City of Beverly

Community Resilience Building

Summary of Findings

June 2019

Beverly City Hall
Photo Source:
BSC Group

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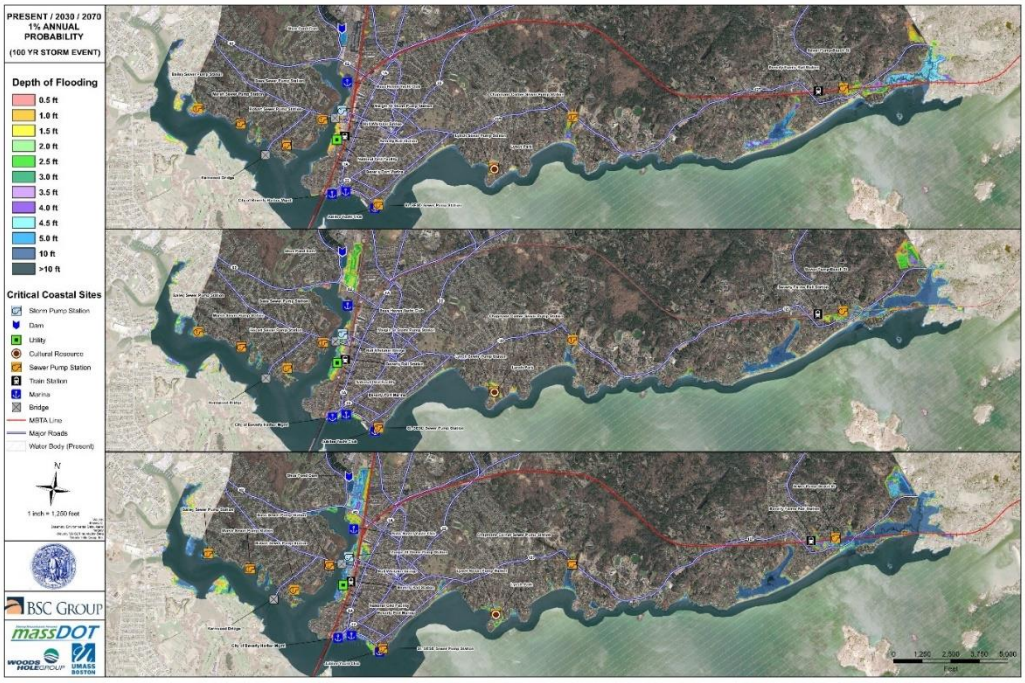
Beverly Coastline
Source: drone photography from BevCam 2017

EXECUTIVE SUMMARY

In accordance with Executive Order 569, which seeks to build resilience and adapt to the impacts of climate change, the City of Beverly, Massachusetts is pleased to submit this Summary of Findings Report. In 2018, the City of Beverly applied for and received a Municipal Vulnerability Preparedness (MVP) program planning grant from the Massachusetts Executive Office of Energy and Environmental Affairs (EEA) to complete a vulnerability assessment and action oriented resilience plan (Findings Report). This planning effort 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 City to achieve MVP community designation status from the EEA and receive preference for future state grants under the MVP program or other participating funding entities. As climate change continues to alter the way municipalities evaluate risk and manage resources, it is important to evaluate the effects of climate change and the solutions to address these challenges in a manner that assesses the interdependency of Beverly's infrastructural, societal, and environmental features. This Findings Report provides an important step in Beverly's journey to establish climate resilience within this coastal community and builds upon the City of Beverly's previous work on the *Beverly Coastal Vulnerability Assessment* in 2017 and the *City of Beverly Hazard Mitigation Plan* in 2018. Beverly Mayor Cahill also joined the Mayors' National Climate Action Agenda on behalf of the City of Beverly in 2017 and the City intends to next prepare a Climate Action Plan to address the reduction of greenhouse gas emissions and climate resilience in the City.



Beverly Coastal Vulnerability Assessment 2017
Source: BSC Group and Woods Hole Group

COMMUNITY RESILIENCE BUILDING PLANNING AND WORKSHOPS

The CRB process began with the establishment of a Core Team comprised of municipal staff members. The Core Team held strategic planning sessions on October 11, 2018, December 19, 2018, February 14, 2018, March 11, 2018 and April 23, 2019. Core Team meetings involved developing a broad understanding of the Hazards, Vulnerabilities, and Strengths that characterize the City of Beverly, and to identify a list of Preliminary Resilience Actions that the community may consider at the CRB Workshop. Core Team meetings were also used to identify the goals of the workshop within the context of community interests and needs. The Core Team decided that it was important to use the workshop as a mechanism to engage with the community using interactive media platforms such as a GIS community data viewer prepared specifically for the workshop and an interactive demonstration of the Massachusetts Data Clearinghouse Website, resilientma.org.

The Community Resilience Building Workshop was held on April 9, 2019 at the Beverly Golf and Tennis Club. Workshop participants included a diverse set of community stakeholders from municipal departments, local businesses, non-government entities, and local interest groups. Presentations were given by the City of Beverly and BSC Group, as well as Salem Sound Coastwatch and Endicott College to support the CRB workshop breakout groups in the morning and afternoon. BSC Group led two engagement and education Adaptation Action Stations giving participants interactive use of GIS mapping of hazards, particularly coastal flooding risk and project depth from previous coastal vulnerability work with Woods Hole Group. Solutions derived from the breakout groups were integrated in the CRB Planning Matrix and the day concluded with a brainstorming effort intended to identify interdependent project types that may be eligible for funding under the MVP program or other Massachusetts grant sources.

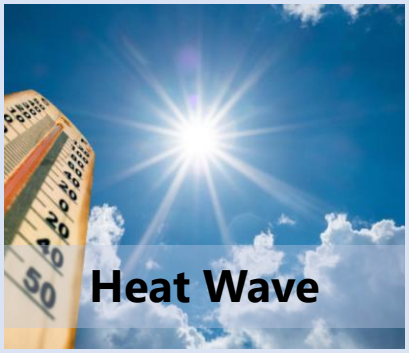
Climate resilience planning requires an ongoing effort by community stakeholders. Workshop attendees and other interested stakeholders are encouraged to provide comments, corrections, updates, or additional information of findings transcribed in this report to Aaron Clausen at aclausen@beverlyma.gov. The success of climate resilience planning in Beverly is contingent upon ongoing participation of community stakeholders.

DEFINING HAZARDS

The City of Beverly has several challenges related to establishing resilience to the effects of climate change. Beverly has over fourteen (14) miles of coastline and is already familiar with coastal storm damage. In 2017, coastal storms damaged sea walls at Lynch Park, Endicott College and other coastal structures and coastal erosion at Obear Park and Independence Park. Flooding of coastal roadways was also documented. Inland flooding of neighborhoods for intense precipitation events is also a challenge for Beverly. Climate change is expected to increase the occurrence and intensity of weather-related events and further stress municipal resources to address these types of incidents.

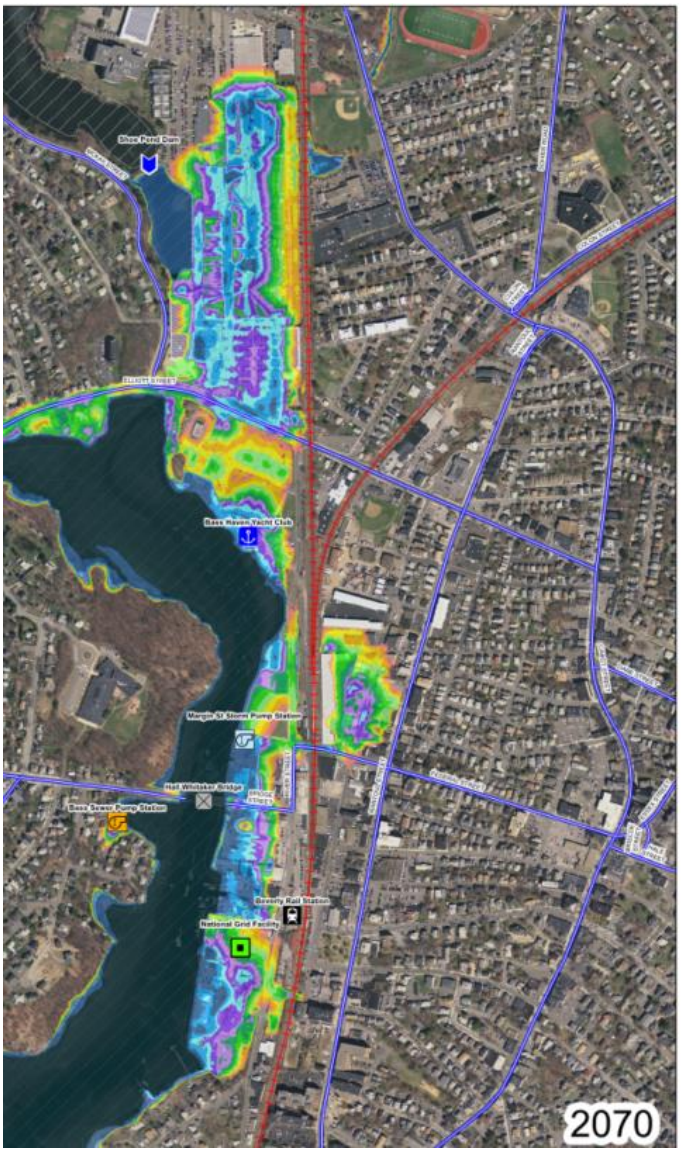
During the Core Team and CRB planning efforts, stakeholders identified the top natural hazards for the City of Beverly. Coastal flooding was identified as the top hazard among most participants. Inland flooding from precipitation events, extreme temperatures, extreme snow events, and drought represented additional climate exposure hazards and were highlighted as significant concerns for the City. Collectively, it was agreed upon by the group that the City of Beverly top hazards present ongoing and cumulative adverse impacts on the community's most important infrastructural, societal, and environmental resources.

TOP HAZARDS WITHIN BEVERLY



CHARACTERIZING A CLIMATE RESILIENT BEVERLY'S MUNICIPAL VULNERABILITIES AND STRENGTHS

The CRB process involves a robust stakeholder engagement effort and can be used to characterize the vulnerabilities and strengths unique to a given community. The Beverly CRB process revealed important characteristics that broadly represent the identity and culture of the community. Collectively, these characteristics provide a *snapshot* of the community's vulnerabilities and strengths and is an important starting point to identify community features most at risk to the effects of climate change.



Beverly Coastal Vulnerability Assessment – Bass River Flood Projections
Source: BSC Group and Woods Hole Group

Bass River District

The Bass River District contains the heart of Beverly's commercial activity at the Cummings Center, one of the MBTA Beverly commuter rail stations, multiple marinas, Innocenti Park, the Margin Street stormwater pump station and National Grid Substation No. 12. It is also an area of potential economic development for the City of Beverly with several parcels likely to be redeveloped in the near term. The Bass River District is extremely vulnerable to coastal flooding from the tidal Bass River. The district also has the potential for Urban Heat Island Effect because of the built environment that includes buildings, roadways, stormwater management infrastructure, parking lots, and traffic congestion.

The City of Beverly has been proactive to work with Cummings Center and MEMA to propose a tide gate solution for the stormwater outlet near Route 62/Elliott Street to address flooding in the roadway and parking areas at Cummings Center. The City has also initiated sediment dredging activities within the Bass River to increase the volume and nautical use of this natural resource with a proposed salt marsh restoration near Obear Park as a mitigation project. Beverly is also evaluating coastal erosion at Obear Park for a future grant-funded project to transform this recreational space into a resilient resource.

The community recognizes the district as an important source of strength and vulnerability within the community because of the resources it provides and the challenges it presents for the City of Beverly.

Emergency Preparedness and Response – Collaboration to Increase Climate Resilience

Emergency preparedness and response operations are managed by an established and collaborative effort between the Police Department, Fire Department, and MEMA Task Force 1. The City of Beverly has a well-defined and established operational procedure to prepare for the effects of natural hazards and associated response. Emergency preparedness and response systems in Beverly consist of a variety of communication procedures that that have proven effective in past emergency situations. The community recognizes these systems may be adequate and effective, but lack a detailed understanding of the tenets of this effort and agree that improvements to these systems may be both appropriate and necessary in the face of changing climate-related hazards. Upgrades to systems such as Reverse 911 was mentioned as an important first step to reach more residents on a variety of electronic devices. Proactive approaches that draw upon emergency coordination resources or capacity across municipal departments to increase the "buy-in" from other city departments was mentioned as a necessary preliminary planning effort.

The City of Beverly also hosts many educational, medical and social services institutions, such as Beverly Hospital, Endicott College, Landmark School, Monserrat School of Art, River House, and others. These entities sent representatives to the community workshop to participate in Beverly's Municipal Vulnerability Preparedness effort and provide input into ways to more closely communication with the City of Beverly. A major theme of the workshop was the need for more of these collaborative community events to foster resilience and preparedness between the City of Beverly and these third-party institutions. To ensure appropriate response in the event of climate hazard or other emergency, a network of key personnel should be established to foster greater understanding of municipal and private needs and resources.

Coastal Assets – Opportunity for Co-Benefits

Dung the CRB stakeholder engagement and the City's public listening process for the Beverly Harbor/Waterfront Plan, participants stressed the importance of the land/water connection and the recreational and commercial opportunities along the shoreline. Beverly has a diversity of coastal environments including rocky outcroppings, tidal river basins, sandy beaches, salt marshes and extensive eelgrass beds. The City is rich in public parks with beach access, recreational boating and a commercial fishing fleet. The community seeks to maintain these highly valued coastal resources and expand opportunities for recreational and commercial boating, waterfront walkways, parks, beaches and public access throughout the community while acknowledging that these resources are vulnerable to climate change impacts.

Lynch Park Seawall
Source: City of Beverly

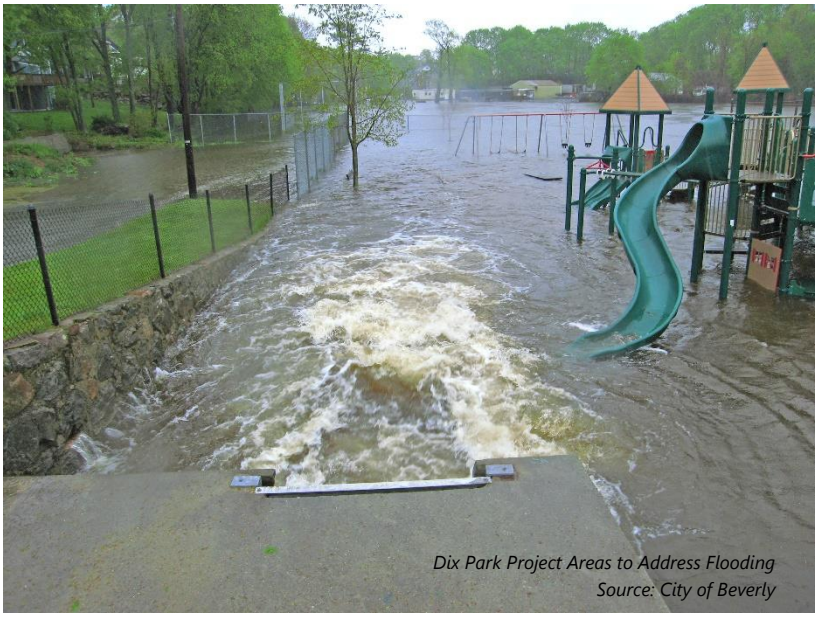
The Beverly Harbor/Waterfront Plan, completed in 2019 with funding from the

Seaport Economic Council, focused on the Beverly Harbor, the confluence of the Danvers and Bass Rivers (Goat Hill neighborhood area), and the eastern bank of the Bass River waterfront. Goals for the Beverly Harbor and the Bass River waterfront include protecting the City's marine and waterfront resources while encouraging new opportunities for development and increasing the resiliency of the waterfront to current flooding, projected sea level rise, and increased storm events. The landside of Beverly Harbor, the eastern bank of the Bass River and associated areas' water cover about 118 acres, while the City of Beverly owns just 9.7 acres of land within this area. This brings home the importance of building private/public partnerships that will be a community strength into the future. In addition, the City has partnerships with Salem Sound Coastwatch and other local non-profit partners that will support and implement the MVP actions.

Inland Flooding – Meeting Past Challenges and Taking on New Ones

Because of sea level rise predictions and current damage to coastal infrastructure from intense storms, much of the MVP adaptation actions focus on coastal assets. However, inland flooding of neighborhoods and roadways from intense precipitation events is also a challenge for Beverly. Workshop participants called for expanded climate awareness throughout the community, which could include information on how to reduce flooding at residential properties. The City may develop incentive programs that include retrofitting buildings, elevating critical utilities and using residential green infrastructure practices, such as rain gardens and porous surfaces that infiltrate or detain stormwater on site.

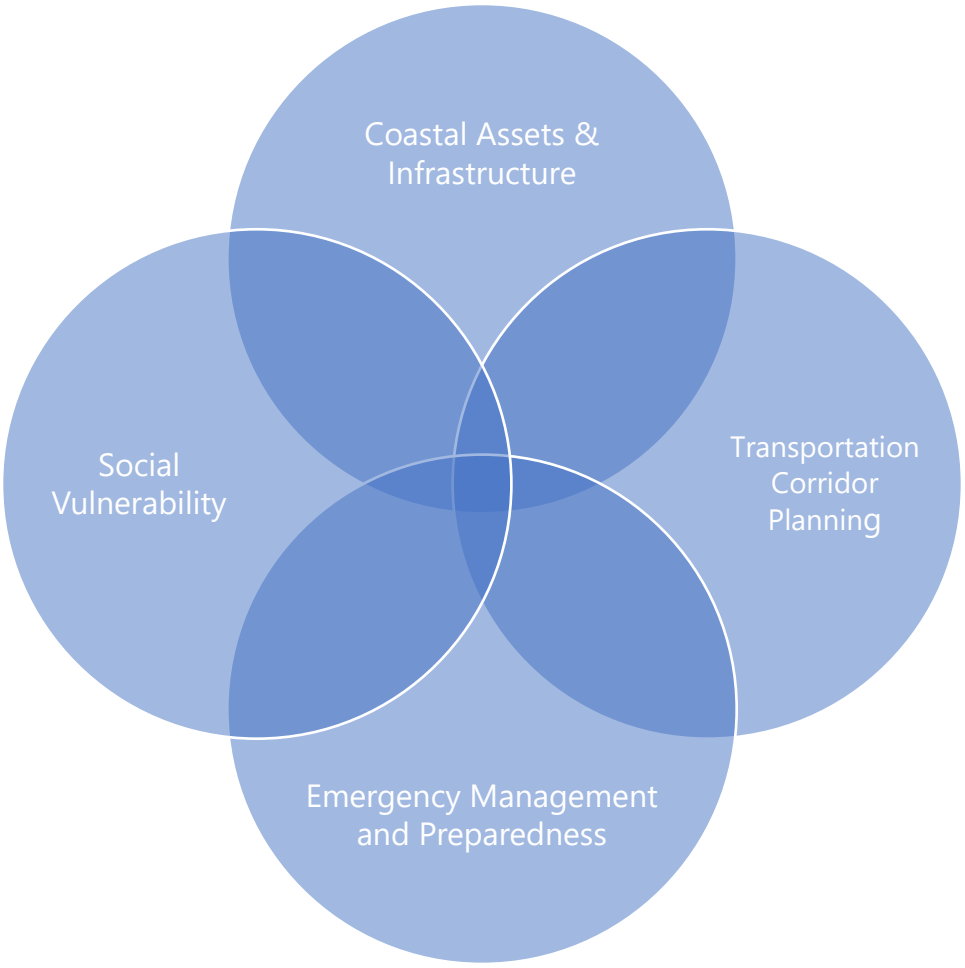
After the Mother Day Storm of 2006 when over 12 inches of rain caused severe flooding, the City of Beverly embarked on many inland flooding improvement projects, which have resulted in noticeably less flooding in the targeted areas. However, with the changing climate, the City understands the importance of performing updated watershed modeling to understand stormwater impacts on inland areas, roads and neighborhoods as well as the need for updated ordinances to require or incentive residential and commercial use of green infrastructure and limited impervious surfaces. Projects like the new Beverly Middle School that detains stormwater upstream of the Cummings Center has set an excellent example for the community and future development.



Dix Park Project Areas to Address Flooding
Source: City of Beverly

CATEGORIZING CONCERNS AND CHALLENGES

Workshop participants used the CRB process to collaboratively identify action-oriented solutions to address the climate vulnerabilities faced by the City of Beverly. These actions are organized into four categories based on a combination of community characteristics (i.e. strengths and vulnerabilities) and solutions identified by workshop participants. During the workshops, an emphasis was placed on the interdependence of these categories that allowed for the development of climate resilience solutions that span infrastructural, societal, and environmental features. Through this lens, overlapping solutions that provide co-benefits were identified and prioritized.



Coastal Assets and Infrastructure

The City, CRB stakeholders and the MVP process benefited from the *Beverly Coastal Vulnerability Assessment* completed in 2017 with funding from the Massachusetts Coastal Zone Management (CZM) Coastal Resilience Grant. This vulnerability assessment focused on the impacts of coastal flooding on municipal assets such as the sewer and stormwater pump stations, roadways and coastal structures as well as privately-owned, critical infrastructure assets, which included private utility substations, state-owned roadways and rails, private marinas and regional sewer infrastructure. This assessment evaluated coastal structures for the potential projected flood elevation (present, 2030 and 2070) to exceed the height of the coastal structure. The increased flood impacts to these structures and adjacent properties from wave run-up and storm surge were not conducted in the 2017 assessment, but CRB stakeholders understood that the impacts of coastal storms along with rising sea level may further stress coastal structures and properties. Therefore, coastal structures, such as seawalls, were given high priority actions, particularly Lynch Park/Woodbury Beach area, Beverly Harbor Management site and Independence Park, along with identifying privately-owned seawalls that protect public assets. One unique action encourages the use of "Q-Send" reporting by residents who notice damage to seawalls and coastal structures.

Coastal Assets & Infrastructure

Coastal Structures

Vulnerable Roads and Infrastructure – Route 62, Route 127, etc.

Pump Stations

Independence Park

Lynch & Obear Park

MBTA Commuter Rail

National Grid Substation

Located 23 miles north of Boston, the City's five commuter rail stops on the Newburyport and Rockport MBTA lines are assets that the community does not want to lose. The Beverly Depot commuter rail station is one of the top three busiest stops in the MBTA commuter rail system. It is in the Bass River District along with the Cummings Center, multiple marinas, Innocenti Park, the Margin Street stormwater pump station and National Grid Substation No. 12, which are all addressed as high action priorities in the MVP Risk Matrix. Other portions of the MBTA tracks located in inland areas in Beverly and in neighboring communities are also at risk and could jeopardize operation of this asset.

Some actions require coordination with state agencies and neighboring towns. The MassDOT Hall-Whitaker Bridge crosses the Bass River at Bridge Street and presents an opportunity for a regional intervention to protect the northerly upstream sectors of the river. Further upstream from Bridge Street, flooding is possible over the banks of Elliott Street/Route 62 as well as through a culvert located at the intersection of McKay and Elliott streets. Potential multi-element intervention is provided in the

Beverly Coastal Vulnerability Assessment as a resiliency option for the MassDOT Hall-Whitaker Bridge that crosses the Bass River at Bridge Street. North of Bridge Street, inundation due to storm surge is also likely down the length of Federal Street, expanding northwards into industrial areas. The *Beverly Coastal Vulnerability Assessment* identifies possible flooding scenarios for the coastal regions and scaled responses that range from deployable flood barrier to infrastructure changes such as tide gates and raised street elevations.

2016 King Tide Photo – Coastal Residences
Source: City of Beverly

CRB participants voiced the sentiments often expressed by Beverly residents, businesses and visitors that the natural resources, parks and shoreline are crucial to the City's character and quality of life. Several high priority actions address the resiliency of these natural assets, such as considering living shoreline opportunities to stop the erosion at Obear park, identifying dune restoration candidates where feasible in areas such as Woodbury Beach and exploring options to accommodate coastal flooding/sea level rise at Lynch park, Independence Park and Dane Street Beach. Options for preserving the Chubb Creek Marsh system while protecting large residential areas along Hale and West Street would most likely be a regional effort with the Town of Manchester-by-the-Sea, MassDOT and the MBTA Commuter Rail.

Transportation Corridor Planning

A key planning feature identified by Workshop participants is the interdependent sources of vulnerability and strengths that exist within the primary transportation corridor within Beverly. Two major arterial routes connect the majority of coastal Beverly to its neighboring communities – Route 127 and Route 62/Elliott Street. These areas are likely local evacuation routes yet both roadways are extremely vulnerable to coastal flooding at key intersections such as adjacent to the Cumming Center and at the MBTA rail crossing near West Beach. Workshop participants emphasized the need to coordinate with state agencies such as MassDOT and MBTA to mobilize projects in these locations while maintaining a focus on climate mitigation and adaptation efforts.

Workshop participants identified solutions such as promoting multimodal transportation (public transit, bicycle, walking) and green infrastructure options to address anticipated issues related to climate change. The need for the City of Beverly to revisit its transportation and

Transportation Corridor Planning

Carbon Mitigation

Urban Heat Island Mitigation

Evacuation Routes

Multimodal Transportation Network

Transportation/Parking Policy

parking policies going to forward to limit the use of impervious surfaces where feasible was highlighted by participants using concepts like shared parking arrangements in business districts to maximize use of these amenities and limit potential for urban heat island effect. Community engagement and outreach efforts were also noted as an important aspect of this initiative. Identifying ways to address the lack of awareness by non-resident daytime populations and utilize this transportation corridor that may not be aware of vulnerabilities or evacuation procedures was considered an important action.

Emergency Management and Preparedness

The City of Beverly has an established emergency management plan that municipal stakeholders feel adequately addresses the needs of the community in an emergency. The Police Department, Fire Department and MEMA Task Force 1 local personnel work in close coordination to implement emergency management and preparedness for the community. Current emergency management procedures include preparation, mitigation, response, and recovery actions, activation and operation of the Beverly Emergency Communications system, activation and operation of shelters, and municipal emergency preparedness training. Workshop participants agreed that increased emergency preparedness coordination and communications is among the most important action items the City can implement to improve resilience to the effects of a changing climate. Stakeholders indicated a need for additional knowledge sharing from all City departments regarding the City's emergency preparedness operations and coordination. The City has in place various systems to notify the community of important information (e.g. City website, social media, Reverse 911), but participants felt these resources lack dynamic use and promotion within the community. Participants felt strongly that an informational outreach/network that used multiple types of communications platforms appropriate for residents of all ages should be developed within the community to plan for climate change preparedness and response. Regional coordination should also occur within neighboring communities, and the City should draw upon the capacity provided by state agencies to enhance its overall climate preparedness and resilience. The need to improve the capacity of existing shelters/cooling centers to function during a storm event was also acknowledged. Increasing the number of shelters within the community was also emphasized, and participants expressed a need to increase the awareness of these resources at a city-wide scale. Understanding the needs and limitations of socially vulnerable populations (e.g. elderly population, medically vulnerable population, student population) should also be explicitly addressed within future planning efforts.

Emergency Management and Preparedness

Community Outreach

Evacuation Routes

Regional Coordination

Coordination with State Agencies

Municipal Communication Networks

Coordination with Private Schools/Colleges

Coordination with Beverly Hospital

Emergency Shelter/Assembly Areas

Social Vulnerability

Elderly Residents

Students/College Students

Commuters

Economically Stressed Individuals

Medically Dependent Individuals

Community Outreach, Education & Preparedness

Shelters/Assembly Areas

Social Vulnerability

Pictures from Coastal Vulnerability Workshop 2017
Source: BSC Group

Workshop participants expressed a diverse set of viewpoints pertaining to the need to address the considerations of socially vulnerable populations in response to the anticipated effects of climate change. Social vulnerability in Beverly is characterized by a few major potential populations such as the elderly population (anticipated that more than 30% of Beverly resident population will be over the age of 65 by 2025) and youth/students that attend numerous local public and private schools from elementary school through the non-resident college student populations at Endicott College and Monserrat School of Art. As such, stakeholders agreed that a central feature of climate adaptation planning within the community must ensure planning efforts do not reinforce existing sources of vulnerability. Participants agreed that future climate change planning should draw upon local resources such as the Council on Aging, Beverly Hospital and private schools, such as Endicott College, Monserrat School of Art, Landmark School and others to increase Beverly's capacity to address the needs of the most vulnerable, to improve communications with these third parties, and to provide appropriate levels of emergency management services based upon climate hazards. Community outreach and education initiatives were recommended. Alignment with ongoing efforts to improve emergency management, response, and communication was identified as an opportunity to reach groups that may otherwise be neglected during hazard mitigation planning. Efforts to identify socially vulnerable populations (e.g. elderly groups) was encouraged.

Climate Resilience Actions to address these concerns were prioritized through workshop activities and coordination with Core Team leadership. These Climate Resilience Actions are organized by High Priority, Medium Priority, and Low Priority Actions.

High Priority Actions

Category	Action
Infrastructure	SESD Pump Station – Beverly to serve as sponsor community for SESD to pursue grant funding opportunities to evaluate near term dry floodproofing of SESD pump station in Beverly and long-term scenario planning for relocating this pump station.
	Lynch Park – Perform assessment of Lynch Park property and evaluate comprehensive flood protection strategies for the facility. Incorporate permanent educational signage related to climate change at Lynch Park.
	Municipal New Construction (Police Station) – Incorporate climate resilience strategies and coastal flood protections into final design of new police station in Bass River District. Consider police station outposts for staff and storage of fleet equipment to decentralize resources in case of a flood event.
	Elliott Street/Route 62 – Undertake a conceptual redesign of Elliott Street/Route 62 to explore raising the roadway and associated infrastructure or provide deployable flood barriers near the Bass River/Cummings Center. Prepare a Climate Action Plan to address reduction of greenhouse gas emissions and climate resilience.
	Route 127 (Beach Street to MBTA Rail Crossing at West Street/Hale Street) – Review coastal flood pathway data and incorporate stormwater watershed modeling where needed to evaluate solutions for this section of roadway. Work with MBTA to discuss options for temporary and permanent flood protection strategies. Prepare a Climate Action Plan to address reduction of greenhouse gas emissions and climate resilience.
	Heavily Utilized Arterial Roadways- Review coastal flood pathway data and incorporate stormwater watershed modeling where needed to evaluate sections of roadway that are vulnerable and limited in their ability to function as part of local evacuation route. Prepare a Climate Action Plan to address reduction of greenhouse gas emissions and climate resilience.
	MBTA Commuter Rail – Newburyport-Rockport Line – Work with MBTA on flood protection projects to protect track lines and MBTA infrastructure (elevate tracks, deployable flood barriers, modification of elevations of adjacent municipal assets/infrastructure, etc.), as well as the potential to provide larger community benefits.
	MBTA Parking Garage near Beverly Depot Station – Identify ways partner with MBTA to use structured parking garage during storm events (other than snow emergency procedures, which are currently in place) to protect additional vehicles in a neighborhood vulnerable to flooding.

	National Grid Substation No. 12 – Work with National Grid to understand their climate-ready planning for this substation and how it could impact Beverly. Consider ways to work with National Grid on district-wide flood protection measures for Bass River District to protect substation and other assets.
	MassDOT Route 128 – Work with MassDOT to understand their climate-ready planning for this regional asset and how it will impact Beverly, particularly for regional evacuations on this roadway through other communities.
	Cummings Center – Continue to work with property owner to address flood risk - on-going engagement regarding proposed tide gate project and upstream culvert project. Study Cummings Center/Bass River district for a neighborhood-level vulnerability assessment with strong stakeholder engagement. Consider floodproofing options for Cummings Center facilities.
	Pump Stations (Sewer) Multiple Locations – Develop/purchase an asset management tool to track city infrastructure and maintenance, as well as record storm damage incidents. Evaluate options for floodproofing Marsh Street pump station located in residential neighborhood highly susceptible to coastal flooding events.
	Pump Station (Sewer) Beach Street – Redesign Beach Street sewer pump station to include an earthen berm design for flood protection and dry floodproofing methods for resilience.
	Pump Station (Stormwater) Margin Street – Prepare a conceptual plan to look at feasibility of redesigning Innocenti Park to prepare for coastal flood impacts and rebuild/relocate Margin St pump station.
	Commercial & Residential Development – Update zoning ordinances & regulations to promote climate resilience. Require/incentive green infrastructure (green roofs, rain gardens, etc.). Identify potential for public-private partnerships to mitigate climate risks. Develop a climate review checklist for permitting. Prepare a Climate Action Plan to address reduction of greenhouse gas emissions and climate resilience.
	Coastal Structures – Consider options for elevated coastal walkway to provide public access and flood/erosion protection measures. Complete inventory of all coastal structures to determine ownership and maintenance responsibilities. Follow up inventory with structural evaluation of identified at-risk coastal structures, particularly at Lynch Park/Woodbury Beach, Beverly Harbor Master Building and Independence Park. Work with private owners of coastal structures to promote maintenance and repair as needed. Encourage use of "Q-Send" reporting for residents who notice damage to seawalls and coastal structures.
	Evacuation Routes – Develop a local evacuation plan to evaluate flood impacts to arterial roadways such as Rte. 62/Elliott St and Rte. 127 that facilitate evacuation of neighboring communities. Work with adjacent communities to understand how their local evacuation plans intersect with Beverly's plan.

Environmental	Bass River – Evaluate district-wide flood protection options. Incorporate public access, open space and an urban waterfront redevelopment along Bass River to provide flood resilience and smart growth in Beverly.
	Coastal Erosion – Obear Park – Develop potential grant-funded project to address erosion at Obear Park, including salt marsh restoration and other nature-based solutions.
	Coastal Erosion – Independence Park/Dane Street Beach – Redesign Independence Park/Dane Street Beach to accommodate coastal flooding/sea level rise. Restore dune areas where possible.
	Coastal Erosion - Evaluate coastal erosion at Rice's Beach/Sandy Point/Woodbury Beach/Pleasant View/etc. Restore dune areas where feasible in areas such as Woodbury Beach.

Medium Priority Actions

Category	Action
Infrastructure	Department of Public Works Yard – Identify relocation options for DPW yard or decentralize storage of DPW assets for resilience to coastal flooding. Evaluate flood protection options for DPW yard.
	Municipal Green Infrastructure – Undertake city-wide evaluation of green infrastructure opportunities to infiltrate stormwater and reduce inland flooding.
	Tidal Control Structures – Evaluate potential for tidal control structures in the Bass River District, including, but not limited to, Bridge Street, and areas near Chubbs Creek marsh system at Hale Street.
	Beverly Harbor/port area/marinas – Incorporate coastal resiliency planning at Beverly Harbor and consider a "Clean & Resilient Marinas" Initiative for public facilities. Provide additional outreach and education to private marinas and recreational boaters.
	Low-lying residential neighborhoods – Conduct an assessment of regulatory incentive programs – retrofits/education/relocations/etc. Require new development in these areas to consider floodproofing and elevation of first floors and utility infrastructure.
	Municipal Infrastructure – Sewer/Storm Drain/Water - Develop/purchase an asset management tool to track city infrastructure and maintenance. Update stormwater ordinance to require/incentive residential use of green infrastructure and limited impervious surfaces. Update sewer I&I requirements and undertake projects to infiltrate stormwater throughout the community. Perform updated watershed modeling to understand stormwater impacts in changing climate on inland areas and neighborhoods.

	Municipal Buildings - Incorporate underground flood/stormwater storage systems at municipal facilities. Evaluate need/use of emergency backup power generation and status/condition of HVAC systems at municipal facilities throughout the community. Develop GIS inventory of building equipment and resilience measures. Address deferred maintenance issues. Prepare a Climate Action Plan to address reduction of greenhouse gas emissions and climate resilience.
	Parking & Transportation Policy - Develop comprehensive policy to judicially use impervious surfaces in city right-of-way areas by limiting parking, promoting pedestrian, bicycle and transit use activity, incorporating street trees and green infrastructure. Promote shared parking agreements on private commercial properties. Prepare a Climate Action Plan to address reduction of greenhouse gas emissions and climate resilience.
	Beverly Residents- Establish a Climate Working Group to meet and collaborate regularly to discuss resiliency planning in Beverly. Provide additional opportunities for resident education on climate change and resilience measures.
	Aging Housing Stock - Educate residents on building retrofit and floodproofing opportunities and state incentives for building energy upgrades. Encourage development of additional housing stock, including down-sizing options for seniors.
	Beverly Harbor Management Authority - Work with Beverly Harbor Management Authority to pursue grant opportunities that could fund coastal resiliency planning in Beverly Harbor and the Bass River District and to provide additional opportunities for education on climate change and resilience measures to waterfront stakeholders such as private marinas and recreational boaters.
	Beverly Hazard Mitigation Plan - Follow up on recommendations of the Beverly Hazard Mitigation Plan. Focus the next five-year update to the plan by 2023 on a combined hazard mitigation and climate vulnerability assessment like the Massachusetts State Hazard Mitigation and Vulnerability Assessment model/approach.
	Public Education- Conduct a comprehensive campaign to promote climate awareness throughout community. Incorporate climate science education into school curriculum. Work with local non-profit partners like Salem Sound Coastwatch to improve and maintain these efforts.
	Municipal Staffing/Resources - Support municipal staffing levels by engaging student interns from local colleges/universities. Develop an overall community preparedness plan to integrate all departments/facilities and resources to prepare for climate hazards. Train city staff in new skill sets needed to address climate change from emergency prep to maintaining green infrastructure, etc. Start a department heads meeting, including members of the MVP Core Team, to maintain MVP designation and track climate goal metrics.
	Beverly Coastal Vulnerability Assessment- Follow up on recommendations of the Beverly Coastal Vulnerability Assessment. Pursue further CZM Coastal Resilience grants to further climate adaptation work in Beverly.

Social	Vulnerable Population – Seniors- Work on strategies to reach isolated seniors such as an "Adopt-a-Grandparent" program or neighborhood check-ins. Develop program for seniors living alone to register with Beverly Fire Department and Council-on-Aging. Develop transit network for increased access during hazards.
	Vulnerable Population – Students/Youth Under Age 18 - Develop volunteer opportunities for Beverly youth and school programs to promote climate change education and awareness, including environmental cleanups, maintenance of green infrastructure, etc. Develop Grades K-3 science programs to enhance love of nature and to prepare students for future climate change education. Incorporate climate change education into all Grades 4-12 education and engage with private schools.
	Business Community- Partner with Chamber of Commerce and Beverly Main Streets to engage with business community. Explore public-private partnerships to further climate adaptation strategies and implementation. Educate small businesses and tenants about climate hazards.
	Vulnerable Population – Economically Stressed - Work with adjacent cities and towns to coordinate additional permanent housing shelters. Work with River House to understand the community needs and improve communications prior to hazard events.
	Vulnerable Population – Medically Dependent- Increase communications, including alerts system, with social service providers & Beverly Hospital to aid medically dependent residents.
Environmental	Dane Street Beach/Lyons Park- Perform structural evaluation of coastal structures - seawalls/groins/jetties/etc. Undertake a feasibility study to redesign Dane Street Beach and Lyons Park for resilience and flood protection for adjacent residential neighborhood.
	Independence Park - Perform structural evaluation of coastal structures. Undertake a feasibility study to redesign Independence Park for resilience.
	Tree Canopy- Prepare a community-wide assessment of municipal trees for health, location, quantity, etc. and incorporate into overall asset management tracking. Develop comprehensive tree planting plan and strategy. Perform a community-wide analysis of opportunities for the use of green infrastructure throughout Beverly. Test for gas leaks before street trees are planted. Prepare a Climate Action Plan to address reduction of greenhouse gas emissions and climate resilience.
	Salt Marshes - Salt marsh restoration projects at Obear Park (on-going culvert repair associated with Bass River dredging project), Chubbs Creek and Thissel Marsh.

Low Priority Actions

Category	Action
Infrastructure	Beverly Regional Airport - Engage with Beverly Airport coordinator and be involved directly with the airport's upcoming planning process. Evaluate potential flooding impacts to roadway access to airport for deliveries/access/etc. Enhance community awareness of airport facilities and resources.
	Renewable Energy Sources- Evaluate municipal properties for use of renewable energy/solar facilities. Engage with the Clean Energy Committee to promote resilient, clean energy options throughout the City.
	Drinking Water Supply- Implement water conservation measures and education and promote water reuse technologies.
	Private Schools - Improve communications between City & private schools (public safety hotline, multiple methods of communications (e-mail/internet/phone call/text/physical beacons, markers or alarms/etc.). Form working group with private schools and City to discuss emergency management and include them in Beverly CEMP updates going forward. City of Beverly to participate in upcoming Endicott College Vulnerability Assessment.
	Beverly Hospital - Improve communications between City & hospital (public safety hotline, multiple methods of communications (e-mail/internet/phone call/text/physical beacons, markers or alarms/etc.). Form working group with hospital and City to discuss emergency management and public health.
	Public Schools - Evaluate shelter facilities to identify additional needs and resources - generators, supplies and other items. Create comprehensive map and inventory of sheltering facilities. Develop a communications plan for staff, students, residents and people who work in Beverly and implement city-wide.
Environmental	Air Quality - Promote clean energy technologies - solar and wind - in Beverly. Develop transit plan for the City of Beverly to reduce single-occupant vehicle trips within the city. Promote bicycle share programs, increase multi-use pathways throughout City and improve connectivity between neighborhoods. Prepare a Climate Action Plan to address reduction of greenhouse gas emissions and climate resilience.
	Open Space – Beaches/Parks/Recreational Facilities- Purchase additional municipal open space for coastal and inland flood protection.

Community Workshop Participants

Name	Affiliation
Mayor Michael Cahill	City of Beverly
Eric Barber	City of Beverly DPW/Engineering
Lisa Chandler	City of Beverly DPW/Engineering
Amy Maxner	City of Beverly Conservation Agent
Aaron Clausen	City of Beverly Planning Department
Walt Kosmowski	BevCam
Denise Deschamps	City of Beverly Economic Development
Emily Flaherty	Salem Sound Coastwatch
Edmund Lydon	Beverly Hospital
MaryAnn Holak	Beverly Council on Aging
Chris Bertoni	Beverly Conservation Commission
David Lacaillade	Beverly Hospital
Barbara Warren	Salem Sound Coastwatch
Peter Pommersheim	South Essex Sewerage District (SESD)
Michael Trembley	Beverly Hospital
Roland Adams	City of Beverly DPW/Engineering
Katie Moniz	BSC Group
Alfa Zimmerman	BSC Group/Beverly Resident
Brian Cullinan	BSC Group
Robert Buchsbaum	Mass Audubon/Beverly Conservation Comm.
Anthony Michetti	Endicott College
Leslie Gould	GBCC
Sue Goganian	Historic Beverly
David Liebmann	Glen Urquhart School
Jeffrey Malloy	BSC Group
Meghan Wrenn	Endicott College
Gin Wallace	Beverly Main Streets
David Lang	Beverly City Council
John Cuffe	W2CA
Jeannette Cuffe	W2CA
Caroline Mason	Beverly Historic District Commission
Anna Langstaff	Beverly Public Library
Loren Meicher	Landmark School
Mari Butler	Endicott College
Rob Dever	City of Beverly DPW
Sue Charochak	Beverly Schools
Claire-Marie Hart	North Shore Community College
Gloria Bouillan	Beverly Airport
Sue Gabriel	Beverly Bootstraps
Maureen Wark	Monserrat College of Art

Citation

Beverly (2019) Community Resilience Building Workshop Summary of Findings, BSC Group, Inc., Salem Sound Coastwatch, and City of Beverly, Beverly, Massachusetts

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Workshop Facilitators

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Acknowledgements

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Thank you to the Massachusetts Office of Coastal Zone Management (CZM) and its North Shore Coordinator Kathryn Glenn who previously funded the *Beverly Coastal Vulnerability Assessment* in FY16 and who participated in the Public Listening Session for this project.

Thank you to Mayor Michael Cahill for his support and participation in the Beverly CRB Workshop, the Public Listening Session and other core team meetings. His participation in this process was an inspiration to the community and reaffirmed the City's commitment to continued climate resilience planning and adaptation measures. Mayor Cahill also joined the Mayors' National Climate Action Agenda on behalf of the City of Beverly in 2017.

Thank you to the community leaders within Beverly who attended the Beverly CRB Workshop, Public Listening Session and other core team meetings. The institutional knowledge provided by workshop participants was essential to the success of this process.

CLIMATE CHANGE INFOGRAPHIC

CLIMATE CHANGE

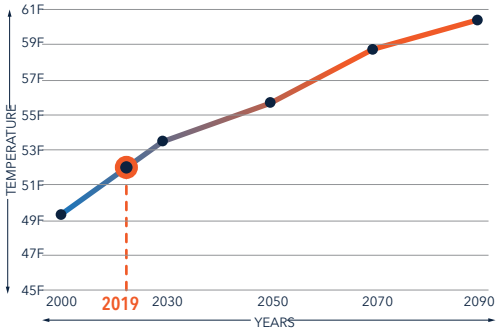
Beverly, Massachusetts,
Ipswich and North Coastal Watershed Basin

Andover, Beverly, Billerica, Boxford, Burlington, Danvers, Hamilton, Ipswich, Lynnfield, Middleton, North Andover, North Reading, Peabody, Reading, Rowley, Tewksbury, Topsfield, Wenham, Wilmington,Woburn, Danvers, Essex, Everett, Gloucester, Hamilton, Ipswich, Lynn, Malden, Manchester, Marblehead, Melrose, Nahant, Reading, Revere, Rockport, Salem, Salisbury, Saugus, Stoneham, Swampscott and Wakefield

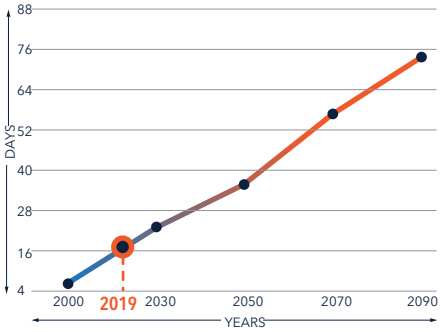
Global warming is caused by the accumulation of greenhouse gases within the atmosphere. Gases that contribute to the greenhouse effect include water vapor, carbon dioxide, methane, and nitrous oxide. On earth, human activities such as burning fossil fuels, land deforestation and wetland loss/conversion have altered the delicate balance of atmospheric conditions that regulate our climate. The effect of these changes cause global climate change that are likely to be significant and to increase over time.

EXTREME TEMPERATURES

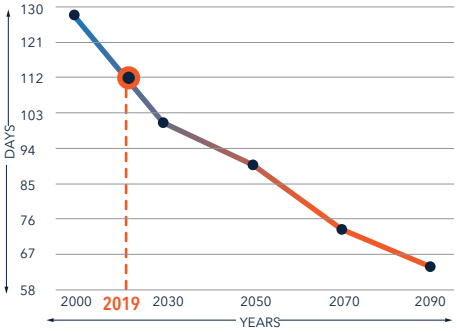
Average Temperatures



Days with Maximum Temperature over 90˚F



Fewer Days Below Freezing

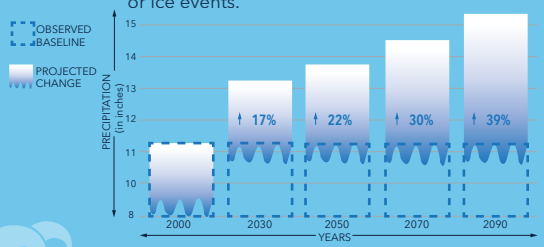


What can Beverly expect as CLIMATE CHANGES?

Climate change has already had observable effects on the environment. Rising temperatures, changes in precipitation patterns, droughts and heat waves, sea-level rise, and extreme storm events have **altered the distribution of risk and how resources are managed.**

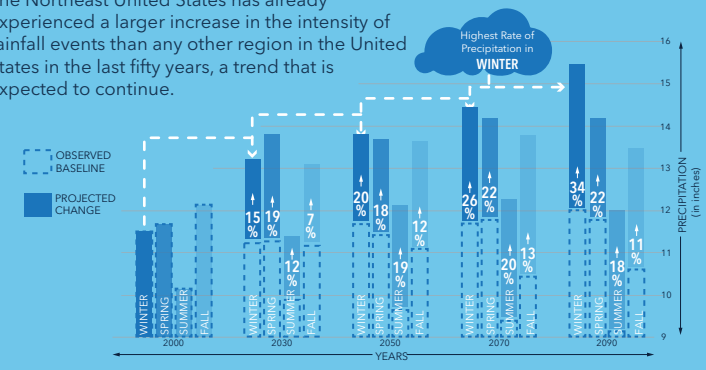
Extreme Snow And Ice Events

Total Annual Precipitation is expected to increase within the Ipswich and North Coastal Basin over the remainder of the century. Most of this increase is expected to occur during winter months where precipitation will fall as either rainfall or extreme snow or ice events.



More Annual Precipitation and Inland Flooding

The Northeast United States has already experienced a larger increase in the intensity of rainfall events than any other region in the United States in the last fifty years, a trend that is expected to continue.

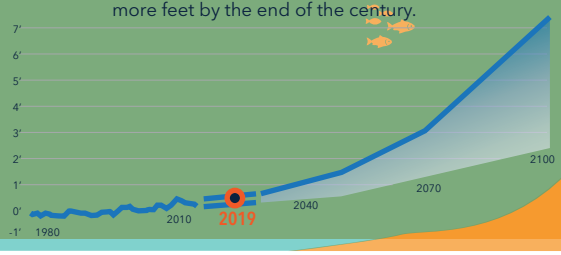


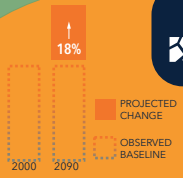
Blizzards, Nor'Easters and Hurricanes

Storm events fueled by higher temperatures, increased evaporation, and atmospheric moisture leads to stormy weather of increased duration and intensity.

Sea level Rise

Sea levels are rising as the oceans warm, ice melts and water expands. Sea levels have already risen about a foot and could rise several more feet by the end of the century.





Drought Conditions

Due to the combined effects of higher temperatures, reduced groundwater recharge from extreme precipitation events, earlier snowmelt, summer and fall droughts may become more frequent.

Heatwaves

Extreme heat events are expected to become more frequent and intense. Socially vulnerable populations are particularly vulnerable to the dangers related to extreme temperature conditions.

Sources: Massachusetts Executive Office of Energy and Environmental Affairs; ResilientMA.org

BSC GROUP

COMMUNITY RESILIENCE BUILDING MATRIX

Community Resilience Building Risk Matrix

www.CommunityResilienceBuilding.org

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

1 - Coastal Flooding (Sea Level Rise/Storm Surge)	2- Inland Flooding (due to Precipitation/Storm Event)	3- Heat Wave	4- Extreme Storms	5 - Drought

	Vulnerabilities (V) and/or Strengths (S)	V / S	Location	Owner	Solutions	Top Priority Hazard #	Infrastructural	Societal	Environmental	Hight, Medium or Low priority for action over the Short or Long term and Ongoing	
										H/M/L	S/L/O
1	South Essex Sewerage District (SESD) - Pump Station and Sewerage Infrastructure	V/S	city-wide	SESD	City of Beverly to be sponsor community for SESD to pursue grant opportunities to evaluate near term dry floodproofing of pump station and long-term scenario planning for relocating the pump station.	1	X			H	S
2	Historic/Recreation Facilities - Lynch Park	V/S	Lynch Park	City of Beverly	Perform assessment of Lynch Park property and evaluate comprehensive flood protection strategies for Lynch Park. Incorporate permanent education signage related to climate change at Lynch Park.	1&4	X			H	S
3	Municipal New Construction - Police Station	V/S	Elliott Street/Rte 62 near Cummings Center	City of Beverly	Incorporate climate resilience strategies and coastal flooding projections into design of new police station. Develop phased approach to protecting and operating this municipal asset over time. Promote clean energy initiatives such as Net Zero goals using thermal heat pump technology and solar installations at police station and future municipal buildings. Consider police station outposts for staff and storage of fleet equipment to decentralize resources in case of a flooding event.	1&2	X			H	S
4	Heavily Utilitized Arterial Roadways (Rte 62/Elliott Street, Rte 127 - Beach Street to MBTA Rail Crossing at West Street/Hale Street - Lee's Crossing, etc.)	V	city-wide	City of Beverly	Review coastal flood pathway data and identify areas where roadways should be elevated or flood mitigation/stormwater projects are necessary. Update stormwater watershed modeling to incorporate additional data on floodprone roadways using increased rainfall amount and intensity projections. Undertake a conceptual redesign of Elliott Street study to explore raising the roadway and associated infrastructure near Bass River. Explore deployable flood barrier options for this area as an alternate scenario. Prepare a Climate Action Plan to address reduction of greenhouse gas emissions and climate resilience.	1-2-4	X			H	L
5	Commuter Rail - Newburyport-Rockport Line	V/S	city-wide	MBTA	Work with MBTA on flood protection projects that could protect track lines and MBTA infrastructure (elevate tracks, deployable flood barriers, etc.), as well as provide larger community resiliency benefits. Identify ways to use MBTA structured parking garage during storm events (other than snow emergency) to protect vehicles in vulnerable neighborhood.	1-4	X			H	L
6	National Grid Substation No. 12 (River Street site) & overhead electrical infrastructure	V	River Street	investor-owned utility	Work with National Grid to understand their climate-ready planning for this substation and how it will impact Beverly.	1-3-4	X			H	L

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										H/M/L	S/L/O
7	Transportation - Highways (Route 128)	S	Route 128	MassDOT	Work with MassDOT to understand their climate-ready planning for this asset and how it will impact Beverly. Regional evacuations utilize the Route 128 corridor and Beverly should be aware of any potential vulnerabilities to this infrastructure in neighboring communities.	2&4	X			H	L
8	Commercial/Employment Center - Cummings Center	V/S	Cummings Center	private	Continue to work with property owner to address flood risk - on-going engagement regarding proposed tide gate project and upstream culvert project. Study Cummings Center/Bass River district for a neighborhood-level vulnerability assessment with strong stakeholder engagement. Consider floodproofing options for Cummings Center facilities.	1 & 2	X			H	O
9	Pump Stations - Sewer (multiple City of Beverly owned assets)	V	city-wide	City of Beverly	Develop/purchase an asset management tool to track city infrastructure and maintenance. Prioritize flood protection of these assets and address deferred maintenance. Evaluate options for floodproofing Marsh Street Pump Station, which is located in a neighborhood highly susceptible to coastal flooding events.	1	X			H	O
10	Pump Station (Sewer) - Beach Street	V	Beach Street	City of Beverly	Redesign Beach Street sewer pump station site to include an earthen berm design for flood protection and dry floodproofing methods for resilience.	1 & 2	X			H	O
11	Pump Stations - Stormwater - Margin Street	V	Margin Street (adjacent to Innocenti Park)	City of Beverly	Develop/purchase an asset management tool to track city infrastructure and maintenance. Prepare a conceptual plan to look at feasibility of redesigning Innocenti Park to prepare for coastal flood impacts and rebuild/relocate the Margin Street pump station to a more protected area of the site.	1	X			H	O
12	Commercial & Residential Development	V/S	city-wide	private	Update zoning ordinances & regulations to promote climate resilience. Require/incentive green infrastructure (green roofs, rain gardens, etc.). Identify potential for public-private partnerships to mitigate climate risks. Develop a climate review checklist for permitting.	1-5	X			H	O
13	Coastal Structures (seawalls, etc.)	V/S	city-wide	public/ private	Consider elevated coastal walkway options along coastline to provide access and flood/erosion protection measures. Complete on-going inventory all seawalls and determine ownership and maintenance responsibilities. Follow up this inventory effort with structural evaluation of identified at-risk coastal structures, particularly Lynch Park/Woodbury Beach area, Beverly Harbor Management site and Independence Park. Identify privately-owned seawalls that are protecting public assets and work with owners to promote maintenance and repair as needed. Encourage Q-Send use for residents who notice damage to seawalls and coastal structures.	1-2-4	X			H	O

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										H/M/L	S/L/O
14	Evacuation/Emergency Routes - Local	V	city-wide	public	Develop a local evacuation plan to evaluate flooding impacts to arterial roadways such as Rte 62/Elliott Street and Rte 127 that facilitate a potential evacuation of neighborhoods or community. Work with adjacent communities to understand how their local evacuation plans intersect with Beverly's evacuation plans.	1&2	X			H	O
15	Coastal/Tidal Rivers	V/S	city-wide	public	Evaluate large-scale flood protection options for Bass River to address significant coastal flooding risk associated with climate change that limits an area of potential economic development. Incorporate public access, open space and an urban waterfront design along Bass River redevelopments to provide flood resilience and smart growth in Beverly going forward.	1&4			X	H	L
16	Coastal Erosion (beaches/riverbanks)	V	city-wide	public/ private	Develop project to address erosion at Obear Park - consider living shoreline opportunities. Redesign Independence Park/Dane Street Beach to accommodate coastal flooding/sea level rise. Restore dune areas where feasible in areas such as Woodbury Beach. Evaluate coastal erosion at Rice's Beach/Sandy Point/Woodbury Beach/Pleasant View/etc.	1-2-4			X	H	O
17	Department of Public Works Yard	V	Roundy Street	City of Beverly	Identify relocation options for the DPW Yard or decentralize storage of DPW assets for resilience to coastal flooding. Evaluate flood protection options for DPW Yard.	1 & 4	X			M	L
18	Inland Flooding	V	city-wide	City of Beverly	Update stormwater modeling for Beverly neighborhood watersheds using increased precipitation projections to prepare for climate change. Identify neighborhoods prone to inland flooding and evaluate opportunities for green and grey infrastructure solutions to address flood risk.	2	X			M	L
19	Municipal Green Infrastructure	V	N/A	City of Beverly	Undertake a city-wide evaluation of green infrastructure opportunities to infiltrate stormwater and reduce inland flooding ,	2-3	X			M	O
20	Tidal Control Structures	V/S	Bass River District	City of Beverly/ private	Evaluate potential for tidal control structures in the Bass River District, including, but no limited to, at Bridge Street and near Chubbs Creek marsh system at Hale Street.	1	X			M	L
21	Beverly Harbor/port area/marinas	V	Beverly Harbor	public/ private	Incorporate coastal resiliency planning in Beverly Harbor with City facilities leading the way in best management practice and design under a "Clean & Resilient Marinas Initiative". Provide additional opportunities for education on climate change and resilience measures to waterfront stakeholders such as private marinas and recreational boaters.	1-2-4	X			M	L

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22	Low-lying coastal residential neighborhoods (Marsh Ave, Fosters Point, Willow St, etc.)	V	Marsh Ave, Quincy Park, etc.	private	Conduct assessment of regulatory incentive programs - retrofits/education/relocations/etc. Require new development in these areas to consider floodproofing and elevation of building first floors and utilities.	1	X			M	L
23	Municipal Infrastructure - Sewer/Storm Drain/Water	V	city-wide	City of Beverly	Develop/purchase an asset management tool to track city infrastructure and maintenance. Update stormwater ordinance to require/incentive residential use of green infrastructure and limited impervious surfaces. Update sewer I&I requirements and undertake projects to infiltrate stormwater throughout the community. Perform updated watershed modeling to understand stormwater impacts in changing climate on inland areas and neighborhoods.	1-2-4-5	X			M	O
24	Municipal Buildings	V	city-wide	City of Beverly	Incorporate underground flood/stormwater storage systems at municipal facilities. Evaluate need/use of emergency backup power generation and status/condition of HVAC systems at municipal facilities throughout the community. Develop GIS inventory of building equipment and resilience measures. Address deferred maintenance issues.	1-2-4	X			M	O
25	Parking & Transportation Policy	V	city-wide	City of Beverly	Develop comprehensive policy to judicially use impervious surfaces in city right-of-way areas by limiting parking, promoting pedestrian, bicycle and transit use activity, incorporating street trees and green infrastructure. Promote shared parking agreements on private commercial properties.	3	X			M	O
26	Educated and engaged City of Beverly residents/Good civic participation	S	city-wide	N/A	Establish a Climate Working Group to meet and collaborate regularly to discuss resiliency planning in Beverly. Provide additional opportunities for resident education on climate change and resilience measures.	1-5		X		M	S
27	Older housing stock (lack of HVAC, building envelope/roof/insulation issues, etc.)	V	city-wide	private	Educate residents on building retrofit and floodproofing opportunities and state incentives for building energy upgrades. Encourage development of additional housing stock, including down-sizing options for seniors.	3&4		X		M	L
28	Beverly Harbor Management Authority	S	Beverly Harbor	public	Work with Beverly Harbor Management Authority to pursue grant opportunities that could fund coastal resiliency planning in Beverly Harbor and the Bass River District and to provide additional opportunities for education on climate change and resilience measures to waterfront stakeholders such as private marinas and recreational boaters.	1		X		M	O

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29	*Beverly Hazard Mitigation Plan Update (FEMA/MEMA FY17)*	S	city-wide	City of Beverly	Follow up on recommendations of the *Beverly Hazard Mitigation Plan.* Focus the next five-year update to the plan on a combined hazard mitigation and climate vulnerability assessment similar to the *Massachusetts State Hazard Mitigation and Vulnerability Assessment* model/approach.	1-5		X		M	O
30	Public Education/Awareness	V/S	city-wide	City of Beverly	Conduct a comprehensive campaign to promote climate awareness throughout community. Incorporate climate science education into school curriculum. Work with local non-profit partners like Salem Sound Coastwatch to improve and maintain these efforts.	1-5		X		M	O
31	Municipal Staffing/Finances/Resources/ Infrastructure Recordkeeping/GIS/etc.	S	city-wide	City of Beverly	Support municipal staffing levels by engaging student interns from local colleges/universities. Develop an overall community preparedness plan to integrate all departments/facilities and resources to prepare for climate hazards. Train city staff in new skill sets needed to address climate change from emergency prep to maintaining green infrastructure, etc. Start a department heads meeting, including members of the MVP Core Team, to maintain MVP designation and track climate goal metrics.	1-5		X		M	O
32	*Beverly Coastal Vulnerability Assessment (CZM CR Grant FY17)*	S	city-wide	City of Beverly	Follow up on recommendations of the *Beverly Coastal Vulnerability Assessment.* Pursue further CZM Coastal Resilience grants to further climate adaptation work in Beverly.	1		X		M	O
33	Vulnerable Population - Growing number of Seniors (65 yrs of age and older)	V	city-wide	N/A	Work on strategies to reach isolated seniors such as an "Adopt-a-Grandparent" program or neighborhood check-ins. Develop program for seniors living alone to register with Beverly Fire Department, as well as Council-on-Aging. Develop a transit network for increased access during hazards.	1-5		X		M	O
34	Vulnerable Population - Students/Youth (children under 18 years old)	V	city-wide	N/A	Develop volunteer opportunities for Beverly youth and school programs to promote climate change education and awareness, including env cleanups, maintenance of green infrastructure, etc. Develop Grades K-3 science programs to enhance love of nature and to prepare students for future climate change education. Incorporate climate change education into all Grades 4-12 education and engage with private schools.	1-5		X		M	O
35	Business Community/Commercial Uses - Retail, Office, etc.	S	city-wide	private	Partner with Chamber of Commerce and Beverly Main Streets to engage with business community. Explore public-private partnerships to further climate adaptation strategies and implementation. Educate small businesses and tenants about climate hazards.	1-5		X		M	O

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36	Vulnerable Population - Economically Stressed (Housing/Financial Resources)	V	city-wide	N/A	Work with adjacent cities and towns to coordinate additional permanent housing shelters. Work with River House to understand the community needs and improve communications prior to hazard events.	1-2-3-4		X		M	O
37	Vulnerable Population - Medically Dependent Residents	V	city-wide	N/A	Increase communications with social service providers and Beverly Hospital to aid medically dependent residents. Improve alert system to include social service providers.	3&4		X		M	O
38	Recreational Area - Independence Park	V	Lothrop Street	City of Beverly	Perform structural evaluation of coastal structures - seawalls/groins/jetties/etc. Undertake a feasibility study to redesign Independence Park for resilience.	1			X	M	L
39	Recreation Area - Dane Street Beach/Lyons Park	V	Lothrop Street at Dane Street	City of Beverly	Perform structural evaluation of coastal structures - seawalls. Undertake a feasibility study to redesign Dane Street Beach and Lyons Park for resilience and flood protection for adjacent residential neighborhood.	1			X	M	L
40	Trees (numerous, but not well distributed throughout community, some aged/diseased, some endangered by recent storms, etc.) and other vegetation	V/S	city-wide	public/ private	Prepare a community-wide assessment of municipal trees for health, location, quantity, etc. and incorporate into overall asset management tracking. Develop comprehensive tree planting plan and strategy. Perform a community-wide analysis of opportunities for the use of green infrastructure throughout Beverly. Test for gas leaks before street trees are planted.	4&5			X	M	L
41	Salt Marshes (Obear Park, Thissel Marsh, etc.)	V/S	city-wide	public/ private	Salt marsh restoration projects at Obear Park (on-going culvert repair associated with Bass River dredging project), Chubbs Creek and Thissel Marsh.	1, 4&5			X	M	O
42	Beverly Regional Airport	V/S	Henderson Road	City of Beverly	Engage with Beverly Airport coordinator and be involved directly with the airport's upcoming planning process. Evaluate potential flooding impacts to roadway access to airport for deliveries/access/etc. Enhance community awareness of airport facilities and resources.	2&4	X			L	L
43	Renewable Energy Sources - Solar Installations (Residential/Commercial)	S	city-wide	public/ private	Evaluate municipal properties for use of renewable energy/solar facilities or installations. Engage with the Clean Energy Committee to promote resilient, clean energy options throughout the City.	3	X			L	L

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1 - Coastal Flooding (Sea Level Rise/Storm Surge)	2- Inland Flooding (due to Precipitation/Storm Event)	3- Heat Wave	4- Extreme Storms	5 - Drought

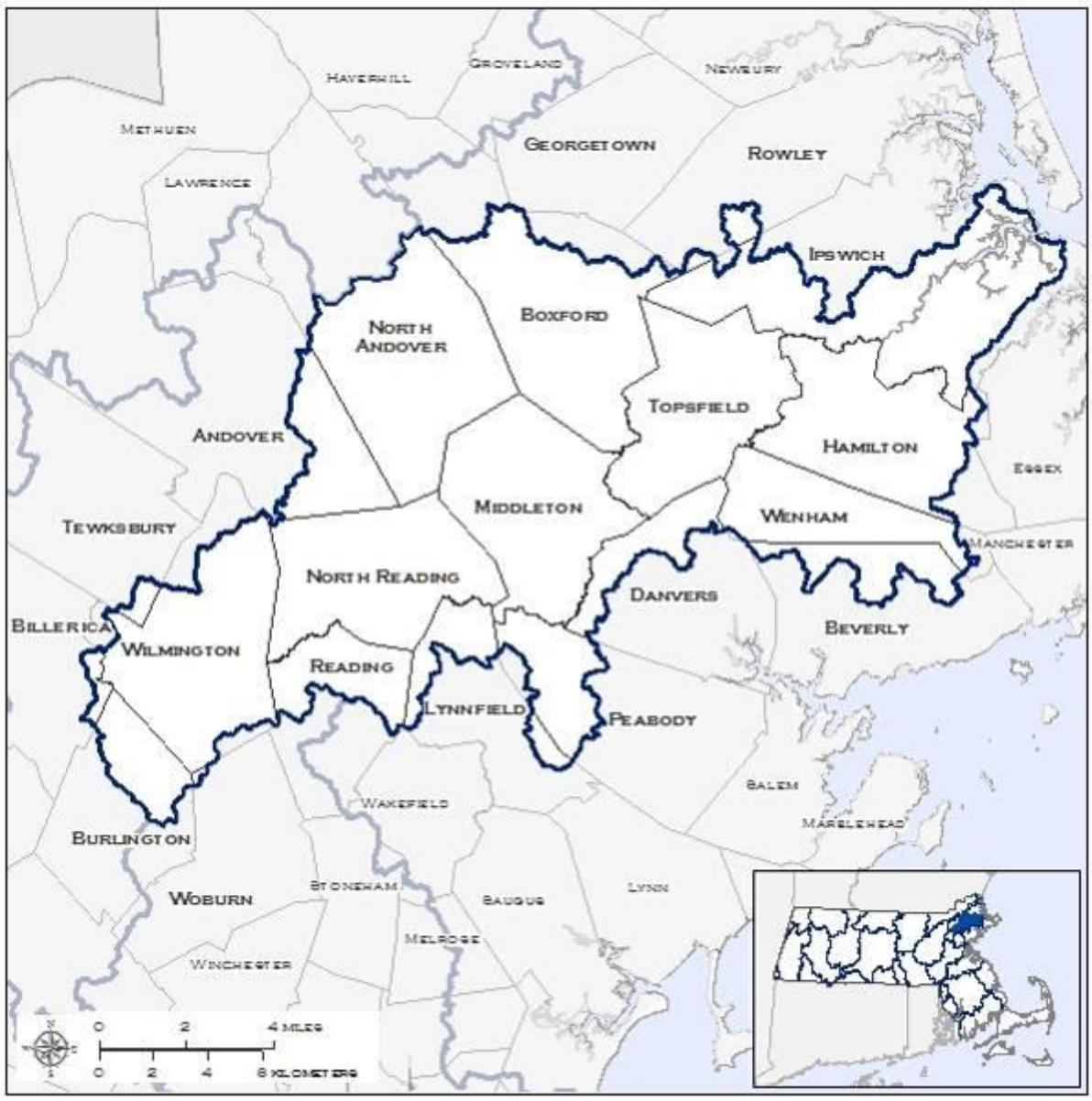
	Vulnerabilities (V) and/or Strengths (S)	V / S	Location	Owner	Solutions	Top Priority Hazard #	Infrastructural	Societal	Environmental	Hight, Medium or Low priority for action over the Short or Long term and Ongoing	
										H/M/L	S/L/O
44	Drinking Water Supply	V/S	regional	public	Implement water conservation measures and education and promote water reuse technologies.	5	X			L	L
45	Private Schools - Endicott College, Monseratt School of Art, Landmark School, Waring School, Glen Urquhart, etc.	V/S	city-wide	private	Improve communications between City & private schools (public safety hotline, multiple methods of communications (e-mail/internet/phone call/text/physical beacons, markers or alarms/etc.). Form working group with private schools and City to discuss emergency management and include them in Beverly CEMP updates going forward. City of Beverly to participate in upcoming Endicott College Vulnerability Assessment.	1-4	X			L	O
46	Beverly Hospital	V/S	85 Herrick Street	Lahey Health	Improve communications between City & hospital (public safety hotline, multiple methods of communications (e-mail/internet/phone call/text/physical beacons, markers or alarms/etc.). Form working group with hospital and City to discuss emergency management and public health.	2-3-4	X			L	O
47	Public Schools (mult. new facilities used as shelters/heating & cooling centers)	S	city-wide	City of Beverly	Evaluate shelter facilities to identify additional needs and resources - generators, supplies and other items. Create comprehensive map and inventory of sheltering facilities. Develop a communications plan for staff, students, residents and people who work in Beverly and implement city-wide.	1-4	X			L	O
48	Air Quality	V/S	city-wide	public	Promote clean energy technologies - solar and wind - in Beverly. Develop transit plan for the City of Beverly to reduce single-occupant vehicle trips within the city. Promote bicycle share programs, increase multi-use pathways throughout City and improve connectivity between neighborhoods.	3&4			X	L	L
49	Open Space - Beaches, Parks & Recreational Facilities	S	city-wide	City of Beverly	Purchase additional municipal open space for coastal and inland flood protection.	1-5			X	L	L

IPSWICH & NORTH COASTAL BASIN CLIMATE PROJECTIONS

IPSWICH BASIN

MUNICIPALITIES WITHIN IPSWICH BASIN:

Andover, Beverly, Billerica, Boxford, Burlington, Danvers, Hamilton, Ipswich, Lynnfield, Middleton, North Andover, North Reading, Peabody, Reading, Rowley, Tewksbury, Topsfield, Wenham, Wilmington, and Woburn



Many municipalities fall within more than one basin, so it is advised to use the climate projections for the basin that contains the majority of the land area of the municipality.

IPSWICH BASIN

Ipswich Basin		Observed Baseline 1971-2000 (°F)	Projected Change in 2030s (°F)	Mid-Century Projected Change in 2050s (°F)	Projected Change in 2070s (°F)	End of Century Projected Change in 2090s (°F)
Average Temperature	Annual	49.5	+2.1 to +4.3	+2.7 to +6.2	+3.3 to +8.9	+3.6 to +10.8
	Winter	29.0	+2.1 to +4.8	+2.8 to +7.2	+3.6 to +9.0	+3.9 to +10.5
	Spring	47.0	+1.9 to +3.7	+2.6 to +5.5	+2.7 to +7.9	+3.4 to +9.6
	Summer	69.6	+2.1 to +4.2	+2.7 to +6.6	+3.1 to +9.5	+3.7 to +12.0
	Fall	52.0	+1.9 to +4.6	+3.3 to +6.5	+3.0 to +9.4	+3.5 to +11.8
Maximum Temperature	Annual	59.6	+2.0 to +4.0	+2.5 to +6.0	+3.0 to +8.9	+3.3 to +10.7
	Winter	38.3	+1.8 to +4.3	+2.4 to +6.7	+3.1 to +8.3	+3.4 to +9.6
	Spring	57.4	+1.8 to +3.5	+2.3 to +5.5	+2.7 to +8.1	+3.2 to +9.5
	Summer	80.2	+1.8 to +4.3	+2.6 to +6.5	+3.0 to +9.7	+3.5 to +12.2
	Fall	62.2	+2.0 to +4.4	+2.9 to +6.7	+2.9 to +9.6	+3.4 to +12.1
Minimum Temperature	Annual	39.3	+2.2 to +4.6	+3.0 to +6.3	+3.6 to +8.9	+3.9 to +10.9
	Winter	19.7	+2.4 to +5.2	+3.2 to +7.7	+4.1 to +9.7	+4.3 to +11.1
	Spring	36.5	+2.0 to +3.9	+2.9 to +5.8	+2.9 to +7.7	+3.5 to +9.5
	Summer	58.9	+2.2 to +4.3	+2.8 to +6.9	+3.2 to +9.3	+3.9 to +11.9
	Fall	41.8	+1.8 to +4.8	+3.2 to +6.3	+3.1 to +9.3	+3.7 to +11.6

- The Ipswich basin is expected to experience increased average temperatures throughout the 21st century. Maximum and minimum temperatures are also expected to increase throughout the end of the century. These increased temperature trends are expected for annual and seasonal projections.
- Seasonally, maximum summer and fall temperatures are expected to see the highest projected increase throughout the 21st century.
    - Summer mid-century increase of 2.6 °F to 6.5 °F (3-8% increase); end of century increase of 3.5 °F to 12.2 °F (4-15% increase).
    - Fall mid-century increase of 2.9 °F to 6.7°F (5-11% increase); end of century increase by and 3.4 °F to 12.1 °F (5-19% increase).
- Seasonally, minimum winter and fall temperatures are expected to see increases throughout the 21st century.
    - Winter mid-century increase of 3.2 °F to 7.7 °F (16-39% increase); end of century increase by 4.3 °F to 11.1 °F (22-56% increase).
    - Fall mid-century of 3.2 °F to 6.3 °F (8-15% increase); end of century increase of 3.7°F to 11.6 °F (9-28% increase).

IPSWICH BASIN

Ipswich Basin		Observed Baseline 1971-2000 (Days)	Projected Change in 2030s (Days)	Mid-Century Projected Change in 2050s (Days)	Projected Change in 2070s (Days)	End of Century Projected Change in 2090s (Days)
Days with Maximum Temperature Over 90°F	Annual	7	+6 to +17	+8 to +31	+10 to +50	+12 to +69
	Winter	0	+0 to +0	+0 to +0	+0 to +0	+0 to +0
	Spring	<1[60]	+<1[60] to +1	+<1[60] to +1	+<1[60] to +2	+<1[60] to +4
	Summer	6	+5 to +15	+7 to +25	+9 to +41	+11 to +55
	Fall	<1[60]	+<1[60] to +2	+1 to +5	+1 to +9	+1 to +12
Days with Maximum Temperature Over 95°F	Annual	1	+2 to +6	+2 to +13	+3 to +26	+5 to +41
	Winter	0	+0 to +0	+0 to +0	+0 to +0	+0 to +0
	Spring	0	+<1[60] to +<1[60]	+<1[60] to +<1[60]	+<1[60] to +1	+<1[60] to +1
	Summer	1	+2 to +6	+2 to +11	+3 to +23	+4 to +35
	Fall	0	+<1[60] to +1	+<1[60] to +1	+<1[60] to +3	+<1[60] to +5
Days with Maximum Temperature Over 100°F	Annual	<<1[60]	+<1[60] to +1	+<1[60] to +3	+<1[60] to +8	+<1[60] to +14
	Winter	0	+0 to +0	+0 to +0	+0 to +0	+0 to +0
	Spring	0	+0 to +<1[60]	+0 to +<1[60]	+0 to +<1[60]	+0 to +<1[60]
	Summer	<1[60]	+<1[60] to +1	+<1[60] to +3	+<1[60] to +7	+<1[60] to +13
	Fall	0	+0 to +<1[60]	+0 to +<1[60]	+0 to +1	+0 to +1

- Due to projected increases in average and maximum temperatures throughout the end of the century, the Ipswich basin is also expected to experience an increase in days with daily maximum temperatures over 90 °F, 95 °F, and 100 °F.
    - Annually, the Ipswich basin is expected to see days with daily maximum temperatures over 90 °F increase by 8 to 31 more days by mid-century, and 12 to 69 more days by the end of the century.
    - Seasonally, summer is expected to see an increase of 7 to 25 more days with daily maximums over 90 °F by mid-century.
    - By end of century, the Ipswich basin is expected to have 11 to 55 more days.

[60] Over the observed period, there were some years with at least 1 day with seasonal Tmax over a certain threshold while in all the other years that threshold wasn't crossed seasonally at all.

IPSWICH BASIN

Ipswich Basin		Observed Baseline 1971-2000 (Days)	Projected Change in 2030s (Days)	Mid-Century Projected Change in 2050s (Days)	Projected Change in 2070s (Days)	End of Century Projected Change in 2090s (Days)
Days with Minimum Temperature Below 0°F	Annual	4	-1 to -3	-1 to -3	-1 to -3	-1 to -3
	Winter	4	-1 to -3	-1 to -2	-1 to -3	-1 to -3
	Spring	<1[61]	-0 to +<1[61]	-0 to -0	-0 to -0	-0 to -0
	Summer	0	-0 to -0	-0 to -0	-0 to -0	-0 to -0
	Fall	<1[61]	-0 to -0	-0 to -0	-0 to -0	-0 to -0
Days with Minimum Temperature Below 32°F	Annual	130	-12 to -28	-18 to -42	-21 to -55	-23 to -65
	Winter	79	-3 to -9	-4 to -16	-6 to -24	-8 to -31
	Spring	31	-5 to -11	-7 to -15	-8 to -18	-9 to -20
	Summer	0	-0 to -0	-0 to -0	-0 to -0	-0 to -0
	Fall	20	-4 to -9	-6 to -11	-7 to -15	-6 to -16

- Due to projected increases in average and minimum temperatures throughout the end of the century, the Ipswich basin is expected to experience a decrease in days with daily minimum temperatures below 32 °F and 0 °F.
- Seasonally, winter, spring and fall are expected to see the largest decreases in days with daily minimum temperatures below 32 °F.
    - Winter is expected to have 4 to 16 fewer days by mid-century, and 8 to 31 fewer days by end of century.
    - Spring is expected to have 7 to 15 fewer days by mid-century, and 9 to 20 fewer days by end of century.
    - Fall is expected to have 6 to 11 fewer days by mid-century, and 6 to 16 fewer days by end of century.

[61] Over the observed period, there were some years with at least 1 day with seasonal Tmin under a certain threshold while in all the other years that threshold wasn't crossed seasonally at all.

IPSWICH BASIN

Ipswich Basin		Observed Baseline 1971-2000 (Degree-Days)	Projected Change in 2030s (Degree-Days)	Mid-Century Projected Change in 2050s (Degree-Days)	Projected Change in 2070s (Degree-Days)	End of Century Projected Change in 2090s (Degree-Days)
Heating Degree-Days (Base 65°F)	Annual	6269	-515 to -1104	-690 to -1507	-829 to -2019	-925 to -240
	Winter	3257	-189 to -442	-248 to -660	-316 to -816	-358 to -960
	Spring	1682	-158 to -305	-215 to -458	-230 to -625	-295 to -735
	Summer	88	-32 to -56	-40 to -71	-48 to -80	-52 to -83
	Fall	1240	-124 to -333	-232 to -427	-221 to -612	-241 to -701
Cooling Degree-Days (Base 65°F)	Annual	590	+213 to +448	+292 to +754	+342 to +1152	+399 to +1521
	Winter	0	-1 to +2	-0 to +6	+0 to +3	+0 to +6
	Spring	23	+14 to +34	+22 to +57	+26 to +98	+20 to +147
	Summer	507	+154 to +335	+197 to +539	+233 to +797	+280 to +1025
	Fall	54	+31 to +93	+45 to +178	+54 to +276	+79 to +358
Growing Degree-Days (Base 50°F)	Annual	2628	+398 to +811	+556 to +1237	+632 to +1938	+716 to +2438
	Winter	6	+0 to +15	+2 to +18	+6 to +31	+5 to +40
	Spring	299	+82 to +158	+105 to +258	+120 to +387	+130 to +502
	Summer	1800	+190 to +388	+247 to +603	+286 to +874	+341 to +1107
	Fall	516	+96 to +289	+167 to +424	+154 to +645	+210 to +815

- Due to projected increases in average, maximum, and minimum temperatures throughout the end of the century, the Ipswich basin is expected to experience a decrease in heating degree-days, and increases in both cooling degree-days and growing degree-days.
- Seasonally, winter historically exhibits the highest number of heating degree-days and is expected to see the largest decrease of any season, but spring and fall are also expected to see significant change.
    - The winter season is expected to see a decrease of 8-20% (248 -660 degree-days) by mid-century, and a decrease of 11-29% (358-960 degree-days) by the end of century.
    - The spring season is expected to decrease in heating degree-days by 13-27% (215-458 degree-days) by mid-century, and by 18-44% (295 -735 degree-days) by the end of century.
    - The fall season is expected to decreases in heating degree-days by 19-34% (232-427 degree-days) by mid-century, and by 19-57% (241 -701 degree-days) by the end of century.

- Conversely, due to projected increasing temperatures, summer cooling degree-days are expected to increase by 39-106% (196 -539 degree-days) by mid-century, and by 55-202% (280-1025 degree-days) by end of century.
- Seasonally, summer historically exhibits the highest number of growing degree-days and is expected to see the largest decrease of any season, but the shoulder seasons of spring and fall are also expected to see an increase in growing degree-days.
    - The summer season is projected to increase by 14-34% (247 -603 degree-days) by mid-century, and by 19-61% (341 -1107 degree-days) by end of century.
    - Spring is expected to see an increase by 35-86% (105 -258 degree-days) by mid-century and 43-168% (130 -502 degree-days) by end of century.
    - Fall is expected to see an increase by 32-82% (167 -424 degree-days) by mid-century and 41-158% (210 -815 degree-days) by end of century.

IPSWICH BASIN

Ipswich Basin		Observed Baseline 1971-2000 (Days)	Projected Change in 2030s (Days)	Mid-Century Projected Change in 2050s (Days)	Projected Change in 2070s (Days)	End of Century Projected Change in 2090s (Days)
Days with Precipitation Over 1"	Annual	8	+<1[62] to +2	+<1[62] to +3	+1 to +2	+1 to +3
	Winter	2	+<1[62] to +1	+<1[62] to +1	+<1[62] to +1	+<1[62] to +2
	Spring	2	+0 to +1	+0 to +1	+<1[62] to +1	+<1[62] to +1
	Summer	2	+0 to +<1[62]	+0 to +1	+0 to +1	+0 to +1
	Fall	2	+0 to +1	+0 to +1	+0 to +1	+0 to +1
Days with Precipitation Over 2"	Annual	1	+<1[62] to +<1[62]	+0 to +1	+<1[62] to +1	+<1[62] to +1
	Winter	<1[62]	+0 to +<1[62]	+0 to +<1[62]	+0 to +<1[62]	+<1[62] to +<1[62]
	Spring	<1[62]	+0 to +<1[62]	+0 to +<1[62]	+0 to +<1[62]	+0 to +<1[62]
	Summer	<1[62]	+0 to +<1[62]	+0 to +<1[62]	+0 to +<1[62]	+0 to +<1[62]
	Fall	<1[62]	+0 to +<1[62]	+0 to +<1[62]	+<1[62] to +<1[62]	+0 to +<1[62]
Days with Precipitation Over 4"	Annual	<1[62]	+0 to +<1[62]	+0 to +<1[62]	+0 to +<1[62]	+0 to +<1[62]
	Winter	0	+0 to +0	+0 to +0	+0 to +<1[62]	+0 to +<1[62]
	Spring	0	+0 to +<1[62]	+0 to +<1[62]	+0 to +<1[62]	+0 to +<1[62]
	Summer	0	+0 to +<1[62]	+0 to +<1[62]	+0 to +<1[62]	+0 to +<1[62]
	Fall	0	+0 to +<1[62]	+0 to +<1[62]	+0 to +<1[62]	+0 to +<1[62]

- The projections for expected number of days receiving precipitation over one inch are variable for the Ipswich basin, fluctuating between loss and gain of days.
    - Seasonally, the winter season is generally expected to see the highest projected increase.
    - The winter season is expected to see an increase in days with precipitation over one inch of 0-1 days by mid-century, and of 0-2 days by the end of century.
    - The spring season is expected to see an increase in days with precipitation over one inch of 0-1 days by mid-century, and of an increase of 0-1. days by the end of century.

[62] Over the observed period, there were some years with at least 1 day with seasonal precipitation over a certain threshold while in all the other years that threshold wasn't crossed seasonally at all.

IPSWICH BASIN

Ipswich Basin		Observed Baseline 1971-2000 (Inches)	Projected Change in 2030s (Inches)	Mid-Century Projected Change in 2050s (Inches)	Projected Change in 2070s (Inches)	End of Century Projected Change in 2090s (Inches)
Total Precipitation	Annual	45.6	-0.1 to +4.3	+0.0 to +5.4	+0.5 to +6.6	+0.7 to +7.0
	Winter	11.6	-0.3 to +1.7	+0.1 to +2.3	+0.2 to +3.0	+0.5 to +4.0
	Spring	11.6	-0.4 to +2.3	-0.1 to +2.1	+0.1 to +2.6	+0.1 to +2.6
	Summer	10.2	-0.4 to +1.3	-0.6 to +1.9	-0.8 to +2.0	-1.6 to +1.8
	Fall	12.2	-1.0 to +0.9	-1.1 to +1.4	-1.8 to +1.6	-1.6 to +1.3

- Similar to projections for number of days receiving precipitation over a specified threshold, seasonal projections for total precipitation are also variable for the Ipswich basin.
    - The winter season is expected to experience the greatest change with an increase of 1-20% by mid-century, and of 4-34% by end of century.
    - Projections for the summer and fall seasons are more variable, and could see either a drop or increase in total precipitation throughout the 21st century.
        - The summer season projections for the Ipswich or basin could see a decrease of 0.6 to an increase of 1.9 inches by mid-century (decrease of 5% to increase of 19%) and a decrease of 1.6 to an increase of 1.8 inches by the end of the century (decrease of 16% to increase of 18%).
        - The fall season projections for the Ipswich basin could see a decrease of 1.1 to an increase of 1.4 inches by mid-century (decrease of 9% to increase of 12% and a decrease of 1.6 to an increase of 1.3 inches by the end of the century (decrease of 13% to increase of 11%).

Ipswich Basin		Observed Baseline 1971-2000 (Days)	Projected Change in 2030s (Days)	Mid-Century Projected Change in 2050s (Days)	Projected Change in 2070s (Days)	End of Century Projected Change in 2090s (Days)
Consecutive Dry Days	Annual	17	+0 to +2	-0 to +3	-1 to +3	-0 to +3
	Winter	12	-1 to +1	-1 to +1	-1 to +2	-1 to +2
	Spring	11	-1 to +1	-1 to +1	-1 to +1	-1 to +1
	Summer	13	-1 to +2	-1 to +2	-1 to +3	-1 to +2
	Fall	12	+0 to +2	+0 to +3	-0 to +4	-0 to +3

- Annual and seasonal projections for consecutive dry days, or for a given period, the largest number of consecutive days with precipitation less than 1 mm (~0.04 inches), are variable throughout the 21st century.
    - For all the temporal parameters, the Ipswich basin is expected to see a slight decrease to an increase in consecutive dry days throughout this century.
    - Seasonally, the fall and summer seasons are expected to continue to experience the highest number of consecutive dry days.
        - The summer season is expected to experience an increase of 0-3 days in consecutive dry days by the end of the century.

NORTH COASTAL BASIN

MUNICIPALITIES WITHIN NORTH COASTAL BASIN:

Beverly, Danvers, Essex, Everett, Gloucester, Hamilton, Ipswich, Lynn, Lynnfield, Malden, Manchester, Marblehead, Melrose, Nahant, Peabody, Reading, Revere, Rockport, Salem, Salisbury, Saugus, Stoneham, Swampscott, Wakefield, and Wenham

Many municipalities fall within more than one basin, so it is advised to use the climate projections for the basin that contains the majority of the land area of the municipality.

NORTH COASTAL BASIN

North Coastal Basin		Observed Baseline 1971-2000 (°F)	Projected Change in 2030s (°F)	Mid-Century Projected Change in 2050s (°F)	Projected Change in 2070s (°F)	End of Century Projected Change in 2090s (°F)
Average Temperature	Annual	49.7	+2.1 to +4.2	+2.7 to +6.2	+3.2 to +8.9	+3.5 to +10.8
	Winter	29.5	+2.1 to +4.7	+2.8 to +7.0	+3.5 to +8.9	+3.9 to +10.4
	Spring	47.0	+2.0 to +3.8	+2.7 to +5.7	+2.8 to +8.1	+3.4 to +9.9
	Summer	69.6	+1.9 to +4.1	+2.5 to +6.4	+2.9 to +9.5	+3.5 to +12.1
	Fall	52.3	+2.0 to +4.6	+3.3 to +6.5	+3.0 to +9.2	+3.5 to +11.6
Maximum Temperature	Annual	59.2	+2.0 to +4.0	+2.5 to +6.0	+3.0 to +8.9	+3.2 to +10.7
	Winter	38.1	+1.8 to +4.3	+2.4 to +6.6	+3.1 to +8.3	+3.4 to +9.5
	Spring	56.8	+1.9 to +3.7	+2.4 to +5.7	+2.8 to +8.3	+3.3 to +9.8
	Summer	79.6	+1.8 to +4.2	+2.4 to +6.3	+2.8 to +9.6	+3.3 to +12.2
	Fall	61.7	+2.0 to +4.4	+3.0 to +6.6	+2.9 to +9.5	+3.4 to +11.9
Minimum Temperature	Annual	40.2	+2.2 to +4.5	+2.9 to +6.4	+3.5 to +9.0	+3.8 to +10.9
	Winter	20.9	+2.4 to +5.1	+3.1 to +7.4	+4.0 to +9.5	+4.3 to +10.9
	Spring	37.3	+2.1 to +4.0	+2.9 to +5.9	+3.0 to +7.9	+3.5 to +9.8
	Summer	59.5	+2.0 to +4.1	+2.6 to +6.7	+3.0 to +9.3	+3.7 to +12.0
	Fall	42.9	+1.9 to +4.7	+3.3 to +6.3	+3.1 to +9.2	+3.7 to +11.4

- The North Coastal basin is expected to experience increased average temperatures throughout the 21st century. Maximum and minimum temperatures are also expected to increase throughout the end of the century. These increased temperature trends are expected for annual and seasonal projections.
- Seasonally, maximum summer and fall temperatures are expected to see the highest projected increase throughout the 21st century.
    - Summer mid-century increase of 2.4 °F to 6.3 °F (3-8% increase); end of century increase of 3.3 °F to 12.2 °F (4-15% increase).
    - Fall mid-century increase of 3 °F to 6.6 °F (5-11% increase); end of century increase by and 3.4 °F to 11.9 °F (5-19% increase).
- Seasonally, minimum winter and fall temperatures are expected to see increases throughout the 21st century.
    - Winter mid-century increase of 3.1 °F to 7.4 °F (15-36% increase); end of century increase by 4.3 °F to 10.9 °F (20-52% increase).
    - Fall mid-century of 3.3 °F to 6.3 °F (8-15% increase); end of century increase of 3.7°F to 11.4 °F (9-27% increase).

NORTH COASTAL BASIN

North Coastal Basin		Observed Baseline 1971-2000 (Days)	Projected Change in 2030s (Days)	Mid-Century Projected Change in 2050s (Days)	Projected Change in 2070s (Days)	End of Century Projected Change in 2090s (Days)
Days with Maximum Temperature Over 90°F	Annual	8	+5 to +15	+7 to +26	+8 to +45	+10 to +62
	Winter	0	+0 to +0	+0 to +0	+0 to +0	+0 to +0
	Spring	<1[75]	+<1[75] to +1	+<1[75] to +1	+<1[75] to +2	+<1[75] to +4
	Summer	7	+4 to +13	+6 to +22	+7 to +37	+9 to +50
	Fall	<1[75]	+<1[75] to +2	+1 to +4	+1 to +7	+1 to +10
Days with Maximum Temperature Over 95°F	Annual	1	+1 to +6	+2 to +11	+3 to +23	+4 to +37
	Winter	0	+0 to +0	+0 to +0	+0 to +0	+0 to +0
	Spring	0	+<1[75] to +<1[75]	+0 to +<1[75]	+<1[75] to +1	+<1[75] to +1
	Summer	1	+1 to +5	+2 to +10	+3 to +20	+3 to +32
	Fall	<1[75]	+<1[75] to +<1[75]	+<1[75] to +1	+<1[75] to +3	+<1[75] to +4
Days with Maximum Temperature Over 100°F	Annual	<1[75]	+<1[75] to +1	+<1[75] to +3	+<1[75] to +7	+<1[75] to +13
	Winter	0	+0 to +0	+0 to +0	+0 to +0	+0 to +0
	Spring	0	+0 to +<1[75]	+0 to +<1[75]	+0 to +<1[75]	+0 to +<1[75]
	Summer	<1[75]	+<1[75] to +1	+<1[75] to +3	+<1[75] to +6	+<1[75] to +11
	Fall	0	+0 to +<1[75]	+0 to +<1[75]	+0 to +<1[75]	+0 to +1

- Due to projected increases in average and maximum temperatures throughout the end of the century, the North Coastal basin is also expected to experience an increase in days with daily maximum temperatures over 90 °F, 95 °F, and 100 °F.
    - Annually, the North Coastal basin is expected to see days with daily maximum temperatures over 90 °F increase by 7 to 26 more days by mid-century, and 10 to 62 more days by the end of the century.
    - Seasonally, summer is expected to see an increase of 6 to 22 more days with daily maximums over 90 °F by mid-century.
    - By end of century, the North Coastal basin is expected to have 9 to 50 more days.

[75] Over the observed period, there were some years with at least 1 day with seasonal Tmax over a certain threshold while in all the other years that threshold wasn't crossed seasonally at all.

NORTH COASTAL BASIN

North Coastal Basin		Observed Baseline 1971-2000 (Days)	Projected Change in 2030s (Days)	Mid-Century Projected Change in 2050s (Days)	Projected Change in 2070s (Days)	End of Century Projected Change in 2090s (Days)
Days with Minimum Temperature Below 0°F	Annual	3	-1 to -2	-1 to -2	-1 to -2	-1 to -3
	Winter	3	-1 to -2	-1 to -2	-1 to -2	-1 to -2
	Spring	<1[76]	-0 to +<1[76]	-0 to -0	-0 to -0	-0 to -0
	Summer	0	-0 to -0	-0 to -0	-0 to -0	-0 to -0
	Fall	<1[76]	-0 to -0	-0 to -0	-0 to -0	-0 to -0
Days with Minimum Temperature Below 32°F	Annual	121	-12 to -29	-18 to -44	-22 to -56	-23 to -66
	Winter	77	-4 to -11	-5 to -18	-7 to -27	-9 to -34
	Spring	27	-5 to -11	-7 to -15	-8 to -18	-9 to -20
	Summer	0	-0 to -0	-0 to -0	-0 to -0	-0 to -0
	Fall	17	-4 to -8	-6 to -10	-7 to -12	-6 to -14

- Due to projected increases in average and minimum temperatures throughout the end of the century, the North Coastal basin is expected to experience a decrease in days with daily minimum temperatures below 32 °F and 0 °F.
- Seasonally, winter, spring and fall are expected to see the largest decreases in days with daily minimum temperatures below 32 °F.
    - Winter is expected to have 5 to 18 fewer days by mid-century, and 9 to 34 fewer days by end of century.
    - Spring is expected to have 7 to 15 fewer days by mid-century, and 7 to 20 fewer days by end of century.
    - Fall is expected to have 6 to 10 fewer days by mid-century, and 7 to 14 fewer days by end of century.

[76] Over the observed period, there were some years with at least 1 day with seasonal Tmin under a certain threshold while in all the other years that threshold wasn't crossed seasonally at all.

NORTH COASTAL BASIN

North Coastal Basin		Observed Baseline 1971-2000 (Degree-Days)	Projected Change in 2030s (Degree-Days)	Mid-Century Projected Change in 2050s (Degree-Days)	Projected Change in 2070s (Degree-Days)	End of Century Projected Change in 2090s (Degree-Days)
Heating Degree-Days (Base 65°F)	Annual	6194	-529 to -1103	-692 to -1517	-830 to -2019	-929 to -2401
	Winter	3212	-188 to -430	-243 to -645	-310 to -808	-355 to -950
	Spring	1675	-166 to -316	-222 to -473	-239 to -650	-302 to -763
	Summer	88	-33 to -56	-40 to -71	-47 to -81	-51 to -83
	Fall	1215	-134 to -331	-239 to -425	-228 to -604	-249 to -688
Cooling Degree-Days (Base 65°F)	Annual	590	+204 to +434	+276 to +731	+320 to +1139	+371 to +1509
	Winter	0	+0 to +5	+0 to +6	+0 to +5	+0 to +6
	Spring	24	+13 to +33	+23 to +57	+24 to +94	+19 to +142
	Summer	507	+142 to +326	+182 to +523	+217 to +790	+264 to +1025
	Fall	56	+30 to +89	+44 to +177	+53 to +272	+76 to +354
Growing Degree-Days (Base 50°F)	Annual	2635	+387 to +795	+539 to +1228	+610 to +1942	+689 to +2449
	Winter	6	+1 to +15	+3 to +18	+6 to +33	+5 to +42
	Spring	296	+84 to +161	+108 to +262	+118 to +396	+129 to +514
	Summer	1800	+179 to +378	+228 to +588	+267 to +870	+322 to +1109
	Fall	528	+100 to +283	+171 to +427	+160 to +645	+214 to +811

- Due to projected increases in average, maximum, and minimum temperatures throughout the end of the century, the North Coastal basin is expected to experience a decrease in heating degree-days, and increases in both cooling degree-days and growing degree-days.
- Seasonally, winter historically exhibits the highest number of heating degree-days and is expected to see the largest decrease of any season, but spring and fall are also expected to see significant change.
    - The winter season is expected to see a decrease of 8-20% (243 -645 degree-days) by mid-century, and a decrease of 11-30% (355 -950 degree-days) by the end of century.
    - The spring season is expected to decrease in heating degree-days by 13-28% (222-473 degree-days) by mid-century, and by 18-46% (302-763 degree-days) by the end of century.
    - The fall season is expected to decreases in heating degree-days by 20-35% (239-425 degree-days) by mid-century, and by 20-57% (249 -687 degree-days) by the end of century.
- Conversely, due to projected increasing temperatures, summer cooling degree-days are expected to increase by 36-103% (182 -523 degree-days) by mid-century, and by 52-202% (264-1025 degree-days) by end of century.

- Seasonally, summer historically exhibits the highest number of growing degree-days and is expected to see the largest decrease of any season, but the shoulder seasons of spring and fall are also expected to see an increase in growing degree-days.
    - The summer season is projected to increase by 13-33% (228 -588 degree-days) by mid-century, and by 18-62% (322-1109 degree-days) by end of century.
    - Spring is expected to see an increase by 36-88% (108 -262 degree-days) by mid-century and 44-173% (129 -514 degree-days) by end of century.
    - Fall is expected to see an increase by 32-81% (171 -427 degree-days) by mid-century and 40-154% (214 -811 degree-days) by end of century.

NORTH COASTAL BASIN

North Coastal Basin		Observed Baseline 1971-2000 (Days)	Projected Change in 2030s (Days)	Mid-Century Projected Change in 2050s (Days)	Projected Change in 2070s (Days)	End of Century Projected Change in 2090s (Days)
Days with Precipitation Over 1"	Annual	8	+<1[77] to +2	+<1[77] to +3	+1 to +3	+1 to +4
	Winter	2	+<1[77] to +1	+<1[77] to +1	+<1[77] to +2	+<1[77] to +2
	Spring	2	+0 to +1	+0 to +1	+<1[77] to +1	+<1[77] to +1
	Summer	2	+0 to +1	+0 to +1	+0 to +1	+0 to +1
	Fall	2	-0.29 to +1	+0 to +1	+0 to +1	+0 to +1
Days with Precipitation Over 2"	Annual	1	+<1[77] to +1	+0 to +1	+<1[77] to +1	+<1[77] to +1
	Winter	<1[77]	+0 to +<1[77]	+<1[77] to +<1[77]	+0 to +<1[77v]	+<1[77] to +<1[77]
	Spring	<1[77]	+0 to +<1[77]	+0 to +<1[77]	+0 to +<1[77]	+0 to +<1[77]
	Summer	<1[77]	+0 to +<1[77]	+0 to +<1[77]	+0 to +<1[77]	+0 to +<1[77]
	Fall	<1[77]	+0 to +<1[77]	+0 to +<1[77]	+0 to +<1[77]	+0 to +<1[77]
Days with Precipitation Over 4"	Annual	<1[77]	+0 to +<1[77]	+0 to +<1[77]	+0 to +<1[77]	+0 to +<1[77]
	Winter	0	+0 to +0	+0 to +0	+0 to +<1[77]	+0 to +<1[77]
	Spring	0	+0 to +<1[77]	+0 to +<1[77]	+0 to +<1[77]	+0 to +<1[77]
	Summer	<1[77]	+0 to +<1[77]	+0 to +<1[77]	+0 to +<1[77]	+0 to +<1[77]
	Fall	<1[77]	+0 to +<1[77]	+0 to +<1[77]	+0 to +<1[77]	+0 to +<1[77]

- The projections for expected number of days receiving precipitation over one inch are variable for the North Coastal basin, fluctuating between loss and gain of days.
    - Seasonally, the winter season is generally expected to see the highest projected increase.
    - The winter season is expected to see an increase in days with precipitation over one inch of 0-1 days by mid-century, and of 0-2 days by the end of century.
    - The spring season is expected to see an increase in days with precipitation over one inch of 0-1 days by mid-century, and of an increase of 0-1 days by the end of century.

[77] Over the observed period, there were some years with at least 1 day with seasonal precipitation over a certain threshold while in all the other years that threshold wasn't crossed seasonally at all.

NORTH COASTAL BASIN

North Coastal Basin		Observed Baseline 1971-2000 (Inches)	Projected Change in 2030s (Inches)	Mid-Century Projected Change in 2050s (Inches)	Projected Change in 2070s (Inches)	End of Century Projected Change in 2090s (Inches)
Total Precipitation	Annual	45.3	+0.0 to +4.4	+0.0 to +5.5	+0.7 to +6.7	+0.8 to +7.2
	Winter	11.7	-0.3 to +1.8	+0.2 to +2.4	+0.3 to +3.1	+0.5 to +4.1
	Spring	11.5	-0.2 to +2.2	-0.1 to +2.1	+0.1 to +2.6	+0.1 to +2.7
	Summer	10.1	-0.3 to +1.4	-0.6 to +1.9	-1.0 to +2.1	-1.7 to +1.8
	Fall	12.1	-1.1 to +0.9	-1.1 to +1.4	-1.9 to +1.5	-1.8 to +1.2

- Similar to projections for number of days receiving precipitation over a specified threshold, seasonal projections for total precipitation are also variable for the North Coastal basin.
    - The winter season is expected to experience the greatest change with an increase of 1-20% by mid-century, and of 4-35% by end of century.
    - Projections for the summer and fall seasons are more variable, and could see either a drop or increase in total precipitation throughout the 21st century.
        - The summer season projections for the North Coastal or basin could see a decrease of 0.3 to an increase of 2.2 inches by mid-century (decrease of 6% to increase of 19%) and a decrease of 1.1 to an increase of 2.2 inches by the end of the century (decrease of 17% to increase of 18%).
        - The fall season projections for the North Coastal basin could see a decrease of 1.2 to an increase of 1.8 inches by mid-century (decrease of 9% to increase of 11% and a decrease of 1.4 to an increase of 1.5 inches by the end of the century (decrease of 14% to increase of 10%).

North Coastal Basin		Observed Baseline 1971-2000 (Days)	Projected Change in 2030s (Days)	Mid-Century Projected Change in 2050s (Days)	Projected Change in 2070s (Days)	End of Century Projected Change in 2090s (Days)
Consecutive Dry Days	Annual	17	-0 to +2	-0 to +3	-1 to +3	-0 to +3
	Winter	11	-1 to +1	-1 to +1	-1 to +2	-1 to +2
	Spring	11	-1 to +1	-1 to +1	-1 to +1	-1 to +1
	Summer	13	-1 to +1	-1 to +2	-1 to +3	-1 to +3
	Fall	12	-0 to +2	-0 to +3	-1 to +4	-0 to +3

- Annual and seasonal projections for consecutive dry days, or for a given period, the largest number of consecutive days with precipitation less than 1 mm (~0.04 inches), are variable throughout the 21st century.
    - For all the temporal parameters, the North Coastal basin is expected to see a slight decrease to an increase in consecutive dry days throughout this century.
    - Seasonally, the fall and summer seasons are expected to continue to experience the highest number of consecutive dry days.
        - The fall season is expected to experience an increase of 0-3 days in consecutive dry days by the end of the century.

PUBLIC LISTENING SESSION - FLYER

PLEASE JOIN US FOR A PUBLIC LISTENING SESSION TO LEARN ABOUT THIS IMPORTANT PLANNING EFFORT AND PROVIDE FEEDBACK

PUBLIC LISTENING SESSION

TAKE ACTION!

- DEVELOP AND PRIORITIZE ACTIONS
- COMPLETE ASSESSMENT OF VULNERABILITIES AND STRENGTHS
- IDENTIFY CLIMATE IMPACTS AND HAZARDS
- ENGAGE COMMUNITY

The City of Beverly has received a Municipal Vulnerability Preparedness (MVP) Planning Grant from the Commonwealth of Massachusetts. Over the past 10 months, Beverly Stakeholders have engaged in a planning initiative to better understand **HOW OUR COMMUNITY IS VULNERABLE TO THE EFFECTS OF CLIMATE CHANGE,** and to prioritize actions to increase the climate resilience of our town.

WHERE: Beverly High School Auditorium
100 Sohier Road, MA 01915

WHEN: Thursday, MAY 30, 2019

TIME: 6:30 pm - 8:00 pm

the city of BEVERLY massachusetts | Salem Sound COASTWATCH | | | BSC GROUP