance matrix shown in the following Table provides a synopsis of responsibilities for plan monitoring, evaluation, and update, which are discussed in further detail in the sections below.

Task	Approach	Timeline	Lead Responsibility	Support Responsibility
Monitoring	Outreach to planning partners to recommend update of mitigation strategies and progress toward implementation of project, identification of new projects, and to provide updated information on funding opportunities	Each August or after the occurrence of a presidentially declared disaster	Jurisdictional points of contact – Hazard Mitigation Implementation Team	HMP Coordinators – Town Planner and Zoning Enforcement Officer OCPC
Integration	For integration of mitigation principles	August of each year with interim email	Hazard Mitigation Implementation Team	HMP Coordinators – Town Planner and

	action to become an organic part of the ongoing municipal activities, the town will incorporate the distribution of the safe growth checklist for annual review and update by all participating jurisdictions.	reminders to address integration in municipal activities.	HMP Coordinators	Zoning Enforcement Officer
Evaluation	Review the status of previous actions as submitted by the monitoring task lead and support to assess the effectiveness of the plan; compile and finalize update of mitigation strategy	Updated progress report completed by September 30 of each year	Hazard Mitigation Implementation Team HMP Coordinators	Alternate jurisdictional points of contact
Update	Reconvene the Hazard Mitigation Implementation Team, at a minimum, every 5 years to guide a comprehensive update to review and revise the plan.	Every 5 years or upon major update to Comprehensive Plan or after the occurrence of a major disaster.	Hazard Mitigation Implementation Team	HMP Coordinators – Town Planner and Zoning Enforcement Officer

Monitoring, Evaluating, and Updating the Plan

A6. Is there a description of the method and schedule for keeping the plan current (monitoring, evaluating, and updating the mitigation plan within a 5-year cycle)? 44 CFR 201.6(c)(4)(i)

The procedures for monitoring, evaluating, and updating the plan are provided below.

The HMP Coordinators are assigned to manage the maintenance and update of the plan during its performance period. The HMP Coordinators will chair the Hazard Mitigation Implementation Team and be the prime point of contact for questions regarding the plan and its implementation as well as to coordinate incorporation of additional information into the plan.

Monitoring

The Hazard Mitigation Implementation Team will monitor progress on the HMP, evaluate the HMP's effectiveness, and document annual progress. Each year, beginning 1 year after development of the HMP, the Team will collect and process information from persons in departments, agencies, and organizations involved in initiating and/or overseeing mitigation projects or in activities identified within their jurisdiction.

Annual Plan Review

The following tasks may be completed during the annual plan review:

- Evaluate overall progress on hazard mitigation and climate adaptation actions, especially those identified as short-term actions. The most recent status updates provided by municipal departments shall be reviewed and discussed to measure progress.
- Identify any problems or barriers associated with plan implementation (technical, administrative, financial, political, or legal), along with any required or recommended corrective actions.
- Examine any notable changes in the risks or vulnerabilities related to natural hazards and climate change based on new data and information, updated climate change projections or lessons learned through actual hazard occurrences. Special attention should be given to technical reports or scientific studies or hazard/climate risks, local HMPs from local cities and towns, the regional planning agency, and other sectors.
- Identify any major changes to federal or state laws, authorities, regulations, funding, or other measures that may necessitate revisions or amendments to the HMP.
- Prepare an internal summary of the results and findings of the above tasks, in addition to any other notable updates to the general status and implementation of the HMP. The summary may highlight any proposed additions, amendments, or improvements required for the plan to increase its overall effectiveness.

It is anticipated that all participating partners will update the HMP progress on an annual basis, providing an incentive for participants to refresh their mitigation strategies and to continue implementation of projects. In addition to progress on the implementation of mitigation actions, including efforts to obtain outside funding and obstacles or impediments to implementation of actions, the information that planning partners shall be expected to document, as needed and appropriate, include:

- Any grant applications filed on behalf of any of the participating jurisdictions.
- Hazard events and losses occurring within the jurisdiction.
- Progress on implementation of mitigation actions, including efforts to obtain outside funding.
- Obstacles or impediments to implementation of actions.
- Additional mitigation actions believed to be appropriate and feasible.
- Public stakeholder input.

Integration Process of the HMP into Municipal Planning Mechanisms

C6. Does the Plan describe a process by which local governments will integrate the requirements of the mitigation plan into other planning mechanisms, such as comprehensive or capital improvement plans, when appropriate? (Requirement §201.6(c)(4)(ii))

Hazard mitigation is sustained action taken to reduce or eliminate the long-term risk to human life and property from natural hazards. Integrating hazard mitigation into the Town's existing plans, policies and programs leads to development patterns that do not increase risk from known hazards or leads to redevelopment that reduces risk from known hazards.

The Hazard Mitigation Implementation Team will incorporate mitigation planning as an integral component of daily municipal operations. HMP Coordinators will work with municipal officials to integrate the newly adopted hazard mitigation goals and actions into the general operations of government and partner organizations. By doing so, the Hazard Mitigation Implementation Team anticipates:

1. Hazard mitigation planning will be formally recognized as an integral part of overall planning and emergency management efforts; and
2. The HMP, Comprehensive Plans, Emergency Management Plans, and other relevant planning mechanisms will become mutually supportive documents that work in concert to meet the goals and needs of residents.

The Town will identify additional policies, programs, practices, and procedures that could be modified to accommodate hazard mitigation actions and include those findings and recommendations in the ***Annual HMP Progress Report.*** The following checklist was adapted from FEMA's *Local Mitigation Handbook (2013), Appendix A, Worksheet 4.2.* This checklist will help the Town analyze how hazard mitigation is integrated into local plans, ordinances, regulations, and policies. By completing the checklist, it will help the Town identify areas that integrate hazard mitigation currently and where to make improvements and reduce vulnerability in future development. In this manner, the integration of mitigation into municipal activities will evolve into an ongoing culture within the community.

Planning Mechanisms	Do You Do This? Yes	No	Notes: How is it being done or how will this be utilized in the future?
Operating, Municipal and Capital Improvement Program Budgets			
• When constructing upcoming budgets, hazard mitigation actions will be funded as budget allows. Construction projects will be evaluated to see if they meet the hazard mitigation goals.			
• Annually, during adoption process, the municipality will review mitigation actions when allocating funding.			
• Do budgets limit expenditures on projects that would encourage development in areas vulnerable to natural hazards?			
• Do infrastructure policies limit extension of existing facilities and services that would encourage development in areas vulnerable to natural hazards?			
• Do budgets provide funding for hazard mitigation projects identified in the HMP?			
Human Resource Manual			
• Do any job descriptions specifically include identifying and/or implementing mitigation projects/actions or other efforts to reduce natural hazard risk?			
Building and Zoning Ordinances			
• Prior to, zoning changes, or development permitting, the municipality will review the HMP and other hazard analyses to ensure consistent and compatible land use.			
• Does the zoning ordinance discourage development or redevelopment within natural areas including wetlands, floodways, and floodplains?			
• Does it contain natural overlay zones that set conditions			
• Does the ordinance require developers to take additional actions to mitigate natural hazard risk?			
• Do rezoning procedures recognize natural hazard areas as limits on zoning changes that allow greater intensity or density of use?			
• Do the ordinances prohibit development within, of filling of, wetlands, floodways, and floodplains?			
Subdivision Regulations			
• Do the subdivision regulations restrict the subdivision of land within or adjacent to natural hazard areas?			
• Do the subdivision regulations restrict the subdivision of land within or adjacent to natural hazard areas?			
• Do the regulations provide for conservation subdivisions or cluster subdivisions in order to conserve environmental resources?			
• Do the regulations allow density transfers where hazard areas exist?			
Comprehensive Plan			
• Are the goals and policies of the plan related to those of the HMP?			

Planning Mechanisms	Do You Do This? Yes	No	Notes: How is it being done or how will this be utilized in the future?
• Does the future land use map clearly identify natural hazard areas?			
• Do the land use policies discourage development or redevelopment with natural hazard areas?			
• Does the plan provide adequate space for expected future growth in areas located outside natural hazard areas?			
Land Use			
• Does the future land use map clearly identify natural hazard areas?			
• Do the land use policies discourage development or redevelopment with natural hazard areas?			
• Does the plan provide adequate space for expected future growth in areas located outside natural hazard areas?			
Transportation Plan			
• Does the transportation plan limit access to hazard areas?			
• Is transportation policy used to guide growth to safe locations?			
• Are transportation systems designed to function under disaster conditions (e.g. evacuation)?			
Environmental Management			
• Are environmental systems that protect development from hazards identified and mapped?			
• Do environmental policies maintain and restore protective ecosystems?			
• Do environmental policies provide incentives to development that is located outside protective ecosystems?			
Grant Applications			
• Data and maps will be used as supporting documentation in grant applications.			
Municipal Ordinances			
• When updating municipal ordinances, hazard mitigation will be a priority			
Economic Development			
• Local economic development group will take into account information regarding identified hazard areas when assisting new businesses in finding a location.			
Public Education and Outreach			
• Does the municipality have any public outreach mechanisms / programs in place to inform citizens on natural hazards, risk, and ways to protect themselves during such events?			

Evaluating

The evaluation of the HMP is an assessment of whether the planning process and actions have been effective, whether the HMP goals are being achieved, and whether changes are needed. The HMP will be evaluated on an annual basis to determine the effectiveness of the programs and to reflect changes that could affect mitigation priorities or available funding.

The status of the HMP will be discussed and documented at an annual plan review meeting of the Hazard Mitigation Implementation Team, to be held in person or via teleconference approximately 1 year from the date of local adoption of this update, and successively thereafter.

The HMP Coordinators will ask the Town to assess progress toward meeting plan goals and objectives. These evaluations will assess whether:

- Goals and objectives address current and expected conditions.
- The nature or magnitude of the risks has changed.
- Current resources are appropriate for implementing the HMP and if different or additional resources are now available.
- Actions are cost effective.
- Schedules and budgets are feasible.
- Implementation problems are present (such as technical, political, legal, or coordination issues with other agencies).
- Outcomes have occurred as expected.
- Changes in county or town resources impacted plan implementation (e.g., funding personnel or equipment).
- New agencies, departments, or staff that should be included, including other local governments.

The HMP Coordinators will evaluate how other programs and policies have conflicted or augmented planned or implemented measures and shall identify policies, programs, practices, and procedures that could be modified to accommodate hazard mitigation actions. Other programs and policies can include those that address the following:

- Economic development
- Environmental preservation
- Historic preservation
- Redevelopment
- Health and safety
- Recreation
- Land use/zoning
- Public education and outreach
- Transportation

The HMP Coordinators shall be responsible for preparing an Annual HMP Progress Report for each year of the performance period, based on the information provided by the Hazard Mitigation Implementation Team meeting, and other information as appropriate and relevant. These annual reports will provide data for the 5-year update of this HMP and will assist in pinpointing any implementation challenges. By monitoring the implementation of this HMP on an annual basis, the Hazard Mitigation Implementation Team will be able to assess which projects are completed, which are no longer feasible, and which projects should require additional funding.

The Annual Progress Report should be posted on the Town website to keep the public apprised of the plan’s implementation.

The HMP will also be evaluated and revised following any major disasters to determine if the recommended actions remain relevant and appropriate. The risk assessment will also be revisited to see if any changes are necessary based on the pattern of disaster damages or if data listed in the Hazard Profiles of this Plan. This is an opportunity to increase the community's disaster resistance and build a better and stronger community.

Updating

The facilitate the updating process, the HMP Coordinators shall, with support of the Hazard Mitigation Implementation Team, use the second annual Hazard Mitigation Implementation Team meeting to develop and commence the implementation of a detailed plan update program. Prior to the 5-year update, the HMP Coordinators shall invite representatives to provide guidance on plan update procedures. This shall, at a minimum, establish who shall be responsible for managing and completing the plan update effort, what needs to be included in the updated plan, and a detailed timeline with milestones to ensure that the update is completed according to regulatory requirements.

At this meeting, the project team shall determine what resources will be needed to complete the update and seek to secure these resources.

Following each 5-year update of the HMP, the updated plan will be distributed for public comment. After all comments are addressed, the HMP will be revised and distributed to all members of the Hazard Mitigation Implementation Team.

Grant Monitoring and Coordination

The HMP Coordinators will keep members of the Hazard Mitigation Implementation Team apprised of Hazard Mitigation Assistance grant openings.

Grant monitoring and coordination is expected to occur as needed or annually based on the availability of non-HMP or post-disaster funding opportunities.

Continued Public Involvement

The Town is committed to continued involvement of the public in the hazard mitigation process. Therefore, this HMP will be posted online on the Town's website and will make hard copies available for review at public locations identified as such on the website. In addition, public outreach, and dissemination of the HMP might include:

- Continued utilization of existing social media outlets (Facebook, Twitter) to inform the public of flood hazards and severe storm events.
- Education of the public via jurisdictional websites on how to use these applications during an emergency event.
- Promotion of articles or workshops on hazards to educate the public and keep them aware of the dangers of hazards.

The Hazard Mitigation Implementation Team and the HMP Coordinators will be responsible for receiving, tracking, and filing public comments regarding this HMP. The public will have an opportunity to comment on the plan via the hazard mitigation website at any time. The HMP Coordinators will maintain this website, posting new information and maintaining an active link to collect public comments. The public can also provide input at the Annual Review meeting for the HMP and during the next 5-year plan update. The HMP Coordinators are responsible for coordinating the plan evaluation portion of the meeting, soliciting feedback, collecting, and reviewing the comments, and ensuring their incorporation in the 5-year plan update as appropriate. Additional meetings might also be held as deemed necessary by the planning group. The purpose of these meetings would be to provide the public an opportunity to express concerns, opinions, and ideas about the HMP.

The Hazard Mitigation Implementation Team shall be responsible to ensure that:

- Public comment and input on the plan, and hazard mitigation in general, are recorded and addressed, as appropriate.
- Copies of the latest approved plan (or draft in the case that the five-year update effort is underway) are available for review, along with instructions to facilitate public input and comment on the plan.
- Appropriate links are included on the Town website.
- Public notices are made as appropriate to inform the public of the availability of the plan, particularly during plan update cycles.

The HMP Coordinators shall be responsible to ensure that:

- Public and stakeholder comment and input on the plan, and hazard mitigation in general, are recorded and addressed, as appropriate.
- The HMP website is maintained and updated as appropriate.
- Copies of the latest approved plan are available for review at appropriate town facilities along with instructions to facilitate public input and comment on the plan.
- Public notices, including media releases, are made as appropriate to inform the public of the availability of the plan, particularly during plan update cycles.

Mitigation Action Progress Report Form

Progress Report Period	From Date:	To Date:
Action/Project Title		
Responsible Agency		
Contact Name		
Contact Phone/Email		
Project Status	❏ Project completed ❏ Project canceled ❏ Project on schedule ❏ Anticipated completion date:______________________________ ❏ Project delayed Explain ______________________________________	

Summary of Project Progress for this Report Period

1. What was accomplished for this project during this reporting period?

2. What obstacles, problems, or delays did the project encounter?

3. If uncompleted, is the project still relevant? Should the project be changed or revised?

4. Other comments

Top Hazards

To ensure a bottom-up approach, the planning team made the decision to allow the workshops' participants to identify their own top four hazards rather than pre-determining the hazards beforehand. To facilitate that process, OCPC presented a variety of past and current weather- and infrastructure-related challenges the town faces. These challenges were identified based on findings from previous planning processes such as the 2015 OCPC Regional Hazard Mitigation Plan, stakeholder input, and new climate change projections. The participants used this information to talk through the suite of priority climate hazards and negotiate common agreement on their top four hazards. For the workshop, four hazards were selected as the most pressing for the Town.

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

1. ***Inland Flooding*** – 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.

2. ***Hurricanes and Tropical Storms*** – 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. Serious power outages can also be associated with these types of events.

3. ***Extreme Wind and Thunderstorms -*** 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.

4. ***Snowstorms and Nor'easters*** – Severe winter storms include ice storms, nor'easters, heavy snow, blowing snow, and other extreme forms of winter precipitation. 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.

Areas of Concern

Infrastructure: Pole-based electricity and communication lines, town and state-owned roads, road pass ability.

Water Infrastructure: Dams, culverts, and bridges; drinking water, storage, pump, and distribution system.

Natural Resources: Tree canopy and hazard trees, invasive species, habitat change.

Human and Social: Changing age-related demographics, residents with limited mobility, poverty-level and low-income populations, emergency shelter network, emergency communications platform.

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 the Table 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 Whitman

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	Locally Identified Flood Area	100-Year Wind Event (MPH)	Average Annual Snowfall	Wildfire Susceptibility (Vegetation)	Peak Ground Acceleration Zone
1	Dam	Hobart Pond Dam	N/A	AE	No	120	36" – 48"	N/A	Zone 4
2	Fuel Station	7 Eleven	359 Bedford St	N/A	Within 300 feet	120	36" – 48"	N/A	Zone 4
3	Fuel Station	Citgo	180 South Ave.	N/A	No	120	36" – 48"	N/A	Zone 4
4	Fuel Station	Cumberland Farms	280 Temple St	N/A	No	120	36" – 48"	N/A	Zone 4
5	Fuel Station	Diamond Fuel	311 South Ave	N/A	No	120	36" – 48"	N/A	Zone 4
6	Fuel Station	Prime Energy	79 Temple St	N/A	No	120	36" – 48"	N/A	Zone 4
7	Tier II Site	Verizon	630-632 Washington St	N/A	No	120	36" – 48"	N/A	Zone 4
8	Library	Whitman Public Library	100 Webster St	N/A	No	120	36" – 48"	N/A	Zone 4
9	Public Works, Fuel Storage	Public Works	100 Essex St.	A/E	No	120	36" – 48"	Deciduous Forest	Zone 4
10	School	Hope Christian School	503 South Ave	N/A	No	120	36" – 48"	N/A	Zone 4
11	School, Childcare, Antenna, Public Safety, Repeater Site	John H. Duval, Jr. Elementary School	60 Regal St	N/A	No	120	36" – 48"	N/A	Zone 4
12	School, Childcare, Mass Care Shelter	Louise A. Conley Elementary School	100 Forest St.	N/A	No	120	36" – 48"	N/A	Zone 4
13	School, Mass Care Shelter, Antenna, Public Safety, Repeater Site	Whitman Middle School	100 Corthell Ave	N/A	No	120	36" – 48"	N/A	Zone 4
14	Senior Center	Council on Aging	16 Hayden Ave	N/A	No	120	36" – 48"	N/A	Zone 4
15	Town Hall	Town Hall	54 South Ave	N/A	No	120	36" – 48"	N/A	Zone 4

16	Fire Emergency Operations Center, Antenna, Public Safety, Repeater Site	Fire Station	56 Temple St.	N/A	No	120	36” – 48”	N/A	Zone 4
17	Health, Medical Facility	Beth Israel Deaconess Medical	312 Bedford St	N/A	Within 400 Feet	120	36” – 48”	N/A	Zone 4
18	Police, Antenna, Public Safety, Repeater Site	Police Station	20 Essex St	N/A	No	120	36” – 48”	N/A	Zone 4
19	Childcare	A Child’s Place Pre-School	49 School St	N/A	No	120	36” – 48”	N/A	Zone 4
20	Childcare	Busy Bee Pre-School	69 Washington St	N/A	No	120	36” – 48”	N/A	Zone 4
21	Childcare	Jack-n-Jill Child Care of Whitman	991 Bedford St.	N/A	No	120	36” – 48”	N/A	Zone 4
22	Childcare	Merry Deb Nursery School	127 Warren Ave	N/A	No	120	36” – 48”	N/A	Zone 4
23	Childcare	Self Help Inc. Head Start Whitman	168 Whitman Ave	N/A	No	120	36” – 48”	N/A	Zone 4
24	Cultural Resources	All Saints Episcopal Church	44 Park Ave	N/A	No	120	36” – 48”	N/A	Zone 4
25	Cultural Resources	Congregational Church of Whitman	519 Washington St	N/A	No	120	36” – 48”	N/A	Zone 4
26	Cultural Resources	Holy Ghost Church	518 Washington St	N/A	No	120	36” – 48”	N/A	Zone 4
27	Cultural Resources	Methodist Church	503 South St	N/A	No	120	36” – 48”	N/A	Zone 4
28	Cultural Resources	South Shore Pentecostal Church	58 West St	N/A	No	120	36” – 48”	N/A	Zone 4
29	Cultural Resource, Fuel Station	Stop & Shop Supermarket	475 Bedford St	N/A	No	120	36” – 48”	N/A	Zone 4
30	Housing Authority	Whitman Housing Authority	101 Harvard Ct	N/A	No	120	36” – 48”	N/A	Zone 4
31	Housing Authority	Whitman Housing Authority	0 Pine Circle	N/A	No	120	36” – 48”	N/A	Zone 4

32	Housing Authority	Whitman Housing Authority	0 Stetson Ter	N/A	No	120	36” – 48”	N/A	Zone 4
33	Postal & Shipping	USPS Whitman Office	64 South Ave	N/A	No	120	36” – 48”	N/A	Zone 4
34	Railroad	MBTA Whitman Station	383 South Ave	N/A	No	120	36” – 48”	N/A	Zone 4
35	Special Needs	Choice Residence	26 Park Ave	N/A	No	120	36” – 48”	N/A	Zone 4
36	Special Needs	Road to Responsibility	50 Paul St	N/A	No	120	36” – 48”	N/A	Zone 4
37	Special Needs	Special Needs	87 Stetson St	N/A	No	120	36” – 48”	N/A	Zone 4
38	Special Needs	Special Needs	207 Stetson St	N/A	No	120	36” – 48”	N/A	Zone 4
39	Special Needs	Vinyl Residence	777 Washington St	N/A	No	120	36” – 48”	N/A	Zone 4
40	Antenna	Commonwealth Building	7 Marble St	N/A	No	120	36” – 48”	N/A	Zone 4
41	Antenna	Franklin Street Cell Tower	Franklin St	N/A	No	120	36” – 48”	N/A	Zone 4
42	Antenna	Ridder Air	1 Castle Pl	N/A	No	120	36” – 48”	N/A	Zone 4
43	Cable Television	Whitman Hanson Community Access TV	115 South Ave	N/A	No	120	36” – 48”	N/A	Zone 4
44	Sewer Pumping Station	Auburn Street #1050 East Station	Auburn St	N/A	No	120	36” – 48”	N/A	Zone 4
45	Sewer Pumping Station	Auburn St. #1266 West Station	Auburn St	N/A	No	120	36” – 48”	N/A	Zone 4
46	Sewer Pumping Station	Auburn St. P-48 Station	Auburn St	N/A	No	120	36” – 48”	N/A	Zone 4
47	Sewer Pumping Station	Bedford St Station	Bedford St	N/A	No	120	36” – 48”	N/A	Zone 4
48	Sewer Pumping Station	Bedford St. Station Chlorination	Bedford St.	N/A	No	120	36” – 48”	N/A	Zone 4
49	Sewer Pumping Station	Belcher Avenue Station	Belcher Ave	N/A	No	120	36” – 48”	N/A	Zone 4
50	Sewer Pumping Station	Bell Drive Station	Bell Drive	N/A	No	120	36” – 48”	N/A	Zone 4
51	Sewer Pumping Station	Candlewick Lane Station	Candlewick Lane	N/A	No	120	36” – 48”	N/A	Zone 4

52	Sewer Pumping Station	Commercial Street P31 A Station	Commercial St	N/A	No	120	36" – 48"	N/A	Zone 4
53	Sewer Pumping Station	Kimberly Drive Station	Kimberly Drive	N/A	No	120	36" – 48"	N/A	Zone 4
54	Sewer Pumping Station	Lombard Avenue Station	Lombard Ave	N/A	No	120	36" – 48"	N/A	Zone 4
55	Sewer Pumping Station	Oakwood Avenue Station	Oakwood Ave	N/A	No	120	36" – 48"	N/A	Zone 4
56	Sewer Pumping Station	Old Coach Road Station	Old Coach Road	N/A	No	120	36" – 48"	N/A	Zone 4
57	Sewer Pumping Station	Old Colony Way Station	Old Colony Way	N/A	No	120	36" – 48"	N/A	Zone 4
58	Sewer Pumping Station	Pine Street Station	Pine St	N/A	No	120	36" – 48"	N/A	Zone 4
59	Sewer Pumping Station	Rowena Avenue Station	Rowena Ave	N/A	No	120	36" – 48"	N/A	Zone 4
60	Tier II Site	Whitman Co	356 South Ave	N/A	No	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)			
Flooding (Localized)		Roadway	Rt. 14, 18, 58
Severe Snow/Ice Storm	Trees	Roadway	Rt. 14, 18, 58
Hurricane/Severe Wind	Trees	Roadway	Rt. 14, 18, 27, 58
Wildfire/Brushfire	Forest	Roadway	
Dam Failure		Roadway	
Wellhead Protection			Rt. 18
Hazardous Materials			Rt. 27

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: Critical Facilities Category 1

ID	Facility	Name	Address or Water crossing	FEMA Flood Zone	Locally Identified Flood Area	100-Year Wind Event (MPH)	Average Annual Snowfall	Wildfire Susceptibility (Vegetation)	Peak Ground Acceleration Zone
9	Public Works	Fuel Storage	100 Essex St	A/E	No	120	36" – 48"	Deciduous Forest	Zone 4
16	Fire Emergency Operations Center, Antenna, Public Safety, Repeater Site	Fire Station	56 Temple St	N/A	No	120	36" – 48"	N/A	Zone 4
18	Police, Antenna, Public Safety, Repeater Site	Police Station	20 Essex St	N/A	No	120	36" – 48"	N/A	Zone 4

Table 6: Whitman Culverts Spanning Waterways

Structure Category	Facility Carried	Feature Intersected	Bridge Dept. #	Year Built	Length	Deck Area	Inspection Date	Owner
Culvert	ST 27 South Ave	Shumatuscacant River	W34003	1935	28.7	1,125.05	10/20/2018	MUN
Culvert	ST 27 South Ave	Brigham Pond OTLT	W34004	1850	57.9	57960.43044	12/13/2017	MUN
Culvert	HWY Essex St	Shumatuscacant River	W34005	1850	42.1	10014.84942	9/25/2018	MUN

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 Whitman.

Table 7: Critical Facilities Category 2

ID	Facility	Name	Address or Water crossing	FEMA Flood Zone	Locally Identified Flood Area	100-Year Wind Event (MPH)	Average Annual Snowfall	Wildfire Susceptibility (Vegetation)	Peak Ground Acceleration Zone
1	Dam	Hobart Pond Dam	N/A	A/E	No	120	36" – 48"	N/A	Zone 4
7	Tier II Site	Verizon	630-632 Washington St	N/A	No	120	36" – 48"	N/A	Zone 4
15	Town Hall	Town Hall	54 South Ave	N/A	No	120	36" – 48"	N/A	Zone 4
33	Postal and Shipping	USPS Whitman Office	64 South Ave	N/A	No	120	36" – 48"	Deciduous Forest	Zone 4
34	Railroad	MBTA Whitman Station	383 South Ave	N/A	No	120	36" – 48"	Deciduous Forest	Zone 4
40	Antenna	Commonwealth Building	7 Marble St	N/A	No	120	36" – 48"	Deciduous Forest	Zone 4
41	Antenna	Franklin St. Cell Tower	Franklin St	N/A	No	120	36" – 48"	Deciduous Forest	Zone 4
42	Antenna	Ridder Air	1 Castle Pl	N/A	No	120	36" – 48"	Deciduous Forest	Zone 4
43	Cable Television	Whitman Hanson Community Access TV	115 South St	N/A	No	120	36" – 48"	Deciduous Forest	Zone 4
44	Sewer Pumping Station	Auburn St. #1050 East Station	Auburn St	N/A	No	120	36" – 48"	Deciduous Forest	Zone 4
45	Sewer Pumping Station	Auburn St #1266 West Station	Auburn St	N/A	No	120	36" – 48"	Deciduous Forest	Zone 4
46	Sewer Pumping Station	Auburn St P48 Station	Auburn St	N/A	No	120	36" – 48"	Deciduous Forest	Zone 4
47	Sewer Pumping Station	Bedford St. Station	Bedford St	N/A	No	120	36" – 48"	Deciduous Forest	Zone 4
48	Sewer Pumping Station	Bedford St Station Chlorination	Bedford St.	N/A	No	120	36" – 48"	Deciduous Forest	Zone 4
49	Sewer Pumping Station	Belcher Avenue Station	Belcher Ave	N/A	No	120	36" – 48"	Deciduous Forest	Zone 4
50	Sewer Pumping Station	Bell Drive Station	Bell Drive	N/A	No	120	36" – 48"	Deciduous Forest	Zone 4
51	Sewer Pumping Station	Candlewick Lane Station	Candlewick Lane	N/A	No	120	36" – 48"	Deciduous Forest	Zone 4
52	Sewer Pumping Station	Sewer Pumping Station	Commercial St. P31 A Station	N/A	No	120	36" – 48"	Deciduous Forest	Zone 4

53	Sewer Pumping Station	Kimberly Drive Station	Kimberly Drive	N/A	No	120	36” – 48”	Deciduous Forest	Zone 4
54	Sewer Pumping Station	Lombard Avenue Station	Lombard Ave	N/A	No	120	36” – 48”	Deciduous Forest	Zone 4
55	Sewer Pumping Station	Oakwood Ave Station	Oakwood Ave	N/A	No	120	36” – 48”	Deciduous Forest	Zone 4
56	Sewer Pumping Station	Old Coach Road Station	Old Coach Road	N/A	No	120	36” – 48”	Deciduous Forest	Zone 4
57	Sewer Pumping Station	Old Colony Way Station	Old Colony Way	N/A	No	120	36” – 48”	Deciduous Forest	Zone 4
58	Sewer Pumping Station	Pine St. Station	Pine St	N/A	No	120	36” – 48”	Deciduous Forest	Zone 4
59	Sewer Pumping Station	Rowena Avenue Station	Rowena Ave	N/A	No	120	36” – 48”	Deciduous Forest	Zone 4
60	Tier II Site	Whitman CO	356 South Ave	N/A	No	120	36” – 48”	Deciduous Forest	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: Critical Facilities Category 3

ID	Facility	Name	Address	FEMA Flood Zone	Locally Identified Flood Area	100-Year Wind Event (MPH)	Average Annual Snowfall	Wildfire Susceptibility (Vegetation)	Peak Ground Acceleration Zone
8	Library	Whitman Public Library	100 Webster St	N/A	No	120	36” – 48”	N/A	Zone 4
10	School	Hope Christian School	503 South Ave	N/A	No	120	36” – 48”	N/A	Zone 4
11	School, Childcare, Antenna, Public Safety, Repeater Site	John H. Duval, Jr. Elementary School	60 Regal St	N/A	No	120	36” – 48”	N/A	Zone 4
12	School, Childcare, Mass Care Shelter	Louise A. Conley Elementary School	100 Forest St.	N/A	No	120	36” – 48”	N/A	Zone 4
13	School, Mass Care Shelter, Antenna, Public Safety, Repeater Site	Whitman Middle School	100 Corthell Ave	N/A	No	120	36” – 48”	N/A	Zone 4

14	Senior Center	Council on Aging	16 Hayden Ave	N/A	No	120	36" – 48"	N/A	Zone 4
15	Town Hall	Town Hall	54 South Ave	N/A	No	120	36" – 48"	N/A	Zone 4
19	Childcare	A Child's Place Pre-School	49 School St	N/A	No	120	36" – 48"	N/A	Zone 4
20	Childcare	Busy Bee Pre-School	69 Washington St	N/A	No	120	36" – 48"	N/A	Zone 4
21	Childcare	Jack-n-Jill Child Care of Whitman	991 Bedford St.	N/A	No	120	36" – 48"	N/A	Zone 4
22	Childcare	Merry Deb Nursery School	127 Warren Ave	N/A	No	120	36" – 48"	N/A	Zone 4
23	Childcare	Self Help Inc. Head Start Whitman	168 Whitman Ave	N/A	No	120	36" – 48"	N/A	Zone 4
24	Cultural Resources	All Saints Episcopal Church	44 Park Ave	N/A	No	120	36" – 48"	N/A	Zone 4
25	Cultural Resources	Congregational Church of Whitman	519 Washington St	N/A	No	120	36" – 48"	N/A	Zone 4
26	Cultural Resources	Holy Ghost Church	518 Washington St	N/A	No	120	36" – 48"	N/A	Zone 4
27	Cultural Resources	Methodist Church	503 South St	N/A	No	120	36" – 48"	N/A	Zone 4
28	Cultural Resources	South Shore Pentecostal Church	58 West St	N/A	No	120	36" – 48"	N/A	Zone 4
29	Cultural Resource, Fuel Station	Stop & Shop Supermarket	475 Bedford St	N/A	No	120	36" – 48"	N/A	Zone 4
30	Housing Authority	Whitman Housing Authority	101 Harvard Ct	N/A	No	120	36" – 48"	N/A	Zone 4
31	Housing Authority	Whitman Housing Authority	0 Pine Circle	N/A	No	120	36" – 48"	N/A	Zone 4
32	Housing Authority	Whitman Housing Authority	0 Stetson Ter	N/A	No	120	36" – 48"	N/A	Zone 4
35	Special Needs	Choice Residence	26 Park Ave	N/A	No	120	36" – 48"	N/A	Zone 4
36	Special Needs	Road to Responsibility	50 Paul St	N/A	No	120	36" – 48"	N/A	Zone 4
37	Special Needs	Special Needs	87 Stetson St	N/A	No	120	36" – 48"	N/A	Zone 4
38	Special Needs	Special Needs	207 Stetson St	N/A	No	120	36" – 48"	N/A	Zone 4
39	Special Needs	Vinyl Residence	777 Washington St	N/A	No	120	36" – 48"	N/A	Zone 4

Category 4: Potential Resources

Contains facilities that provide potential resources for services and supplies.

Table 9: Critical Facilities Category 4

ID	Facility	Name	Address or Water crossing	FEMA Flood Zone	Locally Identified Flood Area	100-Year Wind Event (MPH)	Average Annual Snowfall	Wildfire Susceptibility (Vegetation)	Peak Ground Acceleration Zone
17	Health Medical Facility	Beth Israel Deaconess Medical	312 Bedford St, Whitman	N/A	Within 400'	120	36" – 48"	N/A	Zone 4
	Health Medical Facility	Compass Medical	1 Compass Way, East Bridgewater						
	Health Medical Facility	Signature Healthcare	680 Centre St., Brockton						
29	Cultural Resource, Fuel Station	Stop & Shop Supermarket	475 Bedford St., Whitman	N/A	No	120	36" – 48"	N/A	Zone 4
	Restaurant	Nellie Rose Restaurant	557 Bedford St., Whitman						
		Venus Café	47 South Ave., Whitman						
		Christo's To Go	785 Bedford St., Whitman						
		Uncle David's	643 Washington St., Whitman						
		Supreme Pizza	585 Washington St., Whitman						
		Mia Regazza	268 Washington St., Abington						
	Building Supplies	Lowe's Home Imp	400 Bedford St., Abington						
		Home Depot	715 Crescent St., Brockton						
		Robert N. Karpp Building Materials	245 North Ave., Abington						
	Waste Management	Troupe Waste	1477 Bedford St., Abington						
		B&B Waste Disposal	1461 Main St., Brockton						

	Waste Management	40 Ledin Dr., Avon	

Dams

There is one dam in Whitman according to the Massachusetts Department of Conservation and Recreation Office of Dam Safety.

Table 10: Whitman Dams

ID	Facility	Name	Address or Water crossing	FEMA Flood Zone	Locally Identified Flood Area	100-Year Wind Event (MPH)	Average Annual Snowfall	Wildfire Susceptibility (Vegetation)	Peak Ground Acceleration Zone
1	Dam	Hobart Pond Dam	N/A	AE	No	120	36" – 48"	N/A	Zone 4

Areas of Concern

Infrastructural

Table 11: Infrastructural Areas of Concern

Features	Vulnerabilities	Strengths/Mitigation	Priority	Timing
Wastewater Forced Main	Forced main lies in wetland soils in an unmaintained easement	Replacement of the forced main would prevent a major environmental event	High	Long-Term
Hobart Pond Dam	Erosion on the sides of the dam during a heavy rain or flood event	Trail around the pond receives >1000 visitors daily	High	Long-Term
Radio Tower next to Police Station	Prone to being struck by lightning resulting in loss	Communication and Reverse 911 System	High	Long-Term
Drainage System	Prone to flooding	Culvert maintenance and repair plan with long-term implementation to protect natural resources	High	Short-term
Town Hall heating and cooling system is aging	Protection of public resources from climate change impacts	An energy efficient HVAC system	High	Long-Term
Electrical Grid Power Outages	Previous microburst resulted in power loss for more than a week in 1997	Tree Trimming Plan, easement maintenance to protect against power loss	Medium	Short-Term
Duvall School	Water problems during wind and rain events	Study potential for adaptive reuse	High	Long-Term

Societal

Table 12: Societal Areas of Concern

Features	Vulnerabilities	Strengths/Mitigations	Priority	Timing
School is used as an emergency shelter	Regional school does not have a generator.	Provides shelter during emergency or storm related events	High	Short-Term
Library	Does not have a generator to protect contents	Provides temporary shelter and storage of historical documents. Revamp of website and social media presence.	Low	Long-Term
High School, Middle School and Duval School	One way access	Back up plans at each school. Explore opportunities for alternate access.	Low	Long-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/ Mitigations	Priority	Timing
Water	There are a lot of properties connected to town water for irrigation.	Outreach and Education regarding the effects of drought. Modify rate structure to influence active water conservation.	Medium	Ongoing
Potential Brownfield Locations: Marvel St. Shoe Factory, BFI Building Bedford St., 602 Bedford St., Dells on South Avenue	Potential Brownfield location.	Explore grant opportunities for clean-up, remediation	High	Long-Term
Old Railroad between Auburn Street	Small brook that feeds into the marsh in the wet season	Might be suitable location for installation of NBS	Medium	Long-Term

Flood Prone Areas

- Auburn Street (Route 14) at Pine Haven Drive
- Bedford Street at Stop & Shop (at an unnamed brook, just north of May Street)
- Pond Street near South Avenue and the MBTA Station
- Woodlawn Circle at Pine Haven Drive
- Temple Street (Route 27) at Joyce Terrace
- Temple Street (Route 27) over Rock St.
- Belmont Street at Meadow Brook
- Plymouth Street at Shumatuscacant River
- Oldman Drive near Route 14
- Star Street
- Bedford Street culverts

Maps Created for CRB Workshop

Figure 1: Whitman Development Constraints

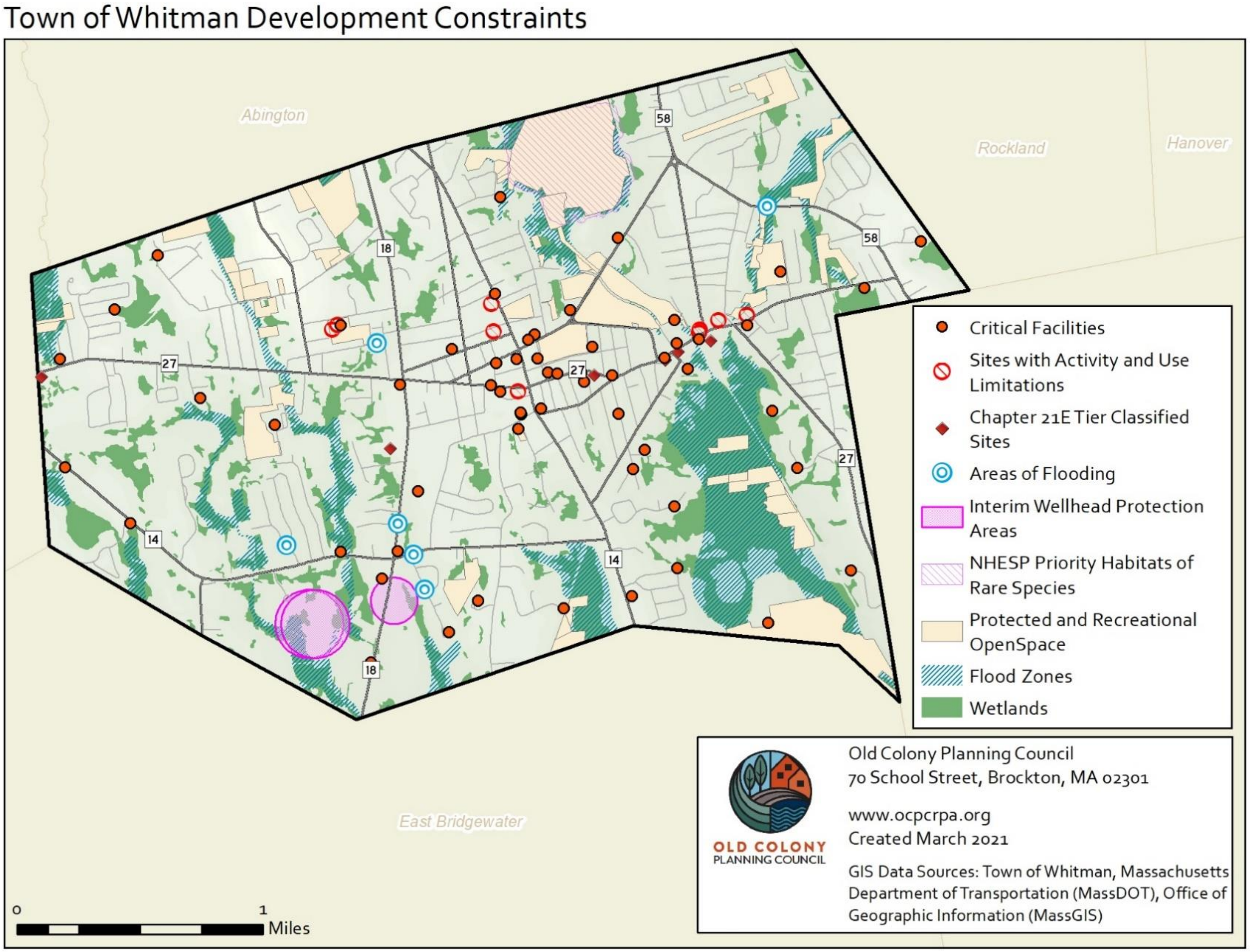


Figure 2: Whitman Sidewalk Gap Analysis

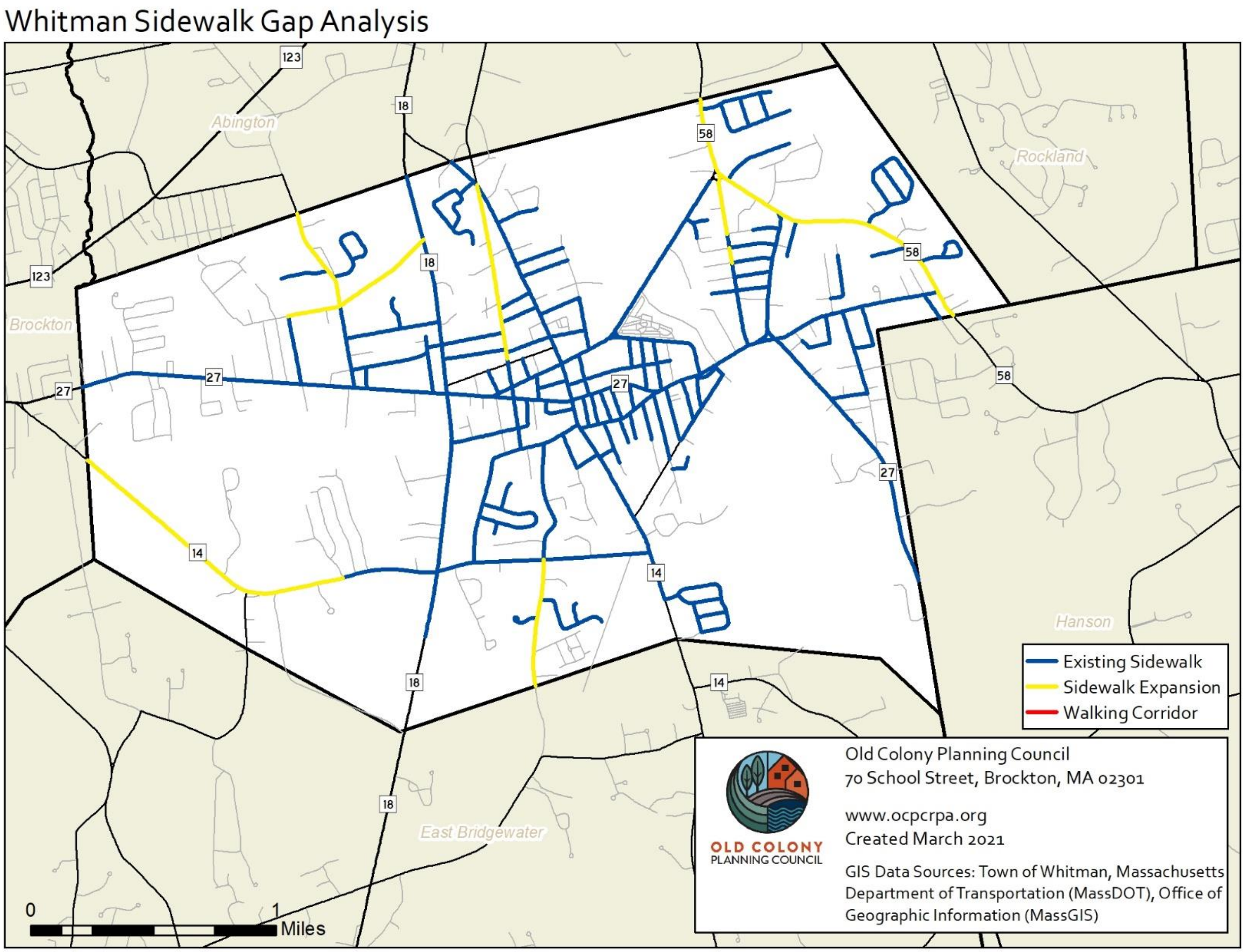
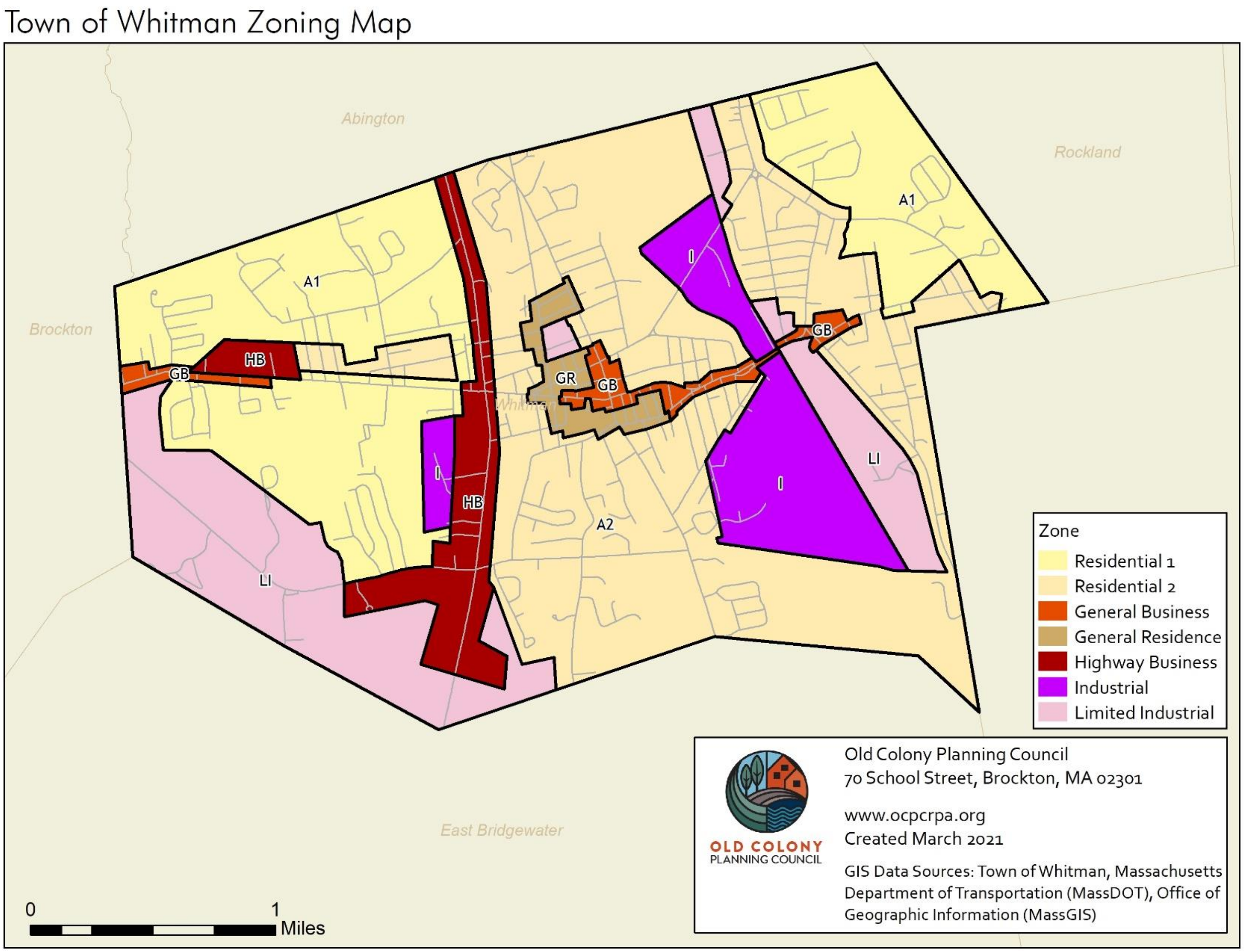


Figure 3: Whitman Zoning Map



CRB Workshop MVP Goals

The Core Team reviewed and discussed the goals from the 2015 Old Colony Planning Council Hazard Mitigation Plan. The Team has chosen to expand upon those goals with more focused and localized mitigation goals.

Goal 1: To be prepared to reduce the loss of life, property, infrastructure, and cultural resources throughout the Town from natural disasters through a multiple hazard mitigation program that involves coordination, planning, education, and capital improvements.

Goal 2: Incorporate hazard and climate change vulnerability into capital planning, master planning and facilities management functions and implement proactive solutions to adapt to climate change.

Goal 3: To investigate, design, and implement projects that will reduce and minimize the risk of flooding.

Goal 4: To organize and prepare to provide adequate shelter, water, food, basic first aid to displaced residents, evacuation procedures, etc. to residents in the event of a natural disaster. To inventory supplies at existing shelters and develop a needs list and storage requirements, and to establish arrangements with local and neighboring vendors for supplying shelters with food and first aid supplies in the event of a natural disaster.

Goal 5: Increase awareness of hazard mitigation activities among town officials, private organizations, businesses, and the public through education and outreach activities.

CRB Workshop Priority Mitigation Actions

- Action Title
- Action Description
- Estimated Cost
  - Very High (over $1 million)
  - High ($500,000 - $1 million)
  - Medium ($100,000 - $500,000)
  - Low ($50,000 - $100,000)
  - Very Low (under $50,000)
- Potential Funding Source
- Lead Department
- Possible Partners
- Implementation Schedule (month/year start and end dates within a five-year period)

Beyond the bulleted list above, the Priority Mitigation Actions includes the following categories of information.

1. Relevant Mitigation Plan Goal (Overall Goal Statement, Goals 1-6).
2. Type of Mitigation Project (local plans and regulations, structural projects, natural systems protection, education programs, and preparedness and response actions).
3. Critical Facility Protection (Yes or No).
4. Community Components (infrastructure, society, or environment).
5. Hazards Addressed
   a. Storms/Nor'easters
   b. Extreme Wind/Thunderstorms
   c. Hurricanes/Tropical Storms
   d. Algae Blooms
   e. Rising Temperatures (average or extreme temperatures, wildfires, invasive species)
   f. Dam Failure

Below is a list of all mitigation actions (sorter by priority order) as determined by the Community Resilience Workshop. Additional mitigation actions from the Hazard Mitigation Plan are also shown in Section 6 of this Integrated MVP HMP Plan.

CRB Workshop Mitigation Actions Prioritization Plan

1	Wastewater Forced Main: The existing main lies in wetland soils via an unmaintained easement. These unsuitable soil conditions are causing failure of the forced main.	
Goal	1, 2	
Action Description	Replace 5 miles of forced main adjacent to the existing main, backfilled with less vulnerable materials to prevent a major environmental event.	
High		
	Lead Department	Board of Selectmen
	Partners	Water Dept., Conservation Commission
	Cost	Very High
	Possible Funding Sources	FEMA/MEMA, DCR, General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Infrastructure, Environmental Health, Natural Systems Protection
	Critical Facility Protection	Yes
	Community Components	Infrastructure, Environment
	Implementation Schedule	September 2021-September 2024

2	Brownfields: Marvel St. Shoe Factory, BFI Building, 602 Bedford St. 30 Temple St.
Goal	1, 2
Action Description	Study grant opportunities for clean-up and remediation, suitable reuse for sites
High	

	Lead Department	Town Administration, Planning Board
	Partners	Board of Selectmen
	Cost	Low
	Possible Funding Sources	FEMA/MEMA, DCR, General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Environmental Health, Natural Systems Protection
	Critical Facility Protection	No
	Community Components	Environment, Infrastructure
	Implementation Schedule	September 2021-September 2024

3	Landfill – Not Capped.	
Goal	1, 2	
Action Description	Study grant opportunities for bringing the landfill into compliance with a proper cap, closure, monitoring, and maintenance plan under the Massachusetts Solid Waste Management Regulations.	
High		
	Lead Department	Board of Health, Conservation Commission
	Partners	Board of Selectmen, Town Administration
	Cost	Very High
	Possible Funding Sources	FEMA/MEMA, DCR, General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter

	Type of Mitigation Project	Ecological, Environmental Health, Natural Systems Protection
	Critical Facility Protection	No
	Community Components	Environment, Infrastructure
	Implementation Schedule	September 2021-September 2024

4	Identify flood prone areas and conduct an inventory of culverts and bridges, create a prioritization plan to improve infrastructure and lessen the likelihood of loss due to climate change. Culvert Maintenance and Repair Plan with long-term implementation.	
Goal	1, 2, 3	
Action Description	Implement priority projects from the inventory of culverts and bridges for increased flooding resiliency and storm-hardening, including re-sizing or replacement projects. Green infrastructure, low-impact design, and other nature-based solutions should be integrated with hard-infrastructure improvement to establish robust approaches in the face of natural hazards and climate-change scenarios, and that meet Massachusetts stream-crossing standards. ***CRB Workshop identified the following culverts at the following locations:*** • Auburn Street (Route 14) at Pine Haven Drive • Bedford Street at Stop & Shop (at an unnamed brook, just north of May Street) • Pond Street near South Avenue and the MBTA Station • Woodlawn Circle at Pine Haven Drive • Temple Street (Route 27) at Joyce Terrace • Temple Street (Route 27) over Rock St. • Belmont Street at Meadow Brook • Plymouth Street at Shumatuscacant River • Oldman Drive near Route 14 • Star Street • Bedford Street culvert	
High		
	Lead Department	Highway Dept.,
	Partners	Planning Board, Conservation Commission

	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Infrastructure, Environment
	Critical Facility Protection	No
	Community Components	Infrastructure, Environment
	Implementation Schedule	September 2021-September 2024

5	Culvert Maintenance and Repair Plan with long-term implementation. Develop an Action Plan for the stormwater system with a vulnerability assessment for stormwater flooding and culvert upsizing.	
Goal	1, 2, 3	
Action Description	Assess and upgrade drainage infrastructure. Develop an action plan for the stormwater system with a vulnerability assessment for stormwater flooding and culvert upsizing and determine whether nature-based solutions can be utilized to ameliorate the problem.	
High		
	Lead Department	Highway Dept.,
	Partners	Conservation Commission
	Cost	Medium
	Possible Funding Sources	FEMA/MEMA, DCR, General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Infrastructure, Environment, Natural Systems Protection

	Critical Facility Protection	No
	Community Components	Infrastructure, Environment
	Implementation Schedule	September 2021-September 2024

6	Radio Tower adjacent to the Police Station has been struck by lightning several times.	
Goal	1, 2	
Action Description	Study other town owned properties or appropriate areas for relocation or other protection from further damage.	
High		
	Lead Department	IT, Police Dept., Fire Dept.,
	Partners	Board of Selectmen, Town Administration
	Cost	Medium
	Possible Funding Sources	FEMA/MEMA, State Grants, General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Infrastructure, Emergency Preparedness and Readiness
	Critical Facility Protection	Yes
	Community Components	Infrastructure, Emergency Preparedness and Readiness
	Implementation Schedule	September 2021-September 2024

7	Town Hall HVAC system is aging.	
Goal	1, 2	
Action Description	Seek grant opportunities to fund an energy efficient HVAC system to protect public resources from the impacts of climate change to protect public property and resources.	
Medium	1, 2	
	Lead Department	Town Administration
	Partners	Board of Selectmen, Finance Committee
	Cost	Medium
	Possible Funding Sources	State Grant, FEMA/MEMA, General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter.
	Type of Mitigation Project	Infrastructure
	Critical Facility Protection	Yes
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

8	Zoning and Regulatory: Wetlands Protection Ordinance	
Goal	1, 2, 3	
Action Description	Support wetlands restoration as part of a green infrastructure approach to hazard mitigation. Inclusion of Green Infrastructure and nature-based solutions in site plan permitting and development.	
Medium		
	Lead Department	Planning Board, Conservation Commission
	Partners	Building Dept., Zoning Board of Appeals
	Cost	Low

	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter.
	Type of Mitigation Project	Local Plans and Regulations, Infrastructure, Environment, Natural Systems Protection
	Critical Facility Protection	No
	Community Components	Local Plans and Regulations, Environment, Infrastructure, Natural Resources Protection
	Implementation Schedule	September 2021-September 2024

9	Trail along the Hobart Pond, Town Park, Essex Street to South Avenue. Auburn Street, Donald Flaherty Trail.	
Goal	1, 2, 3	
Action Description	Study suitable locations for the implementation of Nature-based solutions to protect water quality and habitat of the pond and natural resources.	
	Lead Department	Highway Dept., Conservation Commission
	Partners	Building Dept.,
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
Medium		
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter.
	Type of Mitigation Project	Infrastructure, Environment, Natural Systems Protection
	Critical Facility Protection	No

	Community Components	Environment, Infrastructure, Natural Resources Protection
	Implementation Schedule	September 2021-September 2024

10	Identify key road networks and develop safe evacuation routes.	
Goal	1, 2, 4	
Action Description	Install evacuation route signage; Develop a robust local transportation plan that addresses emergency access to transportation and the social and economic consequences that accompany service interruptions. Planning should include supplemental funding and equipment for snow removal, a review of available drivers, and the understanding of potential insurance and union contracts issues that may influence access to certain transportation resources. Access to critical resources such as childcare and provisions should be considered. Promote public transportation to reduce cars on the road during inclement weather and reduce greenhouse gas emissions. Traffic and roadway improvements plan to deal with more people.	
Medium		
	Lead Department	Emergency Management
	Partners	Highway Dept.
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter.
	Type of Mitigation Project	Emergency Preparedness and Readiness
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

11	High use of public water supply for non-essential uses like outdoor irrigation.		
Goal	1, 2, 5		
Action Description	Outreach and education regarding the effects of drought. Modify rate structure to influence and incentivize active water conservation.		
Medium			
	Lead Department	Water Dept.,	
	Partners	Town Administration	
	Cost	Low	
	Possible Funding Sources	General Fund, Staff Time	
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter.	
	Type of Mitigation Project	Infrastructure, Natural Resource Protection	
	Critical Facility Protection	No	
	Community Components	Infrastructure	
	Implementation Schedule	September 2021-September 2024	

12	Vector-borne diseases prevention	
Goal	1, 2, 5	
Action Description	Implement vector information outreach including placing vector information at trail heads and ball fields. Assess mosquito/tick/pest control options, integrated pest management approaches, and determine future risk due to increase in type and quantity of pests/disease vectors due to climate change. Update the education and outreach program. Targeted medical providers to increase awareness of new diseases and encourage early testing. Develop local funding and resources to make it easier for residents to have tick bites tested.	
Low		
	Lead Department	Board of Health
	Partners	Conservation Commission, Open Space Committee, Recreation

	Cost	Very Low
	Possible Funding Sources	State Grants, General Fund, Staff Time, UMass Lab of Medical Zoology
	Hazards	Changes in Precipitation, Flood. Rising Temperatures: Average/Extreme Temperatures. Wildfires, Invasive Species
	Type of Mitigation Project	Environment, Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Environment
	Implementation Schedule	September 2021-September 2024

13	Hobart's Dam	
Goal	1, 2, 3	
Action Description	Develop a comprehensive plan to mitigate the impacts of unpredictable flooding and impoundment breaches. Consider residual risk associated with protection provided by dams in future land use decisions.	
Low		
	Lead Department	Conservation Commission
	Partners	MA DCR, Local officials of state delegation
	Cost	Medium
	Possible Funding Sources	MA DFG, State Grants, General Fund, Staff Time, UMass Lab of Medical Zoology
	Hazards	Changes in Precipitation, Flood. Drought
	Type of Mitigation Project	Local Plans and Regulations, Environment, Natural Systems Protection
	Critical Facility Protection	Yes
	Community Components	Environment

	Implementation Schedule	September 2021-September 2024

14	Provide emergency back-up power to all critical facilities, municipal generator maintenance.	
Goal	1, 2	
Action Description	Evaluate opportunities to provide improvements at critical facilities, especially emergency backup power, including feasibility of green power and battery storage. Develop an assessment of generator needs and facility upgrades to protect public buildings and infrastructure from freezing and improve services for residents who may lose power during emergencies or hazard events. Library, Regional High School	
Low		
	Lead Department	Building Dept.
	Partners	Facilities Management
	Cost	Medium
	Possible Funding Sources	FEMA/MEMA, State Grants, General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter.
	Type of Mitigation Project	Infrastructure, Critical Facilities Protection, Capital Investment
	Critical Facility Protection	Yes
	Community Components	Infrastructure, Critical Facilities Protection
	Implementation Schedule	September 2021-September 2024

15	Old Park Avenue School Building by Hobarts Pond is an aged structure with 4 feet of water in the basement.	
Goal	1, 2	
Action Description	Basement located below the water table. Remove the structure to protect environment.	
Low		
	Lead Department	Building Dept.
	Partners	Town Administration
	Cost	Very High
	Possible Funding Sources	FEMA/MEMA, State Grants, General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter.
	Type of Mitigation Project	Infrastructure, Environment
	Critical Facility Protection	No
	Community Components	Infrastructure, Environment
	Implementation Schedule	September 2021-September 2024

16	Duvall School has water problems during wind and rain events.	
Goal	1, 2	
Action Description	Access the structure to determine future use.	
Low		
	Lead Department	Building Dept.
	Partners	Town Administration
	Cost	Very High
	Possible Funding Sources	FEMA/MEMA, State Grants, General Fund, Staff Time

	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter.
	Type of Mitigation Project	Infrastructure
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

17	Middle School ball fields subject to flooding	
Goal	1, 2, 3	
Action Description	Assess and upgrade drainage infrastructure of the ball field. Develop an action plan for the stormwater system with a vulnerability assessment for flooding and culvert upsizing and determine whether nature-based solutions can be utilized to ameliorate the problem.	
Low		
	Lead Department	Building Dept., School Dept
	Partners	Town Administration, Conservation Commission
	Cost	Medium
	Possible Funding Sources	FEMA/MEMA, State Grants, General Fund, School Dept., Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter.
	Type of Mitigation Project	Infrastructure, Flooding, Social
	Critical Facility Protection	No
	Community Components	Infrastructure

	Implementation Schedule	September 2021-September 2024

18	Whitman-Hanson Regional High School	
Goal	1, 2	
Action Description	One-way access road could be a problem during emergency events. Consider secondary access road where possible. School could be used as a cooling and warming center but does not have a generator for protection from power loss. Seek grant opportunities or an intermunicipal agreement to acquire a generator.	
Low		
	Lead Department	Planning Board, School Dept.,
	Partners	Highway Dept., Town Administration
	Cost	Medium
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Infrastructure
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

19		
Goal	1, 2, 5	
Action Description	Outreach and education regarding the effects of drought. Modify rate structure to influence and incentivize active water conservation.	
Low		
	Lead Department	Planning Board, School Dept.,

	Partners	Highway Dept., Town Administration
	Cost	Medium
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Infrastructure
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

CRB Summary of Findings Matrix

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.)

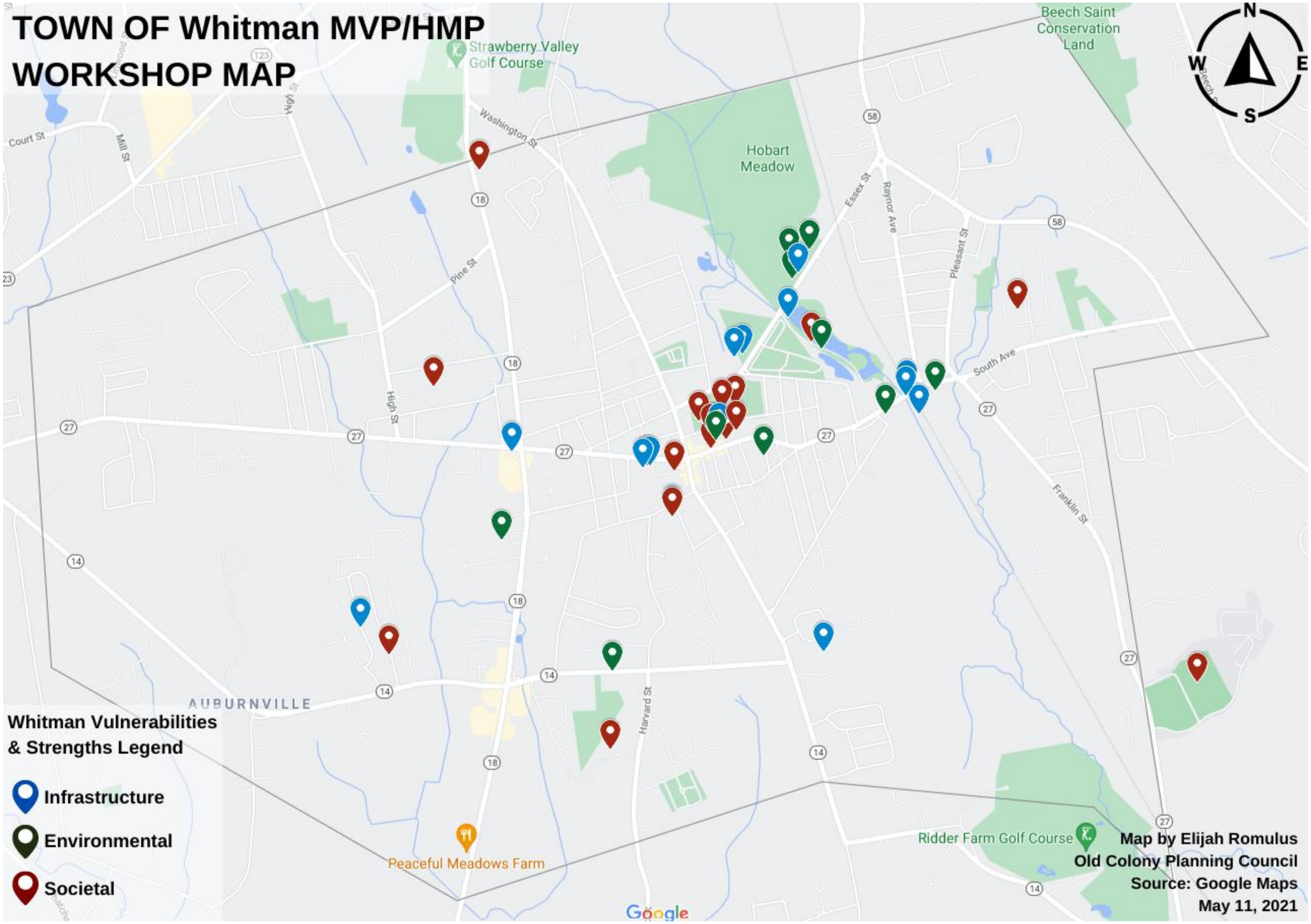
Features	Location	Ownership	V or S	Inland Flooding	Hurricanes Tropical Storms	Extreme Wind Thunderstorms	Snowstorm Nor'easters	Priority H - M - L	Time Short Long Ongoing
Infrastructural									
Hobart Pond off Pond Street.	Off Pond St.	Town Owned	V	Erosion on the sides of the dam during a heavy rain or flood event. Map dam failures areas. Enhance emergency operations plan to include a dam failure component.				M	L
Radio tower next to the police station has been struck by lightening many times resulting in loss of communications		Town Owned	V/S	Assess appropriate areas for relocation or protection from further damage				H	L
Wastewater forced main	Mostly public tied into Brockton system	Brockton	V/S	There is an issue with a forced main from Whitman into Brockton. The main lies in wetland soils via an unmaintained easement that is causing failure. Replace 5 miles of forced main adjacent to the existing main backfilled with less vulnerable materials to prevent a major environmental event.				H	L
Flooding: South Avenue near Pond Street - flooding could undermine the railroad tracks. Star Street and Bedford Street culvert. Temple Street (Rt. 27) over Rock Street	Pond St., Oldman Drive near Route 14 going towards Brockton, Star Street, Bedford St.	Town Owned	V	Previous street flooding with >3 feet water.	Assess and upgrade drainage infrastructure. Develop an Action Plan for the stormwater statyem with a vulnerability assessment for stormwater flooding nad culvert upsizing. Areas of localized flooding should be assessed to determine whether nature-based solutions can be used to ameliorate the problem.	Culvert maintenance and repair plan with long-term implementation.	Inventory and prioritize culverts for repairs and replacement.	H	S
Town Hall heating and cooling system is aging.		Town Owned	V		An energy efficient HVAC system to protect public resources from the impacts of climate change			H	L
Railroad MBTA Station		State	S	Culvert near Pond St. Train runs through some wetlands					

Power Outages - previous microburst resulted in power loss for more than a week in 1997	East Bridgewater Side is the most problematice, coming from Brockton		V				Tree Trimming Plan, eastment maintenance	M	S
Evacuation Routes are well posted. Reverse 911 is available			S	Lack of signage regarding evacuation. Old Pilgrim Nuclear Evacuation Signs should be replaced				M	L
Zoning and Regulatory: Whitman does nto have a local wetlands ordinance. All permitting subject only to state regulations. The Floodplain bylaw was just rewritten and is on the upcoming tonw meeting warrant.			V	Adopt a local wetland ordinance to ensure that proposed activities will not alter resource areas and the public interests they provide.	Consider zoning amendments that promote the use of LID standards using nature-based solutions to manage stormwater in new subdivision development			M	S
Old Park Avenue School building by Hobarts Pond: basement flooding, basement is below the water table. Aged structure with 4 feet of water in the basement.			V	Remove the aged structure from the water table to protect natural resources				M	L
Duvall School has water problems during wind and rain storms			V	Assess the structure to determine future use.				H	L
Societal									
Middle School ball fields flood			v						
Senior Center COA has been used as a cooling center in the past. Has a generator and a transportation plan for vulnerable populations.			S						
School is used as an emergency shelter			S/V	Regional school does not have a generator. Used as an emergency shelter.				H	S
Reverse 911 - Town currently provides this service. Determine if there are pockets where Englilsh is not the 1st language (need for translation)	South Whitman EJ Census Tracts - Washington, Route 14 and Route 18		S		Housing Authority will add staff as needed for cooling centers. Fire Dept. went door to door during the last hurricane to assist vulnerable populations.				
Conley School: large ESL population.			S/V	Language translation equipment for the police station. Town pays for language line for interpretation services.	They have a list of officers who speak several languages. Translators are available through the courts.			L	O
Social Groups - Faith Based Organizations, community groups			S	CERT Team	VFW Group, Legion Group, and Knights of Columbus				

Library: needs a generator to protect contents from damage due to the effects of climate change			S/V	Revamp of website and social media presence				L	L
Trail along the Hobart Pond, Town Park			S	Daily use approaching 1000	Determine suitable locations for the implementation of Nature-based solutions to protect water quality and natural habitat of the pond.				
Nursing for sheltering events: 2 public health nurses on staff work with TB cases, COVID contact tracing, following up on EEE and other issues.			S						
Transportation Plans to evacuate neighborhoods	Halmond Drive off Route 14		S	BAT works with Whitman to assist with evacuation. COA has buses and 2 drivers to assist with transportation.					
Food Banks - private organizations, St. Vincent D'Paul and Greater Boston Food Bank Brown Bag			S	Shelter in place would deploy CERT team and other volunteers to go door to door for food security	MRE for residents in emergencies				
High School and Middle School and Duval School			S/V	One way in and out access	Back up plans at each school			L	L
Shelter Management Plan in place	Main shelter is WHRHS opened during a long-term 48-72 hours event.		S	Regional Shelter is located in Hanson					
Public engagement on a regular basis through Fire and Police			S	Cable TV, social media (Twitter and Facebook) used daily, weekly newspaper with local circulation	Whitman Hanson Express				
Evacuation Plan - Reverse 911 immediately to Social Media, abutting towns social media			S	15,000 views within 15 min	Evacuation Route not posted on website.	The Town owns 2 movable electronic information signs that they can use for emergency communication			
Environmental									
Water: High use of limited public water supply for non-essential uses like outdoor irrigation.			V		Outreach and Education regarding the effects of drought. Modify rate structure to influence and incentivize active water conservation.			M	O

Potential Brownfields: Marvel St. Shoe Factory, BFI Building Bedford St. Close to Rt. 18 and Rt. 27, Building is boarded up.	602 Bedford St. Dells on South Av		V	Explore grant opportunities for clean up, remediation and suitable reuse for sites (ex. solar fields, apiaries)				H	L
Landfill			V	landfill not capped					
Vector Diseases:			S	Participate in the Plymouth County Mosquito Program	Town currently provides spray notifications through IT Social Medial Outreach	Spot-treat areas known as mosquito-breeding grounds; improve water flows when possible		M	O
Trail from Essex Street to South Ave: DPW did a great job on clearing and maintenance of the trail.			S						
Suitable location for Nature Based Solutions - old railroad between Auburn street and on Conservation Commission oversight. Donald Flaherty Trail			S/V	Small brooks that feed into the marsh in the wet season.	Nice place to enjoy hiking and wildlife.			M	L

Map Created During CRB Workshops



TOWN OF Whitman MVP/HMP
WORKSHOP MAP
Strawberry Valley Golf Course
Beech Saint Conservation Land
Hobart Meadow
Washington St
Court St
Mill St
High St
Pine St
Essex St
Raynor Ave
Pleasant St
South Ave
Franklin St
Harvard St
AUBURNVILLE
Ridder Farm Golf Course
Peaceful Meadows Farm
Google
N
W
E
S
Whitman Vulnerabilities & Strengths Legend
Infrastructure
Environmental
Societal
Map by Elijah Romulus
Old Colony Planning Council
Source: Google Maps
May 11, 2021

Town of Whitman, Massachusetts

Integrated Municipal Vulnerability Preparedness and Hazard Mitigation Plan (MVP-HMP)

Hazard Mitigation Plan

Prepared by

Old Colony Planning Council

April 2021

Certificate of Local Adoption

E.1. Does the Plan include documentation that the Plan has been formally adopted by the governing body of the jurisdiction requesting approval? (Requirement §201.6(c)(5)

CERTIFICATE OF ADOPTION
BOARD OF SELECTMEN
TOWN OF WHITMAN, MASSACHUSETTS

A RESOLUTION ADOPTING THE
TOWN OF WHITMAN INTEGRATED MVP HMP PLAN 2021 UPDATE

Ordered:
That the Town of Whitman, by and through its Town Administrator Lincoln Heineman and Board of Selectmen, is hereby authorized to adopt the Town of Whitman Integrated Municipal Vulnerability Preparedness and Hazard Mitigation Plan (MVP HMP).

WHEREAS the Town of Whitman established a committee to prepare the Town of Whitman Integrated Municipal Vulnerability Preparedness and Hazard Mitigation Plan; and

WHEREAS the Town of Whitman participated in the development of the Town of Whitman Integrated Municipal Vulnerability Preparedness and Hazard Mitigation Plan.

and WHEREAS, the Town of Whitman Integrated Municipal Vulnerability Preparedness and Hazard Mitigation Plan 2021 contains several potential future projects to mitigate potential impacts from natural hazards in the Town of Whitman, and

WHEREAS duly noticed public meetings were held by the LOCAL HAZARD MITIGATION PLANNING Team on April 8, 2021, for the public and municipality to review prior to consideration of this resolution; and

WHEREAS the Town of Whitman authorizes responsible departments and/or agencies to execute their responsibilities demonstrated in the plan.

NOW, THEREFORE BE IT RESOLVED that the Town of Whitman Board of Selectmen formally approves and adopts the Town of Whitman 2021 Integrated Municipal Vulnerability Preparedness and Hazard Mitigation Plan, in accordance with M.G.L. c. 40.

That the Town of Whitman by and through its Town Administrator and Selectboard is further authorized to execute all documents necessary to implement t this order.

Adopted and Signed this Date ____.

Section 1. Introduction

The Town of Whitman 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 Whitman 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 Whitman Integrated 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 Whitman.

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 Whitman.

In 2019, the Town of Whitman 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]

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

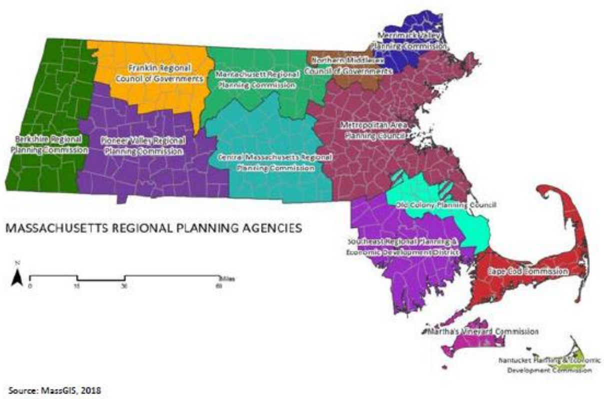
Executive Order 569 also directs GHG emissions reductions and natural hazard resilience planning to wherever possible to employ strategies that conserve and sustainably employ the natural resources of

[3] (44 CFR §201.1(b)
[4] (44 CFR § 201.2)
[5] https://www.mass.gov/files/documents/2016/09/nl/executive-order-climate-change-strategy.pdf

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]

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.

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

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 Vulnerability 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 Whitman 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.

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

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.

This 2021 Whitman Integrated Municipal Vulnerability Preparedness and Hazard Mitigation Plan (MVP-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 Whitman, 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]

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

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 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 14: 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 the 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 15: 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)

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 Whitman 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.

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

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 4: Annual Total Precipitation, Massachusetts, and Plymouth County

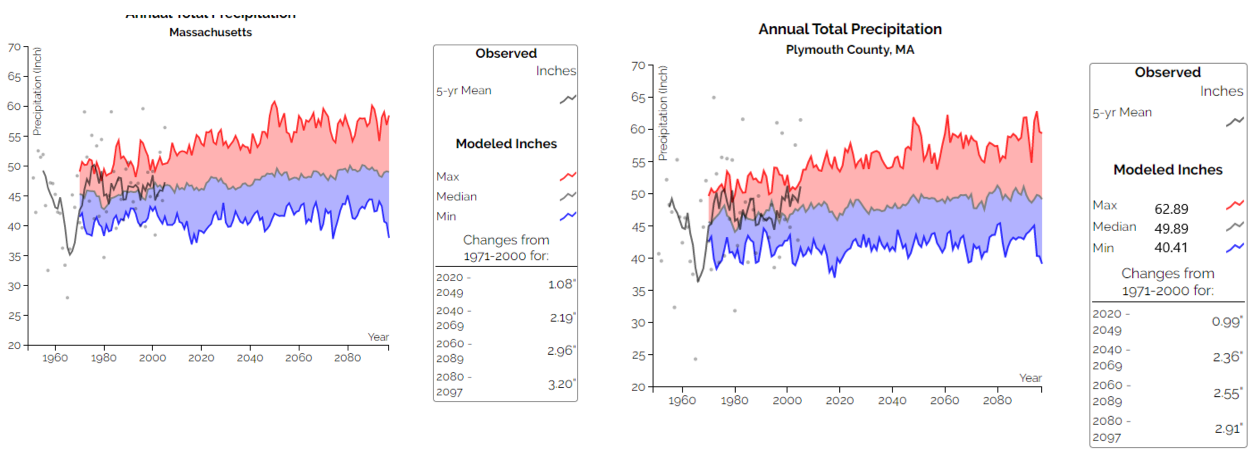
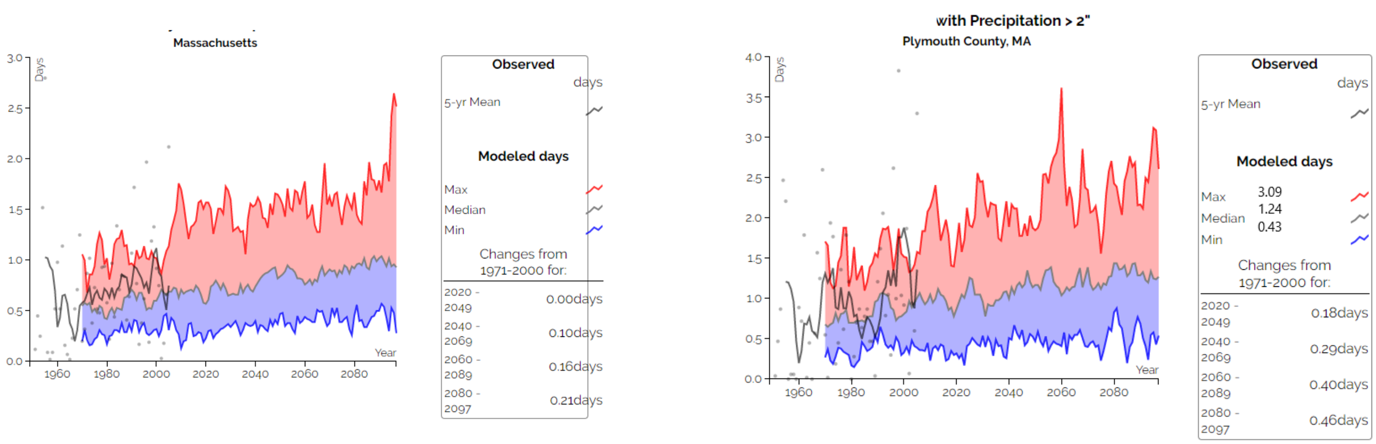


Figure 5: Annual Days with Precipitation>2", Massachusetts, and Plymouth County



Source: ResilientMA.org, 2020

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 depicted in the Annual Average Temperature.

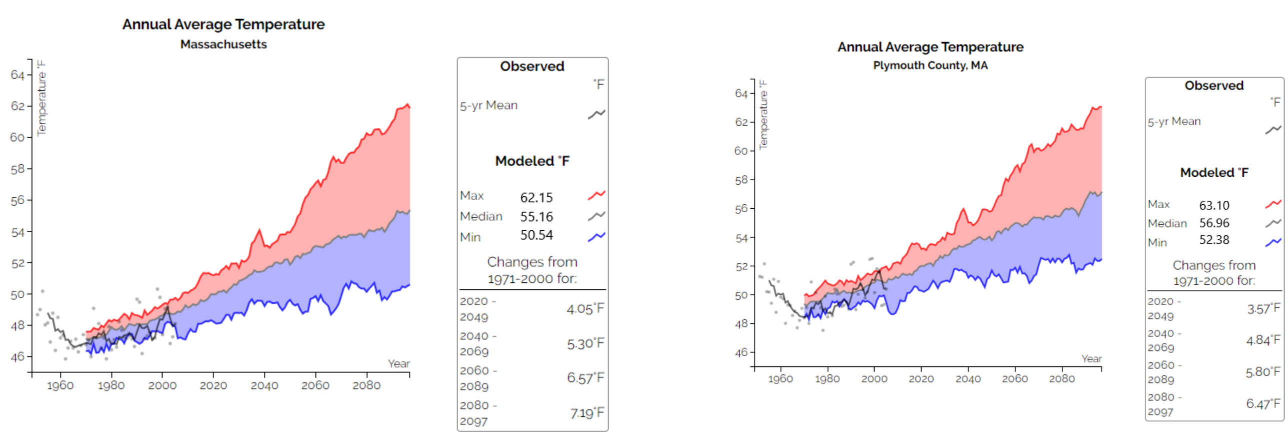
Table 16: Maximum Daily Projected Temperature Changes through 2100

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 6: 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] The Projected Annual Days with temperature below 32° displays this trend of fewer days below freezing.

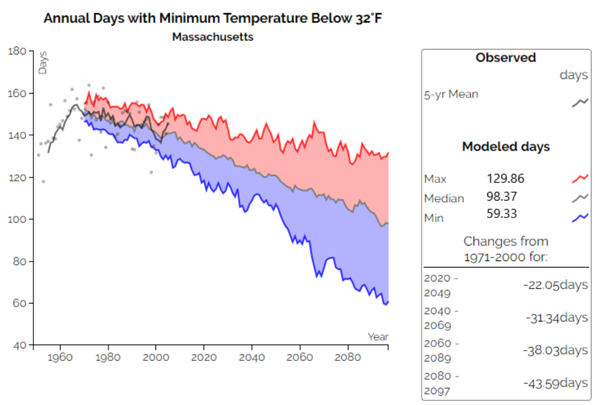
Although minimum temperatures are projected to increase at a greater rate than maximum temperatures in all seasons, significant increases in maximum temperatures are anticipated. Summer highs are projected to reach 85.6°F by mid-century, and 91.4°F by the end of this century, compared to the historical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

Table 17: 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 7: Annual Days Minimum Temperature Below 32F, Massachusetts



Source: ResilientMA.org, 2020

[15] **SHMCAP, 2018**

[16] **SHMCAP, 2018**

[17] **SHMCAP,2018**

Figure 8: Annual Days with Minimum Temperature Below 32F, Plymouth County

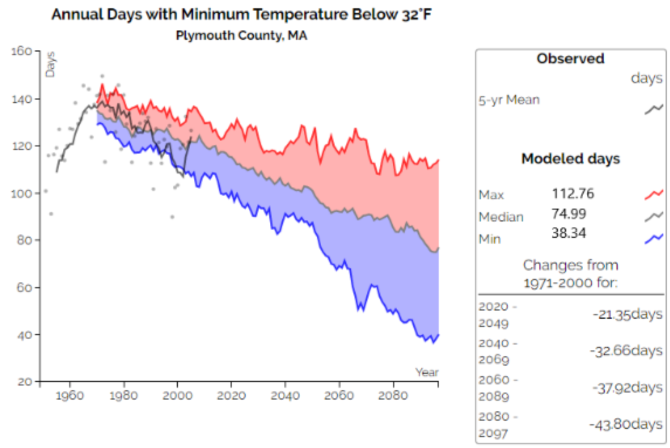


Figure 9: Annual Days with Minimum Temperature Below 0F, Massachusetts

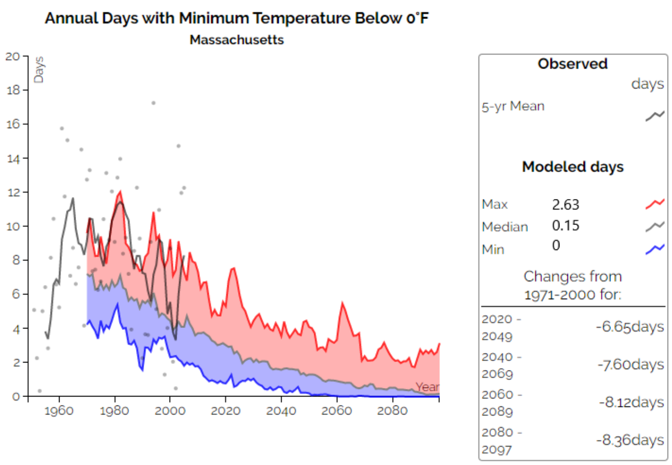
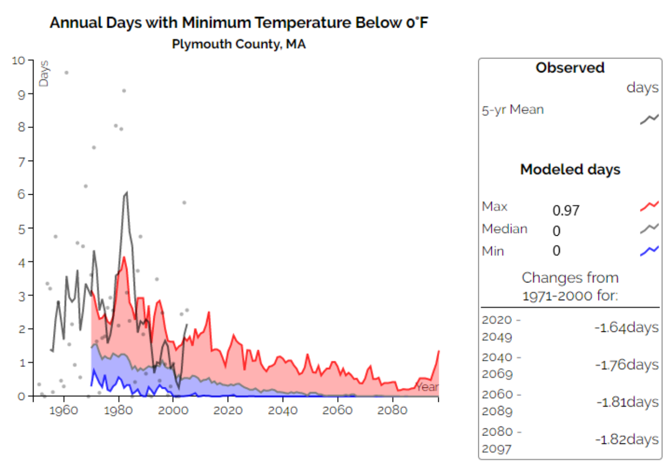


Figure 10: Annual Days with Minimum Temperature Below 0F, Plymouth County



Source: ResilientMA.org, 2020

Figure 11: Annual Minimum Temperature, Massachusetts

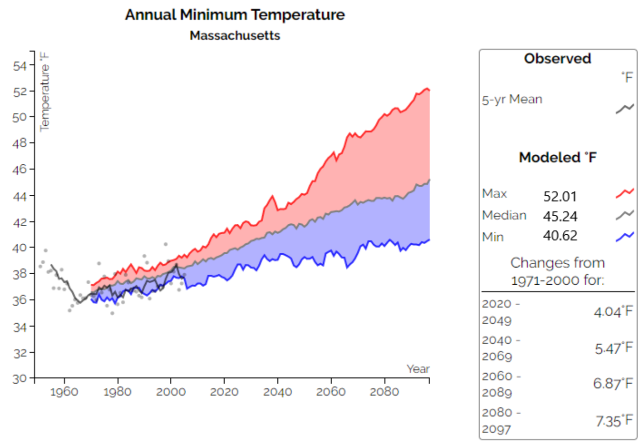


Figure 12: Annual Minimum Temperature, Plymouth County

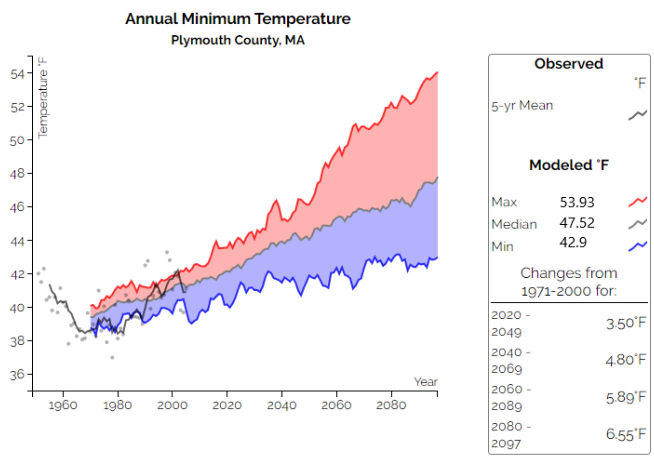
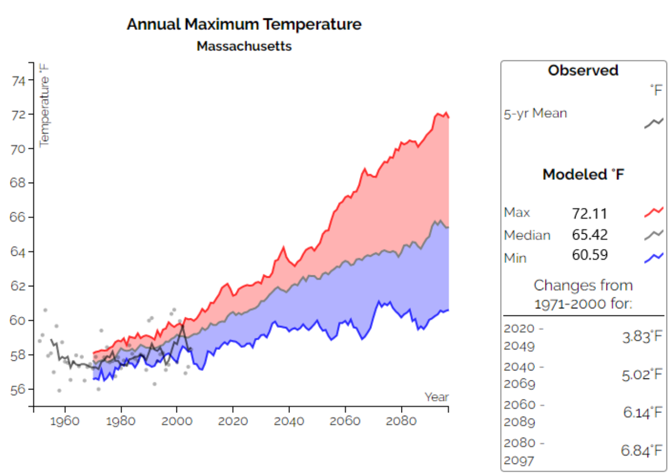


Figure 13: Annual Maximum Temperature, Massachusetts



Source: ResilientMA.org, 2020

Figure 14: Annual Maximum Temperature, Plymouth County

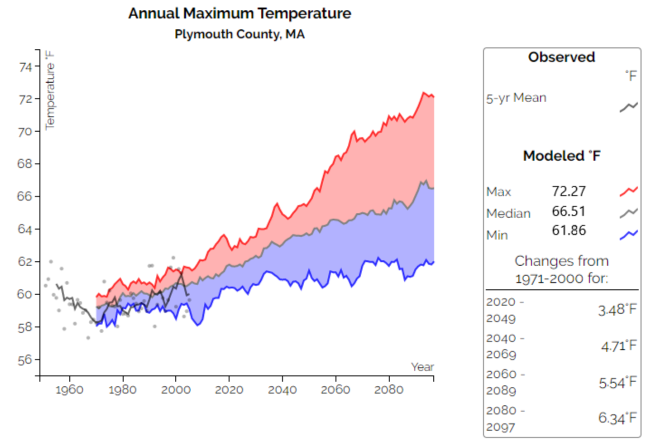


Figure 15: Annual Days with Maximum Temperature Above 95F, Massachusetts

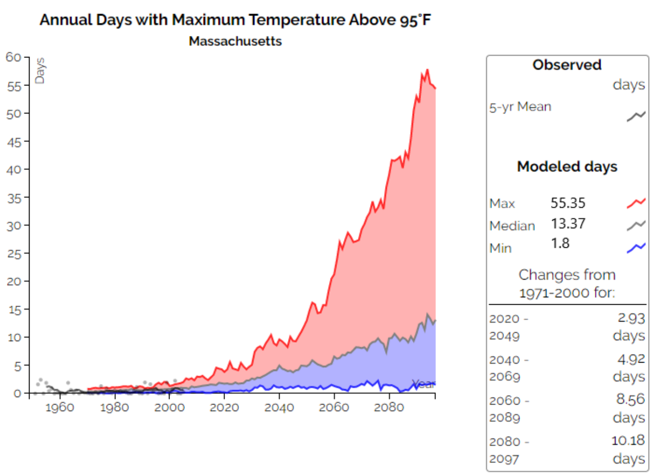
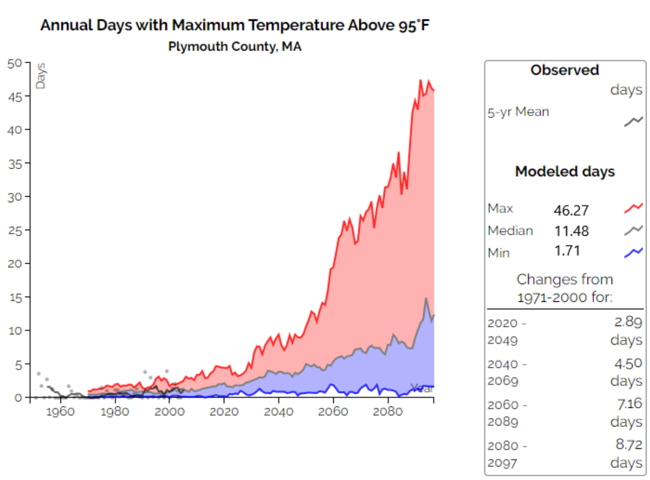


Figure 16: Annual Days with Maximum Temperature Above 95F, Plymouth County



Source: ResilientMA.org, 2020

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

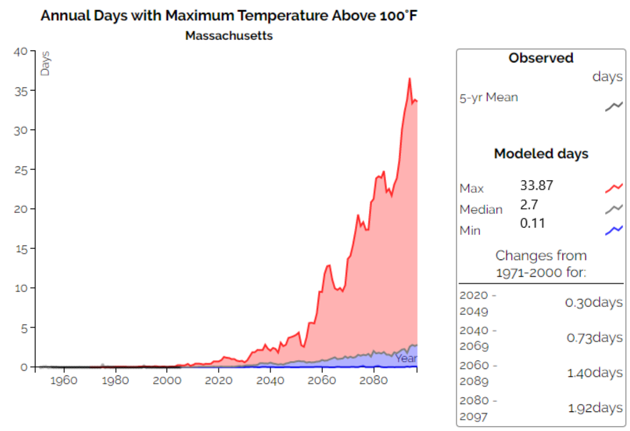
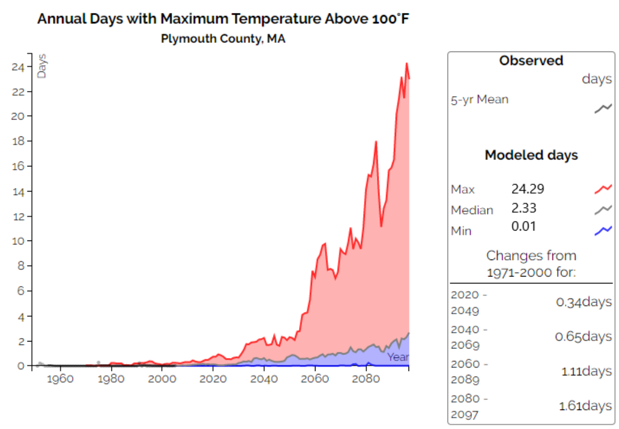


Figure 18: Annual Days with Maximum Temperature Above 100F, Plymouth County



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]

[18] **resilientMA**

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

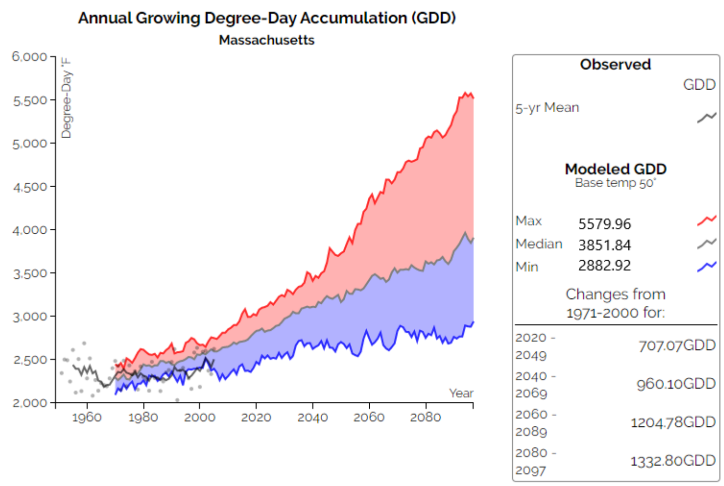
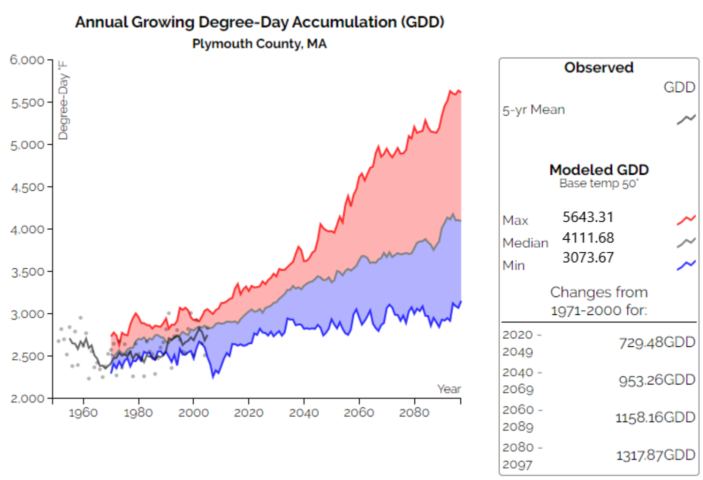
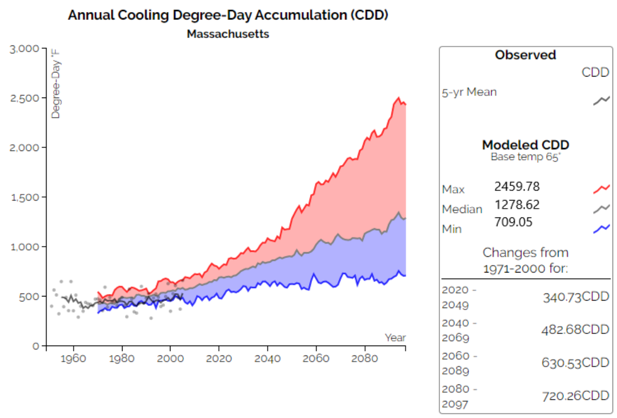


Figure 20: Annual Growing Degree-Day Accumulation (GDD), Plymouth County



[19] **SHMCAP, 2018**

Figure 21: Annual Cooling Degree-Day Accumulation (CDD), Massachusetts



Source: ResilientMA.org, 2020

Figure 22: Annual Cooling Degree-Day Accumulation (CDD), Plymouth County, MA

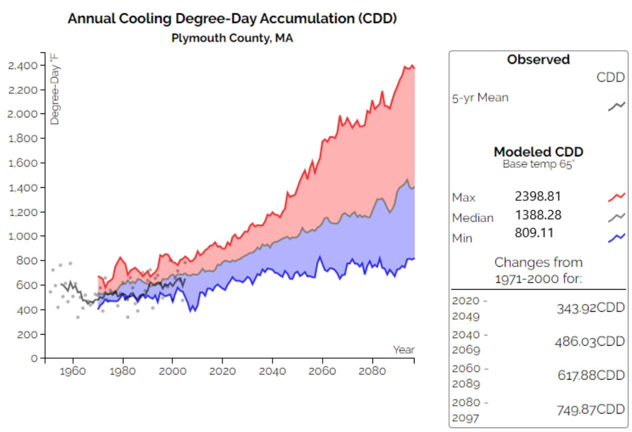
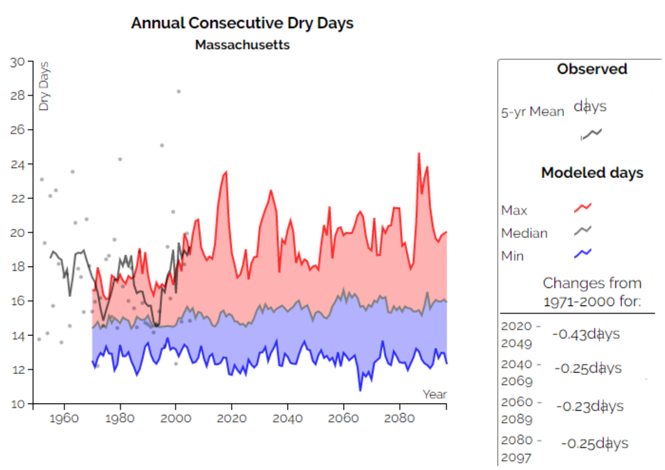


Figure 23: Annual Consecutive Dry Days, Massachusetts



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 18: Northeast Climate Adaptation Science Center Relative Mean Sea Level Projections for Boston, MA

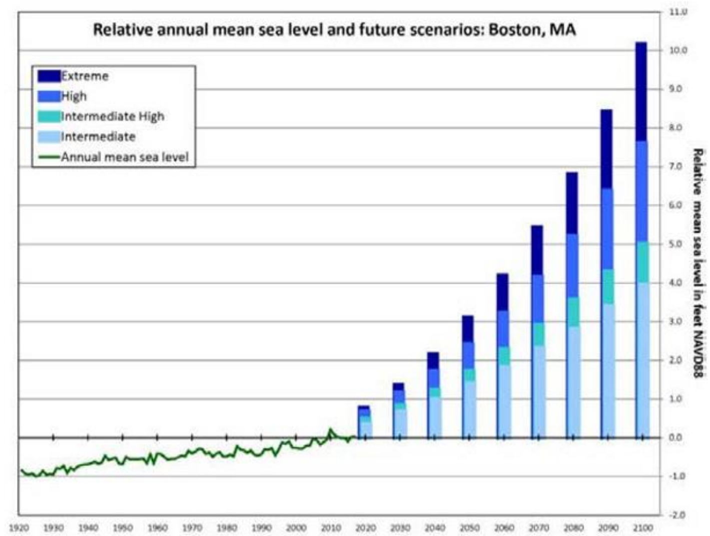
Boston Relative Mean Sea Level (feet NAVD88)									
Scenario	**Summary**	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**	**2090**	**2100**
Intermediate	Intermediate scenario primarily based on medium and high emissions scenarios and accounts for possible higher ice sheet contributions to sea 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 24: 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. Hazard Mitigation and Climate Adaptation Goals

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 four 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

C4. Does the Plan identify and analyze a comprehensive range of specific mitigation actions and projects for each jurisdiction being considered to reduce the effects of hazards, with emphasis on new and existing buildings and infrastructure? (Requirement §201.6(c)(3)(ii))

The Core Team reviewed the mitigation actions from the 2015 plan to identify completed actions and those needing revision. The Table below indicates the status of all actions from the 2015 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 update local and regional Hazard Mitigation Plans.
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.
Emergency Services Protection All Hazards	Conduct local disaster response drills	Community Emergency Management	1-3 years/Medium	Low/Low	CEMA Budget, Department of Homeland Security (DHS), Mass Dept.	Region has participated in local disaster response drills

		Agencies (CEMA)			of Public Health (DPH)	
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	This is an ongoing mitigation strategy.
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, and it continues through this process.
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	Ongoing
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	Ongoing
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	Mutual Aid Agreement was developed in Comprehensive Emergency Management Plan.
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 and continues through updating HMP.

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	Compliance with updated FEMA floodplain data.
Property, Protection, Emergency Services Protection – Flooding	Floodproof or relocate municipally owned critical facilities located within floodplains.	CEMA, DPW	Ongoing/Medium	High/High	Local Community, FEMA, HMP Program	Ongoing.
Property Protection – Flooding	Selectively elevate high-risk structures where /when appropriate.	CEMA, Property Owners	Ongoing/Medium	High/High	Local Community, FEMA, HMA Program, Private Property Owner	Communities have not had the funding to pursue this further. Although private property owners may have.
Property Protection – Flooding	Very selectively elevate key appliances in basements of homes that frequently flood where/when appropriate.	CEMA, Property Owners	Ongoing/Medium	Medium/Medium	FEMA, HMA Programs, Private Property Owners	Communities have not had the funding to pursue this further. Although private property owners may have.
Property Protection – Flooding	Consider voluntary flood area acquisition programs where appropriate as well as provide incentives for land protection.	FEMA, MEMA, CEMA, Property Owners	1-10 years/Low	Medium/High	Local Community, FEMA, HMA Program, Private Property Owner	Communities have not had the funding to pursue this further. Although private property owners may have.
Prevention – Flooding	Improve enforcement of existing floodplain bylaws.	Local Community, Building Inspectors	Ongoing/Medium	High/Low	Local Community	Some communities have enforced these fully, whereas others have not had the funding to fully enforce. Whitman has

						updated their floodplain bylaw in 2021.
Prevention – Flooding	Limit the expansion of infrastructure in hazard-prone areas.	Local Community	Ongoing/Medium	Medium/Low	Local Community	Ongoing
Prevention – Flooding	Develop bylaws that require the utilization of green infrastructure for on-site containment of stormwater.	Local Community	1-5 Years/Medium	Medium/Low	Local Community	Some communities have achieved this, while others have not due to funding constraints. This has been identified as an Mitigation Action Item for this Plan Update.
Prevention – Flooding	Study opportunities for selective enhancement of low-lying natural areas for flood storage, habitat, open space, along waterways.	Local Community	1-10 Years/Low	Low/Low	Local Community	Some communities have achieved this, while others have not due to funding constraints.
Prevention, Structural Project – Flooding	Remove or modify obstacles to flow in confined spaces, such as bridges and culverts with inadequate clearance.	MADOT, Local Community, DPW	1-3 Years/High	High/High	Local Community, MADOT	Some communities have achieved this, while others have not due to funding constraints.
Prevention – Flooding	Ensure that each dam has an updated Emergency Action Plan and Inundation Map.	DCR Office of Dam Safety, Local Community	1-10 Years/High	Medium/Medium	Local Community	Some communities have achieved this, while others have not due to funding constraints.
Prevention, Structural Project – Flooding	Inspect, maintain, and upgrade older dams for present functions and stormwater management potential.	MEMA, DCR Office of Dam Safety, Local Community, Property Owner	1-3 Years/High	High/High	DCR, Local Community, Property Owners	Some communities have achieved this for each of their dams while others have not due to a lack of funding.
Prevention – Flooding	Educate local Emergency Management Directors about dams and the risk level of the dams in their communities	DCR Office of Dam Safety, Local Community	1-3 Years/High	Low/Low	DCR	Ongoing

Multi-Hazard Mitigation Measures from 2015 Plan

Green Community Designation: The Town has been designated by the Department of Energy Resources as a Green Community. Hence, the Town conducts projects annually that improve energy efficiency and reduce greenhouse gas emissions. This is an ongoing program that the Town is actively participating in.

Capital Improvement Program: The Town has a capital improvement program that includes projects that will benefit natural hazard mitigation, such as the implementation of stormwater management improvements. The program is updated annually and is currently receiving input.

Reverse 911: The Town has had a Reverse 911 system for many years.

Comprehensive Emergency Management Plan (CEMP): Every community in Massachusetts is required to have a Comprehensive Emergency Management Plan. These plans address mitigation, preparedness, response, and recovery from a variety of natural and man-made emergencies. These plans contain important information regarding flooding, hurricanes, tornadoes, dam failures, earthquakes, and winter storms. Therefore, the CEMP is a mitigation measure that is relevant to al the hazards discussed in this plan.

Massachusetts State Building Code: The Massachusetts State Building Code contains many detailed regulations regarding wind loads, earthquake resistant design, flood-proofing, and snow loads.

Floodplain Overlay District Bylaw: The Town's floodplain overlay district zoning bylaw was revised in May 2013. All development in the district must comply with Chapter 131, Section 40 MGL; 780 CMR (State Building Code) for flood resistant construction which addresses floodplain; 310 CMR Section 10.00; and 302 CMR 6.00, as well as DEP Title 5 regulations for subsurface disposal of sanitary sewage.

Discharges to Municipal Storm Sewers Bylaw: Includes enforcement by the DPW on illicit connections to prevent pollutant from entering the system.

Local Wetlands Protection Bylaw: The Town has a local wetlands protection bylaw which states that no person shall alter land within 100 feet of any resource area. Resource areas can include vegetated wetland, meadow, swamp, or bog; or within 100 feet of any river, brook, stream (intermittent or otherwise), pond or lake; any land under water; or within 100 feet of bordering or isolated land subject to flooding or inundation by groundwater or surface water. The local bylaw gives the Commission authority to regular buffers to resource areas.

Stormwater Management and Erosion Control Bylaw: The bylaw was approved by town meeting in May 2013.

Subdivision Regulations: Address drainage, erosion, and sediment control, and have additional standards for the floodplain district. The peak rate of stormwater runoff shall not exceed the rate prior to construction based on the 10, 25, 50 and 100-year storm design. Street drainage cannot be channeled into a wetland or water body without first going to a vegetated detention basin in accordance with DEP stormwater regulations. Where possible, streets must be laid out so that filling or construction in the flood plain district is not required.

Groundwater Protection Overlay District: The Groundwater Overlay District bylaw protects wellhead for the Whitman drinking water supply.

Massachusetts Stormwater Regulations: These regulations are applied to development within the jurisdiction of the Conservation Commission.

Wetlands Protection Act: The Whitman Conservation Commission administers the state's Wetlands Protection Act (Chapter 131, Section 40 MGL) to protect resource areas in and around wetlands, including land subject to flooding.

Open Space and Recreation Plan: The current Plan was recently approved by the State and includes a chapter on flood hazard areas and related data.

Street Sweeping Program: As part of the Town's program, street sweeping is conducted twice a year.

Cleaning Catch Basins and Culverts: As part of the Town's program, all catch basins are cleaned annually.

Existing Dam Mitigation Measures

DCR Dam Safety Regulations: All jurisdictional dams are subject to the Division of Conservation and Recreation's dam safety regulations (302 CMR 10.00). The dams must be inspected regularly, and reports filed with the DCR Office of Dam Safety. The Town communicates with the DCR Office of Dam Safety to confirm regular maintenance is performed to make sure the dams in Whitman are stable.

Permits Required for Construction: State law requires a permit for the construction of any dam.

Existing Town-Wide Mitigation for Wind-Related Hazards

Massachusetts State Building Code: The Town enforces the Massachusetts State Building Code whose provisions are generally adequate to protect against most wind damage. The code's provisions are the most cost-effective mitigation measure against tornados given the extremely low probability of occurrence. If a tornado were to occur, the potential for severe damages would be extremely high.

Tree Maintenance by Energy Utility National Grid: National Grid trims along power lines every five years.

Tree Warden Forestry Department Tree Maintenance Program: The Town Tree Warden has an ongoing program for removing diseased and dead trees which pose a risk to public safety and utility lines.

Existing Town-Wide Mitigation for Winter-Related Hazards

Snow Removal: The Town conducts snow plowing operations and provides standard sanding and salting.

Existing Town-Wide Mitigation for Fire-Related Hazards

Measures to Address Wildfire Risk: The Town requires fireproof roofing shingles. Vegetative fuel under power lines is also removed to reduce fire risk.

Road Maintenance: This includes removing road debris that poses a fire risk.

Open Burning Permits Required: The Town allows controlled open burning in accordance with state regulations, but a permit is required for the Fire Department. Open burning is only allowed from January 15th to May 1st. Residents can call the department with questions and complaints.

Fire Department Review of Proposed Development: The Fire Department reviews all subdivision and site plans for compliance with site access, water supply needs, and other applicable regulations within their jurisdiction.

Existing Town-Wide Mitigation for Geologic Hazards

Massachusetts State Building Code: The State Building Code contains a section on designing for earthquake loads (780 CMR 1612.0). Section 1612.1 states that the purpose of these provisions is "to minimize the hazard to life to occupants of all buildings and non-building structures, to increase the expected performance of higher occupancy structures as compared to ordinary structures, and to improve the capability of essential facilities to function during and after an earthquake". This section goes on to state that due to the complexity of seismic design, the criteria presented are the minimum considered to be "prudent and economically justified" for the protection of life safety. The code also states that absolute safety and prevention of damage, even in an earthquake event with a reasonable probability of occurrence, is not economically achievable for most buildings.

Mitigation Capabilities and Local Capacity for Implementation: Under the Massachusetts system of "Home Rule," the Town of Whitman is authorized to adopt and from time to time amend several local bylaws and regulations that support the Town's capabilities to mitigate natural hazards. These include the Zoning Bylaws, Stormwater Bylaws, Subdivision and Site Plan Review Regulations, Wetlands Ordinance, Health Regulations, Public Works regulations, and local enforcement of the State Building Code. Local Ordinances may be amended by the Town Board of Selectmen to improve the Town's capabilities, and changes to most regulations simply require a public hearing and a vote of the authorized board or commission. The Town of Whitman has recognized several existing mitigation measures that require implementation or improvements, and has the capacity based on these Home Rule powers within its local boards and departments to address them. The Town also can expand on and improve the existing policies and programs listed in the sections above.

2015 Whitman Mitigation Action Plan

D2. Was the plan revised to reflect progress in local mitigation efforts? (Requirement §201.6(d)(3))

Category of Action & Hazard Addressed	Description of Action	Responsible Party	Timeframe/Priority	Benefit/Cost	Potential Funding Sources	Status from 2015
Comprehensive Emergency Management Plan (CEMP)	The CEMP addresses mitigation, preparedness, response, and natural recovery from a variety of natural and man-made emergencies	Town Administrator, Board of Selectmen, Fire Chief, Police Chief	1-5 Years/Medium	Medium/Medium	General Fund	This Action was completed
Emergency Power Generators	The Town maintains emergency power generators in several important public facilities/shelters	Highway Department, Town Administrator	1-5 Years	Medium/High	General Fund	Generators need to be maintained and replaced as needed
Regional and Local Emergency Planning Committee	The Town regularly participates in local and regional emergency planning committees	Town Wide	1-5 Years/Medium	Medium/Medium	General Fund	This action was completed
Public Information and Outreach	The Town provides residents with information about potential natural hazards with leaflets and brochures in municipal buildings throughout the Town	Municipal	1-5 Years/Medium	Medium/Medium	General Fund	Information could be updated and/or replaced on a regular basis.
Natural Hazard Mitigation Plan	Update and adopt the Natural Hazard Mitigation Plan every five years.	Town Wide	1-5 Years/Medium	Medium/Medium	General Fund, Grant Program	This action was completed and is currently being updated
Participation in the National Flood Insurance Program NFIP	Provides flood insurance for structures located within a floodplain	Planning Board, Board of Selectmen	1-5 Years/Medium	Medium/Medium	General Fund,	This action was completed and is included in this update
Floodplain & Watershed Protection District	The district provides that lands subject to seasonal or periodic flooding is not used for housing or	Planning Board, Conservation	1-5 Years/Medium	Medium/Medium	General Fund,	This action was completed and is included in this update

	other purposes as to endanger the health and safety of the public or burden the public with costs resulting from unwise land choice; protects, preserves, and maintains the water table and water recharge areas to preserve present and potential water supplies; assures the continuation of the natural flow of watercourses to provide for adequate and safe floodwater storage capacity.	Commission, Board of Selectmen				
Catch Basin Maintenance	The Town regularly cleans and maintains the catch basins and culverts throughout the town on a semi-annual basis	Highway Department	1 Year	High	General Fund	This action was completed.
Street Sweeping	The Town conducts street sweeping on a semiannual basis	Highway Department	1 Year	High	General Fund	This action was complete
Enforcement of State Building Code	The Building Inspector enforces the state building code	Building Department	1 Year	High	General Fund	This action was complete
Tree Trimming	The Town works with utility providers to trim trees that may impact utility lines	Tree Warden, Highway Department	1 Year	High	General Fund	This action was complete
Burn Permit	The Town requires residents to obtain a burn permit from the Fire Department before conducting outdoor burns	Fire Dept	1 Year	High	General Fund	The action was complete
Fire Department Review of New Development	The Fire Department participates in the review of all new development in town	Fire Department, Building Department, Planning Board	1 Year	High	General Fund	This action was complete
Cooling Centers	The Town opens cooling centers as weather conditions warrant	Fire Department, Building Department, Board of Health, Board of Selectmen	1 Year	High	General Fund	This action was complete

D3. Was the Plan revised to reflect changes in priorities? (Requirement §201.6(d)(3))

The Mitigation Strategy chapter details previous hazard mitigation actions and their status. Several actions were completed, as indicated in the Table above. One action was deemed incomplete, and the is included in this Plan Update. Another significant change in the 2021 Plan is the list of goal statements. The current list is consistent with the State mitigation plan and includes climate adaptation; it also more accurately reflected the current risks and priorities of the Town. The Town has prioritized identifying and implementing solutions to adapt to climate change. They have also prioritized public education, awareness, and outreach. The high risk of flood and mitigation actions related to flooding is consistent with the previous plan.

Authority and Assurances

The Town of Whitman will continue to comply with all applicable Federal laws and regulations during the periods for which it receives grant funding, in compliance with 44 CFR 201.6. It will amend its Plan whenever necessary to reflect changes in Town, State, or Federal laws and regulations, as required in 44 CFR 201.6.

The Core Team recognizes the following FEMA publications:

- *Local Mitigation Planning Handbook (March 2013)*
- *Local Mitigation Plan Review Guide (October 2011)*
- *Demonstrating Good Practices Within Local Hazard Mitigation Plans (January 2017, FEMA Region 1)*

Plan Adoption

E1. Does the Plan include documentation that the Plan has been formally adopted by the governing body of the jurisdiction requesting approval? (Requirement §201.6(c)(5))

The Town of Whitman will adopt the Plan when it has received "approved-pending adoption" status from the Federal Emergency Management Agency. The Certificate of Adoption is included on Page 85.

Section 3. Community Profile, Land Use, and Development Trends

Community Profile

Whitman 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 Whitman 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 2019 Whitman had a population of 15,056 persons. [21]

The 2010 Census data shows a population count of 14,489, an increase of 4.19 percent from the 2000 US Census, the total population increase of 607 persons. The 2010 Census data indicates there were 5,300 households and 3,746 (70.7%) family households residing in town. [22] Of those family households 1,964 (54.4%) have related children under the age of 18 living with them, and 1,817 of those total households (48.5%) live with their own children under 18 years of age. Of the total households in Whitman, 704 households were female households had no husband present, 412 (58.5%) have related children under 18 years. [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

According to the 2010 US Census, of all households within town, 535 (10.1%) were made of male individuals living alone and 682 (12.9%) were female individuals living alone. Of the total households in 2010 1,181 (22.3%) were households with individuals 65 years and over. The average household size was 2.73 and the average family size was 3.25.

Whitman is a relatively affluent community with high median annual income and a low poverty rate. According to the 2019 ACS, the median household income, was $86,570 while 3.5 percent of all Whitman families was living below the poverty level.

Table 19: Whitman Demographics

	2000 Census	2010 Census	2019 ACS
Population	13,882	14,489	15,216
Median Age	34.7	38.2	38.0
Under 5 Years	950	944	871
21 years and Over	6,498	10,326	10,852
62 Years and Over	1,010	2,058	2,479
85 Years and Over	59	165	226
Average Households Size	3.03	2.73	2.74
Average Family Size	3.38	3.25	3.33
Owner-Occupied Housing Units	3,123[24]	3,822	3,856
Renter -Occupied Housing Units	11.0%	1,478	1,610

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

Table 20: Demographics of Whitman and Plymouth County

People QuickFacts	Massachusetts	Plymouth County	Whitman
Population			
Population estimates July 1, 2019 (V2019)	6,892,503	521,202	15,216
Population estimates base, April 1, 2010	6,547,785	494,932	14,485
Population, percent change – April 1, 2010 (estimates base) to July 1, 2019 (V2019)	5.3%	5.3%	5.0%
Population, Census, April 1, 2010	6,547,629	494,919	14,489
Age and Sex			
Persons under 5 years, percent	5.2%	5.3%	5.8%
Persons under 18 years, percent	19.6%	21.2%	22.9%
Persons 65 years and over, percent	17.0%	18.6%	12.8%
Female persons, percent	51.5%	51.4%	50.5%

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

People QuickFacts	Massachusetts	Plymouth County	Whitman
Race and Hispanic Origin			
White alone, percent	80.6%	84.2%	92.5%
Black or African American alone, percent	9.0%	11.7%	1.9%
American Indian or Alaska Native alone, percent	0.5%	0.3%	0.0%
Asian alone, percent	7.2%	1.6%	0.8%
Native Hawaiian and Other Pacific Islander alone, percent	0.1%	0.1%	0.0%
Two or More Races, percent	2.6%	2.0%	2.7%
Hispanic or Latino, percent	12.4%	4.2%	2.5%
White alone, not Hispanic or Latino, percent	71.1%	81.1%	91.7%

People QuickFacts	Massachusetts	Plymouth County	Whitman
Population Characteristics			
Veterans, 2014-2018	315,859	29,831	789
Foreign born persons, percent, 2014-2018	16.5%	9.35%	3.9%

People QuickFacts	Massachusetts	Plymouth County	Whitman
Housing			
Housing units, July 1, 2019 (V2019)	2,928,732	209,542	
Owner-occupied housing unit rate, 2015-2019	62.3%	75.9%	70.5%
Median value of owner-occupied housing units, 2015-2019	$366,800	$356,700	$327,100
Median selected monthly owner costs – with a mortgage 2015-2019	$2,165	$2,205	$2,167
Median selected monthly owner costs – without a mortgage, 2015-2019	$786	$805	$746
Median gross rent, 2015-2019	$1,225	$1,227	$1,240
Building permits, 2019	17,365	1,114	

People QuickFacts	Massachusetts	Plymouth County	Whitman
Families & Living Arrangements			
Households, 2014-2018	2,601,914	186,306	5,466
Persons per household, 2014-2018	2.53	2.69	2.74
Living in same house 1 year ago, percent of persons aged 1 year+, 2014-2018	87.1%	89.6%	92.4%
Language other than English spoken at home, percent of persons aged 5 years+, 2014-2018	23.6%	13.2%	5.6%

People QuickFacts	Massachusetts	Plymouth County	Whitman
Computer and Internet Use			
Households with a computer, percent, 2014-2018	90.1%	92.0%	93.4%
Households with a broadband internet subscription, percent, 2014-2018	84.7%	86.9%	84.9%

People QuickFacts	Massachusetts	Plymouth County	Whitman
Education			
High school graduate or higher, percent of persons aged 25 years+, 2014-2018	90.4%	92.9%	94.1%
Bachelor's degree or higher, percent of persons aged 25 years+, 2014-2018	42.9%	36.7%	29.0%
Health			
With a disability, under age 65 years, percent, 2014-2018	7.9%	7.6%	6.7%
Persons without health insurance, under age 65 years, percent	3.2%	2.8%	2.9%

People QuickFacts	Massachusetts	Plymouth County	Whitman
Transportation			
Mean travel time to work (minutes), workers aged 16 years+, 2015-2019	29.7	33.3	32.7

People QuickFacts	Massachusetts	Plymouth County	Whitman
Income & Poverty			
Median household income (in 2019 dollars), 2015-2019	$77,378	$85,654	$86,570
Per capita income in past 12 months (in 2018 dollars), 2014-2018	$41,794	$41,343	$37,256
Persons in poverty, percent	10.0%	6.2%	6.2%

Businesses QuickFacts	Massachusetts	Plymouth County	Whitman
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	1,145
Men-owned firms, 2012	357,154	26,404	597
Women-owned firms, 2012	199,210	14,089	489
Minority-owned firms, 2012	89,967	3,987	31
Non-Minority-owned firms, 2012	499,959	38,762	1,055
Veteran-owned firms, 2012	58,339	4,843	84
Nonveteran-owned firms, 2012	525,667	37,423	1,038
Geography			
Population per square mile, 2010	839.4	750.9	2,087.8
Land area in square miles, 2010	7,800.06	659.08	6.94

People QuickFacts	Massachusetts	Plymouth County	Whitman
Economy			
In civilian labor force, total, percent of population age 16 years+, 2014-2018	67.1%	67.6%	72.6%
In civilian labor force, female, percent of population age 16 years+, percent	63.4%	63.7%	69.0%
Total accommodation and food services sales, 2012 ($1,000)	17,508,975	909,430	16,918
Total retail sales, 2012 ($1,000)	63,583,090	6,889,614	148,779
Total retail sales per capita, 2012	81,927,799	$13,786	$10,184

Source: U.S. Census Bureau QuickFacts: Whitman town, Plymouth County, Massachusetts

Population Characteristics

Population Trends

Local, regional, and statewide populations in Massachusetts were prepared by the University of Massachusetts Donahue Institute in 2019. The projected population of Whitman and the Commonwealth is displayed in the following Table.

Table 21: Population Trends Whitman and Massachusetts

Town	**Census 2000**	**Census 2010**	**2020**	**2030**	**2040**
Whitman	13,882	14,489	15,169	15,389	15,583
Massachusetts	6,349,097	6,547,629	6,933,887	7,225,472	7,380,399

According to these projections, the population of Whitman is projected to increase by 7.55 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: UMass Donahue Institute Population Projections

	2010	**Forecast Year**			**% Increase**
	Census	**2020**	**2030**	**2040**	**2010 - 2040**
Massachusetts	***6,547,629***	*6,933,887*	*7,225,472*	*7,380,399*	*12.72%*
OCPC Region	***362,406***	***379,936***	***391,583***	***396,418***	***9.39%***
Abington	15,985	17,386	18,764	19,000	18.86%
Avon	4,356	4,385	4,444	4,500	3.31%
Bridgewater	26,563	27,800	28,333	28,689	8.00%
Brockton	93,810	96,000	96,700	97,100	3.51%
Duxbury	15,059	15,030	15,307	15,500	2.93%
East Bridgewater	13,794	14,400	14,616	14,800	7.29%
Easton	23,112	23,830	24,689	25,000	8.17%
Halifax	7,518	7,600	7,620	7,640	1.62%
Hanover	13,879	13,864	13,999	14,084	1.48%
Hanson	10,209	10,600	10,863	11,000	7.75%
Kingston	12,629	13,369	14,814	15,000	18.77%
Pembroke	17,837	18,300	18,695	18,931	6.13%
Plymouth	56,468	64,166	68,559	70,312	24.52%
Plympton	2,820	2,910	2,963	3,000	6.38%
Stoughton	26,962	27,900	28,279	28,635	6.21%
West Bridgewater	6,916	7,227	7,549	7,644	10.53%
Whitman	14,489	15,169	15,389	15,583	7.55%

Figure 26: Percent Change in Population

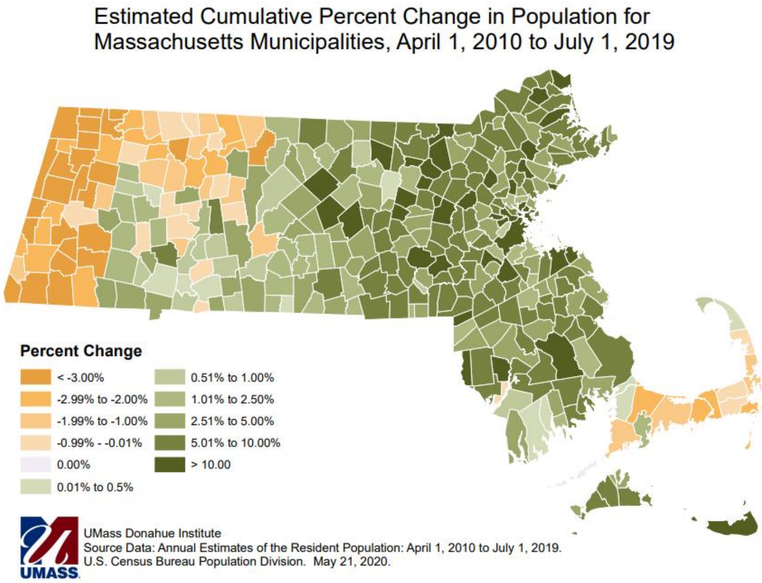
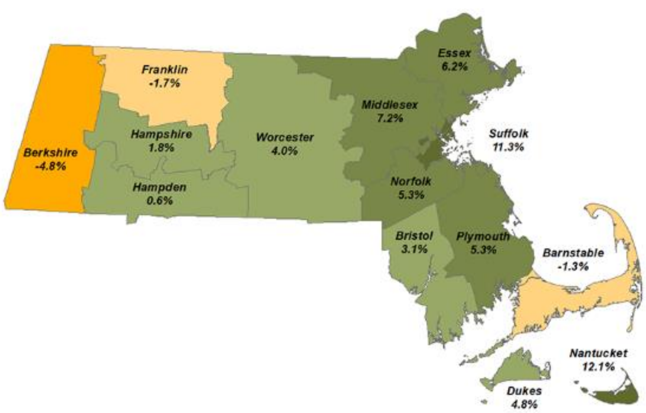


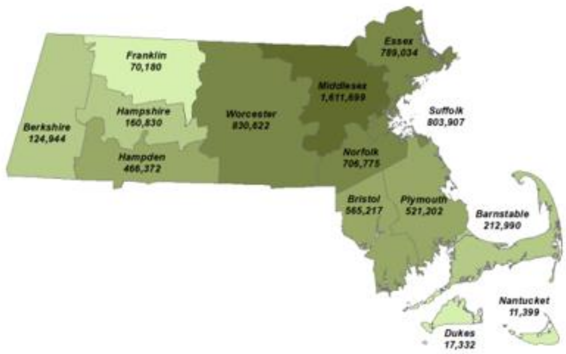
Figure 27: Massachusetts 2019 County Population Estimates: Cumulative Change, Census 2010 to July 1, 2019



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. [25]

Figure 28: 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

Table 22: Population Density

County	Population 2000[1]	Population 2010[2]	Population 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 Whitman are getting older. In the decade between 2000 and 2010, Whitman's elderly population increased, from 618 residents (4.4%) over the

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

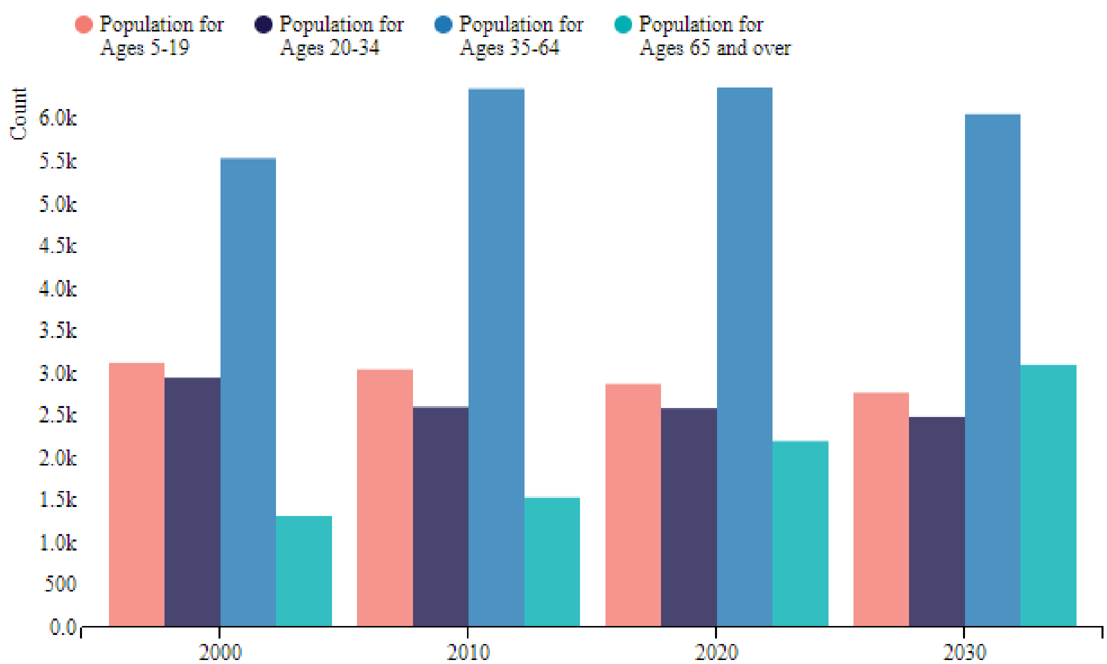
age of 75 in Census year 2000 to 650 residents (4.4%) in 2010. The population increased 5.2 percent between 2000 and 2010. The data shows significant population growth in all age groups above age 45, with the highest population growth from 2000 to 2010 occurring in the 55 to 64 age group. This trend reflects the growth and maturing of the "Baby Boom" generation (those born between 1946 and 1964) as they move across the age ranges. This aging trend is also reflected in the increase in the median age, which rose from 34.7 years in 2000 to 38.2 years in 2010. At the same time, the "Young Professional" (ages 25-44) age group has been declining in population. From 2000 to 2010, the population of this age group has declined 14.7 percent. At the same time, the decline in the 25 to 44 age group could reflect both demographic trends and the limited supply of affordable and workforce housing in town.

Table 23: Age Distribution in Whitman, 2000-2010

	2000		2010		Change 2000 - 2010	
	Number	Percent	Number	Percent	Number	Percent
<5 Years	950	6.8%	944	6.5%	-6	-0.6%
5 to 9 Years	1,053	7.6%	1,035	7.1%	-18	-1.7%
10 to 14 Years	1,110	8.0%	0,14	7.0%	-96	-8.6%
15 to 19 Years	962	6.9%	997	6.9%	35	3.6%
20 to 24 Years	799	5.8%	855	5.9%	56	7.0%
25 to 34 Years	2,152	15.5%	1,748	12.1%	-404	-18.8%
35 to 44 Years	2,507	18.1%	2,227	15.4%	-280	-11.2%
45 to 54 Years	1,912	13.8%	2,407	16.6%	495	25.9%
55 to 64 Years	1,119	8.0%	1,727	11.9%	608	54.3%
65 to 74 Years	700	5.0%	885	6.1%	185	26.4%
75 Years and Over	618	4.4%	650	4.4%	32	5.2%
Median Age (Years)	34.7		38.2		3.5	10.1%

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

Figure 29: Whitman Population by Age Group 2000 - 2030



Source: Housing Whitman MA

In Whitman, the aging of the Baby Boomers will cause the senior population to increase by 1,600 people, or 110 percent, through 2030. The total population is projected to increase by 1,000 or 7.1 percent, over the same period.[26]

Race and Ethnicity

The racial demographics of Whitman and the South Subregion towns are similar, but the area is far less diverse than Massachusetts as a whole. In Whitman, 92.5 percent of all residents are white, compared with 79 percent of Massachusetts residents. Additionally, Whitman's Latino population (2.5 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 Whitman and so many suburbs on the South Shore is inextricably linked to the region's lack of housing diversity.

The racial and ethnic composition of Whitman has changed over the last decade. Whitman by and large is a racially and linguistically homogenous community. In 2010, 95.0 percent of residents identified

[26] **Housing Whitman MA**

themselves as White, a slight decrease from 97.2 percent in 2000. While the White population increased only slightly from 2000 to 2010, most minority populations increased at a greater rate. Specifically, the Other Race Alone population grew by 127.3 percent from 2000 to 2010, increasing from 66 to 150, the Hispanic population by 118.9 percent from 122 to 267, the African American population by 100 percent, from 90 to 180 residents, and the Asian population by 88.1 percent from 59 to 111. While these minority populations are still small, constituting just 5 percent of the total population, their growth over the past decade is significant and shows that Whitman is slowly transitioning to a more diverse community.

Table 24: Race and Ethnicity in Whitman 2000-2010

	2000		2010		Change 2000-2010	
	Number	Percent	Number	Percent	Number	Percent
White Alone	13,487	97.2%	13,768	95.0%	281	2.1%
Black or African American Alone	90	0.6%	180	1.2%	90	100%
American Indian or Alaskan Native Alone	22	0.2%	35	0.2%	13	59.1%
Some Other Race Alone	66	0.5%	150	1.0%	84	127.3%
Two or More Races	156	1.1%	240	1.7%	84	53.8%
Total Population	13,882	100.0%	14,489	100.0%	607	4.4%
Hispanic or Latino (of any race)	122	0.9%	267	1.8%	145	118.9%

Source: US Census Bureau, 2000 & 2010

Economy

Income

According to the US Census Bureau, the income per capita for Whitman is $37,256 which is more than the Massachusetts average of $35,485 and greater than the National average of $28,051. The income per capita in Whitman is 4.75 percent higher than the national average.

The median household income for Whitman residents is $86,570 which is substantially more than the Massachusetts average of $66,658 and the National average of $53,046. The median household income in Whitman is 38.72 percent higher than the National average. The percentage of Whitman residents living below the poverty level is 6.2% percent according to the 2019 American Community Survey, 5-year profiles. Male median earnings in Whitman are 12.9 percent higher at $65,163 than female median earnings of $56,792. The female median year-round, full-time earnings in the US are $43,022, 24 percent less that the female median earnings for Whitman.

Table 25: Employment and Labor Force Data

OCPC Region Cities and Towns				
Average Data from March 2020 to February 2021				
Area Name	Labor Force	Employment	Unemployment	Rate
Abington Town	9,193	8,250	942	10.3
Avon Town	2,715	2,427	288	10.6
Bridgewater City	14,657	13,313	1,344	9.2
Brockton City	48,796	41,859	6,937	14.2
Duxbury Town	7,474	6,859	615	8.2
East Bridgewater Town	8,598	7,796	801	9.3
Easton Town	13,993	12,866	1,127	8.1
Halifax Town	4,361	3,916	445	10.2
Hanover Town	7,585	6,929	656	8.7
Hanson Town	6,326	5,733	592	9.4
Kingston Town	7,368	6,668	701	9.5
Pembroke Town	10,488	9,511	976	9.3
Plymouth Town	32,457	29,244	3,213	9.9
Plympton Town	1,633	1,481	152	9.3
Stoughton Town	16,262	14,616	1,646	10.1
West Bridgewater Town	3,876	3,498	378	9.8
Whitman Town	9,236	8,315	921	10.0

Source: Massachusetts Executive Office of Labor and Workforce Development

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. Whitman'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.

In Whitman, three industries account for almost half of the employment of its residents, with the educational services, healthcare and social assistance industry accounting for 26.7 percent, the retail trade industry accounting for 12.4 percent and the finance, insurance, real estate rental and leasing industry accounting for 9.6 percent. Employment data is important to review because it gives a sense as to how many people in Town are working in traditional high-paying industries (professional, management, finance) versus people working in traditional low-paying industries, such as retail, hospitality, and food service industries.

Table 26: Percent Change in Annual Labor Force, 2000 - 2019

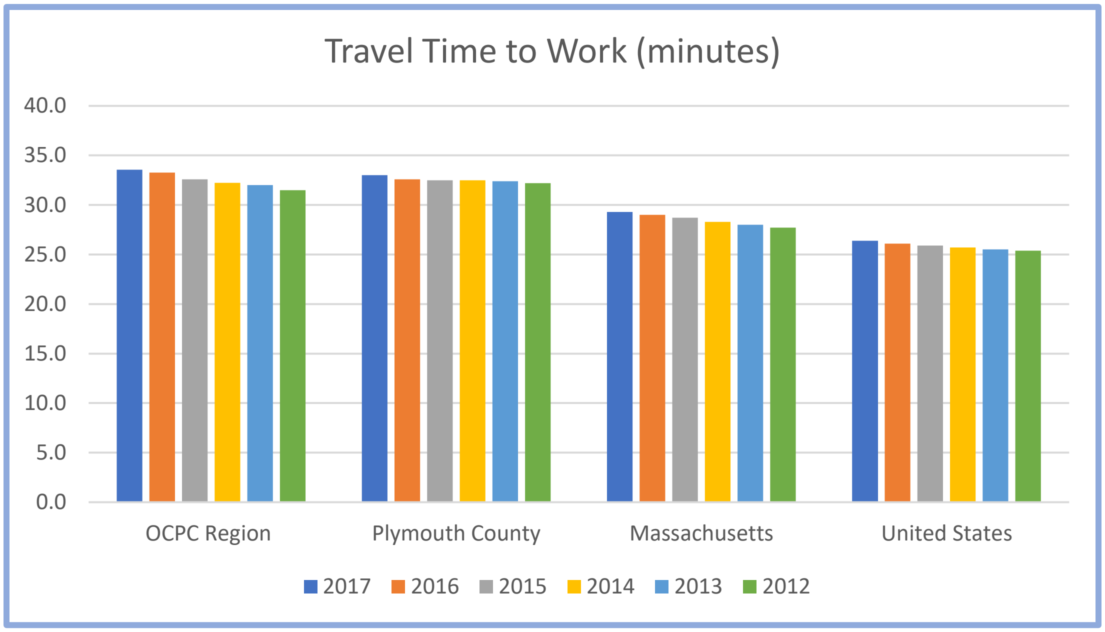
Percent Change in Average			
Annual Labor Force 2000 to 2019			
Community	**2000 Labor Force**	**2019 Labor Force**	**Percent Change 2000 - 2019**
Abington	8,416	9,527	11.3%
Avon	2,370	2,821	14.43%
Bridgewater	13,151	15,436	14.3%

Brockton	45,357	49,574	5.55%
Duxbury	7,208	8,005	4.05%
East Bridgewater	7,156	9,102	20.81%
Easton	13,082	14,978	5.10%
Halifax	4,180	4,561	3.71%
Hanover	7,211	8,010	6.21%
Hanson	5,374	6,648	17.06%
Kingston	6,120	7,630	17.14%
Pembroke	9,464	11,042	11.23%
Plymouth	27,609	33,379	14.35%
Plympton	1,563	1,724	4.41%
Stoughton	15,392	16,888	5.02%
West Bridgewater	3,511	4,079	9.20%
Whitman	8,026	9,644	14.08%
OCPC Region	185,190	213,048	9.59%
Massachusetts	3,273,400	3,630,583	10.91%

Table 27: Employment versus Population Ratio

Employment versus Population Ratio			
	Total Employed	Total Population	Ratio
Abington	9,240	16,275	1.8
Avon	2,500	4,468	1.8
Bridgewater	14,204	27,434	1.9
Brockton	44,155	95,161	2.2
Duxbury	6,936	15,444	2.2
East Bridgewater	7,353	14,301	1.9
Easton	12,892	24,001	1.9
Halifax	4,285	7,739	1.8
Hanover	6,897	14,328	2.1
Hanson	5,919	10,560	1.8
Kingston	6,843	13,210	1.9
Pembroke	10,365	18,230	1.8
Plymouth	29,807	58,695	2.0
Plympton	1,417	2,912	2.1
Stoughton	15,084	28,338	1.9
West Bridgewater	3,493	7,117	2.1
Whitman	8,291	14,864	1.8
OCPC Region	189,681	373,077	2.0
Massachusetts	3,454,047	6,789,319	2.0

Figure 30: Travel Time to Work



Source: American Community Survey, Selected Economic Characteristics DP03

Housing Needs Assessment

An analysis of population, household, age, race, and ethnicity, education, disability, income, and employment data were reviewed to help provide insight into the existing housing need and demand.

Key Findings:

- The population of Whitman increased 9.4 percent from 13,240 in 1990 to 14,489 in 2010. It is expected to increase an additional 5.1 percent to 15,583 in 2040.
- The number of households in Whitman increased 6.0 percent from 4,999 in 2000 to 5,300 in 2010. It is expected to increase an additional 16.4 percent to 6,195 in 2040.
- The large majority (70.7%) of Whitman's households are family households.
- The average household size in Whitman decreased from 2.77 persons in 2000 to 2.73 persons in 2010. A significant majority (71.0%) of households of Whitman over the age of 45 increased 30.4 percent from 2000 to 2010, whereas the population under the age of 45 decreased 7.5 percent during the same period.
- The racial and ethnic composition of Whitman is largely homogenous, with 95 percent of the population identifying as white.
- Enrollment at the three Whitman-based schools in the Whitman-Hanson Regional School District increased slightly from 1,649 in the 2006-2007 school year to 1,661 in the 2015-2016 school year.
- The population of Whitman is well-educated, with 40.7 percent of the population age 25 and over having a college degree.

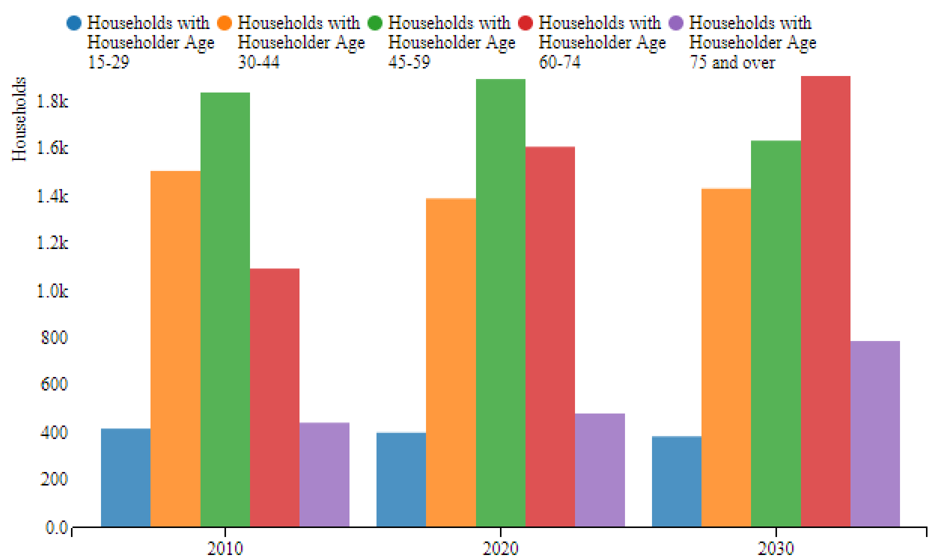
- Approximately 9.5 percent of the residents in Whitman reported having some type of disability in 2019. The most common types of disability were ambulatory difficulty (4.4%) and cognitive difficulty (4.1%).
- Whitman's median income was $86,570 which is substantially more than the Massachusetts average of $66,658 and the National average of $53,046.
- Children (under age 18) and seniors (over age 65) have the highest levels of poverty in Whitman.
- Whitman has a low percentage of families below the federal poverty level; however, some family types are more likely than others to live in poverty, such as female householders with no husband present who have children under 18 years of age.
- Slightly more than one-third of the households in Whitman are low-income, earning less than 80 percent of AMI and potentially eligible for federal and state housing assistance.

Households by Age Cohort

Just as aging Baby Boomers will dominate the overall population dynamics of the state, they will also have a substantial influence on household changes and housing needs in Whitman. As this large generation ages, it will increase the number of householders over 60 by 80 percent statewide through 2030, and their share of all households will increase from 28 to 44 percent over the same period. Meanwhile, the total number of householders under age 60 will change only slightly from one decade to the next, and most age groups under 60 will see a decline in the number of households between 2010 and 2030.

In Whitman, householders over 60 will decrease from 28 percent of the population in 2010 to 44 percent in 2030, an increase of 80 percent. Meanwhile, under 60 households will decrease by 300, or 7.9 percent, as seen in the following Figure.

Figure 31: Whitman Households by Age



Source: [Housing Whitman MA]

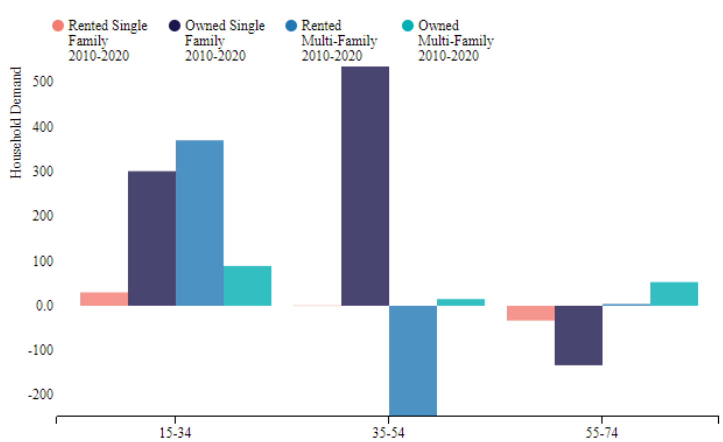
Housing Unit Demand Change

Changes in housing unit demand result from household formation, dissolution, and mortality. Young adults currently between the ages of 15 and 30 are poised to form households after they leave home, dorm, or roommates. Thousands are projected to do so each year, and each will need a housing unit, typically multi-family rental units. Meanwhile, older adults have typically already formed households. Combined with mortality, outmigration, or transition to nursing homes and other group quarter situations, this translates to a decline in housing unit demand among householders 55 and over, despite a sharp increase in the number of senior-headed households.

The decline in demand from older householders will partly offset increased demand from their younger counterparts. However, shifts in preferences among younger households towards multi-family units means that only 29 percent of new multi-family demand will be met through existing units freed up by householder over 55.

Through 2020, new households headed by someone currently under the age of 35 will need an additional 790 housing units. Households headed by someone currently between the ages of 35 and 55 will demand 300 more units. Householders currently over the age of 55 will need 620 fewer units than they do today. After accounting for the units freed up by departing seniors and the units needed to maintain a healthy vacancy rate, this translates into net demand for 310 single family and 160 multi-family units. The following Figure breaks projected demand down by householder cohort, unit type, and tenure.[27]

Figure 32: Projected Household Demand by Householder Cohort, Unit Type, and Tenure



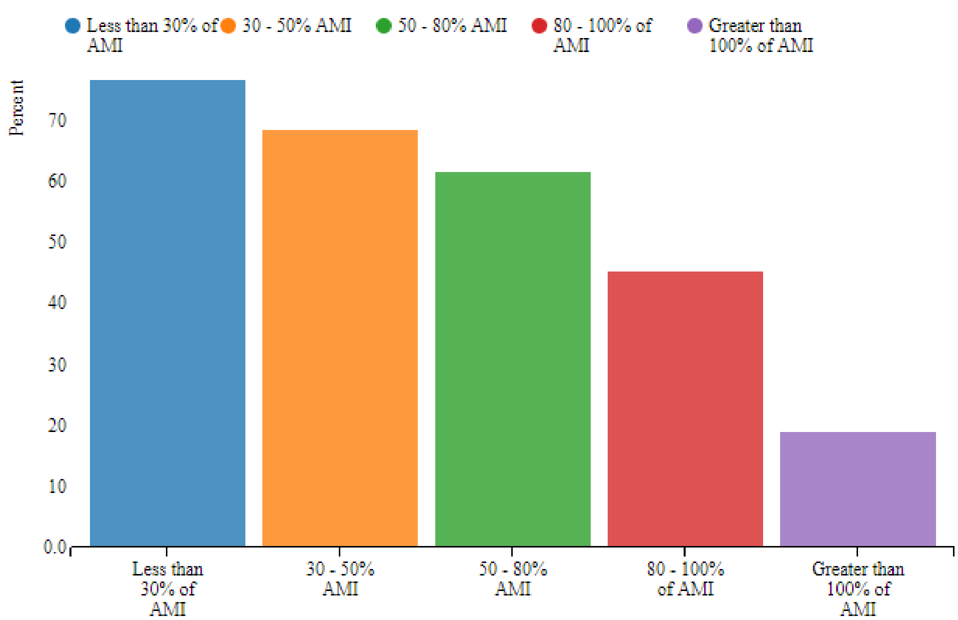
[27] Housing Whitman MA

Housing Cost Burden

The most common measure of housing affordability is the percent of income that households spend on housing costs. According to most federal and state agencies, households that spend more than 30 percent of income on housing costs are "cost burdened." Households that spend more than 50 percent of income on housing are "severely cost burdened." Areas where more than 30 percent of households are cost burdened face an affordable housing shortage. In Whitman, 39 percent and 15 percent of households are cost burdened and severely cost burdened, respectively, compared to 29 percent and 14 percent of households statewide.

As expected, cost burden is also more common among low-income households. Statewide, 81 percent of all extremely low-income households, 67 percent of very low-income households, and 49 percent of low-income households are cost burdened, versus 14 percent of households with incomes above 100 percent AMI. The following Figure shows the percent of Whitman households that are cost burdened and severely cost burdened by income level.

Figure 33: Percent of Whitman Households Cost Burdened by Income Level



Source: [Housing Whitman MA]

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 Whitman 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).

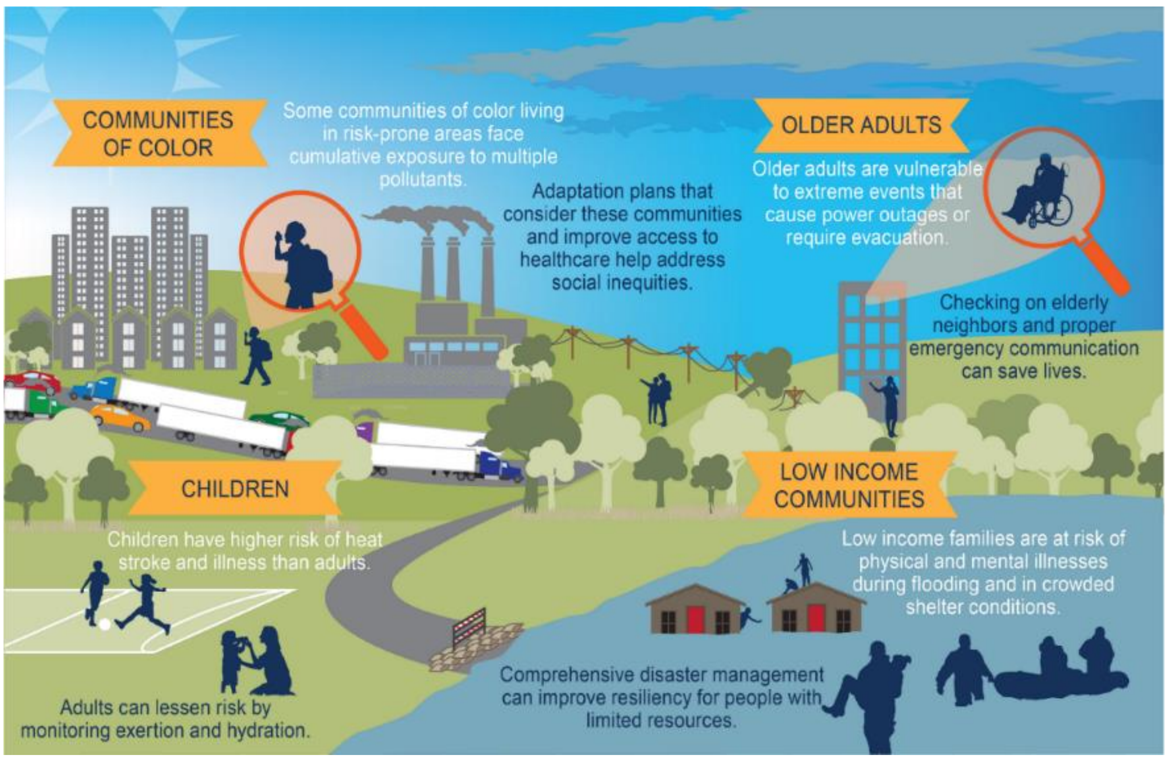
B. Increases in food and waterborne illnesses and other infectious diseases from altering geographic and seasonal distributions of existing vectors and vector-borne diseases) SHMCAP, 2018).

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).

Figure 34: Vulnerable Populations



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 Whitman

The following Table provides a snapshot of vulnerable populations in Whitman, 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.

Table 28: Environmental Justice Census Data

	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
Whitman	5.8%	12.8%	9.5%	7.5%	29.5%	93.4%	84.9%
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%

Source: 2019 ACS DP02, DP05

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.

Whitman has a block group that meets the criteria to be designated an Environmental Justice population for Income whose annual median household income is equal to or less than 65 percent of the statewide median ($62,072 in 2010).

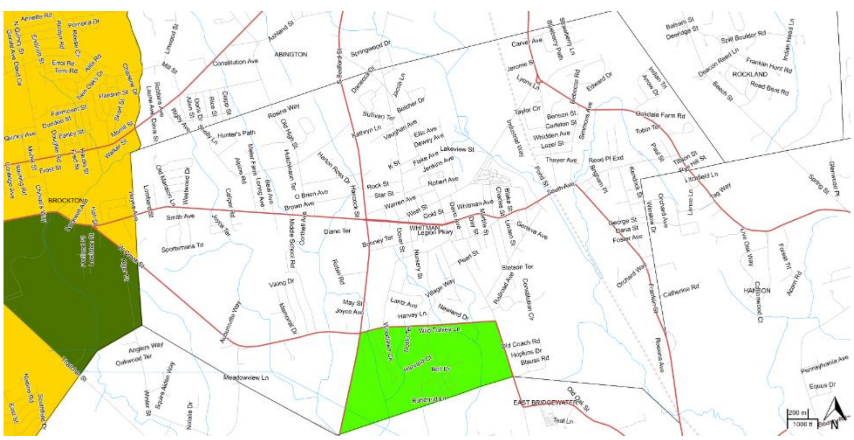
Table 29: Environmental Justice Demographics

Environmental Justice Demographics

Race	2019 ACS % of the Population	Percent
Total Population	15,056	100%
One Race	14,650	97.3%
White	13,926	92.5%
African American	288	1.9%
American Indian	0	0.00%
Asian	116	0.8%
Native Hawaiian	0	0.00%
Some other race	320	2.1%
Hispanic or Latino	379	2.5%
Mexican	7	0.0%
Puerto Rican	199	1.3%

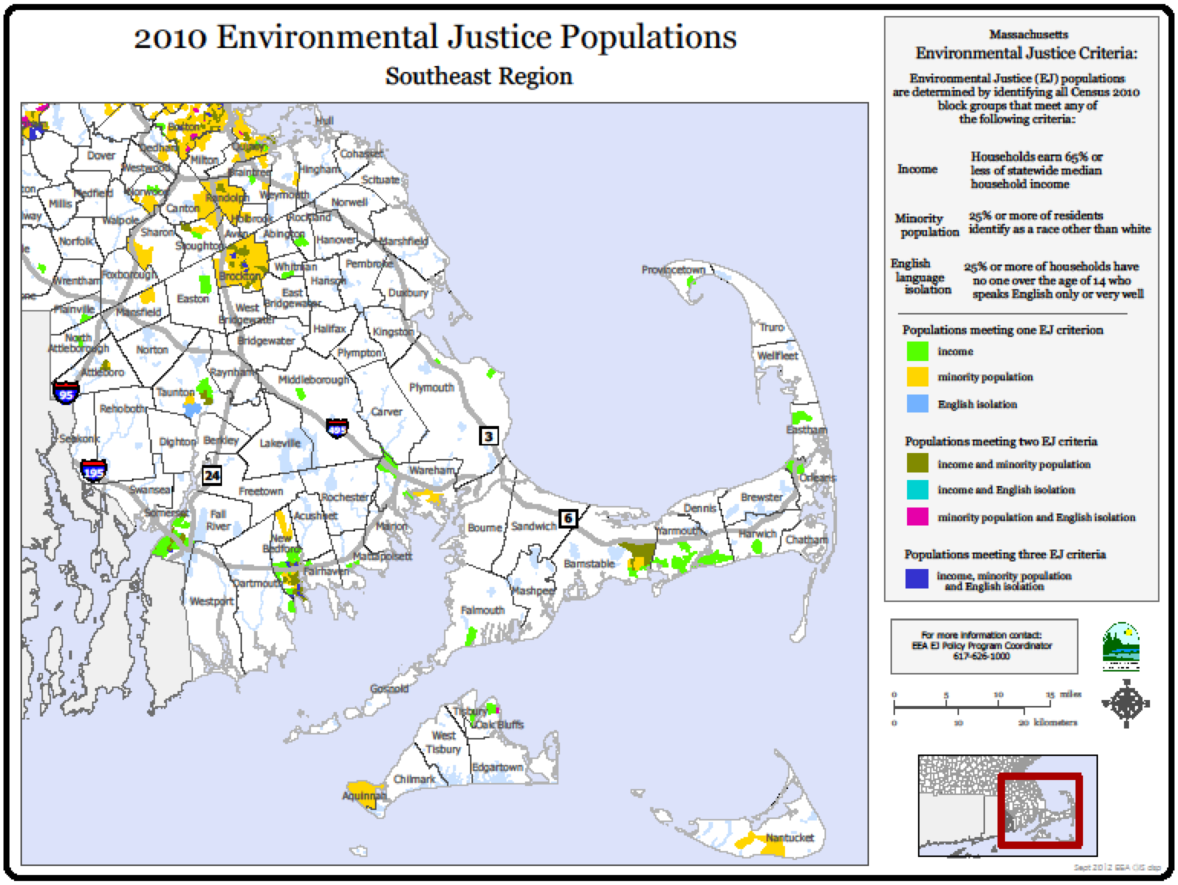
Source: 2019 ACS, DP05

Figure 35: Whitman, MA Environmental Justice Block Groups



Source: [Environmental Justice Viewer (state.ma.us)]

Figure 36: 2010 Environmental Justice Populations, Southeast Region



Source: Environmental Justice Viewer (state.ma.us)

Historical Overview

Early Industry

During its early development, the Town of Whitman was largely an agricultural community. The first industry developed on the downstream side of Schumatuscacant River. It was in this area that he first industrial canal and tunneling of the colony were constructed in 1745. Trees from the town's forests provided a source of timber for several seaport towns. Timbers from Whitman were used to construct the frigate USS Constitution also known as Old Ironsides. The Town soon developed into an important manufacturing center. The first show racks were manufactured, cannon balls were cast at Colonel Hobart's Bell and Cannon Foundry, nails and tacks were made, and wooden boxes were built. During the 1800s, many cottage industries established in the1700s began to develop into larger businesses. By the mid-1800s, several of these businesses grew into large scale assembly line factories. At one time, the Dunbar, Hobart, and Whidden Tack Factory, erected in 1864, were the largest in the world. The DB Gurney Company dates to 1825 and is still in operation in Whitman today. The leading manufactured products were shoes and boots. The shoe industry and related industries became the largest employer in the Town and remained as the largest employer until the mid-1900s at which time the shoe industry began its steady decline.

The Toll House Restaurant was built in 1817. In 1930, Kenneth and Ruth Wakefield purchased the old Smith house. The Wakefield's combined their talents to establish a fine restaurant at this location. The Toll House cookie was apparently an accidental creation by Mrs. Wakefield. These cookies became so popular locally that she contacted the Nestle' Company, and with this, the Toll House Restaurant and the Town of Whitman were on the map.

Dairy farming has also been an important part of Whitman's history and its local economy. At one time, several family operated dairy farms existed in the town, selling their products to local markets. A great deal of farmland has been developed, leaving Peaceful Meadows as the only full dairy operation still in business.

Land Use and Development Trends

Whitman was first settled in 1670 and became part of neighboring Abington before incorporating as the separate town of South Abington in 1875. The name Whitman was adopted in 1886 to honor Augustus Whitman, a prominent citizen. There is a monument to Whitman, built in 1908 located in Whitman Town Park on Park Avenue. The park itself was designed by famed landscape architect Frederick Law Olmsted. The monument was dedicated on October 10, 1908. Originally, the monument was to be entirely granite with the customary soldier depicted at parade rest. The monument committee changed their minds and greatly enhanced the memorial by opting for a bronze statue in a unique skirmish line stanch. Built by Long & Sanders of Quincy, the cost was $5,000.

Whitman's population grew quite rapidly between 1890 and 1910 and then again in the 1960s and 70s. Since 1970, the Town's population has remained relatively steady. Evidence of Whitman's manufacturing heyday can be seen in the remaining factory buildings. Though largely abandoned, some of these former factories have been converted into condominiums, helping to address the increasing demand for housing in the Town. Whitman is working to reinvigorate the local economy by supporting business development, improving walkability, supporting traffic circulation, protecting recreational and ecologically sensitive open spaces and planning for future development.

Historically, many Whitman residents worked in town, but that number has decreased dramatically since the middle of the 1900s. Between 1900 and 2000, the number of businesses located in Whitman decreased by almost 50, but the number of jobs rose by more than 100. The expansion of the public sewer system enables Whitman's infrastructure to support a larger economic base.

Despite being a few towns removed from the limited access highways, Whitman remains very well connected to other communities as well as to Boston and Brockton. There are several regional roads that run through Whitman, and it has an MBTA commuter rail stations on the Kingston/Plymouth Line.

Whitman is comprised of only 7.1 square miles, making it one of the smallest towns in the Commonwealth of Massachusetts, it ranks 327th out of 351 communities in the Commonwealth in terms of total area and it is the second smallest community in Plymouth County after Hull. Due to its small size and moderate growth (the population has increased 42% since 1950, from 8,413 in 1950 to 14,489 in 2010) there is little available developable land in Whitman.

The Table below depicts population data for Whitman 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 30: 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

Geographic Overview

Whitman lies just east of Brockton and is a largely residential community with a mixed economy. According to the MassGIS L3 parcel file, which categorizes each parcel by type or land use, it was found that Whitman has 4,453 acres, 15 of which are open water, leaving 4,438 acres of land. For analyzing land availability in Whitman, OCPC excluded any parcels that are in an area with a restriction on construction, including 100-year flood zones, wetlands, and permanently protected open space. After excluding those areas, the analysis showed that Whitman is largely residential, with 2,474 acres or 55.6 percent of the total land area dedicated for residential use, of which only 58 acres are vacant. The analysis showed that 717 acres or 16.1 percent of the total land area is dedicated for commercial or industrial use, of which only 11 acres are vacant. The analysis also showed that 624 acres or 14.0 percent of the total land area is town-owned land, of which only 21 acres are vacant.

With the analysis showing that there are only 58 acres of developable residential land left in Whitman (1.3% of the total land area); this dictates that most of the new residential development would be the redevelopment of underutilized parcels. Redevelopment however can be more expensive given the costs for preservation, rehabilitation, demolition, or other expenses. Thus, the Town will need to identify and focus on implementation strategies that promote and simplify redevelopment.

Land Use Assessment

The Town of Whitman signed the Commonwealth Community Compact agreement on April 21, 2016. Through the Community Compact program, the Town received a grant to engage consulting services to explore development opportunities for an approximate 17+ acre parcel of land that was a former manufacturing site, and to develop strategies for marketing the Site by identifying a highest and best use approach. The Site has a long history of being home to manufacturing companies whose waste disposal practices caused ground pollution to the property. Several shoe factories operated at the Site from the mid 1880’s to the 1960’s, and several businesses leased the Site in the early 1970s. The Site buildings were razed in 1973 and the Site has been vacant since that time. The site comprises 17+ acres on a heavily traveled street adjacent to the Commuter Rail train station.

Aware that the site had been contaminated, the Town requested assistance from Mass Development to conduct a Phase 2 assessment and received a grant. Knowing that a part of the land would be restricted from development we sought assistance through the Community Compact to determine best-use options and develop a plan to market the property once a determination was made of the conditions. The Phase 2 assessment was conducted by Tracy Costa, Senior Project Manager with Ransom Consulting, who identified areas of contamination at the Site. The assessment found the Site contained a cistern with three interconnected underground vaults that contained contaminants. The underground storage tanks were removed in 1989 and the cistern was demolished in 2006. With the Community Compact grant, Ransom Consulting was contracted to conduct follow up Phase II assessment activities to further investigate and identify the extent of the contamination and report conditions and concerns. The Phase 2 assessment identified the parts of the property that would require an AUL leaving to question what remainder of the property would be developable.

As part of the analysis being conducted with funding from the Community Compact grant, C.W. Garvey, Co., Inc., was contracted to conduct a site survey to provide an outline of the developable land, identify wetland delineation and report preparation addressing wetland delineation with respect to the Massachusetts Wetlands Protection Act. The wetland delineation and use limitation area survey report generated by C.W. Garvey, Co., Inc., reveals just under four acres that have potential for redevelopment. It is anticipated that the limitation in the size of developable land will impact Whitman's ability to market the property.

Watersheds

Whitman is located within the 562 square-mile Taunton River Watershed, which encompasses all or portions of 40 cities and towns in southeastern Massachusetts. Within the watershed itself, Whitman is located within the 77 square-mile Matfield River sub-watershed, located in the northeast portion of the Taunton River Watershed.

Of the total acreage in Whitman, 61 acres, or 1.4 percent, falls within Wellhead Protection Areas. These areas were defined and regulated according to the 1996 Safe Drinking Water Act as part of the Source Water Assessment Program.

Protected Open Space, Habitats, Wetlands & Floodplains

Of Whitman's total acreage, 373 acres, or 8.4 percent, is legally and permanently protected as open space that cannot be developed. Approximately 445 acres or 10 percent of Whitman's land consists of habitats for rare, vulnerable, or uncommon species or areas critical for preserving biodiversity. Wetlands and floodplains also have a significant presence in Whitman. Approximately 20.2 percent of the town's acreage, or 900 acres, are wetlands, which are concentrated in the eastern half of town particularly in and around the Hobart Meadow and Bear Meadow. Approximately 16.3 percent or 725 acres of the town's land is within a 100-year floodplain. Whitman's zoning ordinance via the Floodplain and Watershed Protection District limits development in these areas, stating that these lands "shall not be used for residence or other purposes in such a manner as to endanger the health or safety of occupants thereof, or of the public generally, or as to burden the public with costs resulting from unwise individual choices of land use."[28]

Contamination

The Massachusetts Department of Environmental Protection (DEP) Bureau of Waste Site Cleanup, in accordance with M.G.L. Chapter 21E, lists seven sites in Whitman as Activity and Use Limitation (AUL) sites, indicating the presence of hazardous materials. Whitman also has three 21E sites, whose owner is legally obligated to follow certain protocols and maintain the property according to specific guidelines. There is also one 21E Tier 1D site in town, where the responsible party has failed to provide a required submittal to DEP by a specific deadline. Additionally, there is one Tier II site, which does not require a permit, but must be remediated by a Licensed Site Professional.

Zoning Districts

In Whitman, as-of-right zoning is limited to single-family dwellings in the three residential zoning districts. All other housing types are either prohibited or require the granting of a special permit.

Whitman has three residential zoning districts: Single Residence A-1, Single Residence A-2, and General Residence, though housing is also allowed in the Highway Business, General Business and Limited Industrial zoning districts by special permit. There are also Industrial Districts and Flood Plain & Watershed Protection Districts.

Single-family dwellings in Single Residence A-1, Single Residence A-2, and General Residence are the only type of housing permitted as-of-right in Whitman. All other housing development is either prohibited or requires a special permit. Two-family dwellings (both new and conversions), multi-family

[28] Town of Whitman By-Laws, General Provisions, Revised December 1, 1997

dwellings, planned cluster developments, lodging houses and nursing homes are allowable with special permits in certain districts, whereas mobile homes and mobile home parks are prohibited across all districts.

Table 31: Whitman Residential Zoning Bylaw

	Single Residence A-1	Single Residence A-2	General Residence	Highway Business	General Business	Limited Industrial
Single-Family Dwelling	P	P	P	N	N	N
Two-Family Dwelling-Conversion (min. 18,000 s.f. lot)	SP	SP	SP	SP	SP	SP
Two-Family Dwelling-New (min. 22,500 s.f. lot)	SP	SP	N	N	N	N
Multi-family Dwelling (min. 87,000 s.f. lot)	N	N	SP	SP	N	N
Planned Cluster Development	N	N	N	N	N	N
Lodging House	N	N	SP	SP	N	N
Nursing Home	SP	SP	SP	SP	SP	N
Mobile Home	N	N	N	N	N	N
Mobile Home Park	N	N	N	N	N	N

Source: Town of Whitman By-Laws General Provisions
Note: P=Permitted; SP=Special Permit; N=Not Permitted

Whitman's zoning bylaws require a minimum lot area of 22,500 square feet in its Single-Residence A-1 District, 18,000 square feet in its Single-Residence A-2 District, and 10,000 square feet in its General Residence District.

Parking is required for all residential development throughout all districts. Single-family dwellings must provide two spaces per unit and single-family attached and multi-family dwellings must provide 1.3 spaces for each one-bedroom unit, 2.0 spaces for each two-bedroom unit, 2.6 spaces for each three-bedroom unit, and 3.0 spaces for each four-bedroom unit.

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 Whitman'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 the Town'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

Transportation

Roadways

The Whitman Department of Public Works is responsible for maintaining 62 miles of town roadway, which includes State Highways Route 14, Route 18, Route 27, and Route 58. These roadways not only serve the residents of Whitman, but also serve the residents of the region, as these are all important north-south and east-west corridors on the South Shore. Overall, the roadways in Whitman are in good condition and currently support the level of the development within the town. There are critical intersections that may need to be upgraded or considerations made for future traffic-control devices. It is important to note however, that Whitman is not easily accessible to limited access highways (Route 3 and Route 24). It is approximately 8 miles or a 20-minute drive from Route 24 and approximately 11 miles or a 20-minute drive from Route 3. This can limit the appeal of Whitman for people who need to access those highways regularly.

Bedford Street (Route 18) at Auburn Street (Route 14)

Bedford Street (Route 18) and Auburn Street (Route 14) form a four-legged intersection under traffic signal control. Auburn Street is classified as an Urban Minor Arterial and is under Town jurisdiction. The signal is owned and maintained by MassDOT. Auburn Street (Route 14) is a primary connection to Brockton to the west and Hanson to the east.

Land use in the area is commercial, with Wendy's restaurant on the northwest corner, Jay's Market on the northeast corner, CVS on the southeast corner and Mutual Bank on the southwest corner. Adjacent businesses impact operations at the intersection. Walgreens is adjacent to and shares a parking area with Wendy's on the northwest corner, while McDonald's restaurant is adjacent to and shares parking access with CVS on the southeast corner.

Bedford Street provides two lanes in each direction at Auburn Street, which turns accommodated within shared lanes. A solid white edge line is provided to delineate a shoulder, but widths are not sufficient to safely accommodate bicycles. The northbound and southbound approaches widen to two lanes at the intersection and merge back to a single lane departing the intersection. The northbound approach widens to two defined lanes just north of the shared CVS/McDonald's driveway, approximately 110 feet in advance of the northbound stop line. The roadway provides two lanes northbound departing the intersection for approximately 380 feet before merging back to a single lane. It was noted that drivers show aggressive tendencies when traveling through the intersection because they are aware of the impending merge and want to “beat” the driver in the adjacent lane. The southbound approach provides two defined lanes for approximately 225 feet in advance of the stop line. The roadway provides two defined lanes in the vicinity of the shared Wendy’s/Walgreens driveway, which is approximately 100 feet in advance of the stop line. The roadway provides enough width for two lanes for approximately 100 feet departing the intersection southbound but is not marked as such.

Auburn Street (Route 14) generally provides a single lane in each direction but widens to provide a shared lane for left turns and through vehicles as well as a right turn lane eastbound at Bedford Street. The westbound Auburn Street approach widens to provide an exclusive left turn lane, and a shared lane for through vehicles and right turns. Arrow and ONLY markings are provided for the eastbound right turn lane and the westbound left turn lane. A solid white edge line is provided to delineate a shoulder, but widths are not sufficient to safely accommodate bicycles. The traffic signal provides a phase for the Bedford Street approaches, a protected advance phase for the Auburn Street eastbound approach, and a concurrent phase for the Auburn Street approaches. The eastbound left turn is the only left turn which is afforded a protected phase. An exclusive pedestrian phase is activated by pedestrian pushbutton on all four corners of the intersection. No Turn on Red restrictions are signed for all four approaches. Continuous sidewalks are provided along the east side of Bedford Street and along the north side of Auburn Street. Sidewalk on the southwest corner extends to a sidewalk leading to Mutual Bank, while sidewalk on the southeast corner does not extend along the CVS property on Auburn Street.

Bedford Street (Route 18) at Temple Street (Route 27)

Bedford Street (Route 18) and Temple Street (Route 27) form a four-legged intersection under traffic signal control. The signal is owned and maintained by MassDOT. Temple Street is classified as an Urban Principal Arterial and is under MassDOT jurisdiction in the vicinity of the intersection. State jurisdiction of Temple Street ends approximately 1000 feet east of Bedford Street at West Street. Temple Street connects to Brockton to the west, and to Whitman Center ½ mile east of Bedford Street. Land use in the area is commercial, with Cumberland Farms on the southwest corner of the intersection, Marcello’s Restaurant on the southeast corner, TLC Auto Sales and Service on the northwest corner, and a vacant lot on the northeast corner. The vacant lot separates Temple Street from Warren Avenue, which intersects Bedford Street approximately 125 feet north of the intersection. Intersection operations are also impacted by a shopping plaza adjacent to Cumberland Farms, which has two driveways on Bedford Street and an access road intersecting Temple Street. Figure 3 provides a detailed view of adjacent commercial properties. Bedford Street provides similar geometry at Temple Street as at Auburn Street, providing two lanes in each direction, with turns accommodated within shared lanes. A solid white edge line is provided to delineate a shoulder, but widths are not sufficient to safely accommodate bicycles. The northbound and southbound approaches both widen to two lanes at the intersection and merge back to a single lane departing the intersection. The northbound approach widens to two defined lanes north of the Marcello’s driveway, approximately 65 feet from the northbound stop line. The roadway provides two lanes northbound departing the intersection for approximately 110 feet before merging back to a single lane in the vicinity of Warren Avenue, which intersects Bedford Street from the east. The southbound approach provides two defined lanes for approximately 320 feet in advance of the stop line. The roadway provides enough width for two cars to travel side by side immediately departing the intersection but is not marked as such.

Temple Street (Route 27) generally provides a single lane in each direction but widens to provide two shared lanes in each direction at Bedford Street. The two-lane section extends approximately 100 feet eastbound and approximately 60 feet westbound departing the intersection before merging back into a single lane. A solid white edge line is provided to delineate a shoulder, but widths are not sufficient to safely accommodate bicycles. The traffic signal provides a phase for the Bedford Street approaches, a protected advance phase for the Temple Street westbound approach, and a concurrent phase for the Temple Street approaches. An exclusive pedestrian phase is activated by pedestrian pushbutton on all four corners of the intersection. No Turn on Red restrictions are signed for all four approaches. Continuous sidewalks are provided along both sides of both intersecting streets in the vicinity of the intersection. The sidewalk on the west side of Bedford Street south of the intersection does not extend beyond the Cumberland Farms property.

South Avenue (Route 27)/Franklin Street/Pleasant Street Intersection

The intersection of South Avenue (Route 27)/Franklin Street/Pleasant Street is located approximately 800 feet east of the Whitman MBTA Passenger Rail Station and the at-grade train crossing across South Avenue (Route 27). The Whitman MBTA Commuter Rail Station is located on South Avenue approximately 800 feet west of the intersection. The intersection has undergone improvements in the 1990's as mitigation for traffic generated by the commuter rail station. At that time, Franklin Street was not aligned opposite of Pleasant Street and two islands channeled traffic in and out of Franklin Street. Improvements were made to the turning radii, two islands were removed, and a new raised island was added to line up Franklin Street as much as possible with Pleasant Street.

Route 27 is an important regional highway in Whitman that connects to Brockton to the west and Hanson, Kingston, and Plymouth to the east. South Avenue is designated as Route 27 east of the intersection, and Route 27 continues southward from the intersection into Hanson as Franklin Street. Both South Avenue and Pleasant Street connect to Route 58, with South Avenue providing access to Route 58 (east of the intersection), and Pleasant Street providing access north to Route 58 to Abington to Weymouth and Route 18 to the north.

The South Avenue (Route 27)/Franklin Street/Pleasant Street intersection in Whitman is un-signalized with a stop control on the northbound Route 27 Franklin Street approach and the southbound Pleasant Street approach. The intersection alignment is such that the southbound Pleasant Street approach is not directly lined up with Route 27 Franklin Street. The northbound Franklin Street approach provides two lanes, including an exclusive left turn lane and a through lane. The right turn northbound is channeled with a raised island off the through lane.

Table 32: Whitman Culverts

Structure Category	Facility Carried	Feature Intersected	Bridge Dept. #	Year Built	Length	Deck Area	Inspection Date	Owner
Culvert	ST 27 South Ave	Shumatuscacant River	W34003	1935	28.7	1,125.05	10/20/2018	MUN
Culvert	ST 27 South Ave	Brigham Pond OTLT	W34004	1850	57.9	57960.43044	12/13/2017	MUN
Culvert	HWY Essex St	Shumatuscacant River	W34005	1850	42.1	10014.84942	9/25/2018	MUN

Public Transit

The Town of Whitman hosts a Massachusetts Bay Transportation Authority (MBTA) Commuter Rail Station on the Kingston/Plymouth commuter rail line. The Kingston/Plymouth lines runs from South Station in Boston to Plymouth's waterfront in the south. Whitman's MBTA station and its 208-space parking lot is located at the intersection of South Avenue (Route 27) and Raynor Avenue on the eastern side of town. Despite having a commuter rail station in town, Whitman has no fixed route bus service. The only bus service in Whitman is provided by the Brockton Area Transit (BAT) Dial-A-BAT para-transit service.

Bicycle and Pedestrian Facilities

Whitman has a limited amount of bicycle and pedestrian infrastructure in town, as there are no regional bike paths and few walking trails, except for the Flaherty Trail from Auburn Street to the East Bridgewater line. The town's density in certain areas and its distribution of schools does however allow many children to walk to school. This could be further encouraged by removing remaining obstacles and closing gaps in off-road pathways.

Sidewalks and Bicycle Routes

The goal, objectives, and policies of the Town of Whitman are to increase walking in the community. Whitman seeks to promote pedestrian circulation in Town, especially between neighborhoods and schools and between the community and the MBTA Commuter Rail Station. Additionally, Whitman seeks to improve pedestrian access in the Town center.

Whitman has an extensive network of sidewalks throughout the community, especially compared to other communities in the Old Colony region. Only a few sections of the Town or deep in neighborhood subdivisions can one find a lack of sidewalks. When one reviews the state of sidewalks in the community, they would find uneven, cracked and a hodgepodge of asphalt patch work. This is not a situation unique to the Town of Whitman. The Town of Whitman does not have an established bicycle network.

Pedestrian Network Needs

While the Town of Whitman is fortunate to enjoy an extensive sidewalk network, there are a few areas where sidewalks should be installed to help complete the network. Those areas in need of sidewalks are the northeast sections of the Town along Route 58 and along the remaining portion of Route 14. In addition, there are areas in the northern sections of the Town along Pine Street and Beulah Street that require completion of the pedestrian network. Along with the need to expand the sidewalk network, much of Whitman's sidewalk network needs maintenance or repair and upgrading to make walking in the community a more pleasurable experience.

Bicycle Network Needs

Currently, a bicycle network does not exist in Whitman.

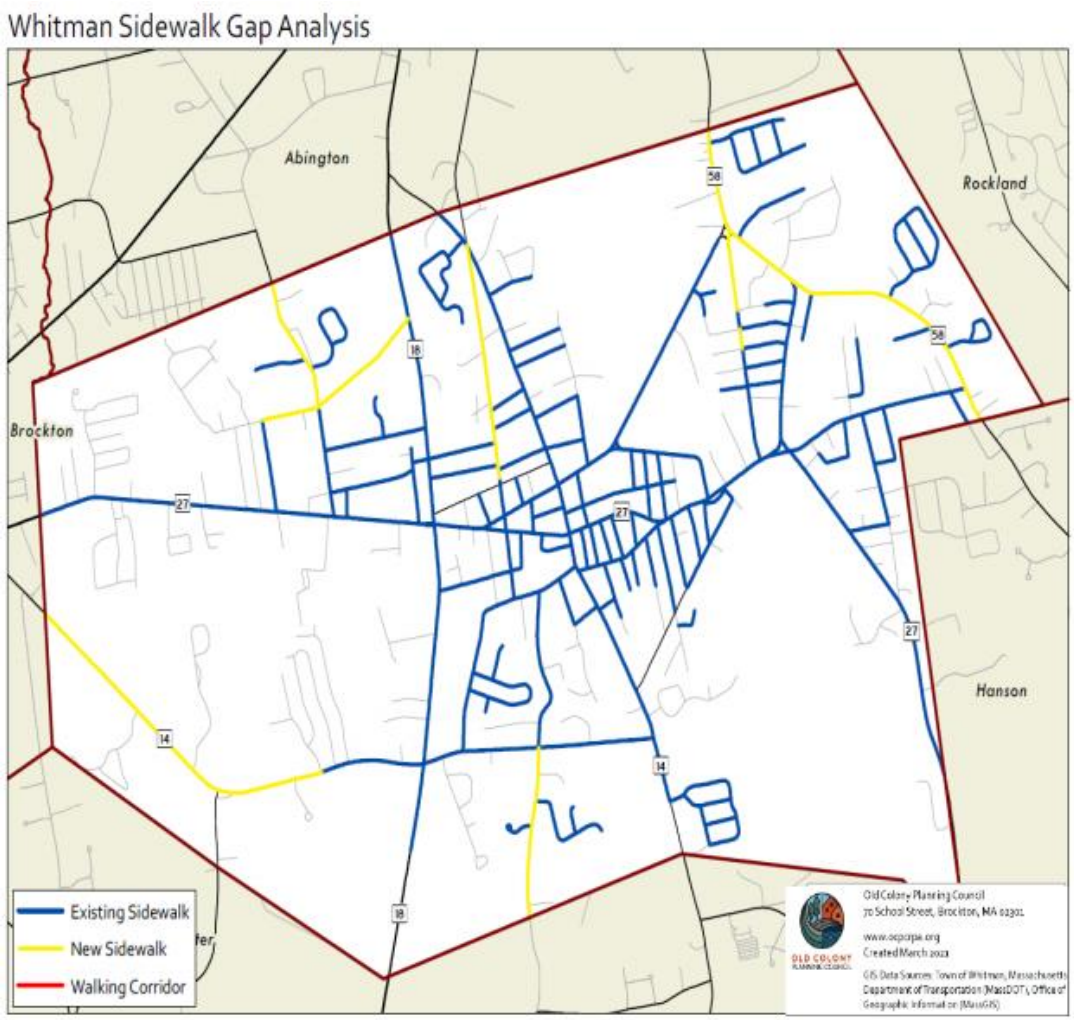
Pedestrian Transportation Recommendations

Whitman should make every effort to improve the appeal of its pedestrian network. Encouraging walking in the community can help reduce traffic congestion, and spur greater economic activity as well. Even though the Town of Whitman is fortunate to be well covered with sidewalks with only a few roads in need of sidewalk installation, not much pedestrian activity takes place. To spur more pedestrian activity, there is a need to focus on the quality of its pedestrian amenities. Providing pedestrian amenities like street trees to offer shade and protection from rain along with the removal of obstacles and clutter from sidewalks can increase pedestrian enjoyment.

Bicycle Transportation Recommendations

Old Colony recommends that the Town of Whitman create a bicycle network by utilizing the Whitman Proposed Bicycle Network map provided by Old Colony Planning Council. High traffic routes are identified on the Network map and include Temple Street (Route 27), Auburn Street (Route 14), Washington Street, and Franklin Street (Route 27). Beulah Street is designated as a Moderate Traffic Route and can be utilized as an alternative for Bedford Street (Route 18) due to the heavy traffic. OCPC would also recommend that the Town of Whitman provide bicycle amenities for cyclists such as repair stations and bicycle parking racks and facilities where warranted.

Figure 37: Sidewalk Gap Analysis



Water & Sewer

Whitman's water supply and sewer treatment is managed by the City of Brockton's Water & Sewer Division. Whitman's water is supplied by Brockton's Silver Lake system and is released to the Town through metered gates at Bedford Street and Temple Street. Other sources used to augment Silver Lake, include Furnace Pond in Pembroke, Monponsett Pond in Halifax, and the Brockton Reservoir in Avon. Brockton also can purchase desalinated water from Aquaria Water Treatment Plant in Dighton. According to the Whitman Department of Public Works present water supplies are sufficient to accommodate future development.

Whitman's municipal sewer system is also served by the City of Brockton via an intermunicipal agreement that allows Whitman to transfer an annual average daily flow of 1 million gallons per day to the Brockton Wastewater Treatment Facility. The effluent collected by the Whitman's municipal sewer system is collected via gravity sewers and force mains consisting of more than 50 miles of gravity sewers. The two main pumping stations in Whitman are the South Avenue Pump Station and the Auburn Street Pump Station. The town's collection system also contains nine small sewage pump stations which all flow to the Auburn Street Pump Station, which is pumped via 20-inch force main to a 24-inch gravity pipe that discharges into the Brockton WWTF.

Schools

The Town of Whitman, along with the neighboring Town of Hanson forms the Whitman-Hanson Regional School District. The district maintains a total of seven school buildings, including four elementary schools (two each in Whitman and Hanson), two middle schools (one each in Whitman and Hanson), and the shared High School, which is in Hanson along the Whitman town line. In addition, some Whitman students attend South Shore Vocational Technical High School in Hanover as well as private and parochial schools in Abington, Brockton, and Rockland.

Whitman-Hanson Regional High School is the newest school in the district. With funding partially provided by the Massachusetts School Building Authority (MSBA), the district opened the $49.2 million 232,000 square foot high school in 2005. The MSBA has since designated the High School as a "Model School". MSBA "Model Schools" are efficient in design and easy to maintain, contain optimal classroom and science lab space, can easily accommodate higher or lower enrollments, incorporate sustainable, "green" design elements when possible and are flexible in educational programming spaces while encouraging community use.

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. [29]

Table 33: 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%**

Source: US Census

[29] Summary of the US Census Bureau's 2019 County-Level Population and Component Estimates for Massachusetts, UMass Donahue Institute March 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 Whitman will grow from 14,489 residents in 2010 to 15,583 residents by 2040. Whitman's expected 7.55 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 Whitman, 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 34: Educational Attainment 25+, OCPC Region

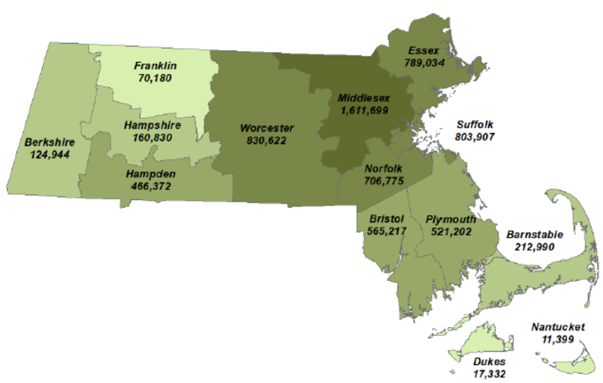
	Population 25 Years and Over	Less than 9th Grade	9th to 12th Grade, no diploma	High School Graduate or GED	Some College, no degree	Associate degree	Bachelor's Degree	Graduate or Professional Degree	Bachelor's Degree or Higher
Avon	3,389	95	177	1,403	553	250	699	212	911
Abington	11,793	255	372	3,251	2,099	1,201	3,185	1,430	4,615
Bridgewater	16,935	296	677	4,802	3,480	1,619	4,009	2,052	6,061
Brockton	62,411	6,270	5,913	20,985	12,862	4,750	8,382	3,249	11,631
Duxbury	10,760	40	85	1,084	1,161	593	4,279	3,518	7,797
East Bridgewater	9,804	145	253	3,078	2,358	977	1,819	1,174	2,993
Easton	16,162	235	408	3,397	2,572	1,613	4,671	3,266	7,937
Halifax	5,461	64	170	2,179	831	544	984	689	1,673
Hanover	9,527	117	217	2,156	1,468	927	2,938	1704	4,642
Hanson	7,610	117	349	2,271	1,670	732	1,774	697	2,471
Kingston	9,331	103	265	2,586	1,418	902	2,814	1,243	4,057
Pembroke	12,856	171	294	3,787	2,135	1,481	3,368	1,620	4,988
Plymouth	44,860	751	1,353	12,688	8,125	4,727	10,824	6,392	17,216
Plympton	2,147	2	72	807	353	199	454	260	714
Stoughton	20,942	861	1,006	5,476	3,683	2,050	4,865	3,001	7,866
West Bridgewater	5,087	53	140	1,589	934	568	1,188	615	1,803
Whitman	10,171	156	449	3,388	2,159	1,073	2,121	825	2,946
Plymouth County	359,125	10,608	14,756	99,923	65,002	33,759	85,080	49,997	135,077
Massachusetts	**4,781,683**	**208,460**	**233,484**	**1,148,525**	**738,484**	**363,665**	**1,151,870**	**937,195**	**2,089,065**

Source: U.S. Census Bureau, 2019 ACS, DP02

Table 35: Population Projections 2010 – 2040, OCPC Region

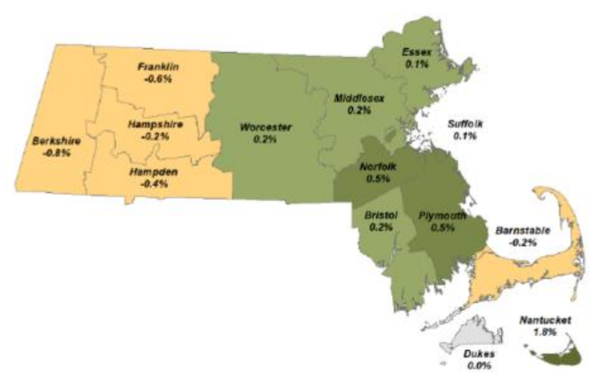
	Census 2010	Projection 2015	Projection 2020	Projection 2025	Projection 2030	Projection 2035	Projection 2040	Change 2010-2040	
								Number	Percent
Abington	15,985	17,066	17,386	18,522	18,764	18,903	19,000	3,015	18.86%
Avon	4,356	4,384	4,385	4,387	4,444	4,477	4,500	144	3.31%
Bridgewater	26,563	27,712	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

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 Whitman grew 18.9 percent from 4,435 in 1990 to 5,466 in 2019. This 18.9 percent increase in the number of households exceeded the Commonwealth, but was less than the County, Kingston, Plymouth, and Pembroke.

Table 36: Households OCPC Region 1990 – 2019

	1990 Census	2000 Census	2010 Census	2019 ACS	Change 1990-2019	
					Number	**Percent**
Abington	4,817	5,263	6,080	6,396	1,579	24.7%
Avon	1,591	1,705	1,709	1,574	-17	-1.08%
Bridgewater	5,947	7,526	7,995	8,133	2,186	26.9%
Brockton	32,850	33,675	33,303	31,817	-1,033	-3.25%
Duxbury	4,625	4,946	5,344	5,714	1,089	19.1%
East Bridgewater	3,593	4,344	4,750	4,828	1,235	25.6%
Easton	6,436	7,489	7,865	8,477	2,041	24.1%
Halifax	2,362	2,758	2,863	2,094	-268	-12.8%
Hanover	3,742	4,349	4,709	4,913	1,171	23.8%
Hanson	2,838	3,123	3,468	3,907	1,069	27.4%
Kingston	3,224	4,248	4,665	4,949	1,725	34.9%
Pembroke	4,666	5,750	6,298	6,563	1,897	28.9%
Plymouth	15,875	18,423	21,269	23,345	7,470	32.0%
Plympton	766	854	1,006	1,010	244	24.2%
Stoughton	9,394	10,254	10,295	10,900	1,506	13.8%
West Bridgewater	2,232	2,444	2,571	2,499	267	10.7%
Whitman	4,435	4,999	5,300	5,466	1,031	18.9%
Plymouth County	149,519	168,361	181,126	187,460	37,941	20.3%
Massachusetts	**2,247,110**	**2,443,580**	**2,547,075**	**2,617,497**	**370,387**	**14.2%**

Source: U.S. Census Bureau, 1990, 2000 & 2010 Census, 2019 ACS DP02

Table 37: Household Projections 2000 – 2040, OCPC Region

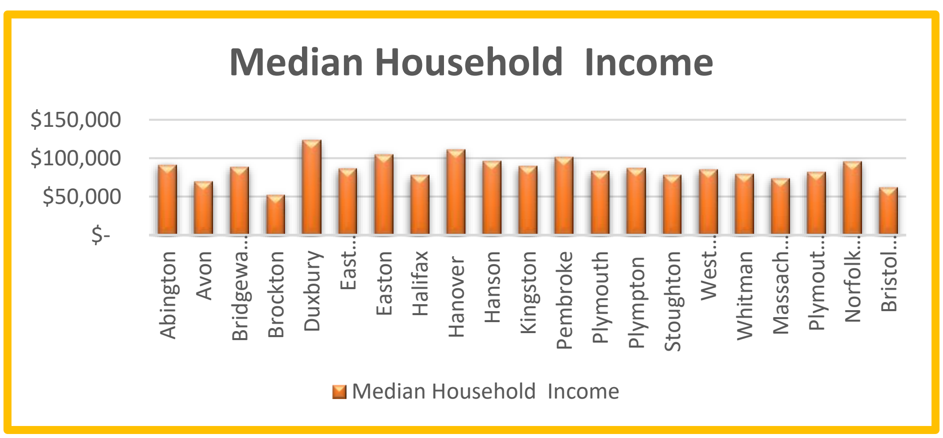
	Census 2000	Census 2010	2020	2030	2040	Change 2000 - 2040	
						Number	Percent
Abington	5,263	6,080	6,887	7,589	7,767	2,504	47.58%
Avon	1,705	1,709	1,793	1,902	2,008	303	17.79%
Bridgewater	7,526	7,995	8,946	9,553	9,626	2,100	27.91%
Brockton	33,675	33,303	34,967	35,465	35,668	1,993	5.92%
Duxbury	4,946	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 Whitman in 2019 was $86,570. When compared to the surrounding communities, the Commonwealth and the County, Whitman's median household income was trailed by Brockton, Stoughton, Halifax, and Avon.

Figure 38: Median Household Income, OCPC Region



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

Table 38: 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 39: 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 Whitman increased by 8.69 percent. The towns of Avon, Brockton, Halifax, Marshfield, and West Bridgewater were the only communities to receive a lower percent change in housing units for the OCPC region.

Table 40: Housing Units, 2000 – 2017, 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 41: 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

Employment Trends and Occupations

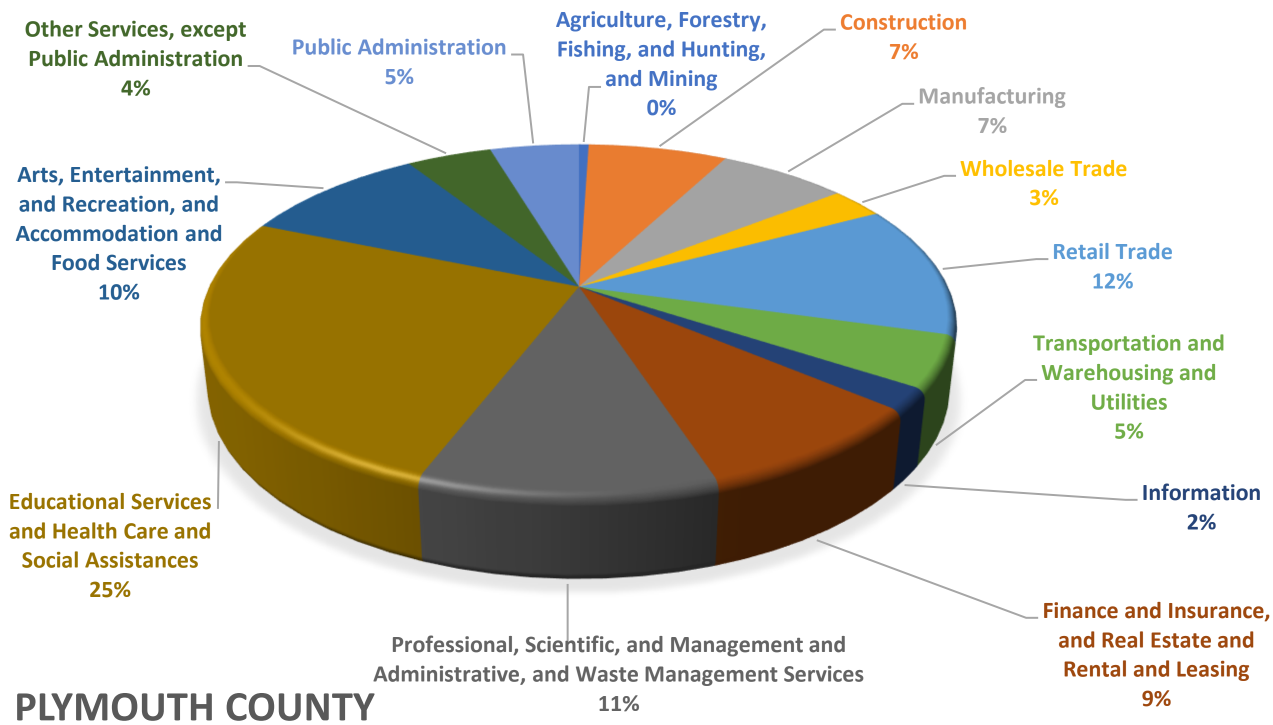
The largest numbers of jobs in the region are in Health Care and Social Assistance. Other large employment areas include Retail Trade, Construction, Professional, and Technical Services.

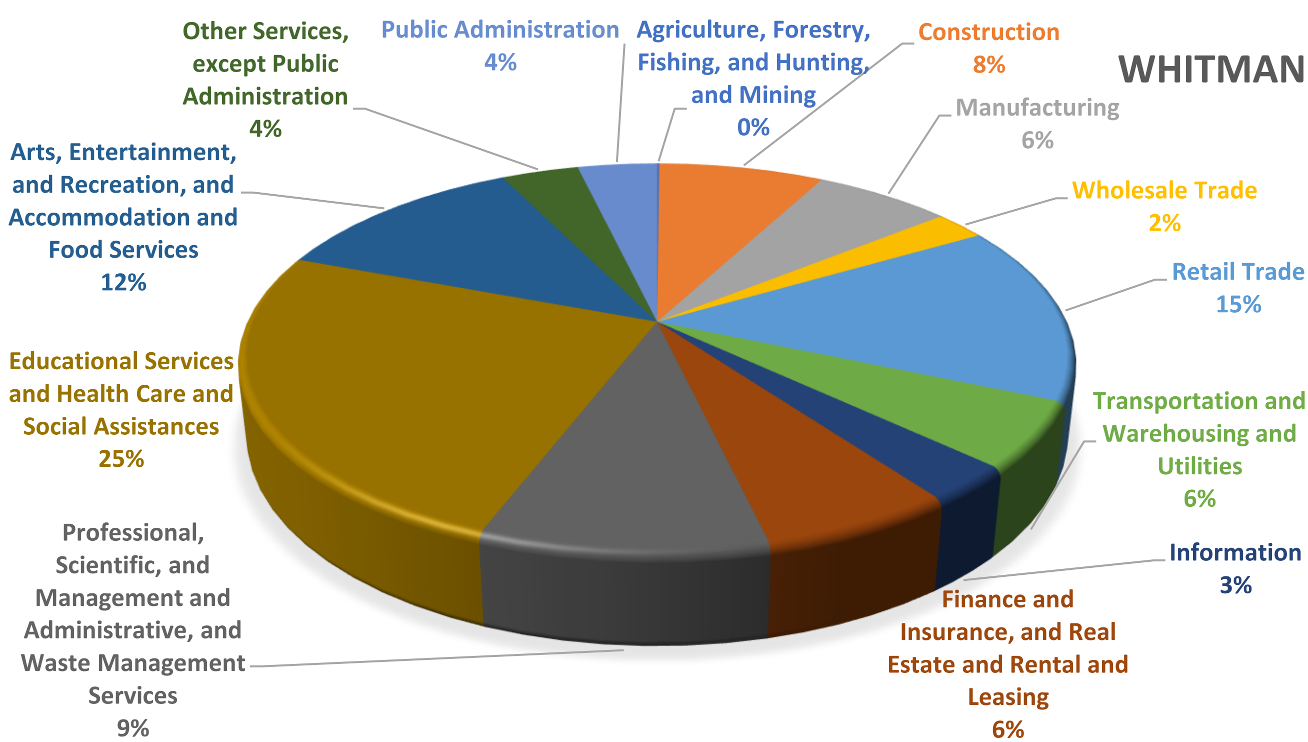
Table 42: Employment Projections for the OCPC Region, 2020 - 2040

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 Whitman is reflective of the region, with educational services, health care and social assistances industry providing 25 percent of all employment, followed by retail trade at 15 percent.


Other Services, except Public Administration 4%
Public Administration 5%
Agriculture, Forestry, Fishing, and Hunting, and Mining 0%
Construction 7%
Manufacturing 7%
Wholesale Trade 3%
Retail Trade 12%
Transportation and Warehousing and Utilities 5%
Information 2%
Finance and Insurance, and Real Estate and Rental and Leasing 9%
Professional, Scientific, and Management and Administrative, and Waste Management Services 11%
Educational Services and Health Care and Social Assistances 25%
Arts, Entertainment, and Recreation, and Accommodation and Food Services 10%
PLYMOUTH COUNTY


WHITMAN
Other Services, except Public Administration 4%
Public Administration 4%
Agriculture, Forestry, Fishing, and Hunting, and Mining 0%
Construction 8%
Manufacturing 6%
Wholesale Trade 2%
Retail Trade 15%
Transportation and Warehousing and Utilities 6%
Information 3%
Finance and Insurance, and Real Estate and Rental and Leasing 6%
Professional, Scientific, and Management and Administrative, and Waste Management Services 9%
Educational Services and Health Care and Social Assistances 25%
Arts, Entertainment, and Recreation, and Accommodation and Food Services 12%

Occupations

The following Figure shows the occupations of employed residents in Whitman compared to those in Plymouth County and Massachusetts overall. A measurably higher proportion of Whitman residents are employed in Management, Business, Science, and Arts (37.10%) but is still less than Plymouth County averages (39%).

A relatively lower proportion of Whitman residents hold occupations in Natural Resources, Construction and Maintenance (9.40%) but it is higher than Plymouth County averages (8%).

Figure 39: Whitman Occupations

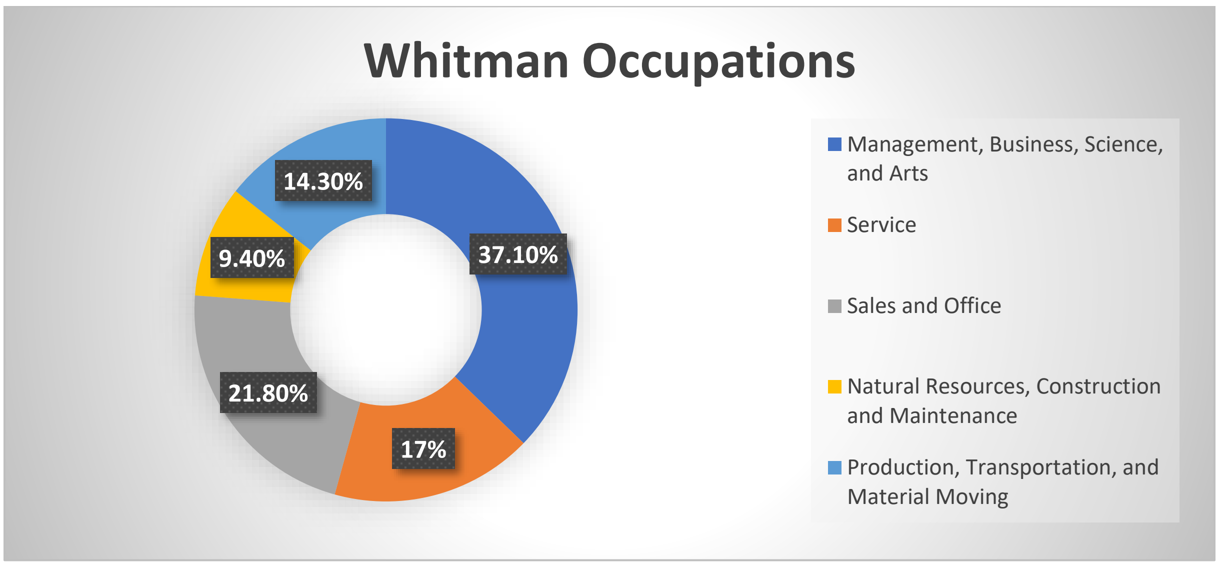
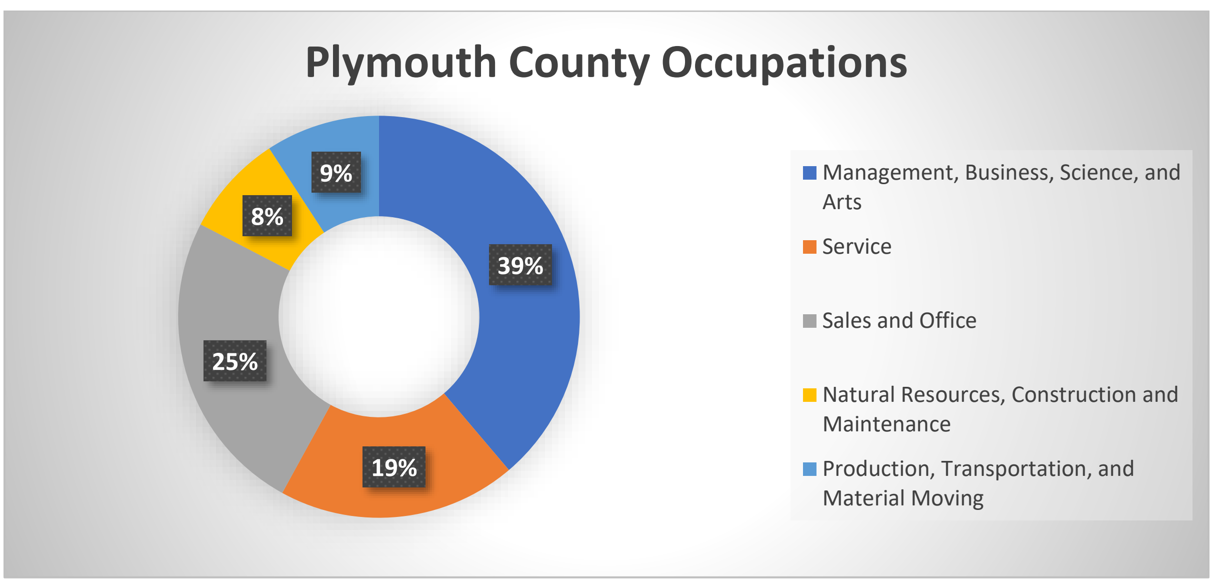


Figure 40: Plymouth County Occupations



Source: 2019 ACS, DP03

Table 43: 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

The town maintains a website at: Whitman, MA - Official Website | Official Website (whitman-ma.gov)

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

- Whitman has been proactive in addressing the impact of climate on natural hazards. Whitman is in the process of becoming certified by the Commonwealth as a Municipal Vulnerability Preparedness community.

Workforce Characteristics

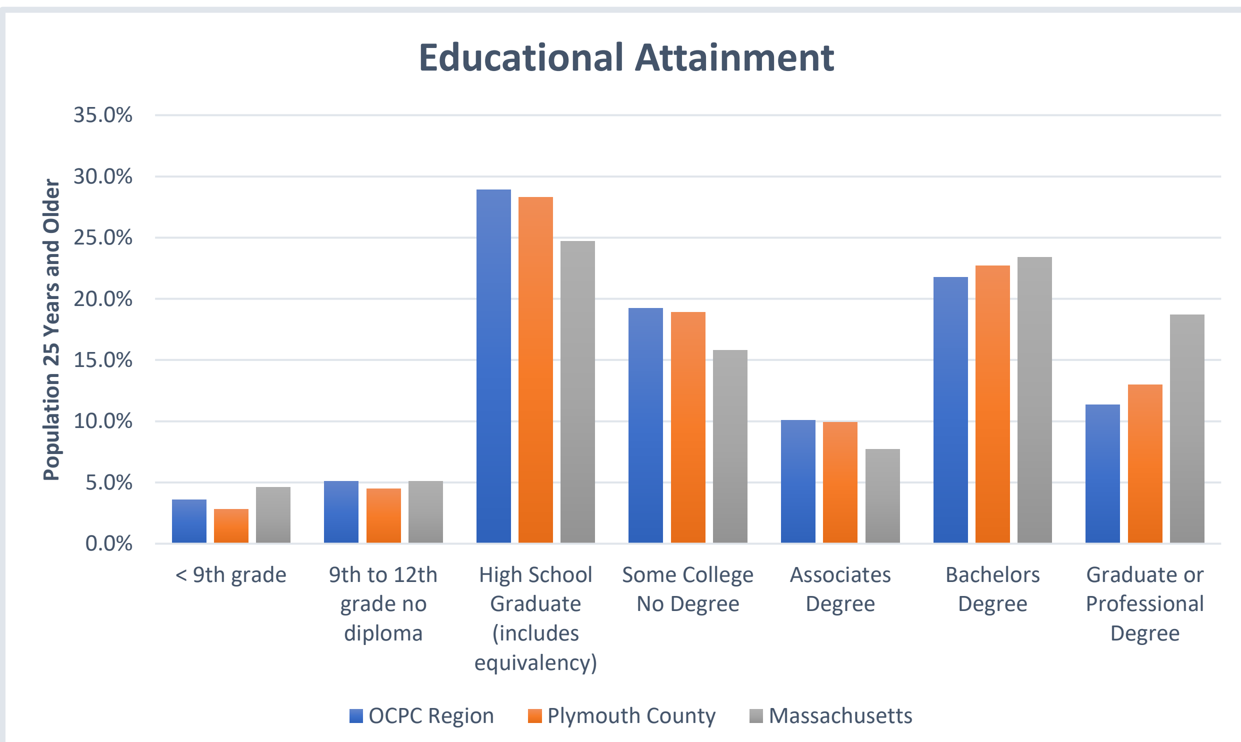
The data in the following tables show that the proportion of residents aged 25+ with a bachelor's degree or higher for the Town of Whitman is 8.84 percentage points less than the OCPC region and 14.6 percentage points less than for the Commonwealth.

Table 44: Percentage Educational Attainment, Aged 25+

	High School Diploma or Higher (% Completed)	*Bachelor's Degree or Higher (% Completed)*
Abington	*94.5%*	*25.7%*
Avon	*97.0%*	*25.9%*
Bridgewater	*90.6%*	*32.9%*
Brockton	*82.5%*	*17.5%*
Duxbury	*99.0%*	*72.2%*
East Bridgewater	*93.2%*	*25.4%*
Easton	*94.9%*	*47.4%*
Halifax	*94.3%*	*23.0%*
Hanover	*95.4%*	*45.6%*
Hanson	*93.6%*	*28.7%*
Kingston	*94.0%*	*38.6%*
Pembroke	*94.6%*	*33.6%*
Plymouth	*93.0%*	*32.6%*
Plympton	*88.4%*	*31.1%*
Stoughton	*87.8%*	*32.1%*
West Bridgewater	*91.2%*	*28.5%*
Whitman	*93.8%*	*24.4%*
OCPC Region	***92.8%***	***33.24%***
Massachusetts	***89.0%***	***39.0%***

Source: 2018 ACS, DP02

Figure 41: Educational Attainment, Aged 25+



Source: 2017 American Community Survey, S1501

Section 4. Risk and Vulnerability Assessment

The risk assessment includes four parts: natural hazard identification, profile hazards, inventory assets, and estimate losses. The risk assessment is updated according to FEMA local hazard mitigation planning regulations as found in C.F.R. 44 201.6. Conducting a risk assessment is a way of asking and answering "what if …" questions. For instance, what if the Town of Whitman experiences a hurricane? The risk assessment answers questions regarding history, location, frequency, probability, and impact for each hazard. These answers are used toward developing a mitigation strategy. Gathering information for the risk assessment included historical research, conversations with stakeholders, and available hazard mapping. It also includes information gathered from the MVP Workshop and the Massachusetts State Hazard Mitigation and Climate Adaptation Plan of September 2018.

Natural Hazards Identification

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 Whitman.

- 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

The 2015 HMP identified three biggest natural hazards to impact the OCPC region include flooding, hurricanes, and tropical storms and winter storms.

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 Whitman due to the Town's location and therefore not considered within this update.

The hazards identified in the *May 2015 Natural Hazard Mitigation Plan for the Old Colony Region* were assessed for this update and are shown below.

Table 45: Hazard Rationale

2015 Regional Plan	2021 Integrated MVP HMP Rationale
Flooding	Flooding remains a significant concern.
Wind-Related Hazards – Hurricanes & Tropical Storms, Tornados	Severe storms are of increasing concern due to climate change.
Winter-Related Hazards – Winter Storms and Nor'easters	Winter storms continue to occur regularly.
Coastal Related Hazards – Coastal Erosion & Shoreline Change	Whitman is not located on the coast and does not experience any of the hazards related to sea level rise.
Fire-Related Hazards – Wildfires, Major Urban Fires	Wildfire is a concern due to climate change.
Geologic Hazards – Earthquakes, Landslides and Tsunamis	Earthquakes continue to be a concern for Whitman. Landslides are not a risk in Whitman.
Other Natural Hazards – Extreme Temperatures	Extreme temperatures are more likely to occur with climate change and present significant challenges to marginalized populations.
Climate Change	Climate change continues to be a concern for Whitman.

The Core Team conducted a review of the recently updated Massachusetts State Hazard Mitigation and Climate Adaptation Plan of September 2018. The list of hazards from the State Plan are included in the Table below, along with the rationale for including them in the Town of Whitman Integrated MVP HMP Plan.

Table 46: Rationale for Hazards Identified in the State Plan

MA State Plan Hazards	Rationale for Inclusion/Exclusion
Inland Flooding	Flooding remains a significant concern.
Drought	Drought risk is of increasing concern due to climate change.
Landslide	Landslides are not a risk in Whitman.
Coastal Flooding	Whitman is not located on the coast and does not experience any of the hazards related to sea level rise.
Coastal Erosion	Whitman is not located on the coast and does not experience any of the hazards related to sea level rise.
Tsunami	Whitman is not located on the coast and does not experience any of the hazards related to sea level rise.
Average/Extreme Temperatures	Extreme temperatures are a concern due to climate change.
Wildfires	Wildfire is a concern due to climate change.
Invasive Species	The increase in tick-borne diseases was determined to be a concern due to climate change.
Hurricanes/Tropical Storms	Hurricanes continue to be a risk.
Severe Winter Storm/Nor'easter	Severe winter storms are a risk every year.
Tornadoes	Tornadoes are an increasing threat in the region.
Other Severe Weather (including strong wind and extreme precipitation)	An increasing threat as storms occur more intensely with climate change.
Earthquake	Whitman, with the entire Commonwealth, is at risk from earthquakes.
Dam Failure	Dam failure is a concern to Whitman, as mentioned by multiple Core Team members and by MVP Workshop participants.

The 2021 CRB Workshop identified the four major climate change interactions that are of the biggest concern to the residents of Whitman:

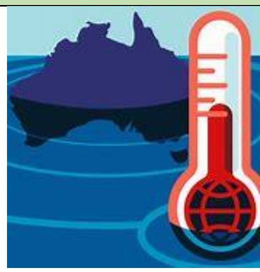
1. Inland Flooding
2. Hurricanes/Tropical Storms
3. Extreme Wind/Thunderstorms
4. Snowstorms/Nor'easters.

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. These categories are also consistent with the Commonwealth's Resilient Massachusetts Climate Change Clearinghouse website www.resilientma.org . To ensure consistency with the State Plan and to emphasize the impact of climate change hazards, this Plan used five categories to group hazards. All hazards identified fit into one of these categories, except for earthquake, which is considered a non-climate induced hazard, and dam failure, which is a technological, human-caused hazard. The five categories and definitions are reflected in the Tables below.

Table 47: Definitions of Climate Change Interactions

Climate Change Interaction	Definition
1. Changes in Precipitation	Changes in the amount, frequency, and timing of precipitation – including both rainfall and snowfall – are occurring across the globe as temperatures rise and other climate patterns shift in response.
2. Sea Level Rise	Climate change will drive rising sea levels, and rising sea will have wide-ranging impacts on communities, natural resources, and infrastructure along the Commonwealths' 1,519 tidal shoreline miles.
3. Rising Temperatures	Average global temperatures have risen steadily in the last 50 years, and scientists warn that the trend will continue unless greenhouse gas emissions are significantly reduced. The nine warmest years on record all occurred in the last 20 years (2017, 2016, 2015, 2014, 2013, 2010, 2009, 2005, and 1998), according to the US National Oceanographic and Atmospheric Administration (NOAA).
4. Extreme Weather	Climate change is expected to increase extreme weather events across the globe as well as in Massachusetts. There is strong evidence that storms – from heavy downpours and blizzards to tropical cyclones and hurricanes – are becoming more intense and damaging and can lead to devastating impacts for residents across the state.

Table 48: Five Primary Climate Change Interaction Categories

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 Epidemic Pandemic Infectious Disease	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	Rising Temperatures, Changes in Precipitation	

	Extreme Precipitation).		
Non-Climate Influenced Hazards			
	Earthquake	N/A	There is no established correlation between climate change and this hazard.

Hazard Profiles

The next step in the risk assessment process was to develop hazard profiles. These were developed to be consistent with Element B, Hazard Identification and Risk Assessment, from 44 C.F.R. 201.6.

B1. Does the Plan include a description of the type, location, and extent of all natural hazards that can affect each jurisdiction? (Requirement §201.6©(2)(i))

The hazard profiles are organized into the following sections: Hazard Description, Location, Previous Occurrences, Severity/Extent, Probability of Future Events and Changes Since the Previous Plan, Secondary Hazards, and sorted by primary climate change interaction. Several key sectors were evaluated for impacts of climate change as part of the risk assessment for each of the hazards profiled.

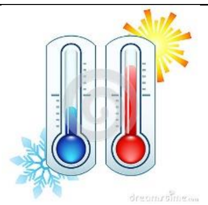
Table 49: Categories for Hazard Analysis

Categories	Definition
Location	Location refers to the geographic areas within the planning areas that are affected by the hazard. Some hazards affect the entire planning area universally, while others apply to a specific portion, such as a floodplain or area that is susceptible to wildfires.
Previous Occurrences	Previous hazard events that have occurred are described. Depending on the nature of the hazard, events listed may have occurred on a local or regional level.

Frequency	A measure of how often events of a particular magnitude is expected to occur. Frequency describes how often a hazard of a specific magnitude, duration, and/or extent typically occurs, on average. Statistically, a hazard with a 100-year recurrence interval is expected to occur once every 100 years on average and would have a 1-percent change of happening on any given year. The reliability of this information varies depending on the kind of hazard being considered.
Severity/Extent	Extent describes the strength or magnitude of a hazard. Where appropriate, extent is described using an established scientific scale or measurement system. Other descriptions of extent include water depth, wind speed, and duration.
Probability of Future Events	A statistical measure of the likelihood of a future event for each natural hazard and any significant changes to probability since the previous plan are listed.
Secondary Hazards	Secondary hazards are those that occur because of the primary effects and tertiary effects are the long-term changes that take place.

The following Table summarizes the 2021 natural hazard risks for the Town of Whitman.

Natural Hazard Type	**Location**	**Extent**
Inland Flooding 	See FIRM Panel: 25023C0183J	It is anticipated that the severity of flood-inducing weather events and storms will increase because of climate change. The historical record indicates the Commonwealth has experienced 22 coastal and inland flood-related disaster declaration events from 1954 to 2017. Based on these statistics, the Commonwealth may experience a flood event of disaster declaration proportions approximately once every 3 years. The frequency of flooding varies significantly based on watershed, riverine reach, and location along each reach. It is important to note that floods of lesser magnitude occur at a much higher frequency; in the last 10 years along (2007-2017), the National Oceanic and Atmospheric Administration (NOAA) Storm Events Database reports that there were 433 flood events, which is an average of more than 43 floods per year.
Drought 	Geographic-specific location cannot be identified, the entire area is equally at risk to the impacts of drought.	Drought was not identified as a hazard in the 2015 HMP for OCPC. Current frequency for Whitman 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	Geographic-specific location cannot be identified, the entire area is equally at risk to	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.

	the impacts of extreme temperatures.	• 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 	Geographic-specific location cannot be identified, the entire area is equally at risk to tornados.	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 	Geographic-specific location cannot be identified, the entire area is equally at risk to the impacts of thunderstorms and severe winds.	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 	Due to the rural, wooded environment, the entire Town of Whitman is subject to the impacts of wildfire.	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 	Geographic-specific location cannot be identified, the entire area is equally at risk to the impacts of hurricanes and thunderstorms.	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 	Geographic-specific location cannot be identified, the entire area is equally at risk to the impacts of severe winter storms and Nor'easter weather events.	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 Whitman, 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.
Earthquake 	Geographic-specific location cannot be identified the entire area is equally at risk to the impacts of earthquake events.	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%.

The following Table summarizes the frequency and severity of hazard risks for Massachusetts and Whitman. Only hazards identified as significant were included. Hazards not identified for inclusion at this time may be addressed during future evaluations and updates.

The Massachusetts frequency assessment is based on data in the SHMCAP. The Whitman frequency assessment reflects data from the National Climatic Data Center (NOAA) for Plymouth County*, from the SHMCAP** and from the MVP Core Team***.

Natural Hazard	Frequency		Severity	
	Massachusetts	Whitman	Massachusetts	Whitman
Inland Flooding				
	Substantial every 3rd year	2.61 per year* Halifax gets precipitation, on average, 129 days per year. March is the wettest month inWhitman with 5.4 inches of rain. There were 13 flash flood events in Plymouth County from 2000-2021 resulting from heavy rain.	Serious	Serious Whitman receives 50 inches of rain, on average, per year making it one of the wettest places in Massachusetts.
Drought				
	1% any given month	Based on historical precipitation data analyzed in the Drought Management Plan, there is approximately an 8% chance of a Watch level drought occurring in any given month.	Minor	Minor
Extreme Temperatures				
	Since 1994, there have been 33 cold weather events within the Commonwealth, ranging from Cold/Wind Chill to Extreme Cold/Wind Chill events. There were 43 warm weather events (ranging from Record Warmth/Heat to Excessive Heat events) in Massachusetts between 1995 and 2018, the most	The probability of future extreme heat and extreme cold is “high”, or between 40 and 70 percent in any given year. 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. *	Serious High, low, and average temperatures in Massachusetts are all likely to increase significantly over the next century because of climate change.	Serious 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.

	recent of which occurred in July 2013. In 2012, Massachusetts temperatures broke 27 heat records.	There were 2 recorded events of excessive heat. This is an average of 1 per decade. *		
Tornados				
	Massachusetts experiences an average of 1.7 per year.	There was 1 reported tornado in Plymouth on White Horse Beach. *	Serious Massachusetts ranks 35th among the states for frequency of tornados, 14th for the frequency of tornados per square mile, and 12th for cost of damage.	Serious
Extreme Wind/Thunderstorms				
	Massachusetts experiences 20-30 Thunderstorms annually; 43.5 high wind events annually.	There were 53 Thunderstorm and wind events in Plymouth County. *	Minor Extreme precipitation projections indicate increased precipitation will occur in every county and the probability of future thunderstorm events is anticipated to increase.	Minor Projected increase in temperatures due to climate change will increase the probability of future thunderstorm events.
Hurricane and Tropical Storms				
	One every two years in MA.	No notable event in recent years.	Serious	Serious

Severe Winter Storm and Nor'easter				
	One notable event per year in MA.	There were 51 Winter Storm events in Plymouth County.	Minor 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.	Minor
Invasive Species				
	Increased rates of global trade and travel have created new pathways for the dispersion of exotic species, increasing the frequency with which these species are introduced.	Invasive species are a widespread problem in Massachusetts and throughout the country. Because plant and animal life are so abundant throughout the Commonwealth, the entire area is exposed to the invasive species hazard.	Minor	Minor
Earthquake				
	Research has found that the probability of a magnitude 5 or greater earthquake centered somewhere in New England in a 10-year period is about 10-15%.	Earthquakes represent a very low-frequency, serious severity hazard for Whitman. Based on historical events, earthquakes in the region will likely be in the 2-3 magnitude range.	Serious Cannot be predicted and may occur at any time.	Serious

Severity

- **Minor:** Limited and scattered property damage; limited damage to public infrastructure and essential services not interrupted; limited injuries or fatalities.
- **Serious:** Scattered major property damage; some minor infrastructure damage; essential services are briefly interrupted; some injuries and/or fatalities.
- **Extensive:** Widespread major property damage; major public infrastructure damage (up to several days for repairs); essential services are interrupted from several hours to several days; many injuries and/or fatalities.

- **Catastrophic:** Property and public infrastructure destroyed; essential services stopped; numerous injuries and fatalities.

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.

Previous hazard events since the last Plan was developed.

B2. Does the Plan include information on previous occurrences of hazard events and on the probability of future hazard events for each jurisdiction? (Requirement §201.6©(2)(i))

Since the May 2015 Natural Hazard Mitigation Plan for the Old Colony Region, Whitman has experienced the following hazards events, as depicted in the Tables below.

Table 50: Flash Flood, 2015 - 2020

LOCATTION	DATE	PROPERTY DAMAGE (Numbers)	HAZARD	FLASH FLOOD CAUSE

LONG POND	9/18/2018	0	Flash Flood	Heavy Rain
MANOMET	7/12/2019	70,000	Flash Flood	Heavy Rain
BROCKTON	06/28/2020	0	Flash Flood	Heavy Rain
BROCKTON HTS.	06/28/2020	6,000	Flash Flood	Heavy Rain

Table 51: Flooding Events, 2015 - 2020

LOCATION	DATE	PROPERTY DAMAGE (Numbers)	HAZARD	FLOOD CAUSE
Plymouth ARPT	5/31/2015		Flood	Heavy Rain
Tremont	7/28/2015	15,000	Flood	Heavy Rain
Marion	9/10/2015		Flood	Heavy Rain
Plymouth	10/29/2015		Flood	Heavy Rain
Five Corners	5/30/2016		Flood	Heavy Rain
Scituate	4/1/2017	5,000	Flood	Heavy Rain
Whitman	4/6/2017	5,000	Flood	Heavy Rain
Parkwood Beach	6/24/2017	1,000	Flood	Heavy Rain
Stanley	10/25/2017		Flood	Heavy Rain
East Weymouth	10/25/2017		Flood	Heavy Rain
Kingston	10/29/2017		Flood	Heavy Rain
Nameloc Heights	1/12/2018		Flood	Heavy Rain
Kingston	11/3/2018	1,000	Flood	Heavy Rain
West Hingham	4/15/2019		Flood	Heavy Rain
Kingston	7/12/2019		Flood	Heavy Rain
East Marion	7/22/2019		Flood	Heavy Rain
Brockton Heights	9/2/2019	1,000	Flood	Heavy Rain
Montello	9/2/2019	1,000	Flood	Heavy Rain

Table 52: Drought, 2015 - 2020

Date	Area Affected	Recurrence Interval (years)	Remarks	Reference
Jul 2016 – Apr 2017	Statewide	-	Level 3 drought (out of 4 levels)	DCR 2017

Table 53: Extreme Cold and Wind Chill Occurrences, 2015 - 2020

Date	Location	Event Type	Damage
02/16/2015	Eastern Plymouth (Zone)	Extreme Cold/Wind Chill	0
02/14/2016	Eastern Plymouth (Zone)	Extreme Cold/Wind Chill	0

Table 54: Excessive Heat Events, 2015 - 2020

Date	Location	Event Type	Remarks
07/03/2018	Eastern Plymouth	Excessive Heat	The Automated Surface Observing System platform at Marshfield Municipal Airport reported a Heat Index of 107 from 2:30 PM EST to 5:30 PM EST.

Table 55: Winter Storm, Nor'easter Events, 2015 - 2020

Date of Event	Event Type	Losses/Impacts
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 across much of eastern Massachusetts Heavy Snow Eleven to eighteen inches of snow fell across southern Plymouth County.	Low pressure off the Delmarva peninsula intensified rapidly as it moved northeastward. Its path just southeast of Nantucket brought heavy snow 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	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

	across south coastal Plymouth County.	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.

Table 56: High Wind Events, 2015 - 2020

DATE	PROPERTY DAMAGE (Numbers)	HAZARD	MAG	DEATHS	INJURIES	DATE	PROP DAMAGE (Numbers)	MAG	DEATHS	INJURIES
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					

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 geographical size of the region is 6.96 square miles and contains 4 census tracts. There are over 5,000 households in the region and a total population of 14,489 people (2010 Census Bureau data).
	Government	For essential facilities there are no hospitals, 4 schools, 1 fire station, 1 police station and 2 emergency operation facilities. All municipal sites including the Police Station, Fire Station and the Highway Department, schools, the Library and Town Hall. Municipal assets such as transportation (e.g., roads, bridges), buildings, landholdings, and other infrastructure such as dams. The Critical Facilities list identifies 60 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.
	Built Environment	There are an estimated 4,683 buildings in the region with a total building replacement value (excluding contents) of $1,898,000 (2014 dollars). Approximately 92% of the buildings (and 81% of the building value) are associated with residential housing.

	Natural Resources and Environment	The Natural Resources and Environment sector includes land-based assets owned by the Town 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.

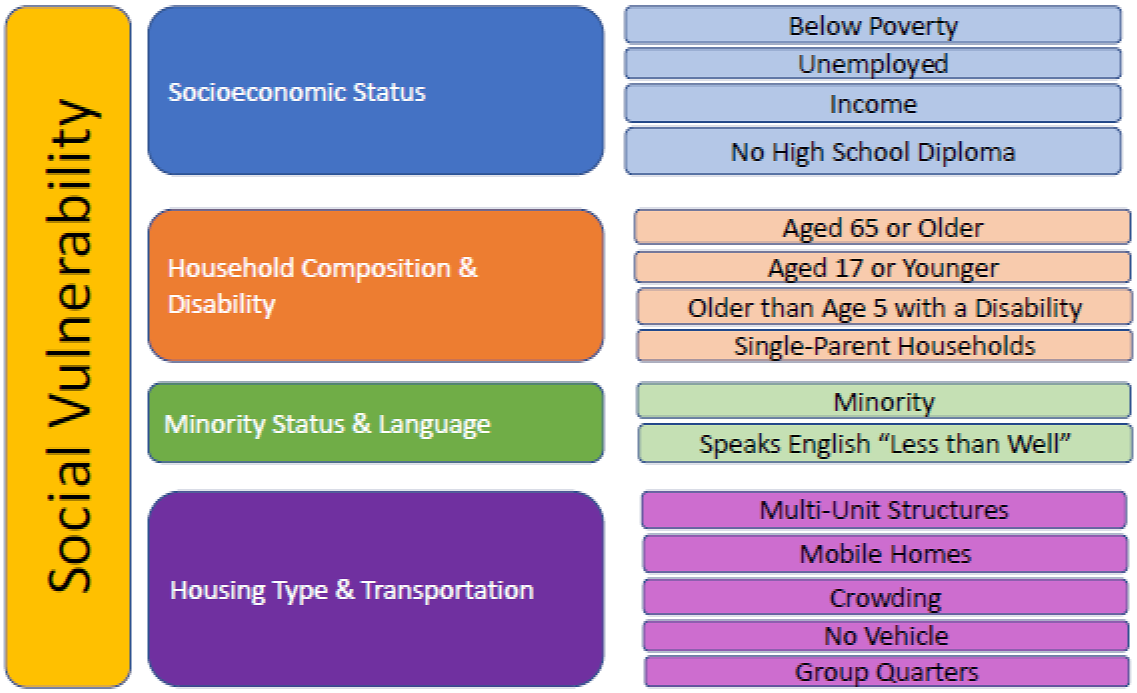
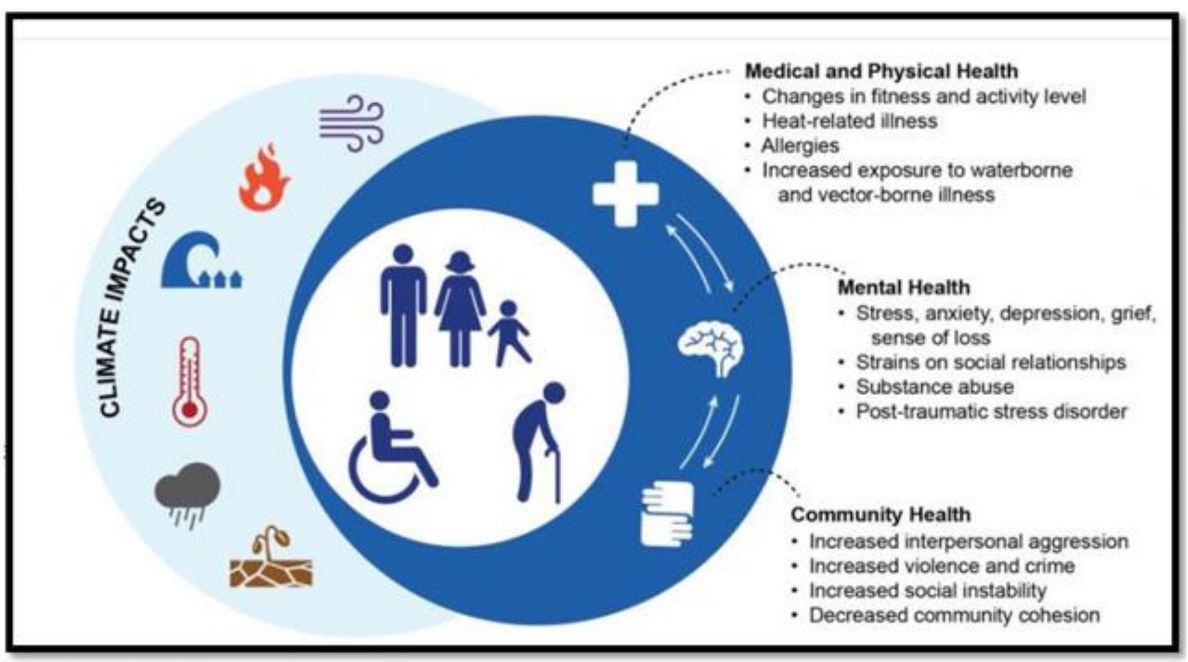


Figure 42: Potential Impacts of Climate Change on Physical, Mental, and Community Health



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.

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 [30] 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

[30] Quarantelli, 1982

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.

Natural Resources and Environment

The natural resources and environment sector include key habitats and natural landscapes documented in Whitman's BioMap 2 (Conserving the Biodiversity of Massachusetts in a Changing World) and Areas of Critical Environmental Concern.

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).

Changes in Development

D1. Was the plan revised to reflect changes in development? (Requirement §201.6(d)(3)

There were no changes in development which impact the overall vulnerability since the previously approved plan.

The following Table depicts the number of building permits issued by the Building Inspector's Office with a total of fees collected during 2020.

Table 57: Building Permits Issued, 2020

Total Building Permits	575	Combined Value	$349,666
New Single-Family Homes	27		
Single-Family Homes/Attached	14		
Additions, Renovations, Misc.	361		
Wiring Permits	321	Fees Collected	$43,880
Plumbing Permits	187	Fees Collected	$18,226

Gas Permits	162	Fees Collected	$10,600
Commercial/Industrial			
New Buildings	2		
Additions & Alterations	10		
Pools	32		
Signs	15		
Wood Burning Stoves	4		
Demolition Permits	9		
Detached Buildings & Accessory Buildings	11		
Solar Permits	47		
Sheet Metal Permits	31		
Demolition Permit Fees	9		

The Heritage Park Subdivision has nearly been completed with 30 homes currently occupied. Mosaic Gardens at 1190 Bedford Street, now has 13 condominiums occupied out of a total of 27. The structure at 629 Washington Street has been demolished and a building permit has been issued for the construction of a new mixed-use building. This building will contain commercial space on the 1st floor and 24 apartments above. The Old Cart Path condominium project is well underway with 2 buildings complete and 2 additional buildings in progress. Once completed, it will contain 37 units in total. The Vincent Street Extension now contains 3 new homes; 1 is currently occupied, 2 are under construction and 3 more to come. The 316 Commercial Street structure was raised due to a fire. A building permit has been issued to replace the 6-family unit with a new 5-family structure in the same footprint.

Table 58: Building Permits Issued, 2019

Total Building Permits	518	Fees Collected	$217,134
New Single-Family Homes	20	Combined Value	
Single-Family Homes/Attached	6		
Additions, Renovations, Misc.	344		
Wiring Permits	294	Fees Collected	$31,458
Number of Inspections	496		
Fire Calls	18		
Plumbing Permits	130	Fees Collected	$11,500
Number of Inspections	350		
Gas Permits	145	Fees Collected	$8,675
Number of Inspections	350		
Certificates of Inspections Issued	20		
Commercial/Industrial			
New Buildings	2	Value	
Additions & Alterations	17	Combined Value	

Pools	27	Combined Value	
Signs	12		
Wood Burning Stoves	6		
Buildings Demolished			
Detached Buildings & Accessory Buildings	6		
Occupancy Permit Fees	44		
Demolition Permit Fees	11		
Solar Roof Permits	39		
Sheet Metal Permits	22		

The Paradise Gardens development is complete, with 44 new townhouse condominiums currently occupied. The Patio at McGuiggans opened in Mary, 2019. The Heritage Park Subdivision (off Hogg Memorial) is in progress. There are 8 new homes now occupied out of the 35 approved. The Mosaic Gardens Condominiums on Bedford Street is underway. There will be 8 buildings containing 27 units. The road at Vincent Street Extension is construction. There will be 6 new single-family homes.

Table 59: Building Permits Issued, 2018

Total Building Permits	**482**	**Fees Collected**	**$160,070**
New Single-Family Homes	11		
Single-Family Homes/Attached	13		
Additions, Renovations, Misc.	380		
Wiring Permits	250	Fees Collected	$21,649
Number of Inspections	402		
Fire Calls	27		
Mutual Aid	3		
Plumbing Permits	134	Fees Collected	$13,945
Number of Inspections	350		
Gas Permits	127	Fees Collected	$7,520
Number of Inspections			
Certificates of Inspections Issued	32		
Commercial/Industrial			
New Commercial Buildings	3		
Additions & Alterations	18		
Pools	12		
Signs	5		
Wood Burning Stoves	3		
Buildings Demolished			
Detached Buildings & Accessory Buildings	16		
Occupancy Permit Fees	45		

Demolition Permit Fees	13		
State Mandated Inspections/Misc.	17		

Table 60: Building Permits Issued, 2017

Total Building Permits	**446**	**Fees Collected**	**$149,431**
New Single-Family Homes	58	Combined Value	$8,050,000
Additions, Renovations, Misc.	332	Combined Value	$4,221,202
Wiring Permits	299	Fees Collected	$23,613
Number of Inspections	427		
Fire Calls	23		
Mutual Aid	1		
Plumbing Permits	149	Fees Collected	$11,860
Number of Inspections	360		
Gas Permits	129	Fees Collected	$6,970
Number of Inspections	360		
Certificates of Inspections Issued			
Commercial/Industrial			
New Buildings	1	Value	$432,000
Additions & Alterations	27	Combined Value	$943,684
Pools	21	Combined Value	$242,241
Signs	4		
Wood Burning Stoves	5		
Buildings Demolished	3		
Detached Buildings & Accessory Buildings	12	Combined Value	$174,500
Number of Inspections Performed			
Permit Fees Collected			
Building Permit Fees	446	Combined Value	$13,698,877
Occupancy Permit Fees	27	Fees Collected	$1,770
Demolition Permit Fees	3	Fees Collected	$120
State Mandated Inspections	33	Fees Collected	$725

Table 61: Building Permits Issued, 2016

Total Building Permits	**481**	**Combined Value**	**$10,433,445**
New Dwellings	13	Combined Value	$2,977,020
Additions, Renovations, Misc.	306	Combined Value	$4,360,338
Commercial/Industrial			
New Buildings	1	Value	$446,900
Additions & Alterations	19	Combined Value	$575,104
Pools	11	Combined Value	$159,845
Signs	17		

Wood Burning Stoves	5		
Buildings Demolished	10		
Detached Buildings & Accessory Buildings	15	Combined Value	$146,525
Number of Inspections Performed	2,100		
Permit Fees Collected			
Building Permit Fees	481	Fees Collected	$108,989
Occupancy Permit Fees	19	Fees Collected	$590
Demolition Permit Fees	10	Fees Collected	$400
State Mandated Inspections	33	Fees Collected	$550

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.

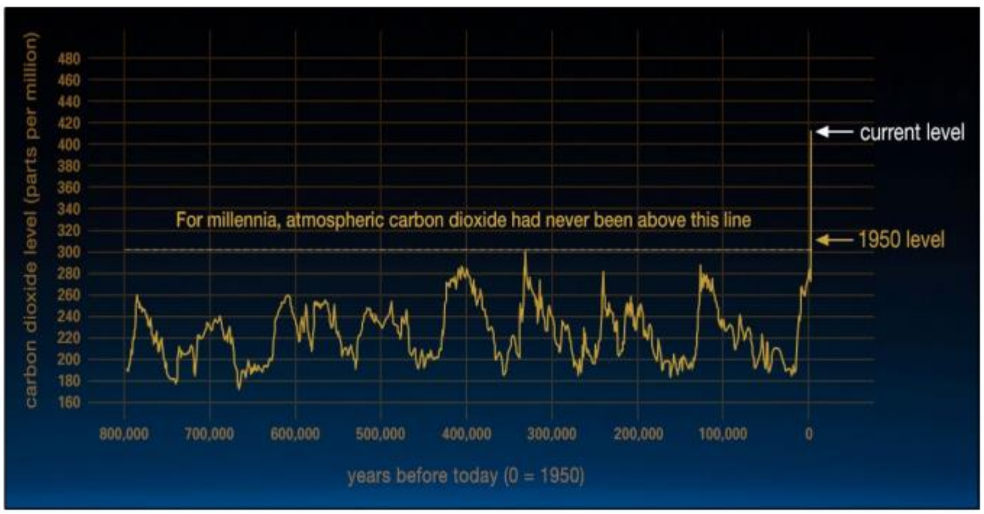
The Town of Whitman, like many communities in Massachusetts, has already been impacted by and is expected to face further impacts from two major changes: the shift from more heating days to more cooling days and the increase in the intensity of precipitation events. Some of the impacts include the following:

- 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 Whitman. 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 43: 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.

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.

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

Section 5. Risk Assessment

The risk assessment for the Town of Whitman Integrated Municipal Vulnerability Preparedness and Hazard Mitigation 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.

B3. Is there a description of each identified hazard's impact on the community as well as an overall summary of the community's vulnerability for each jurisdiction? (Requirement §201.6©(2)(ii))

Primary Climate Change Interaction - Changes in Precipitation

Flood-Related Hazards

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. [31]

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

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

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.

- ***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. [32]

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 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

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

water and groundwater. Over time, sediments that are deposited in floodplains develop into fertile, productive farmland like that found in Whitman. 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.

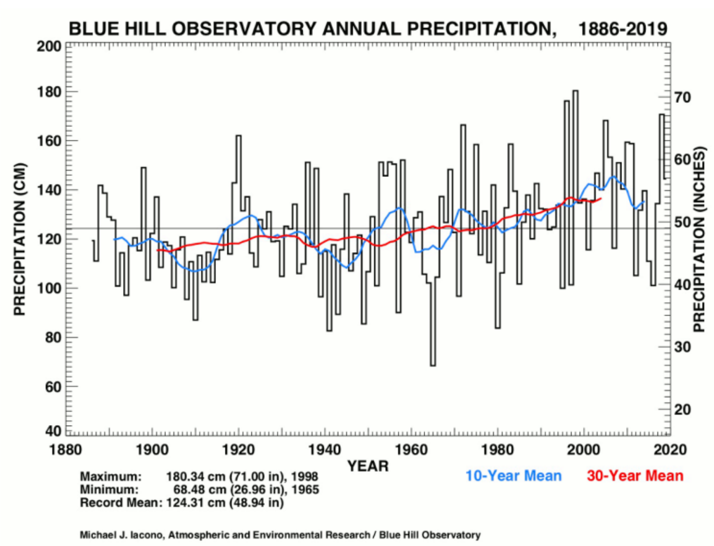
Use of historical hydrologic data has long been the standard of practice for designing and operating water supply and flood protection projects. However, the hydrologic record cannot be used to predict changes in frequency and severity of extreme climate events such as floods. Climate change is already 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. Scientist's 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.

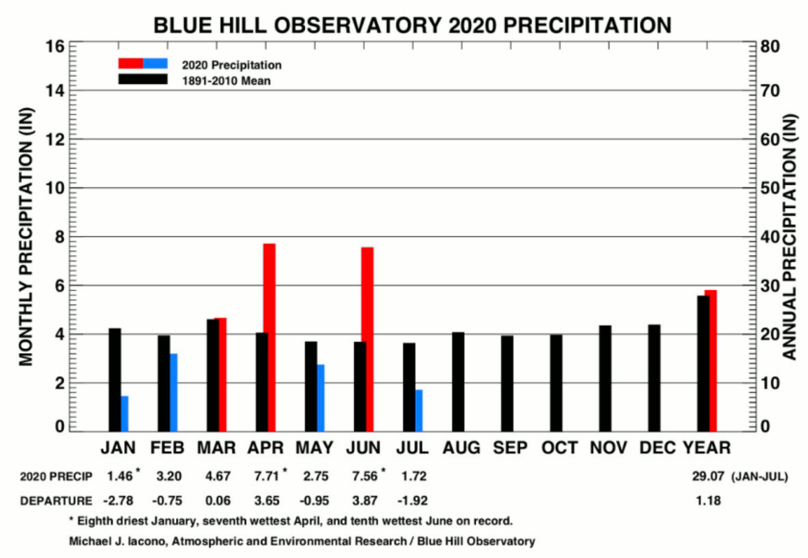
Figure 44: Annual Precipitation



- 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	**Location**	**Extent**
Inland Flooding 	See Firm Panel: 25023C0183J	It is anticipated that the severity of flood-inducing weather events and storms will increase because of climate change. The historical record indicates the Commonwealth has experienced 22 coastal and inland flood-related disaster declaration events from 1954 to 2017. Based on these statistics, the Commonwealth may experience a flood event of disaster declaration proportions approximately once every 3 years. The frequency of flooding varies significantly based on watershed, riverine reach, and location along each reach. It is important to note that floods of lesser magnitude occur at a much higher frequency; in the last 10 years along (2007-2017), the National Oceanic and Atmospheric Administration (NOAA) Storm Events Database reports that there were 433 flood events, which is an average of more than 43 floods per year.
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.
	Built Environment	Several critical facilities may be subject to flooding. 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	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 45: 2020 Precipitation, Bill Hill Observatory



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

Location

Table 62: 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 63: 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 64: 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

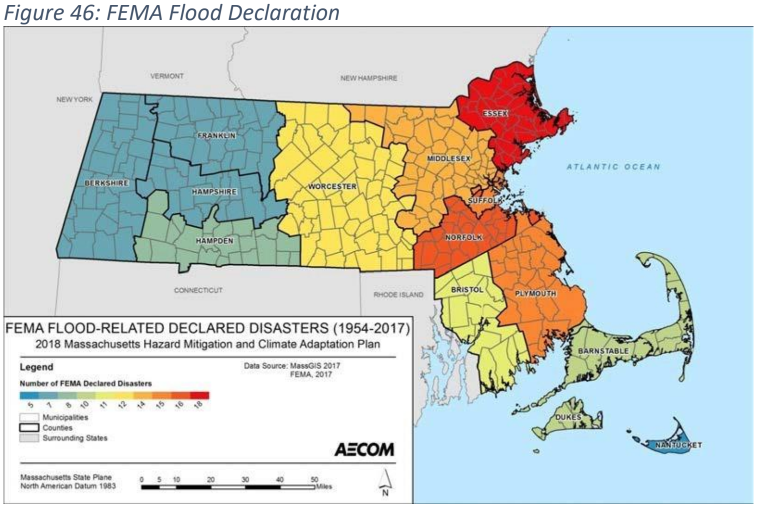
Previous Occurrences

Table 65: 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 46: FEMA Flood Declaration



Source: SHMCAP, 2018

Table 66: Flooding Events 2000 - 2020

LOCATION	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	
Hingham	5/13/2006	500,000	Flood	
Plymouth County	5/13/2006		Flood	
Plymouth County	6/7/2006	30,000	Flood	
Hull	6/23/2006	2,000	Flood	
Hingham	8/20/2006	5,000	Flood	
Brockton	10/28/2006	10,000	Flood	Heavy Rain
Hingham	3/2/2007	10,000	Flood	Heavy Rain
Hingham	3/17/2007	8,000	Flood	Heavy Rain
Hingham	4/15/2007	25,000	Flood	Heavy Rain
Plymouth	2/13/2008		Flood	Heavy Rain
Wareham	3/8/2008	5,000	Flood	Heavy Rain
Accord	3/8/2008		Flood	Heavy Rain
Pinehurst Beach	9/27/2008	50,000	Flood	Heavy Rain
Whitman	5/24/2009		Flood	Heavy Rain
Antassawamock	8/29/2009		Flood	Heavy Rain
Hanover	3/14/2010	16,150,000	Flood	Heavy Rain
Stanley	3/29/2010	8,070,000	Flood	Heavy Rain
Stanley	4/1/2010		Flood	Heavy Rain
West Wareham	7/13/2011	5,000	Flood	Heavy Rain
Montello	8/10/2012	30,000	Flood	Heavy Rain
East Wareham	5/11/2013		Flood	Heavy Rain
Marion	5/11/2013		Flood	Heavy Rain
Marion	6/7/2013		Flood	Heavy Rain Tropical System
East Marion	9/3/2013		Flood	Heavy Rain
Brockton	3/30/2014		Flood	Heavy Rain
Harbor Beach	3/30/2014		Flood	Heavy Rain
Middleboro	10/22/2014		Flood	Heavy Rain
Marion	11/17/2014		Flood	Heavy Rain

Plymouth ARPT	5/31/2015		Flood	Heavy Rain
Tremont	7/28/2015	15,000	Flood	Heavy Rain
Marion	9/10/2015		Flood	Heavy Rain
Plymouth	10/29/2015		Flood	Heavy Rain
Five Corners	5/30/2016		Flood	Heavy Rain
Scituate	4/1/2017	5,000	Flood	Heavy Rain
Whitman	4/6/2017	5,000	Flood	Heavy Rain
Parkwood Beach	6/24/2017	1,000	Flood	Heavy Rain
Stanley	10/25/2017		Flood	Heavy Rain
West Weymouth	10/25/2017		Flood	Heavy Rain
Kingston	10/29/2017		Flood	Heavy Rain
Nameloc HGTS	1/12/2018		Flood	Heavy Rain
Kingston	11/3/2018	1,000	Flood	Heavy Rain
West Hingham	4/15/2019		Flood	Heavy Rain
Kingston	7/12/2019		Flood	Heavy Rain
East Marion	7/22/2019		Flood	Heavy Rain
Brockton HGTS	9/2/2019	1,000	Flood	Heavy Rain
Montello	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.[33]

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.

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.[34]

[33] NOAA, National Weather Service.

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

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

Floods of March 2010

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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.

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.

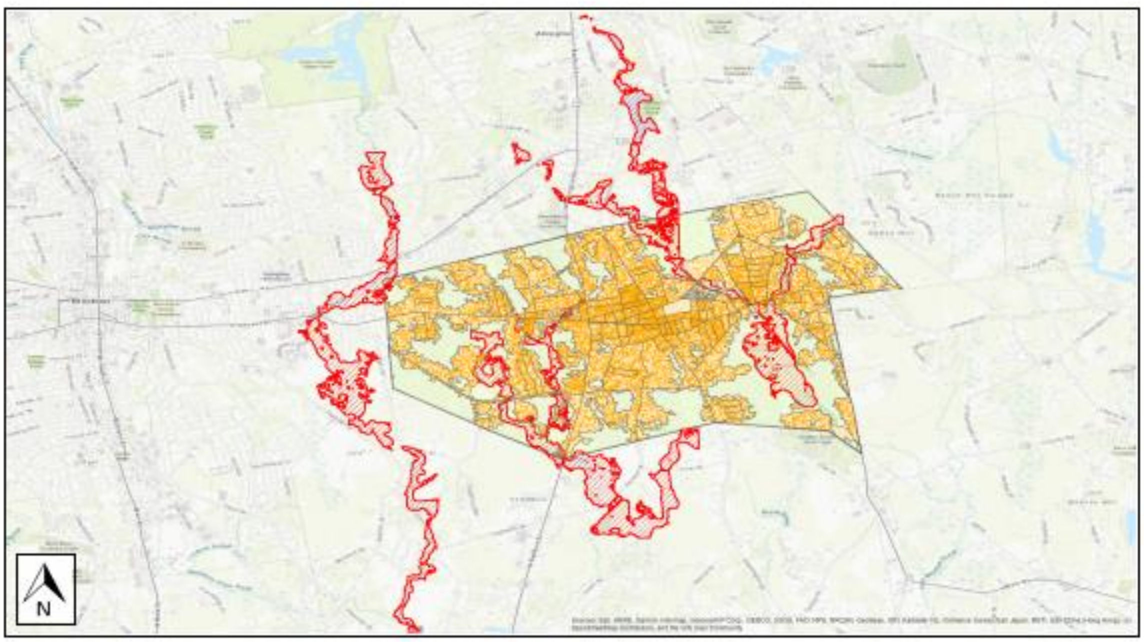
Flood Scenario Parameters

Hazus used the following set of information to define the flood parameters for the flood loss estimate provided in this report.

Study Region Name:	Whitman
Scenario Name:	Whitman_Scenario_1
Return Period Analyzed:	100
Analysis Options Analyzed:	No What-Ifs

Study Region Overview Map

Illustrating scenario flood extent, as well as exposed essential facilities and total exposure



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)

B4. Does the Plan address NFIP jurisdiction that have been repetitively damaged by floods? 44 CFR 201.6©(2)(ii)

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.

C2. Does the Plan address each jurisdiction's participation in the NFIP and continued compliance with NFIP requirements, as appropriate? (Requirement §201.6(c)(3)(ii))

During 2021 the Town adopted an updated Floodplain District bylaw in compliance with 44CFR 60.3 of the National Flood Insurance Program and updates this bylaw as revisions to the FIRM maps are made. All development in the floodplain district, including structural and non-structural activities, whether permitted by right or by special permit must follow Chapter 131, Section 40 of the Massachusetts General Laws and with the following:

- Sections of the Massachusetts State Building Code (780 CMR) which address floodplain and coastal high hazard areas.

- Wetlands Protection Regulations, Department of Environmental Protection (DEP) currently 310 CME 10.00.
- Inland Wetlands Restrictions, DEP (currently 310 CMR 13.00).
- Minimum Requirements for the Subsurface Disposal of Sanitary Sewage, DEP (currently 310 CMR 15, Title 5).

The Town actively takes part in preventing and controlling stormwater runoff. Multiple departments have contributed to developing its stormwater management plan (SWMP) and follows EPA's 2016 MS4 Stormwater permits. The Town of Whitman has also adopted a Wetlands Protection By-law and accompanying regulations to protect the wetlands, related water resources, and adjoining land areas by controlling activities deemed by the Whitman Conservation Commission likely to have a significant or cumulative effect upon wetland values by establishing criteria and standards for the uniform and coordinated administration of the provisions of the By-law.

Community Overview

Community:	WHITMAN, TOWN OF	State:	MASSACHUSETTS
County:	PLYMOUTH COUNTY	CID:	250285

Program:	Regular	Emergency Entry:	03/12/1975	Regular Entry:	07/02/1981
Status:	PARTICIPATING			Status Effective:	07/02/1981
Current Map:	07/17/2012	Study Underway:	NO	Level of Regs:	
FIRM Status:	REVISED			Initial FIRM:	07/02/1981
FHBM Status:	SUPERCEDED BY FIRM			Initial FHBM:	10/18/1974

Probation Status:			
Probation Effective:		Probation Ended:	
Suspension Effective:		Reinstated Effective:	
Withdrawal Effective:		Reinstated Effective:	

CRS Class / Discount:				Policies In Force:	10
Effective Date:				Insurance In Force:	$3,098,400.00
CAV Date:	01/24/2006	Workshop Date:	07/28/2020	No. of Paid Losses:	17
CAC Date:	04/05/2012	GTA Date:	04/11/2018	Total Losses Paid:	$210,736.86
☐ Tribal Community		Community Website:		Sub. Damage Claims Since 1978:	1
☐ Upton Jones Claims		☐ HMGP Projects			
☐ ICC Claims		☐ FMA Projects			

Insurance Occupancy

As of 06/02/2021

Community:	WHITMAN, TOWN OF	**State:**	MASSACHUSETTS
County:	PLYMOUTH COUNTY	**CID:**	250285

Overview | Occupancy | Zone | Pre/Post FIRM

	Policies in Force	Premium	Insurance in Force	Number of Closed Paid Losses	$ of Closed Paid Losses	Adjustment Expense
Single Family	8	$5,967	$2,248,400	13	$198,605.04	$6,310.00
2-4 Family	0	$0	$0	0	$0.00	$0.00
All Other Residential	1	$394	$350,000	1	$10,436.28	$550.00
Non Residential	1	$312	$500,000	3	$1,695.54	$370.00
Total	10	$6,673	$3,098,400	17	$210,736.86	$7,230.00

	Policies in Force	Premium	Insurance in Force	Number of Closed Paid Losses	$ of Closed Paid Losses	Adjustment Expense
Condo	1	$394	$350,000	1	$10,436.28	$550.00
Non Condo	9	$6,279	$2,748,400	16	$200,300.58	$6,680.00
Total	10	$6,673	$3,098,400	17	$210,736.86	$7,230.00

Community Repetitive Loss

COMMUNITY : WHITMAN, TOWN OF

Community | State | Regional | National

	AE, A1-30, AO, AH, A	VE, V1-30, V	B, C, X	TOTAL
RL Buildings (Total)	4	0	0	4
RL Buildings (Insured)	0	0	0	0
RL Losses (Total)	7	0	0	7
RL Losses (Insured)	0	0	0	0
RL Payments (Total)	$171,023.36	$.00	$.00	$171,023.36
Building	$149,745.49	$.00	$.00	$149,745.49
Contents	$21,277.87	$.00	$.00	$21,277.87
RL Payments (Insured)	$.00	$.00	$.00	$.00
Building	$.00	$.00	$.00	$.00
Contents	$.00	$.00	$.00	$.00

Post - FIRM SFHA RL Buildings:	0
Insured Buildings with 4 or More Losses:	0
Insured Buildings with 2-3 Losses > Building Value:	0
Total Target RL Buildings:	0

Insurance Zone

As of 06/02/2021

Community:	WHITMAN, TOWN OF	State:	MASSACHUSETTS
County:	PLYMOUTH COUNTY	CID:	250285

Overview | Occupancy | Zone | Pre/Post FIRM

	Policies in Force	Premium	Insurance in Force	Number of Closed Paid Losses	$ of Closed Paid Losses	Adjustment Expense
A01-30 & AE Zones	1	$312	$500,000	7	$204,471.44	$4,470.00
A Zones	1	$2,803	$148,400	6	$5,396.62	$2,195.00
AO Zones	0	$0	$0	0	$0.00	$0.00
AH Zones	0	$0	$0	0	$0.00	$0.00
AR Zones	0	$0	$0	0	$0.00	$0.00
A99 Zones	0	$0	$0	0	$0.00	$0.00
V01-30 & VE Zones	0	$0	$0	0	$0.00	$0.00
V Zones	0	$0	$0	0	$0.00	$0.00
D Zones	0	$0	$0	0	$0.00	$0.00
B, C & X Zone						
Standard	1	$682	$350,000	0	$0.00	$0.00
Preferred	7	$2,876	$2,100,000	1	$0.00	$275.00
Total	10	$6,673	$3,098,400	14	$209,868.06	$6,940.00

Insurance Pre/Post FIRM

As of 06/02/2021

Community:	WHITMAN, TOWN OF	**State:**	MASSACHUSETTS
County:	PLYMOUTH COUNTY	**CID:**	250285

Overview | Occupancy | Zone | Pre/Post FIRM

Pre-FIRM

	Policies in Force	Premium	Insurance in Force	Number of Closed Paid Losses	$ of Closed Paid Losses	Adjustment Expense
A01-30 & AE Zones	1	$312	$500,000	7	$204,471.44	$4,470.00
A Zones	0	$0	$0	6	$5,396.62	$2,195.00
AO Zones	0	$0	$0	0	$0.00	$0.00
AH Zones	0	$0	$0	0	$0.00	$0.00
AR Zones	0	$0	$0	0	$0.00	$0.00
A99 Zones	0	$0	$0	0	$0.00	$0.00
V01-30 & VE Zones	0	$0	$0	0	$0.00	$0.00
V Zones	0	$0	$0	0	$0.00	$0.00
D Zones	0	$0	$0	0	$0.00	$0.00
B, C & X Zone	5	$2,258	$1,470,000	1	$0.00	$275.00
Standard	1	$682	$350,000	0	$0.00	$0.00
Preferred	4	$1,576	$1,120,000	1	$0.00	$275.00
Grand Total	6	$2,570	$1,970,000	14	$209,868.06	$6,940.00

Post-FIRM

	Policies in Force	Premium	Insurance in Force	Number of Closed Paid Losses	$ of Closed Paid Losses	Adjustment Expense
A01-30 & AE Zones	0	$0	$0	0	$0.00	$0.00
A Zones	1	$2,803	$148,400	0	$0.00	$0.00
AO Zones	0	$0	$0	0	$0.00	$0.00
AH Zones	0	$0	$0	0	$0.00	$0.00
AR Zones	0	$0	$0	0	$0.00	$0.00
A99 Zones	0	$0	$0	0	$0.00	$0.00
V01-30 & VE Zones	0	$0	$0	0	$0.00	$0.00
V Zones	0	$0	$0	0	$0.00	$0.00
D Zones	0	$0	$0	0	$0.00	$0.00
B, C & X Zone	3	$1,300	$980,000	0	$0.00	$0.00
Standard	0	$0	$0	0	$0.00	$0.00
Preferred	3	$1,300	$980,000	0	$0.00	$0.00
Grand Total	4	$4,103	$1,128,400	0	$0.00	$0.00

CRS What-If

Application | CRS Coord. | 2ndPOC | Activity Points | Chronology | Comments | What If | GTA

Community:	WHITMAN, TOWN OF	**State:**	MASSACHUSETTS
County:	PLYMOUTH COUNTY	**CID:**	250285

Current CRS Class = 10 *[Printable Version]*

CRS Class		TOTAL	SFHA *	X-STD/AR/A99 **	PRP ***
	PIF	10	2	1	7
	PREMIUM	$6,673	$3,115	$682	$2,876
	AVERAGE PREMIUM	$667	$1,558	$682	$411
09	Per Policy	$19	$78	$34	$0
	Per Community	$190	$156	$34	$0
08	Per Policy	$35	$156	$34	$0
	Per Community	$346	$312	$34	$0
07	Per Policy	$50	$234	$34	$0
	Per Community	$501	$467	$34	$0
06	Per Policy	$69	$312	$68	$0
	Per Community	$691	$623	$68	$0
05	Per Policy	$85	$389	$68	$0
	Per Community	$847	$779	$68	$0
04	Per Policy	$100	$467	$68	$0
	Per Community	$1,003	$934	$68	$0
03	Per Policy	$116	$545	$68	$0
	Per Community	$1,158	$1,090	$68	$0
02	Per Policy	$131	$623	$68	$0
	Per Community	$1,314	$1,246	$68	$0
01	Per Policy	$147	$701	$68	$0
	Per Community	$1,470	$1,402	$68	$0

* SHFA (Zones A, AE, A1-A30, V, V1-V30, AO, and AH): Discount varies depending on class.

** SFHA (Zones A99, AR, AR/A, AR/AE, AR/A1-A30, AR/AH, and AR/AO): 10% discount for Classes 1-6; 5% discount for Classes 7-9.

Figure 47: Digital Flood Map Status

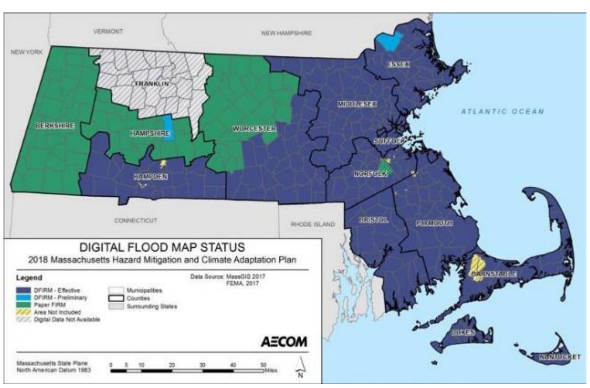
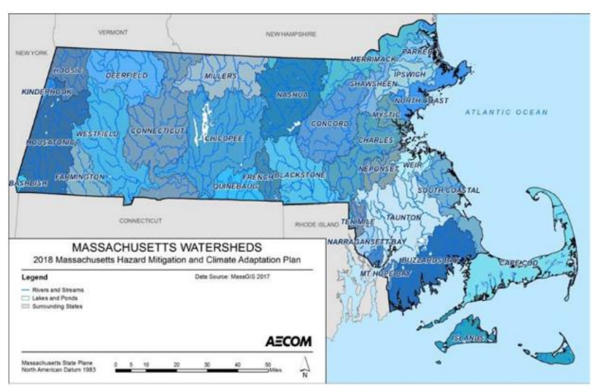


Figure 48: Massachusetts Watersheds



Source: SHMCAP, 2018

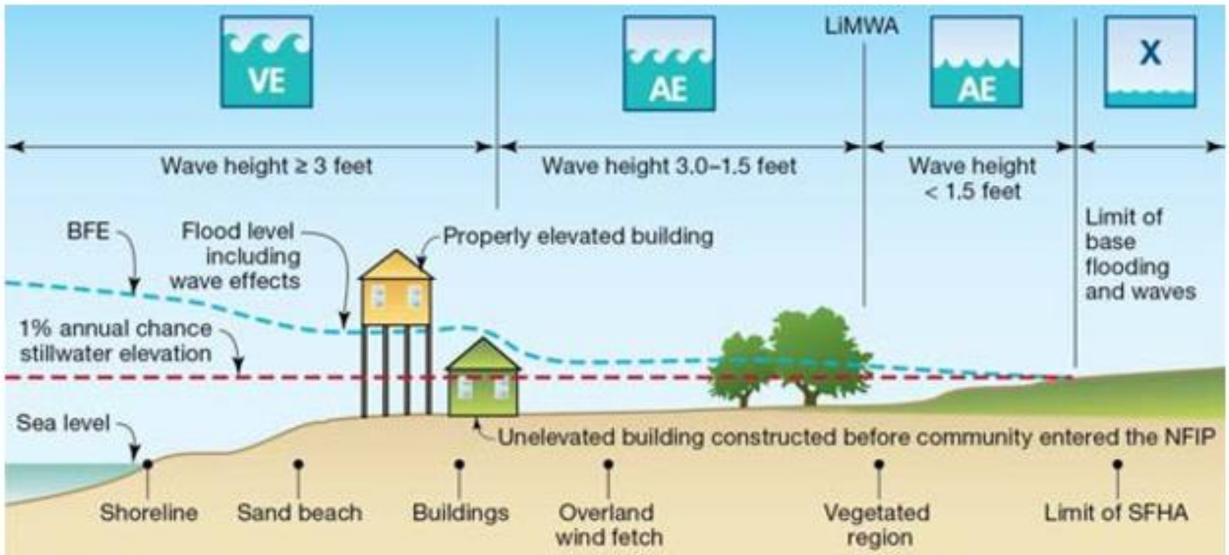
HAZUS Flooding Vulnerability Assessment

Table 67: HAZUS Flood Scenario

Scenario - Flood	10-Year	25-Year	50-Year	100-Year	500-Year
Population	14,489	14,489	14,489	14,489	14,489
Building Characteristics					
Estimated Total Number of Buildings	4,683	4,683	4,683	4,683	4,683
Estimated total building replacement value	$1,897,672,000	$1,897,672,000	$1,897,672,000	$1,897,672,000	$1,897,672,000
Estimated residential building value	$1,530,859,000	$1,530,859,000	$1,530,859,000	$1,530,859,000	$1,530,859,000
Estimated non-residential building value	$366,813,000	$366,813,000	$366,813,000	$366,813,000	$366,813,000
Building Damages					
Damage Level 1-10	9	9	9	11	12
Damage Level 11-20	2	3	3	3	6
Damage Level 21-30	0	0	0	0	0
Damage Level 31-40	0	0	0	0	0
Damage Level 41-50	0	0	0	0	0
Damage Level >50	0	0	0	0	0
Population Needs					
# Of households displaced	103	114	122	129	159
# Of people seeking public shelter	1	1	1	1	2
Debris					
Building debris generated (tons)	49	56	63	73	109
# Of truckloads to clear building debris (@ 25 tons/truck)	2	3	3	3	5
Value of Damages (Millions of dollars)	5.78	6.63	7.34	7.97	10.13
Total property damage	2.75	3.27	3.73	4.18	5.49
Total losses due to business interruption	3.03	3.36	3.61	3.79	4.63

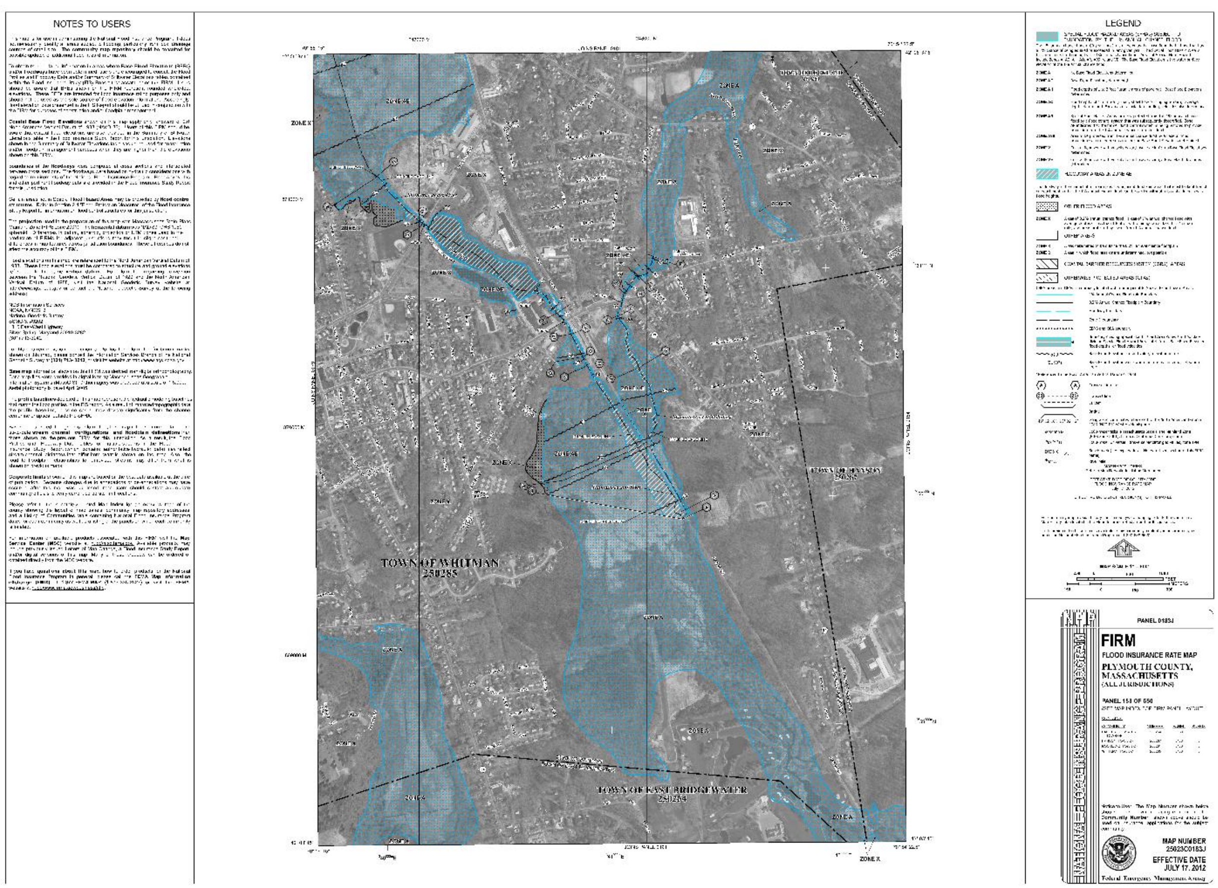
The Town has an active Conservation Commission who monitor activities within the floodplain. The Town actively takes part in preventing and controlling stormwater runoff. Multiple departments have contributed to developing its stormwater management plan (SWMP) and follows EPA's 2016 MS4 Stormwater permits.

Figure 49: FEMA Flood Zones along the Coast



Source: FEMA, n.d.

Figure 50: FIRM Panel 25023C0183J



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. [35]

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.

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

[35] SHMCAP, 2018

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.

There is 1 dam in Whitman according to the Massachusetts Department of Conservation and Recreation Office of Dam Safety.

Table 68: Whitman Dams

Name	Impoundment	Waterway	Hazard Code	Owner
Hobart Pond Dam	Hobart Pond	Shumatuscacant River	Low	Town

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.

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.

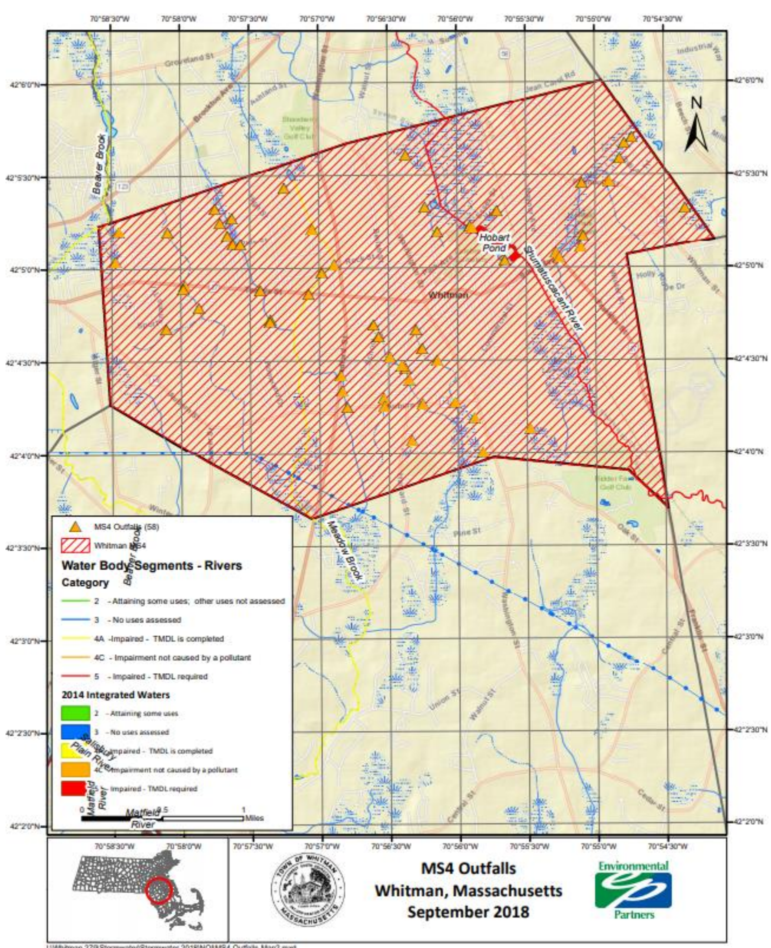
Flood Prone Areas

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 Whitman are areas along the Meadow Brook, Shumatuscacant River, Bear Meadow, Hobart Meadow, and the areas between Route 14 and Route 27. In addition to these areas, town officials also noted the following locations where flooding has historically occurred:

- Auburn Street (Route 14) at Pine Haven Drive
- Bedford Street at Stop & Shop (at an unnamed brook, just north of May Street)
- Pond Street near South Avenue and the MBTA Station
- Woodlawn Circle at Pine Haven Drive
- Temple Street (Route 27) at Joyce Terrace
- Temple Street (Route 27) over Rock St.
- Belmont Street at Meadow Brook
- Plymouth Street at Shumatuscacant River
- Oldman Drive near Route 14
- Star Street
- Bedford Street culverts

Stormwater Infrastructure

Figure 51: Stormwater Management System



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.

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.

Table 69: 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

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.

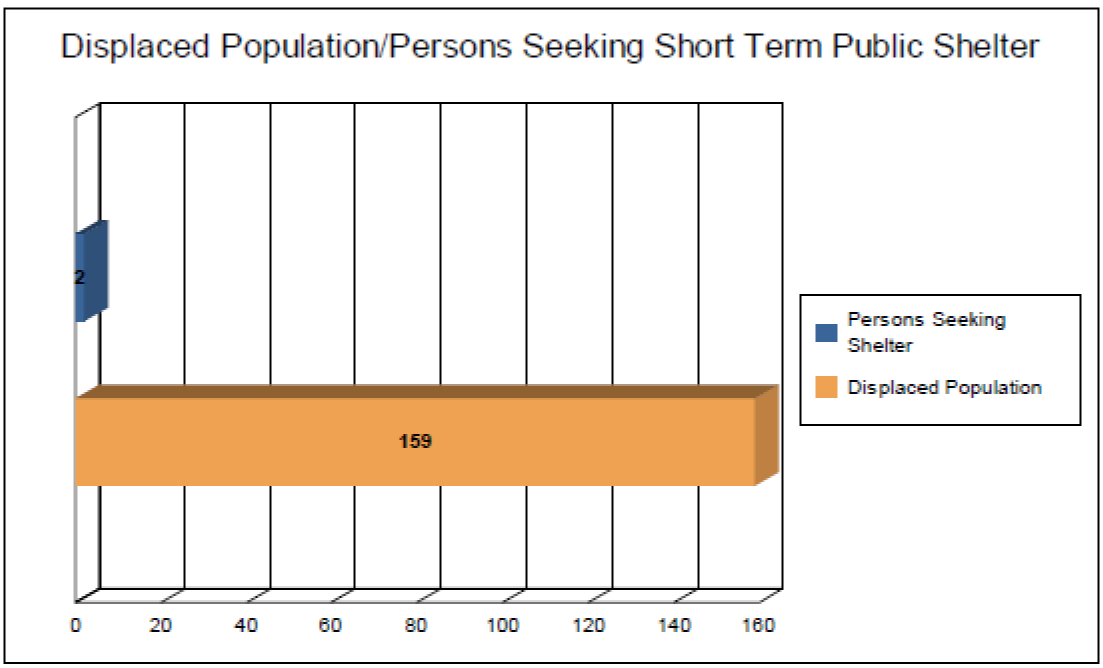
HAZUS Shelter Requirements

Figure 52: HAZUS Shelter Requirements

Social Impact

Shelter Requirements

Hazus estimates the number of households that are expected to be displaced from their homes due to the flood and the associated potential evacuation. Hazus also estimates those displaced people that will require accommodations in temporary public shelters. The model estimates 53 households (or 159 of people) will be displaced due to the flood. Displacement includes households evacuated from within or very near to the inundated area. Of these, 2 people (out of a total population of 14,489) will seek temporary shelter in public shelters.



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).

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). [36]

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 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

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

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. [37]

Table 70: Massachusetts Eastern Equine Encephalitis Experience

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

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

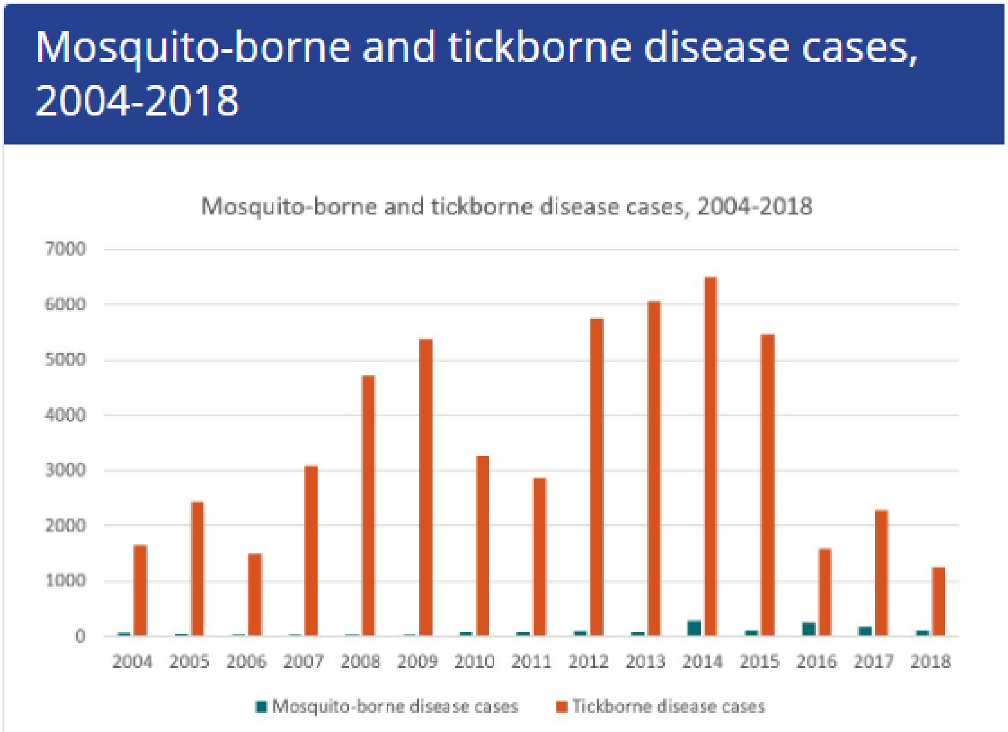
Vector-borne Diseases

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 Whitman 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. [38]

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.

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

Figure 53: Mosquito-borne and Tick-borne Disease Cases, 2004 - 2018

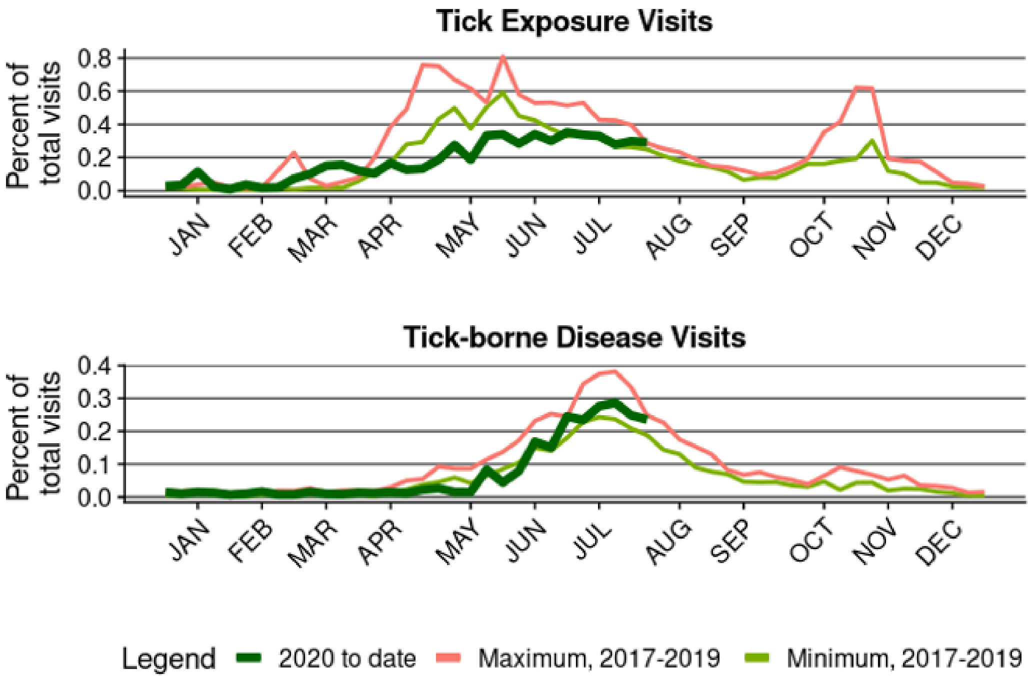


Source: https://www.cdc.gov/ncezid/dvbd/vital-signs/massachusetts.html

The graphs below show that in July of 2020, less than 0.4 percent of visits to Emergency Rooms 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. [39]

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

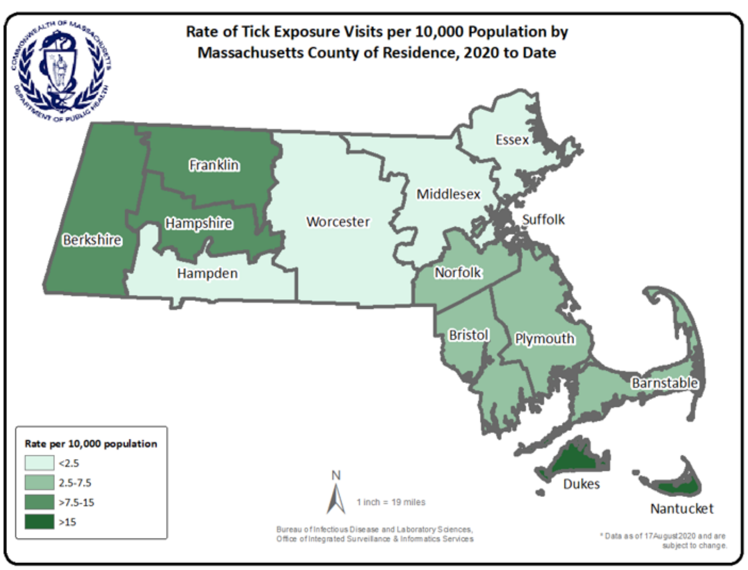
Figure 54: Tick Exposure Visits



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

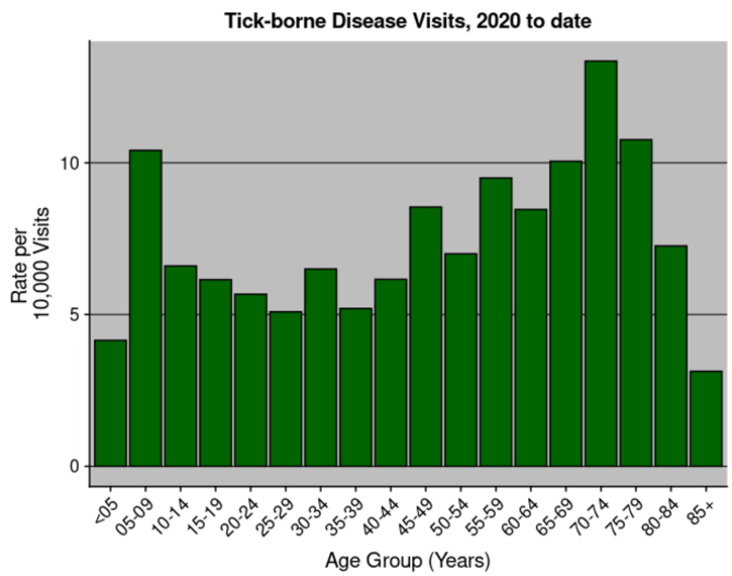


Source:

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 56: 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 71: Emergency Department Visits

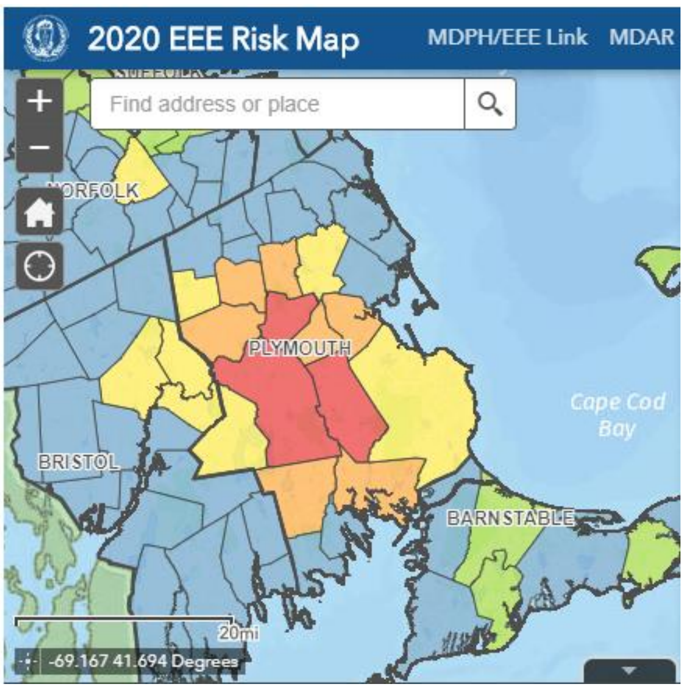
County	Total Visits	Number of Tick-borne Disease Visits	Rate (per 10,000) of Tick-borne Disease Visits
Barnstable	52,155	56	10.74
Berkshire	36,437	41	11.25
Bristol	145,095	130	8.96
Dukes/Nantucket	8,218	101	122.9
Essex	177,821	47	2.64
Franklin	15,469	21	13.58
Hampden	129,922	40	3.08
Hampshire	28,768	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 region. 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. [40] 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.

Figure 57: 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. [41]

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

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

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

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.

Figure 58: HAZUS Essential Facility Damage

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Essential Facility Damage

Before the flood analyzed in this scenario, the region had 0 hospital beds available for use. On the day of the scenario flood event, the model estimates that 0 hospital beds are available in the region.

Table 5: Expected Damage to Essential Facilities

		# Facilities		
Classification	Total	At Least Moderate	At Least Substantial	Loss of Use
Emergency Operation Centers	2	0	0	0
Fire Stations	1	0	0	0
Hospitals	0	0	0	0
Police Stations	1	0	0	0
Schools	4	0	0	0

If this report displays all zeros or is blank, two possibilities can explain this.

(1) None of your facilities were flooded. This can be checked by mapping the inventory data on the depth grid.

(2) The analysis was not run. This can be tested by checking the run box on the Analysis Menu and seeing if a message box asks you to replace the existing results.

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).

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 Whitman 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.

Roads, Bridges, and Related Infrastructure

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.

According to the Massachusetts Department of Transportation, there are nearly 49 miles of Town-maintained roads in Whitman. Another approximately 1.63 miles are unaccepted (or private) ways. Additionally, Whitman has four bridges or large culverts identified on the MassDOT's bridge inventory. The State is responsible for inspecting these bridges, but the Town is responsible for repairs and replacement. There are also many other smaller municipally owned culverts in Town.

Table 72:: Whitman Bridges Spanning Waterways

Bridge Name	Facility Carried	Waterway Spanned	Year Built	Length	Deck Area	Inspection Date	Owner	Bridge Dept. #
Bridge	St. 27 South Ave	Shumatuscacant River	1935				MUN	
Culvert	St. 27 South Ave	Shumatuscacant River	1935				MUN	
Culvert	St. 27 South Ave	Brigham Pond	1850				MUN	
Culvert	Hwy Essex St	Shumatuscacant River	1850				MUN	

Figure 59: HAZUS Building Inventory General Building Stock

Building Inventory

General Building Stock

Hazus estimates that there are 4,683 buildings in the region which have an aggregate total replacement value of 1,898 million dollars. Table 1 and Table 2 present the relative distribution of the value with respect to the general occupancies by Study Region and Scenario respectively. Appendix B provides a general distribution of the building value by State and County.

Table 1
Building Exposure by Occupancy Type for the Study Region

Occupancy	Exposure ($1000)	Percent of Total
Residential	1,530,859	80.7%
Commercial	241,050	12.7%
Industrial	82,189	4.3%
Agricultural	2,639	0.1%
Religion	12,856	0.7%
Government	7,857	0.4%
Education	20,222	1.1%
Total	**1,897,672**	**100%**

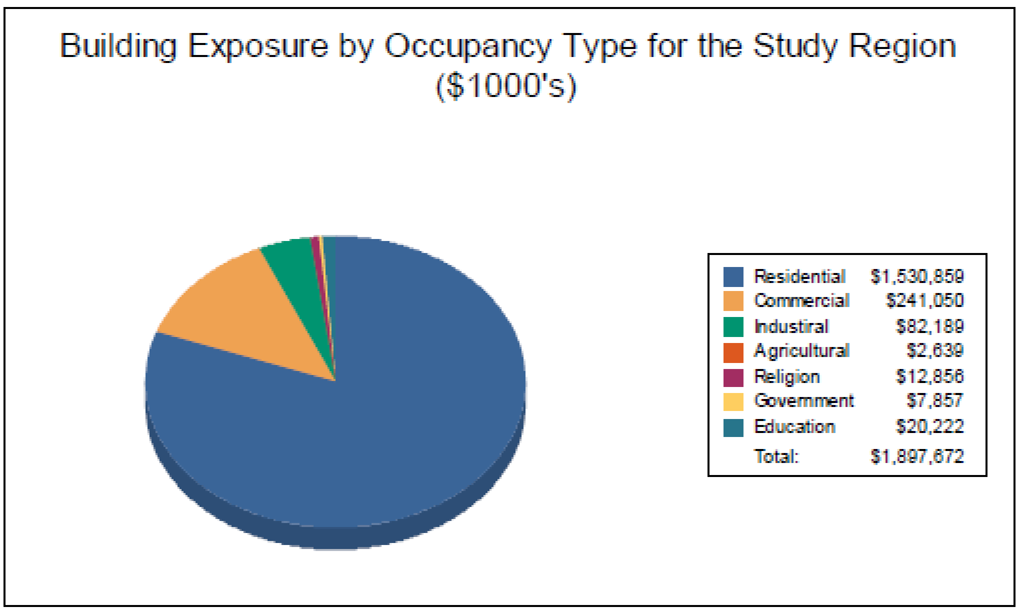
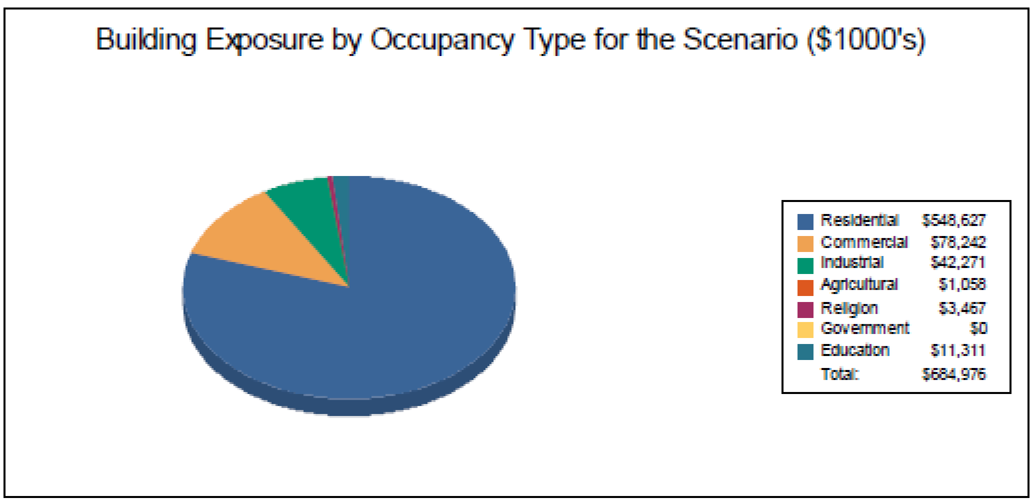


Figure 60: HAZUS Building Exposure by Occupancy Type

Table 2
Building Exposure by Occupancy Type for the Scenario

Occupancy	Exposure ($1000)	Percent of Total
Residential	548,627	80.1%
Commercial	78,242	11.4%
Industrial	42,271	6.2%
Agricultural	1,058	0.2%
Religion	3,467	0.5%
Government	0	0.0%
Education	11,311	1.7%
Total	**684,976**	**100%**



Essential Facility Inventory

For essential facilities, there are no hospitals in the region with a total bed capacity of no beds. There are 4 schools, 1 fire station, 1 police station and 2 emergency operation centers.

Figure 61: HAZUS Expected Building Damage by Occupancy

Table 3: Expected Building Damage by Occupancy

	1-10		11-20		21-30		31-40		41-50		>50	
Occupancy	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0
Commercial	0	0	0	0	0	0	0	0	0	0	0	0
Education	0	0	0	0	0	0	0	0	0	0	0	0
Government	0	0	0	0	0	0	0	0	0	0	0	0
Industrial	0	0	0	0	0	0	0	0	0	0	0	0
Religion	0	0	0	0	0	0	0	0	0	0	0	0
Residential	12	63	6	32	1	5	0	0	0	0	0	0
Total	**12**		**6**		**1**		**0**		**0**		**0**	

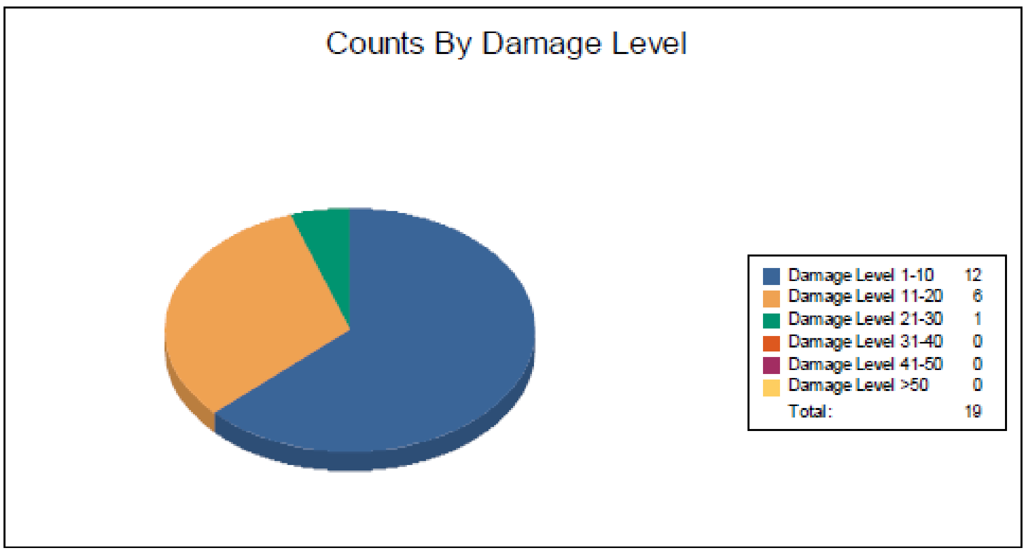


Figure 62: HAZUS Expected Building Damage by Building Type

Table 4: Expected Building Damage by Building Type

Building Type	1-10		11-20		21-30		31-40		41-50		>50	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	0	0	0	0	0	0	0	0	0	0	0	0
ManufHousing	0	0	0	0	0	0	0	0	0	0	0	0
Masonry	0	0	0	0	0	0	0	0	0	0	0	0
Steel	0	0	0	0	0	0	0	0	0	0	0	0
Wood	12	63	6	32	1	5	0	0	0	0	0	0

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.

Figure 63: HAZUS Flood Damage Debris Generation

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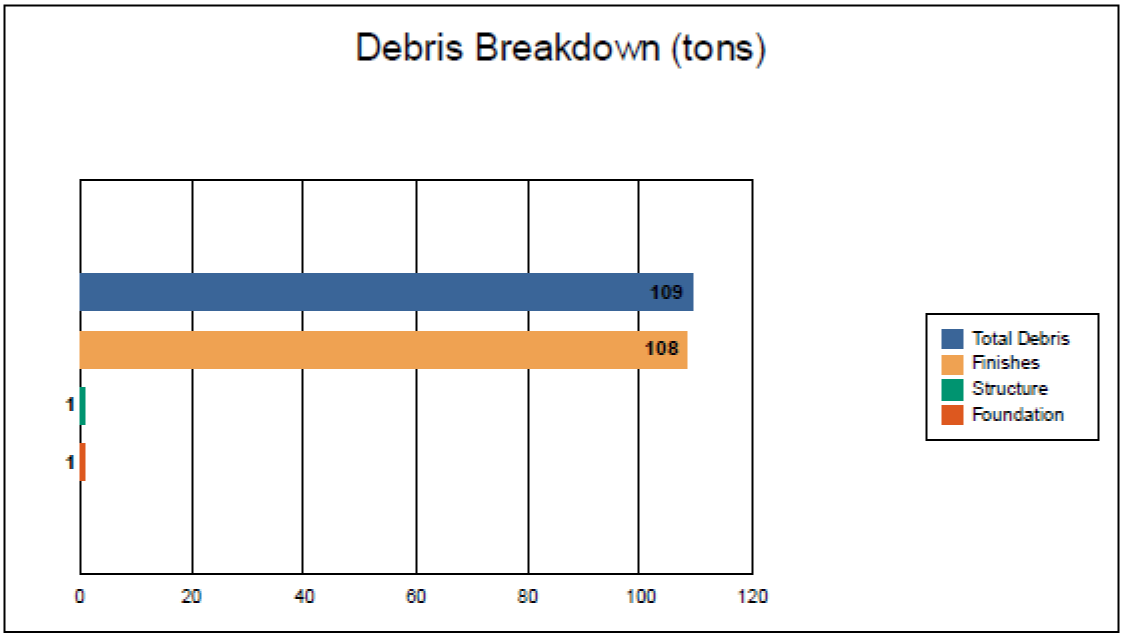
Induced Flood Damage

Debris Generation

Hazus estimates the amount of debris that will be generated by the flood. The model breaks debris into three general categories: 1) Finishes (dry wall, insulation, etc.), 2) Structural (wood, brick, etc.) and 3) Foundations (concrete slab, concrete block, rebar, etc.). This distinction is made because of the different types of material handling equipment required to handle the debris.



The model estimates that a total of 109 tons of debris will be generated. Of the total amount, Finishes comprises 99% of the total, Structure comprises 1% of the total, and Foundation comprises 0%. If the debris tonnage is converted into an estimated number of truckloads, it will require 5 truckloads (@25 tons/truck) to remove the debris generated by the flood.

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.

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.

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.

Figure 64: HAZUS Economic Loss Building-Related Losses

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Economic Loss

The total economic loss estimated for the flood is 10.13 million dollars, which represents 1.48 % of the total replacement value of the scenario buildings.

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the flood. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the flood.

The total building-related losses were 5.49 million dollars. 46% of the estimated losses were related to the business interruption of the region. The residential occupancies made up 32.46% of the total loss. Table 6 below provides a summary of the losses associated with the building damage.

Figure 65: HAZUS Building-Related Economic Loss Estimates

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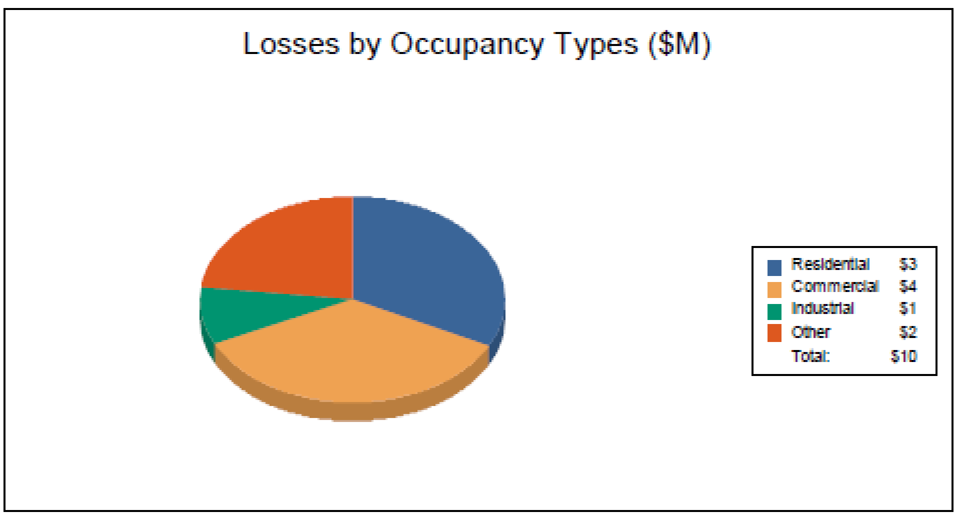
Table 6: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Residential	Commercial	Industrial	Others	Total
Building Loss						
	Building	1.67	0.32	0.22	0.11	2.31
	Content	0.73	1.14	0.58	0.62	3.07
	Inventory	0.00	0.03	0.09	0.00	0.12
	Subtotal	**2.40**	**1.49**	**0.88**	**0.73**	**5.49**
Business Interruption						
	Income	0.00	0.79	0.02	0.42	1.22
	Relocation	0.68	0.18	0.01	0.19	1.06
	Rental Income	0.21	0.14	0.00	0.01	0.36
	Wage	0.00	0.98	0.02	0.99	1.99
	Subtotal	**0.89**	**2.09**	**0.05**	**1.60**	**4.63**
ALL	**Total**	**3.29**	**3.58**	**0.94**	**2.33**	**10.13**



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.

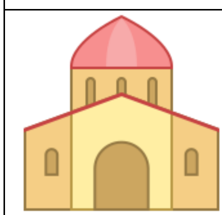
Between 2000 and 2009, approximately 30 to 60 percent of the United States experienced drought conditions at any one time (NRDC, n.d.).

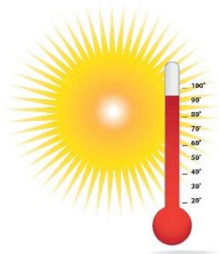
Drought is a period characterized by long durations of below normal precipitation. Drought diminishes natural stream flow and depletes soil moisture, which can cause social, environmental, and economic impacts. In general, the term "drought" is reserved for periods of moisture deficiency that are relatively 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. [42] 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.

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

Drought		
Hazard	**Location**	**Extent**
Drought 	Geographic-specific location cannot be identified, the entire area is equally at risk to the impacts of drought.	Drought was not identified as a hazard in the 2015 HMP for OCPC. Current frequency for Whitman 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 and Local 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 [43] 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

[43] 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.

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 droughts 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.

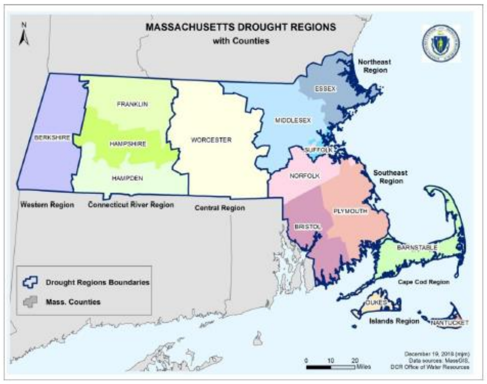
Location

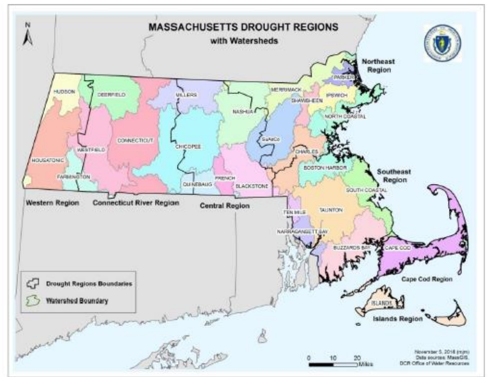
Regions across the Commonwealth differ in precipitation patterns, topography, land use, population density, and other factors that affect drought propensity and intensity. This Plan delineates seven Drought Regions to allow flexibility and customization of drought declarations and response actions for 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 73: 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 66: 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. [44] 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

[44] **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**

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).

Table 74: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[45]
1908-12				
1929-32	Statewide	10 to > 50	Water-supply sources altered in 13 communities. Multistate	USGS 1989[46]
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

[45] **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.**

[46] **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.**

1995	-	-	Based on statewide average precipitation	DMP 2013[47]
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[48]
Oct 2007 – Mar 2008	Statewide except West and Cape & Islands Region	-	Level 1 drought (out of 4 levels)	DCR 2017
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 75: 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

[47] 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.

[48] 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 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).

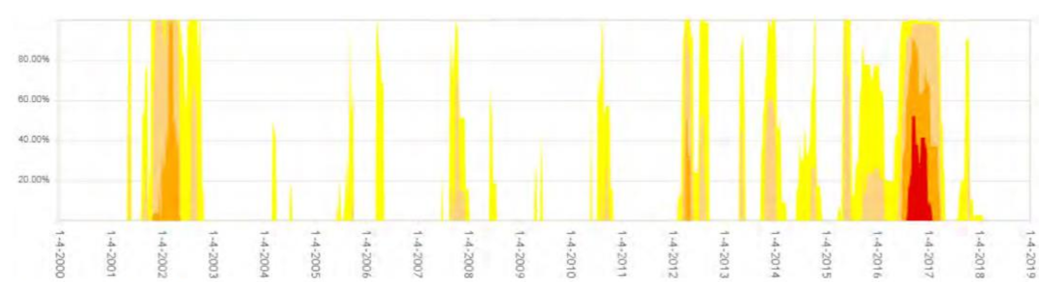
Table 76: Evolution of 2016 - 2017 Drought

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 67: 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.

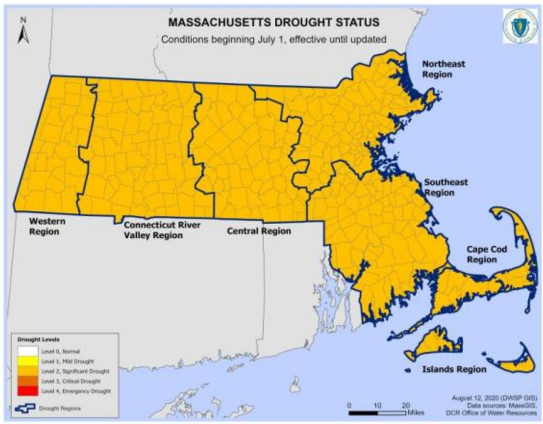


Figure 68: Massachusetts Drought Status Summer 2020

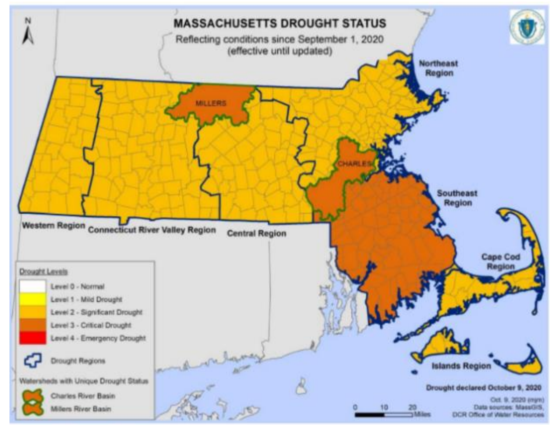


Figure 69: Massachusetts Drought Status Fall 2020

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

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.

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 77: Example of Staged Drought Response Matrix**

ACTION CATEGORY	ACTIONS	STATE DROUGHT LEVEL and DESCRIPTION			
		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			
	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. [49] 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 78: 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. ► Review petitions from public water systems to declare a state of water emergency and declare such emergencies with applicable requirements for communities

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

	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 79: 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 Whitman. December 2015 marked the ninth consecutive month of below average rainfall. In response to the drought, surface drinking water supply was severely impacted.

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 Whitman 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 Whitman, 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 Whitman 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 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.

The 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.).

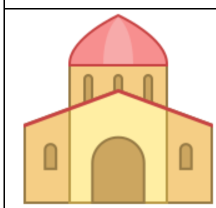
Economy

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 Whitman. The Town has not experienced a recorded landslide and is not especially vulnerable to landslides due to its lack of hills and generally flat topography.

Landslide		
Hazard	**Location**	**Extent**
Landslide 	Due to topography, this hazard does not impact Whitman.	The effects of landslide are localized, and it is difficult to determine Whitman 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 Whitman.
	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.

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).

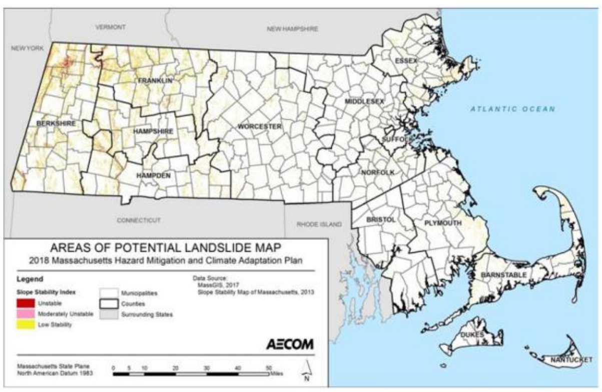
Potential Effects of Climate Change - Landslide		
	Changes in Precipitation and Extreme Weather – Slope Saturation	Regional climate change models suggest that Massachusetts will likely experience more frequent and intense storms throughout the year. This change could result in more frequent soil saturation 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.

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.

Location

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 70: Areas of Potential Landslide Map



Source: SHMCAP, 2018

Previous Occurrences

Due to the topography of Whitman, there are no recorded instances where landslides caused an impact. 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. [50]

Table 80: 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 is negligible.

[50] **SHMCAP, 2018**

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. [51]

Government

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

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.

[51] SHMCAP, 2018

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. Whitman 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 Whitman. There are no recorded instances of landslides having occurred in the Town of Whitman.

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.

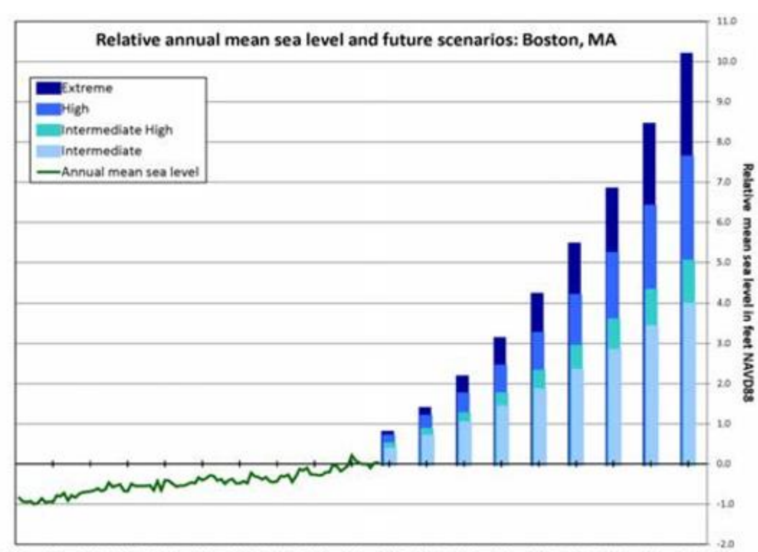
The values presented in the Table reflect a high emissions pathway (RCP 8.5). A 19-year reference time for sea level (tidal epoch) centered on the year 2000 was used to reduce biases caused by tidal, seasonal, and interannual climate variability. Sea level projections for the Boston tide station are 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 81: 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

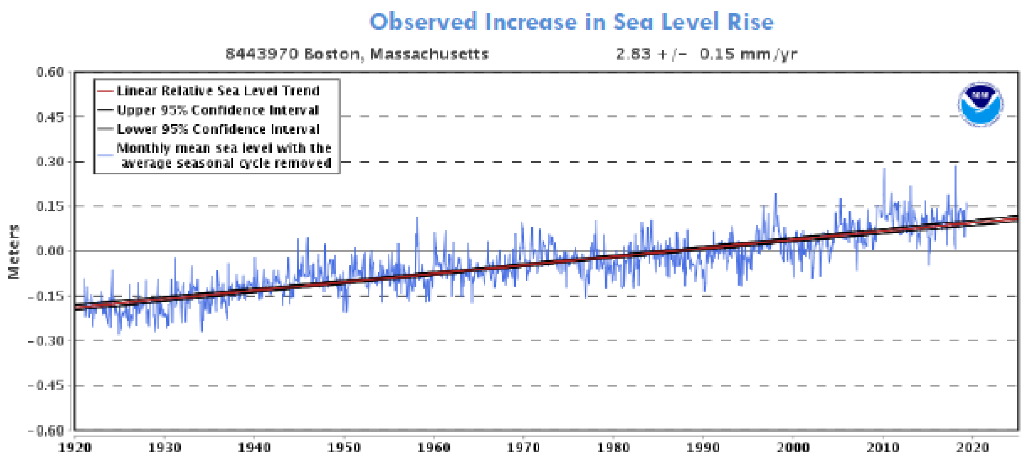
Figure 71: Relative Annual Mean Sea Level and Future Scenarios: Boston, MA



Source: resilient MA, 2018

Records from the Boston Tide Station show nearly one foot of sea level risk in the past century (see Figure: 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 72: 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.

Sea Level Rise - Coastal Flooding		
Hazard	**Location**	**Extent**
	Due to the inland location, this hazard does not impact Whitman.	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 Whitman 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 Whitman.
	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 economy of Whitman is not impacted by coastal flooding.

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.

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 hurricanes and Nor'easters. As a result, storm surge sufficient to cause coastal flooding is likely to occur more often.

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.

Location

Due to its inland location, the Town of Whitman is not subject to the impacts of sea level rise and coastal flooding.

Previous Occurrences

Whitman is not located directly on the coast. Local data for previous coastal flooding occurrences are not collected by the Town of Whitman. The best available local data is for Plymouth County through the National Climatic Data Center. Plymouth County, which includes the Town of Whitman, experienced 48 coastal flood events from 2006 through 2020 [52].

Table 82: 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
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

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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

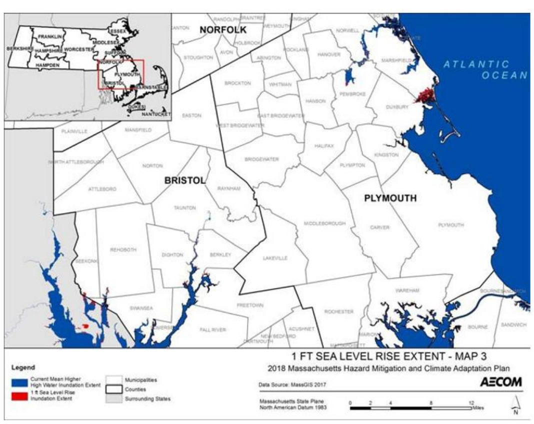
2/9/2013	EASTERN PLYMOUTH	Coastal Flood	9,200,000	0
3/7/2013	EASTERN PLYMOUTH	Coastal Flood	500,000	0
12/15/2013	EASTERN PLYMOUTH	Coastal Flood	-	0
1/2/2014	EASTERN PLYMOUTH	Coastal Flood	-	0
1/2/2014	EASTERN PLYMOUTH	Coastal Flood	-	0
1/3/2014	EASTERN PLYMOUTH	Coastal Flood	-	0
3/26/2014	EASTERN PLYMOUTH	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
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 73: Plymouth County Inundation Extent of 1-Foot Sea Level Rise to MHHW



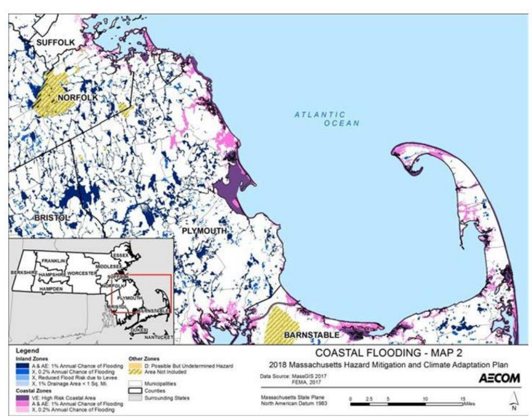
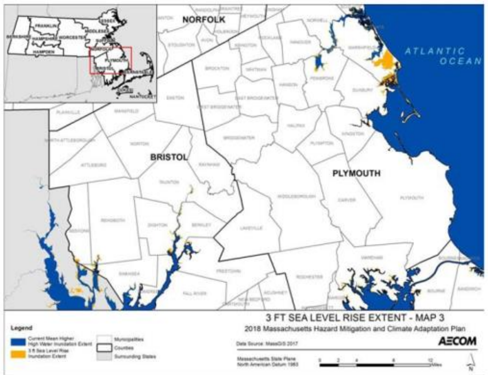


Figure 74: Coastal Flooding

Figure 75: Plymouth County Inundation Extent of 3-Foot Sea Level Rise Relative to MHHW



Secondary Hazards

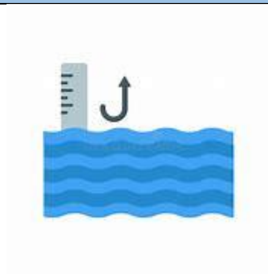
Many of the secondary hazards described for inland flooding can also occur due to coastal flooding if the necessary physical elements (rivers and slopes) are present within the impacted portion of the coastal zone. Although sea level rise does not result directly in coastal erosion, by increasing tidal 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 Whitman.

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 Whitman. There are no populations within the Town vulnerable to coastal flooding or coastal erosion.

Vulnerable Populations

As there are no coastal areas within the Town of Whitman, 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

Whitman is not located directly on the coast. There are no government facilities in the Town of Whitman subject to the impacts of coastal flooding.

The Built Environment

Whitman 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 83: 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): [53]

Table 84: 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

[53] https://www.ncdc.noaa.gov/extremes/scec/records/ma

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.

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 Whitman.

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 76: 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 85: Average, Maximum, and Minimum Temperatures.

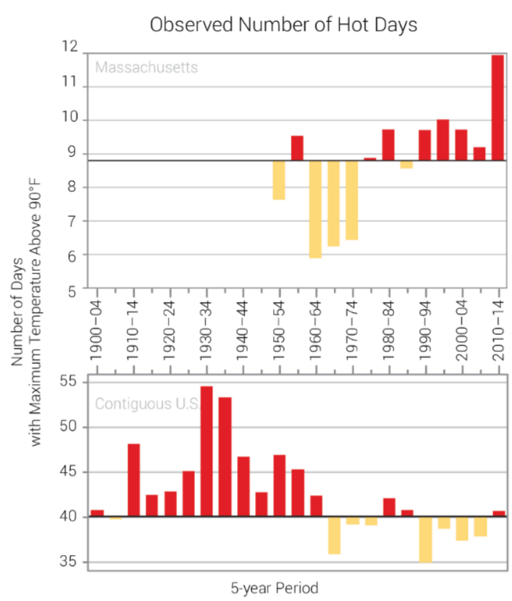
	Baseline (1971-2000)	Mid-Century (2050s)	End of Century (2090s)
Average annual temperature (°F)	46.8°F	+ 3.0 to 6.4°F	+ 3.9 to 11.0°F
Average days max temperature >90°F	4 days	9 to 30 more days	13 to 70 more days
Annual days min temperature <32°F	156 days	19 to 38 fewer days	23 to 64 fewer days

Source: resilientMA.org

Temperatures in Massachusetts have increased almost 3°F since the beginning of the 20th century.[54] 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 77: Observed Number of Hot Days

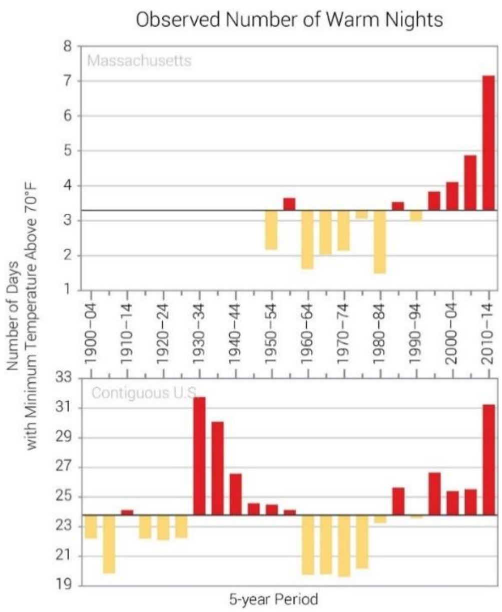


Source: https://statesummaries.ncics.org/chapter/ma/

[54] **NOAA National Centers for Environmental Information, State Summaries, 2017**

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.

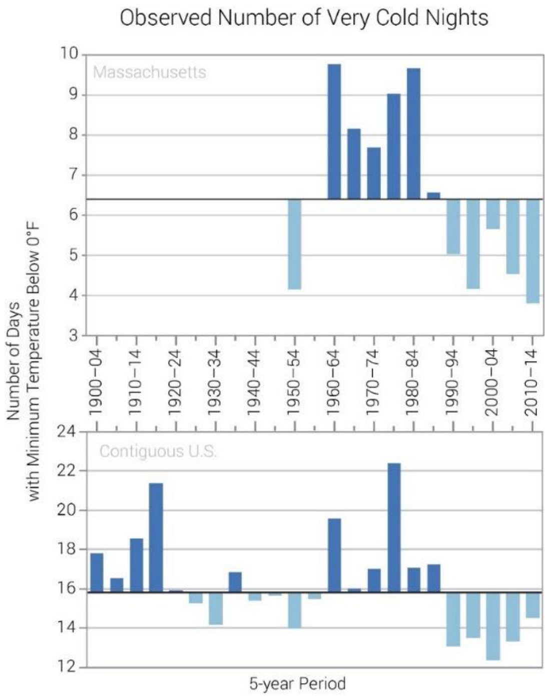
Figure 78: Observed Number of Warm Nights



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 79: 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. [55]

The highest temperature recorded in the Commonwealth for the period 1895 to present was 107°F [56] 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 80: 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

Figure 81: 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

[55] https://www.weather.gov/safety/heat-index

[56] **https://www.ncdc.noaa.gov/extremes/scec/records**

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 86: Average High and Average Low

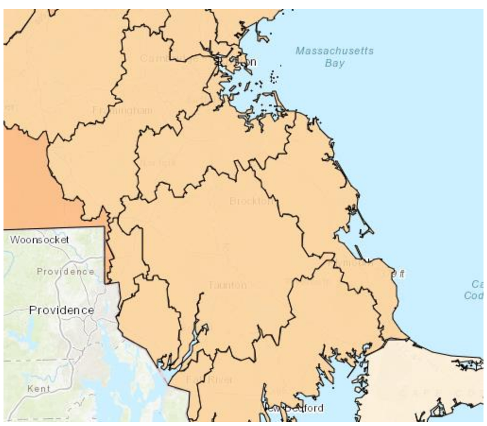
	July (Hottest Month)	January (Coldest Month)
Average High (°F)	81°	36°
Average Low (°F)	65°	22°

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 82: Average Temperature Projected 2050, Medium RCP 4.5



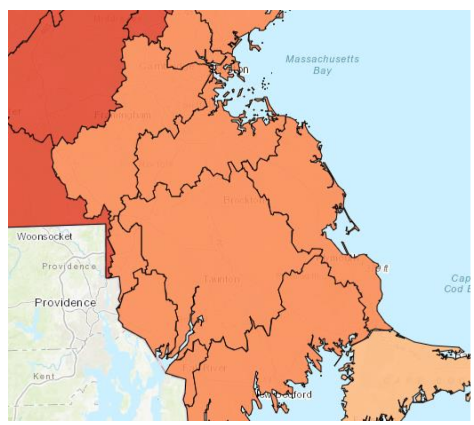
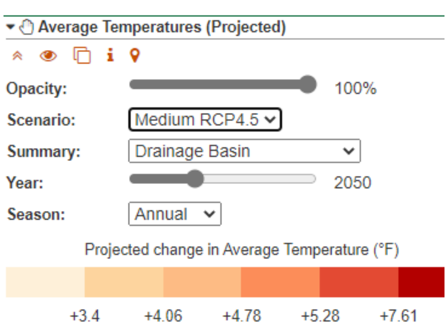
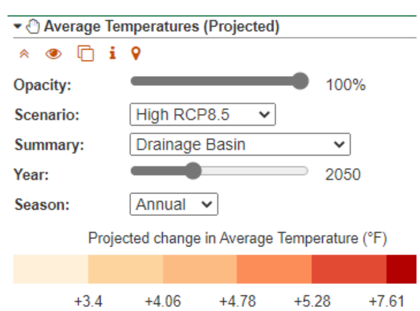
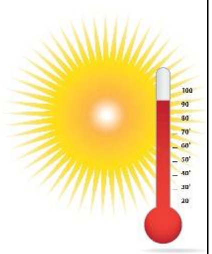
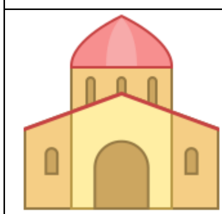


Figure 83: Average Temperature Projected 2050, High RCP 8.5





Rising Temperatures Extreme Heat		
Hazard	**Location**	**Extent**
Extreme Heat 	Geographic-specific location cannot be identified, the entire area is equally at risk to the impacts of extreme temperatures.	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)
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. • Young and elderly populations and people with pre-existing health conditions are especially vulnerable to heat and cold.
	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.

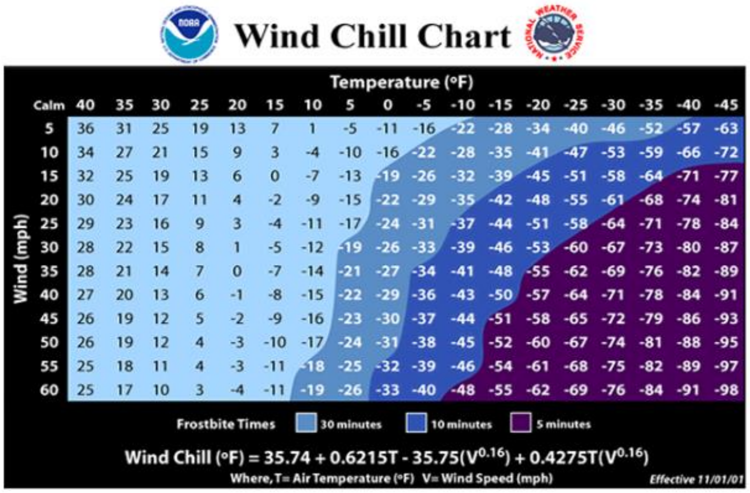
	Economy	Extreme temperature events can have significant economic impacts including loss of business function and damage/loss of inventory. The agricultural industry is the industry most at risk in terms of economic impact and damage due to extreme temperature and drought events.

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 84: 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.

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. Whitman sits within the Coastal Division.

Figure 85: Climate Divisions of Massachusetts

Source: NOAA, n.d.

The Town of Whitman 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.

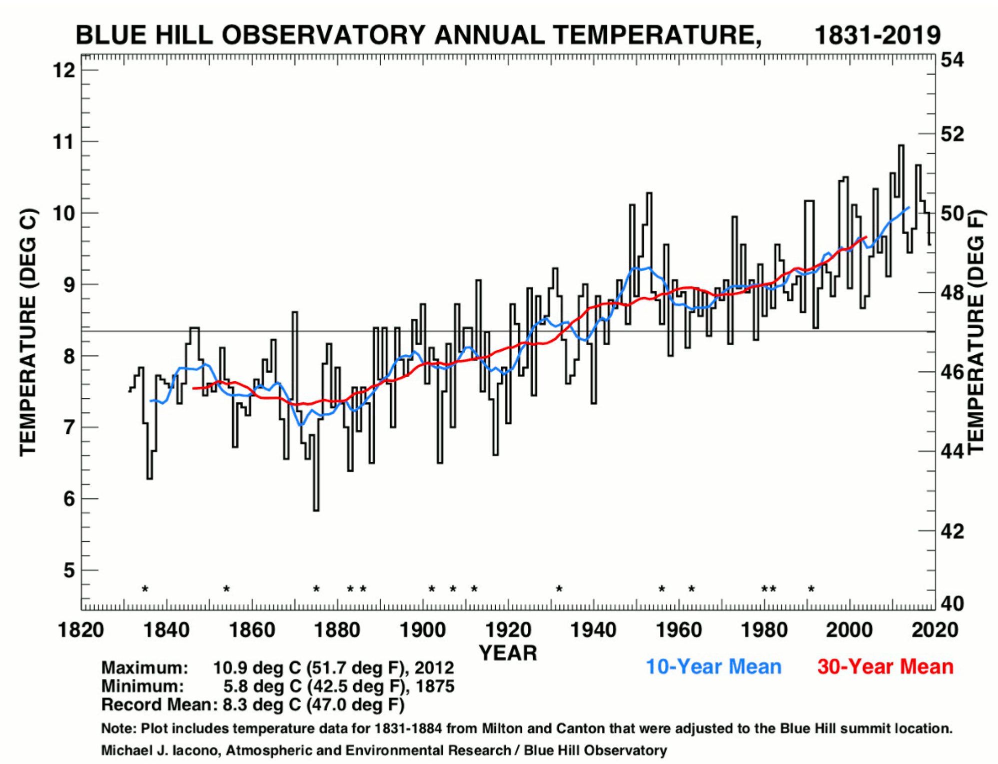
Table 87: Plymouth County Extreme Cold and Wind Chill Occurrences, 2010 through 2020

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. [57]

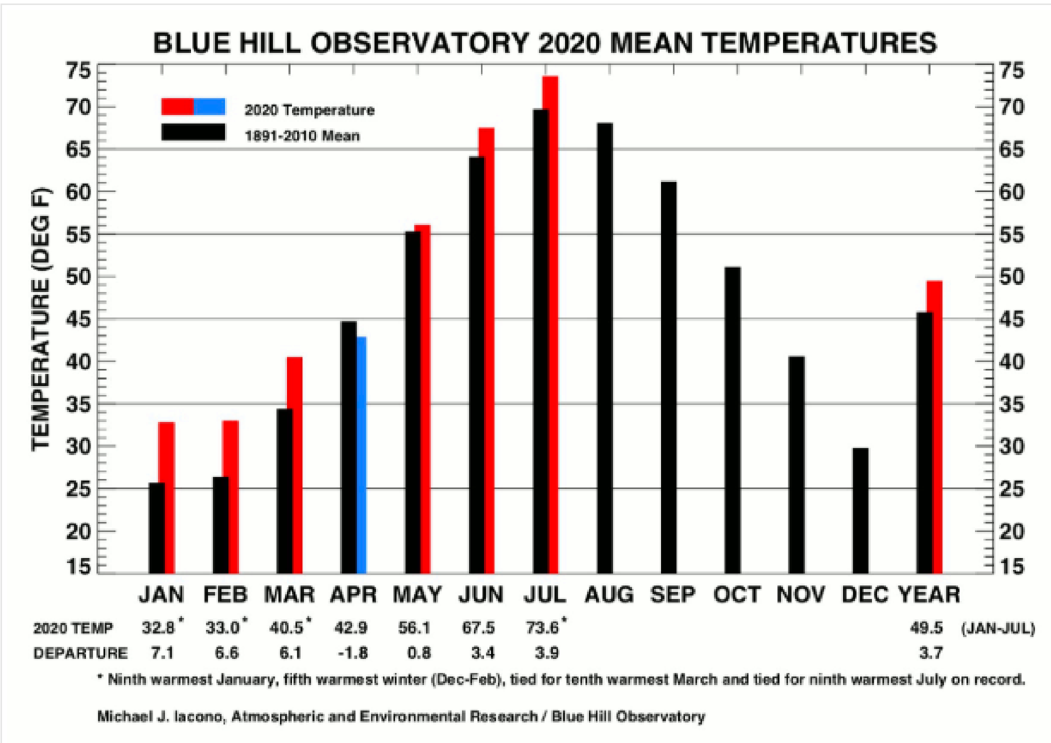
Figure 86: Blue Hill Observatory Annual Temperature, 1831 - 2019



[57] https://bluehill.org/climate/anntemp.gif

- 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)
- 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 87: Blue Hill Observatory 2020 Mean Temperatures 2020 [58]



[58] https://bluehill.org/observatory/2018/02/2018-mean-temperatures/

Figure 88: Blue Hill Observatory Daily Temperature Records

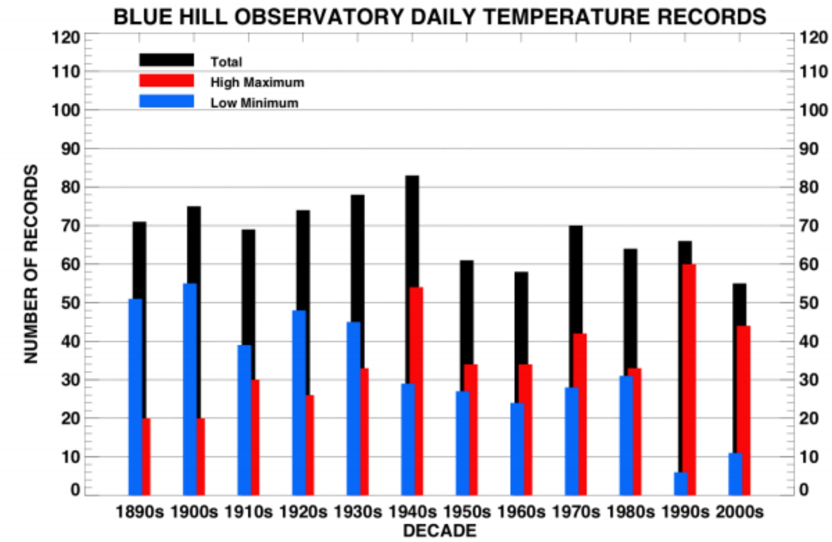
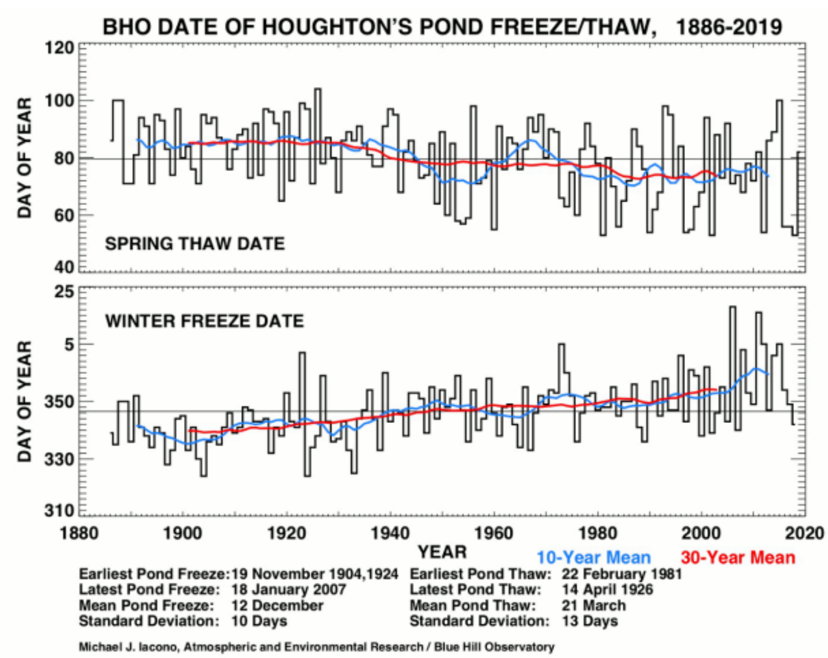


Figure 89: Pond Freeze/Thaw Dates



- 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.

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) [59].

- 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

[59] **https://www.ncdc.noaa.gov/extremes/scec/records**

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 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 90: Projected Annual Days with Temperature Above 95°F, Plymouth County

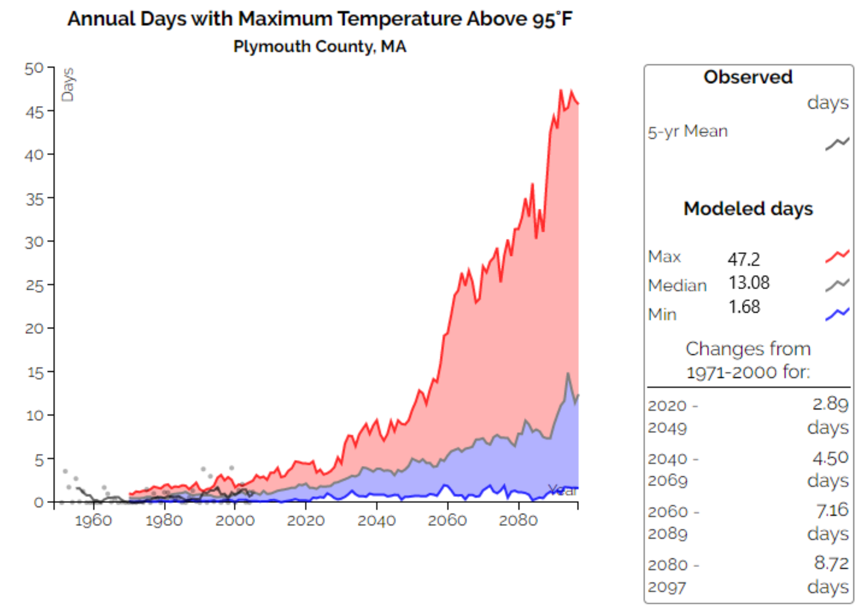


Figure 91: Annual Days with Maximum Temperature Above 100°F, Plymouth County

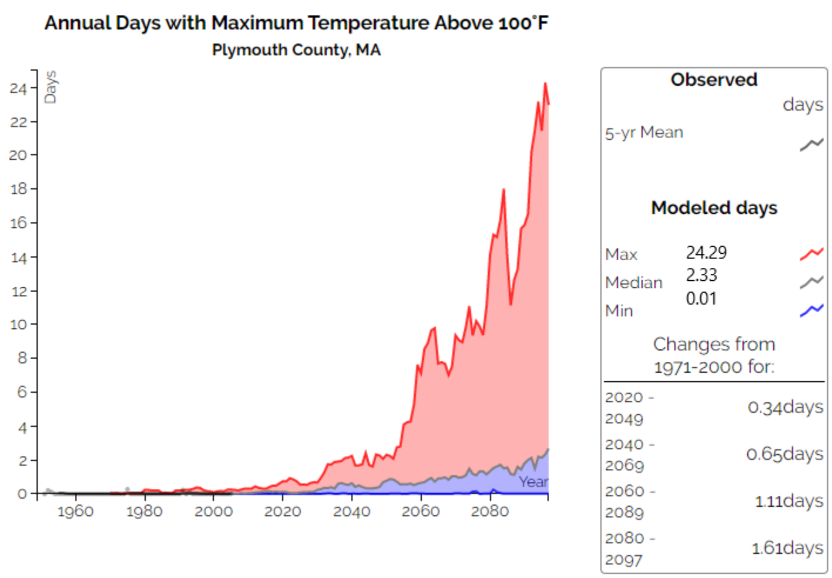
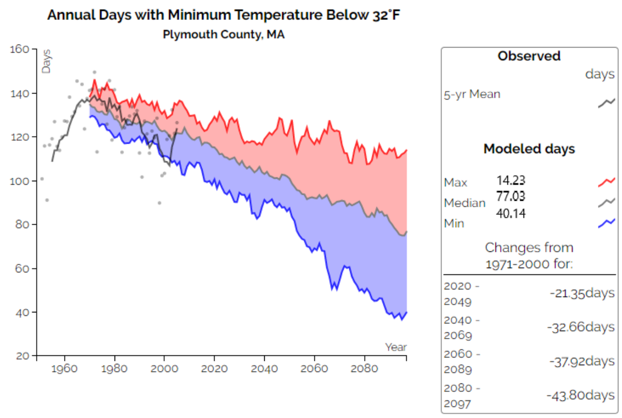
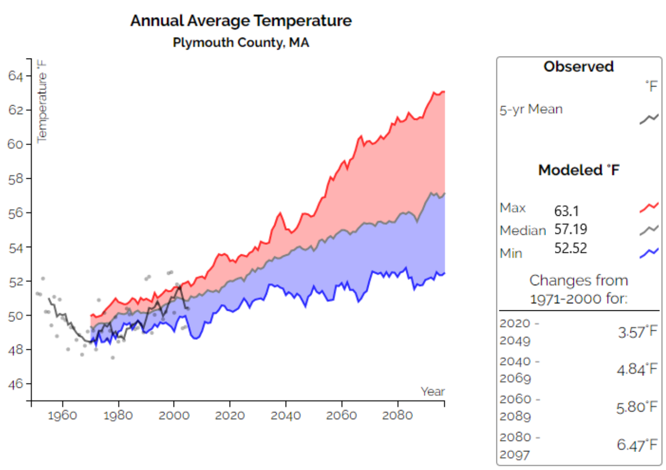


Figure 92: Projected Annual Days with Temperature Below 32°F, Plymouth County



Source: ResilientMA

Figure 93: 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 Whitman 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 88: 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%
Whitman		12.8%	5.8%	3.5%

Source: 2019 ACS, DP03

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.

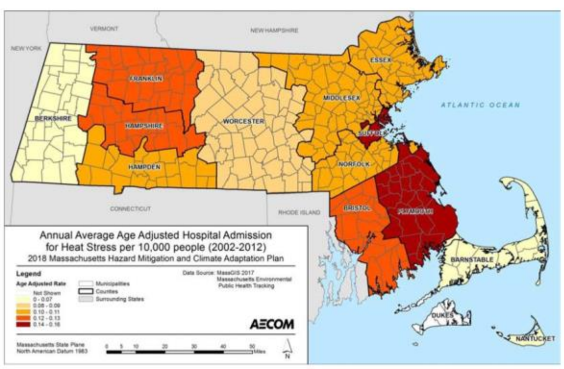
The urban heat island effect can exacerbate vulnerability to extreme heat in urban areas. Other research, including a study of the spatial variability of heat-related mortality in Massachusetts, found that sociodemographic variables, including percent African American and percent elderly, may be more 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 94: Rates of Heat Stress-Related Hospitalization by County

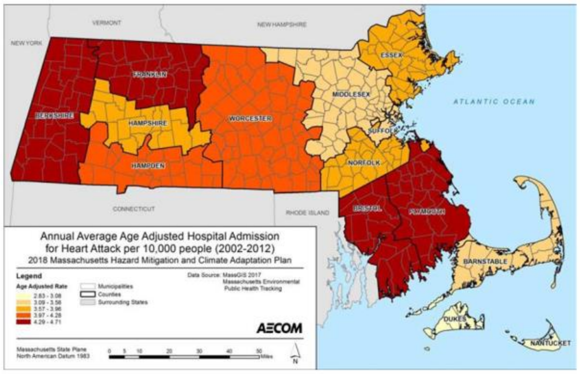


Source: SHMCAP, 2018

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 the following Figure, 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 95: 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.

The 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. Whitman 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).

Wildfire

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. 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.

Although somewhat common, most brushfires in Whitman 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.

Wildfires		
Hazard	**Location**	**Extent**
Wildfires 	Due to the rural, wooded environment, the entire Town of Whitman is subject to the impacts of wildfire.	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	Elementary School and Silver Lake Regional Middle and High Schools, the Holmes Public Library and Town Hall.
	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.

Location

Due to its geography the entire Town of Whitman is subject to the impacts of wildfire.

While wildfires or brushfires have not been a significant problem in Whitman, 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.

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

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 Whitman 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, as shown in the following Table. 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 89: 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 most of the 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.

The 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.

Species that may have negative impacts in Whitman include purple loosestrife, phragmites, which are susceptible to wildfire.

Invasive Species		
Hazard	**Location**	**Extent**
	Geographic-specific location cannot be identified, the entire area is equally at risk to the impacts.	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.

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.

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.

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 90: 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.

Species	Common name	Notes
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.
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 wereobserved 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

Location

Although the entire Town of Whitman 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. [60]

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.

[60] https://www.massnrc.org/mipag/

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 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. [61]

Probability

The likelihood that a significant negative impact would occur due to the presence of these species is possible, but not 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 Whitman, 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.

[61] **https://www.mass.gov/service-details/invasive-plants**

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.

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 Whitman 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.

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 Whitman 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 governments 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 Whitman can take multiple approaches to fill recovery manager positions [62] 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.

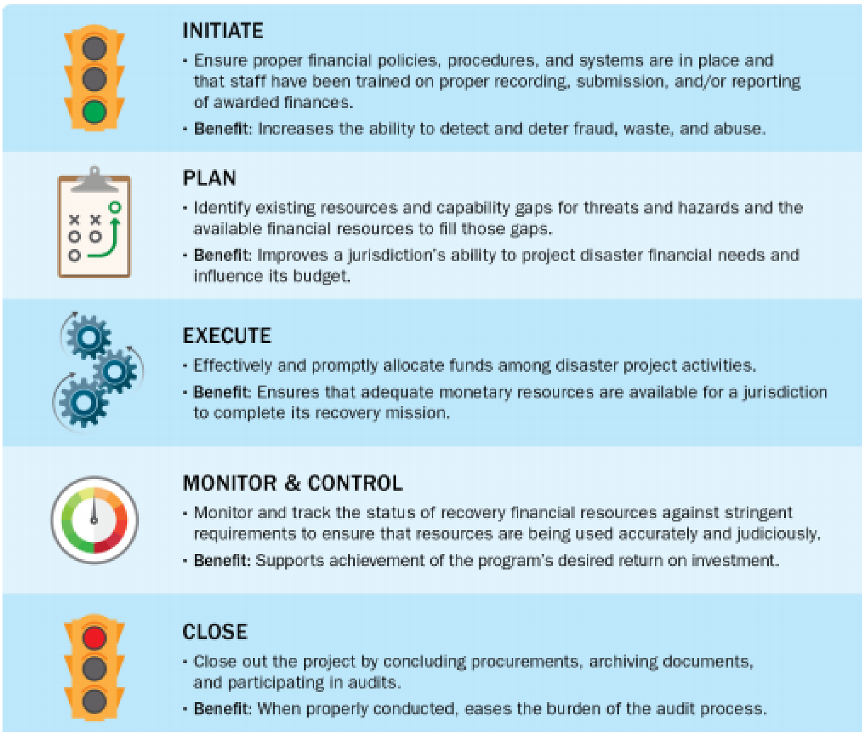
Post-Disaster

- **Use State Funding** to hire a recover manager.

[62] The examples shown are situationally dependent and may require waivers, supplemental or reallocation of non-expended Federal funds.

- **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.

Figure 96: 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, through the time of this report.

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 91: Pandemic Severity Index

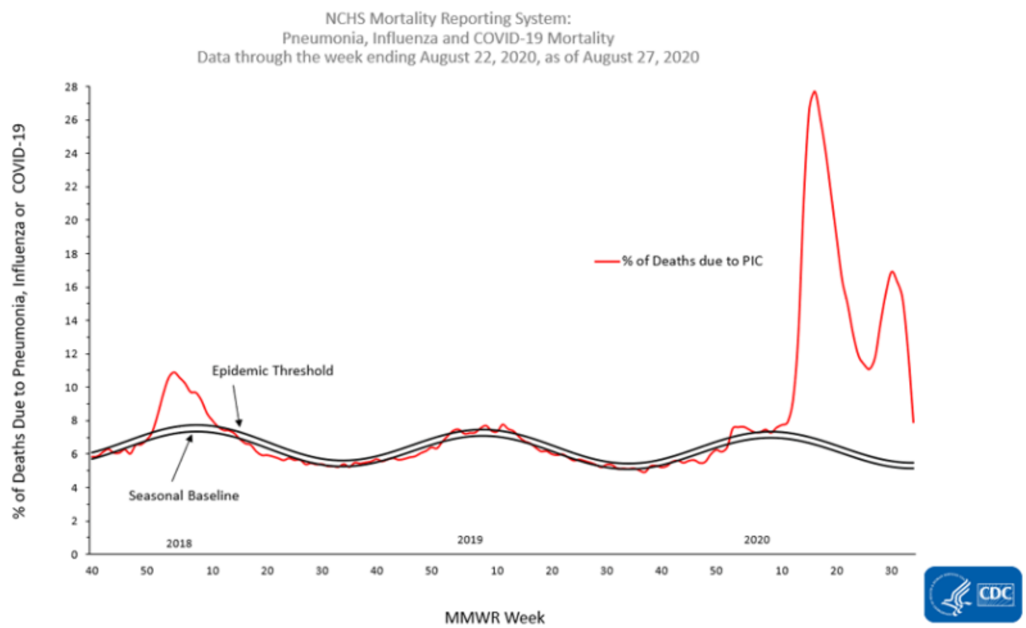
Category	Case-Fatality Ratio	Example Illness
1	Less than 0.1%	Seasonal flu, Swine flu (H1N1)
2	0.1% to 0.5%	Asian flu, Hong Kong Flu
3	0.5% to 1%	No example illness provided
4	1% to 2%	No example illness provided
5	2% or Higher	Spanish Flu

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***. [63]

[63] **https://www.cdc.gov/coronavirus/2019-ncov/covid-data/covidview/index.html**

Figure 97: 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.

Table 92: 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.

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 93: 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 94: Estimated Pandemic Attack Rate

People QuickFacts	Massachusetts	Plymouth County	Whitman
Population			
Population estimates July 1, 2019 (V2019)	6,892,503	521,202	15,056
Attack Rate 25%	1,723,125	130,300	3,764
Attack Rate 50%	3,446,251	260,601	7,528
Fatality Rate 1.7% of Attack Rate (25%)	29,293	2,215	64
Fatality Rate 5% of Attack Rate (50%)	86,156	6,515	376
Require Hospitalization 4% of 25% Attack Rate	68,925	5,212	151
Require Hospitalization 4% of 50% Attack Rate	137,850	10,424	301

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.

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 Whitman 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. [64]

Figure 98: Total Number of Deaths

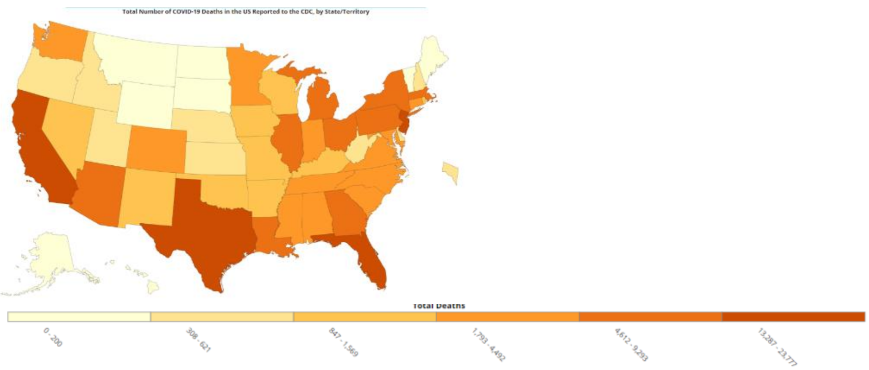
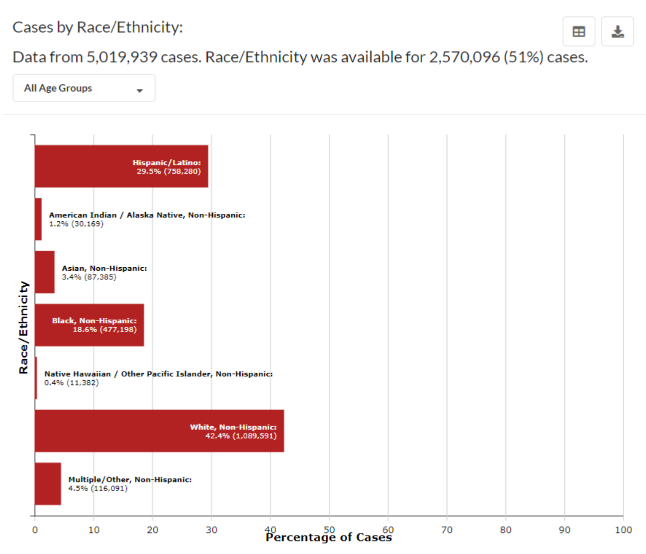


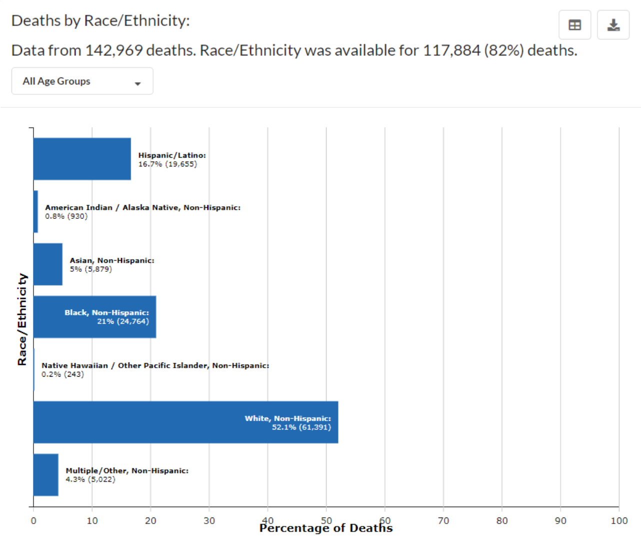
Figure 99: COVID-19 Cases by Race/Ethnicity



Source: https://covid.cdc.gov/covid-data-tracker

[64] **San Antonio Metropolitan Health District**

Figure 100: Deaths by Race/Ethnicity



Source: https://covid.cdc.gov/covid-data-tracker

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. [65]

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.

[65] **Commonwealth of Massachusetts All Hazards Disaster Debris Management Plan, Rev. #6**

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 Whitman.

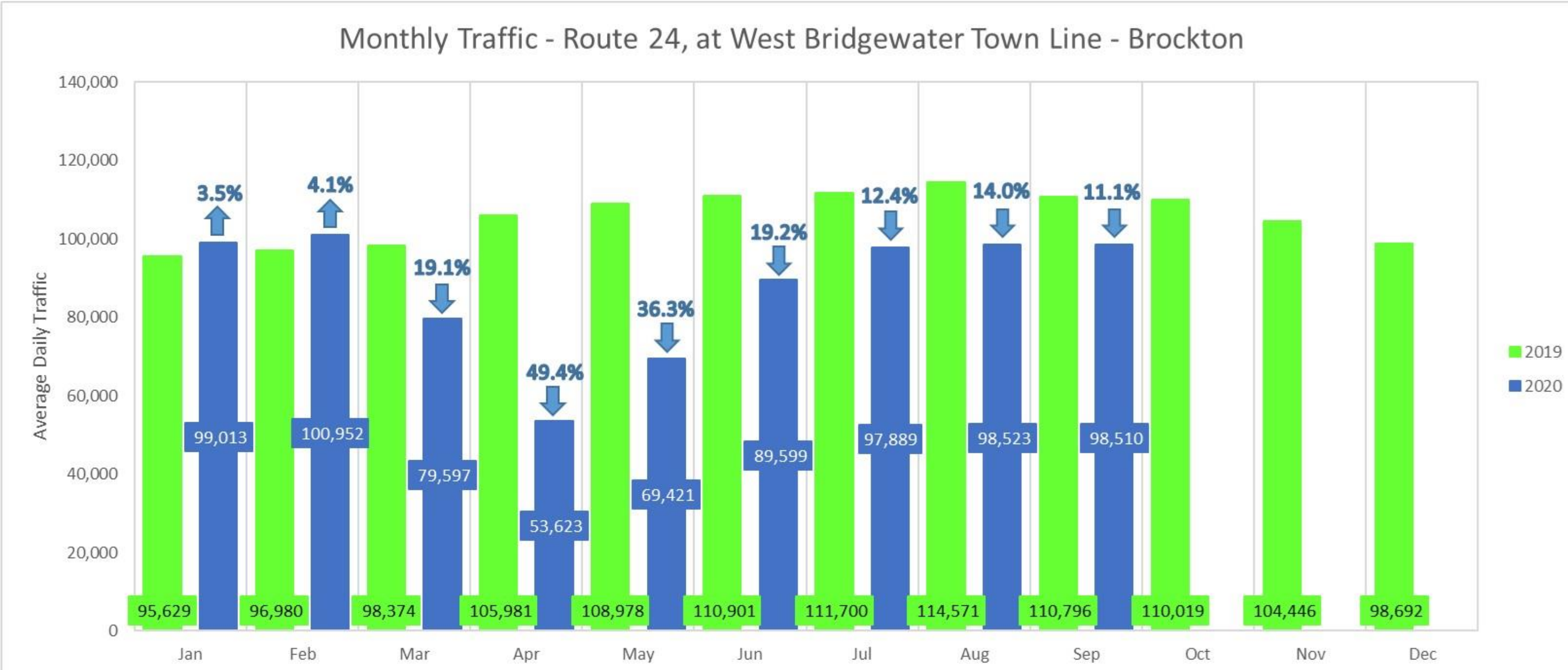
Transportation

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.

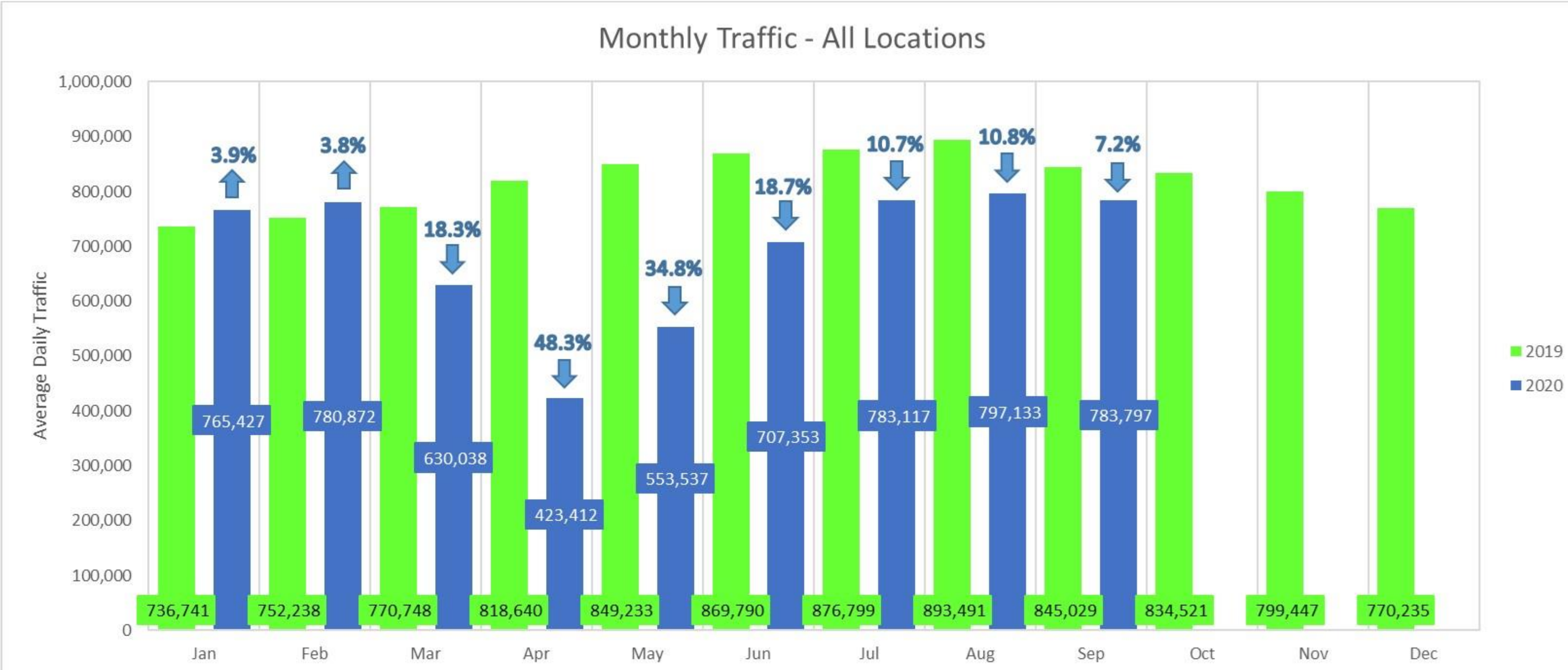
Resources for disaster mitigation are sparse, and it is particularly difficult to prioritize funding preparedness for uncertain events, but the consequences of such events can result in loss of lives and widespread damage. Responding to COVID-19 and preparing for future pandemics is likely to increase 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 101: Monthly Traffic – Route 24, at West Bridgewater Town Line - Brockton



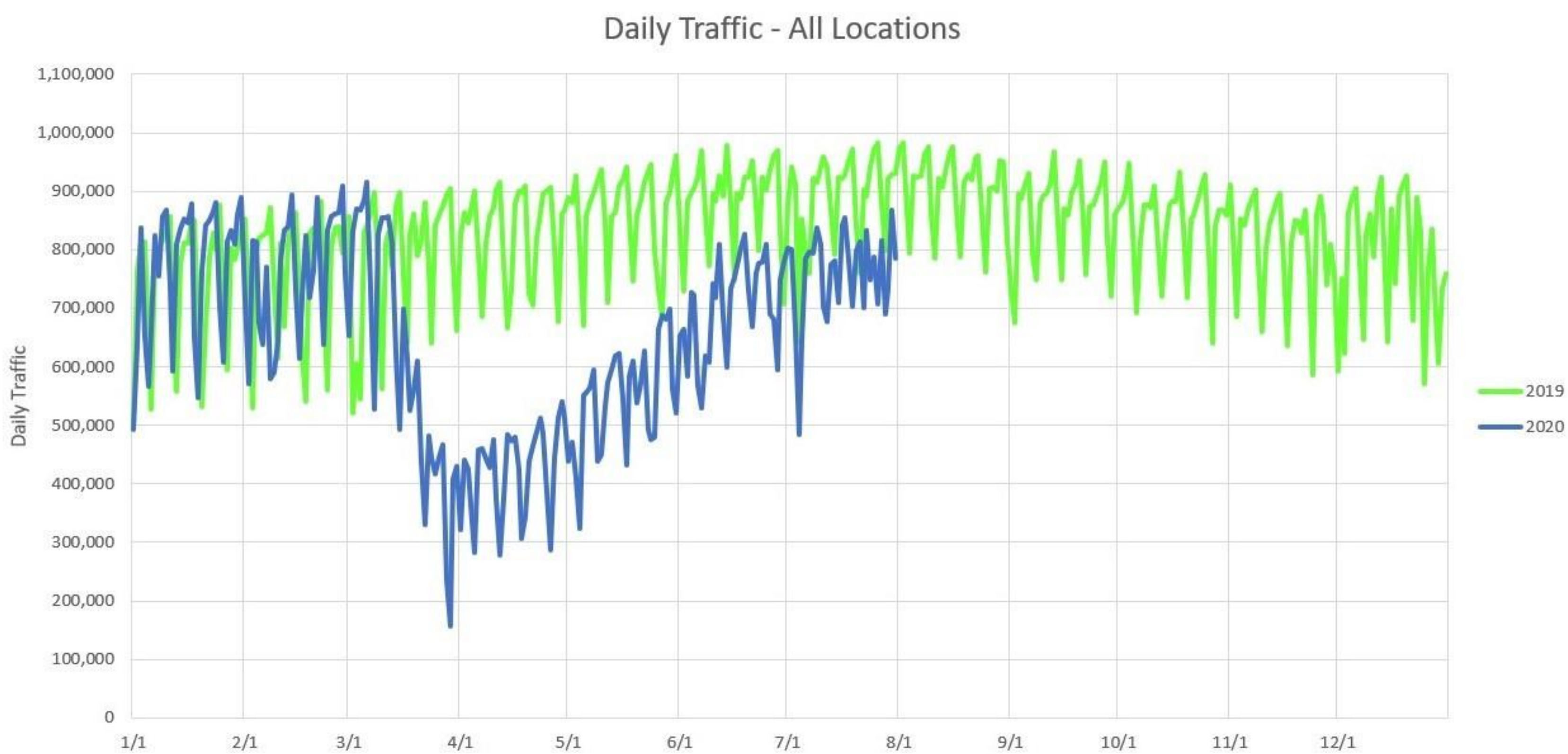
Source: OCPC Traffic Counts

Figure 102: Monthly Traffic All Locations



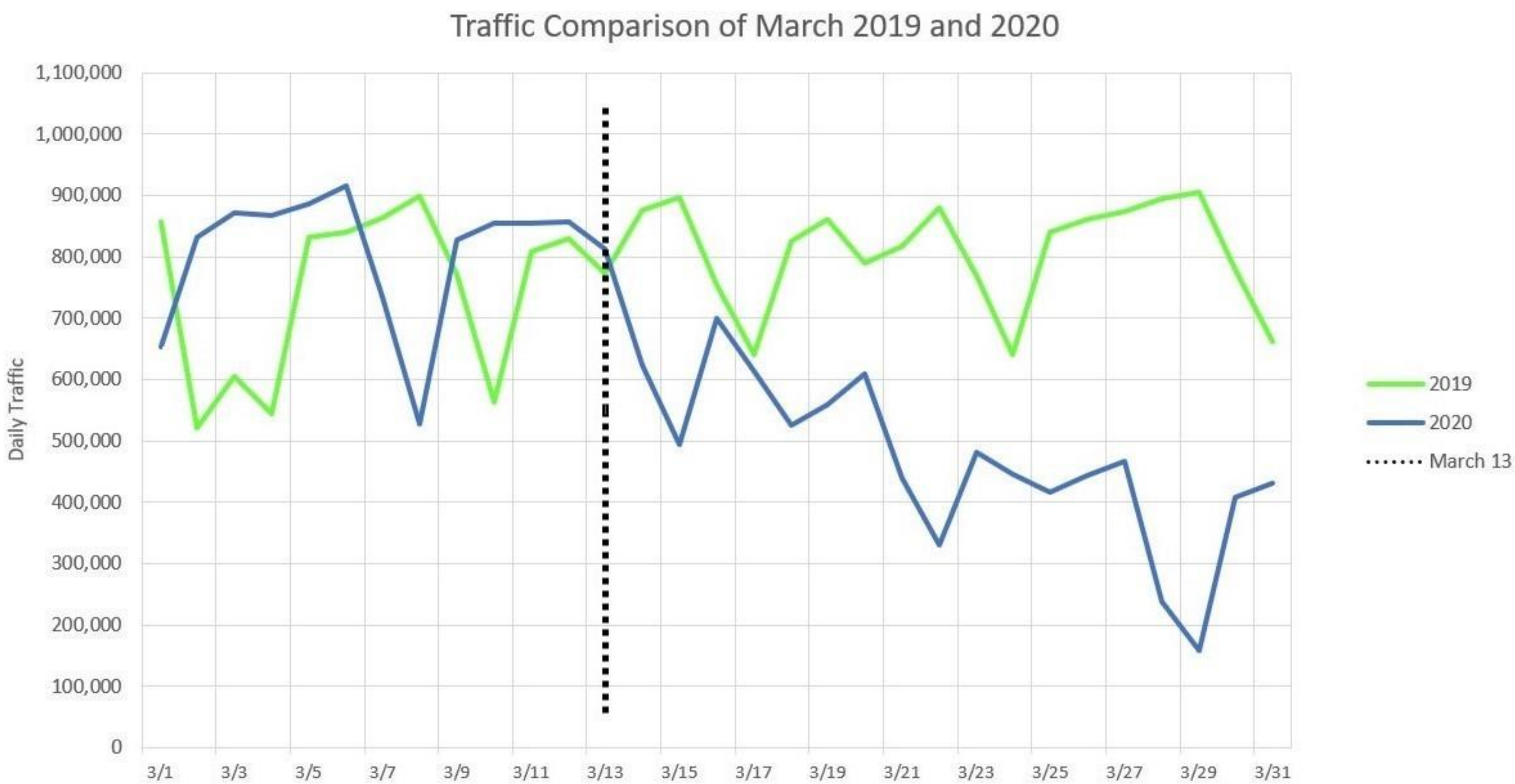
Source: OCPC Traffic Counts

Figure 103: Daily Traffic - All Locations



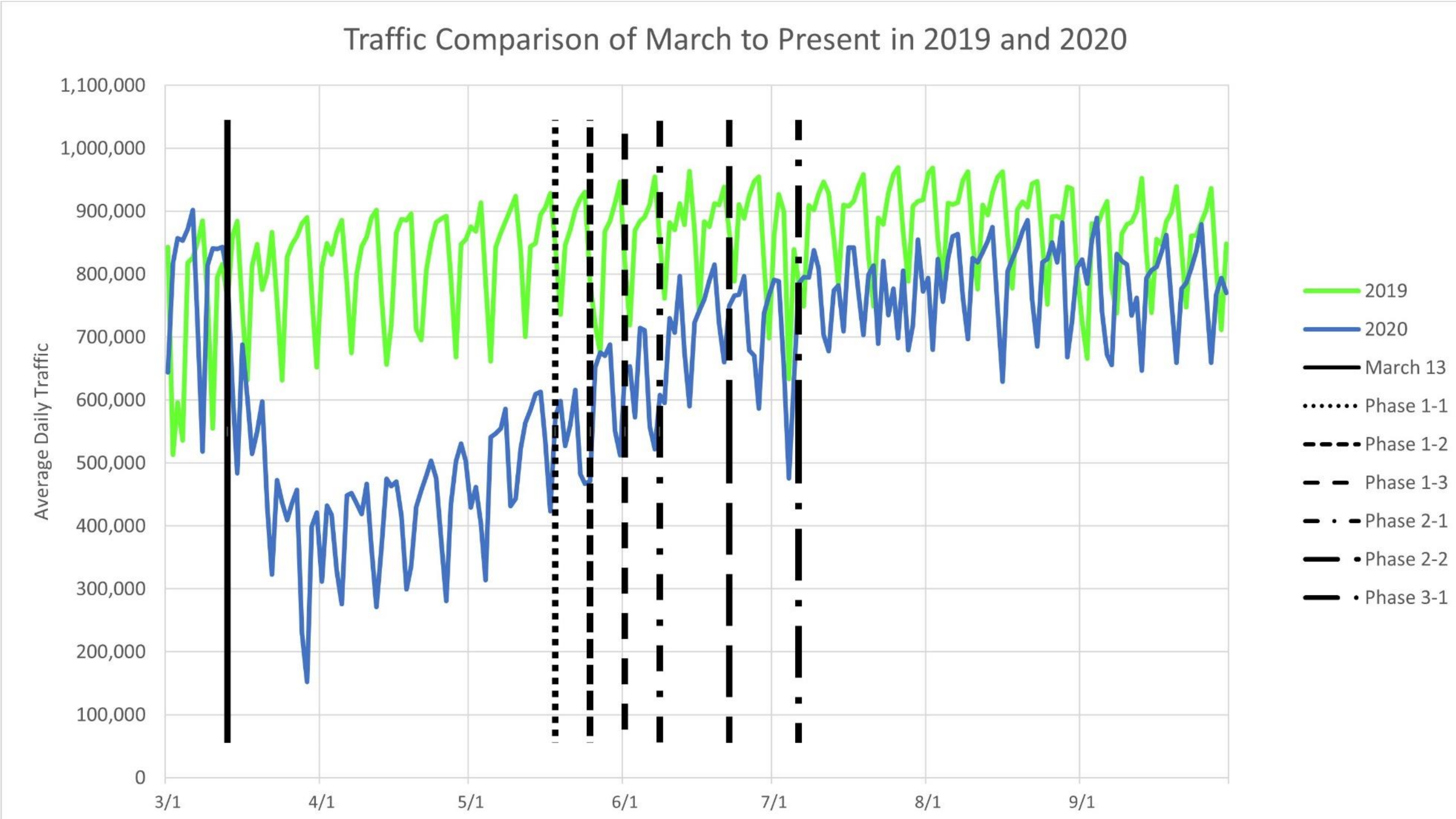
Source: OCPC Traffic Counts

Figure 104: Traffic Comparison of March 2019 and 2020



Source: OCPC Traffic Counts

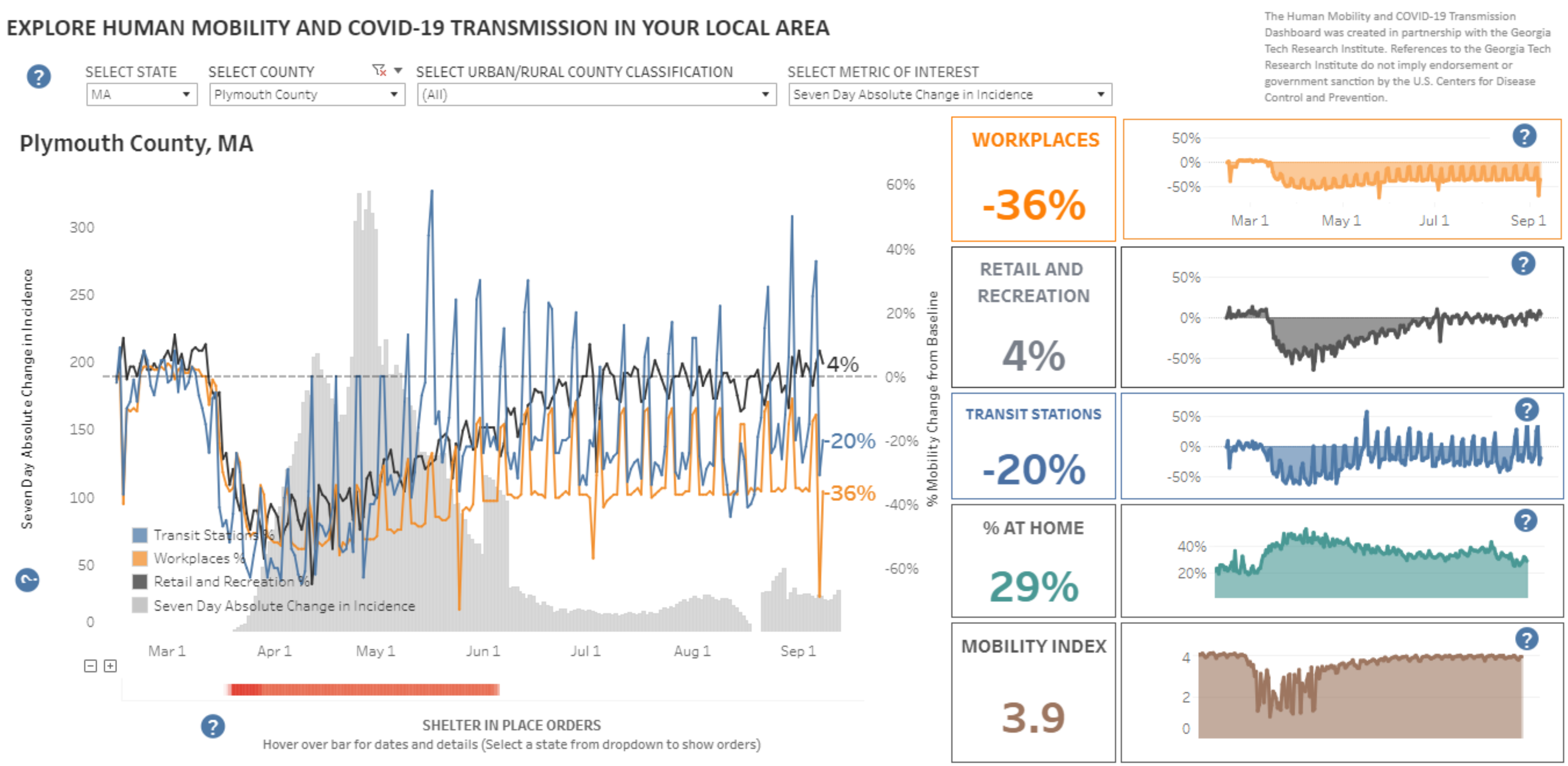
Figure 105: Traffic Comparison of March to Present 2019 and 2020



Source: OCPC Traffic Counts

Human Mobility and COVID-19 Transmission

Figure 106: 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 Whitman.

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. [66] 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." [67] 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.

[66] **https://research.noaa.gov/article/ArtMID/587/ArticleID/2617/NOAA-exploring-impact-of-coronavirus-response-on-the-environment**

[67] **NOAA**

- 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.

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.[68]

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.

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

[68] Commonwealth of Massachusetts All Hazards Disaster Debris Management Plan, Rev. #6

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.

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.

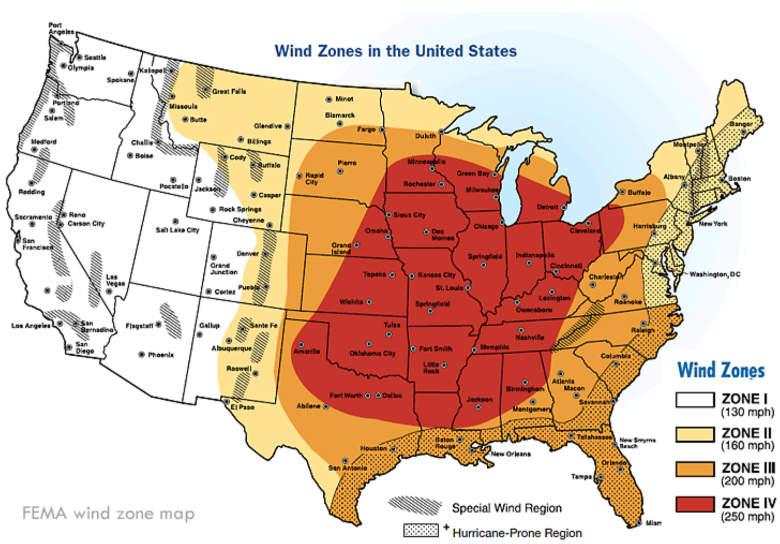
There is no wind damage scale developed specifically for thunderstorm high winds or straight-line winds. Two scales that provide damage descriptions consider the extent and type of damage that may result from extreme winds. These scales are the Beaufort Wind Scale and the Saffir-Simpson Hurricane Wind 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 95: 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 107: Wind Zones in the United States



Wind Related Hazards in Whitman

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.

Location

All locations in Whitman are subject to wind related hazards. 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. [69] Many of the events caused power outages, downed trees, and some property damage, but the costs of property damage are not available.

[69] **NOAA Storm Events Database** https://www.ncdc.noaa.gov/stormevents/details.jsp

Table 96: Plymouth County 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
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.

The 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

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.

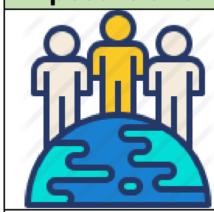
Future Trends in Development

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.

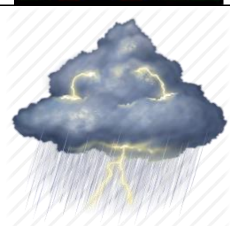
Hurricanes and Tropical Storms

Of all the natural disasters that could potentially impact Whitman, 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, Whitman 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.

Hurricanes and Tropical Storms		
Hazard	**Location**	**Extent**
	Geographic-specific location cannot be identified, the entire area is equally at risk to the impacts of hurricanes and thunderstorms.	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.
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, the 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.

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.

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.

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. [70]

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.

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 are also 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.

Location

Geographic specific locations cannot be identified as all of Whitman is subject to the impacts of hurricanes and tropical storms. 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.

[70] **NOAA**

The Saffir-Simpson Hurricane Scale gives an overview of the wind speeds, surges, and range of damage caused by different hurricane categories:

Table 97: Saffir-Simpson Hurricane Scale

Scale No. Category	Wind Speed 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

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). [71] The following Table shows the hurricanes and storms that affected Massachusetts since 1938.

Table 98: 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

Table 99: 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

[71] **NESEC** http://nesec.org/hurricanes/

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. [72]

[72] SHMCAP, 2018

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.

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

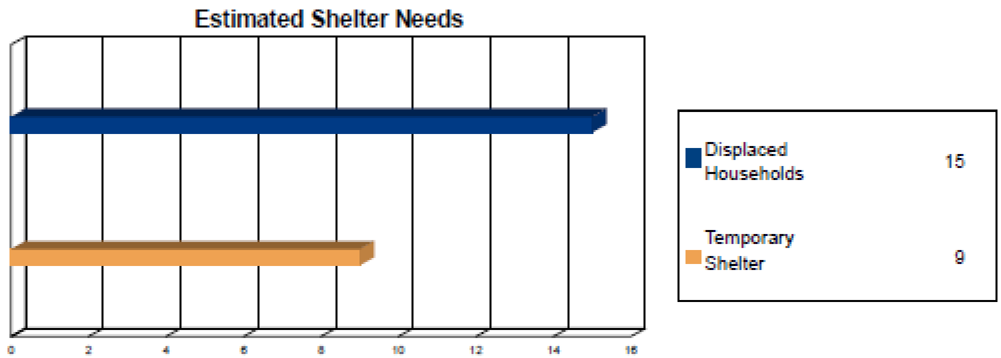
Among the exposed populations, the most vulnerable include people with low socioeconomic status, people over the age of 65, people with medical needs, and those with low English language fluency. Individuals with medical needs may have trouble evacuating and accessing needed medical care while displaced. 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.

Social Impact Shelter Requirement

Social Impact

Shelter Requirement



Hazus estimates the number of households that are expected to be displaced from their homes due to the hurricane and the number of displaced people that will require accommodations in temporary public shelters. The model estimates 15 households to be displaced due to the hurricane. Of these, 9 people (out of a total population of 14,489) will seek temporary shelter in public shelters.

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. [73]

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.

According to HAZUS data, before the hurricane, the region had no hospital beds available for use. On

[73] **https://www.nationalgeographic.com/science/2020/08/how-hurricane-evacuations-shelters-change-with-coronavirus/**

the day of the hurricane, the model estimates are that 0 hospitals are available for use by patients already in the hospital and those injured by the hurricane.

Figure 108: Expected Damage to Essential Facilities

Expected Damage to Essential Facilities

		# Facilities		
Classification	Total	Probability of at Least Moderate	Probability of Complete Damage > 50%	Expected Loss of Use < 1 day
EOCs	2	0	0	2
Fire Stations	1	0	0	1
Police Stations	1	0	0	1
Schools	4	0	0	4

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.

HAZUS Hurricane Vulnerability Assessment

Table 100: HAZUS Hurricane Vulnerability Assessment

Scenario – Hurricane	**10-Year**	**20-Year**	**50-Year**	**100-Year**	**200-Year**	**500-Year**
Population	14,489	14,489	14,489	14,489	14,489	14,489
Building Characteristics						
Estimated Total Number of Buildings	4,683	4,683	4,683	4,683	4,683	4,683
Estimated total building replacement value	$1,897,672,000	$1,897,672,000	$1,897,672,000	$1,897,672,000	$1,897,672,000	$1,897,672,000
Estimated residential building value	$1,530,859,000	$1,530,859,000	$1,530,859,000	$1,530,859,000	$1,530,859,000	$1,530,859,000
Estimated non-	$366,813,000	$366,813,000	$366,813,000	$366,813,000	$366,813,000	$366,813,000

residential building value						
Building Damages						
No damage	4,683	4,677	4,569	4,285	3,863	3,170
Minor damage	0	6	106	358	700	1,180
Moderate damage	0	0	8	38	110	288
Severe damage	0	0	0	2	7	29
Destruction	0	0	0	0	3	16
Population Needs						
# Of households displaced	0	0	2	15	38	89
# Of people seeking public shelter	0	0	2	9	21	49
Debris	0	264	2,067	4,219	6,885	12,055
Building debris generated (tons)	0	41	508	1,357	2,636	5,211
Tree debris (tons)	0	233	1,559	2,862	4,245	6,827
# Of truckloads to clear building debris (@ 25 tons/truck)	0	2	20	54	106	209
Value of Damages						
Total property damage	$55,260	$1,506,880	$9,130,790	$19,955,450	$36,089,130	$75,488,220
Total losses due to business interruption	$3,000	$12,370	$375,020	$913,460	$2,340,550	$6,479,120
Population	14,489	14,489	14,489	14,489	14,489	14,489

Figure 109: HAZUS Building Inventory General Building Stock

EARTHQUAKE • WIND • FLOOD • TSUNAMI

FEMA

Building Inventory

General Building Stock

Hazus estimates that there are 4,683 buildings in the region which have an aggregate total replacement value of 1,898 million (2014 dollars). Table 1 presents the relative distribution of the value with respect to the general occupancies. Appendix B provides a general distribution of the building value by State and County.

Building Exposure by Occupancy Type

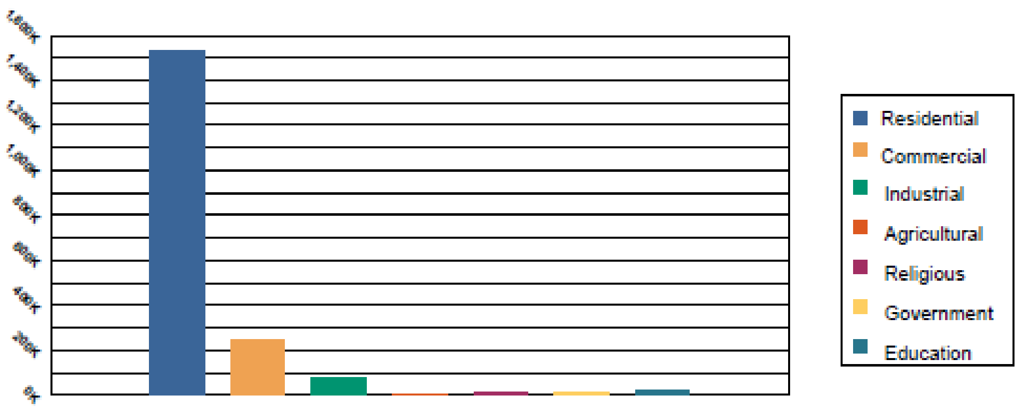


Table 1: Building Exposure by Occupancy Type

Occupancy	Exposure ($1000)	Percent of Tot
Residential	1,530,859	80.67%
Commercial	241,050	12.70%
Industrial	82,189	4.33%
Agricultural	2,639	0.14%
Religious	12,856	0.68%
Government	7,857	0.41%
Education	20,222	1.07%
Total	**1,897,672**	**100.00%**

Essential Facility Inventory

For essential facilities, there are no hospitals in the region with a total bed capacity of no beds. There are 4 schools, 1 fire stations, 1 police stations and 2 emergency operation facilities.

Figure 110: HAZUS Building Damage by Occupancy

HAZUS EARTHQUAKE • WIND • FLOOD • TSUNAMI FEMA

Building Damage

General Building Stock Damage

Hazus estimates that about 40 buildings will be at least moderately damaged. This is over 1% of the total number of buildings in the region. There are an estimated 0 buildings that will be completely destroyed. The definition of the 'damage states' is provided in the Hazus Hurricane technical manual. Table 2 below summarizes the expected damage by general occupancy for the buildings in the region. Table 3 summarizes the expected damage by general building type.

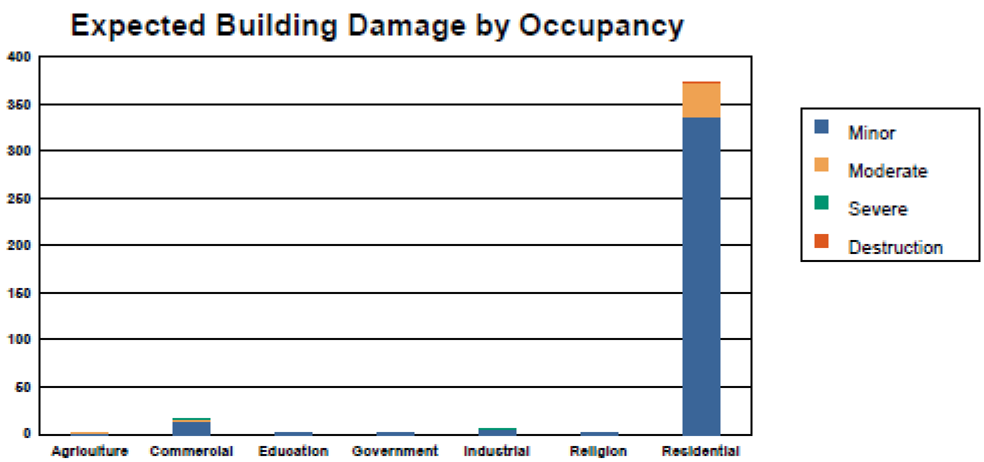


Table 2: Expected Building Damage by Occupancy : 100 - year Event

	None		Minor		Moderate		Severe		Destruction	
Occupancy	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**
Agriculture	8.25	91.62	0.59	6.58	0.11	1.24	0.05	0.52	0.00	0.03
Commercial	232.74	93.47	13.96	5.61	2.09	0.84	0.21	0.08	0.00	0.00
Education	9.41	94.07	0.54	5.43	0.05	0.49	0.00	0.01	0.00	0.00
Government	4.70	93.96	0.27	5.50	0.03	0.53	0.00	0.01	0.00	0.00
Industrial	88.85	93.53	5.21	5.49	0.76	0.80	0.17	0.18	0.01	0.01
Religion	9.36	93.59	0.59	5.91	0.05	0.48	0.00	0.02	0.00	0.00
Residential	3,931.28	91.32	337.30	7.84	34.75	0.81	1.32	0.03	0.35	0.01
Total	**4,284.57**		**358.48**		**37.84**		**1.74**		**0.36**	

Figure 111: HAZUS Expected Building Damage by Building Type

Expected Building Damage by Building Type : 100 - year Event

Building Type	None		Minor		Moderate		Severe		Destruction	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	49	93.52	3	5.84	0	0.63	0	0.01	0	0.00
Masonry	349	90.24	28	7.30	9	2.31	1	0.14	0	0.01
MH	20	98.21	0	1.27	0	0.37	0	0.00	0	0.15
Steel	177	93.91	10	5.12	2	0.85	0	0.11	0	0.00
Wood	3,693	91.69	313	7.76	21	0.52	1	0.02	0	0.01

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]

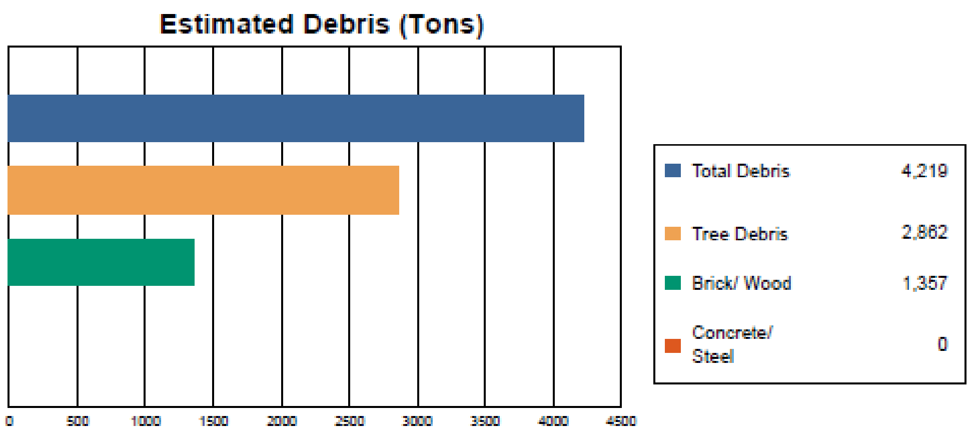
Using the United States Army Corps of Engineers (USACE) model, the estimated cubic yards of debris that might be generated, and space needed to manage that debris for a worst-case (category 3 hurricane) for each county in Massachusetts is presented in the following Table.

[74] Commonwealth of Massachusetts All Hazards Disaster Debris Management Plan, Rev. #6

Figure 112: HAZUS Hurricane Damage Debris Generation

Induced Hurricane Damage

Debris Generation



Hazus estimates the amount of debris that will be generated by the hurricane. The model breaks the debris into four general categories: a) Brick/Wood, b) Reinforced Concrete/Steel, c) Eligible Tree Debris, and d) Other Tree Debris. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 4,219 tons of debris will be generated. Of the total amount, 1,296 tons (31%) is Other Tree Debris. Of the remaining 2,923 tons, Brick/Wood comprises 46% of the total, Reinforced Concrete/Steel comprises of 0% of the total, with the remainder being Eligible Tree Debris. If the building debris tonnage is converted to an estimated number of truckloads, it will require 54 truckloads (@25 tons/truck) to remove the building debris generated by the hurricane. The number of Eligible Tree Debris truckloads will depend on how the 1,566 tons of Eligible Tree Debris are collected and processed. The volume of tree debris generally ranges from about 4 cubic yards per ton for chipped or compacted tree debris to about 10 cubic yards per ton for bulkier, uncompacted debris.

Table 101: 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

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 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.

BioMap2
Conserving the Biodiversity of Massachusetts in a Changing World

Town Overview

Whitman 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. Species of Conservation Concern Cores are found east and west of Harvard Street. An Aquatic Core and Species of Conservation Concern Core are found along the Abington border.

Whitman at a Glance

- Total Area: 4,453 acres (7.0 square miles)
- Human Population in 2010: 14,489
- Open space protected in perpetuity: 371 acres, or 8.3% percent of total area*
- *BioMap2* Core Habitat: 297 acres
- *BioMap2* Core Habitat Protected: 153 acres or 51.5%
- *BioMap2* Critical Natural Landscape: 148 acres
- *BioMap2* Critical Natural Landscape Protected: 131 acres or 88.5%

BioMap2 Components

Core Habitats

- 1 Aquatic Core
- 3 Species of Conservation Concern Cores**
  - 2 birds, 2 amphibians

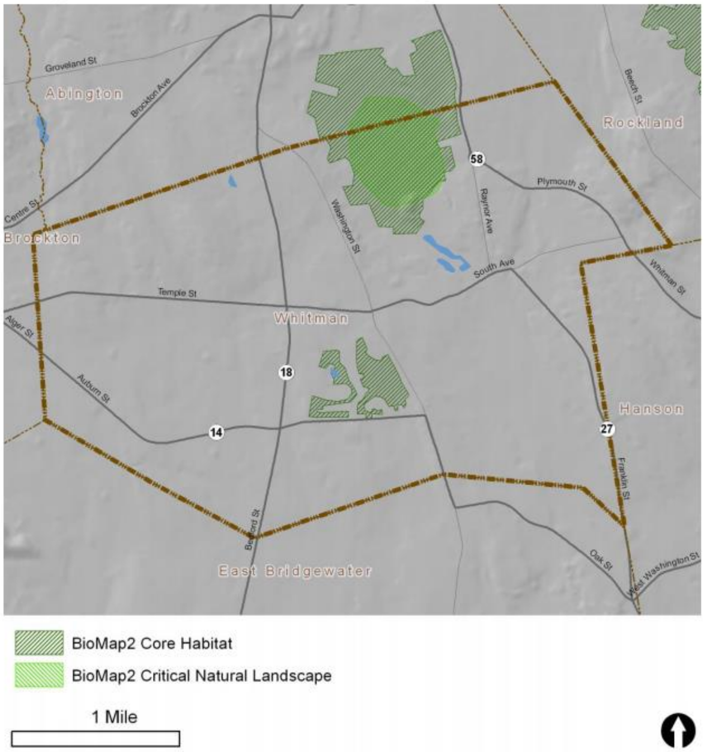
Critical Natural Landscapes

- 1 Aquatic Core Buffer

* 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* Core Habitat and Critical Natural Landscape in Whitman**



BioMap2
Conserving the Biodiversity of Massachusetts in a Changing World

Species of Conservation Concern, Priority and Exemplary Natural Communities, and Other Elements of Biodiversity in Whitman

Amphibians

Marbled Salamander, (*Ambystoma opacum*), T
Northern Leopard Frog, (*Rana pipiens*), Non-listed SWAP

Birds

American Bittern, (*Botaurus lentiginosus*), E
Least Bittern, (*Ixobrychus exilis*), E

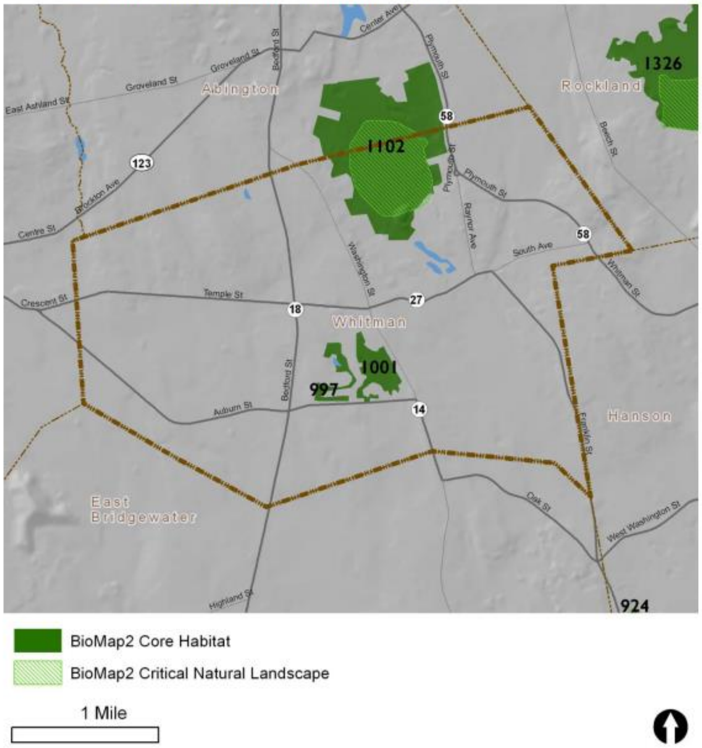
Other *BioMap2* Components

Aquatic Core
Aquatic Core Buffer

E = Endangered
T = Threatened
SC = Special Concern
S1 = Critically Imperiled communities, typically 5 or fewer documented sites or very few remaining acres in the state.
S2 = Imperiled communities, typically 6-20 sites or few remaining acres in the state.
S3 = Vulnerable communities, typically have 21-100 sites or limited acreage across the state.

***BioMap2* Core Habitat in Whitman**

Core IDs correspond with the following element lists and summaries.



BioMap2
Conserving the Biodiversity of Massachusetts in a Changing World

<u>Elements of *BioMap2* Cores</u>

This section lists all elements of *BioMap2* Cores that fall *entirely or partially* within Whitman. The elements listed here may not occur within the bounds of Whitman.

Core 997

Species of Conservation Concern		
Marbled Salamander	*Ambystoma opacum*	T

Core 1001

Species of Conservation Concern		
Marbled Salamander	*Ambystoma opacum*	T

Core 1102

Aquatic Core		
Species of Conservation Concern		
American Bittern	*Botaurus lentiginosus*	E
Least Bittern	*Ixobrychus exilis*	E
Northern Leopard Frog	*Lithobates pipiens*	Non-listed SWAP

Core Habitat Summaries

Core 997

A 24-acre Core Habitat featuring a Species of Conservation Concern.

Adult and juvenile Marbled Salamanders inhabit upland forests during most of the year, where they reside in small-mammal burrows and other subsurface retreats. Adults migrate during late summer or early fall to breed in dried portions of vernal pools, swamps, marshes, and other predominantly fish-free wetlands. Eggs are deposited under logs, leaf-litter, or grass tussocks and hatch after being inundated by fall rains. Larvae metamorphose during late spring, whereupon they disperse into upland forest.

Core 1001

A 47-acre Core Habitat featuring a Species of Conservation Concern.

Adult and juvenile Marbled Salamanders inhabit upland forests during most of the year, where they reside in small-mammal burrows and other subsurface retreats. Adults migrate during late summer or early fall to breed in dried portions of vernal pools, swamps, marshes, and other predominantly fish-free wetlands. Eggs are deposited under logs, leaf-litter, or grass tussocks and hatch after being inundated by fall rains. Larvae metamorphose during late spring, whereupon they disperse into upland forest.

Core 1102

A 445-acre Core Habitat featuring Aquatic Core and Species of Conservation Concern.

To delineate integrated and functional ecosystems for fish species and other aquatic Species of Conservation Concern, beyond the species and exemplary habitats described above, *BioMap2* identified intact river corridors within which important physical and ecological processes of the river or stream occur. To identify those areas integrally connected to each river and stream, each river segment was buffered 30 meters. All wetlands wholly or partially contained within this buffer were then included, and the combination of the river channel, the adjacent buffer, and the connected wetlands make up the riverine Core Habitat.

American Bitterns are heron-like birds that nest primarily in large cattail, tussock or shrub marshes and are very sensitive to disturbance.

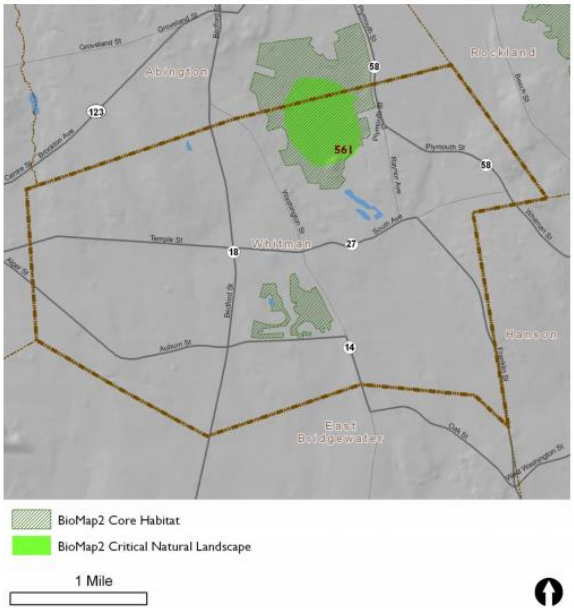
Least Bitterns are heron-like birds that typically nest in cattail marshes interspersed with open water and are very sensitive to disturbance.

Adult Northern Leopard Frogs are found in marshes, wet meadows, and peatlands in the narrow transition zone between open water and uplands; they retreat to the water of ponds and small streams when threatened. The herbivorous tadpoles require open water of sufficient permanence for their development.

BioMap2
Conserving the Biodiversity of Massachusetts in a Changing World

***BioMap2* Critical Natural Landscape in Whitman**

Critical Natural Landscape IDs correspond with the following element lists and summaries.



BioMap2
Conserving the Biodiversity of Massachusetts in a Changing World

Critical Natural Landscape Summaries

CNL 561

A 183-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 also include adjacent uplands that are important for many species that move between habitat types.

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.

Figure 113: HAZUS Economic Loss Building-Related Losses

HAZUS EARTHQUAKE • WIND • FLOOD • TSUNAMI

FEMA

Economic Loss

The total economic loss estimated for the hurricane is 20.9 million dollars, which represents 1.10 % of the total replacement value of the region's buildings.

Building-Related Losses

The building related losses are broken into two categories: direct property damage losses and business interruption losses. The direct property damage losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the hurricane. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the hurricane.

The total property damage losses were 21 million dollars. 4% of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 95% of the total loss. Table 5 below provides a summary of the losses associated with the building damage.

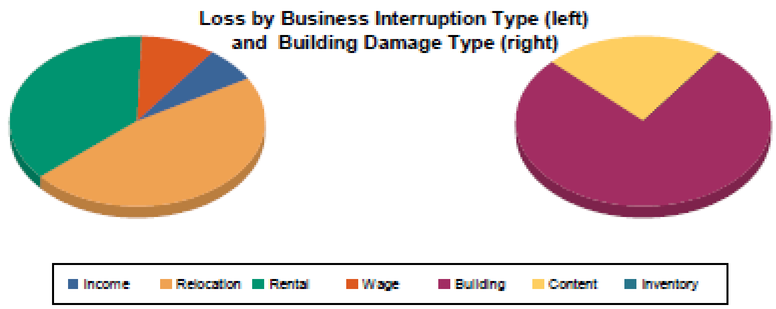
HAZUS EARTHQUAKE • WIND • FLOOD • TSUNAMI

FEMA

Regional Population and Building Value Data

		Building Value (thousands of dollars)		
	Population	Residential	Non-Residential	Total
Massachusetts				
Plymouth	14,489	1,530,859	366,813	1,897,672
Total	**14,489**	**1,530,859**	**366,813**	**1,897,672**
Study Region Total	**14,489**	**1,530,859**	**366,813**	**1,897,672**

Figure 114: HAZUS Loss by Business Interruption Type & Building Damage Type



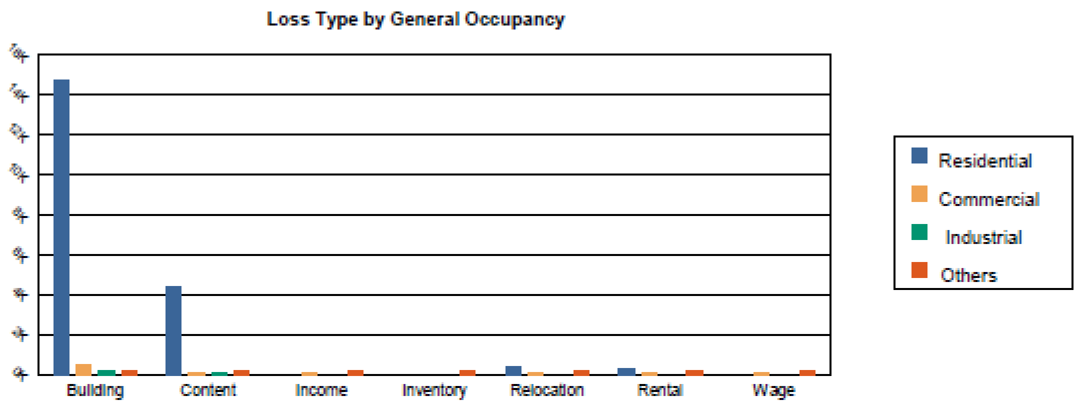


Table 5: Building-Related Economic Loss Estimates

(Thousands of dollars)

Category	Area	Residential	Commercial	Industrial	Others	Total
Property Damage						
	Building	14,739.07	468.73	153.92	72.14	15,433.85
	Content	4,371.34	72.87	56.72	11.19	4,512.12
	Inventory	0.00	1.50	7.68	0.31	9.49
	Subtotal	**19,110.41**	**543.09**	**218.32**	**83.64**	**19,955.46**
Business Interruption Loss						
	Income	0.00	54.14	1.66	5.38	61.18
	Relocation	356.89	59.64	6.03	5.92	428.48
	Rental	300.96	35.57	0.95	0.47	337.96
	Wage	0.00	55.88	1.96	28.00	85.84
	Subtotal	**657.85**	**205.24**	**10.61**	**39.77**	**913.46**
Total						
	Total	**19,768.26**	**748.33**	**228.92**	**123.40**	**20,868.92**

Nor’easter – Severe Winter Storm

Severe winter storms include ice storms, nor’easters, heavy snow, blowing snow, and other extreme forms of winter precipitation.

Nor’easter – Severe Winter Storms		
Hazard	**Location**	**Extent**
Nor’easter 	Geographic-specific location cannot be identified, the entire area is equally at risk to the impacts of severe winter storms and Nor’easter weather events.	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 Whitman, 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.
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, the 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.

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.

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.

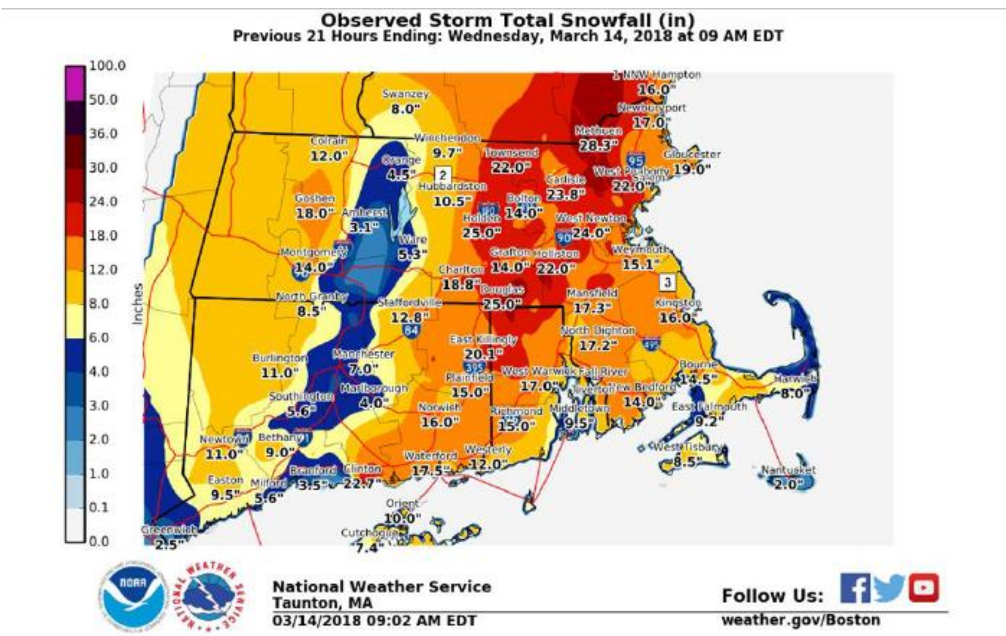
Location

Geographic specific locations cannot be identified, the entire area is equally at risk to the impacts of severe winter storms and nor'easter events.

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'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.

Figure 115: Observed Storm Total Snowfall (in)



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	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

	Snowfalls of 6 to 7 inches	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. Maximum totals of more than 30 inches were reported in southeast Worcester County, where Milford had a phenomenal total of 36 inches.	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 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 Most places ended up with 6 to 8 inches of 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 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	A low-pressure system in the Great Lakes redeveloped south of New England, spreading snow across the area.

	Five and a half inches of snow fell in eastern Plymouth County.	
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	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

	Amateur Radio operator reported 5 to 8 inches of snow on the ground.	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	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

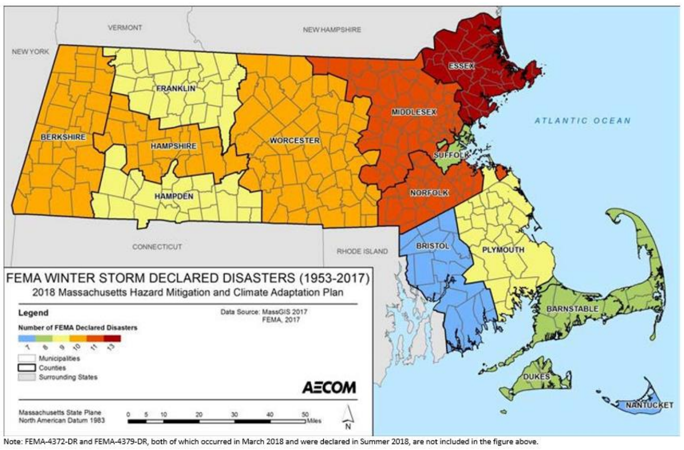
	Five to twelve inches of snow fell across southern Plymouth County.	due to concerns about precipitation type and boundary layer temperature. In the end, precipitation type turned out to be all snow for much of the area, with most locations receiving 1 to 2 feet of snow. In addition, the Massachusetts 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 across much of eastern Massachusetts Heavy Snow Eleven to eighteen inches of snow fell across southern Plymouth County.	Low pressure off the Delmarva peninsula intensified rapidly as it moved northeastward. Its path just southeast of Nantucket brought heavy snow 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 116: FEMA Winter Storm-Related Declared Disasters by County (1953 to 2017)



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. [75]

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.

[75] Commonwealth of Massachusetts All Hazards Disaster Debris Management Plan, Rev. #6

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.

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

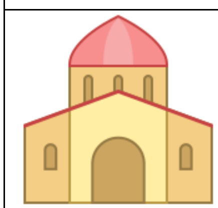
The location and extent of potential damaging impacts of a tornado are completely unpredictable. Most damage from tornadoes or microbursts comes from high winds that can fell trees and electrical wires, generate hurling debris and possibly, hail. According to the Institute for Business and Home Safety, 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	**Location**	**Extent**
	Geographic-specific location cannot be identified, the entire area is equally at risk to tornados.	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.
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, the 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.

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 102: 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 103: 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*

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.

<table>
<tr><th colspan="3">Potential Effects of Climate Change – Tornado</th></tr>
<tr><td></td><td>Extreme weather – Increase in frequency and intensity of severe thunderstorms</td><td>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.</td></tr>
</table>

Probability

Although tornadoes have not been recorded in Whitman 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 Whitman.

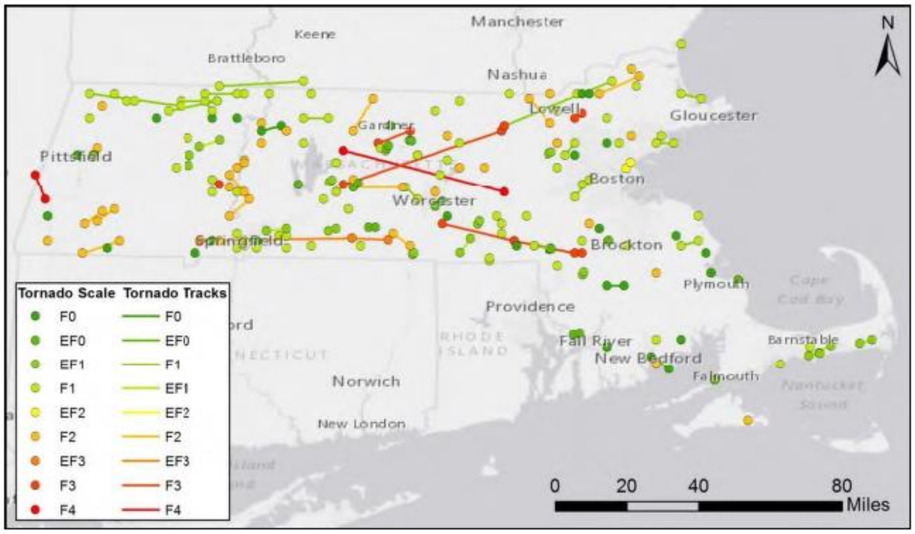
On average there are six tornados that touchdown somewhere in the Northeast region every year. On average, (between 1950 and 2008), more than two tornadoes per year strike the Commonwealth of Massachusetts alone, with New England as a whole recording more than 8. Most tornadoes reported in the region 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).

Location

As per the Massachusetts Hazard Mitigation Plan, the entire Town of Whitman 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 Whitman, and only ten have occurred within all of Plymouth County.

Figure 117: Massachusetts Tornadoes Between 1950 and 2019



Source: NOAA

Previous Occurrences

There have been ten tornados between September 7, 1958 [76] 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 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

[76] https://www.ncdc.noaa.gov/data-access/severe-weather

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 104: 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 105: 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.

The 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

Earthquakes		
Hazard	**Location**	**Extent**
	Geographic-specific location cannot be identified the entire area is equally at risk to the impacts of earthquake events.	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, the 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	Earthquake 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.

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. [77]

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 these faults or in any other areas of the state. Consequently, earthquakes are arguably the most difficult natural hazard to plan for.

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 Whitman 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.

[77] **Northeast States Emergency Consortium http://nesec.org/earthquakes-hazards/.**

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 106: 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 107: 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	Tree's 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. [78]

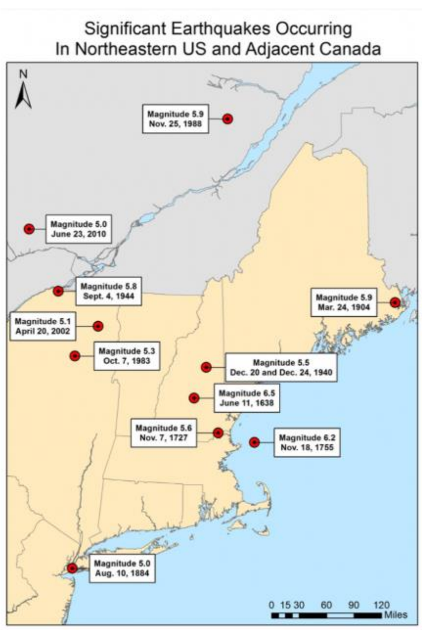
[78] **SHMCAP, 2018**

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.

Figure 118: 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.

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 119: Historic Wood Cut Print of 1744 Newburyport, MA 5.6 Earthquake

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 108: 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 109: 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

HAZUS Earthquake Vulnerability Assessment

Table 110: HAZUS Earthquake Vulnerability Assessment

Scenario	5 Magnitude, Center of Town	5.8 Magnitude, Epicenter approx. 50 miles NE
		(Cape Ann Earthquake of 1755)
Population	14,489	14,489
Building Characteristics		
Estimated Total Number of Buildings	4,683	4,683
Estimated total building replacement value	$1,897,672,000	$1,897,672,000
Estimated residential building value	$1,530,859,000	$1,530,859,000
Estimated non-residential building value	$366,813,000	$366,813,000
Building Damages		
# Of buildings sustaining no damage	2,793	4,526
# Of buildings sustaining slight damage	1,117	127
# Of buildings sustaining moderate damage	578	27
# Of buildings sustaining extensive damage	156	3
# Of buildings completely damaged	39	0
Population Needs		
# Of households displaced	177	4
# Of people seeking public shelter	100	2
Debris		
Building debris generated (tons)	34,000	1,000
Brick/Wood	14,280	720
Reinforced Steel/Concrete	19,720	280
# Of truckloads to clear building debris (@ 25 tons/truck)	1,360	40
Value of Damages		
Total property damage	$165,791,900	$3,252,100
Total losses due to business interruption	$25,974,200	$899,600
Casualties		
2:00 AM		
Level 1 Injuries[1]	24	1
Level 2 Injuries[2]	5	0
Level 3 Injuries[3]	1	0

Deaths	1	0
2:00 PM		
Level 1 Injuries[1]	72	1
Level 2 Injuries[2]	18	0
Level 3 Injuries[3]	2	0
Deaths	5	0
5:00 PM		
Level 1 Injuries[1]	46	1
Level 2 Injuries[2]	11	0
Level 3 Injuries[3]	2	0
Deaths	3	0

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.

HAZUS Shelter Requirement

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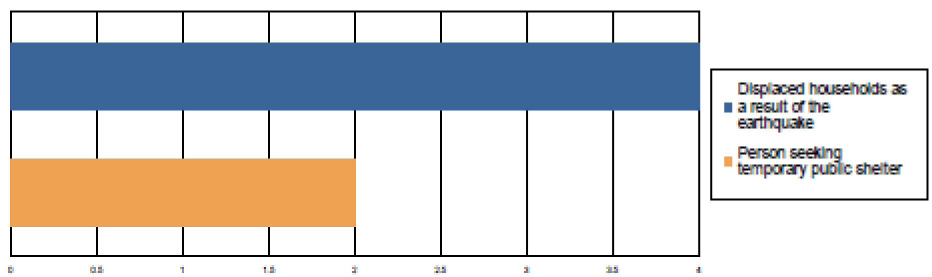
Social Impact

Shelter Requirement

Hazus estimates the number of households that are expected to be displaced from their homes due to the earthquake and the number of displaced people that will require accommodations in temporary public shelters. The model estimates 4 households to be displaced due to the earthquake. Of these, 2 people (out of a total population of 14,489) will seek temporary shelter in public shelters.

Displaced Households/ Persons Seeking Short Term Public Shelter



Displaced households as a result of the earthquake	Persons seeking temporary public shelter
4	2

Casualties

Hazus estimates the number of people that will be injured and killed by the earthquake. The casualties are broken down into four (4) severity levels that describe the extent of the injuries. The levels are described as follows;

- Severity Level 1: Injuries will require medical attention but hospitalization is not needed.
- Severity Level 2: Injuries will require hospitalization but are not considered life-threatening
- Severity Level 3: Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4: Victims are killed by the earthquake.

The casualty estimates are provided for three (3) times of day: 2:00 AM, 2:00 PM and 5:00 PM. These times represent the periods of the day that different sectors of the community are at their peak occupancy loads. The 2:00 AM estimate considers that the residential occupancy load is maximum, the 2:00 PM estimate considers that the educational, commercial and industrial sector loads are maximum and 5:00 PM represents peak commute time.

Table 10 provides a summary of the casualties estimated for this earthquake

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.

HAZUS Earthquake Casualty Estimates

Table 10: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	Commercial	0.02	0.00	0.00	0.00
	Commuting	0.00	0.00	0.00	0.00
	Educational	0.00	0.00	0.00	0.00
	Hotels	0.00	0.00	0.00	0.00
	Industrial	0.02	0.00	0.00	0.00
	Other-Residential	0.36	0.05	0.00	0.01
	Single Family	0.33	0.03	0.00	0.00
	Total	**1**	**0**	**0**	**0**
2 PM	Commercial	0.90	0.12	0.01	0.02
	Commuting	0.00	0.00	0.00	0.00
	Educational	0.30	0.04	0.00	0.01
	Hotels	0.00	0.00	0.00	0.00
	Industrial	0.14	0.02	0.00	0.00
	Other-Residential	0.06	0.01	0.00	0.00
	Single Family	0.06	0.01	0.00	0.00
	Total	**1**	**0**	**0**	**0**
5 PM	Commercial	0.64	0.08	0.01	0.01
	Commuting	0.00	0.00	0.00	0.00
	Educational	0.03	0.00	0.00	0.00
	Hotels	0.00	0.00	0.00	0.00
	Industrial	0.09	0.01	0.00	0.00
	Other-Residential	0.14	0.02	0.00	0.00
	Single Family	0.13	0.01	0.00	0.00
	Total	**1**	**0**	**0**	**0**

Government

There are many ways in which Whitman'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.

HAZUS breaks critical facilities into two (2) groups, essential facilities, and high potential loss facilities (HPL), there are no dams identified within the inventory. The inventory also includes no hazardous material sites, no military installations, and no nuclear power plants.

Figure 120: HAZUS Essential Facility Damage

Essential Facility Damage

Before the earthquake, the region had hospital beds available for use. On the day of the earthquake, the model estimates that only hospital beds (%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, % of the beds will be back in service. By 30 days, % will be operational.

Table 5: Expected Damage to Essential Facilities

		# Facilities		
Classification	Total	At Least Moderate Damage > 50%	Complete Damage > 50%	With Functionality > 50% on day 1
Hospitals	0	0	0	0
Schools	4	4	0	0
EOCs	2	2	0	0
PoliceStations	1	1	0	0
FireStations	1	1	0	0

The Built Environment

All elements of the built environment in the Town of Whitman 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 Whitman'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.

According to HAZUS, there are an estimated four thousand buildings in Whitman with a total building replacement value (excluding contents) of 1,897 (millions of dollars). Approximately

92 percent of the buildings (and 81 percent of the building value) are associated with residential housing. The replacement value of the transportation and utility lifeline systems is estimated to be 201 and 7 (millions of dollars), respectively. In terms of building construction types found in the region, wood frame construction makes up 86 percent of the building inventory. The remaining percentage is distributed between the other general building types.

Figure 121: HAZUS Expected Building Damage by Type

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Table 4: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	3935.48	86.96	86.00	67.54	8.50	32.02	0.40	12.81	0.00	0.00
Steel	177.40	3.92	8.67	6.81	3.13	11.81	0.30	9.55	0.01	4.86
Concrete	38.38	0.85	1.82	1.43	0.61	2.29	0.03	1.06	0.00	0.00
Precast	10.36	0.23	0.67	0.53	0.45	1.71	0.09	2.85	0.00	0.35
RM	64.40	1.42	2.49	1.95	1.36	5.11	0.20	6.38	0.00	0.00
URM	282.44	6.24	25.83	20.29	11.70	44.09	2.06	66.62	0.24	94.79
MH	17.35	0.38	1.84	1.45	0.79	2.97	0.02	0.73	0.00	0.00
Total	4,526		127		27		3		0	

*Note:
RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Figure 122: HAZUS Regional Population and Building Value Data

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Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Massachusetts	Plymouth	14,489	1,530	366	1,897
Total Region		14,489	1,530	366	1,897

Figure 123: HAZUS Building Damage, Earthquake

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Direct Earthquake Damage

Building Damage

Hazus estimates that about 29 buildings will be at least moderately damaged. This is over 1.00 % of the buildings in the region. There are an estimated 0 buildings that will be damaged beyond repair. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the Hazus technical manual. Table 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 below summarizes the expected damage by general building type.

Damage Categories by General Occupancy Type

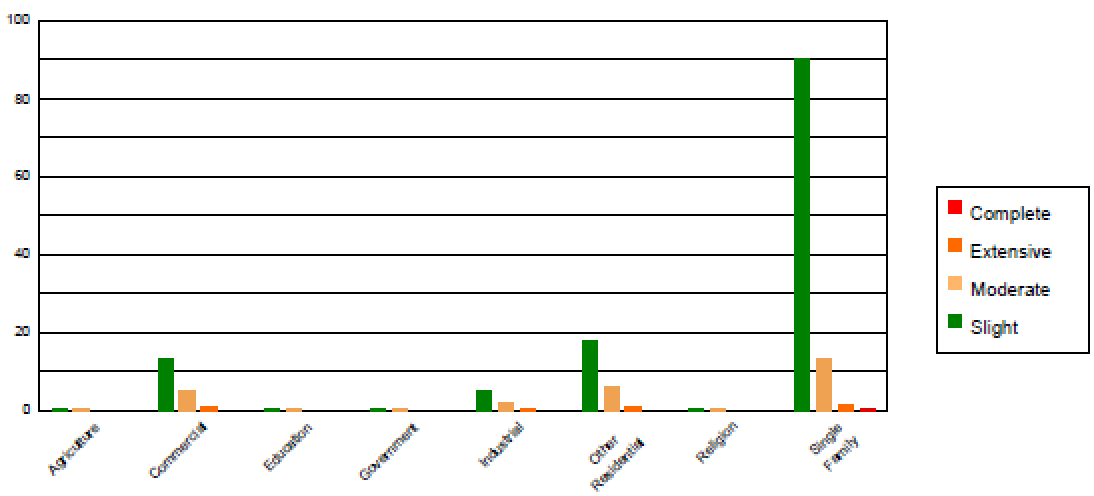

Table 3: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	8.39	0.19	0.45	0.36	0.14	0.53	0.02	0.62	0.00	0.42
Commercial	230.42	5.09	13.05	10.25	4.82	18.17	0.66	21.32	0.05	19.22
Education	9.31	0.21	0.49	0.39	0.18	0.67	0.02	0.72	0.00	0.81
Government	4.65	0.10	0.25	0.19	0.09	0.35	0.01	0.36	0.00	0.32
Industrial	88.20	1.95	4.76	3.74	1.81	6.80	0.23	7.32	0.01	5.84
Other Residential	430.36	9.51	17.81	13.99	5.98	22.54	0.78	25.11	0.07	27.52
Religion	9.30	0.21	0.48	0.38	0.19	0.71	0.03	0.96	0.00	1.10
Single Family	3745.17	82.75	90.03	70.71	13.33	50.24	1.35	43.59	0.11	44.77
Total	4,526		127		27		3		0	

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.

Figure 124: HAZUS Earthquake Debris Generation

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Induced Earthquake Damage

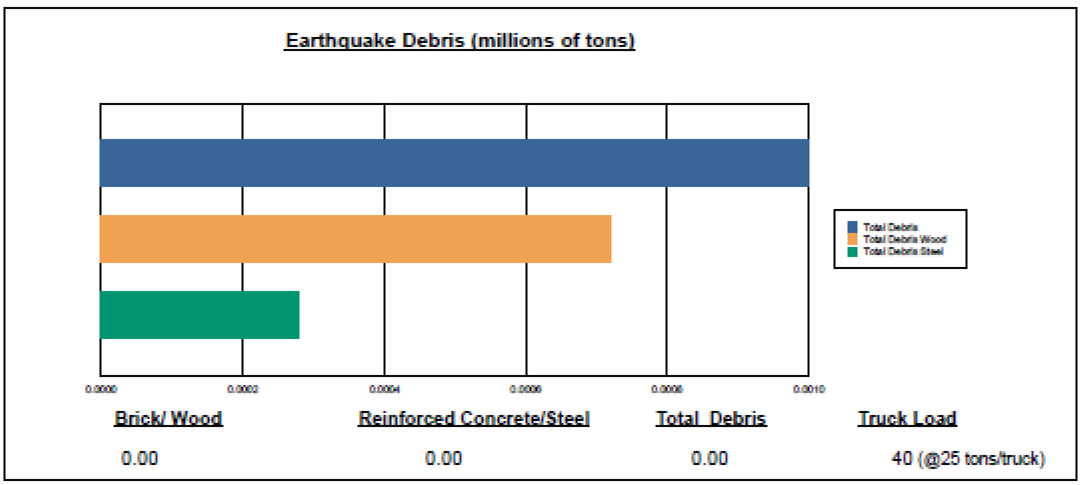
Fire Following Earthquake

Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. Hazus uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. For this scenario, the model estimates that there will be 0 ignitions that will burn about sq. mi % of the region's total area.) The model also estimates that the fires will displace about 0 people and burn about 0 (millions of dollars) of building value.

Debris Generation

Hazus estimates the amount of debris that will be generated by the earthquake. The model breaks the debris into two general categories: a) Brick/Wood and b) Reinforced Concrete/Steel. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 1,000 tons of debris will be generated. Of the total amount, Brick/Wood comprises 72.00% of the total, with the remainder being Reinforced Concrete/Steel. If the debris tonnage is converted to an estimated number of truckloads, it will require 40 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.



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.

Within HAZUS, the lifeline inventory is divided between transportation and utility lifeline systems. There are seven (7) transportation systems that include highways, railways, light rail, bus, ports, ferry, and airport. There are six (6) utility systems that include potable water, wastewater, natural gas, crude & refined oil, electric power, and communications. The lifeline inventory data are provided in the following Tables.

Figure 125: HAZUS Transportation System Lifeline Inventory

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Table 1: Transportation System Lifeline Inventory

System	Component	# Locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	0	0.0000
	Segments	9	152.5633
	Tunnels	0	0.0000
		Subtotal	**152.5633**
Railways	Bridges	1	5.3607
	Facilities	0	0.0000
	Segments	5	17.4764
	Tunnels	0	0.0000
		Subtotal	**22.8371**
Light Rail	Bridges	0	0.0000
	Facilities	1	3.4308
	Segments	3	22.4440
	Tunnels	0	0.0000
		Subtotal	**25.8748**
Bus	Facilities	0	0.0000
		Subtotal	**0.0000**
Ferry	Facilities	0	0.0000
		Subtotal	**0.0000**
Port	Facilities	0	0.0000
		Subtotal	**0.0000**
Airport	Facilities	0	0.0000
	Runways	0	0.0000
		Subtotal	**0.0000**
		Total	**201.30**

Figure 126: HAZUS Utility System Lifeline Inventory

Table 2: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	3.8218
	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**3.8218**
Waste Water	Distribution Lines	NA	2.2931
	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**2.2931**
Natural Gas	Distribution Lines	NA	1.5287
	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**1.5287**
Oil Systems	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**0.0000**
Electrical Power	Facilities	0	0.0000
		Subtotal	**0.0000**
Communication	Facilities	0	0.0000
		Subtotal	**0.0000**
		Total	**7.60**

Figure 127: HAZUS Expected Damage to the Transportation Systems

Table 6: Expected Damage to the Transportation Systems

System	Component	Number of Locations				
		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality > 50 % After Day 1	With Functionality > 50 % After Day 7
Highway	Segments	9	0	0	8	8
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
Railways	Segments	5	0	0	4	4
	Bridges	1	0	0	1	1
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Light Rail	Segments	3	0	0	3	3
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	1	1	0	1	1
Bus	Facilities	0	0	0	0	0
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	0	0	0	0	0
	Runways	0	0	0	0	0

Table 6 provides damage estimates for the transportation system.

Note: Roadway segments, railroad tracks and light rail tracks are assumed to be damaged by ground failure only. If ground failure maps are not provided, damage estimates to these components will not be computed.

Tables 7-9 provide information on the damage to the utility lifeline systems. Table 7 provides damage to the utility system facilities. Table 8 provides estimates on the number of leaks and breaks by the pipelines of the utility systems. For electric power and potable water, Hazus performs a simplified system performance analysis. Table 9 provides a summary of the system performance information.

Figure 128: HAZUS Expected Utility Systems Facility Damage

Table 7 : Expected Utility System Facility Damage

System	# of Locations				
	Total #	With at Least Moderate Damage	With Complete Damage	with Functionality > 50 %	
				After Day 1	After Day 7
Potable Water	0	0	0	0	0
Waste Water	0	0	0	0	0
Natural Gas	0	0	0	0	0
Oil Systems	0	0	0	0	0
Electrical Power	0	0	0	0	0
Communication	0	0	0	0	0

Table 8 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (miles)	Number of Leaks	Number of Breaks
Potable Water	119	0	0
Waste Water	71	0	0
Natural Gas	47	0	0
Oil	0	0	0

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

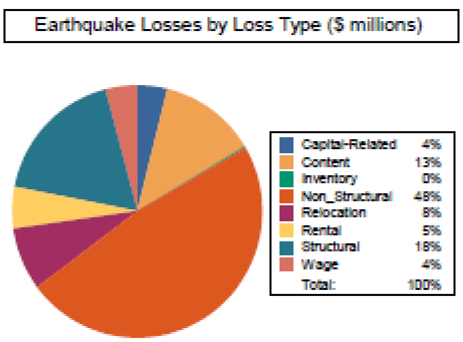
The total economic loss estimated for the earthquake is 5.73 (millions of dollars), which includes building and lifeline related losses based on the region's available inventory. The following three sectors provide more detailed information about these losses.

Figure 129: HAZUS Building-Related Losses

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the earthquake.

The total building-related losses were 4.15 (millions of dollars); 22 % of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 58 % of the total loss. Table 11 below provides a summary of the losses associated with the building damage.



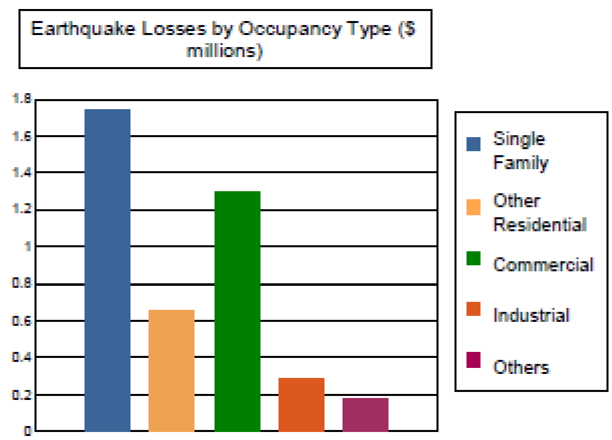


Table 11: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	0.0000	0.0021	0.1553	0.0064	0.0147	0.1785
	Capital-Related	0.0000	0.0009	0.1574	0.0047	0.0018	0.1648
	Rental	0.0297	0.0672	0.1141	0.0033	0.0027	0.2170
	Relocation	0.0960	0.0546	0.1426	0.0196	0.0265	0.3393
	Subtotal	**0.1257**	**0.1248**	**0.5694**	**0.0340**	**0.0457**	**0.8996**
Capital Stock Losses							
	Structural	0.3094	0.1144	0.2136	0.0582	0.0366	0.7322
	Non_Structural	1.0814	0.3544	0.3708	0.1131	0.0687	1.9884
	Content	0.2245	0.0598	0.1406	0.0683	0.0260	0.5192
	Inventory	0.0000	0.0000	0.0032	0.0090	0.0001	0.0123
	Subtotal	**1.6153**	**0.5286**	**0.7282**	**0.2486**	**0.1314**	**3.2521**
	Total	**1.74**	**0.65**	**1.30**	**0.28**	**0.18**	**4.15**

Figure 130: HAZUS Transportation and Utility Lifeline Losses

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Transportation and Utility Lifeline Losses

For the transportation and utility lifeline systems, Hazus computes the direct repair cost for each component only. There are no losses computed by Hazus for business interruption due to lifeline outages. Tables 12 & 13 provide a detailed breakdown in the expected lifeline losses.

Table 12: Transportation System Economic Losses
(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	152.5633	0.0000	0.00
	Bridges	0.0000	0.0000	0.00
	Tunnels	0.0000	0.0000	0.00
	Subtotal	**152.5633**	**0.0000**	
Railways	Segments	17.4764	0.0000	0.00
	Bridges	5.3607	0.0601	1.12
	Tunnels	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Subtotal	**22.8371**	**0.0601**	
Light Rail	Segments	22.4440	0.0000	0.00
	Bridges	0.0000	0.0000	0.00
	Tunnels	0.0000	0.0000	0.00
	Facilities	3.4308	1.5217	44.35
	Subtotal	**25.8748**	**1.5217**	
Bus	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Ferry	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Port	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Airport	Facilities	0.0000	0.0000	0.00
	Runways	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
	Total	**201.28**	**1.58**	

Figure 131: HAZUS Utility System Economic Losses

HAZUS
EARTHQUAKE · WIND · FLOOD · TSUNAMI

FEMA

Table 13: Utility System Economic Losses
(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Distribution Lines	3.8218	0.0000	0.00
	Subtotal	**3.8218**	**0.0000**	
Waste Water	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Distribution Lines	2.2931	0.0000	0.00
	Subtotal	**2.2931**	**0.0000**	
Natural Gas	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Distribution Lines	1.5287	0.0000	0.00
	Subtotal	**1.5287**	**0.0000**	
Oil Systems	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Electrical Power	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Communication	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
	Total	**7.64**	**0.00**	

Table 111: 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 Whitman has adopted the state building Code	Effective for new buildings.

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 Whitman Integrated Municipal Vulnerability Preparedness and Hazard Mitigation 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 Whitman'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 Whitman 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 112: Hazardous Materials Site Locations

ID	Facility	Name	Location	FEMA Flood Zone	Locally Identified Flood Area	100 Year Wind Event (MPH)	Wildfire	Peak Ground Acceleration Zone
2	Fuel Station	7 Eleven	359 Bedford St	No	Within 300 ft	120 MPH	Low	Zone 4
3	Fuel Station	Citgo	180 South Ave	No	No	120	Low	Zone 4
4	Fuel Station	Cumberland	280 Temple St	No	No	120	Low	Zone 4
5	Fuel Station	Diamond Fuel	311 South Ave	No	No	120	Low	Zone 4
6	Fuel Station	Prime Energy	79 Temple St	No	No	120	Low	Zone 4
9	Fuel Station	Public Works	100 Essex St	No	No	120	Low	Zone 4

Table 113: 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 Whitman 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 Whitman. 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 Whitman.

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 Whitman 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 Whitman 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 infrastructures 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.

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. [79] 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 [80] and widely varying testing capabilities [81] make it difficult to accurately quantify their magnitude.

[79] **Phillips, C.A.*et al.* Compound climate risks in the COVID-19 pandemic. *Nat. Clim. Change* 10, 586-588 (2020)**

[80] **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.**

[81] **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).**

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.

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 6. Capability Assessment

The purpose of conducting the capability assessment is to identify the strengths and weaknesses of the Town in terms of mitigating risks. The capability assessment looks at current proficiencies as well as any change in capabilities from the previous mitigation plan. The capability assessment serves as the foundation for designing an effective hazard mitigation strategy. It not only helps establish the goals for the mitigation plan, but it ensures that those goals are realistically achievable under given local conditions.

The capability assessment looks at the Town's pre-and post-disaster hazard management capabilities as well as the Town's financial resources in terms of mitigating risk. Municipal departments, first responders, and regional resources were each considered. The Town of Whitman is prone to floods, extreme winds, and winter storms. Municipal and business leaders are aware of these risks and work to proactively mitigate risks.

C1. Does the Plan document each jurisdiction's existing authorities, policies, programs, and resources and its ability to expand on and improve these existing policies and programs? (Requirement §201.6(c)(3))

The Summary of Findings from the Community Resilience Building Workshop section included a list of current strengths and weaknesses. This list was reviewed and then sorted to represent strengths and assets in society, environment, and infrastructure. These three categories were chosen because of their relevance and consistency with the Municipal Vulnerability Preparedness Program. In addition, these categories were used in the Mitigation Strategy.

FEMA defines four types of capabilities as shown below.

1. **Planning and Regulatory Capabilities.** Includes capabilities based on the jurisdiction's implementation of ordinances, policies, local laws, and State statutes, and plans and programs that relate to guiding and managing growth and development.
2. **Administrative and Technical Capabilities.** Includes capabilities associated with the jurisdiction's staff and their skills and tools that can be used for mitigation planning and implementing specific mitigation actions.
3. **Financial Capabilities.** Refers to the fiscal resources that a jurisdiction has access to or is eligible to use to fund mitigation actions.
4. **Education and Outreach.** Refers to education and outreach programs and methods already in place that could be used to implement mitigation activities and communicate hazard-related information.

Planning and Regulatory Capabilities

Planning and regulatory capabilities are the plans, policies, codes, and bylaws that prevent and reduce the impacts of hazards. The first step in the capability assessment was to gather and review existing plans to gain and understanding of the region's ability to mitigate risk.

Table 114: Capability Assessment Planning & Regulatory

Planning/Regulatory Tool	Responsible Authority	General Description and Effectiveness for Hazard Risk Reduction
Plans		
Comprehensive Master Plan	Planning Board	Adopted 2004 this document is out of date. This document analyzed the town's land use patterns, undeveloped land, population trends, and influences on the community. It then discussed the need for community facilities, circulation improvements and utility needs, and recommended a future land use plan. Finally, it set out an implementation strategy focusing on a recommended zoning bylaw and a set of subdivision regulations.
Community Development Plan	Planning Board	Last approved in 2012 this document is out of date. An effort to engage in community-based planning, conduct needs assessments, and identify strategies for addressing those needs.
Open Space and Recreation Plan	Conservation Commission	The plan speaks to smart growth techniques and open space preservation. None in Place
Comprehensive Emergency Management Plan	Emergency Management Director	A Comprehensive Emergency Management Plan (CEMP) provides a framework for a community-wide emergency management system to ensure a coordinated response to emergencies and coordinated support of certain pre-planned events. The CEMP addresses the roles and responsibilities of all community departments, agencies, government organizations,

		volunteers and community partners that may be involved in response operations, and identifies how regional, state, federal, private sector, and other resources may be activated to address disasters and emergencies in the community. None in Place.
Economic Development Plan	Dept. of Community Development	None in place.
Capital Improvements Plan	Town Administration	Town of Whitman Capital Improvement Plan FY2021-FY2025 Holmes Public Library Long Range Plan FY18-FY22
Continuity of Operations Plan		
Transportation Plan		Complete Streets Program Prioritization Plan
Stormwater Management Plan	Planning Board Highway Dept.	Date of Plan: June 2019 Stormwater Management Program EPA NPDES Permit. Triggers specific development requirements for disturbances greater than one acre.
Wastewater Management Plan		
Historic Preservation Plan	Historical Commission	No plan
Community Wildfire Protection Plan	Emergency Management Director	No Plan found.
Building Code, Permitting and Inspections		
Building Code	Building Dept.	Stretch code has been adopted. Green Community Designation received.
Fire Department ISO Mitigation Ratings	Fire Dept	
Site Plan Review Requirements	Planning Board	Site Plan Review procedures in place.
Zoning and Development Bylaws		
Zoning Bylaws	Planning Board	General opportunity to mitigation impacts; projects that trigger floodplain special permit.
Subdivision Regulations	Planning Board	Regulations governing the subdivision of land in the Town of Whitman presents a general opportunity to mitigate impacts.
Floodplain regulations	Conservation Commission	Updated 2021 The district helps to prevent new development from aggravating flooding and to protect such development from present hazards by proper construction methods. Since the land involved is the most

		difficult to develop due to septic limitations and wetlands, the Flood XII-18 Plain bylaw does not constrain development so much as modify that which is otherwise allowable.

Administrative and Technical Capabilities

Table 115: Administrative and Technical Capabilities

Administrative/Technical Resource	Full Time (FT) Part-time (PT) Volunteer (V)	General Description and Effectiveness for Hazard Risk Reduction
Administration		
Planning Board	V	Has the ability to require mitigation where necessary
Core Team for MVP HMP	FT	The MVP Process created a Core Team that was used as the "Mitigation Planning Team" for purposes of developing this plan.
Conservation Commission	V	Has the ability to require mitigation where necessary.
Building Inspector	FT	Has the ability to require mitigation where necessary.
Emergency Management Director	FT	Fire Chief
Community Planner		Planning Board and Secretary
Information Technology	FT	
Staff with knowledge of land development and land management practices	FT	As part of overall projects
Staff trained in construction practices related to buildings and/or infrastructure	FT	As part of overall projects
Natural Hazards data and information	FT	GIS

Financial Capabilities

Table 116: Financial Capabilities

Financial Tool/Source	Accessible for Hazard Mitigation (Yes/No)	General Description.0
General Funds	Yes	General funds are utilized with grant funding to staffing this planning effort.
Capital Improvement Program	Yes	Road repairs, bridge/culvert replacement, other typical activities that could be linked to mitigation.
Special purposes taxes	No	
Stormwater Utility Fee	No	
Development Impact Fees	No	
State Funding Programs	Yes	MassWorks, EPA Brownfields

Public Education & Outreach Capabilities

Table 117: Public Education & Outreach Capabilities

Program/Organization	Yes/No	Description and Effectiveness for Hazard Risk Reduction
Local citizen groups or non-profit organizations focused on environmental protection, emergency preparedness, access, functional needs populations, etc.	Yes	Youth group united for plastic bag ban
Ongoing public education or information program (e.g., responsible water use, fire safety, household preparedness, environmental education).	Yes	Education on stormwater pollution prevention is included as part of the SWMP.
Stormready Certification	No	

Section 7. Hazard Mitigation and Climate Adaptation Strategies and Action Plan

C3. Does the Plan include goals to reduce/avoid long-term vulnerabilities to the identified hazards? (Requirement §201.6(c)(3)(i))

Mitigation Goals from the 2021 HMP Update

The Core Team reviewed and discussed the goals from the 2015 Old Colony Planning Council Hazard Mitigation Plan. The Team has chosen to expand upon those goals with more focused and localized mitigation goals.

Goal 1: To be prepared to reduce the loss of life, property, infrastructure, and cultural resources throughout the Town from natural disasters through a multiple hazard mitigation program that involves coordination, planning, education, and capital improvements.

Goal 2: Incorporate hazard and climate change vulnerability into capital planning, master planning and facilities management functions and implement proactive solutions to adapt to climate change.

Goal 3: To investigate, design, and implement projects that will reduce and minimize the risk of flooding.

Goal 4: To organize and prepare to provide adequate shelter, water, food, basic first aid to displaced residents, evacuation procedures, etc. to residents in the event of a natural disaster. To inventory supplies at existing shelters and develop a needs list and storage requirements, and to establish arrangements with local and neighboring vendors for supplying shelters with food and first aid supplies in the event of a natural disaster.

Goal 5: Increase awareness of hazard mitigation activities among town officials, private organizations, businesses, and the public through education and outreach activities.

C5. Does the Plan contain an action plan that describes how the actions identified will be prioritized (including cost-benefit review), implemented, and administered by each jurisdiction?

Global/Cross-Cutting Hazards Mitigation Actions

During the Community Resiliency Building Workshop, participants prioritized all identified actions by high, medium, or low for priority. Choices were made based on:

- Funding availability and terms.
- Agreement on outstanding impacts from recent hazard events.
- Necessity for advancing longer-term outcomes.
- Contribution towards meeting existing local and regional planning objectives.

After each item was prioritized, workshop participants discussed and then agreed upon the highest-priority actions across the three profiles of infrastructure, environment, and society. These decisions were made based on "existing programs into which priority actions can be integrated easily or used or used to strengthen related actions with existing funding." The Core Team reviewed these lists and refined them to develop the current list of mitigation actions and their priority order.

The Core Team further refined the list of mitigation actions to include:

- Action Title
- Action Description
- Estimated Cost
    - Very high (over $1 million)
    - High ($500,000 to $1 million)
    - Medium ($100,000 to $500,000)
    - Low ($50,000 to $100,000)
    - Very Low (under $50,000)

- Potential Funding Source
- Lead Department
- Possible Partners
- Implementation Schedule (month/year start and end dates within a five-year period)

Beyond the bulleted list above, the Mitigation Plan includes the following categories of information.

1. Relevant Mitigation Plan Goal (1-5).
2. Type of Mitigation Project (local plans and regulations, structural projects, natural systems protection, education programs, and preparedness and response actions).
3. Critical Facility Protection (yes or no).
4. Community Components (infrastructure, society, or environment)
5. Hazards Addressed
    a. Changes in Precipitation (flooding, drought, or landslide)
    b. Rising Temperatures (average or extreme temperatures, wildfires, invasive species)
    c. Extreme Weather (hurricanes/tropical storms, severe winter storm/nor'easter, tornadoes, severe weather).
    d. Earthquake
    e. Dam Failure
    f. Algae Blooms

Below is a list of all mitigation actions (sorted by priority order).

1	Comprehensive Emergency Management Plan (CEMP)	
Goal	1, 2, 4, 5	
Action Description	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 man-made emergencies. It organizes information, includes supply and inventories.	
High		
	Lead Department	Police Dept., Fire Dept.
	Partners	Board of Selectmen, Town Administration, Highway Department
	Cost	Medium
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

2	Infrastructure Capital Project and Preparedness and Response.	
Goal	1, 2, 4	
Action Description	Obtain funding to supply shelters with food, water, and supplies; recruit volunteers to assist the shelters.	
High		
	Lead Department	Police Dept., Fire Dept.
	Partners	Board of Selectmen, Emergency Management
	Cost	Very Low

	Possible Funding Sources	General Fund, Staff Time, State Grants
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations, Social Vulnerability
	Critical Facility Protection	No
	Community Components	Social Vulnerability
	Implementation Schedule	September 2021-September 2024

3	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.	
Goal	1, 2, 4	
Action Description	Coordinate emergency management planning with climate change vulnerabilities that include vulnerable populations and road system interconnectivity.	
High		
	Lead Department	Police Dept., Fire Dept.
	Partners	COA, Highway Dept., CERTs
	Cost	Very Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

4	Multi-department review of subdivision and site plan review applications.	
Goal	1, 2, 3	
Action Description	Multiple departments within town review and comment on site plans before development. Most effective for new construction	
High		
	Lead Department	Planning Board, Zoning Board of Appeals
	Partners	Conservation Commission, Board of Health, Highway Department, Building Department
	Cost	Very Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

5	Conduct one exercise annually, involving members of the public, regarding the 4 phases of emergency management.	
Goal	1, 2, 4	
Action Description	Increase public understanding of each person's role during a disaster, including public health issues such as pandemics.	
High		
	Lead Department	Police Dept., Fire Dept.
	Partners	COA, Highway Dept., CERTs
	Cost	Very Low
	Possible Funding Sources	General Fund, Staff Time

	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Societal
	Implementation Schedule	September 2021-September 2024

6	Mass Gathering Plan	
Goal	1, 2, 4	
Action Description	Develop a plan that includes policies, procedures, and protocols, for conducting mass gathering events.	
High		
	Lead Department	Police Dept., Fire Dept.
	Partners	COA, Highway Dept., CERTs
	Cost	Very Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations, Preparedness and Response
	Critical Facility Protection	No
	Community Components	Social Vulnerability

	Implementation Schedule	September 2021-September 2024

7	Emerging Hazards	
Goal	1, 2, 3, 4	
Action Description	Review and adopt plan for emerging hazards that fall outside of traditional natural hazards.	
Medium		
	Lead Department	Police Dept., Fire Dept.
	Partners	Highway Dept., CERTs
	Cost	Very Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations, Preparedness and Response
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

8	Master Plan Updates	
Goal	1, 2	
Action Description	Provide training, webinars, workshops on integration of local mitigation plans into local Comprehensive Plans to improve integration of local mitigation plans and improve understanding of vulnerability. Include a new section on Climate Change resiliency in the next Master Plan update.	
Medium		
	Lead Department	Planning Board

	Partners	Support from Town Department Heads, RPA
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations, Preparedness and Response
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

9	Create a Climate Action Plan and update regulations to reduce vulnerability to flooding, severe weather, and extreme temperatures.		
Goal	1, 2		
Action Description	Create an implementation committee to manage the process of creating and monitor implementation of a comprehensive Climate Action Plan. Identify opportunities to update zoning and stormwater regulations to address these issues.		
Medium			
	Lead Department	Planning Board	
	Partners	Town Department Heads, Emergency Management, RPA	
	Cost	Low	
	Possible Funding Sources	General Fund, Staff Time	
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter	
	Type of Mitigation Project	Local Plans and Regulations, Preparedness and Response	
	Critical Facility Protection	No	
	Community Components	Infrastructure	
	Implementation Schedule	September 2021-September 2024	

10	Budgeting, coordinating administrative functions, and planning. Incorporate hazard and climate change vulnerability into personnel and workplace policies, training, and guidance as appropriate.	
Goal	1, 2	
Action Description	Incorporate climate change vulnerability, resiliency, and adaptation standards into budgeting, coordination, and capital planning. 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.	
Medium		
	Lead Department	Planning Board, Town Administration
	Partners	Town Department Heads, RPA
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations, Preparedness and Response
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

11	Review, evaluate, and implement revisions as needed to environmental and energy policies, regulations, and plans.	
Goal	1, 2, 5	
Action Description	Conduct outreach with stakeholders to review, evaluate, and implement revisions needed to key state environmental and energy policies, regulations, and plans maintained by EOEEA and its agencies.	
Low		
	Lead Department	Planning Board, Town Administration
	Partners	Town Department Heads, RPA
	Cost	Low

	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations, Preparedness and Response
	Critical Facility Protection	No
	Community Components	Environment
	Implementation Schedule	September 2021-September 2024

12	Open Space Residential Design and Low Impact Development Standards	
Goal	1, 2, 5	
Action Description	Consider zoning amendments that promote the use of LID Standards using nature-based solutions and green infrastructure to manage stormwater in new subdivision development.	
Low		
	Lead Department	Planning Board
	Partners	ZBA, Building Department
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No

	Community Components	Environment
	Implementation Schedule	September 2021-September 2024

13	Local Transportation Plan	
Goal	1, 4, 5	
Action Description	Develop a robust local transportation plan that addresses emergency access to transportation and the social and economic consequences that accompany service interruptions. Planning should include supplemental funding and equipment for snow removal, a review of available drivers, and the understanding of potential insurance and union contracts issues that may influence access to certain transportation resources. Access to critical resources such as childcare and provisions should be considered. Promote public transportation to reduce cars on the road during inclement weather and reduce greenhouse gas emissions.	
Low		
	Lead Department	Planning Board
	Partners	Town Administration, Emergency Management, Highway Dept.
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

Inland Flooding Hazards Mitigation Actions

14	Floodplain Education and Awareness	
Goal	1, 2, 5	
Action Description	Develop education and outreach to residents living in flood-prone areas to ensure that all individuals and families residing there are aware of potential risks, as well as mechanisms to reduce their risk exposure (such as flood insurance). Target renters as well as property owners.	
High		
	Lead Department	Planning Board, Emergency Management
	Partners	Town Administration, RPA
	Cost	Very Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Environment
	Implementation Schedule	September 2021-September 2024

15	Identify flood prone areas and conduct an inventory of culverts and bridges, create a prioritization plan to improve infrastructure and lessen the likelihood of loss due to climate change. Culvert Maintenance and Repair Plan with long-term implementation.
Goal	1, 2, 3
Action Description	Implement priority projects from the inventory of culverts and bridges for increased flooding resiliency and storm-hardening, including re-sizing or replacement projects. Green infrastructure, low-impact design, and other nature-

	based solutions should be integrated with hard-infrastructure improvement to establish robust approaches in the face of natural hazards and climate-change scenarios, and that meet Massachusetts stream-crossing standards.	
High		
	Lead Department	Highway Dept.,
	Partners	Town Administration, Planning Board, Conservation Commission
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Environment
	Implementation Schedule	September 2021-September 2024

16	Identify key road networks and develop safe evacuation routes.	
Goal	1, 2, 3	
Action Description	Install evacuation route signage; Develop alternative methods of evacuation.	
Medium		
	Lead Department	Emergency Management, Police Dept., Fire Dept.
	Partners	Highway Dept.
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time

	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

17	Acquisition of vacant flood prone lands	
Goal	1, 2, 3	
Action Description	Identify lands subject to flooding and rank by priority.	
Low		
	Lead Department	Conservation Commission
	Partners	Highway Dept., Planning Board, Town Administration
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Environment
	Implementation Schedule	September 2021-September 2024

Goal Statement for Flooding

To prepare emergency staff and volunteers to minimize the loss of life, damage to property, and the disruption of governmental services and general business activities due to flooding.

- To continue to participate in the National Flood Insurance Program, and to have the flood maps periodically updated.
- To develop a priority list and seek funding through the Hazard Mitigation Grant Program (HMGP) for the replacement of undersized culverts throughout the Town.

Inland Flooding Hazards Mitigation Actions – Dam Failure

18	Dam Improvements	
Goal	1, 2, 3	
Action Description	Dam is in structurally good condition, but automated controls would more efficiently and effectively manage flows. Best management practices will consider releasing water to help improve water quality (by flushing out nutrients); management plan should factor in water quality improvements. Collaborate closely with stakeholders to arrive at a management plan.	
Medium		
	Lead Department	Town Administration
	Partners	Highway Dept.
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter. Dam Failure.
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No

	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

19	Map dam failures areas. Enhance emergency operations plan to include a dam failure component.	
Goal	1, 2, 3	
Action Description	Consider residual risk associated with protection provided by dams in future land use decisions.	
Medium		
	Lead Department	Planning Board, GIS
	Partners	Conservation Commission
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter. Dam Failure.
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

Drought Hazards Mitigation Actions

20	Identify and protect water supplies for time of drought.	
Goal	1, 2, 3	
Action Description	Investigate need for emergency water supply interconnections. Work with the City of Brockton and other stakeholders to reduce reliance on Monponsett Pond and Silver Lake for drinking water supply to restore more natural flows to the water system. Water supply ownership must require maintenance to ensure drinking water purposes.	
High		
	Lead Department	Water Commission
	Partners	Planning Board, Town Administration
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter.
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Environment
	Implementation Schedule	September 2021-September 2024

21	Research options, cost, funding, and acquisition of back up water resources including increasing storage capacity.	
Goal	1, 2, 3	
Action Description	Long-term waterline infrastructure investment into the well systems and treatment for the wells. Assess what the infrastructure looks like and where improvements can be made. Dead end water lines, lengths of pipe that do not have the flow needed. Treatment. Testing for water treatment needs	
High		
	Lead Department	Water Commission

	Partners	Planning Board, Town Administration
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter.
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

22	Educate the public about ways to lessen the effects of drought and the need to be water wise. Reduce water system losses.	
Goal	5	
Action Description	Develop and education and outreach program for residents to help build awareness of heat island risks and establish a foundation for action. Provide incentives and awards as an effective way to spur individual heat island reduction actions. Promote Save Water Campaigns and other ways to reduce water consumption. Evaluate opportunities for improved watershed protection to preserve or improve water quality. Modify Rate Structure to influence active water conservation.	
Medium		
	Lead Department	Water Commission, Board of Health
	Partners	Conservation Commission, Building Department
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time

	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter.
	Type of Mitigation Project	Local Plans and Regulations, Education and Outreach
	Critical Facility Protection	No
	Community Components	Societal
	Implementation Schedule	September 2021-September 2024

23	Encourage drought resistance landscapes and rainwater catchments in subdivision and site plan review regulations.	
Goal	1, 2, 3, 5	
Action Description	Continue to regulate water use during summer months. No irrigation without private well system. Amend subdivision regulations to require use of LID or nature-based solutions as first option for stormwater management.	
Medium		
	Lead Department	Water Commission, Board of Health
	Partners	Conservation Commission, Building Department
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter.
	Type of Mitigation Project	Local Plans and Regulations, Education and Outreach
	Critical Facility Protection	No
	Community Components	Environment
	Implementation Schedule	September 2021-September 2024

Wildfire Hazard Mitigation Actions

24	Encourage residents to proactively manage vegetative problem areas.	
Goal	5	
Action Description	Support programs such as a "tree watch" program. Support regional efforts to conduct strategic planning related to agriculture and forestry in the face of climate change. Encourage residents and businesses to create and maintain defensible space around structures and infrastructure.	
Medium		
	Lead Department	Tree Warden, Conservation Commission
	Partners	Fire Dept.
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter.
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Environment
	Implementation Schedule	September 2021-September 2024

25	**Tree and Forest Management Program**	
Goal	5	
Action Description	Develop a comprehensive tree and forest management program to identify, remove, and replace problem trees, preserve intact forests and street-tree cover, and provide guidance and resources for moving toward more climate-resilient trees and forest communities (e.g., species that tolerate warmer temperatures).	
Medium		
	Lead Department	Conservation Commission, Tree Warden
	Partners	MA DCR
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter. Dam Failure.
	Type of Mitigation Project	Local Plans and Regulations, Environment
	Critical Facility Protection	No
	Community Components	Environment
	Implementation Schedule	September 2021-September 2024

Extreme Temperatures, Snowstorms, Ice Storms Hazard Mitigation Actions

26	Public Education on snow operations and winter maintenance on town website.
Goal	5

Action Description	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.		
Low			
	Lead Department	Conservation Commission	
	Partners	Highway Dept., Planning Board, Town Administration	
	Cost	Low	
	Possible Funding Sources	General Fund, Staff Time	
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter	
	Type of Mitigation Project	Local Plans and Regulations	
	Critical Facility Protection	No	
	Community Components	Infrastructure	
	Implementation Schedule	September 2021-September 2024	

27	Review of Building Stock	
Goal	5	
Action Description	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.	
Low		
	Lead Department	Building Dept.
	Partners	Planning Board, Town Administration
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time

	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

28	Alternate Power Supply	
Goal	1, 2	
Action Description	Redundancy of power supply must be evaluated to ensure continuity of power at critical facilities throughout Whitman.	
Medium		
	Lead Department	Building Department
	Partners	Planning Board, Town Administration
	Cost	Medium
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Infrastructure

	Implementation Schedule	September 2021-September 2024

29	Public Outreach for Isolated Population Centers.	
Goal	5	
Action Description	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.	
Medium		
	Lead Department	Emergency Management, Police Dept., Fire Dept.,
	Partners	Elder Services, COA, Housing Authority
	Cost	Very Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations, Social Vulnerability
	Critical Facility Protection	No
	Community Components	Social Vulnerability
	Implementation Schedule	September 2021-September 2024

30	Green Site design to control stormwater.	
Goal	1, 2, 3	
Action Description	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.	
Medium		
	Lead Department	Emergency Management, Police Dept., Fire Dept.,

	Partners	Elder Services, COA, Housing Authority
	Cost	Very Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations, Social Vulnerability
	Critical Facility Protection	No
	Community Components	Social Vulnerability
	Implementation Schedule	September 2021-September 2024

Goal Statement for Extreme Temperature

To minimize the threat to health and the disruption of governmental service and general business activities due to extreme temperatures.

- Assess open space opportunities to create green infrastructure and nature-based solutions.
- Identify strategies to remove impervious pavement, a significant source of urban heat island effect.

Goal Statement for Winter Related Hazards

To minimize the loss of life, damage to property, and the disruption of governmental services and general business activities due to severe snow and ice storms.

- To develop a plan for providing access to water, information, shelter, and food stores to vulnerable populations in remote locations in the event of a severe winter storm.
- Incorporate safe snow management stockpiling into DPW practices particularly where snow storage occurs along wetlands,

rivers, or tributaries.

- Identify potential areas for Ice Jams and monitor during winter months.

Extreme Wind, Thunderstorms Hazards Mitigation Actions

31	Require underground electrical for all new construction.	
Goal	1, 2	
Action Description	Update zoning bylaws and subdivision regulations to require the use of underground utilities in new construction.	
Medium		
	Lead Department	Planning Board
	Partners	Building Department
	Cost	Very Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

32	Reduce exposure to hazards caused by high winds.	
Goal	1, 2	
Action Description	Retrofit public buildings and critical facilities to reduce future wind damage.	
Medium		
	Lead Department	Building Department
	Partners	Town Administration

	Cost	Medium
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	Yes
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

33	Reduce exposure to tree limb damage from extreme wind events	
Goal	1, 2	
Action Description	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.	
Low		
	Lead Department	Tree Warden
	Partners	Highway Dept., Planning Board, Conservation Commission
	Cost	Very Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations

	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

Hurricane and Tropical Storm Hazards Mitigation Actions

34	Vulnerable Trees – Inventory and Maintain Street tree canopy.	
Goal	1, 2	
Action Description	There is a significant tree exposure to hurricane wind forces in Whitman. The vulnerability of these trees to wind forces should be monitored by the town to pre-identify potential problem areas prior to pending storms.	
High		
	Lead Department	Tree Warden
	Partners	Highway Department, Conservation Commission
	Cost	Very Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter.
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

35	Debris Management Plan	
Goal	1, 2	
Action Description	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.	
Medium		
	Lead Department	Building Department
	Partners	Planning Board
	Cost	Very Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Environment
	Implementation Schedule	September 2021-September 2024

36	Emergency Shelter Wind Speed Capability Assessment	
Goal	1, 2	
Action Description	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.	
Low		
	Lead Department	Building Department
	Partners	Town Administration

	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

Vector-borne Disease and Pandemics Hazards Mitigation Actions

37	Disaster Financial Management Team	
Goal	1, 2, 3, 4, 5	
Action Description	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.	
High		
	Lead Department	Emergency Management
	Partners	Police Dept., Fire Dept., Town Administration
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time

	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter.
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

38	Creation of an Economic Recovery Task Force	
Goal	1, 2	
Action Description	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.	
Medium		
	Lead Department	Emergency Management
	Partners	Town Administration, RPA
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Infrastructure

	Implementation Schedule	September 2021-September 2024

39	Fund an Economic Recovery Manager Position and Economic Recovery Task Force	
Goal	1, 2	
Action Description	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.	
Low		
	Lead Department	Town Administration, Board of Selectmen
	Partners	Finance Committee
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

40	Future Infrastructure Improvements.
Goal	1, 2, 3
Action Description	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.
Low	

	Lead Department	Planning Board
	Partners	Building Department
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

40	Remote Technology to support elections, municipal government, and educational needs	
Goal	1, 2	
Action Description	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.	
Low		
	Lead Department	Town Administration, IT Dept.,
	Partners	Board of Selectmen, Emergency Management
	Cost	Very Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter

	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Societal Vulnerability
	Implementation Schedule	September 2021-September 2024

41	Increase mosquito surveillance and control capacity	
Goal	1, 2, 3	
Action Description	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.	
Low		
	Lead Department	Board of Health
	Partners	Conservation Commission
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

40	Decrease barriers to mosquito surveillance and control competency	
Goal	1, 2	
Action Description	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.	
Low		
	Lead Department	Board of Health
	Partners	Park and Recreation
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

41	Flu Vaccine Protocol	
Goal	1, 2	
Action Description	Protocol can serve as a template for when a new vaccine becomes available	
Low		
	Lead Department	Board of Health
	Partners	Town Administration
	Cost	Low

	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Societal Vulnerability
	Implementation Schedule	September 2021-September 2024

Zoning and Regulatory Hazard Mitigation and Climate Adaptation Actions

42	Stormwater Management in New Development and Redevelopment	
Goal	1, 2	
Action Description	Include a requirement that new development and redevelopment stormwater management BMPs be optimized for phosphorus removal with nature-based solutions	
High		
	Lead Department	Planning Board
	Partners	Building Dept., Zoning Board of Appeals
	Cost	Low

	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter.
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

43	Stormwater Management in Existing Development and Redevelopment	
Goal	1, 2	
Action Description	Retrofit inventory and priority ranking shall include consideration of BMPs that infiltrate stormwater where feasible.	
Medium		
	Lead Department	Planning Board
	Partners	Building Dept., Zoning Board of Appeals
	Cost	Low - Medium
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No

	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

44	Design Standards	
Goal	1, 2	
Action Description	Incorporate designs that allow for shutdown and containment where appropriate to isolate the system in the event of an emergency spill or unexpected event.	
Medium		
	Lead Department	Planning Board
	Partners	Building Dept., Zoning Board of Appeals
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

45	Design Standards
Goal	1, 2
Action Description	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.

Medium		
	Lead Department	Planning Board
	Partners	Building Dept., Zoning Board of Appeals
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

46	Design Standards	
Goal	1, 2	
Action Description	Excavation and Grading – regulates how earth removal must be conducted. Effective for minimizing earth removal and preventing sedimentation	
Medium		
	Lead Department	Planning Board
	Partners	Building Dept., Zoning Board of Appeals
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter

	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

Hazardous Materials Hazards Mitigation Actions

47	Continue all facets of emergency preparedness training	
Goal	1, 2	
Action Description	Police, Fire, Public Works, and public information staff training in responding to HAZMAT incidents.	
Medium		
	Lead Department	Emergency Management
	Partners	Police Dept., Fire Dept., Highway Dept.,
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Infrastructure

	Implementation Schedule	September 2021-September 2024

48	Work proactively with hazardous materials facilities to follow best management practices	
Goal	1, 2	
Action Description	Notification of the types of materials being transported through the Town of Whitman. • Placards and labeling of containers. • Emergency plans and coordination • Standardized response procedures	
Medium		
	Lead Department	Emergency Management
	Partners	Police Dept., Fire Dept., Highway Dept.,
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

49	Work proactively with hazardous materials facilities to follow best management practices
Goal	1, 2
Action Description	Work with the private sector to enhance and create Business Continuity Plans

Medium		
	Lead Department	Emergency Management
	Partners	Chamber of Commerce, Small Business Association
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

50	Work proactively with hazardous materials facilities to follow best management practices	
Goal	1, 2	
Action Description	Coordinate with school district to ensure that their emergency preparedness plan includes preparation for hazardous material releases	
Medium		
	Lead Department	Emergency Management
	Partners	School Dept.,
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter

	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

Environmental Hazards Mitigation Actions

51	Risk Assessment	
Goal	1, 2	
Action Description	Consider a risk assessment to determine vulnerability of town well source from contamination.	
Medium		
	Lead Department	Board of Health
	Partners	Town Administration
	Cost	Medium
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Local Plans and Regulations
	Critical Facility Protection	No
	Community Components	Infrastructure, Environment

	Implementation Schedule	September 2021-September 2024

52	Public Education and Outreach	
Goal	5	
Action Description	Distribute an annual message in the spring that encourages the proper use and disposal of grass clippings and encourages the proper use of slow-release and phosphorus-free fertilizers.	
Medium		
	Lead Department	Conservation Commission
	Partners	Board of Health, Building Dept.,
	Cost	Very Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Public Education and Outreach
	Critical Facility Protection	No
	Community Components	Environment
	Implementation Schedule	September 2021-September 2024

53	Public Education and Outreach
Goal	5
Action Description	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.

Medium		
	Lead Department	Town Clerk
	Partners	Board of Health, Building Dept.,
	Cost	Very Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Public Education and Outreach
	Critical Facility Protection	No
	Community Components	Environment
	Implementation Schedule	September 2021-September 2024

54	Public Education and Outreach	
Goal	5	
Action Description	Distribute information to owners of septic systems about proper maintenance in any catchment that discharges to a water body impaired for bacteria or pathogens.	
Medium		
	Lead Department	Board of Health,
	Partners	Building Dept.,
	Cost	Very Low
	Possible Funding Sources	General Fund, Staff Time

	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Public Education and Outreach
	Critical Facility Protection	No
	Community Components	Societal Vulnerability, Environment
	Implementation Schedule	September 2021-September 2024

55	Water Quality Assessment	
Goal	1, 2	
Action Description	To assess the impact of climate change on groundwater quality. Measure road salt impacts on drinking water quality	
Medium		
	Lead Department	Board of Health
	Partners	Conservation Commission, Highway Dept.,
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	
	Critical Facility Protection	No
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

Earthquake Hazards Mitigation Actions

56	Build local capacity to respond to or prepare for the hazard	
Goal	1, 2, 3	
Action Description	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.	
Medium		
	Lead Department	Emergency Management
	Partners	Highway Dept., Building Dept., Planning Board
	Cost	Medium
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Infrastructure, Preparedness and Response Actions
	Critical Facility Protection	Yes
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

57	Assess the earthquake vulnerability of all public buildings. Investigate options to make buildings earthquake resistant.
Goal	1, 2
Action Description	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).

Medium		
	Lead Department	Emergency Management
	Partners	Highway Dept., Building Dept., Planning Board
	Cost	Low
	Possible Funding Sources	General Fund, Staff Time
	Hazards	Changes in Precipitation, Flood, Drought. Rising Temperatures: Average/Extreme Temperatures, Wildfires, Invasive Species. Extreme Weather: Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter
	Type of Mitigation Project	Preparedness and Response Actions
	Critical Facility Protection	Yes
	Community Components	Infrastructure
	Implementation Schedule	September 2021-September 2024

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.

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.
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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.

- Detail 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.
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.
Transportation	
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.
Power Outages	
Power Outages can reduce access to food through spoilage and reduced ability to store and cook food.	Resources and support for local food banks prior to extreme weather to prepare for need.
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 – Extreme Weather/Power Outages

Extreme Weather Power Outages	
Dangerous extreme weather events 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.
Transportation	
Extreme weather can impact transportation modes and traveled ways, leaving vulnerable populations without safe access to shelters. Individuals using electricity-dependent medical equipment or medications that need additional assistance with transportation needs.	People who lack mobility or may be sick such as elderly or disabled population are at risk during extreme weather events and may remain isolated in their homes rather than traveling to a public shelter. Poor road conditions may impact ability for vulnerable populations to seek 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.
Food Insecurity	
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:

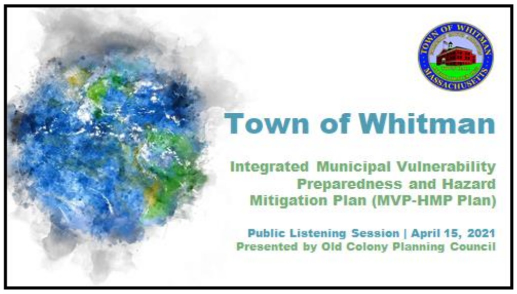
- Larger quantities of debris resulting from the disaster.
- Wider variety of generated debris at one time, including atypical wastes in greater quantities.
- Wider area of impact, possibly affecting more than one jurisdiction.

- 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)

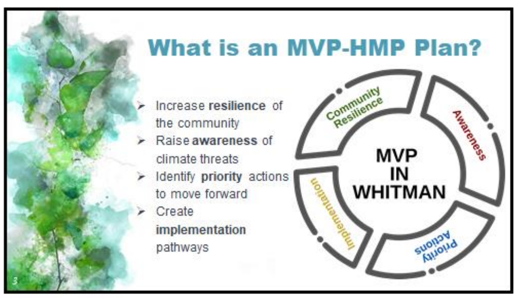
Appendix A: Public Listening Sessions


Town of Whitman
Integrated Municipal Vulnerability Preparedness and Hazard Mitigation Plan (MVP-HMP Plan)
Public Listening Session | April 15, 2021
Presented by Old Colony Planning Council

1


Old Colony Planning Council
At Old Colony Planning Council, we assist cities and towns in planning for present and future needs, utilizing our local knowledge, technical expertise, and regional collaboration.
Laurie Muncy, AICP
Director of Community Planning & Economic Development
Joanne Zygmunt
Senior Planner, Economic Development & Environment
Elijah Romulus
Senior Comprehensive Planner

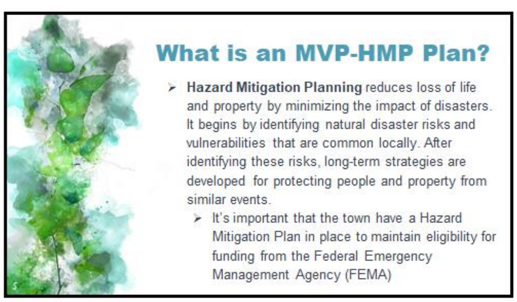
2


What is an MVP-HMP Plan?
➢ Increase resilience of the community
➢ Raise awareness of climate threats
➢ Identify priority actions to move forward
➢ Create implementation pathways
Community Resilience
Awareness
Priority Actions
Implementation
MVP IN WHITMAN

3


What is an MVP-HMP Plan?
➢ Funded by the state and federal government
➢ The Municipal Vulnerability Preparedness Grant Program supports municipalities plan for climate change resiliency and implement priority projects
➢ Communities who complete the MVP Program become certified as an MVP Community and are eligible for MVP Action Grant funding and other opportunities

4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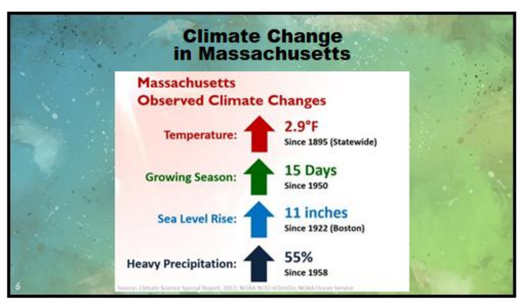
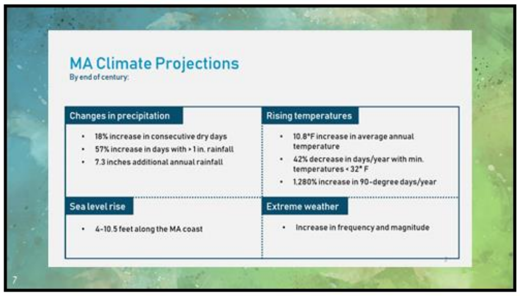
➢ It's important that the town have a Hazard Mitigation Plan in place to maintain eligibility for funding from the Federal Emergency Management Agency (FEMA)

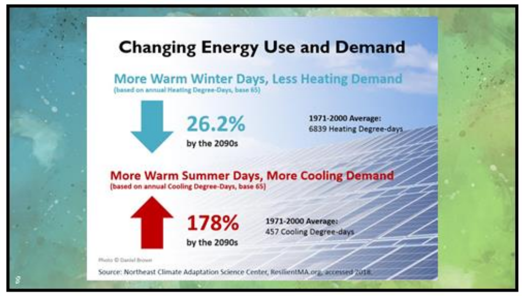
5


Climate Change in Massachusetts
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

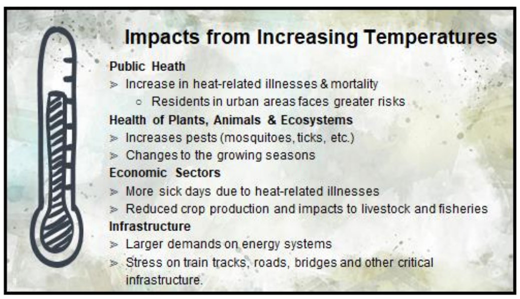
6


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

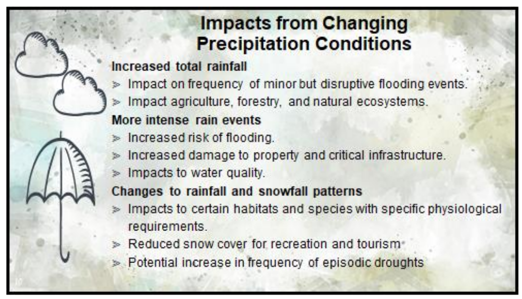
7


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.

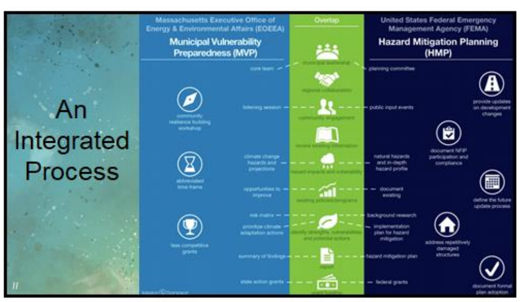
8


Impacts from Increasing Temperatures
Public Heath
Increase in heat-related illnesses & mortality
Residents in urban areas faces greater risks
Health of Plants, Animals & Ecosystems
Increases pests (mosquitoes, ticks, etc.)
Changes to the growing seasons
Economic Sectors
More sick days due to heat-related illnesses
Reduced crop production and impacts to livestock and fisheries
Infrastructure
Larger demands on energy systems
Stress on train tracks, roads, bridges and other critical infrastructure.

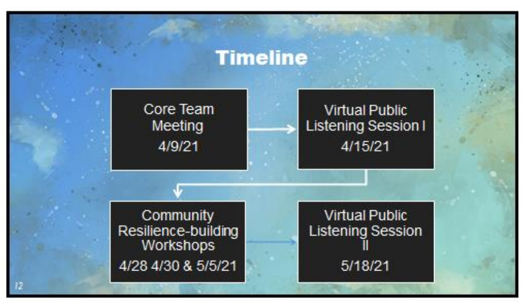
9


Impacts from Changing Precipitation Conditions
Increased total rainfall
Impact on frequency of minor but disruptive flooding events.
Impact agriculture, forestry, and natural ecosystems.
More intense rain events
Increased risk of flooding.
Increased damage to property and critical infrastructure.
Impacts to water quality.
Changes to rainfall and snowfall patterns
Impacts to certain habitats and species with specific physiological requirements.
Reduced snow cover for recreation and tourism
Potential increase in frequency of episodic droughts

10

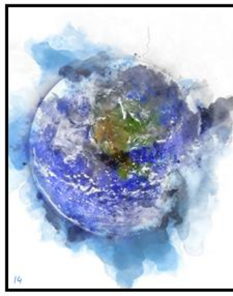

An Integrated Process
Massachusetts Executive Office of Energy & Environmental Affairs (EOEEA)
Municipal Vulnerability Preparedness (MVP)
Overlap
United States Federal Emergency Management Agency (FEMA)
Hazard Mitigation Planning (HMP)

11


Timeline
Core Team Meeting
4/9/21
Virtual Public Listening Session I
4/15/21
Community Resilience-building Workshops
4/28 4/30 & 5/5/21
Virtual Public Listening Session II
5/18/21

12

13



Critical Infrastructure

The following slides show the Critical Infrastructure that participants developed during this Hazard Mitigation process. The list captures the community's key facilities, buildings, and other infrastructure such as bridges and dams.

The tables provide information necessary to develop strategies, inform community plans and advance actions to lessen hazard impacts and build resilience.

14

Critical Infrastructure in Hazard Areas

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

Table 1: Critical Infrastructure in Hazard Areas

ID	Facility	Name	Address or Water crossing	FEMA Flood Zone	Locally Identified Flood Area	100-Year Wind Event (MPH)	Average Annual Snowfall	Wildfire Susceptibility (Vegetation)	Peak Ground Acceleration Zone
1	Dam	Hobart Pond Dam	N/A	AE	No	120	36" – 48"	N/A	Zone 4
2	Fuel Station	7 Eleven	359 Bedford St	N/A	Within 300 feet	120	36" – 48"	N/A	Zone 4
3	Fuel Station	Citgo	180 South Ave.	N/A	No	120	36" – 48"	N/A	Zone 4
4	Fuel Station	Cumberland Farms	280 Temple St	N/A	No	120	36" – 48"	N/A	Zone 4
5	Fuel Station	Diamond Fuel	311 South Ave	N/A	No	120	36" – 48"	N/A	Zone 4
6	Fuel Station	Prime Energy	79 Temple St	N/A	No	120	36" – 48"	N/A	Zone 4
7	Tier II Site	Verizon	630-632 Washington St	N/A	No	120	36" – 48"	N/A	Zone 4
8	Library	Whitman Public Library	100 Webster St	N/A	No	120	36" – 48"	N/A	Zone 4
9	Public Works, Fuel Storage	Public Works	100 Essex St.	A/E	No	120	36" – 48"	Deciduous Forest	Zone 4
10	School	Hope Christian School	503 South Ave	N/A	No	120	36" – 48"	N/A	Zone 4

15

11	School, Childcare, Antenna, Public Safety, Repeater Site	John H. Duval, Jr. Elementary School	60 Regal St	N/A	No	120	36" – 48"	N/A	Zone 4
12	School, Childcare, Mass Care Shelter	Louise A. Conley Elementary School	100 Forest St.	N/A	No	120	36" – 48"	N/A	Zone 4
13	School, Mass Care Shelter, Antenna, Public Safety, Repeater Site	Whitman Middle School	100 Corthell Ave	N/A	No	120	36" – 48"	N/A	Zone 4
14	Senior Center	Council on Aging	16 Hayden Ave	N/A	No	120	36" – 48"	N/A	Zone 4
15	Town Hall	Town Hall	54 South Ave	N/A	No	120	36" – 48"	N/A	Zone 4
16	Fire Emergency Operations Center, Antenna, Public Safety, Repeater Site	Fire Station	56 Temple St.	N/A	No	120	36" – 48"	N/A	Zone 4
17	Health, Medical Facility	Beth Israel Deaconess Medical	312 Bedford St	N/A	Within 400 Feet	120	36" – 48"	N/A	Zone 4

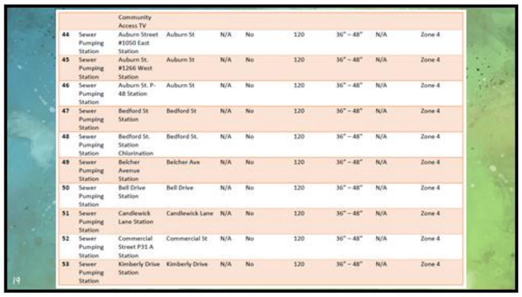
16

18	Police, Antenna, Public Safety, Repeater Site	Police Station	20 Essex St	N/A	No	120	36" – 48"	N/A	Zone 4
19	Childcare	A Child's Place Pre-School	49 School St	N/A	No	120	36" – 48"	N/A	Zone 4
20	Childcare	Busy Bee Pre-School	69 Washington St	N/A	No	120	36" – 48"	N/A	Zone 4
21	Childcare	Jack-n-Jill Child Care of Whitman	991 Bedford St.	N/A	No	120	36" – 48"	N/A	Zone 4
22	Childcare	Merry Deb Nursery School	127 Warren Ave	N/A	No	120	36" – 48"	N/A	Zone 4
23	Childcare	Self Help Inc. Head Start Whitman	168 Whitman Ave	N/A	No	120	36" – 48"	N/A	Zone 4
24	Cultural Resources	All Saints Episcopal Church	44 Park Ave	N/A	No	120	36" – 48"	N/A	Zone 4
25	Cultural Resources	Congregational Church of Whitman	519 Washington St	N/A	No	120	36" – 48"	N/A	Zone 4
26	Cultural Resources	Holy Ghost Church	518 Washington St	N/A	No	120	36" – 48"	N/A	Zone 4
27	Cultural Resources	Methodist Church	503 South St	N/A	No	120	36" – 48"	N/A	Zone 4
28	Cultural Resources	South Shore Pentecostal Church	58 West St	N/A	No	120	36" – 48"	N/A	Zone 4
29	Cultural Resource,	Stop & Shop Supermarket	475 Bedford St	N/A	No	120	36" – 48"	N/A	Zone 4

17

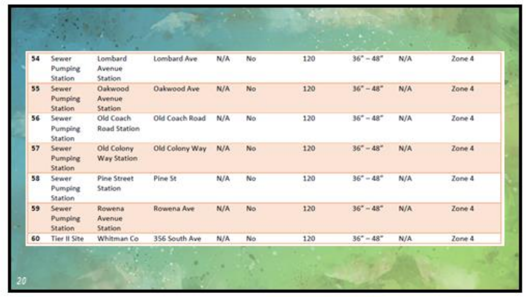
	Fuel Station								
30	Housing Authority	Whitman Housing Authority	101 Harvard Ct	N/A	No	120	36" – 48"	N/A	Zone 4
31	Housing Authority	Whitman Housing Authority	0 Pine Circle	N/A	No	120	36" – 48"	N/A	Zone 4
32	Housing Authority	Whitman Housing Authority	0 Stetson Ter	N/A	No	120	36" – 48"	N/A	Zone 4
33	Postal & Shipping	USPS Whitman Office	64 South Ave	N/A	No	120	36" – 48"	N/A	Zone 4
34	Railroad	MBTA Whitman Station	383 South Ave	N/A	No	120	36" – 48"	N/A	Zone 4
35	Special Needs	Choice Residence	26 Park Ave	N/A	No	120	36" – 48"	N/A	Zone 4
36	Special Needs	Road to Responsibility	50 Paul St	N/A	No	120	36" – 48"	N/A	Zone 4
37	Special Needs	Special Needs	87 Stetson St	N/A	No	120	36" – 48"	N/A	Zone 4
38	Special Needs	Special Needs	207 Stetson St	N/A	No	120	36" – 48"	N/A	Zone 4
39	Special Needs	Vinyl Residence	777 Washington St	N/A	No	120	36" – 48"	N/A	Zone 4
40	Antenna	Commonwealth Building	7 Marble St	N/A	No	120	36" – 48"	N/A	Zone 4
41	Antenna	Franklin Street Cell Tower	Franklin St	N/A	No	120	36" – 48"	N/A	Zone 4
42	Antenna	Ridder Air	1 Castle Pl	N/A	No	120	36" – 48"	N/A	Zone 4
43	Cable Television	Whitman Hanson	115 South Ave	N/A	No	120	36" – 48"	N/A	Zone 4

18



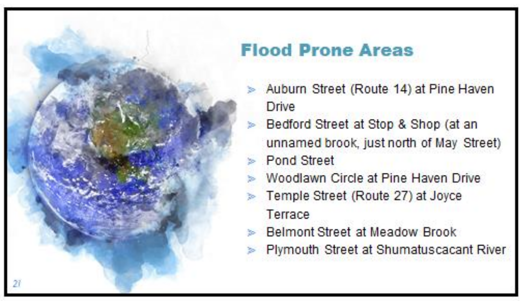
		Community Access TV							
44	Sewer Pumping Station	Auburn Street #1050 East Station	Auburn St	N/A	No	120	36" – 48"	N/A	Zone 4
45	Sewer Pumping Station	Auburn St. #1266 West Station	Auburn St	N/A	No	120	36" – 48"	N/A	Zone 4
46	Sewer Pumping Station	Auburn St. P-48 Station	Auburn St	N/A	No	120	36" – 48"	N/A	Zone 4
47	Sewer Pumping Station	Bedford St Station	Bedford St	N/A	No	120	36" – 48"	N/A	Zone 4
48	Sewer Pumping Station	Bedford St. Station Chlorination	Bedford St.	N/A	No	120	36" – 48"	N/A	Zone 4
49	Sewer Pumping Station	Belcher Avenue Station	Belcher Ave	N/A	No	120	36" – 48"	N/A	Zone 4
50	Sewer Pumping Station	Bell Drive Station	Bell Drive	N/A	No	120	36" – 48"	N/A	Zone 4
51	Sewer Pumping Station	Candlewick Lane Station	Candlewick Lane	N/A	No	120	36" – 48"	N/A	Zone 4
52	Sewer Pumping Station	Commercial Street P31 A Station	Commercial St	N/A	No	120	36" – 48"	N/A	Zone 4
53	Sewer Pumping Station	Kimberly Drive Station	Kimberly Drive	N/A	No	120	36" – 48"	N/A	Zone 4

19



54	Sewer Pumping Station	Lombard Avenue Station	Lombard Ave	N/A	No	120	36" – 48"	N/A	Zone 4
55	Sewer Pumping Station	Oakwood Avenue Station	Oakwood Ave	N/A	No	120	36" – 48"	N/A	Zone 4
56	Sewer Pumping Station	Old Coach Road Station	Old Coach Road	N/A	No	120	36" – 48"	N/A	Zone 4
57	Sewer Pumping Station	Old Colony Way Station	Old Colony Way	N/A	No	120	36" – 48"	N/A	Zone 4
58	Sewer Pumping Station	Pine Street Station	Pine St	N/A	No	120	36" – 48"	N/A	Zone 4
59	Sewer Pumping Station	Rowena Avenue Station	Rowena Ave	N/A	No	120	36" – 48"	N/A	Zone 4
60	Tier II Site	Whitman Co	356 South Ave	N/A	No	120	36" – 48"	N/A	Zone 4

20



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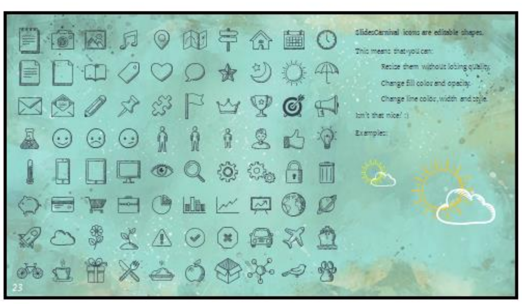

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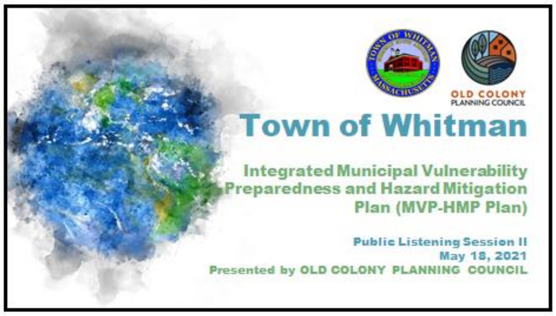
OLD COLONY PLANNING COUNCIL
Town of Whitman
Integrated Municipal Vulnerability Preparedness and Hazard Mitigation Plan (MVP-HMP Plan)
Public Listening Session II
May 18, 2021
Presented by OLD COLONY PLANNING COUNCIL

1


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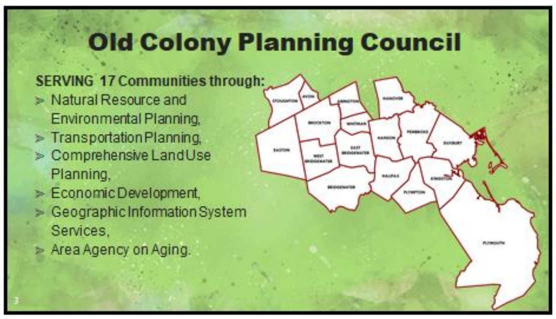
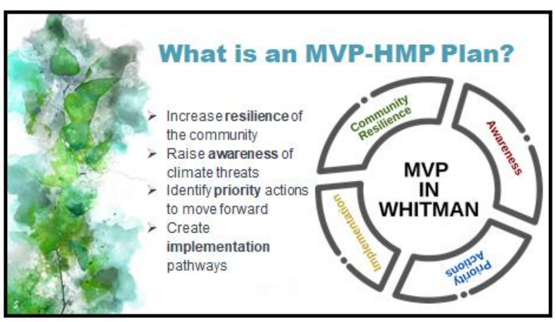

Old Colony Planning Council
SERVING 17 Communities through:
➢ Natural Resource and Environmental Planning,
➢ Transportation Planning,
➢ Comprehensive Land Use Planning,
➢ Economic Development,
➢ Geographic Information System Services,
➢ Area Agency on Aging.

3


Core Team Members
➢ Lincoln Heineman, Town Administrator
➢ Timothy Hanlon, Police Chief
➢ Timothy Grenno, Fire Chief
➢ Robert Curran, Building Inspector
➢ Daniel Kelly, Board of Health Agent
➢ Mary Holland, Council on Aging Director
➢ Dennis Smith, Water Department
➢ Bruce Martin, Highway Department

4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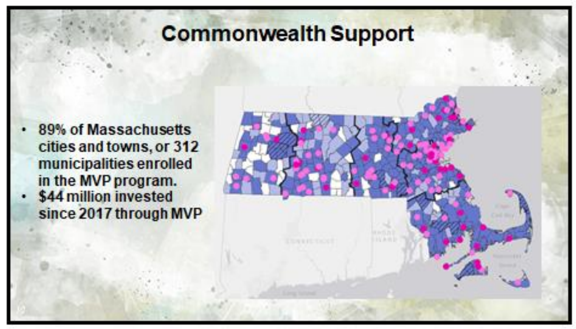
7


Commonwealth Support
EXECUTIVE ORDER 569: AN INTEGRATED CLIMATE CHANGE STRATEGY FOR THE COMMONWEALTH 9.16.16
Reducing greenhouse gas emissions to combat climate change
Preparing for the impacts of climate change
State Adaptation Plan
Agency Vulnerability Assessments
Municipal Support
Climate Coordinators

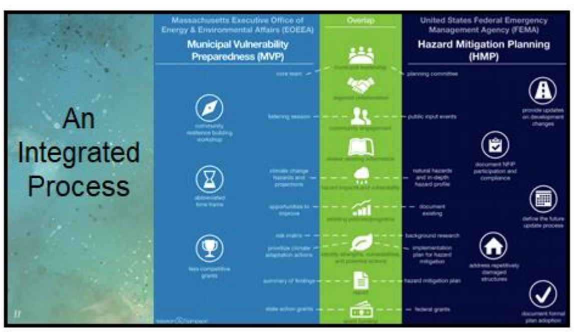
8


Commonwealth Support
Environmental Bond - 2018
$2.4 billion bond bill with focus on climate change resiliency
Over $200 million authorized for climate change adaptation
Codifies EO 569, including the MVP Program

9


Commonwealth Support
89% of Massachusetts cities and towns, or 312 municipalities enrolled in the MVP program.
$44 million invested since 2017 through MVP

10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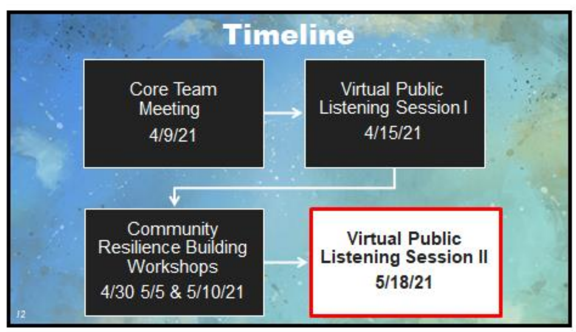
Timeline
Core Team Meeting 4/9/21
Virtual Public Listening Session I 4/15/21
Community Resilience Building Workshops 4/30 5/5 & 5/10/21
Virtual Public Listening Session II 5/18/21

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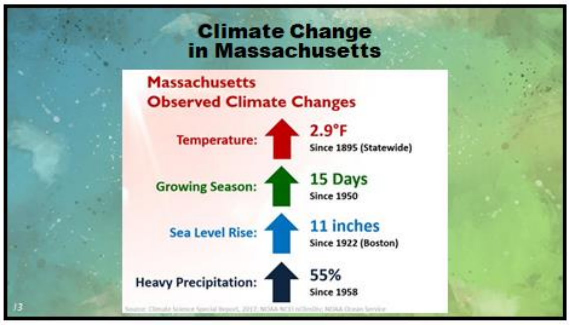

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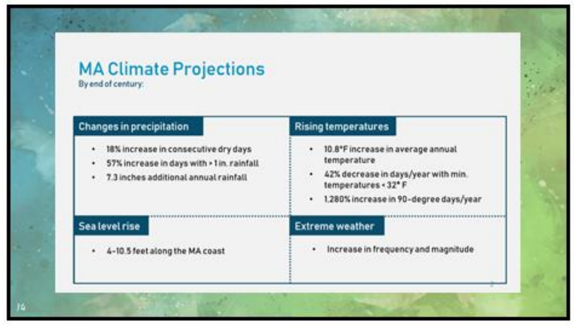

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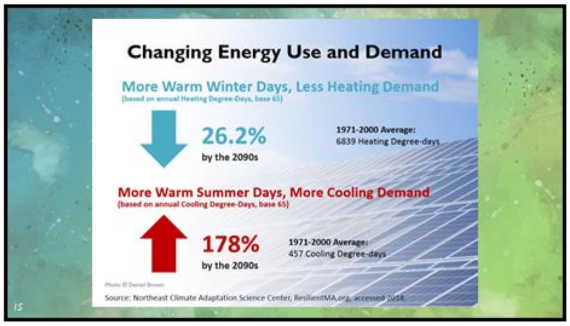

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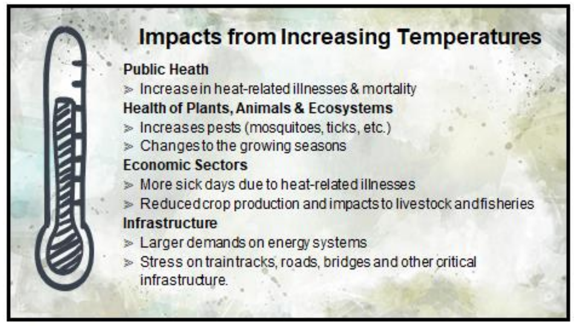

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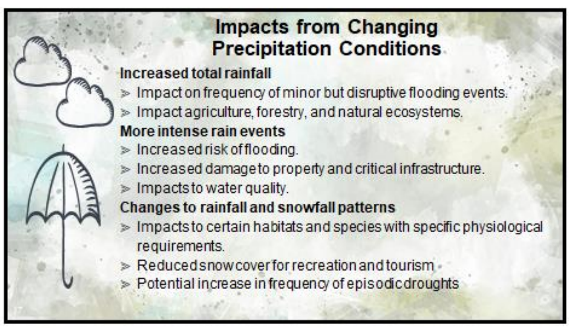

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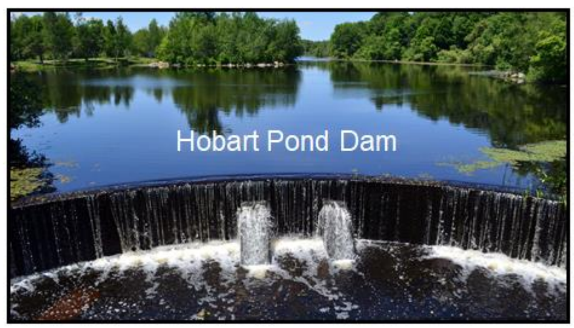

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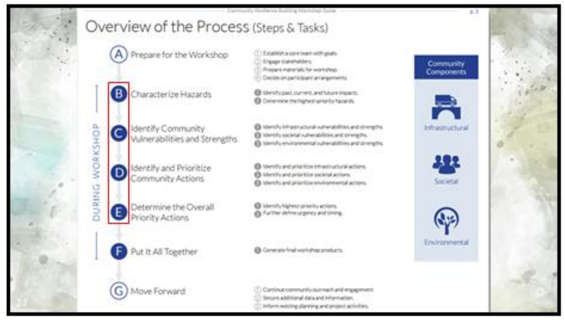

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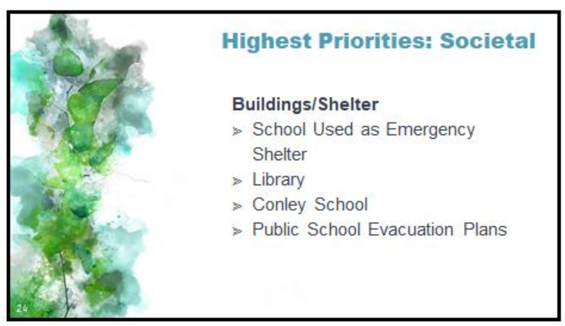

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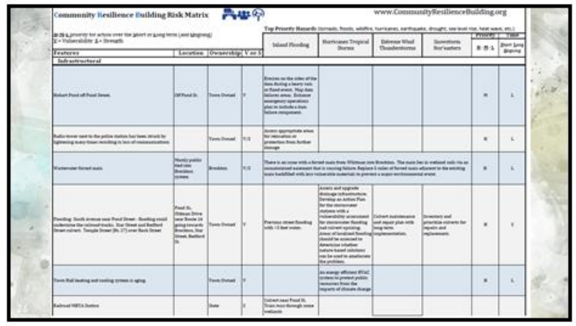

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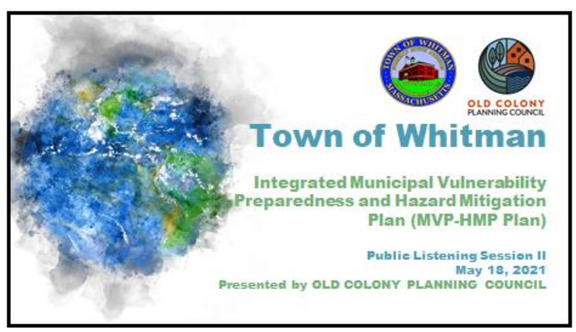

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Appendix B: CRB Workshop Materials

CRB Workshop Presentations

CRB Workshop #1 April 28, 2021

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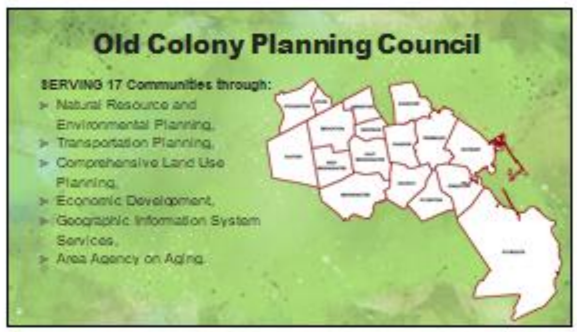

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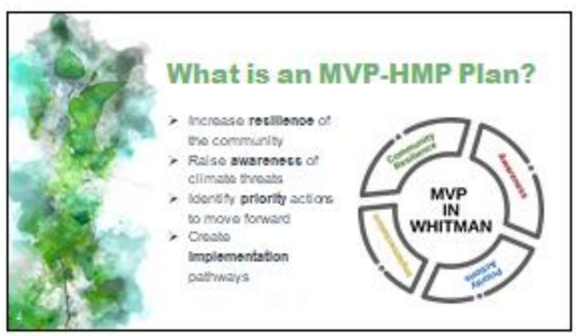


6


What is an MVP-HMP Plan?
➢ Funded by the state and federal government
➢ The Municipal Vulnerability Preparedness Grant Program supports municipalities plan for climate change resiliency and implement priority projects
➢ Communities who complete the MVP Program become certified as an MVP Community and are eligible for MVP Action Grant funding and other opportunities

7


What is an MVP-HMP Plan?
➢ Hazard Mitigation Planning reduces loss of life and property by minimizing the impact of disasters. It begins by identifying natural disaster risks and vulnerabilities that are common locally. After identifying these risks, long-term strategies are developed for protecting people and property from similar events.
➢ It's important that the town have a Hazard Mitigation Plan in place to maintain eligibility for funding from the Federal Emergency Management Agency (FEMA)

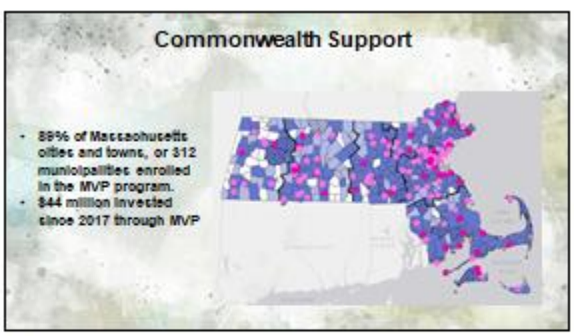
8


Commonwealth Support
EXECUTIVE ORDER 569: AN INTEGRATED CLIMATE CHANGE STRATEGY FOR THE COMMONWEALTH 9.16.16
• Reducing greenhouse gas emissions to combat climate change
• Preparing for the impacts of climate change
• State Adaptation Plan
• Agency Vulnerability Assessments
• Municipal Support
• Climate Coordinators

9


Commonwealth Support
Environmental Bond - 2018
• $2.4 billion bond bill with focus on climate change resiliency
• Over $200 million authorized for climate change adaptation
• Codifies EO 569, including the MVP Program

10


Commonwealth Support
• 89% of Massachusetts cities and towns, or 312 municipalities enrolled in the MVP program.
• $44 million invested since 2017 through MVP

11


An Integrated Process
Municipal Vulnerability Preparedness (MVP)
Hazard Mitigation Planning (HMP)

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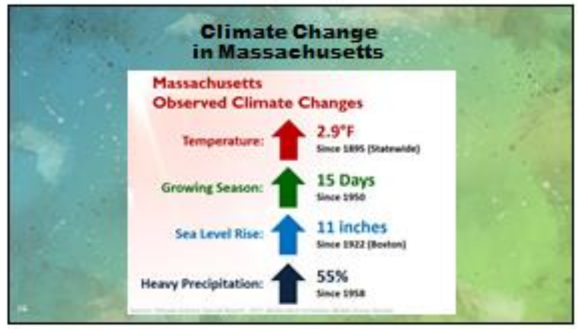

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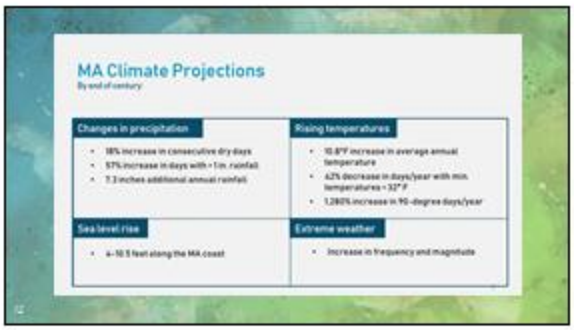

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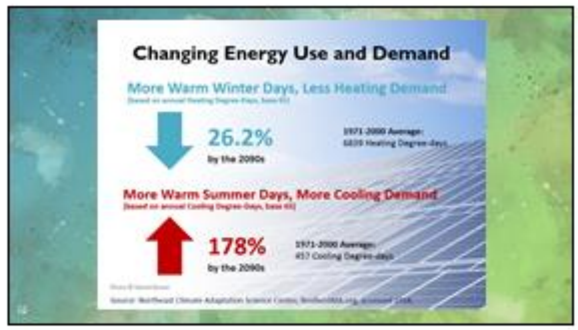

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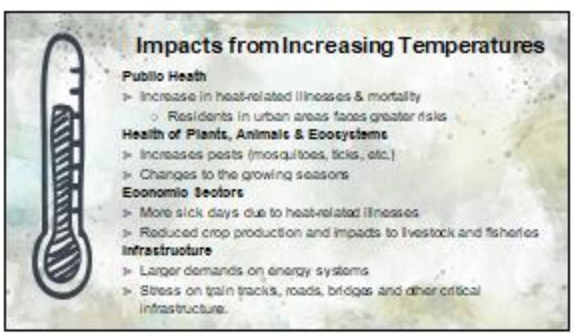

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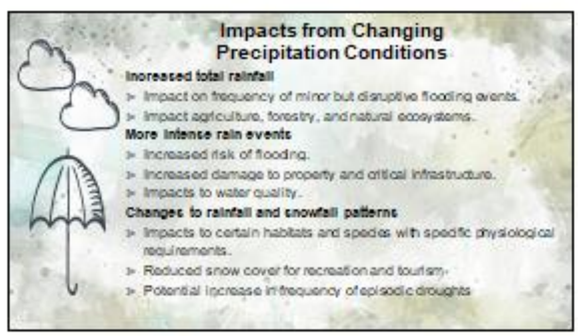

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CRB Workshop #2 May 5, 2021

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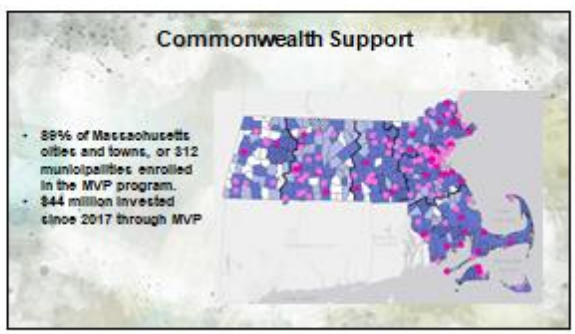


6


An Integrated Process
Massachusetts Executive Office of Energy & Environmental Affairs (EOEEA)
Municipal Vulnerability Preparedness (MVP)
United States Federal Emergency Management Agency (FEMA)
Hazard Mitigation Planning (HMP)

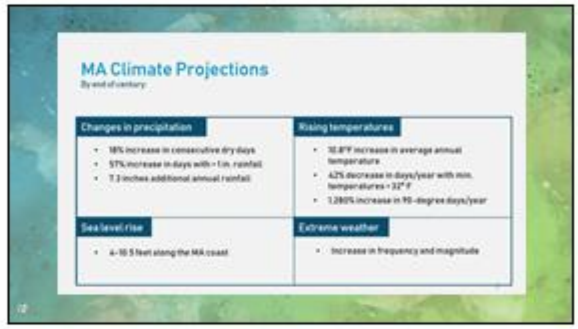
7


Timeline
Core Team Meeting
4/9/21
Virtual Public Listening Session I
5/6/21
Workshop Series
4/30, 5/5 & 5/10/21
Virtual Public Listening Session II
5/18/21

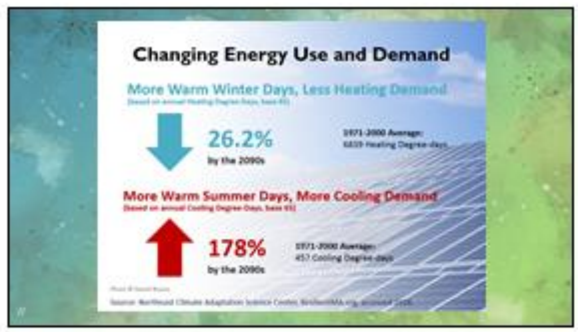
8


Climate Change in Massachusetts
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

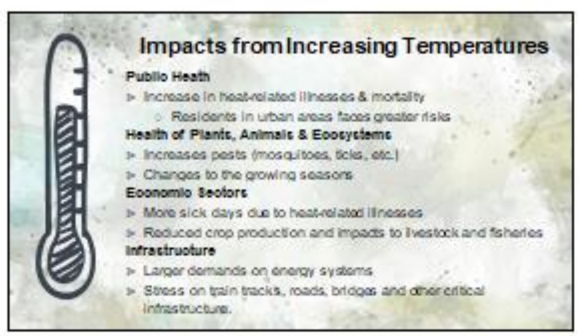
9


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

10


Changing Energy Use and Demand
More Warm Winter Days, Less Heating Demand
26.2%
by the 2090s
1971-2000 Average:
More Warm Summer Days, More Cooling Demand
178%
by the 2090s
1971-2000 Average:
457 Cooling Degree-days

11


Impacts from Increasing Temperatures
Public Health
Increase in heat-related illnesses & mortality
Residents in urban areas faces greater risks
Health of Plants, Animals & Ecosystems
Increases pests (mosquitoes, ticks, etc.)
Changes to the growing seasons
Economic Sectors
More sick days due to heat-related illnesses
Reduced crop production and impacts to livestock and fisheries
Infrastructure
Larger demands on energy systems
Stress on train tracks, roads, bridges and other critical infrastructure.

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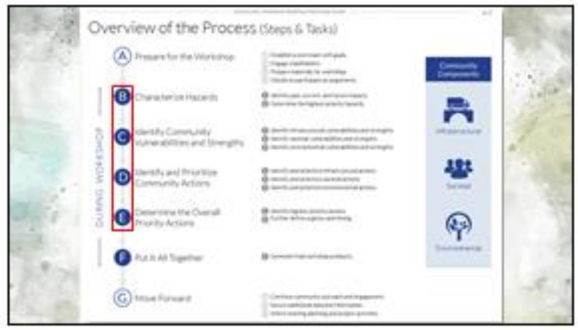

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CRB Workshop #3 May 10, 2021

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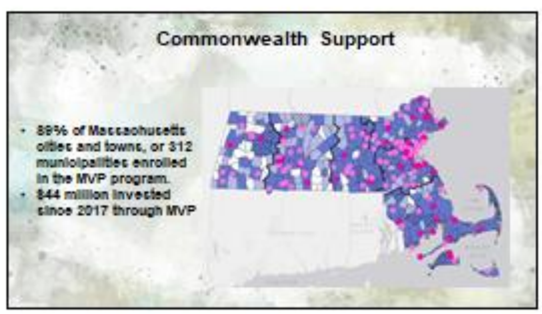


6


An Integrated Process
Municipal Vulnerability Preparedness (MVP)
Hazard Mitigation Planning (HMP)

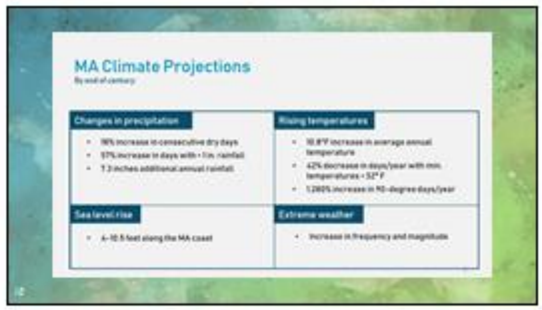
7


Timeline
Core Team Meeting 4/9/21
Virtual Public Listening Session I 4/15/21
Workshop Series 4/30, 5/5 & 5/10/21
Virtual Public Listening Session II 5/18/21

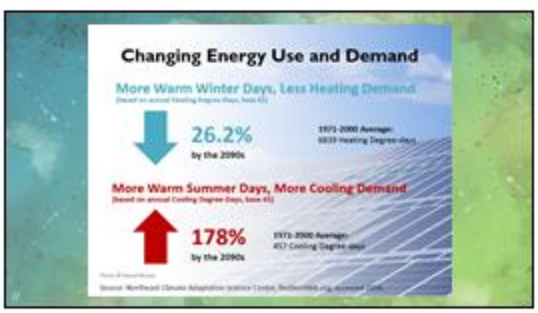
8


Climate Change in Massachusetts
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

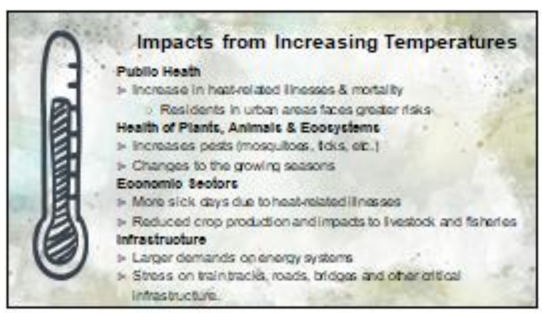
9


MA Climate Projections
Changes in precipitation
Rising temperatures
Sea level rise
Extreme weather

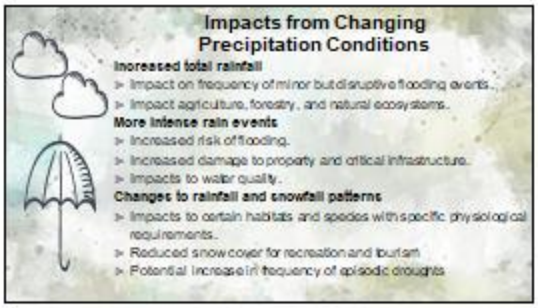
10


Changing Energy Use and Demand
More Warm Winter Days, Less Heating Demand
26.2% by the 2090s
More Warm Summer Days, More Cooling Demand
178% by the 2090s

11


Impacts from Increasing Temperatures
Public Health
Increase in heat-related illnesses & mortality
Residents in urban areas faces greater risks
Health of Plants, Animals & Ecosystems
Increases pests (mosquitoes, ticks, etc.)
Changes to the growing seasons
Economic Sectors
More sick days due to heat-related illnesses
Reduced crop production and impacts to livestock and fisheries
Infrastructure
Larger demands on energy systems
Stress on train tracks, roads, bridges and other critical infrastructure.

12



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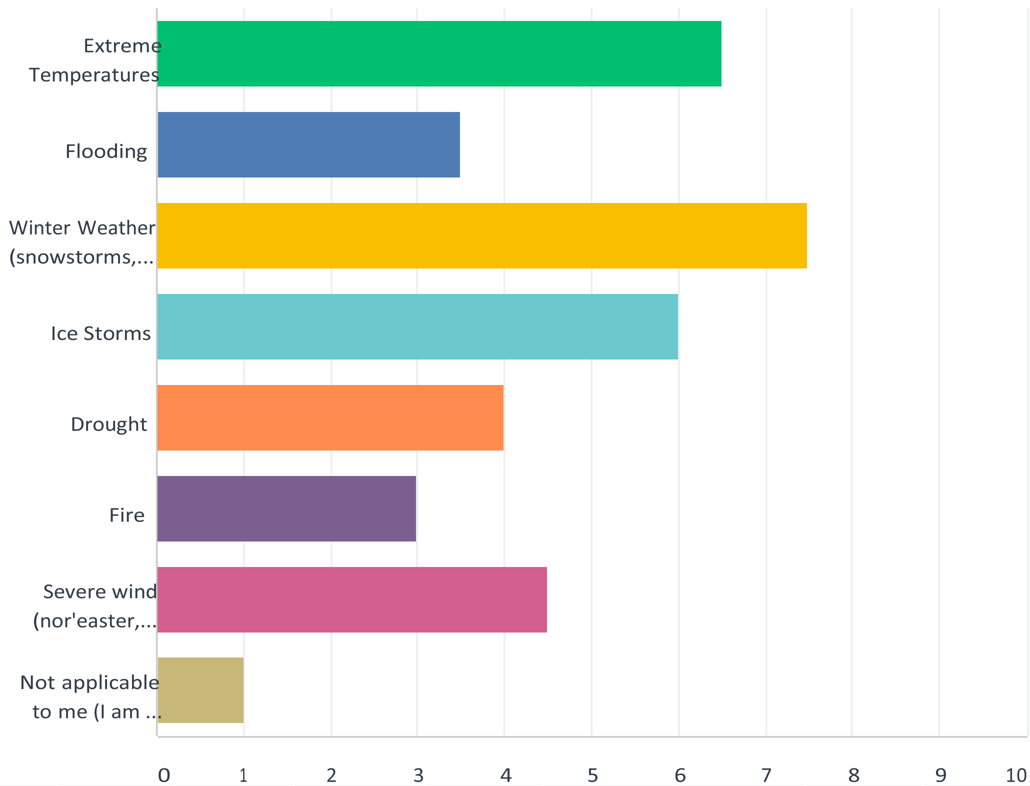
Appendix C: Community Survey Results

Public Survey Results

Q1 What climate hazard are you most concerned about? Rank the following options, with the first option being the hazard you are most concerned about.

Answered: 2 Skipped: 0



	1	2	3	4	5	6	7	8	TOTAL	SCORE
Extreme Temperatures	50.00% 1	0.00% 0	0.00% 0	50.00% 1	0.00% 0	0.00% 0	0.00% 0	0.00% 0	2	6.50
Flooding	0.00% 0	0.00% 0	0.00% 0	50.00% 1	0.00% 0	0.00% 0	50.00% 1	0.00% 0	2	3.50
Winter Weather (snowstorms, blizzards)	50.00% 1	50.00% 1	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	2	7.50

Ice Storms	0.00% 0	0.00% 0	100.00% 2	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	2	6.00
Drought	0.00% 0	0.00% 0	0.00% 0	0.00% 0	100.00% 2	0.00% 0	0.00% 0	0.00% 0	2	4.00
Fire	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	100.00% 2	0.00% 0	0.00% 0	2	3.00
Severe wind (nor'easter, tornado, thunderstorm)	0.00% 0	50.00% 1	0.00% 0	0.00% 0	0.00% 0	0.00% 0	50.00% 1	0.00% 0	2	4.50
Not applicable to me (I am a representative from a surrounding community)	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	100.00% 1	1	1.00

Q2 How have these climate hazards impacted you or the Town more broadly? Memories of climate hazards could include impacts from:

Flooding of local roads, Drought conditions in 2020, Four Nor'easters in one month in 2018, or Heat waves with multiple days over 90 degrees F

Answered: 2 Skipped: 0

Q3. Do you have any photos to share of events mentioned in question #2? If so, please upload:

Answered: 0 Skipped: 2

Q4 Are there any specific infrastructure issues that Whitman should address and where is it located? (Replace a dam, bridge, or culvert? Fix a road?)

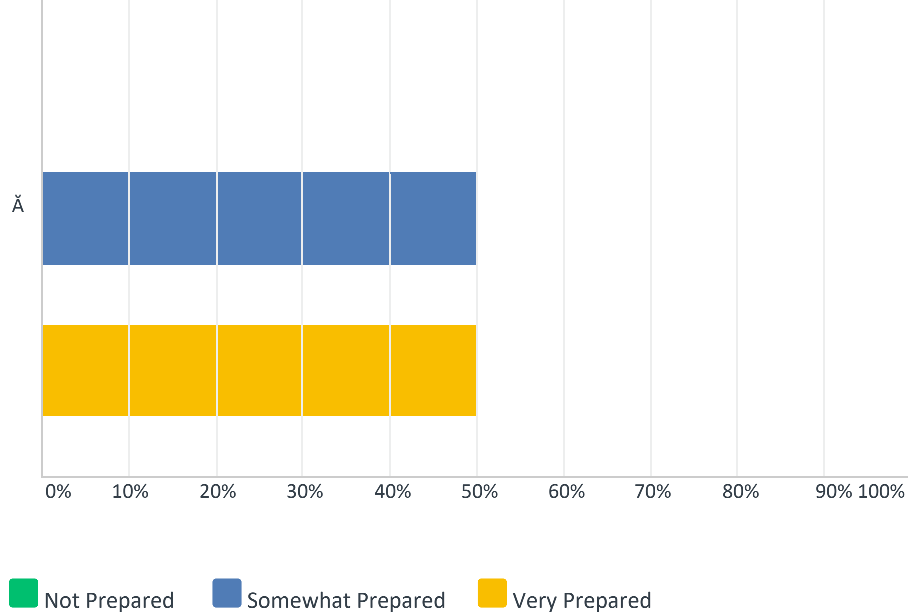
Answered: 1 Skipped: 1

Q5. Do you have any photos to share of issues mentioned in question #4? If so, please upload:

Answered: 0 Skipped: 2

Q6 How prepared do you feel Whitman is for extreme climate hazard events?

Answered: 2 Skipped: 0



	NOT PREPARED	SOMEWHAT PREPARED	VERY PREPARED	TOTAL	WEIGHTED AVERAGE
Ă	0.00% 0	50.00% 1	50.00% 1	2	2.50

Q7 Please explain your reason for selecting your answer in Question 4.

Answered: 1 Skipped: 1

Q8 What does Whitman do well to mitigate climate hazards or prepare for climate change? Examples could include, but are not limited to: Town shelters, warming centers, and cooling centers, Reverse 911, Regional collaboration, including Mutual Aid Agreements with town departments or organizations in neighboring communities.

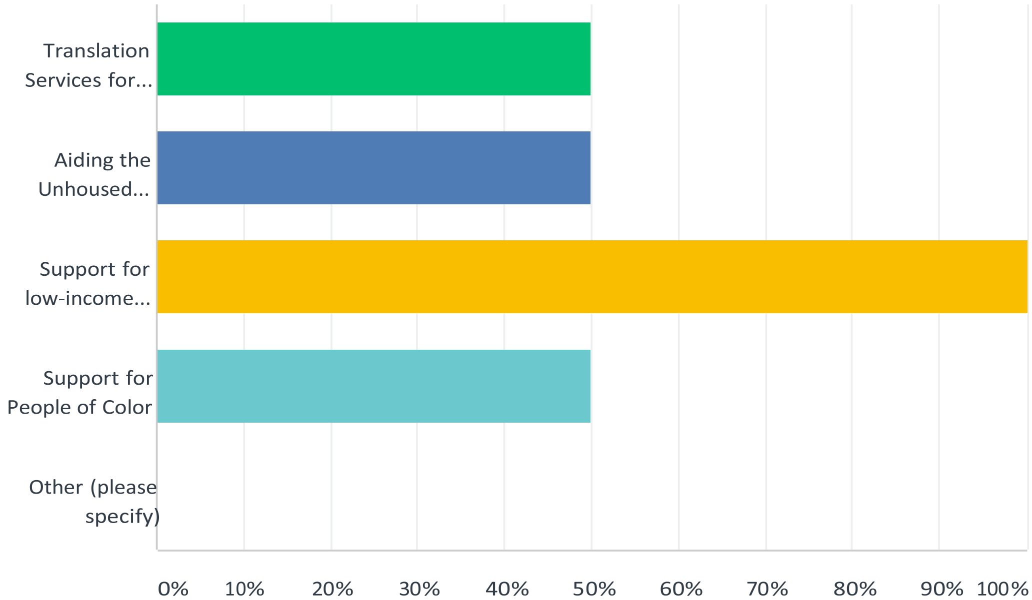
Answered: 2 Skipped: 0

Q9 What are the opportunities to address potential natural or climatic hazards? Examples could include, but are not limited to: Providing transportation to shelters for vulnerable populations, including elderly and low-income residents, addressing frequently flooded roads, including Auburn Street (Route 14) at Pine Haven Drive

Answered: 1 Skipped: 1

Q10 What social impediments do you feel should be addressed for greater resilience in Whitman?

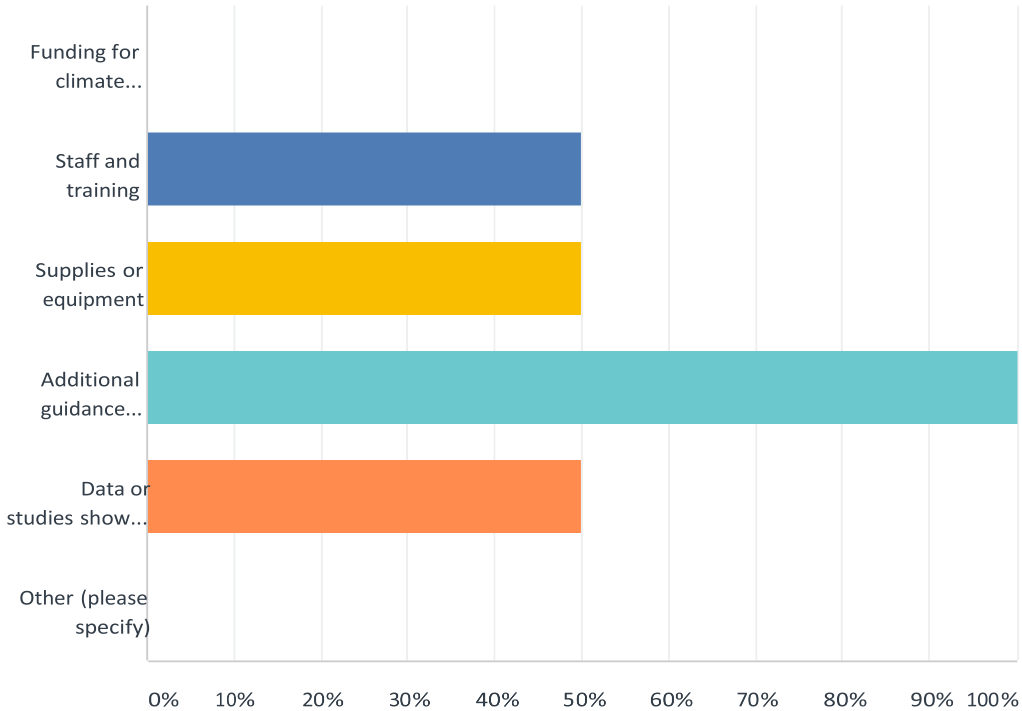
Answered: 2 Skipped: 0



ANSWER CHOICES	RESPONSES
Translation Services for English Language Learners	50.00%
Aiding the Unhoused Population	50.00%
Support for low-income Families	100.00%
Support for People of Color	50.00%
Other (please specify)	0.00%
Total Respondents: 2	

Q11 What resources does the Town of Whitman need to be more prepared?

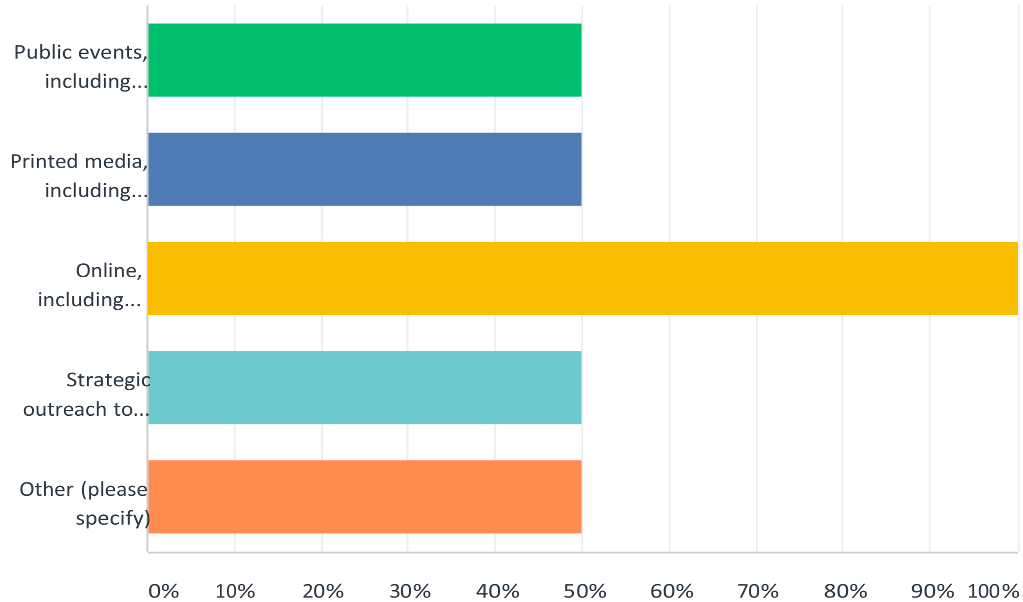
Answered: 2 Skipped: 0



ANSWER CHOICES	RESPONSES
Funding for climate adaptation projects	0.00%
Staff and training	50.00%
Supplies or equipment	50.00%
Additional guidance related to Town operations before, during, and after a hazard event	100.00%
Data or studies showing the projected impacts of future climate hazards in Whitman	50.00%
Other (please specify)	0.00%
Total Respondents: 2	

Q12 How does your Town share information with the public?

Answered: 2 Skipped: 0



ANSWER CHOICES	RESPONSES
Public events, including virtual webinars	50.00%
Printed media, including reports, fact sheets, or brochures	50.00%
Online, including through the Town website, Facebook, and Twitter	100.00%
Strategic outreach to specific populations, such as elderly residents or other groups	50.00%
Other (please specify)	50.00%
Total Respondents: 2	

Q13 We recognize the preparation and response to any challenge in our community has overlapping strategies and challenges. We are interested in documenting the community experience of COVID19. What worked well, and what could improve?

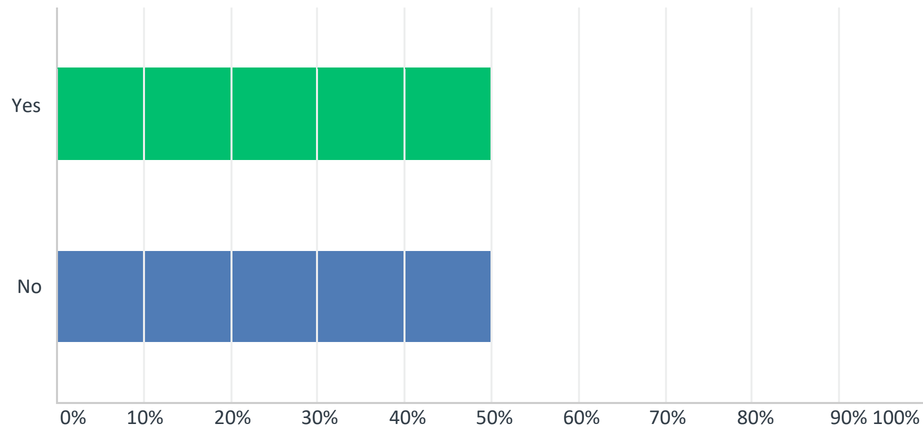
Answered: 2 Skipped: 0

Q14 Are there any additional comments or questions you would like to share with the project team?

Answered: 1 Skipped: 1

Q15. Are you interested in attending future events, workshops, listening session, and other learning opportunities?

Answered: 2 Skipped: 0



ANSWER CHOICES	RESPONSES	
Yes	50.00%	
No	50.00%	
TOTAL		

Q16 Thank you for completing the survey. Please enter your information below

Answered: 2 Skipped: 0

ANSWER CHOICES	RESPONSES	
Full Name	100.00%	
Phone or Email	100.00%	
Home Address	100.00%	2

#1

COMPLETE

Collector: Web Link 1 (Web Link)

Started: Thursday, April 22, 2021 5:23:05 PM

Last Modified: Thursday, April 22, 2021 5:45:30 PM

Time Spent: 00:22:25
IP Address: 98.216.41.234

Page 1

Q1

What climate hazard are you most concerned about? Rank the following options, with the first option being the hazard you are most concerned about.

Extreme Temperatures	**1**
Flooding	4
Winter Weather (snowstorms, blizzards)	2
Ice Storms	3
Drought	**5**
Fire	**6**
Severe wind (nor'easter, tornado, thunderstorm)	**7**

Q2

How have these climate hazards impacted you or the Town more broadly? Memories of climate hazards could include impacts from: Flooding of local roads, Drought conditions in 2020, Four Nor'easters in one month in 2018, or Heat waves with multiple days over 90 degrees F

$to heat and cool house. The heat also brings mosquitoes.

Q3 Respondent skipped this question.

Do you have any photos to share of events mentioned in question #2? If so, please upload:

Q4

Are there any specific infrastructure issues that Whitman should address and where is it located? (Replace a dam, bridge, or culvert? Fix a road?)

Rt 18 😁

Q5 Respondent skipped this question.

Do you have any photos to share of issues
mentioned in question #4? If so, please upload:

Q6

How prepared do you feel Whitman is for extreme climate hazard events?

Ă Somewhat Prepared

Q7

Please explain your reason for selecting your answer in Question 4.

Stocking up.

Q8

What does Whitman do well to mitigate climate hazards or prepare for climate change? Examples could include, but are not limited to: Town shelters, warming centers, and cooling centers, Reverse 911, Regional collaboration, including Mutual Aid Agreements with town departments or organizations in neighboring communities.

Whitman dpw does a great job of cleaning the snow, leaves from the drains, and trimming overhanging branches.

Q9

What are the opportunities to address potential natural or climatic hazards? Examples could include, but are not limited to: Providing transportation to shelters for vulnerable populations, including elderly and low-income residents, addressing frequently flooded roads, including Auburn Street (Route 14) at Pine Haven Drive

The shelters and transportation are a great idea. Also, some training on what to do if an emergency happens.

Q10

What social impediments do you feel should be addressed for greater resilience in Whitman?

Aiding the Unhoused Population, Support for low-income Families

Q11

What resources does the Town of Whitman need to be more prepared?

Staff and training,
Supplies or equipment,
Additional guidance related to Town operations before, during, an
after a hazard event

Q12 Public events, including virtual webinars,

How does your Town share information with the public? **Printed media, including reports, fact sheets, or**

brochures,

Online, including through the Town website, Facebook, and Twitter,

Strategic outreach to specific populations, such as elderly residents or other groups

Q13

We recognize the preparation and response to any challenge in our community has overlapping strategies and challenges. We are interested in documenting the community experience of COVID19. What worked well, and what could improve?

I would like to see the mask off and cleaned up. They are everywhere. I think our town does a great job.

Q14

Are there any additional comments or questions you would like to share with the project team?

Not at this time. Thank you.

Q15 Yes

Are you interested in attending future events, workshops, listening session, and other learning opportunities?

Q16

Thank you for completing the survey. Please enter your information below

Full Name **Ellie Flynn**

Phone or Email **781-985-6305**

Home Address	**37 Beulah St Whitman**

#2

COMPLETECOM

Collector:	Web Link 1 (Web Link)
Started:	Monday, May 10, 2021 9:39:44 AM
Last Modified:	Monday, May 10, 2021 9:48:59 AM
Time Spent:	00:09:14
IP Address:	50.206.94.194

Page 1

Q1

What climate hazard are you most concerned about? Rank the following options, with the first option being the hazard you are most concerned about.

Extreme Temperatures	**4**
Flooding	**7**
Winter Weather (snowstorms, blizzards)	**1**
Ice Storms	**3**
Drought	**5**
Fire	**6**
Severe wind (nor'easter, tornado, thunderstorm)	**2**
Not applicable to me (I am a representative from a surrounding community)	**8**

Q2

How have these climate hazards impacted you or the Town more broadly? Memories of climate hazards could include impacts from: Flooding of local roads, Drought conditions in 2020, Four Nor'easters in one month in 2018, or Heat waves with multiple days over 90 degrees F.

Loss of Power- cooling, heating, and charging stations.

Respondent skipped this question

Q3
Do you have any photos to share of events mentioned in question #2? If so, please upload:

Respondent skipped this question

Q4
Are there any specific infrastructure issues that Whitman should address and where is it located? (Replace a dam, bridge, or culvert? Fix a road?)

Respondent skipped this question

Q5
Do you have any photos to share of issues mentioned in question #4? If so, please upload:

Q6

How prepared do you feel Whitman is for extreme climate hazard events?

Ă **Very Prepared**

Q7 Respondent skipped this question.

Please explain your reason for selecting your answer in Question 4.

Q8

What does Whitman do well to mitigate climate hazards or prepare for climate change? Examples could include, but are not limited to: Town shelters, warming centers, and cooling centers, Reverse 911, Regional collaboration, including Mutual Aid Agreements with town departments or organizations in neighboring communities.

Reverse 911 to keep residents informed.

Q9 Respondent skipped this question.

What are the opportunities to address potential natural or climatic hazards? Examples could include but are not limited to: Providing transportation to shelters for vulnerable populations, including elderly and low-income residents, addressing frequently flooded roads, including.

Auburn Street (Route 14) at Pine Haven Drive

Q10
What social impediments do you feel should be addressed for greater resilience in Whitman?

Translation Services for English Language Learners,
Support for low-income Families,
Support for People of Color

Q11
What resources does the Town of Whitman need to be more prepared?

Additional guidance related to Town operations before, during, an
after a hazard event.
,
Data or studies showing the projected impacts of future climate hazards in Whitman

Q12
How does your Town share information with the public?

Online, including through the Town website, Facebook, and Twitte
,
Other (please specify):
Local Newspaper

Q13

We recognize the preparation and response to any challenge in our community has overlapping strategies and challenges. We are interested in documenting the community experience of COVID19. What worked well, and what could improve?

Reopening hesitancy

Q14 Respondent skipped this question.

Are there any additional comments or questions you would like to share with the project team?

Q15 No

Are you interested in attending future events, workshops, listening session, and other learning opportunities?

Q16

Thank you for completing the survey. Please enter your information below

Full Name	**Mary Holland**
Phone or Email	**mholland@whitman-ma.gov**
Home Address	**104 Birchbark Dr**