Nature-Based Solutions for Flood Resiliency

Salisbury Brook & Salisbury Plain River

City of Brockton

Brockton, Massachusetts

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FUSS & O'NEILL

1550 Main Street, Suite 400
Springfield, MA 01103

Executive Summary

In 2019 the City of Brockton received a Municipal Vulnerability Preparedness (MVP) Action Grant from the Massachusetts Executive Office of Energy and Environmental Affairs to conduct a study that would develop an accurate understanding of risks to infrastructure, environment, and residents resulting from flooding events in the City and to identify solutions to address those risks and increase flood resiliency along Salisbury Brook and the Salisbury Plain River. This report documents the process and findings of that study, and presents recommendations for nature-based approaches that mimic and/or work with natural systems to increase flood storage capacity, decrease flooding risk, and proactively increase the City's resilience to climate change impacts.

Project Background and Overview

The City has been experiencing an increasing frequency of storms causing flooding problems in neighborhoods and roads. Intense storms occurring throughout the year are producing high volumes of rain, causing rivers and streams to overflow their banks, placing significant pressure on dams and culverts and overwhelming the stormwater infrastructure system. Flooding frequently has City-wide impacts, including road closures at susceptible locations, such as Crescent Street and the Kmart Plaza on Main Street. Extreme precipitation and flooding events are expected to become more frequent due to climate change impacts.

Because of a high degree of impervious surfaces in the City, even moderate volumes of stormwater in Brockton can result in flooded buildings and infrastructure. In 2010 rescuers had to pull residents out of flooded homes from a boat, and certain neighborhoods are known to be particularly susceptible to flooding and related power outages. Along Belmont Avenue, four homes have already been bought-out by the City and demolished due to having experienced repetitive losses from flooding

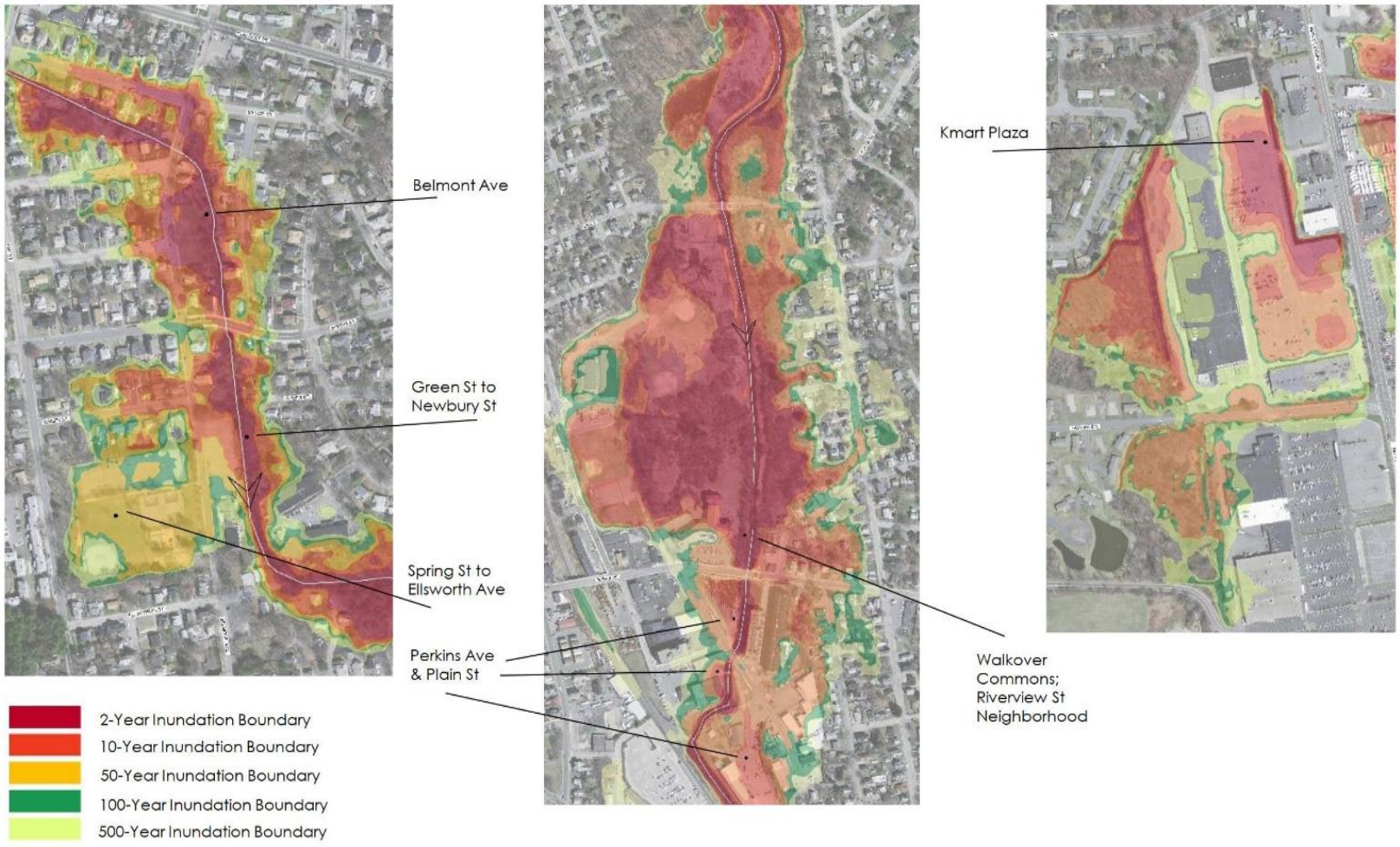
In order to develop a plan to address these flooding issues on a City-wide scale, rather than on a site-by-site basis, the City partnered with Fuss & O'Neill to secure funding through the MVP Action Grant program to develop an integrated all-waters approach to increase flood resiliency City-wide. From the start of this project, the City has been very cognizant of its downstream neighbors, recognizing that moving water through the City faster might alleviate some flooding concerns, but would only cause greater impacts for downstream communities. The approaches highlighted here focus on detaining and infiltrating water higher up in the watershed to limit downstream flooding impacts. The project was designed to assess the viability of using nature-based solutions such as restoration of wetlands and floodplain or implementation of green infrastructure to address both riverine flooding and stormwater drainage-driven flooding, and to prioritize future projects to increase flood storage capacity and mitigate flooding risk.

Example Inundation Mapping within River Corridor

Flood Prone Areas

Fuss & O'Neill conducted hydraulic and hydrologic modeling of the Salisbury Brook and Salisbury Plain River corridor, which bisects the City from north to south. This type of modeling allows us to predict and map the limits of inundation—that is, how far flood waters will spread—during different size storm events. The results of the analyses identified areas most susceptible to frequent flooding, including those shown here. Inundation mapping for the entire river corridor is available in the full report.

Modeling also revealed that several bridges throughout the river system overtop during the 10-year flood event, including Prospect Street, Belmont Avenue, North Arlington Street/Newbury Street, Pine Avenue, and Perkins Avenue. These are considered to be the bridges most susceptible to flooding during significant rainfall events.



Projected Climate Impacts

Climate change is impacting rainfall patterns, making heavier and more intense rainfall events more frequent throughout the northeast. Increasing intensity and frequency of larger storm events will contribute to a worsening of flooding conditions along the Salisbury Brook/Salisbury Plain River system. To account for predicted future conditions, the hydraulic model built for this project applies a precipitation magnification factor that models future precipitation events as approximately 20% larger than current storms. (This magnification factor is consistent with climate projections at the regional and local scales.) By the year 2040, projections indicate that at various points in the river system, the 2-year flood will result in flood elevation levels that vary from 1 inch to 16 inches higher than currently experienced during the 2-year flood, while the 100-year flood in 2040 will result in increased flood elevation levels that range from 1 inch to 31 inches higher than currently experienced during the 100-year flood.

Risk Assessment and Prioritization

A risk assessment and prioritization tool was developed specifically for the City of Brockton that utilizes a weighted scoring method to prioritize property/parcels and road and bridge infrastructure located within the mapped inundation areas. Parcels within the floodplains of Salisbury Brook and the Salisbury Plain River were categorized and scored based on the following factors:

- 'criticality', where more critical facilities are those where even a small chance of flooding poses a significant threat to public health and safety (e.g. hospitals, police stations)
- potential impacts to economic development and jobs
- value in providing housing for City residents
- value of potential direct financial damages in a flooding event
- geographic extent of impacts for roadways

The prioritization process was used to identify individual properties with high risk scores, as well as to identify locations where risk clusters. Such clusters help to highlight areas of residential or otherwise non-critical use which may not score high individually, but which represent a risk 'hotspot' within the City.

Darker shades indicate locations with higher assessed risk scores.

Nature-Based Solutions for Flood Storage

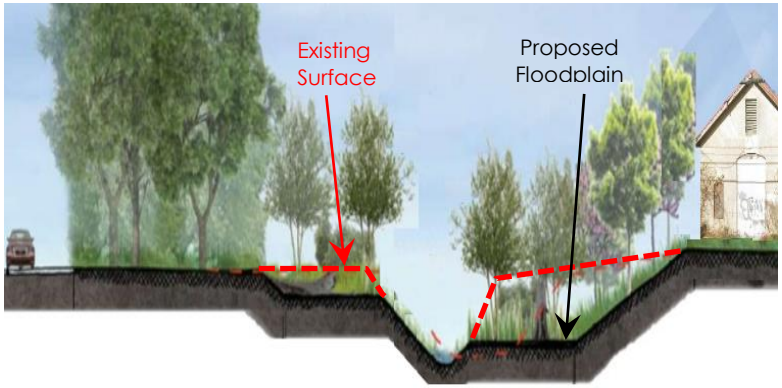
Nature-based solutions focus on restoring and/or enhancing natural habitat and flood storage functions of pond or floodplain areas to increase flood storage and lower water flood elevations. Restoration techniques include excavation to increase floodplain storage, widening the river channel in areas where development has resulted in encroachment into the river's natural floodplain, and daylighting buried stream channels.

City-owned and undeveloped parcels were given first consideration as sites for nature-based solutions; acquisitions and buy-outs of developed property were also considered, though these options are typically more costly.

Assessment included an evaluation of three types of alternatives:

- Excavation and ecological enhancement of Ellis Brett Pond or Cross Pond
- Floodplain restoration at undeveloped parcels
- Buy-out/relocation and floodplain restoration at developed sites

Order of magnitude cost/benefit analyses were conducted for each alternative to aid in prioritization of recommended projects. Three prospective solutions emerged from the analysis as among the most beneficial and cost-effective options.



Typical Floodplain Restoration Section (modified from VDOT, 2018)

1) Installation of a spillway gate and implementation of water level management strategy at Ellis Brett Pond

A remotely-controlled bottom-hinged crest gate would allow the City to better take advantage of existing flood storage available in Ellis Brett Pond. With a gate installed, water levels could be lowered before large storm events, then the gate could be raised to allow for detention of runoff for later release to the river in a controlled manner.

- Best independent alternative
- Benefits throughout river system
- 6 inch to 1 foot+ flooding reductions throughout upper reaches
- Primary benefits for 2-year and 10-year events
- Estimated cost: $400K to $900K (excludes operation/maintenance)

Installation of Spillway Gate at Ellis Brett Pond: Modeled Change in Water Surface Elevation for Each Storm Event (feet). Reductions of 0.2 feet or greater shown in blue.

Location in River System	2-Year	10-Year	50-Year	100-Year
Elmwood Ave to Pleasant St	-1.0	-0.7	-0.0	0.0
Pleasant St to Moraine St Conduit	-1.1	-0.9	-0.1	0.0
Moraine St Conduit to Ash St	-0.8	-0.7	-0.3	0.0
Ash St to Belmont Ave	-0.8	-0.4	-0.1	0.0
Belmont Ave to Carleton St	-0.6	-0.3	-0.1	0.0
Carleton St to N. Arlington Culvert	-0.9	-0.5	-0.1	0.0
Belmont St to Allen St	-0.6	-0.3	0.0	0.0
Allen St to White Ave	-0.4	-0.1	-0.1	0.0
White Ave to Railroad Bridge	-0.5	-0.2	-0.1	0.0
Railroad Bridge to Otis St	-0.4	-0.1	-0.1	0.0
Otis St to Grove St	-0.3	-0.2	-0.1	0.0
Pine Ave to Perkins Ave	-0.4	-0.1	-0.1	0.0
Perkins Ave to Plain St	-0.4	-0.2	-0.1	0.0
Plain Street to Sargent's Way	-0.2	-0.1	0.0	0.0
Sargent's Way to K-Mart Plaza	-0.2	-0.1	0.0	0.0

2) Excavation and ecological enhancement of Ellis Brett Pond

Ellis Brett Pond currently has a normal impoundment surface area of approximately 1.6 acres and normally holds approximately 13,000 cubic yards of water. The pond is impounded by a dam and is generally maintained under dry conditions with minimal flow controls (weir boards) applied to the dam's primary spillway. Excavation and wetland restoration/enhancement is proposed for up to a nine acre area, primarily to the north of the existing impoundment, to increase the available storage area below the typical water surface elevation.

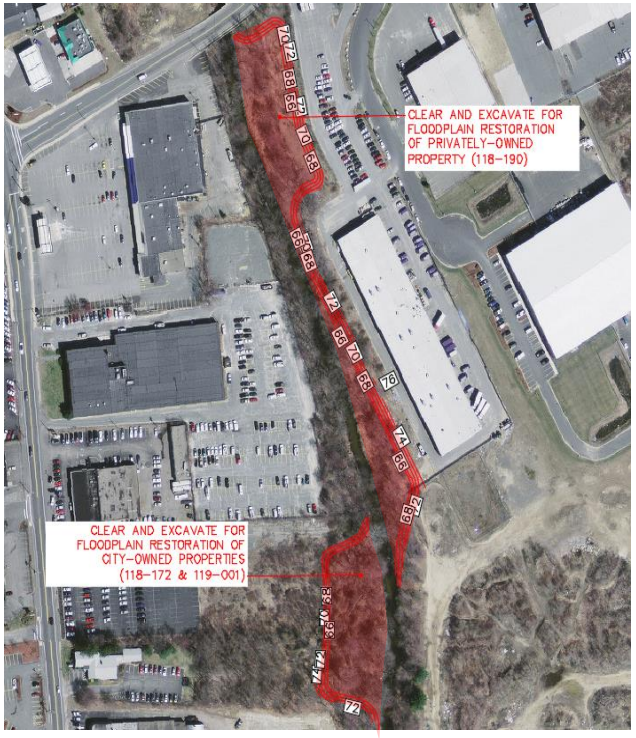
- Up to six inch reduction in flood elevation for 2-year through 100-year events as an independent alternative
- Benefits extend from impoundment to Otis Street
- Potential permitting challenges
- Estimated cost: $2.5M to $5M

Proposed Ellis Brett Pond Excavation Limits

3) Floodplain restoration of undeveloped parcels near Sargent's Way

Excavation is proposed at three undeveloped City-owned parcels between Plain Street and Sargent's Way to create an additional 18,300 cubic yards of floodplain storage. An additional 22,500 cubic yards of flood storage is propose to be created through excavation at three undeveloped areas within privately-owned parcels immediately downstream of Sargent's Way along a constricted section of the river channel.

- 7 inch to 9 inch reductions in flood elevation for the 2-year through 100-year events
- Impacts limited to Pine Street and downstream
- Increases flood elevation reductions at the south end of the City relative to Ellis Brett Pond alternatives
- Estimated cost $2.5M to $4.8M



Potential Floodplain Restoration areas between Plain Street and Sargent's Way (top) and downstream of Sargent's Way (bottom)

Recommended Approach

Our recommended approach is to implement a nature-based approach that includes both excavation of Ellis Brett Pond to increase flood storage volume and the installation of a gate structure at Ellis Brett Pond, as well as restoration of floodplain at the three undeveloped parcels in the vicinity of Sargent's Way. This alternative combines two key approaches:

- Utilizing the Ellis Brett Pond Dam, to hold additional water during storm events and control its release.
- Applying floodplain restoration approaches that excavate key properties along the river corridor to create additional floodplain storage where Salisbury Plain River is currently restricted by channelized banks and/or development within the floodplain.

Together, these approaches yield additional flood storage at key points in the river system, resulting in up to 18 inch reductions in flood elevations during more frequent flood events. Significant benefits are seen throughout the length of the river during the 2-year and 10-year floods, and several bridges are protected from overtopping during the 10-year flood. This alternative also provides flood reduction benefits throughout the river system for the 50-year flood, including protection of the White Avenue Bridge crossing from overtopping during that event. The downstream floodplain restoration work provides additional protection for commercial properties at the south end of the City, adding significant additional benefit between Pine Ave. and Sargent's Way for the 10-yr through 500-yr storm events relative to inclusion of the Ellis Brett components alone.

This cost-effective, high-impact solution can reduce the risk of flooding City-wide, with up to 18 inch reductions in flood elevations during more frequent flood events.

The order of magnitude costs for the combined approach is estimated at $7 million, with a likely cost range between $5M and $10.5M. By prioritizing this cost-effective, high-impact solution, the City can reduce the risk of flooding City-wide. This strategy is much more efficient than implementing site-by-site protections for at-risk buildings or infrastructure.

Despite these benefits, the preferred alternative does not address all known flooding areas. Additional flood protection measures will be needed to round out a comprehensive resiliency strategy for the City.

Green infrastructure applications for on-site stormwater management should be explored throughout the City, including during any future redevelopment of the K-Mart Plaza or Westgate Mall properties. Modeling revealed that because of the Westgate Mall's relatively small size relative to the watershed, coupled with the high degree of impervious cover throughout the watershed, installing green infrastructure at the mall would have little impact on flooding at a City-wide scale. However, wider implementation of green infrastructure throughout the watershed and throughout the City could certainly have important impacts on downstream flooding by infiltrating water in place and reducing peak flows. Such practices also have significant value improving water quality.

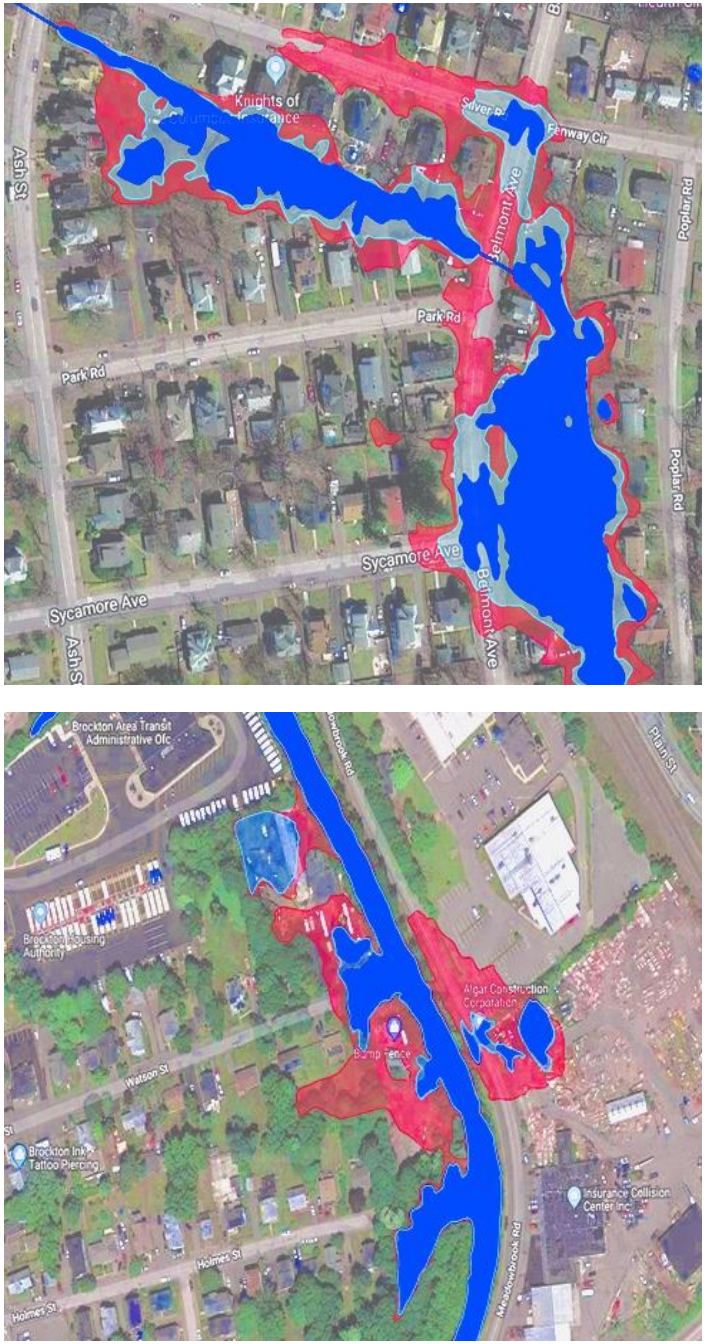
The results of our hydraulic and hydrologic modeling also indicate the importance of attenuating floodwaters upstream in the City's other watersheds, before they contribute to the flows in the Salisbury Plain River. Additional study and modeling should also focus on developing appropriate, parallel nature-based solutions for Trout Brook and other areas of the City in order to develop a comprehensive approach to nature-based flood protections.

Over time, proposed additional measures may include property buy-outs to facilitate planned retreat, and relocating land uses at flood-prone properties to more protected areas of the City. Done strategically, these efforts can be part of a planned redevelopment strategy that simultaneously protects residents and established businesses from climate impacts, creates green space in the City, and opens up opportunities for mixed-use densification to invigorate the City's economic base.

Modeled Flood Reductions for the Recommended Approach

(Ellis Brett Pond Spillway Gate and Excavation, downstream floodplain restoration)

	Modeled Change in Water Surface Elevation for Each Storm Event (feet)				
Location in River System	2-Year	10-Year	50-Year	100-Year	500-Year
Elmwood Ave to Prospect St	-1.3	-0.9	-0.1	0.0	0.0
Prospect St to Pleasant St	-1.4	-1.0	-0.1	0.0	0.0
Pleasant St to Moraine St Conduit	-1.5	-1.4	-0.3	-0.2	-0.1
Moraine St Conduit to Ash St	-1.3	-1.0	-0.8	-0.6	-0.1
Ash St to Belmont Ave	-1.3	-0.7	-0.3	-0.3	-0.1
Belmont Ave to Carleton St	-1.1	-0.9	-0.3	-0.1	-0.1
Carleton St to N. Arlington Culvert	-1.1	-1.1	-0.3	0.0	-0.1
Belmont St to Warren Ave	-0.8	-0.5	-0.2	-0.1	-0.1
Warren Ave to Allen St	-0.8	-0.4	-0.2	-0.1	0.0
Allen St to White Ave	-0.5	-0.2	-0.7	-0.1	0.0
White Ave to Railroad Bridge	-0.7	-0.3	-0.8	-0.2	0.0
Railroad Bridge to Otis St	-0.6	-0.2	-0.4	-0.2	-0.1
Otis St to Grove St	-0.5	-0.3	-0.2	-0.1	-0.1
Grove St to Pine Ave	-0.6	-0.3	-0.2	-0.1	-0.1
Pine Ave to Perkins Ave	-0.9	-0.5	-0.3	-0.2	-0.1
Perkins Ave to Plain St	-1.0	-0.8	-0.4	-0.5	-0.2
Plain Street to Sargent's Way	-0.9	-0.8	-0.7	-0.7	-0.6
Sargent's Way to K-Mart Plaza	-0.4	-0.2	-0.2	-0.2	-0.2



Flood Inundation Limit Comparisons for Belmont Ave (top) and Plain Street/Sargent's Way. Boundaries shown are existing conditions (red); predicted inundation boundary after installation of the Ellis Brett gate alone (light blue); predicted boundary for the composite alternative (dark blue).

Financial assistance was provided by the Executive Office of Energy & Environmental Affairs (EEA) under the FY19 Municipal Vulnerability Preparedness (MVP) Grant Program. The MVP Action Grant offers financial resources to municipalities that are seeking to advance priority climate adaptation actions to address climate change impacts resulting from extreme weather, sea level rise, inland and coastal flooding, severe heat, and other climate impacts.

Consultant Team

Fuss & O'Neill, Inc. – Julianne Busa, PhD; Sean Arruda, PE, CFM; Dean Audet, PE; Liz Isenstein, MSc, EIT; Nelson Tull, EIT; Sarah Hayden, MBA, MSc; Arnold Robinson, AICP

Document photos and graphics produced by Fuss & O'Neill unless otherwise noted.