Memo

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Project name:
Point of Pines and Riverside Area Coastal Resilience Feasibility Study

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Past Studies, Case Studies, and Historical Data Memo – DRAFT

1. Introduction

Resiliency is essential for coastal communities such as the City of Revere, MA. These coastal communities are likely to face severe hazards from climate change threats including sea level rise, coastal surge, and erosion. The purpose of this Memorandum is to provide an overview of historical research and studies conducted for the City of Revere Point of Pines (PoP)/Riverside area, as well as present applicable case studies from similar communities. Over the past few decades, the PoP/Riverside area has been susceptible to coastal hazards such as flooding, beach erosion and sea level rise. This Memorandum is the first task in a six-task feasibility study that will provide the City with an overview of both historic and present hazards that the City faces in the PoP and Riverside areas, which will be referred to as the Study Area. This is the first of five technical memoranda that will be provided as part of the feasibility study; the findings from the five technical memoranda as well as three stakeholder meetings will be summarized in a final report which will also include an implementation plan identifying prioritized action items, responsibilities and potential funding sources to address coastal vulnerabilities in the Study Area. The information summarized in this Memorandum provides a basis to evaluate past, current, and future coastal threats as well as recommendations for potential mitigation measures to increase the climate resiliency of this portion of the City of Revere.

2. Past Studies and Reports for the Point of Pines and Riverside Area

The Study Area has experienced hazards due to flooding and coastal storms for over three decades. In that time, a number of studies have been conducted by the US Army Corps of Engineers (USACE), the City, as well as local planning organizations to describe and recommend solutions for flooding. This section summarizes the past studies conducted, their findings, and associated recommendations. Information from these past studies will be considered as short- and long-term resilience measures are identified as part of the current study. Key points of the relevant past studies are provided in Table 1 below, starting with the most recent, followed by a short summary of each study.

Table 1: Summary of Past Studies and Reports for the Point of Pines and Riverside Area

Title	Author	Date of Source	Source Overview	Definition of Study Area	Summary of Findings	Recommendations
Boston Region Metropolitan Planning Organization's Route 1A Corridor Vulnerability Assessment	Boston Regional Metropolitan Planning Organization	November 2020	The objective of this pilot study was to work with MassDOT and the City of Revere to identify problems and develop recommendations to make Route 1A more resilient. Route 1A was selected for the pilot study because portions of the road are both located in natural low-lying areas with elevations less than 10 feet above sea level and close to the flood pathways of the Pines River estuary to the north and the Chelsea Creek estuary to the south.	Route 1A near Pines River	The corridor is highly vulnerable to coastal flooding resulting from high tides, storm surge, rainstorms, and inundation from sea level rise - all hazards that are expected to worsen in the future	• **Structural Recommendations:** - Installation of bulkheads and breakwaters to rescue shoreline erosion. - Plant marsh vegetation - Installation of edging devices and Rock Sills, Revetment and Bulkhead - Raise roads and upgrade culverts • **Non-Structural Recommendations:** - Regulatory policy and pricing/incentive policy - Structure acquisitions or relocations - Flood proofing of structures - Implementing flood warning systems - Flood preparedness planning -Establishment of land use regulations - Emergency response plans

Municipal Vulnerability Preparedness Summary of Findings Report	AECOM	June 2019	This report discussed the climate change concerns and solutions that Revere residents established during the MVP workshops. The MVP Program provides cities and towns with monetary and technical support to begin the process of planning for climate change resiliency and implementing priority projects. This report identified the top climate change hazard for the City of Revere, identifying actions to promote resilience and potential solutions.	Beachmont, Point of Pines/ Riverside, Oak Island/Revere Beach, West/North Revere and Sales Creek	The top hazards that the City of Revere faces consist of: -Coastal Flooding - Erosion - Extreme Temperatures/ High Temperatures - High Winds - High(er) Water Table - Hurricanes and Nor'easters - Inland Flooding -Invasive Species - Sea Level Rise - Severe Storms and Winter Storms	• **Beachmont:** - Reconstruct seawall and revetments. -Install levee and/or natural berm to prevent flooding of properties that abut the marsh. - Dredge Belle Isle Creek. - Improve emergency access and reduce hazards to vehicles by changing one-way traffic patterns and encouraging use of public parking garages during high tide and storm events. • **Point of Pines / Riverside** - Construct and rehabilitate seawall. Install snow fencing and restore dunes. - Increase public safety and access to shelters for evacuation and construct a new fire station. - Reduce exposure to pollution by prohibiting an increase to volume of fill/waste at the Wheelabrator landfill. - Conduct feasibility study to determine the best mitigation plan to address flooding, erosion, and storm impacts. - Investigate and streamline the permit process for sand transfer between the vicinity of the PoP Yacht Club, where it is accreting, and PoP Beach Association, where there is coastal erosion. • **Oak Island / Revere Beach** - Upgrade drainage system to help control flooding. - Beach nourishment and erosion control. - Repair, replace, and install flood gates. - Promote thoughtful future development with respect to flooding and drainage. Implement best management practices and include natural flood storage in new developments. - Build a new high school. - Create and establish multilingual communication. - Repurpose Route 1A oil tanks for stormwater storage.

						• **West / North Revere** - Seek funding for and develop a program to dredge and maintain Town Line Brook. • Identify illegal sewer hookups. - Develop a program or policy to install emergency generators at and maintain pumping stations. - Reduce illegal dumping through surveillance. - Expand Route 1 travel lanes, • **Sales Creek** - Develop municipally-administered vulnerability assessments for homeowners. - Distribute multilingual information. - Develop, promote, and incentivize green infrastructure, and new and/or retrofitted stormwater and green building standards. - Liaison between City and State to position for funding sources and increase communication. - Incorporate MVP findings into the City's Master Plan and Hazard Mitigation Plan updates.
City of Revere Hazard Mitigation Plan (HMP)	Metropolitan Area Planning Council	June13,2015	The HMP planning is a proactive effort to identify actions that can be taken to reduce the dangers to life and property from natural hazard events.	City of Revere	The coastal area of the City of Revere is subject to floods, hurricanes, tornadoes, coastal hazards, earthquakes, brush fires and extreme temperatures. Geographically, the City is extremely vulnerable to tsunamis and winter storms.	• Provide backup power at all sewer pump stations. • Install a diesel generator at the Reservoir pumping station. • Install tide gates at Route 1. • Install a new sewer pump stations at Martin Street and Oak Island. • Construct a seawall along Miller Avenue from North Shore Road to Alden Avenue. • Construct a seawall from Cary Circle to Alden Avenue
USACE Revere Beach Erosion Control Report	United States Army Corps of Engineers	1991	This report discusses beach erosion at Revere Beach.	Revere Beach Reservation	Revere Beach Reservation was only 4 ft above mean low water level, rendering the area vulnerable to coastal .	• Widening the beach. • Elevating the beach area so that it is higher above the Mean Low Water (MLW) level

USACE Flood Damage Reduction Study for the Saugus River and Tributaries	United States Army Corps of Engineers	1990	This is a feasibility investigation carried out in partial response to the 1969 SENE study authority. This report presents the USACE investigation of potential regional solutions to serious and recurring coastal flooding problems in eastern Massachusetts.	Lynn, Saugus and Revere	Coastal flooding.	• **Non-structural:** -Maintaining existing beaches, seawalls, tides gates and ponding area - Development of flood preparedness plan • **Structural:** - Tide gate along Sales Creek - Dike installation behind Revere Beach - Develop a wall to protect ponding area in the North end of Revere -Stone revetment installation along PoP shorefront from Carey Circle - Installation of tidal floodgates by the mouth of the Saugus River and installation of 10 flushing gates, 9 of which will be installed on the Lynn side of the navigation gates and 1 on the Revere side - Dike installation in Lynn Harbor
USACE Environmental Impact Statement/Environmental Impact Report for Flood Damage Reduction Study for the Saugus River and Tributaries	United States Army Corps of Engineers	1989	This source summarized the coastal flooding problems in the study area and alternative solutions; described the selected plan, implementation responsibilities of the plan; identified environmental resources in the study area, and the potential impacts of alternative solutions as required by the Federal (NEPA) and State (MEPA) environmental processes.	Lynn, Saugus, Malden and Revere	The study area is impacted by sea level rise, flooding and degrading shorefront structures. Flooding impacted the Ocean Ave and Wonderland MBTA stations	• **Overview:** **-**Seawall at Revere Beach from Eliot Circle to Carey Circle must be maintained. **-**A tide gate is required to protect Crescent Beach and Garfield School. **-**Raise park land that is bounded by Ocean Avenue and Revere Beach Boulevard. -Install a new concrete wall that extends from the Boulevard sidewalk along the north side of the Seaview Condo driveway. • **Point of Pines:** **-**Heighten existing seawall - Rebuild damaged seawalls
USACE Pines River Navigation Report and Environmental Assessment	United States Army Corps of Engineers	1986	This report detailed and selected a plan to alleviate issues with anchorage in the study area along with the overall channel condition. The report also analyzed small improvements for small	West of Lynn Harbor where Pine and Saugus River joins	There was a shortage of recreational anchorage in Lynn and Revere areas, Pine River was one of the areas impacted by the shortage. The Pine River had a vast amount of	• The recommended plan consisted of the construction of an access channel along with anchorage areas.

			commercial fishing vessels and recreational crafts at the Pine River.		recreational and small commercial fishing fleets. The lack of recreational anchorage resulted in overcrowding in areas of the harbor that have a sufficient water depth. Shoaling that occurred within the river channel caused tidal delays. The lack of recreational anchorage and traffic within the channel discouraged growth and declined navigational efficiency.	
USACE Saugus River Navigation and Environmental Assessment	United States Army Corps of Engineers	1986	The study investigated whether navigational improvements are necessary within the Saugus River and Pine River.	Saugus River in Saugus and Lynn MA	The problem observed in the study area was that there was a lack of navigational system that could provide a safe and efficient utilization of the water. The channel leading to and from the harbor is narrow and shallow as well which restricts vessel traffic, creating a hazardous two-way navigation. The shallowness of the channel also resulted in icing, making it difficult for fishing	• Deepen and widen the channel to alleviate traffic and construction of new anchorage areas to meet current and future demands.
USACE Coastal Flood Protection Report and Environmental	United States Army Corps of Engineers	1986	This report summarizes the coastal flooding problems in the study area and alternative solutions by describing the selected plan, implementation responsibilities, identifies	Revere Beach Reservation, Lynn Harbor,	There was a considerable amount of erosion along seawalls at the beach. SLR posed issues for the beach and the surrounding	• Flooding Mitigation: Installation of breakwaters, seawalls or revetments, beach restoration and nourishment, dikes, floodwalls, sand dune development

Assessment for Point of Pines			environmental resources in the study, area and potential impacts of alternative solutions, as required by the Federal (NEPA) and state (MEPA) environmental processes.	PoP, Saugus River	area. All the study areas are subject to flooding	

1986 United States Army Corps of Engineers (USACE) Coastal Flood Protection Report and Environmental Assessment for Point of Pines

This report focused on the coastal flooding concerns that impacted Revere Beach Reservation, Lynn Harbor, PoP and the Saugus River. The report found that along Revere Beach Reservation, there was a significant amount of erosion along the seawalls. In 1986, the existing revetments were insufficient to protect the Study Area from flooding and storm surge, and these revetments are still those present in the Study Area.

Reach A is a 230 ft. long located adjacent to the north end of Revere Beach and consist of 12 ft. high vertical concrete wall extending in a semi-circle around Carey Circle. The top of this Reach has an elevation of 15 ft NGVD. Reach B is a 440 ft. long section with an average top elevation of 15 ± ft. NGVD. Reach C is 430 ft. long section with a top elevation of 15 ± ft. NGVD. Reach D is a 430 ft. long section with a top elevation of 14± ft. NGDV. Reach E is the longest section of beachfront extending for about 1,720 ft to the mouth of Saugus River. The top elevation varies between 12.1 and 16.6 ft NGVD. Reach F is a 970 ft. long section that extends on the western side of Saugus River and has a top elevation of 12 ft NGVD that is located adjacent to Rice Avenue. Lastly, Reach F extends 730 ft from Reach F to the embankment of North Shore Road at the General Edwards Bridge. **Figure 1 below** displays the Reaches, proposed actions and the station numbers. Figure 1 is taken directly from the 1986 report, and therefore its resolution of the figure is not very high, which makes it difficult to view the reaches identified at the time .

The proposed revetment would start with a transitional section in Reach A. The top elevation of the revetment would gradually increase from 13.6 ft NGVD to 16 ft t NGVD at station 0 +00 as displayed in **Figure 1**. This proposed revetment would remain the same elevation until station 10 +00. At station 14 +00, the top elevation of the revetment wall would decrease to 14.5 ft. NGVD. The proposed revetment would have an 8 ft. armor stone.

Another structural recommendation was to install a 36-inch gravity drain that would extend from Rice Ave. to the east side of the existing pumping station east of Reach G. The proposed gravity drain will extend from a new catch basin on Rice Avenue through the line of protection east of the existing pump station. The proposed gravity drain would be equipped with flap gates and an emergency sluice gate closure at the line of protection. With the addition of the gravity drain the drainage system would have a maximum capacity of 100 cubic feet per second (cfs).

The recommended plan also consisted of raising the elevations of the existing sand dunes. The existing sand dunes had a top elevation between 12.1 to 16.6 ft. NGVD. In Reach E, the existing sand dunes would be raised to a continuous elevation of 14 ft . NGVD, beach grass and plants would also be planted to stabilize the dune. In order to raise the elevation of the sand dune an estimated 6,700 cubic yards of sand fill would be needed. The seawalls located at Reach F would be raised to a top elevation of 13.3 ft. NVGD by adding a pre-casted concrete wall to the top of the existing seawall along the northern side of Rice Ave. along the Saugus River.

The recommendations were developed based off an approximated Standard Project Northeaster (SPN) tide of 13 feet NGVD. This tide level was approximated by calculating the maximum storm surge and adding that value to the maximum probable high tide.

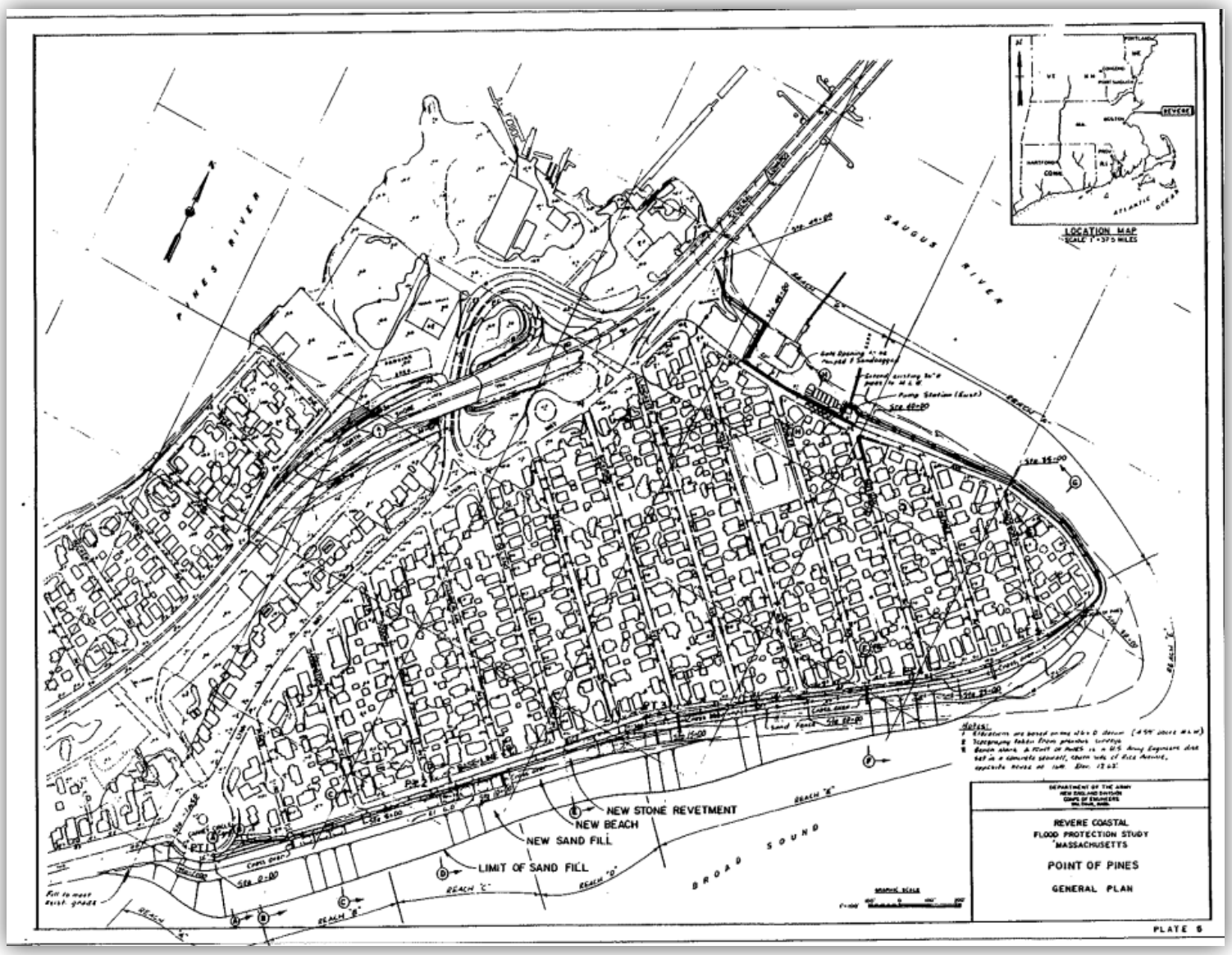

Figure 1: Locations of Proposed Actions and Reaches

1986 USACE Pines River Navigation Report and Environmental Assessment

This report addressed concerns regarding a shortage of recreational anchorage locations within the Pines River channel. The shortage of recreational anchorage posed a problem for the city of Revere and Lynn. Within the Pines River, there were a large number of recreational and small commercial fishing fleets, and the shortage of anchorages resulted in overcrowding in certain areas of the River, resulting in watercraft traffic and delays. Shoaling within the river also caused delays for watercraft due to tidal restrictions on water depths needed for safe navigation. This overcrowding and lack of anchorage negatively impacted economic growth. The USACE recommended a plan to increase anchorage areas as well as construction of an improved access channel. The recommended plan consisted of construction of an access channel spanning 6,500 ft. at the confluence of the Saugus and Pine River, upstream of the head of navigation. The 2,500 ft. downstream of the channel was proposed to be dredged to a depth of 8 ft. 4,000 feet upstream of the channel would be dredged to 6 feet Mean Low Water (MLW) and width of 80 feet. Dredging was also proposed to create a 5-acre (ac.) anchorage area with a depth of 6 ft. MLW along the western side of the downstream channel. The recommended plan would require the removal of 76,500 cubic yards of material. The plan was intended to mitigate shoaling in the channel as well as alleviate water vessel congestion and delays.

1986 USACE Saugus River Navigation and Environmental Assessment

This study analyzed potential navigational improvements within the Saugus and Pine River. The navigational issues within the Saugus River consisted of a narrow and shallow channel which resulted in a hazardous navigation area. In addition, the shallowest areas of the channel were prone to freezing, rendering fishing in these areas difficult. The recommended plan suggested the development of a wider and deeper channel through Lynn Harbor, Saugus River and Pine River to mitigate traffic and hazardous traveling conditions. The construction of a 3-acre anchorage area and basin were also recommended. The report recommended that the area would have to be dredged 6 ft MLW in order to construct the anchorage area and basin. Two additional anchorage areas were proposed upstream of Western Avenue. The recommended plan required dredging and the removal of 162,000 cubic yards of existing material.

1989 USACE Flood Damage Reduction Study for the Saugus River and Tributaries

In this report, the USACE presented a descriptive plan on how to mitigate the damaging effects of sea level rise, flooding, and degrading shoreline in Lynn, Revere, Saugus and Malden. An overview of USACE recommendations for flood damage reduction can be observed in **Figure 2**. The USACE suggested both structural and non-structural recommendations to mitigate flooding damage. As described below, one of the more significant recommendations in the report was the construction of a floodgate at the mouth of the Saugus River to provide regional flood protection.

The non-structural recommendations were to maintain existing seawalls, tides gates and ponding area within the study area. In 1989, the ponding area was 20 acres and was located along North Shore Road (i.e. Route 1A), which is located on the north end of Revere Beach. Part of this recommendation included protection of the existing ponding area by installation of a wall. If water levels were to exceed the ponding area's capacity, water would flow over North Shore Road into the estuary, where the water levels would be regulated by a floodgate. The recommendations included a 3 to 4-foot-high gravity wall to be located along located along the top of an old railroad embankment located between Route 1A and the Seaview Condominiums on Revere Beach Boulevard. The USACE also proposed a 500-foot-long wall that would be located at the south end of the ponding area. This 500-foot wall was recommended to prevent flooding on Oak Island Street. It was also recommended that the project sponsor develop a flood preparedness plan. The USACE would prepare an Operation and Management (O&M) Plan, which would provide information that could be used in the development of the Flood Preparedness Plan.

Structural recommendations consisted of the installation of a tide gate along Sales Creek and a dike behind Revere Beach. USACE also recommended the construction of a wall revetment along Point of Pines as displayed in **Figure 3**.

Other structural recommendations consisted of the installation of tidal floodgates by the mouth of the Saugus River; ten flushing gates on the left and right side of the navigation gates along Lynn and Revere; and a dike in Lynn harbor. The recommended tidal floodgates consisted of 1,290 ft. of structures at the mouth of the Saugus River, including a navigational gate, ten flusher gates and two concrete gravity wall sections. The proposed navigational and flushing gates are displayed in **Figures 4 and 6.** These gates would initially close two to three times a year for approximately an hour or two during the peak of the tides. In the conceptual design, the gates were envisioned to open as tides retreated back to the level of estuary. If sea level rise approached 2 feet, the floodgate would close more often; the study predicted that the gates might experience up to closures 200 times a year to provide protection for the 50-year flood level. In general, the proposed floodgates were envisioned to close whenever the tides were projected to rise to or above 8 feet elevation NGVD. Both the navigational and flushing gates were identified as 730 feet long with 8,800 sq. ft of gated opening at 0 NGVD, mid-tide. To prevent scour, a 30-foot wide stone structure was identified along the edge of the gate. Concrete gravity walls were situated at each end of the floodgate, including a 140 ft. long wall in Lynn and 420 ft long wall in Revere. The proposed floodgate would connect to 8,900 ft. of dikes and walls along Lynn Harbor.

Another structural recommendation was to raise the elevation of land in a park along Ocean Avenue and Revere Beach Boulevard, as displayed in **Figure 5.** Raising the ground elevation in the park was intended to enable the formation of a dike consisting of impervious surfaces, with a peak elevation of 23 ft.

The USACE structure recommendations for PoP are displayed in **Figure 6**. A new 1,550-foot long revetment was proposed to be installed along the PoP shorefront to an elevation of 16 ft. NGVD. Another 1,600-foot long revetment was proposed to be installed underneath the existing sand dunes, including armor stone and an elevation of 14 ft NGVD. Recommendations for PoP also included raising the height of the existing seawall an additional 1 to 3 feet and re-building damaged seawalls. PoP and Park recommendations were optimized for the 100-year flood level. The other recommendations are optimized to provide full SPN level of protection.

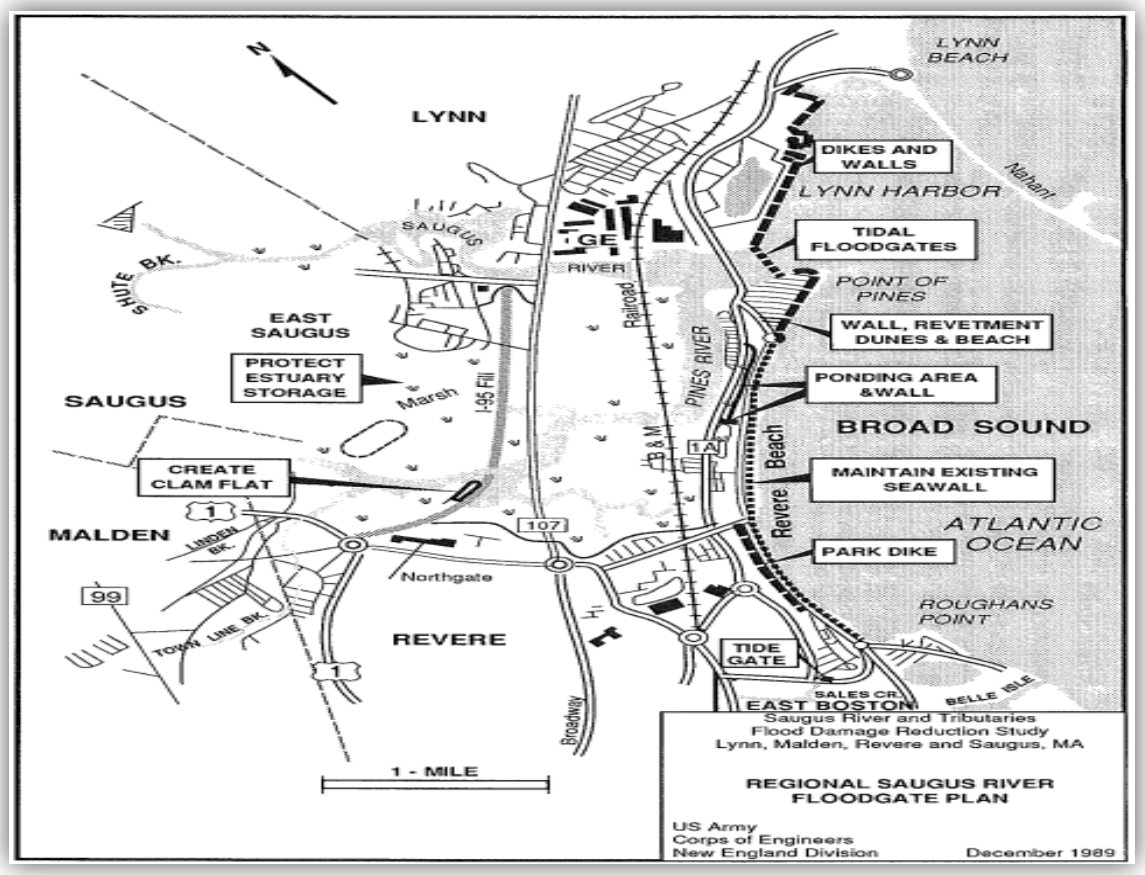

Figure 2: Overview of Flood Damage Reduction Recommendations

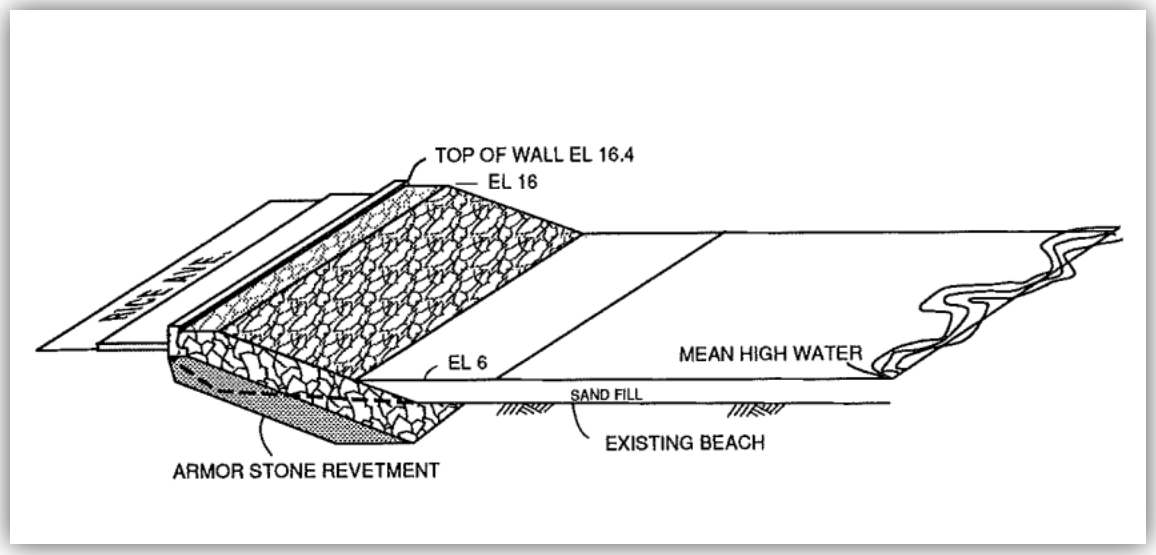

Figure 3: Proposed Revetments for Point of Pines

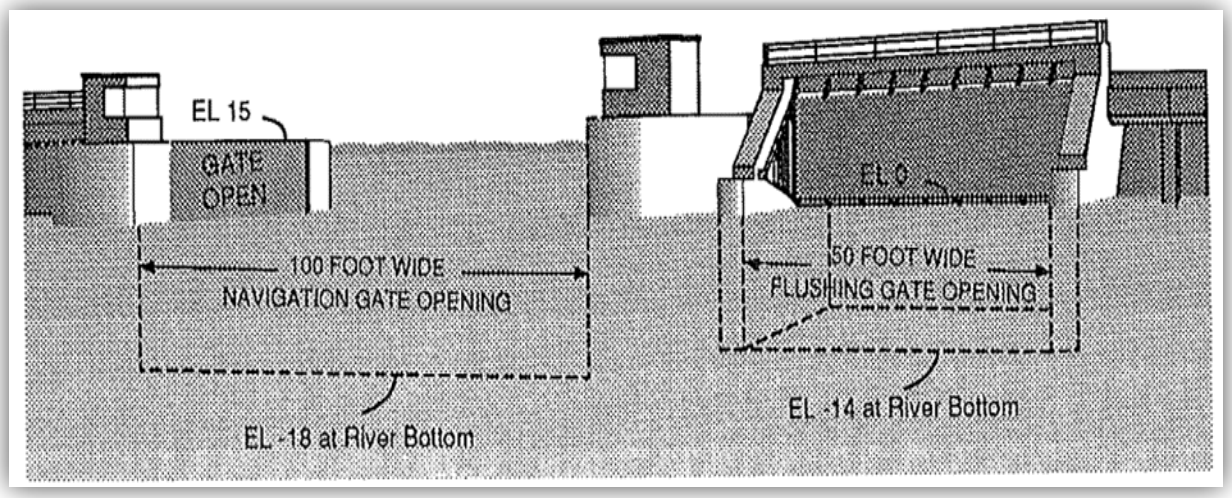

Figure 4: Proposed Navigation and Flushing Gate

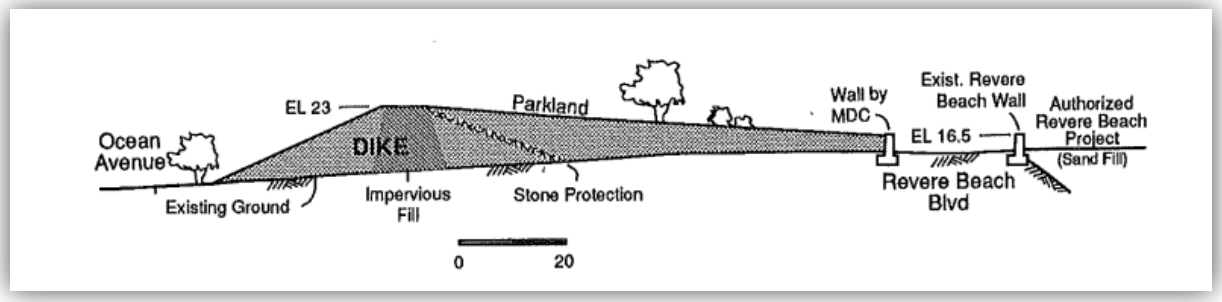

Figure 5: Proposed Park Dike

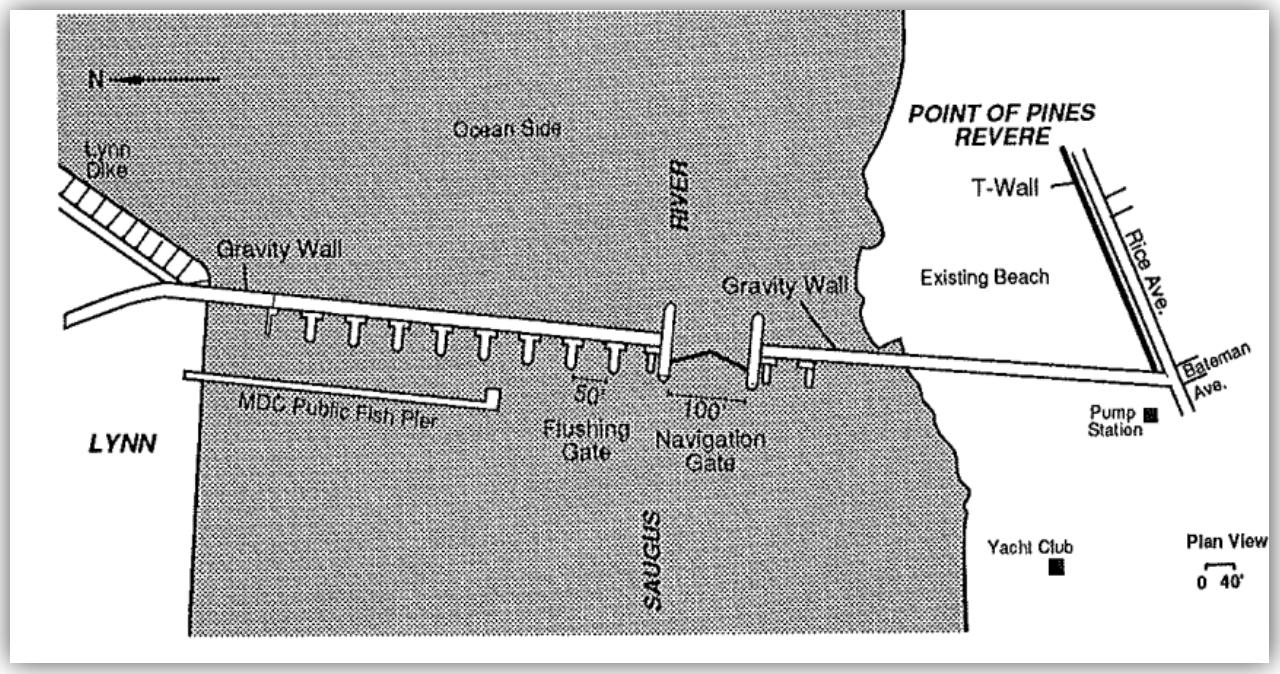

Figure 6: Point of Pines Structural Recommendation Overview

1991 USACE Revere Beach Erosion Control Report

This report focused on beach erosion issues at Revere Beach Reservation. The report identified that Revere Beach Reservation was only 4 ft. above MLW which made the seawall structures vulnerable to the daily erosion from saltwater and sedimentation. The USACE stated in the report that the primary reasoning for the advancement was due to development along the shore and natural erosion. The recommended plan suggested widening Revere Beach Reservation by placing sand fill along 13,000 ft. of beach fronting the Metropolitan District Commission Reservation to a backshore elevation of 18 ft. above MLW. The design included an elevated area consisting of fill material, resulting in the area being above MLW, which reduced the surface area impacted by tides, waves and currents. It was estimated that 800,000 cubic yards of sand fill would be needed for construction. These recommendations provide an adequate amount of protection against the storm surge and sea level conditions in 1991. The recommendation would not provide complete protection for hurricane and any infrequent major storm events.

2015 City of Revere Hazard Mitigation Plan

Hazard Mitigation planning is a proactive effort to identify actions that can be taken to reduce the dangers to life and property from natural hazard events. In the communities of the Boston region of Massachusetts, hazard mitigation planning tends to focus most on flooding, the most likely natural hazard to impact these communities. The Federal Disaster Mitigation Act of 2000 requires all municipalities that wish to be eligible to receive FEMA funding for hazard mitigation grants, to adopt a local multi-hazard mitigation plan and update this plan in five-year intervals. Planning for the Revere Hazard Mitigation Plan (HMP) update was led by the Revere Local Hazard Mitigation Planning Committee, composed of staff from several different City Departments. This committee discussed where the impacts of natural hazards most affect the City, goals for addressing these impacts, and hazard mitigation measures that would benefit the City.

The 2015 HMP summarized hazards faced by the City of Revere in the period up to 2014. The report found that the City is subjected to floods, hurricanes, tornadoes, coastal hazard, earthquakes, brush fires and extreme temperatures. There are many areas in the City that were vulnerable to the effects of flooding. During high tide and storm events, overtopping occurred at Eliot Circle, Revere Beach from Cary Circle to Eliot Circle, and the seawall located at the PoP on Miller Ave. Areas vulnerable to storm surge and high tide events were also identified in this report, including Cary Circle to Alden Avenue, Rice Ave. near the Yacht Club, and the Winthrop

Parkway Neighborhood. Furthermore, the Belle Isle Ave. neighborhood is susceptible to flooding during a storm surge that results in overtopping from Belle Isle Inlet. The report also found that Revere is extremely vulnerable to tsunamis and winter storms based on its geographical location and topography. Recommendations discussed in the report consisted of the installation of a 24- in. drainage pipeline along lower Pear Avenue; purchasing three 8 and 12-in. trailer mounted diesel pumps and hoses; the installation of a diesel generator at 17 sewer pump stations and at the Reservoir pumping station; and the installation of a tide gate along Rout 1A. The report recommended the addition of a seawall from Cary Circle to Alden Avenue and along Miller Avenue from North Shore Road to Alden Avenue. The final recommendation was for the City to install new sewer pump stations at Martin Street and Oak Island.

2019 Municipal Vulnerability Preparedness (MVP) Summary of Findings Report

This report summarized climate change concerns and solutions that Revere residents established during the MVP workshops. The top City hazards identified by the attendees included: coastal and inland flooding, erosion, extreme temperatures, sea level rise, hurricanes and severe storms. There were five areas in Revere that the MVP groups focused on Beachmont, PoP and Riverside, Oak Island and Revere Beach, West and North Revere and Sales Creek. Within the Beachmont area, there are several neighborhoods that are vulnerable to flooding. There are portions of Beachmont that are within the 100-year and 500-year FEMA Floodplain. This region is home to schools, pump stations, a tide gate, and areas designated as Areas of Critical Environmental Concern by the State. The Majority of the PoP/Riverside Ara excluding Route 1A, is located within the 100-year floodplain. The Point of Pines Yacht Club, Point of Pines Beach, and associated piers, docks, and water access points are exposed to wind and storm surge. Sales Creek and West and North Revere are located within the 100 100-year floodplain. Some of the most severe flooding occurs in the vicinity of Belle Isle Marsh and Rumney Marsh during high tide rainstorm events. MVP workshop participants noted that flooding resulted in the pollution of nearby marshes, wetlands, and other surface water bodies due to associated sediment and nutrient loading. Many recommendations were made for the Study Area. The top priority action items were to construct a seawall and in the PoP and Riverside area; to conduct feasible studies to determine the best mitigation methods for flooding, erosion, and storm impacts in the PoP and Riverside area; rehabilitate the existing seawalls to mitigate flooding in the Beachmont area; dredge and maintain Town Line Brook in the northwest side of Revere; form a liaison between the City of Revere and the State for funding sources and improve communication between the City and State; promote future developments in relation to flooding and drainage in the City; investigate permit process for sand transfer to mitigate coastline erosion in the PoP and Riverside area. All the recommendations suggested by the workshop would allow Revere to be more resilient against one of its major threats - flooding.

2020 Boston Region Metropolitan Planning Organization's (MPO) Route 1A Corridor Vulnerability Assessment

The MPO conducted a community survey and identified Route 1A as a location to conduct a pilot study. During the study, the MPO identified that the Study Area is vulnerable to high tides, flooding, storm surge and sea level rise. Currently, Route 1A has a flood probability between 10 percent to 20 percent with a 1 percent flood depth of approximately 1.5 ft. Within the next 10 years, the flood probability increases to 20 to 25 percent with a flood depth between 2 to 3.5 ft. In 30 to 50 years, Route 1A will be overtopped with a flood probability of 100 percent and an estimated flood depth between 5 to 10 ft. The MPO provided both structural and non-structural recommendations for Route 1A. The structural recommendations consisted of installing bulkhead, breakwater, edging devices rock sills and revetment structures, planting wetland vegetation, and raising the roads to upgrade culverts. The non-structural recommendations were to develop an emergency response plan, a flood preparedness plan and establish land use regulations. The MPO recommended that the City acquire certain structures and possibly relocate those structures, along with flood-proofing structures. Lastly, it was recommended that a flood warning system should be implemented.

Figure 7: High Tide Flood Frequency of the Study Area Limits

3. Ongoing Relevant Projects in the Project Area

Riverfront Master Plan

The Riverfront Master Plan is an in-progress initiative lead by the Revere Office of Strategic Planning & Economic Development. The goal of the Plan is to analyze and discuss current challenges and opportunities for the districts within and near Gibson Park, the Riverside neighborhood, and the PoP area. The report will focus on coastal flooding, climate resiliency, green spaces, transportation and development within the study area, along with the City of Revere as a whole. The mayor of Revere, Mayor Arrigo, selected the advisory group for this project, consisting of community advocates, neighborhood representatives and city officials. The group will provide feedback and input throughout the study. four public meetings were held between November 2020 and December 2020.

The preliminary draft report recommends non-structural improvements including to incorporation of a public pier in Gibson Park that could be used for public fishing, or a gangway and a float for excursions and water taxi services. Another recommended non-structural improvement is to develop a community boating area, which would provide opportunities for community rowing. One of the structural improvements recommended is to combine the eastern portion of the Boatworks location with Gibson Park to provide extra parking, recreational and stormwater management space for the study area. This improvement would also result in the existing revetment wall to be rebuilt with additional stones and rip rap. The wall would be built to a height that protects the area from storm surge. The last structural improvement was to convert the northwestern portion of the waterfront to a salt marsh.

Rowing Facility and Long-Term Uses for Gibson Park

This project will develop waterfront access for rowing. The St. Mary's rowing team will be the primary users of the new waterfront access. After the initial access for rowing is completed, there may be further developments on the waterfront to create a public waterfront access facility for Revere. The preliminary investigations will consist of an above-water and underwater investigation of the existing waterfront infrastructure along the 250 ft. shoreline. The underwater investigation will begin at the shoreline and extend 200 ft. into the river. When the preliminary investigation is completed, the City will be provided with a preliminary planning report that will detail the waterfront access options both for the rowing team and a future public access facility as well. The report will also include schematic plans of options, planning and construction processes, regulatory and permits required; a project schedule; potential challenges and design considerations; a rough initial cost for the project, and potential funding sources.

4. Relevant Case Studies

In order to successfully assess and recommend climate mitigation strategies and actions for this feasibility study, research was conducted to identify strategies implemented by other communities of similar geographic location, vulnerabilities to climate hazards, topography, and population. The City can use the research performed by other municipalities to advise this feasibility study and next steps in the project process. Similar studies and projects in the northeast region of the country and are summarized and presented below. Each text section describes the applicable case study's goals and solutions and includes a summary statement in bold that identifies how each study's conclusion applies to the current scope and goals of this project.

Table 2: Summary of Relevant Case Studies

Title	Author	Date of Source	Source Overview	Definition of Study Area	Summary of Findings	Recommendations
Coastal Resiliency Planning for Surf Drive, Falmouth, MA	Woods Hole Group, Inc.	2020	This study discussed the MVP planning process undertaken by the Town after conducting a climate change flood vulnerability assessment. It evaluated high priority areas and infrastructure in Falmouth that are vulnerable to climate change events, in particular flooding and erosion due to sea level rise. This study recommended actions the Town can take to protect infrastructure, improve resiliency of natural resources and ecosystems, and maintain coastal resources to preserve Town's cultural identity around the Surf Drive Area.	Falmouth, MA - Surf Dr	The most common actions for the studied area discussed throughout the workshops were flood mitigation through natural and structural barriers, promote public awareness and education, and abandonment of maintenance for vulnerable areas.	• Beach/dune nourishment for vulnerable roadway sections • Remove existing pavement along beach barriers and construct extended bridge • Construct tall flood barrier (i.e. seawall) • Abandon Surf Dr • Cease maintenance along Surf Dr • Research and develop policies for phasing out Town services to private homes and roads in vulnerable areas • Engage in public outreach to prepare residents for future changes

Title	Author	Date of Source	Source Overview	Definition of Study Area	Summary of Findings	Recommendations
Climate Ready Boston - Climate Resiliency Study	City of Boston & Green Ribbon Commission	2016	Climate Ready Boston used three climate projection scenarios to develop an extensive feasibility study for 7 Boston neighborhoods. This was done by examining various strategies for climate adaptation that differed in time and cost. The City prepared a vulnerability assessment and used those findings to prepare climate resiliency initiatives which addressed the impacts of future climate change.	Boston, MA	The findings of this study suggested implementing various community engagement efforts, land use planning, infrastructure adaptation planning, adapted structures, and development of financial strategies and governance structures.	• Flood protection systems • Adapted buildings • Green Infrastructure • Feasibility study for energy solutions
Resilient Cape Cod Project	Cape Cod Commission	2018	In this study, CCC and partners developed a tool and public outreach program to investigate the environmental and socio-economic efforts of local and regional coastal resiliency strategies in hopes of enhancing the resilience of communities to the effects of extreme weather, climate hazards, and changing ocean conditions. This study focused on the effects of erosion, storm surge, and sea level rise.	Cape Cod, MA	The study produced The Coastal Planner - a communication and decision support tool which is used to communicate the impacts of coastal threats and adaptation strategies, including cost and benefits, and implications for local infrastructure and ecosystems.	• Do nothing • Beach nourishment, dune restoration • Offshore Reefs • Coastal Armoring • Structure elevation •Wetland and salt marsh restoration • Retrofitting existing utilities, roadways, and structures for flooding • Living shoreline • Regulation of development

Title	Author	Date of Source	Source Overview	Definition of Study Area	Summary of Findings	Recommendations
Manchester, MA Sawmill Brook Restoration	Tighe & Bond	2019	This MVP funded feasibility study describes a 5-year planning process to restore Sawmill Brook in Manchester-by-the-Sea. Goals for this project included: fish passage improvement, wildlife habitat enhancement, public safety, and aesthetics. These goals must be balanced with flood mitigation and climate change resiliency. This study includes a permit level design for the preferred restoration project for Central Pond.	Sawmill Brook, Manchester-by-the-Sea	Work completed under the grant included identification of town owned land along the eastern banks of Central Pond, reducing the required number of easements for the restoration project, geotechnical studies, and public outreach to discuss analysis of alternatives for the restoration design	• Salt marsh planting • Flexible block retaining wall with public stairway access to water
Breezy Point - NY Rising Community Reconstruction Plan	Multiple Engineering Consulting Firms	2014	This study looks at the Breezy Point Community coastal resiliency project as a proposed project for the NYRCR Program. This study examines long term initiatives that will protect and enhance the community and outlines a comprehensive approach for reconstruction based on a 7-month planning process.	Breezy Point, located at the end of the Rockaway Peninsula in Queens, New York	The study produced various recommendations and strategies to mitigate the effects of sea level rise, erosion, and extreme weather events due to climate change. The goals of these mitigation efforts are to improve and expand coastal protection, strengthen community resilience, and protect and bolster infrastructure.	• Enhanced dune walkways • Bayside coastal protection • Natl. Park Service collaboration • Boulevard elevation • Housing elevation study •Multi-purpose community relief center • Summer store relocation • Repaired docks • Stormwater drainage improvements

2020, Coastal Resiliency Planning for Surf Drive

This study, performed by the Woods Hole Group, Inc. (WHG), discusses the MVP Planning Process undertaken by the Town of Falmouth, MA after conducting a climate change flood vulnerability assessment on a coastal road (Surf Drive). Similar to the Revere MVP planning process and feasibility study, the Surf Dr. planning study evaluated high priority areas and infrastructure in Falmouth that are vulnerable to climate change events; in particular, flooding and erosion due to sea level rise. The Surf Drive area is particularly vulnerable to inundation during a storm and typically requires frequent maintenance in the form of debris clearing and road damage repairs. This study recommended various actions the Town can take to protect infrastructure, improve resiliency of natural resources and ecosystems, and maintain coastal resources to preserve Town's cultural identity around the Surf Drive Area. The possible actions were for the Town to perform beach and dune nourishment/rehabilitation in vulnerable roadway areas, remove existing pavement along beach barriers, construct a seawall, abandon Surf Dr., cease maintenance, and research phasing out public maintenance to the Surf Dr. area. All recommended options were presented with a cost-benefit assessment. **The presented recommendations for the Surf Dr. road will be a beneficial asset when examining the PoP and Riverside areas in Revere due to similarities in residential use, coastal proximity, and existing infrastructure.**

2016, Climate Ready Boston - Climate Resiliency Study

Climate Ready Boston used three climate projection scenarios to develop an extensive feasibility study for seven Boston neighborhoods under the MVP Planning Process. This was done by examining various strategies for climate adaptation that differed in time and cost. The City prepared a vulnerability assessment and used those findings to prepare climate resiliency initiatives, which addressed the impacts of future climate change. The findings of this study suggested implementing various community engagement efforts, land use planning, infrastructure adaptation planning, adapted structures, and development of financial strategies and governance structures. Notable actions included flood protection systems, adapted buildings, green infrastructure, and a future feasibility study for energy solutions. Flood protection systems include the construction of large harbor barriers, use of temporary flood barriers, creation of coastal tree canopies, and building protective and floodable waterfront parks. Green infrastructure and adapted building options discussed in the plan include retrofitting buildings with solar panels and microgrids, creating bioswales, and elevating buildings and mechanical systems out of flood range. **Although Boston is much larger than Revere, the geographic location, population diversity, goals and strategies are similar and will be useful in advising the feasibility study for the Study Area.**

2018, Resilient Cape Cod Project

In this study, Cape Cod Commission (CCC) and partners developed a tool and public outreach program to investigate the environmental and socio-economic efforts of local and regional coastal resiliency strategies in hopes of enhancing the resilience of Cape Cod communities to the effects of extreme weather, climate hazards, and changing ocean conditions. Similar to the Revere feasibility study, this study focused on the effects of erosion, storm surge, and sea level rise. The study produced The Coastal Planner - a communication and decision support tool which is used to communicate the impacts of coastal threats and adaptation strategies, including cost and benefits, and implications for local infrastructure and ecosystems. Also parallel to the Falmouth MVP study, the recommendations included in this study were beach nourishment, offshore reefs, coastal armoring in the form of seawalls and barriers, wetland and marsh restoration, infrastructure retrofitting, developing a living shoreline, and regulation development. **Revere’s feasibility study can draw from the adaptation strategies set forth in this project in terms of cost, impacts to local infrastructure and ecosystems, and overall project feasibility.**

2018, Manchester, MA Sawmill Brooke / Central Pond Restoration

This MVP funded feasibility study describes a 5-year planning process to restore Sawmill Brook in Manchester-by-the-Sea. Goals for this project included: fish passage improvement, wildlife habitat enhancement, public safety, and aesthetics. These goals must be balanced with flood mitigation and climate change resiliency. This study includes a permit level design for the preferred restoration project for Central Pond. Work completed under the grant included identification of town owned land along the eastern banks of Central Pond, reducing the required number of easements for the restoration project, geotechnical studies, and public outreach to discuss

analysis of alternatives for the restoration design. **Although a different scope than the Revere study, it sheds light on the 'next steps' in the planning and design process on how to bring a project idea into action.**

2014, Breezy Point – New York Rising Community Reconstruction Plan

This study examines the Breezy Point Community Coastal Resiliency Project as a proposed project for the New York Rising Community Reconstruction (NYRCR) Program. This study looks at long term initiatives that will protect and enhance the communities located on the westernmost end of the Rockaway Peninsula in Queens that make up the Breezy Point Community. This community faces threats from future climate change in the form of flooding from sea level rise, extreme weather events, and coastal erosion. The plan outlines a comprehensive climate-based approach for reconstruction based on a 7-month planning process that identified strategies for building economic and social resiliency in the area. Resilience goals would be achieved by improving and expanding coastal protections, strengthening community resilience, and protecting and bolstering current and future infrastructure. Recommendations from the study include enhancing dune walkways, elevating the boulevard, a housing elevation study, relocating summer stores, building bay seawalls and armored dunes, improving stormwater drainage, and collaborating with the National Parks Service to identify vulnerabilities on NPS land that threaten the Breezy Point Community. **The Breezy Point Community mirrors the Revere PoP/Riverside Community in that they are both coastal peninsulas with similar vulnerabilities looking to build resiliency towards the increased threats from climate change. Revere can implement the cost, risk, regulatory, and general project findings from this study as various strategies are assessed for the feasibility study.**

5. Historical Data

In examining resilience strategies to mitigate the impacts of future climate change, it is necessary to understand the area's geographic layout as well as any current vulnerabilities that have been illuminated by past natural hazard events. This section summarizes historical information that has been gathered in the form of surveys, maps, charts, studies, and records of historical events that will inform this feasibility study of ongoing vulnerabilities in order to prioritize future mitigation strategies and actions.

Thayer Boat Yard Existing Survey

The Thayer Boat Yard, also known as North Shore Boat Works, is a 1.15-acre parcel located on the northwesterly end of the Revere Beach peninsula along Thayer and Hayes Ave, bordered by Gibson Park to the north (See Figure 5 below). The boatyard/marina facility has existed since the early 1900s and has historically been a location where significant flooding has occurred due to its proximity to the ocean and low elevation. The lot has been assessed for potential development on numerous occasions, two of which were in 1989 and 2006. The boatyard consists of a dirt lot containing a one-story building on the southwestern side of the property closest to the waterfront, a parking area, and storage for boats, equipment, and parts on the remaining lot area. The property has an approximate <0.5% slope from the upland area to the shoreline, which consists of a bulkhead retaining wall and riprap. Most notably, the 1920 mean high water mark, as displayed on the 2006 survey, encroaches 10-15 ft onto the boatyard property. Because the property sits at a low elevation on the water's edge with little protection from rising tides, it is in danger of continual coastal flooding with sea level rise.

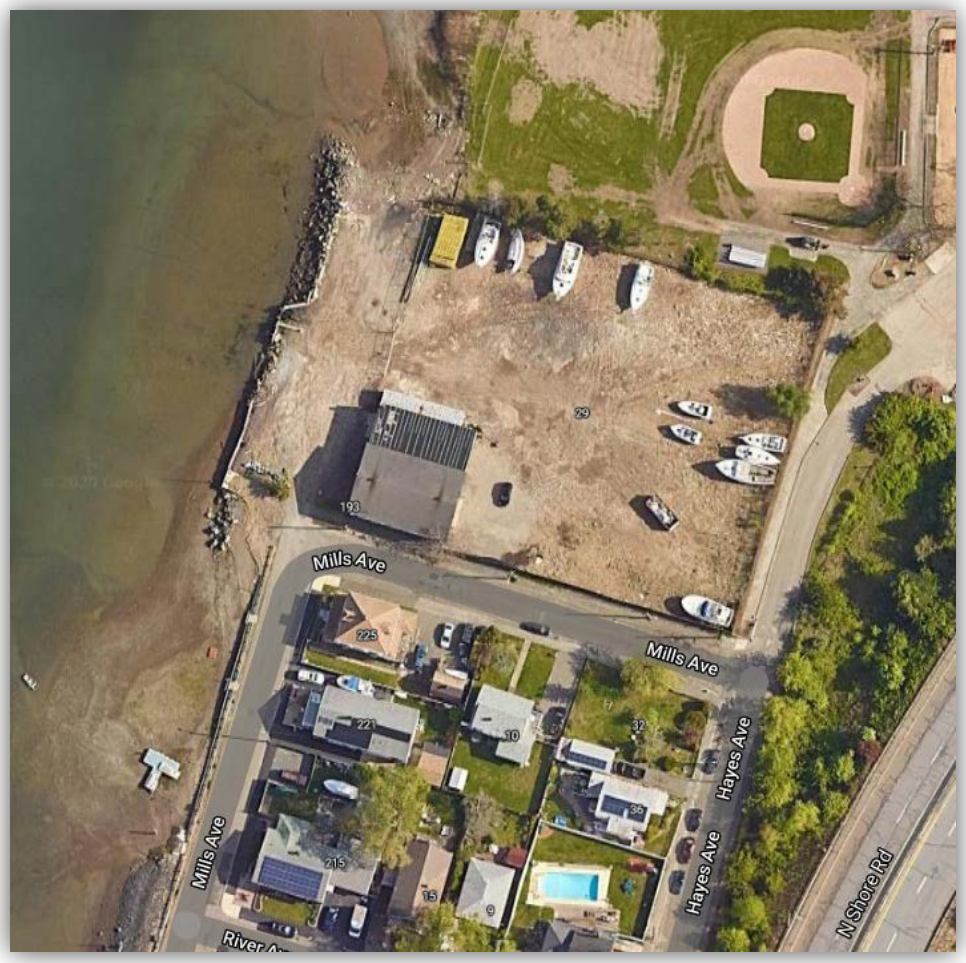

Figure 8: Thayer Boat Yard, 2020 Aerial Photo

Navigational Charts

The Study Area is a peninsula located within the Broad Sound, just west of Nahant. As displayed on the NOAA navigational chart (see Figure 6 below), the Study Area is in a low-lying bay within the Sound, surrounded by sandy tidal flats extending significantly into the bay on the eastern side. A channel extends from the deep Sound up to the Saugus River, crossing under the General Edwards Bridge located on the northern point of PoP. The channel edges the sandy area on the northeastern side of PoP at a low tide depth of 8 ft. Just beyond the sandy shores around the PoP, the water depth drops to between 0.5 to 8 ft in the surrounding shallow bay. The high tide depth in the PoP area is typically between 9.5 -10.5 ft at a normal high tide but was recorded at over 12 ft in 2018.

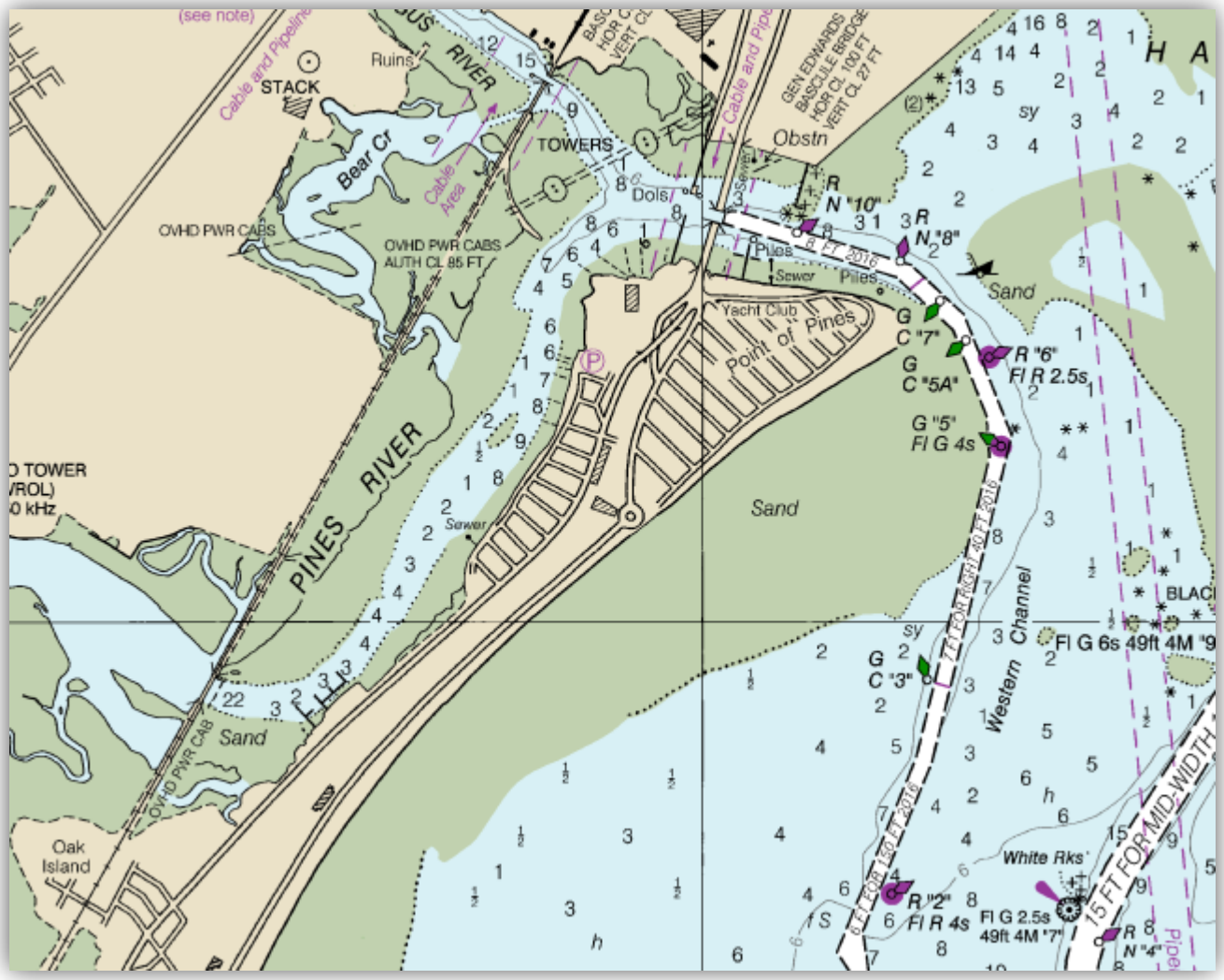

Figure 9: NOAA Navigational Chart, Point of Pines, Revere, MA, 2016

Historical Storm Events

Revere has experienced numerous coastal storms over the past few decades, largely in the form of nor'easters. Most notably were the well-known Blizzard of 1978 and the more recent Winter Storm Grayson that occurred in the winter of 2018 causing severe flooding and evacuations in Revere. In 1978, the City experienced a tide surge creating a 100-year water level, causing extensive damage to 25% of the City's homes. Dubbed as the 'bomb cyclone', the storm in 2018 resulted in almost identical levels of severe flooding paired with precipitation and cold temperatures, which caused infrastructure damage and the evacuation of 20 people from their homes, some needing emergency assistance.

The revere Hazard Mitigation Plan, last updated in 2014, lists a total of 17 natural disasters that triggered federal or state disaster declarations since 1991 in Revere. City specific flood data was unavailable at the time the plan was written, but the county in which Revere is located experienced six flooding events since 1996 totaling $25.733 million dollars in property damages.

This plan also notes the repetitive loss structures in Revere, which are properties that have filed two or more flood claims of $1,000 or more in any given 10-year period. That number of properties has increased from 249 in 2005 to 293 in 2014. 270 of these properties are located within a FEMA flood zone and are mostly comprised of single or multi-family residences.

Coastal Erosion and Shoreline Change

Coastal shorelines change in response to wind, tides, waves, sea level rise, human interaction, and climate variation that influence the movement of sand and sediment. Shorelines are shaped by the gain and loss of sand and sediment due to these influences. Revere is situated in such a way that the Study Area is exposed to waves and wind on the eastern side facing Broad Sound, pushing sand towards the northern tip of the peninsula. This northern area of PoP sees a constant deposit of sand from the southern Riverside shoreline, which can result in the blockage of tide gates and stormwater structures. These conditions are exacerbated in the winter months when weather conditions are typically more severe in comparison to the calmer summer months. The Coastal Erosion Commission reported in 2015 that attempting to halt the natural process of erosion through seawall construction or other hard structures will only worsen the problem by eliminating downdrift from sediment held behind the structure. In Revere, beach nourishment has taken place on several occasions to rehabilitate the dunes for natural storm protection.

The Massachusetts Hazard Mitigation Plan references a study which examined coastal erosion along the shorelines in Massachusetts and found that 68% (513 miles) of Massachusetts shoreline exhibited long-term erosion and 30% (226 miles) showed long-term accretion. Approximately 46% of the Massachusetts shoreline is eroding at one foot or less per year. Sea level rise and coastal flooding contribute to coastal change and are frequent events along the coast of Massachusetts. Flooding has been increasing as a result of sea level rise and land sinking over the last 100 years. If climate change trends continue, coastal flooding will become more frequent as oceans warm and glaciers melt, resulting in higher risk for coastal communities such as Revere. When sea levels rise, smaller storms will exhibit the same amount of damage as larger storms do currently.

Massachusetts Office of Coastal Zone Management's (MA CZM) Shoreline Change Project

The MA CZM 2010 Shoreline Change report analyzed historical shoreline changes on the New England and Mid Atlantic coasts. Throughout the report, long and short-term trends and rates of erosional change were examined. The project also studied how different coastal communities are impacted by coastal erosion. The study found that New England and Mid Atlantic sandy shorelines are subjected to a long-term erosion rate of 65 percent and a short-term rate of 60 percent. The study suggested that the erosion rates are caused by sea level rise. The effects of sea level rise can be mitigated by beach nourishment projects and thoughtful engineered structures, as suggested by the study. Beach nourishment was noted as a highly effective option because it slows down the rate of which sand recedes, allowing the rate of erosion to stabilizes or slow down.

6. Conclusion

The review of current and historical weather conditions, studies, assessments, testimonials, and maps of the City of Revere reestablishes the prior conclusions stated in 1986 – they show how vulnerable the City is to the imminent coastal threats that climate change presents. Erosion, sea level rise and flooding have been coastal hazards affecting the Point of Pines and Riverside communities for years and are only becoming more severe. Measures to mitigate the effects of these hazards will need to be prioritized by the City in order to prevent future damage as climate change exacerbates these conditions. The historical data from this area has shown that sea level rise in conjunction with high tides have resulted in the increased frequency of coastal flooding in the PoP and Riverside communities. Furthermore, due to its positioning in the Broad Sound, the Study Area has also been exposed to erosion and shoreline change as wind, currents, and waves alter sand placement on the Riverside and Point of Pines coasts. The historical data collected from Revere, paired with local case studies,

will be used to inform the next steps in this feasibility study, which will ultimately be used to develop a coastal resiliency toolkit for Revere to utilize when addressing future climate change threats.

7. Acronyms

Ac.	Acres
Ft. or ft	Feet
In. or in	Inches
MLW	Mean Low Water
MPO	Metropolitan Planning Organization
NYRCR	New York Rising Community Reconstruction
NGVD	National Geodetic Vertical Datum
PoP	Point of Pines
USACE	United States Army Corps of Engineers

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